Ref. Ares(2016)2167005 - 09/05/2016

MOEEBIUS

Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability

D2.1 End-user & business requirements

Version number: 1.0
Dissemination Level: PU
Lead Partner: HYPERTECH
Due date: 01/05/2016
Type of deliverable: R
STATUS: Delivered

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680517

Published in the framework of:

MOEEBIUS - Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability

MOEEBIUS website: www.moeebius.eu

Authors:

Tsatsakis Konstantinos, Papapolyzos Dinos, Papapolyzos Thomas, Lazaropoulou Melina, Tsiakoumi Stamatia, Kakardakos Nikos – HYPERTECH

Djordje Lazic – BELIT

Akshat Kulkarni, Mircea Bucur – KIWI

Cláudia S. Mafra, Ricardo A. Rato – ISQ

Bojan Bogdanovic, Radmilo Savic – BEOLEK

Dário Jacinto, Joaquim Sardinha – MAFRA

Revision and history chart:

VERSION	DATE	EDITORS	COMMENT
1.0	09/05/2016	Tsatsakis Konstantinos	Submitted to the EC

Disclaimer:

The project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 680517.

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Table of content

List of tables

List of figures

Glossary

Acronym	Full name
MOEEBIUS	Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability
BMS/ EMS	Building Management System/Energy Management System
HVAC	Heating Ventilation and Air conditioning
ESCO	Energy Service Company
DoA	Description of Action
URD	User Requirements Document
DER	Distributed Energy Resource
IAQ	Indoor Air Quality
TSO/DSO	Transmission system operator/ Distribution system operator
LL	Living Lab
LCA/ LCC	Life-Cycle Assessment/ Life-Cycle Cost
EPC	Energy Performance Contract
DSS	Decision Support System
BEPS	Building Energy Performance Simulation
FM	Facility Manager
BSC/SC	Business Scenario
UC	Use Case
VPP	Virtual Power Plant
DR	Demand Response
BIM	Building Information Model
ROI	Return On Investment
DSM	Demand Side Management
KPI	Key Performance Indicator
C&I	Commercial &Industrial
UI	User Interface

1 Executive summary

This task involves a thorough analysis of the **end-user requirements** in order to create the necessary inputs for defining the different components of the platform and therefore setting the skeleton for MOEEBIUS framework. The list of requirements is derived through the active end users participation and involvement in the MOEEBIUS Living Lab as part of the open innovation approach introduced in MOEEBIUS project. **Business scenarios** and **use-cases definition** at the very early phase of the work, drive the whole requirement definition process for the proposed framework so as to allow end-users to easily grasp the intention, functionality and use of MOEEBIUS results. Suitable **end-user questionnaires** are compiled to capture the view and requirements of all types of **MOEEBIUS System Stakeholders**, from ESCOs and facility managers, to Maintenance Experts and Aggregators, while considering **regulatory and legal barriers** imposed in the different pilot sites of the project.

The results of these activities, which are presented in this document, are the basis for the design and development work packages of the project. Therefore this document, acts as the root point of the work, setting the guidelines for the development of MOEEBIUS platform. The use cases and requirements definition will enable the definition of MOEEBIUS reference architecture and further guide the development and evaluation phase of the project in pilot premises.

2 Objectives of the report

The objective of the deliverable is to describe the end **users and business requirements** for MOEEBIUS project. In addition, the main **stakeholders** of the system are defined in this document, along with the definition of **business scenarios** and **technical use cases** that screen the landscape for the proposed MOEEBIUS framework.

2.1 Scope of the document

The scope of this document is to define the user and business requirements of the MOEEBIUS project which will further directly serve as inputs to the specifications extraction of the MOEEBIUS system architecture – focus of T3.1 - as well as to the whole system implementation.

We adopt a top down methodological framework, starting from the high level overview (definition of business scenarios and use cases) to the extraction of the final list of end users and business MOEEBIUS requirements.

End users' requirements, often referred to as user needs, describe what the user does with the system, such as what activities the user must be able to perform. User requirements are generally documented in a User Requirements Document (URD) using narrative text. User requirements are generally signed off by the user and used as the primary input for creating software requirements. An important and difficult step in designing a software product is determining what the user actually wants it to do. This is because the users are often not able to communicate the entirety of their needs, and the information they provide may also be incomplete, inaccurate and self-conflicting.

On the other hand, the **Business requirements** describe why a specific business entity is undertaking the project. By the term Business, we define the high level categorization of the entities with special business interest for the project (Building Level Operation, District Level Operation. These entities state some benefits that the developing organization or its customers expect to receive from the product. Essentially, in MOEEBIUS project an overview of the main Business Requirements is illustrated in the DoA [1]. Therefore, the purpose of the business process analysis is to determine, in a high level, how the business process will operate.

2.2 Relevance to other deliverables

The purpose of this document is to present a summary of MOEEBIUS activities in order to get a commonly shared understanding of the goals and scope of the project. The starting point of discussion and agreement between partners is about project scope, scenarios and use cases of interest and finally the definition of end users and business requirements. The results of these activities, which are presented in this document, are the basis for the design and development of the MOEEBIUS platform. Therefore this document, acts as the entry point of the work,

setting the guidelines for the development of the platform. More specifically, this task will contribute on the list of MOEEBIUS technical work packages:

- The extraction of end users and business requirements will lead the definition of MOEEBIUS Architecture and Data Models in WP3 along with the definition of the constituent MOEEBIUS models for:
  - DER and District Heating
  - Occupants Comfort
  - Indoor Air Quality
  - Local and Global Energy Performance
- The definition of end users and business requirements along with the extraction of MOEEBIUS KPIs will provide feedback on the technical framework of the project and more specifically:
  - Data Acquisition and Management
  - MOEEBIUS Simulation-Based Dynamic Assessment Environment
  - MOEEBIUS Decision Support System for Holistic Energy Performance Optimization
- The definition of innovative business models along with MOEEBIUS Energy Performance Assessment Methodology will enable the Pilot Roll-Out and Validation activities towards the evaluation of MOEEBIUS framework in pilot premises

It is obvious that this document is considered as the guideline for the whole project, highlighting end users' needs and \main business scenarios. Towards this direction, this deliverable is considered as a "lighthouse" document setting the requirements for the design, the development and evaluation of MOEEBIUS holistic framework.

2.3 Deliverable Structure

The document is structured as follow:

- **Chapter 3** illustrates the methodological framework that has been adopted in order to realize the project objectives through the definition of MOEEBIUS Users & Business requirements
- **Chapter 4** presents the list of system stakeholders addressed by the project, setting the starting point for business oriented analysis
- **Chapters 5** identifies the key business scenarios of the project taking into account the business needs of system stakeholders
- **Chapter 6** defines the list of technical use cases associated to the business scenarios
- Following the definition of business scenarios and use cases, different questionnaires are circulated among MOEEBIUS stakeholders to get their feedback about system functionalities. The analysis of questionnaires is presented in **Chapter 7**
- **Chapter 8** is following questionnaires analysis towards the extraction of end users and business requirements of MOEEBIUS project.
- **Chapter 9** finally presents the summary of the work along with the next steps focusing on the interconnection of requirements extraction phase with MOEEBIUS specifications definition.

3 Methodological Framework

The final list of end users and business requirements is defined in line with major MOEEBIUS objectives. The main goals of the MOEEBIUS framework are:

- To advance the capabilities of current Building and District Energy Performance Simulation Tools, to enable accurate predictions through addressing current modelling and measurement & verification inefficiencies
- To further optimize the performance gap through human-centric fine grained control, predictive maintenance and retrofitting at building and district level
- To enabling the efficient Integration of distributed energy resources into the Smart Grid and enhancing reliability and security of energy supply
- To facilitate Energy Performance Contracting penetration in EU Energy Services Markets through the provision of a replicable and easily transferable framework
- To introduce Novel ESCO Business Models and New Energy Market Roles enabling the transition to demand-driven Smart Grid Services

Under these objectives, a number of requirements should be extracted, setting the baseline for the definition of the MOEEBIUS framework architecture (T3.1). Based on the proposed methodology, several tools have been provided towards the extraction of end users' and business requirements. These tools (templates, questionnaires, etc.) have been created by consortium partners and have been further disseminated to experts and pilot participants via MOEEBIUS Living Lab (interviews with key stakeholders, organization of workshops, etc.), in order to take into account their valuable feedback. The applied methodology is described in details in the next section.

3.1 Methodology

A thorough discovery of end users business requirements is never available at an analyst's fingertips, as it resides in the minds of end users stakeholders. Towards this direction, we have adopted a **loop methodological approach**, for the extraction of end user's needs. Therefore, the feedback from system stakeholders, members of MOEEBIUS Living Lab, is requested during each phase of the requirement analysis phase. As shown in the following schema, our methodology is composed by four main steps through which we capture the thoughts and needs coming from system stakeholders and consortium parties.

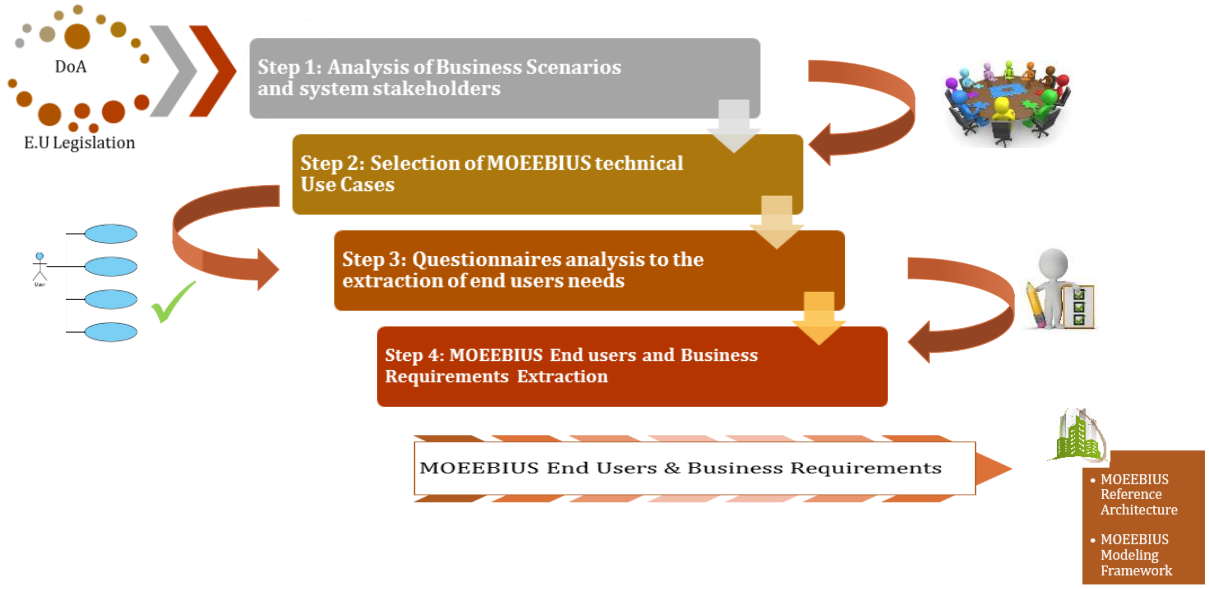


Figure 1 Requirements Extraction Methodological Framework

The different phases in the above figure are hereafter described:

Step 1: Analysis of Business Scenarios and system stakeholders

The major objective of this phase is to define the list of stakeholders and the associated Business Scenarios examined in the project. The starting point for this analysis is the DoA where some High level Business Scenarios along with the system stakeholders are defined pointing to the main objectives of MOEEBIUS. The refinement and final selection of MOEEBIUS business scenarios is based on the review of State of the Art (E.C. guidelines) along with consultation with the pilot site stakeholders, early engaged in project activities.

Step 2: Selection of MOEEBIUS technical Use Cases

Following the selection of the list of Business Scenarios, the list of technical use cases is defined. The aim is to start from the high level MOEEBIUS concepts, as defined in the DoA, and by taking into account the business needs to extract the list of system use cases that highlight the main principles of MOEEBIUS framework**.** Again, the list of system use cases is defined after consultation with the system stakeholders, actively participating on MOEEBIUS Living Lab activities.

Step 3: Questionnaires analysis for the extraction of end users needs

Further to the definition of MOEEBIUS Use Cases, a set of questionnaires are prepared to address the needs of main system stakeholders. The goal of these questionnaires is to engage the different types of business stakeholders in project activities and further retrieve their valuable feedback towards the extraction of their needs and requirements related to MOEEBIUS concept. The questionnaires created are further filled in by the Living Lab members, as part of their engagement to MOEEBIUS project activities.

Step 4: MOEEBIUS End users and Business Requirements Extraction

In this last step, we take into account questionnaires analysis results that are further transformed to MOEEBIUS end users and business requirements. These are further complemented by additional requirements mainly related to ethical and legislation constrains in pilot regions of MOEEBIUS project. The prioritization of end users requirements is also a main task performed at this phase, setting the guidelines for the design and development of MOEEBIUS platform.

This "four-step" methodological approach, clearly defines the work in the deliverable. The next section focuses on the definition of system stakeholders and business scenarios, towards the extraction of technical use cases and MOEEBIUS end users and business requirements.

4 MOEEBIUS Business Stakeholders

4.1 Overview of MOEEBIUS Framework Stakeholders

Different types of actors groups with specific roles address the different types of services provided by MOEEBIUS framework. MOEEBIUS's goal is to bring together different stakeholders with the ultimate goal of the optimal management of building premises. (Either local level operation or coordination in groups of buildings). The list of system stakeholders is aligned with the definition of main users groups that set the MOEEBIUS Living Lab. The next schema provides the list of main system stakeholders followed by a short description of each role in MOEEBIUS concept.

Figure 2 Overview of MOEEBIUS System Stakeholders

4.2 List of MOEEBIUS Stakeholders

A short description of MOEEBIUS system stakeholders is provided.

Building Occupant

This actor is the final customer, the agent that consumes electricity for end-uses. Within MOEEBIUS project we address this role as one of the major roles as the main objective of the project is to establish an energy efficient environment fully preserving end users' needs and preferences. Towards this direction, tools and

applications will be available for building to further address the high level need of establishing a sustainable environment.

Facility Manager

This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In case of a third-party company, it could provide additional services to the owner of the facility (e.g., maintenance, cleaning services, etc.) addressing also the role of ESCO Company as examined in the project. Within MOEEBIUS, the role of the Facility Manager or ESCO is to operate the building in an energy efficient way, fully preserving building occupants' preferences and needs. In addition, the role of facility manager is to examine the participation on business strategies that are beneficiary for building owners.

Demand Side Aggregator

The Aggregator stands between the final customers (consumers/producer) and market stakeholders (TSOs, DSOs, Utilities etc.) as well as specific market operations and needs (wholesale market, ancillary services etc.). The aggregator manages the customer portfolio in an optimized way, trading with the market stakeholders on behalf of the customers. Aggregators usually act as subcontractors of DSOs or utilities, for providing vertical business services (energy contracts & services to specific customer categories) as well as location and event based management services (demand side management services for grid relief on specific locations and for specified time periods). The Aggregator's role is to gather ("aggregate"), analyse and efficiently organize its customer loads portfolio, towards identifying appropriate clusters of prosumer and respective DER flexibilities and eventually define specific strategies based on actual energy market needs. Within MOEEBIUS project, and as one of the objectives is to provide tools for the optimal management of groups of buildings, the role of Aggregator is thoroughly examined.

Maintenance Responsible Partner

The primary goal of maintenance is to avoid or mitigate the consequences of failure of equipment. It is designed to preserve and restore equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include partial or complete overhauls at specified periods, equipment changes, minor adjustments etc... In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. The role of Maintenance Responsible Partner (mainly addressed by ESCOs) is to periodically check the status of the building equipment and define the maintenance activities needed in order to avoid equipment failures. Within MOEEBIUS, the goal is to provide tools to Maintenance Responsible Partners for the prompt operation of building equipment.

Retrofit Advisor

Moving beyond predictive maintenance, retrofitting means "*to provide something with a component or accessory not fitted during manufacture or to add something that did not have when first constructed*". It is frequently related to the installation of new systems but it may also refer to the fabric of a building such as retrofitting insulation, walls or windows. Towards this direction, the role of the **Retrofit Advisor** is to examine different alternatives for the building and further recommend a list of retrofitting activities that are beneficiary in terms of energy efficiency. Again, this role is mainly addressed by ESCOs as companies responsible for maintenance and operation of tertiary buildings.

It is obvious that the role of ESCO is critical in MOEEBIUS, as the actor providing a broad range of energy solutions including design and implementation of retrofitting projects, energy conservation and building operation addressing both individual buildings and groups of building premises. Towards this direction, ESCOs are examined in their broader role, covering different types of services for buildings or groups of buildings as presented in Figure 3

Figure 3 Business Views of Energy Service Companies

Following the definition of the different stakeholders, the MOEEBIUS business scenarios are described in the next section. The extraction of business scenarios is following the Description of Work after with consultation with pilot partners towards the extraction of meaningful scenarios for their premises.

5 MOEEBIUS Business Scenarios

An initial list of Business Scenarios is defined in order to screen the landscape for the MOEEBIUS framework. A list of **5 Business Scenarios** is defined after consultation with pilot partners and taking into account the main objectives of the project:

- **Improved Building Energy Performance Assessment** on the basis of enhanced BEPS models (seamlessly addressing dynamic aspects of building operation, such as occupancy and weather conditions), that are iteratively and dynamically updated through feedback received from actual building measurements to allow for more accurate representation of the real-life complexities of the building
- Precise allocation of detailed performance contributions of critical building components, for directly **assessing actual performance against predicted values** and easily identifying performance deviations, their root causes and further optimization needs
- **Real-time building performance optimization** (during the operation and maintenance phase) including advanced simulation-based (human-centric) control and real-time self-diagnosis features, to resolve problems occurring due to user-behaviour, occupancy and climatic alterations and continuously tackle performance deviations that emerge throughout the building's life due to non-efficient controls, low performing systems or poor maintenance
- Optimized **retrofitting decision making** on the basis of improved and accurate LCA/ LCC-based (Life-Cycle Assessment/ Life-Cycle Cost) performance predictions, ensuring that the building performs as intended (regarding structural, environmental and energy performance, along with health, safety and comfort of occupants) and enabling optimized ROI along the building lifecycle
- **Real-time peak-load management optimization** at the district level. By upscaling the holistic optimization approach at the level of blocks of buildings and whole districts, MOEEBIUS should address uncertainties imposed by the stochastic nature of intermittent RES and allow their efficient integration into the Smart Grid, through fine-grained control and exploitation of the aggregated capacity and flexibility of buildings and district heating systems (forming dynamic Virtual Power Plants-VPP) in highly effective energy efficiency and demand response schemes.

These high level principles further lead us to the definition of the main business scenarios of the project.

5.1 SC-01: Real-time building performance optimization towards the establishment of a sustainable environment

MOEEBIUS scenario	
ID	**BSC-01**
Title	**Real-time building performance optimization towards the establishment of a sustainable environment**
Description	Facility Managers of tertiary buildings have a specific task to deal with in their every-day operations of the building: they need to optimise the operation of the **building's energy resources** (HVAC, Lights, Office equipment, including generation when referring to prosumers) towards reducing overall energy consumption and minimizing energy waste, while balancing the impact on final occupants' comfort. By utilizing advanced Building Management Systems (BMS) Facility Managers are provided with powerful real-time monitoring and control capabilities over building's Distributed Energy Resources (DERs), being able to apply direct control over them. Furthermore, based on historical and simulation information they can further apply operational schedules at device level, highly improving building's energy efficient operation. The commercial tools lack of accurate **holistic performance models**, causing occupants' disturbance by "remotely" manipulating and controlling their working/living environment, leading to undesired end users' discomfort The goal is to overcome the existing gap in automated building operation in an energy efficient manner and the preservation of final **occupants' comfort**. This can be realised by introducing a continuous adaptive framework for accurate extraction of building condition, addressing also occupants as a critical parameter affecting building performance. Based on a multi-sensorial network installation, building's context conditions will be extracted in real-time and further modelled in order to create occupancy preferences and more accurate device profiles. These dynamic profiles are continuously updated in order to provide a **holistic simulation-automation environment** towards the selection of optimal control strategies in real time.
Main Actors	**Facility Manager or ESCO:** This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In case of a third-party company- ESCO-, it could provide additional services to the owner of the facility (e.g., maintenance, cleaning services, etc.). The role of the Facility Manager is to operate in real time building premises towards the establishment of a sustainable and cost efficient building environment. **Building Occupants:** This actor is the final customer, the agent that requires electricity for end-uses. As the focus on the business scenario is on public building, the goal is to establish an energy efficient framework fully preserving end users' needs and preferences. Therefore the goal is to establish a framework that ensures the minimum of intrusiveness of building occupants, setting also the constraints towards the optimal management of building premises.

Table 1: MOEEBIUS BSC-01 Real-time building performance optimization

5.2 SC-02: Active Participation in Demand Response Schemas through the optimal management of buildings' portfolio

MOEEBIUS scenario	
ID	**BSC-02**
Title	**Active Participation in Demand Response Schemas through the optimal management of consumers portfolio**
Description	As part of the deregulation of energy markets and towards the active participation of consumers in energy market, the Aggregator role has been promoted in E.C. regulation. The Aggregator stands between the final customers (consumers/producer) and market stakeholders (TSOs, DSOs, Utilities etc.) as well as specific market operations and needs (wholesale market, ancillary services etc.). The aggregator **manages the customer portfolio in an optimized way,** trading with the market stakeholders on behalf of the customers. Aggregators usually act as subcontractors of DSOs or utilities, for providing vertical business services (energy contracts & services to specific customer categories) as well as location and event based management services (demand side management services for grid relief on specific locations and for specified time). Therefore, the role of the aggregator is to participate in those markets offering its **demand flexibility** in a similar way as generating units do. The goal of the business case is focused on **providing flexibility resources** to market stakeholders, setting that way buildings or groups of buildings as active elements on energy markets. By further exploiting DER and Flexibility models, the Aggregators are able to accurate estimate the amount of flexibility on their portfolio and further aggregate this amount of flexibility towards small customers' participation on innovative market models (Demand Response programmes).
Main Actors	**Aggregator:** The Aggregator's role is to gather ("aggregate"), analyse and efficiently organize its customer loads portfolio, towards identifying appropriate clusters of prosumer and respective DER flexibilities and eventually define specific strategies based on actual energy market needs: create agreements with industrial, commercial, institutional and residential electricity consumers to aggregate their capability to reduce energy and/or shift loads on short notice in order to help utilities, grid and transmission operators to shave peak power demands, etc.. Therefore the role of the Aggregator is to act as the mediator of consumers towards their participation in Demand Response Programmes in energy markets. **Facility Manager or ESCO:** This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In this business scenario, the role of the FM or ESCO is to act as the contact point with the Aggregator, towards the implementation of Demand Response Strategies in Local/ Building level. The facility manager is responsible for successful participation of building in energy markets, while also ensuring the establishment of a sustainable and operational environment in premises.

