MEZeroE

**Measuring Envelope products and systems contributing to next generation of healthy nearly Zero Energy buildings**

# Deliverable 5.3

MARCH 2023

WP5: Report on the development of the fully deployed and virtual LLs

Dissemination level:
Public

The MEZeroE Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953157

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|---|---|---|
| **Deliverable No.** | D5.3 | 2023-02-28 |
| Related WP | WP5 | |
| Deliverable Title | Report on the development of the fully deployed and virtual LLs | |
| Deliverable Dates | 2023-02-16 | |
| Deliverable Type | Report | |
| Dissemination level | Public | |
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| Checked by | Urška Blumauer, ZAG | 2023-01-30 |
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| Approved by | Project Coordinator | 2023-02-28 |
| Status | Final | 2023-01-31 |
| | Updated | 2024-06-07 |

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## Executive summary


Technological innovation in the construction sector is considerably difficult to implement due to several factors such as the fragmentation and complexity of this sector. Many disciplines are involved at various stages, design and production are usually separated, there is a large number of players with a vast majority of small-medium enterprises (SME), and supply chains are long and variegated. As a result, gathering the different specialists together is difficult, and many potentially effective innovative solutions do not even reach the market.

H2020 MEZeroE project aims at tackling this complex issue by creating an EU distributed open innovation ecosystem for (i) developing nearly Zero Energy Building (nZEB) Enabler Envelope technology solutions; (ii) transferring knowledge; (iii) matching testing needs with existing facilities; (iv) providing monitoring in living labs; and (v) standardizing cutting-edge solutions coming from SMEs and larger industries, to foster inclusive change in the building sector, being accessible via a single-entry point to all users. MEZeroE ecosystem will be accessed via a single-entry point web-based multi-side virtual marketplace which will include 9 Pilot Measurement & Verification Lines (PM&VL), 3 Open Innovation Services (OIS), and resources for training, business model development, systematic intellectual property (IP) and knowledge management. MEZeroE will fast-track prototypes to the market as fully characterized products.

One of the tools of product verification at the highest reality level is establishing living laboratories where products are tested in real buildings with permanent occupants. This offers the manufacturer insights on the performance of their product in real life. Depending on the degree of building user's involvement and degree of utility of the building (moving from testing in a laboratory to a real building) different living lab types were determined. Living lab type 1 is offering product testing in a laboratory environment, type 2 is offering product testing in a specially build building whereas living lab type 3 offers testing in a real building with permanent occupants.

This deliverable gives an overview of a general protocol (among other information) that can be implemented in a building with the potential of being used as a living laboratory (type 3). The document explains the steps needed for implementing the living lab. This approach can be adapted specifically to the characteristics and requirements of each building and the details of implementation will be done later for the specific cases. The steps to prepare and deploy a living laboratory are as follows:

- Definition of the scope of the activity to be performed in the living lab (testing protocol, activities to adapt the building, tasks definition, budget, schedule, monitoring system, involvement of the users, installation of the products, implementation of the testing protocol, data collection, data analysis and reporting).
- Definition of responsibilities of the different stakeholders who participate in the living lab.
- Finally, with the above information, the implementation of the living lab, the execution of the activity, the monitoring, the data analysis, and the reporting are carried out.

The identified target readers of this specific deliverable are manufacturers of nZEB envelope products, companies providing monitoring in a living lab and interested public – building owners who provided or are interested in providing a building as a living laboratory.

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# 1 Introduction

## 1.1 Definition of the living laboratory

One of the definitions of the living laboratory is presented by Claude et al (2017) where a living lab is described as a physical space in a real context where certain conditions of use are still recreated. A simulation of occupation (heating period, humidification cycle) and the study of changes in physical properties of the frame (conductivity of the walls, control of the temperature and humidity in the room, energy consumption trends, etc.) provide answers about the adequacy of some technical solutions.

Similar to the previously presented definition MEZeroE living laboratory is a real-life environment where both open innovation and user innovation processes can be studied and subjected to experiments and where new solutions are developed.

## 1.2 Mission of the living laboratory

The mission of the MEZeroE living laboratory is to facilitate faster deployment of innovative, nearly zero energy building (nZEB) enabler envelope products to the market by testing them in real buildings. The mission is realized through design and deployment of a toolbox enabling agile feedback for all stakeholders, aligning deep involvement of product users into the innovation process and through co-creation of nZEB envelope products.

## 1.3 Objectives of the living laboratory

The main objective of the living laboratory is the provision of real-life environments geared towards product evaluation in real conditions. Concrete objectives are focused on improving competitiveness of companies producing nZEB envelope products.

MEZeroE living laboratory aims to answer questions and needs raised by manufacturers of innovative envelope products, such as: access to information on legal requirements and procedures of releasing new products, verification of environmental friendliness of their products, how to install a prototype of an innovative product in fully functional building to receive feedback, access to new technological expertise and practical tools in order to improve or develop their product, how to test such novel products to fit the provisions of selected countries and information about ‘good practice’ for such products in different countries.

MEZeroE living laboratories have an important role in the project. The project is establishing a channel for the stakeholders to feed their needs and ideas into a single entry point virtual marketplace which acts as a collector of innovation needs. Such needs aim to be addressed through connecting specialized testing facilities and providers of technological solutions to interested parties, establishing pilot measurement and verification lines and open innovation services. The final step of product testing is conducted in the living laboratory by testing the products’ performance during their use in real buildings and following user’s feedback. Living laboratory offers product testing in real life environment, knowledge transfer and supporting the open innovation processes in fulfilling the technological development of the product before entering the market.

## 1.4 Technical content of the deliverable

The deliverable is summarizing the process that has been followed to define the development of fully deployed living laboratories in real buildings:

- Collecting good practices from living laboratory experiences done until now in other European projects and as part of the activities of some research centres.
- Defining the information that is important for the living laboratory design that needs to be collected from each building owner to improve and reduce the complexity of the set-up process and measurement protocol.
- Consideration regarding the treatment and usage of the measured data.
- The application forms from building owners collected and presented to industrial partners who indicated their interests in specific locations, building types and resources that they have available before living laboratories were defined.

A general living laboratory design protocol was defined before being customized for each of the living laboratory applicants, reducing complexity and problems during the process and allow the involved actors to understand their role and the process to be followed. A summarised information of all living laboratory applications is also presented as well as a short description of the active living labs as of June 2024.

# 2 State-of-the-art related to living laboratories

As initial work for the living laboratory implementation a review of scientific papers was done to collect the best practices. These practices have been used to design the living laboratory monitoring protocol defined in this deliverable. Some of the conclusions extracted from these articles (the references can be found in section 11 of this document) are summarized below.

## 2.1 Background of the living laboratories

Living labs emerged in the late 90s as a new approach for researching and testing innovative technologies in real-life situations and environments. The main objective was to validate new technologies through the engagement of citizens and stakeholders in the design process. This approach has since spread to higher education institutions worldwide and can be applied to any field. Living labs were originally associated with the "House of the Future" concept, a high-tech house for testing new technologies in an immersive environment. Today, living labs are mainly associated with the co-design process of new technologies and involve the focus on user communities, IT infrastructure, and the interaction between environment, users, and objects (Cottafava et al, 2019).

## 2.2 Living laboratory definition

A living lab can be defined as: "*User-centered, open innovation ecosystem based on a systematic co-creation approach, integrating research and innovation processes in real-life communities and settings*". They are used to validate the test of prototypes in the real world (in contrast to simulations) and due to which it allows for a better understanding of contextual and human factors as well as to

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reduce risks of being influenced by wrong (personal) perceptions (Baedeker et al, 2020). Additionally, it can be said that a living lab is "*a physical space in a real context where certain conditions of use are still recreated. A simulation of occupation (heating period, humidification cycle) and the study of changes in physical properties of the frame (conductivity of the walls, control of the temperature and humidity in the room, energy consumption trends, etc.) provide answers about the adequacy of some technical solutions*" (Claude et al, 2017).

