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PLATOON

Digital platform and analytic tools for energy

Deliverable D1.1

Business case definition, requirements and KPIs

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Keyword List:	Business requirements, business cases, use cases, methodology, standards

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Executive Summary

This document lies under the scope of work package WP1- Energy system management challenges. Its content is based on the work of the Task 1.1 - Challenges/ Business case definition- and Task 1.4 -Business requirements.

This deliverable has been divided into two stages, the first called High Level Use Cases-HLUC and the second called Low Level Use Cases-LLUC. The second description (LLUC) is based on the Smart Grid Architecture Model (SGAM) framework**[2]**. The latter allows the description of the specifications of the use cases for each Pilot in accordance and compliance with the SGAM Framework.s showed in **Error! Reference source not found.**, the work in task 1.1 and Task 1.4, described in this deliverable, is closely related to all WP1 tasks, namely:

- Task 1.2-Data exchange requirements (Lead by INDRA)
- Task 1.3-Platform requirements (lead by TECNALIA)
- Task 1.5 -Legal & Ethics requirements (Lead by MANDAT INTERNATIONAL)

All these tasks are crucial for all the demonstrations preparations related to all PLATOON's Pilots. More detailed work on the basis of the use cases provided in this deliverable will be used by WP2-Reference Architecture, Interoperability and Standardization, by WP3-Data governance, security and privacy (especially Task T3.1-Data governance, security and privacy requirement analysis) and by WP4-Analyticial Toolboxes. The different elements developed in WP2-WP4 will be used to set a data sharing and analysis reference platform implementation in WP5 that will be used to conduct an integration testing of the developed components. In addition, as part of WP6-Large Scale Pilot Implementation and Validation, in T6.1 the low-level use cases described in this document will be further defined creating a detailed implementation and validation plan for each use case. Finally, based in the defined plan, in T6.2-T6.4 different platforms will be implemented and validated for each use case. The reference architecture and the new components developed, integrated, and validated in WP2-WP5, as well as the developments, requirements and KPI's analysed from WP1-WP5 will play important role for the assessment and evaluation of the 7 pilots.

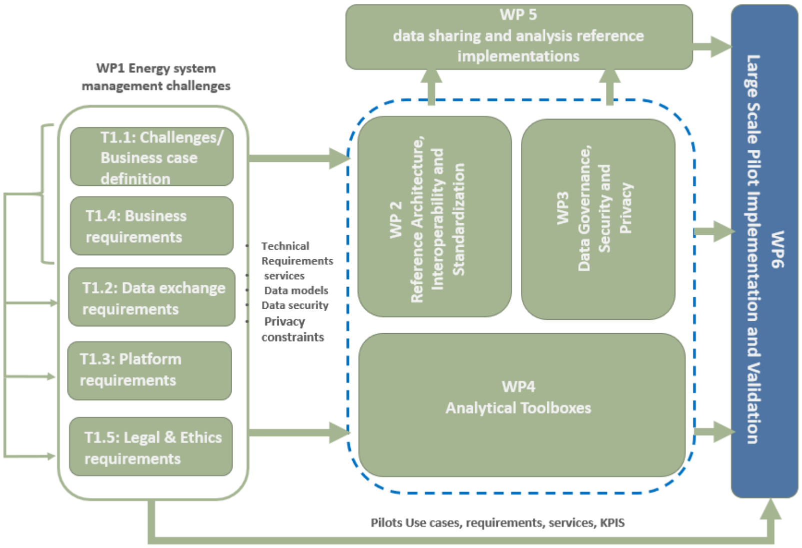

Figure 1: Main interactions of WP1 with other WPs of PLATOON project

To define PLATOON use cases, both PM2 Methodology**[5]** and IEC-62559 specifications**[3]** are followed. The used methodologies ensure a full compatibility with both international standards and work around energy in the European Union in a comprehensive manner. For all PLATOON's pilots, Key Performance Indicators (KPIs) will be identified for each use case arising from the project objectives and from the pilot's applications and services.

The combination of both project and partner's objectives has been considered during interactive sessions of use cases definition and based on a precise IEC 62559 oriented methodology. This process has generated a final list of 12 HLUCs, classified according to five business domains, based on The Smart Grid Architecture Model (SGAM) Framework presented in CEN-CENELEC-ETSI Smart Grid Coordination Group -European Conceptual Model for the Smart Grid **[2]**:

1. Generation,
2. Transmission,
3. Distribution,
4. DER
5. Customer premises

The following **Error! Reference source not found.** depicts the classification of PLATOON's HLUCs.

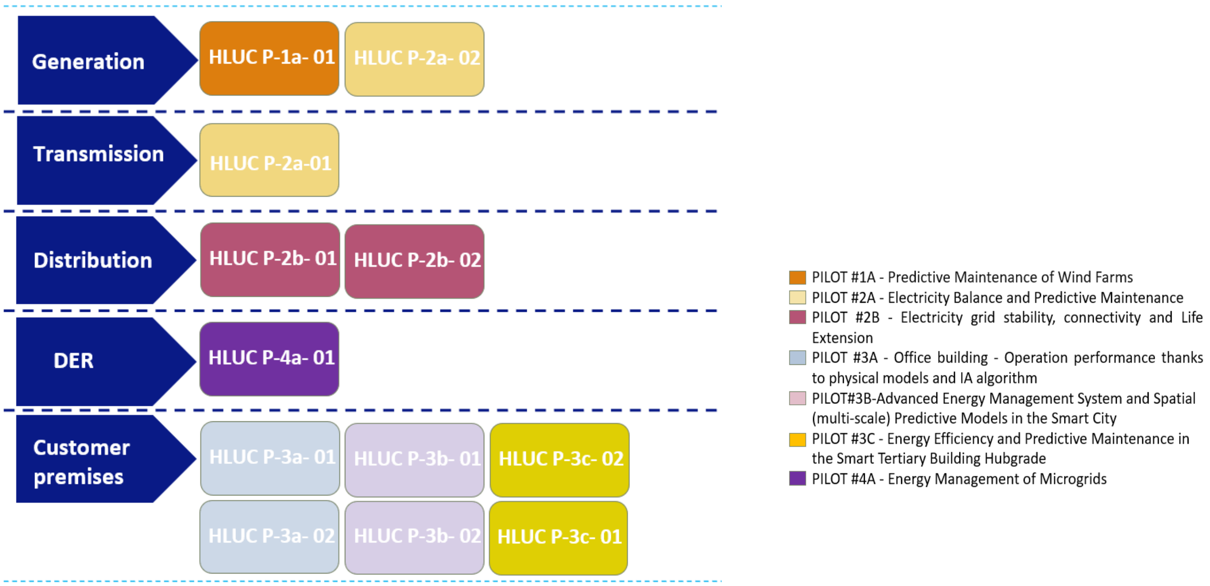

Figure 2.PLATOON's HLUC classification according to SGAM - domains

The identified High Level Use Cases (HLUCs) served as a basis for functionalities identification and are described more precisely in Low Level Use Cases (LLUCs). This document also describes the tools and associated services which will be demonstrated in the framework of the PLATOON project pilots. The main goal of LLUC document was to extract technical needs and functional requirements which are the basis for a set of common and transversal functions and services. The result of this work of low level functional description has resulted in 19 LLUCs, classified according SGAM business domains in the following figure **Error! Reference source not found.**.

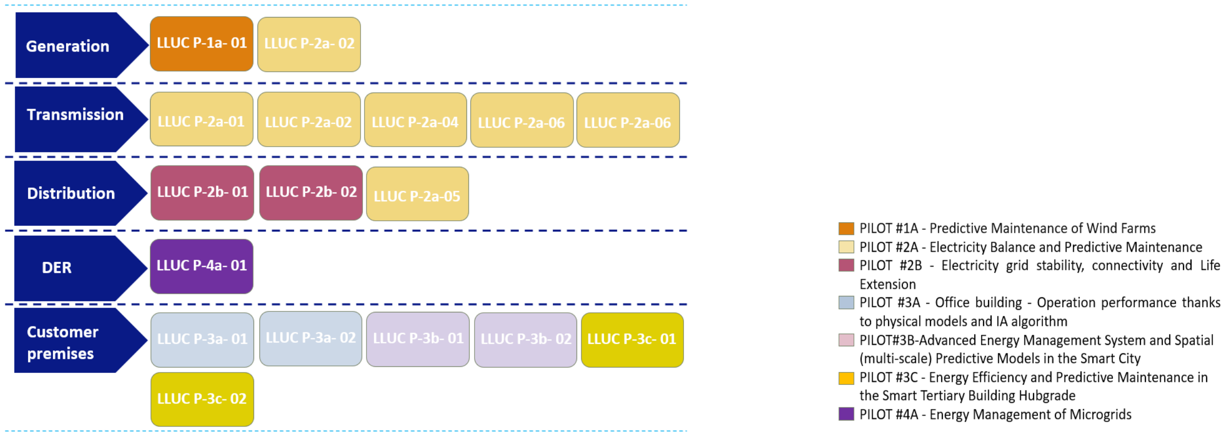

Figure 3 PLATOON's LLUC classification according to SGAM – domains

Each use case is classified per pilot in this deliverable. The level of the innovation within PLATOON, tools and services in each LLUC is identified, together with KPIS to measure key core functions performance. The set of use cases described in this deliverable fully covered the objectives defined in PLATOONs grant proposal.

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Terms and abbreviations

aFRR	automatic Frequency Restoration Reserve
AGC	Automatic Generation Control
AHU	Air Handling Units (AHU),
BMS	Building Management System
BRP	Balance Responsible Party
BSP	Balancing Server Provider
CoP	Community of Practice
CSC	Critical Success Criteria
CSF	Critical Success Factor
DB	Data Base
DER	Distributed Energy Resources
DR	Demand Response
DSM	Demand-side Management
DSO	Distribution System Operator
EC	Energy Consumptions of the building
EMS	Energy Management System
EMO	Energy Management Office
ENTSO-E	European Network of Transmission System Operators
EP	Energy Performances of the building
EV	Electric Vehicle
FCR	frequency containment reserves
FRR	Frequency Regulation Reserve
GHG	Green house Gas
HLUC	High-level Use Case
HVAC	Heating, Ventilation and Air-Conditioning
IDS	Industrial Data Space
IPP	independent power producers
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
KPI	Key Performance Indicators
LLUC	Low Level Use Case
LV	Low Voltage
mFRR	manual Frequency Restoration Reserve
ML	Machine learning
NDC	National Dispatcher Center
NRA	National Regulatory Authority
NTL	Non-technical losses

PUE	Power Usage Effectiveness
PV	Photovoltaic
RDCs	Regional Dispatch Centers
RDM	Research Data Management
RES	Renewable Energy Sources
RTL	Real-Time Linux
RR	Rapid Regulation
RUL	Remaining Useful Life
SCADA	Supervisory Control and Data Acquisition
SGAM	Smart Grids Architecture Model
SG-CG	Smart Grid Coordination Group (SG-CG)
T	Task
TSO	Transmission System Operator
UML	Unified Modelling Language
UMO	UTILITIES METERS OFFICE
WP	Work package

1. Introduction

A use case is a way to identify, clarify and organize requirements for a specific system. The deliverable D1.1-Business case definition, requirements and KPIs- provides a detailed description and categorization of PLATOON's use cases. These Use Cases also identify the activities and specification to be tested within the 7 pilots. To comprehensively describe PLATOON's use cases, it was essential to be able to identify the different actors such as for example, devices, systems or human actors, their position in the market and in the energy value chain on the one hand and, on the other, to depict requirement specifications related to the project's main goals.

Use cases can be described and specified on different levels of granularity. In PLATOON project case, the specifications are made at two levels: a business level to describe High Level Use Cases (HLUC) and a more precise and specific functional level to describe Low level Use Cases (LLUCs) related to each pilot.

PLATOON's objectives

The PLATOON H2020 project **[1]** vision is to digitalize the energy sector by developing a new generation of digital solutions and products that will enable the energy sector to transit from the current centralized system, based on the use of mainly non-renewable energy sources (fossils' based), towards a more decentralized and distributed system with an energy mix using renewables sources or even relying on consumption and CO2 footprint reduction with new extended digital capabilities.

The main objectives of the project are:

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, according to COSMAG reference.

PLATOON will address the objectives in an integrated approach that will be demonstrated across different demonstration locations. 7 pilots in 5 different countries.

1.1 PLATOON's pilot's location

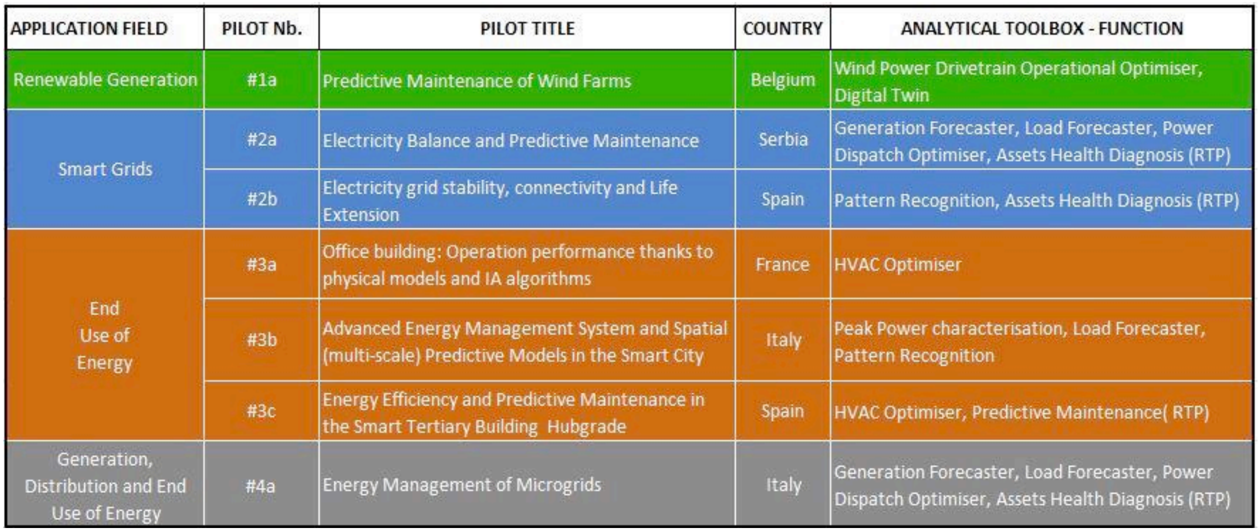
Figure 4 .PLATOON's pilots location

In total, seven pilots' activities will be carried out in five different European countries, namely France, Spain, Italy, Belgium and Serbia.
The pilots cover (described in Figure 5) a whole range of potential energy services along the energy value chain:

1. Predictive maintenance in renewables (Wind Farm – Green.
2. Distribution grids efficient operation and assets life extension - Blue color.
3. Efficient End Use of Energy, peak avoidance and demand side response (Smart Building) - Orange color.

4. Optimum Energy Management in a Microgrid, which moreover is linked to the previous services of the other pilots - Grey color.

The different pilots can be grouped according to the specific application field and the specific analytical tools that will be developed in each of them as summarized in next figure.



APPLICATION FIELD	PILOT Nb.	PILOT TITLE	COUNTRY	ANALYTICAL TOOLBOX - FUNCTION
Renewable Generation	#1a	Predictive Maintenance of Wind Farms	Belgium	Wind Power Drivetrain Operational Optimiser, Digital Twin
Smart Grids	#2a	Electricity Balance and Predictive Maintenance	Serbia	Generation Forecaster, Load Forecaster, Power Dispatch Optimiser, Assets Health Diagnosis (RTP)
	#2b	Electricity grid stability, connectivity and Life Extension	Spain	Pattern Recognition, Assets Health Diagnosis (RTP)
End Use of Energy	#3a	Office building: Operation performance thanks to physical models and IA algorithms	France	HVAC Optimiser
	#3b	Advanced Energy Management System and Spatial (multi-scale) Predictive Models in the Smart City	Italy	Peak Power characterisation, Load Forecaster, Pattern Recognition
	#3c	Energy Efficiency and Predictive Maintenance in the Smart Tertiary Building Hubgrade	Spain	HVAC Optimiser, Predictive Maintenance(RTP)
Generation, Distribution and End Use of Energy	#4a	Energy Management of Microgrids	Italy	Generation Forecaster, Load Forecaster, Power Dispatch Optimiser, Assets Health Diagnosis (RTP)

Figure 5 .PLATOON pilots grouped by application field and the specific analytical tools

In each pilot, different Data models, Analytical tools and Energy services will be created, tested and deployed for flexible and optimized management of energy systems in real time.

1.2 Structure and objective of the document

This deliverable D1.1- Business case definition, requirements and KPIs- presents the activities carried out in tasks T1.1 and T1.4 of the WP1 and their outcomes.

The outcomes include the description of relevant PLATOON's use cases. The purpose is to provide a detailed description of the functionalities and corresponding specific requirements for PLATOON and related to each pilot. This include information about the involved actors, whether they present devices, systems or persons. As well as the information exchanges between all of the actors, their nature (signals or data) and specifies the requirement to be met when exchanging the information.

To achieve this purpose, T1.1 and T1.4 (WP1) defined uses cases for both business (High Level Use Cases) and specialized functional levels (Low level Use Cases). This definition then makes it possible to specify lower level requirements. These uses cases for digitalization the energy sector will be crucial and serve as a fundamental guideline for the remaining WPs of PLATOON.

To define PLATOON use cases, both PM^2 Methodology **[5]** and from IEC-62559-2 **[3]**are followed. The used methodologies ensure a full compatibility with both international standards and work around energy in the European Union in a comprehensive manner. For each PLATOON pilot, one or more separate HLUC (High Level Use Case) is elaborated which, in turn, generated a set of LLUCs (Low Level Use Cases).

The definition of this use cases includes:

- Complete description of the use case, in terms of scope, objectives, Key Performance Indicators (KPIs) and the use case conditions.
- Use case diagram depicting the general architecture of the uses case including actors and the interactions between them.
- Use case sequence of actions and information exchanged.

The remaining of this document is structured as follow:

- Section2 presents the PLATOON's methodology used to identify and write the uses cases (use case templates are available in Annex I and II of the document)
- Section 3 provides an overview of High Leve Use Cases (HLUCs) and their complete details can be found on Annex III
- Section 4 provides an overview of the Low-Level Use Cases (LLUCs) and their complete description can be found in Annex IV
- Section 5 presents the conclusions, which synthesize the use cases and the related services.

2. PLATOON's use cases definition.

The definition of the use case is one of the first steps to consider when addressing a project development process. These use cases define the different actors and their links with the services within the project system(s). Being able to describe the interactions between these different elements within the use case allows you to describe the functioning of the system as a whole.

In order to facilitate the definition and the development of the use cases, a common methodology has been defined based both PM^2 Methodology and IEC-62559 -2. The methodology allows the description of the specifications of the use cases for each pilot in accordance and compliance with the SGAM Framework.

2.1 Definitions

The following terms and definitions are used across all this deliverable. The IEC 62559-2 is the reference document for these definitions.

- **Use case**

A use case is a way to identify, clarify and organize requirements for a specific system. It identifies the main actors that can be, for instance, devices, systems or human actor that are playing a role within this use case.

Use cases can be described and specified on different levels of granularity: a business level to describe High Level Use Cases (HLUC) and specialized functional level to describe Low Level Use Cases (LLUCs).

- **Use case Template**

The use case template is a form which allows the structured description of a use case in predefined fields. In other words, a use case template is an effective tool that helps to ensure that a design and the implementation of a system meets the business requirements defined for the system. It describes all information refers to system actors, interactions between all of them, constraints and standards to be respected to implement the use case described**.**

- **High Level Use Case**

Describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution.

- **Low level Use Case**

Use case which describes in detail the functionalities of (a part of) business process.

- **Actor**

An actor is an entity that communicates and interacts. It can cover people, software applications, systems, databases, and even the power system itself.

- **Role**

Role played by an actor in interaction with the system under discussion.

Example - A legally defined market participant (e.g. grid operator, customer), a generic role which represents a bundle of possible roles (e.g. flexibility operator) or an artificially defined body needed for generic process and use case descriptions.

- **Domain**

A Domain presents an area of knowledge or activity characterized by a set of concepts and terminology understood by the practitioners in that area.

Example- for the energy system according to the smart grid architecture model (SGAM), the following domains are suggested: generation, transmission, distribution, DER, costumer premises.

- **Functional requirement**

A functional requirement captures the intended behaviour of the system. This behaviour may be expressed as services or functions, which the system is required to perform. Use cases are used to more fully identify the functional requirements of a system.

- **Non-Functional requirements**

Non-Functional requirements capture general restrictions the system is subject to, such as: Pre-existing architectural constraints, architectural qualities (extensibility, flexibility…), security, etc.

It is important to note that in order to describe a use case in a comprehensive manner, all of the functional requirements of a given system (business process or function), and part of its non-functional requirements (performance, security, …) should be considered.

2.2 Standards used for the definition of use cases

2.2.1 PM² Methodology

PM² is a methodology [5] developed by the European Commission. Its purpose is to enable Project Managers (PMs) to deliver solutions and benefits to their organizations by effectively managing project work. PM² has been created considering the environment and needs of EU Institutions and projects, in order to facilitate the management of projects' complete lifecycle.

PM² incorporates elements from a wide range of globally accepted project management best practices, described in standards and methodologies, as well as relevant European Commission communications and operational experience from various internal and external projects.

PM² is a light and easy-to-implement methodology which makes it possible for project teams to tailor it to their specific needs. PM² is fully supported by a comprehensive training program, workshops, coaching sessions, online documentation, and an active Community of Practice (CoP) (currently only available within the European Commission and several affiliate European Institutions).

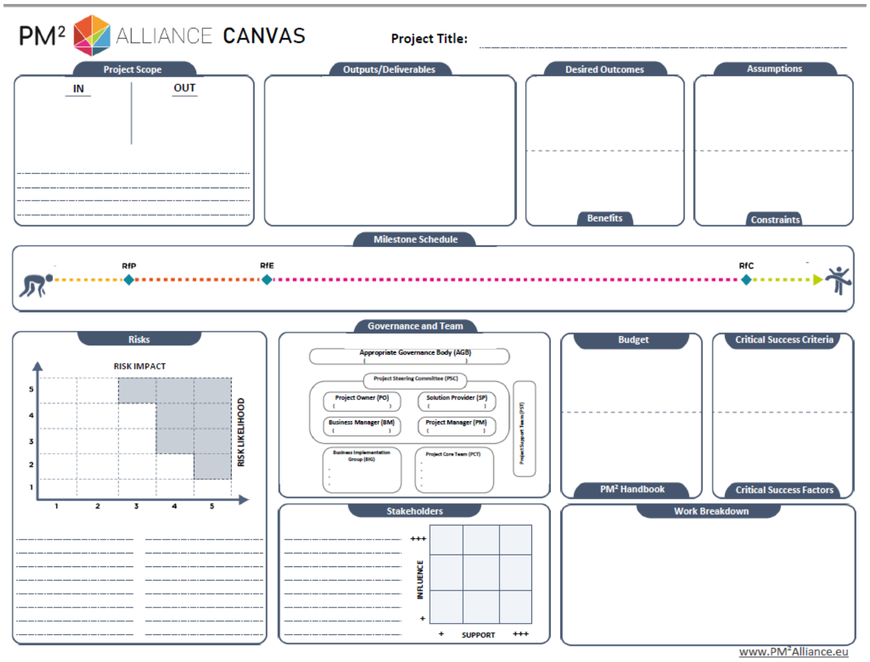


Figure 6. PM^2 Template

Figure 7 shows the different sections linked to PM^2 Template. The sections description in a short overview are:

- **Project Scope:** Indicate the scope of the product or service that is being considered for this project and clarify what is in scope and what is out of scope.
- **Assumptions:** Identify the assumptions (hypotheses) the team is making about the project and solution.

- **Outputs/Deliverables:** Identify the main deliverables for the project including the tasks and activities necessary to prepare them.
- **Desired Outcomes:** Indicate the primary objectives of the project, including success metrics.
- **Benefits:** Show the overall value proposition and benefits users will get after the project is successfully completed.
- **Critical Success Criteria**: (Critical Success Criteria (CSC) are measurements established to determine whether the project has satisfied its objectives and met its requirements. Success criteria can be qualitative or quantitative and should measurable at project closure.
- **Critical Success Factors:** Critical Success Factors (CSF) are those factors that are critical for the success of the projects.
- **Budget:** Identify the main expenses for the project.
- **Stakeholders**: List the stakeholders and third parties involved in the project. Also list the users of the product or service as target groups or segments.
- **PM^2 Handbook**: Reflect on the project specificities.
- **Risks:** What events could have a negative impact on the project in the (near) future, Identify the Impact and how can we avoid, reduce or transfer the major risks.
- **Milestone Schedule**: List the key dates and events that will define the timeline of the project.

Based on the Template depicted in Figure 6, a use case template dedicated for PLATOON's HLUCs definition has been conceived. Complete details related the different sections of this template and guidelines to writers are provided in **Annex I** of the document.

2.2.2 IEC 62559-2 Use case methodology

As illustrated in Figure 7, IEC 62559-[3] use case methodology adopts a top-down approach.[4] From a high-level business case, detailed uses cases are identified and developed to describe in a concrete manner the functional and the technical details.

The process of this methodology can be divided into four parts, General Information, Function, Technical Details, and Additional Information.

The General Information emerges from the high-level business case information and includes a unique identifier, explicit goals of the use case and the distinction from other use cases. The Function of the use case is described in plaintext fields and with diagrams. After that, the Technical Details focus on actors and the information flow with presentation of process sequences, data types and requirements. The Additional Information is collected in parallel to these other parts and helps to clarify terms and classify the use case.

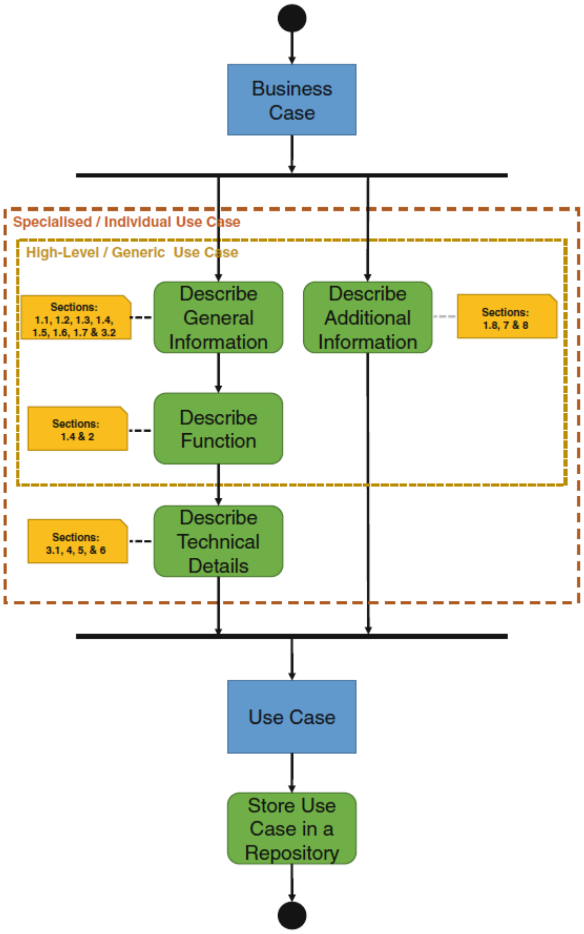


Figure 7. Use case methodology by IEC 62559[4]

Furthermore, Figure 7 shows how these four parts are linked to the eight sections of the Use Case Template. The sections titles in a short overview are:

1. Description of the use case,
2. Diagrams of use,
3. Technical details,
4. Step by step analysis of the use case,
5. Information exchanged,
6. Requirements,
7. Common terms and definitions,
8. Custom information.

Complete details related to the different sections of this template and guidelines to writers are provided in **Annex II** of the document.

2.2.3 SGAM

The CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) **[2]** has defined the Smart Grid Architecture Model **[4]**, which describes the different levels of abstraction within a smart grid through three dimensions (**Error! Reference source not found.**). The first dimension covers the domain ranging from generation through transmission and distribution to end-consumers. The second dimension describes the zones of operation from the processes through field, station and operation to enterprise and market zones. Finally, the interoperability layers range from the component layer to the business layer.

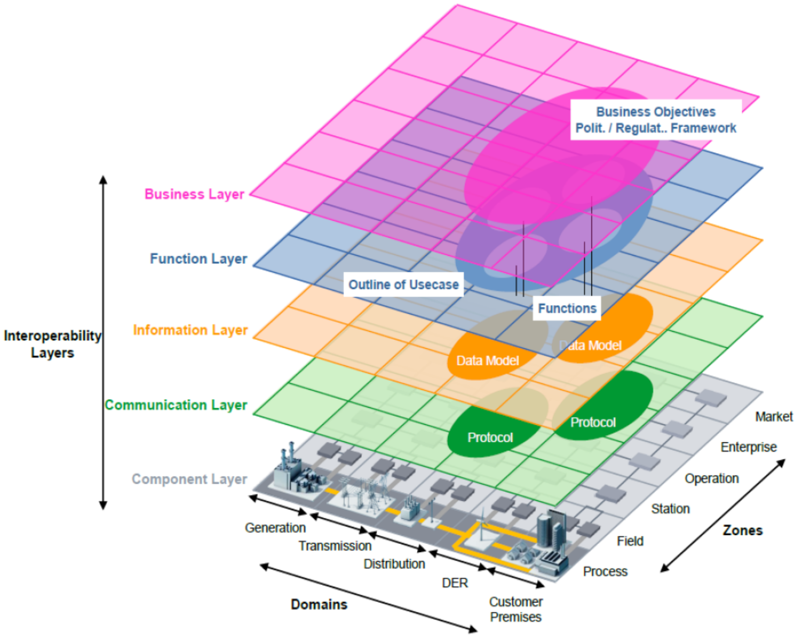


Figure 8. SGAM Framework

Interoperability layers are:

- **The business layer** represents the business view of the smart grid model. This layer can be used to map different stakeholders within the zones and domains. In addition, their roles and responsibilities can be categorized and mapped.
- **The Function Layer** includes services and functions derived from the business view, independent from involved actors
- **The Information Layer** is focused on the description of the information ex-changed between systems and actors
- **The Communication Layer** describes the protocols and mechanism for the inter-change of data between components
- **The Component Layer** pays attention to the components in the Smart Grid context, including system actors, components, applications, power system equipment, smart meters, etc.

As it can be appreciated in Figure 8, each of these layers is a two-dimensional plane, composed of Domains and Zones. The Domains focus on the steps that energy travels from its production to its consumption:

- **Generation includes** big generation plants, like nuclear and fossil, connected usually to the transmission system
- **Transmission** alludes to the equipment responsible of connecting generators and cities, distributing the generated energy
- **Distribution** represents the infrastructure that directly contact and supply power to customers, like households
- **DER** stands for Distributed Energy Resources. In this domain small generators directly connected to the distribution grid are included.
- **Customer Premises** represents conventional consumers, photovoltaic generation, electric vehicles storage, microturbines, hosted to the distribution grid.

Finally, Zones describe the way information is treated:

- **Process** includes physical, chemical and spatial information of energy and directly involved equipment, such as generators or wires.
- **Field** focuses on a higher-level management, focusing on control, protection and monitoring of the system, as well as any intelligent device.
- **Station** is an aggregation of field zones. It can include monitoring and aggregation systems.
- **Operation** focus on the management and control operation in a given domain.
- **Enterprise** includes services focuses in commercial processes and services, as well as their infrastructures.
- **Market** reflects market operations along the energy conversion path.

2.3 Use cases writing process

The process for identifying and describing PLATOON's use cases, their respective functionalities and requirements are divided in two differentiated phases.

A first extraction phase dedicated to define the most relevant uses case related to each pilot, to identify the scope, the objectives and the role of business actors of this use cases, the main steps of the use cases and determine the functionalities needed to realize these use cases.

The outcome of this phase is a set of High-Level Use Cases (HLUCs) describing in an exhaustive manner the functional implementation of the business goals. The description of the HLUCs were formulated with the PM^2 Template adapted for the PLATOON project depicted on Annex I.

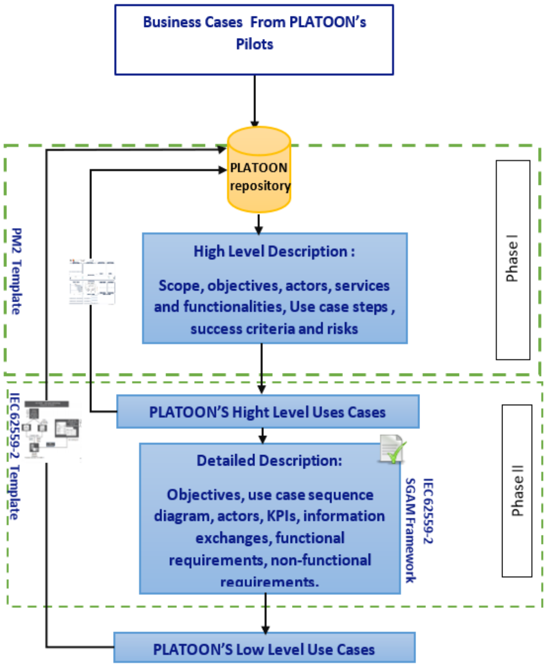


Figure 9.Use Case methodology

The second phase served to further breakdown developed HLUCs into Low Level Use Cases (LLUCs) described with IEC 62559-2 methodology that divides the description of the use cases in eight principal steps, each of them focused on a determined aspect **[4].**

The outcome of this phase is Low Level Use Cases (LLUCs) defining the involved actors and the role of each of them, and describing in detail the functionalities, the components, exchanged information, use case diagrams, functional and non-functional requirements. The description of the LLUCs were formulated with the IEC 62559-2 Template detailed in **Annex II.**

3. High level use cases overview

This section presents a brief overview of the HLUC defined in PLATOON. High Level Use Cases describe business functions, i.e., the business layer of the SGAM framework. For each HLUC, a short description of the scope, objectives and LLUC generated form each HLLUC are identified. **Error! Reference source not found.** depicts the 12 HLUC divided on the five SGAM business domains.

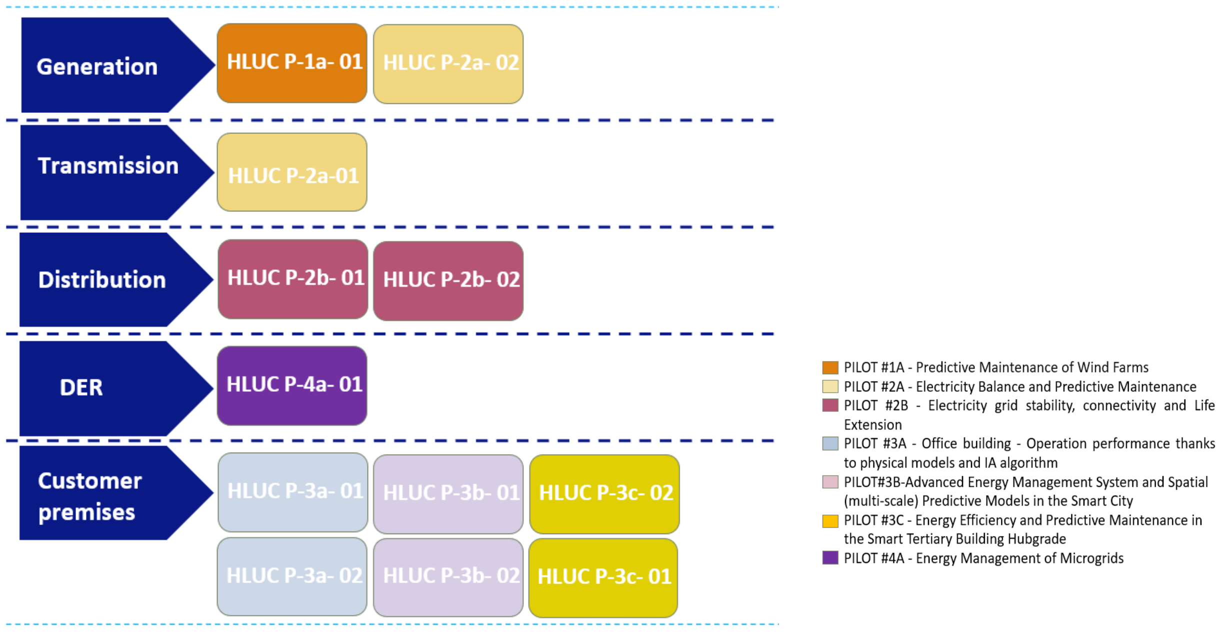


Figure 10 PLATOON'S High Level Use Cases

3.1 PILOT #1A - Predictive Maintenance of Wind Farms

HLUC-P-1a- 01: Predictive Maintenance for Wind Farms

The main goal of this pilot is to reduce operations and maintenance costs linked to unexpected downtimes for a fleet of wind turbines.

Scope

Reduce operation and maintenance costs linked to the unexpected downtimes for a fleet of wind turbines is being considered in this HLUC. The scope is the following:

- Optimize wind turbine availability.
- Optimize wind turbine condition during production.
- Optimize Data Quality.
- Monitoring Data Quality.

Objectives

The main objective of this use case is to optimize the turbine availability.

Short description

This HLUC is related to the development of an integrated monitoring strategy for predictive maintenance of electrical drivetrain components, more specifically the generator and the power converter of wind turbines. Focus is on the combination of data-driven models with physical models of the generator and potentially of the power converter into an integrated digital twin strategy. High frequency (kHz range) detailed measurements will be used in a first step. In a later stage the focus of the analysis will shift towards fleet-wide analytics. At this stage lower frequency SCADA data (10-min) and status logs are used. In addition to the anomaly detection for problem identification also load history of the electrical components is identified. The potential for edge computations of the models is explored. More specifically, the optimization of the computational load for anomaly detection is investigated.

This HLUC comprises the following general steps:

- Short List Failure Modes scoped out.
- Developing detailed understanding of how the failure mode works.
- Define modeling strategy to capture failure mode influence factors.
- Validate model with known failure cases -> Confusion Matrix.
- Test on larger dataset.
- Increase robustness software code.

LLUC generated from this Use case

- LLUC P-1a- 01: Enhanced diagnostics of failure in electrical drivetrain components in wind turbines using a digital twin approach.

3.2 PILOT #2A - Electricity Balance and Predictive Maintenance

HLUC P-2a- 01: Electricity Balance

Scope

Improve demand response and production forecast at regional and national level is being considered in this HLUC. The scope is the following:

- Short term load forecasting.
- Forecast about the power production from renewable energy sources (wind power plant).
- State estimation and balancing strategy.

Objectives

The objectives of this HLUC are:

- To balance market operator.
- To improve state Estimation.
- To plan power generation.
- To improve flexibility from existing sources of generation and demand.
- To optimize dispatching schedules and power grid operations.

Short description

Electricity must be ‘consumed’ as soon as it is produced, because it cannot be stored easily. Balance management is a power system operation service vital for ensuring security of supply through the continuous, real-time balancing of power demand and supply. At each point in time, total production must be equal to total consumption in order to stabilize system frequency; it is therefore also called frequency control. Historically, balancing the system has been maintained mostly by directing thermal power plants to increase or reduce output in line with changes in demand. Storage and interconnectors have also played a part, but a much smaller one.

As the volume of intermittent generation on the system grows, the system is balanced by utilizing both supply and demand resources. However, the existing electric power systems were not initially designed to incorporate different kinds of generation technology in the scale that is required today. With significant penetration of distributed generation, the distribution network has become an active system with power flows and voltages determined by the generation as well as by the loads. Therefore, it is difficult to predict the impact of distributed generation (e.g. from wind offshore farms) on the future energy mix. As a response to this, smart grids are expected to enhance grid flexibility & robustness and enable existing grids to accept power injections from distributed energy resources without contravening critical operational limits (such as voltage control, switching equipment capability and power flow capacity). In this use case, PLATOON services will be developed that will upgrade the IMP SCADA system with electricity balancing functionalities needed in case of power injections from wind farms. With the increased penetration of distributed generation (e.g. wind power), the risk of temporary imbalances also increases caused by wind power uncertainties due to its dependence on the volatility of the wind. So, advanced demand/response optimization services are needed to prevent power outages or blackout (complete interruption of power in a given service area). The role of the SCADA / EMS on the production side is monitoring, control of generation and data exchange.

This HLUC comprises the following general steps:

- Define the balancing challenges for the system operator due to increasing amounts of renewable energy sources embedded within the distribution networks (e.g. solar photovoltaic (PV), wind power plants).
- Define supply and demand variables.
- Analysing integration of the state estimation (SE) applications with the IMP proprietary SCADA system.
- Build ML models based on historical data.
- Integrate with the state estimation applications.
- Testing and validation.

LLUC generated from this Use case

- LLUC P-2a-01 Balancing on regional level.
- LLUC P-2a-02 Balancing on country level.
- 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-06 Research Data Management.

HLUC P-2a- 02: Predictive Maintenance in power plants

Scope

Develop a predictive layer on top of exiting SCADA in power plant is being considered in this HLUC. The scope is the following:

- Health state estimation.
- Alert generation in case of expected problems with the assets.

Objectives

The objectives of this HLUC are:

- To develop timely and accurate insights for predictive maintenance.
- To decrease in outage costs.
- To improve the system reliability.

Short description

This HLUC comprises the following general steps:

- Defining the requirement and KPIs.
- Defining the measuring variables, and the current functionalities of the Maintenance Management System - MMS, Outage Management System and Asset Management System.

- Defining the integration of SCADA with PLATOON tools.
- Defining the pre-processing approach.
- Development of ML model based on historical data given the system's parameters, draw strategies to deal with similar events in the future.
- Deployment of ML model for real-time monitoring of advanced sensors and monitoring equipment.
- Define the communication with emergency services.
- Testing and validation of the service (SCADA for Thermal Power Plant).

LLUC generated from this Use case

- LLUC P-2a- 07 Predictive maintenance in RES power plants

3.3 PILOT #2B - Electricity grid stability, connectivity and Life Extension

HLUC P-2b- 01: Predictive Maintenance in Transformers

Scope

The scope of this HLUC is the following:

- Health Monitoring.
- Remaining Useful Life (RUL) estimation.
- Maintenance Planning.
- New scenario cost evaluation.

Objectives

The objectives of this HLUC are:

- To develop a predictive maintenance tool for LV/MV transformers using available data from Sampol´s smart grid in ParcBit, Majorca (Spain).
- To determine remaining useful life and calculate health index of the transformers
- To optimize maintenance plan in order to reduce O&M costs

Short description

This HLUC focuses 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.

This HLUC comprises the following general steps:

- Gather available transformer information and measurements, and maintenance logs, and create a database.
- Define the transformer components and the failure modes that will be analysed.
- Define required measurements and install new sensors.

- Specify the requirements for the asset health management platform, including all its functionalities.
- Exploratory data analysis, including data cleaning and pre-processing, and labelling of the dataset: Identification of faulty periods and check the maintenance logs.
- Develop virtual sensor models to estimate the state of the transformer, avoiding the over monitoring of the transformer.
- Develop a model to calculate the RUL of the critical components of the transformer, for different failure modes, due to aging in working conditions.
- Develop a model to calculate the health index of the transformer.
- Develop an economic calculation method for defining the optimal maintenance plan of the transformer.
- Develop a model to simulate the effect of different operational actions in the grid O&M cost sheet.
- Implement and validate the asset health management platform.

LLUC generated from this Use case

- LLUC P-2b- 01 Predictive Maintenance for MV/LV Transformers

HLUC P-2b- 02: Non-technical loss detection

Scope

The scope of this HLUC is the following:

- Quantification of losses in the distribution grid.
- Characterization of prosumers' energy profile.
- Detection and identification of non-technical losses (NTL).

Objectives

The main objective of this HLUC is to develop a tool for the quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL), using the available smart meter data from Sampol´s smart grid in ParcBit, Majorca (Spain).

Short description

This HLUC considers different techniques to calculate the losses, detect NTL appearance and identify NTL authors (prosumers and non-customers) using data from the smart meters of prosumers and measurements at the substations and transformation centers.

This HLUC comprises the following general steps:

- Gather electricity grid topology and parameters.
- Gather historical load data, at the MV substation level, and for the smart meter of each of the prosumers connected to the distribution grid.
- Historical load data cleaning and pre-processing.
- Labelling of prosumer load dataset: Identify historic known NTL, if any, based on evidences of fraud.

- Exploratory assessment of energy losses, based on energy balances, to determine thresholds of reasonable level of technical losses.
- Prosumer segmentation based on clustering techniques applied to their load profiles.
- Development of an NTL detection algorithm to detect PTUs in which NTL would have occurred, based on losses higher than reasonable technical losses, which accuracy can be improved taking into account grid topology.
- Development of an NTL identification algorithm for identification of NTL authors, based on the detection of abnormal behaviours of prosumers.
- Development of a software platform which integrates load data acquisition with use case logic (prosumer segmentation, NTL detection and identification algorithms), with a friendly user interface.
- Validation of NTL detection and identification algorithms.

3.4 PILOT #3A - Office building - Operation performance thanks to physical models and IA algorithm

HLUC-P-3a- 01: Save X% on the GHG emissions

Scope

The scope of this HLUC is the following:

- Optimize energy production regulation.
- Optimize use of energy storage for optimizing generation efficiency.
- Optimize energy distribution regulation (return water temperature...).
- Optimize window opening and blinds.

Objectives

The objectives of this HLUC are:

- To follow and guarantee energy savings.
- To follow and guarantee GHG emission savings.

Short description

This HLUC concerns the reduction of energy consumption and greenhouse gases emissions for the building. It can be realized through optimization of HVAC operation and control in the building, as well as the use of local renewable energy sources (PV) that could be installed on the building. The different possibilities and strategies to reduce the energy consumption, using the data available on the building and the different equipment, will be evaluated and tested.

This HLUC comprises the following general steps:

- Check the level of data available for the building.
- Follow the building on a full year, appoint a team for being sure that the data are clean.
- Build an algorithm for comparing the various years (occupancy, climate, energy efficiency of appliances ...).

- Develop a digital twin of the building compatible with energy management constraints.
- Define the management strategies, test them on the digital twin.
- Install new appliances in Stains building.
- Conclude with the comparison algorithm brick, compare the various years.

LLUC generated from this Use case

- LLUC P-3a 01 Optimization of HVAC operation regarding building occupancy

HLUC-P-3a- 02: Power Management and flexibility

Scope

The scope of this HLUC is the following:

- Storage capability of the buildings.
- Thermal storage.
- Battery storage (including those in laptops).
- H2 storage.
- Comfort level and acceptability of lowering comfort.
- Flexibility mechanism.

Objectives

The objectives of this HLUC are:

- To reduce the load peak.
- To response to flexibility demands.

Short description

This HLUC concerns the electrical load management with flexibility services that could be offered to the grid. It can be realized through specifics controls of the electrical loads in the building: heating and cooling loads, using the building inertia and other type of electrical load that could be shifted. Switching to other energy sources or using storage equipment (batteries, H2) could also be part of the scope. An analysis of the flexibility available in the building, and the use of digital twin can enable to evaluate the potential and predict the available flexibility on the building.

This HLUC comprises the following general steps:

- Assess the building against existing flexibility framework.
- Define the priority actions (focus on PC batteries? focus on reduced comfort? Add thermal storage?).
- Simulate on digital twin. Essential to define what specific service is most beneficial, and thus what is the complexity needed for the digital twin.
- Install on Stains, run on 1 year.
- Comparison with the test year.

LLUC generated from this Use case

- LLUC P-3a 02 Provide Demand Response services through building inertia and HVAC controls

3.5 PILOT#3B-Advanced Energy Management System and Spatial (multi-scale) Predictive Models in the Smart City

HLUC P-3b- 01: Building Energy Management System

Scope

The scope of this HLUC is the following:

- Energy consumption analysis and forecast.
- Daily and hour energy consumption forecast.
- Lighting optimization.
- Predictive maintenance.
- Energy efficiency plans (heating, cooling).

Objectives

The objectives of this HLUC are:

- To improve efficiency and flexibility of energetic systems and distribution on selected buildings.
- To ensure energy saving on selected buildings.
- To improve energy efficiency plans.

Short description

Poste Italiane manages around 220 buildings in the area of Rome Municipality. In the context of this HLUC, 16 of the 220 building are selected as 'test set' grouped according to the end use and characteristics: Data center, Logistic Centers, Retail, Office Space. These buildings will be used for modelling, benchmarking, and evaluating PLATOON components, algorithms and optimization actions in the following areas: Cooling and Heating Plants Consumptions Forecasting; Cooling and Heating Plants Predictive Maintenance and Lighting Consumption Estimation.

This HLUC comprises the following general steps:

- Identify a set of significative buildings.
- Identify the data set to be collected.
- Define frequency and check the data volumes to be produced.
- Define data flows and exchange requirements.
- Define criteria and outputs for data analysis.
- Install the new devices in the PI buildings.
- Activate and test the new devices.
- Activate the data flow toward PLATOON Platform.
- Validate pilot hypothesis.

LLUC generated from this Use case

- LLUC P-3b 01 Buildings Heating & Cooling consumption Analysis and Forecast.
- LLUC P-3b 02 Predictive maintenance of cooling & heating plants.
- LLUC P-3b 03 Lighting Consumption Estimation & Benchmarking.

HLUC P-3b- 02: Building Asset Energy Management System

Scope

The scope of this HLUC is the following:

- Energy consumption analysis and forecast.
- Power peak consumptions.
- Predictive maintenance.
- Energy Auditing improvement and validation.
- RES and Storage self-consumptions potentiality.

Objectives

The objectives of this HLUC are:

- To improve forecast capability and to update Energy Efficiency scenarios (EMS and Audits).
- To detect critical issues for plant and building envelope systems (Peak Power, Anomalies, …).
- To improve energy management by using analysis tools and algorithms.
- To integrate predictive maintenance toolset in EMS and DSS.
- To perform energy audits data exploitation/integration for the municipal asset EM.
- To perform spatial analysis and visualization of energy Big Data.
- To maximize self-consumption for each building through RES and storage potentiality.

Short description

This HLUC includes about 1600 buildings owned by ROME with different uses and different plants and devices, including 165 photovoltaics, located in Rome. The data collected from the meters (power and gas) and from the available Energy Audits will be sent to the PLATOON platform for energy consumption analysis and forecast, for anomalies detection, for automated validation/updating of energy efficiency scenarios, for data integration and new EMS tools implementation.

This HLUC comprises the following general steps:

- Identify the datasets to be collected (energy meters, energy audits).
- Define extent of ROME buildings (number/typologies) and check the data volumes to be produced.
- Define data flow and exchange requirements for energy meters.
- Define criteria and outputs for data analysis (Use Case and Business Case final definition).
- Test data treatment and outputs for a control set of buildings.
- Activate the data flow toward PLATOON Platform.
- Proceed to Big Data analytics and to the outputs progressive assessment.
- Co-work to define the tools and user interfaces matching the EM needs (Usability Check).
- Validate pilot hypothesis and expectations.

LLUC generated from this Use case

- LLUC P-3b 04 Monitor and analysis system for the Data flow coming from 8950 power and gas energy meters of ROME Municipality buildings asset

3.6 PILOT #3C - Energy Efficiency and Predictive Maintenance in the Smart Tertiary Building Hubgrade

HLUC P-3C- 01: Advanced EMS in Smart Tertiary Building

Scope

This HLUC focuses on the Advanced EMS to be implemented in PLATOON. This EMS will optimize the local renewable energy resources (RES) and HVAC operation following a multi-objective pattern which targets to reduce the overall energy bill and maximize the usage of RES.

The scope of this HLUC is the following:

- Develop an optimization algorithm for the HVAC system of the building to reduce the energy cost taking into account PV panels energy production and energy cost while ensuring comfort requirements (temperature, humidity and air flows).

Objectives

The objectives of this HLUC are:

- To reduce energy costs.
- To reduce GHG emissions.

Short description

This HLUC addresses the main functionalities and requirements related to the advanced EMS to be implemented within PLATOON. The foresaid EMS will optimize the local renewable energy resources (RES) and HVAC operation as function of building and RES characteristics, building comfort constraints, ambient conditions and energy market price following a multi-objective pattern which targets to reduce the overall energy bill and maximize the usage of RES.

This HLUC comprises the following general steps:

- Extract the data.
- If necessary, look for external data sources (weather, electricity market ...) to extract remaining parameters.
- Data Cleaning: analyse the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...)
- Exploratory data analysis: analyse the data using visual and statistical methods (unipara metric analysis, multiparametric analysis, correlation analysis...).
- If necessary, apply signal processing/smoothing methods to reduce the noise.
- Pattern recognition and benchmarking.

- Create a data driven or hybrid model of the building which simulates the thermal behaviour of the building using historical off-line data.
- Build, train and validate the HVAC optimisation algorithm using historical off-line data.
- Validate the developed algorithm with online data and modify the algorithm as necessary to get an acceptable performance.
- Implement the developed algorithm in the production system.

LLUC generated from this Use case

- LLUC P-3c 01 Advanced EMS for Tertiary Buildings.

HLUC- P-3C- 02: Predictive Maintenance in Smart Tertiary Building

Scope

The scope of this HLUC is predictive maintenance of:

- Air handling units.
- Water pumps.
- Chillers
- Heat pumps.

As for the previous HLUC, this HLUC will at first be focused on a single tertiary building (Donostia's CIC Nanogune), then, the outcomes will be extended to more than 10 buildings.

Objectives

The objectives of this HLUC are:

- To increase the availability of the assets.
- To increase the useful life of the assets.
- To reduce maintenance costs.

Short description

This use case describes the process of the ddevelopment and the implementation of predictive maintenance tools for the thermal control assets of smart tertiary buildings (Boilers, Chillers, Air Handling Units (AHU), Split Systems, Fan coils, Extractors and Pumps). as Additional targets are improving the maintenance policy increasing the availability and useful life of these assets and reducing the general maintenance costs.

This HLUC comprises the following general steps:

- Extract the data.
- Data Cleaning: analyse the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...)
- Exploratory data analysis: analyse the data using visual and statistical methods (unipara metric analysis, multiparametric analysis, correlation analysis...).
- If necessary, apply signal processing/smoothing methods to reduce the noise.

- Label the dataset: Identify faulty periods and check the maintenance logs.
- Develop a data driven or hybrid model to simulate normality using the data records for healthy condition.
- Analyse deviations from faulty points compared to the normal simulated by the developed normality model.
- Feature creation to quantify deviations from faulty points compared to normal condition modelled by the developed model.
- Train and validate algorithms using the newly created features and other features to detect failures. Use historical off-line data.
- Validate the developed algorithms with online data and modify the algorithm as necessary to get an acceptable performance.
- Implement the developed algorithm in the production system.

LLUC generated from this Use case

LLUC P-3c 02 Predictive Maintenance in Smart Tertiary Building Assets.

3.7 PILOT #4A - Energy Management of Microgrids

HLUC-P-4A- 01: Energy Management of Microgrids

Scope

The scope of this HLUC is the following:

- EMS with real-time processing and optimization for small-scale/renewable electricity generation.
- Generation and load forecast.
- Smart storage/generation.
- V2G.

Objectives

The objectives of this HLUC are:

- To improve the availability of big data and big data management,
- To provide 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
- To assess the advantages of innovative strategies.

Short description

This HLUC applies to a microgrid test-bench, to provide an analysis facility for real-life scale research, simulation and test purposes.

The aforementioned microgrid test-bench is dedicated to improve the availability of big data and big data management, providing 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 HLUC comprises the following general steps:

- Install all needed meters.
- Gather data from different sources internal/external (weather condition/forecast).
- Create an integrated, clean and consolidated DB.
- Create a data driven model of the grid using historical off-line data.
- Build and train a forecasting algorithm.
- Develop a robust optimization model for optimal power flow.
- Validate the model and the predictive algorithms.
- Implement the production system with edge computing capability.
- Develop an interface and data monitoring software.

LLUC generated from this Use case

- LLUC P-4A 01 Energy Management of Microgrids

4. Low level use cases

This section presents an overview of the LLUCs identified in the HLUC described in section 3. These LLUCs are also organized into five domains, as depicted in Figure 11. The functional description of the LLUCs identifies the services and tools required to perform a specific step of the main function. These tools are also identified in this section.

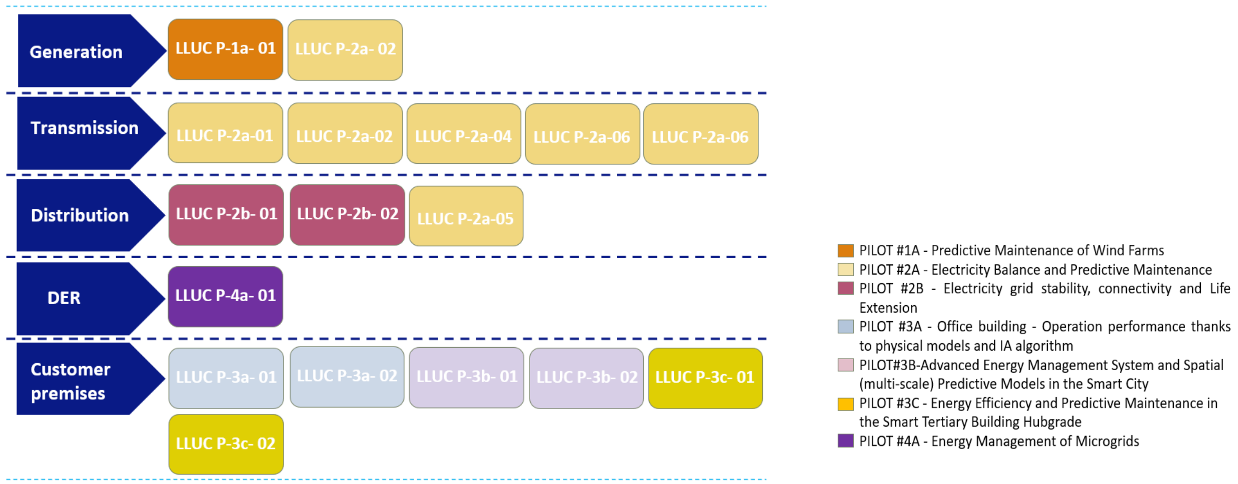


Figure 11 PLATOON's Low Level Use Cases

4.1PILOT #1A - Predictive Maintenance of Wind Farms

LLUC-P-1a- 01: Enhanced diagnostics of failure in electrical drivetrain components in wind turbines using a digital twin approach.

Scope and Objectives

The use case focuses 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.

The main objectives of this LLUC are:

- Develop, implement and validate accurate physical and data-driven models of the wind turbine electrical drivetrain components: generator and power converter.
- Develop anomaly detection methods for identification of unhealthy behaviour of the components in scope.
- Develop an approach to convert the identified anomalies towards health indicators to create a diagnostic tool.
- Extract the relevant events that the electrical drivetrain components are exposed to and have a potential negative effect on the lifetime of the electrical components.

Short description

The goal of this pilot is the development of an integrated monitoring strategy for predictive maintenance of electrical drivetrain components, more specifically the generator and the power converter of wind turbines. Focus is on the combination of data-driven models with physical models of the generator and potentially of the power converter into an integrated digital twin strategy. High frequency (kHz range) detailed measurements will be used in a first step. In a later stage the focus of the analysis will shift towards fleet-wide analytics. At this stage lower frequency SCADA data (10-min) and status logs are used. In addition to the anomaly detection for problem identification also load history of the electrical components is identified. The potential for edge computations of the models is explored. More specifically, the optimization of the computational load for anomaly detection is investigated.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Modelling quality**: Modelling approach capable to fit healthy component data.
- **Integration**: Tool interaction/integration.
- **Detection**: Anomaly detection speed + accuracy (false vs true positives).
- **Load characterization**: Important historical loading events can be captured using automated methods.
- **Processing reach**: Size of fleet dataset that can be analysed automatically: number of turbines, channels, …
- **Processing speed**: Speed of the anomaly analysis.
- **Maintenance costs**: Maintenance cost reduction.
- **Availability / Increase of RES usage**: Increase availability of Wind Turbines (increase RES usage).

Use case diagram

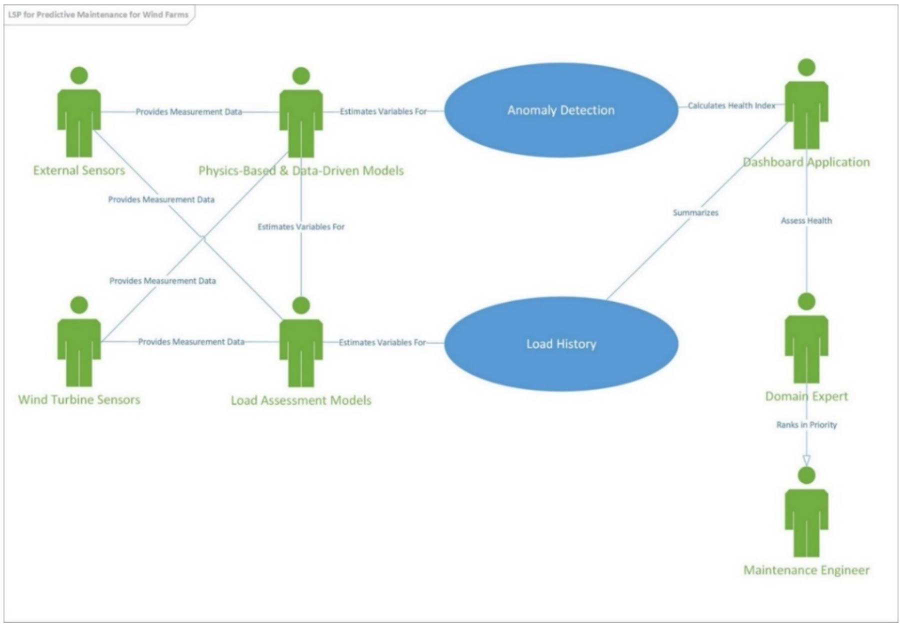


Figure 12 . Enhanced diagnostics of failure in electrical drivetrain use case diagram

4.2 PILOT #2A - Electricity Balance and Predictive Maintenance

Scope and Objectives

In the Case of the pilot #2A, the **LLUC-P-2a-01 to LLUC-P-2a-06** represented below, lie within the scope of electricity balancing on different levels and cover all energy domains.

The **LLUC-P-2a-01 to LLUC-P-2a-06** are dedicated to test and deploy intelligent smart grid services delivered by PLATOON for the following purposes:

- Electricity balancing and dispatch optimization at TSO.
- Energy production forecast for renewable energy sources (wind power plant).
- Implementation of IDS Connectors for the Serbian System Operator (EMS), the Balancing Server Provider (EPS), one representative Balance Responsible Party (BRP).
- Real-time integration and big data analysis upon the high-volume data streams from SCADA/EMS.
- State estimation.
- Short term load forecasting.

LLUC -P-2a-01: Balancing on regional level

Short description

This LLUC is dedicated to explaining the electricity balancing process on regional level. Serbia and the neighboring countries Montenegro and Macedonia form the SMM control block. The Automatic Generation Control (AGC) component of the TSO SCADA/EMS system , especially its load frequency control (LFC) part, plays a very important role in continuous and secure operation of interconnected power system (SMM block) The main role of AGC is to maintain balance between generation and consumption and to, consequently, keep system frequency and interchanges as close to scheduled values as possible. One of the new challenges related to AGC is the introduction of “Imbalance Netting Process”. Imbalance netting is a process of automatic secondary (FRR – Frequency Regulation Reserve) reserve activation optimization in which two or more TSO’s participate. It serves the cross-border electricity balancing, where the main idea is to avoid activation of secondary balancing reserves in opposite directions in participating TSO’s. Imbalance netting platform typically includes two main functions:

• Optimization module (Imbalance Netting optimization algorithm) which executes in real time.

• Settlement module which executes in each “settlement cycle” (each 15 minutes or each hour).

Considered KPIS

The following KPIs were considered for this LLUC:

- **Cost efficient distribution and transmission:** Improved operation of Smart Grid and cost-efficient distribution and transmission network operation.
- **Savings from tertiary reserve trading**: Increase the annual net savings from tertiary reserve trading.
- **Better demand response:** Responding better to changes in demand.
- **Curtailment avoidance:** Percentage of curtailment avoidance.

Use case diagram

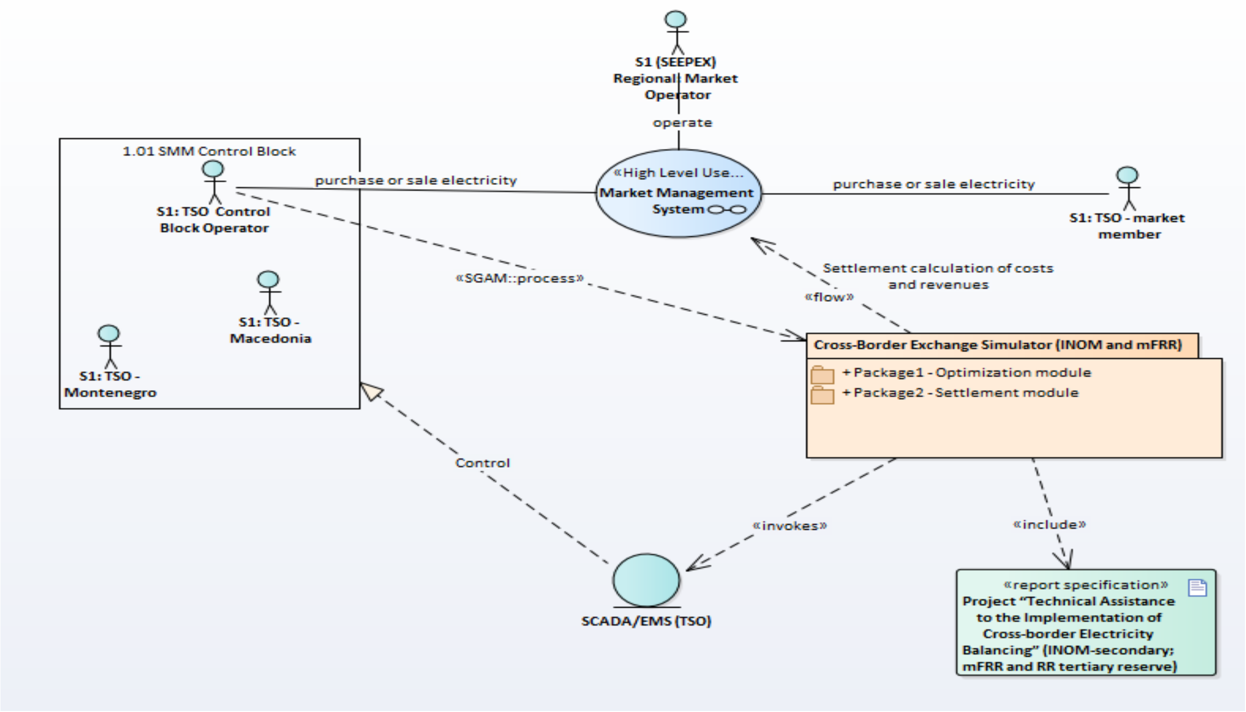


Figure 13.Balancing on regional level use case diagram

LLUC-P-2a-02: Balancing on country level

Short description

This LLUC concentrates on tertiary reserve/energy exchange process. Currently the Electric Power Industry of Serbia (PEEPS) is the only supplier of the balance reserve, but independent producers (IPP) and producers from distributed and renewable sources (DER) will be actors in the balance reserve market in the future.

A balancing market consists of three main phases (balance planning, balancing service provision, and balance settlement) and concerns three main actors (the System Operator (TSO), Balancing Service Providers (BSPs), and Balance Responsible Parties (BRPs). As presented in LLUC P-2a-01, the Serbian TSO (PE EMS) is performing all balancing services and activates tertiary reserve using a merit order list, defined by PE EPS in advance. EPS performs electricity trading for the purpose of balancing and optimization of single energy portfolio of Balance Responsible Parties (in the Serbian electricity market, all market participants are balancing parties and their relations are regulated by contracts).

Considered KPIS

The following KPIs were considered for this LLUC:

- **Cost efficient distribution and transmission:** Improved operation of Smart Grid and cost-efficient distribution and transmission network operation.
- **Better demand response:** Responding better to changes in demand.
- **Improved RES integration:** Better evaluation of the effects from RES integration.
- **Balanced energy mix:** Reduction in peak use of fossil fuels.

Use case diagram

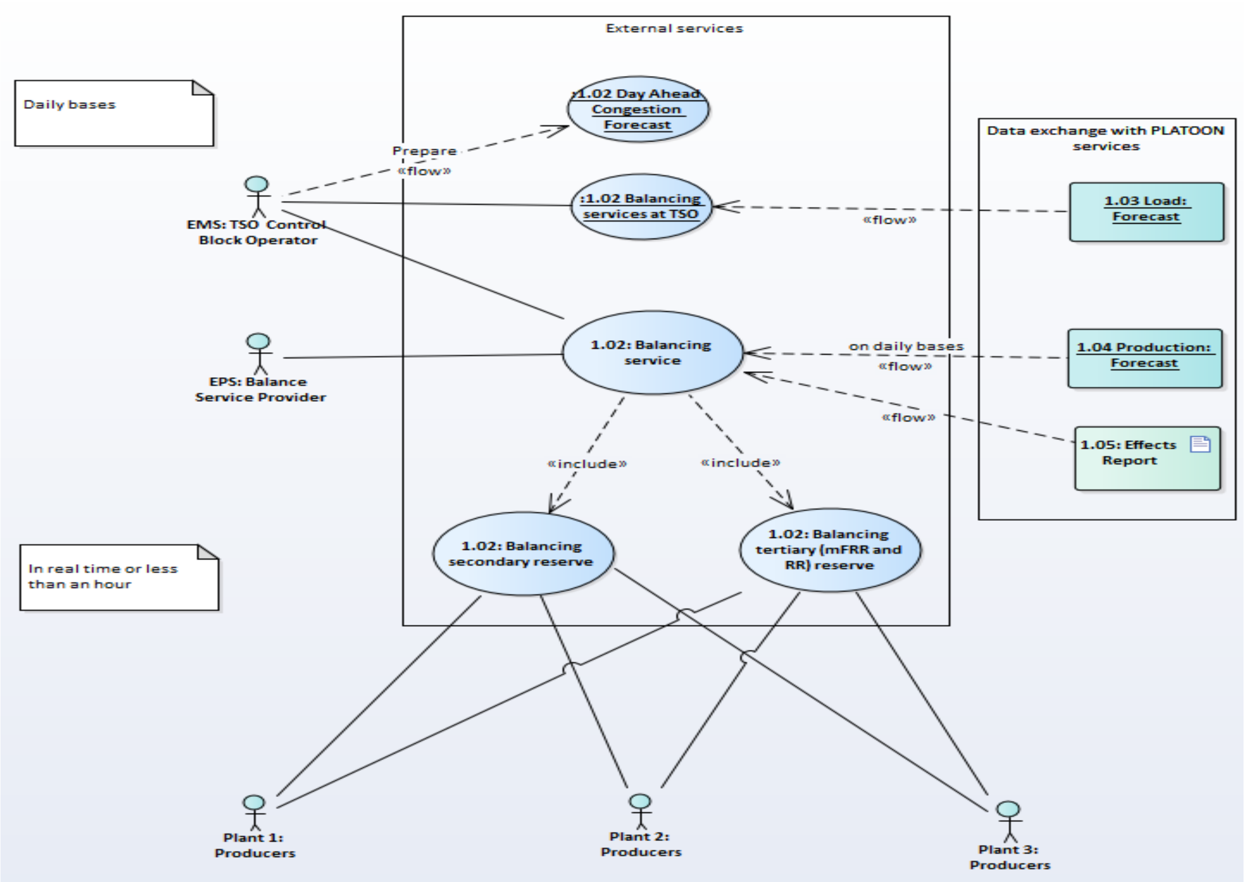


Figure 14. Balancing on regional level use case diagram

LLUC- P-2a-03: Demand forecast on transmission level

Short description

This LLUC describes the use of PLATOON tools for load demand forecast analysis. Electricity demand forecasting is a central and integral process for planning periodical operations and facility expansion in the electricity sector. Load demand forecasting involves accurate prediction of both magnitudes and geographical locations of electric load over the different periods of the planning horizon

Considered KPIS

The following KPIs were considered for this LLUC:

- **Cost efficient distribution and transmission:** Improved operation of Smart Grid and cost-efficient distribution and transmission network operation.
- **Better demand response:** Responding better to changes in demand.

Use case diagram

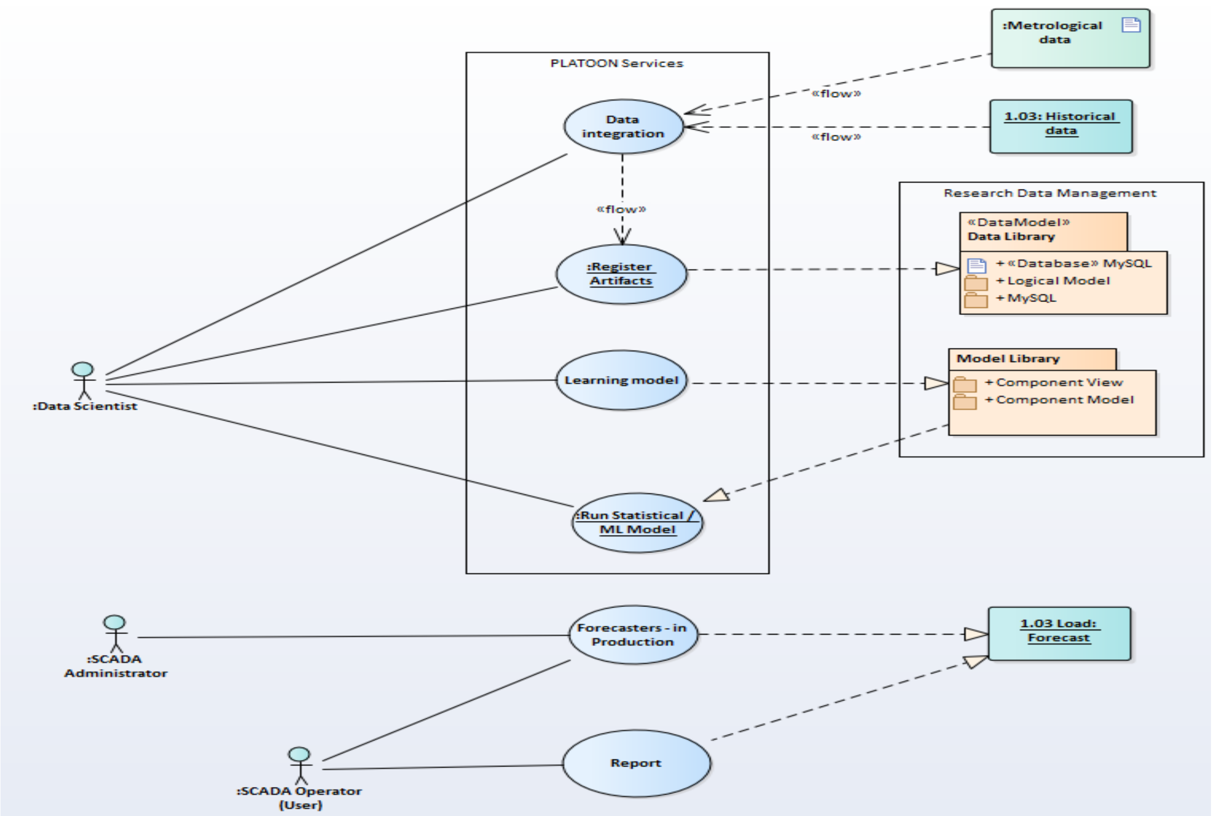


Figure 15.Demand forecast on transmission level use case diagram

LLUC- P-2a-04: Wind generation forecasters

Short description

This LLUC aims to develop and test a PLATOON service for more accurate prediction of renewable energy generation. Different energy supplier strategies for RES should be considered that will support and improve strategic optimization of the resources on the side of the balancing reserve provider (EPS). The wind power forecasting yields an estimate of the variable power injected in the distribution grid. This allows prediction of when the transformer connecting the distribution grid to the transmission grid will be overloaded, i.e. when local wind turbine generator production will be very high. The various forecasting approaches can be classified according to the type of input**[6]** (weather prediction, wind turbine generators data, historical production data). Statistically based approaches allow very short-term predictions (2 hours). One of the key challenges for day-ahead forecasting of wind energy remains unscheduled outages that can have large effects on the forecasts for small systems, while the effect is small on the overall grid.

Considered KPIS

The following KPIs were considered:

- **Cost efficient distribution and transmission:** Improved operation of Smart Grid and cost-efficient distribution and transmission network operation.
- **Curtailment avoidance:** Percentage of curtailment avoidance.
- **Portfolio optimization:** Improved portfolio optimization of Balance Responsible Parties (Optimization/Management of Renewable Energy Systems).

Use case diagram

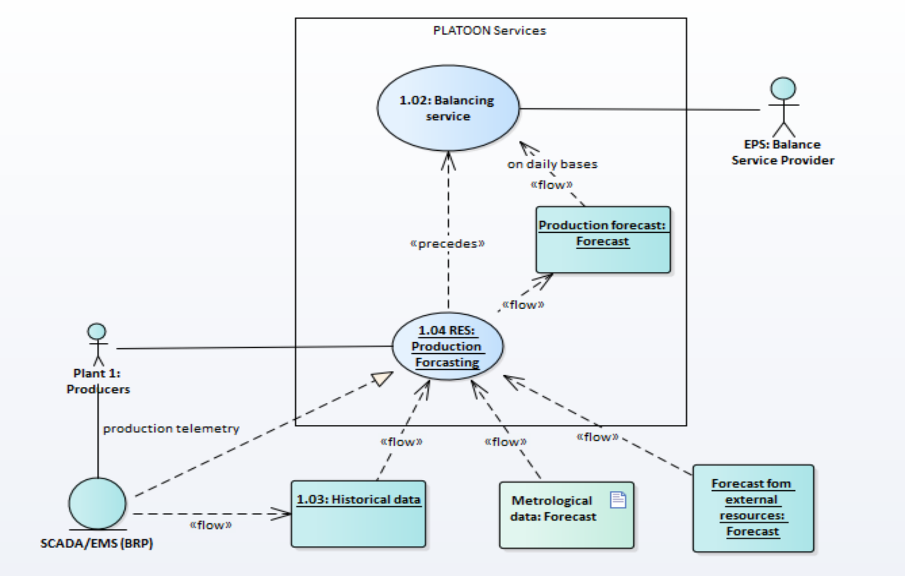


Figure 16 .Wind generation forecasters use case diagram

LLUC -P-2a-05: Effects of Renewable Energy Sources on the Power System

Short description

This LLUC aims at testing the PLATOON analytical services for analysis of unexpected variations (voltage profile of the power system) before and after RES integration to the power system. A service should be developed and the effects of RES on the existing power system should be evaluated and presented graphically. The Effect of RES can be analyzed by PMU and edge computing. The PMU is used for the analysis of the real-time power flows, while edge computing for investigating the integration of RES to the power system. Additionally, phasor-based control could be exploited to perform power flow optimization and improve the power quality in the real-time domain.

Considered KPIS

The following KPIs were considered:

- **Improved RES integration**: Better evaluation of the effects from RES integration.
- **Balanced energy mix**: Reduction in peak use of fossil fuels.
- **Curtailment avoidance**: Percentage of curtailment avoidance.
- **Increased stability:** Increased degree of stability in the real power plant operation.

Use case diagram

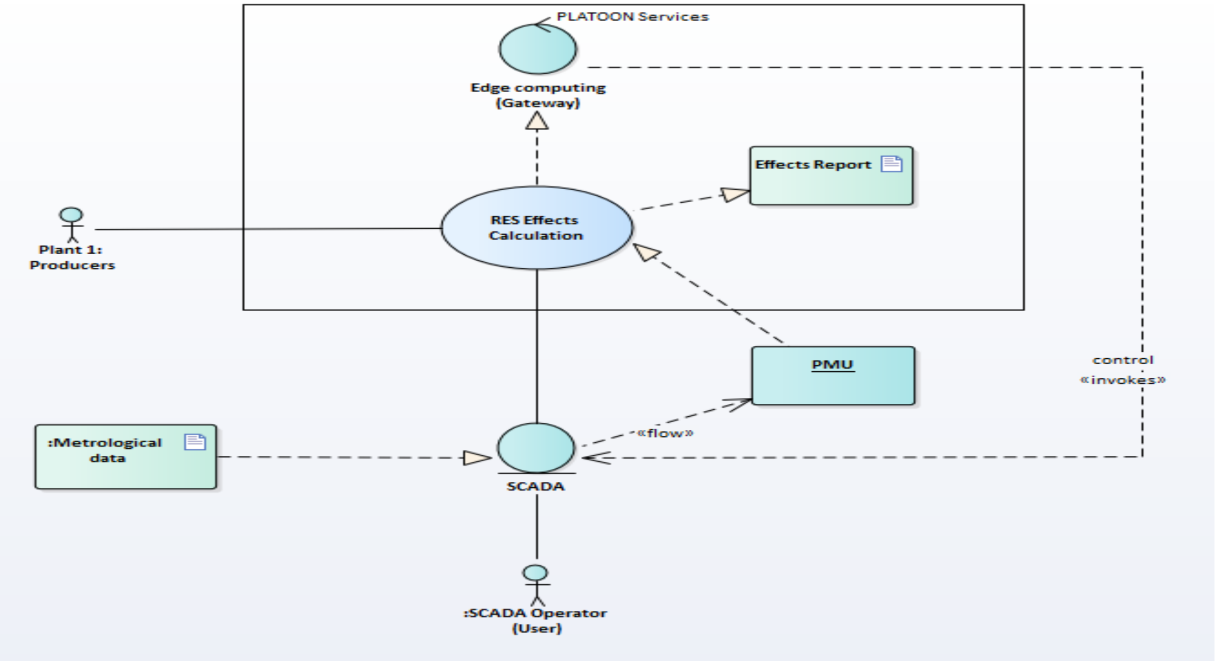


Figure 17. Effects of Renewable Energy Sources on the Power System use case diagram

LLUC- P-2a-06: Research Data Management

Short description

This LLUC showcases how the process of storing and retrieval of artefacts (data models, external datasets, research results/outputs) can be managed with a CKAN repository. It assumes that end-users (e.g. data scientists) in their work will need a repository where relevant re-usable artifacts can be stored, curated and shared with other stakeholders. The tool shall support visualization (ontologies, vocabularies), as well as running of example statistical / ML algorithms.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Metadata models**: Number of metadata specifications prepared and registered with CKAN related to the data that will be used in the analytical services.

Use case diagram

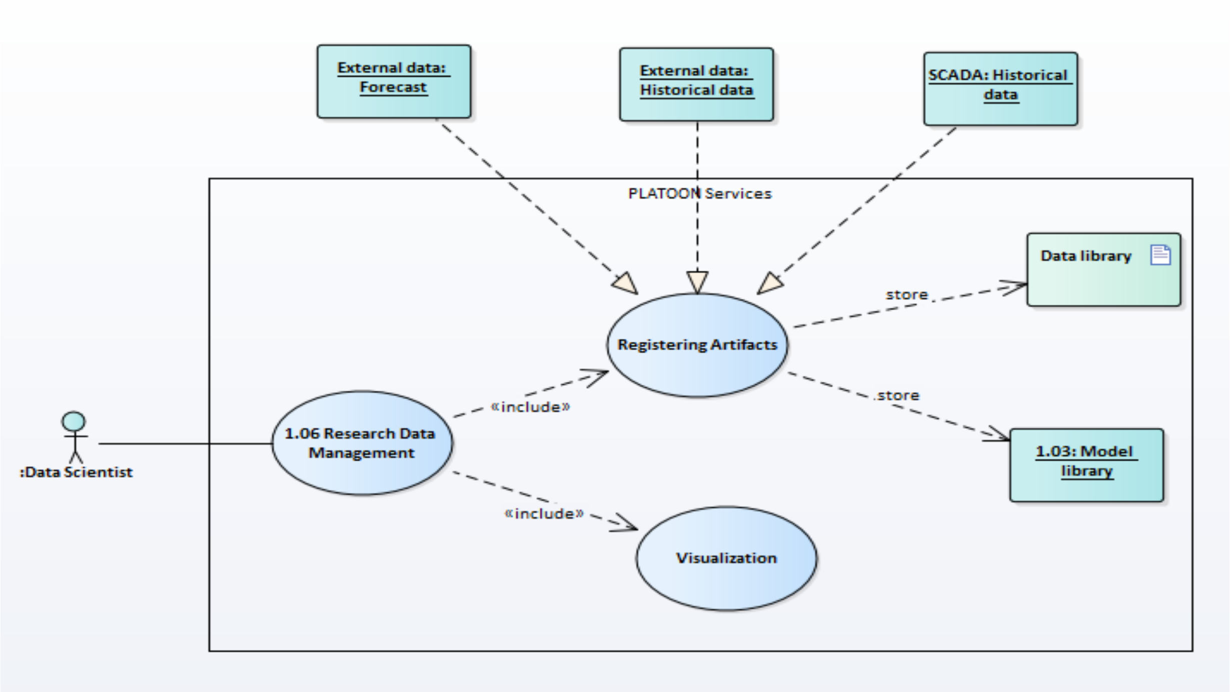


Figure 18.Research Data Management use case diagram

LLUC P-2a- 07: Predictive maintenance in RES power plants

Scope and Objectives

The scope of the LLUC P-2a- 07concerns the predictive maintenance in RES power plants.

