This project has received funding from the European Union's Horizon 2020 research & i
agreement n°815301.

Deliverable D1.3

Functional requirements, benchmarking indicators and evaluation framework definition

Imprint

Programme	Horizon 2020 – Competitive Low-Carbon Energy
Project acronym	RE-COGNITION
Grant agreement number	815301
WP/Task related	WP1 / T1.3
Number of the Deliverable	D1.3
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Status and Version	Version 1.0
Confidentiality	Public
Contractual Date of Delivery to the EC:	30/09/2019
Actual Date of Delivery to the EC:	30/9/2019

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Version history

Version	Date	Author/Reviewer	Notes
1.0	30/09/2019	Andrea Lanzini, Alessandro Colangelo (POLITO) / Andrei Ceclan (TUCN), Radu Moldovan (SVT)	

Executive summary

This first deliverable aims at 1) defining the general requirements of RE-COGNITION platform, 2) identifying benchmarking indicators and their targets and 3) recognising potential shortcomings for guiding the evolution of low TRL developed technologies.
To this extent, high-level use cases (UCs) are first delineated. They represent possible interactions between actors communicating with RE-COGNITION platform (such as building managers) and the platform's constitutive elements (ACEME, iGateway, BE-PLATO and VAD). At this level, two broad categories of interactions are identified: long-term or short-term energy planning with one or more renewable energy technologies (RETs) in the framework of near Zero Energy Buildings (nZEB). Subsequently, high-level UCs are translated into the key functional requirements, i.e. the general actions that the platform should be able to perform, relying on the Volere methodology. Functional requirements are indeed essential for guiding the platform's design. More specifically, they include communication compatibility, data storage, simulation performing and results visualisation.
Then, a group of benchmarking indicators is presented to provide quantitative and qualitative feedbacks on the project itself and on the scenarios that will be implemented. Starting from RE-COGNITION various objectives, several key performance indicators (KPIs) are thus described. They attempt to assess the performance of RE-COGNITION solution from different perspectives: buildings' energy management towards nZEB mode, overall and technology specific economic performance, technical performance of each new RET, technology acceptance and overall project outcomes. After defining this group of indicators, an evaluation framework is presented, where indications on how to measure, calculate and assess them are suggested. More specifically, challenging targets are set.
Finally, the social aspect is further inspected through a focus on the acceptance of low TRL technologies in urban environments.

Table of contents

List of Tables

1 Introduction

1.1 Context

This deliverable constitutes one of the outcomes of WP1, which deals with the initial project activities such as barriers identification, requirements specification, users' needs elicitation, delineation of benchmarking conditions and system architecture definition.

1.2 Notations, abbreviations and acronyms

Table 1 - Acronyms list

ACEME	Automated Cognitive Energy Management Engine
BE-PLATO	Building Energy Plant Planning Tool
BESS	Battery Energy Storage System
BIPV	Building Integrated Photovoltaics
BMS	Building Management System
BoB	Blocks of Buildings
CHP	Combined Heat and Power
COP	Coefficient of Performance
D	Deliverable
DR	Demand Response
ERoEI	Energy Return on Energy Invested
EV	Electric Vehicle
FR	Functional Requirement
GA	Grant Agreement
IRR	Internal Rate of Return
KPI	Key Performance Indicator
LCOE	Levelized Cost of Energy
M	(Project) Month
NPV	Net Present Value
nZEB	Nearly Zero Energy Buildings
PCM	Phase Change Material
PU	Public
R	Report

RES	Renewable Energy Source
RET	Renewable Energy Technology
ROI	Return on Investment
RRI	Responsible Research Innovation
RTO	Research Institute
SME	Small Medium Enterprise
T	Task
TSR	Tip-speed Ratio
UC	Use case
UML	Unified Modelling Language
UNI	University
VAD	Visual Analytics Dashboard
VAWT	Vertical Axis Wind Turbine
WP	Work Package

1.3 Purpose of this deliverable

As summarised in "D7.1 – Project Management Plan", the purpose of this deliverable is to define RE-COGNITION platform's functional requirements, identify KPIs to be tested for benchmarking purposes and highlight potential shortcomings for guiding the evolution of low TRL developed technologies.

2 Definition of the high-level use cases

This section refers to the initial version of the High-level use cases for the RE–Cognition framework and the functional requirements for the associated platform. The main objective of the RE – Cognition platform is the accomplishment of high-level RES penetration to reach near zero (or even positive) energy buildings. This would be realized through the ACEME. The RE – COGNITION platform would be able to increase the level of integrated renewables penetration through optimized system sizing and integration, alongside optimized operation (power flow dispatched). The detailed, low-level use cases will be defined and delivered in task T1.4 alongside the system architecture.

Taking into consideration the timescale of the planning scenarios along with the possibility of either single or multiple renewables installation, four high – level use cases have been identified. Indicatively, the examination of long – time or short time plan is critical. This has to do with the variables that are exploited in each case and the competitive design of the platform's features. In long- term planning a holistic aspect is examined, based on a combination of criteria that should be fulfilled in the long term.

Nevertheless, in short term planning priorities are altered depending on the real (or close to real) time needs and the RES generation availability respectively. Last but no least is the fact that the possibility of using one or more renewables along with storage systems, inserts a level of complexity in the system that should be scrutinized. According to the above stated, the definition of these four use cases is of imperative need. A UML use case diagram is presented below including the four high level use cases. The respective use cases are described in the following paragraphs.