As explained before the main idea is to simulate as close as possible to the reality conditions that are usual in buildings with different profiles and purposes: "*The living lab satisfies a dual purpose: through the experimental renovation, different solutions are tested, but also the various participants can interact and meet in an experimental setting without financial pressure"* (Claude et al, 2017). As part of the process, different environmental configurations from the point of view of acoustic, lighting, thermal, energetic, heating, cooling, life cycle analysis, $CO_2$ concentration in the indoor air, temperature, humidity, movement, presence, comfort requirements can be tested. Moreover, the combination of these conditions and the way they affect the user can be studied as part of the process simulating different possibilities. It is known that changes in these conditions affect the environmental satisfaction of the user (Jamrozik et al, 2017; Woods & Korsnes, 2019; Korsnes, Berker, & Woods, 2018).

The idea about this approach which is different from a traditional laboratory is that living labs support typical occupant behaviour. A living lab can support occupants working for weeks or months in the space. This implies that real behaviour of the occupants can be captured and its corresponding real behaviour and real reactions. Moreover, conditions can be modified and the impact of them can be collected properly. This will also depend on the possibilities of the living lab (not always all conditions may be modified) but as the scope will be defined previously, the ones important for the experiment will have the possibility to be modified (Jamrozik et al, 2017).

Living labs can be described as embedded environments, such as homes or workplaces, where real-life practices are studied. This method allows observation of users in their natural habitat, surrounded by familiar people and objects. A mix of methods with varying degrees of user participation can be used in these living labs. The initial stage involves gaining insight into current user practices at home through both qualitative and quantitative methods (Eon, Morrison, & Byrne, 2018).

## 2.3 Users and spaces of the living laboratories

The importance of defining the scope of data to be collected in a living lab, where real-life data is collected from actual users, cannot be overstated. Proper user consent, clear explanation of the type of information to be gathered, confidentiality of data (no user-data link), and the final use of data must be established. Surveys with users at regular intervals (daily or weekly based on the activity being monitored) with 1 to 5 ratings or simple yes/no answers can serve as a starting point (Jamrozik et al, 2017).

These interviews, surveys and studies can be used in many different stages of the project as defined by Sovacool et al (2020): "*pre-installation interviews; undirected diary studies and blogging, done in written and video forms; directed diary studies and blogging, done in written and video forms; repeated satisfaction surveys; annual discernment surveys (used to understand how discerning living lab participants were in terms of the comfort experiences they valued; one market segmentation survey;*

*interactive interviews (sharing screens and data); heat plan demos or workshops run to show participants how their systems worked, how to plan their configuration, what theirs would cost and to answer their questions; semi-structured household interviews*".

It is important that users receive a description of the aims of the experiment and the methods that shall be implemented. This can be done based on semi-structure interviews to make such kind of follow up of the households (Woods & Korsnes, 2019; Korsnes, Berker, & Woods, 2018).

Different techniques, with varying degrees of user involvement, can be used in living labs depending on the objective. Techniques can range from observing daily practices to co-developing and testing new technologies and solutions with the user at the centre (Eon, Morrison, & Byrne, 2018).

Using real-life settings and actual users in experiments can lead to complications in setup. Households frequently have conflicting goals for indoor climate control, such as thermal comfort for people, pets, or objects. These goals are not always aligned among different users within the same indoor environment (Dabaieh et al, 2019). Furthermore, the lack of understanding of home dynamics and intra-home practices and behaviours results in substantial energy demand variability between dwellings, where one house may use up to five times more energy compared to a similar one (Eon, Morrison, & Byrne, 2018).

In recent decades, a significant research effort has been focused on comprehending and modelling occupant behaviour in buildings, with the goal of making more accurate predictions of building performance during design using dynamic simulation. Post-occupancy evaluation, or even better, pre-occupancy evaluation, enables understanding the relationship between user needs, satisfaction, and actual energy consumption (Piselli & Pisello, 2019). To do so Piselli and Pisello (2019) propose the following approach:

1. *"Experimental continuous monitoring campaign of equivalent office rooms of a building occupied by peer occupants. Analysis of occupancy-related parameters such as indoor air temperature, illuminance over the working plane, appliances electricity consumption, windows and door operation;*
2. *Development of building model and dynamic thermal-energy simulation when considering various occupancy and activity schedules, i.e. existing static standard and stochastic approaches and developed real monitored data-driven approach;*
3. *Data analysis and comparison of simulation results for the different scenarios, in terms of daily trends of occupancy related parameters and building total energy consumption, to evaluate existing models' prediction capability;*
4. *Evaluation of the data-driven models representing occupants' behaviour in the monitored office rooms against additional monitored data, to evaluate developed models' reliability;*
5. *Neural response experimental test of selected occupants under different environmental conditions to assess the correlation of workers' emotional response and external thermal stimuli for improving models' prediction reliability".*

Another important point in real users' behaviour is related to the furniture defined in the space to be monitored: in case of a residential building living lab, kitchen appliances (oven, hob, fridge-freezer, dishwasher, washer dried), living room appliances (tv, furniture, electronic equipment), bedroom

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(lamps, beds, heating and cooling systems) and bathroom need to be studied carefully as they have big impact in the configurations defined (Woods & Korsnes, 2019; Korsnes, Berker, & Woods, 2018). The same is valid for office configurations in which the way the furniture is placed (tables, shelves, etc.) can have also big impact in the final perception of the user and hence the final results.

## 2.4 Implementation of the living laboratory

A possible process to perform the implementation of the living lab can be the following: designing the system based on living lab objectives and capabilities, implementing, and reviewing building services and technology installation and commissioning, and establishing procedures for operation, maintenance, and management. Conducting a qualitative review of system and control usability and conducting physical assessments of the building construction system through diagnostic tests and thermographic surveys. Measuring and collecting data on occupant satisfaction, energy, and environmental performance (including temperature, humidity, and $CO_2$ concentrations) for a specified period of time are all key steps in the process (Gupta & Gregg, 2016).

This implementation can be summarized as research and design, prototyping and implementation, testing and evaluation (Baedeker et al, 2020).

On the other hand, Norwegian Zero Emission Building Laboratory propose the following steps: project delivery - contract models, design-bid-build contract and design-build, partnering/collaborative contract and ZEB design method (Time et al, 2019).

Dabaieh et al (2019) proposes for the analysis of Trombe wall different phases similar to those proposed by Baedeker et al (2020) - the process has five phases:

1. workshop and onsite participatory construction and training,
2. on-site monitoring with data loggers for temperature and humidity,
3. Trombe wall's thermal performance and user satisfaction,
4. follow-up visits after 1 year of operation, and
5. self-critical assessment for lessons learned and future improvement recommendations.

Another possibility for the implementation has been defined by Pisello et al (2016) in the following steps:

1. Choosing a building as a case study and its occupants with similar age, education, work schedules, and office rooms with the same orientation, design, heating/cooling systems, and building technologies to monitor.
2. Monitoring key indoor parameters and occupants' activity in selected office rooms with microclimate monitoring stations during spring, summer, and winter.
3. Surveying the occupants to supplement indoor monitoring data and better understand the behaviour.
4. Analysing and comparing the data through statistical analysis and post-processing.

## 2.5 Monitoring in the living laboratories

The process of data collection is also important to be defined. The actual approach based on the available technologies is to collect the data remotely accessing the building management system implemented in the building. One important element to define in this process of monitoring is the type of sensors to be used, which can be either wireless, wired or with batteries and the amount of time needed between measurements (minutes, hours, days) (Gupta & Gregg, 2016). The criticality of the installation and commissioning process for services requires technicians to be familiar with the process and have proper documentation. On-site training is provided to ensure proper fitting of materials and equipment. A user-friendly building user guide, detailing technical information, is developed to promote efficient use of equipment, minimize energy consumption, facilitate informed maintenance and timely seasonal commissioning. (Gupta & Gregg, 2016; Christensen, & Pinson, 2020). Mobile apps as part of the IT infrastructure can simplify user access to information. Algorithms connected to these apps and sensor information aim to analyse collected data and explore various configurations.