The abovementioned LLUC aims to test and to deploy intelligent services delivered by PLATOON for the following purposes:

- Analysis of performance of power plant.
- Predicting component failures to increase the power plant efficiency.
- Making recommendation for corrective and predictive maintenance of the components.
- Implementation of IDS Connectors for the Balance Responsible Party (BRP).
- Real-time integration and big data analysis upon the high-volume data streams from SCADA/EMS.

Short description

The continuous monitoring of asset performance generates inputs that can be used for predictive analytics and to provide early warnings of component/object failures (e.g. RES plant/component). Identifying problems before they occur helps to reduce unscheduled downtime, improve plant maintenance and optimize asset performance.

In this use case we propose to design, develop and test a set of machine learning algorithms to perform predictive maintenance of power plant infrastructure. Machine learning techniques (e.g. Support vector machine and logistic regression algorithms) have been used to explore and compare rare events that could occur in power plant infrastructure. Additionally, by monitoring the output from the RES power plant using the PMU unit and doing advanced power quality (PQ) analytics close to the source, events can be detected and labeled. By gradually creating a database of events by learning from historical data, one could use this classification to find abnormal functioning of the system before it leads to failure.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Saving costs:** The installation of the machine learning algorithm for detection of abnormal behaviour shall reduce the maintenance costs.
- **Increased stability:** Increased degree of stability in the real power plant operation.

Use case diagram

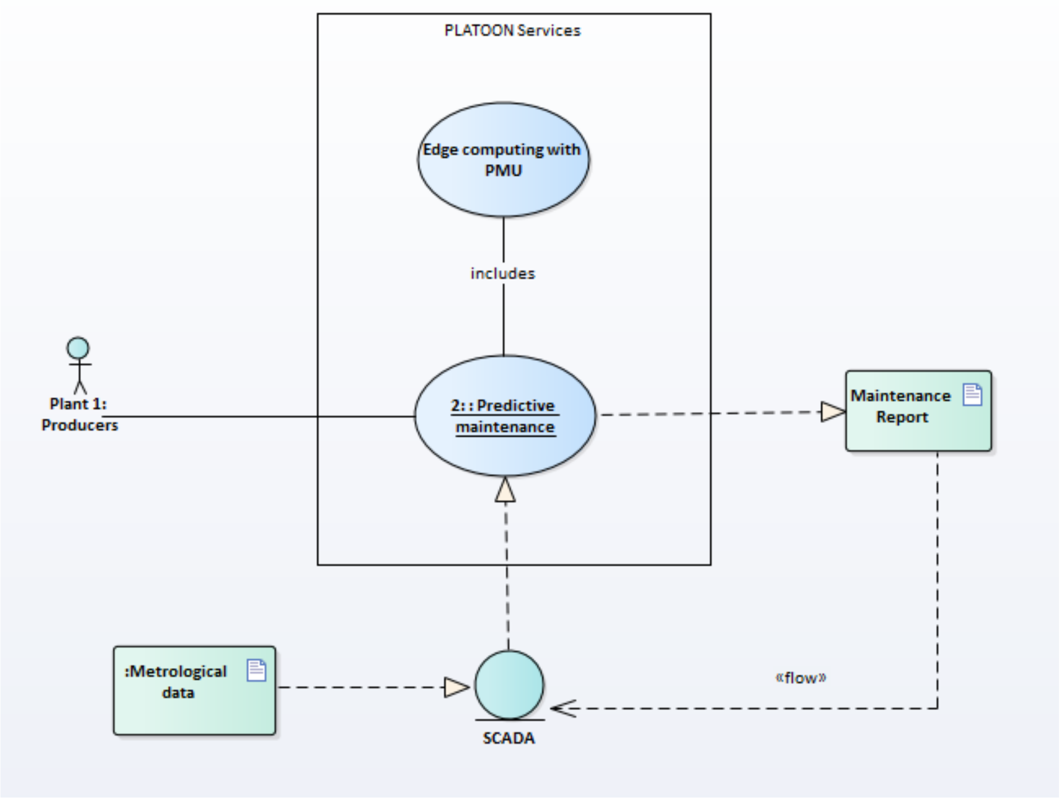


Figure 19. diagram: Predictive maintenance in RES power plants use case diagram

4.3 PILOT #2B - Electricity grid stability, connectivity and Life Extension

LLUC- P-2b- 01: Predictive Maintenance for MV/LV Transformers

Scope and Objectives

This LLUC focuses 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.

The objective of this use case is to develop a predictive maintenance tool for LV/MV transformers, this tool will use available data in this kind of installations or installing new sensors considering the small budget normally used in LV/MV transformers. To develop this tool, Sampol´s smart grid in ParcBit, Majorca (Spain) will be under study.

Maintenance actions are based in the Remaining Useful Life (RUL), in this project, different failures modes of the transformer critical components will be estimated and reflected to the health index of the transformer. Once it is obtained the health index and considering maintenance and failure costs, the transformer maintenance plan will be defined.

Finally, a prescriptive analytics tool will be developed. This tool will allow to evaluate the effect of different operational actions in the grid O&M cost sheet.

Short description

To supervise the operation of distribution transformers, new sensors will be installed, and new algorithms and models will be developed, which will be tested in some distribution transformers in a distribution grid in Parc Bit (Mallorca). This infrastructure will be used to estimate operation variables, estimate the health index of the critical components of the transformer, optimize the transformer maintenance plan, support grid upgrade decision making process and generate predictive alarms.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Temperature estimation accuracy (%)** : Hourly temperature accuracy estimation based on estimated temperature (ET) and actual (measured) temperature (AT) for top oil: (ET-AT)/AT (%).
- **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.
- **Risk decrease (€):** Risk decrease comparing risk-based maintenance supported by the tool to the ordinary preventive maintenance (equal maintenance expenditure is assumed in both cases).
- **Maintenance cost savings (€):** Maintenance cost savings comparing risk-based maintenance supported by the tool to the ordinary preventive maintenance (equal risk level is assumed in both cases).
- **Useful Life Extension (years**): Based on the estimation of the RUL (Remaining Useful Time) it indicates the achievable extension of life relative to that indicated by the manufacturer.

Use case diagram

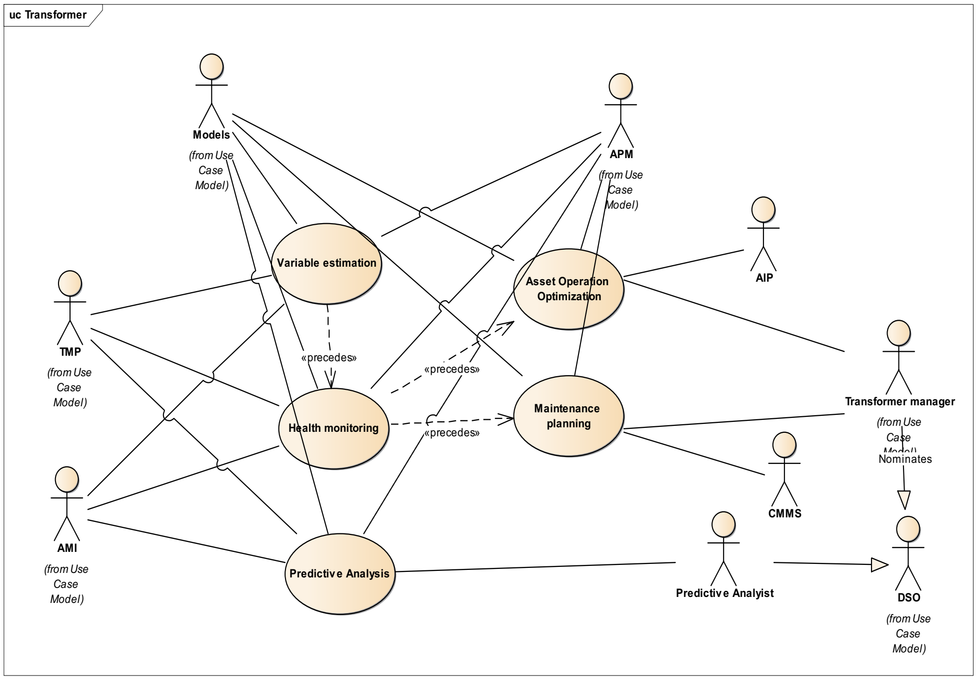


Figure 20 . Predictive Maintenance for MV/LV Transformers use case diagram

LLUC- P-2b- 02: Non-technical loss detection in Smart Grids

Scope and Objectives

The scope of the LLUC- P-2b- 02 concerns the detection of non-technical losses (NTL) in electrical grids.

The abovementioned LLUC aims to develop a tool for the quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL), using the available smart meter data from Sampol´s smart grid in ParcBit, Majorca (Spain).

Short description

Non-technical losses (NTL) in the electric system is one of the biggest fraud factors, generally due to smart meter and/or connection to the grid (bypass of certain consumer loads) manipulation. NTL can be attributed to i) administrative losses due to accounting errors and record keeping, ii) customer theft, iii) customer non-payment and iv) theft by non-customers.

For instance, in the last years, losses in the Spanish electric system have been about the 8% and almost half of that amount could be due to NTL. NTL detection is a complex task as DSOs do not have the appropriate tools and resources to avoid fraud techniques, and the only effective way to fight against NTL is to detect it once it has been committed, and to establish legal actions in that case.

Many theoretical studies in detecting NTL using different techniques have been conducted in the last years. One of these techniques is data science, very popular in the academia.

The main output of this UC is to develop a solution for NTL detection using data analytics, which just requires measurement data available from the Automatic Metering Infrastructure-AMI, and optionally information on the grid topology.

Considered KPIS

The following KPIs were considered for this LLUC:

- **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 Energy Percentage**: Percentage of the energy that is provided from a MV substation or LV CT that is lost due to NTL.
- **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.

Use case diagram

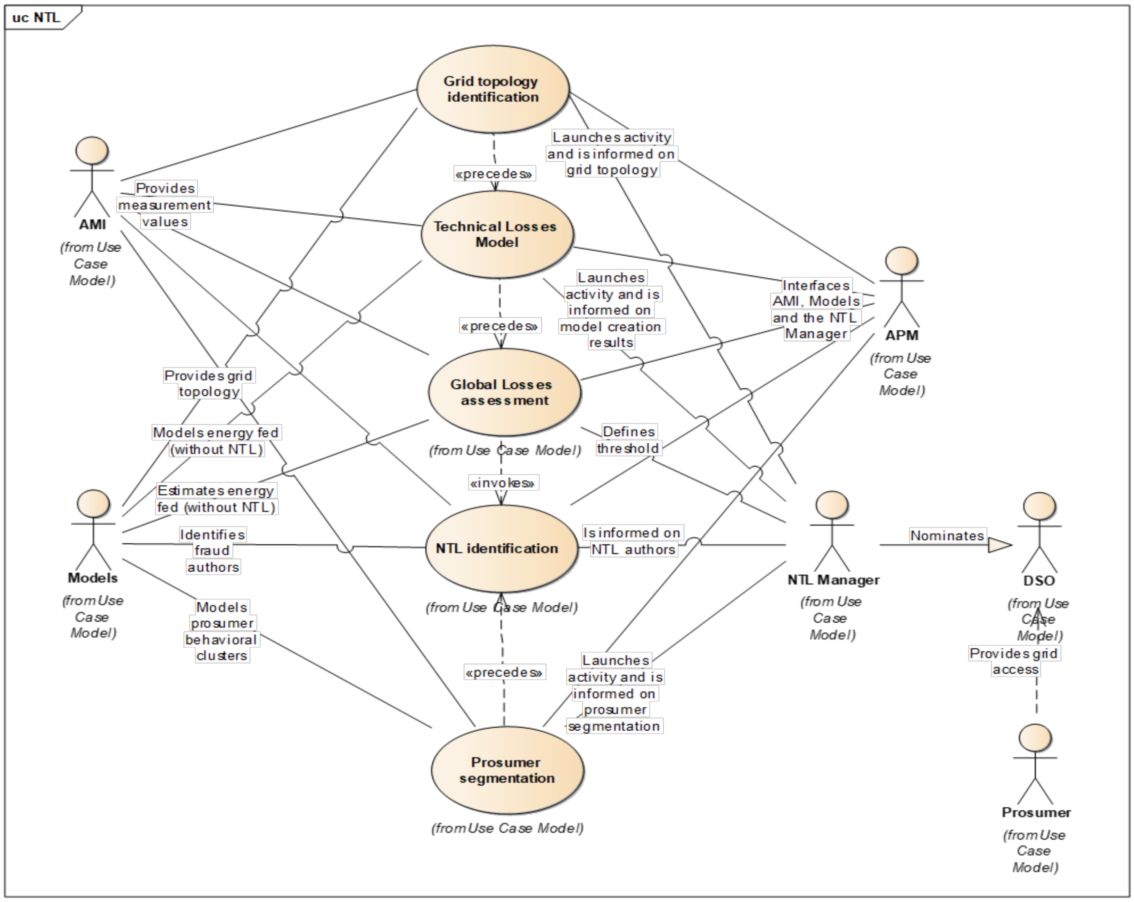


Figure 21 . Non-technical loss detection in Smart Grids use case diagram

4.4 PILOT #3A - Office building - Operation performance thanks to physical models and IA algorithm

LLUC-P-3a-01: Optimization of HVAC operation regarding building occupancy

Scope and Objectives

This use case focus on an office building where a BMS is already installed to monitor the air temperature and control local heating and cooling emission. In general HVAC systems have a fixed operation schedule for each day of the week, which is not always very energy efficient and adapted to the actual use of the building.
Using some extra occupancy sensors, some learning algorithm and models, the occupancy schedule and HVAC controls, including preheating and precooling periods, can be optimized in the BMS to reduce energy consumption while providing the best comfort to occupants

The main objectives of this LLUC are:

- To reduce energy consumption of the building and GHG emissions (NB: depend on the initial regulations and comfort level).
- To maximize the comfort of occupants with the best energy efficiency.
- To automate HVAC system control and reduce manual intervention on system controls.

Short description

The LLUC-P-3a-01 intends to provide a smart module for an office building that optimize HVAC operation in function of real 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.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Comfort level 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.
- **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.
- **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).

- **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).

Use case diagram

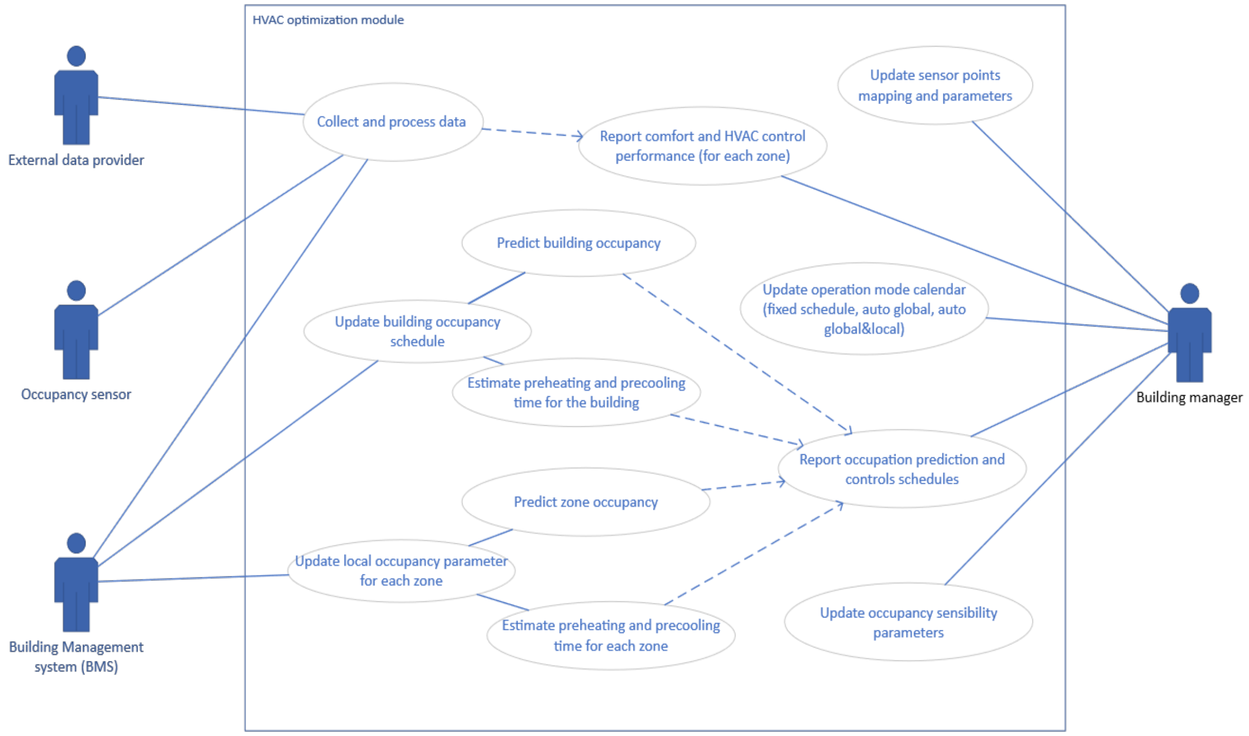


Figure 22. Optimization of HVAC operation regarding building occupancy use case diagram

LLUC -P-3a- 02: Provide Demand Response services through building inertia and HVAC controls

Scope and Objectives

This use case focuses on 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.

The BMS enable to control the HVAC systems and give access to comfort data (temperatures) in the building.

It is assumed that an aggregator is implicated in the project and will value the load flexibility on the French energy and capacity markets. A contract will be signed between the Building manager and the Aggregator specifying the conditions and compensations related to the demand response services implementation. Prediction algorithms will be developed to estimate daily, in function of the building behavior and weather forecast, the load flexibility available and thus help the Aggregator to engage reliable demand response services.

The objectives of this LUUC are:

- To provide flexibility services to contribute to the grid balance (helping to reduce peak demand on the grid).
- To provide accurate predictions of the flexibility available for the next day to help the aggregator value the Demand Response service provided on the market.
- To generate income by contracting with an aggregator.

Short description

The use case intends to provide a smart module to supervise the implementation of Demand Response services in an office Building using HVAC control and building inertia. Collecting data on the building and using weather forecast, the module developed is providing predictions of the HVAC load and the potential flexibility available while maintaining a given level of comfort in the building. 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 activate or plan load interruptions on the building. After validation of the requests (within conditions of the agreement and respecting available flexibility), they are implemented and supervised through the BMS. Feedbacks and eventual alerts are shared with the aggregator if it is relevant.

The predictions of the HVAC load will be assessed regularly. The availability of the flexibility and the capacity to react to a demand response request will also be evaluated.

Considered KPIS

The following KPIs were considered for this LLUC:

- **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).

- **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).
- **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).
- **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.
- **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).
- **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.

Use case diagram

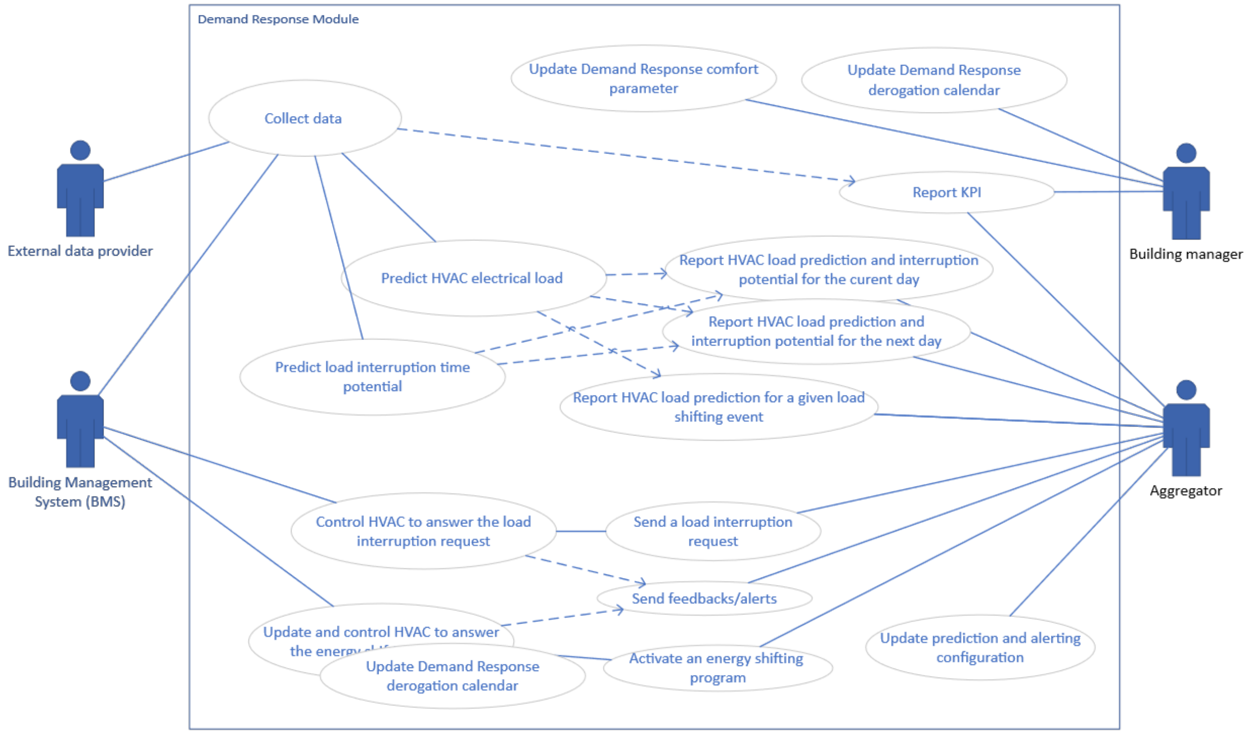


Figure 23. Provide Demand Response services through building inertia and HVAC controls use case diagram

4.5 PILOT #3B - Advanced Energy Management System and Spatial (multi-scale) Predictive Models in the Smart City

LLUC P-3b- 01: Buildings Heating & Cooling consumption Analysis and Forecast

Scope and Objectives

Creating favourable 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 objectives of this LLUC are:

- Energy efficiency plans (heating, cooling).
- Daily and hourly energy consumption forecast.
- Building energy usage benchmark.
- Ensure energy saving and costs reduction on selected buildings.
- Reduction of emissions (CO2 / TOE correlation).

Short description

This use case aims to Benchmark and predict the consumption of cooling and heating plants installed in the 16 pilot buildings in the municipality of Rome (for both summer and winter seasons), taking into account the following factors:

- The comfort of the working environments that can positively affect the productivity of working human resources and quality of customer interactions in retail offices.
- The cooling (power) and heating (power & gas) systems installed at the Italian Post buildings currently managed and monitored in many different ways depending on hardware & SW installed locally, skills of the building managers, maintenance service companies and energy experts following the building.
- The correlation with external weather conditions, building characteristics and past performances together with benchmark with similar building which 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.

Considered KPIS

The following KPIs were considered for this LLUC:

- **PUE Decrease:** % of reduction of PUE (by comparison with similar building or historical data).
- **kWh/Y/sqm** %: of energy consumption reduction (before/after) for each type of building,
- **kWh/Y/sqm:** % of energy consumption reduction (heating, cooling) for line of use of each type of building.

- **CO2% :** CO2 emission reduction.
- **€ Euros (€) saved:** costs savings.

Use case diagram

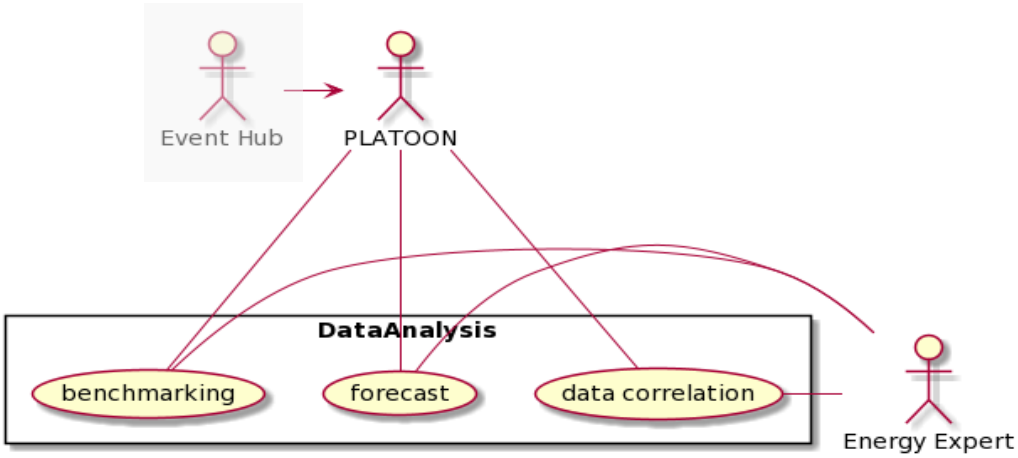


Figure 24. Buildings Heating & Cooling consumption Analysis and Forecast use case diagram

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

Scope and Objectives

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 scope of the use case focuses on optimizing the number of interventions, and the number of plant failures 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.

The objectives of this LLUC are:

- Improve plants efficiency.
- Technical plants fine tuning.
- Increase the availability of heating/cooling plants.
- Reduce maintenance costs.

Short description

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.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Mean Time Between Failure (MTBF) increase:** MTBF increase in heating and cooling plants due to the predictive analysis (expressed in %).
- **Maintenance cost reduction (cost/y/sqm):** Evaluation of maintenance cost reduction for each building or total referred to the heating and cooling plants (expressed in %).

Use case diagram

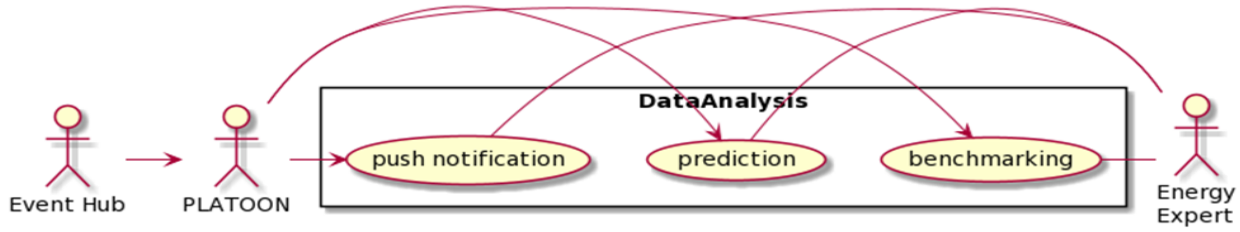


Figure 25.Predictive maintenance of cooling & heating plants use case diagram

LLUC P-3b- 03: Lighting Consumption Estimation & Benchmarking

Scope and Objectives

The weight of consumption due to lighting is estimated to be greater than 20% of the overall electrical consumption of buildings. The scope of this use case is a deeper understanding of the lighting optimization levers and correlation (hours of artificial lighting use, number of users, sqm, …) order to reduce lighting consumption.

The objectives of this use case are:

- Estimation and benchmarking between different lighting solutions.
- Optimization and reduction of Lighting consumption.
- Correlation between the number of building user and the lighting consumption.
- GHG emissions reduction.

Short description

Optimizing lighting consumption means reducing of costs and at the same time promoting environmental sustainability. Trough lighting consumption analysis and benchmarking it will be possible to evaluate the efficacy of the adopted technologies and/or better address planning actions.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Energy consumption/ people presence**: Value of consumption of the light plants compared with the number of people in the building.
- **Lighting Cost** saving: % of cost saving due to the adoption of new lighting lamps for each type of building.
- **Lighting consumption reduction**: % of consumption reduction due to the adoption of new lighting lamps for each type of building.
- **GHG emissions** : % GHG emissions per square meter due to lighting in different scenarios.

Use case diagram

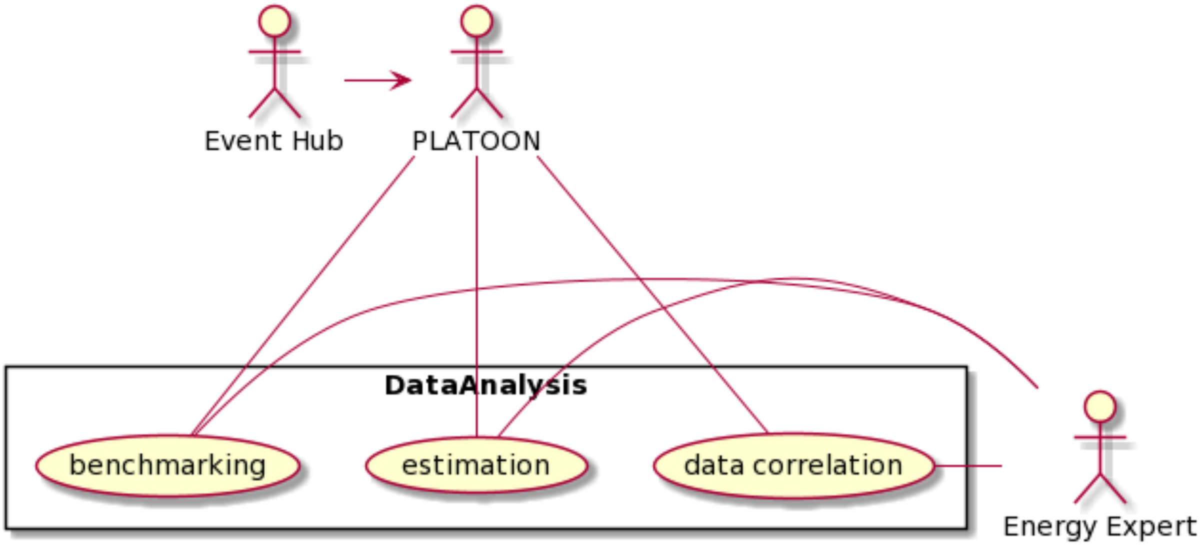


Figure 26. Lighting Consumption Estimation & Benchmarking use case diagram

LLUC P-3b- 04: Monitor and analysis system of Data coming from energy meters of ROME Municipality buildings asset

Scope and Objectives

The use case scope includes almost 2000 buildings owned by ROM with different uses and different plants and devices, including 165 photovoltaics. The data collected from the 8950 meters (power and gas) will be sent to the PLATOON platform. The automated benchmarking analysis of this big data will help the personnel of the ROM EM office to increase the knowledge and awareness about the energy consumptions and the quickness in planning and programming.

The objectives of this LLUC are:

- ROM EM office support: Automated analysis of the data flow coming from the energy meters will help the personnel of the ROM EM office to increase the knowledge and awareness about the energy consumptions.
- Saving Energy and Emissions: anomalies detection, general maintenance planning; updated energy performance baselines aim to address the EE of the asset.
- RES Potentialities Estimation: analysis of the self-consumptions rate and calculations of the RES and storage plants potentialities
- Saving costs: a monitor system free up time and resources of the EM office; the energy saving, and RES implementation produce direct saving costs.

Short description

The energy manager office of Roma Capital, within the SIMU Department, manages more than 8950 energy meters (6500 electric meters and 2450 gas meters) related to almost 2000 buildings owned by the municipality. To help the office in this activity, considering the huge amount of data coming from the meters each months, a monitor system shall be implemented.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Energy Savings:** Total Energy Savings [kWh / Y].
- **Costs Savings:** Saving Personnel costs [Euros saved/Y].
- **Number of Energy Savings Results:** this indicator counts the number of energy meters for which PLATOON services produce actions resulting in energy saving during the year [Nb / Y].
- **Number of Anomalies detected:** Number of Anomalies occurred during a period (Year or month of observation).
- **CO2 reduction**: % of CO2 emission reduction (using CO2/TOE).
- **RES suggested [KWh/Y]**: The calculation 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.

Use case diagram

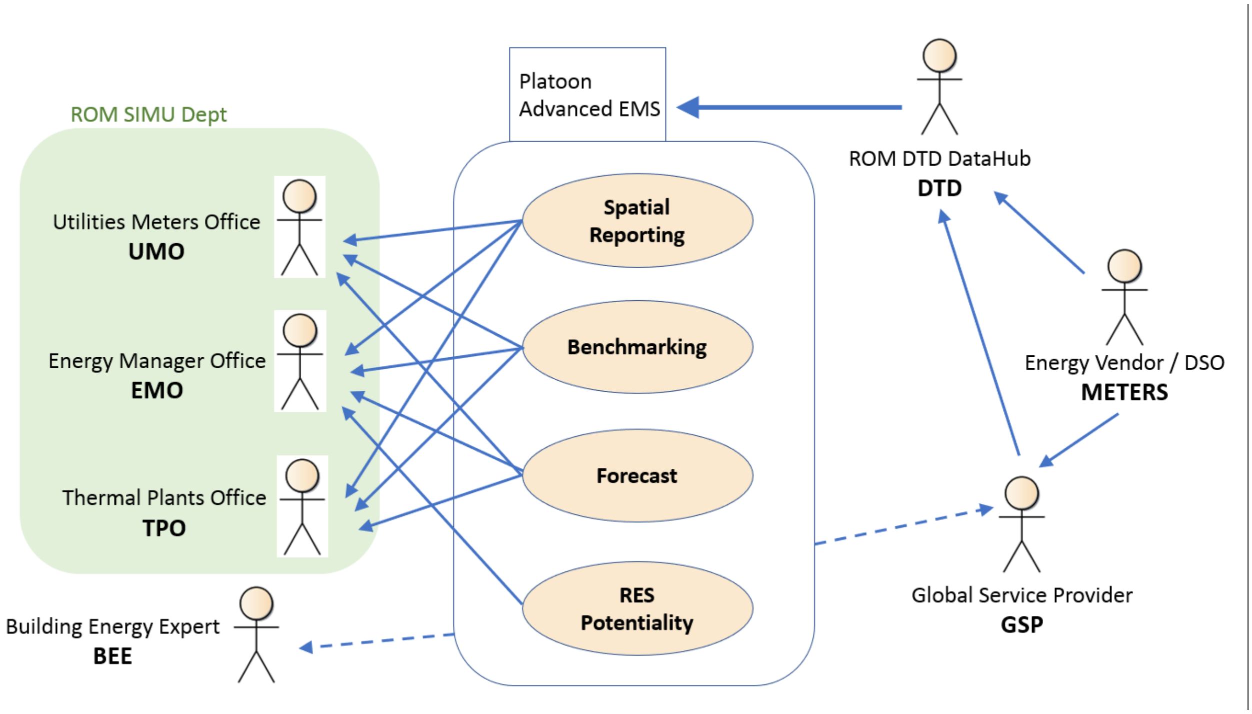


Figure 27.Lighting Consumption Estimation & Benchmarking use case diagram

4.6PILOT #3C - Energy Efficiency and Predictive Maintenance in the Smart Tertiary Building Hubgrade

LLUC P-3C- 01: Advanced EMS for Tertiary Buildings

Scope and Objectives

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 main objective of the functionality described in this LLUC is to enhance existing BMS systems with capabilities to optimize the energy usage maximizing the use of local RES in order to minimize the energy bill.

Short description

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.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Energy Bill reduction**: Evaluate the energy bill reduction achieved.
- **RES ratio**: Evaluate the RES usage versus overall energy consumption.

Use case diagram

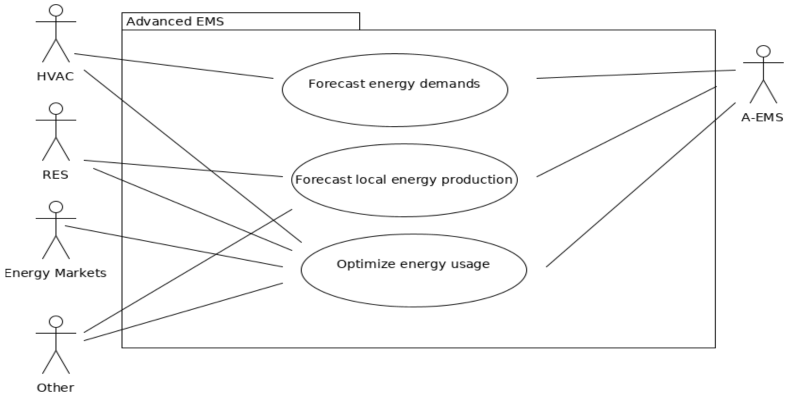


Figure 28.Advanced EMS for Tertiary Buildings use case diagram

LLUC P-3C- 02: Predictive Maintenance in Smart Tertiary Building Assets

Scope and Objectives

The scope of this LLUC is Improving the maintenance policies in the tertiary buildings by implementing the predictive maintenance in some specific assets, increasing the availability, increasing useful life of these assets and reducing the general maintenance costs.

The objectives of the LLUC are:

- Increase the availability of the assets.
- Increase the useful life of the assets.
- Reduce the maintenance costs.

Short description

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 due to legal aspects must be reviewed and controlled every X time) 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 lower 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 the situation of the corresponding asset and be able to act accordingly.

Considered KPIS

The following KPIs were considered for this LLUC:

- **Availability:** increase the availability of the assets.
- **Useful Life**: increase the useful life of the assets.
- **Maintenance Costs**: reduce the total maintenance costs of the assets.

Use case diagram

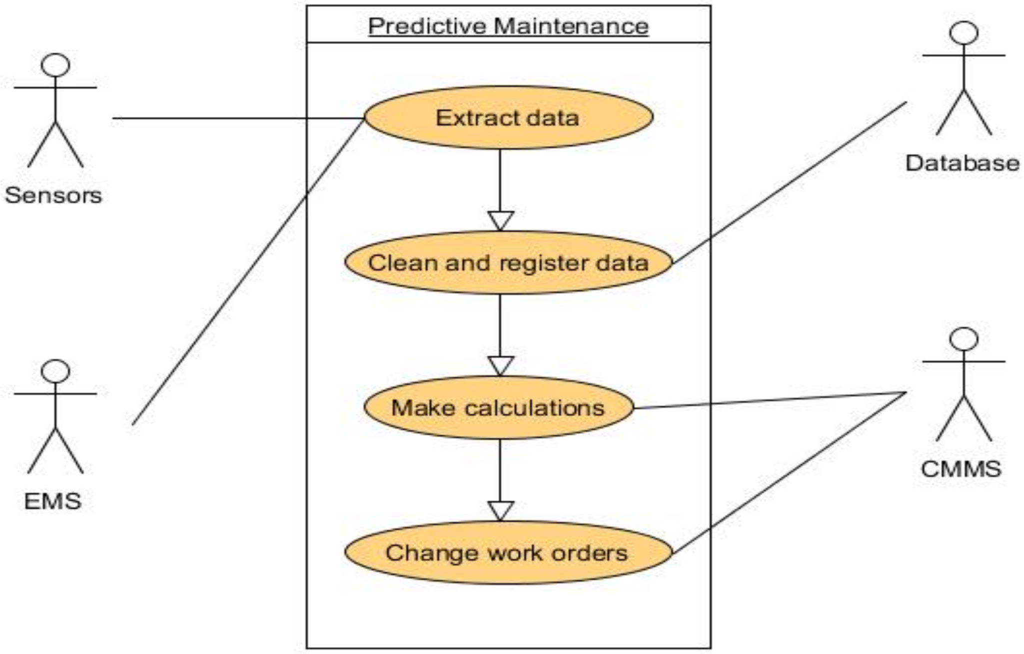


Figure 29. Predictive Maintenance in Smart Tertiary Building Assets use case diagram

4.7 PILOT #4A - Energy Management of Microgrids

LLUC-P-4A- 01: Energy Management of Microgrids

Scope and Objectives

The current use case applies to a micro-grid test-bench, providing an analysis facility for real-life scale research, simulation and test purposes.

The goal of the functionality described in the current use case is to study data-driven energy management able to deal with increased complexity of the energy systems and to assess the advantages of innovative strategies:

- EMS with real-time processing and optimization for small-scale/renewable electricity generation.
- Generation and load forecast.
- Smart storage/generation.
- V2G.

Short description

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.

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

Considered KPIS

The following KPIs were considered for this LLUC:

- **Energy availability:** Optimal energy consumption (increase in energy availability).
- **Cost:** Reduction of maintenance effort and costs.
- **Forecast:** Reduced forecasting errors.
- **Realtime**: Ability to monitoring/analyse/optimize data and the system at real time rate.

Use case diagram

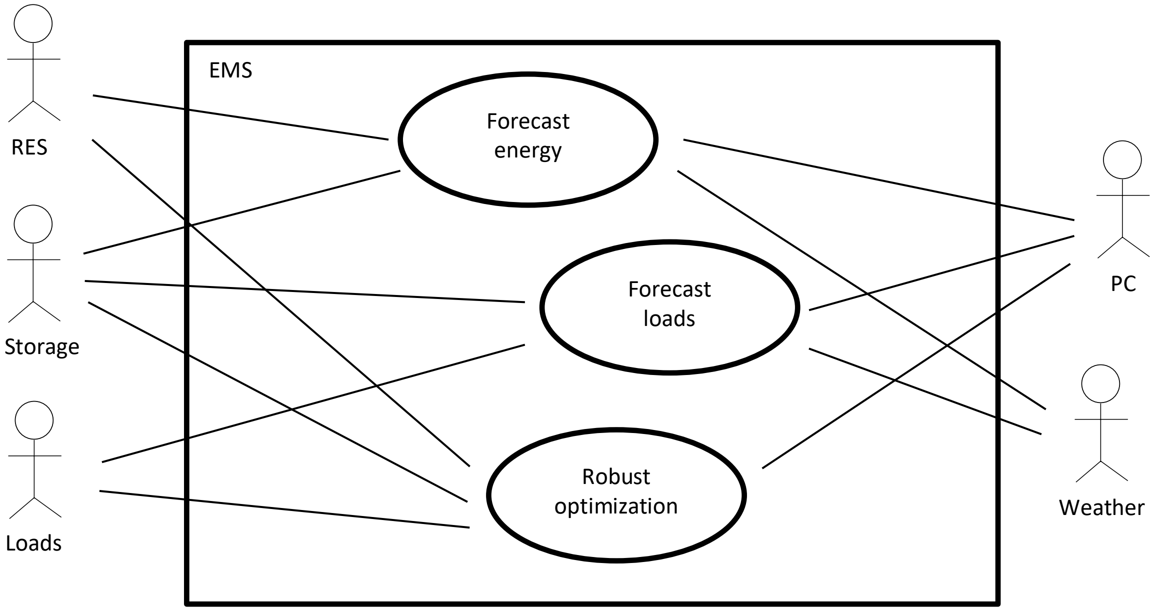


Figure 30. Energy Management of Microgrids use case diagram

5. Conclusions

The steady increase of energy produced by the RES sources to meet the challenges of energy transition and boost decarbonization of the energy sector on the one hand , and on the other, the digitization of the energy sector through IoT and big data analytics has created new challenges for all the energy actors and within all energy sectors. The response from PLATOON to these challenges covers fives domains:

1. Generation
2. Distribution
3. Transmission
4. DER
5. Customer premises/End User.

The main idea is to combine new digital technologies and software solutions with the identified business cases linked to these 5 areas of the energy value chain , in order to create a digital platform for the energy sector that helps reducing the carbon footprint and fighting the climate change while improving the flexibility, the efficiency and the sustainability of the energy systems.

PLATOON project should be able to:

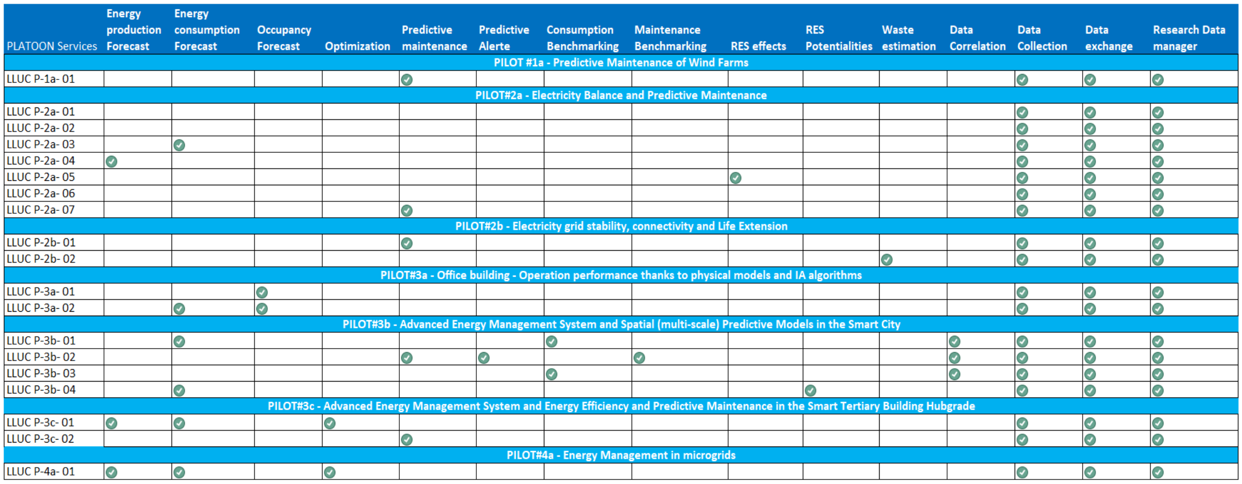
- Explore information collected from the advanced data collection infrastructure for asset health diagnostics and predictive maintenance.
- Design optimized managements tool to improve stability and flexibility in the transmission and the distribution power network.
- Develop and test technology for the identified business models (new and existing) and leverage the integration of DER in the electricity market and power grid management operations.
- Improve consumer engagement for demand response services.
- Enhance multi-party cooperation by developing and implementing a digital platform that foster data-driven energy services and allows data exchange, processing and monetization all governed by clear data governance policy.

The use case methodology applied in PLATOON project for the definition of the use cases (tasks T1.1 and T1.4) provides a structured description of actors and their roles, requirements, services and system processes related with the project goals.

The following results were obtained from these two tasks:

- 12 HLUCs and 19 LLUCs that fully address PLATOON's objectives and challenges
- Identification of the actors and roles (existing and new) who in digitalized energy market will make use of the PLATOON platform (inputs for WP1-T1.3: Platform requirements).
- Identification of data sets used in each pilot and all data exchange requirements to establish a generic data model (inputs for WP2-T2.3: Data models).
- Identification of the data security and privacy requirements regarding all the pilots (inputs for WP3- T3.1 Data governance, security, and privacy requirement analysis).
- Identification of the conditions and the available data of each use case (inputs for WP4- T4.1: PLATOON analytical toolbox design).
- KPIs for measuring overall project objectives and systems performance (Inputs for WP6- T6.1: Implementation & Validation and WP6- T6.5: Evaluation & Validation).

The sections of this deliverable dedicated to each pilot describe in detail the relevant functionalities and services identified through the definition and the development of the Low-Level Use Cases. These services present the core input for the development of the software tools.



PLATOON Services	Energy production Forecast	Energy consumption Forecast	Occupancy Forecast	Optimization	Predictive maintenance	Predictive Alerte	Consumption Benchmarking	Maintenance Benchmarking	RES effects	RES Potentialities	Waste estimation	Data Correlation	Data Collection	Data exchange	Research Data manager
PILOT #1a - Predictive Maintenance of Wind Farms															
LLUC P-1a- 01					✓								✓	✓	✓
PILOT#2a - Electricity Balance and Predictive Maintenance															
LLUC P-2a- 01													✓	✓	✓
LLUC P-2a- 02													✓	✓	✓
LLUC P-2a- 03		✓											✓	✓	✓
LLUC P-2a- 04	✓												✓	✓	✓
LLUC P-2a- 05									✓				✓	✓	✓
LLUC P-2a- 06													✓	✓	✓
LLUC P-2a- 07					✓								✓	✓	✓
PILOT#2b - Electricity grid stability, connectivity and Life Extension															
LLUC P-2b- 01					✓								✓	✓	✓
LLUC P-2b- 02											✓		✓	✓	✓
PILOT#3a - Office building - Operation performance thanks to physical models and IA algorithms															
LLUC P-3a- 01			✓										✓	✓	✓
LLUC P-3a- 02		✓	✓										✓	✓	✓
PILOT#3b - Advanced Energy Management System and Spatial (multi-scale) Predictive Models in the Smart City															
LLUC P-3b- 01		✓					✓					✓	✓	✓	✓
LLUC P-3b- 02					✓	✓		✓				✓	✓	✓	✓
LLUC P-3b- 03							✓					✓	✓	✓	✓
LLUC P-3b- 04		✓								✓			✓	✓	✓
PILOT#3c - Advanced Energy Management System and Energy Efficiency and Predictive Maintenance in the Smart Tertiary Building Hubgrade															
LLUC P-3c- 01	✓	✓		✓									✓	✓	✓
LLUC P-3c- 02					✓								✓	✓	✓
PILOT#4a - Energy Management in microgrids															
LLUC P-4a- 01	✓	✓		✓									✓	✓	✓

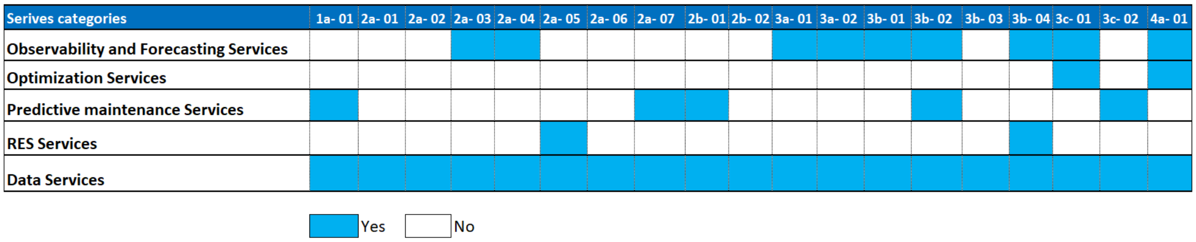
Table 1 PLATOON Services Matrix

In order to highlight the identified services, the Table 1 shows the mapping of LLUC into specific services related to each pilot.

These services are defined as follows:

- **Energy production Forecast Service**: encompasses day-ahead and 7 days ahead energy produces by RES, namely: wind power and solar power to estimate the variable power injected to the power grid.
- **Energy consumption Forecast Service**: revolves around load pattern forecasting, its concerns different types of usages (electric, heating & cooling,…) and takes into account serval factors (weather conditions, occupancy, assets characteristics…) in order to anticipate the demand and the technical-economical actions to put in place in order to meet the consumption target.
- **Occupancy Forecast Service** : concerns the prediction of the occupancy status in a zone of building taking to account serval local factors such as: Type of the day (week, weekend), local holidays calendar information (bank holidays, public holidays), current occupancy data of the building and sensibility parameters on occupancy.
- **Optimization Service**: is about optimizing the energy assets control and usage in order to lead up the energy system towards an optimized behaviour at least economic costs while considering the RES fluctuations.
- **Predictive maintenance**: this service is composed by of a set of machine learning algorithms to perform predictive maintenance and health state estimation of power plant infrastructure, heating and cooling plants (failures prediction), MV/LV transformers and serval types of assets installed generally in tertiary buildings (boilers, chillers, fan coils, extractors and pumps…).

- **Predictive Alert**: sends notifications to the Energy Expert when a fault is expected, based on anomalies of consumption or other indicators.
- **Consumption Benchmarking**: allows plants (heating/cooling) performances analysis in terms of energy consumption. Comparing the building with itself or with similar others over time it's possible to estimate impacts of optimization actions, specific user/plants behaviours, weather conditions.
- **Maintenance Benchmarking**: allows comparison for heating and cooling maintenance costs/performances on the same building over time or among buildings
- **RES effects calculation service:** these services provides analysis of unexpected variations (voltage profile of the power system) before and after RES integration to the power system
- **RES Potentialities Service**: aims at identifying RES potentialities on the buildings in terms of plants power, dimensions and storage capacity to be installed or upgraded to maximize self-consumption.
- **Waste estimation and NTL calculation**: estimate the quantity the of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL), using the available smart meter data.
- **Data Correlation**: allows to evaluate correlation between the energy consumption (lightening, heating, cooling…) and the Occupancy Profile (human presence) in the buildings according to serval factors (number of operating hours, areas with different usage, occupancy status of different areas …)
- **Data Collection**: Allow to receive and collect data from other system's actors (TSO, DSO, BMS, sensors, external data providers …)
- **Data exchange**: allows data to be shared between PLATOON platform and other tools or systems.
- **Research Data manager**: concerns the process of storing and retrieval of artefacts (data models, external datasets, research results/outputs).



Serives categories	1a- 01	2a- 01	2a- 02	2a- 03	2a- 04	2a- 05	2a- 06	2a- 07	2b- 01	2b- 02	3a- 01	3a- 02	3b- 01	3b- 02	3b- 03	3b- 04	3c- 01	3c- 02	4a- 01
Observability and Forecasting Services	⬜	⬜	⬜	🟦	🟦	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	⬜	🟦	🟦	⬜	🟦
Optimization Services	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	⬜	🟦
Predictive maintenance Services	🟦	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	⬜	⬜	⬜	⬜	🟦	⬜	⬜	⬜	🟦	⬜
RES Services	⬜	⬜	⬜	⬜	⬜	🟦	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	⬜	⬜	⬜
Data Services	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

🟦 Yes ⬜ No

Table 2 Mapping of PLATOON LLUC with services categories

Table 2 presents the categories of PLATOON's services. The identified LLUC were divided into five distinguished categories, namely:

- **Observability and Forecasting Services**: this category includes production, consumption and occupancy forecast as well as predictive alarms.

- **Optimization Services:** this category includes the optimal control of energy assets and the optimal planning of energy systems.
- **Predictive maintenance Services:** this category includes power generation plants, transmission assets (Transformers) and consumption assets (heating, cooling, boiler, fan coils) heath state and predative maintenance.
- **RES Services**: this category includes RES potentialities in terms of dimension, producible, storage capacity and the impact of the integration of these technologies on the power grid.
- **Data Services:** this category includes data collection, change, analytics related to PLATOON services or shared with external tools or systems.

6. Internal Review

Internal Review 1

Mark with X the corresponding column:

Y= yes	N= no	NA = not applicable

Name of reviewer: Erik Maqueda

Organisation: TECN

Date: 28/06/2020

ELEMENT TO REVIEW	Y	N	NA	COMMENTS
FORMAT: Does the document … ?				
…include editors, deliverable name, version number, dissemination level, date, and status?	x			
… contain a license (in case of public deliverables)?		x		
… include the names of contributors and reviewers?		X		
… contain a version table?	X			
… contain an updated table of contents?	X			
… contain a list of figures?	X			
… contain a list of tables?	X			
… contain a list of terms and abbreviations?	X			
… contain an Executive Summary?	X			
… contain a Conclusions section?	X			
… contain a List of References (Bibliography) in the appropriate format?		X		
… use the fonts and sections defined in the official template?	X			
… use correct spelling and grammar?	X			
… conform to length guidelines (50 pages maximum (plus Executive Summary and annexes)		X		
… conform to guidelines regarding Annexes (inclusion of complementary information)	X			
… present consistency along the whole document in terms of English quality/style? (to avoid accidental usage of copy&paste text)	X			
About the content…				

ELEMENT TO REVIEW	**Y**	**N**	**NA**	**COMMENTS**
Is the deliverable content correctly written?	X			
Is the overall style of the deliverable correctly organized and presented in a logical order?	X			
Is the Executive Summary self-contained, following the guidelines and does it include the main conclusions of the document?	X			
Is the body of the deliverable (technique, methodology results, discussion) well enough explained?	X			
Are the contents of the document treated with the required depth?	X			
Does the document need additional sections to be considered complete?	X			LLUC-P-4A-01 needs to be added at the end of the anex. Also,It would be useful if all the results/requirements listed in the conclusion section could be listed in a requirement summary table that the subsequent WPs can use as a basis.
Are there any sections in the document that should be removed?		X		
Are all references in the document included in the references section?		X		
Have you noticed any text in the document not well referenced? (copy and paste of text/picture without including the reference in the reference list)		X		
TECHNICAL RESEARCH WPs (WP2-WP5)				
Is the deliverable sufficiently innovative?				
Does the document present technical soundness and its methods are correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	
What do you think is the weakest aspect of the deliverable?			X	
Please perform a brief evaluation and/or validation of the results, if applicable.			X	
VALIDATION WP (WP6)				
Does the document present technical soundness and the validation methods are correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	
What do you think is the weakest aspect of the deliverable?			X	

ELEMENT TO REVIEW	Y	N	NA	COMMENTS
Please perform a brief evaluation and/or validation of the results, if applicable.			X	
DISSEMINATION AND EXPLOITATION WPs (WP7)				
Does the document present a consistent outreach and exploitation strategy?			X	
Are the methods and means correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	
What do you think is the weakest aspect of the deliverable?			X	
Please perform a brief evaluation and/or validation of the results, if applicable.			X	

SUGGESTED IMPROVEMENTS

PAGE	SECTION	SUGGESTED IMPROVEMENT
403	Anex- LLUC-P-4A- 01: Energy Management of Microgrids	*LLUC needs to be added in order the document to be complete and approved.*
	New section - Requirement summary	*It would be useful if all the results/requirements listed in the conclusion section could be listed in a requirement summary table that the subsequent WPs can use as a basis.*

CONCLUSION

Mark with X the corresponding line.

	Document accepted, no changes required.
x	Document accepted, changes required.
	Document not accepted, it must be reviewed after changes are implemented.

Please rank this document globally on a scale of 1-5 (1 = poor, 5= excellent) – using a half point scale. Mark with X the corresponding grade.

Document grade	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**

						x			

Internal Review 2

Mark with X the corresponding column:

Y= yes	N= no	NA = not applicable

Name of reviewer: Fernando Merino Blanco

Organisation: INDRA

Date: June 29th 2020

ELEMENT TO REVIEW	Y	N	NA	COMMENTS
FORMAT: Does the document … ?				
…include editors, deliverable name, version number, dissemination level, date, and status?	X			
… contain a license (in case of public deliverables)?		X		
… include the names of contributors and reviewers?	X			
… contain a version table?	X			
… contain an updated table of contents?	X			
… contain a list of figures?	X			
… contain a list of tables?	X			
… contain a list of terms and abbreviations?	X			
… contain an Executive Summary?	X			
… contain a Conclusions section?	X			
… contain a List of References (Bibliography) in the appropriate format?		X		Some inconsistencies have been detected in the revision regarding bibliographical references. There is a list of references at the end of the document which is not clear. The Reference section should properly contain all references plus the ones included in the main text as footnotes
… use the fonts and sections defined in the official template?	X			
… use correct spelling and grammar?	X			

ELEMENT TO REVIEW	**Y**	**N**	**NA**	**COMMENTS**
… conform to length guidelines (50 pages maximum (plus Executive Summary and annexes)		X		
… conform to guidelines regarding Annexes (inclusion of complementary information)	X			
… present consistency along the whole document in terms of English quality/style? (to avoid accidental usage of copy&paste text)	X			
About the content…				
Is the deliverable content correctly written?	X			
Is the overall style of the deliverable correctly organized and presented in a logical order?	X			
Is the Executive Summary self-contained, following the guidelines and does it include the main conclusions of the document?	X			
Is the body of the deliverable (technique, methodology results, discussion) well enough explained?	X			
Are the contents of the document treated with the required depth?	X			
Does the document need additional sections to be considered complete?		X		
Are there any sections in the document that should be removed?		X		
Are all references in the document included in the references section?		X		Some inconsistencies have been detected in the revision regarding bibliographical references. There is a list of references at the end of the document which is not clear. The Reference section should properly contain all references plus the ones included in the main text as footnotes
Have you noticed any text in the document not well referenced? (copy and paste of text/picture without including the reference in the reference list)		X		
TECHNICAL RESEARCH WPs (WP2-WP5)				
Is the deliverable sufficiently innovative?			X	
Does the document present technical soundness and its methods are correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	

ELEMENT TO REVIEW	Y	N	NA	COMMENTS
What do you think is the weakest aspect of the deliverable?			X	
Please perform a brief evaluation and/or validation of the results, if applicable.			X	
VALIDATION WP (WP6)				
Does the document present technical soundness and the validation methods are correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	
What do you think is the weakest aspect of the deliverable?			X	
Please perform a brief evaluation and/or validation of the results, if applicable.			X	
DISSEMINATION AND EXPLOITATION WPs (WP7)				
Does the document present a consistent outreach and exploitation strategy?			X	
Are the methods and means correctly explained?			X	
What do you think is the strongest aspect of the deliverable?			X	
What do you think is the weakest aspect of the deliverable?			X	
Please perform a brief evaluation and/or validation of the results, if applicable.			X	

SUGGESTED IMPROVEMENTS

PAGE	SECTION	SUGGESTED IMPROVEMENT
	References	Include a comprehensive “List of References” section to properly organize all the references in the document currently distributed in footnote, the Reference sections and a list of additional references at the end of Annex IV
	Annex IV	Complete the description of LLUC-P-4A-01 at the end of annex IV (it is currently missing)

CONCLUSION

Mark with X the corresponding line.

	Document accepted, no changes required.
X	Document accepted, changes required.
	Document not accepted, it must be reviewed after changes are implemented.

Please rank this document globally on a scale of 1-5 (1 = poor, 5= excellent) – using a half point scale. Mark with X the corresponding grade.

7. References

PLATOON documents:

[1]. PLATOON Grant Proposal GA 8725922019.

External documents

[2]. CEN-CENELEC-ETSI Smart Grid Coordination Group (2012). Smart grid reference architecture. Final Technical Report for adoption by M/490, version 3.0.

[3]. IEC 62559-2:2015: Use case methodology – Part 2: Definition of the Templates for Use Cases, Actor List and Requirements List ,2015.

[4]. M. Gottschalk,M.Uslar, C.Delfs . The Use Case and Smart Grid Architecture Model Approach, the IEC 62559-2 Use Case Template and the SGAM Applied in Various Domains, Switzerland: Springer Briefs in Energy,104,2016.

[5]. Project Management Methodology Guide Open Edition, Luxembourg: Publications Office of the European Union, 2016.

[6]. G. Giebel (eds) . The State of the Art in Short-Term Prediction of Wind Power, A Literature Overview, 2nd Edition,2011.

Annex I - High level Use Case Template

PLATOON
Digital platform and analytic tools for energy
USE CASE BASED ON PM² ALLIANCE CANVAS

Use Case Title:

ID Pilot

ID Usecase

PROJECT SCOPE

IN | OUT

SERVICES

USE CASE DESIRED OUTCOMES

Benefits

ASSUMPTIONS

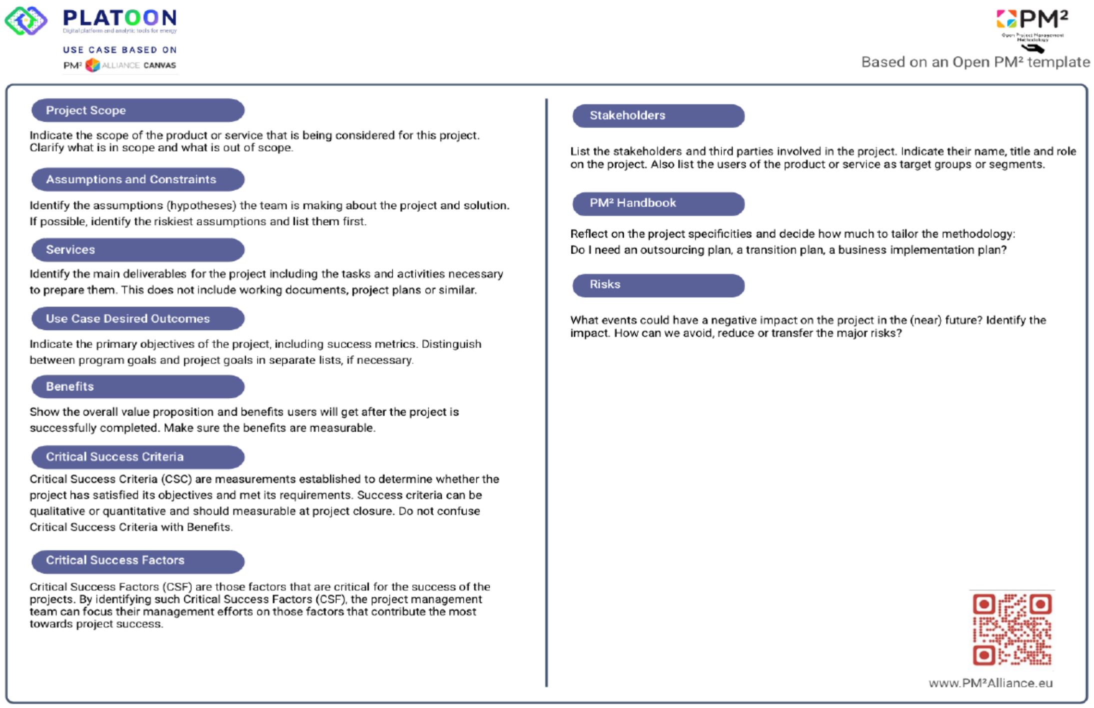
Constraints

USE CASE RISKS

WORK BREAKDOWN

CRITICAL SUCCESS CRITERIA

STAKEHOLDERS



PLATOON
Digital platform and analytic tools for energy
USE CASE BASED ON PM² ALLIANCE CANVAS

PM²
Based on an Open PM² template

Project Scope

Indicate the scope of the product or service that is being considered for this project. Clarify what is in scope and what is out of scope.

Assumptions and Constraints

Identify the assumptions (hypotheses) the team is making about the project and solution. If possible, identify the riskiest assumptions and list them first.

Services

Identify the main deliverables for the project including the tasks and activities necessary to prepare them. This does not include working documents, project plans or similar.

Use Case Desired Outcomes

Indicate the primary objectives of the project, including success metrics. Distinguish between program goals and project goals in separate lists, if necessary.

Benefits

Show the overall value proposition and benefits users will get after the project is successfully completed. Make sure the benefits are measurable.

Critical Success Criteria

Critical Success Criteria (CSC) are measurements established to determine whether the project has satisfied its objectives and met its requirements. Success criteria can be qualitative or quantitative and should measurable at project closure. Do not confuse Critical Success Criteria with Benefits.

Critical Success Factors

Critical Success Factors (CSF) are those factors that are critical for the success of the projects. By identifying such Critical Success Factors (CSF), the project management team can focus their management efforts on those factors that contribute the most towards project success.

Stakeholders

List the stakeholders and third parties involved in the project. Indicate their name, title and role on the project. Also list the users of the product or service as target groups or segments.

PM² Handbook

Reflect on the project specificities and decide how much to tailor the methodology: Do I need an outsourcing plan, a transition plan, a business implementation plan?

Risks

What events could have a negative impact on the project in the (near) future? Identify the impact. How can we avoid, reduce or transfer the major risks?

www.PM²Alliance.eu

Annex II- Low Level Use case Template

1. Description of the use case.

The first section of the use case template considers the description of the use case where all functions of a system were described. It identifies all participating actors (human or systems) which are playing a role within the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
Provide a unique identification e.g.:UC-STN-01	Provide the framework domain and zone e.g.: if perfectly mapped with SGAM. domains and SGAM.zones, they can be mentioned	Provide a short name, which refers to the activity of the use case itself using “Verb + description”.

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
	DD.MM.YYYY	Define who has provided the document (person or organization)	Document the general changes.	

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	Define the limit of the use case in a short and precise text.
Objective(s)	List the objectives of the use case in form of bullet points and small headlines.
Related business case(s)	Provides a description or reference with some rationale for the suggested use case. Usually the business case is related to several use cases. Therefore, an external reference or link to a business case/business requirement might be more efficient and can be added here.

1.4 Narrative of Use Case.

Narrative of use case
Short description
Provide a brief overview of the use case of no more than **150** words.
Complete description
Provide a comprehensive longer narrative description from user viewpoint about how, where, when, why, and under which assumptions. The complete description should be written in a way that its can be also understood by non-domain experts.

1.5 Key performance indicators (KPI).

This information should be used for the remaining WPs of PLATOON. So it is CRUCIAL.

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
Provide a unique identification for the KPI	Provide a short name to describe the KPI	Provide a description in form of few sentences to specify the KPI. The description may include specific targets in relation to one of the objectives of the use case and the calculation of these targets.	Provide the link to one of the objectives which are specified in the targets and the KPI before.

1.6 Use case conditions.

Use case conditions
Assumptions
Provide a general presumption about conditions or system configurations.
Prerequisites
Specify which requirements have to be met so that the basis scenario use case can be successfully accomplished.

(!) If there are more than one assumption or prerequisites, a greater number of tables has to be created.

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

Classification information
Relation to other use cases
Provide known relations to other use cases in the pilot and if possible beyond (other Pilots) e.g. if the described use case related to other detailed use case, to a high level use case, or it is an alternative to an existing use case. It could be used to include IDs of PLATOON use cases related to this one.
Level of depth
Define the level of depth of the use case. For PLATOON, this template is used in particularly to define detailed use case, which described in details the functionalities of a business process.
Prioritization
Rate the use cases and sub described parts of the UC, in the context of PLATOON from very important to nice-to-have with labels like obligatory/mandatory or optional. ❖ Labels to be defined and agreed with all PLATOON's partners
Generic, regional or national relation
On international level, the use case description might be generic enough to describe a use case in a more general way independently from the national or regional market design. But use cases might be used to describe regional or national specific circumstances like laws or even project-specific details. If the use case reflects those circumstances, it should be characterized accordingly. ❖ In PLATOON, Use Cases (UC) demonstrated in more than one country should be classified and written as generic.
Nature of the use case
Classify the main focus of the use case. EXAMPLE: Technical/system use case, business use cases (e.g. market processes), political, test use cases.
Further keywords for classification
Define keywords in order to support extended search functionalities within a use case repository. Multiple keywords should be provided as a comma-separated list. EXAMPLE: Smart grid, electric vehicles, loading of vehicles, electricity metering, storage.

1.8 General remarks.

General remarks
Note further comments which do not fit in any other category in form of bullet points.

2. Diagrams of use case.

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Paste below the use case diagram to show how actors interact within the Use Case by participating in the technical functions

3. Technical details.

This part of the template provides in :

Section 3.3.1: a description of the actors involved in the use case .These can for instance include people, systems, applications, databases, devices, etc.

Section 3.3.2: a list of used references (standards, reports, mandates, regulatory constraints) to realize the use case and improve the replicability of the solution.

3.1 Actors.

Actors			
Grouping		**Group description**	
Place the actor in a group according to its properties.		Provide a short description of the group.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Provide a unique actor name.	E.g. device, system, human, etc.		

(!) A separate table should be used for each actor grouping

3.1 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
			The status of the document. e.g. Draft, final	e.g. copy right, IPR		

4. Step by step analysis of use case.

This section of the template focuses on describing the possible scenarios of the use case a step by step analysis. There should be a clear correlation between these scenarios and steps and the use case narrative in section 1.4 of the template.

4.1 Overview of scenarios.

The section provides an overview of the different scenarios of the use case like normal and alternative scenarios which are described in section 4.2 of the template.

In general, the writer of the use case starts with the normal sequence (success). In case precondition or post-condition does not provide the expected output (e.g. no success = failure), alternative scenarios have to be defined. In PLATOON project for the sake of clarity, this information is maintained in graphical UML sequence diagram and description of the use case is given in textual form as in below table where pre/post conditions are maintained

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
			Refers to the actor that triggers the scenario. For instance, a function called "Protection" would probably be triggered by an "Intelligent Electronic Device (IED)". It is worth pointing out that the names of the Actors should be consistent with Actors List in all	Event that triggers the scenario. It can be a real event (such as, "a fault occurs in the grid"), or it is also possible to define scenarios that occur "periodically	Describes the state of the system before the scenario starts.	Describes the expected state of the system after the scenario is realized

			sections of the Use Case description.			

4.1 Steps-Scenarios.

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).

Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new “sub” use case, then referring to that “subroutine” in this scenario.

Scenario								
Scenario name:		**No. 1 – …**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
	Describe the event that triggers the activity. This triggering event can be an event, such as “a fault that occurs in the grid”, or it may refer to an activity that occurs “periodically”.	Define the label that would appear in a process diagram. Action verbs should be used when naming activity. EXAMPLE: “Fault occurs in the grid”.	Describe what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between actors.	Identify the nature of flow of information and the originator of the information (*).	Identify the name of the actor that produces the information. When the activity is an internal process, the information producer is the actor that carries out the internal process. For instance, when the activity is an internal algorithm within an Intelligent Electronic Device (IED),	Identify the name of the actor that receives the information. When the activity is an internal process, the information receiver is the same actor as the information producer.	Here the information can use a short ID referring to template section 5 for further details. Several information exchanged IDs can be listed, comma separated.	Refer to the identifiers (R-ID) of the detailed requirements that apply for each activity.

(*) Available options are:

- CREATE means that an information object is to be created at the Producer.
- GET (this is the default value if none is populated) means that the Receiver requests information from the Producer (default).
- CHANGE means that information is to be updated. Producer updates the Receiver's information.
- DELETE means that information is to be deleted. Producer deletes information from the Receiver.
- CANCEL, CLOSE imply actions related to processes, such as the closure of a work order or the cancellation of a control request.
- EXECUTE is used when a complex transaction is being conveyed using a service, which potentially contains more than one verb.
- REPORT is used to represent transferal of unsolicited information or asynchronous information flows. Producer provides information to the Receiver.
- TIMER is used to represent a waiting period. When using the TIMER service, the Information Producer and Information Receiver fields shall refer to the same actor.
- REPEAT is used to indicate that a series of steps is repeated until a condition or trigger event. The condition is specified as the text in the "Event" column for this row or step. Following the word REPEAT, shall appear, in parenthesis, the first and last step numbers of the series to be repeated in the following form REPEAT(X-Y) where X is the first step and Y is the last step

5. Information exchanged.

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
Refers to an identifier used in the field "Information Exchanged" in the table of section 4.2.	Define a unique ID which identifies the selected information in the context of the use case.	Provide a brief description, in case a reference to existing data models/information classes should be added. Using existing canonical data models is recommended.	To be used to define requirements referring to the information and not to the step as in the step by step analysis (see template section 6 below): EXAMPLE: Data protection class corresponding to this information object.

6. Requirements.

The section 6 of the use case template summarizes the requirements of all steps in the use case and it is linked to template section 4 “Step by Step Analysis”. These requirements are divided into categories with a unique category ID and a unique requirements ID (R-ID).

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Unique identifier for the category. Name for the category of requirements.	A name of the requirement.	Description of the requirement category.
Requirement R-ID	**Requirement name**	**Requirement description**
Unique identifier which identifies the requirement within its category	A name of the requirement.	Description of the requirement .

7. Common terms and definitions.

The section 7 of the use case template contains common terms and definitions in a glossary. Each important term used in course of the project has to be followed by its definition.

Common terms and definitions	
Term	**Definition**

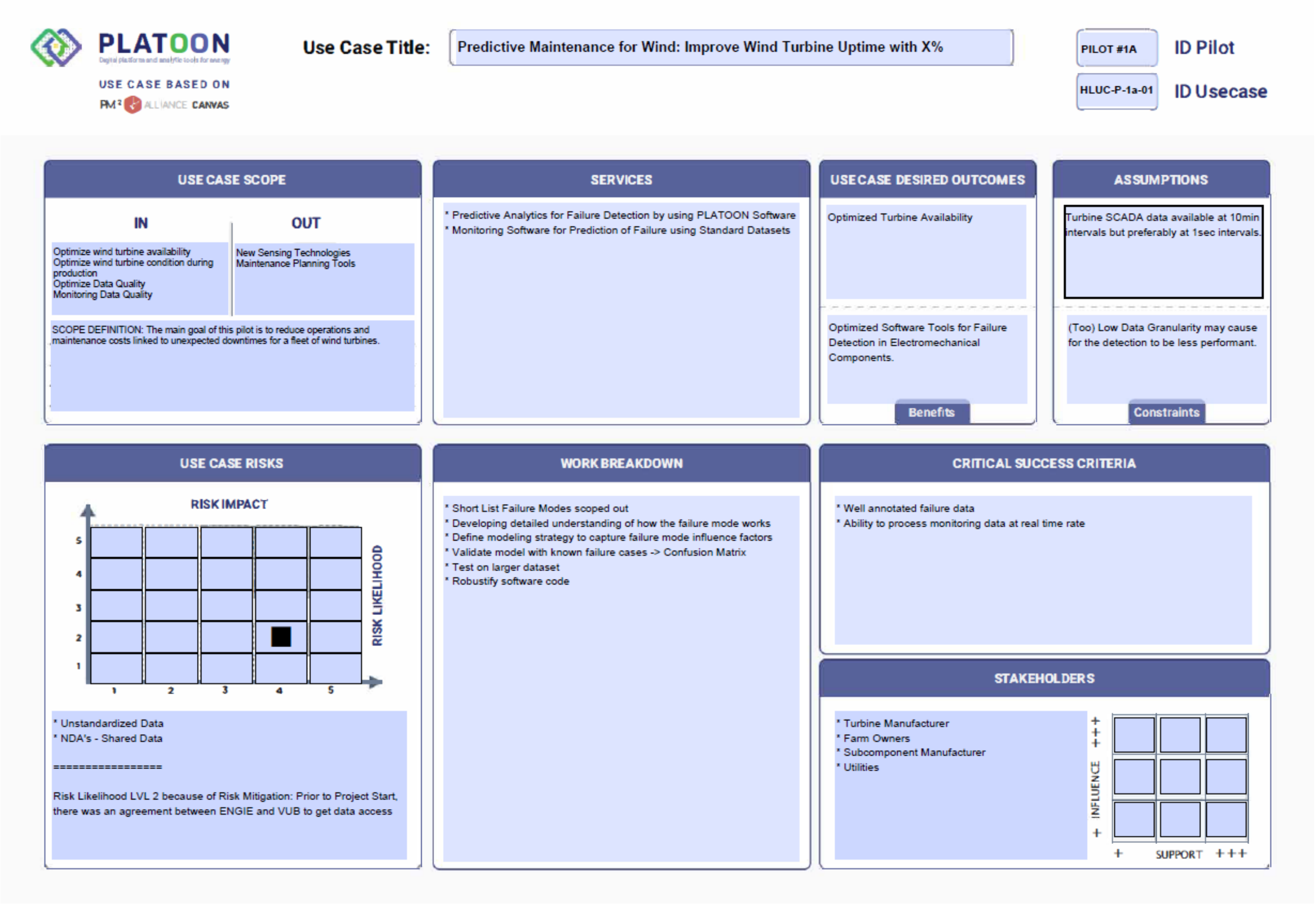
8. Custom information (optional).

This section of the use case template entails a key and its value. It has to be remarked to which section the pair refers.

Custom information (optional)		
Key	**Value**	**Refers to section**

Annex III High Level Use Cases

HLUC-P-1a- 01: Predictive Maintenance for Wind Improve Wind Turbine Uptime with X%



Use Case Title: Predictive Maintenance for Wind: Improve Wind Turbine Uptime with X%

PILOT #1A **ID Pilot**

HLUC-P-1a-01 **ID Usecase**

USE CASE SCOPE

IN

Optimize wind turbine availability
Optimize wind turbine condition during production
Optimize Data Quality
Monitoring Data Quality

OUT

New Sensing Technologies
Maintenance Planning Tools

SCOPE DEFINITION: The main goal of this pilot is to reduce operations and maintenance costs linked to unexpected downtimes for a fleet of wind turbines.

SERVICES

* Predictive Analytics for Failure Detection by using PLATOON Software
* Monitoring Software for Prediction of Failure using Standard Datasets

USECASE DESIRED OUTCOMES

Optimized Turbine Availability

Optimized Software Tools for Failure Detection in Electromechanical Components.

Benefits

ASSUMPTIONS

Turbine SCADA data available at 10min intervals but preferably at 1sec intervals.

(Too) Low Data Granularity may cause for the detection to be less performant.

Constraints

USE CASE RISKS

* Unstandardized Data
* NDA's - Shared Data

=================

Risk Likelihood LVL 2 because of Risk Mitigation: Prior to Project Start, there was an agreement between ENGIE and VUB to get data access

WORK BREAKDOWN

* Short List Failure Modes scoped out
* Developing detailed understanding of how the failure mode works
* Define modeling strategy to capture failure mode influence factors
* Validate model with known failure cases -> Confusion Matrix
* Test on larger dataset
* Robustify software code

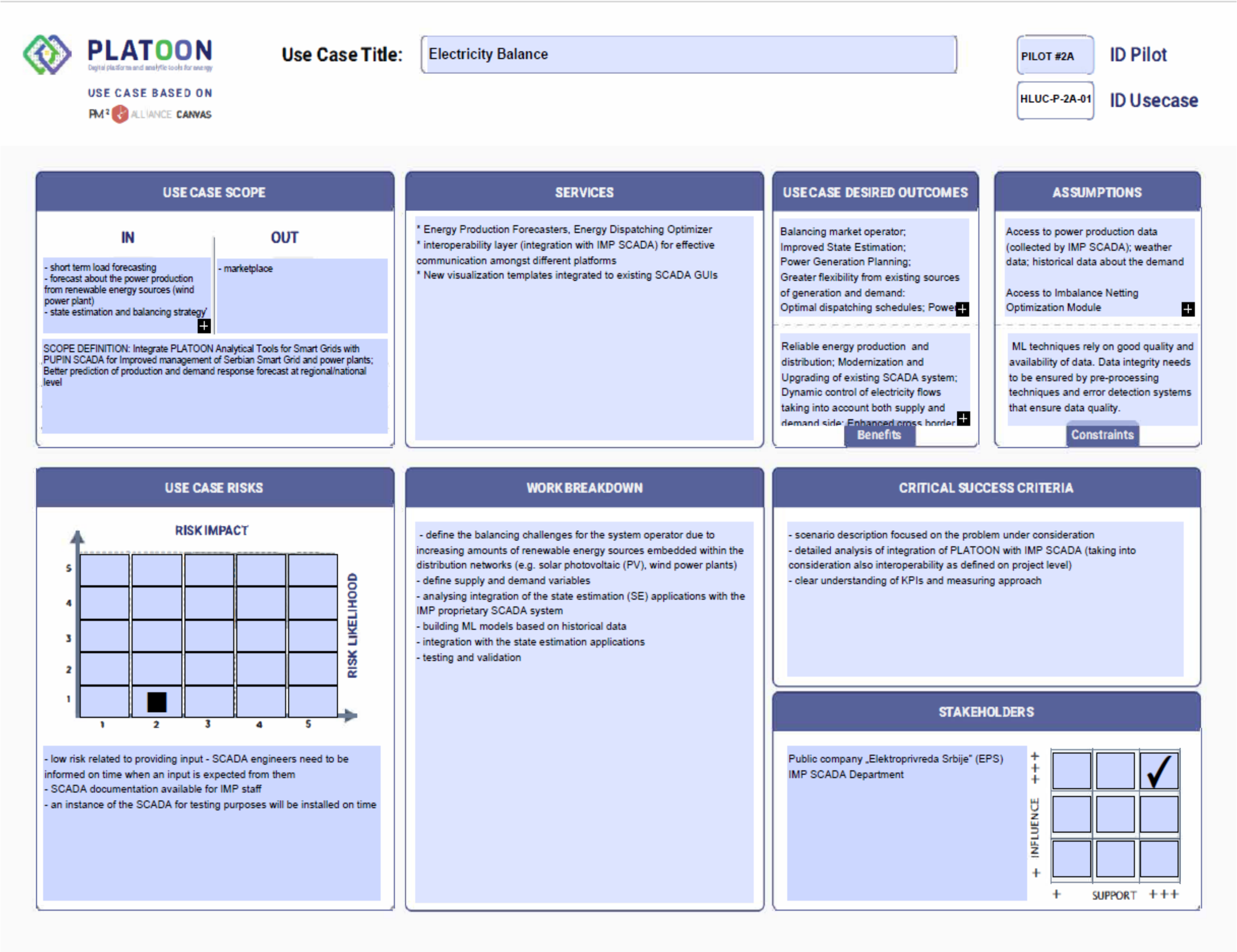
CRITICAL SUCCESS CRITERIA

* Well annotated failure data
* Ability to process monitoring data at real time rate

STAKEHOLDERS

* Turbine Manufacturer
* Farm Owners
* Subcomponent Manufacturer
* Utilities

HLUC P-2a- 01: Electricity Balance



Use Case Title: Electricity Balance

PILOT #2A ID Pilot

HLUC-P-2A-01 ID Usecase

USE CASE SCOPE

IN

- short term load forecasting
- forecast about the power production from renewable energy sources (wind power plant)
- state estimation and balancing strategy'

OUT

- marketplace

SCOPE DEFINITION: Integrate PLATOON Analytical Tools for Smart Grids with PUPIN SCADA for Improved management of Serbian Smart Grid and power plants; Better prediction of production and demand response forecast at regional/national level

SERVICES

* Energy Production Forecasters, Energy Dispatching Optimizer
* interoperability layer (integration with IMP SCADA) for effective communication amongst different platforms
* New visualization templates integrated to existing SCADA GUIs

USECASE DESIRED OUTCOMES

Balancing market operator;
Improved State Estimation;
Power Generation Planning;
Greater flexibility from existing sources of generation and demand:
Optimal dispatching schedules; Powe

Reliable energy production and distribution; Modernization and Upgrading of existing SCADA system; Dynamic control of electricity flows taking into account both supply and demand side; Enhanced cross border

Benefits

ASSUMPTIONS

Access to power production data (collected by IMP SCADA); weather data; historical data about the demand

Access to Imbalance Netting Optimization Module

ML techniques rely on good quality and availability of data. Data integrity needs to be ensured by pre-processing techniques and error detection systems that ensure data quality.

