E-LAND

*Integrated multi-vector management system for **E**nergy is**LAND**s*

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Abbreviations and Acronyms

Acronym	Description
API	Application programming interface
BMS	Building Management System
BRP	Balance Responsible Party
BC	Business Case
CHP	Combined Heat and Power
CIM	Common Impact Model
DER	Distributed Energy Resources
DH	District Heating
DHO	District Heating Operator
DR	Demand Response
DSO	Distribution System Operator
DSM	Demand Side Management
EMS	Energy Management System
ENTSO-E	European Network of Transmission System Operators for Electricity
ESCO	Energy Service Company
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
HLUC	High-Level Use Case
HVAC	Heating, Ventilation, and Air Conditioning
HW	Hot Water
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LES	Local Energy System
LNG	Liquefied Natural Gas
PUC	Primary Use Case
PV	Photovoltaics
RES	Renewable Energy Sources
SoC	State of Charge
SUC	Secondary Use Case
UC	Use Case
WP	Work Package

Executive summary

The scope of the deliverable is the definition of the requirements for the development of the E-LAND toolbox. The document transforms the concepts envisioned in earlier phases of the project into a coherent, complete and detailed requirements specification for the technological tools that are part of the E-LAND toolbox solution.

The work builds on the work of the Use Case analysis of the project (as documented in D3.1) and on active interaction and information exchange between the different partners of the project in order to create a list of functional and non-functional requirements of the toolbox. The former will describe the functions or tasks to be performed by the system, whilst the latter will define the qualitative characteristics and properties of the system.

The methodology employed involved the elicitation and elaboration of requirement from the different partners, based on their role: end-users, solution providers, developers. On the basis of the different viewpoints of the stakeholders, different types of requirements were identified:

- Business stakeholder requirements, depicting the business operation perspective, providing a high-level view of E-LAND solution;
- Systemic requirements, functional and non-functional requirements mapped at the individual components of the systems of interest.

An iterative and recursive approach was followed in order to elaborate high-level requirements to lower-level ones, group them and allocate them to individual elements. Towards this, a draft architecture was devised to identify the system's main components, their main responsibilities and their interfaces. The later action is part of the architectural design process which needs to proceed in parallel with the definition of requirements (recursive process). Finally, functional requirements were prioritized, whilst specific KPIs were defined for the non-functional ones, on the basis of the goals of the project with regards to the scenarios that will be studied in the project's pilots.

The requirements specifications presented in this document will serve as a basis for the definition of the architectural design and the detailed technical specifications in the context of Task 3.3. This document will also be used in later phases of the project as a guideline for implementing the ICT tools of the project (WP4) as well as for integrating the toolbox with the Energy Management Systems (WP5) of the project's pilots.

1 Introduction

1.1 The E-LAND project

The continued decarbonisation of the energy sector through the use of renewable energy sources provides both interesting opportunities for Local Energy Systems (LES) and challenges for existing electricity networks. Mainland regions such as isolated villages, small cities, urban districts or rural areas oftentimes have issues with weak or non-existing grid connections. These areas are known as energy islands.

The goal of the European-funded H2020 project E-LAND is to provide a synergistic solution between technological, societal and business challenges that the energy sector faces. The main outcome will be the E-LAND Toolbox – a modular set of methodologies and ICT tools to optimize and control multi energy islands and isolated communities. The modular toolbox can be customized to meet local requirements and is expandable to incorporate new tools as new challenges arise.

1.2 Purpose

The purpose of this document is to define the requirements for the development of the E-LAND Toolbox. It builds upon the identification of E-LAND's high-level goals and the analysis and definition of the project's use cases (produced in T3.1 and documented in D3.1 [1]) and aims at exemplifying the various functionalities that are going to be developed and deployed in the project's sites, safeguarding their feasibility, as well as the congruity between the different development and integration tasks. The five major targets identified in E-LAND are: the integration of an energy management system combining the various building management systems and DER technologies, the optimization of operation of LES, the optimal planning of LES, the market-driven analysis and business modelling and the community engagement of the LES.

The analysis that was performed in T3.2 during the requirements elicitation campaign is documented in this deliverable and steered towards T3.3 which will handle the definition of E-LAND's platform architecture and technical specifications.

1.3 Intended Audience and Reading Suggestions

The document is intended to address a diverse audience. The main target group is E-LAND project's partners, irrespectively of the role they perform, e.g. the software tools developers, the integrators, the solution providers, the end-users, the project managers, etc. Furthermore, the authors of the document aimed at addressing interested readers such as possible end-users of E-LAND's solutions, Smart Grids domain experts (either academic researchers or industrial partners), as well as requirements and systems engineers involved in the development of similar solutions.

Prior to reading this document it is highly recommended to have a clear overview of E-LAND´s vision, its business goals and technological innovation aspirations, as well as a good understanding of the project's Use Cases. Therefore, readers outside E-LAND's consortium, are advised to refer to sections 2.1, 2.2, 2.3 in order to better understand the project's main concepts, the possible stakeholders and the envisioned solution (further information are also available in [2]).

1.4 Overview

The document is structured as follows:

- The first chapter provides a small introduction to the project and a recapitulation of the work done in T3.1, briefly discussing the project's stakeholders, its basic concepts (multi-vector LES, E-LAND Toolbox, basic interactions with systems inside the LES) and the identified use cases.
- In the second chapter, the methodology that was followed for the requirements elicitation campaign is analysed, presenting the basic terminology and documentation archetypes followed in the project.
- The third chapter comprises the business requirements from the perspective of different stakeholders of the project dealing with the operation of the LES, and their respective functional and non-functional requirements.
- The fourth chapter details the systemic requirements of E-LAND solution, differentiating between the functional and non-functional requirements of the E-LAND Toolbox and the Energy Management System of the LES respectively.

2 E-LAND Concepts

2.1 Multi-vector Local Energy System

A conceptual description of a Multi-vector Local Energy System (LES) is presented in this section, detailing the various assets and the possible synergies between the different energy vectors. Local Energy Systems (or Energy Islands) pose important challenges in their operation due to their weak interconnection with the bulk power system. One aspect for effectively reducing operational, planning and CO2 emission costs in such isolated parts of the grid is the utilization of Smart Grid solutions (e.g. Demand Response schemes, Smart EV charging) and DER assets (especially storage). On the other hand, the co-optimization of electricity, gas and heat networks - which have been traditionally designed and operated in an independent manner- can significantly improve the overall system efficiency [3].

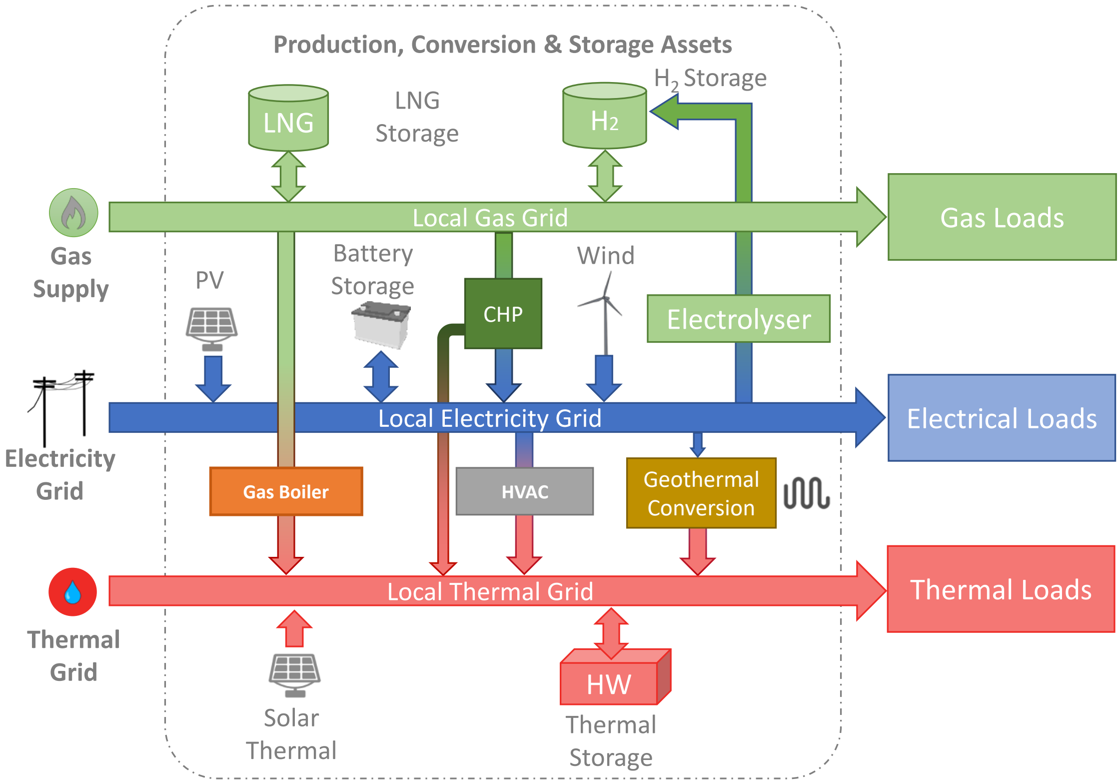


Figure 1: Multi-vector Local Energy System Asset Overview.

This conceptual architecture of a LES is depicted in Figure 1, providing a unified view of various assets from different energy vectors, whilst their interconnections represent energy flows among them (energy transformations). For example, a Gas Boiler transforms the chemical energy of the Gas vector to thermal energy and reroutes it to the Thermal vector. Additionally, importing energy into different vectors can be performed either from the bulk grid or from local generation units, while storage systems can also be employed where necessary. This conceptual view was used in the E-LAND project as a framework for mapping different infrastructures per site and validating specific scenario-based UCs, by taking into account all the specificities of a site and the different technologies available.

2.2 Business Stakeholders

The operation of the LES may involve a diverse set of stakeholders. The list of E-LAND´s business stakeholders was formulated based on the goal to accurately reflect the high-level objectives of the project (handling of the multi-vector scenarios and modelling of the LES). These stakeholders involve local entities inside the LES. To map the objectives and responsibilities of the stakeholders, a market model was created, inspired by the ENTSO-E role model [4] for the electricity market, where new market roles were introduced or pre-existing were extended respectively, aiming at the same time at identifying actors pertinent to different energy vectors. The role model is presented in Figure 2, whilst the set of the identified business actors along is depicted is analysed in Table 1. The different colours that are used in the role model represent the different categories of defined actors as explained in the legend.

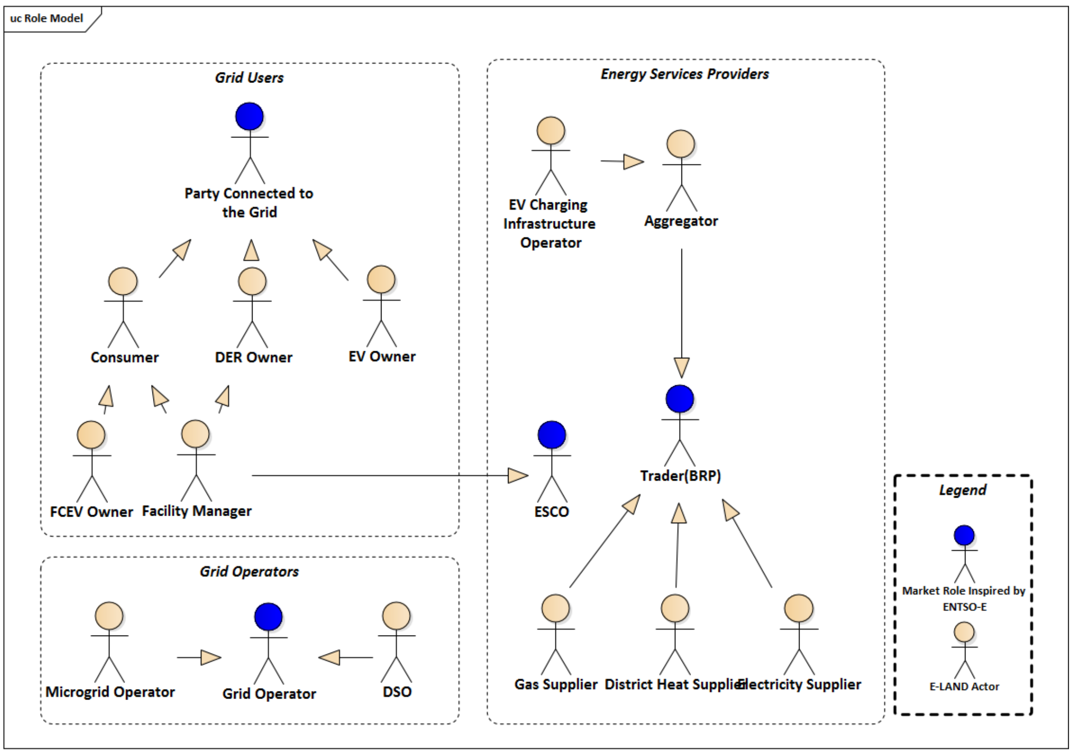


Figure 2: The E-LAND role model.

Table 1 Business Actors.

Business Actor	Market Role	Short Description
Aggregator (incl. Virtual Power Plant)	Trader and/or BRP	A party that is selling or buying energy.
Community	Aggregation of Consumers / Employees / Students	Aggregation of parties that contracts for the right to consume or produce electricity at an Accounting Point.
Consumer	Party Connected to the Grid	A party that consumes energy from one or multiple energy vectors.
DER Owner	Party Connected to the Grid	A party that contracts for the right to consume or produce electricity at an Accounting Point. Electrochemical and H2-based storage systems are also considered within the scope of this actor.
Distribution System Operator (DSO)	Grid Operator	A party that operates the distribution grid of one or more energy vectors.
District Heat (DH) Supplier	Supplier of thermal energy and operator of DH grid.	A party that procures heat.
Electricity Supplier	Retailer of electricity	A party that is selling or buying electricity.
EV Charging Infrastructure Operator	Trader and/or BRP	A party that is selling or buying energy / A party that has a contract proving financial security and identifying balance responsibility.
EV Owner	Party Connected to the Grid	A party that contracts for the right to consume or produce electricity at an Accounting Point.
Facility Manager	Consumer / DER Owner or ESCO	A party that consumes electricity / A party that contracts for the right to consume or produce electricity at an Accounting Point / A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may

		provide insight services as well as energy management services.
FCEV Owner	Party Connected to the Grid	A party that contracts for the right to consume or produce electricity at an Accounting Point.
Gas Supplier	Trader of Natural Gas	A party that is selling or buying Natural Gas.
Microgrid Operator	Grid Operator	A party that operates the local distribution grid.

2.3 E-LAND Toolbox

The E-LAND solution aims at tackling the aforementioned challenges in the current and future operation of a LES by providing an innovative framework that will effectively couple and co-optimize the different energy vectors and increase the system's overall efficiency. The E-LAND Toolbox comprises several components concerning its different functionalities in order to accommodate the vast requirements of the project's pilot sites, as well as simplify its future wide-scale deployment in Multi-Vector LES. The different layers of the toolbox implement E-LAND's major pillars towards achieving the project's goals in a modular unified architecture. The higher layer handles the community engagement pillar through the community Common Impact Model (CIM) that facilitates the communication and coordination of the local community. A market-oriented layer copes with the development and assessment of the business models regarding the actions and the operation of the LES and the technical layer integrates the innovative decision-making support tools i.e. the consumption and RES production forecasting, the optimization of operation, the planning, etc. The Enterprise Service Bus (ESB) securely integrates the above layer with the pilots, ensuring privacy and safety of the information exchanged. An overview of the conceptual E-LAND's architecture is presented in Figure 3.