An example of this, an implementation of a Building Management System has been done by Causone et al (2019) with the following configuration: a system created to control and monitor the building and its service systems, with the aim of monitoring energy and comfort. The system comprised of two parts, with the first part for monitoring indoor environment and controlling shading devices and heat pump using Konnex communication protocol. The second part integrated and oversaw the first, using the BACnet protocol. The second part of the control and monitoring system gathered data from various monitoring points, including conditioned areas, soil, courtyard, building systems, appliances, and lighting. This allowed for advanced control algorithms for the heat pump and ventilation systems. The thermal energy meters, positioned along all hydraulic loops, also communicated with the system via the integrated Meter-Bus protocol.

It is important to use sensors that do not interfere with the activities performed in a living lab. Motamed, Deschamps, and Scartezzini (2017) propose that the best practice for daylight-linked electric lighting and shading control within non-residential buildings, relies on the measurements of ceiling mounted rudimentary luminance meters. This approach guarantees that the users' visual comfort and performance on the optimal energy management of the electric lighting and shading is achieved. This can be applied to all the typologies of sensors being used.

# 3 Definition of different living laboratory types

Living laboratories could be found in all typologies, shapes, and sizes. In the scope of the MEZeroE project the living laboratories are used for product testing that is done outside of standard testing protocols needed for product certification or declaration of properties. As briefly introduced in the Executive summary three different approaches to living laboratories were identified depending on the user interaction and resemblance to a real building:

**Approach 1**: anticipates setting-up the living laboratory with user interaction, but without use of inhabitable building, while using already available and accessible infrastructures at MEZeroE project's research partners at – TECNALIA (Spain), EURAC (Italy), DTU (Denmark), Polimi (Italy), and UIBK (Austria). Here, performance of the tested product does not depend on whether it is installed on a

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building under operation or not. The important influence on the product is introduced by its users by for example influencing ventilation, lighting, internal heat sources and occupancy patterns.

**Approach 2**: anticipates setting-up the living laboratory in a specific test building with installed products under testing. Here smaller model buildings built as testing facilities can be used. In these buildings some of the utilities may not be available due to the nature of the building and its use, but still the use as a real building can be provided. Users are here involved in testing for a specific, representative testing time.

**Approach 3**: anticipates setting-up the living laboratory in a fully inhabited real building. Here a fully functional building with its necessary utilities is set-up and inhabited for a longer period of time, sufficient to yield real user feedback. The testing protocols for the users and for monitoring was determined and is presented in chapter 6. The advantage of this type is that the experimental results obtained from the laboratory could be compared to product's real-life performance in buildings equipped with monitoring system as well as taking into account user's feedback regarding the installed product.

A short schematic and textual presentation of the three types of living lab is presented in Figure 1.

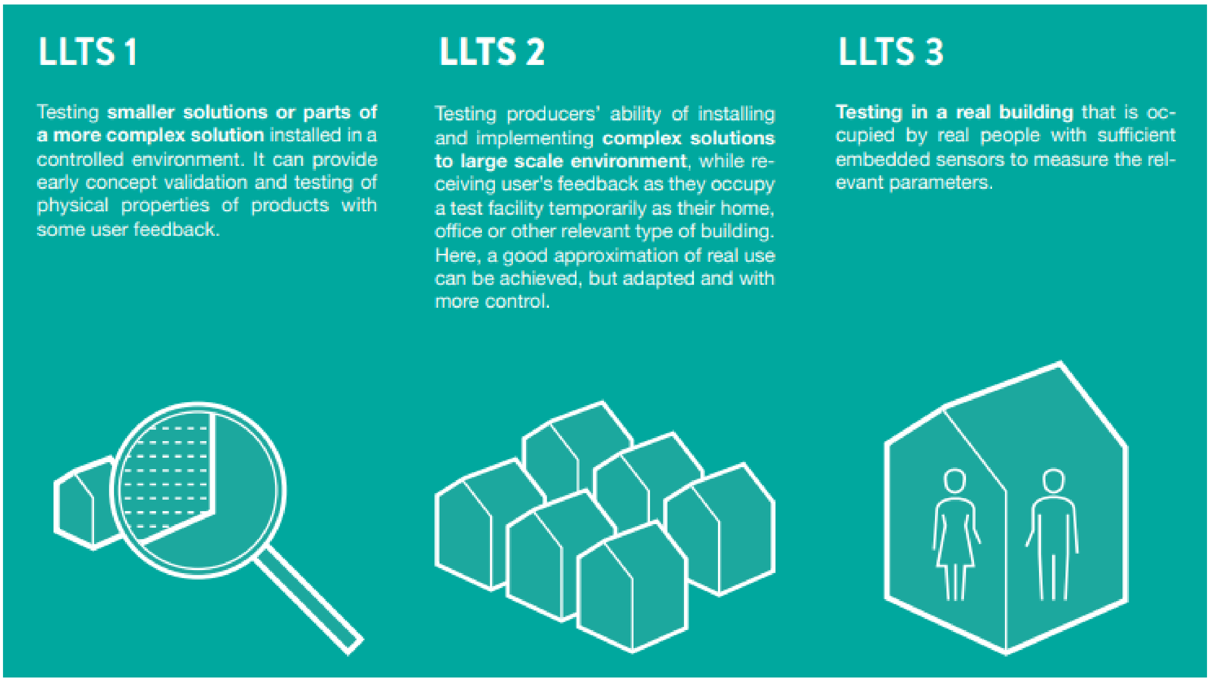


*Figure 1 Different types of living labs*

When the project proposal was written the phase to which the nZEB envelope products involved in the project will be developed was not known and all three types were considered to be used. In the middle of the second year of the project (June 2022) it was realized that products will be developed and ready to be installed in living labs type 3 since this option provided the industrial partners real-life performance data as well as users' feedbacks. The developed living lab protocol is done for the living lab type 3.

# 4 Information needed for setting-up the living laboratories

As part of the process of setting-up the living laboratories the data regarding the applied building, monitoring system and nZEB envelope products is needed. First a set of information about the buildings was determined in order to cover the living lab set-up. This is presented in section 4.1. Second, a list of sensors that will be used for monitoring purposes was defined and briefly presented in section 4.2. The last set of information needed for setting-up the living laboratories was the information about the products that will be installed in the buildings. This data is included in section 4.3. Part of this information has been requested on the living laboratory application form (available on the project website during the launch of the call) and the rest of the information will be collected during the living laboratory implementation process.

## 4.1 Information about the buildings that applied to be living laboratories

Based on literature review and collaboration between all partners of the project a list of data was prepared in order to provide relevant information about the building that will be used as living laboratory. The list of building descriptors contained the following topics:

1. Legal aspects and agreements:
    - Users' agreement – signed agreement of users of the building to participate in the project.
    - Commitment – level of dedication to the project and its activities, if possible, even in after-life of the project.
    - Ownership – percentage of the building ownership.
    - Legal aspects – documentation and permits needed for product installation.
2. Data availability:
    - Number of installed products – number of products that can be installed in parallel, checked for compatibility.
    - Building envelope characteristics – e.g., thermal insulation thickness, U value, envelope area, g value of transparent surfaces.
    - Achievable timeline – detailed timeline of the building's availability to the project (foreseen schedule and start date).
    - Technical possibilities – description of building's dimensions, existing installations.
    - Adaptability – ability to accommodate various envelope systems including defined possibilities for additional loads.
3. Building characteristics:
    - Use mode – building type e.g., residential, educational, institutional, business.
    - Climatic representativeness – climate type e.g., tropical, dry, temperate, continental.
    - Building age – year of construction, years passed since last energy related retrofit.
    - Micro location – site accessibility, neighbourhood and environment.
    - Type of load-bearing system – main material and type of load bearing elements (e.g., walls, columns) as well as type and number of openings.
    - Social representativeness – Eurostat based GDP per capita and acceptance.
    - Building defects – identified mechanical, thermal or other deficiencies and operational problems.
    - Internal climate – indoor conditions such as temperature, humidity.