Constraints

USE CASE RISKS

- low risk related to providing input - SCADA engineers need to be informed on time when an input is expected from them
- SCADA documentation available for IMP staff
- an instance of the SCADA for testing purposes will be installed on time

WORK BREAKDOWN

- define the balancing challenges for the system operator due to increasing amounts of renewable energy sources embedded within the distribution networks (e.g. solar photovoltaic (PV), wind power plants)
- define supply and demand variables
- analysing integration of the state estimation (SE) applications with the IMP proprietary SCADA system
- building ML models based on historical data
- integration with the state estimation applications
- testing and validation

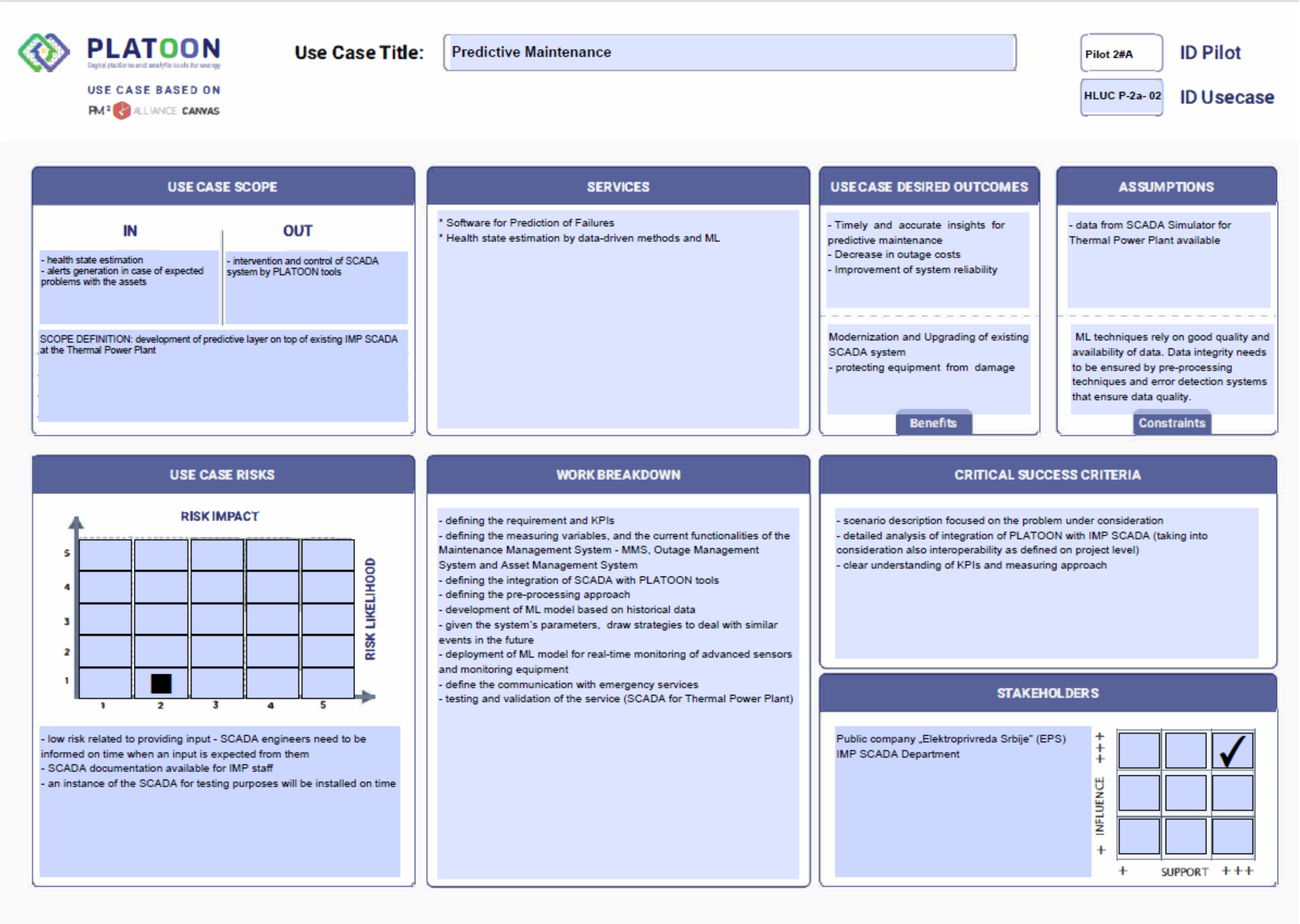
CRITICAL SUCCESS CRITERIA

- scenario description focused on the problem under consideration
- detailed analysis of integration of PLATOON with IMP SCADA (taking into consideration also interoperability as defined on project level)
- clear understanding of KPIs and measuring approach

STAKEHOLDERS

Public company „Elektroprivreda Srbije" (EPS)
IMP SCADA Department

HLUC P-2a- 02: Predictive Maintenance



Use Case Title: Predictive Maintenance

Pilot 2#A ID Pilot

HLUC P-2a- 02 ID Usecase

USE CASE SCOPE

IN

- health state estimation
- alerts generation in case of expected problems with the assets

OUT

- intervention and control of SCADA system by PLATOON tools

SCOPE DEFINITION: development of predictive layer on top of existing IMP SCADA at the Thermal Power Plant

SERVICES

* Software for Prediction of Failures
* Health state estimation by data-driven methods and ML

USECASE DESIRED OUTCOMES

- Timely and accurate insights for predictive maintenance
- Decrease in outage costs
- Improvement of system reliability

Modernization and Upgrading of existing SCADA system
- protecting equipment from damage

Benefits

ASSUMPTIONS

- data from SCADA Simulator for Thermal Power Plant available

ML techniques rely on good quality and availability of data. Data integrity needs to be ensured by pre-processing techniques and error detection systems that ensure data quality.

Constraints

USE CASE RISKS

- low risk related to providing input - SCADA engineers need to be informed on time when an input is expected from them
- SCADA documentation available for IMP staff
- an instance of the SCADA for testing purposes will be installed on time

WORK BREAKDOWN

- defining the requirement and KPIs
- defining the measuring variables, and the current functionalities of the Maintenance Management System - MMS, Outage Management System and Asset Management System
- defining the integration of SCADA with PLATOON tools
- defining the pre-processing approach
- development of ML model based on historical data
- given the system's parameters, draw strategies to deal with similar events in the future
- deployment of ML model for real-time monitoring of advanced sensors and monitoring equipment
- define the communication with emergency services
- testing and validation of the service (SCADA for Thermal Power Plant)

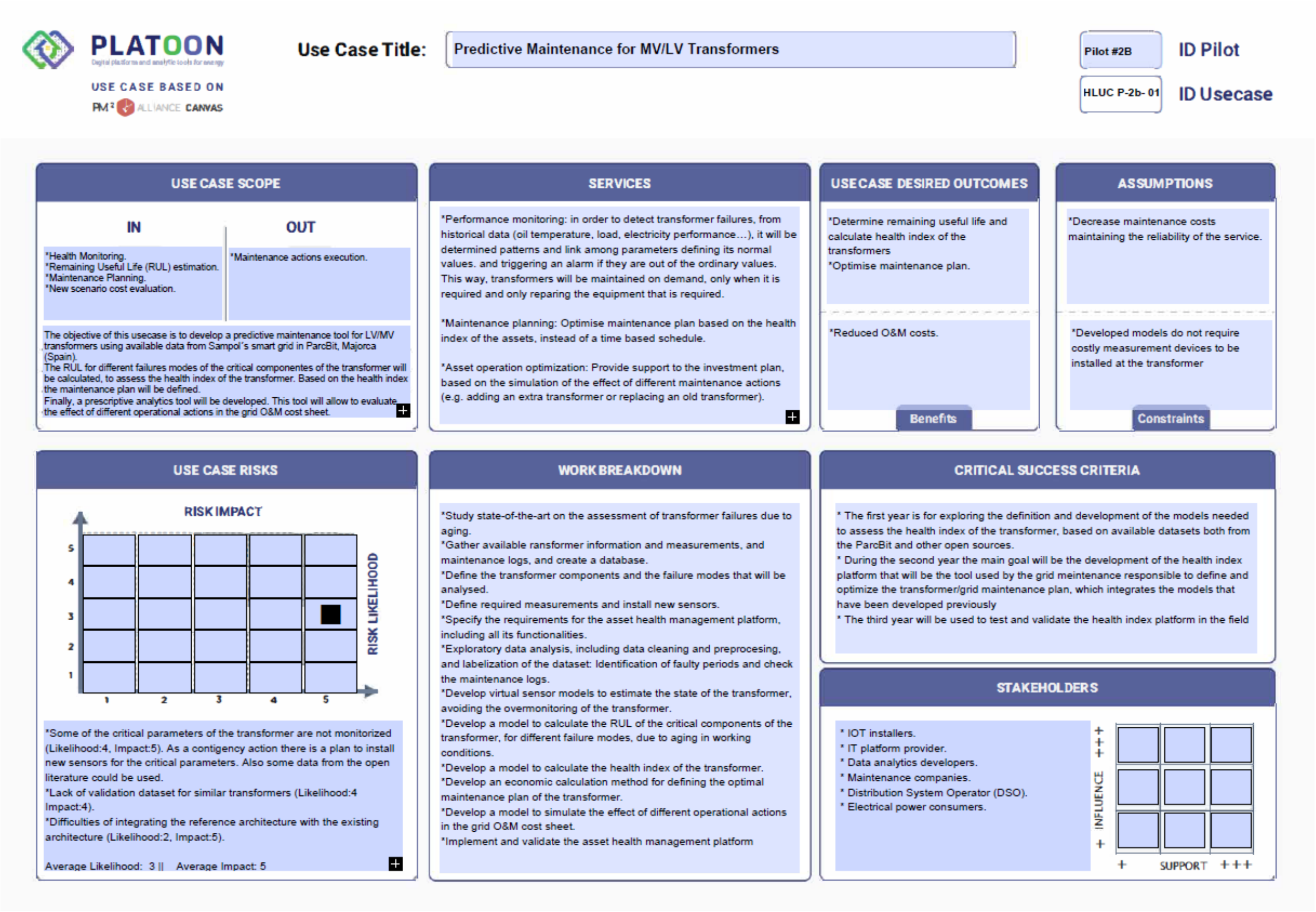
CRITICAL SUCCESS CRITERIA

- scenario description focused on the problem under consideration
- detailed analysis of integration of PLATOON with IMP SCADA (taking into consideration also interoperability as defined on project level)
- clear understanding of KPIs and measuring approach

STAKEHOLDERS

Public company „Elektroprivreda Srbije" (EPS)
IMP SCADA Department

HLUC P-2b- 01: Predictive Maintenance in Transformers



Use Case Title: Predictive Maintenance for MV/LV Transformers

Pilot #2B **ID Pilot**

HLUC P-2b- 01 **ID Usecase**

USE CASE SCOPE

IN	OUT
*Health Monitoring. *Remaining Useful Life (RUL) estimation. *Maintenance Planning. *New scenario cost evaluation.	*Maintenance actions execution.

The objective of this usecase is to develop a predictive maintenance tool for LV/MV transformers using available data from Sampol's smart grid in ParcBit, Majorca (Spain).
The RUL for different failures modes of the critical componentes of the transformer will be calculated, to assess the health index of the transformer. Based on the health index the maintenance plan will be defined.
Finally, a prescriptive analytics tool will be developed. This tool will allow to evaluate the effect of different operational actions in the grid O&M cost sheet.

SERVICES

*Performance monitoring: in order to detect transformer failures, from historical data (oil temperature, load, electricity performance…), it will be determined patterns and link among parameters defining its normal values. and triggering an alarm if they are out of the ordinary values. This way, transformers will be maintained on demand, only when it is required and only reparing the equipment that is required.

*Maintenance planning: Optimise maintenance plan based on the health index of the assets, instead of a time based schedule.

*Asset operation optimization: Provide support to the investment plan, based on the simulation of the effect of different maintenance actions (e.g. adding an extra transformer or replacing an old transformer).

USECASE DESIRED OUTCOMES

*Determine remaining useful life and calculate health index of the transformers
*Optimise maintenance plan.

*Reduced O&M costs.

Benefits

ASSUMPTIONS

*Decrease maintenance costs maintaining the reliability of the service.

*Developed models do not require costly measurement devices to be installed at the transformer

Constraints

USE CASE RISKS

*Some of the critical parameters of the transformer are not monitorized (Likelihood:4, Impact:5). As a contigency action there is a plan to install new sensors for the critical parameters. Also some data from the open literature could be used.
*Lack of validation dataset for similar transformers (Likelihood:4 Impact:4).
*Difficulties of integrating the reference architecture with the existing architecture (Likelihood:2, Impact:5).

Average Likelihood: 3 || Average Impact: 5

WORK BREAKDOWN

*Study state-of-the-art on the assessment of transformer failures due to aging.
*Gather available ransformer information and measurements, and maintenance logs, and create a database.
*Define the transformer components and the failure modes that will be analysed.
*Define required measurements and install new sensors.
*Specify the requirements for the asset health management platform, including all its functionalities.
*Exploratory data analysis, including data cleaning and preprocesing, and labelization of the dataset: Identification of faulty periods and check the maintenance logs.
*Develop virtual sensor models to estimate the state of the transformer, avoiding the overmonitoring of the transformer.
*Develop a model to calculate the RUL of the critical components of the transformer, for different failure modes, due to aging in working conditions.
*Develop a model to calculate the health index of the transformer.
*Develop an economic calculation method for defining the optimal maintenance plan of the transformer.
*Develop a model to simulate the effect of different operational actions in the grid O&M cost sheet.
*Implement and validate the asset health management platform

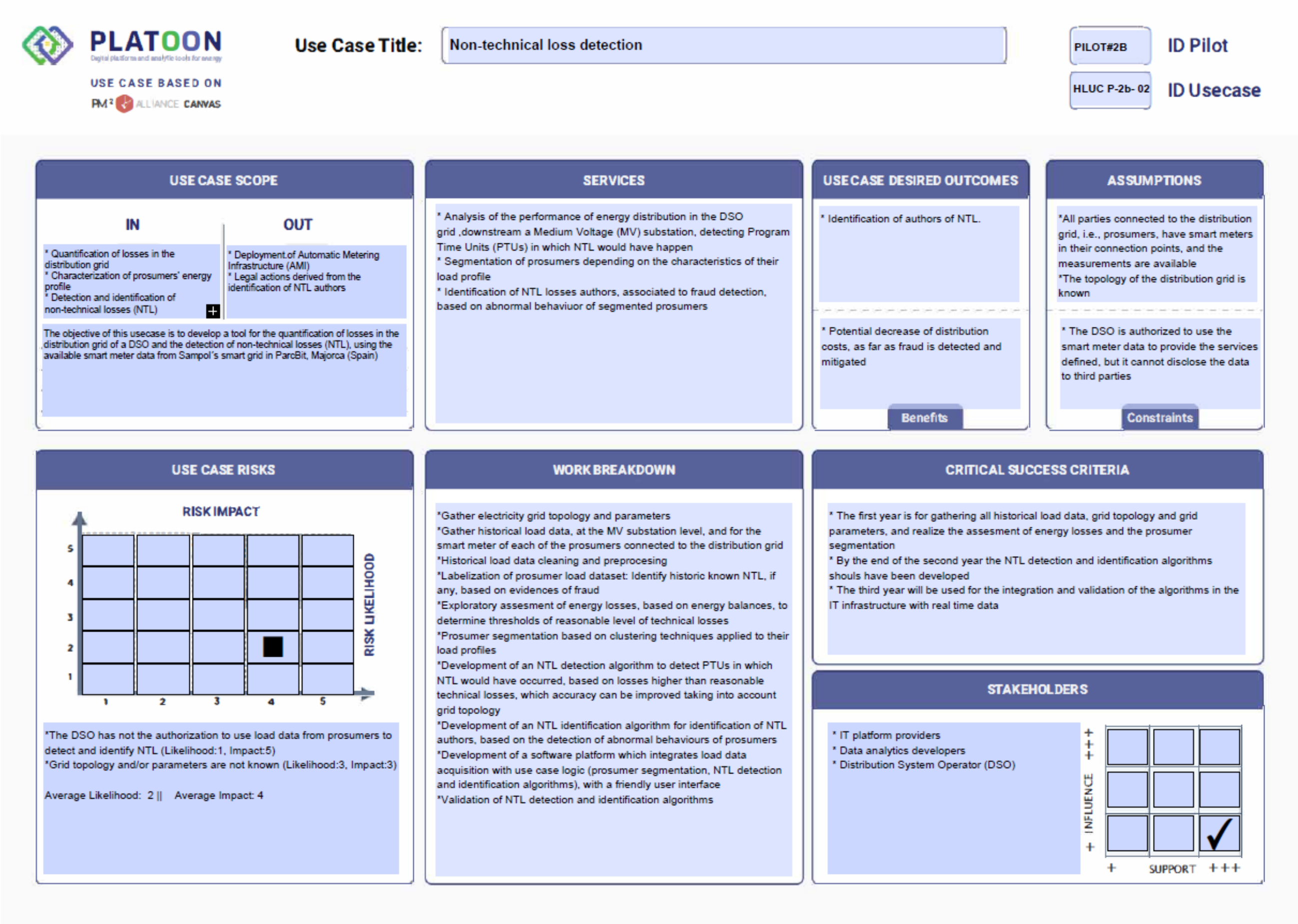
CRITICAL SUCCESS CRITERIA

* The first year is for exploring the definition and development of the models needed to assess the health index of the transformer, based on available datasets both from the ParcBit and other open sources.
* During the second year the main goal will be the development of the health index platform that will be the tool used by the grid meintenance responsible to define and optimize the transformer/grid maintenance plan, which integrates the models that have been developed previously
* The third year will be used to test and validate the health index platform in the field

STAKEHOLDERS

* IOT installers.
* IT platform provider.
* Data analytics developers.
* Maintenance companies.
* Distribution System Operator (DSO).
* Electrical power consumers.

HLUC P-2b- 02: Non-technical loss detection



PLATOON
Digital platforms and analytic tools for energy

USE CASE BASED ON PM² ALLIANCE CANVAS

Use Case Title: Non-technical loss detection

PILOT#2B **ID Pilot**

HLUC P-2b- 02 **ID Usecase**

USE CASE SCOPE

IN

- Quantification of losses in the distribution grid
- Characterization of prosumers' energy profile
- Detection and identification of non-technical losses (NTL)

OUT

- Deployment.of Automatic Metering Infrastructure (AMI)
- Legal actions derived from the identification of NTL authors

The objective of this usecase is to develop a tool for the quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL), using the available smart meter data from Sampol's smart grid in ParcBit, Majorca (Spain)

SERVICES

- Analysis of the performance of energy distribution in the DSO grid ,downstream a Medium Voltage (MV) substation, detecting Program Time Units (PTUs) in which NTL would have happen
- Segmentation of prosumers depending on the characteristics of their load profile
- Identification of NTL losses authors, associated to fraud detection, based on abnormal behaviuor of segmented prosumers

USECASE DESIRED OUTCOMES

- Identification of authors of NTL.

Benefits

- Potential decrease of distribution costs, as far as fraud is detected and mitigated

ASSUMPTIONS

- All parties connected to the distribution grid, i.e., prosumers, have smart meters in their connection points, and the measurements are available
- The topology of the distribution grid is known

Constraints

- The DSO is authorized to use the smart meter data to provide the services defined, but it cannot disclose the data to third parties

USE CASE RISKS

- The DSO has not the authorization to use load data from prosumers to detect and identify NTL (Likelihood:1, Impact:5)
- Grid topology and/or parameters are not known (Likelihood:3, Impact:3)

Average Likelihood: 2 || Average Impact: 4

WORK BREAKDOWN

- Gather electricity grid topology and parameters
- Gather historical load data, at the MV substation level, and for the smart meter of each of the prosumers connected to the distribution grid
- Historical load data cleaning and preprocesing
- Labelization of prosumer load dataset: Identify historic known NTL, if any, based on evidences of fraud
- Exploratory assesment of energy losses, based on energy balances, to determine thresholds of reasonable level of technical losses
- Prosumer segmentation based on clustering techniques applied to their load profiles
- Development of an NTL detection algorithm to detect PTUs in which NTL would have occurred, based on losses higher than reasonable technical losses, which accuracy can be improved taking into account grid topology
- Development of an NTL identification algorithm for identification of NTL authors, based on the detection of abnormal behaviours of prosumers
- Development of a software platform which integrates load data acquisition with use case logic (prosumer segmentation, NTL detection and identification algorithms), with a friendly user interface
- Validation of NTL detection and identification algorithms

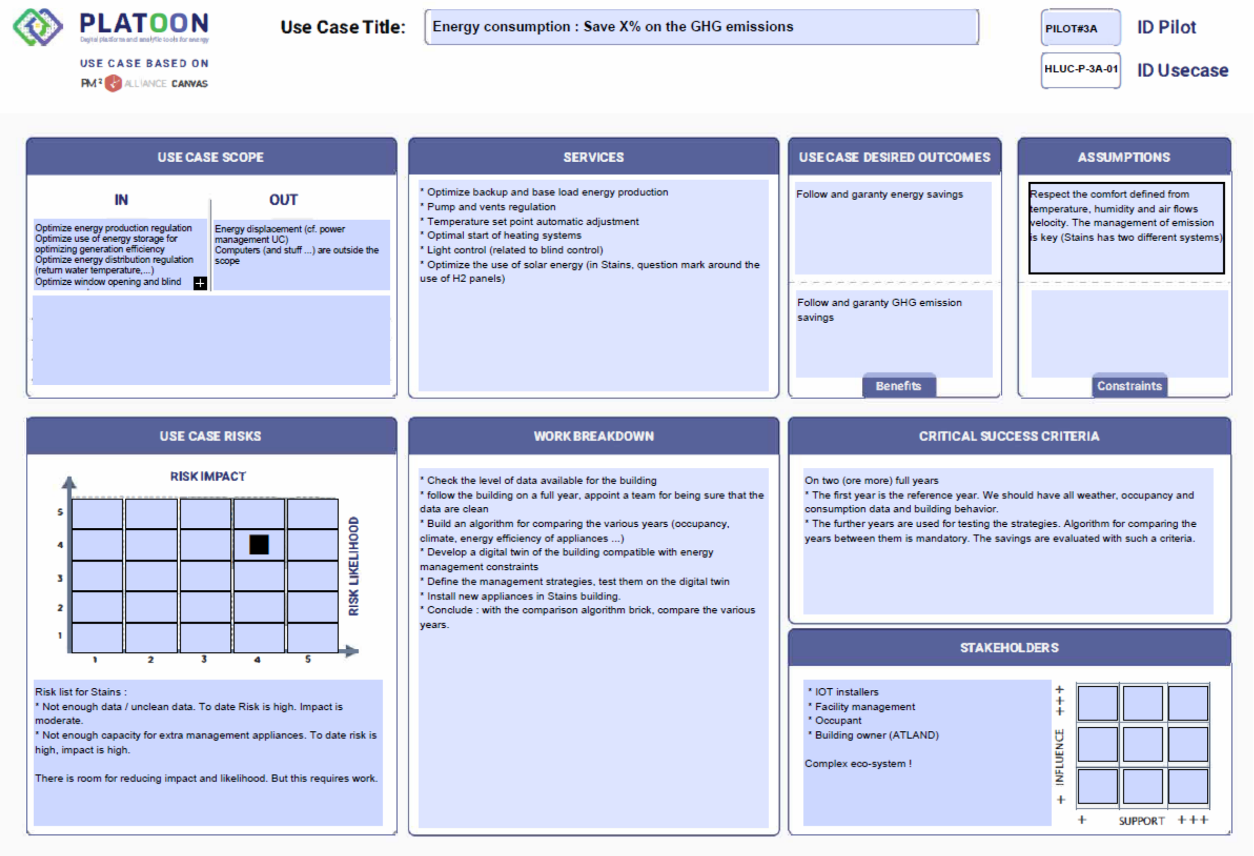
CRITICAL SUCCESS CRITERIA

- The first year is for gathering all historical load data, grid topology and grid parameters, and realize the assesment of energy losses and the prosumer segmentation
- By the end of the second year the NTL detection and identification algorithms shouls have been developed
- The third year will be used for the integration and validation of the algorithms in the IT infrastructure with real time data

STAKEHOLDERS

- IT platform providers
- Data analytics developers
- Distribution System Operator (DSO)

HLUC-P-3a- 01: Save X% on the GHG emissions



Use Case Title: Energy consumption : Save X% on the GHG emissions

PILOT#3A **ID Pilot**

HLUC-P-3A-01 **ID Usecase**

USE CASE SCOPE

IN	OUT
Optimize energy production regulation Optimize use of energy storage for optimizing generation efficiency Optimize energy distribution regulation (return water temperature,...) Optimize window opening and blind	Energy displacement (cf. power management UC) Computers (and stuff ...) are outside the scope

SERVICES

* Optimize backup and base load energy production
* Pump and vents regulation
* Temperature set point automatic adjustment
* Optimal start of heating systems
* Light control (related to blind control)
* Optimize the use of solar energy (in Stains, question mark around the use of H2 panels)

USE CASE DESIRED OUTCOMES

Follow and garanty energy savings

Follow and garanty GHG emission savings

Benefits

ASSUMPTIONS

Respect the comfort defined from temperature, humidity and air flows velocity. The management of emission is key (Stains has two different systems)

Constraints

USE CASE RISKS

Risk list for Stains :
* Not enough data / unclean data. To date Risk is high. Impact is moderate.
* Not enough capacity for extra management appliances. To date risk is high, impact is high.

There is room for reducing impact and likelihood. But this requires work.

WORK BREAKDOWN

* Check the level of data available for the building
* follow the building on a full year, appoint a team for being sure that the data are clean
* Build an algorithm for comparing the various years (occupancy, climate, energy efficiency of appliances ...)
* Develop a digital twin of the building compatible with energy management constraints
* Define the management strategies, test them on the digital twin
* Install new appliances in Stains building.
* Conclude : with the comparison algorithm brick, compare the various years.

CRITICAL SUCCESS CRITERIA

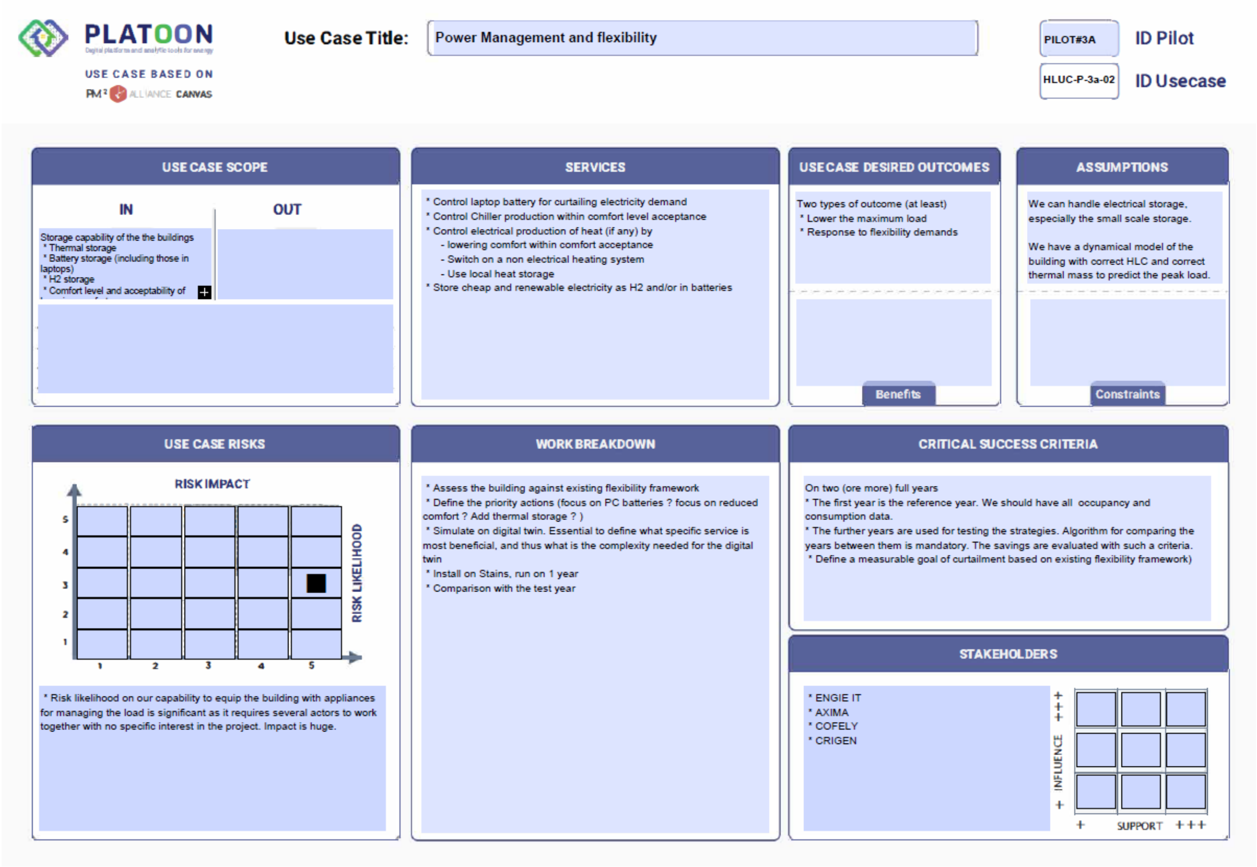
On two (ore more) full years
* The first year is the reference year. We should have all weather, occupancy and consumption data and building behavior.
* The further years are used for testing the strategies. Algorithm for comparing the years between them is mandatory. The savings are evaluated with such a criteria.

STAKEHOLDERS

* IOT installers
* Facility management
* Occupant
* Building owner (ATLAND)

Complex eco-system !

HLUC-P-3a- 02: Power Management and flexibility



Use Case Title: Power Management and flexibility

PILOT#3A **ID Pilot**

HLUC-P-3a-02 **ID Usecase**

USE CASE SCOPE

IN

Storage capability of the the buildings
* Thermal storage
* Battery storage (including those in laptops)
* H2 storage
* Comfort level and acceptability of

OUT

SERVICES

* Control laptop battery for curtailing electricity demand
* Control Chiller production within comfort level acceptance
* Control electrical production of heat (if any) by
  - lowering comfort within comfort acceptance
  - Switch on a non electrical heating system
  - Use local heat storage
* Store cheap and renewable electricity as H2 and/or in batteries

USECASE DESIRED OUTCOMES

Two types of outcome (at least)
* Lower the maximum load
* Response to flexibility demands

Benefits

ASSUMPTIONS

We can handle electrical storage, especially the small scale storage.

We have a dynamical model of the building with correct HLC and correct thermal mass to predict the peak load.

Constraints

USE CASE RISKS

* Risk likelihood on our capability to equip the building with appliances for managing the load is significant as it requires several actors to work together with no specific interest in the project. Impact is huge.

WORK BREAKDOWN

* Assess the building against existing flexibility framework
* Define the priority actions (focus on PC batteries ? focus on reduced comfort ? Add thermal storage ?)
* Simulate on digital twin. Essential to define what specific service is most beneficial, and thus what is the complexity needed for the digital twin
* Install on Stains, run on 1 year
* Comparison with the test year

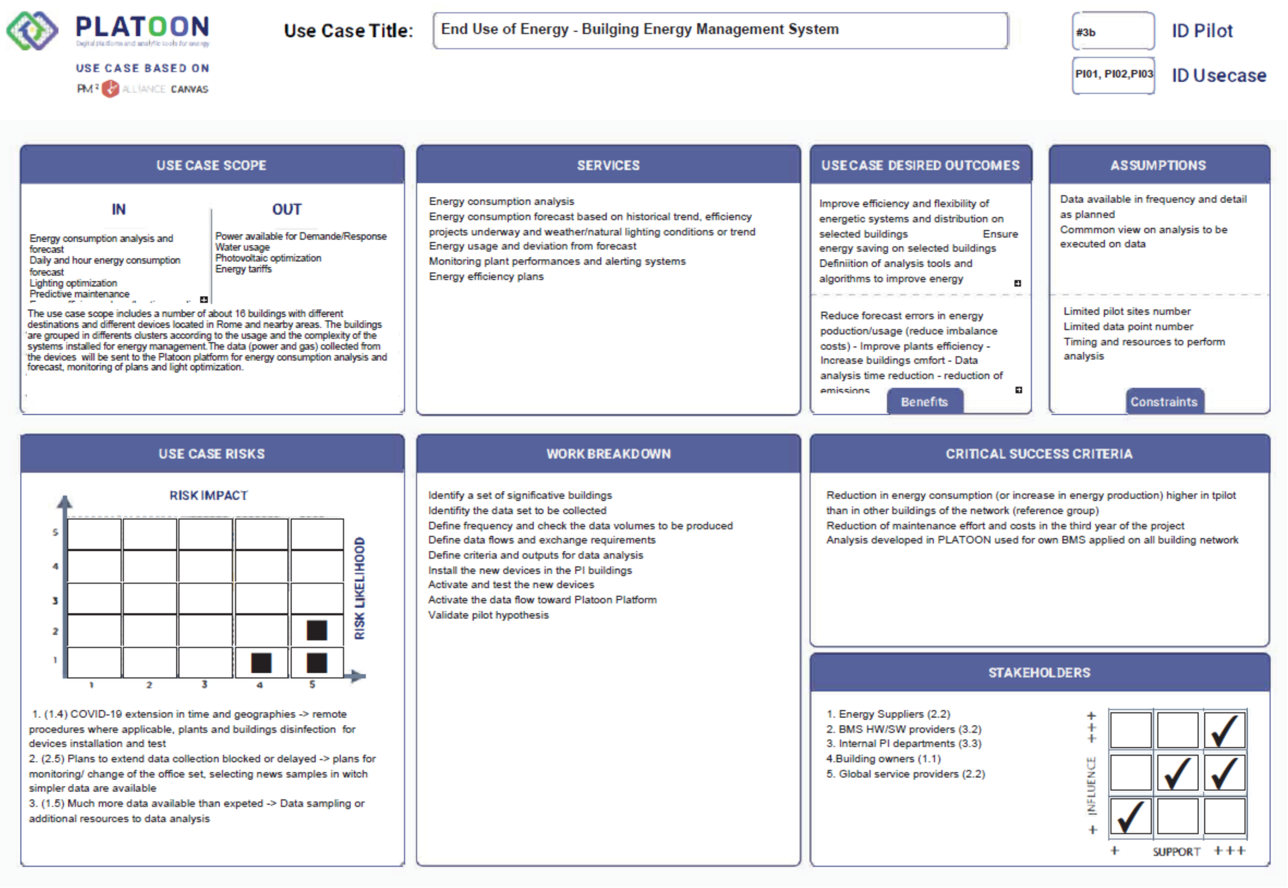
CRITICAL SUCCESS CRITERIA

On two (ore more) full years
* The first year is the reference year. We should have all occupancy and consumption data.
* The further years are used for testing the strategies. Algorithm for comparing the years between them is mandatory. The savings are evaluated with such a criteria.
* Define a measurable goal of curtailment based on existing flexibility framework)

STAKEHOLDERS

* ENGIE IT
* AXIMA
* COFELY
* CRIGEN

HLUC P-3b- 01: Building Energy Management System



PLATOON

USE CASE BASED ON PM² ALLIANCE CANVAS

Use Case Title: End Use of Energy - Builging Energy Management System

ID Pilot: #3b

ID Usecase: PI01, PI02,PI03

USE CASE SCOPE

IN

Energy consumption analysis and forecast
Daily and hour energy consumption forecast
Lighting optimization
Predictive maintenance

OUT

Power available for Demande/Response
Water usage
Photovoltaic optimization
Energy tariffs

The use case scope includes a number of about 16 buildings with different destinations and different devices located in Rome and nearby areas. The buildings are grouped in differents clusters according to the usage and the complexity of the systems installed for energy management. The data (power and gas) collected from the devices will be sent to the Platoon platform for energy consumption analysis and forecast, monitoring of plans and light optimization.

SERVICES

Energy consumption analysis
Energy consumption forecast based on historical trend, efficiency projects underway and weather/natural lighting conditions or trend
Energy usage and deviation from forecast
Monitoring plant performances and alerting systems
Energy efficiency plans

USE CASE DESIRED OUTCOMES

Improve efficiency and flexibility of energetic systems and distribution on selected buildings Ensure energy saving on selected buildings
Definiition of analysis tools and algorithms to improve energy

Benefits

Reduce forecast errors in energy poduction/usage (reduce imbalance costs) - Improve plants efficiency - Increase buildings cmfort - Data analysis time reduction - reduction of emissions

ASSUMPTIONS

Data available in frequency and detail as planned
Commmon view on analysis to be executed on data

Constraints

Limited pilot sites number
Limited data point number
Timing and resources to perform analysis

USE CASE RISKS

1. (1.4) COVID-19 extension in time and geographies -> remote procedures where applicable, plants and buildings disinfection for devices installation and test
2. (2.5) Plans to extend data collection blocked or delayed -> plans for monitoring/ change of the office set, selecting news samples in witch simpler data are available
3. (1.5) Much more data available than expeted -> Data sampling or additional resources to data analysis

WORK BREAKDOWN

Identify a set of significative buildings
Identifity the data set to be collected
Define frequency and check the data volumes to be produced
Define data flows and exchange requirements
Define criteria and outputs for data analysis
Install the new devices in the PI buildings
Activate and test the new devices
Activate the data flow toward Platoon Platform
Validate pilot hypothesis

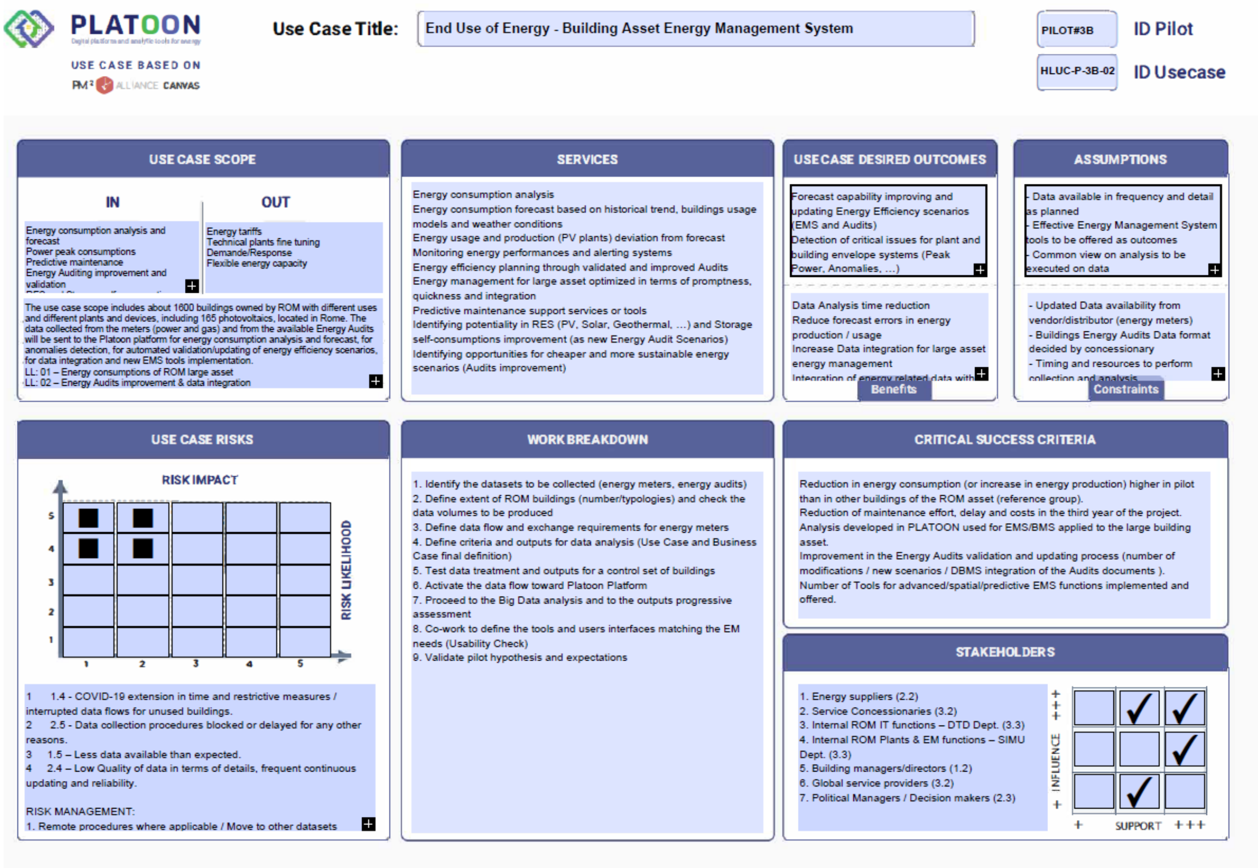
CRITICAL SUCCESS CRITERIA

Reduction in energy consumption (or increase in energy production) higher in tpilot than in other buildings of the network (reference group)
Reduction of maintenance effort and costs in the third year of the project
Analysis developed in PLATOON used for own BMS applied on all building network

STAKEHOLDERS

1. Energy Suppliers (2.2)
2. BMS HW/SW providers (3.2)
3. Internal PI departments (3.3)
4.Building owners (1.1)
5. Global service providers (2.2)

HLUC P-3b- 02: Building Asset Energy Management System



Use Case Title: End Use of Energy - Building Asset Energy Management System

PILOT#3B **ID Pilot**

HLUC-P-3B-02 **ID Usecase**

USE CASE SCOPE

IN

Energy consumption analysis and forecast
Power peak consumptions
Predictive maintenance
Energy Auditing improvement and validation

OUT

Energy tariffs
Technical plants fine tuning
Demande/Response
Flexible energy capacity

The use case scope includes about 1600 buildings owned by ROM with different uses and different plants and devices, including 165 photovoltaics, located in Rome. The data collected from the meters (power and gas) and from the available Energy Audits will be sent to the Platoon platform for energy consumption analysis and forecast, for anomalies detection, for automated validation/updating of energy efficiency scenarios, for data integration and new EMS tools implementation.
LL: 01 – Energy consumptions of ROM large asset
LL: 02 – Energy Audits improvement & data integration

SERVICES

Energy consumption analysis
Energy consumption forecast based on historical trend, buildings usage models and weather conditions
Energy usage and production (PV plants) deviation from forecast
Monitoring energy performances and alerting systems
Energy efficiency planning through validated and improved Audits
Energy management for large asset optimized in terms of promptness, quickness and integration
Predictive maintenance support services or tools
Identifying potentiality in RES (PV, Solar, Geothermal, ...) and Storage self-consumptions improvement (as new Energy Audit Scenarios)
Identifying opportunities for cheaper and more sustainable energy scenarios (Audits improvement)

USECASE DESIRED OUTCOMES

Forecast capability improving and updating Energy Efficiency scenarios (EMS and Audits)
Detection of critical issues for plant and building envelope systems (Peak Power, Anomalies, ...)

Data Analysis time reduction
Reduce forecast errors in energy production / usage
Increase Data integration for large asset energy management
Integration of energy related data with

ASSUMPTIONS

- Data available in frequency and detail as planned
- Effective Energy Management System tools to be offered as outcomes
- Common view on analysis to be executed on data

- Updated Data availability from vendor/distributor (energy meters)
- Buildings Energy Audits Data format decided by concessionary
- Timing and resources to perform collection and analysis

USE CASE RISKS

1 1.4 - COVID-19 extension in time and restrictive measures / interrupted data flows for unused buildings.
2 2.5 - Data collection procedures blocked or delayed for any other reasons.
3 1.5 – Less data available than expected.
4 2.4 – Low Quality of data in terms of details, frequent continuous updating and reliability.

RISK MANAGEMENT:
1. Remote procedures where applicable / Move to other datasets

WORK BREAKDOWN

1. Identify the datasets to be collected (energy meters, energy audits)
2. Define extent of ROM buildings (number/typologies) and check the data volumes to be produced
3. Define data flow and exchange requirements for energy meters
4. Define criteria and outputs for data analysis (Use Case and Business Case final definition)
5. Test data treatment and outputs for a control set of buildings
6. Activate the data flow toward Platoon Platform
7. Proceed to the Big Data analysis and to the outputs progressive assessment
8. Co-work to define the tools and users interfaces matching the EM needs (Usability Check)
9. Validate pilot hypothesis and expectations

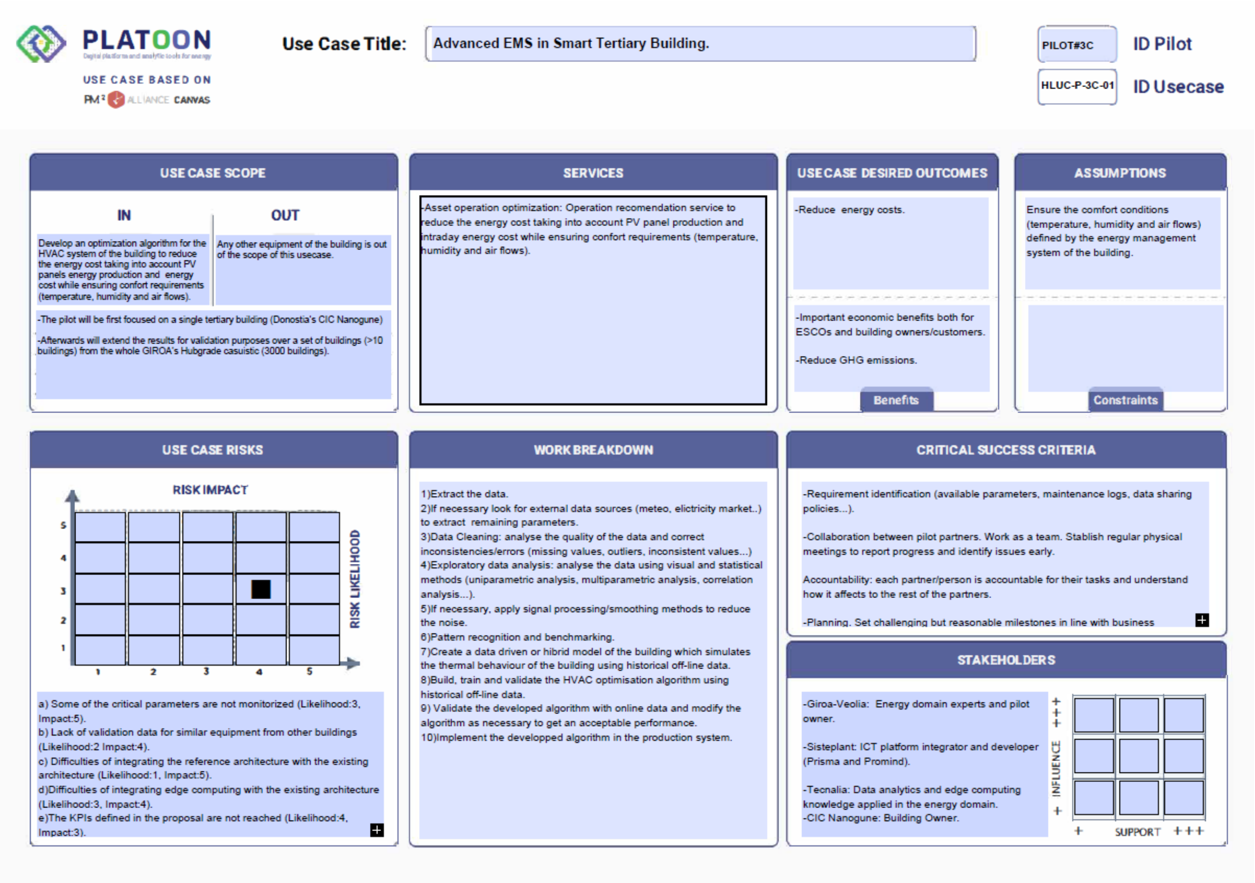
CRITICAL SUCCESS CRITERIA

Reduction in energy consumption (or increase in energy production) higher in pilot than in other buildings of the ROM asset (reference group).
Reduction of maintenance effort, delay and costs in the third year of the project.
Analysis developed in PLATOON used for EMS/BMS applied to the large building asset.
Improvement in the Energy Audits validation and updating process (number of modifications / new scenarios / DBMS integration of the Audits documents).
Number of Tools for advanced/spatial/predictive EMS functions implemented and offered.

STAKEHOLDERS

1. Energy suppliers (2.2)
2. Service Concessionaries (3.2)
3. Internal ROM IT functions – DTD Dept. (3.3)
4. Internal ROM Plants & EM functions – SIMU Dept. (3.3)
5. Building managers/directors (1.2)
6. Global service providers (3.2)
7. Political Managers / Decision makers (2.3)

HLUC P-3C- 01: Advanced EMS in Smart Tertiary Building



PLATOON

USE CASE BASED ON PM² ALLIANCE CANVAS

Use Case Title: Advanced EMS in Smart Tertiary Building.

PILOT#3C ID Pilot

HLUC-P-3C-01 ID Usecase

USE CASE SCOPE

IN	OUT
Develop an optimization algorithm for the HVAC system of the building to reduce the energy cost taking into account PV panels energy production and energy cost while ensuring confort requirements (temperature, humidity and air flows).	Any other equipment of the building is out of the scope of this usecase.

-The pilot will be first focused on a single tertiary building (Donostia's CIC Nanogune)

-Afterwards will extend the results for validation purposes over a set of buildings (>10 buildings) from the whole GIROA's Hubgrade casuistic (3000 buildings).

SERVICES

-Asset operation optimization: Operation recomendation service to reduce the energy cost taking into account PV panel production and intraday energy cost while ensuring confort requirements (temperature, humidity and air flows).

USECASE DESIRED OUTCOMES

-Reduce energy costs.

-Important economic benefits both for ESCOs and building owners/customers.

-Reduce GHG emissions.

Benefits

ASSUMPTIONS

Ensure the comfort conditions (temperature, humidity and air flows) defined by the energy management system of the building.

Constraints

USE CASE RISKS

a) Some of the critical parameters are not monitorized (Likelihood:3, Impact:5).
b) Lack of validation data for similar equipment from other buildings (Likelihood:2 Impact:4).
c) Difficulties of integrating the reference architecture with the existing architecture (Likelihood:1, Impact:5).
d)Difficulties of integrating edge computing with the existing architecture (Likelihood:3, Impact:4).
e)The KPIs defined in the proposal are not reached (Likelihood:4, Impact:3).

WORK BREAKDOWN

1)Extract the data.
2)If necessary look for external data sources (meteo, elictricity market..) to extract remaining parameters.
3)Data Cleaning: analyse the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...)
4)Exploratory data analysis: analyse the data using visual and statistical methods (uniparametric analysis, multiparametric analysis, correlation analysis...).
5)If necessary, apply signal processing/smoothing methods to reduce the noise.
6)Pattern recognition and benchmarking.
7)Create a data driven or hibrid model of the building which simulates the thermal behaviour of the building using historical off-line data.
8)Build, train and validate the HVAC optimisation algorithm using historical off-line data.
9) Validate the developed algorithm with online data and modify the algorithm as necessary to get an acceptable performance.
10)Implement the developped algorithm in the production system.

CRITICAL SUCCESS CRITERIA

-Requirement identification (available parameters, maintenance logs, data sharing policies...).

-Collaboration between pilot partners. Work as a team. Stablish regular physical meetings to report progress and identify issues early.

Accountability: each partner/person is accountable for their tasks and understand how it affects to the rest of the partners.

-Planning. Set challenging but reasonable milestones in line with business

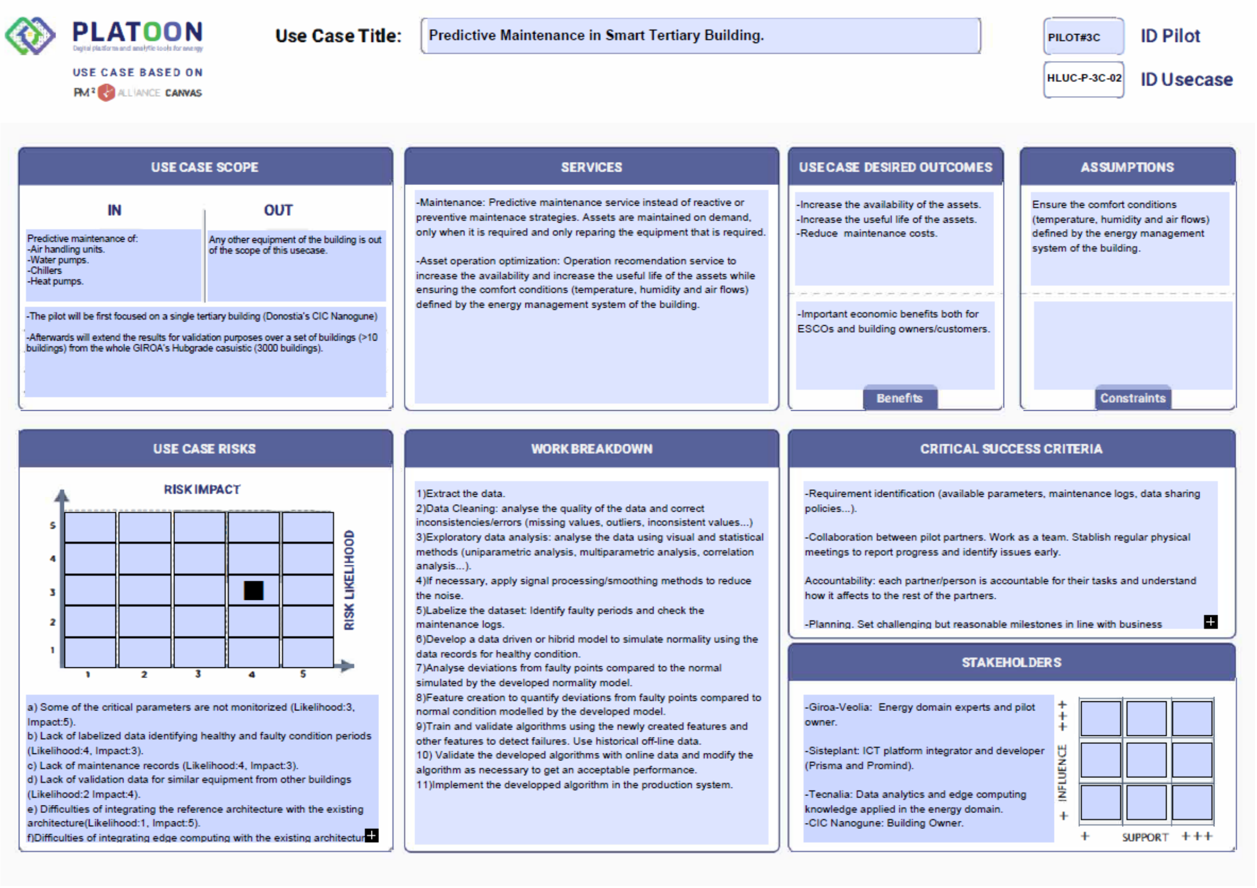
STAKEHOLDERS

-Giroa-Veolia: Energy domain experts and pilot owner.

-Sisteplant: ICT platform integrator and developer (Prisma and Promind).

-Tecnalia: Data analytics and edge computing knowledge applied in the energy domain.
-CIC Nanogune: Building Owner.

HLUC- P-3C- 02: Predictive Maintenance in Smart Tertiary Building



Use Case Title: Predictive Maintenance in Smart Tertiary Building.

PILOT#3C ID Pilot

HLUC-P-3C-02 ID Usecase

USE CASE SCOPE

IN

Predictive maintenance of:
-Air handling units.
-Water pumps.
-Chillers
-Heat pumps.

OUT

Any other equipment of the building is out of the scope of this usecase.

-The pilot will be first focused on a single tertiary building (Donostia's CIC Nanogune)

-Afterwards will extend the results for validation purposes over a set of buildings (>10 buildings) from the whole GIROA's Hubgrade casuistic (3000 buildings).

SERVICES

-Maintenance: Predictive maintenance service instead of reactive or preventive maintenace strategies. Assets are maintained on demand, only when it is required and only reparing the equipment that is required.

-Asset operation optimization: Operation recomendation service to increase the availability and increase the useful life of the assets while ensuring the comfort conditions (temperature, humidity and air flows) defined by the energy management system of the building.

USE CASE DESIRED OUTCOMES

-Increase the availability of the assets.
-Increase the useful life of the assets.
-Reduce maintenance costs.

-Important economic benefits both for ESCOs and building owners/customers.

Benefits

ASSUMPTIONS

Ensure the comfort conditions (temperature, humidity and air flows) defined by the energy management system of the building.

Constraints

USE CASE RISKS

a) Some of the critical parameters are not monitorized (Likelihood:3, Impact:5).
b) Lack of labelized data identifying healthy and faulty condition periods (Likelihood:4, Impact:3).
c) Lack of maintenance records (Likelihood:4, Impact:3).
d) Lack of validation data for similar equipment from other buildings (Likelihood:2 Impact:4).
e) Difficulties of integrating the reference architecture with the existing architecture(Likelihood:1, Impact:5).
f)Difficulties of integrating edge computing with the existing architectur

WORK BREAKDOWN

1)Extract the data.
2)Data Cleaning: analyse the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...)
3)Exploratory data analysis: analyse the data using visual and statistical methods (uniparametric analysis, multiparametric analysis, correlation analysis...).
4)If necessary, apply signal processing/smoothing methods to reduce the noise.
5)Labelize the dataset: Identify faulty periods and check the maintenance logs.
6)Develop a data driven or hibrid model to simulate normality using the data records for healthy condition.
7)Analyse deviations from faulty points compared to the normal simulated by the developed normality model.
8)Feature creation to quantify deviations from faulty points compared to normal condition modelled by the developed model.
9)Train and validate algorithms using the newly created features and other features to detect failures. Use historical off-line data.
10) Validate the developed algorithms with online data and modify the algorithm as necessary to get an acceptable performance.
11)Implement the developped algorithm in the production system.

CRITICAL SUCCESS CRITERIA

-Requirement identification (available parameters, maintenance logs, data sharing policies...).

-Collaboration between pilot partners. Work as a team. Stablish regular physical meetings to report progress and identify issues early.

Accountability: each partner/person is accountable for their tasks and understand how it affects to the rest of the partners.

-Planning. Set challenging but reasonable milestones in line with business

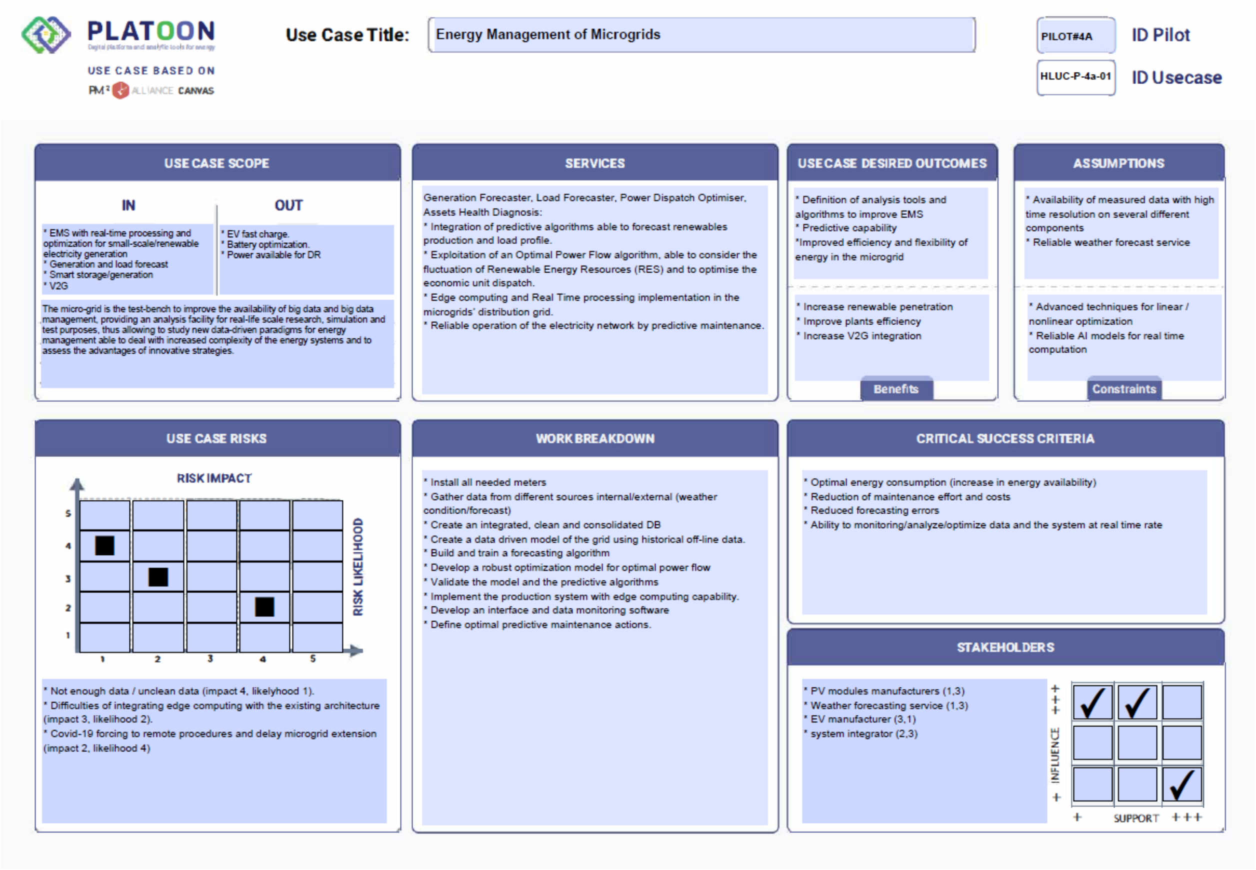
STAKEHOLDERS

-Giroa-Veolia: Energy domain experts and pilot owner.

-Sisteplant: ICT platform integrator and developer (Prisma and Promind).

-Tecnalia: Data analytics and edge computing knowledge applied in the energy domain.
-CIC Nanogune: Building Owner.

HLUC-P-4A- 01: Energy Management of Microgrids



Use Case Title: Energy Management of Microgrids

ID Pilot: PILOT#4A

ID Usecase: HLUC-P-4a-01

USE CASE SCOPE

IN

* EMS with real-time processing and optimization for small-scale/renewable electricity generation
* Generation and load forecast
* Smart storage/generation
* V2G

OUT

* EV fast charge.
* Battery optimization.
* Power available for DR

The micro-grid is the test-bench to improve the availability of big data and big data management, providing 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.

SERVICES

Generation Forecaster, Load Forecaster, Power Dispatch Optimiser, Assets Health Diagnosis:

* Integration of predictive algorithms able to forecast renewables production and load profile.
* Exploitation of an Optimal Power Flow algorithm, able to consider the fluctuation of Renewable Energy Resources (RES) and to optimise the economic unit dispatch.
* Edge computing and Real Time processing implementation in the microgrids' distribution grid.
* Reliable operation of the electricity network by predictive maintenance.

USECASE DESIRED OUTCOMES

* Definition of analysis tools and algorithms to improve EMS
* Predictive capability
*Improved efficiency and flexibility of energy in the microgrid

* Increase renewable penetration
* Improve plants efficiency
* Increase V2G integration

Benefits

ASSUMPTIONS

* Availability of measured data with high time resolution on several different components
* Reliable weather forecast service

* Advanced techniques for linear / nonlinear optimization
* Reliable AI models for real time computation

Constraints

USE CASE RISKS

* Not enough data / unclean data (impact 4, likelyhood 1).
* Difficulties of integrating edge computing with the existing architecture (impact 3, likelihood 2).
* Covid-19 forcing to remote procedures and delay microgrid extension (impact 2, likelihood 4)

WORK BREAKDOWN

* Install all needed meters
* Gather data from different sources internal/external (weather condition/forecast)
* Create an integrated, clean and consolidated DB
* Create a data driven model of the grid using historical off-line data.
* Build and train a forecasting algorithm
* Develop a robust optimization model for optimal power flow
* Validate the model and the predictive algorithms
* Implement the production system with edge computing capability.
* Develop an interface and data monitoring software
* Define optimal predictive maintenance actions.

CRITICAL SUCCESS CRITERIA

* Optimal energy consumption (increase in energy availability)
* Reduction of maintenance effort and costs
* Reduced forecasting errors
* Ability to monitoring/analyze/optimize data and the system at real time rate

STAKEHOLDERS

* PV modules manufacturers (1,3)
* Weather forecasting service (1,3)
* EV manufacturer (3,1)
* system integrator (2,3)

Annex IV Low Level Use Cases

LLUC-P-1a- 01: Enhanced diagnostics of failure in electrical drivetrain components in wind turbines using a digital twin approach.

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
UC-1A-01	Generation	Enhanced diagnostics of failure in electrical drivetrain components in wind turbines using a digital twin approach.

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
	DD.MM.YYYY	Define who has provided the document (person or organization)	Document the general changes.	
1	02.06.2020	VUB	Draft	
2	03.06.2020	Tecnalia	Draft update	
3	05.06.2020	ENGIE	Draft update	

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	The use case 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.
Objective(s)	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 indicators to create a diagnostic tool. O.4.Extract the relevant events that the electrical drivetrain components are exposed to and have a potential negative effect on the lifetime of the electrical components.

Related business case(s)	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.

1.4 Narrative of Use Case.

Narrative of use case
Short description
The goal of this pilot is the development of an integrated monitoring strategy for predictive maintenance of electrical drivetrain components, more specifically the generator and the power converter of wind turbines. Focus is on the combination of data-driven models with physical models of the generator and potentially of the power converter into an integrated digital twin strategy. High frequency (kHz range) detailed measurements will be used in a first step. In a later stage the focus of the analysis will shift towards fleet-wide analytics. At this stage lower frequency SCADA data (10-min) and status logs are used. In addition to the anomaly detection for problem identification also load history of the electrical components is identified. The potential for edge computations of the models is explored. More specifically, the optimization of the computational load for anomaly detection is investigated.
Complete description
This pilot focusses on predictive maintenance of wind turbines (onshore and offshore). In the case explored in this pilot the focus is on wind turbines in the range of 1.5-3MW which are typically installed onshore. Since the wind turbine is a complex system consisting of many subcomponents a clear focus is taken. The scope is limited to the electrical components of the drivetrain of the wind turbine. Both the generator and the power converter are in focus. Since there are turbines of different type on the market we explicitly focus on one technology: the doubly fed induction generator type. This type of wind turbine has a converter sized to a percentage of the nominal power capacity of the wind turbine. This allows the converter to be more cost effective but limits the percentage of speed variation the turbine is able to achieve. It is today however still the most used type of power converter for onshore wind turbines.

Figure: Onshore 1.5MW wind turbine (picture by Jeroen Van Dam NREL)

How?

The methods developed in the use case will allow the end user to accurately detect failures in the electrical components of wind turbines using diagnostic tools based on anomaly detection approaches as part of a digital twin approach. Healthy system behavior is modelled using data-driven and physical models to serve as baseline for the anomaly detection approaches. The results will be fused into health indicators that form the basis for maintenance decisions. The end user will be responsible for the interpretation of the health indicators and the actual decision taking. The health indicators are specifically linked to the different failure modes that are targeted. The focus is on the detection of failures in the generator and the converter.

The following generator failures are in scope:

- Generator winding short circuit fault
- Generator bearing damage
- Generator looseness and imbalance

The following converter failures are in scope:

- Open switch fault
- IGBT short-circuit

In addition to the diagnostic capabilities also the identification of the historical loading of the machine is assessed in order to allow the user to gain insights in the loading that potentially led to the failure. Focus is on the loading that is relevant for the electrical components. As such turbine power production, rpm, current, voltage and local or ambient temperature and humidity values are in focus.

The overall architecture of the modelling approach is available to the user in a UML diagram, shown further in this document.

Where?

The data flow that results in the diagnostics of the electrical components is distributed as follows. The sensor data is collected on the wind turbine in two ways. The low frequency data (sampled typically at 10-minute level) is collected using embedded sensors of the SCADA system of the turbine. Data is exported towards a central data repository at ENGIE and exported in csv format afterwards through the ENGIE Open Data website (when applicable). The high frequency sensor data (sampled in kHz range) is collected using a custom data acquisition system and retrofitted sensors. This data is stored locally and then in batches transferred to a central location at ENGIE. Dedicated python h5 file formats are used.

During the PLATOON project, the available historical data will be stored at the VUB data-lake. From this data-lake different representative training datasets are extracted. Each of these training datasets will be accessible through a dedicated API interface (discussed further on in the document). In addition, a parameter set description is made available through the API. Different approaches for dividing the available datasets into training and validation datasets are investigated. The competence of the different models with regard to the capability of modelling healthy data will be assessed for these different approaches. The models are trained and stored locally at the different partners participating in the use case.

Once the models are trained, they are deployed to process the continuous data-stream generated during the operational use of the machine being monitored. In this step the models are used to predict healthy behavior of the system under investigation. Anomaly detection algorithms are run to identify abnormal behavior. At each timestamp an anomaly score is calculated for each prediction model deployed. The deployment of the anomaly detection based on the prediction model is done at the partner responsible for that specific model. Using a structured API interface (defined further in this document) the anomaly scores for the different models are made available to the different partners to allow for integrated digital twin calculations based on anomaly fusion. Each partner can combine different models and anomaly scores of models of other partners to generate a final health score for his subpart. These health scores are benchmarked in a last step. These benchmarking algorithms will run on the VUB processing platform or (depending on the necessary input data for a model) an ENGIE data platform is available that has the required data available.

In addition to the anomaly detection approaches, also load case extraction is done. These models run at the specific partners by ingesting data using API interface and report the extracted load history histogram.

Finally, the health scores and load history histogram can be visualized in a dashboard.

When?

The user will need to make a training dataset available that is sufficiently rich to allow data-driven model training prior to the model being able to be deployed in an operational context. Care needs to be taken that when maintenance actions are done to the monitored components a novel training dataset is made available prior to further use of the model.

The calculation of the health scores will not be done in real-time. As soon as results of the integrated digital twin model are calculated, they will be made available to the user throughout the dashboard.

Assumptions

The main assumptions to have a decent digital twin performance is that a sufficiently rich model training dataset is available for healthy system behavior. In addition, the most important electrical properties of the generator and converter need to be available for the digital twin model to be able to work.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
Provide a unique identification for the KPI	Provide a short name to describe the KPI	Provide a description in form of few sentences to specify the KPI. The description may include specific targets in relation to one of the objectives of the use case and the calculation of these	Provide the link to one of the objectives which are specified in the targets and the KPI before.

		targets.	
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

1.6 Use case conditions.

Use case conditions

Assumptions

The main assumptions to have a decent digital twin performance is that a sufficiently rich model training dataset is available for healthy system behavior. In addition, the most important electrical properties of the generator and converter need to be available for the digital twin model to be able to work.

Prerequisites

The main requirements are data availability identified in the assumptions. Particularly detailed generator parameters are essential:

- Rated power
- Rated Torque
- Stator and rotor resistances
- Stator and rotor reactances/inductances
- Pole pair number
- Nominal voltages and currents
- Nominal speed
- Frequency
- Power Factor
- Moment of inertia of rotor
- Efficiency
- Bearing characteristics
- Type and location of existing sensors

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

Classification information

Relation to other use cases

Different cases in PLATOON target predictive maintenance through advanced diagnostics. Typically, these approaches use anomaly detection techniques. As such from a methodological point of view this pilot links to the predictive maintenance aspect of other use cases, i.e. pilots 2a-02, 2b-01, 3b-01, 3b-02 and 3c-02.

Level of depth

This LLUC has been defined up to the level of the integration of the different modelling approaches and their combination towards integrated health indicators. Furthermore, the available datasets have been listed as well as how they fit the purpose of the use case.

Prioritization

- Develop physical and data-driven models for electrical generator and power converter (Mandatory)
- Develop anomaly detection methods for identification of unhealthy behavior (Mandatory).
- Develop an approach to convert the identified anomalies towards health indicators to create a diagnostic tool (Mandatory).
- Implement part of the processing at the edge (mandatory)
- Implement developed IDS connectors to ensure data sovereignty when exchanging raw and processed data amongst pilot partners.
- Implement the defined common data models and APIs (mandatory).
- Develop a fully fledged dashboard to show the results (nice to have).
- Extract the relevant events that the electrical drivetrain components are exposed to and have a potential negative effect on the lifetime of the electrical components (nice to have).

Generic, regional or national relation

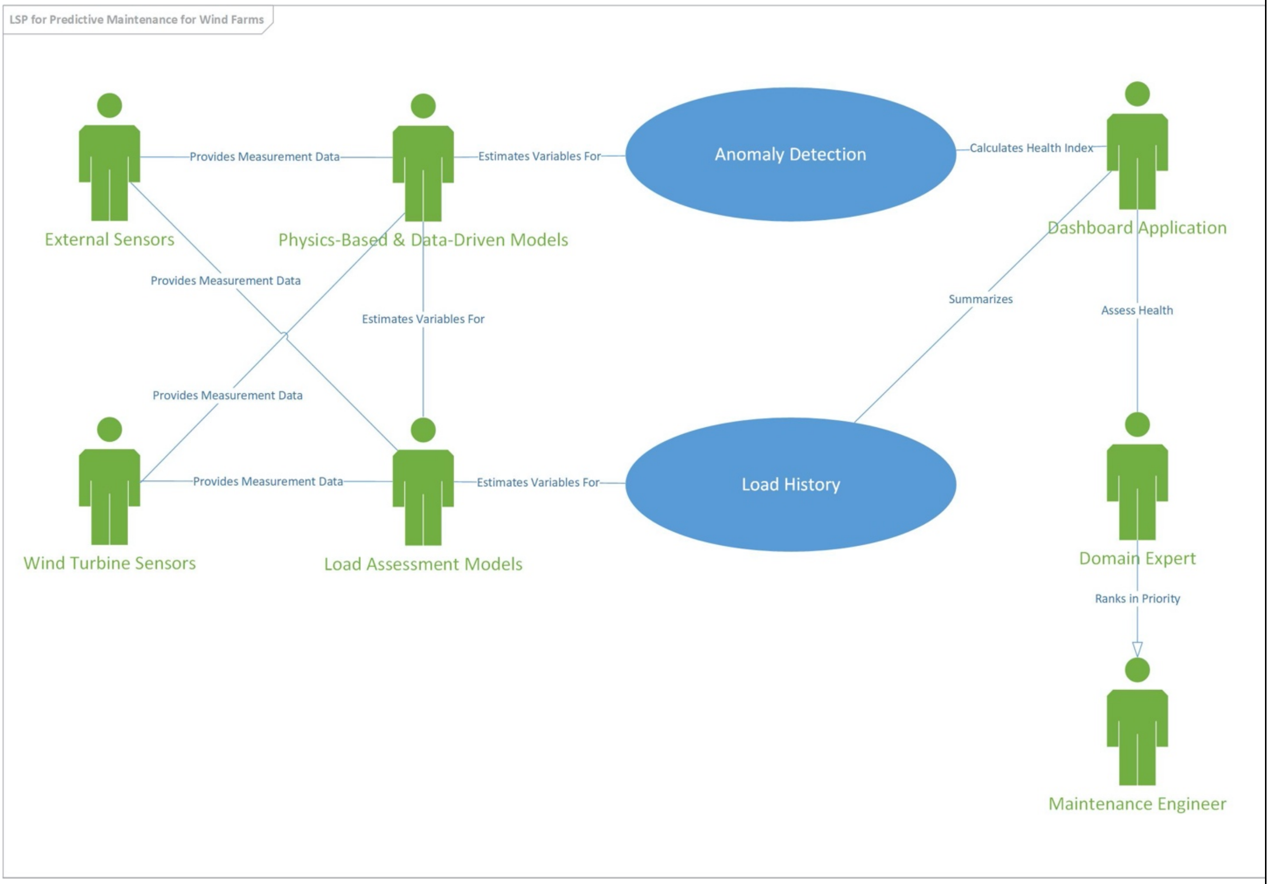
The approach discussed in the use case is targeted towards the predictive maintenance of electrical wind turbine drivetrain components. Wind turbines today are sold all over the world and highly standardized. As such the approach that is developed in this pilot is a generic approach that is applicable all over the world with small modifications to the local context (e.g. the difference in grid frequency between EU and US).

Nature of the use case

Technical/system use case.
Further keywords for classification
Wind energy, wind turbine, generator, converter, IGBT, failure, predictive maintenance, monitoring, digital twin.

2. Diagrams of use case.

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Paste below the use case diagram to show how actors interact within the Use Case by participating in the technical functions 

3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
People		Users involved in the modelling and interpretation of the data	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Provide a unique actor name.	E.g. device, system, human, etc.		
Domain Expert	human	Predictive maintenance engineer responsible for interpretation of health indicators	This person will be responsible for the interpretation of the outcomes of the methods developed in the pilot
Maintenance Engineer	human	The maintenance engineer that will take decisions based on the analytics tools but is not part of the team of PLATOON or its organisations	This person is the true benchmark for validating the effectiveness and clarity of the developed methods.
Data scientist	human	Data analyst responsible for the modelling of the generator and converter	This person will be responsible for the development and training of models used for the predictive maintenance context
Grouping		**Group description**	
Measurement infrastructure		Measurement infrastructure installed at the different components of the wind turbine.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Wind Turbine Sensors	Sensors	Set of sensors that measure different parameters of the wind turbine: -Electrical parameters -Mechanical parameters: rotational speed, mechanical torque and vibrations.	Two different data frequencies (high freq data on the order of kHz)
Wind turbine controller preprocessed data	Controller	Sensor data preprocessed by the turbine controller: -Electrical parameters -Mechanical parameters: rotational speed, mechanical torque and vibrations. - other operational parameters (e.g. temperature)	low freq data 10min SCADA data). Some of these sensors have some logic inside and generate fault logs

External Sensors	Sensors	Set of sensors that measure external contextual information form the wind farm: -Weather data (Temperature, Wind Speed, Wind Direction…) -Others (wave data…)	N/A
Grouping		**Group description**	
Information Systems		Information management platforms	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Datalake	databases	Database for storing the raw time series data of measurement data	Data is exported towards a central data repository at ENGIE and exported in csv format afterwards through the ENGIE Open Data website (when applicable). The high frequency sensor data (sampled in kHz range) is collected using a custom data acquisition system and retrofitted sensors. This data is stored locally and then in batches transferred to a central location at ENGIE. Dedicated python h5 file formats are used. During the PLATOON project, the available historical data will be stored at the VUB data-lake or at the ENGIE data platform. From this data-lake different representative training datasets are extracted. Each of these training datasets will be accessible through a dedicated API interface.
Data Analytics Tools	Application	Analytics models part of the digital twin	Physics based digital twin. Data driven digital twin. Anomaly detection tools Health index calculation model
Dashboard	application	Summary dashboard showing health indicators derived	

3.2 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
			The status of the document. e.g. Draft, final	e.g. copy right, IPR		
1	Technical Document	GE Energy technical documentation wind turbine generator systems GE 1.5sle 60Hz	final	Prerequisite for being able to model the generator and converter of GE 1.5MW wind turbine	General Electric	Provided as confidential by e-mail
2	Technical Document	SCADA tag manual of the wind turbine OEM	final	Prerequisite for being able to perform anomaly detection on the generator and converter SCADA data	Turbine OEM	Will be provided as confidential after NDA is signed

4. Step by step analysis of use case.

4.1 Overview of scenarios.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
			Refers to the actor that triggers the scenario. For instance, a function called “Protection” would probably be triggered by an “Intelligent Electronic Device (IED)”. It is worth pointing out that the names of the Actors should be consistent with	Event that triggers the scenario. It can be a real event (such as, “a fault occurs in the grid”), or it is also possible to define scenarios that occur “periodically	Describes the state of the system before the scenario starts.	Describes the expected state of the system after the scenario is realized

			Actors List in all sections of the Use Case description.			
1	Anomaly detection using combined data-driven and physics-based model	Diagnostics approach for detection of unhealthy behavior of the main electrical drivetrain components	Data scientist responsible for the respective data (ENGIE data scientist/Tecnalia data scientist/VUB data scientist)	Undersupervised wind turbine asset/Asset type with historical problems/Other warnings from SCADA or CMS	Sensor data, WT controller data and machine details are available	Health indicators are shown in dashboard
2	Load history assessment for prognostics assessment	Extraction of the most important loading events the turbine electrical components are exposed to	VUB data scientist	Failure that requires root cause analysis	Load history of the machine should be available	Insights in the most important events heavily loading the electrical drivetrain components

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1 – Failure detection using combined data-driven and physics-based model**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	New measurement data ready to be collected	Data extraction/cleaning and pre-processing	All necessary automated steps necessary to select the most suitable data and preprocess it before it can be used for modelling purposes	GET/CHANGE	Sensors produce raw data; WT controller provides SCADA and/or status log data	Raw sensor data is preprocessed by the PLATOON algorithms	Raw sensor data: I-01-GEN, I-02-CONV, I-03-SCADA	R-DA-1, R-DA-2,R-IF-1
2	No model available or model shows concept drift	Healthy behavior model	Data-driven or physics-based model trained and ready to be used	EXECUTE	Historical database (ENGIE database/VUB database/Tecnalia database	ENGIE/VUB/Tecnalia system modelling and anomaly detection app	I-04-GEN-CL, I-05-CONV-CL, I-06-SCADA-CL	R-IF-2
3	Model for healthy behaviour modeling deployed	Anomaly detection	Anomaly detection methods continuously classifying data in healthy or anomalous including corresponding anomaly score	EXECUTE	ENGIE/VUB/Tecnalia system modelling and anomaly detection app	ENGIE/VUB/Tecnalia system modelling and anomaly detection app	I-07-PHYS-M, I-008-DAT-M	R-IF-3, R-IF-4, R-IF-5

4	All anomaly detection methods have outputted an anomaly score	Health indicator fusion	Integration of the anomaly scores of the different anomaly detection methods in a single health score	EXECUTE	ENGIE/VUB/Tecnalia system modelling and anomaly detection app	VUB system modelling and anomaly detection app	I-09-ANO-E, I-10-ANO-T, I-11-ANO-V	R-IF-3, R-IF-4, R-IF-5
5	New health score available	Health indicator visualization	Visualisation of health score on dashboard	REPORT	Dashboard application	ENGIE Engineer/External End User	I-12-ANO-F	R-HS-1, R-IF-6, R-IF-7

Scenario								
Scenario name:		**No. 2 – Load history assessment of generator and converter**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	New measurement data ready to be collected	Data extraction/cleaning and pre-processing	All necessary automated steps necessary to select the most suitable data from the SCADA data and status logs and preprocess it before it can be used for modelling purposes	GET/CHANGE	SCADA sensors and WT controller produce raw data and status logs	Raw data is preprocessed by the PLATOON algorithms (e.g. outlier removal, missing value reconstruction,…)	data from SCADA system and status logs: I-03-SCADA	R-DA-2,R-IF-1
2	Periodic analysis of turbine history	Loading event identification	Analytics model to identify the main loading events the turbine is exposed to from status log data	EXECUTE	Historical database ENGIE	VUB load history analysis app	I-06-SCADA-CL	R-IF-2
3	Periodic analysis of turbine history	Summary statistics of load history	Application to summarize the identified historical loading in lifetime statistics	EXECUTE	VUB load history analysis app	VUB load history analysis app	I-13-LIFE-E	R-HS-1

Scenario								
Scenario name:		**No. 3 – Ontology optimization for turbine stops and failures (Optional)**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	New stop of the turbine is experienced (not necessarily a failure)	Status log data extraction	The status logs active in the period of the stop are collected	GET/CHANGE	SCADA systems produce status logs	Status log data is collected and preprocessed by the PLATOON algorithms	Status logs: I-03-SCADA	R-DA-2, R-IF-1
2	New stop of the turbine is experienced (not necessarily a failure)	Identification of status log sequences and labelling	Status log patterns are identified. These are used to label the stop according to a standardized ontology	EXECUTE	Status log data that is preprocessed by the PLATOON algorithms	Status log pattern detection app	I-06-SCADA-CL	R-IF-2
3	Periodic analysis of turbine history	Knowledge discovery in stops	Application to learn the links between status log sequences at stop and stop type allowing to optimize ontology	EXECUTE	Status log pattern detection app	Ontology knowledge discovery app	I-14-PAT-L	R-HS-1

5. Information exchanged.

These information objects are corresponding to the “Name of Information” of the “Information Exchanged” column referenced in the scenario steps in template section 4 “Step by Step Analysis”. If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
Refers to an identifier used in the field “Information Exchanged” in the table of section 4.2.	Define a unique ID which identifies the selected information in the context of the use case.	Provide a brief description, in case a reference to existing data models/information classes should be added. Using existing canonical data models is recommended.	To be used to define requirements referring to the information and not to the step as in the step by step analysis (see template section 6 below): EXAMPLE: Data protection class corresponding to this information object.
I-01-GEN	Raw sensor data of the wind turbine generator sampled at high frequency (KHz)	Power, Current, voltage and speed measurements done on the wind turbine generator	R-DA-1
I-02-CONV	Raw sensor data of the wind turbine converter sampled at high frequency (KHz)	Current and voltage measurements done on the wind turbine converter	R-DA-1
I-03-SCADA	SCADA data of the wind turbine sampled at low frequency (10min)	SCADA sensor values measured at different wind turbine subcomponents and sampled at low frequency (10-min)	R-DA-2
I-04-GEN-CL	Preprocessed high frequency generator data	Cleaned and preprocessed equivalent of I-01-GEN	R-IF-1,R-IF-2
I-05-CONV-CL	Preprocessed high frequency converter data	Cleaned and preprocessed equivalent of I-02-CONV	R-IF-1,R-IF-2

I-06-SCADA-CL	Preprocessed SCADA data	Cleaned and preprocessed equivalent of I-03-SCADA	R-IF-1,R-IF-2
I-07-PHYS-M	Physical model of electrical components	Physical model of the electrical component: generator	R-IF-4
I-08-DAT-M	Data-driven model of the electrical components	Data-driven model of the generator and converter	R-IF-3, R-IF-5
I-09-ANO-E	Anomalies identified by ENGIE	Anomalies and health scores identified by the ENGIE analytics tools	R-IF-3
I-10-ANO-T	Anomalies identified by Tecnalia	Anomalies and health scores identified by the Tecnalia analytics tools	R-IF-4
I-11-ANO-V	Anomalies identified by VUB	Anomalies and health scores identified by the VUB analytics tools	R-IF-5
I-12-ANO-F	Fused health score	Health score fused from I-09-ANO-E, I-10-ANO-T, I-11-ANO-V	R-IF-6
I-13-LIFE-E	Identified lifetime events	Loading events identified by VUB load history analysis app	

6. Requirements.

Categories ID	Category name for requirements	Category description
R-DA	Data availability requirement .	Requirement linked to the necessary data to be available for the use case.
R-HS	Health state ground truth info	Requirement linked to the availability of information about the health state of the machine
R-IF	Algorithm interfacing APIs	Requirement linked to the availability of software component interfacing APIs
Requirement R-ID	**Requirement name**	**Requirement description**
R-DA-1	High frequency data available	The required high frequency data for the generator and converter are available
R-DA-2	SCADA and log data available	The required status log data and SCADA data are available
R-HS-1	Health information for case	The health state of the generator and converter ground truth data is available for the sensor data of R-DA-1 and R-DA-2
R-IF-1	Raw data interfacing API	Interface for extracting raw sensor data from data source

R-IF-2	Preprocessed data interfacing API	Interface for storing/extracting preprocessed data
R-IF-3	Model API ENGIE models	Interface for communicating with ENGIE models
R-IF-4	Model API Tecnalia models	Interface for communicating with Tecnalia models
R-IF-5	Model API VBU models	Interface for communicating with VUB models
R-IF-6	Health fusion API	Interface for communicating with health metric fusion algorithms
R-IF-7	Dashboard API	Interface for final dashboard

7. Common terms and definitions.

Common terms and definitions	
Term	**Definition**
Wind turbine	Wind turbine generator. The entire wind turbine including tower, blades and nacelle.
Generator	Subcomponent of the wind turbine that allows to convert rotation of the blades into electricity
(Power) converter	Subcomponent of the wind turbine that allows to convert AC power to DC power and back to AC power at another frequency. It is used to allow the control of the variation of the wind turbine speed.
Doubly fed induction generator	Wind turbine generator type that is able to allow speed variation in the range of 50%. The generator is an induction generator where the rotor

	currents are fed externally using a power converter.
Anomaly	An anomaly is detected when there is sufficient difference between the measured value of a physical quantity and its corresponding value as predicted by a model.
Health score	The translation of anomalies into a metric representing the condition of an asset.