Table 2: MOEEBIUS BSC-02 Participation in Demand Response Schemas

5.3 SC-03: Optimized Predictive maintenance diagnostics and decision making tool to ensure high levels of business performance

MOEEBIUS scenario	
ID	**BSC-03**
Title	**Optimized Predictive maintenance diagnostics and decision making tool to ensure high levels of business performance**
Description	Towards the establishment of a sustainable operational environment in tertiary buildings, a holistic energy performance optimization framework is required to tackle the causal factors that have hindered the ESCO market growth and prohibited the unleashing of the tremendous EE potential of the building sector. An imperative step, towards this direction, is to understand building behaviour and integrate it in dynamic building simulations addressing the optimization needs of different stages of the building lifecycle. Capturing the real-life complexities of building operation in highly accurate, robust and dynamic models will ensure that the building elements (device and user profiles) are taken into account, not only during real time monitoring and control operation, but also, in **maintenance optimization activities** which also continuously adapt the performance of the building to constraints (occupancy, weather, occupants' preferences, etc.), thereby making sure that energy efficiency does not compromise other performance criteria (occupant's comfort, health, wellbeing and security) or the building operations. The goal is to provide capabilities for systematic monitoring of equipment, materials and HVAC system performance, **detecting and diagnosing various mechanical faults** or discrepancies, **detecting anomalous behaviour** and defective equipment/ materials, identifying Indoor Air Quality (IAQ) violations and **recommending optimized maintenance actions**, which will be based on the prediction of future equipment performance.
Main Actors	**Maintenance Responsible Party:** This actor is mainly a third-party operator or a person responsible for the maintenance of all the systems within a facility (e.g., heating, lighting, etc.). Maintenance and repair involves fixing any sort of mechanical, plumbing or electrical device should it become out of order or broken. It also includes performing routine actions which keep the device in working order or prevent trouble from arising (preventive maintenance). **Facility Manager or ESCO:** This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In this business scenario, the role of the FM or ESCO is to take into consideration the maintenance strategies and further align them with the real time building operation as part of the holistic building monitoring and control framework

Table 3: MOEEBIUS BSC-03 Predictive maintenance diagnostics and control

5.4 SC-04: Optimized retrofitting decision making on the basis of improved and accurate LCA/ LCC-based performance predictions

MOEEBIUS scenario	
ID	**BSC-04**
Title	**Optimized retrofitting decision making on the basis of improved and accurate LCA/ LCC-based performance predictions**
Description	The financial crisis in many European countries is reducing the availability of public funding to support **retrofitting activities** of any kind. Therefore the need arises for the development of effective measures and provision of motivations to facilitate private-sector investment in energy efficient retrofitting of buildings. The goal of this business scenario is to highlight this need, to enhance existing tools with add-ons that enable the evaluation of **retrofitting activities** towards the establishment of a sustainable but also cost efficient environment. To further facilitate ESCO market growth and risk alleviation (on the basis of values that are not only consistent with EPC, but, also, create an attractive business environment), the goal is to define optimization approaches (improved prediction and fine-grained control), complemented with innovative retrofitting decision-making tools. These tools may allow the evaluation of alternative retrofitting projects from an LCA-LCC point of view and further reduction of the performance gap through targeted actions upon poorly performing equipment and materials. This will, ultimately enable, even the alignment between predicted and actual energy performance in buildings, under novel Energy Efficiency Service Agreements (ESCO Business models) that involve ESCOs in activities referring to the whole life-cycle of the building.
Main Actors	**Retrofitting Advisory Company:** This actor is mainly a third-party operator or a person responsible for the maintenance & retrofitting of all the systems within a facility. Retrofitting is the process of modifying something after it has been manufactured. For buildings, this means making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation. Therefore, the establishment of an actor able to provide best fitted retrofitting advices is one of the goal of this business scenarios. **Facility Manager or ESCO:** This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In this business scenario, the role of the FM or ESCO is to take into consideration the retrofitting plans and strategies and further align them with the real time building operation as part of the holistic monitoring and control framework

Table 4: MOEEBIUS BSC-04 Optimized retrofitting decision making

5.5 SC-05: Holistic DSS towards the establishment of a sustainable building level and district level environment

MOEEBIUS scenario	
ID	**BSC-05**
Title	**Holistic DSS towards the establishment of a sustainable building level and district level environment**
Description	With the increasing demand for more energy efficient buildings, the construction and energy services industries are faced with the challenge to ensure that the energy performance and savings predicted during energy efficiency measures definition is actually achieved during operation. There is, however, significant evidence to suggest that buildings underperform illustrating a, so called, “performance gap” which is attributed to a variety of causal factors related to both predicted and in-use performance, implying that predictions tend to be unrealistically low whilst actual energy performance is usually unnecessarily high. To this end, a holistic energy performance optimization framework is required to tackle the causal factors that have hindered the ESCO market growth. Therefore the goal is to promote a dynamic modelling and simulation approach that enables: (1) Improved Predictions on the basis of more accurate and dynamically **updated Building Energy Performance Simulation** (BEPS) models; (2) Precise allocation and r**eal-time assessment** of detailed performance contributions of individual critical building components, (3) Real-time **building** and **district** performance optimization through **control and maintenance**, (4) Optimized **retrofitting decision** making on the basis of improved (LCA/ LCC-based) performance predictions. Towards this direction, the goal of this scenario is to take into account the different application layers (examined above) and further perform a real time, meso and macro level analysis for the prompt management of building and district premises.
Main Actors	This is the integrated Business Scenario addressing all the main system stakeholders examined in the project. The main goal is the selection of optimal strategy that takes into account end users’ needs and requirements. More specifically: **Facility Manager or ESCO:** This actor could be a facility owner, third-party operator or a person responsible for the operation of all the systems within a facility (e.g., heating, lighting, etc.). In this business scenario, the role of the FM or ESCO is to ensure the real time operation of building premises, taking into account the context building environment. **Building Occupants:** The goal is to ensure the minimum of building occupants disturbance during optimal building management. Therefore, the implementation of different control strategies should take into account the preferences of building occupants as active elements of the building structure. **Aggregator:** The Aggregator's role is to gather (“aggregate”), analyse and efficiently organize its customer loads portfolio towards their participation in Demand Response Programmes in energy markets. **Maintenance Responsible Party:** This actor is mainly a third-party operator or a person responsible for the maintenance of all the systems within a facility (e.g., heating, lighting, etc.). The perspective on this scenario is to define the optimal **predictive maintenance policies**

	towards the prompt buildings operation **Retrofitting Advisory Company:** This actor is mainly a third-party operator or a person responsible for the maintenance & retrofitting of all the systems within a facility. The perspective on this scenario is to define the optimal **retrofitting decision making** on the basis of improved (LCA/ LCC-based) performance predictions

Table 5: MOEEBIUS BSC-05 Holistic Decision support for building operation

The last scenario is considered as a meta-scenario, integrating the different building operations examined in previous sections. The next figure depicts the list of business scenarios as examined in the project where BSC-05 stands as a strategic scenario with interconnections to the rest of MOEEBIUS business scenarios.

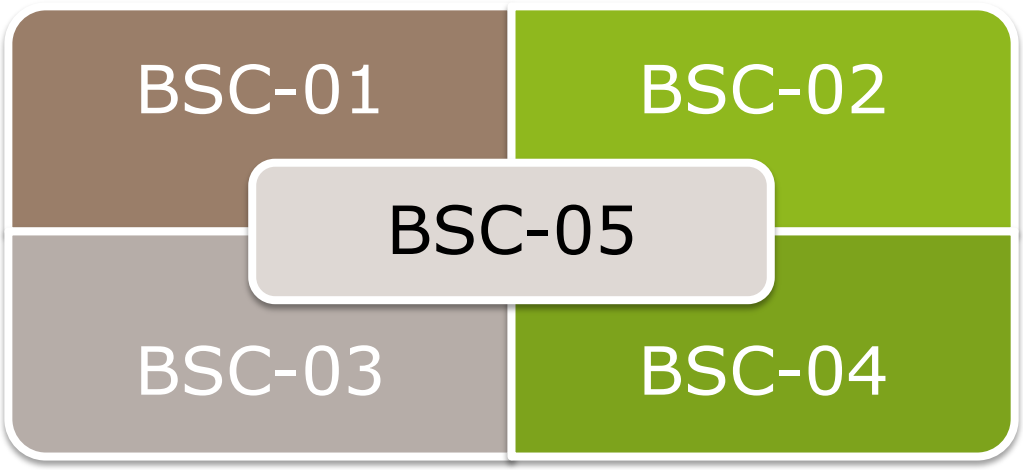


Figure 4 List of MOEEBIUS Business Scenarios

By highlighting the high level functional aspects of the project as defined through the business scenarios analysis, the next section provides an overview of the associated use cases for the proposed framework.

6 MOEEBIUS Use Cases

In this section, different project related use-cases are defined following the identification of the main business scenarios of the project. In summary, the use cases are mapped to the business scenarios identified and presented in previous section in order to provide a quick overview of MOEEBIUS framework.

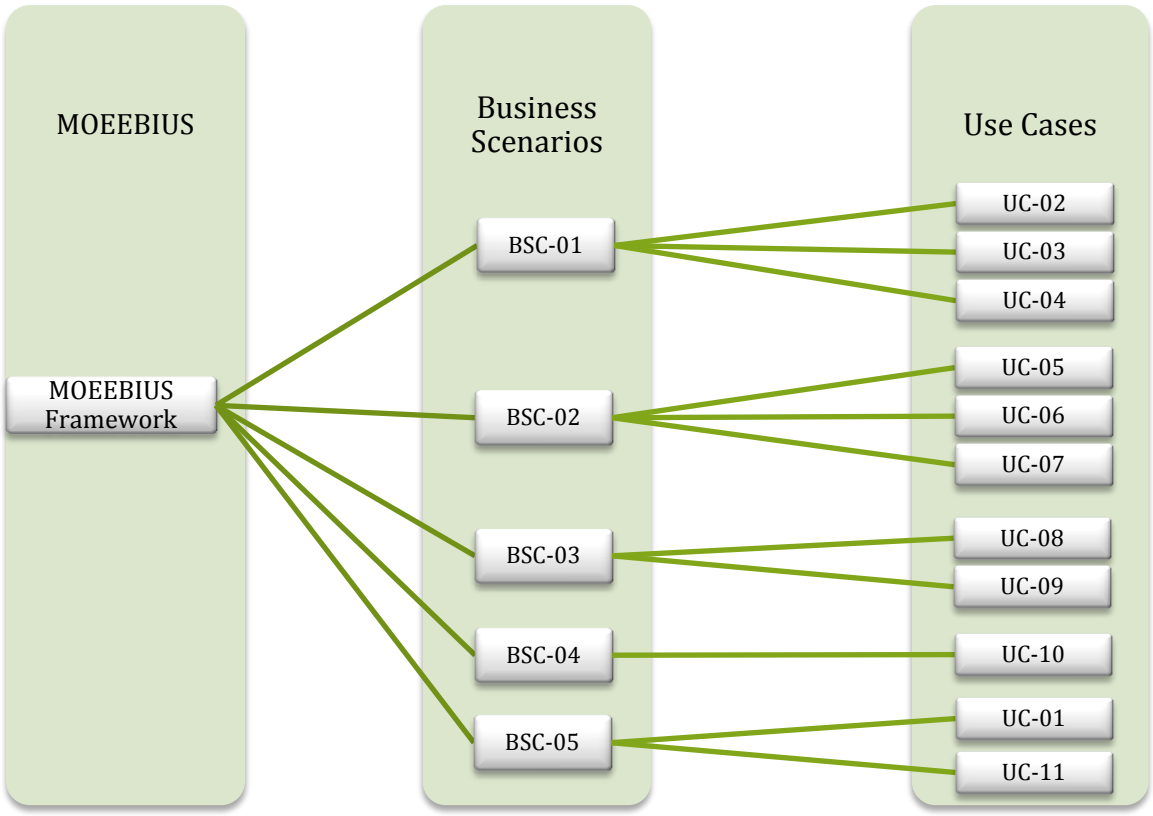


Figure 5 Taxonomy of MOEEBIUS Business Scenarios and Use Cases

The analysis of use cases is delivered in line with the methodological framework as presented in Section 3. Each business scenario is associated with **1 or more** use cases that define the technical perspective of business needs. More specifically, we have identified the following associations.

- BSC-01: Real-time building performance optimization towards the establishment of a sustainable environment
  - UC-02: Real-time Building Optimization through Simulation-based Automation
  - UC-03: Building Energy Performance Assessment on the basis of enhanced BEPS models
  - UC-04: Addressing the role of occupants as a main parameter on buildings operation

- BSC-02: Active Participation in Demand Response Schemas through the optimal management of buildings' portfolio
  - UC-05: Visual Analytics over consumers' historical data
  - UC-06: Hypothesis analysis for the optimal management of consumers on DSM strategies
  - UC-07: District level dynamic assessment framework for energy performance optimization
- BSC-03: Optimized Predictive maintenance diagnostics and decision making tool to ensure high levels of business performance
  - UC-08: Building performance optimization through the selection of predictive maintenance strategies
  - UC-09: Establishment of a Virtual Reality environment for Predictive Maintenance support
- BSC-04: Optimized retrofitting decision making on the basis of improved and accurate LCA/ LCC-based performance predictions
  - UC-10: Supporting retrofitting decision-making by addressing real time building operation
- BSC-05: Holistic DSS towards the establishment of a sustainable building level and district level environment
  - UC-01: Real Time Monitoring of Building Operation
  - UC-11: Holistic DSS addressing real time building and district operation, predictive maintenance and retrofitting strategies

Special focus should be delivered in BSC-05 towards the implementation of the holistic DSS framework. We have to point out that UC-01 (real time monitoring of building operation) should be also mapped to BSC-01 (real-time building performance optimization) but as BSC-05 is an extension of BSC-01 we have explicitly highlighted this use case as part of the holistic management framework.

Prior to the detailed use case analysis, an overview of MOEEBIUS abstract components as derived from DoA is provided. This high level review of conceptual elements will further facilitate the presentation of use cases in the following section. The high level modules of the conceptual framework are presented:

- **Data Acquisition and Management Layer**: Responsible for interfacing with the physical world (WSN and Devices) and providing low level information to applications and business services
- **Data Acquisition and Management Layer (District):** Setting the building gateway, to provide aggregated data to district level stakeholders (mainly Aggregators)
- **Building Energy Performance Simulation Tool:** A tool for Building Energy Performance Simulation towards the evaluation of different operational scenarios. This functionality is essential for both real time and meso level building optimization.

- **Building level Dynamic Assessment Engine:** A tool for real time evaluation of control strategies in Building Level
- **District level Dynamic Assessment Engine:** A tool for real time evaluation of control strategies in District Level
- **Building Occupants User Interface:** In order to address building occupants as main system stakeholders
- **Predictive Maintenance Advisor:** An engine for evaluation of Predictive maintenance strategies
- **Retrofitting Advisor and Investment Evaluation:** An engine for evaluation of Building Retrofitting strategies
- **Demand Aggregation, Flexibility and Management Engine:** An engine for analysis of portfolio data for participation on energy market models
- **Facility Manager & ESCO DSS:** The Decision Support System for the system stakeholders. It also incorporates the GUI for the business stakeholder

The analysis of abstract system modules remains at a preliminary level as a detailed presentation of system components is provided in D2.4 along with the definition of system requirements.

A detailed description of MOEEBIUS Use Cases is provided focusing mainly on the definition of functionalities as requested by the system stakeholders. A template has been selected as a tool for the description of MOEEBIUS Use cases (A detailed presentation of the template is available in Annex I). Following this common template both consortium partners and living lab members contributed on the composition of the final list of use cases.

6.1 UC-01 - Real Time Monitoring of Building Operation

MOEEBIUS Use Case - 01	
Functional Description	
UC ID	UC-01
Use Case Name	Real Time Monitoring of Tertiary Building Operation
Related Business Scenario	BSC-05
Description (narrative)	A core objective of the project is to ensure real time monitoring of building premises operation. In order to establish advanced control strategies, access to real-time - device level - energy information is needed along with the associated user related parameters. Towards this direction, this use case depends on the installed equipment, responsible for real-time monitoring of different parameters (energy& contextual) from local level DERs. Real time data from different sub-systems of the infrastructure will be further analyzed, in order to provide reports about building's energy behaviour. In other words, this use cases is about Facility Manager dashboard/ GUI for real time visualization of building performance.
Pre - conditions	The main objective of this use case is to set up the technical framework required for the seamless access on real-time,

MOEEBIUS Use Case - 01	
	along with historical data, from different subsystems of the local level environment. Further to this, proper manipulation and correlation of collected information (through the simulation –model based- framework) is needed towards providing enriched reports about real time and historical operation of facility elements.
Involved Stakeholders	Facility Manager, ESCOs
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Facility Manager & ESCO DSS
Use Case Path	The building infrastructure already provides a communication network. MOEEBIUS Middleware will get access over different subsystems in the Local Building Environment. MOEEBIUS BEPS will comprise of appropriate models and tools to calculate and compile enriched energy information to the involved actors. The facility manager has to be provided with appropriate User Interfaces, in order to retrieve building's energy reports.
Post Condition	The facility manager accesses real-time building energy reports, assisting his decision making in control actions that may be required. The MOEEBIUS application layer retrieves energy and context data from middleware, transforms them to meaningful information, in order to prepare and present high-level reports to end users through the DSS.
Realization Description	
Leading Partner	THN
Contributing Partners	HON, BELIT, TECNALIA, BEOLEK
Priority	High

Table 6: UC-01 - Real Time Monitoring of Building Operation

6.2 UC-02 - Real-time Building Optimization through Simulation-based Automation

MOEEBIUS Use Case - 02	
Functional Description	
UC ID	UC-02
Use Case Name	Real-time Building Optimization through Simulation-based Automation
Related Business Scenario	BSC-01
Description(narrative)	This use case defines the process where new events or changes on context conditions in premises are detected and consequently trigger changes to control planning. The control plans will be automatically implemented, to cover different contextual conditions that may be encountered. The results of this process are further available to the facility managers and building occupants towards the establishment of a holistic energy efficient environment. The control plan will be performed locally by MOEEBIUS Local Engine, considering building related information, such as building energy data, occupancy and scheduling, as well

MOEEBIUS Use Case - 02	
	as external data, like weather, energy price tariff, KPIs etc. Once a new control plan is applied, previous control plans could be either delayed or dropped according to updated local data.
Pre - conditions	The ultimate goal of this use case is the establishment of a local level automation framework, taking as main parameter the contextual information from building environment. In order to further select the best fitted control strategies, both real time data and simulation performance engine should promptly operate.
Involved Stakeholders	Facility Manager, ESCOs, (Occupants)
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Building level Dynamic Assessment Engine & DSS
Use Case Path	The building infrastructure already provides a communication network. MOEEBIUS Middleware will have access and control over different subsystems within the Building Hub. Building energy and occupancy models are accurate enough (post training phase) to enable the selection of optimal strategies taking into account real time building conditions. The results from Dynamic Assessment analysis are further provided to the holistic DSS for the final implementation of the selected control strategies.
Post Condition	The facility manager gets access to real-time building energy reports, assisting his decision making in control actions that may be required. The MOEEBIUS Building level Dynamic Assessment Engine retrieves real time & simulated data and performs the evaluation of different control strategies (MPC-based model) towards the establishment of a sustainable building environment.
Realization Description	
Leading Partner	CIT
Contributing Partners	TECNALIA, HON, HYPERTECH
Priority	High

Table 7: UC-02 - Real-time Building Optimization through Simulation-based Automation

6.3 UC-03 – Building Energy Performance Assessment on the basis of enhanced BEPS models

MOEEBIUS Use Case - 03	
Functional Description	
UC ID	UC-03
Use Case Name	Building Energy Performance Assessment on the basis of enhanced BEPS models
Related Business Scenario	BSC-01
Description(narrative)	Concerning Building Energy Performance Simulation (BEPS) market, there are currently several energy simulation software tools with different levels of complexity and response to different variables. Though, these tools lack of dynamic aspects and therefore are not able to address the

MOEEBIUS Use Case - 03	
	continuously changing performance of buildings. Towards this direction, the goal is to provide improved Building Energy Performance Assessment on the basis of enhanced BEPS models (seamlessly addressing dynamic aspects of building operation, such as occupancy and weather conditions), that are iteratively and dynamically updated through feedback received from actual building measurements in order to allow for more accurate representation of the real-life complexities of the building. In other words, this is an enhanced BEPS tools with continuously updated models taking into account building operational characteristics.
Pre - conditions	The ultimate goal of this use case is the establishment an enhanced BEPS framework addressing the dynamic elements of building operation. Towards this direction, accurate DER, occupancy and preferences models should be integrated in the enhanced BEPS framework. In addition, these models should be periodically updated taking into account building operational characteristics.
Involved Stakeholders	Facility Manager, ESCOs
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool
Use Case Path	MOEEBIUS Middleware will have access over different subsystems within the Local Building Environment. Building energy and occupancy models are accurate enough (post training phase) to enable the precise simulation of building conditions. A BEPS User Interfaces provides a visual representation of building simulation process.
Post Condition	The BEPS engine stands at the application layer of the overall framework. Output data from BEPS (forecasted demand and forecasted consumption) along with real building characteristics such as occupancy, weather or consumption, will be taken into a fuzzy model engine to support real time automated operation in building premises.
Realization Description	
Leading Partner	TECNALIA
Contributing Partners	HYPERTECH, CIT
Priority	Medium

Table 8: UC-03 Building Energy Performance Assessment on the basis of enhanced BEPS models

6.4 UC-04 – Addressing the role of occupants as a main parameter on buildings operation

MOEEBIUS Use Case - 04	
Functional Description	
UC ID	UC-04
Use Case Name	Addressing the role of occupants as a main parameter of buildings operation
Related Business Scenario	BSC-01

MOEEBIUS Use Case - 04	
Description(narrative)	One of the main goals of the project is to incorporate occupants' Profiling Mechanism as part of the proposed framework, in order to address the role of occupants as a critical element of the building. The proposed profiling mechanism should perform a user-specific continuous & correlated monitoring of ambient /occupancy conditions and occupants' actions in order to extract context-aware user preferences and understand comfort (dis)satisfaction zones. A key task includes identifying what influence factors are most relevant to a given (or estimated) user profile. Therefore and in order to perform this analysis, the building occupants -through interaction with mobile UIs - will continuously provide personalized information to identify individual needs and preferences. On the other hand, and towards the active engagement of building occupants, the users should be informed about building conditions and further triggered to adopt energy efficient behaviours.
Pre - conditions	The main objective of this use case is to set occupants as an active element of the building. The users are able to interact with the system and further set their preferences and non-preferences. In that way, the users directly interface with the platform and set their input parameters towards the establishment of an occupancy oriented framework.
Involved Stakeholders	Building Occupants
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Occupants User Interface
Use Case Path	MOEEBIUS Middleware will have access and control over different subsystems within the Local Hub. Building occupancy models are defined/trained addressing the different occupancy characteristics on building premises. A personalized UI is available for building occupants to express their preferences and operational settings.
Post Condition	The Profiling Mechanism will enable the delivery of Context-Aware Flexibility Profiles, reflecting real-time demand flexibility as a function of multiple parameters, incorporating also the role of occupants on DER operations. The extraction of accurate flexibility profiles will further enable more precise simulation and real time operation of building.
Realization Description	
Leading Partner	HYPERTECH,BELIT
Contributing Partners	CIT, GD, TYNDALL,BEOLEK
Priority	Medium

Table 9: UC-04 – Addressing the role of occupants as a main parameter on buildings operation

6.5 UC-05 – Visual Analytics on consumers historical data

MOEEBIUS Use Case - 05	
Functional Description	
UC ID	UC-05
Use Case Name	Visual Analytics on consumers historical data

MOEEBIUS Use Case - 05	
Related Business Scenario	BSC-02
Description(narrative)	The main objective is to perform analytics over energy consumption and generation data addressing also contextual parameters of various consumers. Multi-parameter criteria analysis algorithms and tools will be utilized by a data Analytics component which will provide visualization and interaction mechanisms to the Aggregators and ESCOs for multidimensional analysis, correlation and efficient management of prosumer profiles and prosumer flexibility. Commonalities and complementarities between loads will be identified towards dynamically extracting load clusters for different purposes.
Pre - conditions	The main objective of this use case is to set the criteria for clustering of portfolio assets under different business and contextual conditions. In order to proceed with this clustering approach, the Local Level Hubs should able to provide accurate real-time and historical data (energy, environmental, flexibility, business etc.…), along with detailed DER profiling mechanism, in order to achieve the highest accuracy on analytics process.
Involved Stakeholders	Aggregator
MOEEBIUS Components Involved	Data Acquisition and Management Layer (District) Demand Aggregation, Flexibility and Management Engine
Use Case Path	MOEEBIUS District Middleware will have access on different consumers of the portfolio. Alternative clustering and classification techniques will be established to support the management of the portfolio under different contextual and business conditions. An enriched UI will further complement data analytics towards the development of a visually appealing tool for the end users.
Post Condition	Continuous (periodic) analysis of prosumer profiles (load and flexibility) will lead to the dynamic extraction of prosumer clusters and consequently to the identification of optimal metrics/KPIs reflecting the specific characteristics/needs of these clusters. In addition, and taking into account historical and real time data, accurate flexibility forecasting profiles will be derived from the system.
Realization Description	
Leading Partner	HYPERTECH
Contributing Partners	TECNALIA, KIWI
Priority	High