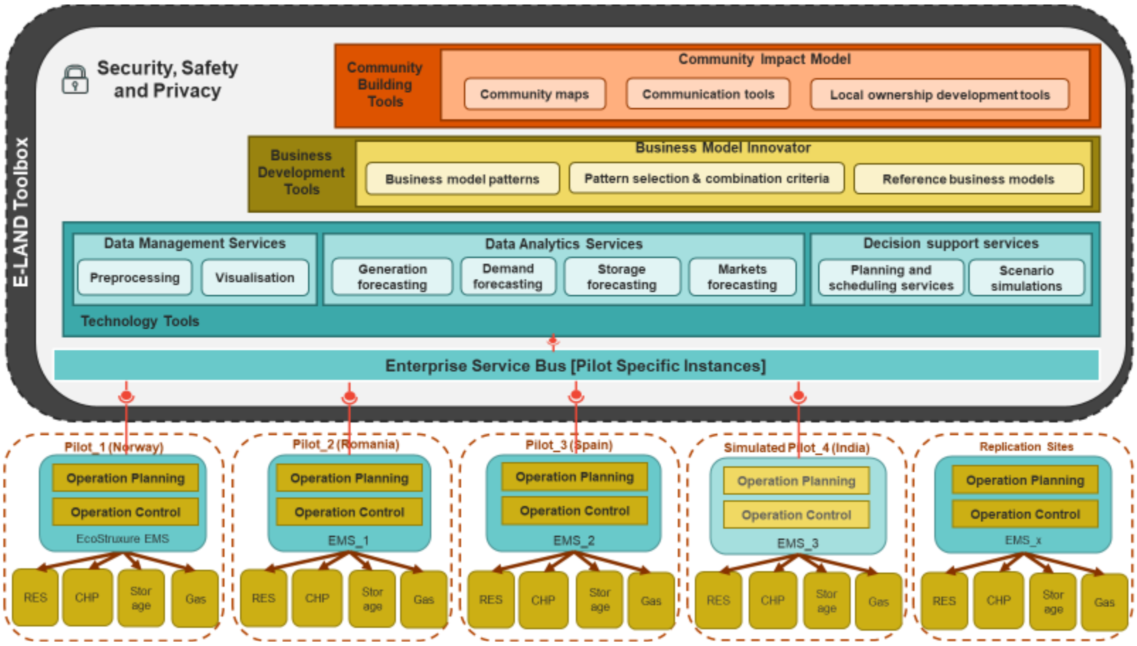


Figure 3: E-LAND conceptual architecture highlighting 3 planes of the toolbox.

The focus of this document is to describe requirements regarding the technological tools that are going to be developed in the project, as well as the EMS (the technical layer as it is presented in the above figure and its integration with the pilot sites' infrastructure).

2.3.1 High-level Functionalities

For the implementation and validation of E-LAND's toolbox, three High-Level Use Cases were formulated and analysed providing the main concept that will be studied by the project. The first UC concerns the integration of the various systems, necessary for modelling the interoperability of the E-LAND solution, the second one regarding the optimal operation of the LES, dealing with the day-to-day operation of the system and the third one on the subject of optimal sizing of a LES, focusing on investments on new energy production and/or storage infrastructure.

HLUC 1. EMS integration with DER and BMS

This HLUC constitutes the enabling vehicle for the successful implementation and deployment of the E-LAND's toolbox. Surrounding all the lower level UCs (Primary Use Case - PUCs, Secondary Use Cases - SUCs), it aims at comprehending the requirements for integrating the EMS with the controllers of the various assets of the pilots and other pre-existing systems such as the BMS, together with the novel decision making and data processing tools and also channels any required information to the business development and community building components. Within the scope of this HLUC is ensuring that all the interactions of the various components are performed optimally and in a secure manner, while at the same time the data of the different users are cautiously maintained private.

The E-LAND solution will encompass the integration of the following systems:

- EMS: integrating the traditional DER Owner energy monitoring and control solution;
- DER Controllers: On-site devices offering monitoring & control of the production assets of DER Owners;
- Storage Controllers (Thermal/Electric/H2) for multi-vector storage management, handling information on capacity and availability of storage assets of DER Owners;
- BMS: Offering a monitoring network at a building level (evaluate energy usage/needs, occupancy, production, weather, etc.) as well as assisting real-time, data-driven decisions for the optimization of the consumption, by analysing offering various modes of operation (demand response, energy storage) for various vectors;
- Field Devices: For sensing or actuation of various loads, integrated through the BMS or directly;
- EV Chargers: Devices enabling the monitoring and control of the charging of Electric Vehicles in the LES, typically owned by the consumer or even third parties (Aggregator)
- External Data Sources: for weather forecasting and energy prices;
- Advanced tools: for energy forecasting (Energy Forecaster) and for optimal scheduling (Optimal Scheduler) and future planning of the LES;
- Enterprise Service Bus (ESB): A system enabling the integration of the above sub-systems.

The added value features attributed to this HLUC comprise the:

- Coordinated DER operation
- Control over the energy mix and optimal use of storage with energy forecasting
- Increased system degree of autonomy and power quality
- Optimal load prioritization and shifting
- Microgrid enabled operations: the ability of all integrated systems to work together as a single system, enabling facilities to operate as autonomous microgrids;
- Quantification and measurement of overall carbon foot-print
- Detailed monitoring of real-time energy-related data
- Alerts for optimizing Operational expenditures by leveraging pro-active maintenance.

HLUC 2. Optimization of operation of LES

The second HLUC tackles the issues of optimal operation of the LES, provided that the integration HLUC (i.e. HLUC 1) is successfully deployed. The primary actor is the entity assigned with the operation of the LES, e.g. the Microgrid/Facility Operator, or the Aggregator whose portfolio holds the assets of LES. Depending on the form and the specificities of each LES, different business cases may apply, but the scope of this HLUC is either the maximization of the profits of the participating actors through smart energy management actions (for the cases that profits accrue in the context of the LES such as by providing ancillary services), or equivalently the minimization of the total operational costs. Other goals that may be complementarily followed in this UC are increasing the degree of autonomy of the LES and reducing its environmental impact. More specifically, the multi-vector assets able to provide some form of flexibility, and thus give the possibility to increase the efficiency of the operation of the LES, are the various type of DERs (wind, PV, solar thermal), flexible loads (EVs, FCEVs, multi-vector controllable loads) and different storage technologies (electrical, thermal, H_2). For the optimal employment of the assets' flexibility, certain rudimentary functions are developed and used within the project such as the forecasting and scheduling modules. Basic methods used for achieving the scope of this HLUC involve the optimal scheduling of multi-vector storage assets for reducing energy wastes, Demand Side Management and Demand Response schemes e.g., shifting of multi-vector loads of building loads, optimal management of EV/FCEV charging, etc.

HLUC 3. Optimal sizing of a Local Energy System

This HLUC aims at assessing the optimal sizing of new (multi-vector) assets to be installed within the premises of the LES, in terms of increasing the long-term efficiency of the LES as well as minimizing the investment costs. The LES operator plays a central role in this UC, pursuing various goals such as:

- Increasing the quality of service for load and production assets (any vector)
- Increasing energy efficiency and degree of autonomy of the LES
- Minimizing total cost of operation
- Reducing the environmental impact (CO2 emissions)
- Maximizing the profits from selling energy to the market

Different investments that the LES operator can consider are the installation of new RES production assets such as PV panels, wind generators, solar thermal panels and more efficient electrical loads and HVAC appliances (e.g. geothermal heat pumps for heating/cooling/HW).

Such assets can be installed in the operator facilities or in the facilities of consumers, which may be involved in the investment by leasing their properties or even investing in the assets. This way, the role of DER Owners is considered to be in close collaboration with the operator that orchestrates the investment. Usually, for investing in new infrastructure as a means to increase the energy efficiency, various parameters should be taken into account including long-term multi-vector load projections, investigation of the relevant energy market, etc. Moreover, the optimisation should consider the synergetic operation of the different energy vectors as well as possible transformations amongst them.

2.3.2 Primary Functions

The three High-Level Use Cases were analysed in a higher granularity and to a more solid instantiation in primary use cases (PUC), mapping actors to specific systems/devices characterized by a defined boundary.

PUC 1. Provide commercial functionality to a multi-vector LES

The first PUC models and analyses the commercial operation of the LES and targets at preparing the specific requirements as an input to the business model development in WP7. Assuming the LES Operator acts as an Aggregator (creating a secondary local market) and represents the participating entities (the members/technical actors of the LES) with the wholesale market. Furthermore, the interaction of the Aggregator with other energy markets is envisioned such as flexibility markets, ancillary services markets and CO2 certificate markets is envisioned.

PUC 2. Shift building loads using Demand Side Management

This PUC is linked with designing and implementing Demand Side Management (DSM) actions that will reduce the energy costs and CO2 emissions of the LES and enhance its reliability through optimal energy management of its buildings' loads focusing on HVAC systems. The utilization of energy forecasting and optimal scheduling algorithms for the realization of this UC is also considered, while special attention will be given to automating Energy Efficiency (EE) activities and Demand Response (DR) actions for the building loads.

PUC 3. Shift harbour loads using Demand Side Management

In this PUC, the DSM actions are designed specifically for the optimal scheduling and flexibility utilization of harbour loads. The goal is to use latent flexibility in the timing of movements of the containers within the harbour area and as a result flatten the energy profile of the LES, which can significantly reduce the cost of operation and the overall efficiency. The utilization of energy forecasting and optimal scheduling algorithms for the realization of this UC is also considered.

PUC 4. Optimal scheduling of thermal and electrical storage

This PUC models the optimal scheduling and co-optimization of electrical and thermal DERs in order to maximize the RES share in the energy mix of the LES, minimize energy wastes, improve degree of autonomy and power quality, reduce CO2 emissions and costs and optimize the use of BESS. The technical actors involved in this PUC are the EMS acquiring the necessary filed data and controlling the field devices, the forecasting and optimization modules, as well as the ESB ensuring their secure and seamless integration and orchestration.

PUC 5. Optimal scheduling of electrical storage and hydrogen storage

PUC 5 copes with the co-optimization of electrical and hydrogen storage assets, targeting at the maximization of the profits of the LES from market participation (handled by the Aggregator) and the reliability improvement. The driver force of this PUC is to leverage multi-vector flexibility, provided by the local DER Owners, through advanced optimization models and realignment (where possible) of enterprise operations within the LES in order to achieve its optimal operation.

PUC 6. Storing excess generation in thermal network

The core idea of this PUC is to harness any capabilities for storage that may be available in (or to) the LES aiming at improving the overall efficiency (both economic and environmental). Specifically, for the cases that excess energy (mostly regarding renewables) would not be used locally due to reduced demand and hence would be exported to the grid with a very low price, alternative approaches for storing it could be evaluated, such as heating hot water tanks, proactive control of HVAC units, selling heat to district heating (DH) network, etc. Advanced optimization and operation scenarios are considered in this UC.

PUC 7. Optimal management of EV and FCEVs in a LES

In this PUC, the optimization within the LES considers the flexibility of Electric Vehicles (EVs) and hydrogen Fuel Cell Vehicles (FCEVs) which are either based within the LES or occasionally arrive in the LES for charging. The optimization model takes into account the day-ahead operation schedule of the vehicle fleets, the local electricity tariffs and the availability of the local storage assets (electricity, hydrogen) and determines the optimal charging schedule of the vehicles as well as possible modifications on the schedule of the storage assets (invocation of PUC 5. Optimal scheduling of electrical storage and hydrogen storage).

PUC 8. Multi-vector Optimization of assets' sizing in a LES

This PUC studies the optimal investment in new assets' deployment within the LES incorporating various goals that the investor might pose, such as increasing the degree of autonomy of the LES (by effectively reducing its dependency on the main grid), increasing profits or reducing cost, whilst the environmental impact of the investment will also be considered. The long-term assessment of the investment considers a large number of technical parameters of pre-existing production/storage assets, as well as historical data of the LES, e.g.: load and local production profiles, etc. which are thereafter fed to the Multi-Vector Simulator (MVS) in order to calculate and provide the optimal decision to the investor. The process is safeguarded and orchestrated by the ESB.

PUC 9. Optimal sizing of electric parts of a LES

In this PUC, the sizing of new electrical parts to be deployed in the LES is analysed through long-term simulations and optimal investment planning. The Multi-Vector Simulator (MVS), responsible for calculating the optimal decision, considers both technical parameters of the LES (e.g. installed capacity, location) of pre-existing energy production/storage assets and historical data (time series) related to the LES operation.

2.3.3 Secondary Functions

Secondary Use Cases (SUCs) were identified for describing functionalities that are used by multiple PUCs, achieving also a more granular presentation of the interactions.

SUC 1. Forecast RES production

Details the operations of the Energy Forecaster (EF), a module responsible for providing local RES production forecasts (i.e. PV panels, wind turbines and solar thermal) that are needed for the optimal operation of a LES, concerning different time horizons: intraday forecasting (e.g. hours ahead), day-ahead forecasting (e.g. day ahead) or long-term (e.g. week or month ahead). Historical production data and related meteorological measurements as well as weather forecasts are utilized for this scope.

SUC 2. Forecast Consumption

The EF module is also responsible for providing the load consumption forecasts (electrical loads, thermal loads, gas loads) concerning intraday forecasting (e.g. hours ahead), day-ahead forecasting (e.g. day ahead) or long-term (e.g. week or month ahead). For this operation, load consumption and weather historical data are required (optionally occupancy related data), as well as weather forecasts.

SUC 3. Calculate Optimal Schedule

This SUC models operations of the tool (Optimal Scheduler) that performs the various optimizations calculating the schedules of the dispatchable assets of a multi-vector LES. Three types of schedules can be provided: long-term (e.g. 1-year-long), short-term (e.g. day-ahead) and ultra-short-term (e.g. intraday) schedules, where various parameters can be taken into account such as: the uncertainty of the forecasts, historical energy prices, information about the operational limits of the assets, etc.

SUC 4. Running a multi-vector simulation with the MVS

This SUC analyses the functionalities of the Multi-Vector Simulator (MVS), together with the necessary interactions and data exchange with other systems that should be performed in order to enable the successful simulations of the LES and handling of the results.

SUC 5. Provide parameters for multi-vector simulation

Provides an overview of the required datasets of input parameters and their possible formats to be given as input to the MVS. The parameters of the MVS model consist of the project input parameters, the components' parameterization and the various constraints.

SUC 6. Communicate with field devices

The scope of this SUC is to describe the way in which field data is exchanged from the various pilot sites by the Energy Management System (EMS), in order to facilitate the advanced operations of forecasting and optimization described in other UC's. Two different architectures are considered, one integrating field devices through BMS, and one with direct integration of the field devices with the EMS.

SUC 7. Data Pre-processing

This SUC handles the data pre-processing functionalities which are required to ensure quality, completeness and proper granularity of the measured and acquired data. It can be triggered either in a periodical basis (e.g. daily) or upon a certain request (e.g. upon request by an external actor).

2.4 System Context

The analysis of the relevant stakeholders of the project, the high-level goals as well as the enumeration of the available assets of the pilot sites and systems to be deployed led to the population and validation of the technical actors' list which is presented and briefly discussed in the following table and in Figure 4.

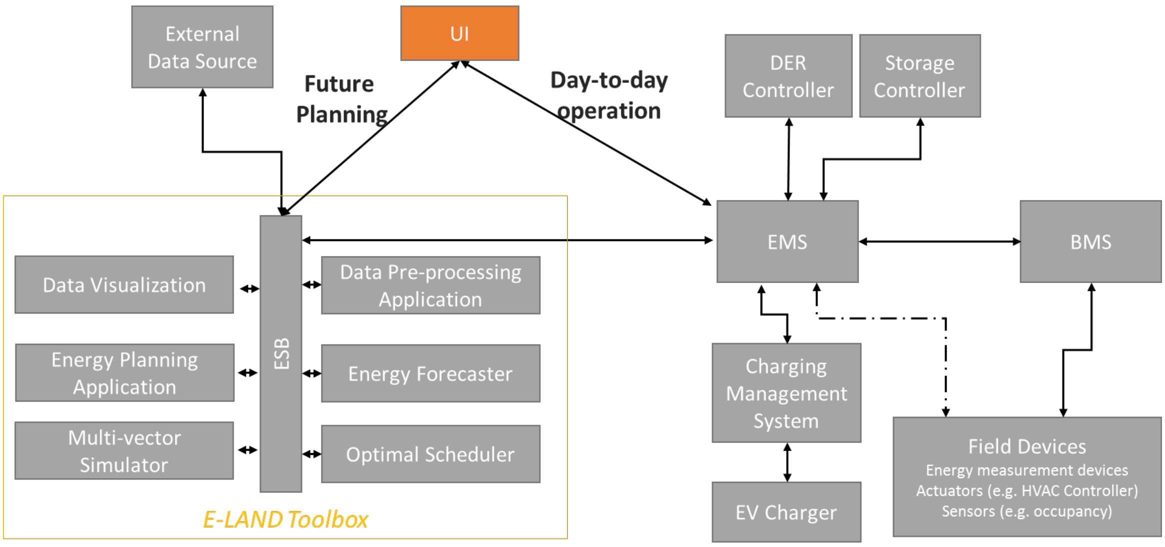


Figure 4: System Context

Table 2 Technical Actors.