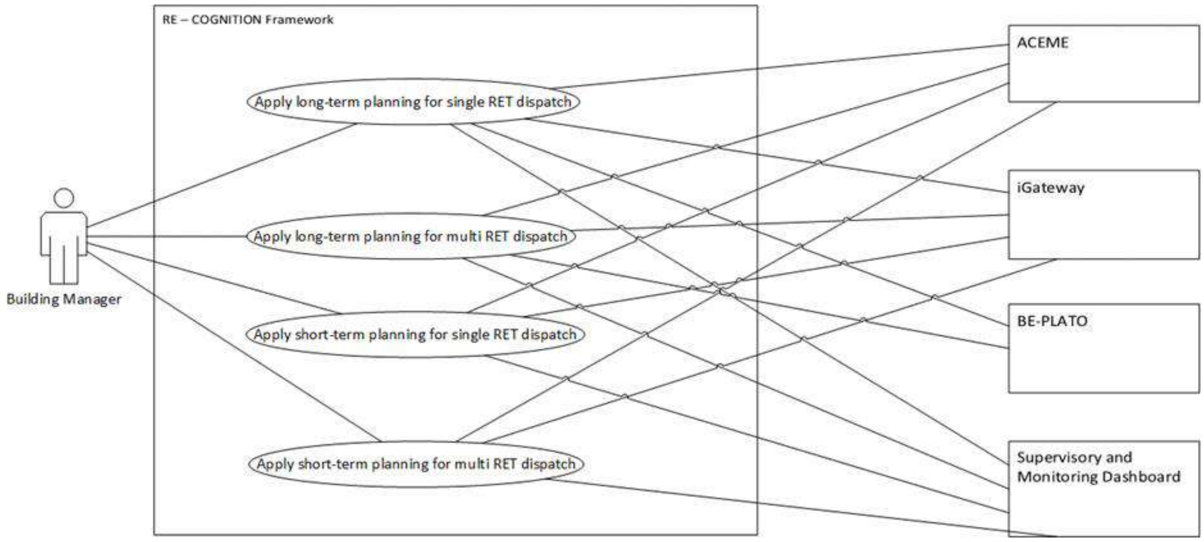

Figure 2.1: UML Use Case Diagram with High-level Use Cases

Apply Long-Term Planning for Single RET dispatch

As far as long-term planning is concerned, a single RET is examined. For example, this could be an expansion of the already installed BIPV equipment, the installation of a BESS or a micro CHP unit. A holistic system design including RES, selection of storage type and size, installation site and yield forecast is considered in this case. Investment indexes (such as CAPEX, NPV etc.) are also very crucial to the system design. The optimum operation scenario here would be the highest possible implementation of the selected RET or storage system (positive energy buildings) into the energy demand in direct relation to a feasible economic outcome.

In the RE-COGNITION Platform, the results produced using BE-PLATO will be visualized through the Supervisory and Monitoring Dashboard (VAD). Various options and simulation scenarios will be displayed to the end – user. Features like RET type and size, installation suggestions along with critical business factors such as cost of investment, ROI values, savings, updated with the contract with the respective utility provider will be available in each simulation scenario. In addition, access and comparison between previously performed planning simulations will be applicable, taking into consideration energy efficiency and financial feasibility as well.

Apply Long-Term Planning for multi RET dispatch

In the event of more than one RETs' implementation in each infrastructure, this is the most suitable long – term planning use case. The divergence from the former case, lies to the fact that more than one RETs are utilized here. As a consequence, more variables are considered leading to a time – consuming case of increased complexity.

The applicable scenarios here could be the installation and operation of two or more different RETs (e.g. VAWT and BIPVs) either alone or with a right sized storage system. A holistic system design including RES and storage type and size selection, installation site and yield forecast is considered in this case. Investment indexes (such as CAPEX, NPV etc.) are also very crucial to the system design. The optimum operation scenario would be the highest possible implementation of RETs (positive energy buildings) into the energy demand in direct relation to a feasible economical outcome.

In the RE Cognition Platform, the results produced using BE – PLATO will be visualized through the Supervisory and Monitoring Dashboard (VAD). Various options and simulation scenarios will be displayed to the end – user. Features like RET type and size, installation suggestions along with critical business factors such as cost of investments, ROI values, cost of savings, updated with the respective utility provider will be available in each simulation scenario. In Addition, access and comparison between previously performed planning simulations will be applicable, taking into consideration energy efficiency and financial feasibility as well.

Apply Short-Term Planning for Single RET dispatch

In this case, short - term planning for a single RET is presented. The applicable scenarios here could be either a day-ahead schedule or even real-time operation planning of the RET, (e.g. VAWT, micro CHP unit, BIPVs). This would be realized via the use of ACEME along with iGateway. The latter would play the role of data collector and translator between the field devices (for instance existing BMS systems and energy meters) and ACEME, in real timescale in order for the planning to be optimized at the highest possible level.

Concerning short – term planning, a forecast of the examined RET's generation would be essential. Particularly, a baseline energy consumption derived from historical energy consumption data and environmental parameters would be calculated. At the same time, the forecast of load and RES generation will be determined through the exploitation of prediction algorithms which will also use available site, environmental and historical data respectively. Available static information and constraints of each asset and applicable storage systems (stored capacity along with charging and discharging status, any other technical limitations on each asset's operation), will be utilized as well. In the end, each renewable or storage energy source should undertake a specific percent of the load demand, in an optimal manner; the most favourable power flow dispatch would derive as a trade-off between the aforementioned main objective of ACEME (mainly focusing on self-consumption) and methodology and the constraints discussed above.

In illustration of the above, in the day – ahead planning, any forecast deviation from the actual generation would result in further optimizing the forecast calculations through the ACEME. Furthermore, in the real – time operation planning, a validation might be required as well. Likewise, whether divergences between forecasted and real – time operation occur, re – optimization algorithms will be performed. As a result, the generation would be finally aligned with the real – time data.

In the RE – COGNITION platform, results including essential features like load and generation forecast, cost savings etc. could be displayed to the end user. This concerns day – ahead schedule as well as shorter-term schedules. In such case that almost real-time operation is required, the values of current state of load, generation and the time instants will be displayed including the appropriate recalculation. In Addition, access and comparison between previously performed planning simulations will be applicable, taking into consideration energy efficiency and financial feasibility as well. All the aforementioned will be realized via the Supervisory and Monitoring Dashboard.

Apply Short-Term Planning for multi RET dispatch

Provided that more than one RETs required in short term planning, the above - mentioned scenario is not applicable. Handling more than one RETs or a combination of a RET and a BESS would enable the multi – RET dispatch. The event of more than one RETs implementation, might lead to a more time - consuming scenario. On the other hand, more flexibility concerning the system's operation could be offered to the end user (such as selecting a particular generation mix etc.)

3 Functional requirements of the platform

3.1 Functional requirements of the RE – COGNITION platform

The intended outcome of the RE – Cognition platform is to achieve an optimized conversion of old infrastructures to near zero or Positive zero Energy Buildings using innovative RES, optimized demand side management and storage technologies. This would be realized by implementing the highest possible level of self – consumption to the pilot buildings. As a result, requirements concerning type and sizing of RES, location and installation techniques, noise levels, environmental forecast and economic feasibility criteria should be defined as requirements. Due to the fact that low-level use cases will be defined during M7 in the context of Task 5.1 for the pilot preparation activities, the functional requirements presented here, are the event of the high – level use cases.

Respectively to the description of the defined high-level use cases, a generic concept of the system's functional requirements has been derived. The notion is that, high level uses cases requirements would fulfil the low – level use cases, as well. For the documentation of the functional requirements, the Volere methodology is proposed. The latter introduces some criteria for meticulous description of the system requirements. In the following table, a broadened template for the functional requirements of the RE-Cognition platform is proposed. In addition, in the initial version of the system non-functional requirements has been presented in a separate table. The identified functional and non-functional requirements of the system will influence the architectural design process within the Task 1.4.