Table 10: UC-05 – Data analytics over consumers' historical operation

6.6 UC-06 – Hypothesis analysis for the optimal management of consumers on DSM strategies

MOEEBIUS Use Case – 06	
Functional Description	
UC ID	UC-06
Use Case Name	Hypothesis analysis for the optimal management of consumers on DSM strategies
Related Business Scenario	BSC-02
Description(narrative)	The main objective of this case scenario is to allow the end users of the system (Aggregators) to continuously re-adjust their strategies for their optimal placement in different business scenarios. Towards this direction, a "what-if analysis" mechanism is provided for the evaluation of consumers load characteristics under different business conditions. This simulation engine will further support the aggregators on the selection of alternative business strategies about portfolio.
Pre - conditions	The ultimate goal of this scenario is to set a simulation engine in order to examine different potential business strategies of Aggregator. Towards this direction, access on historical and real time energy and contextual data is a main prerequisite for this case scenario.
Involved Stakeholders	Aggregators
MOEEBIUS Components Involved	Data Acquisition and Management Layer (District) Demand Aggregation, Flexibility and Management Engine
Use Case Path	MOEEBIUS District Middleware will have access and control over different consumers/ buildings of the portfolio. MOEEBIUS DAFM Engine will comprise of appropriate tools and algorithms to simulate the performance of portfolio consumers under different business strategies in order to define optimal clusters of consumers for specific market conditions.
Post Condition	An analysis over historical data of prosumers, based on pre-defined KPIs and under specific control DR strategies/SLAs, identifies trends and outliers as well as indicates specific factors and metrics that are potentially relevant to these situations. This simulation engine will further facilitate the selection of optimal consumer clusters under real time business cases.
Realization Description	
Leading Partner	HYPERTEH
Contributing Partners	TECNALIA, KIWI
Priority	Medium

Table 11: UC-06 – Hypothesis analysis towards the optimal placement of consumers on DSM strategies

6.7 UC-07 – District level dynamic assessment framework for energy performance optimization

MOEEBIUS Use Case – 07	
Functional Description	
UC ID	UC-07
Use Case Name	District level dynamic assessment framework for energy performance optimization
Related Business Scenario	BSC-02
Description(narrative)	The main objective of this case scenario is to address the role of ESCOs and Aggregators as the entities responsible to manage groups of consumers under different business scenarios (optimal energy performance or participation on market operations). Towards this direction, the goal is to enable the continuous optimization of district level aggregated consumption/demand curves (either through load shedding, or through load shifting), towards optimally accommodating demand side management strategies (DR events, VPP operation etc). In that way, the consumers through their participation in energy markets are transformed from passive elements to active entities of the grid.
Pre - conditions	The main goal of this scenario is to enable the aggregation of consumer clusters for their participation in different business models. In order to enable this use case, it is mandatory to extract accurate consumer profiles and further provide techniques for the optimal clustering and management of consumers under different business conditions. In addition, access on real time aggregated building data should be ensured.
Involved Stakeholders	Aggregators
MOEEBIUS Components Involved	Data Acquisition and Management Layer (District) Demand Aggregation, Flexibility and Management Engine District level Dynamic Assessment Engine
Use Case Path	MOEEBIUS District Middleware will have real time access and control over different consumers/ buildings within the portfolio. By taking into account the real time performance of the consumers, along with the definition of clusters with similar characteristics, the District Level Engine will select the appropriate control strategies, addressing specific business and technical requirements.
Post Condition	By promptly managing consumers' clusters at a neighbourhood level, demand-response capacity and flexibility requests will affect the operation of buildings and district level energy systems (Virtual Power Plant), satisfying in that way both demand response events and energy efficiency requirements. The goal of this use case is to implement the best fitted control actions taking into account business requests and building technical characteristics.
Realization Description	
Leading Partner	TECNALIA
Contributing Partners	CIT, HON, GD
Priority	High

Table 12: UC-07 - District level dynamic assessment framework for energy performance optimization

6.8 UC-08 – Building performance optimization through the selection of predictive maintenance strategies

MOEEBIUS Use Case – 08	
Functional Description	
UC ID	UC-08
Use Case Name	Building performance optimization through the selection of predictive maintenance strategies
Related Business Scenario	BSC-03
Description(narrative)	Apart from real time monitoring and control in tertiary building, one of the main objectives is to set the framework for the establishment of a predictive maintenance framework. The goal is to design an engine that will provide capabilities for systematic monitoring of equipment, materials and HVAC system performance, detecting and diagnosing various mechanical faults or discrepancies, detecting anomalous behaviour and defective equipment/ materials, identifying Indoor Air Quality (IAQ) violations and recommending optimized maintenance actions, which will be based on the prediction of future equipment performance.
Pre - conditions	The ultimate goal of this use case is the establishment of a predictive maintenance framework, taking as input parameters the contextual data from building operation. In order to further select the best fitted maintenance actions, real time building data (energy, occupancy, environmental) will be incorporated to the simulation engine in order to further simulate alternative meso level strategies and define building maintenance plan.
Involved Stakeholders	Maintenance Responsible Party
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Building level Dynamic Assessment Engine Predictive Maintenance Advisor & DSS
Use Case Path	MOEEBIUS Middleware will have access and control over different subsystems within the Building Hub. Building energy and occupancy models are accurate (post training phase) while a Building level Dynamic Assessment Engine enables the simulation of alternative building strategies taking into account also the results from Building Energy Performance Simulation Tool. Then, the Predictive Maintenance Advisor will evaluate different meso–level alternative strategies and further provide the optimal strategies to Building DSS for implementation.
Post Condition	The Maintenance Responsible Party accesses predictive maintenance dashboard reports, assisting his decision making in maintenance actions that may be required. The MOEEBIUS DSS system retrieves the proposed maintenance actions and performs control strategies following the specific constrains as defined by the maintenance activity plans.
Realization Description	
Leading Partner	HON
Contributing Partners	CIT, THN
Priority	High

Table 13: UC-08 - Building performance optimization through the selection of predictive maintenance strategies

6.9 UC-09 – Establishment of a Virtual Reality environment for Predictive Maintenance support

MOEEBIUS Use Case – 09	
Functional Description	
UC ID	UC-09
Use Case Name	Establishment of a Virtual Reality environment for Predictive Maintenance support
Related Business Scenario	BSC-03
Description(narrative)	Complementarily to the functional logic behind the selection of predictive maintenance activities, a Virtual Reality environment for Predictive Maintenance is needed to enable the fusion of BIM information (3D BIM Mapping), equipment and components life-cycle data, discrepancies and anomalous behaviour detection and diagnosis algorithms along with mobile device sensors to offer a highly intuitive interface for maintenance managers. As this process (predictive maintenance) is considered as a complex task that combines heterogeneous data from real time and simulated environment, there is a need to provide a set of visual tools that will facilitate the work of maintenance responsible partners.
Pre - conditions	The goal of this use case is to provide enriched visualization for predictive maintenance activities. Towards this direction, the development of the Predictive Maintenance Engine is a prerequisite as this engine set the back end application of the Virtual Reality Interface. This use case is complementary to the previous one (UC-08)
Involved Stakeholders	Maintenance Responsible Party
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Building level Dynamic Assessment Engine Predictive Maintenance Advisor
Use Case Path	MOEEBIUS Middleware will have access over different subsystems within the Building Hub while the Predictive Maintenance Advisor will enable the simulation of alternative control strategies (taking into account the results from Building Simulation & Building Dynamic Assessment Engines). Real time and simulated results related to predictive maintenance planning will be further visualized through mobile screens (3D Building view).
Post Condition	The user's location within these maps will be tracked and all relevant information will be displayed in the user's local context, allowing Maintenance Experts (or ESCOs/ Facility Managers) to identify weakly performing components, not by analysing a series of data and graphs in their control panels, but through the screen of a mobile device.
Realization Description	
Leading Partner	HON
Contributing Partners	CIT, THN, MAFRA
Priority	High

Table 14: UC-09 - Establishment of a Virtual Reality environment for Predictive Maintenance support

6.10 UC-10 – Supporting retrofitting decision-making by addressing real time building operation

MOEEBIUS Use Case – 10	
Functional Description	
UC ID	UC-10
Use Case Name	Supporting retrofitting decision-making by addressing real time building operation
Related Business Scenario	BSC-04
Description(narrative)	One of the main objectives of the framework is to provide a retrofitting advisory tool as a complement to real time building operation. This module should enable the retrofitting decision maker to **explore a portfolio of potential building retrofitting projects** taking into account national technical codes, regulatory issues, particularities of the buildings and district and financial restrictions. In addition, the engine should enable the definition of a set of optimal solutions for a retrofitting project considering multiple conflicting parameters. This integrated framework that firsts analyses different alternatives and then proposes the optimal case consists of the retrofitting advisory tool.
Pre - conditions	The ultimate goal of this use case is the establishment of a retrofitting decision-making framework, taking as input parameters contextual data from building operation. In order to propose a set of optimal solutions for retrofitting planning, both real time and simulation engine should operate in order to simulate alternative macro-level retrofitting strategies.
Involved Stakeholders	Retrofitting Advisory Company
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Building Level Dynamic Assessment Engine Retrofitting Advisor and Investment Evaluation & DSS
Use Case Path	MOEEBIUS Middleware will have access over different subsystems within the Building Hub. Building energy and occupancy models are accurate (post training phase) while the Dynamic Assessment Engine enables the selection of optimal strategies under real time building conditions (taking into account the results from Building Energy Performance Simulation). The Retrofitting Advisor Module will provide the logic for the selection of optimal control actions for retrofitting, taking into account actual and simulated building parameters.
Post Condition	By first supporting the retrofitting decision maker to evaluate the potential of different building retrofitting projects and further providing the logic for the selection of optimal strategies, the engine will propose a list of optimal retrofitting activities that best fit to building conditions.
Realization Description	
Leading Partner	ALMENDE
Contributing Partners	TECNALIA, SOL, MAFRA
Priority	High

Table 15: UC-10 - Supporting retrofitting decision-making by addressing real time building operation

6.11 UC-11 – Holistic DSS addressing real time building and district operation, predictive maintenance and retrofitting strategies

MOEEBIUS Use Case – 11	
Functional Description	
UC ID	UC-11
Use Case Name	Holistic DSS addressing real time building and district operation, predictive maintenance and retrofitting strategies
Related Business Scenario	BSC-05
Description(narrative)	The goal is to deliver an integrated MOEBBIUS tool to provide support for energy performance optimisation. Decision support shall include real-time (automation) along with short- and mid-term operational recommendation (maintenance) regarding mitigation of operational inefficiencies. Moreover, it should allow guidance for medium-to long-term investment decisions for retrofitting actions that can have a positive impact on ROI. This is the Holistic DSS framework that integrates real time building and district operation, predictive maintenance and retrofitting management of building operation.
Pre - conditions	As the main objective of this use case is to examine the impact of holistic MOEEBIUS framework, all the system components (building level & district level) should be available and integrated under a common framework.
Involved Stakeholders	All
MOEEBIUS Components Involved	Data Acquisition and Management Layer Building Energy Performance Simulation Tool Building level Dynamic Assessment Engine & DSS District level Dynamic Assessment Engine Predictive Maintenance Advisor Retrofitting Advisor and Investment Evaluation
Use Case Path	The main objective of this case scenario is to integrate the main components/ entities that cover the list of system functionalities towards the selection of optimal building strategies. The DSS engine will have access to the different business components (Building level Dynamic Assessment Engine, District level Dynamic Assessment Engine, Predictive Maintenance Advisor, Retrofitting Advisor and Investment Evaluation) and by taking into account the set of proposed strategies will implement the optimal control strategy through the Data Acquisition and Management Layer which set the interaction layer with the physical building environment.
Post Condition	The DSS engine by taking into account building level real time operation, district level real time conditions, predictive maintenance activities and retrofitting plans, implements direct control strategies through Data Acquisition and Management Layer which set the border layer with the physical environment.
Realization Description	
Leading Partner	THN
Contributing Partners	ALM, TECNALIA, HYPERTECH, HON
Priority	High

Table 16: UC-11 - Holistic DSS addressing real time building and district operation, predictive maintenance and retrofitting strategies

The overall analysis defines a list of 11 technical use cases, associated with MOEEBIUS business scenarios. The extraction of use cases is based on feedback received from pilot site representatives and living lab members, towards the definition of functionalities that are closely related to daily activities in premises. Furthermore, we highlighted a leading pilot contribution on each use case taking into account the business perspective of the partners. This does not mean that the pilots are responsible for testing only the specific use cases but they have expressed high interest for the allocated use cases, leading the rest of pilot sites during the demonstration and evaluation period. More specifically, the pilot oriented allocation of use cases is presented as:

- **KIWI:** Use cases addressing the role of Aggregator in the project. This is the core business domain of pilot partner (KIWI is an active Demand Side Aggregator in the UK market) and thus will lead the implementation and testing of Aggregator scenarios
- **BEOELEK**: Use cases addressing the core functionality of Facility Manager as the real time manager of the building. Therefore, scenarios related to real time building operation will be extensively tested in BEOLEK pilot sites.
- **MAFRA:** Use cases addressing the predictive maintenance and retrofitting advisory functionalities. Therefore, MAFRA will act as the lighthouse pilot for evaluating the meso and macro level building management processes.

The final list of use cases set the high level principles of MOEEBIUS platform, providing also the guidelines for the evaluation of project outcomes. The use case analysis will further enable the detailed extraction of system components along with the definition of MOEEBIUS reference architecture.

From business scenarios and use-cases analysis performed, the next step is the extraction of end users and business requirements.

7 Questionnaire Analysis

By defining the list of system stakeholders along with the associated business scenarios and system use cases, the next step is the extraction of end users requirements under specific operational conditions. In order to define end users' needs and following the methodological framework, different types of questionnaires were circulated to the main system stakeholders (also participants of MOEEBIUS Living Lab) towards the definition of users' specific requirements. These are further accompanied with business specific requirements as derived from business oriented analysis. We have to point out that a detailed business analysis is performed in D2.2 though the results from this analysis are incorporated here to the extraction of additional business requirements.

Three types of questionnaires [2] have been created and distributed to the MOEEBIUS stakeholders (Building Occupants, Facility Managers/ESCOs and Aggregators) with different objectives. First of all, these questionnaires have been used to fine-tune the already identified Business Scenarios and Use Cases. The main goal though is to extract from questionnaires analysis, stakeholders' specific needs and further derive the list of end users and business requirements. We have to point out, that in order to avoid any repetition, ESCO questionnaires address both building managers and maintenance/retrofitting companies as in most of cases the same role is responsible for these types of services. Add-ons of the core ESCO questionnaires were prepared in order to retrieve specific requirements related to additional services (add-on questionnaires about predictive maintenance and retrofitting activities). The following sub-sections present the results of questionnaires analysis. Prior to this, the methodological framework for the distribution of questionnaires to living lab members is presented. A brief template for the different types of questionnaires is provided in Annex II.

7.1 Methodological Framework for Questionnaires Analysis

Following description of work (DoA) [1], *"the list of the requirements should be derived through the active end user participation and involvement in the MOEEBIUS Living Lab as part of the open innovation approach introduced in MOEEBIUS".* Toward this direction, *"Suitable questionnaires were compiled and focus group discussions were organized under the auspices of the MOEEBIUS Living Lab to capture the views and requirements of all types of end-users, from ESCOs and facility managers, to Maintenance Experts and Aggregators".*

The 1st part of the work, following the initial identification of business requirements and use cases by M3, was the definition of end users groups to participate on questionnaires analysis. The definition of working groups was delivered along with the early establishment of MOEEBIUS Living Lab. Taking into account the role of the partners and the contribution in the project the following allocations of work were performed:

- KIWI was the partner responsible to circulate Aggregator specific questionnaires. This allocation was delivered taking into account the business perspective of the company.
- BELIT is mainly involved in MOEEBIUS project on the development of visually appealing interfaces for building occupants and thus was responsible for building occupants questionnaires analysis.
- ISQ is a company which provides building inspection, equipment testing and offers technical advices. The company addresses the role of ESCO in the project and thus led the work related to ESCO and Facility Manager Questionnaires.
- BEOELEK and MAFRA are pilot sites of MOEEBIUS project where ESCO scenarios will be evaluated. Therefore, they worked with BELIT and ISQ respectively for the extraction of ESCOs requirements through questionnaire analysis. In addition, they were responsible for circulation of predictive maintenance (BEOELEK) and retrofitting activities (MAFRA) add-on questionnaires to the appropriate living lab members.

SOLINTEL, though not directly involved in Task activities, was actively participated on this action as the coordinator of MOEEBIUS Living Lab. SOLINTEL was acting as the support point for the partners, also involved in the questionnaires analysis process by organizing the clusters of living lab members participating on the process. The next schema depicts the structure of the work among partners involved in this process

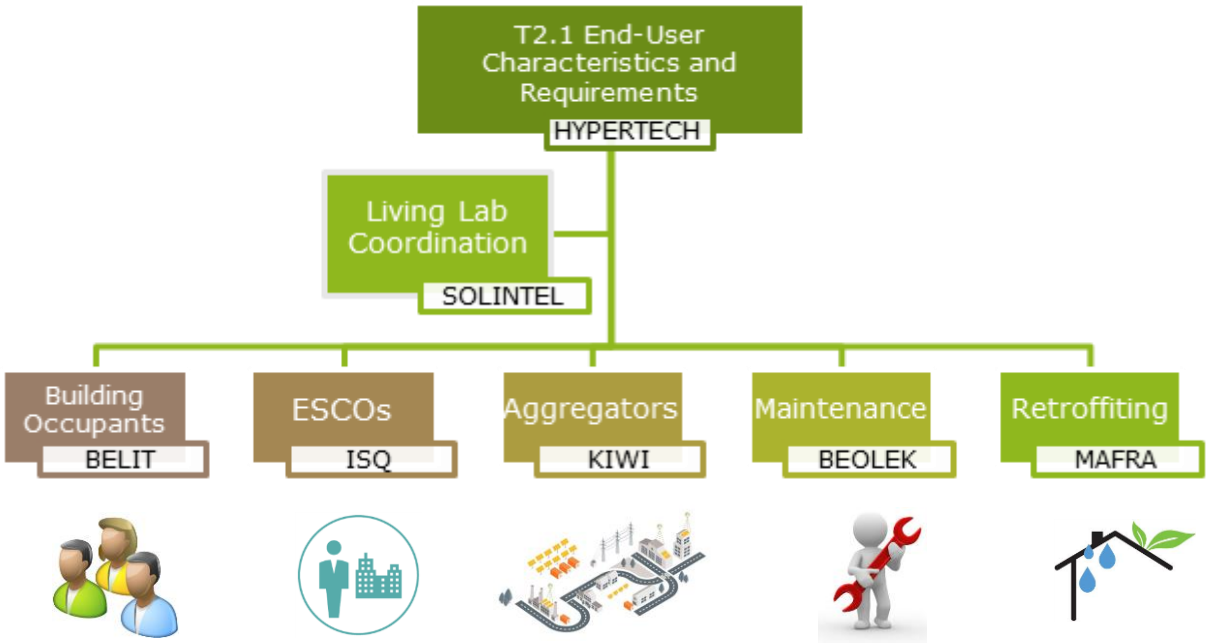


Figure 6 Questionnaires analysis work allocation

Following the allocation of work among partners, the time plan for questionnaires analysis process was defined. **Two rounds** of questionnaires analysis were performed in order to gather feedback from Living Lab members. The **first round** was initiated in **M4** by the early establishment of MOEEBIUS Living Lab. Close contacts of pilot partners were participated, providing feedback on the list of use cases and further enabling the extraction of skeleton/core MOEEBIUS requirements. The **second round** of questionnaires analysis was initiated following the extraction of final list of business scenarios and use cases (Month 5). A wider group of living lab members was enrolled to provide feedback on project activities. The time plan for this activity is depicted in the next figure.

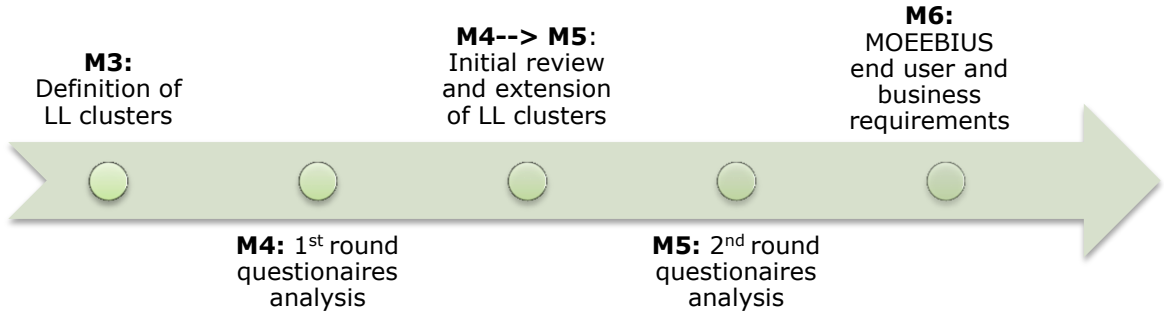


Figure 7 Questionnaires analysis time plan

The next section presents the results from questionnaires analysis that will further lead us to the extraction of MOEEBIUS end users and business requirements.

7.2 Summary of Questionnaires Analysis results

A total number of 117 questionnaires were answered during Task 2.1 period. This activity was performed in parallel with the establishment of MOEEBIUS Living lab and the early engagement of external stakeholders in MOEEBIUS project. Therefore, the LL participants were first informed about project activities and then participate on questionnaires review process. We have to highlight also the diversity of the participants, as we managed to collect feedback from the different end users that operate on different business domains: Building Occupants, ESCOs/Facility managers, acting also as maintenance and retrofitting advisors, and Aggregators. The detailed results from questionnaire analysis process are presented in Annex III. A summary of questionnaires analysis results is provided:

- **Building Occupants** are willing to participate on energy efficiency programmes but have limited knowledge about other market programmes. In addition, their involvement in the different business models should ensure the minimum of their disturbance and intrusiveness to daily operations. Information about building conditions are also welcomed but again in a way that does not affect their patterns and preferences.

- **Facility managers** are familiar with BMS systems but the existing tools don't fulfil their requirements. Accurate occupancy based models along with health related parameters is core elements to be introduced in BMS systems. In addition the enhancement of existing tools with dynamically adapted building models that take into account building operational conditions is a main comment received. Furthermore, one of the main need expressed by facility managers is the enhancement of existing tools with the business logic that will enable the implementation of high level business strategies.
- When going to **predictive maintenance** and **retrofitting activities**, the main requirement is the incorporation of meso and macro level business strategies under a holistic management framework. Again, and towards the selection of predictive maintenance and retrofitting plans, actual building conditions (not only simulated data) should be considered.
- Finally, **Demand Side Aggregator** is a rather new role addressed by the project. DSM Aggregators main request is about tools that will facilitate their operations, namely participation on DR tools. Customized analytics tool that will facilitate them on the selection of optimal clusters or optimal business strategies is a main requirement. In addition, this analytics process should be integrated with their real time DSS tool towards triggering accurate demand response strategies.

The analysis of questionnaires was the main arm towards the extraction of end users and business requirements. The structure of the questionnaire was performed in a way to force end users to express their requirements, pointing out also the missing elements from available commercial tools. The non-exhaustive list of end users and business requirements is reported in the next section.

8 MOEEBIUS End users and Business Requirements

In this section, the MOEEBIUS end user and business requirements are defined. The requirements have been derived following Business Scenarios and Use Cases identification as described in Chapters 4 and 5 using the methodology explained in the Chapter 2. Furthermore, the findings of the project survey, described in Chapter 6 were also taken into account. This step-wise methodological approach is depicted in the following schema.