Actor	***Type***	***Description***
Building Management System (BMS)	System	A system connected to the physical infrastructure of the building (e.g. sensor, actuators), offering monitoring and control capabilities of building's loads.
Charging Management System	System	Responsible for the operation of the EV charging Infrastructure.
Data Pre-processing (DP) Application	System	A system able to label missing/corrupted data, correct or estimate them.
Data Visualization	Application	A system for visualizing the projects KPIs.
DER Controller	Device	Device able to control the operation of DER.
Electrical Storage Controller	Device	Device able to control the operation of electrical batteries.
EMS Operator	Human	Human responsible for the operation of the EMS.

Energy Forecaster (EF)	Application	Predicts generation from local generation assets (e.g. wind turbines, PV panels), as well as consumption assets.
Energy Management System (EMS)	System	A system responsible for controlling the various assets of the LES as well as for the orchestration of its optimal operation. Provides a user interface for the day-to-day operation of the LES.
Energy Planning Application (EPA)	Application	An application providing a user interface for providing the input of the planning of the LES as well as accessing and visualizing the results of the calculations.
Energy Planning Expert	Human	Operator of the Energy Planning Application. Represents the main actor of the LES in terms of preparing the future assets planning study.
Enterprise Service Bus (ESB)	System	A system enabling the integration of the forecasting and optimisation tools, the EMS of the LES and the various external data providers.
EV Charger	Device	Device able to control the charging of EVs.
External Data Source (EDS)	System	An external system providing data required for the operation of the E-LAND tools (e.g. metering, environmental, system parameters, energy prices, grid constraints).
H2 Storage Controller	Device	Device able to control the operation of the electrolyser for producing and storing H2.
HVAC Controller	Device	Device able to control the set-point of the HVAC.
Load Controller	Device	Device able to control the operation of electrical or thermal loads.
Multi-Vector-Simulator (MVS)	Application	A component responsible for simulating the different energy flows in a LES, as well as for handling its future planning.
Optimal Scheduler (OS)	Application	System capable of calculating optimal (long-, short- and ultra-short-term) schedules considering the diverse type of assets of the LES and the various parameters (e.g. uncertainty of the forecasts, energy prices, operational constraints etc.).
Thermal Storage Controller	Device	Device able to control the operation of thermal storage assets (e.g. HW tank).

2.5 User Types

There are different classes of users, within the LES, which have an interest in using the system. The core end-users are the main stakeholders that were envisioned as actors operating or facilitating the operation of the LES:

- Aggregator (incl. EV Charging Infrastructure Operator)
- Facility Manager (e.g. University Campus operator, Harbour operator)
- Microgrid Operator

Furthermore, the following end-users aim at interacting with the system to enable novel services with regards to LES operation:

- DER Owner
- EV/ FCEV Owner

Furthermore, as presented in the functional decomposition previously, the functions envisioned concern two categories: day-to-day operation and future assets planning of the LES, with each one mapping to specific UCs. The two categories could be mapped into two different user roles (operator, planner), which can be played by the possible end-users mentioned above, assuming either one or both roles. Furthermore, the role of an administrator for managing the system's deployment and maintenance is envisioned.

2.6 Constraints

One of the major constraints in specifying the E-LAND Toolbox solution is related to the LES's infrastructure. More specifically, it is assumed that the point of interaction of the toolbox with the LES is the EMS. The EMS will act both as a provider of field data to the toolbox, an enabler of actuator actions calculated by the toolbox and to some extend as the front-end for user interaction (as described in HLUC2 and relevant PUCs). Although, EMS should not be confused with a SCADA system since various underlying subsystems (BMS, Battery management, EV charging management etc.) are required to perform actions on the DER. Hence the existence of such a solution for the energy management of the LES is a prerequisite in utilizing the operations envisioned by the toolbox at its full scale. More details of the types of systems integrated through the EMS are provided in section 2.4 and in HLUC1 (see section 2.3.1).

Considering that different vendors of EMS might exist, the interfaces of the toolbox and interactions with the EMS should aim at the maximum degree of interoperability. In order to achieve interoperability, open protocols at the field component level should be used.

3 Methodology

The task of requirements elicitation and documentation is highly demanding, requiring interdisciplinary skills, given it mediates between the domains of an acquirer/user and a supplier of a system, aiming at establishing a common understanding of what the system should do and specific qualities it must comply with.

This chapter presents the methodology followed in order to transform the acquirer's/user's (a.k.a. stakeholder's) needs to a formal statement of valid stakeholder for the system of interest. The followed terminology and methodology for the description of the systems' functionalities and qualitative characteristics were adapted to the needs of the project, following the work of international standards (ISO/IEC 15288:2008, ISO/IEC 29148:2011).

3.1 Terminology

The basic terminology utilized in the elicitation process is presented in the next list:

- **Requirement**: A statement which translates or expresses a need and its associated constraints and conditions;
- **Constraint**: Externally imposed limitation on system requirements, design, or implementation or on the process used to develop or modify a system;
- **Condition**: Measurable qualitative or quantitative attribute that is stipulated for a requirement;
- **Acquirer:** Stakeholder that acquires or procures a product or service from a supplier;
- **Stakeholder**: Individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their needs and expectations;
- **Supplier:** Organization or individual that enters into an agreement with the acquirer for the supply of a product or service;
- **User:** Individual or group that benefits from a system during its utilization.

3.2 Viewpoints

A viewpoint provides the perspective of a stakeholder with an interest in the system e.g. end-user, design engineer, safety engineer etc. Different viewpoints were identified and requirements were collected, initiating by the end-users of the systems and - upon devising the initial architecture of the system - by design engineers, integrators, tool developers and solution providers (i.e. EMS). This approach helped organizing and prioritizing requirements.

3.3 Requirement Types

Requirements can vary in type, depending on the stakeholder's view they represent, as well as based on the kinds of properties they address.

The requirements can be differentiated in terms of intent:

- *Business Requirements*: Provide the description of the procedures of business activities and possible system interfaces, aiming at presenting what the system shall support and in which context. Business objectives and concerns were identified as a driving activity for requirements elicitation, following a goal oriented approach, aiming at describing as closely as possible the envisioned solution.
- *System Requirements*: Concern the requirements of the system from a technical perspective. Following the elicitation of the business requirements, the technical requirements for the selected systems of interest were identified, based on the draft architectural design, transforming the stakeholders' requirements into a technical view required for documenting the systems.

Requirements can be also differentiated in terms of what kind of properties they represent:

- Functional: Describe the functions or tasks to be performed by the system
- Non-Functional: Provide the qualitative characteristics and properties of the system
- Interface: Define how a system is required to interact with external systems (external interface), or how individual elements of a system (including humans) interact with other elements within the system (internal interface).

3.4 Requirements Elicitation and Elaboration

In the process of working with stakeholders to investigate the problem and to identify their needs and requirements, there are different means of devising the complete list of the requirements which will adequately describe the system of interest:

- Requirements elicitation: During this process requirements are documented directly from the source;
- Requirements elaboration: In many occasions, elicited requirements tend to be at a high level (when stakeholders are from the business domain) hence a decomposition is necessary, which involves breaking a higher-level requirement into lower-level requirements that are explicitly required by it. Furthermore, elicited requirements may not address all aspects of the system (since they are usually focused on business), hence some requirements must be inferred for completing the specification of the system.

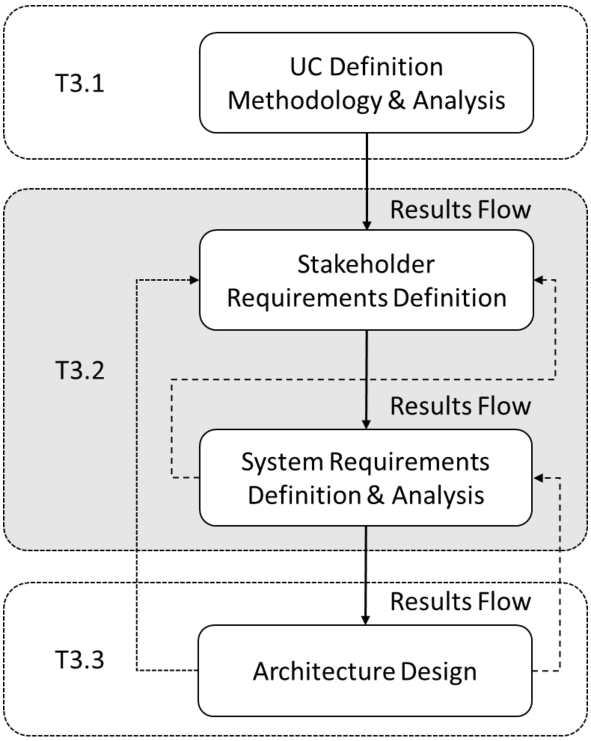


Figure 5: Iterative and Recursive Requirements Specification and Design Process.

Consistent practice has shown that this process requires iterative steps in order to elaborate high-level requirements to lower-level ones, group them and allocate them to system elements. The later action is part of the architectural design process which needs to proceed in parallel with the definition of requirements (recursive process). It may be that some requirements cannot be derived until some portion of the architecture or design evolves, hence there is a feedback loop from the architectural design process to the requirement definition one. Figure 5 presents the above process, as well as a mapping to the project's relevant tasks (T3.1-T3.3). In the context of the project, an initial phase of UC definition took place, in order to understand the stakeholders' high level goals, the system context and relevant functionalities that must be provided by the system of interest.

3.5 Templates

A systematic documentation of a requirement must address the description of the following requirement's attributes:

- **Identification**. Each requirement should be uniquely identified;
- **Title**: A short title should provide a brief description to the reader;
- **Description**: A detailed description of the scope of the requirement;
- **Rationale**. The rationale for establishing each requirement should be captured. The rationale provides the reason that the requirement is needed and points to any supporting material;
- **Author**: Party imposing the specific requirement and their role;
- **Dependency**. The dependency between requirements should be defined (when it exists);
- **Source**. Each requirement should include an attribute that indicates the origin of it;
- **Priority**. The priority of each requirement should be identified.

Non-functional requirement can also have attribute that facilitate their validation:

- **Metric**: Method of quantifying the non-functional requirement;
- **Verification Measurement**: The process or device used to verify the requirement;
- **Target**: The level (value, interval, etc.) at which goal success can be claimed.

Furthermore, information related to the risk based on the consequences of not implementing a specific requirement or the degree of risk avoidance can be documented, following a risk analysis for grading system requirements.

We differentiated requirement among different stakeholders as presented in the following list, as well as on subsystem basis:

- Facility Manager- FM
- Aggregator - AG
- Microgrid Operator - MO
- Other stakeholders (e.g. DER Owner) – ST

Furthermore, requirements were differentiated among different systems or subsystems:

- E-LAND Toolbox - ET
    - Data Pre-processing application - DP
    - Energy Forecaster - EF
    - Energy Planning Application - EPA
    - Enterprise Service Bus - ESB
    - Multi-Vector-Simulator - MVS
    - Optimal Scheduler – OS
    - Data Visualisation application - DV
- Energy Management System - EMS

Table 3 presents the documentation template for the functional requirements, where they are differentiated among:

- Stakeholder requirements: where in Requirement ID, WW is 'BN', XX is the stakeholder abbreviation and YY is an incremental number.
- System requirements: where in Requirement ID WW is 'FN', XX is the subsystem abbreviation and YY is an incremental number.

Table 3 Functional Requirement Template

Requirement ID	**WW-XX-YY**
Title	
Description	
Rationale	
Source/Related Requirements	
Author	
Priority	

Table 4 presents the documentation template for the non-functional requirements, where same differentiation as presented above applies.

Table 4 Non-Functional Requirement Template

Requirement ID	**NF-XX-YY**
Title	
Description	
Author	
Scope	
Metric	
Verification Measurement	
Target	
Related Functional Requirements	

4 Business Requirements

This section presents the main business stakeholders' viewpoints related to the use of E-LAND solutions, elaborating on the business cases.

4.1 Goals and Objectives

A central part in E-LAND's vision is assumed by the LES operator, the business goal of which can differ according to the details of the LES, i.e.: the other business/technical actors of the LES and the different ownership models of the available assets. On this basis, three main business cases are envisioned, with the role of the LES Operator being undertaken by: either the Aggregator, the Microgrid Operator or the Facility Operator.

The three business cases that were identified as the basic drivers behind the project's UCs are presented in the following figures and are briefly explained below:

- The first business case (Figure 8) models the role of LES Operator as an Aggregator. The LES Operator is assumed in this case to conclude "Flexibility Contracts" with the various Grid Users of the LES, e.g. the Consumers, the DER/EV/FCEV owners/users, the Facility Managers, as well as the (multi-vector) Grid Operators (in terms of providing ancillary services). Furthermore, the LES Operator is entrusted with the responsibility to participate in the central energy market, trading and procuring energy for the aforementioned actors. The Aggregator could either trade "Flexibility" directly (assuming a future "Flexibility" market would exist) or participate in the existing energy market and aim at reducing the energy costs of the represented business parties through optimal energy management actions.
- In a similar way, the second BC, presents the LES operator acting as a Facility Manager (Figure 6), by signing supply contracts with multi-vector suppliers and "Flexibility" contracts with the (multi-vector) Grid Operators aiming at profit maximization through provision of ancillary services and costs minimization through reduction of energy usage.

Figure 6 : The LES Operator as a Facility Manager

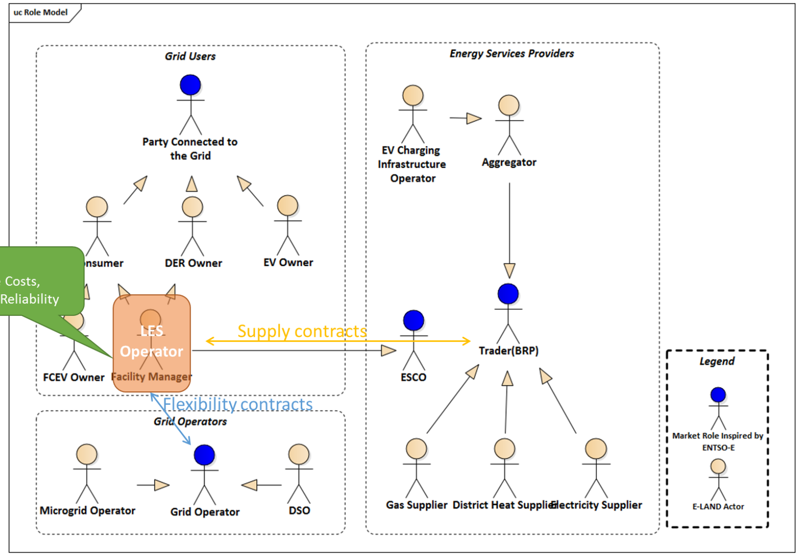


Figure 8 : The LES Operator as an Aggregator.