- Free space for equipment – dedicated free space for technology installation, including space for gateway, sensors and other auxiliary equipment.
- Number of users.
- Number of floors.
- Envelope area.
- Envelope typology.
- Roof area.
- Roof typology.

4. Others:
   - Financing – need for the project to cover the additional costs that might arise due to installation of technology from the project.
   - Past research experience – past research experience at the building owner's side.
5. Location:
   - Country.
   - City.
   - Address.

The first call for buildings was open for 3 months between July and October 2022 and the second one from November to December 2023. It was available on the project's webpage: https://www.mezeroe.eu/living-lab. All the details about the call can be found there.

Another important aspect that needs to be known is the type of facilities that the building had before the living lab set-up and the ones that can be interesting to use as part of the monitoring process:

1. Energy system.
2. Building energy consumption.
3. Management system.
4. Lighting.
5. Ventilation system.
6. Safety system.
7. Building management system.

## 4.2 Information about the living laboratory monitoring system

Living laboratories will be equipped with sensors and the users will be asked to periodically submit their feedback to the questionnaires regarding their personal perception of the indoor environment.

The Open Innovation Service 2 (OIS2 – Data collection in living labs, post-processing and publication of ready to use information) will provide the monitoring protocols for measurement in the living labs based on the needs of the product manufacturers and the scope of the testing, which is under development. For different segments of product manufacture, the needs can vary as per the products as well as the specific type of test that needs to be performed. The design of the on-site monitoring is done within the OIS2 as shown in the scheme in Figure 2.

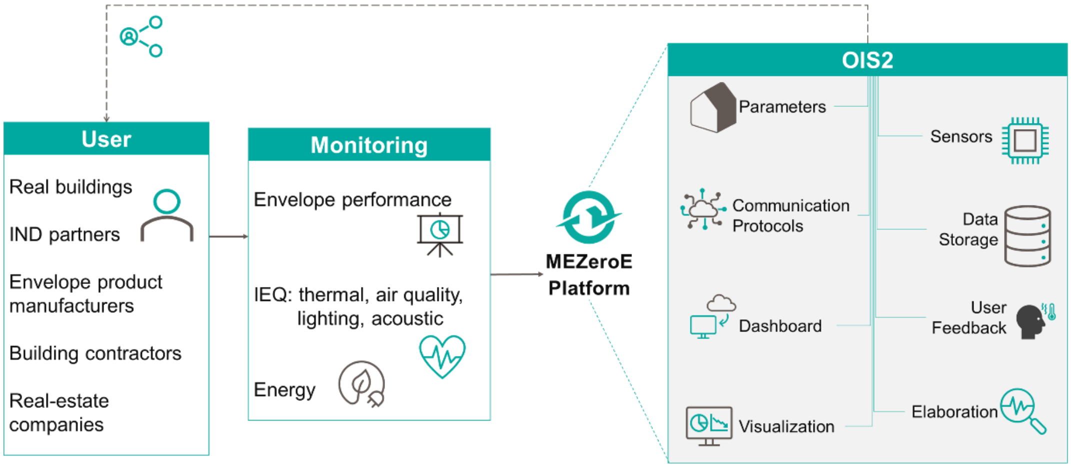


*Figure 2 Application of monitoring in the living labs*

The definition of the type of sensors available in the building is another important point that needs to be collected as part of this process. It is important to obtain the type of connection they have and the tools that are used to collect the measured data to study the compatibility with the systems implemented from the project. An initial list of sensors can be found below. Depending on the characteristics of the products installed this list will be customized on a case-by-case basis to carry out the desired monitoring. The monitoring was divided based on envelope performance, indoor environmental quality, or energy. Monitored characteristics are:

1. Air temperature.
2. Relative humidity.
3. $CO_2$.
4. Particulate matter: PM 1, PM 2.5, PM 4, PM 10.
5. Volatile organic compound: TVOC, formaldehyde.
6. Other harmful gases: $SO_2$, $NO_2$, $O_3$, $NH_3$, radon, methane.
7. Noise.
8. Surface temperature.
9. Heat flux.
10. Energy measurement (heat consumption, cooling load, electricity, etc.).

Synchronized with the installed products' requirements, adequate sensors will be installed in the building to collect the data from the living labs. For the installation of monitoring system, it will be important to have non-intrusive interventions, or use a system that can be installed with ease, such as plug-n-play systems.

For the scope of comparison between pre and post retrofit, some of the sensors will be mounted before the product installation in the living lab and measured data will be collected in order to gather baseline measurements. Beforehand a measuring protocol is defined to understand the type of measured data, the way to obtain it and the way to analyse it. A general protocol is developed but it will be adapted to the specific characteristics of each living lab.


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As part of the living lab users' questionnaire, it is necessary to define the rules to obtain the general information about the individual user complying with the GDPR and to determine meaningful questions related to their indoor environment that could also be quantified. A protocol for the post-occupancy evaluation is developed for collecting user-feedback for different scopes. For reaching this plan users need to periodically answer the questionnaires and report on some unusual activities through online surveys (adapted to each living lab characteristics) to collect meaningful data.

As part of the monitoring process, the data measured through sensors supports the understanding of subjectively provided data by the users regarding the indoor environment. The major established connections are between the users' feedback and measured data:

1. Thermal perception and comfort.
2. Air quality.
3. Visual comfort.
4. Noise perception.

The final objective of the monitoring protocol is the reporting of the monitoring data. Automatically generated reports, key-performance indicators and other visualizations derived from the monitoring campaigns will be communicated to the manufacturer as well as to building owner to promote understanding of how the product performs, what the effect is on indoor environment and energy consumption in the building.

## 4.3 Information about the installed products into the living laboratories

Description of installed products is provided in chapter 5, and it is also available in more detail on project's webpage: [https://www.mezeroe.eu/living-lab](https://www.mezeroe.eu/living-lab). The initial requested information is related to the product description and product readiness level to reach the market.

Information about the construction requirements for each product and country where the product will be installed were reviewed. The products must be compliant with the "Construction Product Regulation" (CPR) as well as local installation requirements. Which CPRs have to be met depends on the product. As sometimes different requirements have to be met depending on the city and the country it is important to have clear information from the beginning to avoid problems once the activities are more advanced. There are 7 categories within CPR (listed below) that are also divided in more requirements depending on the type of the product:

1. Safety in case of fire:
    - Reaction to fire.
    - Fire resistance.
2. Hygiene, health, and the environment:
    - Water tightness.
    - Water vapour permeability.
    - Content and/or release of dangerous substances.
    - Other related requirements product dependent.
3. Safety and accessibility in use:

- Overloading mechanical resistance.
- Wind load resistance.
- Mechanical resistance.
- Resistance to seismic actions.
- Dynamic load resistance; large soft body impact.
- Dynamic load resistance; small hard body impact.
- Equipotentiality.
- Eccentric vertical load resistance.
- Other related requirements product dependent.

4. Protection against noise:
   - Airborne sound insulation.
5. Energy Economy and heat retention:
   - Thermal transmittance.
   - Air permeability.
6. Sustainable use of natural resources.
7. Aspects of durability and serviceability.

Industrial partners provided the information regarding the compliance of their products with CPR. This information is needed to fulfil the requirements to be able to enter the market. Identification of requirements that need to be met before the products will be installed in the living labs was also done case by case in the Open Innovation Service 1 (OIS1) named Standard framework procedures for certification and marking. This service will be a part of Virtual marketplace that is already up and running (https://www.mezeroe-platform.eu/). Some of the requirements can be met by performing tests within the project inside different product verification and measurement lines where focus is on innovative properties of the products. These services are also available on the online Virtual marketplace platform.

Besides fulfilment of the CPR the industrial partners provided a certain duration of warranty for their product in accordance with the product category (for example if a product is part of main bearing structure the warranty is for 10 years). This information is included in a contract that is signed between the building owner and industrial partner. A contract sample is available in Annex A. The industrial partners will be asked for the duration of warranty that they can offer on a case-by-case basis, and this will be collected within the project.