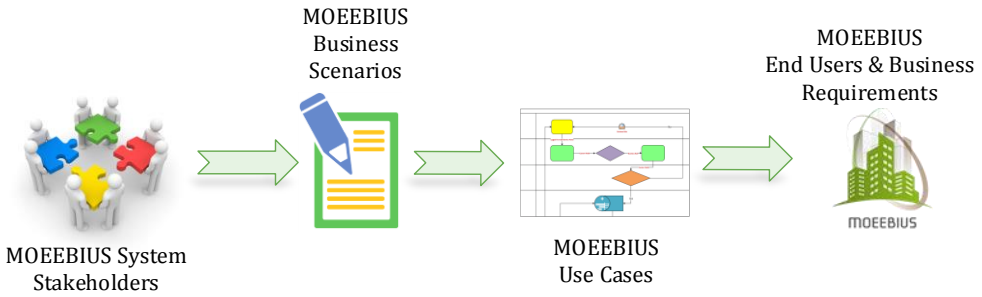


Figure 8 MOEEBIUS End Users & Business Requirements Analysis [3]

The description of the methodological framework for the extraction of the final list of end users & business requirements is presented while the detailed list of MOEEBIUS requirements follows. We have to point out the analysis of system requirements remains at a business layer, while the system (functional) specific representation of MOEEBIUS requirements will be provided in Task T2.4 along with the definition of the main technical components that consist of the MOEEBIUS platform.

8.1 MOEEBIUS Requirements extraction methodological framework

Requirements Elicitation Phase

An important part on the overall approach is the requirements elicitation phase. Requirements elicitation [4] is the process of discovering and clarifying the needs, capabilities, conditions, and constraints that MOEEBIUS must satisfy in order to deliver a system that meets the end users' needs. Requirements elicitation is an iterative and ongoing process which takes care of clarifying, refining requirements and identifying constraints and new changes.

By far, the most common kind of requirements elicitation effort is the one that gets information directly from the people who are going to use the system. Based on this technique, a list of questionnaires has been directly provided to the MOEEBIUS stakeholders, taking into account the Business Scenarios and Use Cases that prioritize the framework's functionality. On the other hand, the pilot partners' representatives and the MOEEBIUS consortium partners participated on the extraction of requirements that fit to the scope of the project. Therefore, by

considering questionnaire review phase and further analysing the different viewpoints among system stakeholders, a non-exhaustive list of end users and business requirements is derived.

Requirements Prioritization Phase

As a second step of the process, we need to provide a hierarchy on requirements and prioritize them [4]. In order to do so, we have adopted different types of priorities. The high level categorization is provided:

1. High: Requirements in this category as defined as a key innovation of the project. These requirements are essential in order to achieve the goals of the project.
2. Medium: These requirements are necessary or very helpful in order to set the application prototypes, but not crucial one for the whole system operation.
3. Low: Requirements in this class are not necessary for the MOEEBIUS system. However, they may be considering as important for the fine-tuned operation of the system examined.

It is essential to realize the requirements with **high priority** in order to define the core aspects of the system. In order to provide a thorough support for the software developers, it is important to realize the requirements with **medium priority**. The requirements with **low priority** are not crucial for the operation of the whole system but they may provide additional features for applications that could provide an added value to the proposed framework. This prioritization phase was delivered internally by the consortium partners, taking into account end users responses on questionnaires.

8.2 MOEEBIUS End Users & Business Requirements

The final list of end users and business requirements of MOEEBIUS project is presented. As the goal is to address both end users priorities along with their business needs, a hierarchical taxonomy is considered. At first, we provide the high level segmentation of requirements addressing the different business roles (end users), while then the analysis is delivered per business case. The template for requirements presentation follows.

Requirement ID	A unique ID for requirements taxonomy
Description	A short Description of Use Case
Classification	Classification on the main business layers of the project
Type	{Functional, Technical, Presentation, Pilot Specific}
Priority	Requirements Prioritization Phase
Comments	Additional comments that complement Requirement Description

While most of the fields are comprehensively defined, a short decrption for each "Type" field follows:

- Functional Requirement: Defines a specific functionality requested by the end users of the system during the requirements phase.
- Technical Requirement: Defines a specific technicality about the implementation of MOEEBIUS solution as requested by end users during the requirements phase.
- Presentation Requirement: Defines the non-functional requirements related to the look and feel of end users applications. This is one of the main objectives of this task for the definition of UI specifications
- Pilot specific Requirement: The goal is to explicitly define pilot specific requirements, as derived from end users of the system due to pilot limitations and constrains (e.g. Specific Demand Response Requirements for UK site due to local legislation). In this case, ethical and legislation related requirements are defined by the pilot site representatives.

This template is further followed for the presentation of 1) end users requirements and 2) business requirements per stakeholder in the following sections.

8.2.1 Building Occupants Requirements

The focus of this section is to define the list of end users requirements as extracted from questionnaire analysis, taking also into account the business perspective of building occupants in MOEEBIUS framework. The goal of the project is to ensure the active participation of end users, though eliminating their disturbance from continuous interaction with the system. The list of requirements are presented:

ID	OCC-01
Des	End-users must be able to **set and reconfigure preferences** for specific context conditions
Class	Building Occupant UI
Type	Functional Requirement
Priority	High
Comments	Set and reconfigure preferences about temperature, humidity, luminance etc…

ID	OCC-02
Des	End-users show high interest on **setting parameters** related to **HVAC** and **lighting** devices
Class	Building Occupant UI
Type	Functional Requirement
Priority	High
Comments	Set and reconfigure preferences about cooling preferences, heating preferences, brightness level etc…

ID	OCC-03
Des	End-users show high interest also on setting **office and home appliances**

	configuration parameters apart from HVAC and lighting devices
Class	Building Occupant UI
Type	Functional Requirement
Priority	Medium
Comments	Set and reconfigure preferences about preferences on specific office devices where patterns are defined

ID	OCC-04
Des	End-users may have the option to **directly trigger control actions** to specific devices (setpoint settings, dimming level etc...)
Class	Building Occupant UI
Type	Functional Requirement
Priority	Medium
Comments	User Interface to ensure interaction with the associated device types

ID	OCC-05
Des	End-users should be informed about **real time environmental condition** (temperature, humidity, etc.) in a personalized way.
Class	Building Occupant UI
Type	Functional Requirement
Priority	High
Comments	Personalized information about current conditions in premises.

ID	OCC-06
Des	End-users should be able to retrieve **energy consumption information** (real time and historical information)
Class	Building Occupant UI
Type	Functional Requirement
Priority	High
Comments	Personalized information about operational status and energy consumption data

ID	OCC-07
Des	End-users must be able to check specific **environmental** and **DERs preferences** as extracted from MOEEBIUS Profiling Engine
Class	Building Occupant UI
Type	Functional Requirement
Priority	Medium
Comments	Personalized information about preference patterns and patterns of usage of devices

ID	OCC-08
Des	End-users must be able to view specific **occupancy profiling data** as extracted from MOEEBIUS Occupancy Profiling Engine

Class	Building Occupant UI
Type	Functional Requirement
Priority	High
Comments	Personalized information about occupancy patterns in premises

ID	OCC-09
Des	Apart from BIM information, **alerts and messages** should be triggered to Occupants' UI (sparsely) towards triggering them to an energy efficient operation
Class	Building Occupant UI
Type	Functional Requirement
Priority	Medium
Comments	Though the main objective is to ensure an automated environment, alarms and messages will be triggered to building occupants as part of the building management process

ID	OCC-10
Des	End-users settings about **user preferences** should be available to other MOEEBIUS system components and thus interfaces with this component should be defined
Class	Building Occupant UI
Type	Technical Requirement
Priority	High
Comments	Information about occupancy patterns should be taken into account for optimal control strategies implementation

ID	OCC-11
Des	End-Users should be able to view **personalized data** by setting a personalized key id as different types/groups of occupants are derived from the Analysis
Class	Building Occupant UI
Type	Presentation Requirement
Priority	High
Comments	Personalized information ensuring the security and privacy of data

ID	OCC-12
Des	End-Users should be able to view data either through a **PC monitor** or through a **mobile device**
Class	Building Occupant UI
Type	Presentation Requirement
Priority	High
Comments	Different ways of accessing personalized information, preference about mobile access

ID	OCC-13
Des	Occupants' UI should exploit different **visualization components (graphs, histograms etc.)** in order to engage users to interact with the system
Class	Building Occupant UI
Type	Presentation Requirement
Priority	High
Comments	Different ways of presenting personalized information, preference about fancy visualization

ID	OCC-14
Des	Data must be presented in an **accessible, understandable and flexible** format that enables users to take action
Class	Building Occupant UI
Type	Presentation Requirement
Priority	High
Comments	Presenting personalized information in a way that is easily understandable by the end users of the tool

ID	OCC-15
Des	The GUI provided by App should support **multiple languages**
Class	Building Occupant UI
Type	Presentation Requirement
Priority	High
Comments	Multiple languages addressing the pilot users in different regions

ID	OCC-16
Des	End-Users should be able to get access on data **remotely**
Class	Building Occupant UI
Type	Technical Requirement
Priority	Medium
Comments	Remote access (web based UI) should be an add on

ID	OCC-17
Des	A **local database** should store historical data to further enable presentation of historical information to end users
Class	Building Occupant UI
Type	Technical Requirement
Priority	High
Comments	In order to ensure a high level of reliability on the service, a local database should ensure access on historical data

ID	OCC-18
Des	The overall development of Occupants UI should take into account the need

	for **consistent and reliable** access on data.
Class	Building Occupant UI
Type	Technical Requirement
Priority	High
Comments	The overall development of the services should ensure a high level of consistency and reliability

8.2.2 Facility Manager/ESCOs Requirements

The main goal of this section is to provide the list of requirements related to the role of ESCOs and Facility Managers in the MOEEBIUS framework. We have to point out that ESCOs is a fundamental role in the project and therefore we have segmented the analysis to the different **business domains** examined. The list of requirements is presented per business domain while some common requirements (mainly related to presentation and technical aspects) for all business applications are delivered. The requirements extracted from analysis are presented:

8.2.2.1 Real Time Building Monitoring and Control

The list of end users and business requirements related to the 1st functionality of the FM tool is presented

ID	FMB -01
Des	Facility managers should get informed about **real time building conditions** (**consumption, environmental, cost** etc.) in an aggregated way.
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Access on real time building information is required

ID	FMB -02
Des	Facility managers should be interested to know the performance of specific device types like **HVAC and lighting**
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Special interest is delivered for specific device types to be managed by a BMS tool: HVAC and lighting

ID	FMB -03
Des	Facility managers should be informed about real time **health related parameters** along with energy related parameters
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Apart from energy related information, health related aspects should be addressed

ID	FMB -04
Des	Facility managers are willing to receive information about **occupants profiles** and **user preferences** as a main innovation of the tool
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Apart from energy related information, occupants operational patterns is an extra feature for the application

ID	FMB -05
Des	Along with real time and model data, **short term prediction** of context parameters will further facilitate the optimization process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	Short term prediction of context parameters (e.g. occupancy prediction) will enable the selection of appropriate control strategies

ID	FMB -06
Des	Facility managers should be able to retrieve **real time and historical information** for building operation on different **time granularity**
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Different types of time granularity is a requirement for the platform

ID	FMB -07
Des	Facility managers should get a detailed BIM planning to enable the analysis on different **spatial granularity** (individual zones/ aggregated zones)
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Apart from temporal granularity, spatial granularity should be ensured

ID	FMB-08
Des	Facility Managers must be able to **set and configure preferences** for specific building operations (tariff policies, operational modes etc.)
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Facility Managers to set high level parameters that affect BMS operation

ID	FMB -09
Des	Facility Managers may have the option to **directly trigger control actions**

	to specific devices (set point settings, dimming level etc...)
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Apart from high level control strategies, direct control settings is a typical functionality supported by BMS tools

ID	FMB -10
Des	Facility Managers should be provided with **alternative control strategies** to further select the optimal strategy
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	A simulation engine should provide different alternatives to ESCOs for optimal building management

ID	FMB -11
Des	Facility Managers should be provided with **alternative options/modes** for implementing automated control strategies
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	Different optimization modes should be defined to set the goal for optimization process (sustainable, cost efficient, comfort model)

ID	FMB -12
Des	Facility Managers should get **alarms** related to deviations during real time operation of building
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	Triggering alarms in abnormal situations is an add-on feature to be provided by the BMS tool

ID	FMB -13
Des	Facility Managers should support building operation in a **fully automated way** where the optimal control strategies will be automatically selected.
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	The goal of the MOEEBIUS is to provide a fully automated platform, without requiring manual interaction of FM with the platform

ID	FMB -14
Des	Facility Managers should get informed about the **operational mode** of the building, even during automation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Even in automated mode, an operational mode (e.g. energy efficiency, sustainability) will trigger the control process

ID	FMB -15
Des	An **integrated FM tool** should take into account the facility managers settings for implementation of building level control strategies
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Along with automation process, the facility managers will be able to interact with the platform. Thus a hybrid approach should be considered.

ID	FMB -16
Des	The **evaluation** of implemented control strategies should be delivered under **different performance criteria** (taking into account the operational model selected)
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	The evaluation of automated control strategies should be delivered taking into account the operational mode in premises

We have extensively highlighted through the requirements analysis the need to provide a tool that will enable us to perform energy performance simulations. Therefore, we extract a list of requirements for this specific engine of ESCO DSS tool.

ID	BEPS -01
Des	The BEPS tool should be an **extended version of already commercial solutions**, incorporating during simulation process heterogeneous aspects.
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	BIM parameters, weather conditions and financial parameters should be incorporated in the BEPS tool

ID	BEPS -02
Des	Facility managers should be able to proceed with Building simulation scenarios taking into account also batches of **real building conditions**

Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Periodical access on real building data –operational data - towards a more accurate building simulation process

ID	BEPS -03
Des	Facility managers should be interested to get updated and **accurate DER** (HVAC and lighting) **models** to be incorporated in simulation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	DER models continuously updated taking into account operational building characteristics

ID	BEPS -04
Des	Facility managers should be interested to incorporate **health related parameters** along with energy related parameters as part of the simulation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	Health related parameters and indicators to be examined as part of building simulation process

ID	BEPS -05
Des	Facility managers requirement to consider updated **occupant profiles** and **user preferences** during simulation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	Accurate extraction of occupancy and activity profiles to be further incorporated in simulation process

ID	BEPS -06
Des	Along with real time and model data, **mid-term prediction** of context parameters will further enable more accurate simulations
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Low
Comments	Short term prediction of context parameters (e.g. occupancy prediction) will facilitate building energy performance simulation process

ID	BEPS-07

Des	Facility Managers must be able to **set and configure parameters** during simulation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	Facility managers to set the input parameters for building energy performance simulation process

ID	BEPS -08
Des	Facility Managers should be able to define **alternative control strategies / high level objectives** on simulation process
Class	Facility Manager DSS
Type	Functional Requirement
Priority	High
Comments	A simulation will be performed as a high level optimization process triggered by the Facility manager/ ESCO

ID	BEPS -09
Des	Facility Managers should perform **a comparative analysis** among real time and simulation towards the evaluation of results from simulation engine
Class	Facility Manager DSS
Type	Functional Requirement
Priority	Medium
Comments	A-posteri evaluation of simulation engine by comparing real time vs. simulation engine data

The aforementioned analysis presented the core aspects to be covered by a building simulation engine. Special focus should be delivered also on the presentation of BEPS analysis results. Therefore, a common set of presentation requirements, defined for the whole list of Facility Manager/ ESCO applications, is provided in these following sections.

8.2.2.2 Predictive Maintenance Engine

The list of end users and business requirements for predictive maintenance application, as an add-on application for Facility Manager/ ESCOs DSS, is presented

ID	PME-01
Des	End-users will be informed about the **optimal predictive maintenance plan** to follow
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	The tool should provide the mechanism for the extraction of optimal predictive maintenance plan

ID	PME-02
Des	The selection of optimal **predictive maintenance** strategy will follow the **evaluation of different alternative plans**
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	A simulation engine should generate different predictive maintenance plans and from them, the DSS tool will selection the optimal case

ID	PME-03
Des	The selection of predictive maintenance plan should take into account all **building parameters** (BIM elements, energy and context conditions) retrieved
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	The selection of predictive maintenance plan should be customized on the specific building parameters (static and dynamic fimbriation)

ID	PME-04
Des	The selection of predictive maintenance plan should take into account also **health related parameters** as retrieved from building premises.
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	Apart from energy and context parameters, health related metrics should be taken into account for the selection of optimal maintenance plan

ID	PME-05
Des	The selection of predictive maintenance plan should take into account also **occupancy patterns** as retrieved from building premises.
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	Medium
Comments	Apart from building and health parameters, occupancy related metrics should be taken into account for the selection of optimal maintenance plan

ID	PME-06
Des	The predictive maintenance analysis should take into account the results from a **simulation tool** in order to evaluate the midterm activity plan
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	The simulation engine will periodically evaluate the performance of a maintenance plan.

ID	PME-07
Des	The predictive maintenance analysis should take into account the **real time building conditions** towards the actual implementation of a maintenance plan
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	Medium
Comments	Apart from simulation analysis engine, real time building conditions should be considered prior to the selection of optimal maintenance plan

ID	PME-08
Des	The main interest for predictive maintenance is delivered on **HVAC units** which are the most typical devices for maintenance activities
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	The requirement analysis phase highlighted HVAC units as the core units to be addressed during the maintenance management process

ID	PME-09
Des	The overall analysis should take into account **financial parameters** as the cost of maintenance activity is high
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	As part of simulation process for the selection of optimal maintenance strategy, we have to take into account the cost of maintenance process

ID	PME-10
Des	ESCOs should be able to **set and configure parameters** for the evaluation of different predictive maintenance alternative plans
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	Medium
Comments	The maintenance tool should accept user configurations. Thus a hybrid tool should be provided (automated selection of optimal maintenance strategies though ESCO managers may interact with the tool)

ID	PME-11
Des	When deviations from normal operation, **alarms** should be triggered to the maintenance responsible parties
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	Medium
Comments	Triggering events in case of abnormal situations is an add on feature for maintenance tool

ID	PME-12
Des	A list of **recommended actions** to prioritize work of servicemen and technicians when maintaining the building systems will be provided
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	The triggering events should be **recommended actions** towards the prompt implementation of the maintenance plan

ID	PME-13
Des	The **evaluation of maintenance plan** should take into account energy, environmental, business and health KPIs
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	Multiple domain indicators should be considered for the evaluation of the selected maintenance plan (in line with the input parameters for the selection of maintenance plan)

ID	PME-14
Des	An **integrated FM tool** should take into account the selection of optimal predictive maintenance plans for implementation of building level control strategies
Class	Predictive Maintenance Engine
Type	Functional Requirement
Priority	High
Comments	An integration of real time automation and predictive maintenance tools should be examined as part of the MOEEBIUS holistic DSS tool

ID	PME-15
Des	Due to fusion of data from different building sources, **enriched visualization** techniques should be examined exclusively for Predictive maintenance management process
Class	Predictive Maintenance Engine
Type	Presentation Requirement
Priority	High
Comments	Enriched visualization techniques (3D tool) for predictive maintenance tool, moving towards augmented reality era

8.2.2.3 Retrofitting Advisory System

The list of end users and business requirements for Retrofitting Advisory tool of FM/ESCO tool is presented:

ID	RAS-01
Des	End-users will be informed about the **optimal Retrofitting strategy** to follow
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	The tool should provide the mechanism for the extraction of optimal Retrofitting strategy

ID	RAS-02
Des	The selection of optimal Retrofitting strategy will follow the **evaluation of different alternatives**
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	The simulation engine should evaluate different alternatives towards the selection of optima retrofitting plan

ID	RAS-03
Des	The retrofitting selection process should take into account **building parameters** (BIM elements, energy and context conditions)
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	The simulation engine should take into account real time and static conditions for the provision of accurate retrofitting plans

ID	RAS-04
Des	The retrofitting selection process should specially take into account the operation of **HVAC units** and the overall **façade** of the building as the core parameters highlighted
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	The core parameters to be evaluated towards the implementation of a retrofiring activities: HVAC units and building façade

ID	RAS-05
Des	The retrofitting selection process should specially take into account **occupancy patterns** and **health parameters** towards the selection of optimal retrofitting strategy
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	Low
Comments	The simulation engine should take into account occupancy model data and health metrics towards the selection of optimal retrofitting strategy

ID	RAS-06
Des	The retrofitting selection process should be based on the **results of a BEPS tool** to further evaluate the impact of this plan
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	The selection of the optimal retrofitting plan should be based on the results from a building simulation engine, able to perform macro scale analysis

ID	RAS-07
Des	The retrofitting selection process should be based on **real time data** from building premises
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	Medium
Comments	The selection of the optimal retrofitting plan should take also into account real time building conditions in building premises

ID	RAS-08
Des	Along with the building technical parameters, economical aspects should also be addressed during the retrofitting analysis, as the **cost of investment** is a critical parameter for the optimal decision
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	For retrofitting activities, the cost is a main parameters and thus we need to integrate this parameter as part of the selection process

ID	RAS-09
Des	ESCOs should be able to **set and configure parameters** for the evaluation of different retrofitting strategies
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	Though the tool should propose optimal retrofitting strategies, the users of the tool should be able to configure their preferences and settings

ID	RAS-10
Des	The **evaluation** of **retrofitting plans** should be performed through different indicator types: energy, context, environmental and health KPIs
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High

Comments	The evaluation of retrofitting strategies should be based on specific indicators (in line with the selection of input parameters that affect the optimization process)

ID	RAS-11
Des	An **integrated FM tool** should take into account the selection of optimal retrofitting action for implementation of building level control strategies
Class	Retrofitting Advisory Tool
Type	Functional Requirement
Priority	High
Comments	As part of a holistic DSS tool we need to ensure the integration of retrofitting tool with the rest of the applications developed for ESCOs/FMs

8.2.2.4 Common application requirements

Along with the definition of requirements for the main functionalities supported by the MOEEBIUS ESCO/FM framework, some common requirements for the different applications are defined. These common requirements are mainly related to the deployment and presentation of FM tool and thus we have to ensure the fulfilment of these requirements for each of the different applications. These requirements are further presented:

ID	COM-01
Des	A **map presentation** should be examined as an option for presenting all the BIM elements of the building
Class	Facility Manager Tool
Type	Presentation Requirement
Priority	High
Comments	A typical representation for building elements is through a map view for ease access on BIM data

ID	COM-02
Des	Data must be presented in an **accessible, understandable and flexible** format that enables ESCOs to take action
Class	Facility Manager Tool
Type	Presentation Requirement
Priority	High
Comments	The data should be provided in a way, understandable by the end users of the tool

ID	COM-03
Des	The visualizations of tools used should support **different types of animation** for the representation of the main functionalities provided by the tool
Class	Facility Manager Tool
Type	Presentation Requirement

Priority	High
Comments	Different visualization techniques should be examined in order to provide a visually appealing tool

ID	COM-04
Des	Different **types of users** should be defined to get access on analytics processes
Class	Facility Manager Tool
Type	Presentation/Functional Requirement
Priority	High
Comments	Different user types should be available to ensure customized access on building data (privacy concerns)

ID	COM-05
Des	Facility Mangers/ ESCOs should be able to get access on data **remotely**
Class	Facility Manager Tool
Type	Technical Requirement
Priority	High
Comments	Remote access (Web based application) is an important feature/requirement for the DSS application

ID	COM-06
Des	Facility Mangers/ ESCOs should be able to get **access from different device types**
Class	Facility Manager Tool
Type	Technical Requirement
Priority	High
Comments	Access through desktop, tablet or a big screen

ID	COM-07
Des	A **local database** should store historical data to further enable presentation of historical information to FMs/ESCOs
Class	Facility Manager Tool
Type	Technical Requirement
Priority	High
Comments	In order to ensure a high level reliability on the service, a local database will track historical and real time data

ID	COM-08
Des	The overall development of Occupants UI should take into account the need for **consistent and reliable** access on data.
Class	Facility Manager Tool
Type	Technical Requirement
Priority	High

Comments	The overall development of the DSS application should ensure the high level of consistency and reliability

ID	COM-09
Des	The GUI provided should support **multiple languages**
Class	Facility Manager Tool
Type	Presentation Requirement
Priority	High
Comments	As we are addressing different regions during pilot testing, service localization should be ensured

8.2.3 Demand Aggregator Requirements

The main goal of this section is to provide the list of requirements related to the role of Aggregators and ESCOs as portfolio managers in the project. Here, the focus is on the provision of services for portfolio managers and therefore their feedback is differentiated from previous analysis. Again, the presentation is based on the main business services as defined through use case analysis. The list of requirements per category/business domain is presented:

8.2.3.1 Real Time Portfolio Monitoring

The role of this service is to select the optimal control strategies that best fits to portfolio management processes. This is a real time service responsible to trigger the appropriate DR commands taking into account portfolio status. The list of requirements is provided:

ID	RTPM-01
Des	Aggregators request access to **high time resolution data** to proceed with real time management of portfolio
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	Access on low level information (low time, minutes level granularity) is required to perform real time management of the portfolio

ID	RTPM-02
Des	Aggregators request access to **individual level information** to proceed with real time management of portfolio
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	Access on low level information (building level/asset level) is required to perform real time management of the portfolio

ID	RTPM-03
Des	Aggregators can **overwrite any command** provided by the system coming from any automation feature
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	The goal is not to provide a fully automated tool but to ensure that the end user of the tool may interact with the platform setting configuration parameters

ID	RTPM-04
Des	Aggregators will communicate to Prosumers **campaign** and **incentives** information about different strategies
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	Addressing the business role, the Aggregator should offer incentives for implementation of DR strategies (contractual agreements among partners)

ID	RTPM-05
Des	Aggregators will communicate **campaign** and **incentives** information to **sub groups** of consumers setting different types of filters (spatial, operational)
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	Medium
Comments	Addressing the business role, the Aggregator should offer incentives for implementation of DR strategies to groups of users based on specific criteria

ID	RTPM-06
Des	Aggregators should define **different contractual agreements** with the consumers towards the promotion of DR programmes
Class	Data Analytics Tool
Type	Functional Requirement
Priority	Medium
Comments	Different types of contractual agreements should be examined/enabled by the tool

ID	RTPM-07
Des	The tool for Aggregators should be enable its user to set and consult the **control strategy based on Context, Energy and Price** indicators automatically evaluated and applied by the System
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	The selection of control strategies should not take into account only energy data but also financial and context parameters

ID	RTPM-08
Des	The tool should have access on different types of information: **energy**, **environmental, market** for the delivery of real time portfolio management
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	Towards the selection of optimal strategies, we need to ensure access on context and market data (apart from energy data from building meters)

ID	RTPM-09
Des	The tool should take into account **real time and historical data** along with **contractual data** towards the selection of optimal control strategies
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	High
Comments	Towards the selection of optimal strategies both real time and historical data (along with static parameters) should be considered

ID	RTPM-10
Des	Aggregators may **re evaluate the performance** of a campaign in order to actively trigger corrective actions
Class	Real Time Portfolio Monitoring Engine
Type	Functional Requirement
Priority	Medium
Comments	The tool should continuously evaluate the performance of a campaign and define adaptive control actions

8.2.3.2 Data Analytics for the optimal management of portfolio

Following the definition of end users (Aggregators/ ESCos) requirements for the real time district level automation process, the review of data analytics tool related requirements is provided.