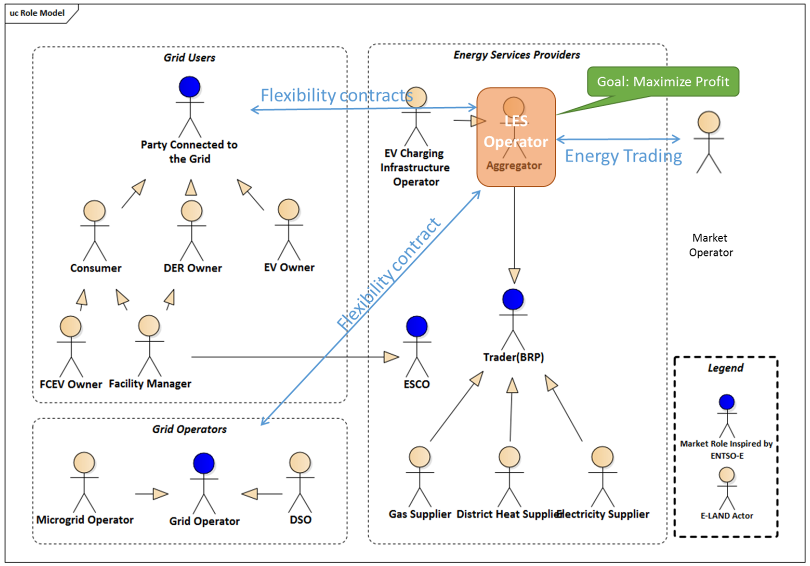
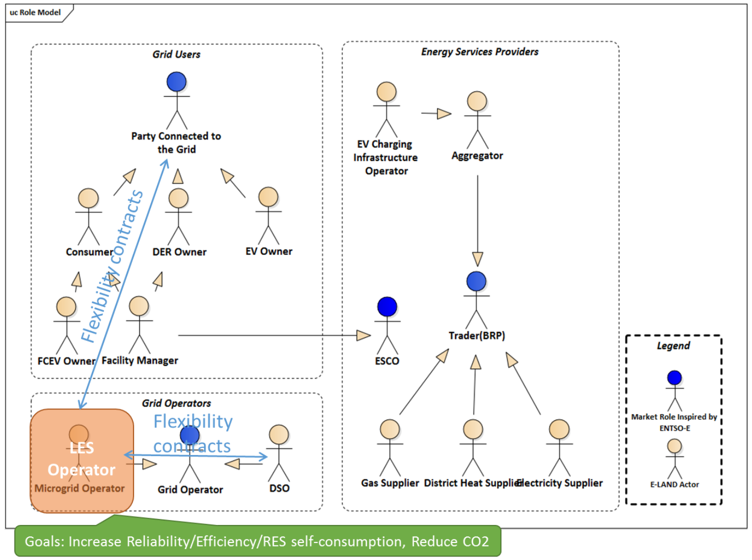


Figure 7 : The LES Operator as a Microgrid Operator.



- In the last BC, the role that was identified to be played by the LES Operator is that of the (possibly multi-vector) Microgrid Operator (Figure 7). In this business case, the LES Operator is assumed to sign “Flexibility” contracts with the Grid Users of the LES and targets at achieving goals related to increased reliability (e.g. through increased degree of autonomy) and efficiency of the local system, increased RES self-consumption, or reduction of CO_2 emissions.

4.2 Business Functions

The different business functions of the various stakeholders are presented in this section, based on the different perspectives presented in the BCs of the previous section, the work of the UC analysis and the viewpoints of the different partners. Apart from the views of the main stakeholders (i.e. Aggregator, Facility Manager, and Microgrid Operator), the view of other stakeholders involved in the operations of the LES (e.g. DER Owner, Prosumer) - which will enable the envisioned advanced operations - is provided.

4.2.1 Facility Manager

Requirement ID	**BN-FM-01**
Title	Cost efficient operation
Description	The solution should calculate and dispatch the optimal day-ahead schedule of the dispatchable assets (i.e. storage) of the LES to achieve the minimized operational cost.
Rationale	Harness flexibility of battery assets of the LES for achieving optimal day-ahead operation.
Source/Related Requirements	PUC05, PUC06/ BN-MO-02
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**BN-FM-02**
Title	Provide flexibility services
Description	The ability to comply with flexibility service request shall be supported.
Rationale	The facility manager must be able to coordinate and provide aggregated flexibility from the controllable assets deployed in its premises.
Source/Related Requirements	PUC1-7 BN-MO-01, BN-AG-03

Author	Tool developer, Integrator (ICOM)
Priority	HIGH

Requirement ID	**BN-FM-03**
Title	Optimal scheduling of flexible loads
Description	Calculation and optimal control of the assets according to a specific load profile shall be provided.
Rationale	For the possibility to effectively respond to the flexibility targets set by upstream flexibility requests, or by the facility manager's business goals, the optimal coordination of the flexible loads should be possible.
Source/Related Requirements	PUC2-7 BN-AG-04, BN-MO-03
Author	BIKS/ICOM
Priority	HIGH

Requirement ID	**BN-FM-04**
Title	Optimal planning of future investments
Description	Ability to calculate the optimal sizing of investments in new assets for the LES shall be supported.
Rationale	For the cases that investment in new equipment or new assets has been decided, the facility manager should be able to evaluate the different possible planning alternatives, retrieving the optimal solution according to the goals that have been set.
Source/Related Requirements	PUC8-9 BN-MO-05, BN-AG-07
Author	End-user(BIKS), Integrator (ICOM)
Priority	HIGH

Requirement ID	**BN-FM-05**
Title	Consider investment in electrical production/storage assets
Description	Ability to calculate the optimal sizing of investments in new electrical production and storage assets shall be supported.
Rationale	For the cases that investing in new equipment/assets has been decided, the facility manager should be able to evaluate the sizing of electrical production/storage assets, retrieving the optimal solution according to the goals that have been set.
Source/Related Requirements	PUC8-9 BN-FM-04
Author	End-user(BIKS), Integrator (ICOM)
Priority	HIGH

Requirement ID	BN-FM-06
Title	Consider investment in thermal production/storage assets
Description	Ability to calculate the optimal sizing of investments in new thermal production and storage assets shall be supported.
Rationale	For the cases that investing in new equipment/assets has been decided, the facility manager should be able to evaluate the sizing of thermal production/storage assets, retrieving the optimal solution according to the goals that have been set.
Source/Related Requirements	PUC8-9 BN-FM-04
Author	End-user(BIKS), Integrator (ICOM)
Priority	HIGH

4.2.2 Aggregator

Requirement ID	BN-AG-01
Title	Participate in balancing market
Description	Ability to define different products and services based on demand response or DER assets for participation in balancing market shall be provided.
Rationale	Prospective DR products for the Balancing market include: Day-Ahead Scheduling Reserves or Non-Spinning Reserves with a longer activation time, for example 30 minutes; Spinning Reserves requiring curtailment at shorter notice (10 or 5 minutes); Regulation Reserves requiring real time load changes for Load-Frequency Control (4 seconds to 1 minute); Specifically in a LES, not all DR resources will be capable of providing every balancing product, since it depends on the established requirements for response time, response frequency, duration and whether an increase in demand is required.
Source/Related Requirements	PUC1
Author	End-user(INYCOM)
Priority	HIGH

Requirement ID	BN-AG-02
Title	Participate in wholesale market
Description	It should be possible to define different products and services based on demand response schemes or DER assets behaviour manipulation, for participating in the wholesale market.
Rationale	The aggregator should be able to participate in the wholesale market for supplying electricity (can be extended for other vectors) to its customers. For the case that controllability of the DER assets or the flexible loads is available, the aggregator has increased capabilities for optimizing its procurement, reaching higher profits and securing lower costs to its customers. The objective is to reduce energy buying costs

	and improve revenues from energy selling by directly participating in the wholesale market. Specifically in a LES, the ability to participate in wholesale market will be determined by whether or not minimum requirement participating thresholds are met both in case of generation and demand.
Source/Related Requirements	PUC1
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-AG-03**
Title	Provide flexibility services
Description	The ability to comply with flexibility service requests shall be supported.
Rationale	The aggregator must be able to coordinate and provide flexibility from the controllable assets of its portfolio. Business can be done through selling flexibility. Interconnection between different vectors results in increased flexibility of LES. The goal is to capitalize on the flexibility and generate revenues by providing flexibility services.
Source/Related Requirements	PUC1 BN-FM-01, BN-MO-01
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-AG-04**
Title	Optimal scheduling of flexible loads
Description	Calculation and optimal control of the assets according to the (flexibility) goals set shall be provided.
Rationale	The aggregator should be able to utilize optimal control mechanisms and algorithms in order to calculate proposed actions for the operation of its assets, according to the economic goals that are set.
Source/Related Requirements	PUC2-7 BN-FM-02, BN-MO-03, BN-AG-03
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-AG-05**
Title	DER portfolio optimization
Description	Optimization that takes into account the assets' operational characteristics, status, contracts and bids, to generate the most efficient and profitable dispatch orders shall be provided.

Rationale	The aggregator has a specific portfolio of assets based on existing contracts with the DER owners. Based on the requests that the aggregator receives, and the baseline, an optimal use of the available assets needs to be calculated to fulfil the order with the TSO/DSO.
Source/Related Requirements	PUC1-7 BN-AG-01, BN-AG-02, BN-MO-04
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-AG-06**
Title	Market bidding
Description	The ability to participate in the market though bidding DER production or DR flexibility shall be supported.
Rationale	For the aggregator to be able to participate in the wholesale and balancing markets, it should be possible to make the relevant biddings in the respective marketplaces.
Source/Related Requirements	PUC1 BN-AG-01, BN-AG-02
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-AG-07**
Title	Optimal planning of future investments
Description	Ability to calculate the optimal sizing of investments in new assets for the LES shall be supported.
Rationale	The aggregator must be able to use a planning tool for calculating the optimal size of new assets to be installed in the LES. This way it will be possible to evaluate the different possible investments and choose the most advantageous.
Source/Related Requirements	PUC8-9 BN-FM-04, BN-MO-05
Author	End-user(INYCOM), Integrator (ICOM)
Priority	LOW

Requirement ID	**BN-AG-08**
Title	Consider investment in electrical production/storage assets
Description	The study for sizing of future investments in the LES concerning production and storage assets should consider the electrical vector.
Rationale	For the cases in which investing in new equipment/assets has been decided, the facility manager should be able to evaluate the sizing of

	electrical production/storage assets, retrieving the optimal solution according to the goals that have been set.
Source/Related Requirements	PUC8-9 BN-AG-07
Author	INYCOM,ICOM
Priority	LOW

Requirement ID	**BN-AG-09**
Title	Consider investment in thermal production/storage assets
Description	The study for sizing of future investments in the LES concerning production and storage assets should consider the thermal vector.
Rationale	For the cases in which investing in new equipment/assets has been decided, the aggregator should be able to evaluate the sizing of thermal production/storage assets, retrieving the optimal solution according to the goals that have been set.
Source/Related Requirements	PUC8-9 BN-AG-07
Author	End-user(INYCOM), Integrator (ICOM)
Priority	LOW

4.2.3 Microgrid Operator

Requirement ID	**BN-MO-01**
Title	Provide flexibility services
Description	Offer grid services including energy, capacity, and ancillary services. The goal is to benefit from the flexibility and create revenues by offering flexibility services.
Rationale	The ability to comply with flexibility service requests shall be supported.
Source/Related Requirements	PUC1-7 BN-AG-03, BN-FM-01
Author	End-user (UVTgv)
Priority	HIGH

Requirement ID	**BN-MO-02**
Title	Operate the grid with efficiency and degree of autonomy
Description	Reduce grid “congestion” and peak loads. Monitor power quality and apply corrective measures. Optimal scheduling of thermal and electrical storage. The goal is to benefit from energy savings and downtime costs.
Rationale	LES optimal operation.
Source/Related Requirements	PUC2-7 BN-FM-06

Author	End-user (UVTgv)
Priority	HIGH

Requirement ID	**BN-MO-03**
Title	Optimal scheduling of flexible loads
Description	Load shedding, peak shaving and other DR scenarios should directly control intelligent electronic devices, HVAC or other similar loads. This could help maximizing earnings and ease operation of the microgrid in stress situations or on aggregator/grid request.
Rationale	Reliability/Comply with flexibility bids
Source/Related Requirements	PUC1-5 BN-AG-04, BN-MO-03
Author	End-user (UVTgv)
Priority	HIGH

Requirement ID	**BN-MO-04**
Title	DER portfolio optimization
Description	Advanced DER integration technologies can support the adaptation of intermittent renewable sources by providing both dispatchable generation assets and essential grid services, including frequency response, capacity, and other degree of autonomy and resilience enhancement functionalities. The goal is to capitalize these advantages.
Rationale	Integrate renewables, thermal and electric storage, and advanced system and building controls. Provide grid support, enhance degree of autonomy and resilience. For example during a large-scale disaster event that causes wide-spread power outages, DER and energy storage have the potential to bring power back faster to customers. Furthermore, the system should be able to prepare for such an event.
Source/Related Requirements	PUC1, PUC4-6, PUC08 BN-AG-05
Author	End-user (UVTgv)
Priority	MEDIUM

Requirement ID	**BN-MO-05**
Title	Optimal planning of future investments
Description	Future investments planning for the LES can achieve less total capital costs, installed generation capacities, higher capacity factors of all assets and higher degree of autonomy.
Rationale	Optimal planning based on operational costs and capacity needs. Planning and operation challenges arise at both the transmission and distribution levels, as well as at the interfaces between them. As the amount of DER continues to grow, generation may exceed demand

	during the middle of the day, leading to solar curtailment unless the energy is stored.
Source/Related Requirements	PUC9 BN-AG-07, BN-FM-04
Author	End-user (UVTgv)
Priority	MEDIUM

Requirement ID	**BN-MO-06**
Title	Consider investment in electrical production/storage assets
Description	Proper asset sizing/planning and smart/timely investments can leverage microgrids potential and boost its flexibility. Well considered investments can produce large impacts in the economic operations mainly due to external flexible services.
Rationale	Considerate strategic investments in a timely manner to maximize revenues from flexible services.
Source/Related Requirements	PUC1, PUC8 BN-MO-05
Author	End-user (UVTgv)
Priority	MEDIUM

Requirement ID	**BN-MO-07**
Title	Consider investment in thermal production/storage assets
Description	Proper asset sizing/planning and smart/timely investments can leverage microgrids potential and boost its flexibility. Well considered investments can produce large impacts in the economic operations mainly due to external flexible services.
Rationale	Considerate strategic investments in a timely manner to maximize revenues from flexible services.
Source/Related Requirements	PUC1, PUC8 BN-MO-05
Author	End-user (UVTgv)
Priority	MEDIUM

4.2.4 Other Stakeholders

Requirement ID	**BN-ST-01**
Title	Provide flexibility
Description	The local stakeholders of the LES (e.g. prosumer, DER Owners, EV Owners) should be able to provide flexibility through proper incentives.
Rationale	The local stakeholders shall participate in flexibility contracts/event and alter their consumption/production profile for the benefit of the LES -

	according to the signals transmitted by the LES operator – in response to the incentives provided.
Source/Related Requirements	PUC1-7
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**BN-ST-02**
Title	Participation in future investments
Description	The local stakeholders of the LES should be able to participate in the evaluation of asset investments.
Rationale	The local energy grid end-users (DER owners, prosumers) might have an interest in participating in future investment in the LES, individually or through association schemes (e.g. energy communities).
Source/Related Requirements	PUC8-9 BN-MO-05, BN-AG-07, BN-FM-04
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**BN-ST-03**
Title	Asset operation
Description	The local stakeholders should be able to provide controllability of their assets for participating in the day-to-day operations of the LES. The LES Operator will comply with the asset operational constraints set by each stakeholder.
Rationale	In order for the DER owners to participate in the LES's optimal operation, their systems should interface the E-LAND solution. The operational policy should respect the goals/constraints of the stakeholder regarding availability and lifespan extension of assets.
Source/Related Requirements	PUC1-7
Author	End-user(BIKS)
Priority	HIGH

4.3 Requirements

The different business functions identified in the previous section were modelled as specific requirements for the E-LAND Toolbox.