8. Custom information (optional).

This section of the use case template entails a key and its value. It has to be remarked to which section the pair refers.

Data list					
Data Description	**Operational Service**	**Data Format**	**Data Category**	**Data Source**	**Data Owner**
La Haute Lys GE 1.5MW turbine high frequency measurement campaign	Predictive maintenance	Custom binary format	Historical data	Sensors	ENGIE
Schelle GE 1.5MW turbine high frequency measurement campaign	Predictive maintenance	.pickle, .tdms	Historical data	Sensors	ENGIE
La Haute Lys GE 1.5MW turbine SCADA 10-min data	Predictive maintenance	.csv	Historical data	Controller data	ENGIE
Schelle GE 1.5MW turbine SCADA 10-min data	Predictive maintenance	.csv	Historical data	Controller data	ENGIE
La Haute Borne SCADA 10-min data + status logs	Predictive maintenance	.csv	Historical data	Controller data	ENGIE

LLUC-P-2a-01 to LLUC-P-2a-06

1 Use case descr'ption

1.1 Name of use case

ID	Title	Scenarios Prioritization	Partners
LLUC P-2a-01	Balancing on regional level	1 Low	IMP (out of scope)
LLUC P-2a-02	Balancing on country level	2 Low	IMP (too specific)
LLUC P-2a-03	Demand forecast on transmission level	5High	IMP, UBO
LLUC P-2a-04	RES (Wind generation) forecasters	5High	IMP, UBO
LLUC P-2a-05	Effects of Renewable Energy Sources on the Power distribution system	3Medium	CS, IMP
LLUC P-2a-06	Research Data Management	3 Medium	TIB, UBO
LLUC P-2a-07	Predictive maintenance in RES power plants	5 High	CS, IMP

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
LLUC P-2a-01 to LLUC P-2a-01	Transmission / Production	Electricity Balance

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	27/04/2020	V. Janev	Initial creation (General description with integration profiles)	Draft
0.2	20/05/2020	V. Janev, M. Batić	UML Definition of Scenarios for Mid-term Review	Draft
0.3	27/05/2020	V. Janev, A. Čampa	Input for UC- Effects of Renewable Energy Sources on the Power distribution system -	Draft
0.4	04/06/2020	V. Janev	Requirements specification	Draft

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Electricity Balance
Objective(s)	Test and deploy intelligent smart grid services delivered by PLATOON for the following purposes: • Electricity balancing and dispatch optimization at TSO • Energy production forecast for renewable energy sources (wind power plant) •Implementation of IDS Connectors for the Serbian System Operator (EMS), the Balancing Server Provider (EPS), one representative Balance Responsible Party (BRP) •Real-time integration and big data analysis upon the high-volume data streams from SCADA/EMS • State estimation • Short term load forecasting
Related business case(s)	

1.4 Narrative of Use Case

Narrative of use case
Short description
Electricity must be 'consumed' as soon as it is produced, because it cannot be stored easily. Balance management is a power system operation service vital for ensuring security of supply through the continuous, real-time balancing of power demand and supply. At each point in time, total production must be equal to total consumption in order to stabilize system frequency; it is therefore also called *frequency control*. Historically, balancing the system has been maintained mostly by directing thermal power plants to increase or reduce output in line with changes in demand. Storage and interconnectors have also played a part, but a much smaller one. As the volume of intermittent generation on the system grows, the system is balance by utilizing both supply and demand resources. However, the existing electric power systems were not initially designed to incorporate different kinds of generation technology in the scale that is required today. With significant penetration of distributed generation, the distribution network has become an active system with power flows and voltages determined by the generation as well as by the loads. Therefore, it is difficult to predict the impact of distributed generation (e.g. from wind off-shore farms) on the future energy mix. As a response to this, smart grids are expected to enhance grid flexibility & robustness and enabling existing grids to accept power injections from distributed energy resources without contravening critical operational limits (such as voltage control, switching equipment capability and power flow capacity). In this use case, PLATOON services will be developed that will upgrade the IMP SCADA system with electricity balancing functionalities needed in case of power injections from wind farms. With the increased penetration of distributed generation (e.g. wind power), the risk of temporary imbalances also increases caused by wind power uncertainties due to its dependence on the volatility of the wind. So, advanced demand/response optimization services are needed to prevent power outages or blackout (complete interruption of power in a given service area). The role of the SCADA / EMS on the production side is monitoring and control of generation and data exchange.
Complete description
This use case aims at enabling a higher penetration of variable renewable generation on national market. Therefore for reliable and efficient operation of the transmission and distribution grid, for flexibility in balancing and trading, different analytical services are needed. PLATOON services will exchange data with the existing SCADA

/ EMS systems that are currently in use stakeholders (actors) in Serbia via IDS connectors. The role of the SCADA / EMS in the transmission system is real-time monitoring and control of transmission and distribution/consumption with the goal to optimize the use of the grid infrastructure.

For this use case more LLUC scenarios has been developed, while the partners (IMP, TIB, UBO, CS) will focus on some of them, see Table 2. Prioritization of Scenarios.

LLUC P-2a-01 (Balancing on regional level): This scenario serves to explain the electricity balancing process on regional level. Serbia and the neighboring countries Montenegro and Macedonia form the SMM control block[**2**]. The Automatic Generation Control (AGC) component of the TSO SCADA/EMS system**[3]**, especially its load frequency control (LFC) part, plays very important role in continuous and secure operation of interconnected power system (SMM block) The main role of AGC is to maintain balance between generation and consumption and to, consequently, keep system frequency and interchanges as close to scheduled values as possible. One of the new challenges related to AGC is the introduction of “Imbalance Netting Process”. Imbalance netting is process of automatic secondary (FRR – Frequency Regulation Reserve) reserve activation optimization in which two or more TSO’s participate. It serves the cross-border electricity balancing, where the main idea is to avoid activation of secondary balancing reserves in opposite directions in participating TSO’s. Imbalance netting platform typically includes two main functions: • Optimization module (Imbalance Netting optimization algorithm) which executes in real time. • Settlement module which executes in each “settlement cycle” (each 15 minutes or each hour).

LLUC P-2a-02 (Balancing on country level, reserve/energy exchange process): This scenario will concentrate on tertiary reserve/energy exchange process. Currently the Electric Power Industry of Serbia (PE EPS) is the only supplier of the balance reserve, but independent producers (IPP) and producers from distributed and renewable sources (DER) will be actors in the balance reserve market in the future.
A balancing market consists of three main phases (balance planning, balancing service provision, and balance settlement) and concerns three main actors (the System Operator (TSO), Balancing Service Providers (BSPs), and Balance Responsible Parties (BRPs). As presented in LLUC P-2a-01, the Serbian TSO (PE EMS) is performing all balancing services and activates tertiary reserve using a merit order list, defined by PE EPS in advance. EPS performs electricity trading for the purpose of balancing and optimization of single energy portfolio of Balance Responsible Parties (in the Serbian electricity market, all market participants are balancing parties and their relations are regulated by contracts). The goal of the new PLATOON service is to improve the optimization strategies taking into consideration all available resources.
Balancing services consist of two main types: balancing energy (the real-time adjustment of balancing resources to maintain the system balance) and balancing capacity (the contracted option to dispatch balancing energy during the contract period).

Balancing reserves:

- the primary reserve is mandatory for all controllable generation units;
- The required secondary reserve depends on the month of the year. It is provided by biggest hydro-power plants and most recently TENT A (thermal power plant). Secondary (automatic Frequency Restoration Reserve, aFRR) is used to restore the availability of the power bandwidth of the activated frequency containment reserves (FCR). aFRR is automatically activated to relieve FCR, so that it can resume its function of balancing the system. aFRR is activated when the system is affected for longer than 30 seconds or it is assumed that the system will be affected for a period longer than 30 seconds. Prior to this, deviations in the system are only covered through FCR.
- Reservation of the balance capacity for secondary (aFRR), tertiary (manual Frequency Restoration Reserve, mFRR) and tertiary rapid (RR) regulation is not market-based. The amount for each reservation is defined by the Agreement on the provision of system services signed between the transmission system operator and the balancing service provider.

According to the rules, the suppliers send daily estimates their needs for the next day and how they plan to balance them to the transmission system operator – EMS and distribution system operators (EPS-DSO).

In emergency cases it is possible to use balancing energy from neighboring TSOs by using “residual” capacity (**LLUC P-2a-01**). The activation of tertiary reserve is executed per minute, but the timeframe for imbalance settlement is 1 hour. Tertiary reserve consists of all plants that are not in operation, and are reported as available, and plants that are in operation but do not operate at maximum capacity.

The incumbent (PE EPS, only balancing reserve provider, purchase of services is regulated by the Energy Agency of the Republic of Serbia) is contracting in the name and for the account of the generating companies (Balance Responsible Parties) that are part of PE EPS´s company holding. In the case of the generated energy from renewable energy sources, it is needed to improve the accuracy of prediction. PE EPS serves as an aggregator and hence needs advanced analytical capabilities to support the balancing services. At present, EPS delivers balancing reserve, black start and voltage regulation services to EMS.

LLUC P-2a-03 (Load Demand forecast on transmission level): This scenario describes the use of PLATOON tools for load demand forecast analysis. Electricity demand forecasting is a central and integral process for planning periodical operations and facility expansion in the electricity sector. Load demand forecasting involves accurate prediction of both magnitudes and geographical locations of electric load over the different periods of the planning horizon. Load forecasting can be divided into three categories: short-term forecasts, medium-term forecasts and long term forecasts:

- Short-term forecasts are usually from one hour to one week.
- Medium-term forecasts are usually from a few weeks to a few months and even up to a few years.
- Long-term electricity demand forecasting is a crucial part in the electric power system planning, tariff regulation and energy trading . A long term forecast is generally known as an annual peak load.

The aims of load forecasting are to predict the load pattern. There are several factors that should be taken into consideration for load forecasting, which can be classified as time factor, economic factor, weather condition and customer factor[4].

LLUC P-2a-04 (RES forecasters): In Serbian case, PE EPS is currently the only supplier of the balance reserve, but independent producers (IPP) and producers from distributed and renewable sources (DER) will be actors in the balance reserve market in the future. **The goal of this scenario is to develop and test a PLATOON service for more accurate prediction of renewable energy generation.**

Different energy supplier strategies for RES should be considered that will support and improve strategic optimization of the resources on the side of the balancing reserve provider (EPS). The wind power forecasting yields an estimate of the variable power injected in the distribution grid. This allows prediction of when the transformer connecting the distribution grid to the transmission grid will be overloaded, i.e. when local wind turbine generator production will be very high. The various forecasting approaches can be classified according to the type of input**[5]** (weather prediction, wind turbine generators data, historical production data). Statistically based approaches allows very short term predictions (2 hours). One of the key challenges for day-ahead forecasting of wind energy remains unscheduled outages that can have large effects on the forecasts for small systems, while the effect is small on the overall grid.

LLUC P-2a-05 (Effects of Renewable Energy Sources on the Power distribution system): Constantly 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. **The goal of this scenario is to test the PLATOON analytical services for analysis of unexpected variations (voltage profile of the power system) before and after RES integration to the power system**. A service should be **developed** and the effects of RES on the existing power system should be evaluated and presented graphically. The Effect of RES**[6]**can be analyzed by PMU and edge computing. The PMU is used for the analysis of the real-time power flows, while edge computing for investigating the integration of RES to the power system. Additionally, phasor based control could be exploited to perform power flow optimization and improve the power quality in the real-time domain.

LLUC P-2a-06 (Research Data Management): The goal of this scenario is to showcase how the process of storing and retrieval of artefacts (data models, external datasets, research results/outputs) can be managed with a CKAN repository. It assumes that end-users (e.g. data scientists) in their work will need a repository where relevant re-usable artifacts can be stored, curated and shared with other stakeholders. The tool shall support visualization (ontologies, vocabularies), as well as running of example statistical / ML algorithms.

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI-1	Cost efficient distribution and transmission	Improved operation of Smart Grid and cost efficient distribution and transmission network operation	LLUC P-2a-01 LLUC P-2a-02 LLUC P-2a-03 LLUC P-2a-04
KPI-2	Savings from tertiary reserve trading	Increase the annual net savings from tertiary reserve trading, see CIGRE 2020**[7]**	LLUC P-2a-01
KPI-3	Better demand response	Responding better to changes in demand	LLUC P-2a-01 LLUC P-2a-02 LLUC P-2a-03
KPI-4	Improved RES integration	Better evaluation of the effects from RES integration	LLUC P-2a-02 LLUC P-2a-05
KPI-5	Balanced energy mix	Reduction in peak use of fossil fuels	LLUC P-2a-02 LLUC P-2a-05
KPI-6	Curtailment avoidance	Percentage of curtailment avoidance	LLUC P-2a-01 LLUC P-2a-04 LLUC P-2a- 05
KPI-7	Portfolio optimization	Improved portfolio optimization of Balance Responsible Parties (Optimization/Management of Renewable Energy Systems)	LLUC P-2a-04
KPI-9	Increased stability	Increased degree of stability in the real power plant operation.	LLUC P-2a-05

1.6 Use case conditions

Use case conditions
Assumptions
Access to power production data (collected by IMP SCADA); load data; weather data; historical data about the demand. Access to Imbalance Netting Optimization Module. Imbalance netting platform typically includes two main functions: • Optimization module (Imbalance Netting optimization algorithm) which executes in real time.

• Settlement module which executes in each “settlement cycle” (each 15 minutes or each hour).
Prerequisites
A prerequisite for implementing the PLATOON analytical services is the Implementation of IDS connectors for communicating with different components of the SCADA View 4 system.

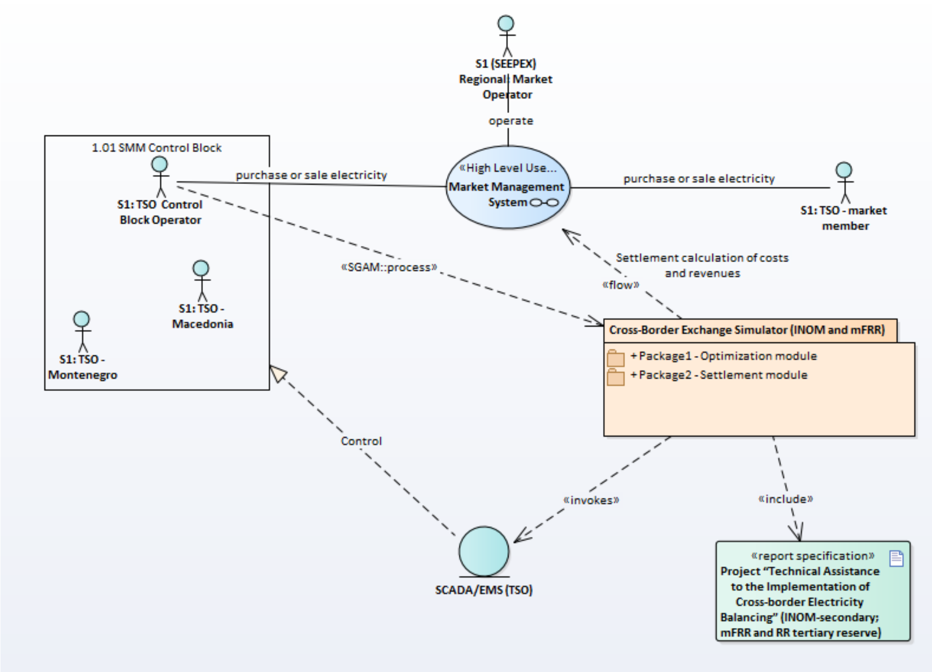
1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Related to - Pilot #2b Electricity grid stability, connectivity and Life Extension and - Pilot #4a Energy management of microgrids
Level of depth
Detailed Use Case.
Prioritization
See Table 2. Scenarios Prioritization.
Generic, regional or national relation
Please see Section 1 and 3.1
Nature of the use case
Technical/system use case
Further keywords for classification
Smart grid, production forecast, electricity balance

2 Diagrams of use case

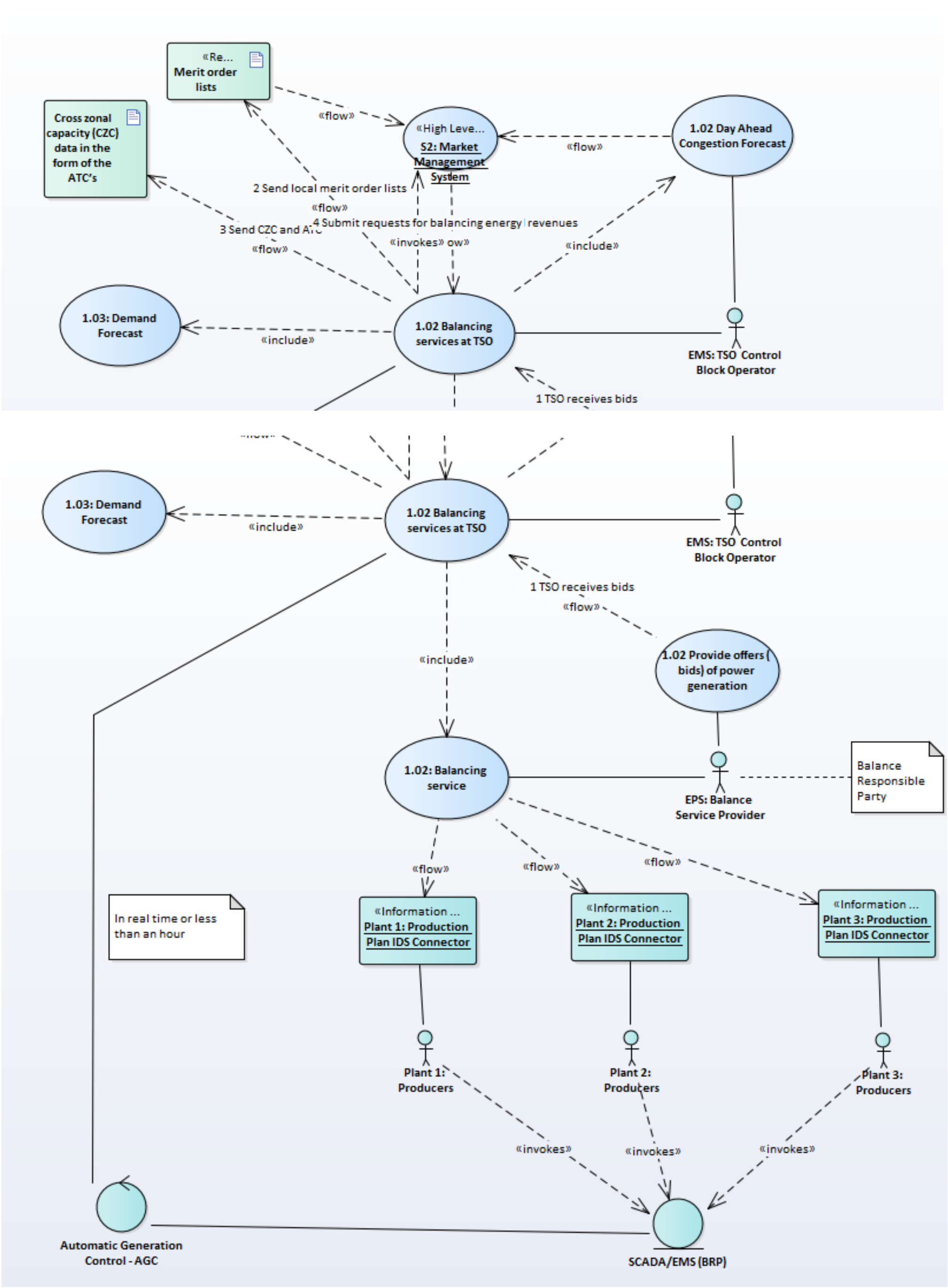
In this section of the use case template, diagrams of the use case are provided as UML graphics.

Balancing on regional level



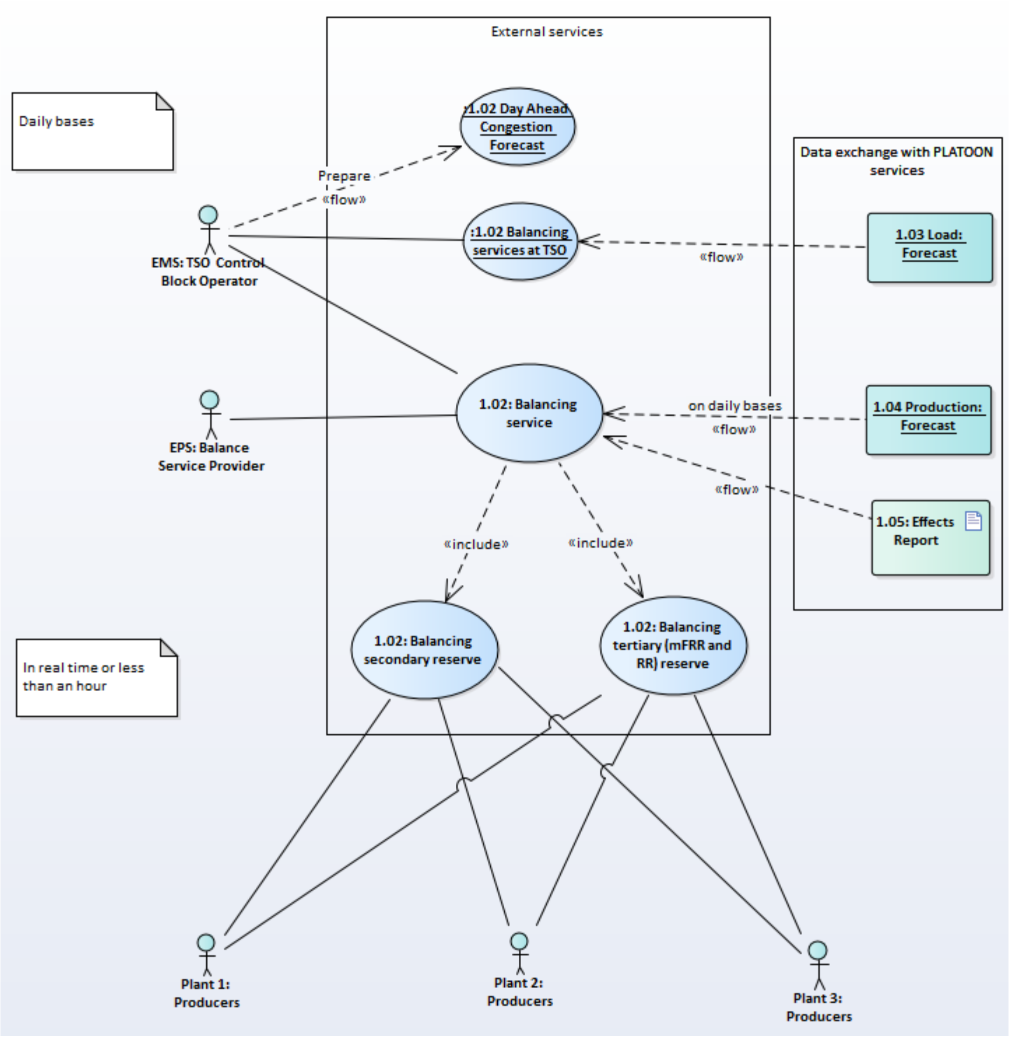
	Scenario			
Scenario name			**01 Balancing the Serbian Grid (Plan / Validate / Operate / Settle phases)**	
No.	**Event**	**Service**	**Name of process/activity**	**Description of process/activity**
01	Send bids	GET	1.02 Provide offers (bids) of power generation	TSO's receive bids from balance service providers (BSP's) within own control areas. [**plan**]
02	Send local merit order lists	REPORT	1.02 Balancing services at TSO	TSO's forward local merit order lists to regional balancing platform [**plan**]
03	Send CZC and ATC	REPORT	1.02 Balancing services at TSO	TSO's forward cross zonal capacity (CZC) data in the form of the ATC's to regional balancing platform. [**plan**]
04	Submit requests for balancing energy	EXECUTE	1.02 Balancing services at TSO	TSO's submit requests for balancing energy [**validate**]
05	Find optimal combinations	REPEAT	1.01: Balancing in SMM Block	Central optimizing module finds optimal combinations of accepted bids and requests. Accepted bids, fulfilled TSO requests and cross-border exchanges are calculated (activation optimization function) [**settle**]
06	Set Settlement calculation of costs and revenues	REPORT	1.02 Balancing services at TSO	Settlement calculation of costs and revenues between TSO's and BSP's [**settle**]

Balancing on country level



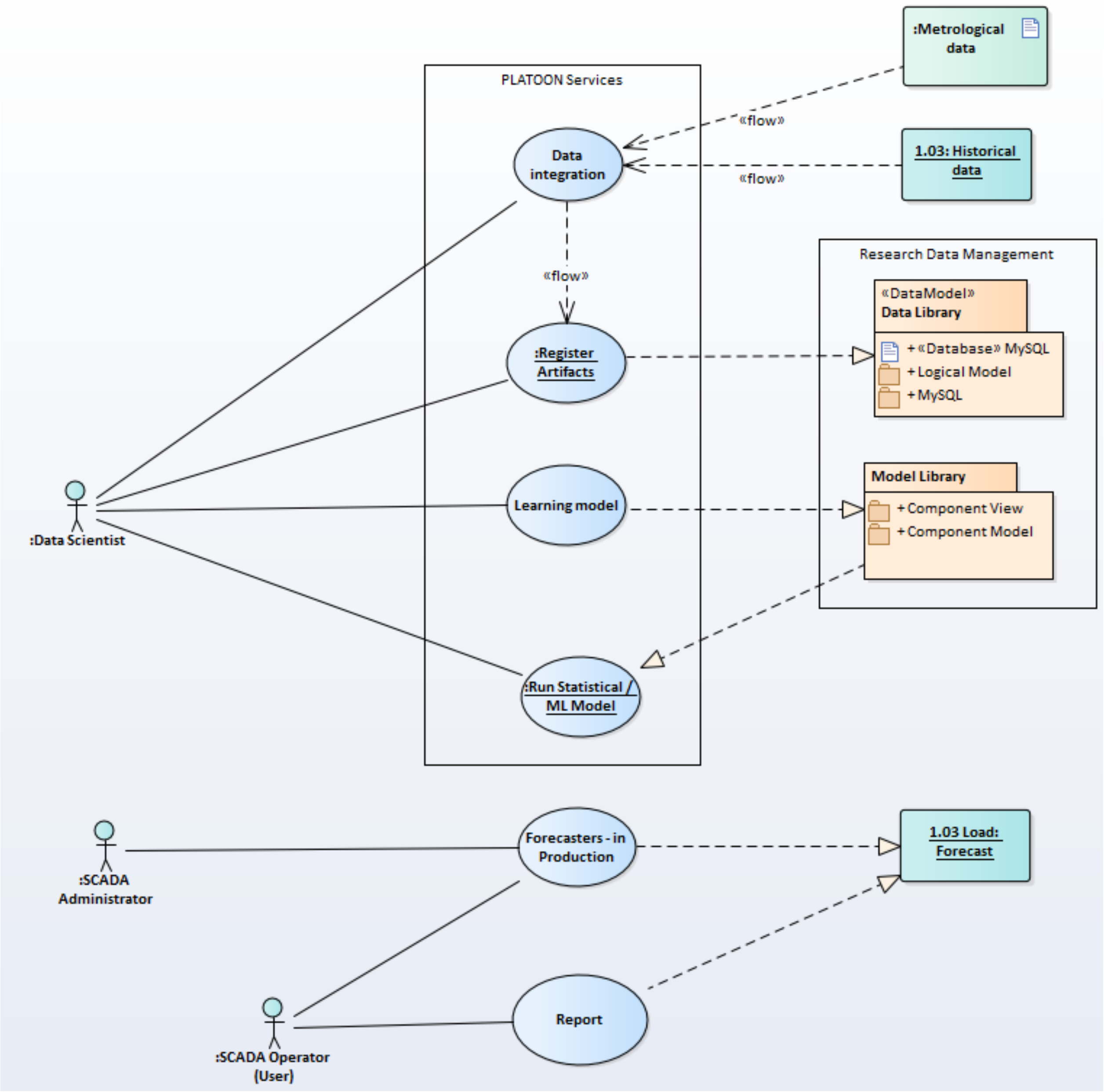
Balancing services consist of two main types: balancing energy (the real-time adjustment of balancing resources to maintain the system balance, see LLUC P-2a-02) and balancing capacity (the contracted option to dispatch balancing energy during the contract period). The time scale of the phases **[plan, validate, operate, settle**] is ranging from already years and months ahead towards one day ahead and ultimately a certain amount of hours before the actual delivery of energy

LLUC P-2a-02 Balancing on country level (balancing services)


External services
Daily bases
:1.02 Day Ahead Congestion Forecast
Prepare
«flow»
:1.02 Balancing services at TSO
«flow»
Data exchange with PLATOON services
1.03 Load: Forecast
EMS: TSO Control Block Operator
1.02: Balancing service
on daily bases
«flow»
1.04 Production: Forecast
EPS: Balance Service Provider
«flow»
1.05: Effects Report
«include»
«include»
1.02: Balancing secondary reserve
1.02: Balancing tertiary (mFRR and RR) reserve
In real time or less than an hour
Plant 1: Producers
Plant 2: Producers
Plant 3: Producers

Demand forecast on transmission level

LLUC P-2a-03 Demand forecast on transmission level



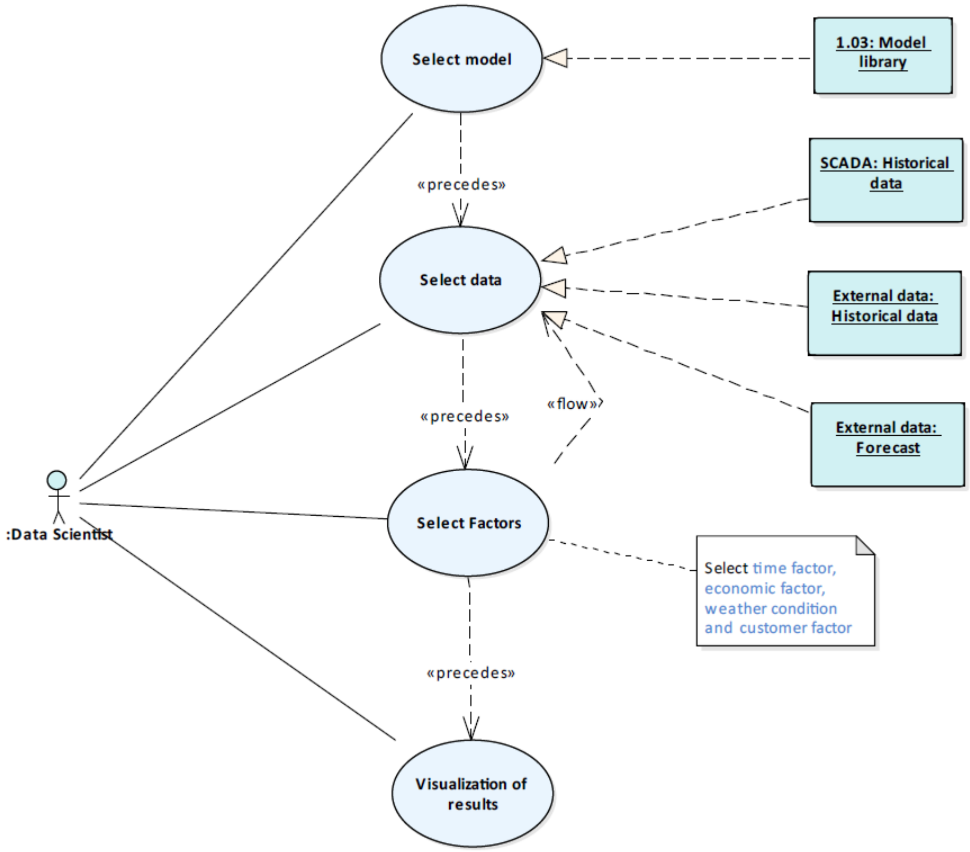
	Scenario			
Scenario name		03 Load Demand forecast on transmission level (using the Research data manager), research mode		
No.	Event	Service	Name of process/activity	Description of process/activity
01	Upload data	GET	Data Integration	Forecaster Receives data from different sources
02	Integrate	CHANGE	Data Transformation	User run the data transformation and integration

03	Register in PLATOON data library	EXECUTE	Registering Artefacts	Data prepared for analysis .User register the integrated dataset in the Data Library
04	Train the model	EXECUTE	Learning Model	User learns the model
05	Run forecaster	EXECUTE	Testing the Forecaster	User test different models from the Model Library
06	Deploy the service	REPORT	Deployment at client side	SCADA Administrator integrate the services locally

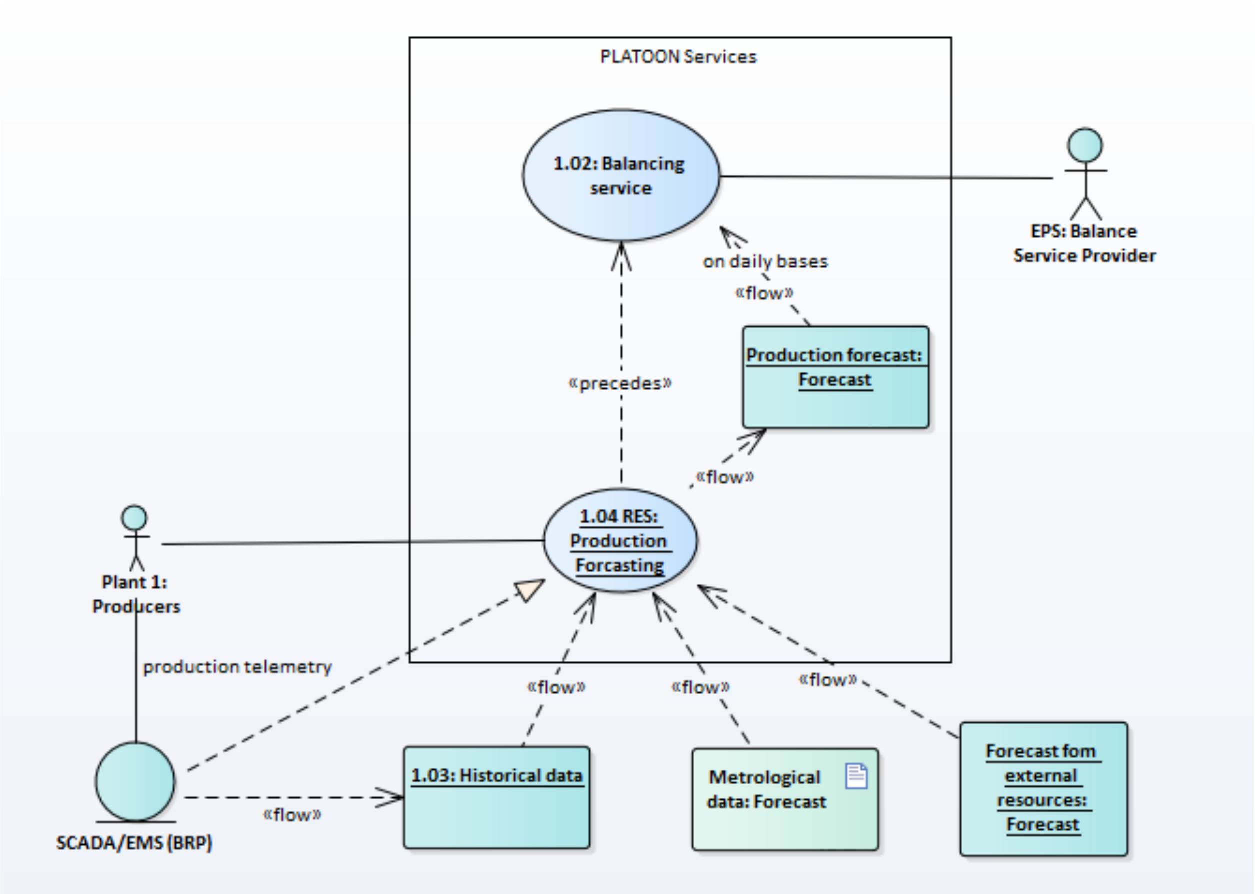
In production

	Scenario			
Scenario name:			**03 Load Demand forecast on transmission level**	
Step No.	**Event**	**Service**	**Name of process activity**	**Description of process/ activity**
01	Start Forecaster	GET	Data uploaded	Receive data from different sources
02	Transform datasets	CHANGE	Data integration	Data transformation and integration is run automatically or manually
03	Run forecast	EXECUTE	Run statistical / ML model	Run the Forecasters
04	Generate report	CREATE	Produce the forecasting report	The Report will be created and send automatically
05	Verify the report	REPORT	Report	User prepare the report for sending

LLUC P-2a-03 Demand forecast on transmission level (model learning)

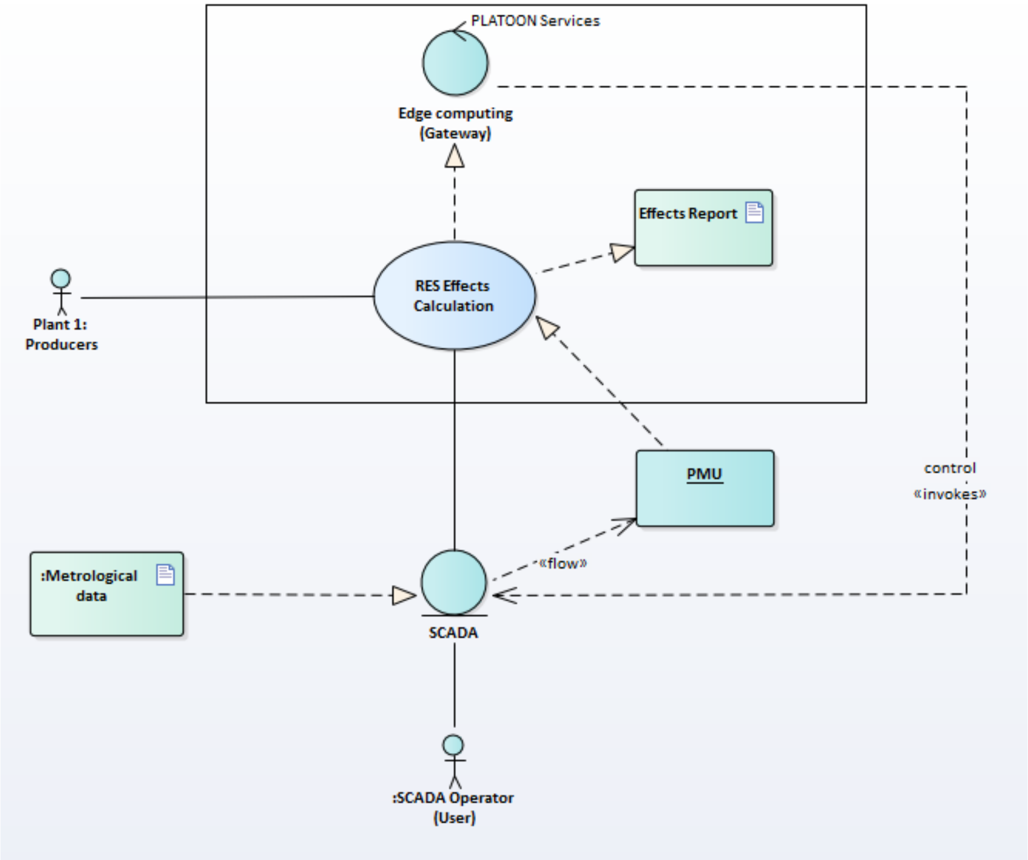


LLUC P-2a-04 RES forecasters



	Scenario			
Scenario name			04 RES forecasters	
No.	Event	Service	Name of process/activity	Description of process/activity
01	Start Forecaster	GET data	1.04: Production (RES) Forecasting	Upload to PLATOON database
02	Transform datasets	CHANGE	1.04: Production (RES) Forecasting	Data from external sources is integrated
03	Run forecast	EXECUTE	1.04: Production (RES) Forecasting	Start the Forecasting (automatic mode) User start the Forecasting (manual)
04	Generate report	EXECUTE	1.04: Production (RES) Forecasting	User Visualize and explore the results (manual)
05	Verify the report	REPORT	1.04: Production (RES) Forecasting	Forecast is send to Balance Service Provider (automatic or manual mode)

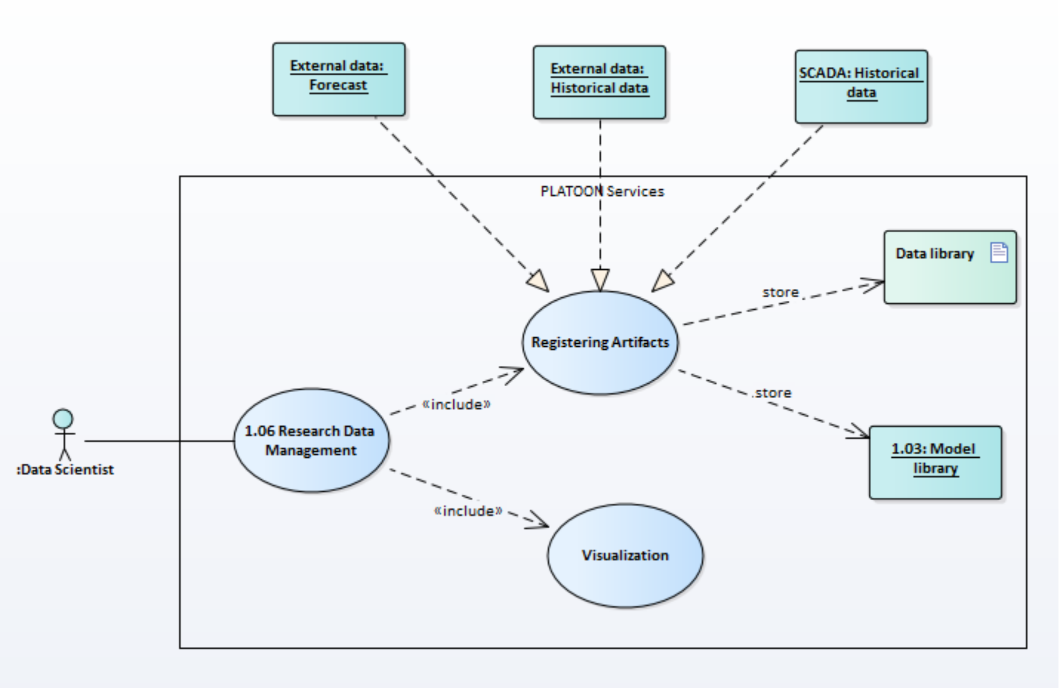
LLUC P-2a-05 Effects of Renewable Energy Sources on the Power Distribution System



	Scenario			
Scenario name			**05 Effects of Renewable Energy Sources on the Power Distribution System**	
No.	**Event**	**Service**	**Name of process/activity**	**Description of process/activity**
01	Get data from all devices	GET	Data integration	RES Effects Calculation receives updates from all PMUs and weather forecasts from DSO/retailer through the SCADA system.
02	Validate	EXECUTE Validate data	Validation of input data	RES effects Calculation validates all necessary input data before calculations and may request for missing data.
03	Phasor based control	EXECUTE	Computes phasor based control	Depend on the external trigger and availability of the RES control, the Edge computer calculates the new optimal state of RES from the current grid status.
04	Set new parameters	REPEAT	Set parameters of RES	Set optimized parameters to the RES. (e.g., change active and reactive of inverters)
05	Compute KPI	EXECUTE	Computes key	RES Effects calculation computes KPI Improved RES integration from historical and current data.

			performance indicators	
06	Prepare report	REPORT	Send the report	Send the Effects Report for visualization in the consumer-oriented interface

LLUC P-2a-06 Research Data Management



Scenario				
Scenario name			**06 Research Data Management**	
No.	**Event**	**Service**	**Name of process/activity**	**Description of process/activity**
01	Star the work on Pilot	CREATE service	Research Data Management (RDM)	The User set up an instance of RDM to serve for registering different data sets and models that will be used in the Pilot
02	New data / metadata / model available	GET	Register Artifact	The User use this functionality to register in the metadata catalog the datasets / model that are used in the Pilot
03	Interaction with catalogues	REPORT	Visualization	The User use this functionality to visualize the time series (data) and/or other contents in the dataset

3 Technical details

This part of the template provides:

3.1 Actors.

<table>
<tr><th colspan="4">Actors</th></tr>
<tr><th colspan="2">Grouping</th><th colspan="2">Group description</th></tr>
<tr><td colspan="2">Production</td><td colspan="2">Renewable Energy Production consists of distributed energy generation resources</td></tr>
<tr><th>Actor name</th><th>Actor type</th><th>Actor description</th><th>Further information specific to this use case</th></tr>
<tr><td>Balancing Service Provider</td><td>Organization</td><td>A market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs.</td><td>PE “Electric Power Industry of Serbia” (EPS), see LLUC P-2a- 02 Balancing the Serbian Grid, LLUC P-2a- 04 (RES forecasters), LLUC P-2a-05</td></tr>
<tr><td>Production forecasters (RES-PF)</td><td>PLATOON Service</td><td>Forecasting in the Smart Grid the production from renewable sources</td><td>Reliable and accurate production forecast service needed. The services provide different forecasts (e.g. 4-hours, 1 day, 4 days), see LLUC P-2a-04</td></tr>
<tr><td>BRP IDS Connector</td><td>PLATOON Service</td><td>IDS Connector on the side of Balance Responsible Parties</td><td>IDS Documentation[8]</td></tr>
<tr><td>SCADA Administrator</td><td>Human</td><td>Person involved in exporting data. Provides instructions for writing the interface services</td><td>Interfaces (IDS Connector)</td></tr>
<tr><td>Data Scientist</td><td>Human</td><td>Person responsible for development of analytical models integrated in PLATOON services</td><td>Production forecasters GUIs for monitoring the forecasts</td></tr>
<tr><td>SCADA Operator</td><td>Human</td><td>Person involved in configuring and testing the PLATOON services</td><td>Production forecasters GUIs for monitoring the forecasts</td></tr>
<tr><td>SCADA/EMS (external)</td><td>Software Platform</td><td>The SCADA / EMS system collects data on current wind turbine production, generator status and current meteorological values from the wind farm.</td><td>IDS Connector needed</td></tr>
</table>

Actors			
Grouping		**Group description**	
Transmission		Transmission system control includes planning activities and activities in real-time, but also coordination of transmission system operators at the regional level and smart grids concept implementation.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
TSO	Organization	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring long-term ability of the system to meet reasonable demands of electricity.	EMS is the Serbian TSO; purchase or sale electricity on the SEE Market; is a founding member of SEEPEX, controls the SMM Electricity Block
TSO System Operator	Organization	A party that is responsible for a stable power system operation (including the organization of physical balance) through a transmission grid in a geographical area. The System Operator will also determine and be responsible for cross border capacity and exchanges. If necessary, he may reduce allocated capacity to ensure operational stability	TSO Control Block Operator. EMS is a Control Block Operator for Serbia, Montenegro and Macedonia
Balancing Service (optional)	PLATOON Service	‘balancing services’ means balancing energy or balancing capacity, or both; ‘balancing energy’ means energy used by TSOs to perform balancing and provided by a balancing service provider; ‘balancing capacity’ means a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract;	A service that complement and improves the existing balancing models needed, see
TSO IDS Connector	PLATOON Service	IDS Connector on the System Operator side	IDS Documentation**[8]**
SCADA Administrator	Human	Person involved in exporting data. Provides instructions for writing the interface services	Interfaces (IDS Connector)
Data Scientist	Human	Person responsible for development of analytical models integrated in PLATOON services	Collect data from different forecasters. Forecasts are also needed for building adequate grid models on weekly basis in accordance to Rules[9] on the release of key market data. See also Transmission System Maps[10]

SCADA Operator	Human	Person involved in configuring and testing the PLATOON services	Production forecasters GUIs for monitoring the forecasts
SCADA/EMS (external)	Software Platform	The SCADA / EMS system collects the required telemetry every 10 seconds, e.g. active power measurements of interconnecting power lines, active power measurements of production units, active power measurements of pumping and storage facilities, meteorological measurements	IDS Connector needed for PLATOON services to IMP SCADA/EMS.
Network Applications & State estimation (NA & SE) (external)	Simulation software	The goal of the service is to alert users (dispatchers and operational planners) of the system about current or potential problems in the network. Condition estimation is performed over a redundant set of process data collected in real time from the EES.	New approaches of modeling the network should be considered.
Imbalance Netting Optimization Module (INOM) (external)	Simulation software	Cross-border Electricity Balancing simulation software is joint tool for both INOM and mFRR platforms	This software solution was developed within “Technical Assistance to the Implementation of Cross-border Electricity Balancing” project for Energy Community Secretariat in Vienna. This project is devoted to analysis of gaps and benefits and defining of roadmaps for Western Balkans integration into European cross border balancing. Simulation software is used for demonstration and analysis of effects of cross border balancing processes
AGC/SMM Regulator (external)	System	Automatic Generation Control. A system for adjusting the power output of multiple generators at different power plants, in response to changes in the load.	Automatic Generation Control and Electricity Balance Regulator has an important role in regulating the frequency (50 Hz) and the exchange power across interconnectors in the exchange plan, see LLUC P-2a-02

Actors			
Grouping		**Group description**	
Distribution		Distribution System Operator. The entity responsible for: the distribution network planning and development; the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
SCADA/EMS (external)	Software Platform	The SCADA / EMS system collects the required telemetry every 10 seconds, e.g. active power measurements of interconnecting power lines, active power measurements of production units, active power measurements of pumping and storage facilities, meteorological measurements	Interfaces needed for PLATOON services to IMP SCADA/EMS. Currently, the SCADA / EMS system at the National Dispatcher Center (NDC)[11] provides supervision of the operation of the entire distribution system, i.e. 182 high-voltage substations of 110/ h kV owned by the ODS and the complete operation of energy facilities and networks of medium and low voltage in Serbia.

Actors			
Grouping		**Group description**	
Production		Production of energy at *photovoltaic power* plants	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Predictive maintenance library	PLATOON Service	Set of services that improve the predictive maintenance at RES power plant	E.g. The library will be used with PMU device and edge computing to test the performance of a PV power plant in Serbia
PE “Electric Power Industry of Serbia” (EPS)	Organization	Balancing Service Provider	E.g. EPS receives telemetry and production forecasts from plants
PV Plant SCADA system	System	System that monitors and controls a power plan	System to be used to test the Predictive maintenance scenario and for testing the ‘effects calculation’ service

Actors			
Grouping		**Group description**	
Market (out of scope)		The unique power exchange of trades for the actual delivery of energy that receives the bids from the Balance Responsible Parties that have a contract to bid. Determines the market energy price taking into account the technical constraints from the Transmission System Operator.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Energy Agency of the Republic of Serbia (AERS)	Organization	The Agency was established by the Energy Law as a regulatory body with competences covering electricity, natural gas, oil and oil product, and CHP heat energy sectors. By executing tasks assigned to it by the Energy Law, the Agency contributes to creation of a stable regulatory framework for the development of an efficient and sustainable energy sector that will be a strong backbone of the country's economic development.	Relevant for the enforcement of the law, and Serbian energy market functioning, see Report[12].
SEEPEX a.d. Beograd (SEEPEX)	Organization	Market operator for an organized electricity market/power exchange established in the form of partnership between A.D. EMS and EPEX SPOT as a joint stock company.	Marketplace.Companies[13] that are certified with valid license from AERS could participate on Organized electricity Market, no matter if they are domestic or foreign ones.
JSC Elektromreža, EMS	Organization	The Serbian TSO (EMS) acts as single buyer for balancing energy and activates balancing energy based on market bids given by Balancing Service Provider(s) on hourly level. EMS activates balancing energy from EPS Generation as well as from neighboring TSOs.	EMS coordinates the balancing integration plans related to SMM (Serbia – Macedonia - Montenegro)[14] Control Block.

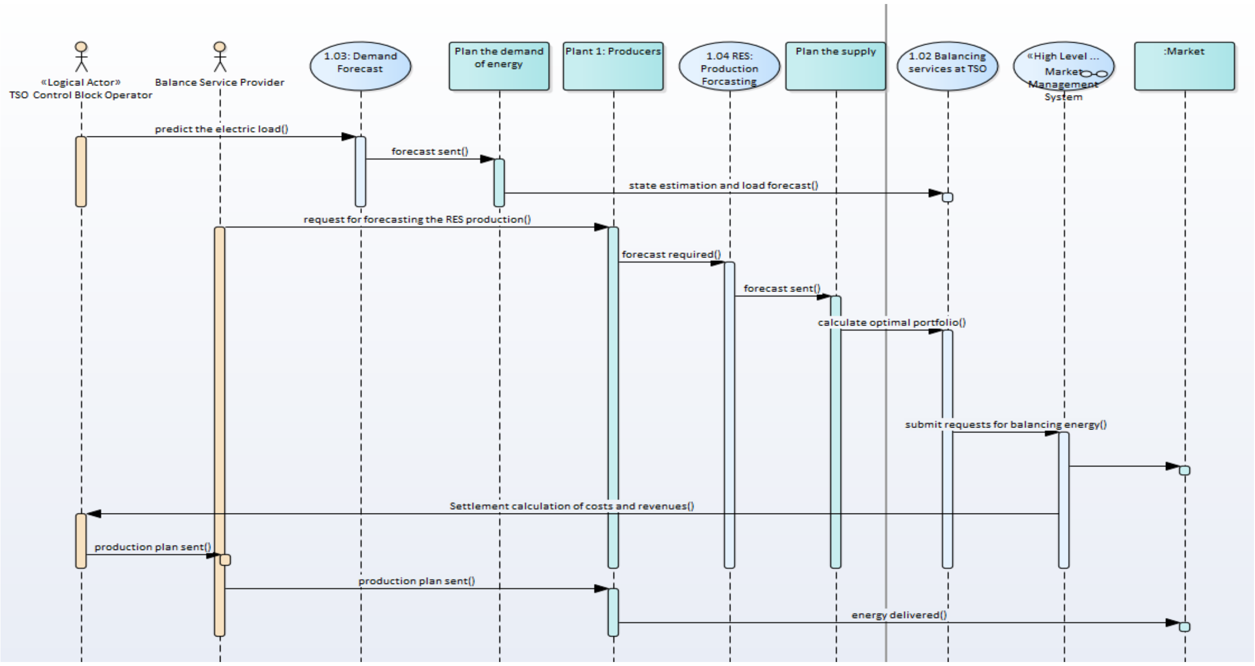
3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
	Project	"Technical Assistance to the Implementation of Cross-border Electricity Balancing"	Completed	Information / SW that can be consulted when defining the new services	„Elektromreža Srbije" and Institute Mihajlo Pupin	Link[15], Paper[16]

	Regulation	Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (Text with EEA relevance.) C/2017/7774	Published	Define the Legal framework	EU Commission	Link[17]
	Report	Renewable energy actions plans and reports	Published	Provide information about actors, -infrastructure and Energy Sector Development Strategy of the Republic of Serbia	The Ministry of Mining and Energy of the Republic of Serbia	Link[18], Link[19]
	Web site	Visualization on export / import of energy from neighboring countries, see Real time measurements	Published	Open data updated each 10 seconds	„Elektromreža Srbije“	Link[20]
	Web site	Description and capacities of the Transmission system in the Republic of Serbia	Published	Description that can be used in the Network Analysis and Smart Grid models	„Elektromreža Srbije“	Link[21]
	Website	Electricity balancing market in Serbia	Published	Energy & Power Generation Industry news from Serbia and markets of Balkans	Serbia Energy Magazine	Link[22]
	Web site	Research Data Manager	Published	Support data integration	Technische Informationsbibliothek (TIB)	Link[23]
	Web site	SANSA Analytical Tools	Published	Supports modeling	University of Bonn	Link[24]

4 Step by step analysis of use case

4.1 Overview of scenarios



Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
01	LLUC P-2a-03	Demand forecast on transmission level (day-ahead for Planning, four hours before delivery in the Operate phase)	TSO	Prepare load forecast	Historical data and other external data available	The forecast is generated and stored in Model Library
02	LLUC P-2a-04	RES (Wind generation) forecasters	BRP	Send bids	Metrological data, historical data and other external data available	The forecast is generated and stored in Model Library
03	LLUC P-2a-05	Effects of Renewable Energy Sources on the Power System (distribution level)	BRP	Calculate RES effects	Metrological data available	The effects are calculated

4.2 Steps-Scenarios

Scenario								
Scenario name:		**01 Balancing the Serbian Grid (Plan / Validate / Operate / Settle phases)** **02 Balancing on country level**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Send bids	1.02 Provide offers (bids) of power generation	TSO's receive bids from balance service providers (BSP's) within own control areas. [**plan**]	GET	BSP	TSO	I01-1 Bids	R01-1
02	Send local merit order lists	1.02 Balancing services at TSO	TSO's forward local merit order lists to regional balancing platform [**plan**]	REPORT			I02-1 Merit order lists	R02-1
03	Send CZC and ATC	1.02 Balancing services at TSO	TSO's forward cross zonal capacity (CZC) data in the form of the ATC's to regional balancing platform. [plan]	REPORT			I02-2 Cross zonal capacity	R02-2
04	Submit requests for balancing energy	1.02 Balancing services at TSO	TSO's submit requests for balancing energy [validate]	EXECUTE				
05	Find optimal combinations	1.01: Balancing in SMM Block	Central optimizing module finds optimal combinations of accepted bids and requests. Accepted bids, fulfilled TSO requests and cross-border exchanges are calculated (activation optimization function) [settle]	REPEAT			I02-3 Send production plan	R02-3

06	Set Settlement calculation of costs and revenues	1.02 Balancing services at TSO	Settlement calculation of costs and revenues between TSO's and BSP's [settle]	REPORT				

Scenario								
Scenario name:		**03 Load Demand forecast on transmission level**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Start Forecaster	Data uploaded	Receive data from different sources	GET	SCADA and other external sources	PLATOON service	I03-1 SCADA Load log	R03-1
							I03-2 Metrological Data	R03-2
							I03-3 Other external Data	R03-3
02	Transform datasets	Data integration	Data transformation and integration is run automatically or manually	CHANGE	PLATOON service	PLATOON service		
03	Run forecast	Run statistical / ML model	Run the Forecasters	EXECUTE	PLATOON service	PLATOON service		
04	Generate report	Produce the forecasting report	The Report will be created and send automatically	CREATE	PLATOON service	TSO Balancing service	I03-4 Load Forecast	R03-4
05	Verify the report	Report	User prepare the report for sending	REPORT	SCADA User	TSO Balancing service	I03-4 Load Forecast	R03-4

<table>
<tr><th colspan="9">Scenario</th></tr>
<tr><th colspan="3">Scenario name:</th><th colspan="6">04 RES forecasters</th></tr>
<tr><th>Step No.</th><th>Event</th><th>Name of process activity</th><th>Description of process/ activity</th><th>Service</th><th>Information-producer (actor)</th><th>Information receiver (actor)</th><th>Information ex-changed (IDs)</th><th>Requirement, R-IDs</th></tr>
<tr><td rowspan="3">01</td><td rowspan="3">Start Forecaster</td><td rowspan="3">1.04: Production (RES) Forecasting</td><td rowspan="3">Upload to PLATOON database</td><td rowspan="3">GET data</td><td rowspan="3">SCADA and other external sources</td><td rowspan="3">PLATOON service</td><td>I04-1 SCADA Production log</td><td>R04-1</td></tr>
<tr><td>I04-2 Metrological Data</td><td>R04-2</td></tr>
<tr><td>I04-3 Other external Data</td><td>R04-3</td></tr>
<tr><td>02</td><td>Transform datasets</td><td>1.04: Production (RES) Forecasting</td><td>Data from external sources is integrated</td><td>CHANGE</td><td>PLATOON service</td><td>PLATOON service</td><td></td><td></td></tr>
<tr><td>03</td><td>Run forecast</td><td>1.04: Production (RES) Forecasting</td><td>Start the Forecasting (automatic mode)
User start the Forecasting (manual)</td><td>EXECUTE</td><td>PLATOON service</td><td>PLATOON service</td><td></td><td></td></tr>
<tr><td>04</td><td>Generate report</td><td>1.04: Production (RES) Forecasting</td><td>User Visualize and explore the results (manual)</td><td>EXECUTE</td><td>PLATOON service</td><td>PLATOON service</td><td></td><td></td></tr>
<tr><td>05</td><td>Verify the report</td><td>1.04: Production (RES) Forecasting</td><td>Forecast is send to Balance Service Provider (automatic or manual mode)</td><td>REPORT</td><td>PLATOON service</td><td>Balance Service Provider</td><td>I04-4 Production Forecast</td><td>R04-4</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Scenario								
Scenario name:		**05 Effects of Renewable Energy Sources on the Power Distribution System**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Get data from all devices	Data integration	RES Effects Calculation receives updates from all PMUs and weather forecasts from DSO/retailer through the SCADA system.	GET	SCADA system	PLATOON service	I05-1 SCADA Production log	R05-1
02	Validate	Validation of input data	RES effects Calculation validates all necessary input data before calculations and may request for missing data.	EXECUTE	PLATOON service	PLATOON service		
03	Phasor based control	Computes phasor based control	Depend on the external trigger and availability of the RES control, the Edge computer calculates the new optimal state of RES from the current grid status.	EXECUTE	PLATOON service	PLATOON service		
04	Set new parameters	Set parameters of RES	Set optimized parameters to the RES. (e.g., change active and reactive of inverters)	REPEAT	PLATOON service	PLATOON service		
05	Compute KPI	Computes key performance indicators	RES Effects calculation computes KPI Improved RES integration from historical and current data.	EXECUTE	PLATOON service	PLATOON service		
	Prepare report	Send the report	Send the Effects Report for visualization in the consumer-oriented interface	REPORT	PLATOON service	SCADA system	I05-2 Effects Report	R05-2

1. Information exchanged

Data source			
ID - Info exchanged	**Data source**	**Description**	**Data Privacy**
I01-1	CSV file	Bids	
I02-1	CSV file	Merit order lists	
I02-2	CSV file	Cross zonal capacity	
I02-3	SCADA system	INOM module set the calculation, SCADA send production plan	
I03-1	SCADA system	SCADA Load log – Load telemetry and Historical data SCADA sends telemetry data to PLATOON service	no
I03-2	SCADA system	Metrological Data	
I03-3	External (TBD)	Other external Data	
I03-4	PLATOON service	Load forecast on transmission level (day-ahead for Planning, four hours before delivery in the Operate phase)	
I04-1	SCADA system	SCADA Production log SCADA sends telemetry data to PLATOON service for production forecast on level of Plant and Balance Responsible Party	
I04-2	SCADA system	Metrological Data	
I04-3	External (TBD)	Other external Data	
I04-4	PLATOON service	Production Forecast	
I05-1	SCADA system	SCADA Infrastructure and Production Performance log SCADA sends data for calculation of effects	
I05-2	PLATOON service	Effects Report Edge computing sends control data to SCADA to mitigate the effects	

Information exchanged			
ID - Info exchanged	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I03-1	SCADA Load log	SCADA Load log – Load telemetry and Historical data SCADA sends telemetry data to PLATOON service	R03-1
I03-2	Metrological Data	Metrological Data	R03-2
I03-3	Other external Data	Other external Data	R03-3
I03-4	Load forecast on transmission level	Load forecast on transmission level (day-ahead for Planning, four hours before delivery in the Operate phase)	R03-4
I04-1	SCADA Production log	SCADA Production log SCADA sends telemetry data to PLATOON service for production forecast on level of Plant and Balance Responsible Party	R04-1
I04-2	Metrological Data	Metrological Data	R04-2
I04-3	Other external Data	Other external Data	R04-3
I04-4	Production Forecast	Production Forecast	R04-4
I05-1	SCADA Infrastructure and Production Performance log	SCADA Infrastructure and Production Performance log SCADA sends data for calculation of effects	R05-1
I05-2	Effects Report	Effects Report Edge computing sends control data to SCADA to mitigate the effects	R05-2

2. Requirements

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
FR – Functional Requirements: The functional requirements specify the functions that the PLATOON platform and services should be able to perform such as *Data and Information Management, System/Service Integration, User Interactions,* and *System/Service Administration, Developing Analytical Services, Storing Statistical /ML models.*		
F.SG	Smart Grid High Level	High Level, Business Requirements related to the Energy Value Chain
F.INT	System/Service Integration	Information and Communication Technologies that support development of innovative, interoperable Smart Grid services
F.PLA	Platform Architecture	PLATOON ICT Platform. Evaluate, promote and adopt a flexible, cost-effective and unified Smart Grid architecture that enables efficient information exchange, and innovation and technology improvements over time;
F.PLSS	Platform specific use case related services /	Additional requirements linked to development and implementation of reusable components / services for the

	components	proposed scenarios
Requirement R-ID	**Requirement name**	**Requirement description**
R01-1	Bids format	Specify format for data exchange of bids
R02-1	Merit order lists	Specify format for data exchange of Merit order lists
R02-2	Cross zonal capacity	Specify format for data exchange of Cross zonal capacity
R02-3	Production plan	Specify format for data exchange of Production plan
R03-1	SCADA Load log	Specify format for data exchange of load data
R03-2	Metrological Data	Specify format for data exchange of metrological data relevant for demand load forecast
R03-3	Other Load/Demand related external data	Specify format for data exchange of other external data that might contain factors for load forecast
R03-4	Load Forecast	Specify format for data exchange of Load forecast
R04-1	SCADA Production log for Wind farms	Specify format for data exchange of production logs
R04-2	Metrological Data related to wind production	Specify format for data exchange of metrological data relevant for production forecast
R04-3	Other production related external data	Specify format for data exchange of other external data that might contain factors for wind production forecast
R04-4	Production forecast	Specify format for data exchange of production forecast
R05-1	SCADA Infrastructure and Production Performance log	Specify format for data exchange between SCADA and PMU
R05-2	Effects Report	Specify format for data exchange between SCADA and PMU

See Also requirement Table LLU-P-2a-01 to LLUC-p-2a-07

3. Common terms and definitions

definitions have been defined in the Commission Regulation 2017/2195[25]:

Common terms and definitions (Electricity Balancing)	
Term	**Definition**
(1)	‘balancing’ means all actions and processes, on all timelines, through which TSOs ensure, in a continuous way, the maintenance of system frequency within a predefined stability range as set out in Article 127 of Regulation (EU) 2017/1485, and compliance with the amount of reserves needed with respect to the required quality, as set out in Part IV Title V, Title VI and Title VII of Regulation (EU) 2017/1485;
(2)	‘balancing market’ means the entirety of institutional, commercial and operational arrangements that establish market-based management of balancing;
(3)	‘balancing services’ means balancing energy or balancing capacity, or both;
(4)	‘balancing energy’ means energy used by TSOs to perform balancing and provided by a balancing service provider;
(5)	‘balancing capacity’ means a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract;
(6)	‘balancing service provider’ means a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs;
(7)	‘balance responsible party’ means a market participant or its chosen representative responsible for its imbalances;
(8)	‘imbalance’ means an energy volume calculated for a balance responsible party and representing the difference between the allocated volume attributed to that balance responsible party and the final position of that balance responsible party, including any imbalance adjustment applied to that balance responsible party, within a given imbalance settlement period;
(9)	‘imbalance settlement’ means a financial settlement mechanism for charging or paying balance responsible parties for their imbalances;
(10)	‘imbalance settlement period’ means the time unit for which balance responsible parties' imbalance is calculated;
(11)	‘imbalance area’ means the area in which an imbalance is calculated;
(12)	‘imbalance price’ means the price, be it positive, zero or negative, in each imbalance settlement period for an imbalance in each direction;
(13)	‘imbalance price area’ means the area for the calculation of an imbalance price;
(14)	‘imbalance adjustment’ means an energy volume representing the balancing energy from a balancing service provider and applied by the connecting TSO for an imbalance settlement period to the concerned balance responsible parties, used for the calculation of the imbalance of these balance responsible parties;
(15)	‘allocated volume’ means an energy volume physically injected or withdrawn from the system and attributed to a balance responsible party, for the calculation of the imbalance of that balance responsible party;
(16)	‘position’ means the declared energy volume of a balance responsible party used for the calculation of its imbalance;
(17)	‘self-dispatching model’ means a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities are determined by the scheduling agents of those facilities;
(18)	‘central dispatching model’ means a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities, in reference to dispatchable facilities, are determined by a TSO within the integrated scheduling process;

(19)	‘integrated scheduling process’ means an iterative process that uses at least integrated scheduling process bids that contain commercial data, complex technical data of individual power generating facilities or demand facilities and explicitly includes the start-up characteristics, the latest control area adequacy analysis and the operational security limits as an input to the process;
(20)	‘integrated scheduling process gate closure time’ means the point in time when the submission or the update of integrated scheduling process bids is no longer permitted for the given iterations of the integrated scheduling process;
(21)	‘TSO-TSO model’ means a model for the exchange of balancing services where the balancing service provider provides balancing services to its connecting TSO, which then provides these balancing services to the requesting TSO;
(22)	‘connecting TSO’ means the TSO that operates the scheduling area in which balancing service providers and balance responsible parties shall be compliant with the terms and conditions related to balancing;
(23)	‘exchange of balancing services’ means either or both exchange of balancing energy and exchange of balancing capacity;
(24)	‘exchange of balancing energy’ means the activation of balancing energy bids for the delivery of balancing energy to a TSO in a different scheduling area than the one in which the activated balancing service provider is connected;
(25)	‘exchange of balancing capacity’ means the provision of balancing capacity to a TSO in a different scheduling area than the one in which the procured balancing service provider is connected;
(26)	‘transfer of balancing capacity’ means a transfer of balancing capacity from the initially contracted balancing service provider to another balancing service provider;
(27)	‘balancing energy gate closure time’ means the point in time when submission or update of a balancing energy bid for a standard product on a common merit order list is no longer permitted;
(28)	‘standard product’ means a harmonised balancing product defined by all TSOs for the exchange of balancing services;
(29)	‘preparation period’ means the period between the request by the connecting TSO in case of TSO-TSO model or by the contracting TSO in case of TSO-BSP model and the start of the ramping period;
(30)	‘full activation time’ means the period between the activation request by the connecting TSO in case of TSO-TSO model or by the contracting TSO in case of TSO-BSP model and the corresponding full delivery of the concerned product;
(31)	‘deactivation period’ means the period for ramping from full delivery to a set point, or from full withdrawal back to a set point;
(32)	‘delivery period’ means the period of delivery during which the balancing service provider delivers the full requested change of power in-feed to, or the full requested change of withdrawals from the system;
(33)	‘validity period’ means the period when the balancing energy bid offered by the balancing service provider can be activated, where all the characteristics of the product are respected. The validity period is defined by a start time and an end time;
(34)	‘mode of activation’ means the mode of activation of balancing energy bids, manual or automatic, depending on whether balancing energy is triggered manually by an operator or automatically in a closed-loop manner;
(35)	‘divisibility’ means the possibility for a TSO to use only part of the balancing energy bids or balancing capacity bids offered by the balancing service provider, either in terms of power activation or time duration;
(36)	‘specific product’ means a product different from a standard product;
(37)	‘common merit order list’ means a list of balancing energy bids sorted in order of their bid prices, used for the activation of those bids;
(38)	‘TSO energy bid submission gate closure time’ means the latest point in time when a connecting TSO can forward the balancing energy bids received from a balancing service provider to the activation optimisation function;
(39)	‘activation optimisation function’ means the function of operating the algorithm applied to optimise the activation of balancing energy bids;
(40)	‘imbalance netting process function’ means the role to operate the algorithm applied for operating the

	imbalance netting process;
(41)	‘TSO-TSO settlement function’ means the function of performing the settlement of cooperation processes between the TSOs;
(42)	‘capacity procurement optimisation function’ means the function of operating the algorithm applied for the optimisation of the procurement of balancing capacity for TSOs exchanging balancing capacity.
(43)	‘TSO-BSP model’ means a model for the exchange of balancing services where the balancing service provider provides balancing services directly to the contracting TSO, which then provides these balancing services to the requesting TSO;
(44)	‘contracting TSO’ means the TSO that has contractual arrangements for balancing services with a balancing service provider in another scheduling area;
(45)	‘requesting TSO’ means the TSO that requests the delivery of balancing energy.

LLUC-P-2a-07: Predictive maintenance in RES power plants

1.Use case description

1.1 Name of use case

Use case identification		
ID	**Area Domain(s)/Zone(s)**	**Name of use case**
#2a-2	Production	Predictive Maintenance

1.2 Version management

Version management				
Version no.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.1	11/05/2020	V. Janev	Initial creation (General description with integration profiles)	Draft
0.2	20/05/2020	V. Janev. M. Batić	UML Definition of Scenarios for Mid-term Review	Draft
0.3	27/05/2020	V. janev, A. Ćampa	Input for Predictive maintenance Use Case	Draft
0.4	04/06/2020	V. Janev	Requirements specification	Draft

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Predictive maintenance in RES power plants
Objective(s)	Test and deploy intelligent services delivered by PLATOON for the following purposes: • Analysis of performance of power plant • Predicting component failures to increase the power plant efficiency. • Making recommendation for corrective and predictive maintenance of the components •Implementation of IDS Connectors for the Balance Responsible Party (BRP) •Real-time integration and big data analysis upon the high-volume data streams from SCADA/EMS
Related business case(s)	•

1.4 Narrative of Use Case

Narrative of use case
Short description
The continuous monitoring of asset performance generates input that can be used for predictive analytics and to provide early warnings of component/object failures (e.g. RES plant/component). Identifying problems before they occur helps to reduce unscheduled downtime, improve plant maintenance and optimize asset performance. In this Use case we propose to design, develop and test a set of machine learning algorithms to perform predictive maintenance of power plant infrastructure. Machine learning techniques (e.g. Support vector machine and logistic regression algorithms) have been used to explore and compare rare events that could occur in power plant infrastructure. Additionally, by monitoring the output from the RES power plant using the PMU unit and doing advanced power quality (PQ) analytics close to the source, events can be detected and labeled. By gradually creating a database of events by learning from historical data, one could use this classification to find abnormal functioning of the system before it leads to failure.
Complete description
The work will be divided into the following activities: • Analyze power plant functionalities and produce advanced PQ analytics from the sensor data (collected by IMP SCADA and PMU unit); • Establish a database of events (historical data) to be used for machine learning; • Apply and optimize machine learning algorithms to support early detection of abnormalities; • Development of IDS connectors for data exchange between the edge computing service and IMP SCADA; • Development of an interface for integration of external data collected from different sources (e.g. metrological data) to the predictive maintenance service; • Development of edge computing service; • Testing the edge computing service and PMU unit provided by ComSence with the photovoltaic power plant at IMP campus. • Continuous improvement of PLATOON analytical services and its integration with IMP SCADA.

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI-8	Saving costs	The installation of the machine learning algorithm for detection of abnormal behavior shall reduce the maintenance costs.	LLUC P-2a-07
KPI-9	Increased stability	Increased degree of stability in the real power plant operation.	LLUC P-2a-07

1.6 Use case conditions

Use case conditions
Assumptions
PMU delivered to IMP on time to collect data from IMP SCADA
Prerequisites
IDS connects exist

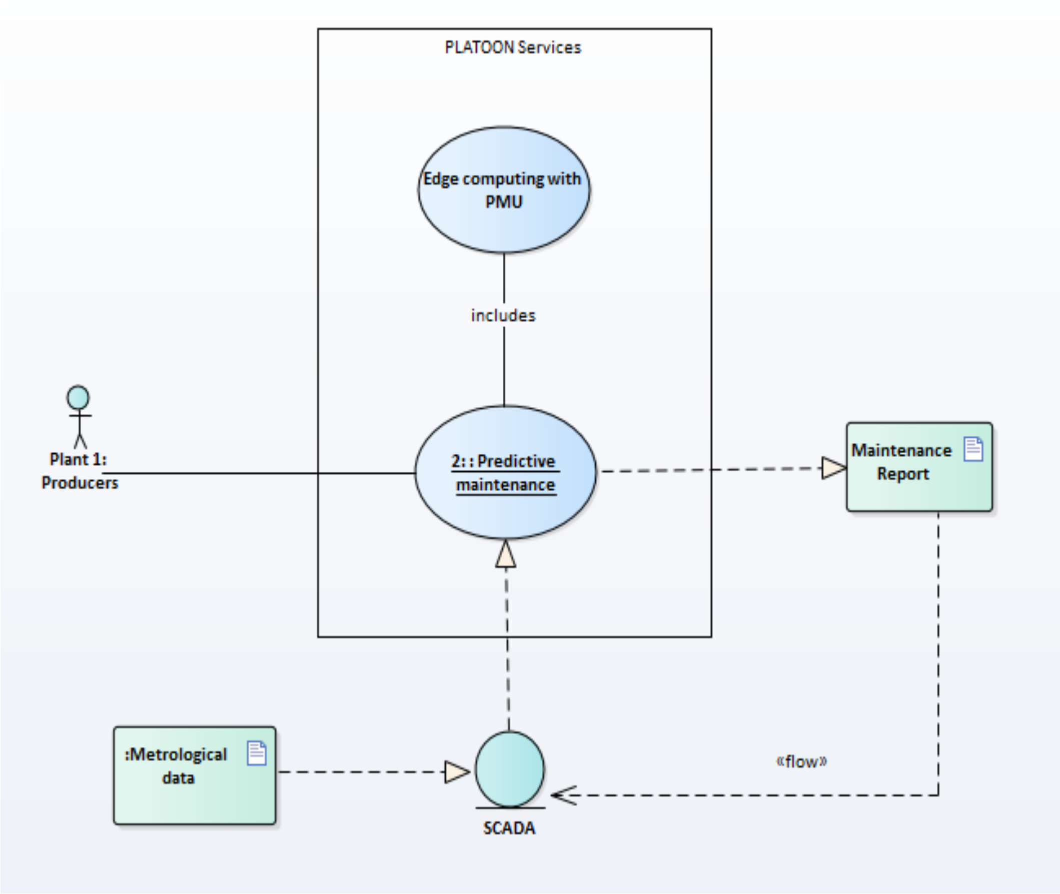
Use case conditions
Assumptions
SCADA system collects also metrological data Standard interfaces exist for integration of CS PMU and IMP SCADA.

1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Pilot #1a Predictive Maintenance of Wind Farms
Level of depth
Detailed Use Case.
Prioritization
See Table 2. Scenarios Prioritization.
Generic, regional or national relation
National.
Nature of the use case
Technical system.
Further keywords for classification
Predictive maintenance.

2.Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics



3 Technical details

3.1 Actors

See below the list of actors (Actors related to LLUC-2a-01- LLUC-2a-07)

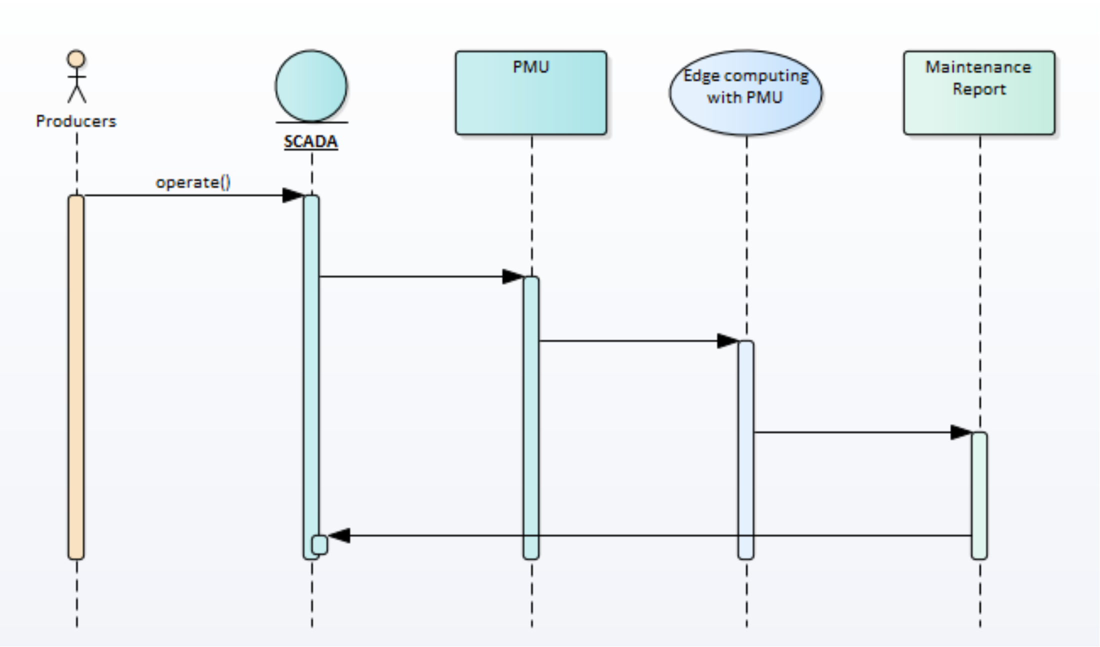
3.2 References

References						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/ organization***	***Link***
1	Product description	QMiner		Improve predictive maintenance	ComSensus	https://www.comsensus.eu/analytics.html

4 Step by step analysis of use case

4.1 Overview of scenarios

Step by step description is presented as a UML sequence diagram followed by a written description.



Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
01	LLUC P-2a-07	Predictive maintenance	Predictive maintenance service	PMU detects decrease in performance / production	PMU constantly monitors and receives signals from SCADA	Send information to Edge processing unit to generate event and send the event to SCADA
02	LLUC P-2a-07	Edge processing	Edge processing unit	Receive information from PMU	Edge processing has a IDS connector to IMP SCADA	The message has been written to SCADA database

4.2 Steps-Scenarios

Scenario								
Scenario name:		**07 Predictive maintenance in RES power plants**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Get data from all devices	Edge computing	Edge computing receives real-time streaming data from PMUs and predictive maintenance gets weather forecasts from DSO/retailer through the SCADA system.	GET	SCADA and PMU	PLATOON service	I07-1 Streaming data from PMUs	R07-1
							I07-2 Weather forecasts	R07-2
							I07-3 Other SCADA related Data	R07-3
02	Validate input data	Predictive maintenance	Predictive maintenance validates all necessary input data before calculations and may request for missing data.	EXECUTE	PLATOON service	PLATOON service		
03	Evaluates the forecasted data with generation forecast	Predictive maintenance	Predictive maintenance processes the incoming data, make comparison with existing data and create suitable Maintenance Report if anomalies are detected.	EXECUTE	PLATOON service	PLATOON service		
04	Send report	Predictive maintenance Report	Generates a visual report and sent it to the service user and SCADA.	REPORT	PLATOON service	SCADA	I07-4 Report	R07-4

5 Information exchanged

Data source			
ID - Info exchanged,	**Data source**	**Description**	**Data Privacy**
I07-1	SCADA and PMU	Real-time streaming data from PMUs and weather forecasts from DSO/retailer through the SCADA system.	no
I07-2	SCADA system	Weather forecast	
I07-3	Other SCADA data (TBD)	Other data	
I07-4	PLATOON service	Maintenance Report (Parameters that points to malfunctioning or decrease of performance)	

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I07-1	SCADA log	Real-time streaming data from PMUs and weather forecasts from DSO/retailer through the SCADA system.	R03-1
I07-2	Weather forecast	Weather forecast	R03-2
I07-3	Other Data	Other data	R03-3
I07-4	Maintenance Report	Maintenance Report (Parameters that points to malfunctioning or decrease of performance)	R03-4

5 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
FR – Functional Requirements: The functional requirements specify the functions that the PLATOON platform and services should be able to perform such as *Data and Information Management, System/Service Integration, User Interactions,* and *System/Service Administration, Developing Analytical Services, Storing Statistical /ML models.*		
F.SG	Smart Grid High Level	High Level, Business Requirements related to the Energy Value Chain
F.INT	System/Service Integration	Information and Communication Technologies that support development of innovative, interoperable Smart Grid services
F.PLA	Platform Architecture	PLATOON ICT Platform. Evaluate, promote and adopt a flexible, cost-effective and unified Smart Grid architecture that enables efficient information exchange, and innovation and technology improvements over time;
F.PLSS	Platform specific use case related services / components	Additional requirements linked to development and implementation of reusable components / services for the proposed scenarios
Requirement R-ID	**Requirement name**	**Requirement description**
R07-1	SCADA log for Predictive maintenance	Specify format for data exchange between SCADA, PMU and Edge computing service
R07-2	Weather forecast	Specify format for data exchange of metrological data relevant for demand load forecast
R07-3	Other Data	Specify format for data exchange of other SCADA data that help assess the heath status
R07-4	Maintenance Report	Specify format for data exchange between S Predictive maintenance service and SCADA

7. Common terms and definitions

Common Terms and Definitions (Predictive maintenance)	
Term	**Definition**
Predictive maintenance	Predictive maintenance techniques are designed to help determine the condition of in-service equipment in order to estimate when maintenance should be performed. This approach promises cost savings over routine or time-based preventive maintenance, because tasks are performed only when warranted. Wikipedia
PMU	A phasor measurement unit (PMU) or synchrophasor is a device which measures the electrical waves on an electricity grid, using a common time source for synchronization. A PMU can measure 50/60 Hz AC waveforms (voltages and currents) typically at a rate of 48 samples per cycle (2880 samples per second for 60Hz systems).

Actors related to LLUC-2a-01- LLUC-2a-07

Actors			
Grouping		**Group description**	
Production		Renewable Energy Production consists of distributed energy generation resources	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Balancing Service Provider	Organization	A market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs.	PE "Electric Power Industry of Serbia" (EPS), see LLUC P-2a- 02 Balancing the Serbian Grid, LLUC P-2a- 04 (RES forecasters), LLUC P-2a-05
Production forecasters (RES-PF)	PLATOON Service	Forecasting in the Smart Grid the production from renewable sources	Reliable and accurate production forecast service needed. The services provide different forecasts (e.g. 4-hours, 1 day, 4 days), see LLUC P-2a-04
BRP IDS Connector	PLATOON Service	IDS Connector on the side of Balance Responsible Parties	IDS Documentation[26]
SCADA Administrator	Human	Person involved in exporting data. Provides instructions for writing the interface services	Interfaces (IDS Connector)
Data Scientist	Human	Person responsible for development of analytical models integrated in PLATOON services	Production forecasters GUIs for monitoring the forecasts
SCADA Operator	Human	Person involved in configuring and testing the PLATOON services	Production forecasters GUIs for monitoring the forecasts
SCADA/EMS (external)	Software Platform	The SCADA / EMS system collects data on current wind turbine production, generator status and current meteorological values from the wind farm.	IDS Connector needed

Actors	
Grouping	**Group description**
Transmission	Transmission system control includes planning activities and activities in real-time, but also coordination of transmission system operators at the regional level and smart grids concept implementation.

Actor name	Actor type	Actor description	Further information specific to this use case
TSO	Organization	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring long-term ability of the system to meet reasonable demands of electricity.	EMS is the Serbian TSO; purchase or sale electricity on the SEE Market; is a founding member of SEEPEX, controls the SMM Electricity Block
TSO System Operator	Organization	A party that is responsible for a stable power system operation (including the organization of physical balance) through a transmission grid in a geographical area. The System Operator will also determine and be responsible for cross border capacity and exchanges. If necessary, he may reduce allocated capacity to ensure operational stability	TSO Control Block Operator. EMS is a Control Block Operator for Serbia, Montenegro and Macedonia
Balancing Service (optional)	PLATOON Service	‘balancing services’ means balancing energy or balancing capacity, or both; ‘balancing energy’ means energy used by TSOs to perform balancing and provided by a balancing service provider; ‘balancing capacity’ means a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contract;	A service that complement and improves the existing balancing models needed, see
TSO IDS Connector	PLATOON Service	IDS Connector on the System Operator side	IDS Documentation[26]
SCADA Administrator	Human	Person involved in exporting data. Provides instructions for writing the interface services	Interfaces (IDS Connector)
Data Scientist	Human	Person responsible for development of analytical models integrated in PLATOON services	Collect data from different forecasters. Forecasts are also needed for building adequate grid models on weekly basis in accordance to Rules [27]on the release of key market data. See also Transmission System Maps[28]
SCADA Operator	Human	Person involved in configuring and testing the PLATOON services	Production forecasters GUIs for monitoring the forecasts
SCADA/EMS (external)	Software Platform	The SCADA / EMS system collects the required telemetry every 10 seconds, e.g. active power measurements of interconnecting power lines, active power measurements of production units, active power measurements of pumping and storage facilities, meteorological measurements	IDS Connector needed for PLATOON services to IMP SCADA/EMS.

Network Applications & State estimation (NA & SE) (external)	Simulation software	The goal of the service is to alert users (dispatchers and operational planners) of the system about current or potential problems in the network. Condition estimation is performed over a redundant set of process data collected in real time from the EES.	New approaches of modeling the network should be considered.
Imbalance Netting Optimization Module (INOM) (external)	Simulation software	Cross-border Electricity Balancing simulation software is joint tool for both INOM and mFRR platforms	This software solution was developed within "Technical Assistance to the Implementation of Cross-border Electricity Balancing" project for Energy Community Secretariat in Vienna. This project is devoted to analysis of gaps and benefits and defining of roadmaps for Western Balkans integration into European cross border balancing. Simulation software is used for demonstration and analysis of effects of cross border balancing processes
AGC/SMM Regulator (external)	System	Automatic Generation Control. A system for adjusting the power output of multiple generators at different power plants, in response to changes in the load.	Automatic Generation Control and Electricity Balance Regulator has an important role in regulating the frequency (50 Hz) and the exchange power across interconnectors in the exchange plan, see LLUC P-2a-02

Actors			
Grouping		**Group description**	
Distribution		Distribution System Operator. The entity responsible for: the distribution network planning and development; the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
SCADA/EMS	Software	The SCADA / EMS system collects the required	Interfaces needed for

(external)	Platform	telemetry every 10 seconds, e.g. active power measurements of interconnecting power lines, active power measurements of production units, active power measurements of pumping and storage facilities, meteorological measurements	PLATOON services to IMP SCADA/EMS. Currently, the SCADA / EMS system at the National Dispatcher Center (NDC)[29]provides supervision of the operation of the entire distribution system, i.e. 182 high-voltage substations of 110/ h kV owned by the ODS and the complete operation of energy facilities and networks of medium and low voltage in Serbia.

Actors			
Grouping		**Group description**	
Production		Production of energy at *photovoltaic power* plants	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Predictive maintenance library	PLATOON Service	Set of services that improve the predictive maintenance at RES power plant	E.g. The library will be used with PMU device and edge computing to test the performance of a PV power plant in Serbia
PE “Electric Power Industry of Serbia” (EPS)	Organization	Balancing Service Provider	E.g. EPS receives telemetry and production forecasts from plants
PV Plant SCADA system	System	System that monitors and controls a power plan	System to be used to test the Predictive maintenance scenario and for testing the ‘effects calculation’ service

Actors			
Grouping		**Group description**	
Market (out of scope)		The unique power exchange of trades for the actual delivery of energy that receives the bids from the Balance Responsible Parties that have a contract to bid. Determines the market energy price taking into account the technical constraints from the Transmission System Operator.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Energy Agency of the Republic of Serbia (AERS)	Organization	The Agency was established by the Energy Law as a regulatory body with competences covering electricity, natural gas, oil and oil product, and CHP heat energy sectors. By executing tasks assigned to it by the Energy Law, the Agency contributes to creation of a stable regulatory framework for the development of an efficient and sustainable energy sector that will be a strong backbone of the country's economic development.	Relevant for the enforcement of the law, and Serbian energy market functioning, see Report[30].
SEEPEX a.d. Beograd (SEEPEX)	Organization	Market operator for an organized electricity market/power exchange established in the form of partnership between A.D. EMS and EPEX SPOT as a joint stock company.	Marketplace. Companies[31] that are certified with valid license from AERS could participate on Organized electricity Market, no matter if they are domestic or foreign ones.
JSC Elektromreža, EMS	Organization	The Serbian TSO (EMS) acts as single buyer for balancing energy and activates balancing energy based on market bids given by Balancing Service Provider(s) on hourly level. EMS activates balancing energy from EPS Generation as well as from neighboring TSOs.	EMS coordinates the balancing integration plans related to SMM (Serbia – Macedonia - Montenegro)[32] Control Block.

Requirements related to LLUC-2a-01- LLUC-2a-07

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
FR – Functional Requirements: The functional requirements specify the functions that the PLATOON platform and services should be able to perform such as *Data and Information Management, System/Service Integration, User Interactions,* and *System/Service Administration, Developing Analytical Services, Storing Statistical /ML models.*		
F.SG	Smart Grid High Level	High Level, Business Requirements related to the Energy Value Chain

F.INT	System/Service Integration	Information and Communication Technologies that support development of innovative, interoperable Smart Grid services
F.PLA	Platform Architecture	PLATOON ICT Platform. Evaluate, promote and adopt a flexible, cost-effective and unified Smart Grid architecture that enables efficient information exchange, and innovation and technology improvements over time;
F.PLSS	Platform specific use case related services / components	Additional requirements linked to development and implementation of reusable components / services for the proposed scenarios
NFR– Non-functional Requirements: The non-functional requirements refer to future PLATOON platform and services “quality” features like *Performance*, *Usability, Scalability, Security, IT standards*, etc.		
N.PER	Smart Grid Efficiency, Reliability and Resiliency	“Grid Efficiency, Reliability and Resiliency” encompasses key capabilities that will improve and optimize the performance, reliability, power quality and operational efficiency of the power grid.
N.USE	Workforce Efficiency	Usability of applications that improve Workforce Efficiency
N.INT	Interoperability	Requirements related to specific interfaces that would allow an easy integration of PLATOON services with IMP SCADA VIEW 4 system and IMP tools
N.SEC	Security	Security on data exchange or data access level
Requirement R-ID	**Requirement name**	**Requirement description**
F.SG-1	Flexibility	Flexibility relates to the ability of the power system to manage changes in real time management of the value chain across suppliers, active networks, meters, customers and corporate systems. International Smart Grid Action Network (ISGAN)[33], a framework created by the International Energy Agency (IEA), categorizes flexibility needs in four categories: Flexibility for Power, Flexibility for Energy, Flexibility for Transfer Capacity, Flexibility for Voltage.
F.SG -2	Distributed Energy Resource Integration	The DER Integration encompasses key capabilities that will increase and improve integration and interconnection services that facilitate the use of fair and affordable DER while maintaining grid stability, reliability, efficiency and safety.
F.SG -3	Innovative services	Develop, implement and maintain highly reliable information systems and smart technologies that meet the future needs of a Smart Grid that supports market demand and prosumer choice;
F.INT-1	Timely massive data processing and analysis	Implement scalable solutions that promote efficient processing and storage of data to enable timely access to information for planning, modelling and simulations;

F.INT-2	Secured, interconnected and efficient network communications	Develop and implement services/components/connectors that provide connectivity across the power grid and enable the operation of an interconnected and integrated network of networks for transmission, sub-station, field and customer communications.
F.INT-3	SCADA-PMU Integration	Specify format for data exchange
F.INT-4	Edge computing - SCADA Integration	Specify format for data exchange
F.PL-1	Open Standards	The PLATOON platform must be based on open standards (as much as possible).
F.PL-2	Data models	Standardized data models for storing and managing data (CIM data model, JSON structures) shall be used.
F.PL-3	Modular	PLATOON platform should be designed according principles of modularity, scalability and interoperability.
F.PL-4	Interoperability and security	PLATOON Services shall have appropriate interfaces for working with SCADA systems and securely exchange data with operational facilities
F.PL-5	Interoperability	PLATOON shall have suitable interface to balancing market platform
F.PL-6	Deployment	Products should be able to run in the cloud and to be deployed locally at stakeholder site.
F.PLSS -1	Grid state estimation	Service shall perform grid state estimation
F.PLSS -2	Load Demand Forecasters	Forecasters shall provide Deterministic and probabilistic forecasts of peak demand in very short (hourly), short (daily) and weekly prognosis.
F.PLSS -3	RES Forecasters	Forecaster library should offer different methods (classical statistical techniques, computational intelligent methods, and hybrid algorithms)
F.PLSS -4	Imbalance volume forecaster	Service shall be able to forecast the system imbalance volume
F.PLSS -5	Real-time visibility and utility control of grid assets	Implement automation at multiple layers of the power grid to increase visibility, utility control and performance of grid assets;
F.PLSS -6	Proactive and timely grid data analysis and modelling	Provide granular data analytics that support proactive modelling and understanding of the various factors that must be considered to make prudent investments in the power grid that meet customers’ future energy needs;
NFR– Functional Requirements: The non-functional requirements refer to future PLATOON platform and services “quality” features like *Performance*, *Usability, Interoperability, Scalability, Security, IT standards*, etc.		
N.PER -1	Smart Grid reliability	Increase power grid reliability by adopting and expanding smart technologies that can predict/prevent/reduce outages and align with standards
N.PER -2	Smart Grid self-	Anticipation and response to system disturbances (self-heal);

	healing	
N.PER -3	Reduce line losses and increase power grid capacity and efficiency	Implement technologies that provide the capability to reduce line losses and increase power grid capacity and efficiency; Voltage quality levels are affected by the increased use of distributed generation and different electronic devices (inverters, battery chargers, energy saving lamps)
N.USE -1	Fully automate manual processes	Increase workforce safety by automating manual tasks and/or confirmation of no back feed of power on a line.
N.USE -2	Smart process automation	Increase safety by reducing and mitigating opportunities for operating errors via automated process steps and the use of smarter tools
N.USE -3	Re-focus work force resources on critical tasks	Increase workforce productivity via the use of remote control and auto-sensing devices that can automate recurring processes and allow skilled workforce resources to focus on critical and complex tasks that require manual intervention.
N.USE -4	Real-time visibility and control	The system should allow real-time visibility and control of the energy value chain (e.g., customer, energy company and / or aggregator).
N.SEC-1	Automated and enhanced grid resiliency	Implement security and outage management measures that improve power grid resiliency, protect against cyber attacks and can with stand natural disasters. Resilience against attack and natural disaster (cyber security).

LLUC- P-2b- 01: Predictive Maintenance for MV/LV Transformers

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
UC-2B-01	Distribution	Predictive Maintenance for MV/LV Transformers

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
1	30.04.2020	Pau J. Cortés Forteza	Including information of UC-2B-01 and UC-2B-02	Draft
2	08.05.2020	Mikel Fernandez	Information of UC-2B-01 and UC-2B-02 split in two use case description documents. Added actor and scenario description	Draft
3	12.05.2020	Mikel Fernandez	Added use case diagram	Draft
4	22.05.2020	Pau J. Cortés Forteza	Added scenario steps	Draft
5	25.05.2020	Pau J. Cortés Forteza	scenario steps modification (n.1)	Draft
6	25.05.2020	Pau J. Cortés Forteza	scenario steps modification (n.2)	Draft
7	03.06.2020	Fernando Merino	Comment unification	Draft
8	04.06.2020	Erik Maqueda	Added additional information in section 3.8.	Draft.
9	07.06.2020	Mikel Fernandez	Revised scenario definition	Draft
10	08.06.2020	Mikel Fernandez	Revised requirements and information exchanged	Draft
1.0	08.06.2020	Mikel Fernandez	Final version	Final

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	This UC will 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.
Objective(s)	The objective of this use case is to develop a predictive maintenance tool for LV/MV transformers, this tool will use available data in this kind of installations or installing new sensors considering the small budget normally used in LV/MV transformers. To develop this tool, Sampol´s smart grid in ParcBit, Majorca (Spain) will be under study. Maintenance actions are based in the Remaining Useful Life (RUL), in this project, different failures modes of the transformer critical components will be estimated and reflected to the health index of the transformer. Once it is obtained the health index and considering maintenance and failure costs, the transformer maintenance plan will be defined. Finally, a prescriptive analytics tool will be developed. This tool will allow to evaluate the effect of different operational actions in the grid O&M cost sheet.
Related business case(s)	Maintenance actions in small transformer are very often not sufficient or inefficient due to the low price of the transformers compared to the maintenance costs, therefore in one hand many maintenance actions are taken only when a fail occur with the consequent expenses, on the other hand many maintenance actions are taken too early in time, replacing components that could work for further time. How to plan maintenance actions in small transformers is struggling DSO because of their low budget and the uncertainty of fails. The tools developed in this UC can be an opportunity for maintenance companies to plan their actions more efficiently. In order to be economically feasible the developed tool must minimize the required monitoring equipment costs (sensors, gateways…) and labor costs while ensuring a high accuracy and maintaining the of the quality of the service.

1.4 Narrative of Use Case.

Narrative of use case
Short description
To supervise the operation of distribution transformers, new sensors will be installed and new algorithms and models will be developed, which will be tested in some distribution transformers in an distribution grid in Parc Bit (Mallorca). This infrastructure will be used to estimate operation variables, estimate the health index of the critical components of the transformer, optimize the transformer maintenance plan, support grid upgrade decision making process and generate predictive alarms.
Complete description
The UC tasks starts at the beginning of 2020 gathering information available from the pilot. Once it is clear all available information, it will be defined the new sensors and the new equipment needed to develop the scenarios defined in this low level use case. During the first year of the project, these new sensors and equipment will be installed, and all the data will be stored in a local database for posterior processing. Data required will be sent to the PLATOON platform following the project defined reference architecture and using the developed Data Governance modules and Data Analytics Toolbox. Furthermore, the state-of-the-art on the assessment of transformer failures due to aging and the use of data science on transformers will be studied.

Functional, non-functional and data requirements for the transformer management platform will be defined, following an approach in which different scenarios will be defined as sequence of steps which include internal functions and information exchange between the different actors that interact in the use case.

All the data gathered will be analyzed (including data cleaning and preprocessing, and labelization) and maintenance logs will be checked for Identification of faulty periods. The monitoring system will be analyzed so as to be able to minimize the needs of new sensor installation in the future operation of the transformers, avoiding the over-monitoring of the transformer and limiting the cost of the transformer performance management system.

Starting in 2020 and during the second year of the project, the following functionalities will be developed:

- Variable estimation: Virtual sensors will be developed to estimate some variables associated to the operation of the transformer. These variables can be measured installed extra physical sensors and their associated monitoring infrastructure, but distribution transformers are equipment which cost is very limited and it makes no sense to try to optimize their maintenance with a new methodology that requires the utilization of new sensoring devices which are not cost effective. The aim is to develop virtual sensors associated for instance to magnitudes like the top oil temperature, which has a high correlation with the hot spot temperature which is the key facto on insulation aging, and to the load factor, which could be profiled with measurements coming from the AMI infrastructure of the connection points downstream the transformer.
- Health monitoring: The Remaining Useful Life (RUL), and its associated health index, of the transformer critical components will be calculated based on the standards that are currently applied (as the IEEE C57.19.100 and IEC 60076-7). The health index of these components will be used to calculate the health index of the transformer, for different failure modes, due to aging in working conditions.
- Maintenance planning: The information derived from the health monitoring functionality will be used to optimize the default maintenance plan provided by the transformer manufacturer based on preventive maintenance, so that the real aging of the transformer depending on its particular utilization will be used to tailor its maintenance plan to both minimize the cost and the probability of a failure. Furthermore, considering the maintenance costs and the health index, maintenance actions will be suggested.
- Asset operation optimization: A model which simulates the effect of different operational actions in the grid O&M cost will be developed. This model will provide support to the investment plan, based on the simulation of the effect of new distribution conditions on the transformer operation costs, being able to assess for instance if it is more convenient to add an extra transformer in a congested feeder with an expected rise of demand or to replace it once its decreased useful life has ended dus to the accelerated aging process on overload conditions.
- Predictive analysis: In order to detect transformer failures, from historical data (oil temperature, load, performance…), it will be determined patterns and link among parameters defining its normal values. and triggering an alarm if they are out of the ordinary values.

All these functionalities, will be implemented in a transformer management platform which will show all data relevant for maintenance, implementing and validating the information provided by the tools developed within this pilot. This will be an interface with the maintenance engineer which will help to plan maintenance actions.

In the last year of the project, all tools will be fit and adjust to the stakeholders needs, their advantages will be evaluated using Sampol´s large scale pilot data and compared to any alternative in the market and different business models will be studied.

Sampol is the owner of the pilot, all the field actions will be executed by Sampol. Sampol will be responsible of the pilot data management, stablishing a local data base, giving access to the data to the partners and the PLATOON platform when required. Sampol will participate in the development of the different tool from a practical and technical side.

Tecnalia will lead the development of the Oil Temperature and RUL estimation within the health monitoring part and will participate in the development of the models for predictive monitoring, maintenance planning and asset operation optimization.

Indra will lead the tasks related to interface management platform. Besides, Indra will participate together with Sampol and Tecnalia in the development of the different tools listed above (i.e. health monitoring, predictive monitoring, maintenance planning and asset operation optimization).

1.5 Key performance indicators (KPI).

Key performance indicators (Virtual sensor)			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
01	Temperature estimation accuracy (%)	Hourly temperature accuracy estimation based on estimated temperature (ET) and actual (measured) temperature (AT) for top oil: (ET-AT)/AT (%)	

Key performance indicators (Predictive)			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
01	True positives (TP)	Number of anomalies detected with early warnings and confirmed with a corrective work order	
02	False positives (FP)	Early warnings with no associated corrective work order	
03	False negatives (FN)	Corrective work order without a previous early warning	
04	True Negatives (TN)	No early warning and no work order	
05	Specificity (%)	Proportion of true negatives relative to all negative cases (TN/(TN+FP))	
06	Sensitivity (%)	Proportion of actual positives correctly identified (TP/(TP+FN))	
07	Cohen's Kappa (%)	Measurement of matches in the predictive tool discounting the probability of randomly matching	
08	Savings (€)	Cumulative measurement of savings associated to True Positives considering: a) Avoided breakdown consequences + b) Downtime cost	
09	Additional Costs (€)	Increased costs due to maintenance activities associated to False Positives. They should be subtracted from Savings to get the net value.	
10	Anticipation time (days)	For each True Positive it represents the delta Time between the moment of detection and the time of failure	

Key performance indicators (Asset Health)			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
01	Risk decrease (€)	Risk decrease comparing risk-based maintenance supported by the tool to the ordinary preventive maintenance (equal maintenance expenditure is assumed in both cases)	
02	Maintenance cost savings (€)	Maintenance cost savings comparing risk-based maintenance supported by the tool to the ordinary preventive maintenance (equal risk level is assumed in both cases)	
03	Useful Life Extension (years)	Based on the estimation of the RUL (Remaining Useful Time) it indicates the achievable extension of life relative to that indicated by the manufacturer	

1.6 Use case conditions.

Use case conditions
Assumptions
The application of the studies to be carried out in this pilot is LV/MV transformers. Even though several sensors will be studied to evaluate the actual health of the transformer, the tools to be developed will take in consideration that this application has a very small budget for installing sensors and even for maintenance actions. The DSO is authorized to use the smart meter data to provide the services defined, but data will be anonymized, and it cannot disclose the data to third parties. All the tools are focus on decreasing maintenance costs, however reliability of the service will remain at the same level.
Prerequisites
The Mallorca pilot has 10 transformers installed with VPN connection taking electrical data every hour. Three different transformers are going to be used for the UC studies: - A new transformer installed in 2019 - A new transformer to be installed in 2020 - An old transformer (installed in 2001)

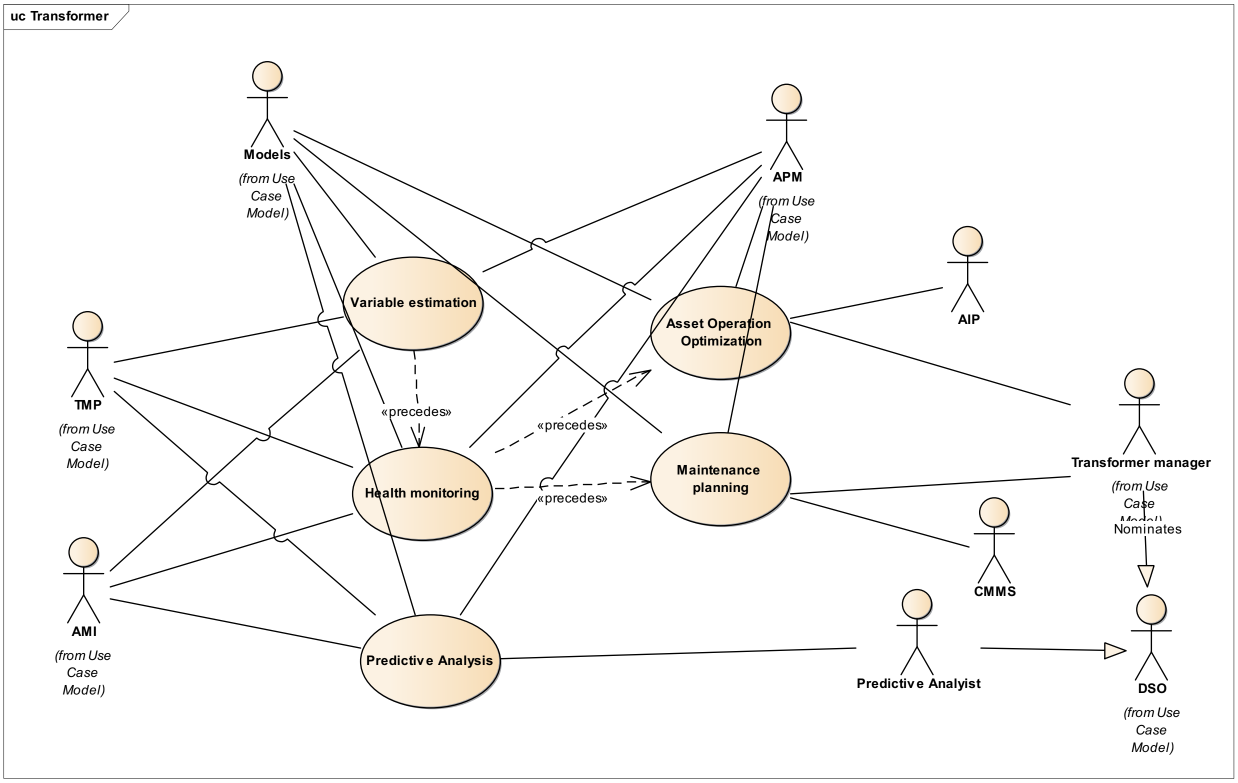
1.7 Further information to the use case for classification / mapping.

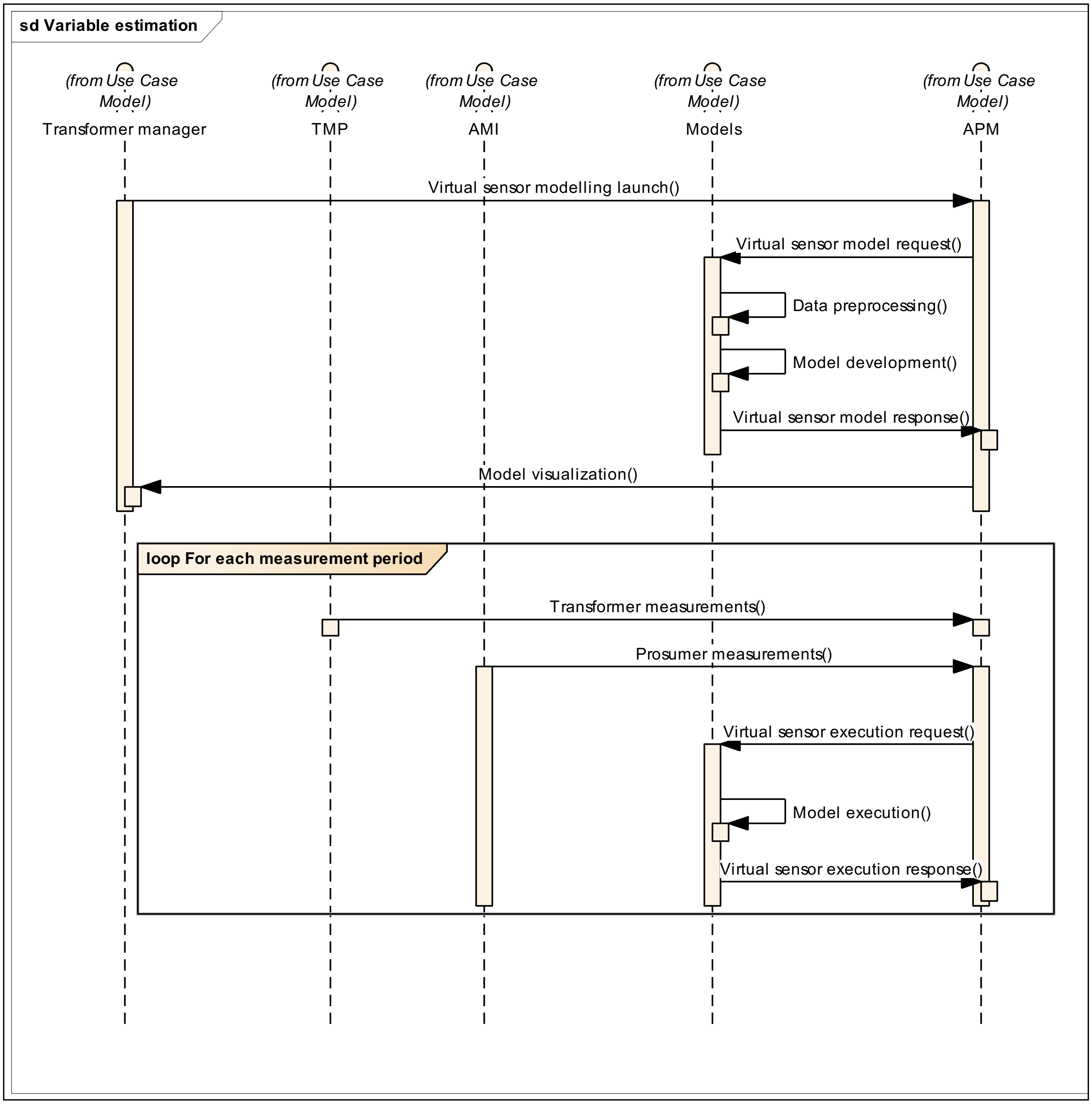
Classification information
Relation to other use cases
It is related to UC-1A-01, UC-2B-02, UC-3B-01, UC-3B-02 and UC-3C-02 in the application of predictive analysis to assess the condition of assets while in operation.
Level of depth
This document defines the functional specification of the use cases, the scenarios that have been identified, the actors and the interactions between them in terms of information flow. No specific requirements or mentions to the software architecture is detailed.
Prioritization
Mandatory.
Generic, regional or national relation
The studies carried out in UC-2B-01 are applicable to any distribution grid with ONAN transformers from medium to low voltage, however, it will be studied the extrapolation to any MV/LV transformer.
Nature of the use case
The focus of the Use Cases will be technical, developing tools to solve maintenance problematic. Afterwards, these tools will be studied in terms of new business models may arise.
Further keywords for classification
Smart grid, predictive maintenance, machine learning, power distribution system, asset health, RUL

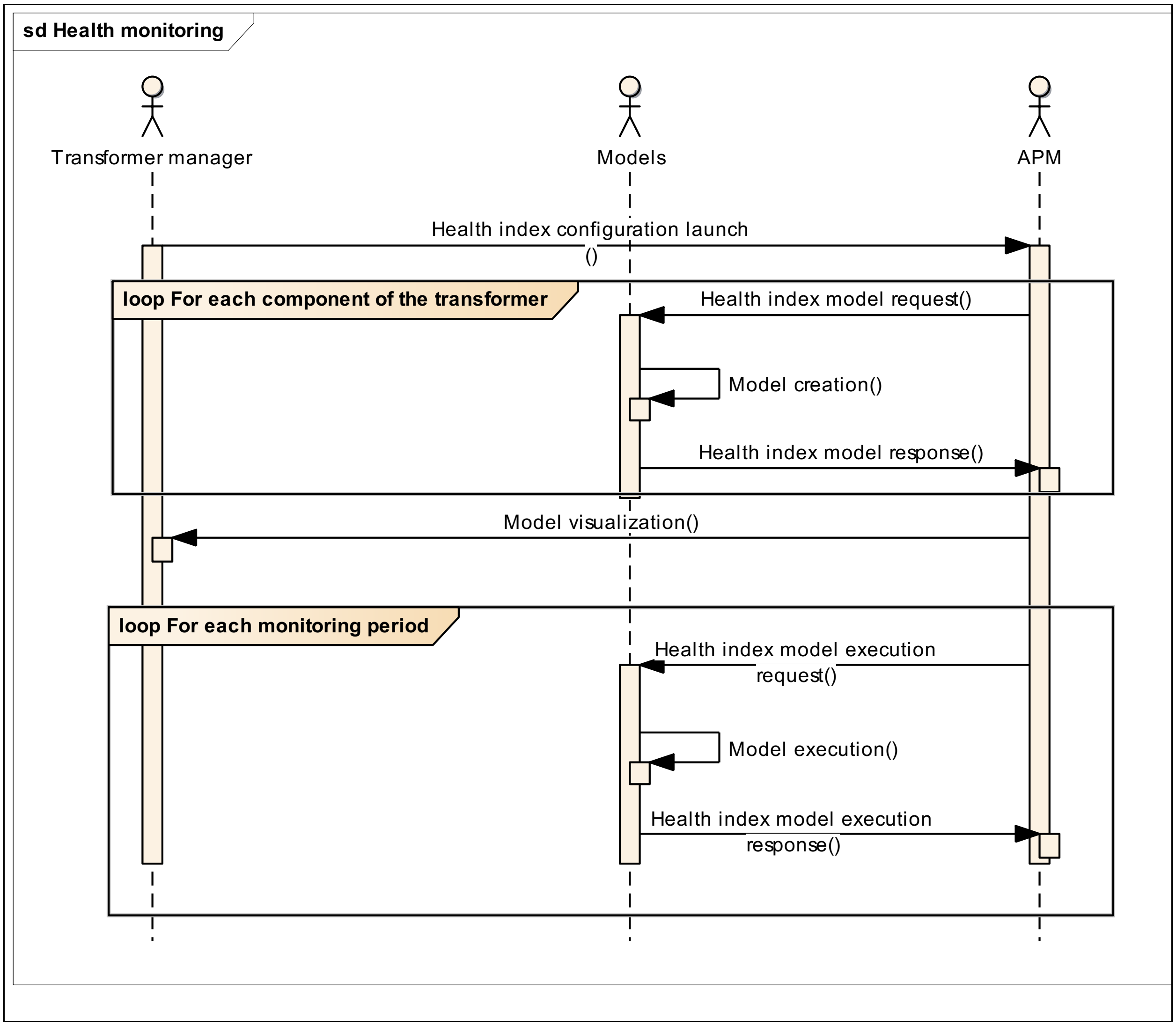
1.8 General remarks.

General remarks
The objective of the use cases defined in this document revolve around the discipline known as APM (*Asset Performance Management*), a part together with EAM (*Enterprise Asset Management*) and AIP (*Asset Investment Planning*) of the general Asset Management strategy in a company. The aim of APM is basically the monitoring and follow-up of the operation of industrial assets using the technical data (instrumentation measurements) with the objective of assessing the true condition of the equipment without interfering in their operation. This assessment of the asset condition is the basis for setting up effective maintenance strategy initiatives thus reducing the impact of maintenance cost and unnecessary facility downtime. The use of models to emulate virtual sensors is also one of the objectives of these Use Cases. Beyond being able to get information from unreachable or unmeasured locations, the results of the sensor emulation will later be used in the predictive analysis and asset health estimations thus improving their accuracy and sensitivity.

2. Diagrams of use case.

Diagram(s) of use case



sd Variable estimation
(from Use Case Model)
Transformer manager
(from Use Case Model)
TMP
(from Use Case Model)
AMI
(from Use Case Model)
Models
(from Use Case Model)
APM
Virtual sensor modelling launch()
Virtual sensor model request()
Data preprocessing()
Model development()
Virtual sensor model response()
Model visualization()
loop For each measurement period
Transformer measurements()
Prosumer measurements()
Virtual sensor execution request()
Model execution()
Virtual sensor execution response()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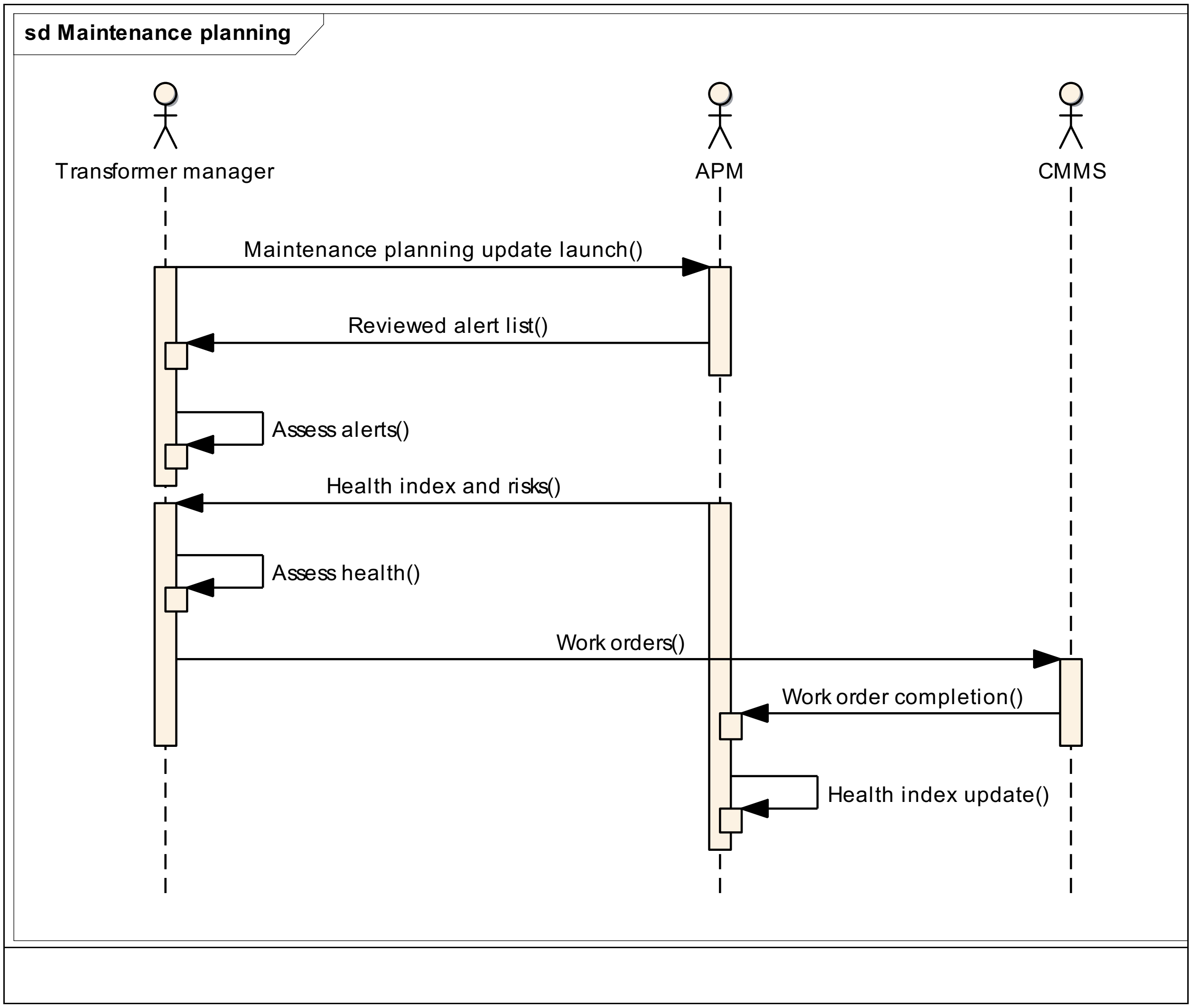
Transformer manager
Models
APM
Health index configuration launch ()
loop For each component of the transformer
Health index model request()
Model creation()
Health index model response()
Model visualization()
loop For each monitoring period
Health index model execution request()
Model execution()
Health index model execution response()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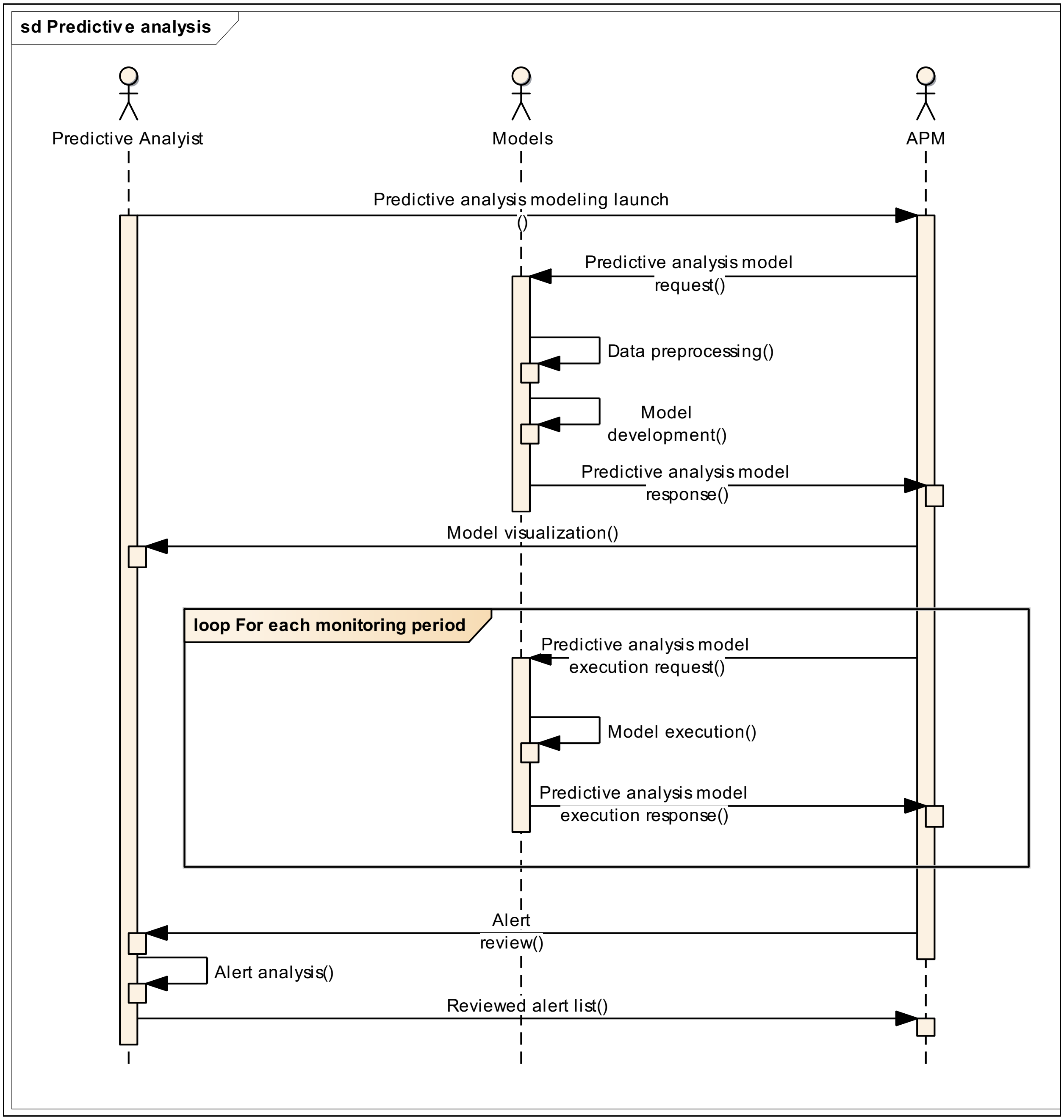
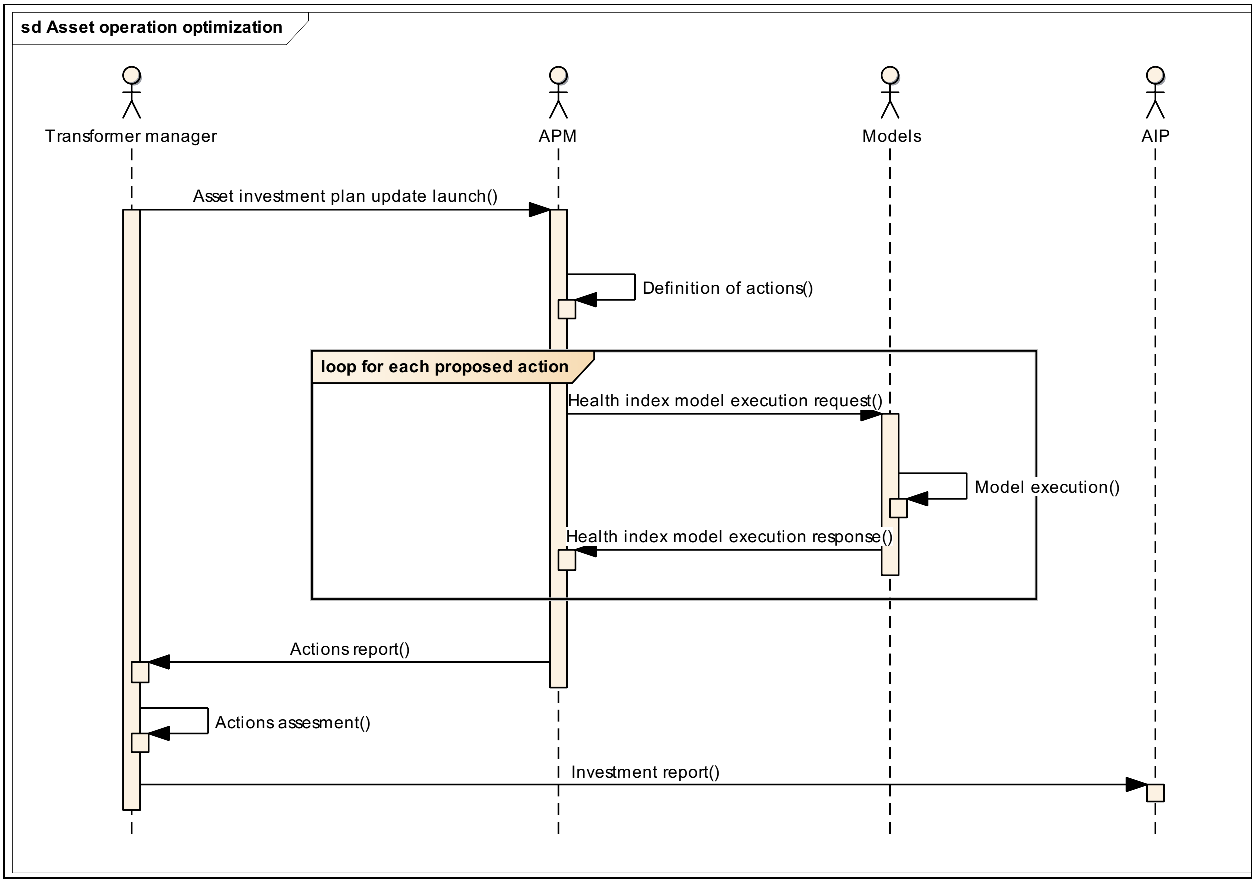
Transformer manager
APM
CMMS
Maintenance planning update launch()
Reviewed alert list()
Assess alerts()
Health index and risks()
Assess health()
Work orders()
Work order completion()
Health index update()


sd Predictive analysis
Predictive Analyist
Models
APM
Predictive analysis modeling launch ()
Predictive analysis model request()
Data preprocessing()
Model development()
Predictive analysis model response()
Model visualization()
loop For each monitoring period
Predictive analysis model execution request()
Model execution()
Predictive analysis model execution response()
Alert review()
Alert analysis()
Reviewed alert list()



3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
Measurement infrastructure		Measurement infrastructure installed at the transformer, the transformation center-CT and the distribution grid downstream the CT.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
TMP	System	Transformer Measurement Platform-TMP composed by the i) Internal sensor, ii) External temperature sensors, iii) LV electrical meter, iv) MV electrical meter and v) Measurement Gateway	• The internal sensor provided by the transformer manufacturer which measures the top oils temperature, the oil pressure and the oil level, and sends the readings to a controller which is considered to

			be a part of the internal sensor itself. • The external temperature sensors are wireless sensors installed on the outer surface of the transformer tank and the inner and outer part of the CT. • The LV electrical meter is the electrical measurement device connected to the secondary circuit of the transformer • The MV electrical meter is the electrical measurement device connected to the primary circuit of the transformer. • The Measurement Gateway is the device which forwards the measurements from the internal sensor, the temperature sensors and the MV and LV electrical meters to the APM, and it is the only device which communicates with the other actor defined in this LLUC
AMI	System	Automatic Metering Infrastructure-AMI, which includes i) the smart meters and ii) the Neighborhood Network Access Point-NNAP.	The NNAP concentrates all the measurements of the smart meters all the consumers (or prosumers) connected downstream the CT. This equipment is also known as data concentrator.

Actors	
Grouping	**Group description**
Information systems	Information management platforms

Actor name	Actor type	Actor description	Further information specific to this use case
APM	System	Asset Performance Management-APM system: data integration, transformer predictive model, health index methodology, risk index, maintenance optimization capabilities, etc.	Onesait APM, by Indra/Minsait
Models	Application	Models needed in APM to assess the aging of the transformer critical components. In principle we consider these models: • Top oil temperature model (virtual sensor) • Hot spot temperature model (virtual sensor) • Isolation aging model (health index model) • Dielectric aging model (health index model) • • Predictive analysis model	It could be implemented based on Model as a Service-MaaS, which is an external model to APM, but which is integrated in its task queue. For instance, in this use case we consider initially a MaaS to estimate the top oil temperature
APM	System	Asset Performance Management-APM system: data integration, transformer predictive model, health index methodology, risk index, maintenance optimization capabilities, etc.	Onesait APM, by Indra/Minsait
AIP	System	Asset Investment Planning	
CMMS	System	Computerized Maintenance Management System	

Actors			
Grouping		**Group description**	
Other actors		Actors not included in other categories	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
DSO	Company	Distribution System Operator	Actor not directly involved in the (technical) use case, but needed in the business use case. Played by Sampol.
Transformer manager	Person	Person which duty is to use the Asset Management Platform, which include tasks as to i) supervise the operation	Defined by the DSO, Sampol

		and maintenance of the transformer, ii) realize the maintenance plan of the transformer and iii) optimize the transformer infrastructure investment plan	
Predictive analyst	Person	Person which duty is to use the Asset Management Platform to review the alert list generated by the predictive analysis	Defined by the DSO, Sampol
Prosumers	Person or Company	Party connected to the DSO distribution grid, which consumes energy.	ParcBit companies, not involved in this use case

3.2 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
1	Standard	IEEE 1538-2000 " IEEE Guide for Determination of maximum Winding Temperature Rise in Liquid-Filled Transformers"	Final	Physical model for isolation aging assessment	IEEE	https://ieeexplore.ieee.org/document/863650
2	Standard	IEC 60076-7:2018 Power transformers - Part 7: Loading guide for mineral-oil-immersed power transformers	Final	Physical model for isolation aging assessment	IEC	https://webstore.iec.ch/publication/34351

4. Step by step analysis of use case.

4.1 Overview of scenarios.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Variable estimation	Acquisition of both physical and virtual measurements by the APM	Models	On demand (model creation), periodic execution (model execution)	Measurement infrastructure has to be up and running.	Measurements are available at the APM

2	Health monitoring	Assessment of the transformer health/risk index calculated with the health index of the critical components of the transformer.	Models	On demand (model creation), periodic execution (model execution)	1. Measurements are available at the APM. 2. The models needed for the assessment of the transformer health index must have been built and validated.	The transformer manager is informed on the health index and the RUL of the transformer, and of its dielectric and isolation
3	Maintenance Planning	Optimization of the transformer maintenance plan.	Transformer manager	Periodic execution	1. Health index calculations are available 2. The cost of each possible maintenance action is known 3. Alerts from the predictive analysis could have been received	The optimized maintenance plan based on minimum budget or maximum risk decrease is updated in the CMMS.
4	Asset operation optimization	Optimization of the grid transformers investment plan.	Transformer manager	Periodic execution	4. Health index model can be executed with different simulated utilization profiles 5. The cost of each possible maintenance action is known	The investment plan on new transformer assets is updated
5	Predictive analysis	Anticipated fault detection using physical or virtual sensor data by means of AI algorithms.	Predictive analyst	On demand (model creation), periodic execution (model execution)	A historical database of transformer operation is available to train the model	Potential failures are investigated and assessed to make decisions regarding asset maintenance.

4.2 Steps-Scenarios.

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).

Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new “sub” use case, then referring to that “subroutine” in this scenario.

Scenario								
Scenario name:		**No. 1 –** Variable estimation						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	On demand by the transformer manager	Virtual sensor modelling launch	The transformer manager initiates the functionality to create a virtual sensor	CREATE	Transformer manager	APM	I1-01	Fc-1-01
02		Virtual sensor model request	The APM issues a model request, forwarding all the necessary information for the model development	GET	APM	Model	I1-02	Fc-1-02
03		Data preprocessing	Cleaning and processing of the input dataset	EXECUTE	Model	Model		
04		Model development	Creation of the virtual sensor model	EXECUTE	Model	Model		

05		Virtual sensor model response	The model results are forwarded to the APM	REPORT	Model	APM	I1-03	
06		Model visualization	The APM shows the results of virtual sensor modelling to the NTL manager	REPORT	APM	Transformer manager	I1-03	Fc-1-03
07	For each measurement period	Transformer measurements	Delivery of measurements of the transformer i) Internal sensor, ii) External temperature sensors, iii) LV electrical meter, iv) MV electrical meter	REPORT	TMP	APM	I1-04	Fc-1-04
08		Prosumer measurements	Delivery of measurements of the consumption of the prosumers downstream the transformer	REPORT	AMI	APM	I1-05	Fc-1-04
09		Virtual sensor model execution request	The APM issues a model execution request for each virtual sensor	GET	APM	Model	1-01	
10		Model execution	Execution of the virtual sensor	EXECUTE	Model	Model		
11		Virtual sensor model execution response	The model results are forwarded to the APM	REPORT	Model	APM	1-06	Fc-1-04

Scenario								
Scenario name:		**No. 2 –** Health monitoring						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
01	On demand by the transformer manager	Health index configuration launch	The transformer manager initiates the functionality to configure the health index calculation for a certain transformer	CREATE	Transformer manager	APM	I2-01	Fc-1-01
02	For each component of the transformer	Health index model request	The APM issues a model request for each critical component of the transformer for which is possible to create an aging model, forwarding all the necessary information for the model development	GET	APM	Model	I2-02 I1-02	Fc-2-01
03		Model creation	Creation of the model, which could be an analytical model (based on physical laws), data driven or a hybrid of both approaches	EXECUTE	Model	Model		

04		Health index model response	The model results are forwarded to the APM	REPORT	Model	APM	I2-03	
05		Model visualization	The APM shows the results of the modelling to the NTL manager, at the transformer level	REPORT	APM	Transformer manager	I2-03	Fc-1-03
06	For each monitoring period	Health index model execution request	The APM issues a health index model execution request	GET	APM	Model	I2-01 I1-04 I1-05 I1-06	
07		Model execution	Execution of the model	EXECUTE	Model	Model		
08		Health index model execution response	The model results are forwarded to the APM	REPORT	Model	APM	I2-04	

<table>
<tr><th colspan="9">Scenario</th></tr>
<tr><td colspan="2">Scenario name:</td><td colspan="7">No. 3 – Maintenance planning</td></tr>
<tr><th>Step No.</th><th>Event</th><th>Name of process activity</th><th>Description of process/ activity</th><th>Service</th><th>Information-producer (actor)</th><th>Information receiver (actor)</th><th>Information ex-changed (IDs)</th><th>Requirement, R-IDs</th></tr>
<tr><td>01</td><td>On demand by the transformer manager</td><td>Maintenance planning update launch</td><td>The transformer manager initiates the functionality to update the</td><td>CREATE</td><td>Transformer manager</td><td>APM</td><td>I2-01</td><td>Fc-1-01</td></tr>
</table>

			maintenance plan of a transformer					
02		Reviewed alert list	The transformer manager gets the reviewed alert list from the APM	REPORT	APM	Transformer manager	I5-04	Fc-3-01
03		Assess alerts	The transformer manager analyses the reviewed alert list generated by the predictive analysis	EXECUTE	Transformer manager	Transformer manager		
04		Health index and risks	The transformer manager gets the health index and risk information	REPORT	APM	Transformer manager	I2-04	Fc-3-01
05		Assess health	The transformer manager analyses the health index and risk information generated by the health monitoring	EXECUTE	Transformer manager	Transformer manager		
06		Work orders	The work orders derived from the assessment of alerts or risks are sent to the CMMS	CREATE	Transformer manager	CMMS	I3-01	Fc-3-02
07		Work order completion	Once the work orders have been completed, a report is sent from the CMMS to the APM	REPORT	CMMS	APM	I3-02	Fc-3-03
08		Health index update	Health index is updated with the information coming from the completed work orders	UPDATE	APM	APM	I3-03	Fc-3-04

Scenario								
Scenario name:		**No. 4 –** Asset operation optimization						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	On demand by the transformer manager	Asset investment plan update launch	The transformer manager initiates the functionality to define the optimal grid investments in future scenarios. The transformer manager has to define these scenarios	CREATE	Transformer manager	APM	I4-01	Fc-1-01 Fc-4-01
02		Definition of actions	Depending on the scenario conditions entered by the transformer manager, a set of possible investments are proposed (for instance, the installation of a new transformer in a feeder)	EXECUTE	APM	APM	I4-02	Fc-3-01
03	For each proposed action	Health index model execution request	The APM issues a health index model execution request	GET	APM	Model	I2-01 I1-04 I1-05 I1-06	

04		Model execution	Execution of the model	EXECUTE	Model	Model		
05		Health index model execution response	The model results are forwarded to the APM	REPORT	Model	APM	I2-04	
06		Actions report	A report with the result of the estimated effect of each proposed action is sent to the transformer manager	REPORT	APM	Transformer manager	I4-03	Fc-4-02
07		Actions assessment	Transformer manager decides which action should be the one to be executed	EXECUTE	Transformer manager	Transformer manager		Fc-4-03
08		Investment report	A report with the assessment of the actions is sent to the investment management system	REPORT	Transformer manager	AIP	I4-04	

Scenario	
Scenario name:	**No. 5 –** Predictive Analysis

Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	On demand by the predictive analyst	Predictive analysis modeling launch	The predictive analyst initiates the functionality to create a predictive analysis model	CREATE	Predictive analyst	APM	I2-01	Fc-5-01
02		Predictive analysis model request	The APM issues a model request, forwarding all the necessary information for the model development	GET	APM	Model	I1-02 I5-01	Fc-5-02
03		Data preprocessing	Cleaning and processing of the input dataset	EXECUTE	Model	Model		
04		Model development	Creation of the predictive analysis model	EXECUTE	Model	Model		
05		Predictive analysis model response	The model results are forwarded to the APM	REPORT	Model	APM	I5-02	
06		Model visualization	The APM shows the results of virtual sensor modelling to the predictive analyst	REPORT	APM	Predictive analyst	I5-02	Fc-1-03

07	For each monitoring period	Predictive analysis model execution request	The APM issues a predictive analysis model execution request	GET	APM	Model	I2-01	
08		Model execution	Execution of the model	EXECUTE	Model	Model		
09		Predictive analysis model execution response	The model results are forwarded to the APM	REPORT	Model	APM	I5-03	
10	Analyst starts daily analysis	Alert review	The analyst checks the status of APM alerts daily	GET	APM	Predictive analyst	I5-03	Fc-5-03
11	There are alerts which potentially can result in future asset failures	Alert analysis	Analyst investigates alerts	EXECUTE	Predictive analyst	Predictive analyst	I	
12		Reviewed alert list	Alerts are forwarded to the APM to be considered by the transformer manager in the Maintenance planning scenario	REPORT	Predictive analyst	APM	I5-04	

5. Information exchanged.

Information exchanged, ID	Name of information	Description of information ex- changed
I1-01	Virtual sensor identifier	Identifier of the virtual sensor.
I1-02	Physical sensor historic measurements	Measurements needed to create the virtual sensor model, related to all variables which would have a correlation with the estimated variable and to the physical sensor to which a virtual image will be modeled.
I1-03	Virtual sensor model creation results	Information related to the validation of the virtual sensor model created.
I1-04	Transformer sensor current measurements	Measurements from the TMP about the last measurement period
I1-05	Smart meter current measurements	Measurements from the AMI about the last measurement period
I1-06	Virtual sensor current estimation	Estimation from a virtual sensor about the last measurement period
I2-01	Transformer identifier	Identifier of the transformer.
I2-02	Transformer component health index model parameters	Set of parameters needed to create the health index model of a component of the transformer.
I2-03	Transformer component health index model creation results	Information related to the validation of the transformer component health index model created.
I2-04	Health Index and Risk information	Asset cards containing information will be displayed.
I3-01	Work orders associated to the alerts potentially ending up in failure	Work orders sent to the CMMS
I3-02	Maintenance results	List of completed maintenance activities to be fed back to APM
I3-03	Asset health index updates	Updated health and risk indexes for those assets in which maintenance activities have been performed
I4-01	Simulation scenario parameters	Parameters that define a future simulation scenario. Could be related for instance to the expected increase of consumption or generation in a certain section of the distribution grid.
I4-02	Grid upgrade action list	List of possible actions that would be assessed to upgrade the grid in the context of the defined scenario.
I4-03	Effect action list	Report with the expected effect of a list of grid upgrade actions.

I4-04	Investment list	Report with the assessment of the investments which should be accomplished in the studied simulation scenario.
I5-01	Virtual sensor historic estimations	Historic estimations from virtual sensors
I5-02	Predictive analysis model creation results	Information related to the validation of the predictive analysis model created.
I5-03	Alert list	List of potential failures as determined by the predictive algorithm based on the instrument information being read on-line
I5-04	Identification of alerts that potentially can result in asset failure and produce a pre-diagnostic	Filtering and pre-diagnostics on the alerts generated by the system with the analyst criteria

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Fc	Functional	Functional requirements that the modules developed for the use case (APM and models) have to comply with
Requirement R-ID	**Requirement name**	**Requirement description**
Fc-1-01	Access to APM platform	The Transformer manager will access APM
Fc-1-02	Virtual sensor model creation	The Transformer manager will be able to create the model of a virtual sensor
Fc-1-03	Model creation result visualization	The Transformer manager will be able to view the results of the model creation process
Fc-1-04	APM measurement storage	APM will be able to store measurements
Fc-2-01	Transformer component health index model creation	The Transformer manager will be able to create the health index model of a transformer component
Fc-3-01	Maintenance task optimization	Several maintenance scenarios will be analyzed depending on the catalogue of available maintenance tasks

Fc-3-02	Connection to CMMS	The Transformer manager can access the CMMS to transfer the final set of maintenance activities once he has reviewed and approved them
Fc-3-03	CMMS connection to APM	CMMS will interface with APM Module Asset Health as the maintenance activities are being completed
Fc-3-04	Health index update based on maintenance actions	Health indexes and risk indexes will be updated for those assets/components where the maintenance activities have been performed
Fc-4-01	Simulation scenario definition	The transformer manager will be able to define future scenarios using the APM
Fc-4-02	Actions report	The transformer manager will be able to get a report with the assessment of the proposed maintenance tasks
Fc-4-03	Actions selection	The transformer manager will be able to select the actions that will be executed in the investment plan
Fc-5-01	Access to APM platform	The Predictive analyst manager will access APM
Fc-5-02	Predictive analysis model creation	The Predictive analyst will be able to create a predictive analysis model
Fc-5-03	Generation of alerts based on predictive analysis	Predictive algorithm analyzing on-line information read from the asset instrumentation will raise alerts whenever significant deviations are detected following some built-in persistence rules. These alerts initiate a work flow where several users will be able to manage the whole process

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Pr	Performance	Non-functional requirements related to scalability and performance
Requirement R-ID	**Requirement name**	**Requirement description**
PR-01	Scalability	The APM has to be scalable to potentially cover the analysis of the whole grid of a DSO, and the consumers connected to it. The grid will be composed of a collection of sub grids, each composed by a MV substation connected to HV, to which there are a collection of connected MV prosumers and CTs (in meshed configuration), and from each CT there is a radial LV feeder where LV prosumers are connected.

7. Common terms and definitions.

The section 7 of the use case template contains common terms and definitions in a glossary. Each important term used in course of the project has to be followed by its definition.

Common terms and definitions	
Term	**Definition**
RUL	Remaining Useful Life is the time remaining before a machine part is likely to require repair or replacement
MV/LV Transformers	An electrical transformer dedicated to transforming the voltage supplied by the medium voltage distribution grid (e.g. 15kV or 20kV), into voltage values suitable for supplying low voltage lines with power (400V – 690V).

LLUC-P-2b- 02: Non-technical loss detection in Smart Grids

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
UC-2B-02	Distribution	Non-technical loss detection in Smart Grids

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
1	30.04.2020	Pau J. Cortés Forteza	Including information of UC-2B-01 and UC-2B-02	
2	08.05.2020	Mikel Fernandez	Information of UC-2B-01 and UC-2B-02 split in two use case description documents. Added actor and scenario description	Draft
3	12.05.2020	Mikel Fernandez	Added use case diagram	Draft
4	17.05.2020	Pau J. Cortés Forteza	Added scenario steps	Draft
5	20.05.2020	Mikel Fernandez	Revised version with sequence diagrams	Draft
6	22.05.2020	Pau J. Cortés Forteza	Small adjustments	Draft
7	27.05.2020	Mikel Fernandez	Added Grid topology identification scenario	Draft
8	01.06.2020	Mikel Fernandez	Defined Grid topology identification scenario steps	Draft

9	03.06.2020	Mikel Fernandez	Revised KPIs	Draft
10	03.06.2020	Erik Maqueda	Added economic savings KPI and Data List Summary annex.	Draft

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	Detection of NTL in electrical grids
Objective(s)	The main objective of this use case is to develop a tool for the quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL), using the available smart meter data from Sampol´s smart grid in ParcBit, Majorca (Spain).
Related business case(s)	NTL in the electric system is one of the biggest fraud factors, generally due to smart meter and/or connection to the grid (bypass of certain consumer loads) manipulation. NTL can be attributed to i) administrative losses due to accounting errors and record keeping, ii) customer theft, iii) customer non-payment and iv) theft by non-customers. For instance, in the last years, losses in the Spanish electric system have been about the 8%[**1**] and almost half of that amount could be due to NTL. NTL detection is a complex task as DSOs do not have the appropriate tools and resources to avoid fraud techniques, and the only effective way to fight against NTL is to detect it once it has been committed, and to establish legal actions in that case. Many theorical studies in detecting NTL using different techniques have been conducted in the last years. One of these techniques is data science, very popular in the academia. The main output of this UC is to develop a solution for NTL detection using data analytics, which just requires measurement data available from the Automatic Metering Infrastructure-AMI, and optionally information on the grid topology.

1.4 Narrative of Use Case.

Narrative of use case

Short description

In this UC, different techniques will be studied to calculate the losses, detect NTL appearance and identify NTL authors (prosumers and non-customers) using data from the smart meters of prosumers and measurements at the substations and transformation centers-CTs.

Complete description

Starting in 2020, the UC will be focused on gathering information related to the distribution grid topology and the parties connected to the grid in Parc Bit and give the partners access to this information according to the project needs. If required, new sensors will be installed at the HV/MV substation and MV/LV CTs in the grid, to be able to calculate the real losses.

Available state of the art concerning NTL will be studied and evaluated, finding the best approach in NTL assessment.

In principle, five different activities are envisaged, which are defined in five main scenarios (Prosumer Segmentation, Grid Topology Identification, Technical Losses Model, Global Losses Assessment and NTL identification):

Grid Topology Identification: The topology of the distribution grid to which it will be applied the assessment of NTL has to be known. It can be either entered by the NTL manager or it can be inferred through the analysis of historical data. Grid topology includes the list of which substations and transformation centers compose the part of the distribution grid that will be analyzed, which connection points are located at the MV or LV branches, what is the distance (or the resistance of the wires) of those connection points to the corresponding CT or substation, to which phase are LV 1-phase consumers connected to….

Prosumer Segmentation: The historical prosumer smart meter data available will be cleaned and processed for the prosumer segmentation process, where prosumers will be clustered depending on their consumption behavior. If historic NTL is known, based on evidences of fraud, the dataset will be labeled accordingly.

Technical Losses Model: A study of global energy losses will be carried out, based on measurements of the energy consumed at the prosumer connection points and the energy fed by the substation and CTs. Global losses are a combination of technical losses (due to power dissipation in lines and transformers) and NTL. The outcome of this scenario is to define a model that estimates the expected value of energy fed by a MV substation if global losses are just due to technical losses, i.e., no NTL occurs. This granularity of the estimation will be provided on a PTU basis, which is the standard time unit in which the smart meters are configured to provide values on accumulated energy consumption. Although the development of this model will be based on data analytics, the information on grid topology (impedance of lines, efficiency of transformers, location of CTs and prosumer connection points…) will enhance the accuracy of the model, as this information is related to the coefficient that could be applied to each prosumer to calculate the energy needed to be disposed at the substation bar (which represents the borderline between the transmission and the distribution grid) to provide a certain consumption at its connection point.

Global Losses Assessment: The Technical Losses model will be used in a procedure that will be defined to assess if NTL has occurred for a certain PTU range, typically in monthly periods. If both the real and the expected energy at the distribution grid borderline differ more than a defined threshold, it would indicate the existence of NTL losses. In the case that this threshold has been exceeded for a significative period within the analyzed time range, it could be determined the profile of the energy that has been theft, calculated at the substation bars.

NTL identification: Once NTL is supposed to have happened, the prosumer segmentation model will be applied to determine the set of prosumers that would be the authors of NTL, based on the variation of its expected behavior (it is also considered the possibility of a verdict including fraud due to non-customers). The combination of the real energy profiles of the customers that have not committed fraud to the expected and the expected profile of those prosumers who are supposed to have committed fraud should fit with the energy profile measured at the control points in which the DSO have measurement capability, i.e. the substation and the CTs. The fulfillment of this condition will be used to define feasible sets of NTL authors, and the persistence in consecutive analysis periods of a certain prosumer in feasible solutions will potentially nominate that prosumer as an NTL author.

The software tool developed on the basis of the previously defined scenarios, will be integrated in the project platform and will include a user interface for showing the assessment results, the information related to the developed models and the historical data to the NTL manager.

The tool will be developed during 2021, leaving 2022 for testing and evaluating tool performance on the field.

Sampol is the owner of the pilot, all the field actions will be executed by Sampol if possible. Sampol will be responsible of the pilot data management, stablishing a local data store and giving access to the partners when they require it. Sampol will be responsible of integrating the tool with its Metering Data Management-MDM platform. Tecnalia will lead the specification of the use case and participate in the design and implementation of the models used by the tool together with Indra, while Indra will develop the tool.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
NTL-KPI-01	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	Quantification of losses in the distribution grid of a DSO
NTL-KPI-02	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	Detection of non-technical losses

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	Detection of non-technical losses
NTL-KPI-04	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.	Detection of non-technical losses
NTL-KPI-05	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.	Detection of non-technical losses
NTL-KPI-06	True positives (TP)	Number of customers identified as fraud authors in the NTL identification scenario which are verified to be committing fraud	Detection of non-technical losses
NTL-KPI-07	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	Detection of non-technical losses
NTL-KPI-08	False negatives (FN)	Number of customers which are not identified as fraud authors in the NTL identification scenario but are really committing fraud	Detection of non-technical losses
NTL-KPI-09	True negatives (TN)	Number of customers which are not identified as fraud authors in the NTL identification scenario, and are not really committing fraud	Detection of non-technical losses
NTL-KPI-10	Specificity (%)	Proportion of true negatives relative to all negative cases (TN/(TN+FP))	Detection of non-technical losses
NTL-KPI-11	Sensitivity (%)	Proportion of actual positives correctly identified (TP/(TP+FN))	Detection of non-technical losses
NTL-KPI-12	Cohen's Kappa (%)	Measurement of matches in the NTL identification scenario discounting the probability of randomly matching	Detection of non-technical losses
NTL-KPI-13	Economic Savings	Economic savings due to detected non-technical losses.	Detection of non-technical losses

1.6 Use case conditions.

Use case conditions
Assumptions
Reliability of the service will remain at the same level. The DSO is authorized to use the smart meter data to provide the services defined, but data will be anonymized, and it cannot disclose the data to third parties.
Prerequisites
Grid topology has to be known. Past fraud evidences can optionally be known.

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

Classification information
Relation to other use cases
It is related to UC-2B-01, as an increase of losses in the distribution grid due to an increase unfair consumption leads to higher load factors in CTs and consequently the aging of MV/LV transformers is accelerated.
Level of depth
The different actors have been defined, the scenarios in which they participate, the steps of those scenarios, and the information exchanged and the requirements have been defined. Therefore, it is a detailed low-level specification, in which the only work to be done to have a final specification is the definition of how the internal modules of the software platforms are orchestrated.
Prioritization
All functional requirements are considered mandatory, with the exception of Fc-13, Grid topology identification, which is considered as nice-to-have, but it is not needed to test the use case in the Sampol Parc Bit distribution grid, as topology is known.
Generic, regional or national relation
The studies carried out in UC-2B-02 are applicable to any distribution grid.
Nature of the use case

The focus of the Use Case is technical, developing a software tool to solve NTL identification. The prosecution of legal actions that would lead to payments from fraud actors or to a cease of their unlegal activities is not in the scope of this technical use case.

Further keywords for classification

Non-technical loses-NTL

1.8 General remarks.

General remarks

In Spain, the Royal Decree 1048/2013 which regulates the distribution activity remuneration, in its article 40, defines a ceiling to the income from fraud for a DSO which is up to the 20% of the grid fees collected if fraud has been detected. The aim of the application of an incentive of this nature, it is fundamentally to reduce administrative NTL losses. Any analysis carried out on technical losses, leads to the conclusion that the final real losses are much higher than the worst scenario of technical losses, so that any DSO would have a wide margin to reduce administrative losses, and, therefore, leave favored by the proposed incentive. That has been the case since the application of the Royal Decree 1048/2013, as all DSOs (around 300) have received the top value of the incentive, the 20% of the distribution fees.

Therefore the regulated incentive did not solved the existing problem, and in 2019 the Comision Nacional de Mercados y la Competencia-CNMD proposed a modification, considering that the modification of the loss incentive proposed in the new methodology included in the communication 6/2019 was sufficient to encourage distributors to pursue this type of action. The decision was to banish the incentive defined by the Royal Decree 1048/2013, and to include the NTL compensation on the compensation due to technical losses (to be applied since 2021).

With the new method, the energy of losses of each DSO is obtained by scaling the energy measured at each of the pf border points to the power station bars, as well as the energy measured in the meter of the prosumers connected to its grid. This scale up is carried out for each tariff period of the year and by voltage level. Based on these losses, the corresponding amount is calculated for each DSO, valorized at the daily market price, and calculated as the arithmetic mean of all the hours of each period of the corresponding year, and also affected by a correction coefficient. The incentive established takes into account, the situation of each DSO with respect to those obtained by applying the average loss coefficients, that is:

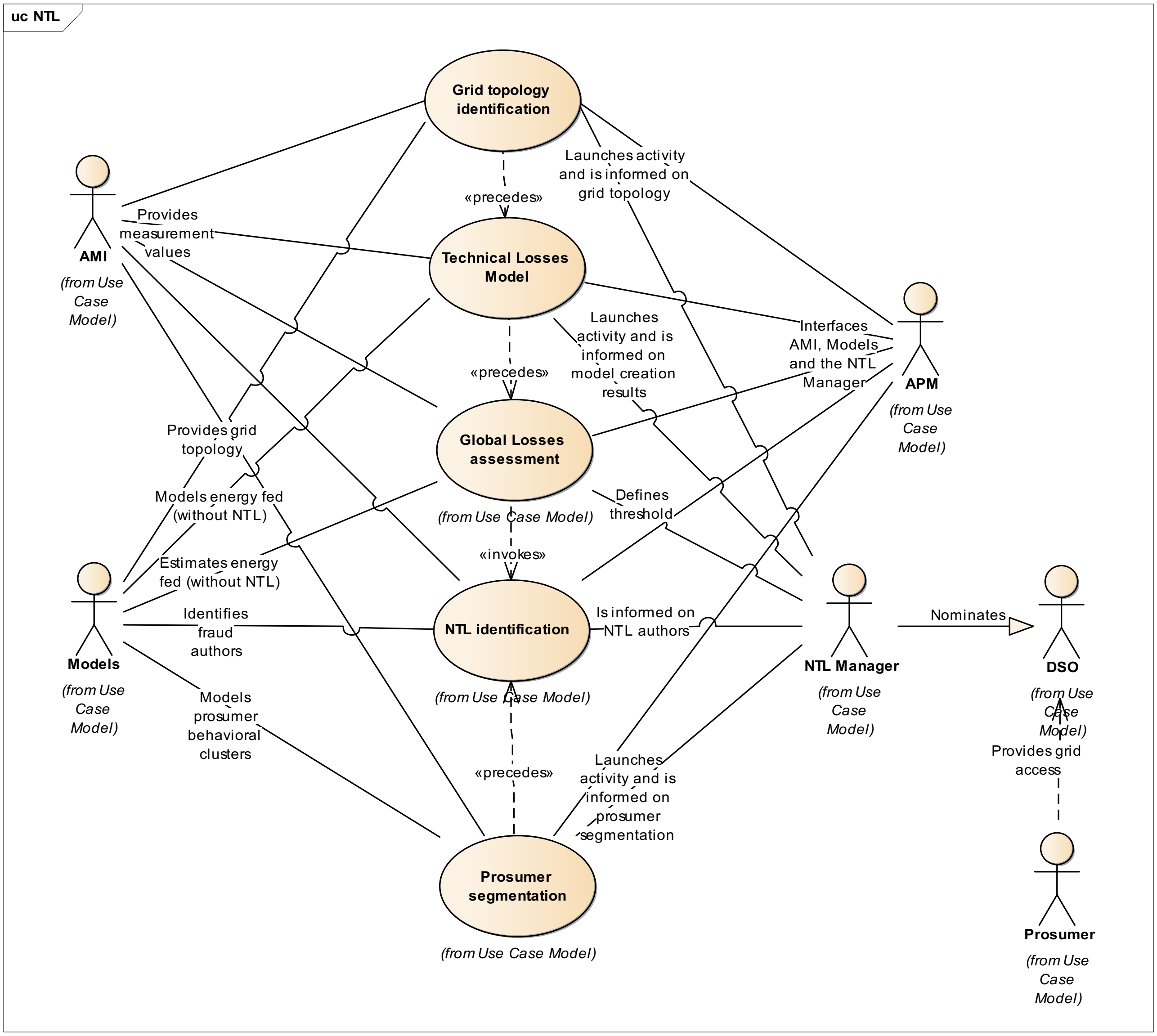
- In case the energy losses obtained is positive, the DSO must pay a penalty, as its losses are higher than the average losses.

- In case the energy losses obtained is negative, the DSO will receive an incentive, because its losses are less than the average losses.

Additionally, the new incentive is, in general, neutral for the system, by making the bonuses of some DSOs financed with the penalties of others. To meet this objective of making the incentive neutral for the system, a distribution coefficient is incorporated, which allows the incentive amount to be assigned to those DSOs that must pay a penalty among those with a positive incentive.

Finally, a maximum value for the penalty and the bonus are established that will be set by the CNMC at the beginning of each regulatory period. In order to carry out a correct comparison of the losses of each DSO with the average of the sector, an analysis will be carried out to characterize the type and topology of the grid that the DSO have to attend to the supply of their clients, depending on their location. This will add to the proposed calculation methodology, an adequate segmentation for each type of grid in which companies carry out their energy distribution.

2. Diagrams of use case.



3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
Measurement infrastructure		**Smart metering infrastructure.**	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
AMI	System	Automatic Metering Infrastructure-AMI, which includes i) the smart meters, ii) the Neighborhood Network Access Points-NNAPs and the Metering Data Management System-MDMS of the DSO	A Smart Meter registers the energy consumption of a party connected to the grid (generators, consumers, prosumers…). The NNAP concentrates all the measurements of the smart meters downstream each CT. This equipment is also known as data concentrator. The MDM receives the measurements of all NNAPs in the distribution grid of a DSO, the measurements from the prosumers connected at MV and the measurements from the equipment which measure the energy flows at the substations and CTs..