ID	DAT-01
Des	Aggregator must be able to set the **temporal**, **spatial** etc. parameter values
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	Data will different spatial and temporal granularity should be stored to handle the analytics process

ID	DAT-02
Des	Aggregators must be able to drill-down to **individual level information**
Class	Data Analytics Tool
Type	Functional Requirement

Priority	High
Comments	A building level granularity should be ensured for analytics process (no aggregation on streams of data)

ID	DAT-03
Des	Aggregators must be able to **compare different buildings** against each other over a common time period
Class	Data Analytics Tool
Type	Functional Requirement
Priority	Medium
Comments	The tool should be able to provide a comparative analysis among assets on different KPIs

ID	DAT-04
Des	Aggregators must be able to **evaluate** the impact of different **control alternatives** through interaction with the tool
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	The simulation engine should provide a functionality for evaluation of different hypothetical control strategies

ID	DAT-05
Des	Aggregators must be able to analyze the portfolio on **different segments** (Energy, Market) defined
Class	Data Analytics Tool
Type	Functional Requirement
Priority	Medium
Comments	Definition of filters of consumers based on input configuration parameters

ID	DAT-06
Des	Aggregators must be able to **define trends** in their portfolio towards the implementation of business strategies
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	Definition of trends in the portfolio under different configuration settings

ID	DAT-07
Des	Aggregators must be able to **define outliers** through trend analysis for the definition of optimal portfolio clusters
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High

Comments	Following the definition of trends, outliers on portfolio performance will be defined and will further enable the revaluation of Aggregator strategies

ID	DAT-08
Des	Aggregators must be able to **cluster** their portfolio taking into account the different energy and business characteristics of the portfolio
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	Definition of clusters of consumers based on input configuration parameters

ID	DAT-09
Des	In order to support the evaluation of different control strategies, the Aggregator Tool should host a **simulation engine** that takes into account both portfolio parameters and business settings
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	The simulation engine should take into account both energy and market data (historical data) towards the evaluation of hypothetical control strategies

ID	DAT-10
Des	The results from **simulation process** should further enable the implementation of optimal portfolio management strategies
Class	Data Analytics Tool
Type	Functional Requirement
Priority	Medium
Comments	The simulation engine will further enable the selection of optimal control strategies under real time conditions

ID	DAT-11
Des	Aggregators tool should take into account not only energy data but also **market data** for the better management of the portfolio
Class	Data Analytics Tool
Type	Functional Requirement
Priority	High
Comments	Apart from energy, market and contextual data should be stored and further handled by analytics engine

ID	DAT-12
Des	Aggregators analytics process should take into account the **continuously gathered data** from portfolio
Class	Data Analytics Tool
Type	Functional Requirement

Priority	High
Comments	The Aggregator repository will be incrementally updated with continuously gathered data from portfolio

Moving from functional/business Data Analytics Tool requirements, we need to specify also requirements related to visualization of Aggregator results. A common pool of requirements is identified for both Real Time Portfolio Monitoring and Data Analytics Tool. Thus, we present here the common subset of requirements that should be taken into account from both applications during the development process

ID	RTPM-11 & DAT-13
Des	The visualizations of Analytics tool used should support **different types of animation** for the representation of the main functionalities provided by the tool
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Presentation Requirement
Priority	High
Comments	Different visualization techniques should be integrated towards the provision of a visually appealing dashboard

ID	RTPM-12 & DAT-14
Des	A **map representation** should be considered as an option for the dashboard in order to further drill in and drill through on the analysis of the portfolio
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Presentation Requirement
Priority	High
Comments	For portfolio visualization at the main dashboard a map widget should be considered

ID	RTPM-13 & DAT -15
Des	Data must be presented in an **accessible, understandable and flexible** format that enables users to take action
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Presentation Requirement
Priority	High
Comments	The data should be understandable by the end users of the tool, Aggregator affecting in that way the selection of visualization widgets

ID	RTPM-14 & DAT-16
Des	Different **types of users** should be defined to get access on real time management and analytics processes
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Presentation/Functional Requirement
Priority	High
Comments	In order to ensure privacy and security, conditional access on tool functionalities should be ensured

ID	RTPM-15 & DAT-17
Des	Aggregators should be able to get access on data **remotely**
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Technical Requirement
Priority	High
Comments	Remote access is a feature requested by the users of the tool (Web based application)

ID	RTPM-16 & DAT-18
Des	A **local database** should store historical data to further enable presentation of historical information to Aggregators/ESCOs
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Technical Requirement
Priority	High
Comments	In order to ensure high level reliability on application, a local database should host the data required by Aggregator application

ID	RTPM-17 & DAT-19
Des	The overall development of UI should take into account the need for **consistent and reliable** access on data.
Class	Real Time Portfolio Monitoring / Data Analytics Tool
Type	Technical Requirement
Priority	High
Comments	The overall development of application should be delivered in a way to ensure high level of consistency and reliability

8.2.4 Pilot Specific Requirements

The previous analysis highlights the list of requirements as derived from questionnaires review and consortium partners' contribution. We have addressed end users' (stakeholders) specific needs taking also into account the business perspective of MOEEBIUS project implementation.

As a parallel activity though, we need to examine the regulatory and legal barriers imposed in the different pilot sites of the project towards the extraction of pilot specific requirements. The analysis here is not focusing on the detailed presentation of each region regulatory and legal framework (this work is delivered in D2.2 through market analysis and D7.3 through Ex-Ante Pilots Analysis), rather on the presentation of the list of pilot requirements that derived from this analysis. The presentation is delivered for each of the three pilot sites of the project.

8.2.4.1 U.K. Pilot Site

The main infrastructure contribution of KIWI in the MOEEBIUS project will be the UK pilot site, which will comprise four diverse buildings, namely:

- The Marriott County Hall, a hotel located in Central London. The building was originally constructed in 1939 and an additional wing was added in 1974. The building has 6 stories. It relies purely on electricity for energy and it consumers about 1300 MWh annually. A selection from hotel areas will be considered in the project.
- Two retail store buildings located in central London. This a specific use case of high interest in the project in order to further address specific operational loads.
- A 5-story apartment building in central London addressing also residential users as part of the pilot site.

The U.K. pilot site is the lighthouse pilot for testing and evaluating Demand Response Scenarios. Taking into account the diversity of building types and the special requirements extracted from UK legislation (mainly for Demand Response Implementation) the list of pilot specific requirements is provided:

ID	UK_01
Des	Due to the type of pilot building premises (hotel premises), the minimum of modifications in building infrastructures should be ensured
Class	Building 1: Marriot Hotel
Type	Pilot specific requirement
Priority	High
Comments	The installation of sensors equipment will be placed in areas where permanent staff is operating

ID	UK_02
Des	Due to the type of pilot building premises (hotel premises), the minimum of occupants disturbance should be ensured
Class	Building 1: Marriot Hotel
Type	Pilot specific requirement
Priority	High
Comments	Special focus on the extraction of occupancy and activity profiles in order to fully preserve end users preferences

ID	UK_03
Des	The installation of innovative MOEEBIUS solution (NOD) should be examined for hotel premises
Class	Building 1: Marriot Hotel
Type	Pilot specific requirement
Priority	High
Comments	This is one of the main innovations of the project, with high willingness to examine this in hotel premises

ID	UK_04
Des	Special interest for HVAC optimal management as one of the highly

	consuming load type in hotel premises
Class	Building 1: Marriot Hotel
Type	Pilot specific requirement
Priority	High
Comments	HVAC energy consumption is high and thus special focus should be delivered on mitigating this cost.

ID	UK_05
Des	Due to the type of pilot building premises (retailer store), the design of UI tool should take into account the lack of end users experience in the domain
Class	Building 2: Retailer store
Type	Pilot specific requirement
Priority	Medium
Comments	The end users of the tool are not familiar with the domain and thus we have to provide a simplified version of the tool

ID	UK_06
Des	MOEEBIUS should share with the personnel, energy related information in order to raise awareness
Class	Building 2: Retailer store
Type	Pilot specific requirement
Priority	Medium
Comments	The information about project MOEEBIUS should be shared with the personnel in order to raise awareness for energy efficiency activities.

ID	UK_07
Des	Due to the type of pilot building premises (retailer stores), the minimum of modifications in building infrastructures should be ensured
Class	Building 2: Retailer store
Type	Pilot specific requirement
Priority	High
Comments	The installation of sensors equipment will be placed in a way to ensure the minimum of pilot areas modification

ID	UK_08
Des	Instillation of sensors/equipment in residential buildings flats / private areas needs to be approved by all flat owners.
Class	Building 3: Residential Premises
Type	Pilot specific requirement
Priority	High
Comments	In order to proceed with any type of installation in private areas, approval from flat owners should be provided.

ID	UK_09
Des	The active participation of end users (residential user) in MOEEBIUS activities will be ensured by defining business models with direct benefit for them
Class	Building 3: Residential Premises
Type	Pilot specific requirement
Priority	High
Comments	We need to define market models that provide actual (and significant) benefit for the end users of MOEEBIUS tools

ID	UK_10
Des	Client dashboard cannot be access remotely due to IT security policies in place and potential risk to the building systems
Class	Building 3: Residential Premises
Type	Pilot specific requirement
Priority	High
Comments	We need to ensure security on data and thus the residential users will not have access on data remotely

ID	UK_11
Des	The definition of tariff policies should take into account the current market legislation about retailer tariff schemas
Class	UK Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	The implementation of dynamic pricing models should take into account the available market approaches

ID	UK_12
Des	The definition of demand response scenarios for UK pilot site should take into account the current legislation promoted by nationalgrid
Class	UK Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	The implementation of demand response scenario that actually fit to current legislation as defined by nationalgrid

ID	UK_13
Des	Equipment response time – between 2s and 30s for specific Frequency Response programmes
Class	UK Pilot sites
Type	Pilot specific requirement

Priority	Medium
Comments	The implementation of demand response scenarios related to Frequency Response programmes should follow the guidelines defined by Nationalgrid

ID	UK_14
Des	The remuneration about DR participation should be aligned with the current market models for Demand Response
Class	UK Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	The different market policies about Demand Response should take into account the commercial market models

ID	UK_15
Des	The implementation of project activities should take into account the Decree-Law 118/2013 of August 20th which defines the SCE (Building Energy Certification System), more specifically the RECS (Regulation of Energy Performance of Commercial and Services Buildings).
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Decree-Law 118/2013 of August 20th which defines the SCE (Building Energy Certification System)

ID	UK_16
Des	Due to the type of buildings examined in the project, non-intrusive equipment installations should be ensured
Class	UK Pilot sites
Type	Pilot specific requirement
Priority	Medium
Comments	The installation of sensors and actuators should fully preserve the building operational characteristics

ID	UK_17
Des	Due to the type of buildings examined in the project, occupancy data should be extracted fully preserving the anonymity of pilot users
Class	UK Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Especially for occupancy related data, special concerns to ensure privacy and security. Occupancy data should ensure the anonymity of the users and if possible provided in an aggregated way

8.2.4.2 Portuguese Pilot Site

The PT pilot site consists of 3 buildings. The buildings span a built area of about 8000 sq.m that have an annual consumption of 535MWh of electricity and 760 MWh of natural gas. All buildings share their HVAC system which is based on district level, natural gas-fired boilers to heat water. In more detail, the pilot site will comprise:

- A complex of two educational/recreational buildings called "Complexo escolar de JI/EB da Venda do Pinheiro" and built on 2005. This building complex uses an energy mix of electricity and gas; it annually consumes about 257MWh of electricity and 760MWh of natural gas.
- The MAFRA city hall building. This building houses about 200 permanent staff and about 50 visitors on a daily basis. It is spread over four stories, each of them has 15 rooms. Apart from HVAC, all other amenities run purely on electricity and the building consumes about 277MWh annually on average.

Following the specific characteristics of pilot premises, a list of requirements is extracted. The Portuguese pilot site will lead testing and evaluation of predictive maintenance and retrofitting scenarios and thus the legislation towards the implementation of that types of services is considered for the extraction of pilot specific requirements.

ID	PT_01
Des	Due to the type of pilot building premises (kindergarten), the safety of the kids is a high priority for the PT pilot.
Class	Building 1: Primary School of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	All safety measures (or procedural changes) need to be discussed with the kindergarten administration.

ID	PT_02
Des	Due to the type of pilot building premises (kindergarten), the design of UI tool should take into account the lack of end users experience in the domain
Class	Building 1: Primary School of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	The end users of the tool are not familiar with the domain and thus we have to provide a simplified version of the tool

ID	PT_03
Des	Due to the type of pilot building premises (primary school), the sensors, actuators and measurement equipment cannot be installed in places which children have access.
Class	Building 1: Primary School of Venda do Pinheiro

Type	Pilot specific requirement
Priority	High
Comments	Specific areas of the pilot sites should be exempted from the pilot selection process

ID	PT_04
Des	Because this building does not have equipment to guarantee an adequate ventilation, special attention should be given to IAQ and ensure a suitable admission of fresh air.
Class	Building 1: Primary School of Venda do Pinheiro
Type	Pilot specific requirement
Priority	Medium
Comments	Special interest on evaluating health related parameters apart from energy related aspects

ID	PT_05
Des	Combination of real time energy consumption towards the selection of optimal retrofitting plans
Class	Building 1: Primary School of Venda do Pinheiro
Type	Pilot specific requirement
Priority	Medium
Comments	Due to almost constant utilization of hot water, special attention should be given to access energy consumption in order to analyse retrofitting the type of equipment and production system.

ID	PT_06
Des	MOEEBIUS should share with the personnel energy related information in order to raise awareness
Class	Building 1: Primary School of Venda do Pinheiro
Type	Pilot specific requirement
Priority	Medium
Comments	The information about project MOEEBIUS should be shared with the students in order to raise awareness for energy efficiency, for the school's energy performance and for the impact of their behaviour in the school's energy performance.

ID	PT_07
Des	Due to the type of pilot building premises (elementary school), the safety of the kids is a high priority for the PT pilot.
Class	Building 2: Kindergarten of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	All safety measures (or procedural changes) need to be discussed with the school administration.

ID	PT_08
Des	Due to the type of pilot building premises (elementary school), the design of UI tool should take into account the lack of end users experience in the domain
Class	Building 2: Kindergarten of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	The end users of the tool are not familiar with the domain and thus we have to provide a simplified version of the tool

ID	PT_09
Des	Due to the type of pilot building premises (kindergarten), the sensors, actuators and measurement equipment cannot be installed in places which children have access.
Class	Building 2: Kindergarten of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	Specific areas of the pilot sites should be exempted from the pilot selection process

ID	PT_10
Des	Because this building does not have equipment to guarantee an adequate ventilation, the special interest of this pilot site is on IAQ and in ensuring a suitable admission of fresh air.
Class	Building 2: Kindergarten of Venda do Pinheiro
Type	Pilot specific requirement
Priority	High
Comments	Special interest on evaluating health related parameters apart from energy related aspects

ID	PT_11
Des	Combination of real time energy consumption towards the selection of optimal retrofitting plans
Class	Building 2: Kindergarten of Venda do Pinheiro
Type	Pilot specific requirement
Priority	Medium
Comments	Due to almost constant utilization of hot water, special attention should be given to access energy consumption in order to analyse retrofitting the type of equipment and production system.

ID	PT_12
Des	Because the City Hall has public attendance services, ensuring the quality of the service is a high priority for the PT pilot.
Class	Building 3: City Hall of Mafra
Type	Pilot specific requirement
Priority	High

Comments	This is the lighthouse PT pilot site and thus we have to ensure high quality of services to end users

ID	PT_13
Des	As different types of users interact with the system, classified access on data should be ensured
Class	Building 3: City Hall of Mafra
Type	Pilot specific requirement
Priority	Medium
Comments	Different types of users will interact with the platform, and thus classified access to the data should be ensured

ID	PT_14
Des	Due to the high costs about HVAC units operation, special interest of this pilot site on the optimal management of this type of device
Class	Building 3: City Hall of Mafra
Type	Pilot specific requirement
Priority	Medium
Comments	We highlight HVAC as the device type of interest but the project should address also additional device types, defined above in the core system functionalities

ID	PT_15
Des	Special interest for this pilot site is foreseen for retrofitting activities of the MOEEBIUS project
Class	Building 3: City Hall of Mafra
Type	Pilot specific requirement
Priority	Medium
Comments	Taking into account the current building status, the interest of the pilot owners is on retrofitting planning and activities

ID	PT_16
Des	Because the building is open to the public, we should use this opportunity to share with the public information about the results achieved with MOEEBIUS project.
Class	Building 3: City Hall of Mafra
Type	Pilot specific requirement
Priority	Medium
Comments	Information about MOEEBIUS platform operation should be available to wider public

ID	PT_17
Des	The definition of tariff policies should take into account the current market legislation about retailer tariff schemas
Class	PT Pilot sites

Type	Pilot specific requirement
Priority	High
Comments	The implementation of dynamic pricing models should take into account the available market approaches

ID	PT_18
Des	The implementation of project activities should take into account the Decree-Law 118/2013 of August 20th which defines the SCE (Building Energy Certification System), more specifically the RECS (Regulation of Energy Performance of Commercial and Services Buildings).
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Decree-Law 118/2013 of August 20th which defines the SCE (Building Energy Certification System)

ID	PT_19
Des	The implementation of project activities should take into account the aspects defined in Decree-Law 68-A/2015 of April 30th on energy efficiency and on the application of ECO.AP (Programme for Energy Efficiency in the Public Buildings) in local and regional administration.
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Decree-Law 68-A/2015 of April 30th on energy efficiency and on the application of ECO.AP

ID	PT_20
Des	The implementation of project activities should take into account the aspects defined in Ministerial Order 353-A/2013 of December 4th on ventilation and IAQ requirements for the RECS.
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Ministerial Order 353-A/2013 of December 4th on ventilation and IAQ requirements for the RECS

ID	PT_21
Des	The implementation of project activities should take into account the ethical aspects defined in Law 67/98 of October 26th on personal data protection and regarding the CNDP (National Commission for Data Protection in Portugal).
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Law 67/98 of October 26th on personal data protection and regarding the

	CNDP (National Commission for Data Protection in Portugal).

ID	PT_22
Des	Due to the type of buildings examined in the project, non-intrusive equipment installations should be ensured
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	Medium
Comments	The installation of sensors and actuators should fully preserve the building operational characteristics

ID	PT_23
Des	Due to the type of buildings examined in the project, occupancy data should be extracted fully preserving the anonymity of pilot users
Class	PT Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Especially for occupancy related data, special concerns to ensure privacy and security. Occupancy data should ensure the anonymity of the users and if possible provided in an aggregated way

8.2.4.3 Serbian Pilot Site

Different types of buildings consist of the Serbian Pilot site. An entire district which includes 48 diverse - functionally and operationally – buildings that have a built area of 434.000 sq.m and an annual electricity consumption of 12.400 MWh comprises a pilot zone of the project. A specific number of premises will be selected for the pilot site. Additionally, the pilot site includes additional buildings with an educational, recreational or commercial purpose.

The first educational building is the primary school "Dragan Lukic", situated in the "Bezanijska Kosa" neighbourhood in the city of Belgrade. The building has 3 floors, including the ground floor, and its total area is 7.242,60 sq.m. Another educational & recreational building is the primary school "Danilo Kis", situated in the "Stepa Stepanovic" neighbourhood in the city of Belgrade. The school employs 50 individuals. Its structure is designed as one unit with basement, ground floor and 2 stories. The last educational building is the combined children facility "Mala Sirena", situated in the "Stepa Stepanovic" neighbourhood of the city of Belgrade. The total built area is 2.468,23 sq.m distributed in two floors.

The Serbian pilot site will lead the evaluation of real time automation process. As we incorporate occupancy related parameters in the MOEEBIUS framework, possible ethical issues as derived from local legal legislation are specified through the list of requirements.

ID	SB_01
Des	Due to the type of pilot building premises, the safety of the kids is a high priority for the Serbian pilot.
Class	Kindergarten of Stepa Stepanovic
Type	Pilot specific requirement
Priority	High
Comments	All safety measures (or procedural changes) need to be discussed with the kindergarten administration

ID	SB_02
Des	Due to the type of pilot building premises , the design of UI tool should take into account the lack of end users experience in the domain
Class	Kindergarten of Stepa Stepanovic
Type	Pilot specific requirement
Priority	High
Comments	Information should be available in a simplified way, considering the lack of experience on concepts addressed by MOEEBIUS.

ID	SB_03
Des	Due to the type of pilot building premises (Kindergarten school), the sensors, actuators and measurement equipment cannot be installed in places which children have access.
Class	Kindergarten of Stepa Stepanovic
Type	Pilot specific requirement
Priority	High
Comments	Specific areas of the pilot sites should be exempted from the pilot selection process

ID	SB_04
Des	Due to the type of pilot building premises, the safety of the kids is a high priority for the Serbian pilot.
Class	Elementary School of Stepa Stepanovic & Elementary School of Dragan Lukic
Type	Pilot specific requirement
Priority	High
Comments	All safety measures (or procedural changes) need to be discussed with the school administration.