4.3.1 End-User Requirements

Requirement ID	FUN-ET-01
Title	Controllability of DER assets
Description	Capability to transmit setpoints for controlling DER units shall be provided.
Rationale	On one hand the LES operator should be able to perform control actions and modify the consumption/production patterns of the LES by transmitting control setpoints to the flexible DER assets. The aggregator, as a business actor intervening in the electricity market, should be able to activate/deactivate generation/loads units as part of their energy pool, depending on the bidding process (accepted bid). For the case of the Microgrid operator, it should be possible to manage local renewable generation and storage. Therefore, a specific requirement is set on the structure of the command system to be sent to the DER devices.
Source/Related Requirements	PUC2-7 BN-AG-05, BN -MO-04
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	FUN-ET-02
Title	Compliance assessment of DER asset schedule
Description	Capability to transmit measurements for monitoring compliance to transmitted schedules shall be supported.
Rationale	The end-user should be able to validate the compliance of the controllable assets with the enforced commands.
Source/Related Requirements	PUC2-7 BN-AG-05, BN-MO-04
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	FUN-ET-03
Title	Communication with DR assets
Description	Capability to transmit DR information for communicating with DR resources shall be provided.
Rationale	The end-user should be able to communicate DR signals in order to modify the load pattern of the assets of the LES.
Source/Related Requirements	PUC1-3 BN-FM-03, BN-AG-04, BN-MO-03

Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-04**
Title	Production forecasting
Description	Multi-vector prediction of production of local DER assets shall be provided.
Rationale	Needed for long-term scheduling as well as market bid formulation.
Source/Related Requirements	PUC1-7 BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-06
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-05**
Title	Demand forecasting
Description	Short-term and long-term load profiles generated for the consumption assets of the LES. Historic consumption data combined with weather data, loads schedules and/or occupancy data (such as hours of operation and percentage of building occupancy) should be considered in the forecasting algorithm.
Rationale	Demand forecasts represent a key factor in optimal operation of a LES, enabling simulations of future operations and in turn short/long term planning
Source/Related Requirements	PUC2-7 BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-06
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-06**
Title	Forecast horizon
Description	Different forecast horizons shall be supported: • A long-term forecast horizon of week-ahead forecasting with daily granularity • A short-term forecast horizon of day-ahead forecasting with hourly granularity • An ultra-short-term forecast horizon of intraday forecasting with hourly granularity
Rationale	Enables the monitoring of the LES and the scheduling of its operation in the different time horizons, with relation to the different business processes.

Source/Related Requirements	BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-11, FUN-ET-12
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-07**
Title	Reporting
Description	Ability to generate dashboards and reports enabling the analysis of assets load profile and compliance to events.
Rationale	The end-user should be able to have access to generated reports regarding the control actions that have taken place in the LES in order to be possible to improve/enhance the control schemes. For example, the aggregator needs to carry out rigorous analysis on the performance of DR programs and events, based on the process of collecting and submitting data and the generation of statistics and analysis of all the demand response actuations carried out. In the same way, reporting and analysis tools are the key enablers in microgrid operations: technical, economical and planning.
Source/Related Requirements	PUC1-7
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	MEDIUM-LOW

Requirement ID	**FUN-ET-08**
Title	Billing and economic settlement of local energy management actions
Description	The calculation impact of the energy management actions (e.g. demand response) in form of settlement actions, or service bill towards internal or external stakeholders shall be provided.
Rationale	When an energy management action is taken (e.g. the aggregator fulfils actions requested by the DSO/TSO), the money flows (bills) from the grid operator to the LES operator and from the latter to the DERs owners/DR resources. The economic benefits of the optimal control actions in the LES operation should be calculated and transferred to the participating customers. Furthermore, each service or settlement should be economically possible for regulatory purposes or economic gains in support of ROI.
Source/Related Requirements	PUC1-7
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	MEDIUM-LOW

Requirement ID	**FUN-ET-09**

Title	Consider operational costs in scheduling
Description	Consideration of techno-economic parameters by the optimization algorithms shall be supported.
Rationale	For the optimization model to provide meaningful results, it is considered necessary to estimate the operational costs of the various assets that will be optimized in the different scenarios. Pre-emptive measures can lower OPEX in both generation and storage assets maintenance.
Source/Related Requirements	PUC1-9 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-10**
Title	Consider assets' technical constraints in scheduling
Description	Consideration of the required technical constraints for the optimization algorithms shall be supported.
Rationale	For the optimization model to provide feasible results (in terms of satisfying the technical constraints of the assets under control), it is considered necessary to identify the various technical limits of each asset. Optimal scheduling can produce best results only when algorithms are fed with each system particularities; e.g. Performance ratio (PV) or solar fraction (thermo-solar) are specific global references of each systems performance.
Source/Related Requirements	PUC1-9 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-11**
Title	Short-term scheduling
Description	A short-term horizon schedule calculation for LES's asset dispatch should be supported.
Rationale	For participating in balancing or relevant markets a short-term horizon is necessary (e.g. 1-hour ahead). Further, grid related operation undertaken by the Microgrid operator might require even shorter time horizon (~min).
Source/Related Requirements	PUC1-7 BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-09, FUN-ET-10, FUN-ET-18 to 30
Author	End-user (BIKS, INYCOM, UVTgv)

Priority	HIGH

Requirement ID	**FUN-ET-12**
Title	Long-term scheduling
Description	A long-term horizon schedule calculation for LES's asset dispatch should be supported.
Rationale	For participating in wholesale or relevant markets a long-term horizon is necessary. Furthermore, long-term scheduling can be enabling the realization optimizing seasonal (e.g. week) scheduling of LES's assets.
Source/Related Requirements	PUC1-7 BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-09, FUN-ET-10, FUN-ET-18 to 30
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-13**
Title	Operator interface
Description	The end-user should be able to control the execution of the various functionalities in the LES and retrieve the results.
Rationale	An UI that the end-user can use for controlling the execution of the various possible functionalities in the LES and retrieving the results of the algorithms enabling the overview for an all interconnected multi-vector energy systems.
Source/Related Requirements	PUC1-9 BN-FM-03, BN-FM-04, BN-AG-04, BN-AG-05, BN-AG-07, BN-MO-03, BN-MO-04, BN-MO-05
Author	End-user (BIKS, INYCOM, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-14**
Title	Bid formulation for DER production for market profit maximization
Description	The aggregator shall be able to formulate and send accurate bids to the wholesale market for selling the electricity generated by managed local DER assets.
Rationale	The aggregator will put together the bids of many small generation units subject to fluctuations due to uncertainty of renewable energy production, mainly solar PV and wind. It needs then not only forecasting tools, but also to minimize the deviation penalties taking advantage of cost asymmetries (less penalties if deviation helps the system) and portfolio effect. If electricity prices forecasts are available the

	aggregator will be able to further optimize the amount of electricity generated.
Source/Related Requirements	PUC1,4,5 BN-AG-06
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-15**
Title	Consider current LES DER assets and contracts in optimal planning
Description	Calculation of investments on the basis of current and future contractual agreement with local DER Owners and own assets shall be supported.
Rationale	For achieving the optimal investment assessment, the end-user should take into account the various contractual agreements with the local asset owners.
Source/Related Requirements	PUC8-9 BN-FM-04, BN-FM-05, BN-FM-06, BN-AG-07, BN-AG-08, BN-AG-09, BN-MO-05, BN-MO-06
Author	End-user (BIKS, INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-16**
Title	Calculate size of assets for maximizing the profits from selling energy/ancillary services to the market(s)
Description	The system shall be able to calculate the optimal size of assets based on the profit maximization goal.
Rationale	The goal of optimal planning for an end-user involves maximizing profits either from market participation through bidding, or with bilateral contract for services.
Source/Related Requirements	PUC8-9 BN-FM-04, BN-FM-05, BN-FM-06, BN-AG-07, BN-AG-08, BN-AG-09, BN-MO-05, BN-MO-06, FUN-ET-15
Author	End-user (BIKS, INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-17**
Title	Calculate ROI and NPV of investment
Description	The calculation of ROI and NPV of investment shall be provided.
Rationale	The calculation of certain values such as the ROI and the NPV is crucial for assessing the different alternative investments in new assets.

Source/Related Requirements	PUC8-9 BN-FM-04, BN-FM-05, BN-FM-06, BN-AG-07, BN-AG-08, BN-AG-09, BN-MO-05, BN-MO-06, FUN-ET-16
Author	End-user (BIKS, INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-18**
Title	Consider transportation loads availability
Description	Optimization should consider transportation loads availability according to end-user's constraints.
Rationale	The availability of the transportation loads should be taken into account by optimization algorithms for providing feasible operational schedules.
Source/Related Requirements	PUC3,6 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS, INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-19**
Title	Energy peak shaving
Description	In order to control the LES operational costs, the assets' scheduling needs to be set right in order to have sufficient energy in a storage solution for compensating upcoming peaks.
Rationale	In the Norwegian energy market (both electricity and DH), a substantial cost stems from the cost of maximal power, not energy. This cost is calculated from peak usage (kWh/h) during one calendar month. Some DSOs / DHOs may even do the calculation based on (calendar) yearly peak or on the average from three peaks during a (calendar) period; Tariffs (cost per kWh/h) have seasonal variations, and even monthly variations. Normally, this means low costs of power during summer and high during winter. Setting of the peak should be done with good margins, as overshoot will be very costly. A good model to do probability and cost analysis is required.
Source/Related Requirements	PUC1, PUC3 and PUC4 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-20**
Title	Availability of electricity prices
Description	The system should import electricity prices (e.g. day-ahead prices) from the electricity market (e.g. Nord Pool) daily at a set time (including daily tariffs and not just real-time energy prices in KWh).

Rationale	The availability of electricity prices is necessary for the calculation of the optimal schedule of the LES's assets, market participation, as well as for the calculation of the optimal sizing of future investments.
Source/Related Requirements	PUC1-9 BN-FM-03, BN-AG-01, BN-AG-02, BN-AG-06, BN-AG-04, BN-MO-03, BN-FM-04, BN-FM-05, BN-FM-06, BN-AG-07, BN-AG-08, BN-AG-09, BN-MO-05, BN-MO-06
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-21**
Title	Availability of DH prices
Description	The system should be able to import DH prices (day-ahead prices) daily at a set time from the customers' DHO.
Rationale	The availability of DH prices is necessary for the calculation of the optimal schedule of the LES's assets as well as for the calculation of the optimal sizing of future investments.
Source/Related Requirements	PUC1-9 BN-FM-03, BN-AG-04, BN-MO-03, BN-FM-04, BN-FM-05, BN-FM-06, BN-AG-07, BN-AG-08, BN-AG-09, BN-MO-05, BN-MO-06
Author	BIKS
Priority	HIGH

Requirement ID	**FUN-ET-22**
Title	Energy pricing model
Description	The system shall be able to model all relevant charges (regulated/ unregulated) for grid end-users.
Rationale	The energy usage cost may consist of energy price, transport price per kWh (from the DSO or DHO), different taxes on these elements as well as peak tariffs expressed as cost per kWh/h.
Source/Related Requirements	PUC1-9 FUN-ET-20, FUN-ET-21
Author	End-user (BIKS)
Priority	High

Requirement ID	**FUN-ET-23**
Title	Granularity of control actions
Description	The control of assets should be done with a specified granularity.
Rationale	The use of available protocols and interfaces to the assets shall enable the operation of control actions in an automated and time responsive

	manner and enable short-term scheduling execution, as opposed to using controllable switches to switch loads on/off manually.
Source/Related Requirements	PUC1-7 BN-FM-03, BN-AG-04, BN-AG-05, BN-MO-03, BN-MO-04, BN-ST-03
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-24**
Title	Setting maximal power available in DER
Description	The total power available for all loads in the DER should be set, for different parts if suitable. The power may be restricted by local grid as well as combined power available from DSO and from DERs own sources (production and stored energy limited by inverters).
Rationale	The total power available needs to be distributed among the loads, where prioritization needs to be performed between loads.
Source/Related Requirements	PUC3,6 BN-FM-03, BN-AG-04, BN-AG-05, BN-MO-03, BN-MO-04
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-25**
Title	Changing maximal power available in DER
Description	The total power available for all loads in the DER should be possible to change, automatically and manually.
Rationale	The available power may change according to production, and will be expanded or reduced together with DSO interconnect and capacity of the internal grid. The available power in the short term will change according to available energy in battery storages.
Source/Related Requirements	PUC2-3 FUN-ET-24
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-26**
Title	Prioritization parameters of LES loads
Description	Each of the loads should have a prioritization to be taken into account when optimizing LES's operation.
Rationale	The different load priorities (ranging from less critical to more critical) should be modelled and taken into account by the optimization algorithms.

Source/Related Requirements	PUC2-7 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-27**
Title	Changing prioritization parameters for loads
Description	The prioritization of loads with regards to scheduling should be possible to be modified manually by the end-user.
Rationale	Due to the changing conditions and/or installation of new equipment in the deployment sites, it should be possible to modify the prioritization parameters of the LES loads.
Source/Related Requirements	PUC2-7 BN-FM-03, BN-AG-04, BN-MO-03
Author	End-user (BIKS, UVTgv)
Priority	HIGH

Requirement ID	**FUN-ET-28**
Title	Prioritization for EV charging
Description	The different EVs priorities (ranging from less critical to more critical) should be modelled and taken into account by the optimization algorithms.
Rationale	Due to the changing conditions and/or installation of new EVs by the EV charging Operator, it should be possible to set different priority parameters.
Source/Related Requirements	PUC7 FUN-ET-26
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-29**
Title	Changing prioritization for EV charging
Description	The different EVs priorities (ranging from less critical to more critical) should be possible to modify.
Rationale	Due to the changing conditions and/or installation of new EVs by the EV Charger Operator, it should be possible to modify the priority parameters.
Source/Related Requirements	PUC7 FUN-ET-27,FUN-ET-28
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	FUN-ET-30
Title	Manual operational constraints for EV charging
Description	Values for power available for EV charging should be possible to be modified manually by the operator.
Rationale	Due to the changing conditions and/or installation of new EVs by the EV charging Operator, it should be possible to modify the available charging power parameters.
Source/Related Requirements	PUC7 BN-FM-03, BN-AG-04, BN-MO-03, FUN-ET-28
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	FUN-ET-31
Title	Interface of the Microgrid Operator with the Facility Manager
Description	The system should have an interface for data exchange with the Facility Manager.
Rationale	In certain cases, the Microgrid Operator might not be able to directly participate in energy markets but through a Facility Manager. For these cases an interface between the two stakeholders would facilitate the effective execution of the energy participation activities.
Source/Related Requirements	PUC1-7
Author	End-user (UVTgv)
Priority	HIGH

Requirement ID	FUN-ET-32
Title	Interface of the Facility Manager with the Aggregator
Description	The Facility Manager should be able to interface the Aggregator for data exchange with regards to energy management actions.
Rationale	The Facility Manager might not be able to directly participate in energy markets but through a representative (usually an Aggregator). For these cases an interface between the two stakeholders would facilitate the effective execution of the energy participation activities.
Source/Related Requirements	PUC1-7
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	FUN-ET-33

Title	Interface with the DSO
Description	The system should have an interface for data exchange with the DSO for providing flexibility services.
Rationale	In certain cases, the LES operator might need to provide ancillary services to the DSO. For these cases an interface between the two stakeholders would facilitate the effective execution of those activities.
Source/Related Requirements	PUC1-7
Author	End-user (UVTgv)
Priority	LOW

4.3.2 External User Requirements

Requirement ID	**FUN-ET-34**
Title	Flexibility incentives calculation
Description	The external end-users (e.g. EV Owner) should know their benefit for providing flexibility
Rationale	To assess the benefits of providing flexibility when charging/discharging, the external end-users (e.g. EV Owner) should be able to retrieve the economic incentives in an easy and transparent way.
Source/Related Requirements	PUC1-7 BN-ST-01
Author	End-user (INYCOM)
Priority	MEDIUM