Actors			
Grouping		**Group description**	
Information systems		**Information management platforms**	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
APM	System	Asset Performance Management-APM system: data integration, NTL model detection, calls to external models when necessary, etc.	Onesait APM, by Indra/Minsait
Models	Application	Models needed in APM for both scenarios, which would be: Grid topology identification model Technical losses model Global losses assessment model Prosumer segmentation model NTL identification model	These models can either be implemented in APM or be implemented based on Model as a Service-MaaS, which is an external model to APM, but integrated in its task queue

Actors			
Grouping		**Group description**	
Other actors		**Actors not included in other categories**	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
DSO	Company	Distribution System Operator	Actor not directly implied in the (technical) use case but needed in the business use case. Played by Sampol.
NTL manager	Person	Person responsible for the detection of NTL	Designed by the DSO

Prosumer	Person or company	Party connected to the DSO distribution grid, which consumes energy	ParcBit companies

3.2 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
1	Royal decree	Royal decree 1048/2013, which sets the methodology to calculate the NTL compensation incentive provided to DSOs.	Final	NTL incentive regulation	MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO	Real Decreto 1048/2013
2	Royal decree update	Communication 6/2019, which sets the methodology to calculate the losses compensation incentive provided to DSOs.	Final	NTL incentive regulation	COMISIÓN NACIONAL DE LOS MERCADOS Y LA COMPETENCIA	https://www.cnmc.es/sites/default/files/2782095_20.pdf
3	Report	Communication 6/2020, which sets the methodology to calculate the losses compensation incentive provided to DSOs.	Final	NTL incentive regulation	COMISIÓN NACIONAL DE LOS MERCADOS Y LA COMPETENCIA	https://www.cnmc.es/sites/default/files/2782095_19.pdf

4. Step by step analysis of use case.

4.1 Overview of scenarios.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Prosumer Segmentation	Segmentation of prosumers depending on the characteristics of their load profiles	NTL manager	Need of prosumer segmentation activity	Energy consumption data from prosumers is available (either at the APM or the AMI), within a time period large enough to avoid the seasonal effect, and if possible, labeled with known fraud events. Information about past fraud evidences is already available at the APM. Information about which prosumers (connection points) are associated to which point of the distribution grid has to be known. Grid topology has to be known at the APM due to a previous execution of the Grid topology identification scenario, so that the NTL manager can choose which part of the grid (list of substations and/or CTs)	Prosumers are clustered depending on its expected consumption behaviour.
2	Grid topology identification	Grid topology is either entered by the NTL manager or calculated by a model	NTL manager	Need of grid topology	The NTL manager has the information about which substations, transformation centers and connection points compose the distribution grid In case that grid topology id inferred by the model,	Grid topology is known

					historic measurements on the substations, transformation centers and connection points is available	
3	Technical Losses Model	Development of a model that estimates the value of technical losses.	NTL manager	Need of technical losses model	Distribution grid topology is known due to the previous execution of the Grid topology identification scenario	Expected technical losses can be calculated
4	Global Losses Assessment	Assessment which indicates if NTL is likely to have occurred in a certain time period, and in that case up to how much energy could have been theft.	APM	Manual activation	The Technical losses model must have been created previously for all the MV substations in the list. The NTL has configured the value of the threshold that represents the difference between the estimated and real energy profile at a substation from which the NTL identification scenario is executed. This number could be represented as the standard deviation of all the energy values within all considered PTUs.	In case of positive assessment result, NTL identification should be executed
5	NTL identification	Identification of NTL losses authors, associated to fraud detection, based on repetitive abnormal behavior of segmented prosumers	APM	Positive result of global losses assessment	Real losses have been significantly higher than the technical losses expected	Fraud candidates have been identified

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1 – Prosumer Segmentation**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	Process activation	Prosumer segmentation tool launch	The NTL manager launches the segmentation activity, because no previous segmentation has been done yet or because a previous activity can be updated due to the existence of new data (for instance, one a season has concluded). The NTL manager has to indicate the MV substations for which it wants to do the analysis. Includes the definition of the time range of the prosumer smart data set that is proposed by the NTL manager, but a default value long enough to cover seasonal effect can be proposed by APM (for instance, a year)	CREATE	NTL manager	APM	I-09 I-02	Fc-01 Fc-02 Sc-03 Sc-04
2		Prosumer identification	Information about the connection points in the portion of the grid to be analyzed, i.e. the unique identifier (CUPS) associated to the prosumers connected to the grid. No privacy sensible information will be used associated to the prosumer themselves.	GET	APM	APM	I-03	

3		Prosumer smart meter data local availability	Check if the APM already has the requested data. If not, missing data has to be asked to the AMI.	REPORT	APM	APM	I-02 I-03 I-04	Fc-05
4		Prosumer smart meter data request	Request of the consumption measurements of a collection of prosumers in the defined time range.	GET	APM	AMI	I-02 I-03	
5		Prosumer smart meter data response	Response of the consumption measurements of a collection of prosumers between to timestamps.	REPORT	AMI	APM	I-02 I-04	Fc-05 Sc-01 Sc-02 Sc-06 Sc-07
6		Fraud evidences availability	Check if the APM has information of fraud evidences of the considered prosumers in the defined time range. Specific information about the fraud type, the detection mechanism…can be used.	REPORT	APM	APM	I-02 I-03 I-05	Fc-04
7		Model request	The APM issues a model request, forwarding all the necessary information for the model development	GET	APM	Model	I-02 I-03 I-04	Sc-07

							I-05	
8		Data preprocessing	Cleaning and processing of the smart meter / fraud evidence dataset	EXECUTE	Model	Model	I-02 I-03 I-04 I-05	Sc-05
9		Model development	Segmentation of the prosumers depending on the characterization of their consumption profiles, optionally labeled with fraud evidences	EXECUTE	Model	Model	I-03 I-05 I-06 I-13	
10		Model response	The model results are forwarded to the APM	REPORT	Model	APM	I-03 I-05 I-06 I-13	Sc-07
11		Model visualization	The APM shows the results of the segmentation process to the NTL manager	REPORT	APM	NTL manager	I-03 I-05 I-06	Fc-01 Fc-03

Scenario								
Scenario name:		**No. 2 – Grid topology identification**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1	Process activation	Grid topology identification launch	The NTL manager launches the grid topology activity. The NTL manager has to provide the list of substations, CTs and connection points that would be included in the grid that will be used to make the NTL analysis.	CREATE	NTL manager	APM	I-03 I-09 I-10	Fc-01 Fc-10 Sc-03 Sc-04
2		Grid topology configuration	The NTL manager can optionally enter the grid topology by means of a configuration file. If not, grid topology will be estimated with a model.	CREATE	NTL manager	APM	I-07	Fc-11 Fc-13
3		Electrical measurements data local availability	Check if the APM already has the data (electrical measurements) about the MV substations, CTs and connection points defined by the NTL manager. If not, missing data has to be asked to the AMI. A default time range will be considered (usually some days).	REPORT	APM	APM	I-02 I-03 I-04 I-08	Fc-05

4		Electrical measurements data request	Request of the electrical measurements of a collection of prosumers, substations and CTs in the defined time range.	GET	APM	AMI	I-02 I-03 I-09 I-10	
5		Electrical measurements data response	Response of the measurements of prosumers, substations and CTs between two timestamps.	REPORT	AMI	APM	I-02 I-03 I-04 I-08	Fc-05 Sc-01 Sc-02 Sc-06 Sc-07
7		Model request	The APM issues a model request, forwarding all the necessary information for the model development	GET	APM	Model	I-02 I-03 I-04 I-08	Sc-07
8		Data preprocessing	Cleaning and processing of the electrical measurements dataset	EXECUTE	Model	Model	I-02 I-03 I-04 I-08	Sc-05

9		Model development	Identification of the most probable grid topology through an optimization process that selects which is the location of each one of the prosumer connection points in the distribution grid	EXECUTE	Model	Model	I-02 I-03 I-04 I-08 I-07	
10		Model response	The topology is forwarded to the APM	REPORT	Model	APM	I-07	Sc-07
11		Grid topology visualization	The APM shows grid topology to the NTL manager	REPORT	APM	NTL manager	I-07	Fc-12

Scenario								
Scenario name:		**No. 3 – Technical Losses Model**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**

1	Process activation	Technical losses modeling launch	The NTL manager launches the modeling activity, because no previous modeling has been done yet or because a previous activity can be updated due to the existence of new data (for instance, grid topology has changed). The NTL manager has to indicate the MV substations for which it wants to do the analysis.	CREATE	NTL manager	APM	I-09 I-02	Fc-01 Fc-06 Sc-03 Sc-04
2		Electrical measurements data local availability	Check if the APM already has the requested data (not only about prosumers, also about the MV substations and CTs). If not, missing data has to be asked to the AMI. A default time range will be considered (for instance, a year).	REPORT	APM	APM	I-02 I-03 I-04 I-08	Fc-05
3		Electrical measurements data request	Request of the electrical measurements of a collection of prosumers, substations and CTs in the defined time range.	GET	APM	AMI	I-02 I-03 I-09 I-10	
4		Electrical measurements data response	Response of the measurements of prosumers, substations and CTs between two timestamps.	REPORT	AMI	APM	I-02 I-04 I-08	Fc-05 Sc-01 Sc-02 Sc-06 Sc-07

5		Fraud evidences availability	Check if the APM has information of fraud evidences of the considered prosumers in the defined time range, to screen fraud related measurements from the electrical measurements data set	REPORT	APM	APM	I-02 I-03 I-05	Fc-04
6		Model request	The APM issues a model request, forwarding all the necessary information for the model development	GET	APM	Model	I-02 I-03 I-04 I-05 I-07 I-08	Sc-07
7		Data preprocessing	Cleaning and processing of the electrical measurements dataset	EXECUTE	Model	Model	I-02 I-03 I-04 I-05 I-08	Sc-05
8		Model development	Development of a predictive model that calculates the expected value of energy fed by a MV substation if global losses are just due to technical losses, i.e., no NTL occurs	EXECUTE	Model	Model	I-02 I-03 I-04	

							I-05 I-07 I-08	
9		Model response	The model results are forwarded to the APM	REPORT	Model	APM	I-12 I-11	Sc-07
10		Model visualization	The APM shows the results of the technical losses model creation process to the NTL manager	REPORT	APM	NTL manager	I-12	Fc-01 Fc-07

Scenario								
Scenario name:		**No. 4 – Global Losses Assessment**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1	Process activation	Global losses assessment launch	The NTL manager initiates the scenario, setting the desired analysis time range, and the list of MV substations for which he wants to make the analysis	CREATE	NTL manager	APM	I-09 I-02	Fc-01 Fc-08 Sc-03 Sc-04

2		Electrical measurements data request	Request of the electrical measurements of the collection of substations (and CTs and prosumers downstream) configured by the NTL manager for the previous analysis period.	GET	APM	AMI	I-02 I-09 I-10 I-03	
3		Electrical measurements data response	Response of the measurements of requested.	REPORT	AMI	APM	I-02 I-08 I-04	Fc-05 Sc-01 Sc-02 Sc-06 Sc-07
4		Model execution request	The APM issues a model execution request, to get an estimation of the electrical measurement at a substation if no NTL has occurred	GET	APM	Model	I-09 I-04 I-08	Sc-07
5		Model execution	Execution of a technical losses model for a given MV substation	EXECUTE	Model	Model	I-02 I-03 I-04 I-05 I-07 I-08/11	

6		Model execution response	The model results are forwarded to the APM	REPORT	Model	APM	I-08 I-09	Sc-07
7		Threshold comparison	If the difference between the real and estimated energy profiles for a substation is higher than the configured threshold, then the NTL identification scenario will be executed for the list of returned MV substations and CTs. The estimated active energy profile due to NTL is provided for each substation or CT.	REPORT	APM	APM	I-09 I-14	

Scenario								
Scenario name:		**No. 5 – NTL identification**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1		Model execution request	The APM issues a NTL identification model execution request, to get an identification of the prosumers that have incurred into fraud (or non-customers)	GET	APM	Model	I-09 I-04 I-08 I-02	Sc-07

							I-13 I-14	
2		Model execution	Execution of the NTL analysis for a given MV substation or CT. The analysis process is an optimization which considers as the most probable candidates to have committed fraud those which behavior during the analysed period differs most with their corresponding cluster.	EXECUTE	Model	Model	I-02 I-03 I-04 I-05 I-07 I-08 I-11	
3		Model execution response	The model results are forwarded to the APM	REPORT	Model	APM	I-15 I-09	Sc-07
4		Model visualization	The APM shows the list of fraud authors (prosumers and non-customers), with estimated energy fraud profile	REPORT	APM	NTL manager	I-15	Fc-01 Fc-09

5. Information exchanged.

Information exchanged, ID	Name of information	Description of information ex- changed
I-01	Grid identifier	Identification of part of the distribution grid
I-02	Analysis time range	Time range
I-03	Connection point identification	Identification of a connection point (i.e, CUPS)
I-04	Prosumer smart meter data	Active (and reactive) energy consumed for each prosumer in a certain PTU
I-05	Fraud evidences	Known periods in which a certain prosumer has committed fraud
I-06	Prosumer behavioural cluster	Cluster defined by the average consumption profile of the prosumers included in it. The characteristics of this consumption profile have to be defined yet (day type, average power, peak to average ratio…)
I-07	Grid topology	Line topology, impedance of lines, efficiency of transformers, location of CTs and prosumer connection points…
I-08	MV substation and CTs electrical measurements data	Active (and reactive) energy provided by a substation (or CT) in a certain PTU
I-09	MV substation identification	Identification of a MV substation
I-10	CT identification	Identification of a LV CT

I-11	Technical losses model identifier	Identification of a technical losses model for a given substation
I-12	Technical losses modeling results	Accuracy results of the created model
I-13	Prosumer cluster identifier	Identification of the cluster of a prosumer
I-14	NTL estimation data	Active energy estimated to be due to NTL at a substation (or CT) in a certain PTU
I-15	Fraud authors	List of fraud authors (prosumers and non-customers), with estimated energy fraud profile

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Fc	Functional	Functional requirements that the modules developed for the use case (APM and models) have to comply with
Requirement R-ID	**Requirement name**	**Requirement description**
Fc-01	NTL manager user interface	The NTL manager has to use a user interface to interact with the APM
Fc-02	Prosumer segmentation trigger	The NTL manager can manually launch the prosumer segmentation process, entering information about the part of the grid to be analyzed and the time range considered.

Fc-03	Prosumer segmentation results	The NTL manager can visualize the results of the prosumer segmentation process
Fc-04	Fraud evidence data storage	The APM has to store the information about fraud evidences: which fraud actions have been detected, of which type, who has committed them, for how long…
Fc-05	Smart meter data storage	The APM has to store the information retrieved from the AMI about the energy flows in both prosumer and grid (substation or CTs) installations
Fc-06	Prosumer segmentation trigger	The NTL manager can manually launch the technical losses modeling process, entering the list of MV substations to which the study will be applied, and the time range to be considered
Fc-07	Technical losses model creation results	The NTL manager can visualize the results of the technical losses model creation process
Fc-08	Prosumer segmentation trigger	The NTL manager can manually launch the Global Losses Assessment process, entering the list of MV substations to which the study will be applied and the time range
Fc-09	NTL identification results	The NTL manager can visualize the results of the NTL identification process
Fc-10	Grid topology trigger	The NTL manager can manually launch the process to define the grid topology, providing the list of substations, CTs and connection points that would be included in the grid that will be used to make the NTL analysis.
Fc-11	Grid topology configuration	The NTL manager can enter the grid topology at the APM, by means of a configuration file

Fc-12	Grid topology visualization	The NTL manager can visualize the grid topology, no matter if it has been configured or identified by a model
Fc-13	Grid topology identification	An automated tool can be used to identify the grid topology, in case that the NTL manager does not provide it at the configuration process

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Sc	Security	Non functional requirements related to authentication, encryption, privacy, user identification, access levels….
Requirement R-ID	**Requirement name**	**Requirement description**
Sc-01	Prosumer smart meter data usage authorization	The NTL manager has to be authorized to use the data retrieved from the AMI about the consumption of prosumers to detect fraud evidences
Sc-02	Prosumer smart meter data privacy	Privacy sensitive information has to be excluded from this data set, so that the NTL manager has access exclusively to the information needed to make the segmentation process, i.e, active energy consumed and CUPS.
Sc-03	NTL manager identification	The NTL manager has to identify itself when accessing the APM (user and password)
Sc-04	NTL manager authorization	The NTL manager has to authorized to perform a certain activity (for instance, prosumer segmentation)

Sc-05	Smart meter data integrity	Smart meter measurements have to reflect the energy profile of the point where the smart meter is connected. In case of missing data interpolation can be used, which the associated accuracy loss
Sc-06	Prosumer smart meter data confidentiality	Data retrieved from the AMI has to be kept confidential, not being any actor, which is authorized to use it, able to disclose it.
Sc-07	Data delivery securization	Any sensible information exchanged between actors which is considered sensible has to be exchanged using a secure communication protocol

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
PR	Performance	Non-functional requirements related to scalability and performance
Requirement R-ID	**Requirement name**	**Requirement description**
PR-01	Scalability	The APM has to be scalable to potentially cover the analysis of the whole grid of a DSO, and the consumers connected to it. The grid will be composed of a collection of sub grids, each composed by a MV substation connected to HV, to which there are a collection of connected MV prosumers and CTs (in meshed configuration), and from each CT there is a radial LV feeder where LV prosumers are connected.

7. Common terms and definitions.

Common terms and definitions	
Term	**Definition**
NTL	Non-technical losses are electricity theft, broken or malfunctioning meters and arranged false meter readings
PTU	Programme Time Unit. Minimum time period in which the consumption from prosumers can be settled (currently in Spain 1 hour, but the future trend is to reduce it to 15 min)
CUPS	Código Universal de Punto de Suministro: Unique identifier of the connection point of a prosumer, defined by an EAN code, where, for instance, information about the DSO identification is coded.
MV	Medium voltage
LV	Low voltage
TC	Transformation centre, which connects the MV grid to the LV grid

LLUC-P-3a- 01: Optimization of HVAC operation regarding building occupancy

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
LLUC-3a-01	Costumer premises	Optimization of HVAC operation regarding building occupancy

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
V1	10.06.2020	PETINOT Romain	First validated version	validated

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	Buildings are responsible for a large part of GHG emissions and energy consumption in developed countries, especially to assure the comfort of occupants through heating, cooling and ventilation systems (HVAC). More and more data are now available on buildings with the development of IOT and BMS, especially concerning comfort, occupancy and HVAC system operation. Through analysis and AI, these data can be used to optimize HVAC system operations in function of the actual building occupancy. This use case focus on an office building where a BMS is already installed to monitor the air temperature and control local heating and cooling emission. In general HVAC systems have a fixed operation schedule for each day of the week, which is not always very energy efficient and adapted to the actual use of the building.

	Using some extra occupancy sensors, some learning algorithm and models, the occupancy schedule and HVAC controls, including preheating and precooling periods, can be optimized in the BMS to reduce energy consumption while providing the best comfort to occupants.
Objective(s)	Reduce energy consumption of the building and GHG emissions (NB: depend on the initial regulations and comfort level). Maximizing the comfort of occupants with the best energy efficiency. Automate HVAC system control and reduce manual intervention on system controls.
Related business case(s)	

1.4 Narrative of Use Case.

Narrative of use case
Short description
The use case intends to provide a smart module for an office building that optimize HVAC operation in function of real 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.
Complete description
The idea is to propose to the building manager of an office building an option to automatically optimize the occupancy planning and control HVAC system to provide the best comfort to the occupants while minimizing energy consumption. The following data is assumed to be collected and aggregated for the different relevant zones of the building: Air temperature

Air temperature setpoint (heating and cooling)

Heating and cooling control order in the different zone (% opening of the valve)

Occupancy

Most of these data can be collected from the BMS: air temperature, setpoints and controls. An aggregation of the data from the local HVAC controller located in the different zones is realized.

For occupancy, the information is not necessarily available through the BMS and some external sensor can be used to gather the information for the different zones.

The definition of the different zones and associated data points is an important step. The zone definition must be relevant from a thermal point of view and from an occupancy point of view.

Energy consumption data concerning HVAC system is also assumed to be collected for the whole building (independently from other usage). Data concerning the external air temperature and the solar radiation (optional) and associated forecast are also required to follow the performance of the controls.

Unless historical data can be collected and treated, a first phase of data collection is required to initialize the system and learn the building behavior. During this phase the default control parameters of the building can be used.

The following parameters are assumed to be controlled in the building through the BMS:

The occupancy schedule of the building: It defines if the building is occupied or unoccupied. It is normally associated with the schedule of HVAC operation and include preheating or precooling periods. During the period where the building is defined as occupied, the heating and cooling network are regulated at their nominal values and the local controller try to reach a given temperature setpoint in the different zone of the building.

Local occupancy parameter for each zone (can be defined as occupied/unoccupied). If the use of these local variables is activated, the whole building is maintained at a minimum stand-by temperature set-point providing basic comfort to the occupants. Only when local zone occupancy is defined as “occupied”, the zone temperature is controlled to reach the normal temperature setpoint for an “occupied” status. If local occupancy control is disabled, the building is maintained at the normal temperature setpoint for occupied periods.

The optimization module that is developed in this use case include 2 independent regulation loops:

A first loop is controlling the global building occupancy schedule, including the required phases of preheating or precooling (especially required in the morning).

A second loop is controlling the local occupancy parameter in the different zones of the building to optimize heating and cooling setpoint locally.

These 2 loops can be activated by the building manager who supervise a calendar defining the occupancy control mode to be used (fixed unoccupied, fixed, auto global, auto global & local). The automatic mode, for the whole building only (auto global), or including the different zones (auto global & local), are the main mode proposed. But the building manager has the possibility to define some fixed occupancy controls, to specify for example some unoccupied periods or fixed schedule (that maybe couldn't' be anticipated by the module for example).

When the automatic mode is activated or a given period, the system can provide for each day an overview of the occupancy prediction and schedule that is planned for the building and for the zones. To achieve that, the following steps are executed:

For the building occupancy schedule:

In function of the calendar, the day of the week, local calendar data, the model estimates the building occupancy probability for the rest of the day.

The effective occupancy schedule for the building (occupied/unoccupied) is calculated in function of the lowest occupancy probability/signal to be considered and constraints to avoid cycling effects. These parameters are assumed to be configurable by the building manager.

For the zone's occupancy schedule:

In function of the calendar, the day of the week and local calendar data, the model estimates the zone occupancy probability for the rest of the day.

The effective occupancy schedule for the zones (occupied/unoccupied) is calculated in function of the lowest occupancy probability/signal to be considered and constraints to avoid cycling effects. These parameters are assumed to be configurable by the building manager.

At the beginning of a new day and throughout the day, the control loops (if activated) will automatically send appropriate orders to the BMS, concerning occupancy schedules and preheating/precooling periods. The real time occupancy in the different zones of the building will be followed to adjust the building controls for the rest of the day if changes are detected. To achieve that, the following steps are implemented:

For the building control loop:

If not already calculated, the system estimates the building occupancy schedule (cf. previous paragraph).

Throughout the day, the system follows the evolution of the real occupancy in the building and predict accordingly the occupancy for the rest of the day. The planned occupancy schedule is updated if a significant change is detected.

If the schedule includes a switch from “unoccupied” to “occupied”, an algorithm predicts the eventual heating or cooling time for the building in function of the building actual state and weather predictions.

When a new occupancy schedule is assessed or updated, the relevant data is sent to the BMS.

For the zones control loop:

If not already calculated, the system estimates the different zones occupancy schedule (cf. previous paragraph).

Throughout the day, the system follows the evolution of the real occupancy in the zones and predicts accordingly the zones occupancy for the rest of the day. The planned occupancy schedules are updated if a change is detected.

If there is a switch from “unoccupied” to “occupied” in a new schedule, an algorithm predicts the heating or cooling time for the zone in function of the zone current state and weather predictions.

The module updates in real time the occupancy parameters (including preheating and precooling) for the different zones in the BMS.

The Building manager can update the following parameters in the systems:

Sensibility parameters concerning the occupancy probability threshold to be considered as sufficient to trigger the HVAC system operation and a status “occupied” in the building or the zones. Some daily cycling constraints can also be specified for the building and the zones occupancy schedule: minimum duration of an “occupied” period and an “unoccupied” period. Number of “occupied” period occurrence per day. For the whole building, only one period of occupancy will be generally considered during the day.

Parameters for the different data points in the building (occupancy sensor and local HVAC controller in the building), in particular the zone they are attached to and some other parameters defining the way the data are aggregated

NB: these parameters are normally defined once at the beginning because they strongly impact the different prediction models and a change in these parameters may require a new phase of initialization/learning for the HVAC optimization module.

For each day and relevant periods (week, months and years), an assessment of the building control performance in function of the building occupancy is realized. The different KPI are calculated and reported to the building manager.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
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.	Optimizing comfort
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	Optimizing energy consumption and GHG emissions

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)	Optimizing energy consumption and GHG emissions
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)	Optimizing energy consumption and GHG emissions

1.6 Use case conditions.

Use case conditions
Assumptions
The building is equipped with a BMS with access to the building data (air temperature, controls for heating and cooling). The BMS is able to control heating and cooling for the different zone of the building and the relevant controls parameter can be adjusted remotely.
Prerequisites
Possibility to access and collect in real time the data in the BMS has to be validated. Possibility to update some data in the BMS has to be validated.
Use case conditions
Assumptions
Some occupancy data is available on the building through the BMS or with some extra sensors installed on the building.
Prerequisites
Possibility to access and collect in real time the data has to be validated.

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

Classification information
Relation to other use cases
The second low level use case (LLUC-P-3a-02) developed in the pilot has similarities in terms of data collection (BMS, external data provider for weather data and forecast) and interaction with the BMS. There are as well some similarities with the low-level use case “Advanced EMS” of the pilot 3c which include the connection with an existing BMS and some controls of the HVAC system (including optimization on precooling and preheating time). The low-level use case seems to focus on renewable energy self-consumption. The installation of “presence” detection sensor is described as “optional”.
Level of depth
Detailed business use case specifying the required information
Prioritization
Important
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
Smart building, HVAC, occupancy, AI, energy savings, GHG savings

2. Diagrams of use case.

Diagram(s) of use case


3. Technical details.

3.1 Actors

Actors	
Grouping	**Group description**
External actors	Provide a short description of the group.

Actor name	Actor type	Actor description	Further information specific to this use case
BMS	system	BMS (Buildings Management System) : system enabling to overview and control the technical equipment of the building. BMS can be more or less evolved or developed. In this case we assume it collects data over the HVAC system of the building and pilot independently heating and cooling in the different zones of the building.	
Occupancy sensor	device	Extra sensors installed in the building to monitor occupancy in the different area or zones of the building.	
External data provider	system	External data are required concerning weather prediction, and calendar information (with public holidays in particular)	
Building manager	human	Person in charge of the building operation	

3.1 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
			The status of the document. e.g. Draft, final	e.g. copy right, IPR		

4. Step by step analysis of use case.

4.1 Overview of scenarios.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post- condition**
1	Collect and process data from BMS	Collect the real time data from the BMS and process it to aggregate relevant information for each zone of the building		Periodical occurrences (<=10min)	Last data not collected from the BMS	The raw data from BMS and associated processed data are stored and available for further use
2	Collect and process data from occupancy sensors	Collect the raw data from the occupancy sensors and process them to estimate occupancy for each relevant zone of the building		Periodical occurrences (<=10min)	Last data not collected from occupancy sensor	The raw data from occupancy sensors and associated processed data are stored and available for further use
3	Collect current weather data	Collect current weather data (external air temperature and solar radiation) from external data provider		Periodical occurrences (<=10min)	Last data for weather not collected	The weather data is stored and available for further use
4	Collect weather data forecast	Collect weather forecast (external air temperature and solar radiation) for the next 48h from external data provider		when required by the system		The weather forecast for the next 48h is available for further use
5	Collect local calendar data	Collect local calendar data (public holidays, school holidays, other calendar data that could impact building occupancy)		Periodical occurrences (<=10min)	Last local calendar data not collected	The local calendar data is stored and available for further use

6	Update building occupancy control mode calendar	Update the occupancy control mode calendar (unoccupied, fixed schedule, auto global, auto global&local) defining for each day which regulation loops are activated.	Building manager	Upon building manager request		Building occupancy control mode calendar is updated
7	Report building and zones occupancy prevision	Based on the occupancy control mode calendar, the system report for each day the building and zones occupancy predicted	Building manager	Upon building manager request		Building and zones occupancy predictions reported
8	Daily automatic update of building occupancy schedule	Regulation loop updating the occupancy schedule of the building through the day, in function of prediction models and real data collected on the building	Building manager, activation based on a calendar	real time update (when activated through calendar)		The building occupancy schedule is updated when required in the BMS
9	Daily real time update of building zone occupancy parameter	Regulation loop updating in real time the occupancy parameter of each zone, in function of prediction models and real data collected on the building. This occupancy parameter will impact the local temperature setpoints considered.	Building manager, activation based on a calendar	real time update (when activated through calendar)		The occupancy parameter for each zone is updated for each zone in real time according to previsions and real-time info
10	Update sensibility parameters for occupancy	Update sensibility parameter for occupancy consideration to define which level of occupancy require actual heating and cooling in the building.	Building manager	upon building manager request		New parameters concerning the regulation loops are updated and available

11	Update data points parameters	Update parameters related to each data points (occupancy sensor points and BMS local controller points) with the zone it is associated to and specific parameter to define how data will be aggregated at the zone or the building level.	Building manager	upon building manager request		Zones (NB: a modification can strongly impact the models and predictions, especially for the zones. It could require a full system reset).
12	Report comfort and HVAC control performance for a given period	For a given period, the system reports the different KPI concerning comfort and building controls	Building manager	When the building manager request it		The KPI for the period are calculated and available to the building manager

4.1 Steps-Scenarios.

Scenario								
Scenario name:	**No. 1 – Collect and process data from BMS**							
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1	Periodical check (<=10min)	Collect real time data from the BMS	The real time data since last request is collected from BMS the concerning : internal air temperature, heating and cooling controls/orders, temperature setpoints. It is collected for each local controller point "i".	GET	BMS	HVAC optimization module	Tia_Pi, Tset_heat_Pi, Tset_cool_Pi, CtlValv_heat_Pi, CtlValv_cool_Pi Cs_heat_gas, Cs_cool_elec	Con_BMS
2	Data received from BMS	Process data from the BMS	The data collected are processed and aggregated for each relevant thermal zone and for the whole building	EXECUTE	HVAC optimization module	HVAC optimization module	Tia_av_Bd, Tia_av_Zk, Ind_heat_Zk, Ind_cool_Zk, Ind_heat_Bd, Ind_cool_Bd	Cfg_Param_P

Scenario								
Scenario name:		**No. 2 – Collect and process data from occupancy sensor**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	Periodical check (<=10min)	Collect real time data from occupancy sensor	The real time data since last request is collected from all the occupancy sensors	GET	Occupancy sensor	HVAC optimization module	Occ_Sj	Con_OccSensors
2	Data collected from occupancy sensor	Process data from occupancy sensor	The occupancy data collected are processed and aggregated for each relevant thermal zone and for the whole building	EXECUTE	HVAC optimization module	HVAC optimization module	Occ_Zk, Occ_Bd	Cfg_Param_S

Scenario								
Scenario name:		**No. 3 – Collect current weather data**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**

1	Periodical check (<=15min)	Collect weather data	Collect current weather data (external air temperature and solar radiation) from external data provider	GET	External data provider	HVAC optimization module	T_ext, Sol_Irr	Con_ExDatProv_ wx

Scenario								
Scenario name:	**No. 4 – Collect weather data forecast**							
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	When required for model application	Collect weather data forecast	Collect weather forecast (external air temperature and solar radiation) for the next 48h from external data provider	GET	External data provider	HVAC optimization module	T_ext_fcst, Sol_Irr_fcst	Con_ExDatProv_wx

Scenario								
Scenario name:		**No. 5 – Collect local calendar data**						
Step No.	**Event**	**Name of processactivity**	**Description of process/ activity**	**Service**	**Informationp roducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	Periodical update	Collect local calendar data	Collect local calendar data (public holidays, school holidays, other calendar data that could impact building occupancy)	GET	External data provider	HVAC optimization module	Cal_sched_info	Con_ExDatProv_cal

Scenario								
Scenario name:		**No. 6 – Update building and zones occupancy control mode calendar**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Building manager request	Update the occupancy control mode calendar for building and zones	Update occupancy control mode calendar for building (unoccupied, fixed schedule, auto) and zones (not activated, auto, unoccupied, fixed schedule) - Initialize calendar for a given period - Define manually some specific occupancy schedules for certain days,	CHANGE	Building manager	HVAC optimization module	Cal_Mode_OccCtl_Bd, Cal_Mode_Occ_Ctl_Zk, D-sch_OccSt_Plan_Bd	

			type of days or periods, or certain zones				D-sch_OccSt_Plan_Zk	
2	For each day with building occupancy automatic mode activated	Assess building occupancy probability schedule for the day	The system assesses the building occupancy probability, in function of the type of day and eventually local calendar information.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Bd	Col_cal
3	For each day with automatic local mode control activated	Assess Zone occupancy probability schedule for the day	The system assesses zones occupancy probability, in function of the type of day and eventually local calendar information.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Zk	Col_cal
4	For each day modified with automatic mode	Define planned occupancy status schedules	In function of building and zones occupancy probability and using some sensibility parameters, the occupancy status planned schedule for the building is calculated.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Bd D-sch_OccSt_Plan_Zk	Cfg_Occ_SE_Bd Cfg_Occ_SE_Zk
5	If the operation mode of the current day is impacted	Update controls for the buildings and the zone in accordance to the mode required	The scenario 8 and 9 are triggered again with the new parameters, predictions and controls have to be updated and sent to the building if required	Cf. scenario 8 &9	Cf. scenario 8 &9	Cf. scenario 8 &9	Cf. scenario 8 &9	Cf. scenario 8 &9

Scenario								
Scenario name:		**No. 7 – Report building and zones occupancy status schedule**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
1	Building manager request	Report building and zone planned occupancy status	For each day of the calendar, the system reports the building and zones occupancy prediction and status prediction. For the current day, preheating or precooling time calculated are displayed, as well as the actual occupancy data for the building and the zones.	GET	HVAC optimization module	Building manager	D-sch_OccSt_Plan_Bd D-sch_OccSt_Plan_Zk, T_preHeatCool_Bd, T_preHeatCool_Zk	Col_Occ, Col_IntAirTemp

Scenario								
Scenario name:		**No. 8 – Daily automatic update of building occupancy schedule**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Every day at 00:00	Predict building occupancy	If not already calculated, the system assesses the building occupancy probability schedule, in function of the	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Bd	Col_cal,

	(or building manager activation)	schedule for the day	type of day and eventually local calendar information.					
2	Periodical, every (5-10 min) (REPEAT)	Predict building occupancy changes in function of real occupancy	Throughout the day, the system monitors the real occupancy in the building and update the building occupancy probability schedule for the rest of the day.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Bd	Col_cal , Col_Occ
3	New building occupancy schedule	Define occupancy status schedule for the building	From the building occupancy prediction and using some sensibility parameters, the occupancy status schedule for the building is assessed. It is only updated during the day when a significant change is monitored.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Bd	Cfg_Occ_SE_Bd
4	New building occupancy schedule	Estimate preheating or precooling time for the building	If there is switch from unoccupied to occupied in the building occupancy schedule, the system evaluates the heating or cooling time required for the building. The estimation is realized in function of current internal air temperature of the building, outside air temperature and weather predictions for the day.	EXECUTE	HVAC optimization module	HVAC optimization module	T_preHeatCool_Bd	Col_wx_fcst, Col_wx, Col_IntAirTemp,
5	New building occupancy schedule	Update building controls in BMS	Update the occupancy schedule of the day and preheating or precooling time in the BMS of the building	CHANGE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Bd, T_preHeatCool_Bd	Con_BMS

Scenario								
Scenario name:		**No. 9 – Daily real time update of building zone occupancy parameter**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement (R-IDs)**
1	Every day at 00:00 (or building manager activation)	Predict zone occupancy schedule for the new day	If not already realized, the system assesses the building occupancy probability schedule, in function of the type of day and eventually local calendar information.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Zk	Col_cal,
2	Periodical, every (5-10 min) (REPEAT)	Predict zone occupancy changes in function of real occupancy	Throughout the day, the system monitors the real occupancy in the zone and adapt accordingly the zone occupancy probability schedule for the rest of the day.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_Occ_Prob_Zk	Col_cal , Col_Occ
3	New zone occupancy schedule	Define occupancy status order for the Zone	From the Zone occupancy prediction and using some sensibility parameters defined for the zone, the occupancy status schedule for the zone is assessed. It is only updated during the day when a significant change is monitored.	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Zk	Cfg_Occ_SE_Z
4	New zone occupancy schedule	Estimate preheating or precooling	If there is switch from unoccupied to occupied in the zone occupancy prevision, the system evaluates the	EXECUTE	HVAC optimization module	HVAC optimization module	T_preHeatCool_Zk	Col_wx_fcst, Col_wx,

		time for the zone	heating or cooling time required for the building. The estimation is realized in function of current internal air temperature of the building, outside air temperature and weather predictions.					Col_IntAirTemp,
5	New zone occupancy schedule	Update local zone controls in BMS	Update the occupancy schedule of the day and preheating or precooling time in the BMS of the building	CHANGE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Zk, T_preHeatCool_Zk	Con_BMS

Scenario								
Scenario name:		**No. 10 – Update sensibility parameters for Building/zone occupancy**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Building manager request	Test a new sensibility parameter for zone occupancy	New sensibility parameters are temporarily defined for the building and/or the zones (but they don't replace the actual ones)	CHANGE	Building manager	HVAC optimization module	Occ_SE_Bd, Occ_SE_Z	
2	New sensibility	Define planned occupancy	In function of building and zones occupancy probability and using the new sensibility parameters, the occupancy status planned schedules	EXECUTE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Bd,	

	parameters defined	status schedules	for the building and the zones are calculated.				D-sch_OccSt_Plan_Zk	
3	New sensibility parameters tested	Validate the new sensibility parameters	The new sensibility parameters are validated and replace the previous parameters.	CHANGE	Building manager	HVAC optimization module	Occ_SE_Bd, Occ_SE_Z	
4	New sensibility parameters validated	Update all the planned occupancy schedule in the system	The planned occupancy status schedule for the building are implemented and updated.	CHANGE	HVAC optimization module	HVAC optimization module	D-sch_OccSt_Plan_Bd, D-sch_OccSt_Plan_Zk	

scenario								
Scenario name:		**No. 11 – Update data points parameters**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Building manager request	Update of the data points parameter	The parameters associated to local zone controller and occupancy sensors are updated (cf Tab_Param_P, Tab_Param_S)	CHANGE	Building manager	HVAC optimization module	Tab_Param_P, Tab_Param_S	

2	New input parameters	Update models predictions and analysis	The different results impacted have to be calculated again, the model have to be updated and run again to get the last predictions	EXECUTE	HVAC optimization module	HVAC optimization module	All internal information impacted	

Scenario								
Scenario name:		**No. 12 – Report comfort and HVAC control performance for a given period**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1	Building manager request	Report KPI	The different KPI are calculated for the different time scale (weeks, month and year) and provided to the building manager	GET	HVAC optimization module	Building manager	Comfort_occ, Cs_heat_gas_occ, Cs_cool_elec_occ, Cs_corr_heat_gas_occ, Cs_corr_cool_elec_occ, Ind_overHeat, Ind_overCool,Acc_preHeatCool_Bd, Acc_preHeatCool_Zk, Acc_pred_Occ_Bd, Acc_pred_Occ_Zk,	Col_IntAirTemp, Col_Occ, Col_weather, Col_cs, Col_TempSet, Col_valv_ctl,

5. Information exchanged

These information objects are corresponding to the “Name of Information” of the “Information Exchanged” column referenced in the scenario steps in template section 4 “Step by Step Analysis”. If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
Tia_Pi	Internal air temperature of the local controller point “i”	Internal air temperature (°C) of the local controller point “i” in the building	Connect_BMS
Tia_av_Zk	Internal air temperature of the zone “k”	Average Internal air temperature (°C) for the zone “k” of the building aggregated from Tia_Pi	
Tia_av_Bd	Internal air temperature of the building	Average Internal air temperature (°C) for the building aggregated from Tia_Pi	
Tset_heat_Pi	Temperature setpoint for heating of the local controller point “i”	Temperature setpoint (°C) for heating of the control point “i” in the building	Connect_BMS
Tset_cool_Pi	Temperature setpoint for cooling of the local controller “i”	Temperature setpoint (°C) for cooling of the control point “i” in the building	Connect_BMS
CtlValv_heat_Pi	Valve heating control for the local controller point “i”	Actual valve heating control (% of opening) for the local point “i”	Connect_BMS
Ind_heat_Zk	Heat emission indicator of the zone K	Heat emission indicator for the zone k (% of maximal capacity) calculated from valve controls and parameters for each local points “i”	
Ind_heat_Bd	Heat emission indicator for the building	Heat emission indicator for the building (% of maximal capacity) calculated from valve	

		controls and parameters for each local points “i”	
CtlValv_cool_Pi	Valve cooling control for the local controller point “i”	Actual valve cooling control (% of opening) for the local point “i”	Connect_BMS
Ind_cool_Zk	Cooling indicator of the zone k	Cooling indicator for the zone k (% of maximal capacity) calculated from valve controls and parameters for each local points “i”	
Ind_cool_Bd	Cooling indicator of the building	Cooling indicator for building (% of maximal capacity) calculated from valve controls and parameters for each local points “i”	
Cs_heat_gas	Gas consumption for heating of the building	Gas consumption (kWh PCI) used for heating of the building	
Cs_cool_elec	Electricity consumption for cooling of the building	Electricity consumption (kWh) for cooling of the building	
Occ_Sj	Current occupancy data of the sensor point “j”	Occupancy data of the local sensor point “j” in the building	
Occ_Zk	Current occupancy parameter of the zone K	Occupancy information for the building zone k calculated from Occ_Sj	
Occ_Bd	Current occupancy parameter of the building	Occupancy information for the building calculated from Occ_Sj	
T_ext	External air temperature for the building location	External air temperature (°C) for the building location	Con_ExDatProv_wx
T_ext_fcst	External air temperature forecast for the building location	Table of the external air temperature (°C) forecast for the next 24h or 48h (timesteps<=1h)	Con_ExDatProv_wx

Sol_irr	Last Solar irradiation data at building location	Diffuse and direct Solar irradiation (W/m²) received at the building location, if available. Total irradiance (W/m²) on a plane surface at the building location. Timestep<=15min	Con_ExDatProv_wx
Sol_irr_fcst	Solar irradiation forecast at building location	Table of the solar irradiation forecast (W/m²), total or divided in diffuse & direct, for the next 24h or 48h at the building location Timestep<=15min	Con_ExDatProv_wx
Cal_sched_info	Information concerning local schedule calendar	Information concerning local calendar data (public holidays, school holidays, other calendar data that could impact building occupancy)	Con_ExDatProv_cal
Cal_Mode_OccCtl_Bd	Occupancy control mode calendar for the building	Calendar of the occupancy control mode for the building. For each day it can take one of these values: unoccupied, fixed schedule, auto. A default mode can be initialized and then some other modes can be defined specifically for some periods or days.	
Cal_Mode_OccCtl_Zk	Occupancy control mode calendar for the zone k	Calendar of the occupancy control mode for the zone k. For each day it can take one of these values: not activated, auto, unoccupied, fixed schedule. A default mode can be initialized for all zones and then some other modes can be defined specifically for some periods or days, or some zones.	
D-sch_Occ_Prob_Bd	Daily schedule probability of Building Occupancy	Table of occupancy probability for the whole building, defined for the day (24h) and with a timestep<=15min This is the raw output of the prediction models	

D-sch_OccSt_Plan_Bd	Daily schedule of Building planned occupancy status	Table of planned occupancy status (occupied/unoccupied) for the building and for the day (24h). It is derived from D-sch_Occ_Prob _Bd in function of sensibility parameters.	
T_preHeatCool_Bd	Time for preheating and precooling of the building	Time required by HVAC system for preheating and precooling of the building for a switch from unoccupied to occupied in the building occupancy schedule	
D-sch_Occ_Prob_Zk	Daily schedule prediction of Zone occupancy	Table of occupancy indicator (to be defined) for the zone “k”, for the day (24h) and with a timestep<=15min This is the raw output of the prediction models	
D-sch_OccSt_Plan_Zk	Daily schedule prediction of zone occupancy status	Table of planned occupancy status (occupied/unoccupied) for the zone k and for the day (24h). It is derived from D-sch_Occ_Prob_Zk in function of sensibility parameters	
T_preHeatCool_ Zk	Time for preheating and precooling of the Zone	Time required by HVAC system for preheating and precooling of the building Zone “k” for a switch from unoccupied to occupied in the building occupancy schedule	
Comfort_occ	Comfort indicator for each zone during occupancy periods	Comfort data during occupancy periods for a given period of time. Presented as a graph, it enables to target the amount of time where adequate comfort is not met while the building is occupied. Related to KPI1	
Cs_heat_gas_occ	Heating gas consumption by hour of building occupancy	Gas consumption for heating (kWh PCS) by hour of building occupancy over a given period Related to KPI2	

Cs_cool_elec_occ	Cooling electricity consumption by hour of building occupancy	Electricity consumption (kWh) for cooling by hour of building occupancy over a given period Related to KPI2	
Cs_corr_heat_gas_occ	Climate corrected heating gas consumption for heating by hour of building occupancy	Gas consumption for heating (kWh PCS), corrected to a given normal climate by hour of building occupancy over a given period Related to KPI3	
Cs_corr_cool_elec_occ	Climate corrected Cooling electricity consumption by hour of building occupancy	Electricity consumption (kWh) for cooling corrected to a given normal climate by hour of building occupancy over a given period Related to KPI3	
Ind_overHeat	Overheating indicator relatively to zone occupancy	Indicator of overheating calculated for the building when heating happens in a zone but is not directly related to an actual need (occupancy wise) Related to KPI 4 Indicator requiring quite a lot of processing and analysis, as well as rules to define when "overheating actually happen".	
Ind_overCool	Overcooling indicator relatively to zone occupancy	Indicator of overcooling calculated for the building when heating happens in a zone but is not directly related to an actual need (occupancy wise) Related to KPI 4 Indicator requiring quite a lot of processing and analysis, as well as rules to define when "overcooling actually happen".	
Acc_preHeatCool_Bd	Accuracy of preheating and precooling prediction time for the building	Accuracy of preheating and precooling prediction time for the building	

Acc_preHeatCool_Zk	Accuracy of preheating and precooling prediction time for each zone	Accuracy of preheating and precooling prediction time for each zone	
Acc_pred_Occ_Bd	Accuracy of occupancy prediction for the building	Accuracy of occupancy prediction for the building	
Acc_pred_Occ_Zk	Accuracy of occupancy prediction for the different Zones	Accuracy of occupancy prediction for the different Zones	
Tab_Param_P	Parameter table for the local controller points	Table giving for each local controller point (P), the corresponding parameter in terms of: Zone where the sensor is located Temperature weight (for aggregation at zone or building level) heating power weight (for aggregation at zone or building level) Cooling power weight (for aggregation at zone or building level)	
Tab_Param_S	Parameter table for the local sensor points	Table giving for each sensor points (S), the following parameter: Zone where the sensor is located Type of occupancy data parameter (depending on type of sensor)	
Occ_SE_Bd	Occupancy sensibility parameters for the building	Sensibility parameters to determine building occupancy status based on occupancy data: Minimum occupancy data threshold to consider the building as occupied Minimum time of threshold overshoot to consider the building as occupie	

		Maximum number of cycle (occupied/unoccupied) per day	
Occ_SE_Z	Occupancy sensibility parameters for the zone	Sensibility parameters to determine Zone occupancy status based on occupancy data: Minimum occupancy data threshold to consider the building as occupied Minimum time of threshold overshoot to consider the building as occupied Maximum number of cycle (occupied/unoccupied) per day	

6. Requirements.

The section 6 of the use case template summarizes the requirements of all steps in the use case and it is linked to template section 4 “Step by Step Analysis”. These requirements are divided into categories with a unique category ID and a unique requirements ID (R-ID).

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Con	Connection to external system or devices	The connection with the external actors (devices or systems) are operational (access right, license)
Requirement R-ID	**Requirement name**	**Requirement description**
Con_BMS	Connection with the BMS	Connection with the BMS is operational with the possibility to collect and update all the required data.
Con_OccSensors	Connection with occupancy sensors network	Connection with the occupancy sensors is operational and all the data can be requested, or the data are sent when available.
Con_ExDatProv_wx	Connection with weather external data provider	Connection with the external data provider is available to have access to real time weather data and to weather forecast. License is up to date.
Con_ExDatProv_cal	Connection with external data provider for local calendar data	Connection with the external data provider is available to have access to local data calendar. License is up to date.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Cfg	Configuration parameters	Define the configuration parameter required to run some of the analysis or processing.
Requirement R-ID	**Requirement name**	**Requirement description**
Cfg_Param_P	Configuration parameters of the controller points	Config parameters for local controller points available in the system (info ID: Tab_Param_P)
Cfg_Param_S	Configuration parameters for the occupancy sensor points	Config parameters for occupancy sensor points available in the system (info ID: Tab_Param_S)
Cfg_Occ_SE_Bd	Configuration parameters for building occupancy sensibility	Configuration parameters defining the occupancy probability to be considered to activate the occupancy status occupied/unoccupied for the building.
Cfg_Occ_SE_Z	Configuration parameters for zone occupancy sensibility	Configuration parameters defining the occupancy probability to be considered to activate the occupancy status occupied/unoccupied for the zone.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Col	State of data collected and preprocessed available in the system	This requirement category concerns the actual availability of data in the system to run analysis or algorithm. Some scenario/analysis can occur only if these data are up to date and available.
Requirement R-ID	**Requirement name**	**Requirement description**
Col_IntAirTemp	Real time internal air temperature collected and preprocessed	Data concerning real time internal air temperature are collected and aggregated for each zone of the building.

Col_valv_ctl	Real time data concerning valve control (heating and cooling) collected and preprocessed	Data concerning real time valve control (heating and cooling) are collected and aggregated for each zone of the building.
Col_TempSet	Real time data concerning temperature setpoint (heating and cooling) collected and preprocessed	Data concerning real time temperature setpoint for heating and cooling are collected and aggregated for each zone of the building.
Col_HVACmode	Real time data concerning valve control (heating and cooling) collected and preprocessed	Data concerning HVAC mode are collected and aggregated for each zone of the building.
Col_Occ	Real time data concerning occupancy collected and preprocessed	Data concerning occupancy are collected and aggregated for each zone and the whole building.
Col_cs	Consumption data for heating and cooling collected	Consumption data for heating and cooling and for the adequate period is collected and available
Col_wx	Real time data concerning external weather collected	Data concerning external weather (external air temperature and solar irradiations) are collected.
Col_wx_fcst	Real time data concerning weather forecast collected	Data concerning external weather forecast for the next 24-48h (including external air temperature and solar irradiations) are collected.
Col_cal	Local calendar data collected	Data concerning local calendar data are collected and available in the system

7. Common terms and definitions.

The section 7 of the use case template contains common terms and definitions in a glossary. Each important term used in course of the project has to be followed by its definition.

Common terms and definitions	
Term	**Definition**
BMS	Building Management System
Local HVAC controller	In the building, local controller with local air temperature sensing and local regulation of heating and cooling (though valves opening)

LLUC-P-3a- 02: Provide Demand Response services through building inertia and HVAC controls

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
LLUC-3a-02	Costumer premises	Provide Demand Response services through building inertia and HVAC controls

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
V1	10.06.2020	PETINOT Romain	First validated version	validated

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	While demand response is viewed as a way to help balancing and managing the grid, there is a lack of available controllable loads on the French market to provide this kind of service. A significant part of the electrical loads are not easy to use for demand response services, as they fluctuate a lot (uncertainty on the available flexibility) and more dispersed and smaller sites have to be aggregated (automatic controls becoming a requirement). Using a building already equipped with a BMS, this use case aims at 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. The BMS enable to control the HVAC systems and give access to comfort data (temperatures) in the building. It is assumed that an aggregator is implicated in the project and will value the load flexibility on the French energy and capacity markets. A contract will be signed between the Building manager and the Aggregator specifying the conditions and compensations related to the demand response services implementation. Prediction algorithms will be developed to

	estimate daily, in function of the building behavior and weather forecast, the load flexibility available and thus help the Aggregator to engage reliable demand response services.
Objective(s)	Provide flexibility services to contribute to the grid balance (helping to reduce peak demand on the grid) Provide accurate predictions of the flexibility available for the next day to help the aggregator value the Demand Response service provided on the market Generate income by contracting with an aggregator
Related business case(s)	

1.4 Narrative of Use Case.

Narrative of use case
Short description
The use case intends to provide a smart module to supervise the implementation of Demand Response services in an office Building using HVAC control and building inertia. Collecting data on the building and using weather forecast, the module developed is providing predictions of the HVAC load and the potential flexibility available while maintaining a given level of comfort in the building. 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 activate or plan load interruptions on the building. After validation of the requests (within conditions of the agreement and respecting available flexibility), they are implemented and supervised through the BMS. Feedbacks and eventual alerts are shared with the aggregator if it is relevant. The predictions of the HVAC load will be assessed regularly. The availability of the flexibility and the capacity to react to a demand response request will also be evaluated.
Complete description
Requirements for the implementation of the Demand Response service on the office Building: Different data must be collected to implement the services developed in this use case: Data from the Building Management System (BMS): Temperature in the different area of the building

Temperature setpoints in the different area of the building

HVAC schedule operation calendar and HVAC controls parameters

Electrical load of HVAC system

Electrical load of the building

Weather data and weather data forecast (next 48h) from external provider:

External air Temperature at the building location

Solar irradiation at the building location

The HVAC system of the building has to be controllable through the BMS in order to send orders when required.

In the case of the pilot, "HVAC mode status" is defined in the BMS and can take one of the following values: Auto, Heat, Cool, Off. While the system is operating (auto, heat, cool), it is assumed that it will be possible to switch this variable to "off" to stop the HVAC operation in the building.

NB: the principle is to be able to shift the HVAC load as fast as possible. A direct action/order on heating or cooling system will be more efficient than for example reducing the temperature setpoint in the building (the inertia in the HVAC network to finally cut down the heating or cooling systems will take more time).

To implement a Demand Response service using HVAC control on an office building, heating and cooling in the Building have to operate mainly on electricity so that the load shifting potential be significant. A minimum annual electrical load may also be requested to assure the business relevance to include a specific building in a flexibility scheme.

NB: for the Building of the pilot, heating is mainly realized with gas system which significantly reduce the relevance of using the building for Demand Response services. A specific analysis will be realized considering that the heating load is provided by an electric system to have a more relevant case of study.

Flexibility prevision and valorization:

It is assumed that the use case will be realized in partnership with an Aggregator who will value the Demand Response Service through the different grid mechanisms available in France. Two main mechanisms are available:

Capacity mechanism where offers for load capacity interruption can be sold regularly to the grid operator (every day for the next one and within the current day). The grid operator can activate these capacities when required.

Energy mechanism where “energy blocks” can be traded on the market (every day for the next one and within the current day).

Over the last years, specific calls for tender are emitted by the French grid operator in order to encourage more actors to provide Demand Response service on the national grid. They are characterized by actors’ engagements to be present on the capacity and energy mechanisms according to certain rules while receiving specific compensations.

The grid operator will check a posteriori according to different methodologies that the services promised (in terms of energy and power) are provided.

Visibility on the available flexibility is therefore a very important aspect for the Aggregator in order to engage demand response services to the grid operator or trade energy blocks on the market.

That’s why, the module developed in this use case will be providing predictions of the flexibility potential available on the building for the current day and for the next one, according the aggregator need (on his request or periodically):

For the current day:

HVAC electrical load (kW, timestep <=10min): prediction in function of the current state of the building, HVAC control schedules and parameters, and weather forecast

Available flexibility duration (min) every 30min: estimated load interruption duration (in minutes) before the minimum comfort threshold defined for the building is reached.

for the next day:

HVAC electrical load (kW, timestep <=10min): prediction in function of HVAC control schedules and parameters, and weather forecast

Available flexibility duration (min) every 30min: estimated load interruption duration (in minutes) before the minimum comfort threshold defined for the building is reached.

Upon request of the aggregator, the system will also provide:

for a given load shifting event (time and duration) for the current day or the next one: prediction of the daily HVAC load (kW, timestep <=10min)

In this case the HVAC load prediction characterizes the deferred load, i.e. the increased load susceptible to arise after the load interruption to restore the “normal” comfort level in the building. This is an important parameter for the aggregator to trade energy blocks on the market.

Implementation of a Demand Response Event & Programs

When the aggregator wants to initiate a load interruption on the building (capacity mechanism), the information concerning the time and expected duration is sent to the Demand Response module. After validation that the load shifting requested is possible, it is implemented on the building. Comfort parameters on the building are monitored to confirm that they stay within adequate levels. If the comfort decreases below a certain threshold, the system will switch on the HVAC system in function of conditions defined with the aggregator. If the flexibility prediction is accurate enough, this situation should not occur. Feedback and eventual alerts are shared to the aggregator concerning the ongoing process.

The aggregator will also be able to send energy shifting programs for the current day or the next one (energy mechanism). These programs will be based on a given demand response time and duration and associated to a HVAC load prediction, previously calculated by the module. Once implemented, the system will send alerts to the aggregator if deviations are detected in comparison with the prevision.

NB1 : during load interruption events, or when a load shifting program is activated, the controls of the HVAC system should not be modified by the building manager or the occupants of the building (or it can be modified within conditions specified in the contract with the aggregator).

NB2 : the occupants of the building should be informed by the building manager that load shifting can happen on the building, inducing a potential temporary comfort reduction. Local and visual warning of the occupants during these events would be optimal but they are not in the scope of the use case.

System configuration and parameters

In the system, the building manager can configure the threshold comfort parameters for demand response events (maximum variations and/or minimum temperature required in the building, it can be defined on average in the building and/or locally). For certain days, and within conditions defined with the aggregator, the building manager can update a calendar of demand response derogations: during these days no demand response services will be implemented on the building.

The aggregator will have the possibility to define the schedule and frequency for which he wishes to receive HVAC load predictions and flexibility predictions. Deviation thresholds, inducing an alert to the Aggregator for energy shifting program can also be updated by the Aggregator in the system.

KPI and performance analysis

The level and availability of demand response services will be assessed throughout the year (cf. KPI).

The accuracy of the different predictions will be assessed concerning:

Daily HVAC load without load shifting or interruptions

Available flexibility (time of load interruption)

Daily HVAC load associated to load shifting program (with characterization of the deferred load).

The actual implementation of Demand Response Request will also be analyzed (capacity to answer the request, response time)

All these KPI will be accessible/transmitted to the Building Manager and the Aggregator.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
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	Contribute to the grid management (reduce peak demand offset)
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	Contribute to the grid management (reduce peak demand offset)
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.	Provide accurate prediction to the aggregator
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.	Provide accurate prediction for the aggregator
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).	Provide accurate prediction to the aggregator

		The error can be characterized over the period: mean, standard deviations, distribution during Demand response event.	
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.	Respect the contract with the aggregator (and generate income)

1.6 Use case conditions.

Use case conditions
Assumptions
The building considered is relevant to implement demand response services: heating and cooling in the Building have to operate mainly on electricity so that the load shifting potential is significant. A minimum annual electrical load may also be requested to assure the business relevance to include a specific building in a flexibility scheme. NB: for the Building of the pilot, heating is mainly realized with gas system which significantly reduce the relevance of using the building for Demand Response services. A specific analysis will be realized considering that the heating load is provided by an electric system to have a more relevant case of study.
Prerequisites
Analysis of the building relevance to be implemented in a demand response scheme must be validated.

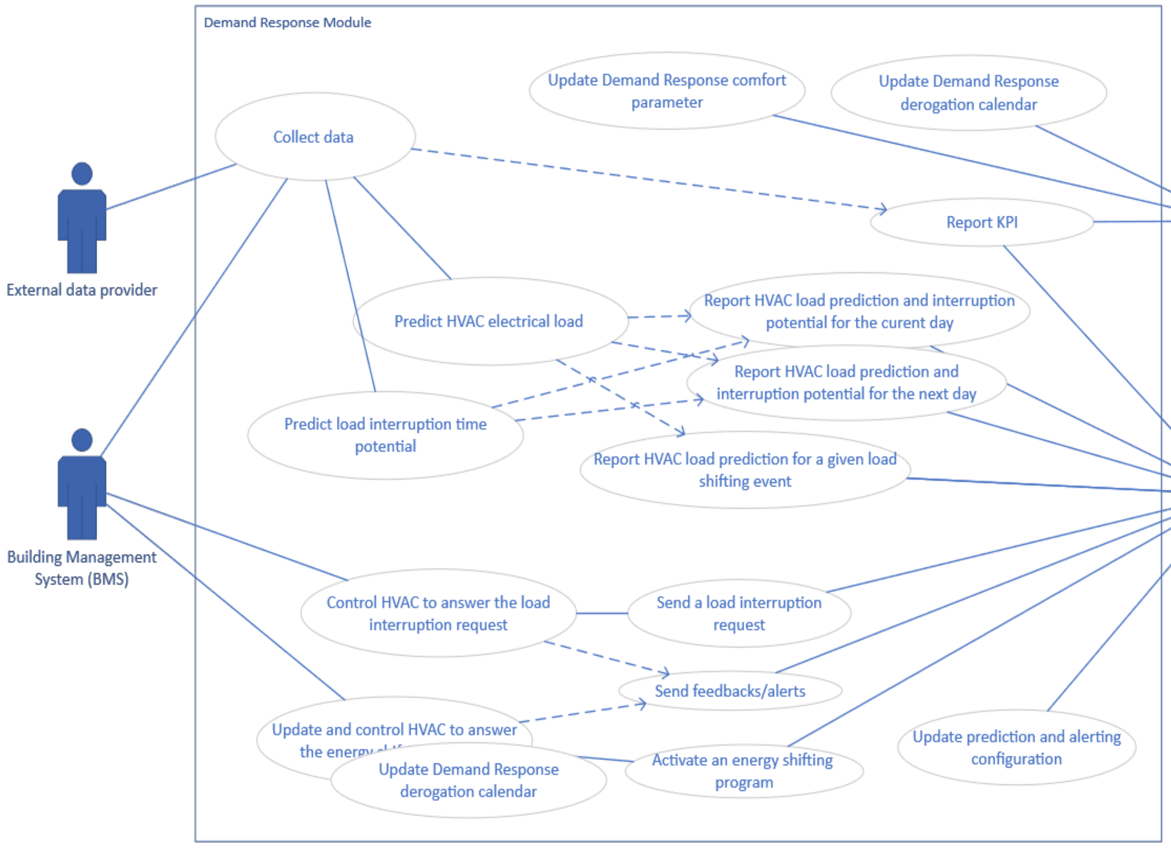
Use case conditions
Assumptions
A partnership is implemented with an aggregator to value the flexibility on the French capacity and energy market.
Prerequisites
Find an aggregator that could be interested or create the required entity to play this role.

Use case conditions
Assumptions
The availability of the data and the possibility to interact and control the BMS is validated with the company in charge of the Building maintenance and the building manager.
Prerequisites
Discussion and agreement have to be reached with the company in charge of the building maintenance and the building manager.

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

Classification information
Relation to other use cases
The data collected is very similar to the low-level use case 1 developed for the pilot. Some services will be similar. NB: there could be a conflict between the 2 low level use cases as the control of HVAC according to real occupancy could be conflicting with the need to predict and pilot the HVAC load in the low-level use case 2. There is a competition between regulating the load to the actual need of the occupants, and respecting engagements (load interruption and shifting) taken towards the grid operator.
Level of depth
Detailed business use case specifying the required information
Prioritization
Important
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
Demand response, HVAC, occupation, AI, energy savings, GHG savings, smart grid

2. Diagrams of use case.

Diagram(s) of use case


3. Technical details.

3.1 Actors

Actors			
Grouping		**Group description**	
External actors		List of external actors of the use case	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
BMS	system	BMS (Buildings Management System) : system enabling to overview and control the technical equipment of the building.	BMS system can be more or less evolved or developed. In this case we assume it collects data over the HVAC system of the building and pilot independently

			heating and cooling in the different zones of the building.
External data provider	system	External data are required concerning weather data and weather forecast	
Building manager	human	Person in charge of the building operation	
Aggregator	System/entity	An aggregator is a service provider which can increase or moderate the electricity consumption of a group of consumers according to the total electricity demand on the grid. The aggregator contributes to the grid management by the demand response services he can provide and that he will value on the different grid mechanisms available.	Interaction with the aggregator will happen with the information system of the aggregator. The constraints related to the information exchanged with the aggregator are not fully defined (depends on the aggregator information system and its strategy/approach to sell services on the French capacity and energy mechanisms)

3.2 References.

No.	Reference	Status	Impact on use case	Originator / organization	Link
1	MA-RE_Mech_RTE	final	Characterize the constraints of the aggregator to provide capacity services on the grid	French TSO (RTE)	https://clients.rte-france.com/htm/fr/offre/telecharge/MARE_Section_1_20200601.pdf
2	NEBEF_Mech_RTE	final	Characterize the constraints of the aggregator to trade energy block on the market	French TSO (RTE)	https://www.services-rte.com/files/live/sites/services-rte/files/pdf/NEBEF/R%c3%a8gles%20SI%20NEBEF%20v3.2.1.pdf

4. Step by step analysis of use case.

4.1 Overview of scenarios.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Precondition**	**Post-condition**
1	Collect data from BMS	Collect the real time data of the building	BMS or Demand response module	Periodical occurrences (<=10min)	Last data not collected from BMS system	The raw data from the BMS are stored and available for further use
2	Collect current weather data	Collect current weather data (external air temperature and solar radiation) from external data provider	Demand response module	Periodical occurrences (<=10min)	Last data for weather not collected	The weather data is stored and available for further use
3	Collect weather data forecast	Collect weather forecast (external air temperature and solar radiations) for the next 48h from external data provider	Demand response module	when required by the system	Last weather forecast not downloaded	The weather forecast for the next 48h is available for further use
4	Update comfort thresholds for demand response events	Update of the controls defining comfort threshold in the building during demand response events.	Building manager	Building manager request		Parameters for demand response events are updated
5	Update of the demand response derogation calendar	Update of the calendar specifying days with demand response services derogations (within constraints defined with the aggregator)	Building manager	Building manager request		Update of the demand response derogation calendar
6	Predict HVAC electrical load with potential interruption duration for the rest of the current day	In function of the last data collected on the building, weather predictions and HVAC operation schedule for the building, the module estimates the HVAC electrical load curve for the rest of the current day. In addition, the module estimates the potential interruption duration, calculating	Demand Response module	Run periodically every day (or on Aggregator request)		The HVAC electrical load and the flexibility predicted for the rest of the day are shared to the aggregator

		for the rest of the day (every 30min) the duration of the load interruption that could be realized relatively to the comfort threshold values defined by the building manager				
7	Predict HVAC electrical load with potential interruption duration throughout the next day	In function of weather predictions and HVAC operation schedule for the building, the module estimates the HVAC electrical load curve for the next day. In addition, the module estimates the potential interruption duration, calculating throughout the next day (every 30min) the duration of the load interruption that could be realized relatively to the comfort threshold values defined by the building manager	Demand Response module	Run periodically (or on Aggregator request)		The HVAC electrical load and the flexibility predicted for the next day are shared to the aggregator
8	Predict HVAC electrical load for a given load interruption request	For a given start and duration of a load interruption event for the next day, the system is predicting the HVAC electrical load with the load interruption and the energy load deferral likely to happen afterwards	Aggregator	Aggregator request		The predicted HVAC load for a given load shifting request is shared with the aggregator
9	Execute a HVAC load interruption on the building	The aggregator is requesting an HVAC load interruption for a given duration. If the order is validated, the system updates the controls of the building HVAC in the BMS to answer the request. Comfort level in the building are monitored and alerts are shared with the aggregator if the load interruption duration cannot be respected.	Aggregator	Aggregator request		The requested load interruption is realized on the building and relevant information are shared with the aggregator
10	Program and supervise a load shifting event on the building	The aggregator is sending a program for a load shifting event (time and duration) with a given HVAC load prediction (scenario 8). If the program is validated, the adequate controls are implemented with the BMS to implement the program. The	Aggregator	Aggregator request		The requested load shifting program is realized on the building and relevant information are

		evolution of the HVAC load is followed, and alerts are sent to the aggregator if significant deviations from the expected program are detected.				shared with the aggregator
11	Report KPI on a given period	An assessment of the KPI on a given period is reported on request to the building manager or the aggregator	Demand Response module	Building manager or aggregator request		The KPI are reported to the building manager or the aggregator
12	Update prediction scheduling and alerting configuration	The aggregator can update the predictions scheduling and the alerting configuration during Demand Response event implemented on the building.	Aggregator	Aggregator request		The configuration parameters for prediction scheduling and alerting are updated

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1 – Collect data from BMS**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement R-IDs**
1	Periodical check or when required	Collect real time data from BMS	The real time data since last request is collected from the BMS concerning internal air temperature and temperature setpoints. These data are collected for each local controller point "i". The planned HVAC status schedule, global HVAC command parameter and the HVAC electrical consumption are collected as well.	GET	BMS	Demand Response module	Tia_Pi Tset_heat_Pi Tset_cool_Pi Param_HVAC_cmd Schd_HVAC_cmd Cs_HVAC_elec	Con_BMS

Scenario								
Scenario name:		**No. 2 – Collect current weather data**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Informationproducer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement R-IDs**
1	Periodical check or when required	Collect weather data	Collect current weather data (external air temperature and solar radiation) from external data provider	GET	External data provider	Demand Response module	T_ext Sol_Irr	Con_ExDatProv_wx

cenario								
Scenario name:		**No. 3 – Collect weather data forecast**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	When required for model application	Collect weather data forecast	Collect weather forecast (external air temperature and solar radiation) for the next 48h from external data provider	GET	External data provider	Demand Response module	T_ext_fcst_48h Sol_irr_fcst_48h	Con_ExDatProv_wx

Scenario								
Scenario name:		**No. 4 – Update comfort controls for demand response events**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Building manager request	Update comfort controls for demand response events	The Building manager can update the comfort threshold in the building, i.e. the maximum variations, or minimum level of comfort in the building accepted during Demand Response event	CHANGE	Building manager	Demand Response module	Param_DR_cmft	

scenario								
Scenario name:		No. 5 – Update of the demand response derogation calendar						
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information ex-changed (IDs)	Requirement (R-IDs)
1	Building manager request	Update of the demand response derogation calendar	The Building manager can update the derogation calendar, specifying some days where no Demand Response services will be provided. The possibility of derogation will depend on the conditions agreed with the aggregator.	CHANGE	Building manager	Demand Response module	Sch_DR_derog	

Scenario								
Scenario name:		**No. 6 – Predict HVAC electrical load with potential interruption duration for the rest of the current day**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Periodically (or manualactivation)	Predict HVAC electrical load for the rest of the current day	Prediction of the HVAC electrical load in function of the current building/HVAC data, HVAC operation schedule and weather forecast.	EXECUTE	Demand Response module	Demand Response module	D-load_HVAC_Pred	Col_Tia Col_Cs_HVAC, Col_Schd_HVAC_cmd

			NB: This is an estimation of the load that can potentially be interrupted.					Col_Param_HVAC_cmd Col_wx Col_wx_fcst
2	Same than step 1	Predict interruption duration potential for the rest of the current day	Every 30min timestep during the rest of the current day, the system estimates the potential duration of a load interruption that could be implemented on the building before reaching the threshold comfort level defined by the building manager.	EXECUTE	Demand Response module	Demand Response module	D-Dur_Inter_Pred	Col_Tia Col_Cs_HVAC, Col_Schd_HVAC_cmd Col_Param_HVAC_cmd Col_wx Col_wx_fcst Cfg_DR_Cmft
3	Step 1 & 2 realized	Report the HVAC load prediction and the interruption duration potential to the Aggregator	The HVAC electrical load and interruption duration potential for the rest of the current day are reported to the Aggregator.	REPORT	Demand Response module	Aggregator	D-load_HVAC_Pred D-Dur_Inter_Pred	Con_Aggr

scenario								
Scenario name:		**No. 7 – Predict HVAC electrical load with potential interruption duration throughout the next day**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Periodically (or manual activation)	Predict HVAC electrical load for the next day	Prediction of the HVAC electrical load in function of HVAC operation schedule and weather forecast data. NB: This is an estimation of the load that can potentially be interrupted.	EXECUTE	Demand Response module	Demand Response module	D-load_HVAC_Pred	Col_Schd_HVAC_cmd Col_Param_HVAC_cmd Col_wx_fcst
2	Same than step 1	Predict interruption duration potential throughout the next day	Every 30min timestep during the next day, the system estimates the potential duration of a load interruption that could be implemented on the building before reaching the threshold comfort level defined by the building manager.	EXECUTE	Demand Response module	Demand Response module	D-Dur_Inter_Pred	Cfg_DR_Cmft Col_Schd_HVAC_cmd Col_Param_HVAC_cmd
3	Step 1 & 2 realized	Report the HVAC load prediction and the interruption duration	The HVAC electrical load and interruption duration potential for the next day are reported to the Aggregator.	REPORT	Demand Response module	Aggregator	D-load_HVAC_Pred D-Dur_Inter_Pred	Con_Aggr

		potential to the Aggregator						
Scenario								
Scenario name:		**No. 8 – Predict HVAC electrical load for a given load interruption request**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Aggregator request	Request for HVAC load simulation	The aggregator sends the information corresponding to a given load interruption event (start time and duration) he wants to simulate on the building for the rest of the day or for the next day	CHANGE	Aggregator	Demand Response module	Tm_st_load_inter Dur_load_inter	Con_Aggr
2	Aggregator request received (step 1 realized)	Predict daily HVAC electrical load for the load interruption event requested	Prediction of the HVAC electrical load in function of the current building/HVAC data, HVAC operation schedule, weather forecast and the load interruption to be simulated. An estimation of the flexibility duration (min) remaining at the end of the load interruption requested is also calculated (it can be negative if comfort thresholds are overstepped)	EXECUTE	Demand Response module	Demand Response module	D-load_HVAC_Pred Dur_RemFlex	Col_Tia Col_Cs_HVAC, Col_Schd_HVAC_cmd Col_Param_HVAC_cmd Col_wx Col_wx_fcst Cfg_DR_Cmft

3	New flexibility schedule calculated (step 1 & 2 realized)	Report the HVAC electrical load predicted and remaining flexibility	The predicted HVAC electrical load and the remaining flexibility are reported to the Aggregator.	REPORT	Demand Response module	Aggregator	D-load_HVAC_Pred Dur_RemFlex	Con_Aggr

Scenario								
Scenario name:		**No. 9 – Execute a HVAC load interruption on the building**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Aggregator request	Request for load interruption	The aggregator sends a request for load interruption (start time and duration) in the building.	CHANGE	Aggregator	Demand Response module	DR_event_state Tm_st_load_inter Dur_load_inter	Con_Aggr
2	Interruption request received (step 1 realized)	Validate implementation of the load interruption request	Check if the building can answer the demand response request: run scenario 6. Evaluation of the flexibility remaining at the end of the load interruption requested.	CHANGE	Demand Response module	Demand Response module	DR_event_state Dur_RemFlex	Cfg_cal_DR_act Cfg_DR_Cmft + Requirements for scenario 6

3	Interruption request validated and beginning of load interruption	Send the controls to the BMS to stop HVAC operation	The module sends the order to the BMS to stop the heating or cooling system operation.	CHANGE	Demand response module	BMS	HVAC_cmd	Con_BMS
4	Interruption request validated and implemented	Send feedback to aggregator that the load interruption is implemented	The feedback that the load interruption is implemented and the estimated flexibility remaining at the end of the load interruption is reported to the aggregator.	REPORT	Demand response module	Aggregator	DR_event_state Dur_RemFlex	Con_Aggr
5	Load interruption currently going on (REPEAT)	Check comfort in the building regarding threshold parameters	The data collected on the building enable to follow the comfort in the building and check the remaining flexibility duration	EXECUTE	Demand response module	Demand response module	DR_event_state Dur_RemFlex	Cfg_DR_Cmft Col_Tia
6	Remaining flexibility duration becoming negative (during step 5)	Send alert on a lack of flexibility to reach the required duration of load interruption	Report alert on a lack of flexibility to maintain the load interruption during the requested duration precising the actual negative flexibility duration estimated	REPORT	Demand response module	Aggregator	Dur_RemFlex	Con_Aggr Cfg_Param_alert
7	End of load interruption requested duration or threshold on comfort	Send the controls to the BMS to switch back the HVAC system operation	The module sends the order to the BMS to switch back the HVAC system operation to the mode before interruption.	CHANGE	Demand response module	BMS	HVAC_cmd	Con_BMS

	parameter reached							
8	Load interruption event completed	Send feedback that load interruption is over to the aggregator	A feedback is sent to the Aggregator to inform him that the load interruption is over and to precise the remaining flexibility duration available at the end of the load interruption.	REPORT	Demand response module	Aggregator	DR_event_state Dur_RemFlex	Con_Aggr

scenario								
Scenario name:		**No. 10 – Program and supervise a load shifting event on the building**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Aggregator request	Request for a load shifting program	The aggregator sends a request for a load shifting program to apply during the day or for the next one, specifying the start time and duration of the interruption to implement and the expected daily HVAC load (calculated according to scenario 8)	CHANGE	Aggregator	Demand Response module	DR_program_state Tm_st_load_inter Dur_load_inter D-load_HVAC_Pred	Con_Aggr
2	Load shifting program requested	Validate the implementation	Validate if the building can implement the load shifting	CHANGE	Demand Response module	Demand Response module	DR_program_state Dur_RemFlex	Cfg_cal_DR_act Cfg_DR_Cmft

		of the load shifting program	program. Predictions like scenario 8 is run. Validate the predicted D-load_HVAC_Pred Evaluation of the flexibility remaining at the end of the load interruption requested.					+ Requirements for scenario 8
3	Load shifting program validated	Feedback to aggregator that load shifting program is validated	The feedback that the program is validated with precision of the remaining flexibility at the end of the load interruption requested are reported to the aggregator.	REPORT	Demand response module	Aggregator	DR_program_state Dur_RemFlex	Con_Aggr
4	Load shifting program request validated & start of the program (REPEAT during the whole program = whole day)	Check evolution of the load shifting request and detect deviation	The data collected on the building enable to follow the HVAC load and the available flexibility in the building. Predictions like scenario 8 is run. Deviations in the HVAC load are calculated in comparison with current data and predictions (scenario 8). The remaining flexibility for the given load interruption requested is estimated as well.	EXECUTE	Demand Response module	Demand Response module	D-load_HVAC_Pred D-load_HVAC_Dev Dur_RemFlex	Scenario 6 to be run + Requirements for scenario 8

5	During step 4 and HVAC load deviation reaching a given threshold (REPEAT as step 4 until end of day)	Report alerts to the Aggregator and send update of the HVAC load prediction	Send alert to the aggregator about deviations in the expected HVAC load and send the new expected HVAC load.	REPORT	Demand response module	Aggregator	D-load_HVAC_Dev D-load_HVAC_Pred	Con_Aggr Cfg_Param_alert
5bis	After step 4 and Remaining flexibility duration becoming negative (REPEAT as step 4 until end of load shifting event)	Send alert on a lack of flexibility to reach the required duration of load interruption	Report alert on a lack of flexibility to maintain the load interruption during the requested duration precising the actual negative flexibility duration estimated	REPORT	Demand response module	Aggregator	Dur_RemFlex	Con_Aggr Cfg_Param_alert
6	Start of the load interruption in the validated program	Send the controls to the BMS to stop HVAC operation	The module sends the order to the BMS to stop the heating or cooling system operation.	CHANGE	Demand response module	BMS	HVAC_cmd	Con_BMS
7	Load interruption implemented on the building	Send feedback to aggregator that the load interruption is implemented	The feedback that the load interruption is implemented and the estimated flexibility remaining at the end of the load interruption is reported to the aggregator.	REPORT	Demand response module	Aggregator	DR_event_state Dur_RemFlex	Con_Aggr

8	End of load interruption requested duration or threshold on comfort parameter reached	Send the controls to the BMS to switch back the HVAC system operation	The module sends the order to the BMS to switch back the HVAC system operation to the mode before interruption.	CHANGE	Demand response module	BMS	HVAC_cmd	Con_BMS
9	Load interruption event completed	Send feedback to the aggregator that load interruption is over	A feedback is sent to the Aggregator to inform him that the load interruption is over and to precise the remaining flexibility duration available at the end of the load interruption.	REPORT	Demand response module	Aggregator	DR_event_state Dur_RemFlex	Con_Aggr
10	End of load shifting program	Send feedback to the aggregator that load shifting program is over	A feedback is sent to the Aggregator to inform him that the load shifting program is over	REPORT	Demand response module	Aggregator	DR_program_state	Con_Aggr
Scenario								
Scenario name:	**No. 11 – Report KPI on a given period**							
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**

1	Building manager or Aggregator request	Report KPI on given period	The different KPI are calculated for the different time scale (weeks, month and year) and provided to the building manager or the Aggregator	GET	Demand response module	Building manager or Aggregator	Tab_load_shift_power Tab_load_shift_ener Tab_Err_load_pred_noDR Tab_Err_load_pred_DR Tab_Err_flex_pred DR_request_stat	Con_Aggr

Scenario

Scenario name:	**No. 12 – Update prediction scheduling and alerting configuration**

Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, (R-IDs)**
1	Aggregator request	Update prediction scheduling and alerting configuration	The aggregator can update the predictions scheduling and the alerting configuration during Demand Response event implemented on the building.	CHANGE	Aggregator	Demand Response module	Param_Pred_sched Param_alert	Con_Aggr

5. Information exchanged.

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Tia_Pi	Internal air temperature of the local controller point "i"	Internal air temperature (°C) of the local controller point "i" in the building	Connect_BMS
Tset_heat_Pi	Temperature setpoint for heating of the local controller point "i"	Temperature setpoint (°C) for heating of the control point "i" in the building	Connect_BMS
Tset_cool_Pi	Temperature setpoint for cooling of the local controller "i"	Temperature setpoint (°C) for cooling of the control point "i" in the building	Connect_BMS
Cs_HVAC_elec	Electrical load for cooling	Electrical load (kW) for building HVAC system Time step <=10smin	Connect_BMS
HVAC_cmd	HVAC status command	Variable defining the HVAC status command in the BMS (Off, Cool, heat, Auto)	Connect_BMS
Schd_HVAC_cmd	HVAC status command calendar for the next 48 hours	Schedule of the HVAC status command for the next 48 hours (cf. variable HVAC_cmd)	Connect_BMS
Param_HVAC_cmd	HVAC command parameters defined in the BMS	Default temperature setpoints for cooling and for heating in the building defined in the BMS	Connect_BMS

T_ext	External air temperature for the building location	External air temperature (°C) for the building location	Con_ExDatProv_wx
T_ext_fcst_48h	External air temperature forecast for the building location	Table of the external air temperature (°C) forecast for the next 48h (timesteps<=1h)	Con_ExDatProv_wx
Sol_irr	Last Solar irradiation data at building location	Diffuse and direct Solar irradiation (W/m²) received at the building location, if available. Total irradiance (W/m²) on a plane surface at the building location. Timestep<=15min	Con_ExDatProv_wx
Sol_irr_fcst_48h	Solar irradiation forecast for the next 48h	Table of the solar irradiation forecast (W/m²), total or divided in diffuse & direct, for the next 48h at the building location Timestep<=15min	Con_ExDatProv_wx
Sch_DR_derog	Schedule for Demand Response derogation	Schedule for demand response derogation on the building (daily derogation activation/deactivation)	
Param_DR_cmft	Threshold comfort parameters during HVAC interruption event	Comfort parameters defining the threshold in terms of comfort variations or absolute value that is acceptable in the building. It can be characterized by a relative temperature variation for the average temperature in the building and a minimum absolute value for the different data point collected in the building.	
Param_Pred_sched	Schedule of the predictions to be shared with the aggregator	Schedule of the different flexibility prediction to be realized (for the current day and the next day)	

Param_alert	Parameters concerning alerting of the aggregator	Parameters specifying aggregator alerting in case of: Given variations in the predictions realized (outside demand response event) Given variations in the predictions during demand response event	
D-load_HVAC_Pred	Daily HVAC load prediction	Daily HVAC load prediction (kW). Timestep<=10min, table for 24hours NB: for current day prediction, prediction is only available for the rest of the day.	
D-Dur_Inter_Pred	Daily interruption duration potential prediction	Every 30min timesteps of the day, duration (min) of load interruption susceptible to happen within comfort threshold defined by the building manager. Timestep= 30min, table for 24hours NB: for current day prediction, prediction is only available for the rest of the day.	
Tm_st_load_inter	Load interruption start time	Specific time of start for a load interruption (time + date)	
Dur_load_inter	Load interruption duration	Duration of a load interruption (min)	
Dur_RemFlex	Remaining flexibility duration	Remaining flexibility duration (min) available at the end of a load interruption NB: flexibility available before comfort threshold are reached	
DR_event_state	Demand Response event status in the building	Variable characterizing demand response event happening in the building: Null, Request, validated Running	

DR_program_state	Demand response program status in the building	Variable characterizing demand response program happening in the building: Null, Request, validated, Running	
D-load_HVAC_Dev	Daily HVAC load deviation	Daily HVAC load deviation (kW) between a first prediction and the real load or a more recent prediction. Timestep<=10min, table for 24hours	
Tab_load_shift_power	Table of power load shifting capacity	Table of power load shifting capacity Table used for data visualization	
Tab_load_shift_ener	Table of energy load shifting capacity	Table of energy load shifting capacity Table used for data visualization	
Tab_Err_load_pred_noDR	Table of error of HVAC load prediction for days without load shifting events	Table of error of HVAC load prediction for the different predictions (previous day, current day) for days without load shifting events Table used for data visualization	
Tab_Err_load_pred_DR	Table of error of HVAC load prediction for days with load shifting events	Table of error of HVAC load prediction for the different predictions (previous day, current day) for days with load shifting events	

		Table used for data visualization	
Tab_Err_flex_pred	Table of error of flexibility prediction	Table of error of flexibility prediction for the different predictions (previous day, current day), specifying period with load shifting event (and periods without) Table used for data visualization	
DR_request_stat	Statistics on demand response request versus realized	Statistics on demand response request versus realized	

6. Requirements.

The section 6 of the use case template summarizes the requirements of all steps in the use case and it is linked to template section 4 “Step by Step Analysis”. These requirements are divided into categories with a unique category ID and a unique requirements ID (R-ID).

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Con	Connection to external system or devices	The connection with the external actors (devices or systems) are operational (access right, license)
Requirement R-ID	**Requirement name**	**Requirement description**
Con_BMS	Connection with the BMS	Connection with the BMS is operational with the possibility to collect and update all the required data.
Con_ExDatProv_wx	Connection with weather external data provider	Connection with the external data provider is available to have access to real time weather data and to weather forecast. License is up to date.