ID	SB_05
Des	Due to the type of pilot building premises , the design of UI tool should take

	into account the lack of end users experience in the domain
Class	Elementary School of Stepa Stepanovic & Elementary School of Dragan Lukic
Type	Pilot specific requirement
Priority	High
Comments	Information should be available in a simplified way, considering the lack of experience on concepts addressed by MOEEBIUS.

ID	SB_06
Des	Due to the type of pilot building premises (primary school), the sensors, actuators and measurement equipment cannot be installed in places which children have access.
Class	Elementary School of Stepa Stepanovic & Elementary School of Dragan Lukic
Type	Pilot specific requirement
Priority	High
Comments	Specific areas of the pilot sites should be exempted from the pilot selection process

ID	SB_07
Des	Instillation of sensors/equipment in residential buildings flats / private areas needs to be approved by all flat owners.
Class	Residential Premises
Type	Pilot specific requirement
Priority	High
Comments	In order to proceed with any type of installation in private areas, approval from flat owners should be provided.

ID	SB_08
Des	Instillation of sensors/equipment in residential buildings common areas (hallways, stairs, basement …) – needs to be approved by house assembly.
Class	Residential Premises
Type	Pilot specific requirement
Priority	High
Comments	In order to proceed with any type of installation in common areas, approval from house assembly should be provided.

ID	SB_09
Des	Due to the high costs about HVAC units operation, special interest of this

	pilot site on the optimal management of this type of device
Class	SB_ Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Special focus should be delivered on the prompt management of HVAC device types

ID	SB_10
Des	The definition of tariff policies should take into account the current market legislation about retailer tariff schemas
Class	SB_ Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	The implementation of dynamic pricing models should take into account the available market approaches

ID	SB_11
Des	Due to the type of buildings examined in the project, non-intrusive equipment installations should be ensured
Class	SB_ Pilot sites
Type	Pilot specific requirement
Priority	Medium
Comments	The installation of sensors and actuators should fully preserve the building operational characteristics

ID	SB_12
Des	Due to the type of buildings examined in the project, occupancy data should be extracted fully preserving the anonymity of pilot users
Class	SB_ Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Especially for occupancy related data, special concerns to ensure privacy and security. Occupancy data should ensure the anonymity of the users and if possible provided in an aggregated way

ID	SB_13
Des	The implementation of MOEEBIUS activities in pilot sites should be aligned with Serbian Law on Personal Data Protection (“New Law”) came into effect on 4 November 2008 and is applied since 1 January 2009
Class	SB_ Pilot sites
Type	Pilot specific requirement
Priority	High
Comments	Personal data is defined very extensively, namely all information relating to a natural person, irrespective of its form or the medium in which it is kept, is considered as personal data and is subject to the New Law

The aforementioned analysis defines pilot specific requirements, taking into account legislative and ethical aspects. We have to point out that the final list of pilot requirements will be extracted through pilot site ex-ante analysis (D7.1) and the final selection of buildings to be considered for the pilot evaluation of MOEEBIUS framework. The updated list of pilot specific requirements will be reported in D2.4 as part of the list of non-functional requirements.

8.3 Summary

A total number of 167 requirements was defined during this period after consultation with the main business stakeholders of the project. In order to organize this work, we proceed with a taxonomy of these requirements presentation on the main stakeholders of MOEEBIUS framework and further on the business domains examined in the project. Special focus is delivered on the extraction of pilot specific requirements addressing also ethical and legislation related aspects. This analysis is in line with the task objectives for the definition of end users and business requirements. We have to point out that this taxonomy, will further enable the taxonomy of requirements per component in T2.4 towards the final delivery of MOEEBIUS framework functional and non-functional requirements.

9 Conclusions

As a first step towards achieving the goals of MOEEBIUS project, deliverable D2.1 provided a thorough description of business scenarios, use cases and system requirements tailored to its envisioned outcomes. D2.1. is an outcome of Task T2.1 that initially defined business scenarios and technical use cases, towards the final definition of end users and business requirements.

To facilitate the realization of project outcomes, an initial consultation with MOEEBIUS pilot representatives enables the definition of high level business objectives of the project. These business cases are further transformed to meaningful use cases that will further lead the development of the respective components that consist of MOEEBIUS framework. A total number of 5 high level business scenarios is defined addressing the main project domains:

- Real-time building performance optimization towards the establishment of a sustainable environment
- Active Participation in Demand Response Schemas through the optimal management of buildings' portfolio
- Optimized Predictive maintenance diagnostics and decision making tool to ensure high levels of business performance
- Optimized retrofitting decision making on the basis of improved and accurate LCA/ LCC-based performance predictions
- Holistic DSS towards the establishment of a sustainable building level and district level environment

Then, starting from business cases a total number of 11 technical use cases is extracted after consultation with consortium and living lab members. By defining the overall field for project implementation, a series of questionnaires (for building occupants, facility managers, maintenance companies, retrofitting advisors, Aggregator) are circulated to the MOEEBIUS system stakeholders in order to further receive their feedback about the different systems and functionalities developed in the project.

Questionnaires analysis results further enabled us to define the list of end users requirements, classified to the specific business domains examined in the project. The total number of requirements defined during this phase of the project is 167. In order to prioritize the list of requirements, we have defined requirements of different classes taking into account the taxonomy addressed in the project. In addition, a priority level is considered for each specific requirement to highlight the MOEEBIUS project primary goals.

To sum up, this deliverable has provided a description of business scenarios, use cases and requirements through an iterative process in order to achieve MOEEBIUS vision. This analysis will set the basis for the detailed definition of system requirements along with the extraction of main system components in

T2.4. We have to point out also that although these requirements constitute the fundamental elements for the realization of project use cases in pilot sites, the context of this deliverable is not restricted to the project demonstration sites. The goal of the project is to provide a framework, generic enough that can be easily adopted in other sites and thus this document could stand as a living document that defines the high level priorities of business stakeholders related to building management process.

10 References

[1] MOEEBIUS DoA, 680517, European Commission, 2015

[2] Nigel Mathers, Surveys and Questionnaires, University of Sheffield, 2007.

[3] Gerald Kotonya and Ian Sommerville: Requirements Engineering, John Wiley & Sons, 1997.

[4] Scott W. Ambler: Agile Modeling, John Wiley & Sons, 2001.

11 Annex I

The template for the description of **MOEEBIUS Use Cases** is provided. We highlight the different fields of the template

MOEEBIUS Use Case - ID	
Functional Description	
UC ID	Unique ID of Use Case
Use Case Name	Name of the Use Cases
Related Business Scenario	Associated Business Scenario
Description(narrative)	A short description, highlighting the business perspective of the use case taking into account MOEEBIUS project main objectives.
Pre - conditions	A short description of the main prerequisites for the implementation of the use case. Input parameters and settings are described.
Involved Stakeholders	The main business actors considered for the use case.
MOEEBIUS Components Involved	The selection from the pool of high level components. This definition will further enable the selection of the core functional components that consist of the MOEEBIUS framework (Task 2.4)
Use Case Path	A short workflow description about the use case. The main steps are defined in order to further enable the extraction of information flows in the definition of MOEEBIUS reference architecture (Task 3.1).
Post Condition	Each use case is associated with a specific functionality. Therefor the goal of this field is to describe how this functionality will be further exploited by the rest of the platform.
Realization Description	
Leading Partner	The consortium partners that are closely involved in the definition of associated functionalities and the development of the respective system elements
Contributing Partners	The partners that will further support the leading partners on the definition of associated functionalities and the development of the respective system elements. In addition, the lighthouse pilots that will extensively test the respective functionalities in pilots.
Priority	The priority level of the use case

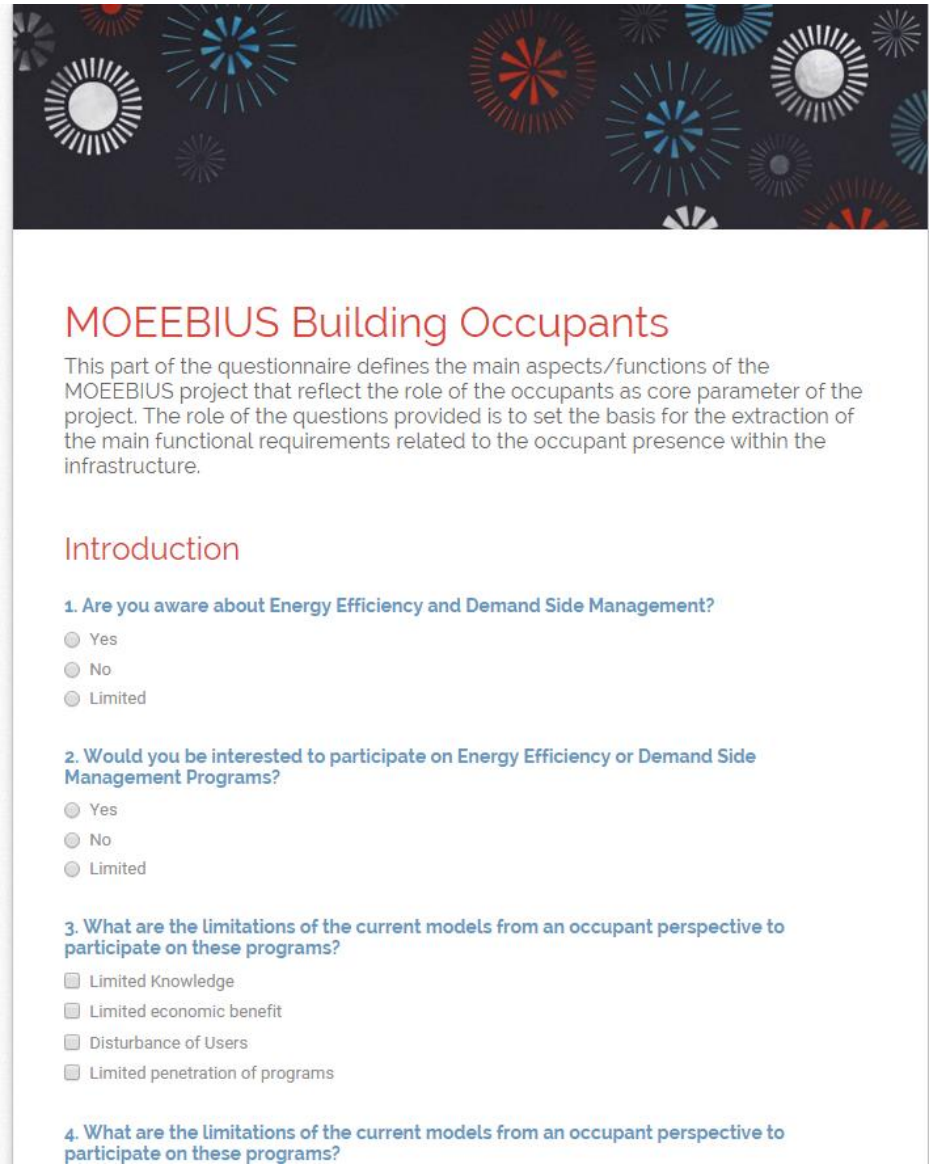
Table 17: MOEEBIUS Use Case Template

12 Annex II

A list of questionnaires were prepared to gather feedback from MOEEBIUS project stakeholders. Therefore, different types of google forms were circulated to get their feedback. The templates of the different version of questionnaires prepared are provided

12.1 Building Occupants' Questionnaire Template

This is a short questionnaire, focusing on the specific role of occupants in the project. The main objective is to ensure the minimum of end users disturbance.



MOEEBIUS Building Occupants

This part of the questionnaire defines the main aspects/functions of the MOEEBIUS project that reflect the role of the occupants as core parameter of the project. The role of the questions provided is to set the basis for the extraction of the main functional requirements related to the occupant presence within the infrastructure.

Introduction

1. Are you aware about Energy Efficiency and Demand Side Management?

- Yes
- No
- Limited

2. Would you be interested to participate on Energy Efficiency or Demand Side Management Programs?

- Yes
- No
- Limited

3. What are the limitations of the current models from an occupant perspective to participate on these programs?

- Limited Knowledge
- Limited economic benefit
- Disturbance of Users
- Limited penetration of programs

4. What are the limitations of the current models from an occupant perspective to participate on these programs?

Figure 9 Building Occupants' Questionnaire Template

12.2 Facility Managers Questionnaire Template

This is the most comprehensive template, as the FM is the main system stakeholder and provided with additional functionalities. The screenshot of the Questionnaire Template is provided:

MOEEBIUS Facility Manager& ESCO Questionnaire

The following template is aimed at gathering information to enrich the MOEEBIUS use cases, focusing on the extraction of requirements from facility managers and ESCOs

Introduction

1. Do you use Building Management System (B.M.S.) tool?

- ○ Yes
- ○ No

2. For what reason do you use BMS tools?

- ☐ Energy Efficiency
- ☐ Economic Benefit
- ☐ Security issues
- ☐ Abnormal Situation Management / Alarms
- ☐ Central Administration
- ☐ Αλλο:

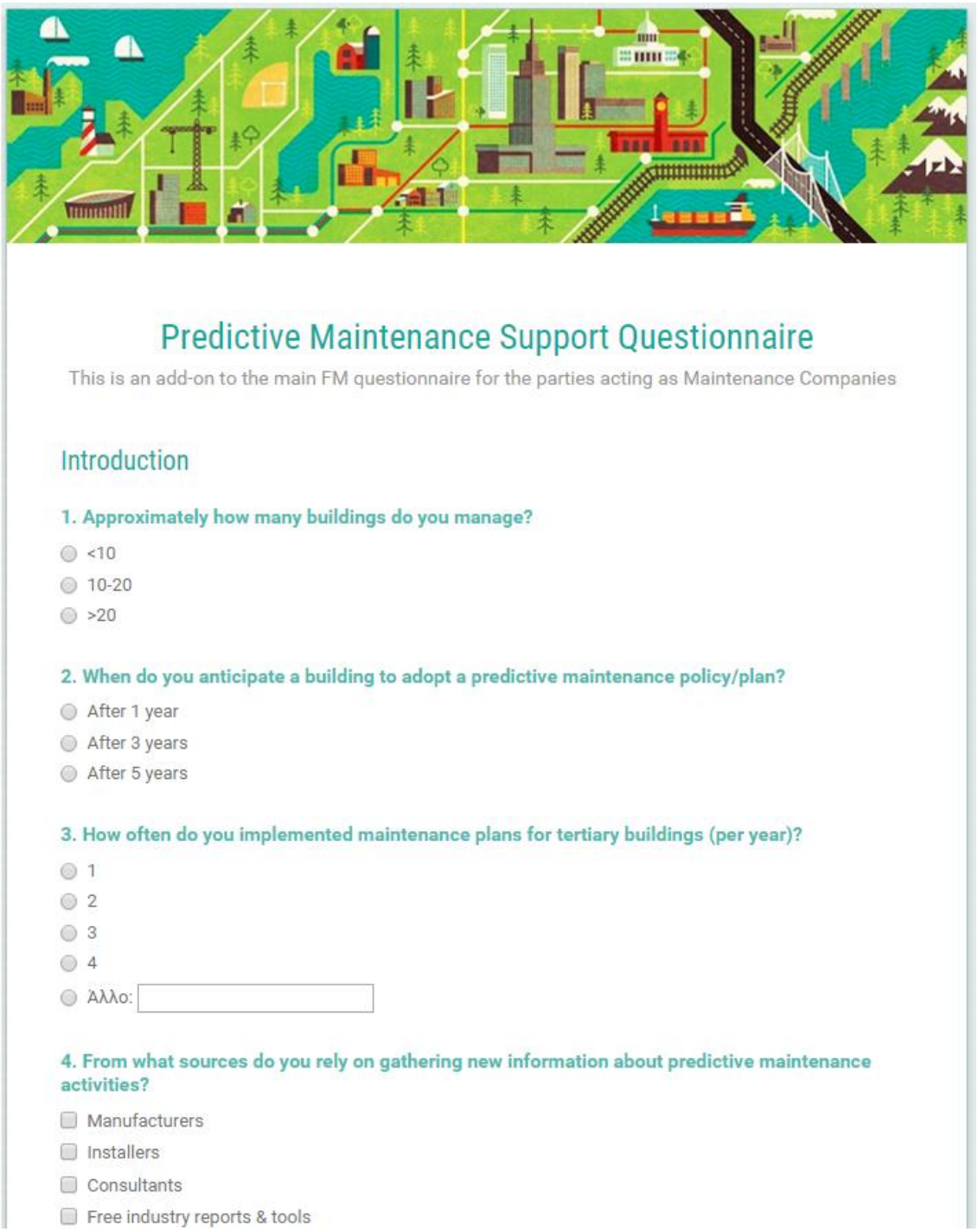
3. What are the limitations of the current tools from a user perspective?

- ☐ Require extensive input and knowledge
- ☐ Complicated and time consuming
- ☐ Tools do not provide alternative solutions
- ☐ Are designed for well-trained users
- ☐ Limited functionality
- ☐ Out-dated/needs constant upgrades

Figure 10 Facility Managers Questionnaire Template

12.3 Predictive Maintenance Company Template

This is an add-on to facility managers' template, as the goal is to address the partners that act as ESCOs and provide maintenance activities. A short version of the questionnaire is provided, focusing on predictive maintenance functionalities.



Predictive Maintenance Support Questionnaire

This is an add-on to the main FM questionnaire for the parties acting as Maintenance Companies

Introduction

1. Approximately how many buildings do you manage?

- <10
- 10-20
- >20

2. When do you anticipate a building to adopt a predictive maintenance policy/plan?

- After 1 year
- After 3 years
- After 5 years

3. How often do you implemented maintenance plans for tertiary buildings (per year)?

- 1
- 2
- 3
- 4
- Άλλο:

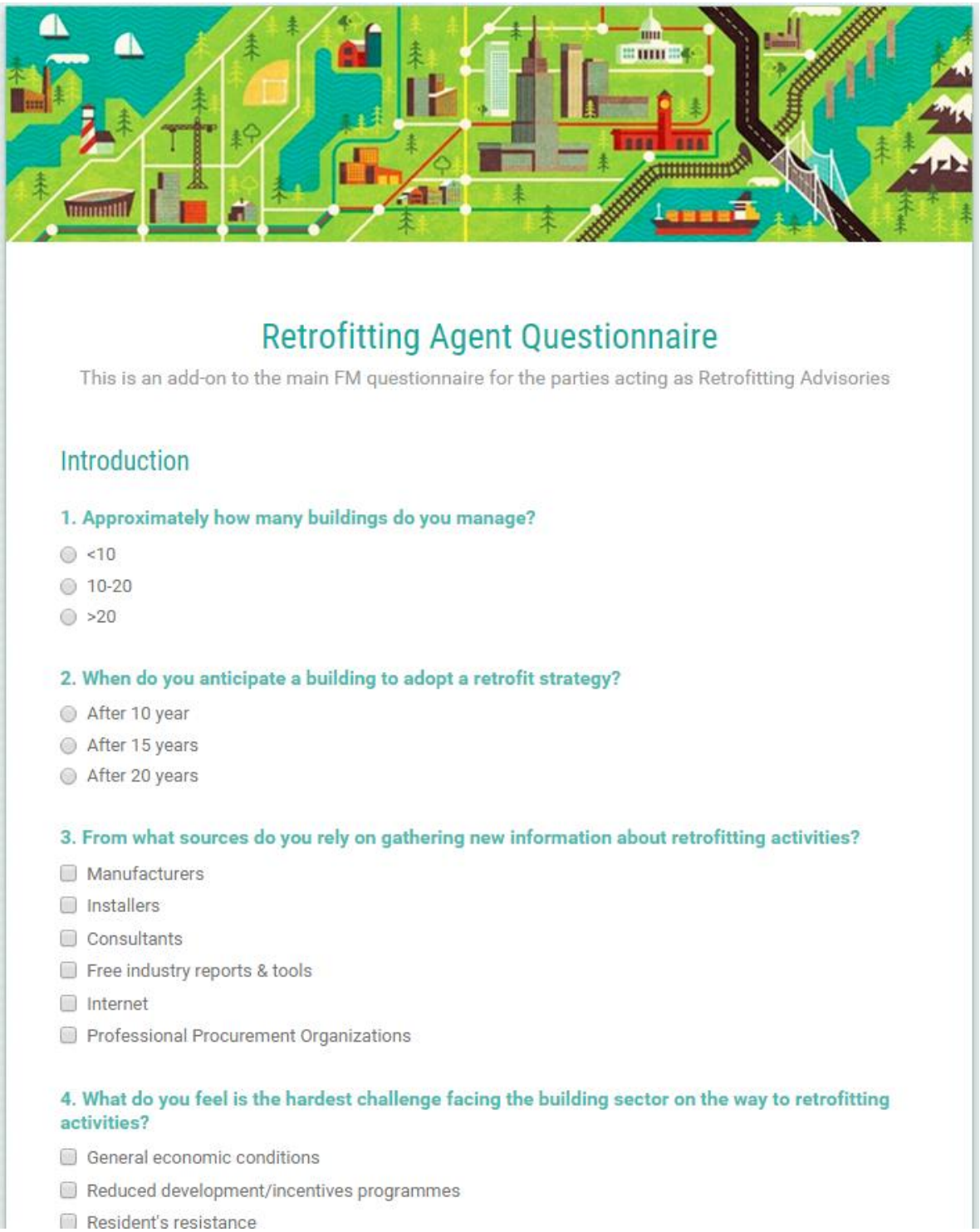
4. From what sources do you rely on gathering new information about predictive maintenance activities?

- Manufacturers
- Installers
- Consultants
- Free industry reports & tools

Figure 11 Predictive Maintenance Questionnaire Template

12.4 Retrofitting Advisor Template

This is an add-on to facility managers' template, as the goal is to address the partners that act as ESCOs and provide retrofitting advices. A short version of the questionnaire is provided, focusing on retrofitting activities functionalities.



Retrofitting Agent Questionnaire

This is an add-on to the main FM questionnaire for the parties acting as Retrofitting Advisories

Introduction

1. Approximately how many buildings do you manage?

- <10
- 10-20
- >20

2. When do you anticipate a building to adopt a retrofit strategy?

- After 10 year
- After 15 years
- After 20 years

3. From what sources do you rely on gathering new information about retrofitting activities?

- Manufacturers
- Installers
- Consultants
- Free industry reports & tools
- Internet
- Professional Procurement Organizations

4. What do you feel is the hardest challenge facing the building sector on the way to retrofitting activities?

- General economic conditions
- Reduced development/incentives programmes
- Resident's resistance

Figure 12 Retrofitting Advisor Questionnaire Template

12.5 Aggregators Questionnaire Template

This is the template for Aggregators and ESCOs responsible for the management of groups of buildings. Therefore this template is focusing on the implementation of DR strategies as the specification of DSM strategies examined in the project.

MOEEBIUS Aggregator Questionnaire

The following template is aimed at gathering information to enrich the MOEEBIUS use cases with further information on requirements related to the role of Demand Side Aggregators in the project.

Introduction

1. What is the total number of Demand Response participants in the portfolio?

2. How many Demand Response requests did you attend??

- <3
- <5
- <10
- <12
- >12

3. Total number of successful implementation of DR signals, DR activation mechanism triggered?

- <3
- <5
- <10
- <12
- >12

4. What is the total amount of power demand of the portfolio per DR signal (average)?

5. What is the total number of the participants involved on the case scenario described (average) ?

Figure 13 Aggregators Questionnaire Template

13 Annex III Questionnaire Analysis presentation

The detailed results of Questionnaire Analysis are presented in this section per each type of questionnaire

13.1 Building Occupants Questionnaire Analysis

The goal of the questionnaires for building occupants is to gather end users' requirements addressing their role in the project. A total number of 48 building occupants filled in the questionnaire. Starting from the definition of use cases, the role of building occupants is to act as major stakeholders in the project, by setting context preferences and further defining the operational parameters for building conditions. Building occupants are considered as active elements of the proposed framework, directly interacting with the MOEEBIUS tools and services. Nevertheless, one of the main objectives of the project is to ensure the minimum of end users disturbance.