Requirement ID	**FUN-ET-35**
Title	Flexibility usage notification to the EV owner (and other end-users)
Description	When charging conditions are changed (or another flexibility event happens), the EV owner should be notified and informed about the expected results (battery charge) of the event triggered.
Rationale	Due to long charging time and the possibility of a flexibility event diverting part of the EV battery charge, the owners should be advised as soon as possible of the expected outcome in terms of battery charge level even if it satisfies their comfort/operation requirements.
Source	PUC2, PUC5, PUC7 BN-ST-01
Author	End-user (INYCOM)
Priority	MEDIUM

Requirement ID	**FUN-ET-36**
Title	Pricing of delivered energy

Description	The DER owner/prosumer needs predefined prices on delivered energy at given times.
Rationale	A clear pricing scheme on delivered energy will facilitate the realisation of the business processes. These prices may differ for delivery of power at short notice. The DER owner/prosumer is assumed to be under contract with a microgrid operator/facility manager/aggregator.
Source/Related Requirements	PUC1-7 BN-ST-01
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-37**
Title	EV charging functionality
Description	The EV owner should be able to negotiate SOC-level at a defined time and cost with the microgrid operator/ facility manager / aggregator.
Rationale	The flexibility might have different values at different times, and both the EV-owner and the charging infrastructure operator need certainty in what is agreed.
Source/Related Requirements	PUC5, PUC7 BN-ST-01
Author	End-user (BIKS)
Priority	HIGH

Requirement ID	**FUN-ET-38**
Title	Calculate size of assets for maximizing the community profits
Description	The community based in the LES shall be able to calculate the optimal size of assets based on the profit maximization goal
Rationale	The goal of optimal planning for a community involves maximizing profits either from market participation through bidding, or with bilateral contract for services.
Source/Related Requirements	PUC8-9 BN-ST-02
Author	End-user (INYCOM)
Priority	HIGH

Requirement ID	**FUN-ET-39**
Title	Flexibility providers comfort zone/business schedules consideration
Description	End-user flexibility usage by other agents should respect some comfort/operation requirements of end-users

Rationale	The use of end-users' energy resources flexibility can't threaten the use of those resources by their owners when needed for their day to day activities, if established in advance.
Source/Related Requirements	PUC1-7 BN-ST-03
Author	End-user (INYCOM)
Priority	HIGH

4.4 Non-functional requirements

Requirement ID	**NF-ET-1**
Title	Remote control communication standard
Description	The exchange of information and setpoints should be performed according to specific communication protocols.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Standard
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator/software attempts to impose remote control signals.
Target	N/A
Related Functional Requirements	**BN-FM-01, BN-FM-02, BN-AG-01, BN-AG-02, BN-AG-04, BN-MO-01, BN-MO-02, BN-MO-04**

Requirement ID	**NF-ET -2**
Title	Demand forecasts accuracy
Description	The accuracy of the prediction values of the demand forecasts should lie within a predefined error interval
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Performance
Metric	Mean Absolute Percentage Error (MAPE)
Verification Measurement	Calculation using time series from historical data and forecasted data.
Target	<10%
Related Functional Requirements	**FUN-ET-04, FUN-ET-05**

Requirement ID	**NF-ET-3**
Title	Scheduling optimization accuracy
Description	The accuracy of the provided solution by the optimization solver (the relative gap) should fit some performance criteria.
Author	Facility Manager/Aggregator/Microgrid Operator

Scope	Performance
Metric	Ratio (%)
Verification Measurement	The relative gap is usually an output of the optimization solver.
Target	<2%
Related Functional Requirements	**FUN-ET-11, FUN-ET-12**

Requirement ID	**NF-ET-4**
Title	Optimal scheduling response time
Description	The scheduling operation for short-term scheduling as well as for long term planning should have an upper time duration limit.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Performance, Usability
Metric	Measured time
Verification Measurement	Time for calculating schedule
Target	short-term: 10 minutes long-term: 30 minutes
Related Functional Requirements	**FUN-ET-11, FUN-ET-12**

Requirement ID	**NF-ET-5**
Title	Planning tool accuracy
Description	The accuracy of the optimization results provided by the planning tool (the relative gap) should fit some performance criteria.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Performance
Metric	Ratio (%)
Verification Measurement	The relative gap is usually an output of the optimization solver.
Target	<2%
Related Functional Requirements	**FUN-ET-15, FUN-ET-16**

Requirement ID	**NF-ET-6**
Title	Planning response time
Description	The planning functionality should have an upper time duration limit.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Performance, Usability
Metric	Measured time

Verification Measurement	Time for calculating the investment plan.
Target	1 day
Related Functional Requirements	**FUN-ET-15, FUN-ET-16, FUN-ET-17**

Requirement ID	**NF-ET-8**
Title	User friendly front end
Description	The designed UI should be user friendly.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	User Interface
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator attempts to access the UI.
Target	N/A
Related Functional Requirements	**FUN-ET-13**

Requirement ID	**NF-ET-7**
Title	UI responsiveness
Description	The visualization applications should detect the user's screen size and orientation and modify the layout accordingly.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	User Interface, Usability
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator attempts to access the UI.
Target	N/A
Related Functional Requirements	**FUN-ET-13**

Requirement ID	**NF-ET-12**
Title	Interoperability
Description	Capability to exchange signals, independent of the technology / architecture of the (LES) operators' assets and/or DER units
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Interface/Integration
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator/software attempts to exchange signals with specific components.

Target	N/A
Related Functional Requirements	**FUN-ET-01, FUN-ET-02, FUN-ET-03**

Requirement ID	**NF-ET-13**
Title	Data end-to-end encryption and authentication
Description	Data communicated between aggregator and operators needs to maintain a trust relationship regardless of the media used for communicating the data. Security is the ability of a communication system to combat the cyber-threats on the network that is exchanging critical information.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Security
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator/software attempts to exchange data with specific components.
Target	N/A
Related Functional Requirements	**FUN-ET-01, FUN-ET-02, FUN-ET-03**

Requirement ID	**NF-ET-14**
Title	Real-time communication
Description	Information frequency exchange between the field assets and the LES Operator.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	Security/Usability Communication
Metric	Time interval
Verification Measurement	Latency for information exchange
Target	<2000msec
Related Functional Requirements	**FUN-ET-01, FUN-ET-02, FUN-ET-03**

Requirement ID	**NF-ET-15**
Title	Setpoint dispatch latency (and/or round trip time)
Description	The time required for information exchange (commands, measurement) through the communication channel among the Aggregator and the DER Owner, shall not exceed a maximum limit.
Author	Facility Manager/Aggregator/Microgrid Operator
Scope	performance/Usability Communication

Metric	Time interval
Verification Measurement	Latency for information exchange
Target	<2000msec
Related Functional Requirements	**FUN-ET-01, FUN-ET-02, FUN-ET-03**

Requirement ID	**NF-ET-16**
Title	Security
Description	All access to port core systems needs security adhering to ISPS regulations.
Author	Facility Manager/Aggregator/Microgrid Operator (BIKS)
Scope	Security, Standard
Metric	Y/N
Verification Measurement	Acceptance from relevant authority may be needed
Target	N/A
Related Functional Requirements	**FUN-ET-01, FUN-ET-02, FUN-ET-03, FUN-ET-13, FUN-ET-31, FUN-ET-32, FUN-ET-33**

5 System Requirements

This section presents the main requirements of E-LAND's solution, elaborated at system component level, mainly presenting the viewpoints of the software tool developers, the integrators and the solution providers. A detailed list of the system's components and the draft high-level architecture is presented in section §2.4 System Context.

E-LAND Toolbox and the LES's EMS are documented separately in this section, detailing their functional, non-functional and interface requirements, whilst trying to elaborate on their integration aspects.

5.1 E-LAND Toolbox

5.1.1 Functional

5.1.1.1 Optimal Scheduler

Requirement ID	**FUN-OS-01**
Title	LES modelling
Description	The OS must be able to model the system, based on available assets, their parameters and constraints.
Rationale	Basic operation of OS
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-OS-02**
Title	Short-term optimal scheduling
Description	The OS must calculate the optimal schedule of operation of the different multi-vector controllable assets and dispatchable loads in the LES in order to optimise a set of given objectives within a horizon of up to a day (i.e. short-term for the day-ahead and ultra-short-term for intraday schedules).
Rationale	Basic operation of OS
Source/Related Requirements	PUC1, PUC4-7 FUN-OS-01, FUN-OS-04 - FUN-OS-10

Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-OS-03**
Title	Long-term optimal scheduling
Description	The OS must calculate the optimal schedule of operation of the different multi-vector controllable assets for the long-term operation in order to take into account the system's seasonal changes.
Rationale	Basic operation of OS
Source/Related Requirements	PUC1 FUN-OS-01, FUN-OS-04 - FUN-OS-07, FUN-OS-10
Author	Tool developer (UdG)
Priority	MEDIUM

Requirement ID	**FUN-OS-04**
Title	Optimization goals
Description	The OS must be able to model the end-user optimization goals, such as emissions reduction, energy cost minimization, etc.
Rationale	Modular design for handling the different of objective of the possible end-users.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	MEDIUM

Requirement ID	**FUN-OS-05**
Title	Forecasted production data
Description	The OS must be able to receive the forecasted production of available generation assets (PV, wind turbine) for the period of scheduling and with a specified granularity.
Rationale	The most up-to-date production forecast data should be considered in the optimal scheduling process.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	FUN-OS-06
Title	Forecasted consumption data
Description	The OS must be able to receive the forecasted consumption (electrical loads, thermal loads, gas loads) for the scheduling period of time and with a specified granularity.
Rationale	The most up-to-date consumption forecast data should be considered in the optimal scheduling process.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	FUN-OS-07
Title	Current state of LES assets
Description	The OS should be provided with the current state of operation of the controllable assets and dispatchable loads.
Rationale	Current state of the controllable assets and dispatchable loads must be considered in the scheduling process.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	FUN-OS-08
Title	EV/FCEV integration
Description	The OS must be able to receive the expected energy use of the next day and the time availability windows of the EV/FCEVs
Rationale	The constraints set by the EV/FCEV owners must be considered in the scheduling process.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	FUN-OS-09

Title	Harbour loads
Description	The OS must be able to receive information of the day-ahead expected consumption of harbour loads (e.g. number of stacking movements, consumption profiles)
Rationale	The constraints set by the harbour operator must be considered in the scheduling process.
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-OS-10**
Title	Energy costs
Description	The OS must be able to receive the day-ahead energy prices (e.g. electricity) with a specified granularity.
Rationale	Energy costs could be one of the parameters considered in the optimisation algorithm (depending the objective set by the end-user).
Source/Related Requirements	PUC1, PUC4-7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-OS-11**
Title	Provide interface for operation scheduling results
Description	The OS must be able to provide the scheduling for the controllable assets and dispatchable loads of the LES.
Rationale	Scheduling results
Source/Related Requirements	PUC1, PUC4-7 FUN-OS-02, FUN-OS-03
Author	Tool developer, Integrator (UdG, ICOM)
Priority	HIGH

5.1.1.2 Energy Forecaster

Requirement ID	**FUN-EF-01**
Title	Production forecast

Description	The EF shall be able provide the (thermal and electric) generation forecast and uncertainty for a specified period and granularity based on a forecasting model.
Rationale	Basic operation of EF.
Source/Related Requirements	PUC4 - 6 FUN-EF-03
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-02**
Title	Consumption forecast
Description	The EF shall be able to provide the (thermal and electric) consumption forecast and uncertainty for a specified period and granularity based on a forecasting model.
Rationale	Basic operation of EF.
Source/Related Requirements	PUC2, PUC4 - 6 FUN-EF-04
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-03**
Title	Energy production forecasts models - training
Description	The EF should enable the training of generation forecasting models, based on historical generation data (optional), weather data (e.g. irradiance, cloudiness, wind speed) and contextual data (i.e. calendar) as well as the technical parameters of the generation assets.
Rationale	Machine learning techniques will be used to build forecasting models for PV generation, wind generation and solar thermal generation.
Source/Related Requirements	PUC4 - 6
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-04**
Title	Energy consumption forecast models - training
Description	The EF should enable the training of consumption forecasting models, based on historical consumption data, weather data (e.g. temperature,

	humidity), contextual data (i.e. calendar) and occupancy data (if relevant).
Rationale	Machine learning techniques will be used to build forecasting models for electrical loads, gas loads and thermal loads.
Source/Related Requirements	PUC2, PUC4 - 6
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-05**
Title	Forecasting models
Description	Different forecasting models with different horizons (short-term, ultra-sort-term, long-term), and different time granularity must be supported.
Rationale	Modularity
Source/Related Requirements	PUC2, PUC4 – 6 FUN-EF-03, FUN-EF-04
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-06**
Title	Model Training
Description	The training of forecasting models upon request must be supported. Once the model is trained the EF shall return a forecast model ID (identifier).
Rationale	Basic operation of EF
Source/Related Requirements	PUC2, PUC4 – 6 FUN-EF-03, FUN-EF-04
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-06**
Title	Forecasting model parameters
Description	The EF shall be provided with the forecasting horizon and the temporal granularity parameters to define the forecasting model to be built.
Rationale	Enables the support of different time horizons and granularities with regards to the optimal scheduling applications.

Source/Related Requirements	PUC2, PUC4 - 6
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-EF-07**
Title	Forecasting Models List
Description	The EF shall be able to provide a list of the trained models, specifying time horizon, required inputs, required data sampling rate (granularity) and model IDs.
Rationale	Basic functionality for integration of EF with other components.
Source/Related Requirements	PUC2, PUC4 - 6
Author	Integrator (ICOM)
Priority	MEDIUM

5.1.1.3 Multi-Vector Simulator

Requirement ID	**FUN-MVS-01**
Title	Solving an energy system optimization model
Description	The MVS shall solve an energy system planning optimization problem and provide the optimal sizing of individual assets.
Rationale	Basic operation of MVS.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI)
Priority	HIGH

Requirement ID	**FUN-MVS-02**
Title	Automatic setting up of an energy system optimization model
Description	The MVS should accept modelling parameters regarding the LES in a specific format.
Rationale	Currently MVS supports the Oemof[1] model. The rationale is to support external entities or users with no experience in Oemof, by automatically generating the respective Oemof model for the agreed format.