Based on the information from the building owners provided in the application form, the industrial partners were notified about the interest in their products. According to the assigned budget for product testing in living laboratories, type of buildings, location, and personal interest they provided the feedback which options are suitable for them.

# 5 Description of the installed products into the living labs

For the installation in the living laboratories 9 industrial partners provided 16 products. The tested products in the living laboratories will remain installed on the buildings after the project ends. All the offered products are briefly presented hereinafter.

## 5.1 Multifunctional façade system produced by Focchi SPA (Italy)

Focchi is offering a multifunctional prefabricated façade integrating different services for achieving nearly zero energy building balance and optimal indoor environmental quality. It integrates heating/cooling pump, heat recovery and ventilation systems embedded in the envelope, and it is applicable to both new and existing buildings. The multifunctional prefabricated façade includes internet of things components for real time monitoring for actuations to energy efficiency, comfort, wellbeing, and indoor environmental quality actions enabled by a dedicated platform. The product is ready to reach the market.

## 5.2 Photovoltaics integrated in an interwoven steel wire mesh, enclosed in a mosaic of brick to control sunlight for energy production and lighting produced by Flexbrick SL (Spain)

Creating a revolutionary, flexible construction system that could easily be adapted to cover all kinds of architectural surfaces in a wide variety of spaces. It was envisaged as a kind of skin that would dress buildings. The advantage of this system lies in combining a material that has been traditionally used for millennia like ceramic with stainless steel, creating a novel format called “ceramic textile”, which is superior to manual, piece-by-piece installation. This is a unique combination of materials that evolves every day and can even successfully incorporate other materials like wood, bamboo, glass, steel, stone, marble, and glazed ceramics, among others. It is a large-scale system made up of small pieces, which allows large sheets to be installed in a very short period of time. As an additional perk, the individual pieces can be easily replaced. See Figure 3.

The product is ready to reach the market.

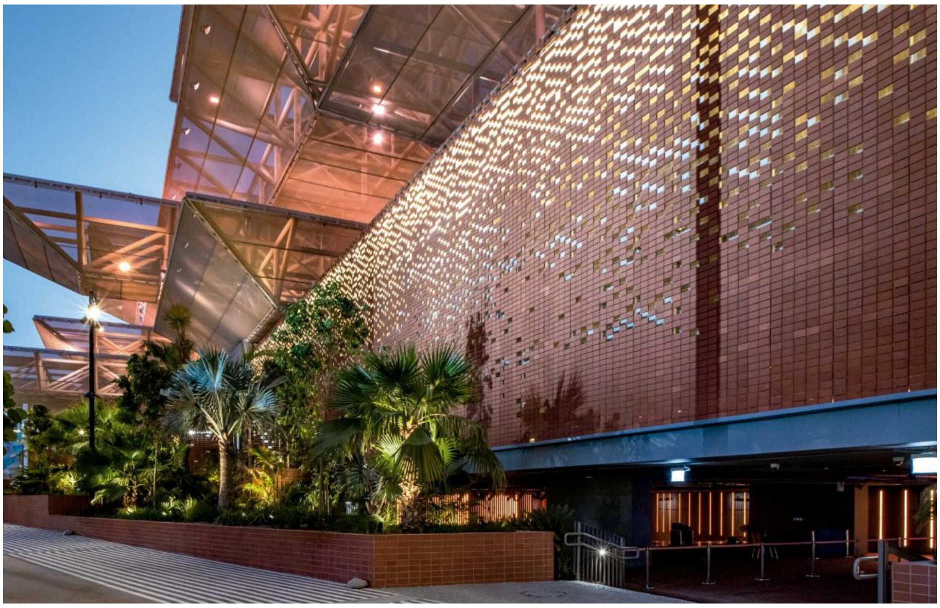

*Figure 3 Façade produced by Flexbrick SL applied on Opportunity pavilion, Expo 2020, Dubai (Flexbrick, 2022)*

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## 5.3 Lightweight, easy-to-install organic building applied photovoltaics film for existing roofs produced by Heliatek GMBH (Germany)

HeliaSol® offers ready-to-use innovative organic solar film, which is ultralight, flexible, ultra-thin and truly green. Equipped with an integrated backside adhesive, HeliaSol® can be glued on a variety of substrate materials such as glass, metal, concrete without the requirement of elaborated substructures. HeliaSol® has been available on the market since 2021.

## 5.4 Glass integrated organic building integrated photovoltaics elements for façade integration produced by Heliatek GMBH (Germany)

HeliaFilm® is organic photovoltaics integration solution for building materials, such as glass. The only 1 mm thin solar film can be integrated almost seamless into customer products to add a solar function. Therefore, a co-developed tailored solutions with integration partners are done to meet their specific integration requirements. HeliaFilm® is planned to enter the market in 2024.

## 5.5 Durable advanced functional coatings for self-cleaning and air- purification produced by Tecnologia Navarra de Nanoproductos SL (Spain)

Hydrophobic and photocatalytic coatings are able to reduce pollutants and improve indoor and outdoor air quality due to their self-cleaning, hydrophobic and photocatalytic properties. This functional coating with advanced properties is transparent to the eye - overcoming limitation of current commercial self-cleaning coatings - and ensures the product activity against NOx, SOx, VOCs, etc. even in the visible range, conversely to what happens today for photocatalytic products which need UV activation. This multifunctional coating can be easily applied leading in an invisible layer with a long useful life due to the advanced properties of the matrix employed and it is able to reduce pollutants and soiling on the treated surface thanks to the hydrophobic behaviour and the interaction of the photocatalytic material with visible light.

The product is ready to reach the market.

## 5.6 Advanced nanomaterials for energy efficient glazing systems produced by Tecnologia Navarra de Nanoproductos SL (Spain)

TECNADIS HEATSHIELD is a nanotechnology-based heat barrier treatment for glass surfaces, which blocks infrared solar radiation by more than 40%. This protector has been designed to block the transmission of heat frequencies (infrared solar radiation) from the outside to the inside of the glass, thus avoiding an excessive increase in the temperature inside living spaces directly exposed to the sun. See Figure 4.

The product is ready to reach the market.

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*Figure 4 Tecnadis Heatshield applied on buildings (Tecnan, 2022)*

## 5.7 Flexible structural connectors produced by Flexandrobust systems spolka z ograniczona odpowiedzialnoscia (Poland)

Flex & Robust line of products is developed from polymer flexible joints and is dedicated to structural and non-structural bonding of elements constructing civil engineering structures, made of various materials (concrete, masonry, wood or metal). The specially designed products are able to carry static, dynamic and cyclic loads and simultaneously transfer high deformations. They are resistant to elevated temperatures and reduce stress concentrations by redistributing them for large bonding areas. Flex & Robust products can be used many times in seismic areas and strong wind areas. There is no need to replace them as other connectors after catastrophic events. They protect connected envelope components against damage.

The product is ready to reach the market.

## 5.8 Tailored roof/facade smart membranes produced by Rotho Blaas SRL (Italy)

The special PA film gives the smart membrane the ability to adapt to the hygrometric conditions of the building. If the membrane comes into contact with high humidity levels, it transforms from a vapour barrier into a breathable product, guaranteeing that the structure remains dry. Product is ready to reach the market. See Figure 5.