Therefore building occupants questionnaire is structured in a way to cover occupants' role in the project. The analysis starts with an overview of occupants' knowledge about the domains examined in the project. While most of Living lab participants are aware about energy efficiency programmes, they are not familiar with services related to demand side management and demand response.

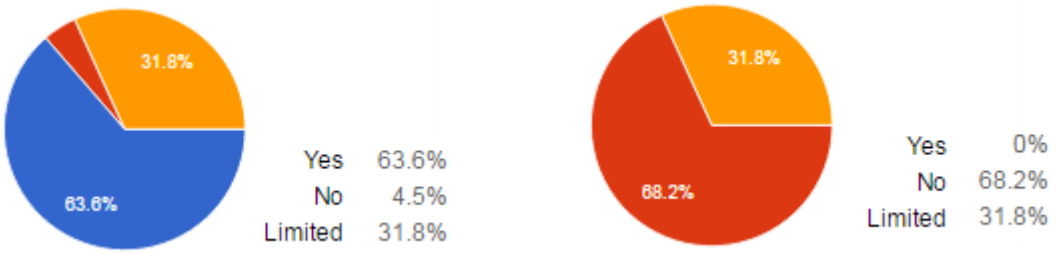


Figure 14 Awareness about energy efficiency and Demand Response Programmes

Nevertheless, the majority of questionnaire participants show an interest to get engaged on that types of programmes, highlighting as a main bottleneck their limited knowledge and limited penetration of energy efficiency programmes on current energy markets.

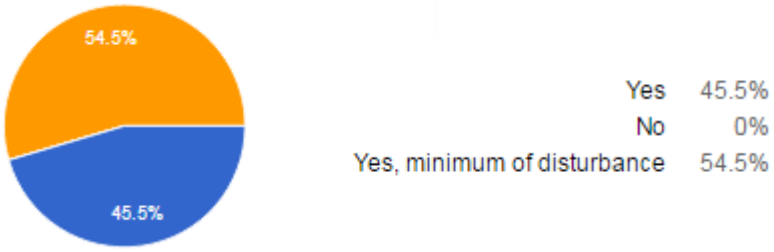


Figure 15 Willingness to participate on energy efficiency and Demand Response Programmes

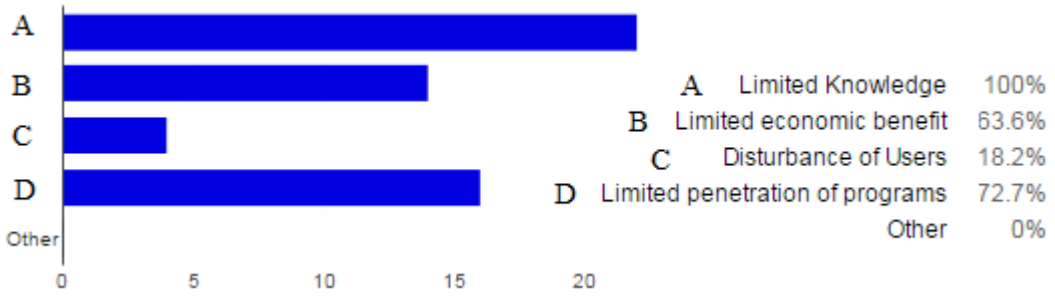


Figure 16 Main factors for non-participation on energy efficiency and Demand Response Programmes

As a main motivation for their active participation, the end users mentioned possible economic benefits and their environmental awareness towards the establishment of a sustainable building environment.

Figure 17 Main factors for participation on energy efficiency and Demand Response Programmes

Moving forward to details about occupants' interaction with building premises, the occupants highlighted as the most critical elements for implementing Energy Efficiency Plans: HVAC devices, Office equipment and building façade. HVAC devices and Office equipment (along with lighting devices) are the ones most frequently used in day to day operations.

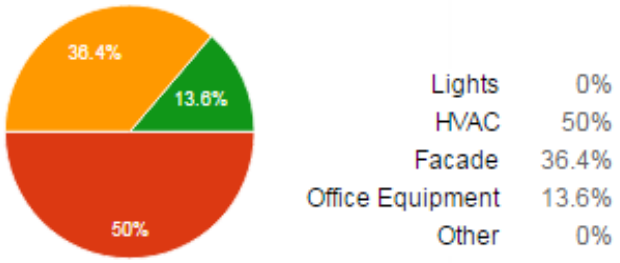


Figure 18 Building aspect critical for implementing Energy Efficiency Plans

Figure 19 Device types used during presence on building

Focusing on usage patterns of devices, the following schemas present the device profiling characteristics taking into account information when available. The density function per device type is presented.

Figure 20 HVAC- Heating Mode Set point

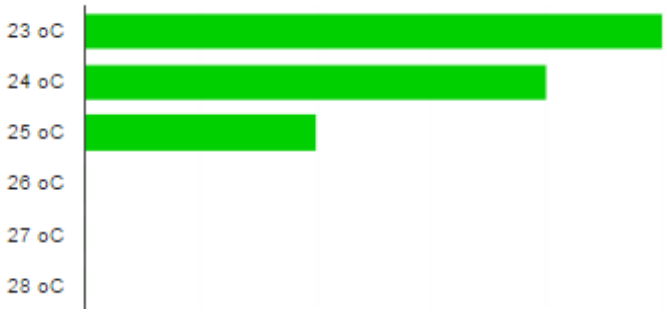


Figure 21 HVAC- Cooling Mode Set point

Figure 22 Lighting- operational mode

Figure 23 Office equipment- operational pattern

A main objective for the project is the taxonomy of activity patterns in building premises. There is a high correlation of occupants' role and business activities, especially in office premises, as depicted in the following figures.

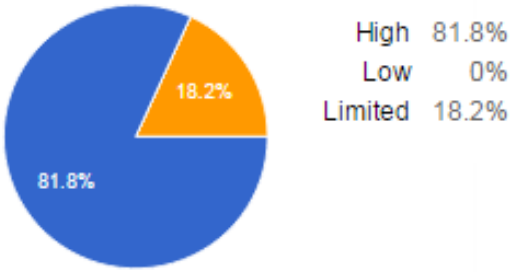


Figure 24 Common patterns on usage of devices

Figure 25 Common patterns on office building areas

The next set of questions is focusing on the establishment of a building automated framework within MOEEBIUS project concept. Most of the living lab participants are willing to evaluate this system, though there are some significant concerns about the final impact of the system.

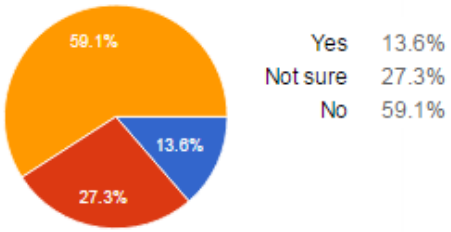


Figure 26 Unwillingness to accept an automatic control mechanism in premises

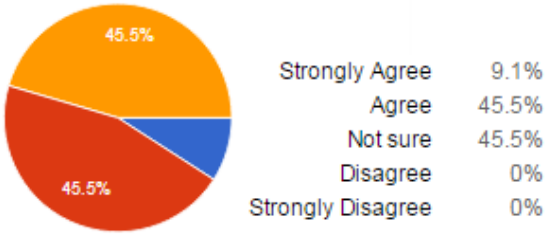


Figure 27 Automatic control system and benefits in terms of energy efficiency

A major boundary to overcome in the project is the unwillingness of building occupants to accept the installation of a non-intrusive WSN system, able to track occupancy patterns. On the other hand, the analysis of questionnaires shows that most of building occupants are willing to receive information related to occupancy patterns or daily activities.

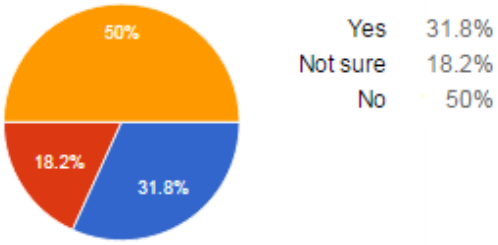


Figure 28 Unwillingness to accept a non-intrusive occupancy sensors WSN installation

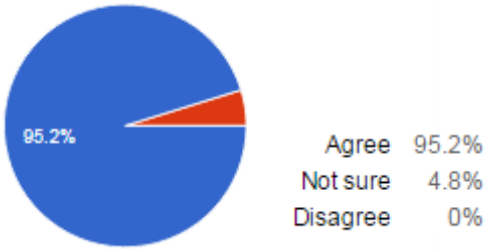


Figure 29 Willingness to receive results about operational preferences patterns

Last but not least, one of the main goals of the project is to provide a **visually appealing User Interfaces** that will trigger building occupants for active participation on the proposed framework. Towards this direction, a set of questionnaires is focusing on extracting UI related requirements. Based on questionnaires analysis, we can define that:

1. Ambient User Interfaces could provide useful energy related information to building occupants

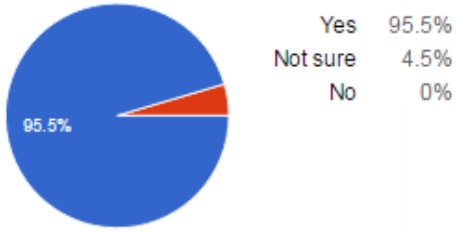


Figure 30 Ambient User Interface could provide useful energy related information to building occupants

2. Total Energy Consumption, CO2 emissions and historical consumption are among the metrics highlighted.

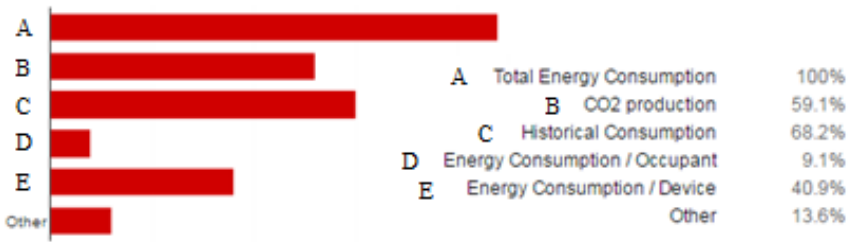


Figure 31 Metrics and KPIs of interest for visualization

3. Various visualization techniques should be considered for presentation of building premises data (2D-3D graphs, Time Series Graphs, Colour Coding graphs)

Figure 32 Selection from Visualization techniques

4. A smartphone app or a web view are highlighted as the best options for presentation of building analytics

Figure 33 Tools for presenting analytics results

5. It is not clear from building occupants analysis, if they prefer an engagement and active participation on building management processes (behavioural triggering application)

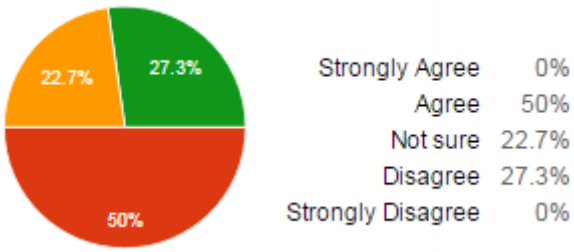


Figure 34 Willingness to participate on behavioural triggering programmes

The analysis of building occupants' questionnaires will further enable the extraction of end users requirements, considering building occupants as main stakeholders of the MOEEBIUS project.

13.2 Facility Manager/ESCO Questionnaire Analysis

Through use case analysis, we highlighted the role of facility managers/ ESCOs as the main stakeholder of the project. Different applications are defined to cover the business domain of the ESCOs, namely real time building management, predictive maintenance services and retrofitting advisory activities. In order to cover these

heterogeneous applications, alternative versions of the questionnaire are available focusing on each specific application. The core ESCO questionnaire was circulated to the list of ESCOs Living lab members participating on questionnaires analysis. A total number of 32 ESCOs filled in the questionnaire. Then, and taking into account the domain of interest of each member involved, add-on questionnaires were also circulated focusing on the specific services (predictive maintenance -14 Questionnaires and retrofitting activities - 12 Questionnaires). The results from questionnaire analysis are presented:

The Introductory section of questionnaires aims at defining the compliance of ESCOs with commercial BMS and extracting the missing features from already available applications. Based on questionnaires analysis, most of ESCOs have a previous experience with BMS tools, utilizing them for different purposes (Energy Efficiency, Security issues, Central Administration).

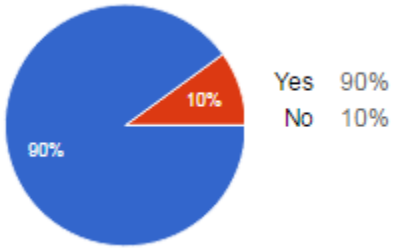


Figure 35 Use of Building Management System (B.M.S.) tool

Figure 36 Reason for use of BMS tools

The commercial tools provide controllability over different device types (HVAC, Lighting, Electric Power Control, and Central Administration), providing also security and fire alarm services.

Figure 37 Systems controlled or monitored by the BMS

The main limitation of existing BMS tools as highlighted by the majority of ESCOs is the fact that these tools are commercialized by large market vendors as standalone applications. Therefore the customization and extension of existing functionalities is a major and in most cases costly task. One of the main drawbacks is also the demanding learning curve as these tools are designed for well-trained users and thus require extensive knowledge.

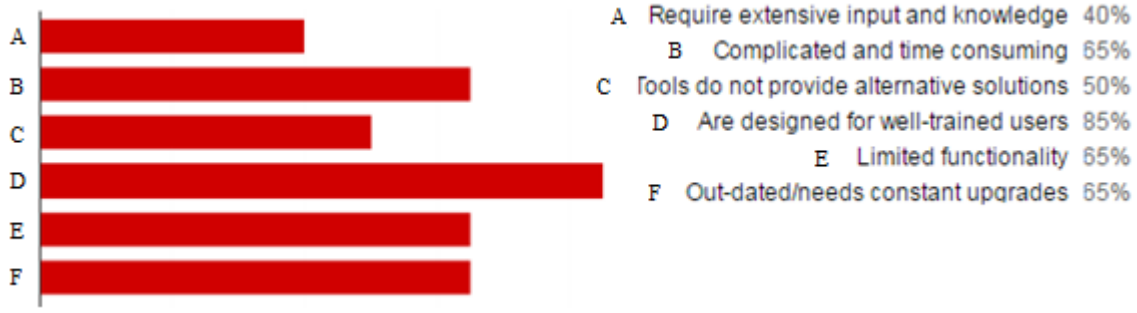


Figure 38 Limitations of commercial BMS tools

As one of the objectives of the MOEEBIUS platform is to provide aggregated management process over BMSs (district level management), knowledge about DSM strategies was required. Though, most of the questionnaire participants are not familiar with Demand Side Management (DSM) and Demand Response, there is high interest on participating on Demand Response Programs. The main limitation to participate on these programs is the lack of incentives from legislation. Though, we need to highlight also the fact that the existing BMS solutions are focusing on building level functionalities without interacting external services (technical limitations).

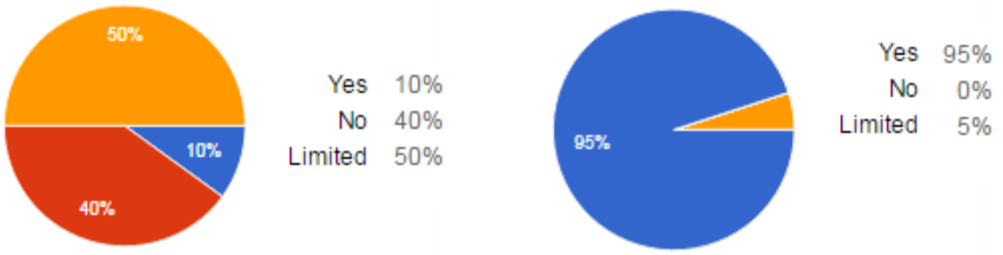


Figure 39 Awareness and willingness to participate on Demand Response Programmes

Figure 40 Existing limitations on Demand Response penetration

The next step of questionnaire's analysis is focusing on the extraction of ESCOs needs about the MOEEBIUS platform. The initial focus is on the functionalities to

be supported by the core engine (The "back-end" of the tool responsible to provide the system functionality). Following the current status on EMS tools, ESCOs demand a holistic monitoring and control tool, addressing all the main loads in premises. As a current trend about BMS solutions, the role of occupants should be also addressed by these tools. The main goal is not only to ensure an energy efficient and cost efficient environment, but also to address building occupants' specific needs.

Figure 41 Critical Device types for BMS tools

Figure 42 Main parameters/indicators for a sustainable environment

This is a unanimous requirements from LL ESCOs, as there is a high need for personalized services taking into consideration business processes and occupants activities. This information (both real time and short term forecasting) should radically affect the control and optimization process in premises.

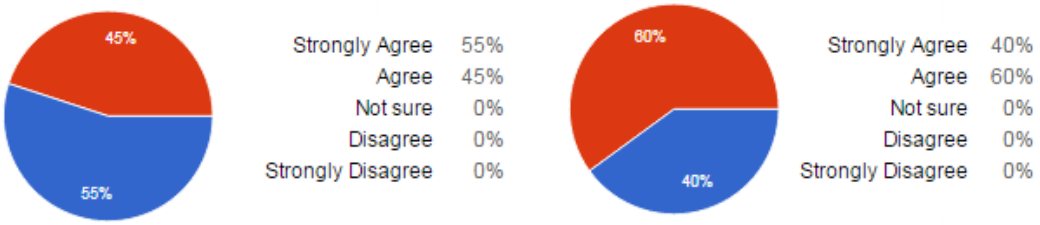


Figure 43 Importance of real time and short term occupancy on BMS tools

We have highlighted the importance of occupants' role on the establishment of a monitoring and control framework in premises; the next step is to identify which occupants' aspects should be addressed. It is a common view among questionnaires participants that both visual/thermal and operational preferences should be addressed by the proposed framework. In other words, the framework should take into account both environmental conditions and user specific preferences towards the establishment of a sustainable building environment.

Figure 44 Comfort aspects/modes to be integrated in BMS tools

The next figures present the preference settings for the main building loads as defined through questionnaires analysis. Compared to results as extracted from building occupants questionnaire analysis, a slight differentiation is considered.

Figure 45 Lighting Devices Model

Figure 46 HVAC devices (Cooling) Model

Figure 47 HVAC devices (Heating) Model

The commercial BMS solutions offer limited controllability on DERs (mainly direct load control or skeleton automated activities). Though, what is required from new solutions is to provide a framework for high level control strategies implementations. ESCOs and Facility managers' highlight through questionnaires the need for minimum and high level configuration towards the establishment of a fully automated environment (Sustainable operation, Cost efficient operation, Comfortable operation, Demand Reduction operation, etc...), that takes into account real time and short term forecasting conditions. Triggering events in

abnormal situations are an add-on feature of the MOEEBIUS building management platform.

Figure 48 Alternative high level control strategies

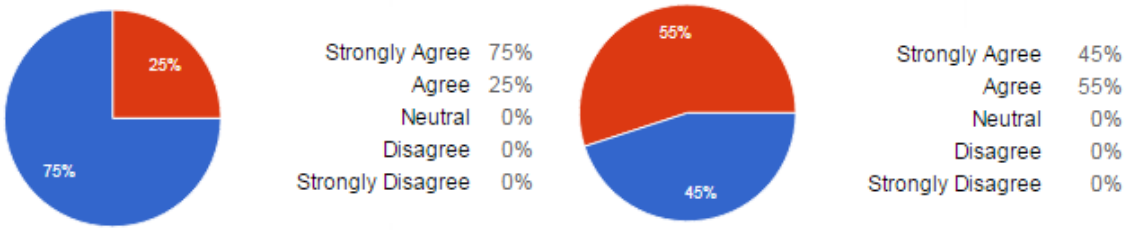


Figure 49 Dynamic and continuous adaptation of BMS tool to real time building conditions

Figure 50 Triggering alarms in abnormal conditions as an add-on feature of BMS tool

In order to implement the aforementioned control strategies, different data types and settings are required from ESCO managers.

Figure 51 Additional types of information for the Decision Analysis of the Facility Manager

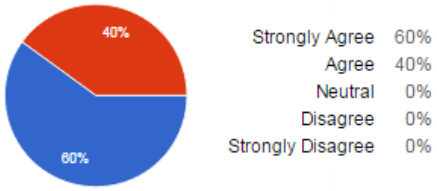


Figure 52 Occupancy profiling models for the Decision Analysis of the Facility Manager

Figure 53 Different types of control settings for the Facility manager

By defining the core functionality of the BMS tool (back engine), special focus is delivered also on the visualization of analytics results.

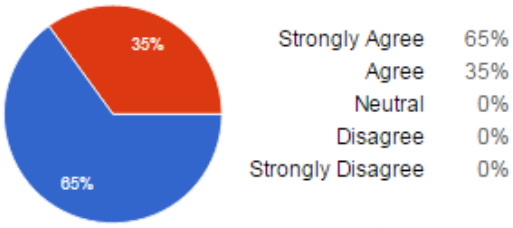


Figure 54 Importance of Ambient User Interface for ESCO DSS tool

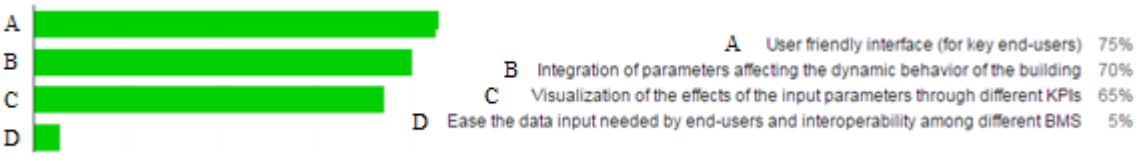


Figure 55 Aspects to be improved in commercial BMS tools

A visually appealing UI is a main requirement from ESCOs and towards this direction we need to adopt different visualization techniques that will enable the presentation of heterogeneous metrics and indicators types. Furthermore, remote and multiple access on application is also required by the end users of the platform.

Figure 56 Appropriate visualization techniques for BMS DSS

Figure 57 Optimal channel for building analytics visualization

Figure 58 Energy performance results/indicators for visualization

Following the ESCOs building management questionnaires analysis, the results from add-on questionnaires are presented. Questionnaire versions for specific services (predictive maintenance and retrofitting) have been circulated to the most relevant Living members in order to get their feedback. The analysis starts with the review of predictive maintenance add on questionnaires. The initial analysis is focusing on the definition of trend towards the implementation of maintenance activities in building premises (timeline period, frequency etc.…). Special focus is delivered on the hardest challenges facing the building sector on the way to maintenance activities.

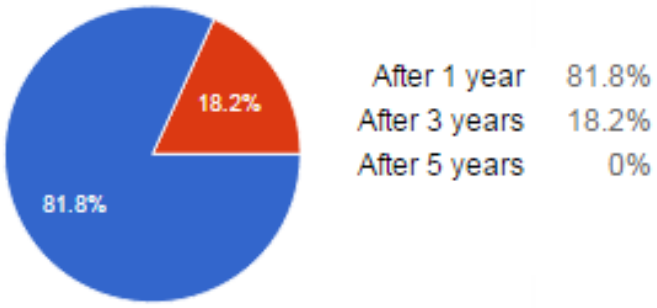


Figure 59 Timeline for a building to adopt a predictive maintenance policy/plan.