Con_Aggr	Connection with the information system of the aggregator	Connection with the information system of the aggregator is operational to enable correct exchange of information

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Cfg	Requirement concerning configuration parameters	Define the configuration parameters required to run some of the analysis or processing.
Requirement R-ID	**Requirement name**	**Requirement description**
Cfg_Sch_DR_derog	Demand Response derogation calendar	Variable “Sch_DR_derog” is defined in the module and available as input for processing
Cfg_Param_DR_cmft	Threshold Comfort parameters for demand response events	Variable “Param_DR_cmft” is defined in the module and available as input for processing
Cfg_Param_Pred_sched	Configuration parameter concerning Prediction scheduling	Variable “Param_Pred_sched” is defined and available as input for processing
Cfg_Param_alert	Configuration parameter concerning alerting	Variable “Param_alert” is defined and available as input for processing

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Col	Requirements for some data to be collected and available in the system	This requirement category concerns the actual availability of data in the system to run analysis or algorithm. Some scenario/analysis can occur only if these data are up to date and available.
Requirement R-ID	**Requirement name**	**Requirement description**

Col_Tia	Real time internal air temperature collected	Data concerning real time internal air temperature are collected and aggregated for each zone of the building.
Col_Cs_HVAC	Real time internal air temperature collected	Data concerning real time internal air temperature are collected and aggregated for each zone of the building.
Col_Schd_HVAC_cmd	Schedule of HVAC command available and up to date for the next 48h.	Schedule of the HVAC status operation for the next 48h is up to date and available in the system.
Col_Param_HVAC_cmd	Parameters concerning HVAC control for the building available and up-to-date.	Parameters of HVAC command control of the building are available and up-to-date: temperature setpoints for heating and for cooling.
Col_wx	Real time data concerning external weather collected	Data concerning external weather (external air temperature and solar irradiations) are collected.
Col_wx_fcst	Real time data concerning weather forecast collected	Data concerning external weather forecast for the next 24-48h (including external air temperature and solar irradiations) are collected.

7. Common terms and definitions.

The section 7 of the use case template contains common terms and definitions in a glossary. Each important term used in course of the project has to be followed by its definition.

Common terms and definitions	
Term	Definition
BMS	Building Management System
Capacity Mechanism	Mechanism implemented for the grid operation so that different actor can provide power capacity that can be activated upon request by the grid operator.
Energy M@Landi52echanism	Mechanism implemented so that different actors on the energy market can trade energy blocks (for the next day, or the current day) that will be certified and verified by the grid operator.

LLUC-P-3b-01: Buildings Heating & Cooling consumption Analysis and Forecast

1. *Description of the use case*

4.1 Name of use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
PI_01	CUSTOMER PREMISES/OPERATION (EMS)	**Buildings Heating & Cooling consumption Analysis and Forecast** Benchmark and predict the consumption of cooling and heating plants installed in the 16 pilot buildings in the municipality of Rome (for both summer and winter seasons).

4.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	24.03.2020.	Poste Italiane	Initial creation	Draft
0.2	13.04.2020.	Poste Italiane	Use Case Scope, Objectives description and KPI	Draft
0.3	05.05.2020	Poste Italiane	Data exchanged	Draft
0.4	12.05.2020	Poste Italiane	UML, Sequence Diagram	Draft
0.5	18.05.2020	Poste Italiane	Step by Step Analysis, Requirements	Draft
0.6	21.05.2020	Poste Italiane	Middle Review	Verified
1.0	05.06.2020	Poste Italiane	Final Version	Internal approval
1.1	08.06.2020	Poste Italiane	Final Version Code Scenarios added	Internal approval

4.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	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.
Objective(s)	▪ Energy efficiency plans (heating, cooling) ▪ Daily and hourly energy consumption forecast ▪ Building energy usage benchmark ▪ Ensure energy saving and costs reduction on selected buildings ▪ Reduction of emissions (CO2 / TOE correlation)
Related business case(s)	*https://www.posteitaliane.it/en/decarbonisation.html*

4.4 Narrative of Use Case

Narrative of use case
Short description
The comfort of the working environments can positively affect the productivity of working human resources and quality of customer interactions in retail offices. The cooling (power) and heating (power & gas) systems installed at the Italian Post buildings are currently managed and monitored in many different ways depending on hardware & SW installed locally, skills of the building managers, maintenance service companies and energy experts following the building. Historical data and weekly calendars are the most common way to manage power on and off criteria. 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.
Complete description
Poste Italiane buildings to be considered in the use case are all located in Rome Municipality Area. They span from 250 to 28.000 sqm. Four different destinations for the building spaces are considered: Datacenter, Logistics, Retail and Offices. The different types of buildings would require specific approaches: • Datacenter is just one in the pilot and the main focus is around power usage to maintain the right operating conditions in all the racks. We expect to benchmark the site performance with other Data Center with similar

characteristics (same period, similar construction technologies) or others PLATOON pilots and to define and implement actions to optimize PUE over time. Only cooling problems will be analyzed.

- Logistic centers may offer the opportunity to analyze gas and power usage during the 24 hours due to their operations with specific activities performed in different timing of the day / week and with the opportunities to reduce energy usage when employees are out for deliveries. Benchmark with previous results and other buildings in the network are the most effective measurement of success. Cooling and Heating problems will be analyzed.
- Retail (Postal Offices) is the building group with the highest number of sites. Simulations and tests could be performed easily comparing results with similar offices. We need to consider distinctive building plants, building physical structure and other characteristic factors (opening hours, numbers of employees/customers, etc.) to define the best cooling and heating behaviors.
- Office spaces (used by staff members), whose characteristics are similar, are comparable between them in terms of energy usage / sqm but will require a specific pre-analysis on building characteristics. Cooling and heating problems will be analyzed.

These further major points should be considered to realize the Use Case for the 4 types of building:

- Environmental temperature / weather conditions must be considered in each of the cases, also integrating these data with BMS specifics data;
- For each type of building we must have the consumption data of the different production and use lines;
- For each type of building is necessary to have the data to define appropriate control metrics such as kWh/Year/sqm, regarding the daily, weekly and monthly trend;
- For each type of building (excluding data center type) the platform must be able to consider also the data about the average number of present people in the specific building for the different time slot, in particular for logistics building;
- Data will be sent to PLATOON platform and its algorithms outputs (reports, forecasts...) will be used to improve cooling and heating plants efficiency, that will be compared to the efficiency of similar building and/or historical data;
- Will be available detailed summer and winter seasons consumption data
- Will be available detailed gas and electrical consumption data

4.5Key performance indicators (KPI)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
PI_01_KPI01	PUE Decrease	% of reduction of PUE (by comparison with similar building or historical data) $\mathbf{PUE = \frac{(PUE_{old} - PUE_{new}) \times 100}{PUE_{old}}}$	- Energy efficiency plans (heating, cooling) - Daily and hour energy consumption forecast - Building energy usage benchmark - Ensure energy saving and costs reduction on selected buildings
PI_01_KPI02	kWh/Y/sqm	% of energy consumption reduction (before/after) for each type of building	- Energy efficiency plans (heating, cooling) - Daily and hour energy

			consumption forecast - Building energy usage benchmark - Ensure energy saving and costs reduction on selected buildings
PI_01_KPI03	kWh/Y/sqm	% of energy consumption reduction (heating, cooling) for line of use of each type of building	- Daily and hour energy consumption forecast - Building energy usage benchmark - Ensure energy saving and costs reduction on selected buildings
PI_01_KPI04	CO2	% of CO2 emission reduction	- Reduction of emissions (CO2 / TOE correlation)
PI_01_KPI05	€	Euros (€) saved	- Ensure energy saving and costs reduction on selected buildings

4.6 Use case conditions

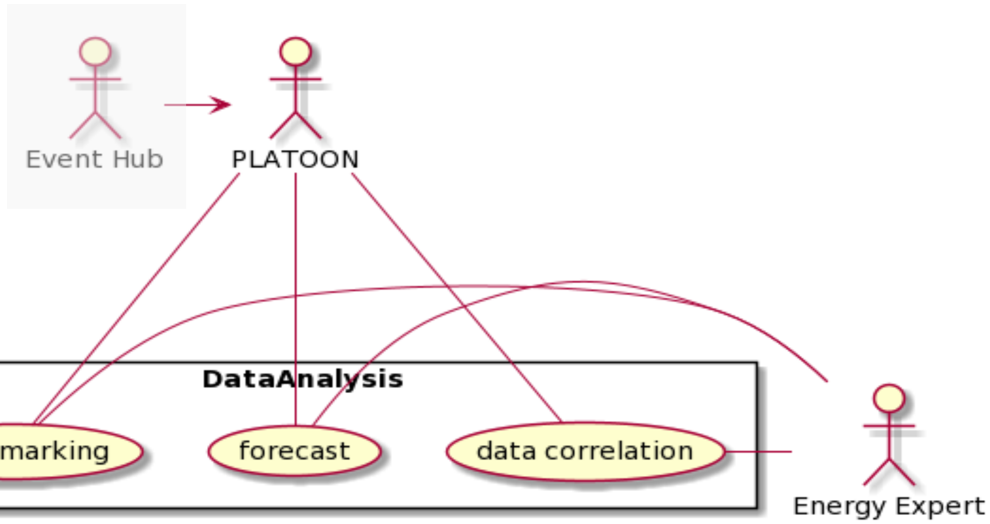
Use case conditions
Assumptions
We assume to go on with internal planned projects covering pilot buildings to apply gateways and metering systems and centralized SW to manage generated data.
Prerequisites
There are three types of tools installed to collect local data: - MOME card to collect data on small buildings - energy usage meters and gateways installed in medium size buildings connected with centralized BMS/EMS - Metering systems for power & gas installed in big size buildings to be connected with existing BMS (2012/27 UE directive)

4.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
• Energy consumption: Save x% on the GHG emissions (pilot #3A) • Advanced EMS in Smart Tertiary Buildings (pilot #3C.1) • Monitor and analysis of Data from Energy Meters (power and gas) of Rome Municipality asset (pilot #3B-ROM_01)
Level of depth
Detailed use case
Prioritization
High Priority / Mandatory if no other UC could be developed
Generic, regional or national relation

Generic
Nature of the use case
Business Use Case
Further keywords for classification

2. Diagrams of use case

Diagram(s) of use case
1 

3. Technical details

3.1 Actors

Actors			
Grouping		**Group description**	
Event Hub		Is a component that collect all data generated by sensors and other formation related to the buildings	
Actor name	**Actor type**	**Actor description**	**Further information specific to is use case**
Event Hub1	System	Collect and send dynamically the information generated by the sensors	

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		installed on the heating and cooling plants by SIB.	
Event Hub2	System	Collect and send dynamically the information generated by the sensors installed on the heating and cooling plants by SB. Besides collect and send static information about building characteristics, profile, and consumption historical data	
Actors			
Grouping		**Group description**	
Energy Expert		People with technical skills, supported by the platform for benchmarking, forecasting and correlation analysis to optimize energy consumption.	
Actor name	**Actor type**	**Actor description**	**Further information specific to his use case**
Energy Expert	Human	He is the specialist that supervises and analyzes the information about all the consumption generated by the plants of all buildings	He can access all services for this use case

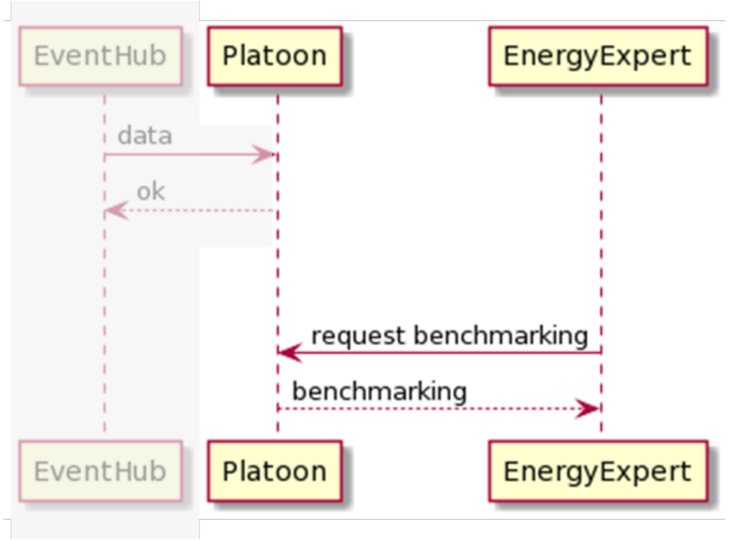
3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
	n.a.	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*

4. Step by step analysis of use case

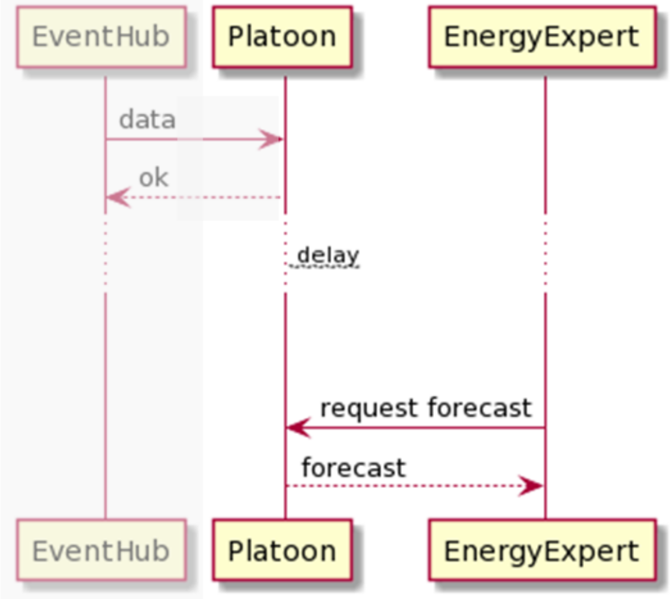
4.1 Overview of scenarios

In the following sequence diagram is represented the step by step scenario:



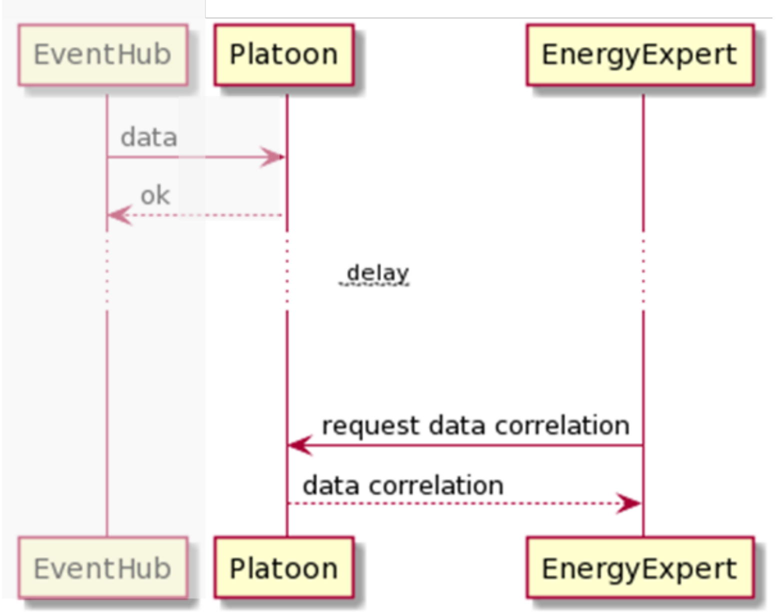
Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
01	Heating & Colling consumption benchmarking	An Energy Expert wants to benchmark heating and cooling consumptions of all buildings or one building with itself or with another building in a time range. He can decide to analyses cooling, heating consumption or both. As regards heating he may choose to evaluate energy,	EE	Periodic (EE decides to evaluate and compare buildings performance)	Event Hubs send detailed consumptions data and others info (see chapter 4.6): I-01, I-02, I-03, I-05, I-06, I-07	All data are available to be elaborated to report to the EE the value of consumption (reduction)

		gas consumption or both.				



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
02	Heating & Colling consumption forecast	The EE wants to forecast heating and cooling consumptions of a building or more buildings in a given time range. He may decide to forecast cooling, heating consumption or both. For heating the EE may decide to	Energy Expert	Periodic (Energy Expert decides to forecast heating/ cooling consumptions)	Event Hubs send detailed consumptions data and others (see chapter 4.6) I-01, I-02, I-03, I-05, I-06, I-07	All data are available to elaborate a response for energy consumption prediction

		evaluate energy, gas consumption or both.				



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
03	Occupancy Impact (Data correlation)	An Energy Expert wants to assess if heating and cooling consumptions of a building or more building are correlated with the average number of people inside the building(s). He may decide to consider cooling, heating	Energy Expert	Periodic (Energy Expert decides to forecast heating/ cooling consumptions)	Event Hubs send detailed consumptions data, average people in buildings, and others info (see chapter 4.6) I-01, I-02, I-03, I-05, I-06, I-07	The value of the impact of occupancy with respect to consumption is released

		consumption or both. For heating he may decide to evaluate energy, gas consumption or both.				

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1** – Heating & Colling consumption benchmarking						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlorw	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05, I-06, I-07	Da-Ex-01 Da-Ex-02 Da-Ex-03
02	Periodically the Energy Expert selects on interface Benchmarking	PLATOON Benchmarking Menu	The system creates and shows Benchmarking Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Insert criteria and parameters	Selecting parameters and sending request	Energy Expert selects parameters for analysis like: **BUILDING PERIMETER** • All buildings • Single Building (if 'Single Building' is selected then opens up 'Benchmark', otherwise jump to 'Plant') **BENCHMARK** • With itself (in a specific time range)	GET	Energy Expert	PLATOON	Criteria and parameters selected by Energy Expert actor	Da-Re-01 Da-Re-02

			• With a different building (same time window) **PLANTS** • Cooling • Heating • Both **Energy** • Power • Gas • Both **Time Range** (as a multiple of a month)					
04	Step 03 completed	Benchmarking report	PLATOON presents benchmarking report responding to criteria selected in step 03	GET	PLATOON	Energy Expert		

Scenario								
Scenario name:	**No. 2** – Heating & Colling consumption forecast							
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05, I-06, I-07	Da-Ex-01 Da-Ex-02 Da-Ex-03

02	Periodically the Energy Expert selects on interface Forecast	PLATOON Forecast Menu	The system creates and shows Forecast Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Step 02 completed	Selecting parameters and sending request	Energy Expert selects: **REPORTS** • All buildings • Single Building • A subset of buildings via checkbox **PLANTS** • Cooling • Heating • Both **Energy** • Power • Gas (only for heating and both) • Both **Time Range** (time range could be a multiple of a week)	GET	Energy Expert	PLATOON	Data selected by Energy Expert	Da-We-01 Da-Re-01 Da-Re-02
04	Step 03 completed	Forecast on energy consumption reporting	PLATOON presents Forecast	GET	PLATOON	Energy Expert	Forecast on EC Report Data	

			report responding to criteria selected in step 03					

Scenario								
Scenario name:		**No. 3** – Occupancy impact on energy consumption of Heating & Cooling plants						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information- producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-05, I-07	Da-Ex-01 Da-Ex-02 Da-Ex-03
02	Periodically the Energy Expert selects on interface Data Correlation	PLATOON Data Correlation Menu	The system creates and shows Forecast Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Step 02 completed	Selecting parameters and sending request	ENERGY EXPERT selects: **REPORTS** • All buildings • Single Building • A subset of buildings via checkbox **PLANTS** • Cooling • Heating	GET	Energy Expert	PLATOON	Data selected by Energy Expert	Da-Re-01 Da-Re-02

			• Both **Energy** • Power • Gas (only for heating and both) • Both **Time Range** • Select Time Range • All Time range in which are available consumption and average people number					
04	Step 03 completed	Occupancy Impact report	PLATOON presents the Occupancy Impact report responding to criteria selected in step 03	GET	PLATOON	Energy Expert	Occupancy Impact Report Data in terms of correlation between energy consumption and people that is present in the building	

5. Information exchanged

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I-01	Building Master Data	Are detailed static data for each building which are sent to the platform. These data give information about building characteristics and general (destination, climate zone, etc.)	Da-Ex-02
I-02	Building type	Indicate the cluster of building based on similar characteristics. In this use case we have four: DataCenter, Logistics, Retail, Office	Da-Ex-02
I-03	Building plants (cooling/heating)	Give information about the type of plant	Da-Ex-02
I-04	Weather forecast information	Information on the external temperature concerning the local climate zone	External system
I-05	Occupancy Profile	Represent the average number of employees and customers in the building	Da-Ex-02
I-06	Internal temperature and humidity	Information on the internal building climate.	Da-Ex-02
I-07	Data Consumption	Information on overall energy consumption of the plants for each building or cluster of building	Da-Ex-02

6. Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Da-Ex	Secure Data Exchange	The possible violation of data during transmission and the consequent risk of alteration can lead to system responses, being processed, with results that do not respond to the real scenario.
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ex-01	Secure Communication	The communication between the End User and the Platform should be on secure channel in order to guarantee the confidentiality of communications.
Da-Ex-02	Secure Data Exchange	Use of secure standard protocols for data transfer, in order to guarantee the confidentiality of communications
Da-Ex-03	Unidirectional Data Exchange	The data flows must take place exclusively from the PI systems (EHub) to PLATOON. Access to PI systems will not be allowed.
Categories ID	**Category name for requirements**	**Category description**
Da-Ac	Data Access	To limit access to information and ensure authorized user access and to prevent unauthorized access to systems and services (§ ISO/IEC 27002:2013)
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ac-01	Access Profile	Differentiate access by user profile
Categories ID	**Category name for requirements**	**Category description**
Da-Re	Reporting	To use the result elaborated by the platform is necessary to receive an output as a report.
Requirement R-ID	**Requirement name**	**Requirement description**

Da-Re-01	Output_Rep	The report produced in response to the EE request should be printable and downloadable.
Da-Re-02	Type_Report	Two kinds of reports are requested as the result of the benchmark analysis. The EE should choose between “Analytical Report” of “Summary Report”
Categories ID	**Category name for requirements**	**Category description**
Da-We	Weather	Information on lighting time and temperature
Requirement R-ID	**Requirement name**	**Requirement description**
Da-We-01	Ext_Weather	Outdoor temperatures to be provided by PLATOON for forecasting

7. Common terms and definitions

Common terms and definitions	
Term	**Definition**
BMS	Building Management System
EE	Energy Expert: is a member of the Energy Management Staff
EMS	Energy Management System
HVAC	Heating Ventilation and Air Conditioning
PUE	Power Usage Effectiveness
SB	Smart Building: a group of buildings, in the Pilot, with new sensors and data
SIB	Smart Info Building: a group of buildings, in the Pilot, with pre-existing data from sensors and historical ones
TOE	Tons Oil Equivalent: Unit of energy. It is equivalent to the approximate amount of energy that can be extracted from one Ton of crude oil.

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

1. Description of the use case.

The use case takes into account the HL UC PLATOON.Canvas.v.1.0(3) [PI] v.1.5.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
PI_02	CUSTOMER PREMISES/OPERATION (EMS)	**Predictive maintenance of cooling & heating plants** Implementing criteria to rationalize and customize the maintenance activities on heating and cooling systems to reduce plants failures while reducing costs.

1.2 *Version management.*

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	24.03.2020.	Poste Italiane	Initial creation	Draft
0.2	17.04.2020	Poste Italiane	Use Case Scope, Objectives description and KPI	Draft
0.3	06.05.2020	Poste Italiane	Data exchanged	Draft
0.4	12.05.2020	Poste Italiane	UML, Sequence Diagram	Draft
1.0	05.06.2020	Poste Italiane	Final Version	Internal approval
1.1	08.06.2020	Poste Italiane	Code Scenarios added	Internal approval

1.3 *Scope and objectives of use case*

Scope and objectives of use case	
Scope	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.
Objective(s)	– Improve plants efficiency – Technical plants fine tuning – Increase the availability of heating/cooling plants – Reduce maintenance costs

Related business case(s)	*https://www.posteitaliane.it/en/decarbonisation.html*

1.4 Narrative of Use Case.

Narrative of use case
Short description
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.
Complete description
We want to implement Predictive Maintenance on cooling and heating plants (HVAC) Poste Italiane buildings to be considered in the use case are all located in Rome Area. They span from 250 to 28.000 sqm. Two different destinations for the building spaces considered: Retail and Office Spaces Each destination cluster contains buildings with similar characteristics (maintenance costs, sqm, frequency of on demand interventions, plants age, plants technical characteristics...) • Retail (Postal Offices): we need to take into account distinctive building plants, peculiar building physical structure and other characteristic factors (opening hours, numbers of employees/customers, etc.) to define the best maintenance practices. Simulations and tests could be performed easily comparing results with similar offices (maintenance cost / sqm; MTBF) or with itself. • Office spaces: they are used by staff members. Simulations and tests could be performed easily comparing results with similar offices (maintenance cost / sqm; MTBF) or with itself. **We have some benchmark value for the maintenance cost referred to these cluster and faults historical data for each building of the pilot sites** The cooling and heating plants installed in our premises will generate data that will be acquired by sensors. This data will be stored and sent together with faults historical data to the PLATOON Platform that will pre-process them and will deploy predictive maintenance algorithms that will suggest us actions to increase MTBF and reduce maintenance cost / sqm). **Generated data will be plants energy consumption.** Such data will be stored as time series data. Trough the plants energy consumption data, PLATOON Platform will be able to identify anomalies (for example: increased energy consumption events) or patterns to predict failures in the plants and suggest corrective actions for avoiding them. **Actions suggested will be implemented to compute new maintenance cost /sqm and MTBF to compare to the historical ones.** The plants and the other data sources will be sent to an Event Hub [EH] in Poste Italiane. The EH will communicate the data to PLATOON Platform in batch mode and using standard and secure protocols.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
PI_02_K01	Mean Time Between Failure (MTBF) increase	MTBF increase in heating and cooling plants due to the predictive analysis (expressed in %)	– Improve plants efficiency – Technical plants fine tuning – Increase the availability of heating/cooling plants
PI_02_K02	Maintenance cost reduction (cost/y/sqm)	Evaluation of maintenance cost reduction for each building or total referred to the heating and cooling plants (expressed in %)	– Improve plants efficiency – Reduce maintenance costs

1.6 Use case conditions.

Use case conditions
Assumptions
We assume to be able to collect the historical maintenance plans, execution and failures together with energy performance to be able to build correlations among them. We will collect also consistency of plants in the 13 sites.
Prerequisites
To Involve facility management from Poste Italiane to get data and maintenance company to collect information and to put in place action proposed by simulation performed in the use case.

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

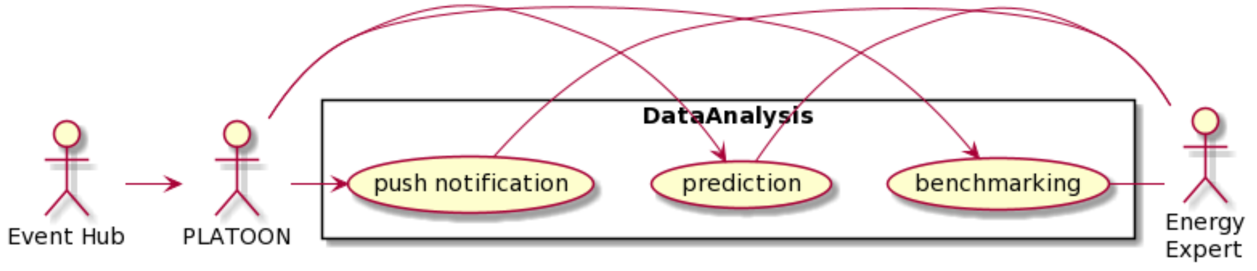
Classification information
Relation to other use cases
• Predictive Maintenance in the Smart Tertiary Building Hubgrade (pilot #3C.02) • Predictive Maintenance in Transformers (pilot #2B.01) • Predictive Maintenance in RES power plants (pilot #2a.07)
Level of depth
Detailed use case
Prioritization
Mandatory
Generic, regional or national relation

Generic
Nature of the use case
Business Use Case
Further keywords for classification
Monitoring of plans performance, Maintenance plan, Maintenance cost, Predictive maintenance, technical plants failures, MTBF, Corrective Actions, Predictive Alert

2. Diagrams of use case.

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case



3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
Event Hub		Is a component that collect all the data generated by the sensors and others information related to the plants (e.g. faults)	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Event Hub1	System	Collect and send the energy consumption data generated by the heating and cooling plants	The same information will be sent for the Building control group

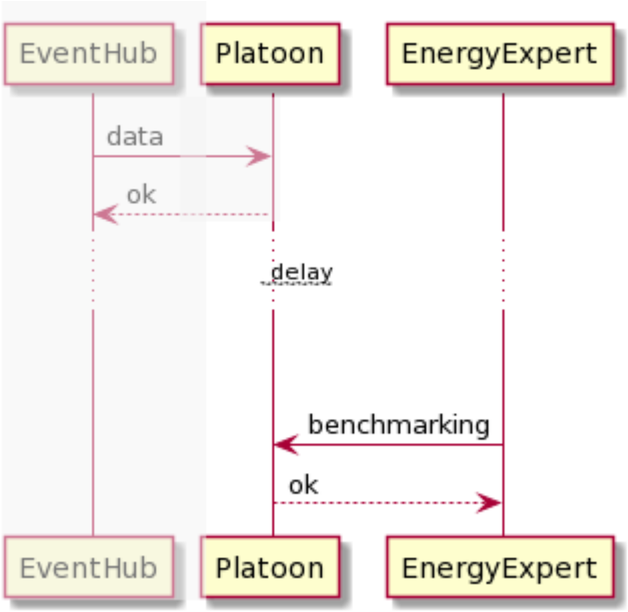
Event Hub2	System	Collect and send one shot information about building characteristics, profile, plants, fault historical data, ect	The same information will be sent for the Building control group
Actors			
Grouping		**Group description**	
Energy Expert		In this case, are the subjects that manage the maintenance plans and supervise the correct status of buildings and plants.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Energy Expert	Human	Include the group that monitors and analyzes the information to take decision in advance for optimizing maintenance	

3.1 References.

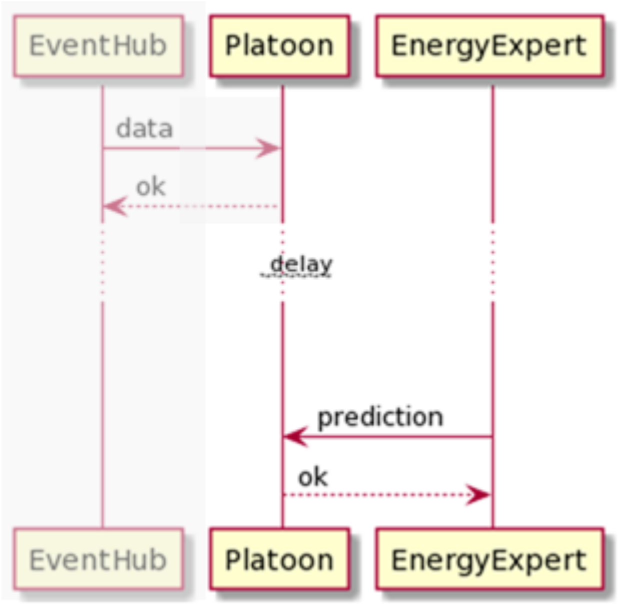
References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
	n.a.	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*

4. Step by step analysis of use case.

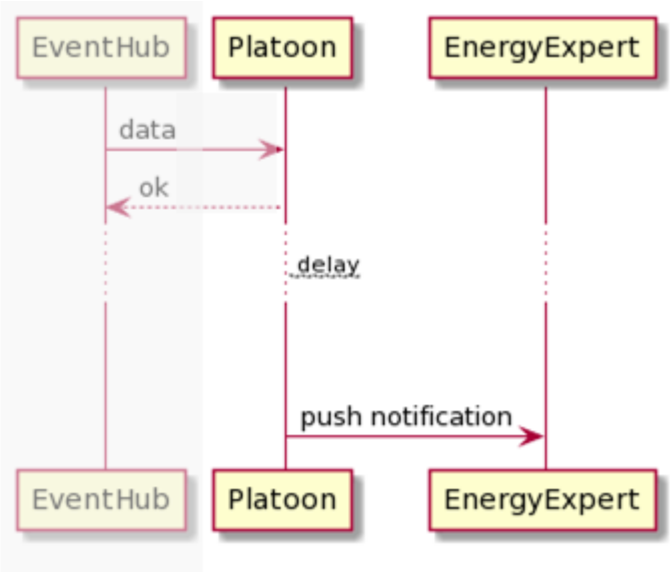
4.1 Overview of scenarios.



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
01	Maintenance Benchmarking on Heating & Cooling plants	An Energy Expert wants to benchmark heating and cooling plants faults of all buildings or one building with itself or with another building in a time range. He can decide to analyses cooling, heating plants faults or both.	EE	Periodic (EE decides to evaluate and compare buildings faults)	Event Hubs send detailed consumptions data, faults data and others info (see chapter 4.6): I-01, I-02, I-03, I-04, I-05	All data are available to elaborate a report on faults



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
02	Fault Prediction on Heating & Cooling plants	An Energy Expert wants to predict faults to heating and cooling plants of all buildings or one building to start maintenance requests to a technical maintainer. PLATOON platform sends plants time to failure data and suggests actions where possible.	EE	Periodic (EE decides to receive plants time to failure estimates)	Event Hubs send detailed consumptions data, faults data and others info (see chapter 4.6): I-01, I-02, I-03, I-04, I-05	The prediction of next failure of the plant has been done and it is sent to the EE to establish the best policy of maintenance



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
03	Predictive Fault Alert	PLATOON platform sends a Push Notification to the energy Energy Expert signaling Time to failure is smaller than planned maintenance (if this info is available) or plants are acting abnormally. Where possible PLATOON suggest to EE the actions to perform	PLATOON	Periodic (PLATOON evaluate time to failure smaller than planned maintenance or plants acting abnormally)	The calculation of failure has been done based on anomalies in the plant behavior. I-01, I-02, I-03, I-04, I-05	An Alert is sent immediately to the EE

4.2 Steps-Scenarios.

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).

Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new "sub" use case, then referring to that "subroutine" in this scenario.

Scenario								
Scenario name:		**No. 1** - Maintenance Benchmarking on Heating & Cooling plants						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05,	Da-Ex-01 Da-Ex-02 Da-Ex-03
02	Periodically the Energy Expert selects on interface Benchmarking	PLATOON Benchmarking Menu	The system creates and shows Benchmarking Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Insert criteria and parameters	Selecting parameters and sending request	Energy Expert selects parameters for analysis like: **BUILDING PERIMETER** • All buildings • Single Building (if 'Single Building' is selected then opens up 'Benchmark',	GET	Energy Expert	PLATOON	Criteria and parameters selected by the Energy Expert actor	Da-Re-01 Da-Re-02

			otherwise jump to ‘Plant’) **BENCHMARK** • With itself (in a specific time range) • With a different building (same time window) **PLANTS** • Cooling • Heating • Both **Time Range** (as a multiple of a month)					
04	Step 03 completed	Benchmarking report	PLATOON presents benchmarking report responding to criteria selected in step 03	GET	PLATOON	Energy Expert		

Scenario								
Scenario name:		**No. 2** – Fault Prediction on Heating & Cooling plants						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05,	Da-Ex-01 Da-Ex-02 Da-Ex-03
02	Periodically the Energy Expert selects on interface Prediction	PLATOON Prediction Menu	The system creates and shows Prediction Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Insert criteria and parameters	Selecting parameters and sending request	Energy Expert selects: **REPORTS** • All buildings • Single Building • A subset of buildings via checkbox **PLANTS** • Cooling • Heating • Both	GET	PLATOON	Energy Expert	Criteria and parameters selected by the Energy Expert actor	Da-Re-01 Da-Re-02

04	Step 03 completed	Fault prediction reporting	PLATOON presents a report responding to criteria selected in step 03 on fault prediction. Plants time to failure and suggested actions (whenever possible) are provided	GET	PLATOON	Energy Expert	Fault prediction report on heating & cooling	

Scenario								
Scenario name:		**No. 3** – Predictive Fault Alert						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information - producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Send a push notification	PLATOON Prediction Alert	When the Time to failure is smaller than planned maintenance or plans are acting abnormally PLATOON platform sends a Push Notification to the Energy Expert signaling Time to failure is smaller than planned or plants are acting abnormally	REPORT	PLATOON	Energy Expert	Time to Failure / Abnormal Plants Detected	Da-Ex-01 Da-Ac-01

5. Information exchanged.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
I-01	Building Master Data	Are detailed static data for each building which are sent to the platform. These data give information about building characteristics and general (destination, climate zone, etc.)	Da-Ex-02
I-02	Building type	Indicate the cluster of building based on similar characteristics. In this use case we have two: Retail, Office	Da-Ex-02
I-03	Building plants (cooling/heating)	Give information about the type of plant	Da-Ex-02
I-04	Faults Historical Data	Information on faults occurred to the plants (type, date…)	Da-Ex-02
I-05	Historical Data Consumption	Information of the previous overall energy consumption of the plants for each building or cluster of building	Da-Ex-02
I-06	Pridective Alert	Alert message sent automatically to the Energy Expert when anomalous plant behaviours are detected	Da-Ex-02

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Da-Ex	Secure Data Exchange	The possible violation of data during transmission and the consequent risk of alteration can lead to system responses, being processed, with results that do not respond to the real scenario.
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ex-01	Secure Communication	The communication between the End User and the Platform should be on secure channel in order to guarantee the confidentiality of communications.
Da-Ex-02	Secure Data Exchange	Use of secure standard protocols for data transfer, in order to guarantee the confidentiality of communications
Da-Ex-03	Unidirectional Data Exchange	The data flows must take place exclusively from the PI systems (EHub) to PLATOON. Access to PI systems will not be allowed.
Categories ID	**Category name for requirements**	**Category description**
Da-Ac	Data Access	To limit access to information and ensure authorized user access and to prevent unauthorized access to systems and services (§ ISO/IEC 27002:2013)
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ac-01	Access Profile	Differentiate access by user profile
Categories ID	**Category name for requirements**	**Category description**
Da-Re	Reporting	To use the result elaborated by the platform is necessary to receive a detailed or high-level (directional) report.
Requirement R-ID	**Requirement name**	**Requirement description**

Da-Re-01	Output_Rep	The report produced in response to the EE request should be printable and downloadable.
Da-Re-02	Type_Report	Two kinds of reports are requested as the result of the benchmark analysis. The EE should choose between “Analytical Report” of “Summary Report”

7. Common terms and definitions.

Common terms and definitions	
Term	**Definition**
EMS	Energy Management System
EE	Energy Expert
TOE	Tonnes Oil Equivalent: Unit of energy. It is equivalent to the approximate amount of energy that can be extracted from one tonne of crude oil.

LLUC P-3b- 03: Lighting Consumption Estimation & Benchmarking

1. Description of the use case.

The use case takes into account the HL UC PLATOON.Canvas.v.1.0(3) [PI] v.1.5.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
PI_03	CUSTOMER PREMISES/OPERATION (EMS)	**Lighting Consumption Estimation & Benchmarking** Estimate of lighting consumption costs due to lighting systems

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	24.03.2020.	Poste Italiane	Initial creation	Draft
0.2	05.05.2020	Poste Italiane	Scope and Description	Draft
0.3	06.05.2020	Poste Italiane	Data exchanged	Draft
0.4	12.05.2020	Poste Italiane	UML, Sequence diagram	Draft
0.5	26.05.2020	Poste Italiane	Detailed description	Draft
1.0	05.06.2020	Poste Italiane	Final Version	Internal approval
1.1	08.06.2020	Poste Italiane	Code Scenarios added	Internal approval

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	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.
Objective(s)	- Estimation and benchmarking between different lighting solutions - Optimization and reduction of Lighting consumption - Correlation between the number of building user and the lighting consumption - GHG emissions reduction
Related business case(s)	*https://www.posteitaliane.it/en/decarbonisation.html*

1.4 Narrative of Use Case.

Narrative of use case
Short description:
Optimizing lighting consumption means reducing of costs and at the same time promoting environmental sustainability. Trough lighting consumption analysis and benchmarking it will be possible to evaluate the efficacy of the adopted technologies and/or better address planning actions.
Complete description
Poste Italiane buildings to be considered in the use case are all located in Rome Municipality Area. There are different building destinations: Logistics centers, Retail and Offices. Lighting consumption has a substantial impact on total electricity consumption of offices and commercial buildings and represents a relevant cost also for Poste Italiane. For these reasons it should be very important knowing lighting consumptions as accurately as possible; 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. The output (estimate of lighting consumption) will be compared with a reference index as LENI or EPs in buildings where we know the actual lighting consumption measured by meters. Given occupancy profiles we also want to identify potential correlations between lightning consumption and building users All the data gathered will be sent to an Event Hub [EH] in Poste Italiane. The EH will communicate the data to PLATOON Platform in batch mode and using standard and secure protocols.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
PI_03_K01	Energy consumption/ people presence	Value of consumption of the light plants compared with the number of people in the building	- Identify the correlation between the number of building user and the lighting consumption
PI_03_K02	Lighting Cost	% of cost saving due to the adoption of	- Estimation and benchmarking

	saving	new lighting lamps for each type of building	between different lighting solutions - Optimization and reduction of lighting consumption
PI_03_K03	Lighting consumption reduction	% of consumption reduction due to the adoption of new lighting lamps for each type of building	- Estimation and benchmarking between different lighting solutions - Optimization and reduction of lighting consumption
PI_03_K04	GHG emissions	% GHG emissions per square meter due to lighting in different scenarios	- Estimation and benchmarking between different lighting solutions - GHG emission reduction

1.6 Use case conditions

Use case conditions
Assumptions
We start from the assumption that we are able to collect, for each building, the data relating to the total energy consumption plants as well as the dimensions in mq^2, type of lighting, time slots, etc.. We will use some buildings also from other areas to be used as comparison between old and new lighting plants in terms of energy consumption.
Prerequisites
Information will be available when our Smart Building project will be implemented in some of the pilot sites.

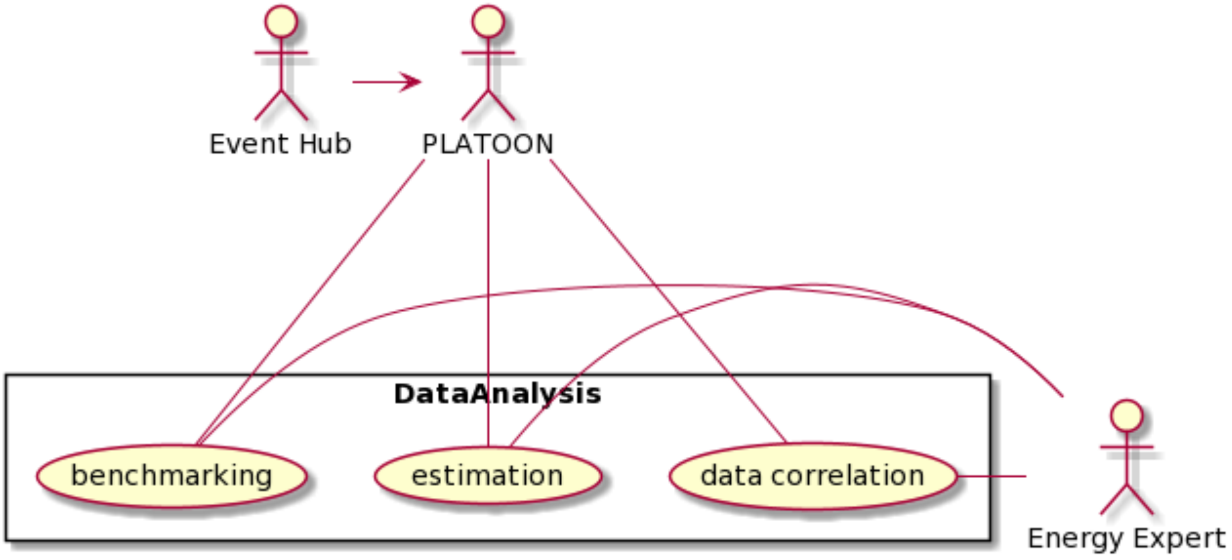
1.7 *Further information to the use case for classification / mapping.*

Classification information
Relation to other use cases
• Building Heating & Cooling consumption Analysis and Forecast (pilot #3 -PI_01)
Level of depth
Detailed use case
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case

Further keywords for classification
Lighting costs saving, Benchmarking, Consumption estimate.

2. Diagrams of use case.

Diagram(s) of use case



3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
Event Hub		Is a component that collect all the data generated by the sensors and others information related to the building	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Event Hub1	System	Collect and send dynamically electrical and energy consumption data	
Event Hub2	System	Collect and send one shot information about building characteristics, profile, type of lamp, etc.	

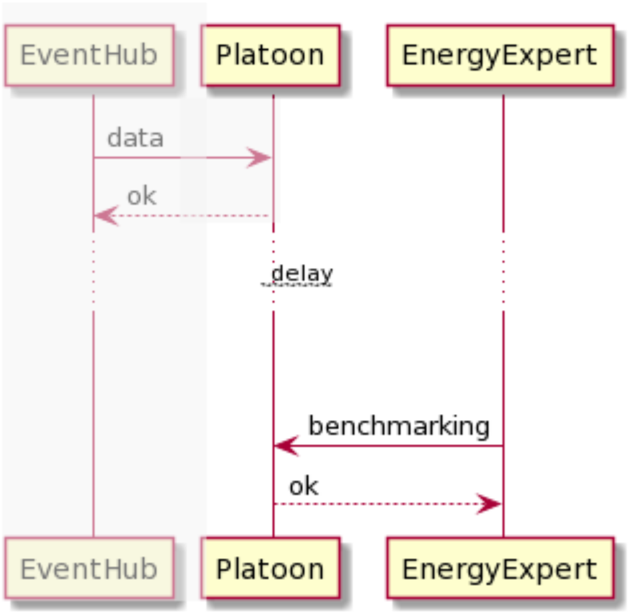
Actors			
Grouping		**Group description**	
Energy Expert		In this case, it is the group who is supported by the platform to estimate of lighting consumption costs.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Energy Expert	Human	Is the group who request to the platform for lighting consumption estimate and benchmark	

3.2 References.

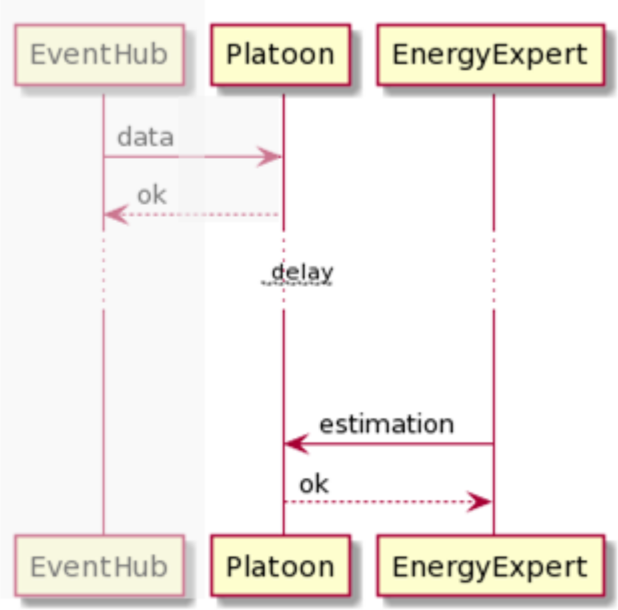
References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
	n.a.	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*

4. Step by step analysis of use case.

4.1 Overview of scenarios.

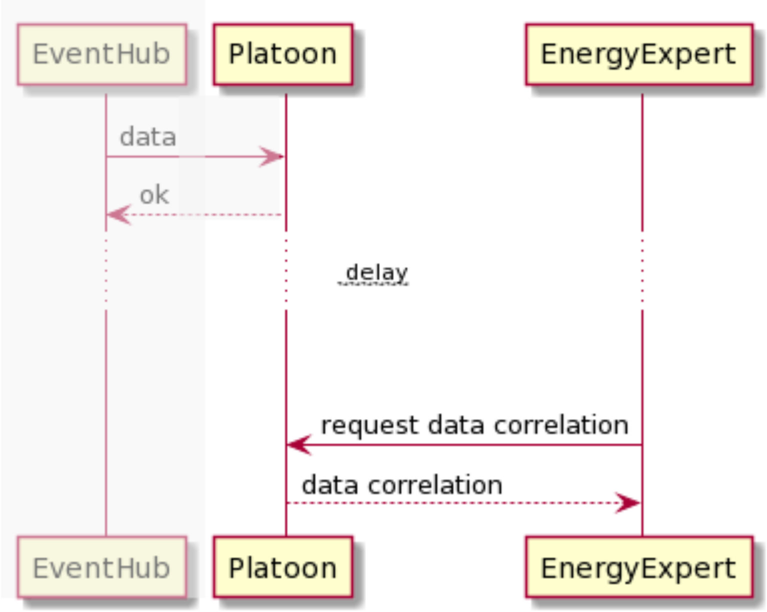


Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
01	Lighting consumption benchmarking	An Energy Expert wants to benchmark lighting consumptions of all buildings or one building with itself or with another building in a time range.	EE	Periodic (EE decides to evaluate and compare buildings performance)	Event Hubs send detailed consumptions data and others info (see chapter 4.6): I-01, I-02, I-03, I-04, I-05	All data are available to be elaborate to report to the EE the value of consumption (reduction)



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
02	Lighting consumption estimation	The EE wants to estimate lighting consumptions of a building or more	Energy Expert	Periodic (Energy Expert decides to estimate lighting consumptions)	Event Hubs send detailed consumptions data and others (see chapter 4.6): I-01, I-02,	All data are available to release the value of the lighting consumption estimation

		buildings in a certain time range and given some data as building total consumption, historical lighting consumption of the same building and other similar, etc.			I-03, I-04, I-05	



Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
03	Occupancy impact on energy consumption for lighting (Data correlation)	An Energy Expert wants to assess if lighting consumption of a building or more building	Energy Expert	Periodic (Energy Expert decides to evaluate the correlation between lighting	Event Hubs send detailed consumptions data, average people in buildings, and others info	The value of the impact of occupancy with respect to consumption is released

		are correlated with the average number of people inside the building(s).		consumptions and average number of people inside the building)	(see chapter 4.6): I-01, I-02, I-03, I-04, I-05	

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1** – Lighting consumption benchmarking						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05,	Da-Ex-01 Da-Ex-02 Da-Ex-03
02	Periodically the Energy Expert selects on interface Benchmarking	PLATOON Benchmarking Menu	The system creates and shows Benchmarking Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Insert criteria and parameters	Selecting parameters and sending request	Energy Expert selects parameters for analysis like: **BUILDING PERIMETER** • All buildings • Single Building (if 'Single Building' is selected then opens up 'Benchmark', otherwise jump to 'Plant') **BENCHMARK**	GET	Energy Expert	PLATOON	Criteria and parameters selected by Energy Expert actor	Da-Re-01 Da-Re-02

			• With itself (in a specific time range) • With a different building (same time window) **Time Range** (as a multiple of a month)					
04	Step 03 completed	Benchmarking report	PLATOON presents benchmarking report responding to criteria selected in step 03	GET	PLATOON	Energy Expert		

Scenario								
Scenario name:		**No. 2** – Lighting consumption estimation						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I-01, I-02, I-03, I-05,	Da-Ex-01 Da-Ex-02 Da-Ex-03
01	Periodically the Energy Expert selects on	PLATOON Evaluation Menu	The system creates and shows	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01

	interface Evaluation		Evaluation Menu to the user					
02	Insert criteria and parameters	Selecting parameters and sending request	Energy Expert selects: **REPORTS** • All buildings • Single Building • A subset of buildings via checkbox **Time Range** (time range could be a multiple of a week)	GET	PLATOON	Energy Expert	Data selected by Energy Expert	Da-Re-01 Da-Re-02
04	Step 03 completed	Estimation report	PLATOON presents the estimation report responding to criteria selected in step 03	GET	PLATOON	Energy Expert		

Scenario								
Scenario name:	**No. 3** – Occupancy impact on energy consumption for lighting							
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information- producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the Event Hub send data to PLATOON	DataFlow	PLATOON receive data from EH	CHANGE	Event Hub	PLATOON	I04, I05	Da-Ex-01 Da-Ex-02 Da-Ex-03

02	Periodically the Energy Expert selects on interface Data Correlation	PLATOON Data Correlation Menu	The system creates and shows Data Correlation Menu to the user	GET	PLATOON	Energy Expert		Da-Ex-01 Da-Ac-01
03	Insert criteria and parameters	Selecting parameters and sending request	ENERGY EXPERT selects: **REPORTS** • All buildings • Single Building • A subset of buildings via checkbox **Time Range** • Select Time Range • All Time range in which are available consumption and average people number	GET	Energy Expert	PLATOON	Criteria and parameters selected by Energy Expert actor	Da-Re-01 Da-Re-02
04	Step 03 completed	Benchmarking report	PLATOON presents the occupancy report responding to criteria selected in step 03	GET	PLATOON	Energy Expert		

5. Information exchanged.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
I-01	Building Master Data	Are detailed static data for each building which are sent to the platform. These data give information about building characteristics and general (destination, climate zone, etc.)	Da-Ex-02
I-02	Building type	Indicate the cluster of building based on similar characteristics. In this use case we have four: DataCenter, Logistics, Retail, Office	Da-Ex-02
I-03	Building plants (lighting)	Give information about the type of plant	Da-Ex-02
I-04	Occupancy Profile	Represent the average number of employees and customers in the building	Da-Ex-02
I-05	Historical Data Consumption	Information of the previous overall energy consumption of the plants for each building or cluster of building	Da-Ex-02

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Da-Ex	Secure Data Exchange	The possible violation of data during transmission and the consequent risk of alteration can lead to system responses, being processed, with results that do not respond to the real scenario.

Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ex-01	Secure Communication	The communication between the End User and the Platform should be on secure channel in order to guarantee the confidentiality of communications.
Da-Ex-02	Secure Data Exchange	Use of secure standard protocols for data transfer, in order to guarantee the confidentiality of communications
Da-Ex-03	Unidirectional Data Exchange	The data flows must take place exclusively from the Pi systems to PLATOON. Access to PI systems will not be allowed.
Categories ID	**Category name for requirements**	**Category description**
Da-Ac	Data Access	To limit access to information and ensure authorized user access and to prevent unauthorized access to systems and services (§ ISO/IEC 27002:2013)
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Ac-01	Access Profile	Differentiate access by user profile
Categories ID	**Category name for requirements**	**Category description**
Da-Re	Reporting	To use the result elaborated by the platform is necessary to receive a detailed or high-level (directional) report.
Requirement R-ID	**Requirement name**	**Requirement description**
Da-Re-01	Output_Rep	The report produced in response to the request should be printable and downloadable.
Da-Re-02	Type_Report	Two kinds of reports are requested as the result of the benchmark analysis. The EE should choose between "Analytical Report" of "Summary Report"

7. Common terms and definitions.

Common terms and definitions	
Term	**Definition**
EE	Energy Expert

GHG	GreenHouse Gas

LLUC-P-3b- 04: Monitor and analysis system of Data coming from energy meters of ROME Municipality buildings asset

1. Description of the use case.

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
LLUC-3b-04	CUSTOMER PREMISES / OPERATION (*based o SGAM*) Energy management System (EMS) / Buildings Performances / Energy Meters (power & gas)	Monitor and analysis system for the Data flow coming from 8950 power and gas energy meters of ROME Municipality buildings asset

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	08.05.2020	P.Maurelli (RpR-ROM)	Initial creation (General description with integration profiles).	Draft
0.2	16.05.2020	P.Maurelli (RpR-ROM)	Narrative for UC 01	Draft
0.3	26.05.2020	P.Maurelli (RpR-ROM)	Added use case diagram ad Actors	Draft
0.4	28.05.2020	P.Maurelli (RpR-ROM)	Added Sequence diagrams	Draft
0.5	01.06.2020	P.Maurelli (RpR-ROM)	Added Step-by-Step scenarios	Draft
0.6	05.06.2020	P.Maurelli (RpR-ROM)	General revision	Final

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	The use case scope includes almost 2000 buildings owned by ROM with different uses and different plants and devices, including 165 photovoltaics. The data collected from the 8950 meters (power and gas) will be sent to the PLATOON platform. **The automated benchmarking analysis of this big data will help the personnel of the ROM EM office to increase the knowledge and awareness about the energy consumptions and the quickness in planning and programming.**
Objective(s)	• ROM EM office support: Automated analysis of the data flow coming from the energy meters will help the personnel of the ROM EM office to increase the knowledge and awareness about the energy consumptions. • Saving Energy and Emissions: anomalies detection, general maintenance planning; updated energy performance baselines aim to address the EE of the asset. • RES Potentialities Estimation: analysis of the self-consumptions rate and calculations of the RES and storage plants potentialities • Saving costs: a monitor system free up time and resources of the EM office; the energy saving and RES implementation produce direct saving costs.
Related business case(s)	SECAP and Resilience Strategy are the general reference framework: SECAP of Roma Capitale : https://www.comune.roma.it/web/it/informazione-di-servizio.page?contentId=IDS322725 • *Il PAESC di Roma Capitale (link to pdf)* • Roma Capitale SECAP for Energy Efficiency and RES *(link to pdf)* Resilience Strategy of Rome: https://www.100resilientcities.org/cities/rome/ • *Roma strategia di Resilenza/Resilience Strategy of Rome (link to pdf)* In particular the ROM-01 Use case is related to the Business Case of supporting the Energy Manager Office, with cloud based EMS tools, with the aim to reduce the total expenditure in energy (48.000.000 €/y): https://www.comune.roma.it/web/it/dipartimento-sviluppo-infrastrutture-e-manutenzione-urbana-uffici-e-contatti.page?contentId=UFF156939 • Improving energy efficiency of each single building • Increasing energy flexible capacity to be negotiated with the DSO (à ref.

	H2020 project PlatONE with Acea/Areti, ENEA, et al.) • Installing new optimized FER plants on/by the buildings

1.4 Narrative of Use Case.

Narrative of use case

Short description

The energy manager office of Roma Capitale, within the SIMU Department, manages more than 8950 energy meters (6500 electric meters and 2450 gas meters) related to almost 2000 buildings owned by the municipality. To help the office in this activity, considering the huge amount of data coming from the meters each months, a monitor system shall be implemented.

Complete description

The data coming from the 8950 power and gas meters for the large building asset of Roma Capitale are nowdays treated by the EM Office personnel mainly for administrative purposes. Only on a few periodic occasions during the year they are re-analyzed to generate reports for EM purpose. The loss of time for conducting these operations produces inefficiency in the Office workflow. PLATOON represents the opportunity to collect historical data (4-5 past years) and set reference baselines linked to some important structural indicators of the buildings (use, typologies, volumes, thermal surface, number of light points, age of the building, Energy Performance Class, shape ratio, relationship between opaque and glass-coated surfaces, and other useful indicators to be discussed and selected within PLATOON team) and of the weather/climatic historical contexts. The next priority is to design and implement a procedure for collecting and analyze more recent data from the energy meters, relating to the actual period (i.e. the last month), in order to observe the energy consumptions evolution through the big data generated from 6500 electric meters and 2450 gas meters.

Theoretically for each power meter is possible to obtain data with 15’ frequency and this means that for each month of observations 2880 rows are available resulting in a total of 19ML rows. Different frequencies are available for the 2450 gas meters. Among the power meters some (around 165) are dedicated to measure the PV plants energy production, each coupled with a second meter dedicate to track the energy exchange with the grid.

This Big data should be analyzed automatically in order to highlight anomalies launching alerts, generate reports for different purposes, produce forecasts in terms of energy consumptions, in brief to support the office personnel thus freeing up time and resources to tackle energy efficiency design activities more effectively.

The **Services** that could be offered by the PLATOON project solutions are:

For Building Energy Consumptions

- Energy consumption Benchmarking analysis
- Energy consumption forecast based on historical trend, buildings usage/structure models and weather conditions
- Monitoring general energy performances for each building

- power peak consumptions analysis
- anomalies detection and alerting systems
- support to general maintenance planning of the general asset

For PV plants on buildings

- Energy usage and production (PV plants) deviation from forecast
- Identifying potentiality in RES (PV, Solar, Geothermal, …) and Storage to maximize self-consumptions (→ improvement of Energy Audit Scenarios)

For the Energy Management System

- Automated validation/updating of energy audits and EE scenarios (baselines updating)
- Identifying opportunities for cheaper and more sustainable energy scenarios (→Audits improvement)
- Spatial Reporting and GIS visualization of the Building Energy Consumptions also integrated in public WebGIS initiatives

The **Benefits** coming from PLATOON can be summarized as follows:

- Data Analysis time reduction
- Reduce forecast errors in energy production / usage
- Energy Asset management will be optimized in terms of promptness, quickness and integration
- Increase Data integration for the asset energy management, in particular through the new EMS tools implementation and the integration of energy related data within existing GIS infrastructure
- Enforcement of assessment/planning practices (EM, AM, FM) to improve plants and building envelopes efficiency and sustainability, in particular of the Energy efficiency planning through validated and improved Audits and EE scenarios
- Increase energy saving and costs reduction on large asset management
- Increase buildings comfort
- Reduction of emissions in accordance with Rome Municipality SECAP objectives

The **Assumptions** at the basis of the success of the project are:

- Data available in frequency and detail as planned
- Effective Energy Management System tools to be offered as outcomes
- Common view on analysis to be executed on data
- Common interest in an holistic approach to energy management (electricity, heat/cool, building envelope, usage models, monitoring/control systems)

These are the main **Constrains**:

- Updated Data availability from vendors/distributors (energy meters)
- Buildings Energy Audits Data format decided by concessionary
- Timing and resources to perform data collection and analysis
- DTD Dept of ROM has to collect big data from meters to transfer to PLATOON, this operation to be stable needs a Data Hub to be selected and activated by DTD

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
ROM_01_Kpi_R01	Total Energy Savings [kWh / Y]	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 unuseful meters, maintenance 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_01_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
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
Rom_01_Kpi_R03	Nb of Energy Savings Results [Nb / Y]	this indicator counts the number of energy meters for which PLATOON services produce actions resulting in energy saving during the year. A Derived Kpi is the Average Energy Saving calculated as : ROM_01_Kpi_01 / ROM_01_Kpi_03	Energy Savings Target to be defined
Rom_01_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 (→ to be developed: Benchmarking, checklist of conditions ; excluding False Positive Alerts) for a specific energy meter is based on the occurrence of the consumption divergence from the expected value. Typically when the building or the usage of the building is highly inefficient PLATOON will send a series of alerts. This must be consider a good result even if the beneficiary (ROME EM Office) is unable to intervene producing energy savings.	ROM EM office support Target to be defined

ID	**Name**	**Description**	**Reference to mentioned use case objectives**
Rom_01_Kpi _R05	CO2 [%]	% of CO2 emission reduction (using CO2/TOE)	Emission reduction Target to be defined
Rom_01_Kpi _R06	RES suggested [KWh/Y]	The calculation 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, … (→ PV-GIS JRC model or other) PLATOON output in terms of Total RES kWh/Y calculation represents a positive impact to be measured.	RES Potentialities Estimations Target to be defined

1.6 Use case conditions.

Use case conditions
Assumptions
Data from energy meters are available in frequency and detail as planned
Prerequisites
The basis scenario of the ROM_01 Use Case can be successfully accomplished when enough energy meters data are offered to PLATOON within the deadlines in order to be processed. More precisely: - at least 10% of the 6500 electric meters (650 meters) provide data with frequency of 15’ - At least 50% of the total 2450 gas meters provide data for at least 3 year (historical and current) - At least 50% of the total 6500 energy meters provide data for at least 3 year (historical and current)

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

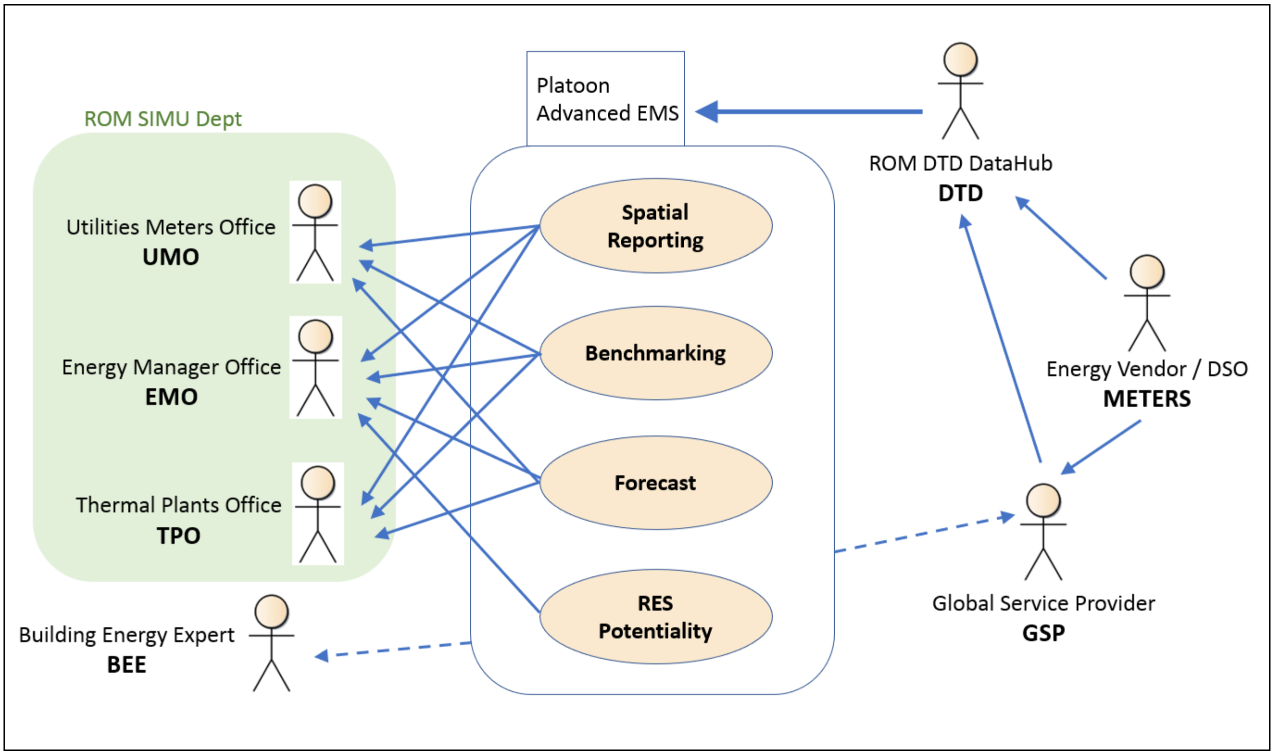
Classification information
Relation to other use cases
This Use Case is related to the eventual 2nd Use Case (ROM_02) both in terms of data sources and in outcomes. ROM_02 will collect around 1200 Energy Audit Documents (DB → pdf) containing data on the buildings, baselines and EE scenarios within a standard format but representing a static picture at 2019. The historical Data of the UC ROM_01 could be compared with those of the ROM_02 and new collected energy meters data could finally update the energy Audit baselines.
Level of depth
❖ The use case is large in terms in buildings (8950 energy meters), representing a high variety of typologies and for a minor quote of the meters is detailed in terms of frequency of the data (15 minutes)

Prioritization
❖ High Priority / Mandatory if no other UC could be developed
Generic, regional or national relation
❖ Generic
Nature of the use case
❖ Business Use Case
Further keywords for classification
Power and gas, electricity metering, RES and storage, building energy performance, Spatial EMS.

2. Diagrams of use case.

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Paste below the use case diagram to show how actors interact within the Use Case by participating in the technical functions



3. Technical details.

3.1 Actors.

Actors			
Grouping		**Group description**	
SIMU Dept – UO Plants		The SIMU Department manages public works and almost all plants in the buildings owned by Roma Capitale. The Operative Unit (UO) Plants is charged of all activities concerning energy and the plants maintenance and new installations	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Energy Manager Office - EMO	**Human**	This personnel support the Roma Capitale Municipality Energy Manager in all functions excluding maintenance (O&M)	Is the main user and beneficiary of all services
Utilities Meters Office - UMO	**Human**	This personnel is mainly dedicated to monitor meters (power and gas) for administrative purposes	Is the user of administrative related services;

			Has direct relationship with Energy Vendor / Distributors
Thermal Plants Office - TPO	**Human**	This personnel is mainly dedicated to the O&M of thermal plants, including the relationship with Global Services	Is the user of all administrative related services (payments, balances)

Actors			
Grouping		**Group description**	
DTD Dept – Digital Transformation – Roma Capitale		The DTD Department manages all ICT services for Roma Capitale and is in charge of Data Management issues.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
DTD Data Hub	**Human** **Data Hub** (DTD will select the Hub available for PLATOON feeding among their DBMS and cloud services)	The DTD team involved in PLATOON will collect the Big Data from the Meters into a Data Hub (probably a component of the current NIC Database)	DTD will setup a procedure and a Data Hub to transmit the Big Data coming from the energy meters; Eventually they will collect Data from GSP and / or UMO and other data related to all buildings of interests (*Buildings Master Data*)

Actors			
Grouping		**Group description**	
Service Concessionaries and Utilities providers		These are companies providing energy or services generally as concessionaries for Roma Capitale	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Global Service Providers – GSP	**Human** **Monitoring System**	These are companies providing global energy services (as SIE3 2018-2024 for thermal energy supply and maintenance)	They have relation with gas provider (ITALGAS); They have relation with the TPO as concessionary They eventually (see

	(as Eventually GSP can Open to PLATOON a monitoring system for the thermal plants)		ROM_UC_02) can provide energy audits for each building and other data for each thermal plant attached to the gas meters
Energy Suppliers - METERS	**Devices** Energy Meters (Power and Gas)	The meters are managed for selling energy by Energy Vendor (ENEL) but are owned and remote monitored by DSO (ARETI for power, ITALGAS for Gas)	The sources of data for this UC. They can provide data flows and historical data to UMO and to DTD (Data Hub)

Actors			
Grouping		**Group description**	
Buildings Managers		This figures (Managers, Directors, Technical Office, …) have sometimes competences and roles on technical plants and energy management for specific single building or for a series of buildings within an area (district) or a typology (i.e. Technical Director for Municipio n.4 manages all schools for electrical plants)	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Building(s) Energy Expert - BEE	Human	(not always exists) Is the referent for the energy analysis of a single building or a lot of buildings	Receive (and in case can request) data for a single building or a sub-set of buildings

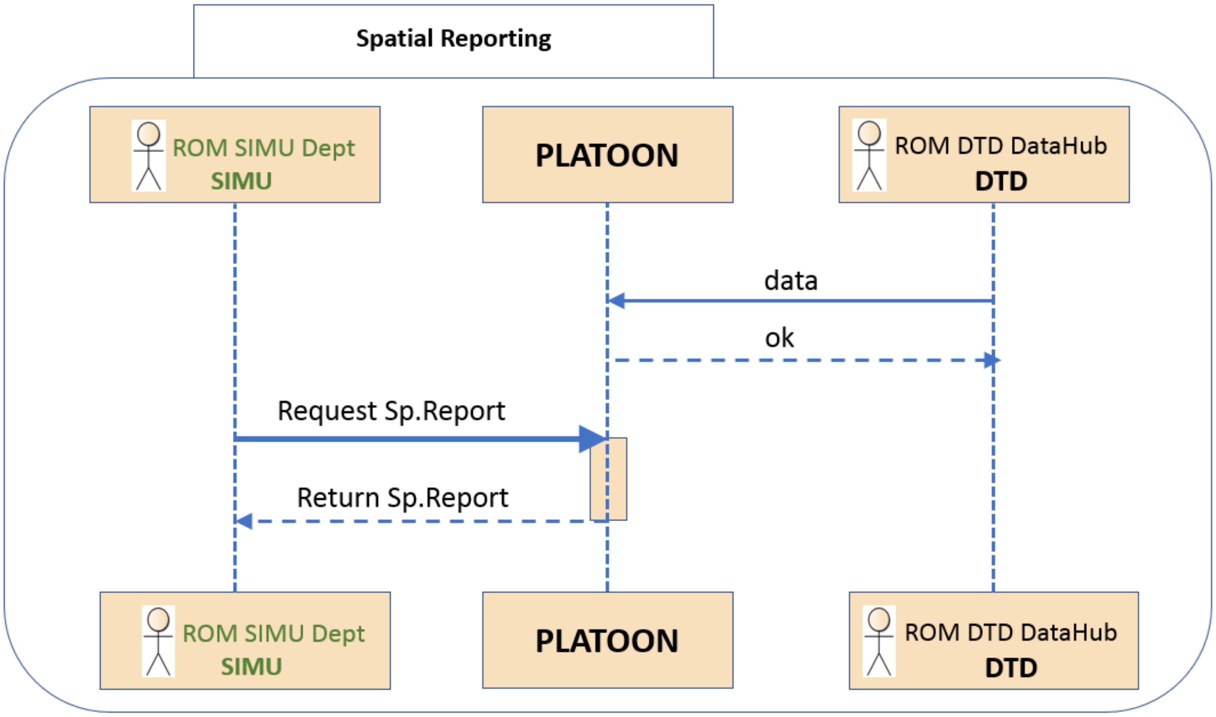
3.2 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
Ref1	Standard methodology	Energy efficiency benchmarking methodology BS EN 16231-2012	Final - 05 sept 2012	DRM UNI-EN	UNI-EN	ISBN 978 0 580 73669 8
Ref2	On line database	PV-GIS EU Database	Final	Free resource	EU JRC	https://ec.europa.eu/jrc/en/pvgis

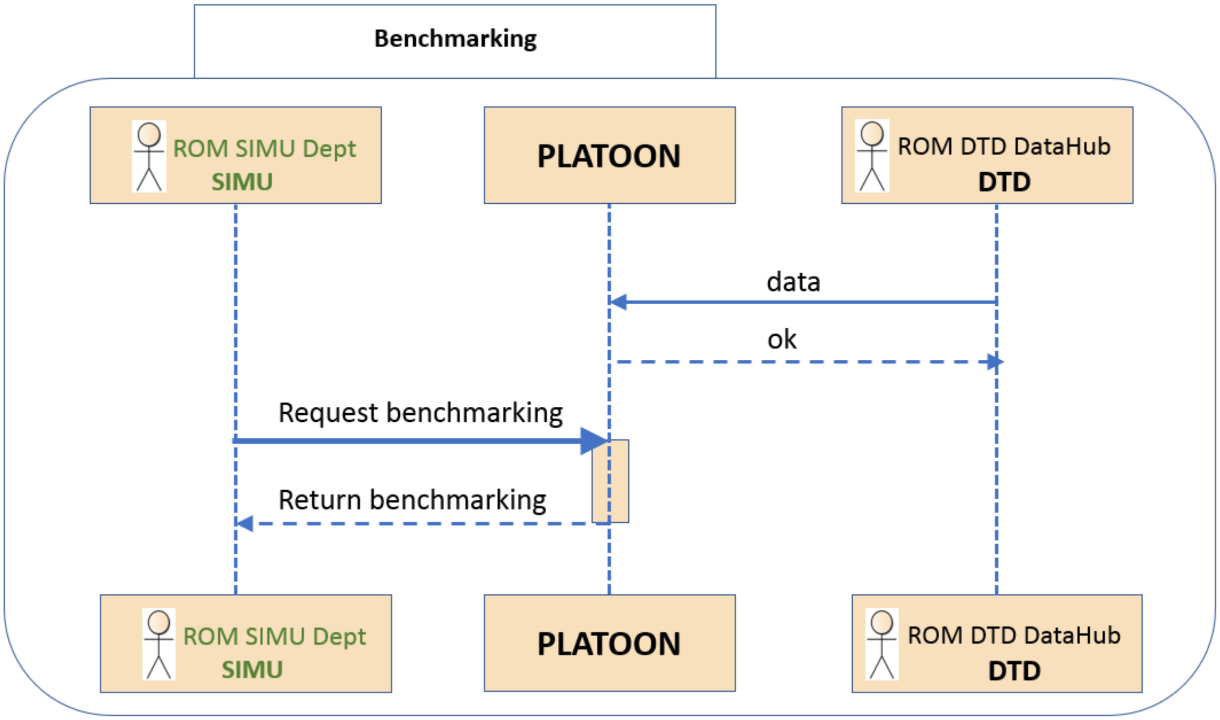
4. Step by step analysis of use case.

4.1 Overview of scenarios.

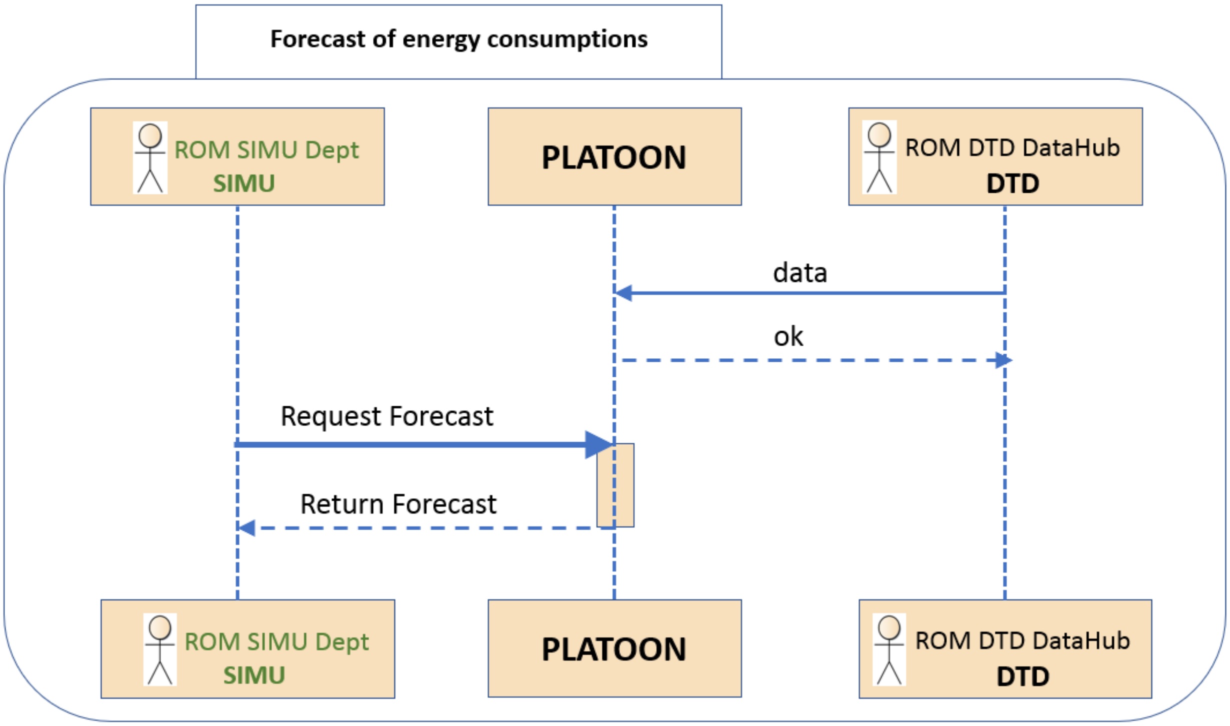
ID	Services Title → SCENARIOS	Description
LL_UC ROM_01a	Spatial Reporting	GIS visualization for the Building Energy Consumptions (EC) and general energy performances (EP)
LL_UC ROM_01b	Benchmarking Analysis	Benchmarking serves to measure EC & EP relative to other similar buildings, or to modeled simulations of a reference buildings set. SUB-SERVICES: Anomalies Detection, Alerting, Support to general asset maintenance planning;
LL_UC ROM_01c	Forecast on energy consumptions	Predicting energy usage of the buildings by analyzing multiple factors
LL_UC ROM_01d	RES potentialities	Identifying potentiality in RES (PV, Solar, Geothermal, …) and Storage to maximize self-consumptions → updating AUDITS



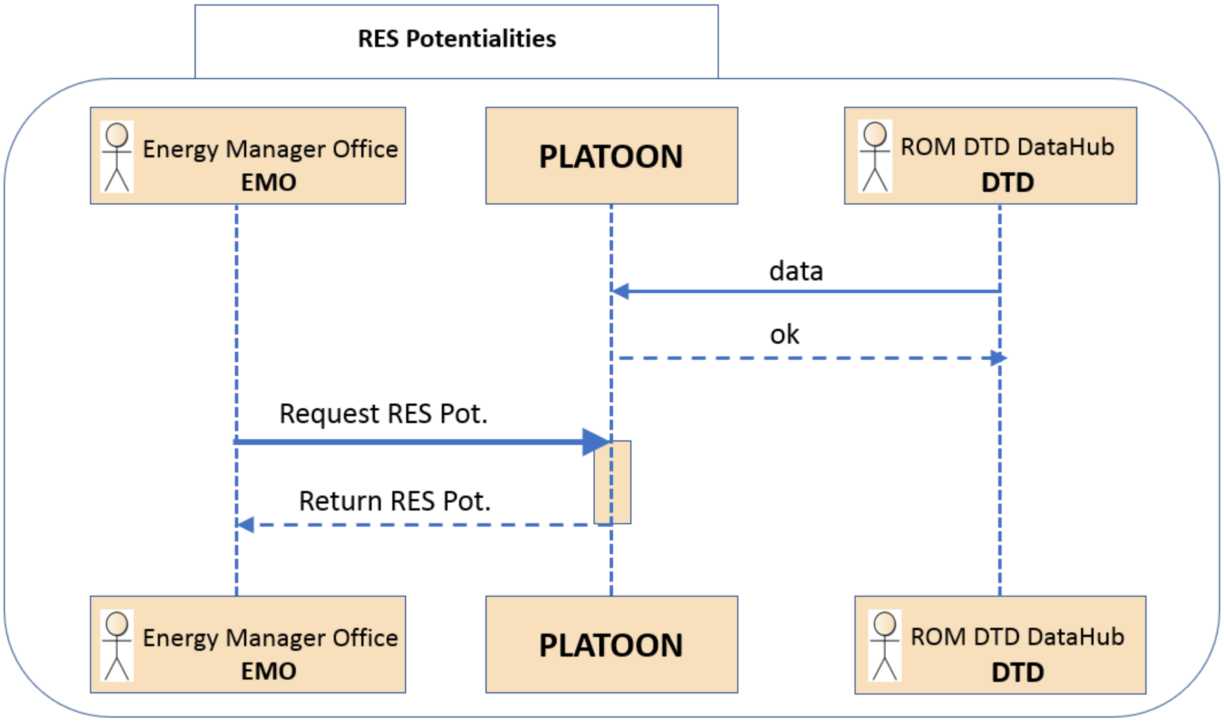
Spatial reporting scenario



Benchmarking Analysis scenario



Forecast of energy consumptions scenario



RES potentialities scenario

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
UC_01a	Spatial Reporting	GIS visualization for the Building(s) Energy Consumptions (EC) and general energy performances (EP)	SIMU Dept actors: EMO UMO TPO	Periodic: Actors ask for a spatial reports on energy consumptions and buildings performances; (**) spatial queries on request phase.	DTD Hub sends detailed consumptions and other data (see chapter 3.5) + Spatial attributes of buildings (shp, kmz); spatial model for the whole asset is ready in PLATOON	Spatial visualization (GIS or WebGIS) of the Buildings EC & EP data is released; Spatial and attributes queries (**) are available; Summary Reports are available
UC_01b	Benchmarking Analysis	Benchmarking serves to measure EC & EP relative to other similar buildings, or to modeled simulations of a reference	SIMU Dept actors: EMO UMO TPO	Periodic: Actors ask to evaluate and compare buildings consumptions (EC) and performance	DTD Hub sends detailed consumptions and other data (see chapter 3.5); comprehensive	All data are available to elaborate and report the values of EC & EP in terms of *Ranking,*

		buildings set. Sub-Services: Anomalies Detection, Alerting, Other services to support to general asset maintenance planning		(EP); Sub-Services: Monthly or weekly: Automatic Alerting service with warning messages on anomalies EC & EP	buildings classification and Benchmarking Models are ready in PLATOON; Sub-Services: Anomalies detection and Alerting models are ready in PLATOON	*Anomalies, Averages for typologies, Deviations* … (Ref: BS EN 16231); Sub-Services: Automatic Alert delivered to Actors
UC_01c	Forecast on energy consumptions	Predicting energy usage of the buildings by analyzing multiple factors	SIMU Dept actors: EMO UMO TPO	Periodic: Actors ask to predict energy consumptions for 1 … more … or all buildings	DTD Hub sends detailed consumptions and other data (see chapter 3.5); Energy Forecast Model is ready	Future (1 month ahead + next year forecast) energy consumptions report is released
UC_01d	RES potentialities	Identifying potentiality in RES (PV, Solar, Geothermal, …) and Storage to maximize self-consumptions → EMO can then proceed updating AUDITS	EMO	Periodic: EMO asks to calculate RES potentialities to maximize self-consumptions for 1 … more …or all buildings	01a 01b 01c scenarios completed successfully; DTD Hub sends detailed consumptions and PV energy production data (see chapter 3.5); RES potential calculation Models are ready (for BAU and optimized scenarios)	RES potentialities plan, in terms of plants power, dimensions & storage capacity to be installed or upgraded to maximize self-consumption, is delivered

4.2 Steps-Scenarios.

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).

Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new "sub" use case, then referring to that "subroutine" in this scenario.