[1] https://oemof.org/

Source/Related Requirements	PUC8, PUC9 FUN-MVS-08 - FUN-MVS-17
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-03**
Title	Manual setting up an energy system optimization model
Description	The MVS shall support adding specific components/constraints from a set of options to an energy system optimization model.
Rationale	Basic operation of MVS
Source/Related Requirements	PUC8, PUC9 FUN-MVS-08 - FUN-MVS-17
Author	Tool developer, Integrator (RLI, ICOM)
Priority	LOW

Requirement ID	**FUN-MVS-04**
Title	Optimisation Results
Description	The MVS shall provide the results of the optimisation process upon completion of calculation in a specific format, which include at least information related to asset costs (CAPEX and OPEX), sizes, as well as aggregated energy flows and overall system performance (autonomy, renewable share, losses).
Rationale	Basic operation of MVS.
Source/Related Requirements	PUC08, PUC09 FUN-MVS-01
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-05**
Title	Production Assets
Description	The MVS should consider a diverse type of production assets in the energy model i.e. PV, BESS, CHP, Thermal Storage
Rationale	Enable support of multi-vector production and storage assets.
Source/Related Requirements	PUC8, PUC9 FUN-MVS-02, FUN-MVS-03
Author	Tool developer (RLI)

Priority	HIGH

Requirement ID	**FUN-MVS-06**
Title	Assets of Energy Conversion
Description	The MVS should consider assets which convert energy from one vector to another i.e. CHP, geothermal conversion (heat pump)
Rationale	Integration of the multi-vector approach in the MVS.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI)
Priority	LOW

Requirement ID	**FUN-MVS-07**
Title	Optimisation goal
Description	The optimisation process should take into account: Increasing the degree of autonomy of the LES, system costs minimization, and CO2 emissions reduction. Optional extension of the MVS is to allow for multi-objective optimisation.
Rationale	Different optimisation goal shall be supported for covering the different perspectives of the possible end-users.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI)
Priority	HIGH

Requirement ID	**FUN-MVS-08**
Title	Electricity cost model
Description	The MVS model shall be provided with data defining electricity grid supply regarding: a. kWh prices (both import and export from/to the grid) b. kWh/h prices (time series of prices) c. Constraints of the interconnection with the main grid (e.g. substation capacity)
Rationale	Information necessary for building the MVS Multi-vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)

Priority	HIGH

Requirement ID	**FUN-MVS-09**
Title	Load profiles
Description	The MVS model shall be provided with annual electric/thermal demand profiles (hourly values) for each load in the LES.
Rationale	Information necessary for building the MVS Multi-vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-10**
Title	DH cost model
Description	For calculations involving district heating, the MVS model shall support data on thermal distribution network supply, concerning: a. kWh prices (both import and export from/to the grid) b. kWh/h prices (time series of prices) c. optional: thermal power cap (e.g. maximum allowable feed-in per day)
Rationale	Information necessary for building the MVS Multi-vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-11**
Title	PV data
Description	For calculations involving PV assets, the MVS model shall be provided with data on PV assets: a. At minimum: Precise location (latitude and longitude) b. Optionally: performance indicators for new PV systems (efficiency - constant or time series, module technology, performance ratio), historical/tracked data (energy generated by existing PV systems, weather data), Inverter efficiency
Rationale	Information necessary for building the MVS Multi-vector Model.
Source/Related Requirements	PUC8, PUC9

Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-12**
Title	Battery data
Description	For calculations involving battery assets, the MVS model shall be provided with data on Battery Energy Storage Systems (BESS): a. Battery type (e.g. lead-acid, lithium ion) b. Technical parameters: C-rate, max and min state of charge (SOC), max. depth of discharge (DOD), roundtrip efficiency (constant or time series) c. Inverter efficiency (optional) d. historical/tracked data from existing BESS
Rationale	Information necessary for building the MVS Multi-vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-13**
Title	CHP data
Description	For calculations involving CHP assets, the MVS model shall be provided with efficiency factors (electric/thermal)
Rationale	Information necessary for building the MVS Multi-Vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	LOW

Requirement ID	**FUN-MVS-14**
Title	Thermal storage data
Description	For calculations involving CHP assets Thermal Storage assets, the MVS model shall be provided with: a. Charging and discharging efficiencies b. Max/Min SOC, initial SOC
Rationale	Information necessary for building the MVS Multi-Vector Model.

Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	LOW

Requirement ID	**FUN-MVS-15**
Title	Autonomous operation data
Description	The MVS model shall be provided with information on the autonomous operation of the LES i.e. minimum/maximum time of autonomy for specific time intervals.
Rationale	Information necessary for building the MVS Multi-vector Model
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-16**
Title	Economic data
Description	The MVS model shall be provided with information on economic assumptions per asset: CAPEX/kW and OPEX/kWh - constant or time series - , lifetime (years), Weighted Average Cost of Capital (WACC).
Rationale	Information necessary for building the Multi-vector Model.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-MVS-17**
Title	Constraints
Description	The MVS model shall be provided with constraints of the optimisation problem: a. Operating reserve provided by the battery (i.e. redundancy, availability) b. Sizing constraints c. Cost constraints
Rationale	Information necessary for building the Multi-vector Model.

Source/Related Requirements	PUC8, PUC9
Author	Tool developer, Integrator (RLI, ICOM)
Priority	HIGH

5.1.1.4 Data Pre-processing Application

Requirement ID	**FUN-DP-01**
Title	Detection of missing values
Description	The Data Pre-processing (DP) application shall detect and label missing values, outliers and wrong values.
Rationale	Basic operation of DP.
Source/Related Requirements	SUC7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-DP-02**
Title	Granularity of data
Description	The DP shall be able to resample (oversample & subsample) and label data.
Rationale	Basic operation of DP. A unified approach will be used to handle different data granularity required by the different components of the toolbox.
Source/Related Requirements	SUC7
Author	Tool developer (UdG)
Priority	HIGH

Requirement ID	**FUN-DP-03**
Title	Data completeness
Description	The DP shall be able to estimate and label the correct values for the detected outliers, missing and wrong values.
Rationale	Basic operation of DP.
Source/Related Requirements	SUC7
Author	Tool developer (UdG)

Priority	HIGH

Requirement ID	**FUN-DP-04**
Title	Data profiling
Description	The DP shall be able to calculate average profiles of continuous variables gathered over a period of time. For example, average historic value of hourly radiation for past year.
Rationale	Basic operation of DP.
Source/Related Requirements	SUC07
Author	Tool developer, Integrator (RLI, UdG, ICOM)
Priority	HIGH

Requirement ID	**FUN-DP-05**
Title	DPA Tuning
Description	The DP Application should be tuned to define the way to perform the basic operations (detection, completeness and resampling) for each variable of the LES.
Rationale	Basic functionality for making DPA's operation parameterisable.
Source/Related Requirements	SUC7
Author	Tool developer (UdG)
Priority	MEDIUM

5.1.1.5 Enterprise Service Bus

Requirement ID	**FUN-ESB-01**
Title	Data access
Description	The ESB shall facilitate data access of E-LAND Toolbox application from the LES EMS or from external sources.
Rationale	Core functionality.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	HIGH

Requirement ID	**FUN-ESB-02**

Title	Data transformation
Description	The ESB shall support data transformation for multiple data formats.
Rationale	Core functionality involving data transformation.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	HIGH

Requirement ID	**FUN-ESB-03**
Title	Communications
Description	Support both synchronous and asynchronous communication.
Rationale	Core functionality for communication.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	HIGH

Requirement ID	**FUN-ESB-04**
Title	Intelligent routing
Description	Support message intelligent routing to multiple destinations based on different conditions/policies e.g. addressability, static/deterministic, content-based, rules-based, policy-based.
Rationale	Core functionality involving the ability to model different policies in information flows.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	MEDIUM

Requirement ID	**FUN-ESB-05**
Title	Service orchestration
Description	The ESB shall support service orchestration, coordinating multiple implementation services to be exposed as a single-aggregated service.

Rationale	Hides the complexity of individual services.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	HIGH

Requirement ID	**FUN-ESB-06**
Title	Business process automation
Description	Support business process automation, offering ability to model and automate complex business processes.
Rationale	Offer the ability to model and perform business processes towards completion of a business goal (e.g. train a forecasting model).
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	HIGH

Requirement ID	**FUN-ESB-07**
Title	Configuration
Description	Offer the ability of configuration (i.e. deployment, service registration, database setup).
Rationale	The ESB should constitute an easily extensible and customizable integration solution.
Source/Related Requirements	SUC 1-5,7
Author	Integrator (ICOM)
Priority	MEDIUM

5.1.1.6 Energy Planning Application

Requirement ID	**FUN-EPA-01**
Title	Investment Plan process
Description	The EPA shall enable the user to initiate and manage an asset investment plan.
Rationale	Basic functionality.
Source/Related Requirements	PUC8, PUC9

Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-EPA-02**
Title	Investment Plan form
Description	The EPA shall provide a form for enabling the user to provide the parameters of a new Investment Plan.
Rationale	Basic functionality
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-EPA-03**
Title	Investment Plan request
Description	The EPA shall be able to request a calculation of an optimal plan from MVS.
Rationale	Integration of MVS for solving the optimal planning problem and providing the result to EPA for user visualization.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	**FUN-EPA-04**
Title	Optimal Asset Sizing and Operation Setpoints
Description	EPA shall visualize the results of the planning calculations to user.
Rationale	Basic functionality
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	FUN-EPA-05
Title	Action History
Description	EPA shall keep the history of investment plans (both input and output) for a specified period of time.
Rationale	Basic functionality
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	FUN-EPA-06
Title	Investment Plan comparison
Description	EPA shall provide the ability to compare different investment plans.
Rationale	Basic functionality.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

Requirement ID	FUN-EPA-07
Title	Energy Model History
Description	The EPA shall provide the ability to store the energy model of a LES.
Rationale	Basic functionality.
Source/Related Requirements	PUC8, PUC9
Author	Tool developer (RLI, ICOM)
Priority	HIGH

5.1.1.7 Data Visualization

Requirement ID	FUN-DV-01
Title	Visualize data about project’s KPIs
Description	The data visualization component should be able to visualize meaningful insights regarding the project’s KPIs.

Rationale	The visualization of the project's data demonstrates the effectiveness of the newly deployed functionalities.
Source/Related Requirements	PUC1-9
Author	Tool developer (ICOM)
Priority	HIGH

Requirement ID	**FUN-DV-02**
Title	Customizable visualizations
Description	The data visualization component should be easily customizable (e.g. modifying calculation period, clustering information, modifying chart type).
Rationale	A customizable visualization component would easily address the varying needs of different end-users of the E-LAND Toolbox.
Source/Related Requirements	PUC1 - 9
Author	Tool developer (ICOM)
Priority	HIGH

Requirement ID	**FUN-DV-03**
Title	Modular visualization component
Description	The data visualization component should be modular, giving the capability to visualize different sources of data regarding the project's KPIs.
Rationale	A modular visualization component would easily address the varying needs of different end-users of the E-LAND system.
Source/Related Requirements	PUC1 - 9
Author	Tool developer (ICOM)
Priority	HIGH

Requirement ID	**FUN-DV-04**
Title	Extensible visualization component
Description	The data visualization component should be easily extensible, giving the capability to add new visualizations regarding the project's KPIs.
Rationale	An extensible visualization component would easily address the varying needs of different end-users of the E-LAND system.

Source/Related Requirements	PUC1 - 9
Author	Tool developer (ICOM)
Priority	HIGH

5.1.2 Non-Functional

5.1.2.1 Optimal scheduler

Requirement ID	**NF-OS-01**
Title	Scheduling execution time
Description	The running time of the calculations should be below a threshold such that its application is feasible at real time.
Author	Tool developer (UdG)
Scope	Performance
Metric	min
Verification Measurement	Evaluation of the execution time
Target	Short term: <10min Long term: <30 min
Related Functional Requirements	**FUN-OS-02**

Requirement ID	**NF-OS-02**
Title	Interface security
Description	Provide a secure and stable interface
Author	Tool developer (UdG)
Scope	Integration, Security
Metric	Y/N
Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-OS-01, FUN-OS-02, FUN-OS-03**

Requirement ID	**NF-OS-03**
Title	Interface availability
Description	High percentage of availability of the interface
Author	Tool developer (UdG)
Scope	Integration, Performance

Metric	Ratio of the expected value of the uptime, to the aggregate of the expected values of up and down time.
Verification Measurement	Observing the interface operation through logs.
Target	>99%
Related Functional Requirements	**FUN-OS-01, FUN-OS-02, FUN-OS-03**

5.1.2.2 Energy Forecaster

Requirement ID	**NF-EF-01**
Title	Uncertainty
Description	The uncertainty of a forecast cannot exceed a specific threshold.
Author	Tool developer (UdG)
Scope	Performance
Metric	Max of uncertainty values
Verification Measurement	Uncertainty values provided by the forecast modules
Target	<10%
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

Requirement ID	**NF-EF-02**
Title	Accuracy
Description	The accuracy of the forecasted values produced by EF should lie within a predefined error interval
Author	Tool developer (UdG)
Scope	Performance
Metric	Mean Absolute Percentage Error (MAPE)
Verification Measurement	Ex-post analysis of forecasted and actual data
Target	<10%
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

Requirement ID	**NF-EF-03**
Title	Scalability
Description	The overall performance of the system must be able to grow with more powerful hardware and complexity of the considered system.
Author	Tool developer (UdG)
Scope	Performance
Metric	Required execution time using different hardware

Verification Measurement	Logging of execution time
Target	Reduced execution times for more powerful hardware
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

Requirement ID	**NF-EF-04**
Title	Security
Description	EF shall protect the data and functionalities from unauthorized access. It shall also provide authentication and secure transaction.
Author	Tool developer (UdG)
Scope	Security
Metric	Y/N
Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

Requirement ID	**NF-EF-05**
Title	Granularity
Description	The granularity of the input data provided in the forecast request shall be the same with the rate of the trained model.
Author	Tool developer (UdG)
Scope	Integration
Metric	Y/N
Verification Measurement	The requirement is validated when a software requests the input data.
Target	N/A
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

Requirement ID	**NF-EF-06**
Title	Training granularity
Description	The granularity must be the same for all training data.
Author	Tool developer (UdG)
Scope	Integration
Metric	Y/N
Verification Measurement	The requirement is validated when a software requests the training data.
Target	N/A

Related Functional Requirements	**FUN-EF-01, FUN-EF-02**

Requirement ID	**NF-EF-07**
Title	Model list interface
Description	The EF shall be able to provide a list of the trained models to the ESB
Author	Integrator (ICOM)
Scope	Interface
Metric	Y/N
Verification Measurement	The requirement is validated when the ESB requests the list of trained models.
Target	N/A
Related Functional Requirements	**FUN-EF-05**

Requirement ID	**NF-EF-08**
Title	Production communication interface
Description	The EF shall provide an interface to the ESB for obtaining forecasts
Author	Integrator (ICOM)
Scope	Interface
Metric	Y/N
Verification Measurement	The requirement is validated when the ESB requests the forecasts.
Target	N/A
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

5.1.2.3 Multi-vector Simulator

Requirement ID	**NF-MVS-01**
Title	MVS pre-processing tools for LES optimization model input
Description	The MVS should support Python-Pandas DataFrames as parameterization input for the LES model
Author	Tool developer (RLI)
Scope	Interface, Usability
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator attempts to input/modify the model parameters.
Target	User can adjust input parameters without any further support
Related Functional Requirements	**FUN-MVS-01**

Requirement ID	**NF-MVS-02**
Title	MVS post-processing tools for LES optimization model output/results
Description	The MVS should provide results aggregation, reports, and plots
Author	Tool developer (RLI)
Scope	User Interface, Usability
Metric	Y/N
Verification Measurement	The requirement is validated by observing the system under test when an operator attempts to access the output results.
Target	User can extract the results in a way that can be directly used for the users purpose
Related Functional Requirements	**FUN-MVS-01, FUN-MVS-03**

Requirement ID	**NF-MVS-03**
Title	Communication interface between MVS and ESB
Description	Communication functionality must be included so that ESB can send requests to MVS and vice versa. This assures that all requests can be coordinated through one platform (e.g. ESB).
Author	Tool developer, Integrator (RLI, ICOM)
Scope	User Interface, Usability
Metric	Y/N
Verification Measurement	Send a set of different requests from ESB to MVS and count received requests. Do vice versa.
Target	Send/receive requests that can be processed without information loss
Related Functional Requirements	**FUN-MVS-01, FUN-MVS-03**

Requirement ID	**NF-MVS-04**
Title	Unit commitment time step restriction
Description	Energy flows between selected components (Unit commitment) are simulated in hourly timesteps.
Author	Tool developer (RLI)
Scope	Performance
Metric	Timestamps
Verification Measurement	Subtract 2-time steps.
Target	Timestep width of 1 hour
Related Functional Requirements	**FUN-MVS-01, FUN-MVS-02, FUN-MVS-03**

Requirement ID	**NF-MVS-05**

Title	Interface for technical parameters and model
Description	Technical parameters are reflected in component modelling
Author	Tool developer (RLI)
Scope	Performance
Metric	Technical variable in energy system model object
Verification Measurement	Technical variable in ESM object being not NAN.
Target	-
Related Functional Requirements	**FUN-MVS-01, FUN-MVS-03**

Requirement ID	**NF-MVS-06**
Title	Interface for economic parameters and model
Description	Cost parameters are reflected in component modelling
Author	Tool developer (RLI)
Scope	Interface
Metric	Cost variable in energy system model object
Verification Measurement	Cost variable in ESM object being not NAN.
Target	N/A
Related Functional Requirements	**FUN-MVS-01, FUN-MVS-03**

5.1.2.4 Data Pre-processing Application

Requirement ID	**NF-DP-01**
Title	Accuracy
Description	The accuracy of the estimated values should lie within a predefined error interval
Author	Tool developer (UdG)
Scope	Test Performance
Metric	MAPE
Verification Measurement	Ex-post analysis of loggings
Target	10%
Related Functional Requirements	**FUN-DP-03, FUN-DP-04**

Requirement ID	**NF-DP-02**
Title	Scalability
Description	The performance of the DP must be able to grow with more powerful hardware and complexity of the considered system.