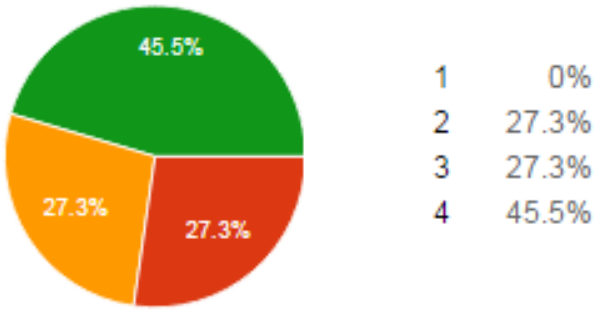


Figure 60 Frequency for implementing maintenance plans for buildings/ annually

Figure 61 Sources relying on gathering information about predictive maintenance activities

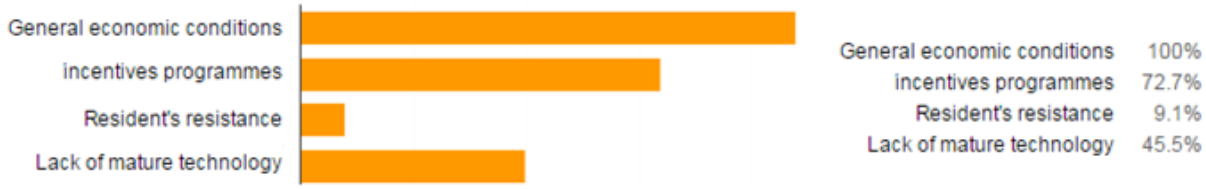


Figure 62 Hardest challenge facing the building sector on the way to maintenance activities

The next step is the definition of metrics and KPIs towards the evaluation of maintenance plans. Not only energy consumption data should be taking into account as the goal is to ensure a sustainable environment, addressing in that way context and health parameters.

Figure 63 Pre and post-performance metrics

Figure 64 Knowledge base to perform a predictive maintenance plan

The rest of the questions are focusing on the innovative features of predictive maintenance tools to be incorporated in MOEEBUIS platform. A knowledge data bee that gathers historical data from maintenance processes is considered as an added value for the maintenance tool while a Decision Support System (MOEEBIUS DSS) that combines real time and simulation data (dynamic adaptation of simulation data taking into account real time conditions) for the

selection of maintenance policies could provide added value on the selection of optimal policies. Furthermore, the incorporation of occupancy profiles and preferences data is considered as an add-on for maintenance tools, towards the selection of optimal maintenance strategies.

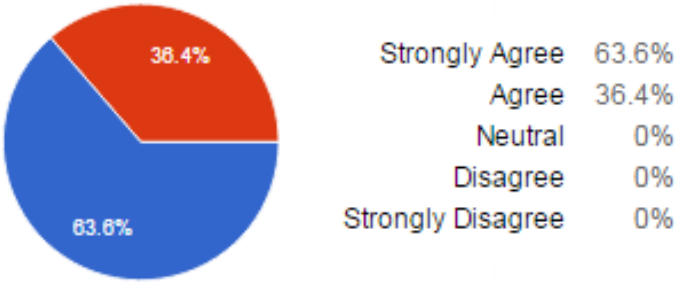


Figure 65 Incorporation of occupancy profiles and preferences data to predictive maintenance tools

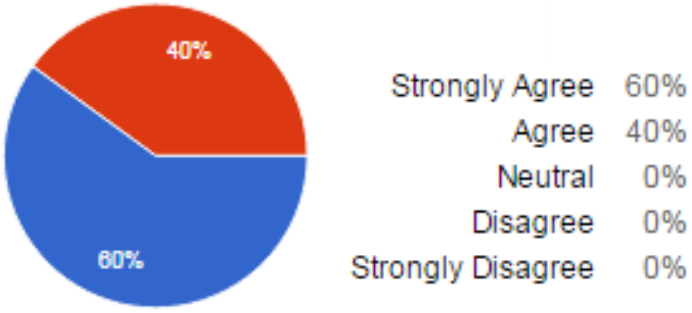


Figure 66 Dynamic adaptation of building simulation engine, taking into account real time conditions and

As an extra feature and along with the selection of optimal maintenance plans, alarms and control alternatives are valuable for maintenance managers. The overall functional framework should be further complemented by the optimal visualization techniques, like 3D building models supporting in that way the transition to augmented reality.

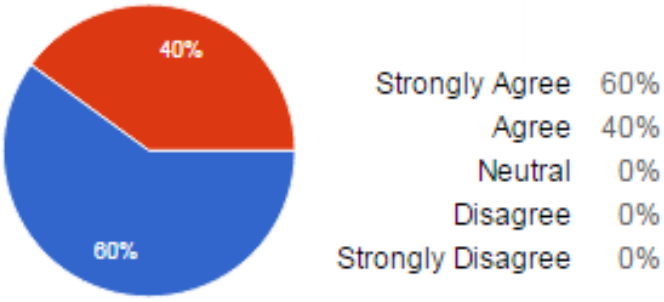


Figure 67 Triggering alarms and control alternatives for maintenance managers

Finally the incorporation of data collected in process of Retrofitting decision-making (following section) for Predictive Maintenance activities should be

considered as an add-on of the tool towards the development of an integrated DSS solution.

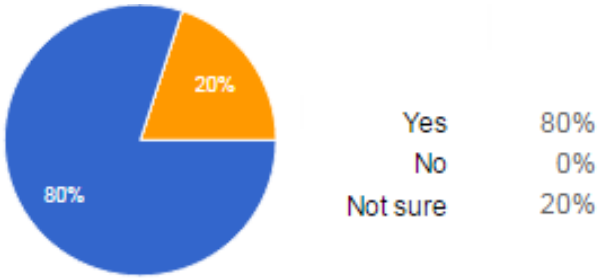


Figure 68 Use data collected in process of Retrofitting decision-making for Predictive Maintenance activities

The results from retrofitting advisory services questionnaires are presented. The initial questions highlight the current status of green retrofitting market (timeline, typical retrofiring actions performed) along with the main boundaries. The main boundaries nowadays are the high costs for retrofitting activities along with the lack of incentives to support that types of actions.

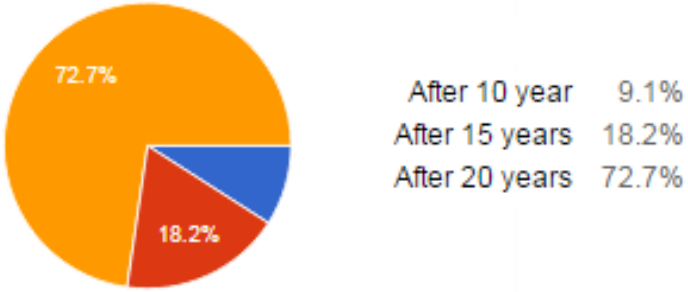


Figure 69 Time plan for adoption of a retrofit strategy

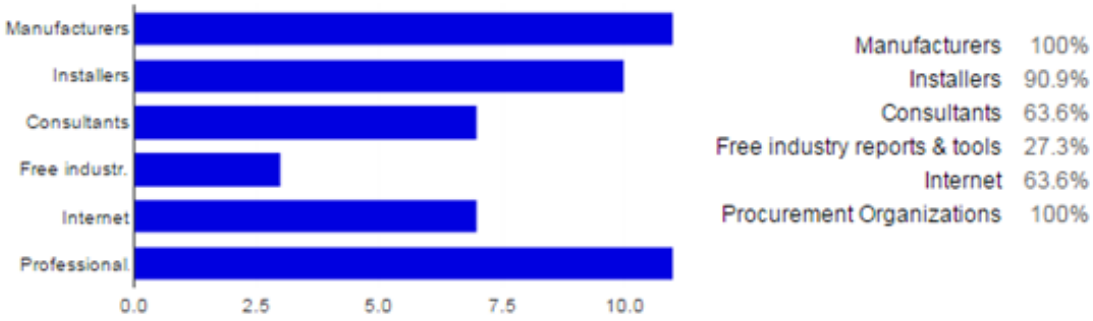


Figure 70 Sources relying on gathering new information about retrofitting activities

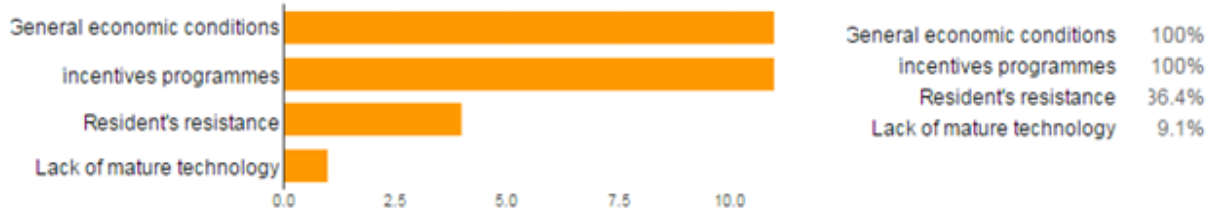


Figure 71 Main boundaries for retrofitting activities planning

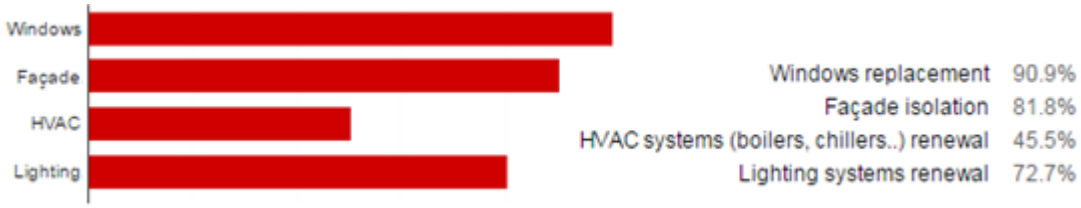


Figure 72 Relevant, or effective, action in building retrofitting process

Different types of metrics and KPIs are considered during retrofitting process towards the selection of best fitted strategies as depicted in the following figures

Figure 73 Pre and post-performance monitoring parameters of the properties

Figure 74 Required metrics to perform a retrofitting plan

Moving to the questions about main innovations that MOEEBIUS platform may bring to retrofitting activities planning, the majority of living lab participants show high interest on the establishment of knowledge database that gathers historical data from retrofitting plans and further incorporates data to a Decision Support System that combines real time and simulation data for the selection of optimal retrofitting activities. This Decision Support System should be part of an integrated DSS tool that combines parameters from the different services running in the BMS tool (automation processes, maintenance services etc.…).

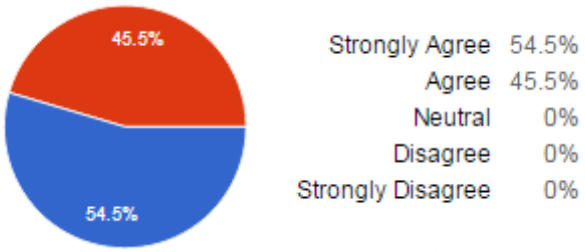


Figure 75 Willingness for a dynamic adaptation of building simulation engine

Moreover, the incorporation of financial aspects as part of retrofitting advisory tool is a valuable feature of the tool. This is a main parameter examined in that types of project, expecting a short payback period for the relative projects.

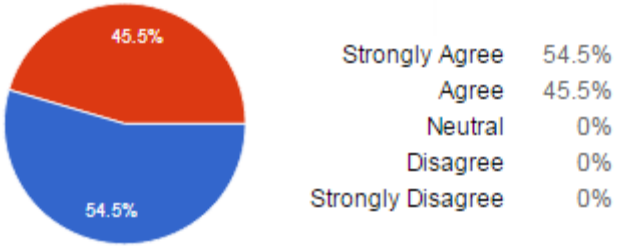


Figure 76 Incorporation of financial aspects as part of retrofitting advisory tool

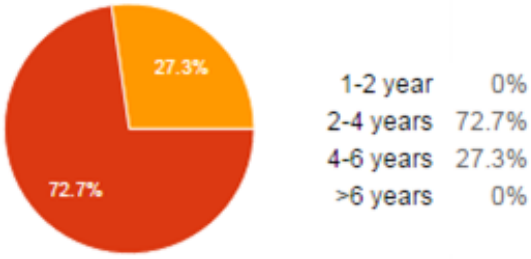


Figure 77 Payback period for a retrofitting intervention

Following the detailed analysis of the role of ESCOs in building premises, the analysis of Aggregator role responsible for the management of clusters of buildings is performed in the next section.

13.3 Demand Side Aggregator Questionnaire Analysis

Along with the role of Facility managers, the role of Aggregator is examined in the project towards the optimal management of clusters of building. We have defined through use cases analysis, two main core applications:

- A real time decision tool for the selection of optimal control strategies
- A data analytics tool that may provide insights of the portfolio (through a dashboard) and further facilitate the selection of optimal control strategies.

Taking into account these main functionalities, a fitted questionnaires is circulated to Living lab members in order to get their feedback for both analytics and real time management tool. A list of 11 questionnaires were answered by Aggregators or similar types of stakeholders (ESCOs responsible for the management of district level buildings)

An introductory section provides insights about the current market status. We have to point out that the questionnaires were circulated only to UK companies, as in UK the Demand Response market is already mature. Most of the Living lab members participated in the analysis, could not provide exact data about DR operations. A limited number of C&I (small) customers are participating in the portfolio, triggered with no more than 5 demand response events during an annual period. As a comment provided by the participants is the fact that the current legislation mandates their participation on Demand Response programmes (and thus there is no flexibility on participating/ non-participating under existing framework). Most of the DR programmes are capacity programmes, though the Living lab participants would be interested to examine price based DR programmes (dynamic pricing schemas).

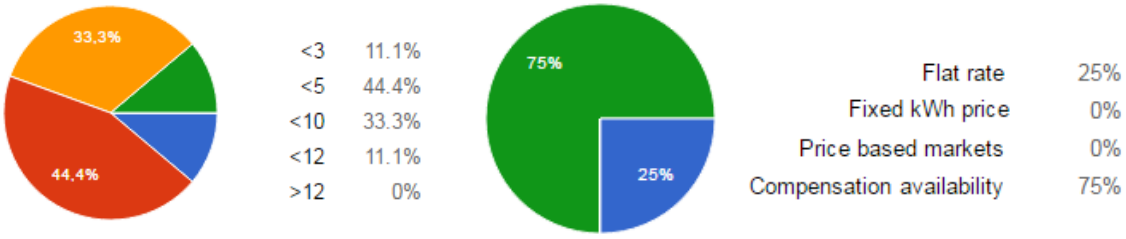


Figure 78 Current Status of Demand Response Market

Moving to the section related to MOEEBIUS platform, the analysis starts with the presentation of needs for real time optimization process (The "back end" of the tool responsible to provide the core functionality of portfolio management and DR dispatching process). The Aggregators participating on questionnaires, expressed their interest for access on low level information (device level), focusing mainly on controllable devices. Taking into account the Demand Response legislation framework, there is no need for low level (seconds) time granularity data.

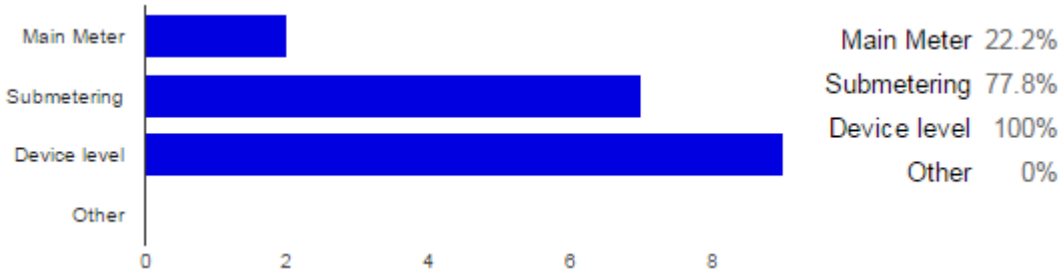


Figure 79 Metering vs. Sub metering requirements

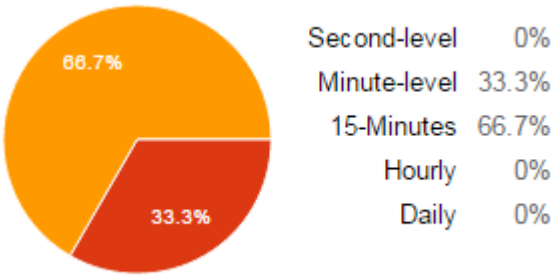


Figure 80 Energy data Time granularity requirement

What is highlighted in questionnaires results is the need to get access on heterogeneous data types. The Aggregators, apart from energy metering data, would like to get access on weather, market, and context data with different spatio-temporal granularity toward calculating an extended list of KPIs that will support their business service.

Figure 81 Different data types requirements

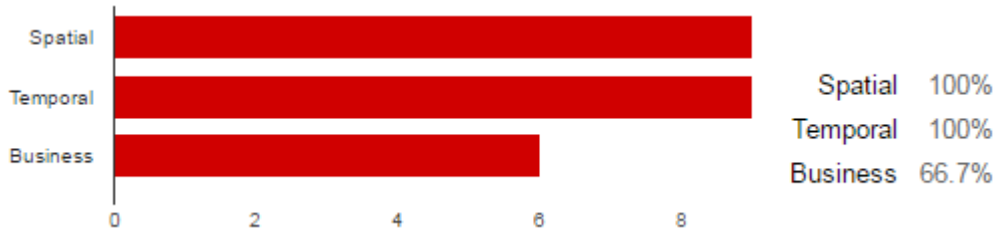


Figure 82 Data types granularity

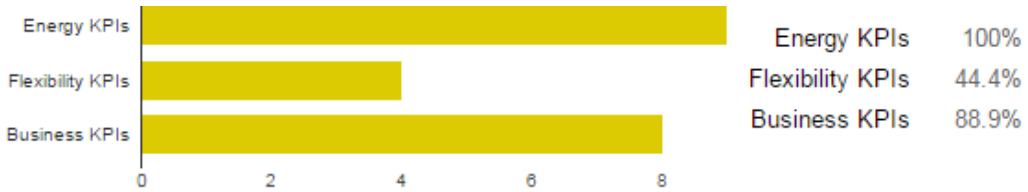


Figure 83 Key Performance Indicators granularity

Moving forwards to requirements about analytics tool, there is a limited interest for this tool compared to the real time optimization engine. The Aggregators periodically perform reporting analytics (daily/weekly) but this process is mainly for internal processes and does not affect the real time operations. The end users of the tool prefer to set customized parameters for comparative analytics towards the evaluation of customers' performance.

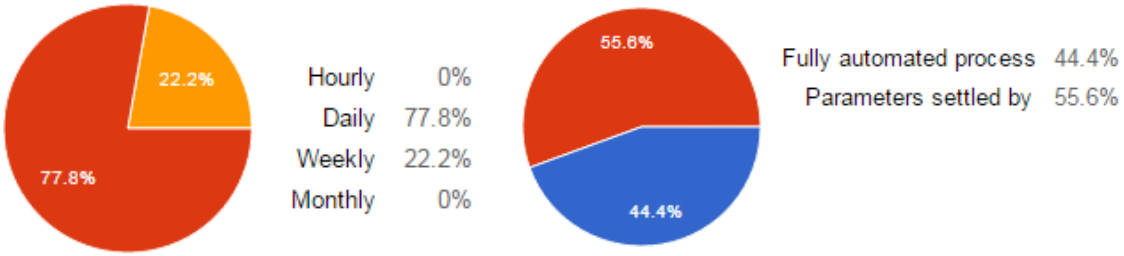


Figure 84 Data analytics usage requirements

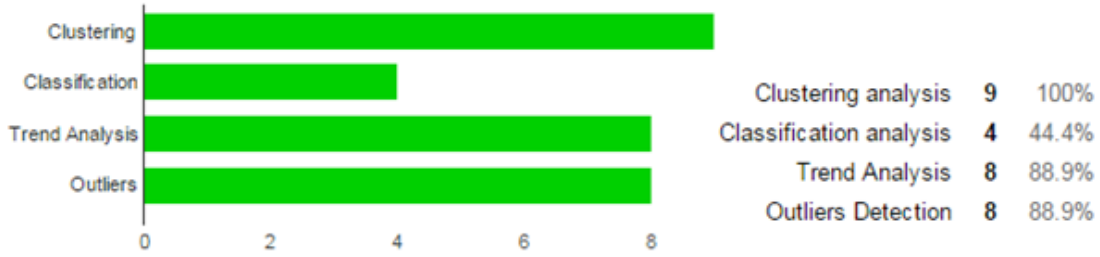


Figure 85 Data analytics- Supported analytics techniques

On the other hand, Aggregators show high interest about a new feature presented for MOEEBIUS project; a "what if simulation" engine to simulate alternative business (demand response) strategies.

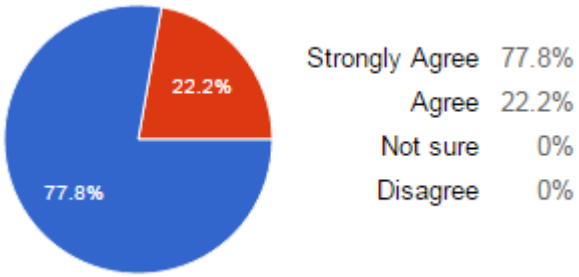


Figure 86 What if Simulation Engine feature

Finally, the majority of living lab Aggregator participants agreed on the need for a fully dynamic and enriched visualization dashboard. The service should be provided through web, enabling also remote access to the different types of users. Various visualization techniques should be considered, to be automatically updated based on the current status of the portfolio. The results from questionnaire analysis process are presented in the following graphs.

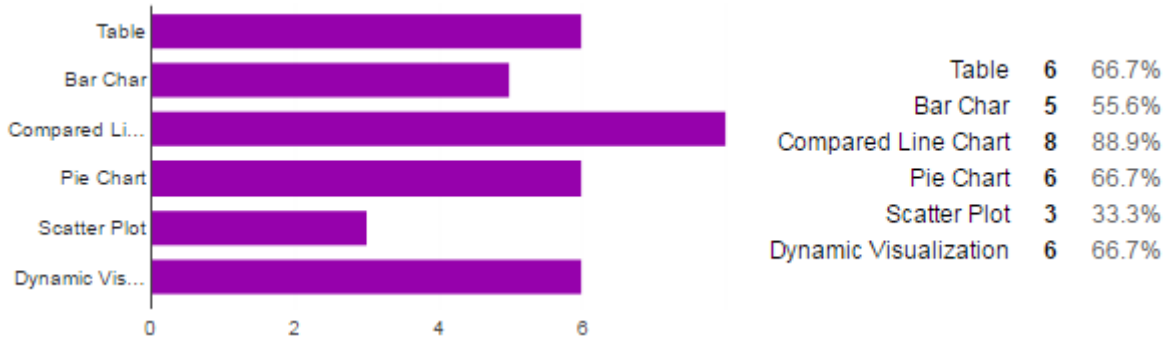


Figure 87 Types of supported visualization techniques

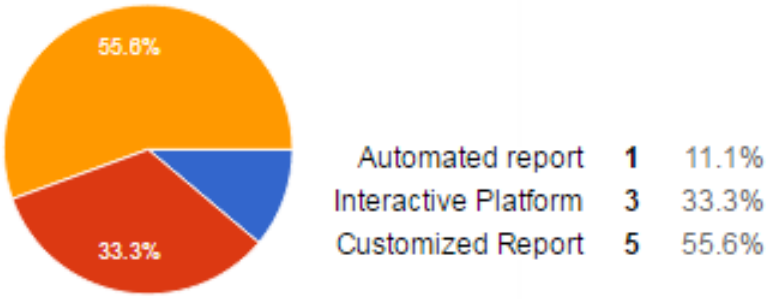


Figure 88 Interactive vs. Customized Reporting process

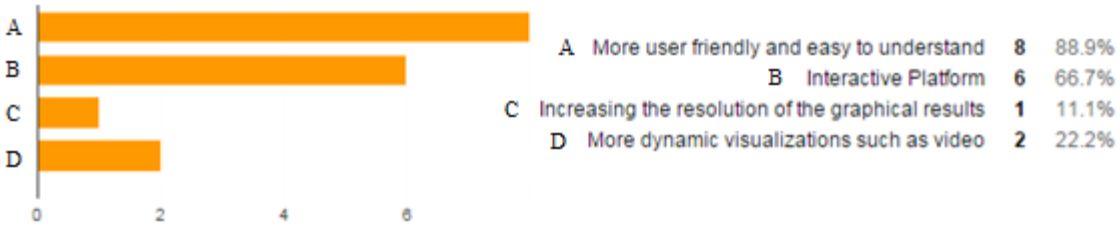


Figure 89 Features to be supported by Analytics GUI

We have to point out that a limited number of questionnaires (9) were collected from Aggregator users. The European DR market is still on an infant level and thus the contribution was mainly delivered from representatives that have limited or no presence on DR markets. Even in this way, the feedback retrieved is useful to enable the extraction of requirements for MOEEBIUS Aggregator platform.