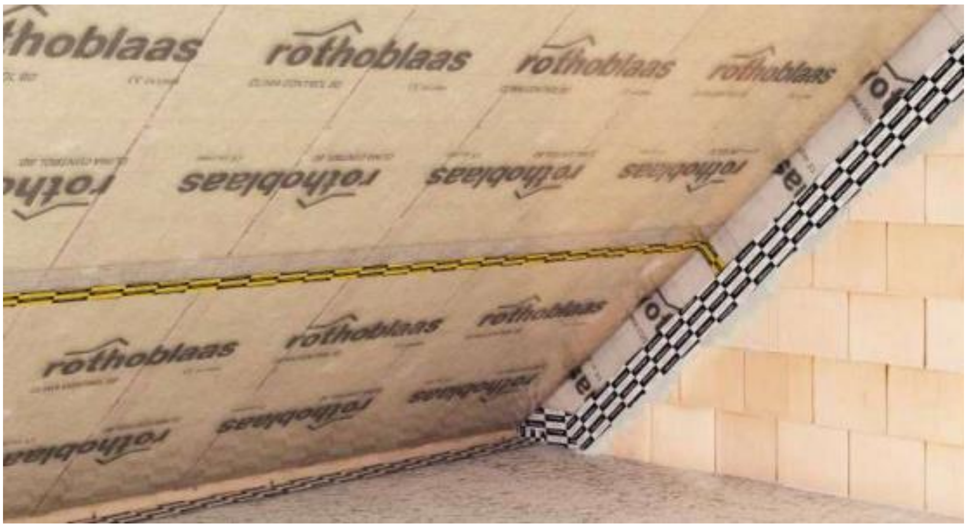


*Figure 5 Rotho Blass's smart membrane (Rotho Blass, 2022a)*

## 5.9 Tailored roof/facade sealing tapes produced by Rotho Blaas SRL (Italy)

The tape achieves the highest level of safety against harmful emissions thanks to the special formulation of the acrylic glue. The combination of carrier and acrylic dispersion glue is designed for good adhesion even in extremely cold temperatures. See Figure 6.

The product is ready to reach the market.

*Figure 6 Rotho Blass's sealing tape (Rotho Blass, 2022b)*

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## 5.10 Tailored roof/facade fastening system produced by Rotho Blaas SRL (Italy)

Galvanized carbon steel double threaded screws for providing a gap for insulation instalment. The screws can be used in timber-based panels, solid timber, glulam (Glued Laminated Timber), CLT (Cross Laminated Timber), LVL and high-density woods of service classes 1 and 2. See Figure 7.

The product is ready to reach the market.

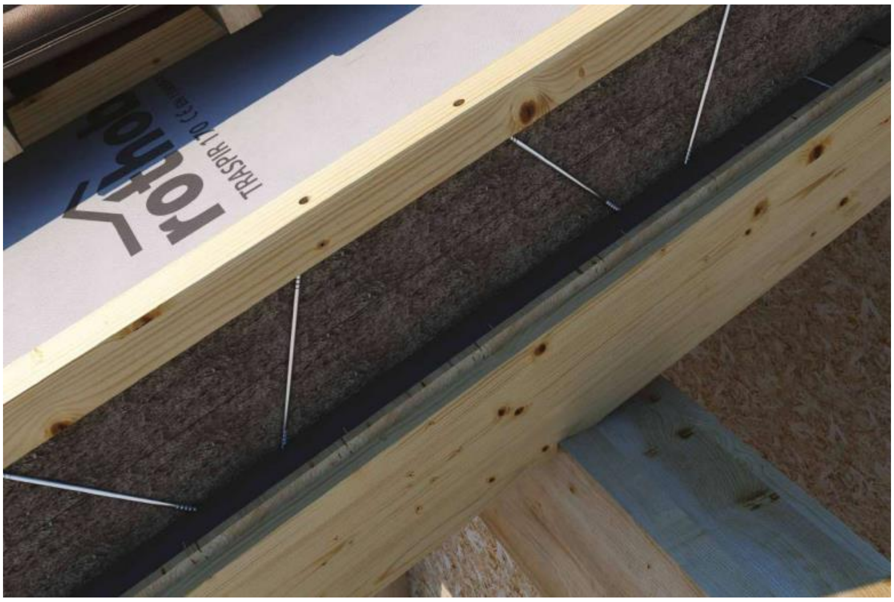


*Figure 7 Rotho Blass's fastening system (Rotho Blass, 2022c)*

## 5.11 Sustainable prefab wooden all-in-one envelope components produced by Riko hiše proizvodnja in trženje d.o.o. (Slovenia)

Various types of wood are used for the facade, each with their unique qualities, such as colour, durability, hardness, visual structure, etc., offering numerous solutions for the design of façades. Wooden façades are suitable for residential as also for larger buildings. They are grouped by tree type or profile and method of attachment. Wooden façades are fitted onto the prepared substructure, on Riko houses or onto other existing buildings. Since wood is a natural material, it is subjected to ageing and, under the influence of the external environment, to decay. To extend the lifespan of wooden façades, we make sure suitably treated wood is used from suitable/resistant tree types, that the wood is structurally appropriately protected and, where necessary, also chemically treated. See Figure 8.

The product is ready to reach the market.

*Figure 8 Application of Riko hiše's envelope components (Riko Hiše, 2022)*

## 5.12 Sustainable prefab wooden external cladding components produced by Riko hiše proizvodnja in trženje d.o.o. (Slovenia)

The product is the same as above just consisting of outer cladding components. See Figure 9.

The product is ready to reach the market.

*Figure 9 Riko hiše's wooden cladding components (Riko Hiše, 2022)*

## 5.13 Polyurethane insulation foams produced by Indresmat SL (Spain)

SAFE-PUR is a new type of polyurethane insulation foam with highly improved fire safety, increased durability, and superior weathering resistance to be used in indoor and outdoor applications. The concept of SAFE-PUR is to provide higher performance, sustainability, and safety to the construction market by using bioPUR as single thermal, acoustic, and moisture barrier material, thus avoiding difficult-to-recycle multilayer materials used nowadays in the construction market, being SAFE-PUR a

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promising foam that can be used as in conventional PUR products. SAFE-PUR foams can be sprayed, injected and used as sheets or sandwich panels for insulation purposes, being optimal for insulating roofs, walls and floating floors, especially for extreme climate areas where small thickness is required having a broad range of working temperatures (-40 to +70ºC). The targeted market for SAFE-PUR foams is the residential segment, mainly for energy renovation and insulation, as well as impermeabilization in renovation activities. See Figure 10.

The product is ready to reach the market.

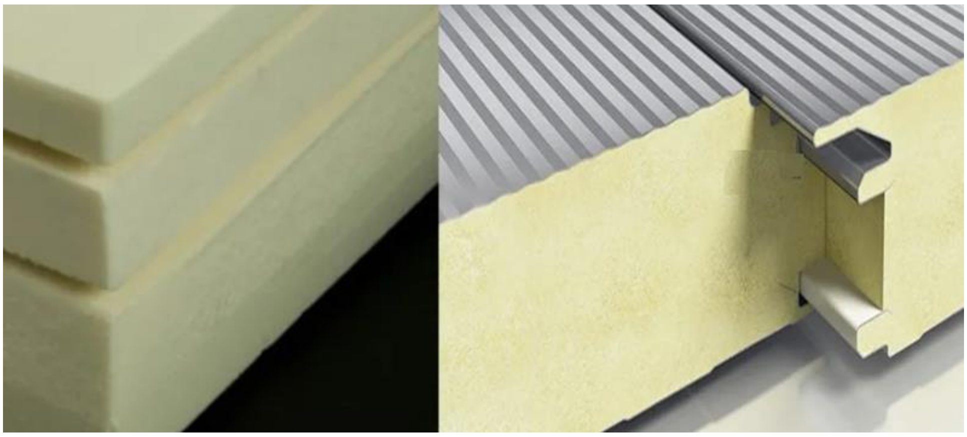

*Figure 10 Indresmat's polyurethane insulation foams in sheets and sandwich panels (INDRESMAT, 2022a)*

## 5.14 Foamed (bio)polyurethane frames produced by Indresmat SL (Spain)

KLIMA-PUR® are windows & doors with superior performance in terms of thermal and acoustic comfort, being optimal for cold climates due to its broad range of working temperatures (- 20 ºC to 70 ºC) and for aggressive environments such as humid and sea-coast areas due to its chemical resilience. KLIMA-PUR® windows & doors are specially designed for new buildings, retrofitting, and energy renovation activities within the residential and commercial segments. See Figure 11.