Table 2 - Preliminary list of functional requirements

ID	Description	Type	Rationale	Originator	Fit Criterion	Priority	Associated Components	Associated Use Cases
1	Communicate with Field Device intermediator (iGateway, existing BMS, or other).	F	Retrieve information regarding building assets and load status	CERTH	Compatibility with iGateway and installed BMSs protocols	Must have	ACEME	UC1, UC2, UC3, UC4
2	Interface with on-site environmental sensors	F	Retrieve information regarding environmental conditions and perform weather forecasting,	CERTH	Compatibility with the installed environmental sensors.	Must have	ACEME, iGateway	UC1, UC2, UC3, UC4

			which leads to load forecasting as well.					
3	Retrieve data from external services (e.g. energy prices, weather data)	F	RETs sizing along with calculation of critical finance and business factors	CERTH	Right sizing and of RETs and their respective storage systems and realistic calculation of critical finance and business factors	Must have	ACEME	UC1, UC2, UC3, UC4
4	Store data in the RECOGNITION Repository	F	All the amount of important data regarding the examined scenarios along with environmental and historical data will be available in the RECOGNITION repository.	CERTH	Historical and environmental database present in the RECOGNITION repository	Must have	ACEME	UC1, UC2, UC3, UC4
5	Retrieve data from the RECOGNITION Repository.	F	Retrieve data from the RECOGNITION repository when needed.	CERTH	Data available in the RECOGNITION repository in order to be used in various simulation scenarios and comparison to one another.	Must have	ACEME	UC1, UC2, UC3, UC4
6	Perform load forecast	F	Load forecast based on historical load measurements, and other information, such as weather conditions, indoor temperature/humidity etc.	CERTH	Projection of load demand calculated by exploiting historical and environmental data.	Must have	ACEME	UC1, UC2, UC3, UC4

7	Perform generation forecast	F	RETs generation forecast based on historical generation measurements, on the attributes of each asset agent	CERTH	Projection of the RETs generation calculated by exploiting historical and environmental data	Must have	ACEME	UC1, UC2, UC3, UC4
8	Conduct simulations regarding the energy balance flow of the building.	F	Running various simulation tests having the opportunity to select either one or various RET and storage equipment	CERTH	Day ahead forecast, close to real time operation.	Must have	ACEME	UC1, UC2, UC3, UC4
9	Perform simulations regarding the optimal decision making for the various assets.	F	Simulation results that contribute to effective selection and sizing of the available assets in order for an optimized solution to be reached.	CERTH	Comparable Power flow dispatch results in various scenarios	Must have	ACEME	UC1, UC2, UC3, UC4
10	Monitor the energy balance flow of the building.	F	Optimal Power flow dispatch and power flow rescheduling when needed	CERTH	Communication with the installed sensors and meters per asset, data retrieval and real time energy flow calculation.	Must have	ACEME	UC1, UC2, UC3, UC4
12	Send control signals to the Field Device intermediator (iGATEWAY, or existing BMS, or other) for each building asset.	F	Retrieve information regarding building assets and load status	CERTH	Based on the functional requirement 1, compatibility with iGateway and installed BMSs protocols	Must have	ACEME	UC1, UC2, UC3, UC4

13	Communicate with the Supervisory and Monitoring Dashboard	F	Present information in a user – friendly interface.	CERTH	Uninterruptible communication with VAD.	Must have	ACEME	UC1, UC2, UC3, UC4
14	Access to historical information of the building sites	F	Historical information is mandatory in order to evaluate the current status of the building and predict future needs.	CERTH	The RECOGNTION repository will implement a historical database. In addition, the communication between ACEME and iGateway will be instant, fetching real time data values.	Must have	ACEME	UC1, UC2, UC3, UC4
15	Energy consumption auditing	F	Real-time energy consumption data should be available to the ACEME. This not only refers to important loads (ie heating, cooling, electricity or crucial loads) but also to overall energy consumption of the building.	CERTH	Given the fact that functional requirement 2 is fulfilled, energy consumption data should be available at time intervals of: 5sec/1min/5min/15min/hourly/monthly	Must have	ACEME, VAD	UC1, UC2, UC3, UC4
16	Energy resources monitoring	F	Real-time energy production stemming from various installed RETs should be available to the building's system manager, as well as to certified users that will be defined.	CERTH	Given the fact that functional requirement 2 is fulfilled, energy production data should be available at time intervals of: 5sec/1min/5min/15min/hourly/monthly	Must have	ACEME, VAD	UC1, UC2, UC3, UC4
17	Information	F	The knowledge of the	CERTH	Asset's status data	Must	ACEME,	UC1, UC2,

	concerning status of buildings' assets		buildings' assets status is essential for the generation forecasting and when power dispatch allocation, due to a faulty condition, is of imperative need.		should not only be stored in the RECOGNTION repository but also be available to the system operator.	have	VAD	UC3, UC4
18	Common Information Model implementation	F	All the RECOGNITION Platform's components should communicate, using a standard that defines their communication and how they are related.	All partners	Real - time data will be available through the RECOGNTION platform.	Must have	iGateway, BEPLATO, ACEME, VAD	UC1, UC2, UC3, UC4
19	Power flow optimization	F	Power flow should be controlled, in order to achieve the highest possible RES penetration level.	CERTH	Power generated by RETs, should be distributed according to the demand loads taking into account, the energy price data and other physical restrictions (the given priority to other stochastic RETs or storage controlling issues)	Must have	ACEME	UC1, UC2, UC3, UC4
20	Optimized power dispatch on single-RET dispatch	F	Power flow should be controlled even in the case of single RES implementation	CERTH	A single-RET dispatch mode should be designed taking into consideration the fact that even in the case of stochastic generation, power generated should be distributed to the	Must have	ACEME	UC1, UC3

					building loads. At this point, Demand Response actions might be applicable.			
21	Optimized power dispatch on multi-RET dispatch	F	Power flow dispatch in a more complex yet effective way should be implemented in the multi-RET dispatch mode as well.	CERTH	The optimization power flow algorithm should take as parameters current buildings' loads' status, all available DERS' status along with the storage units' state of charge, and considering the current energy prices, realize the optimum dispatch solution, altering operation set points of the controllers or implementing Demand Response functions if needed.	Must have	ACEME	UC2, UC4
22	Individual control of DERs and ESSs	F	DERs and ESSs should be controlled according to their type.	CERTH	In the case of RETs, they should be operated close to their MPPT point. As for the mCHP unit, the control algorithms should be designed in order to maximize energy efficiency, considering cost of fuel and operation/ maintenance costs as well. Using	Must have	ACEME	UC1, UC2, UC3, UC4

					similar reasoning, BESS and thermal storage charge and discharge states should be controlled, according to demand/ RE generation forecasts and considering relevant electrical/ mechanical constraints.			