Scenario								
Scenario name:		**No. 01a – Spatial Reporting**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the DTD Hub send data to PLATOON	Asset & Energy Source Data update scheduling	PLATOON receive data from DTD	CHANGE	DTD Hub	PLATOON	R-01 … to R-05	
02	Periodically the SIMU-dept selects on interface Spatial report	PLATOON Spatial Reporting Menu	PLATOON shows Spatial Reporting Menu to the user	GET	PLATOON	SIMU-dept Group	GUI options	
03	Step 02 completed	Selecting parameters and sending request	SIMU-Dept actors select in the menu criteria or parameters asking for Spatial Reporting like: BUILDINGS SET • All buildings • Set of buildings • Single Building (directly to step 05) SPATIAL CRITERIA • perimeter (i.e. a specific District)	GET	SIMU-dept Group	PLATOON	Criteria or parameters selected by SIMU-dept actor	

			• a class of building dimensions (surface or volume) ENERGY METERS • Electric in • Electric out (if PV plant is present) • Gas • Both TIME RANGE: (from month A to month B)					
04	Step 03 completed	Spatial report	PLATOON presents spatial report responding to criteria selected in step 03; Textual Report available to download	GET REPORT	PLATOON	SIMU-dept Group	Spatial report data: Map based (GIS or webGIS) visualization of EC and EP	
05	SIMU-Dept actor select (on map or in scroll menu) specific building from step 04 output	Single building Information request	SIMU-Dept actors select single building asking for the relative full report; Single building full report available to download	GET REPORT	PLATOON	SIMU-dept Group	Single building full data report, including specific map at building scale	

Scenario								
Scenario name:		**No. 01b – Benchmarking Analysis**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the DTD Hub send data to PLATOON	Benchmark Source Data update scheduling	PLATOON receive data from DTD	CHANGE	DTD Hub	PLATOON	R-01 … to R-05	

02	Periodically the SIMU-dept selects on interface Benchmarking	PLATOON Benchmarking Menu	PLATOON shows Benchmarking Menu to the user	GET	PLATOON	SIMU-dept Group	GUI options	
03	Step 02 completed	Selecting parameters and sending request	SIMU-Dept actors select in the menu criteria or parameters for analysis like: BUILDINGS SET • All buildings • Set of buildings • Single Building BENCHMARK • With itself (in a specific time range) • With a different building (same time window) ENERGY METERS • Electric in • Electric out (if PV plant is present) • Gas • Both TIME RANGE: (from month A to month B)	GET	SIMU-dept Group	PLATOON	Criteria or parameters selected by SIMU-dept actor	
04	Step 03 completed	Benchmarking report	PLATOON presents benchmarking report responding to criteria selected in step 03	GET REPORT	PLATOON	SIMU-dept Group	Benchmark report data: *Ranking, Anomalies, Averages for typologies, Deviations* … (Ref: BS EN 16231);	

Scenario								
Scenario name:		**No. 01c – Forecast on Energy Consumptions (EC)**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the DTD Hub send data to PLATOON	Forecast Source Data update scheduling	PLATOON receive data from DTD	CHANGE	DTD Hub	PLATOON	R-01 … to R-05	
02	Periodically the SIMU-dept selects on interface Forecast	PLATOON Forecast Menu	PLATOON shows Forecast Menu to the user	GET	PLATOON	SIMU-dept Group	GUI options	
03	Step 02 completed	Selecting parameters and sending request	SIMU-Dept actors select in the menu criteria or parameters for Forecast like: BUILDINGS SET • All buildings • Set of buildings • Single Building FORECAST PERIOD • A future full year • A future range of months (from month A to month B) ENERGY METERS • Electric in • Electric out (if PV plant is present) • Gas • Both	GET	SIMU-dept Group	PLATOON	Criteria or parameters selected by SIMU-dept actor	

04	Step 03 completed	Forecast on EC report	PLATOON presents Forecast report responding to criteria selected in step 03	GET REPORT	PLATOON	SIMU-dept Group	Forecast on EC Report Data	

Scenario								
Scenario name:		**No. 01d – RES potentialities …**						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodically the DTD Hub send data to PLATOON	Asset & Energy Source Data update scheduling	PLATOON receive data from DTD	CHANGE	DTD Hub	PLATOON	R-01 … to R-05	
02	Periodically the SIMU-dept selects on interface RES potentialities	PLATOON RES potentialities Menu	PLATOON shows RES potentialities Menu to the user	GET	PLATOON	SIMU-dept Group	GUI Options	
03	Step 02 completed	Selecting parameters and sending request	SIMU-Dept actors select in the menu criteria or parameters for analysis like: BUILDINGS SET • All buildings • Set of buildings • Single Building PV PLANTS OPTIONS • Existing PV plants (building with) • New PV plants (building without PV plants)	GET	SIMU-dept Group	PLATOON	Criteria or parameters selected by SIMU-dept actor	

			ENERGY METERS • Electric in • Electric out (if PV plant is present) ➔ Both ALWAYS selected RES SCENARIOS • BAU (based on observed EC) • Optimized (based on ideal reference building EC)					
04	Step 03 completed	Models feeding	PLATOON requests (internal procedure): for EC Reporting (01a) in case of RES SCENARIO = BAU; for Benchmarking (01b) and Forecast (01c) in case of RES SCENARIO = Optimized;	EXECUTE	PLATOON	PLATOON	EC Data (01a), Benchmark Data (01b), Forecast Data (01c)	
05	Step 04 completed	RES potentialities report	PLATOON presents RES potentialities report responding to criteria selected in step 03; RES potentialities Report available to download	GET REPORT	PLATOON	SIMU-dept Group	RES potentialities plan for selected buildings in terms of PV plants and storage power, capacity and dimensions	

5. Information exchanged.

ID	Data source	Description	Data Privacy
RI-01	Buildings Master Data	Detailed static data for each building which are sent to the platform. These data give information about building characteristics and context (dimensions for surfaces, volumes, floors; function & destination classes, climate zone, use & occupancy profile, shell performance, energy plants typologies, electric and thermal energy loads; roof free surfaces & tilt) and includes .SHP or .KML files for geometry of building for spatial visualization.	No
RI-02	Power Meters Data	Historical and current Data flows for 6500 meters – frequency from monthly to 15' (for meters larger than 15kw)	No
RI-03	Gas Meters Data	Historical and current Data flows for 2450 gas meters – frequency from monthly to 30' (for meters remote controlled by the GSP)	No
RI-04	PV Meters Data	Data from 165 meters tracking energy production (out) and energy exchanged (in, out) with the grid → self-consumption quote (Areti / GSE data)	No
RI-05	Weather Data	Historical & current data concerning the Local Climatic context	No

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
RI-01	Buildings Master Data	Detailed static data for each building which are sent to the platform. These data give information about building characteristics and context (dimensions: surfaces, volumes, floors; function & destination classes, climate zone; use & occupancy profile; shell performance [Kwh/mq/y]; energy plants typologies; electric and thermal energy loads; roof free surfaces & tilt) and includes .SHP or .KML file for geometry of building for spatial visualization.	No
RI-02	Power Meters Data	Historical and current Data flows for 6500 meters – frequency from monthly to 15' (for meters larger than 15kw)	No

RI-03	Gas Meters Data	Historical and current Data flows for 2450 gas meters – frequency from monthly to 30’ (for meters remote controlled by the GSP)	No
RI-04	PV Meters Data	Data from 165 meters tracking energy production (out) and energy exchanged (in, out) with the grid à self-consumption quote (Areti / GSE data)	No
RI-05	Weather Data	Historical & current data concerning the Local Climatic context	No

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Unique identifier for the category. Name for the category of requirements.	A name of the requirement.	Description of the requirement category.
Requirement R-ID	**Requirement name**	**Requirement description**
Unique identifier which identifies the requirement within its category	A name of the requirement.	Description of the requirement .

7. Custom information (optional).

Custom information (optional)		
Key	**Value**	**Refers to section**
EC	Energy Consumptions of the building	all
EP	Energy Performances of the building	all

LLUC P-3C- 01: Advanced EMS for Tertiary Buildings

1. Use case description

1.1 Name of use case.

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of use case**
LLUC-3C-01	Tertiary Buildings	Advanced EMS for Tertiary Buildings

1.2 Version management.

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
1	26.03.2020	Borja Tellado (TECNALIA)	Initial version	
2	26.05.2020	Borja Tellado (TECNALIA)	Included additional information on section 3.8	
3	03.06.2020	Borja Tellado (TECNALIA)	Final version	

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	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
Objective(s)	The goal of the functionality described in the current use case is to enhance existing BMS systems with capabilities to optimize the energy usage maximizing the use of local RES in order to minimize the energy bill
Related business case(s)	Use case 3a-01, 3a-02, 3b-01 and 3b-02

1.4 Narrative of Use Case.

Narrative of use case
Short description
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.

Complete description
The objective of this usecase is to match the demand prediction and RES generation prediction and optimize the operation to achieve two objectives, reduce the grid dependency and operate in such a way the additional flexibility helps to reduce the energy bill. The current use case considers four main inputs: • HVAC data: Data related to the HVAC design and operation constraints as well as the user preferences are included in this group. • RES data: Data related to the design and operational constraints of the local installed renewable energy sources are included in this group • Energy Prices: The current scenario assumes that there is a dynamic energy pricing policy aplicable to the building • Weather Data: Weather forecast is a key factor to create accurate forecasts for both energy consumption and local RES production The outcome of this usecase will be an optimized schedule for HVAC loads and RES production and storage (if available). The Advanced EMS periodically will poll the all the inputs mentioned above and making use of the specific trained models release mentioned outcomes. For this purpose, the full functionality of the Advanced EMS will be split following an architecture based on microservices, each of one dealing with one of the required functionalites. (see figure 2) The Advance EMS relies in one relevant preconditions, this is, the availability of the communication interfaces with the described input and output sinks.

1.5 Key performance indicators (KPI).

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI-01	Energy Bill reduction	The KPI will evaluate the energy bill reduction achieved	Reduce the energy bill
KPI-02	RES ratio	The KPI will evaluate the RES usage versus overall energy consumption.	Maximize the RES usage

1.6 Use case conditions.

Use case conditions
Assumptions
Building equipped with remote control and monitoring capabilities HVAC systems
Prerequisites
The basis scenario must be equipped with a BMS system that provides the seamless access to building operation and

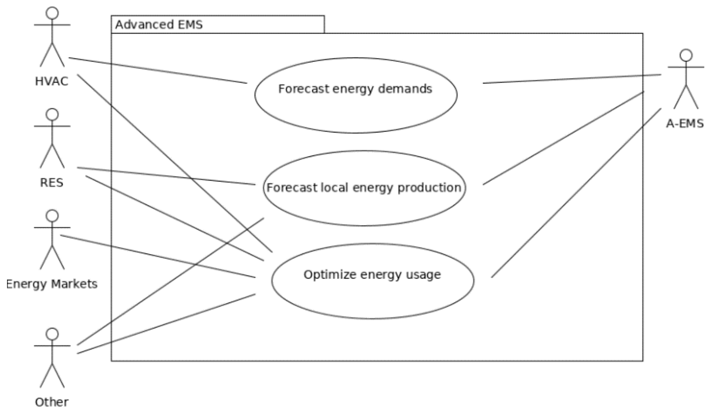
control values. The BMS has to allow as well remote connections to interface with cloud based modules.

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

Classification information
Relation to other use cases
• Optimization of smart grids (pilot 2a, pilot 4a). • Smart building energy efficiency optimization (pilot 3a and 3b)
Level of depth
Detailed use case
Prioritization
Mandatory
Generic, regional or national relation
From the point of view of its application the current use case is limited to one single pilot, so it must be labeled as **Regional**, in any case its generalization is straight forward.
Nature of the use case
Technical use case
Further keywords for classification
machine learning, energy demand forecasting, RES, analytical models, HVAC

2. Diagrams of use case.

The figure below summarizes the advanced EMS functionality and involved main actors



3. Technical details.

The current use case foresees the involvement of four mayor actors, namely "HVAC", "RES", "Energy Markets" and "A-EMS" (Advanced EMS) and a fifth extra actor labeled as "Other" that group any external data source that may enrich the usage scenario.

3.1 Actors.

Actors			
Grouping		**Group description**	
HVAC		The HVAC grouping includes all the sensors and actuators related to the heating and cooling system deployed in the building	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Temperature sensor	Device	Includes any kind of temperature sensor deployed in the HVAC system	
Flow meter	IED	Includes any kind of flow meter deployed in the HVAC system	
Thermal meter	IED	Includes any kind of thermal meter deployed in the HVAC system	
Electrical meter	Device	Includes any kind of electrical meter deployed in the HVAC system	
Thermostat	Device	Includes any kind of device with capabilities to regulate temperatures no matter if they are flow temperatures, indoor temperatures or any other	

Actors			
Grouping		**Group description**	
RES		The RES grouping includes all the sensors and actuators related to the local renewable energy sources	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Electrical meter	IED	Includes meters that measure local electricity production	
Thermal meter	IED	Includes meters that measure local thermal power production	

Actors			
Grouping		**Group description**	
Energy Markets		The Energy Markets grouping makes reference to energy price sources	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Market regulator	External system	It refers to regional electricity and gas market regulators. It defines the electricity price and gas price.	
Utility	External system	It makes reference to any entity that may offer any energy contract. It defines the electricity price and gas price.	

Actors			
Grouping		**Group description**	
Other		Includes all the rest of external data that may be useful to enrich the use case	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Weather data	External System	It makes refence to weather forecasting services.	

Actors			
Grouping		**Group description**	
Advanced EMS		The Advanced EMS grouping includes all the algorithms to optimize the energy management of the building.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Thermal demand forecasting module	Software	Module that predicts the future thermal consumption of the building.	
RES generation forecasting module	Software	Module that predicts the future RES generation of the building.	
Optimization module	Software	Module that optimizes energy demands and local RES usage to	

		minimize the energy bill	

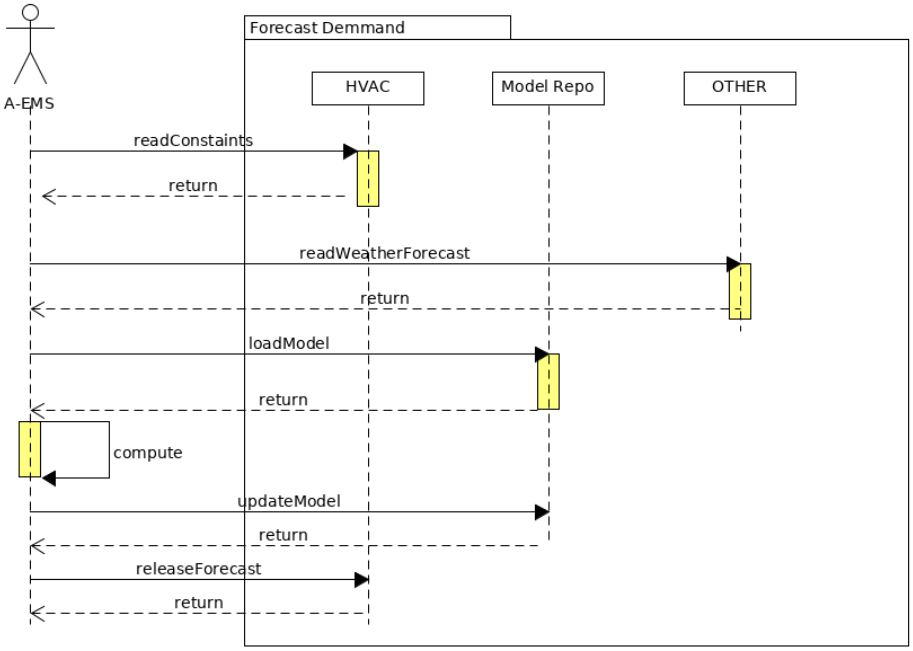
3.2 References.

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
1	Patent	Next24h: Method and System Of Smart Climatization Management (Patent EP17382026, Manjarrés D., Mera A., Lejarazu A., Tellado B., Perea E., Gil-López S., 20th January 2017.) (Software License: Request Number: 1-4218605601 ; Registration number: Txu 2-049-777 ; Registration date: 02/12/2016)			Tecnalia	
2	Software License	SunSet: optimization models for photovoltaic energy management (consumption, storage and injection to the grid). (Software License: Request number: 1-8299353441 ; Registration number: TXu2-180-208; Registration date: 27/11/2019).			Tecnalia	

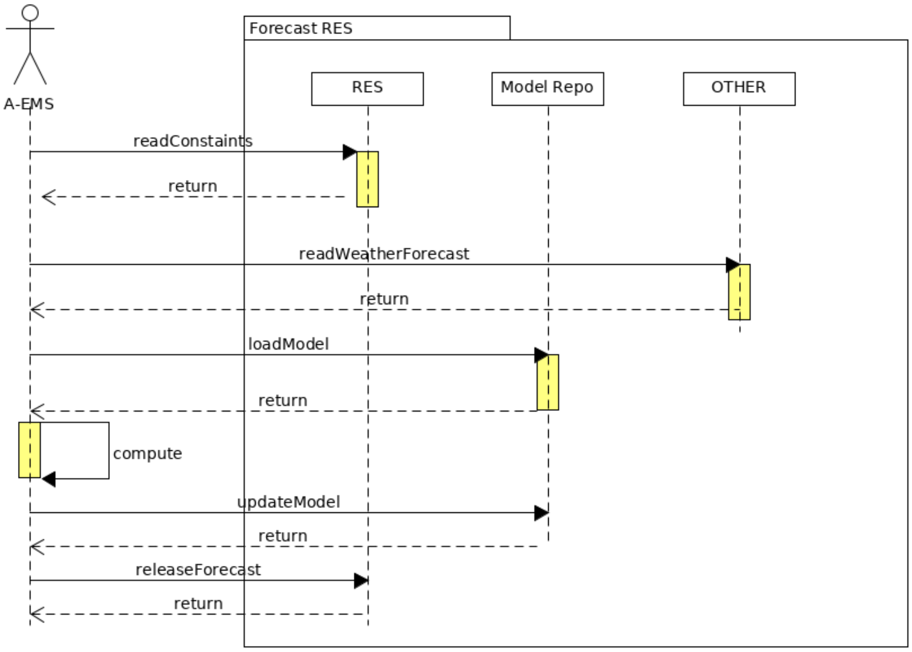
4. Step by step analysis of use case.

4.1 Overview of scenarios.

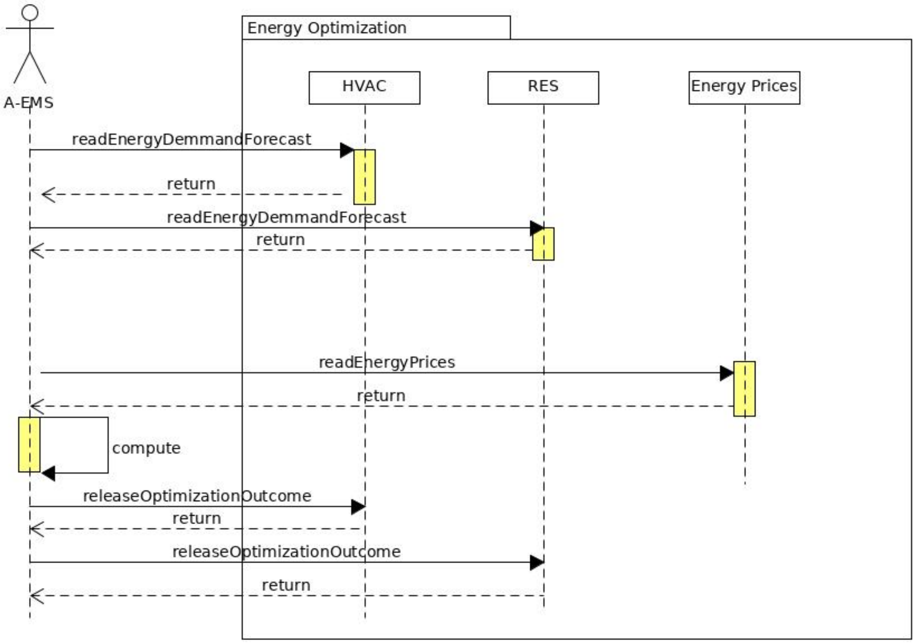
Forecast demand scenario



Forecast RES production scenario



EMS Optimization scenario



Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
01	Energy demands forecast	The scenario covers the prediction of the future (24h) energy demands in building	Advanced EMS and HVAC	Periodic	HVAC system in place, boundary comfort constraints available and model trained	Future, 24h ahead, energy consumption is released
02	Forecast local energy production	The scenario covers the prediction of the future (24h) local RES production	Advanced EMS and RES	Periodic	RES system in place, desing and operation constraints available and model trained	Future, 24h ahead, RES production is released
03	Optimize energy usage	Considering the outcomes of the two scenarios above, the weather forecast and energy prices optimized the local loads and RES to minimize the energy bill	Advanced EMS, External Markets, Other	Periodic	01 and 02 scenarios completed successfully	Optimization for RES and HVAC Systems is released. RES: scheduling for PV energy management (24hr plan including times for buying/selling and consuming produced energy. HVAC: scheduling for HVAC on/off command.

4.2 Steps-Scenarios.

Scenario								
Scenario name:		**No. 1 –** Energy demands forecast						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodic	Fetch HVAC system technical constraints and user preferences	EMS request from the HVAC user preferences, technical and design constraints	GET	HVAC	Advanced EMS	01-HVAC-ConsReq	
02	Step 01 completed	Fetch forecasted weather data	EMS request the future weather data	GET	OTHER	Advanced EMS	01-OTHER-WeatherReq	
03	Step 02 completed	Load analytical model	EMS access the model repository to load the appropriate analytical model	GET	Model Repository	Advanced EMS	01-EMS-LoadModel	
04	Step 03 completed	Compute forecast	Computation of previous inputs	CREATE	Advanced EMS	Advanced EMS	N.A.	
05	Step 04 completed	Update the model	Updates the model	CHANGE	Advanced EMS	Model Repository	01-EMS-updateModel	
06	Step 05 completed	Release forecast and store in HVAC	EMS send the forecast to the HVAC systems	CREATE	Advanced EMS	HVAC	01-EMS-sendForecast	

		system						

Scenario								
Scenario name:		**No. 2 –** Forecast RES						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodic	Fetch RES system technical constraints	EMS request from the RES technical and design constraints	GET	RES	Advanced EMS	02-RES-DataReq	
02	Step 01 completed	Fetch forecasted weather data	EMS request the future weather data	GET	OTHER	Advanced EMS	02-Weather-DataReq	
03	Step 02 completed	Load analytitcal model	EMS access the model repository to load the appropriate analytical model	GET	Model Repository	Advanced EMS	02-Model-ModelReq	
04	Step 03 completed	Compute forecast	Computation of previous inputs	CREATE	Advanced EMS	Advanced EMS	N.A.	

05	Step 04 completed	Update the model	Updates the model	CHANGE	Advanced EMS	Model Repository	02-EMS-UpdateModel	
06	Step 05 completed	Release forecast and store in RES system	EMS send the forecast to the RES systems	CREATE	Advanced EMS	HVAC	02-EMS-sendForecast	

Scenario								
Scenario name:		**No. 3 –** Energy Optimization						
Step No.	**Event**	**Name of process activity**	**Description of process/ activity**	**Service**	**Information-producer (actor)**	**Information receiver (actor)**	**Information ex-changed (IDs)**	**Requirement, R-IDs**
01	Periodic	Fetch HVAC energy demand	EMS request from the HVAC user preferences, technical and design constraints	GET	HVAC	Advanced EMS	03-HVAC-ConsReq	
02	Step 01 completed	Fetch forecasted RES production	EMS request from the RES user preferences, technical and	GET	RES	Advanced EMS	03-RES-DataRec	

			design constraints					
03	Step 03 completed	Fetch energy pricing profile	EMS request the future energy pricing data	GET	Energy Prices	Advanced EMS	03-Enegy-DataReq	
04	Step 04 completed	Compute	Computation of previous inputs	CHANGE	Advanced EMS	Advanced EMS	N.A	
05	Step 05 completed	Release optimization outcome	EMS send the forecast to the systems	CREATE	Advanced EMS	HVAC	03-EMS-sendForecast	
06	Step 06 completed	Release optimization outcome	EMS send the forecast to the RES systems	CREATE	Advanced EMS	RES	03-EMS-sendForecast	

5. Information exchanged.

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information ex- changed**	**Requirement, R-IDs**
01-HVAC-ConsReq	HVAC operation constraints	Indoor comfort boundaries and HVAC system constraints	
01-OTHER-WeatherReq	Weather data	Weather forecast	
01-EMS-LoadModel	Model to calculate forecast	The model to produce to needed forecasting process is retrieved	
01-EMS-updateModel	New data for model	Outcome that will enrich the model for further iterations	
01-EMS-sendForecast	Energy demand forecast	Future, 24h ahead, energy demand forecast	
02-RES-DataReq	RES operation constraints	Request of RES system operational and desing constraints	
02-Weather-DataReq	Weather data	Weather forecast	
02-Model-ModelRe	Model to calculate forecast	The model to produce the needed forecasting process is retrieved	
02-EMS-UpdateMode	New data for model	Outcome that will enrich the model for further iterations	
02-EMS-sendForecast	Energy demand forecast	Future, 24h ahead, energy demand forecast	
03-HVAC-ConsReq	HVAC operation constraints	Indoor comfort boundaries and HVAC system constraints	
03-RES-DataRec	RES operation constraints	Request of RES system operational and design constraints	
03-Enegy-DataReq	Energy Prices data	Will containing future, 24 ahead, energy pricing schema	
03-EMS-sendForecast	Energy demand forecast	Future, 24h ahead, energy demand forecast	

03-EMS-sendForecast	Energy demand forecast	Future, 24h ahead, energy demand forecast	

6. Requirements.

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Unique identifier for the category. Name for the category of requirements.	A name of the requirement.	Description of the requirement category.
Requirement R-ID	**Requirement name**	**Requirement description**
Unique identifier which identifies the requirement within its category	A name of the requirement.	Description of the requirement .

7. Common terms and definitions.

Common terms and definitions	
Term	**Definition**
HVAC	Heating Ventillation and Air Conditioning
RES	Renewable Energy Sources

LLUC P-3C- 02: Predictive Maintenance in Smart Tertiary Building Assets

1. Use case description (Predictive Maintenance in Smart Tertiary Building Assets).

1.1 Name of use case.

Use case identification		
ID	**Area Domain(s)/Zone(s)**	**Name of use case**
LLUC-3C-02	CIC NANOGUNE Building Assets related to Air Handling and Heat Pumps	Predictive Maintenance in Smart Tertiary Building Assets

1.2 Version management.

Version management				
Version no.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.1	28th March 2020	Mario Insunza (SISTEPLANT)	Initial creation (General Description)	Draft
0.2	16th April 2020	Mario Insunza (SISTEPLANT)	Included definition of scenarios	Draft
0.3	27th April 2020	Mario Insunza (SISTEPLANT)	Included comments and information of GIROA	Draft
0.4	16th May 2020	Gorka Naverán (GIROA)	Included list of assets and parameters	Draft
0.5	19th May 2020	Mario Insunza (SISTEPLANT)	Included additional comments	Draft
0.6	29th May 2020	Iker Larrinaga and Guillermo Gomez (SISTEPLANT)	Included UML diagrams and FMEA examples	Draft
0.7	5th June 2020	Mario Insunza (SISTEPLANT) and Gorka Naverán (GIROA)	Final version LLUC	Draft
0.8	5th June 2020	Erik Maqueda	Added Data List Annex	Draft

1.3 Scope and objectives of use case.

Scope and objectives of use case	
Scope	Improve the maintenance policies in the tertiary buildings implementing the predictive maintenance in some specific assets increasing the availability and useful life of these assets and reducing the general maintenance costs
Objective(s)	• Increase the availability of the assets • Increase the useful life of the assets • Reduce the maintenance costs

Related business case(s)	• Predictive maintenance in wind farms (#1A) • Advanced EMS in tertiary buildings (#3C- UC1) • Electricity grid stability, connectivity and life extension (#2B-UC1) • Predictive maintenance of cooling and heating plants (#3B-UC2)

1.4 Narrative of Use Case.

Narrative of use case
Short description
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 due to legal aspects must be reviewed and controlled every X time) 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 lower 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 the situation of the corresponding asset and be able to act accordingly.
Complete description
To carry out a good maintenance policy, it is necessary to start from a clear definition of the group of assets to be controlled by predictive maintenance. Also, the most significant failure modes that may appear in the previous assets must be defined (this can be done through using RCM – Reliability Centred Maintenance – or FMEA – Failure Modes and Effects Analysis - techniques). After and just before the calculation processes, it is necessary to define the main parameters to be obtained and controlled, indicating which are the input and output parameters, as well as their relationships to obtain the next date failure (in a certain failure mode). Once these pre-requirements have been studied and knowing what data they should obtain, the steps to be taken into account in the use case itself will be the following • Extract the data o Obtaining data and its periods of time. It does not seem to make sense to obtain data in real time (it could be off-line - to be defined). There may even be the possibility of different data collection times depending on the parameters collected. o What data is obtained. Define in detail the data to be extracted and its level of need. Special importance is required by those data that are directly relevant in calculating the next failure date. • ‘Cleaning’, data register and ‘Exploratory Data Analysis’ o Data Cleaning: analyze the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...) o Determine if the data comes with errors, if noise has to be eliminated in various data, etc. until the data is ready for registration. o Data registration in a database to have historical data and to be able to carry out various off-line tests when it is desired. It is necessary to determine how and where the data is stored. o Exploratory Data Analysis. Filter the data by identifying and selecting the relevant variables (from all the variables that are available) for each asset, in order to reduce the amount of data used for calculations and save computational cost. ‘Label’ the data necessary for subsequent calculations. Dataset labelled: Identify faulty periods and check the maintenance logs. See the

relationships between input parameters and output parameters (Multi-parameter analysis, correlations, etc.).

- Algorithms and calculation of the next breakdown - failure date
    - Determine the steps of the algorithms to proceed to the calculation:
        - Develop a data driven or hybrid model to simulate normality using the data records for healthy condition.
        - Analyze deviations from faulty points compared to the normal simulated by the developed normality model.
        - Feature creation to quantify deviations from faulty points compared to normal condition modelled by the developed model.
        - Train and validate algorithms using the newly created features and other features to detect failures. Use historical off-line data.
        - Validate the developed algorithms and modify the algorithm as necessary to get an acceptable performance.
    - Determine the failure modes that in the event of appearing lead to the corresponding failure.
    - Final calculation of the next failure date of a specific asset, indicating the failure mode that will occur and its level of importance and risk assessment of this failure mode.

Once the necessary calculations have been made in the use case, it is important to integrate this information with the rest of the general maintenance plan for the selected assets. This is done as follows,

- Obtaining the next asset maintenance date (with predictive maintenance) and decision-making based on the work to be done with the corresponding asset (fits corrective and preventive maintenance tasks)
    a. It starts from the date of the next failure calculated in the calculation stage
    b. It is checked if there are work orders planned in previous dates (we can estimate a value for the previous dates, such as a week).
    c. The decision is made (with the change in the planning of the work orders) to 'join' work orders or not, depending on the use of specific resources, the risk of additional problems with the asset, etc.

How – Controlling the status of the main parameters of the assets with predictive maintenance policy to know their health condition at all times and act accordingly.

Where – In those assets that follow the predictive maintenance policy (those that allow obtaining reliable data on various parameters which are necessary for the control of health condition).

When – In the shortest time as possible. If in any case the data cannot be obtained in a specific period of time, it must be contrasted with historical data to be able to predict the health condition in similar situations (that would be very similar to how meteorology predicts the weather of the following day)
Why – To get to know the health condition of each asset and to be able to act at the right time following the general maintenance guidelines

Under which assumptions - It is necessary to control the main parameters of the assets that allow the prediction of the next failure. It is also important to have historical data that allows knowing the operating rules of the assets and that makes the predictions more accurate. Finally, after predicting the failure, it is essential to have the necessary coordination among all maintenance resources to act at the time that least influences the availability of assets and with the least impact on costs.

1.5 Key performance indicators (KPI)

Key performance indicators

ID	Name	Description	Reference to mentioned use case objectives
AV-01	Availability	It is the availability of the asset in a period of time. As a mathematical formula it would be equal to Working Time divided by Total Time. We can consider Total Time as the time that the asset must be working or the physical time (24 hours a day)	The objective is to increase the availability of the assets
UL-01	Useful Life	It is important to maximize the useful life of each asset. This is done based on various concepts: • Early detection of possible breakdowns • Correct performance of own maintenance tasks (corrective / preventive) • Working with assets in suitable conditions for them (not forcing work in unsuitable conditions, etc.) The mathematical formula is the total time (in hours) that the asset has operated until it has finally been replaced	The objective is to increase the useful life of the assets
MC-01	Maintenance Costs (Total maintenance costs)	The maintenance cost of an asset is the sum of the costs of the work orders that have been carried out on that asset. It is important to indicate that maintenance costs may be higher in some assets that use predictive maintenance. Therefore, the goal should be achieving the lowest possible cost in the set of assets. Thus, the formula is the sum of the maintenance costs of the assets selected for the use case.	The objective is to reduce the total maintenance costs of the assets

1.6 Use case conditions

Use case conditions
Assumptions
It is necessary to control the main parameters of the assets that allow the prediction of the next failure. It is also important to have historical data that allows knowing the operating rules of the assets and that makes the predictions more accurate
Prerequisites
• Definition of asset groups (based on their technology or class of equipment) and definition of specific assets for calculating predictive maintenance. They can all be in CIC NANOGUNE or in several different buildings. • Definition of failure modes of the previously selected assets to be able to calculate and predict when the next failure will occur (and what failure mode it is) • Definition of main input parameters to control and how they take part in the definition of the output parameters to determine the date of the next failure of each asset.

- Previously established maintenance policies, distinguishing between assets with corrective, preventive and predictive maintenance, along with those that work with an approximate percentage of several policies at the same time.

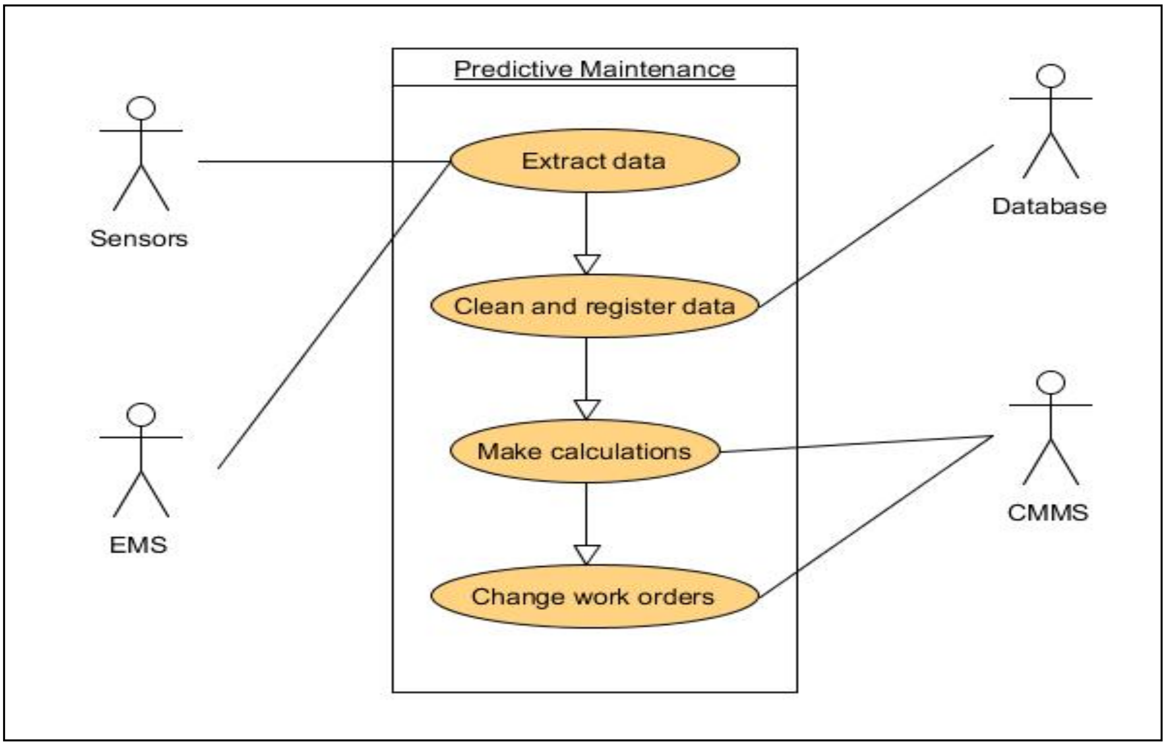
1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Predictive maintenance is useful in cases where assets must have maximum availability and try to reach the maximum of their useful life (in general, assets that are expensive or that can significantly increase the cost of other assets). This operation is similar in the case of wind turbines in the wind generation industry, in which availability is essential in your business, as well as ensuring that the useful life of these wind turbines is extended. The differences between the two cases occur when planning maintenance tasks (for example, every week) since in the wind industry specific resources are required for their work (cranes, etc.), which are expensive and may not be available at any given time, as well as knowledge of wind and weather forecasts are essential. Also, the possibilities of working in different buildings or groups of wind turbines have somewhat different solutions, due to the weather.
Level of depth
Detailed Use Case
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Technical use case (Calculation of availability and useful life) and business use case (maintenance costs)
Further keywords for classification
Availability / Useful Life / Prediction / Forecast / Preventive / Corrective / Planning

1.8 General remarks

General remarks
• General planning of assets maintenance • Preventive maintenance that it is mandatory to make • Decision-making about whether the predictive maintenance on an asset may or may not be the best maintenance policy

2. Diagrams of use case



3. Technical details

The current use case foresees the involvement of 3 major actors, namely “Sensors”, “EMS (Energy Management System)”, “CMMS (Computerized Maintenance Management System)” and a fourth extra actor labeled as “Other” that group any external data source that may enrich the usage scenario.

3.1 Actors

Actors	
Grouping	**Group description**
Sensors	This grouping includes all the sensors and actuators related to the parameters data that we need to capture for obtaining the future calculations.

Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Sensors – Meters	Device	Summarizes all sensors that can be used to obtain parameters data and they cannot be obtained via other devices related to software systems (not possible to capture via EMS, because it is very difficult or very expensive).	

Actors

Grouping	**Group description**
EMS	In this case, the EMS is the software system that registers and sends the information to the software system that works with calculation algorithms.

Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
EMS data	Data	Summarizes all the necessary data to send to the software system that works with the algorithms and their calculations.	
Interchange data	Middleware	Summarizes all the necessary software systems to interchange data and general information between the EMS and the toolbox calculating the next failure in the asset.	

Actors

Grouping	**Group description**
CMMS	In this case, the CMMS is the software system that registers and stores the information related to the maintenance work orders and other historical data (for lessons-learned)

Actor name	***Actor type***	**Actor description**	**Further information specific to this use case**
CMMS data	*Data*	Summarizes all the necessary data to send to software system that works with the algorithms and their calculations (to join to EMS data)	
Interchange data	*Middleware*	Summarizes all the necessary software systems to interchange data and general information between the CMMS and the toolbox calculating the next failure in the asset.	

Actors

Grouping	**Group description**
Other actors	A summary of all actors that are no sensors, EMS or CMMS

Actor name	Actor type	Actor description	Further information specific to this use case
Responsible of Predictive Maintenance	Human	Describes the person who is in charge of all the steps before the decision-making. In summary, these steps are extract information (from sensors and EMS system), clean and interchange the data (between EMS and CMMS systems), and calculate the best solution for predictive maintenance	In this case, is one person, but it is possible that in other cases the functions could be managed by different people (one person for extract data, data cleaning and register, and another for calculations).
General Maintenance Manager	Human	Describes the person in charge of decision-making around of the whole group of work orders, taking into account the different maintenance policies.	
Weather data	External System	It makes refence to weather forecasting services.	
Other data	External System	It makes reference to other data that could help in the best calculation of the algorithms	

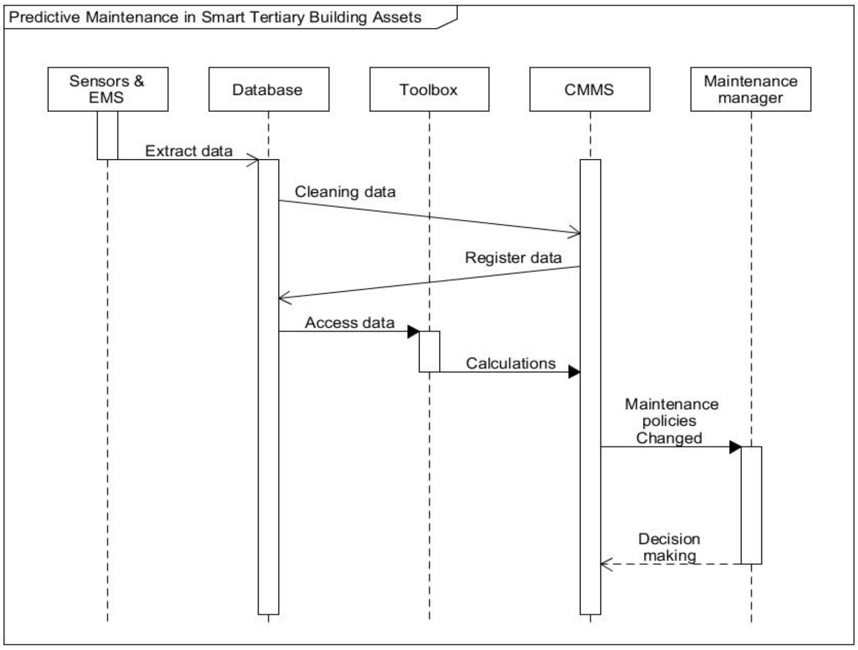
3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organization***	***Link***
1	User manual	PRISMA – CMMS software	Final	High	SISTEPLANT	
2	Standard	API-REST of software system PRISMA of SISTEPLANT	Final	High	SISTEPLANT	

4. Step by step analysis of use case

4.1 Overview of scenarios

Step by step description is presented as a UML sequence diagram followed by a written description.



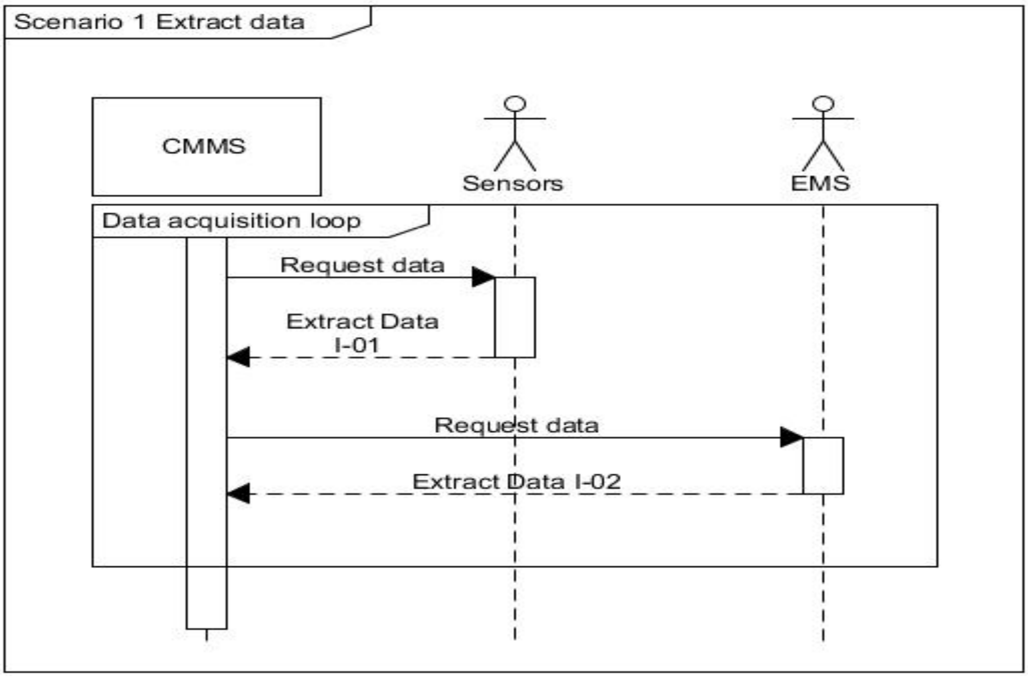
Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary Actor***	***Triggering event***	***Pre-condition***	***Post-condition***
01	Extract data	The scenario covers the fact of extracting data from sensors and EMS system. Depending on some specific data they can need to use different devices.	EMS	Periodic	Sensors and EMS are working in good conditions and they can send the information to next step	All the data are ready to be registered in the CMMS system.
02	Cleaning and data register	The scenario covers the fact of 'cleaning' the information of step 01 and includes all the data in the specific fields of a database connected to CMMS system. The CMMS system is the database when the historical information is stored (work orders, dates of failures, etc.).	CMMS system	Periodic	The data have been extracted in step 01	All the data have been cleaned, filtered and registered in the database. They are ready to start the calculations for the prediction of next failure
03	Calculation and next failure prediction	The scenario covers the calculation (with different steps as develop a normality model, quantify deviations, etc.) obtaining as final result one specific date that remarks the expected next failure of each asset	Toolbox	Periodic	The data are 'cleaned' and registered in the specific database (the previous steps 01 and 02 have been done successfully)	The prediction of next failure of the asset has been done and is sent to the CMMS system to establish the best policy of maintenance and the final maintenance date and time

04	Decision-making on work order planning	The scenario covers the planning of the different maintenance work orders of corrective, preventive and predictive policies	All work orders are ready to be reviewed at the same time and for decision making.	Periodic	The calculation of next failure of the asset has been done and the list of work orders is ready. The general maintenance manager can start with their decisions and changes	The planning has been modified with the best option for maintenance policies

4.2 Steps-Scenarios

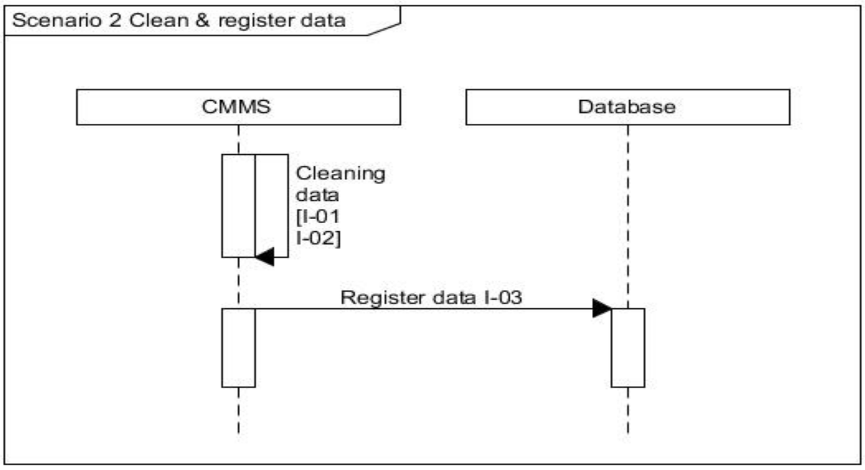
Scenario			
Scenario name		**01 – Extract data**	
No.	**Event**	**Name of process/activity**	**Description of process/activity**
01-01	Periodic	Extract data from sensors	The CMMS System requests the information from the sensors, and they send it to the indicated positions. This activity collects the information from the sensors directly and sends them to the CMMS system.
01-02	Periodic	Extract data from EMS	The CMMS System requests the information from the EMS system, and it sends it to the indicated positions. This activity collects the information from the EMS system directly and sends it to the CMMS system.

Scenario (cont.)					
Scenario name		**01 – Extract Data (cont.)**			
Step no.	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Inf. exchanged (IDs)***	***Requirements (IDs)***
01-01	GET	Sensors	CMMS system	I-01	
01-02	GET	EMS system	CMMS system	I-02	


Scenario 1 Extract data
CMMS
Sensors
EMS
Data acquisition loop
Request data
Extract Data I-01
Request data
Extract Data I-02

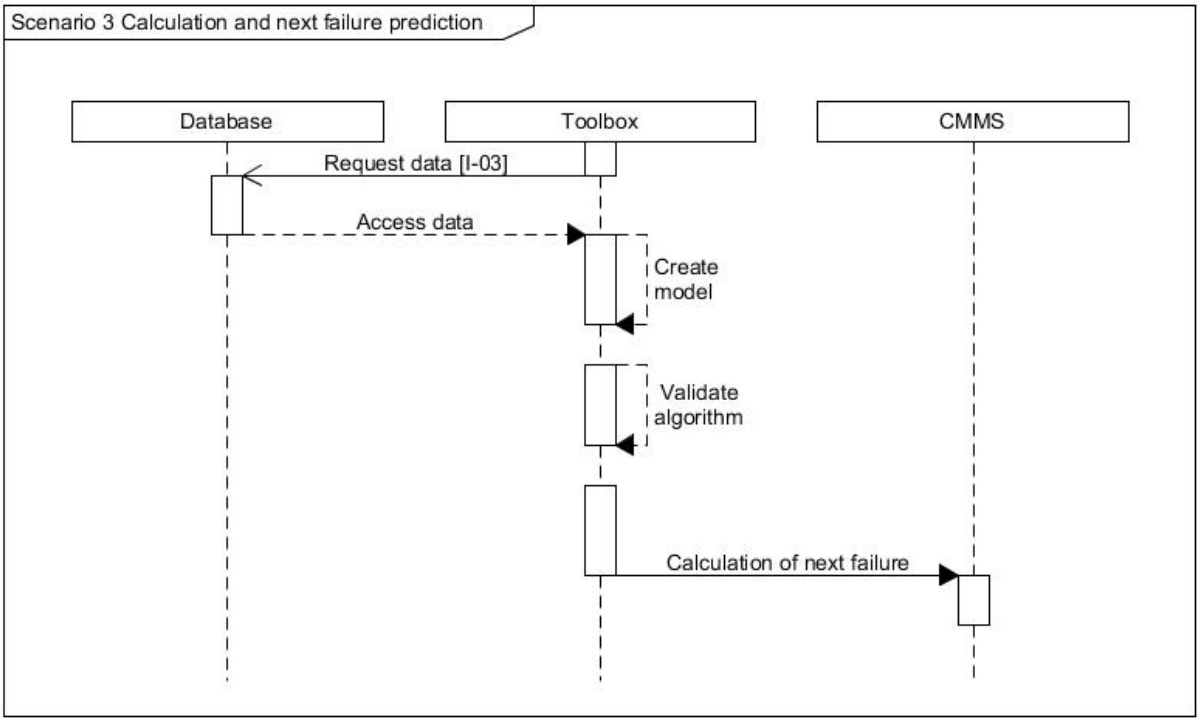
Scenario			
Scenario name		**02 – Cleaning and data register**	
No.	**Event**	**Name of process/activity**	**Description of process/activity**
02-01	Scenario 01 completed	Data cleaning	CMMS system analyses the quality of data and reviews if there are inconsistent values Data Cleaning: analyze the quality of the data and correct inconsistencies/errors (missing values, outliers, inconsistent values...) Determine if the data comes with errors, if you have to eliminate noise in various data, etc. until the data is ready for registration.
02-02	Step 02-01 completed	Data Register	CMMS system registers the data in one database labelling the dataset. Data registration in a database to have historical data and to be able to carry out various off-line tests when it is desired. It is necessary to determine how and where the data is stored

Scenario (cont.)					
Scenario name	**02 – Cleaning and Data Register (cont.)**				
Step no.	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Inf. exchanged (IDs)***	***Requirements (IDs)***
02-01	CHANGE	Scenario 01	CMMS system	I-01 I-02	
02-02	CHANGE	Step 02-01	CMMS system	I-03	



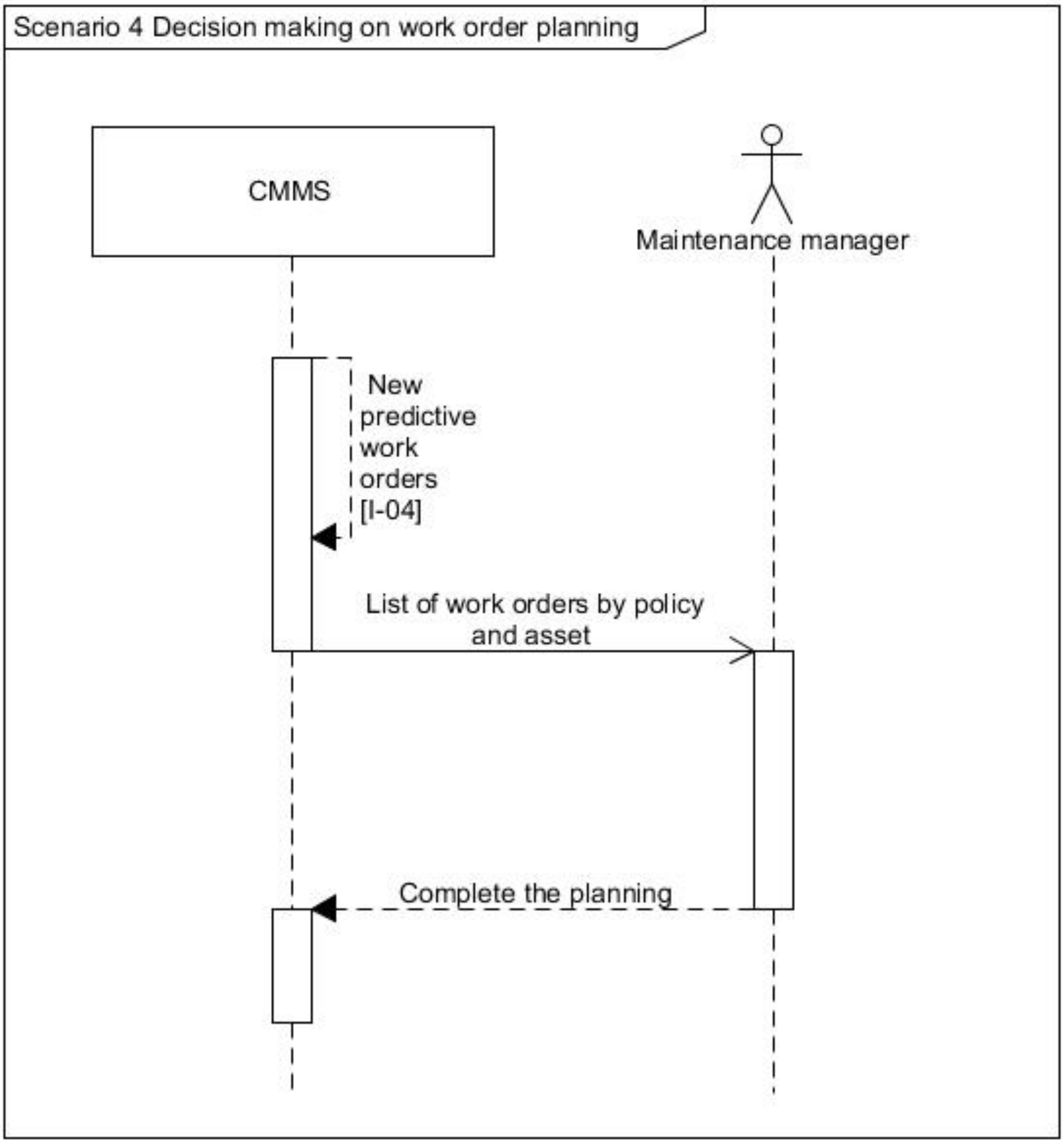
Scenario			
Scenario name		**03 – Calculation and next failure prediction**	
No.	**Event**	**Name of process/activity**	**Description of process/activity**
03-01	Scenario 02 completed	Normality Model	CMMS creates a model that is adjusted to typical data and normal condition
03-02	Step 03-01 completed	Quantifying deviations	Feature creation to quantify deviations from failure points compared to normal condition modelled by the developed model.
03-03	Steps 03-01 and 03-02 completed	Validate the algorithms	Train and validate the developed algorithms and modify the algorithm as necessary to get an acceptable performance
03-04	Step 03-03 completed	Calculation of next failure	Final calculation of the next failure date of a specific asset, indicating the failure mode that will occur and its level of importance and risk assessment that this failure mode can produce.

Scenario (cont.)					
Scenario name	**03 – Calculation and next failure prediction (cont.)**				
Step no.	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Inf. exchanged (IDs)***	***Requirements (IDs)***
03-01	CREATE	Scenario 02	CMMS system	I-03	
03-02	CREATE	Step 03-01	CMMS system		
03-03	CREATE	Step 03-02	CMMS system		
03-04	EXECUTE	Step 03-03	CMMS system		



Scenario			
Scenario name		**04 – Decision-making on the planning of work orders**	
No.	**Event**	**Name of process/activity**	**Description of process/activity**
04-01	Scenario 03 completed	New predictive work orders	CMMS creates some new work orders after knowing the dates of the next expected failures
04-02	Step 04-01 completed	List of work orders	CMMS shows the work orders classified by policy and asset
04-03	Step 04-02 completed	Complete the planning	The general maintenance manager changes the dates of the different work orders if he sees fit (gathering work orders and trying to work with fewer resources, the final cost of maintenance will be less expensive)

Scenario (cont.)					
Scenario name	**04 – Decision-Making on the planning of work orders (cont.)**				
Step no.	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Inf. exchanged (IDs)***	***Requirements (IDs)***
04-01	GET	Scenario 03	CMMS system	I-04	
04-02	REPORT	CMMS system	CMMS system		
04-03	CHANGE	CMMS system	CMMS system		


Scenario 4 Decision making on work order planning
CMMS
Maintenance manager
New predictive work orders [I-04]
List of work orders by policy and asset
Complete the planning

5. Information exchanged

Information exchanged			
Inf. ID	**Name of information exchanged**	**Description of information Exchanged**	**Req. ID**
I-01	Data from the sensors	Parameters and data that cannot be captured directly from EMS system	CONF-01 CONF-02
I-02	Data from EMS system	Parameters and data that can be captured from EMS system	CONF-03 CONF-04
I-03	Database with datasets	All the necessary information between the database and the toolboxes – programs	
I-04	Assets with next failure date	The information related to the assets and their expected dates to fail	

6. Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration issues	Configuration issues reflect the typical, probable, or envisioned communication configurations that are relevant in the data interchanging from one side to another side
Requirement ID	**Requirement name**	**Requirement description**
CONF-01	Number or 'end' entities or sources of data	Number of "end" entities or sources of data (Case of sensors): (TBD)
CONF-02	Elapsed time response requirement for exchanging data	Elapsed time response requirement for exchanging data (Case of sensors): (TBD).
CONF-03	Number or 'end' entities or sources of data	Number of "end" entities or sources of data (Case of EMS system): (TBD)
CONF-04	Elapsed time response requirement for exchanging data	Elapsed time response requirement for exchanging data (Case of EMS system): (TBD).

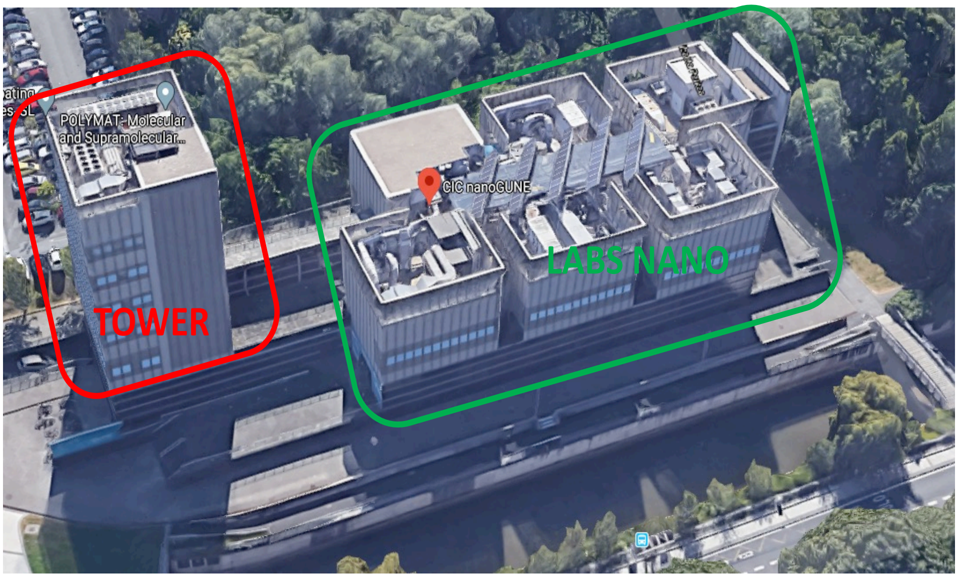
7. Common terms and definitions

Common Terms and Definitions	
Term	**Definition**
CMMS	Computerized Maintenance Management System. It is the system that manage the different maintenance policies and register all the historical information (work orders, routines of preventive maintenance, etc.), ready to be used for the

	toolboxes and algorithms.
EMS	Energy Management System. It is the main system that captures the values of the main parameters and interchanges the information with other systems. In this case, the EMS is specialized in capturing the energy variables and values.
FMEA	Failure Modes and Effects Analysis. It is a methodology based on the definition of the failure modes and the possible solutions according to each asset
Maintenance policies	There are different types of maintenance related to the method that it is used to release the new work orders and their dates for an asset. The main types are: Corrective, when the work order is decided when the failure appears; Preventive, when the work order is decided following one planning and legal issues, and Predictive, when the work order is decided through one prediction and one expected date to fail the asset
RCM	Reliability Centred Analysis. It is a methodology based on the definition of failure modes and the possible consequences in the different components of the asset.
TBD	To Be Defined

8. custom information

This use case will be implemented and validated in the Nanogune facilities in San Sebastian, Spain. As shown in the picture below, Nanogune is formed of two buildings: the tower which comprises several offices, and the Labs Nano building formed of laboratories and offices.



Custom information (optional)		
Key	**Value**	**Refers to section**
Asset groups / classes	Includes Building Assets related to Air Handling and Heat Pumps	1.1 Name of use case
Asset failure modes	Includes the failure modes related to Air Handling and Heat Pumps	1.6 Use case conditions

Input Parameters	Includes the main input parameters that are necessary to calculate next failures	1.6 Use case conditions

LLUC-P-4A- 01: Energy Management of Microgrids

1. Use case description

1.1 Name of use case.

Use case identification		
ID	***Area / Domain(s)/ Zone(s)***	***Name of use case***
LLUC-P-4A- 01	Costumer premises	Energy Management of Microgrids

1.2 Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
	20.05.20	Marco Mussetta	First draft	
	05.06.20	Marco Mussetta	Rev2	

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	The current use case applies to a micro-grid test-bench, providing an analysis facility for real-life scale research, simulation and test purposes,
Objective(s)	The goal of the functionality described in the current use case is to study data-driven energy management able to deal with increased complexity of the energy systems and to assess the advantages of innovative strategies: • EMS with real-time processing and optimization for small-scale/renewable electricity generation • Generation and load forecast • Smart storage/generation • V2G

Related business case(s)	Pilot 3c

1.4 Narrative of Use Case

Narrative of use case
Short description
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. 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.
Complete description

The newly installed MG2lab (https://www.mg2lab.polimi.it/) is a multi-good and multi-fluid micro-grid, featuring 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.

MicroGrid Overview:

- Electric power generation capacity**:** 100 kW
- Thermal power generation capacity**:** 45 kW
- Potable water production**:** 1 m^3/h
- Electric storage**:** 150 kWh
- Hydrogen storage**:** 30 kWh
- Thermal storage**:** 50 kWh
- Electric Vehicles**:** 2
- Electric Bikes**:** 10

More in details, 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 (ready in 2019)
  - 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

MG2lab is the test-bench to improve the availability of big data and big data management, providing an experimental 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:

- Energy Management Systems play a crucial role in the management, real-time processing and optimization of assets connected to the grid (in particular small-scale/renewable electricity generation and those used for demand response): the development of new microgrids control and management strategies involves the integration of data analytics toolboxes and optimization platforms on the EMS that manages the microgrid operation.
- The EMS development includes on one side the incorporation of predictive algorithms able to forecast renewables production and load profile and on the other the exploitation of an Optimal Power Flow (‘OPF’) algorithm, able to consider the fluctuation of Renewable Energy Resources (RES) and to optimize the economic unit dispatch, the reliability of the operation of the electricity network (e.g. by predictive maintenance) and energy efficiency (e.g. by reliably predicting and monitoring energy savings).
- Optimization Algorithms and Control Predictive functions, for both off-grid and on grid applications, require accurate load and energy production profiles to exploit the potentiality: AI-based models are employed to improve the accuracy of the forecast. Models including on-site measurement and sky-images are currently developed to further improve the PV and load forecast and will be tested in the micro-grid.
- Distributed Smart storage/generation and Virtual Power Plant are becoming more relevant in the national power generation part: the use of micro-grid or virtual power plant can be aimed to support the grid, optimize the intraday profile of the exchange of energy, to reduce the cost and to increase the use of renewable energy and energy efficiency based on optimized energy asset management.
- Vehicle-to-Grid analysis to transform a car into a revenue generating asset: V2G is evaluated both in on-grid and off-grid applications, considering the impact of EVs fast charging on the grid structure and optimization strategies and control architecture for the optimal management of an EV fleet.

1.5 Key performance indicators (KPI)

Key performance indicators

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
kpi-1	Energy availability	Optimal energy consumption (increase in energy availability)	Optimization for renewable electricity generation Smart storage/generation
kpi-2	Cost	Reduction of maintenance effort and costs	Optimization for renewable electricity generation
kpi-3	Forecast	Reduced forecasting errors	Generation and load forecast
kpi-4	Realtime	Ability to monitoring/analyze/optimize data and the system at real time rate	EMS with real-time processing Smart storage/generation

4.2 Use case conditions

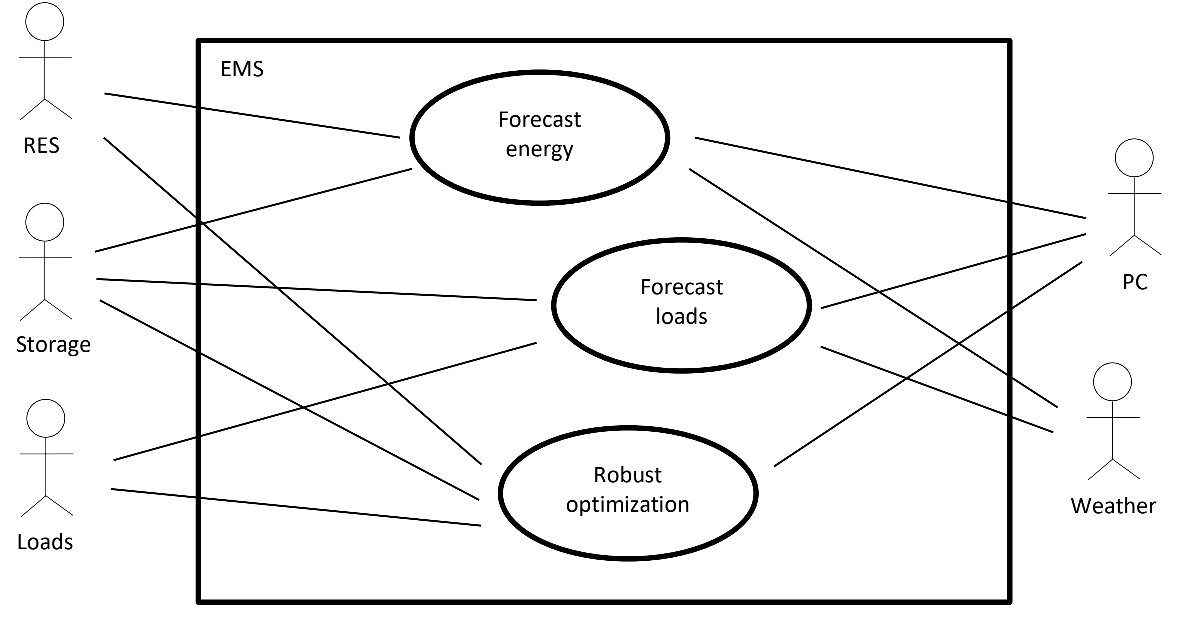
Use case conditions
Assumptions
The micro-grid is in place and working, although some additional features have to be completed
We implement and run advanced techniques for linear / nonlinear optimization
We implement reliable AI models for real time computation
Prerequisites
Ability to record measured data on several different and non-synchronous components with high time resolution has to be validated
Reliability of weather forecast service has to be validated

1.6 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Optimization of smart grids (pilot 2a, pilot 3c). Smart building energy efficiency optimization (pilot 3a and 3b)
Level of depth
Detailed use case
Prioritization
Important
Generic, regional or national relation

Generic
Nature of the use case
Test/technical use case
Further keywords for classification
RES, Smart micro-grid, electric vehicles, storage, machine learning, energy forecasting.

2. Diagrams of use case

Diagram(s) of use case


3. Technical details

3.1 Actors

Actors	
Grouping	**Group description**
RES	The RES grouping includes all the measurements related to the local renewable energy sources

Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
PV1	System	Photovoltaic generation – field 1	
PV2	System	Photovoltaic generation – field 2	
PV3	System	Photovoltaic generation – field 3	
MicroCHP	System	natural gas Micro-CHP system	

Actors			
Grouping		**Group description**	
Storage		The Storage grouping includes all the measurements related to the local energy storage	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
TSS	System	thermal storage system	
BESS1	System	lithium ion Battery Energy Storage Systems – 1	
BESS2	System	lithium ion Battery Energy Storage Systems – 2	
HyESS	System	hydrogen Hybrid Energy Storage System	

Actors			
Grouping		**Group description**	
Loads		The Loads grouping includes all the measurements related to the local loads and energy consumption	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
EGS	System	electric grid simulator	
Heat	System	Heat pumps	
Water	System	Potable water production	
Light	System	Light devices	
EV	System	Fast charging stations for 2 Electric Vehicles	
Bikes	System	charging stations for 10 Electric bikes	

Actors			
Grouping		**Group description**	
PC		The Power Centers (PC) grouping includes all the devices related to the implementation of EMS features and system monitoring, actuation	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
PC1	Device	Main Power Center implementing EMS features	
PC2	Device	2nd Power Center for heating, water and other loads	
PC3	Device	3rd Power Center for lights and storage	

Actors			
Grouping		**Group description**	
Weather		The Weather grouping includes all the additional data related to weather condition	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Weather station	Device	Current weather parameters measurements	
Full-sky imaging	Device	Full-sky pictures for cloud analysis and nowcasting	
Weather forecast	System	Weather forecasting service (external provider)	

4. Step by step analysis of use case

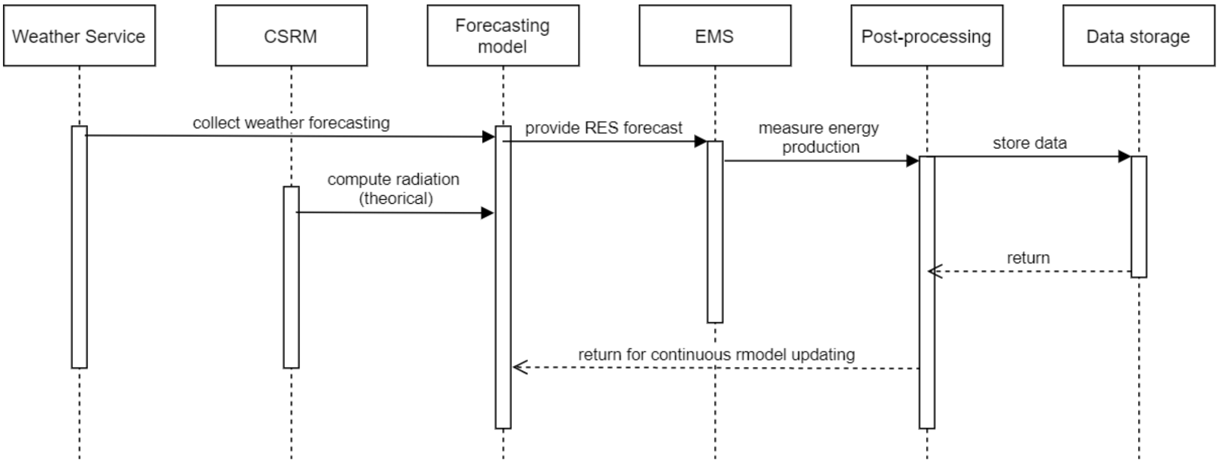
4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
01	Energy forecast	This refers to the prediction of energy production in 24h and 7days ahead	PC, Weather, RES	Periodical	Daily RES production is recorded	Future, 168h ahead, energy production forecasted

02	Load forecast	This refers to the prediction of load and energy consumptions 24h ahead	PC, Loads, Weather	Periodical	Daily loads are recorded	Future, 24h ahead, energy consumption forecasted
03	Robust Optimization	This refers to the optimization of the microgrid behaviour implemented in the EMS	PC	Periodical	All measurements and forecast are recorded	Robust Optimization for RES and storage.

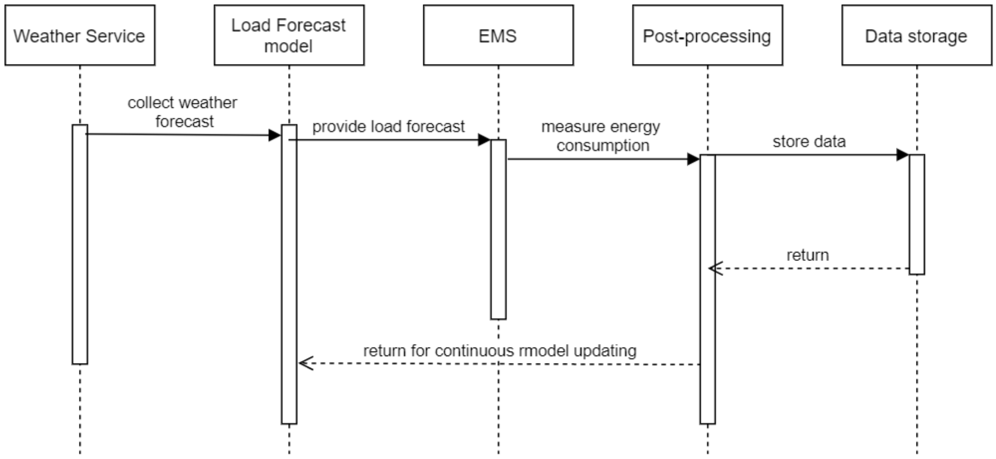
4.2 Steps – Scenarios

Detailed sequence diagram for Scenario 01 – Energy forecast



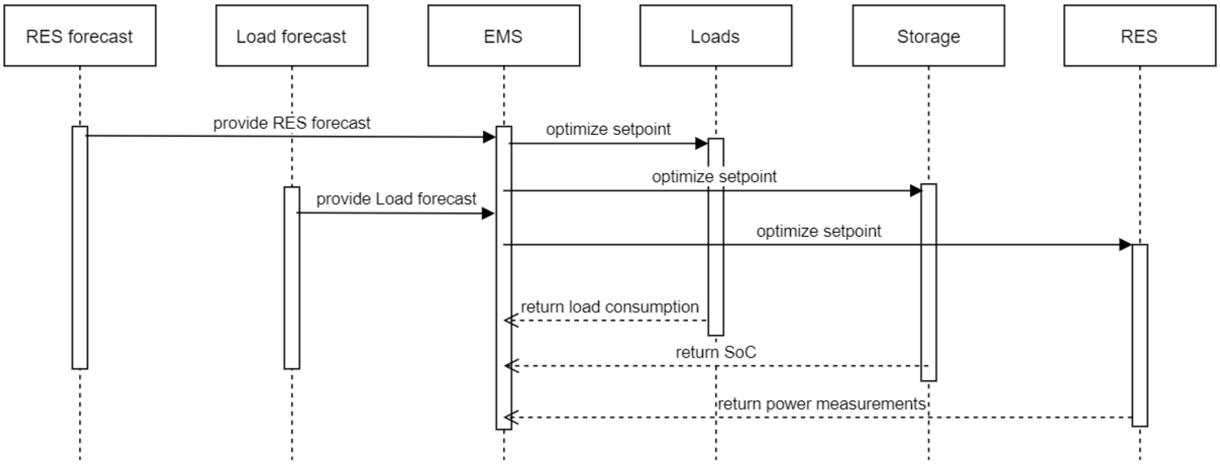
Scenario								
Scenario name:	**No. 01 – Energy Forecast**							
Step No.	***Event***	***Name of process/ actiVity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1	Periodic	Weather forecast	Retrieve updated weather forecast	GET	Weather forecast	Power Center	I_01 Weather data	
2	Periodic	CSRM	Compute deterministic solar radiation model	CREATE	Power Center	Power Center	I_02 Solar radiation	
3	Periodic	RES Forecast model	Compute forecast for next 24 hours	CREATE	Power Center	Power Center	I_03 RES forecast	
4	Periodic	EMS	Setpoint of power units	CHANGE	Power Center	RES units	I_04 RES Setpoints	
5	Periodic	Post-process	Retrieve and validate measurement data	GET	Power Center	Data Storage	I_05 Energy production	
6	Periodic	Model update	Continuous training of the forecasting model	CHANGE	Power Center	Power Center	I_05 Energy production	

Detailed sequence diagram for Scenario 02 – Load forecast



Scenario								
Scenario name:		**No. 02 – Load Forecast**						
Step No.	***Event***	***Name of process/ actiVity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1	Periodic	Weather forecast	Retrieve updated weather forecast	GET	Weather forecast	Power Center	I_01 Weather data	
2	Periodic	Load Forecast model	Compute load forecast for next 24 hours	CREATE	Power Center	Power Center	I_06 Load forecast	
3	Periodic	EMS	Setpoint of load units	CHANGE	Power Center	Load units	I_07 Load Setpoints	
4	Periodic	Post-process	Retrieve and validate measurement data	GET	Power Center	Data Storage	I_08 Energy consumption	
5	Periodic	Model update	Continuous training of the load forecast model	CHANGE	Power Center	Power Center	I_08 Energy consumption	

Detailed sequence diagram for Scenario 03 – Robust Optimization



Scenario								
Scenario name:	**No. 03 – Robust Optimization**							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1	Periodic	RES forecast	Provide energy production scenarios	GET	Power Center	Power Center	I_03 RES forecast	
2	Periodic	Load forecast	Provide energy consumption scenarios	GET	Power Center	Power Center	I_06 Load forecast	
3	Periodic	Load optimization	Setpoint of load units	CHANGE	Power Center	Load units	I_07 Load Setpoints	
4	Periodic	RES optimization	Setpoint of power units	CHANGE	Power Center	RES units	I_04 RES Setpoints	
5	Periodic	Storage optimization	Setpoint of storage units	CHANGE	Power Center	Storage units	I_09 Storage Setpoints	
6	Periodic	Load data	Energy consumption measurement	GET	Load units	Power Center	I_08 Energy consumption	
7	Periodic	RES data	Energy production measurement	GET	RES units	Power Center	I_05 Energy production	
8	Periodic	Storage data	State of charge measurement	GET	Storage units	Power Center	I_10 SoC	

5. Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
I_01	Weather data	Weather forecast for next 168 from external weather forecasting service	
I_02	Solar radiation	Theoretical solar radiation based on clear sky radiation model (CSRM)	
I_03	RES forecast	Forecast of production from RES in the next 24 hours	
I_04	RES Setpoints	Setpoint of RES units	
I_05	Energy production	Measurements of energy produced by RES	
I_06	Load forecast	Forecast of load consumptions in the next 24 hours	
I_07	Load Setpoints	Setpoint of load units	
I_08	Energy consumption	Measurements of energy consumptions by loads	
I_09	Storage Setpoints	Setpoint of storage units	
I_10	SoC	State of charge of storage units	

6. Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
R-DT	Data	Internal data exchange availability
Requirement R-ID	**Requirement name**	**Requirement description**
R-DT-01	Power production	The required measurements of produced power are available at the predefined time resolution
R-DT-02	Power consumption	The required measurements of power consumption are available at the predefined time resolution
R-DT-03	Weather parameters	The required measurements of weather parameters are available at the predefined time resolution

R-DT-04	Data Storage	The required data are correctly stored in the system database

Requirements		
Categories ID	**Category name for requirements**	**Category description**
EC	External communication	Link to external data sources
Requirement R-ID	**Requirement name**	**Requirement description**
R-EC-01	Weather forecast	The required connection to external weather forecast provider is on and data are available at the predefined time resolution

7. Common terms and definitions

Common terms and definitions	
Term	**Definition**
RES	Renewable energy sources
CSRM	Clear sky radiation model
DER	Distributed Energy Resources
SOC	State of charge of a battery

Annex V Use Cases References

[1]. Agencia Internacional de la Energía-AIE, http://www.iea.org/stats/index.asp

[2]. SEE Energy News (2019) Serbia, Macedonia, Montenegro: Balancing market within the SMM block, 10. April 2019

[3]. Goran Jakupović, Ninel Čukalevski (2018) Imbalance Netting Optimization Algorithm Based on Linear Programming For SMM LFC Control Block, Proc. of 2nd South East European Regional CIGRE Conference, Kyiv 2018

[4]. N. Phuangpornpitak and W. Prommee (2016) A Study of Load Demand Forecasting Models in Electric Power System Operation and Planning, GMSARN International Journal 10 (2016) 19 – 24.

[5]. G. Giebel (eds) “The State of the Art in Short-Term Prediction of Wind Power, A Literature Overview, 2nd Edition,2011.

[6]. Alexandra von Meier Elizabeth, L. Ratnam, Kyle Brady, Keith Moffat , Jaimie Swartz (2020) Phasor-Based Control for Scalable Integration of Variable Energy Resources. Energies 2020, 13(1), 190

[7]. G. Jakupović, N. Stojaković, Z. Vujasinović, N. Jović, D. Vlaisavljević, J. Trhulj (2020) Software Environment (Simulator) for Technical Support of Cross-border Electric Energy Balancing In Wb6 Region, CIGRE South East European Regional Council Conference 2020 in Vienna, Austria

[8]. IDS REFERENCE ARCHITECTURE MODEL INDUSTRIAL DATA SPACE, VERSION 2.0,2018. http://www.sindikatems.org.rs/pdf/listems/93.pdf (page 18)

[9]. Production forecast from renewable sources, EMS 93 (March 2020),

[10]. https://www.ems.rs/page.php?kat_id=153

[11]. http://www.pupin.rs/en/2016/04/national-distribution-dispatch-centre-nddc-opened-in-novi-sad/

[12]. AERS Serbian Energy Sector Report (Annual and Financial Report Belgrade, May 2017). https://www.aers.rs/Files/Izvestaji/Godisnji/Eng/AERS%20Annual%20Report%202016.pdf

[13]. SEEPEX Company Info (2020) http://seepex-spot.rs/en/company-info/about-the-shareholders

[14]. Serbia, Macedonia, Montenegro: Balancing market within the SMM block, https://serbia-energy.eu/serbia-macedonia-montenegro-balancing-market-within-the-smm-block/

[15]. Electricity Coordinating Center (2019) Technical Assistance to the Implementation of Cross-border Electricity Balancing in Western Balkan Six region. http://www.ekc-ltd.com/references/technical-assistance-to-the-implementation-of-cross-border-electricity-balancing-in

[16]. Goran Jakupović, Ninel Čukalevski (2018) “Imbalance netting optimization algorithm based on linear programming for SMM LFC control block”, Second SEERC Conference 2018: ENERGY TRANSITION AND INNOVATIONS IN ELECTRICITY SECTOR, 12-13 June 2018, Kiev, Ukraine

[17]. European Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing Official Journal of the European Union,2017.

[18]. Energy Community (2020) Serbia - Action plans, reports and statements. Retrieved from https://energy-community.org/implementation/Serbia/reporting.html

[19]. Energy Community (2020) Browse through Serbia's latest implementation updates. Retrieved from https://energy-community.org/implementation/Serbia.html

[20]. https://www.ems.rs/page.php?kat_id=158 , https://www.ems.rs/page.php?kat_id=38

[21]. https://www.ems.rs/page.php?kat_id=154

[22]. SEE Energy News (2019) Balancing market in Serbia, 9. April 2019. Retrieved from https://serbia-energy.eu/balancing-market-in-serbia/

[23]. TIB (2020) Leibniz Data Manager: A CKAN Distribution for Research Data Management by TIB and Leibniz University of Hannover. Retrieved from https://projects.tib.eu/datamanager/

[24]. University of Bonn (2020) What is SANSA? Retrieved from http://sansa-stack.net

[25]. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32017R2195&from=EN

[26]. IDS REFERENCE ARCHITECTURE MODEL INDUSTRIAL DATA SPACE, VERSION 2.0, https://www.fraunhofer.de/content/dam/zv/de/Forschungsfelder/industrial-data-space/IDS_Referenz_Architecture.pdf

[27]. Production forecast from renewable sources, EMS 93 (March 2020), http://www.sindikatems.org.rs/pdf/listems/93.pdf (page 18)

[28]. https://www.ems.rs/page.php?kat_id=153

[29]. http://www.pupin.rs/en/2016/04/national-distribution-dispatch-centre-nddc-opened-in-novi-sad/

[30]. AERS (2017) Serbian Energy Sector Report (Annual and Financial Report Belgrade, May 2017). https://www.aers.rs/Files/Izvestaji/Godisnji/Eng/AERS%20Annual%20Report%202016.pdf

[31]. SEEPEX Company Info (2020) http://seepex-spot.rs/en/company-info/about-the-shareholders

[32]. Serbia, Macedonia, Montenegro: Balancing market within the SMM block, https://serbia-energy.eu/serbia-macedonia-montenegro-balancing-market-within-the-smm-block/

[33]. ISGAN (2019) Flexibility needs in the future power system Discussion paper. Retrieved from https://www.iea-isgan.org/wp-content/uploads/2019/03/ISGAN_DiscussionPaper_Flexibility_Needs_In_Future_Power_Systems_2019.pdf