The product is ready to reach the market.

*Figure 11 Indresmat's windows with (bio)polyurethane frames filling (INDRESMAT, 2022b)*

## 5.15 Integrated microfilm shading device produced by Pellini SpA (Italy)

ScreenLine® Wave, shown in Figure 12, comes from a range of shading systems encapsulated within insulation glass units, which is designed to optimize heat and light gain, thus reducing air conditioning and heating costs and increasing living comfort. Wave is the innovative integrated shading solution for ScreenLine® systems consisting of a thin wave film (only 23 microns) made of polyester. It can be incorporated within 20-mm or 22-mm insulating glass units. The advantages of this product are:

- Energy performance: the PVD coating reduces the solar factor and increases thermal insulation.
- Darkening effect: the blackout version blocks out all light.
- Privacy: when the blind is completely lowered, occupants are protected from prying eyes from the outside.
- Design: horizontal wave geometry gives a pleasant aesthetic impact.
- Reliability: the Wave system have passed endurance tests for over 20.000 full up/down cycles.
- Motorization: the blind is operated by an internal motor powered by hard wiring or by a rechargeable battery module.

The product is ready to reach the market.

*Figure 12 Pellini's ScreenLine® Wave shading system (Pellini, 2024a)*

### 5.16 Retro reflective shading device produced by Pellini SpA (Italy)

A solar shading device consisting of a venetian blind comprising retro reflective coating based on silicon dioxide micro beads. The main benefit of the solution is that incident radiation on the solar shading device is reflected mainly toward the direction from which it comes. In this way, the proportion of radiation that manages to pass through the shading device is greatly reduced even when slats are kept open, thus preventing heating of the indoor environment. It is possible in this way to obtain a solar shading device to be installed in an insulating glass unit in which the reflected radiation to the outside is directed predominantly towards the sun, and therefore does not affect neighboring buildings, decreasing the urban heat island effect created by reflective glass surface.

## 6 Design of the living laboratory testing protocol

### 6.1 Scope

The protocol for hosting an experimental campaign in the living laboratory includes the activities that, in general, are carried out before, during and after the experimental campaign.

The Living laboratory has been conceptually designed so that it has great flexibility regarding: its constructive elements; building facilities, the control and monitoring system; the supply of electrical energy or water and the associated building information model (if it is available).

To identify if the building can be used as a living laboratory it is essential to evaluate if the technical requirements are met and to check if there is enough available space for the product and monitoring installation, and there is no interference with the current operations in the building.

The activities that are developed in the design of the living laboratory testing protocol can be divided in the following phases:

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1. **Phase 1**: Definition of the testing protocol in the living laboratory.
2. **Phase 2**: Adaptation of the building to become a living laboratory.
3. **Phase 3**: Task definition, budgeting, and scheduling for the monitoring and product installation.
4. **Phase 4**: Setting up monitoring systems, informing users about the questionnaire, product installation after the baseline measurement is performed.
5. **Phase 5**: Implementation of the testing protocol and data collection through the monitoring and control system.
6. **Phase 6**: Data analysis and reporting.

The living laboratory testing protocol serves to highlight the technical feasibility of implementing the living laboratory into a building and agree on the necessary resources.

A dialogue between building owner and manager of the living laboratory applications was established in order to collect missing data. Afterwards the building owners were asked if the renovation works on the building are managed by a construction manager and if this person would be interested in cooperating with the MEZeroE project in order to organize and schedule the product installation with other works being performed at the site. Cooperation and fluid communication between building owner, construction manager, living lab test responsible, living lab site manager and monitoring installation company has to be established. Living lab site manager has to estimate and reserve the necessary resources (material, finance and personal) for the agreed duration of the living laboratory establishment.

Overall, the living lab site manager is in charge of the correct implementation of the testing protocol: the correct communication of the subcontracting works, the management of the risk prevention service, etc. The implementation must be compatible with the current activities and functionalities of the building.

## 6.2 Responsibilities

The living laboratory is run by a team that has a deeper knowledge and experience in such technical areas and is also committed to the MEZeroE project. The living lab team consists of the following groups of members (see Figure 13 for the global scheme):

- **The living lab test responsible:** is a person who designs the testing protocol in each living lab in cooperation with living lab management team, involved industrial partner(s), building owner and OIS2 representative. Gantt chart is prepared for each living laboratory beforehand.
- **The monitoring responsible:** is the person in-charge for the monitoring services, collection of the data and generating reports based on agreed analysis methods.
- **The living lab test site manager:** manages the living lab and is responsible for the coordination of subcontractors to assembly the nZEB envelope products, sensor installation, communication with all relevant parties involved in the living lab (industrial partners, building owners, monitoring providing companies), tracking the Gantt chart and notifying the living lab management team and the project coordinator if there are any delays or changes to the original plan of work. This person is also in charge for identifying and arranging maintenance works related to the running of the living lab as well as of cost overview and providing communication with the living lab financial responsible.

- **The living lab financial responsible** manages the cost of the product installation and other costs related to the living lab set-up process.

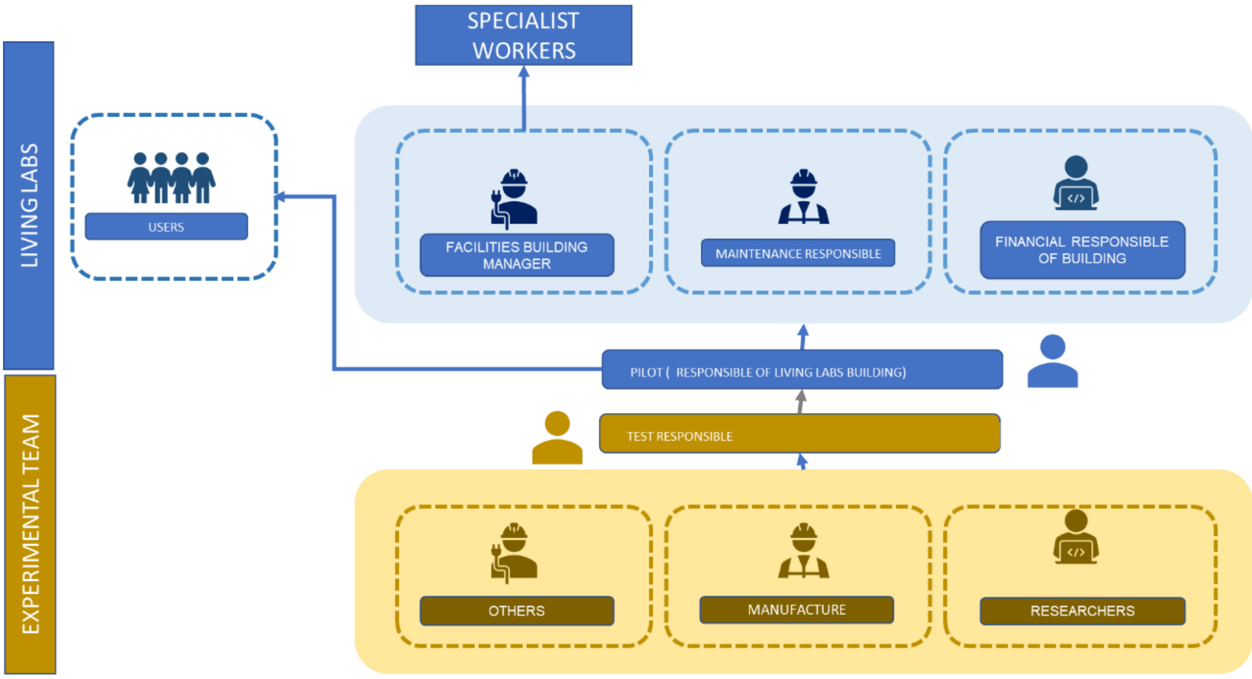


*Figure 13 Responsibilities and profiles involved into the testing protocol in the living lab*

## 6.3 Definition of the living lab test protocol

The living lab test protocol consists of experimental setup considering all the measurements that will be done in a specific living laboratory test site (depending on the nZEB envelope products installed), Gantt chart of the preparational works needed to be done prior on particular living laboratory test site, sensor installation prior the product installation (in order to obtain baseline measurements), product installation, gathering and analysing the data. This is determined in collaboration with industrial partner, building owner, living lab management team and OIS2 representative. The person in charge of the living lab experimental campaign design must contact the living lab test site managers to notify them about the specific living lab test site setup. The requirements of this living lab test site setup as well as the people involved in particular living lab setup are presented to its manager.