3.2 Non-Functional requirements

Table 3 - List of non-functional requirements

	Description	Priority	Comments
Integrity	The system should ensure that the data stored and exchanged are accurate, authentic and without corruption.	Mandatory	
Usability	The system will be made easy to be learnt, and operated.	Desirable	
Accessibility	The system can be used by people with the widest range of capabilities.	Desirable	
Scalability	The system will be able to scale up in order to include more RETs	Mandatory	
Replicability	The system will be able to be a replicable service solution, in order to be deployed to various number of cases.	Mandatory	
Maintainability	The system will be able to be maintained with relative ease, allowing replacement of components, software update, in order to allow it to cope with changing environments and prolonging its lifetime.	Mandatory	
Reliability	The system will be able to provide reliable solutions 100% of the time.	Mandatory	
Availability	The system will guarantee availability of services at any given time	Mandatory	
Resilience	The system will sustain continuity of operation when abnormal situations occur.	Mandatory	
Recoverability	The system will be able to return to its normal state of operations after a system failure, shutdown, or restart.	Mandatory	
Installability	The system will be able to allow the installation and integration of components with relative ease, with little to no disruption	Desirable	
Performance	The system will perform in perfect conditions for the required information load, such as data exchange and optimization.	Mandatory	
Interoperability	The system should allow interaction with external systems.	Mandatory	

4 Benchmarking indicators (KPIs)

Key Performance indicators (KPIs) are essential for benchmarking projects outcomes. This section is structured as follows. First, the RE-COGNITION objectives are summarized, then corresponding performance indicators are analysed and, finally, KPIs are selected.

Key Performance Indicators (KPIs) are indissolubly tied to a project's goals, as they provide a measure of the progress towards those goals for further learning and improvement [1]. RE-COGNITION project foresees several outcomes, which, however, can be grouped within six objectives.

- O1) The proposed system intends to fill the gap between the energy demand of a building and the locally generated RES-based supply through the optimal allocation of energy production between intermittent (solar, wind) and stable (CHP, grid) primary sources with the aim of maximizing the building self-consumption and any energy exchanges within energy islands, called blocks of buildings (BoB) in the same energy contour. This optimal allocation is intended to be performed by an Automated Cognitive Energy Management Engine (ACEME) employing machine learning predictive algorithms.
- O2) This project attempts to demonstrate significant technology advances in the devised solutions: Building Integrated Photovoltaics (BIPV), Vertical Axis Wind Turbine (VAWT), biogas micro-CHP, Latent Heat Thermal Energy Storage (LHTES), hybrid system for solar cooling and controllable EV charger. Advances are meant both in terms of performance and cost-effectiveness.
- O3) This project aims at designing its energy management tools (ACEME and iGateway) in a scalable, modular and interoperable way through a hybrid MAS-based architecture. Indeed, the project's consortium foresees interoperability as a crucial aspect for effectively realizing the future near Zero Energy Buildings (nZEB).
- O4) RE-COGNITION strives to facilitate the adoption of RES technologies by end-users through the creation of the Building Energy Plant Planning Tool (BE-PLATO). This tool is meant to bring the planning process closer to non-expert end-users and ensure optimal design of the local RES energy plant.
- O5) This project intends to validate the integration of all components through multiple tests in different locations and close-to-real life settings, including Demand Response (DR).
- O6) RE-COGNITION also targets the creation of customer-centric business models that will effectively exploit the potential of the proposed solutions at least in the 7 European markets represented in the consortium.

These objectives can be further classified in two categories. The former targets use-cases performance, while the latter concerns the overall project performance. O1 clearly expresses a goal at the building level, aiming at maximum self-consumption and self-sufficiency. Then, O2 inspects the technologies performance, both from a technical and economic point of view. Therefore, O1 and O2 belong to the first category. On the other hand, O3-O6 express targets that go beyond the single pilot cases, pertaining to the sphere of the overall project.

Consequently, the following subsections present evaluation indicators regarding **use-cases performance** and **overall project performance**.

4.1 Use-cases performance indicators

As far as use-cases are concerned, RE-COGNITION performance can be evaluated on three different levels: the building level, the economic/financial level and the technology level.

4.1.1 Building performance indicators

The first objective declared by RE-COGNITION project is the maximization of the self-consumed renewable energy which is locally produced. Therefore, an immediate indicator can be expressed by the following fraction:

$$RES\ self-consumption = \frac{E_{RES,cons}}{E_{RES,prod}} = \frac{E_{RES,prod} - E_{RES,grid}}{E_{RES,prod}} = 1 - \frac{E_{RES,grid}}{E_{RES,prod}}$$

Where:

$E_{RES,cons}$ is the renewable energy that is locally consumed (both directly and stored);
$E_{RES,prod}$ is the renewable energy that is locally produced;
$E_{RES,grid}$ is the renewable energy that is injected into the grid or dissipated.

Due to the presence of both thermal and electrical energy, two distinct indicators should be calculated yielding to an electrical self-consumption and a thermal self-consumption. Furthermore, they can be calculated on a monthly basis, yearly basis or related to a representative interval of time and to an agreed established energy baseline for each demo site.

However, the gap between energy demand and local production cannot be filled only by monitoring and controlling the renewable energy that is locally consumed. Indeed, the renewable energy injected into the grid (or dissipated) might always be null if RES technologies are undersized. In this case, the RES self-consumption parameter would result maximal, even though the building would still be highly dependent on energy imports from an external grid. Therefore, a complementary aspect should be monitored: the building's self-sufficiency and capability to perform Demand Response events. In order to observe the first feature, two interconnected parameters are identified: the fraction of energy imported and the time correlation between energy generation and use. Both pieces of information are relevant: indeed, an elevated amount of imported energy in a limited interval of time may simply suggest a rescheduling of the loads to increase the building's self-sufficiency and even the flexibility provided to the grid. The former indicator is expressed by the following formula:

$$Imported\ energy\ fraction = \frac{E_{imported}}{E_{demand}}$$

Where:
$E_{imported}$ is the energy imported from an external grid;
E_{demand} is the building energy demand.

The time correlation indicator, instead, is calculated by the following formula as suggested by [2]:

$$Time\ correlation\ indicator = \int_0^T P_{Demand\_uncovered\_by\_site\_generation}\, dt$$

Where P is the power demand.

Nevertheless, the imported energy fraction and the time correlation indicator do not immediately highlight the building's level of independency. Therefore, a third indicator is here proposed:

$$Building\ self-sufficiency = \frac{E_{local\ prod}}{E_{demand}} = 1 - \frac{E_{imported}}{E_{demand}} = 1 - Imported\ energy\ fraction$$

Where:
$E_{local\ prod}$ is the energy that is locally produced (in RE-COGNITION coincides with $E_{RES,prod}$)
The following energy balance is assumed: $E_{demand} = E_{local\ prod} + E_{imported}$

Finally, there are other two indicators that are not strictly in line with O1 but are generally discussed when considering performance at the building level. The former is the share of renewable energy sources used for providing electricity, heating and cooling in buildings. However, in RE-COGNITION this parameter coincides with the building self-sufficiency indicator, as all the in-situ generation comes from renewable sources. The latter, instead, is the amount of CO_2 emissions that are saved, which can be calculated by the following formula:

$$CO_{2_{saved}} = \sum_i (E_{imported,old_i} - E_{imported,new_i}) * EF_i$$

Where:

i is the type of energy (electricity or thermal energy);
$E_{imported,old}$ [J] is the amount of energy withdrawn from the grid (electricity or gas) before the installation of RE-COGNITION solution;
$E_{imported,old}$ [J] is the amount of energy withdrawn from the grid (electricity or gas) after the installation of RE-COGNITION solution;
EF_i [kgCO$_2$/kJ] is the carbon emission factor, whose values depends on the national electricity production mix and on natural gas quality in the grid (for thermal energy).