Author	Tool developer (UdG)
Scope	Performance
Metric	Required execution time using different hardware
Verification Measurement	Logging of execution time
Target	Reduced execution times for more powerful hardware
Related Functional Requirements	**FUN-DP-03, FUN-DP-04**

Requirement ID	**NF-DP-03**
Title	Security
Description	DP shall protect the data and functionalities from unauthorized access. It shall also provide authentication and secure transaction.
Author	Tool developer (UdG)
Scope	Security
Metric	Y/N
Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-DP-03, FUN-DP-04**

5.1.2.5 Enterprise Service Bus

Requirement ID	**NF-ESB-01**
Title	Availability
Description	A high percentage of availability should be supported.
Author	Integrator (ICOM)
Scope	Performance
Metric	Ratio of the expected value of the uptime, to the aggregate of the expected values of up and down time.
Verification Measurement	Observing the interface operation through logs.
Target	> 99%
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

Requirement ID	**NF-ESB-02**
Title	Maintainability
Description	Mean Time to Repair (MTTR) due to hardware malfunctions shall not exceed a specific threshold.
Author	Integrator (ICOM)

Scope	Performance
Metric	Time interval (consecutive hours)
Verification Measurement	Observing the ESB operation through logs.
Target	< 72
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

Requirement ID	**NF-ESB-03**
Title	Mean Time Between Fixes
Description	During the operational period of the pilot shall not suffer loss of service more a specific threshold.
Author	Integrator (ICOM)
Scope	Performance
Metric	Mean Time Between Fixes (MTBF) during operation.
Verification Measurement	Observing the ESB operation through logs.
Target	<5 times/month
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

Requirement ID	**NF-ESB-04**
Title	Start-up time
Description	The start-up time and full availability of the ESB's functionality must comply with a specific threshold.
Author	Integrator (ICOM)
Scope	Performance
Metric	Time interval (minutes)
Verification Measurement	Observing the ESB start-up time through logs.
Target	< 5 minutes
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

Requirement ID	**NF-ESB-05**
Title	Scalability
Description	The overall performance of the system must be able to grow with more powerful hardware. Multiple instances of the system shall be able to cooperate for increasing performance.
Author	Integrator (ICOM)
Scope	Performance

Metric	Required execution time using different hardware
Verification Measurement	Logging of execution time
Target	Reduced execution times for multiple instances of ESB
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

Requirement ID	**NF-ESB-06**
Title	Security
Description	Protection from unauthorized access, authentication and secure transaction as well as accounting shall be supported.
Author	Integrator (ICOM)
Scope	Security
Metric	Y/N
Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-ESB-01, FUN-ESB-02, FUN-ESB-03, FUN-ESB-04, FUN-ESB-05, FUN-ESB-06, FUN-ESB-07, FUN-ESB-08**

5.1.2.6 Energy Planning Application

Requirement ID	**NF-EPA-01**
Title	Availability
Description	A high percentage of availability should be supported.
Author	Integrator (ICOM)
Scope	Performance
Metric	Ratio of the expected value of the uptime, to the aggregate of the expected values of up and down time.
Verification Measurement	Observing the interface operation through logs.
Target	> 90%
Related Functional Requirements	**FUN-EPA-01, FUN-EPA-04**

Requirement ID	**NF-EPA-03**
Title	Security
Description	EPA shall protect the data and functionalities from unauthorized access.
Author	Integrator (ICOM)
Scope	Security
Metric	Y/N

Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-EF-03, FUN-EF-04**

5.1.3 External Interfaces

5.1.3.1 Software Interfaces

As presented in Figure 4, different system components are identified with ESB acting as a middleware as well as an interface with the ESM and external data sources. The main software interfaces identified are the following:

- Optimal Scheduler: The OS should communicate with the ESB to exchange the required input (e.g. LES model, forecasts, assets status) and output (i.e. schedules) data, enabling to perform its operation as described in section 5.1.1.1.
- Energy Forecaster: The EF shall provide a web interface to the ESB for exchanging data related to the training of forecasting models and the generation of production and consumption forecasts, as described in section 5.1.1.2.
- Multi-Vector Simulator: The MVS shall provide a web interface for receiving the technical parameters of the operation of the LES and the optimisation parameters set by the end-user, as described in 5.1.1.3.
- Data Pre-processing Application: DP shall provide a web interface to the ESB for receiving the data for performing pre-processing operations (see section 5.1.2.4) and returning the processed data.
- Enterprise Service Bus: The ESB shall provide the web interfaces that will enable secure and transparent integration of the toolbox's components and the external world, by providing a diverse set of functionalities (see section 5.1.1.5). A web interface shall be provided for accessing data required for the operations of the E-LAND Toolbox by external sources or the LES's EMS. It shall also provide an interface for securing communication both among components as well as between the toolbox and external systems.
- Energy Planning Application: The EPA should provide an interface for receiving the results of the MVS calculations (see section 5.1.1.6).

5.1.3.2 User Interfaces

The requirements relating to the user interface offered by the system are briefly described below and mainly concern the administrator (EF, ESB), the planner (MVS, EPA, DV) and the operator (DV) roles:

- The EF should provide a user interface for providing the parameters of a forecasting model in the training phase
- The EPA shall provide a user interface for the visualization of the Investment Plan management process, and the evaluations of the solutions provided by the MVS.
- The MVS should provide results aggregation, reports, and plots. User should be able to extract the results in a way that can be directly used for the users purpose
- The ESB shall provide a user interface that allows for configuration of deployment, service registration, as well as business process automation and orchestration.
- The DV shall provide a responsive and parameterisable user interface for the monitoring of the LES performance through KPIs.

5.2 LES Energy Management System

5.2.1 Functional

Requirement ID	FUN-EMS-01
Title	Field asset communication
Description	The EMS shall able to communicate with the field devices (e.g. DER/Storage Controller, sensing equipment, load controllers) directly or through the BMS. A distinction is made between 1-way and 2-way communication from field devices. For storage assets 2-way communication will be necessary, while for other assets 1-way communication will be sufficient.
Rationale	Field devices make up important data from local assets as well as provide controllability to the dispatchable ones. Hence must be integrated to the EMS in order for the LES to function properly.
Source/Related Requirements	HLUC1
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	FUN-EMS-02
Title	BMS communication
Description	The EMS shall able to communicate with the BMS and exchange information related to field devices.
Rationale	The BMS integrates various infrastructure within the premises of a building, hence can act as intermediate both for information from the field as well as for control actions.
Source/Related Requirements	HLUC1
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	FUN-EMS-03
Title	Consumption and generation data
Description	The EMS should provide consumption and generation data from managed assets to the E-LAND Toolbox.
Rationale	The EMS manages a diverse type of production assets as well as communication with various field devices (e.g. load controller), directly or through the BMS. Such position enables it to act as a provider of relevant energy measurement from the field.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	FUN-EMS-04
Title	Storage assets data
Description	The EMS should provide the status of storage assets to the E-LAND Toolbox.
Rationale	The EMS manages storage assets. Such position enables it to act as a provider of storage information e.g. State of Charge, current schedule
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	FUN-EMS-05

Title	Building's operational data
Description	The EMS should provide information regarding the building's operation (e.g. HVAC setpoint, occupancy) to the E-LAND Toolbox. Occupancy data for non-residential such as offices can be provided as an occupancy scheduling profile (for example, 0% non-occupied, 100% fully-occupied).
Rationale	Such information are necessary for the optimal scheduling of the operation of the LES.
Source/Related Requirements	HLUC1, HLUC2, PUC2, PUC3
Author	Solution provider, Integrator (SE, ICOM)
Priority	MEDIUM

Requirement ID	**FUN-EMS-06**
Title	Weather service communication
Description	The EMS should be able to collect weather data from local weather stations or weather services.
Rationale	Correlation of weather data with consumption and production is important for realizing the analytics operations (e.g. forecasting). The EMS can act as a data collector and provider of such data utilizing local or remote data sources with open APIs.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-07**
Title	Weather data API
Description	The EMS should provide weather data to the E-LAND Toolbox.
Rationale	The EMS is able to provide weather data (if available) to E-LAND Toolbox for correlation of weather data with consumption and production towards realizing analytics operations (e.g. forecasting).
Source/Related Requirements	HLUC1, HLUC2 FUN-EMS-06
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-08**
Title	Operational Schedules
Description	The EMS shall provide and API for receiving operational schedules (commands) for all managed assets from the E-LAND Toolbox
Rationale	Concerns the integration the E-LAND's toolbox optimal scheduling output in the EMS for dispatch to the field assets.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-09**
Title	Operational set-points dispatch
Description	The EMS shall be able to provide the setpoints of operation to all managed field devices (i.e. HVAC/BMS, Storage assets, Generation assets, EV Charger)
Rationale	The operational setpoints calculated by the E-LAND Toolbox must be dispatched to the field assets. The EMS, being responsible for the field asset communication inside the LES, is most appropriate undertaking such a task.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-10**
Title	Schedule visualisation
Description	The EMS shall be able to visualize the schedule of each asset.
Rationale	The operator of the LES should be facilitated to monitor assets' schedules.
Source/Related Requirements	HLUC1, HLUC2 FUN-EMS-08
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-11**

Title	Forecast data
Description	The EMS shall provide an API for receiving and storing energy consumption and production forecast data from the E-LAND Toolbox.
Rationale	Concerns the integration the E-LAND's Toolbox forecasting output in the EMS for better monitoring of LES's operation.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-12**
Title	Forecast visualization
Description	The EMS shall be able to visualize the forecast of energy consumption and production of each assets and for the whole LES.
Rationale	This will provide the LES operator with a critical tool to monitor and control the LES.
Source/Related Requirements	HLUC1, HLUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-13**
Title	EV/FCEV day-ahead scheduling form
Description	The EMS shall be able to visualize the form for the day-ahead scheduling of EV/FCEV charging.
Rationale	This will enable providing the availability of EV/FCEV assets.
Source/Related Requirements	PUC7
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-14**
Title	EV/FCEV scheduling data
Description	The EMS shall be able to keep the history of the day-ahead scheduling input for EV/FCEV charging for a specified period of time.

Rationale	This will facilitate analysing relevant load patterns.
Source/Related Requirements	PUC7 FUN-EMS-13
Author	Solution provider, Integrator (SE, ICOM)
Priority	MEDIUM

Requirement ID	**FUN-EMS-15**
Title	HVAC scheduling
Description	The EMS should be able to send requests to E-LAND Toolbox for scheduling the HVAC loads, in a periodical manner or upon user request.
Rationale	The EMS shall trigger the process for DSM for buildings.
Source/Related Requirements	PUC2
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-16**
Title	HVAC scheduling UI
Description	The EMS should provide a user interface for setting the frequency of periodic request for HVAC load scheduling and or for manually requesting a schedule.
Rationale	The EMS shall enable the operator to trigger/modify the DSM for buildings options.
Source/Related Requirements	PUC2 FUN-EMS-15
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-17**
Title	Harbour load scheduling
Description	The EMS should be able to send requests to E-LAND Toolbox for scheduling the harbour loads, in a periodical manner or upon user request.
Rationale	The EMS shall trigger the process for DSM for harbour.
Source/Related Requirements	PUC3

Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-18**
Title	Harbour scheduling UI
Description	The EMS should provide a user interface for setting the frequency of periodic request for harbour load scheduling and or for manually requesting a schedule.
Rationale	The EMS shall enable the operator to trigger/modify the DSM for harbour options.
Source/Related Requirements	PUC3
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-19**
Title	Storage scheduling
Description	The EMS should be able to send requests to E-LAND Toolbox for scheduling the storage assets, in a periodical manner or upon user request.
Rationale	The EMS shall trigger the process for storage utilization for optimal scheduling of LES operation.
Source/Related Requirements	PUC4, PUC5, PUC6
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-20**
Title	Storage scheduling UI
Description	The EMS should provide a user interface for setting the frequency of periodic request for LES's Vehicles scheduling and or for manually requesting a schedule.
Rationale	The EMS shall facilitate the operator to trigger/modify the relevant scheduling processes' options.
Source/Related Requirements	PUC4, PUC5, PUC6
Author	Solution provider, Integrator (SE, ICOM)

Priority	HIGH

Requirement ID	**FUN-EMS-21**
Title	Vehicle charging scheduling
Description	The EMS should be able to send requests to E-LAND Toolbox for scheduling the LES's Vehicles, in a periodical manner or upon user request.
Rationale	The EMS shall trigger the process for EV utilization for optimal scheduling of LES operation.
Source/Related Requirements	PUC7
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-22**
Title	Vehicle charging scheduling UI
Description	The EMS should provide a user interface for setting the frequency of periodic request for LES's Vehicles scheduling and or for manually requesting a schedule.
Rationale	The EMS shall facilitate the operator to trigger/modify the relevant scheduling processes' options.
Source/Related Requirements	PUC7
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	**FUN-EMS-23**
Title	Data History
Description	The EMS shall keep the history of asset related information (e.g. production/consumption data, schedules) for a specified period of time (at least for one year).
Rationale	Storing historical data will help optimize the LES in the future. It will also make future investment decision easier.
Source/Related Requirements	HLUC02, HLUC03
Author	Solution provider, Integrator (SE, ICOM)
Priority	HIGH

Requirement ID	FUN-EMS-24
Title	API for Data storage
Description	The EMS shall provide an API for receiving and storing pre-processed data (production, consumption, weather…) from the E-LAND Toolbox (ESB).
Rationale	The EMS is able to store the pre-processed data in order to be used by other E-LAND components (EF, OS) through the ESB.
Source/Related Requirements	HLUC01, HLUC02
Author	Tool developer (UdG)
Priority	High

Requirement ID	FUN-EMS-25
Title	API for data retrieval
Description	The EMS should provide an API for retrieving data to the E-LAND Toolbox.
Rationale	The EMS is able to provide the stored data.
Source/Related Requirements	HLUC01, HLUC02
Author	Tool developer (UdG)
Priority	High

5.2.2 Non-Functional

Requirement ID	NF-EMS-01
Title	Availability
Description	A high percentage of availability should be supported.
Author	Solution provider (SE)
Scope	Performance
Metric	Ratio of the expected value of the uptime, to the aggregate of the expected values of up and down time.
Verification Measurement	Observing the interface operation through logs.
Target	> 99%
Related Functional Requirements	**FUN-EMS-01 - FUN-EMS-12**

Requirement ID	NF-EMS-02
Title	Security

Description	Protection from unauthorized access, authentication and secure transaction as well as accounting shall be supported.
Author	Solution provider (SE)
Scope	Security
Metric	Y/N
Verification Measurement	The requirement is validated by auditing the system security.
Target	N/A
Related Functional Requirements	**FUN-EMS-01 - FUN-EMS-12**

5.2.3 External Interfaces

5.2.3.1 Software Interfaces

The EMS shall provide web interfaces that will enable the advanced operations envisioned by the E-LAND Toolbox. More specifically it shall enable the exchange of the information briefly presented below:

- Energy data: Production, consumption and SOC from LES assets will be provided by the EMS
- Weather data: Historic data from local weather stations or weather services as well as weather forecasts shall be provided by the EMS
- Energy charges: Cost of energy (euro per energy or demand unit) shall be provided by the EMS
- Energy forecasts: The EMS shall be able to receive the energy forecast calculated by the toolbox through a web interface
- Dispatch schedules: The EMS shall be able to receive the schedules calculated by the toolbox which are to be dispatched to the local assets.

5.2.3.2 User Interfaces

The requirements relating to the user interface offered by the EMS are briefly described below and concern the operator of the EMS:

- Visualisation of energy forecasts and availability of historic values
- Visualisation of LES's assets' schedules
- Input forms for providing end-user preferences with regards to flexibility of assets

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