Although this indicator does not directly deal with the energy independence of buildings, it is still meaningful in the path towards the realization of nearly Zero (or Energy Positive) Buildings as they aim at the reduction of primary energy consumption from fossil fuels.

Summarizing, the indicators proposed as KPIs are: **RES self-consumption**, **Building self-sufficiency** and **saved CO_2 emissions**, along with the capability to perform Demand Response events for the TUCN demo site, in close connection with the DR BoB already implemented project (www.dr-bob.eu).

4.1.2 Economic performance indicators

The economic performance of the different solutions examined in the pilot cases can be analysed through various indicators. The most commonly used parameters are listed below:

- Levelized cost of energy (LCOE):

  The Levelized Cost of Energy is that cost that, if assigned to every unit of energy produced by the system over the analysis period (usually its lifetime), will be equal to the sum of the total costs occurred in the analysis period discounted to the base year. This indicator is usually recommended when ranking alternatives. The LCOE is calculated according the following formula [3]:

$$LCOE = \frac{\sum_{n=1}^{N} C_n/(1+d)^n}{\sum_{n=1}^{N} Q_n/(1+d)^n}$$

  Where:

  C_n is the cost in period n: investment costs for the demo pilot projects implementation, expected salvage value, O&M costs, replacement costs and energy costs;

  Q_n is the energy output in period n;

  N is the analysis period;

  d is the discount rate.

  Considering the various forms of energy involved in RE-COGNITION, it should be then declined into: Levelized Cost of Electricity, Levelized Cost of Heating and Levelized Cost of Cooling.

- Net Present Value (NPV):

  The NPV of a project allows evaluating the costs (cash outflows) and revenues (cash inflows) together. It is important to choose coherently the form of cash streams (current or constant money) in order to select the correct discount rate. NPV analysis is usually recommended when evaluating mutually exclusive solutions. The formula for NPV can be expressed as [3]:

$$NPV = \sum_{n=1}^{N} \frac{F_n}{(1+d)^n}$$

Where:

F_n is the net cash flow in year n;

N is the analysis period;

d is the annual discount rate.

- Internal Rate of Return (IRR):

  The IRR of an investment is that rate that sets the NPV equal to zero. The IRR analysis is suitable for comparing a wide variety of investment activities, but it is not recommended for those situations in which additional investments after return are required. The IRR is frequently used to accept or reject decisions through a quick comparison with a minimum acceptable rate of return, called hurdle rate. Furthermore, it should not be employed when selecting among mutually exclusive alternatives [3].
  As said, IRR equals the rate for which:

$$NPV = \sum_{n=1}^{N} \frac{F_n}{(1+IRR)^n} = 0$$

- Energy Returned on Energy Invested (ERoEI):

  The ERoEI, also referred as EROI (Energy Return On Investment), is "the ratio of how much energy is gained from an energy production process compared to how much of that energy (or its equivalent from some other source) is required to extract, grow, etc., a new unit of the energy in question" [4]. Although it cannot be strictly considered an economic parameter, it still proves whether investing in a determined solution is reasonable. Indeed, according to [4] and others, ERoEI analysis offers a new way to investigate various energy sources with respect to the tools made available by markets analyses.
  ERoEI is calculated from the following equation:

$$ERoEI = \frac{Energy\ gained}{Energy\ required\ to\ get\ that\ energy}$$

As suggested by [3], it is usually recommended to calculate several measures in order to better evaluate an investment. However, using all these four indicators as KPIs appears excessive to examine the cost-effectiveness of RE-COGNITION solution. The Levelized Cost of Energy is a popular parameter, but it does not seem the best choice when assessing multi-RETs scenarios. Indeed, LCOE is appropriately employed to rank several alternatives, while within RE-COGNITION project the different RES technologies are not competing with each other. Therefore, LCOE can be more profitably used for assessing the economic performance of a single technology, especially when considering its location on the market. Then, the ERoEI is a fascinating indicator, but it requires a well-known and traceable production chain for the technology analysed. Consequently, its deployment will be investigated in T5.4, which deals with life cycle analysis (LCA) and life cycle cost (LCC). On the other hand, NPV and IRR are generally recommended for accepting or rejecting an investment [3]. Indeed, the NPV allows to highlight the benefits (or the disadvantages) of using a set of RES technologies instead of depending on the external grid, while the value of the IRR immediately gives a feedback when compared to a pre-fixed hurdle rate. Therefore, the choice of **Net Present Value** and the **Internal Rate of Return** appears reasonable for monitoring the positive ending of O2.

4.1.3 RE-COGNITION technologies performance indicators

To further detail the outcomes produced by the scenarios foreseen in RE-COGNITION, the technical performance of each new renewable energy technology can be assessed through the following indicators. However, this list could be further expanded and better detailed in the specific tasks about RE-COGNITION technologies included in WP2.

Micro-CHP biogas turbine

Regarding the micro-CHP biogas turbine, three technical KPIs are identified:

- **Gross electrical efficiency**, calculated according to:

$$\eta_{elc,gross} = \frac{Gross\ electricity\ output}{Biogas\ energy\ input}$$

  Where the biogas energy in input to the system is calculated as the quantity of biogas entering the turbine multiplied by its energy content, i.e. its lower heating value (LHV). Depending on the biogas supply at the installation site LHV may vary considerably.

- **Overall efficiency** (thermal + electrical), calculated according to:

$$\eta_{elc+therm} = \frac{Gross\ electricity\ output + Thermal\ energy\ output}{Biogas\ energy\ input}$$

- **NOx emissions** at different power rates (from full power down to 50% modulation of fuel input), expressed in ppm.

Both the efficiencies are easy to measure, while emission measures will depend on the availability of lab instrumentation or validated sheets of performance tests.

Building Integrated Photovoltaics (BIPV)

Regarding BIPV, three KPIs monitoring the technical advances of this solution are identified:

- **Specific module weight**, expressed as kg/m^2;

- Modules **durability** to Damp Heat (DH), Thermal Cycling (TC) and Ultraviolet (UV) radiation;

- **Power yield** of the modules, calculated as:

$$Yield = \frac{Modules\ electricity\ output}{Modules\ surface}$$

Vertical Axis Wind Turbine (VAWT)

Regarding VAWT, three KPIs monitoring the technical advances of this solution are identified:

- Small wind turbine **urban to rural capacity factor ratio** (CF urban/CF rural), which is an indirect measure of the effects that urban wind variability has on the turbine. When this value equals to 1 in an urban environment it indicates that the wind turbine is not affected by urban configurations.

- **Efficiency at self-starting**, which is both identified by the power coefficient in the lower tip-speed ratio range and its variation with respect to the tip-speed ratio (TSR, being the ratio between the tip-speed of the blade and the inlet wind speed). In absolute terms, efficiency at self-starting is also measured by the aerodynamic torque and the acceleration performance of the turbine in no-load condition (or free-run speed).

- **Comfort & Safety in the building integration according to standards and RRI,** which is identified by the noise & vibration levels at the rooftop interface, and by electro-magnetic field exposure (in the extremely low frequencies range) at the generator & grid/load side. For a detailed assessment of these topics, see D1.2.

Hybrid Solar Cooling

Regarding the hybrid solar cooling technology, one KPI monitoring the technical advances of this solution is identified:

- The **thermal COP** (coefficient of performance) at driving temperature as low as 70°C, which is expressed by the following formula:

$$COP_{thermal} = \frac{Q_{cooling}}{Q_{solar\ thermal}}$$

  Where $Q_{cooling}$ is the cooling power delivered and $Q_{solar\ thermal}$ is the input thermal power from solar collectors.

PCM Thermal storage

Regarding the PCM thermal storage unit, two KPIs monitoring the technical advances of this solution are identified:

- The **solidification time** for recovering 90% of the stored energy, which is an indirect measure for the average power rate during the discharge of the unit. This is the most challenging phase for this technology as it often coincides with peak thermal requests from end-users.

- **Efficiency** after 1000 cycles for monitoring long term performance degradation. It is calculated according to the following formula:

$$LHTES\ Efficiency = \frac{E_{stored\_real}}{E_{stored\_initial}}$$

  Where E_{stored_real} is the maximum amount of energy that can be actually stored after a chosen number of cycles, while $E_{stored\_initial}$ is the energy the unit is able to store after its manufacturing.

Automated Cognitive Energy Management Engine (ACEME)

Although it is a different kind of technology compared to the previous ones, a relevant KPI can be identified concerning ACEME's capability of allocating the energy production of different RETs with the demand side and storage management. Such allocation resides on ACEME's ability to perform load and production forecasts. Therefore, two indicators able to evaluate ACEME's **forecasts precision** are proposed as seen below.

- **Load Demand Forecasting Accuracy (LDFA)**:
  This refers to the deviation of the forecasted load consumption from real-time measurements. Several variations of this metric can be relevant, for example, accuracy per interval (e.g. 15') or per day. In any case, varying timeframes do not alter the KPI's structure. Thus, to begin with, accuracy would be defined based on the lowest required resolution (e.g. 15') and from there daily or general holistic values can be easily extracted for further analysis:

$$LDFA = \frac{\mathrm{E}_{c,\mathrm{forecast}}}{\mathrm{E}_{c,\mathrm{real-time}}} * 100\%$$

  where $\mathrm{E}_{c,\mathrm{forecast}}$ is the forecasted value for the consumption expected from the loads, whereas $\mathrm{E}_{c,\mathrm{real-time}}$ is the actual consumption for the same examined timeframe. Based on the required resolution, it is possible to examine this indicator for the aggregated measurements (building-scale) or for each separate load.

- **RES Generation Forecasting Accuracy (RESGFA)**:
  Similarly with the previous KPI, this metric examines the accuracy of the forecasting component for the RES generation. Since weather conditions have a more significant impact on predicting energy generation, certain deviations are expected leading to higher KPI values than the ones referring to the load consumption.

$$RESGFA = \frac{\mathrm{E}_{t,\mathrm{forecast}}}{\mathrm{E}_{t,\mathrm{real-time}}} * 100\%$$

where $\mathrm{E}_{t,\mathrm{forecast}}$ is the forecasted value for the generation expected from the RE assets, whereas $\mathrm{E}_{t,\mathrm{real-time}}$ is the actual generation for the same examined timeframe. Based on the required resolution, it is possible to examine this indicator for the aggregated measurements (building-scale) or for each separate load.

4.2 Overall project indicators

This subsection presents KPIs dealing with the project objectives O3-O6. As already anticipated, these goals are slightly different from the previous ones, as they are related to more general outcomes of the project.
The third objective (O3) hopes for the creation of a platform that is modular, scalable and interoperable. Considering the intrinsic diversity of the pilot buildings in the project (diverse business, social characteristics, use profiles and regulatory restrictions), counting the **number of successful installations** of ACEME and iGateway within the project is enough to monitor the positive ending of this goal.

The fourth objective (O4), instead, strives to extend also to non-expert users the willingness to install RES technologies through the help of BE-PLATO. This tool should be precise, simple and intuitive. Moreover, the solution it proposes to non-expert users should raise their interest and willingness to invest in RETs. Therefore, the **score of a questionnaire** about the usability and persuasiveness of BE-PLATO is a good performance indicator for this goal.

Then, O5 is one of the most important targets as it deals with the validation of RE-COGNITION solution. In order to guarantee a future employment of RE-COGNITION outcomes, hopefully well beyond the temporal scale of the project, the validation should be twofold. On the one hand, it should be technical, meaning that all the scheduled tests must be successfully completed; on the other hand, it should be also "social", meaning that RE-COGNITION solution must be welcomed and accepted by end-users. Therefore, two key performance indicators for this objective are proposed:

- Counting the **number of tests successfully completed** in close-to-real life conditions;
- Evaluating the **score of a questionnaire** about comfort and acceptance of building occupants (or building manager) during tests.

Finally, the last objective (O6) aims at the identification of customer-centric business models. Evidently, it is not possible to evaluate the efficacy and success of the identified business models in the timespan of the project. However, counting the **number of produced business models** appears a reasonable way to monitor this goal.

4.3 Selected KPIs

Below, Table 4 summarizes the project's targets and their corresponding KPIs discussed in the previous sections.

Table 4 - Correlation between RE-COGNITION goals and project KPIs

RE-COGNITION Goals	KPIs
1) Maximum building energy independence through RES	• RES self-consumption *(KPI1.1)* • Building self-sufficiency *(KPI1.2)* • Saved CO_2 emissions *(KPI1.3)*
2) RETs cost-effectiveness and technical performance	• Net present value *(KPI2.1)* • Internal Rate of Return *(KPI2.2)* • Technology specific KPIs *(KPI2.3.x)*
3) Modularity, scalability, interoperability	• Number of successful installations of ACEME and iGateway *(KPI3)*
4) Support to non-expert end-users	• Score of a questionnaire on usability/persuasiveness of BE-PLATO *(KPI4)*
5) Validation	• Number of tests successfully completed *(KPI5.1)* • Score of a questionnaire on comfort/acceptance *(KPI5.2)*
6) Creation of customer-centric business models	• Number of produced business models *(KPI6)*

As already mentioned, KPIs1-2 are helpful for monitoring the performance and the outcomes of the use-cases that will be tested during RE-COGNITION. More specifically, some of them are suitable for long-term scenarios (such as NPV and IRR), while others are suited for short-term scenarios (such as ACEME forecast precision and micro-CHP NOx emissions). RES self-consumption and building self-sufficiency, instead, can be declined in both cases depending on the type of analysis (energy vs. power). On the other hand, KPIs3-6 are suitable for assessing the overall performance of the project. Furthermore, the proposed list of KPIs covers all the four dimensions of sustainability: technical, economic/financial, environmental and social.

5 Evaluation framework

RE-COGNITION pilot sites have different characteristics: different RES-equipment topologies, variable weather conditions, different use profiles, diverse business and social characteristics and possibly different regulatory restrictions related to multi-energy source systems. Therefore, different performances may affect the results reported by the KPIs previously identified. Consequently, this section analyses possible inequalities in the proposed KPIs and presents a methodology to evaluate (measure, calculate, assess) them. Generally, a benchmarking threshold is proposed, but the values that will be assumed by the suggested KPIs should be always contextualized to each situation.

5.1 Evaluation of building-level KPIs

KPIs related to buildings performance (KPI 1.1, 1.2, 1.3) are more sensible to site specific features. But this condition does not necessarily represent a drawback for the project evaluation through these indicators. On the contrary, buildings performance differences represent a precious aid for identifying the best combination of RES equipment and local resources.

Nevertheless, the demonstrative nature of the project's pilot sites requires some extrapolations for KPI 1.1, 1.2, 1.3. Due to the small size of the demo technologies compared to buildings' energy demand, it is likely to obtain a full RES self-consumption combined with low values for the building self-sufficiency. This situation is not optimal and doesn't coincide with the aim of the project, as the examined building would still be highly dependent on external energy grids (electricity and natural gas). Therefore, it is proposed to evaluate KPI 1.1, 1.2, 1.3 by extrapolating the energy production profile of installed RES technologies from the real data of the demo size to a size that is appropriate for the building needs.

Summarizing, the suggested procedure is the following:

1) Measure (through sensors) demo RES technologies energy production profile;
2) Retrieve (through sensors) the real building energy demand profile;
3) Extrapolate a RES energy production profile from 1) assuming a suitable larger size of installed RE technologies;
4) Compare the energy production and demand profiles and calculate KPI 1.1, 1.2, 1.3.

If this framework is followed, it should be clearly stated that the values assumed by KPI 1.1, 1.2, 1.3 are "estimated" or "expected".

Finally, the assessment of these KPIs should be performed through a sensitivity analysis that monitors how self-consumption and self-sufficiency are interrelated when simulating different equipment size. A target for building self-sufficiency > 85% is hoped in combination with high values for RES self-consumption (> 90%-95% if the building is endowed with energy storage units).

5.2 Evaluation of economic KPIs

Disparities in the evaluation of economic KPIs in pilot sites may arise for two reasons: different installed technologies and different taxes. However, NPV and IRR should not be compared between pilot sites, but rather between the solution tested in a pilot site and an alternative currently available on the market. Moreover, these two indicators can be calculated without accounting taxes, thus eliminating location disparities. In this case, cash flows are constituted by the following elements:

- Investment costs for all RE-COGNITION equipment in a specific pilot site
- O&M costs
- Energy costs (for the energy purchased from the grid)
- Revenues, both indirect (i.e. savings of grid energy purchase) and direct (i.e. energy selling to the grid), including also revenues from providing flexibility to the power grid through Demand Response.

The time span of this analysis is fixed to 20 years, while the discount rate is defined case by case.

Finally, the assessment of these two KPIs is performed according the following indications:

- KPI2.1 – Net Present value: if the NPV of the RE-COGNITION solution in a specific pilot site is higher than that of a similar system made with alternatives currently available on the market, then the assessment is positive;
- KPI2.2 – Internal Rate of Return: if the IRR of the RE-COGNITION solution in a specific pilot site is higher than a hurdle rate (that will be identified successively), then the assessment is positive.

5.3 Evaluation of technology specific KPIs

Technology specific KPIs are evaluated fixing target values indicated by RETs manufacturers. A list is reported below.

Micro-CHP biogas turbine

- Gross electrical efficiency target is set to at least 20%, which is a high value for small CHP turbines (3 kW_e) if methane fraction in biogas is >60%;
- Overall efficiency (thermal + electrical) target is set to at least 92% (if methane fraction in biogas is >60%);
- NOx emissions target is the level set by EcoDesign (at full power and in modulation down to 50% fuel input).

Building Integrated Photovoltaics (BIPV)

- Specific module weight target is 5-6 kg/m^2 (compared to weights in the range 15-20 kg/m^2 for conventional glass/glass BIPV products);
- Modules durability to Damp Heat (DH), Thermal Cycling (TC) and Ultraviolet (UV) radiation targets are respectively: less than 5% STC power loss after 3000h DH, 600 cycles TC and 45kWh UV (3 times the test duration required by IEC 61215 norm);
- Power yield target is higher than 100W/m^2.

Vertical Axis Wind Turbine (VAWT)

- Small wind turbine urban to rural capacity factor ratio (CF urban/CF rural) target is set to 1;
- Efficiency target at self-starting is set to at least 0.15.

Hybrid Solar Cooling

- The thermal COP (coefficient of performance) at driving temperature as low as 70°C is set to 0.6.

PCM Thermal storage

- The target for the solidification time for recovering 90% of the stored energy is set to maximum 45-60 minutes, depending on the operating temperature of the heating system;
- Efficiency after 1000 cycles is set to at least 90%.

For further information, desired economic targets of each single technology are here reported.

Table 5 - LCOE for RE-COGNITION and traditional solutions

	Levelized Cost of Electricity/Heating/Cooling (€/KWh)	
	RE-COGNITION	Traditional solutions
Biogas micro-CHP	0,17	0,29

BIPV	0,1	0,16
VAWT	0,102[1]	0,186
Hybrid solar cooling	0,1	0,1-0,3[2]
PCM Thermal storage	0,073	0,085[3]

5.4 Evaluation of other KPIs

The remaining KPIs (KPI3-6) are already independent on the site location thanks to their general purpose. Their evaluation framework is here reported:

- KPI3 - Number of successful installations of ACEME and iGateway
  The installation is considered successful when all these conditions are satisfied:
  - iGateway is able to retrieve data from all the sensors distributed on the pilot site and RES technologies and successively send them to ACEME;
  - ACEME is able to elaborate complex and heterogeneous information from various resources and then undertake automated control decisions;
  - iGateway is able to receive control decisions from ACEME and send them to automation and control equipment.

  KPI3 will be then assessed through a comparison with a threshold, fixed at 5 successful installations (i.e. in each scheduled pilot site).

- KPI4 - Score of a questionnaire on usability/persuasiveness of BE-PLATO
  A suitable questionnaire will be devised with the aim of receiving feedbacks on a pre-determined number of questions from a selected group of non-expert users. Users will be given the possibility to express a preference ranging from 0 (strongly disagree) to 5 (totally agree).
  KPI4 will be then assessed through a comparison with a threshold. If the average value of the questions is higher than 4, the assessment will be considered positive.

- KPI5.1 - Number of tests successfully completed

[1] The LCOE for traditional solutions is calculated for a reference 25 years life 1,5 kW turbine according to the average European [€ per kW] price published by World Wind Energy Association - Small Wind World Annual Report 2017, while the Annual Energy Producibility AEP is reduced according to the ratio between "urban" and "rural" installation utilization factor, that is an indirect measure of the urban wind variability effects, according e.g. to the survey published in the H2020 COST TU1304 Action framework 2015.
The corresponding RE-COGNITION LCOE target is obtained considering a cost reduction from the sharing of power train according to the system integration proposal at the building scale, and by minimizing the AEP producibility difference between an "urban" and a "rural" installation, thanks to the proposed passive variable geometry VAWT concept

[2] The reference case considers a tertiary cooling unit with 900h/y of operation and a load factor of 50%.

[3] The traditional solution considers heat production in peak hours using a boiler with average efficiency of 0.85. Thermal storage is applied to the storage of thermal energy produced with high efficiency cogeneration. The investment cost of the storage was evaluated considering a target investment cost of 9500 €/m3.

A laboratory test is considered successful when all its scheduled activities are performed and reported.
KPI5.1 will be then assessed through a comparison with a threshold, fixed at the number of scheduled tests in WP2.

- KPI5.2 - Score of a questionnaire on comfort/acceptance
  A suitable questionnaire will be devised with the aim of receiving feedbacks on a pre-determined number of questions from a selected group of dwellers and building managers of pilot sites. They will be given the possibility to express a preference ranging from 0 (strongly disagree) to 5 (totally agree).
  KPI5.2 will be then assessed through a comparison with a threshold. If the average value of the questions is higher than 4, the assessment will be considered positive.

- KPI6 - Number of produced business models
  The assessment of KPI6 is considered positive if at least 1 customer-centric business model is produced at the end of RE-COGNITION.

6 Acceptance and evolution of low TRL technologies in urban environments

The low TRL technologies are the core RE components in RE-COGNITION (micro-CHP, VAWT, PV, Thermal storage, solar cooling, EV chagrining systems). Therefore, it is important that we identify and address potential shortcomings of low TRL technologies in order to increase the acceptance of these technologies in urban environments. It is also important to consider that these potential shortcomings will be either societal, technical or economic, therefore in this section we will consider both technical and societal shortcomings; reporting on the work already done to identify these shortcomings (through the outcome of the T1.2 deliverable report) and layout the plans that will be implemented to identify further shortcomings and how the project can address and overcome them.

6.1 Technical shortcomings of low TRL technologies

The T1.2 deliverable required partners that were asked to carry out a comprehensive literature review in relation to their RE-COGNITION RE technology. The literature review reported on the following points:

- The impacts and risks that electromechanically RES equipment has on the human health, animals/plant and the environment.
- The associated tolerance levels & input and validation from end-users' group.
- The regulations and standards in place to minimise the above-mentioned risks and impact.

The review revealed the multiple risks that the potential users of RE-COGNITION might face, but it also showed that there is a very well-articulated regulatory framework at the level of European institutions to face the potential negative implications of the technologies adopted in the project.
These key identified risks should be addressed throughout the project and taken into account when evaluating the system's performance, in order to increase the acceptability and safety of the RES technology operating in urban environments.

6.2 Societal shortcomings of low TRL technologies

Societal acceptance of low TRL technologies will be addressed through the stakeholder engagement process. The T1.2 report details the RRI-framed Stakeholder Engagement strategy, that sets out the plans for reaching and working with both internal and external stakeholder groups. This section will report the Key stakeholders identified in the T1.2 report and gives an overview of the stakeholder engagement strategy and how it relates to the acceptance of low TRL.

6.2.1 Stakeholder group

Key stakeholders were identified through the studies of T1.2 (Table 6). Effort will be made in creating a balanced group of building eco-systems' stakeholders and end-users based on age, gender, socio-cultural backgrounds and technology literacy. This list is by no means exhaustive and is expected to evolve throughout the project developments.

Table 6 - External Stakeholder group identified through the RRI training

RES-related Industry Sector	End Users	Other groups
Leading industries (CHP producers)	Individual citizens	Building owners
System integrators	Small/medium production facilities	Building Managers
RES application designers	Small/medium commercial and public buildings	Utility companies
RES application developers	Technology and service providers (relevant to RES Installation and maintenance)	Building occupants
Private energy providers	Local energy manager	City Councils
Infrastructure operators	Equipment installers	RI Scholars
Energy service company (ESCO)	Equipment maintainers	Other H2020 Projects
Aggregators	Disabled workers	Schools
National Grid	General public (a diverse group of people, from different backgrounds that is representative of the population)	Nearby Communities and Neighbourhoods
Other companies working on similar RES technology	End-prosumer	Policy Makers
		People from countries not represented within the RE-COGNITION consortium countries
		Followers on Social Media

6.2.2 Stakeholder Engagement Activities

This section will report the RE-COGNITION stakeholder engagement activities and how it relates to the societal acceptance of low TRL technologies.

Stakeholder Engagement

The stakeholder engagement activity will explore how long-term engagement, centred around RRI-focused discussions, will foster meaningful engagement between RE-COGNITION partners and the people living in and around RE-COGNITION pilot sites, therefore allowing for valuable external stakeholder engagement. Engagement will take the format of discussions, workshops and creative facilitation techniques, but the focus of these activities will be broadly around the stakeholders' thoughts, attitudes and concerns about the technology and its function in society, enabling us to gather data around their acceptance of the low TRL technology. As this is long-term engagement process it also enables us to work with the external stakeholder group to co-create possible solutions to these shortcomings that could increase the acceptability of the technology. These solutions will be used to inform the development of the RE-COGNITION technology. UoB will lead the Stakeholder Engagement project with the pilot site Corby, alongside this project the UoB will create resources, activities and support that will enable other partners to explore a similar public engagement approach with their pilots. For more detailed description of this activity please refer to T1.2.

Partner Reflection Sessions

Representatives from each partner will be asked to take part in Partner Reflection sessions hosted by the University of Bristol. The format of these session will be via online video calling software i.e. SKYPE. Part of these sessions will focus around discussing some of the issues and concerns that emerged from the stakeholder engagement discussions i.e. socio-technical issues, impacts on human sensory and behaviour, and human factor needs. These sessions will provide a space for internal stakeholders to discuss and reflect upon these emergent societal shortcomings and inspire them to implement tangible actions that will address them. Partner representatives will be encouraged and supported to share these findings and reflections with the rest of their teams. These Partner reflection sessions will occur several times a year and will be scheduled for times when the outputs can optimally influence the project trajectories in order to complement project developments.

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