Subsequently, the living lab test responsible sends the customized testing protocol to the living lab test site managers. Once the living lab protocol has been analysed by the living lab management team, a meeting will be held with the test responsible to define the specific living lab testing protocol in all its scope.

The definition of living lab setup is based on the specific needs/requirements of the same, which are defined by the project.

These needs can be described in detail addressing the following topics:

1. Performance of baseline measurements: ideally up to 12 months to cover all the different seasons.
2. Micro-location: the area of testing, in which floor, envelope location, etc.
3. Needs for the product implementation:
4. Construction elements:
   - Envelope: type of façade, carpentry, glass, shading, roof, etc.
   - Interior: slab, vapor barrier sheet, false ceiling, interior partition, watertight door, shading element, floor.
5. Facilities: air conditioning, lighting, etc.
6. Electricity supply: conventional and/or from renewable energy sources.
7. Monitoring: type of sensors to measure the specific physical variables for the project and their respective locations; meteorological variables. In addition, the sensors must be checked according to the existing calibration protocol.
8. Control needs (interaction with the existing facilities):
   - Needs of the air conditioning and its control: T setpoint, dead band and its daily profiles, in the areas of interest (measurement area and adjacent areas).
   - Lighting needs and their control.
   - Need for thermal demand in the living lab.
   - Need for full control overheat production in the living lab.
9. Other:
   - Need for various tests "in situ": air tightness, water tightness.
   - Thermography.
10. Database and access:
   - Define the living lab database you want to access thought API (Application Programming Interfaces).
   - Need for access passwords.
11. Building information model:
   - Need to modify the building information model of facilities, structure, architecture, sensors of the existing building.
   - Need for family creation.

## 6.4 Adaptation of the living lab for the project

Depending on the requirements of the living lab protocol, the suitability of the living lab for the project may vary greatly. This adaptation of the living lab, defined in the previous section, refers to the following aspects (see Table 1).

*Table 1 Adaptation of the living lab for the project*

| **Adaptation** | |
|---|---|

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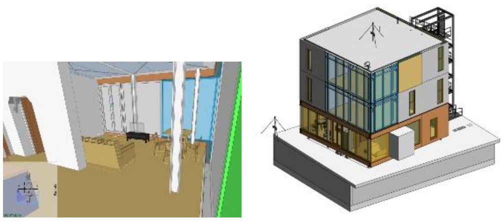
| | |
|---|---|
| Assembly of construction elements: façade, interior partitions, floor slabs, false ceilings, floors, etc. |  |
| Assembly of new installations |  |
| Assembly of specific equipment for the experimental campaign |  |
| Placement of the sensors necessary to measure the physical variables required by the project and, if necessary, the corresponding hardware |  |
| Integration with SCADA, BMS or other systems in the existing building |  |
| Updating of BIM model. Creation of models and incorporation into the model |  |

### 6.4.1 Assembly of the living laboratory

The most consuming thing both in economic terms and in implementation is the adaptation of both the construction elements and the facilities, which require subcontracting of companies and auxiliary means such as a crane and a lifting platform.

The person responsible for managing the assembly/disassembly phase is the living lab test site manager, whereas the work is done by an outside installation company and monitoring installation companies. However, when a change of the façade or roof or the incorporation or transformation of new facilities is made from the initial living lab test site setup, the living lab test responsible is notified and a change is done with collaboration with industry partner, living lab management team and financial representative. The living lab test site manager takes photographs during the assembly phase as they serve to document it and for future broadcasts or communications of the project.

### 6.4.2 Health and safety

The execution of the assembly must always comply with Health and Safety Plan and must have the approval of the living lab prevention service. The plan must oblige the following requirements:

- Supervision of the work is done by the person in charge of the appliance with the Health and Safety Plan, in order to take the appropriate measures and authorize or not for the work to be done.
- Specifically, living lab test site manager sends an email to those responsible for following the Health and Safety Plan detailing what is going to be done. It should be remembered that subcontractors who come to work at the living lab must submit specific documentation and cannot enter to work if they have not submitted it. Outsourcing of the work must have the approval of the living lab management team.
- All personnel who participate in the assembly and/or dismantling processes of a product in the living lab must have the necessary personal protective equipment (PPE). In case the participants in the project do not have their own PPE, they must notify the living lab test site manager that the necessary PPE must be sent to them.
- Under no circumstances may any person who does not have the necessary specific courses participate directly in the assembly and/or disassembly work, for example handling of lifting platforms, pallet trucks, etc.

### 6.4.3 Waste management

When waste is generated in the assembly/dismantling process (for example: change of the façade (non-hazardous waste)) the living lab test site manager calls a waste manager and communicates the type of waste to be generated so that it can manage its delivery to a controlled landfill.

The living lab test site manager must oversee the entire waste management protocol and Environmental Aspects Identification Registration form must be completed.

### 6.4.4 Space occupation

In case the assembly or dismantling of a product in the living lab requires occupying part of the public area or other spaces, it must be communicated to the respective entities sufficiently in advance. In this communication the days and the number of places that would be needed, will be defined.

### 6.4.5 Sensor placement

The placement of the sensors in the living lab is carried out, considering the document prepared by the person responsible for the living lab testing protocol where the position of the sensors is indicated, together with the monitoring responsible. A meeting between the living lab test site manager and test responsible regarding the monitoring and control system is organized to check if the system is working properly before the start of the experimental measurements. This meeting discusses how the work is done, if there have been difficulties and how they have been overcome and the experience gained that may be of interest for future projects. As a result of this meeting, a minute will be issued in which the verification of the sensors will be included. The living lab test site manager delivers a file related to the testing protocol design indicating the objective of the project, the advantages, opportunities and applications and another sheet related only to the experimental testing in the living lab.

### 6.4.6 Extraction and analysis of obtained data

The analysis of the data will be carried out by the project technicians based on the results extracted from the database. Once the report for each living lab experimental campaign has been finalized; a meeting is held to present the results of the measurements. This meeting is attended by: the living lab test responsible and site manager.

### 6.4.7 Preparation of the offer

Once the measurement campaign has been defined, the viability of the campaign has been seen and verified that the implementation of the testing protocol does not compromise the evacuation and occupation requirements, the corresponding budget will be prepared and delivered to the person responsible for the experimental phase of the living lab. The budget shall cover the following aspects:

- Adaptation of the living lab: assembly of construction elements and/or necessary equipment; placement of sensors and if necessary corresponding hardware and programming of the monitoring and control system. Payment to subcontracted companies (cranes, masons, carpenters, electricians, etc.) will be processed by an involved project partner.
- Implementation of the experimental campaign: supervision of the proper functioning of the planned operations and the associated equipment.
- Dismantling construction elements and/or equipment, if necessary.

Once the corresponding budget has been accepted, a schedule of the phases and tasks to be carried out to execute the testing protocol is proposed and a person responsible for each task is assigned. It is advisable to make the necessary purchases within a reasonable period to dispose of the material a few weeks before starting its assembly in the living labs.

# 7 Applied buildings to become living laboratories

A campaign to collect building owner application form to become living labs has been launched twice: (i) from June to September 2022 and (ii) from November to December 2023. This campaign, that has been done using the dissemination resources in the MEZeroE project, requested information from building owners across Europe that could be interested to use their building as living lab for testing

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some of the products that are being included in the MEZeroE project. All together 26 applications were gathered, and the locations are presented in Figure 14.

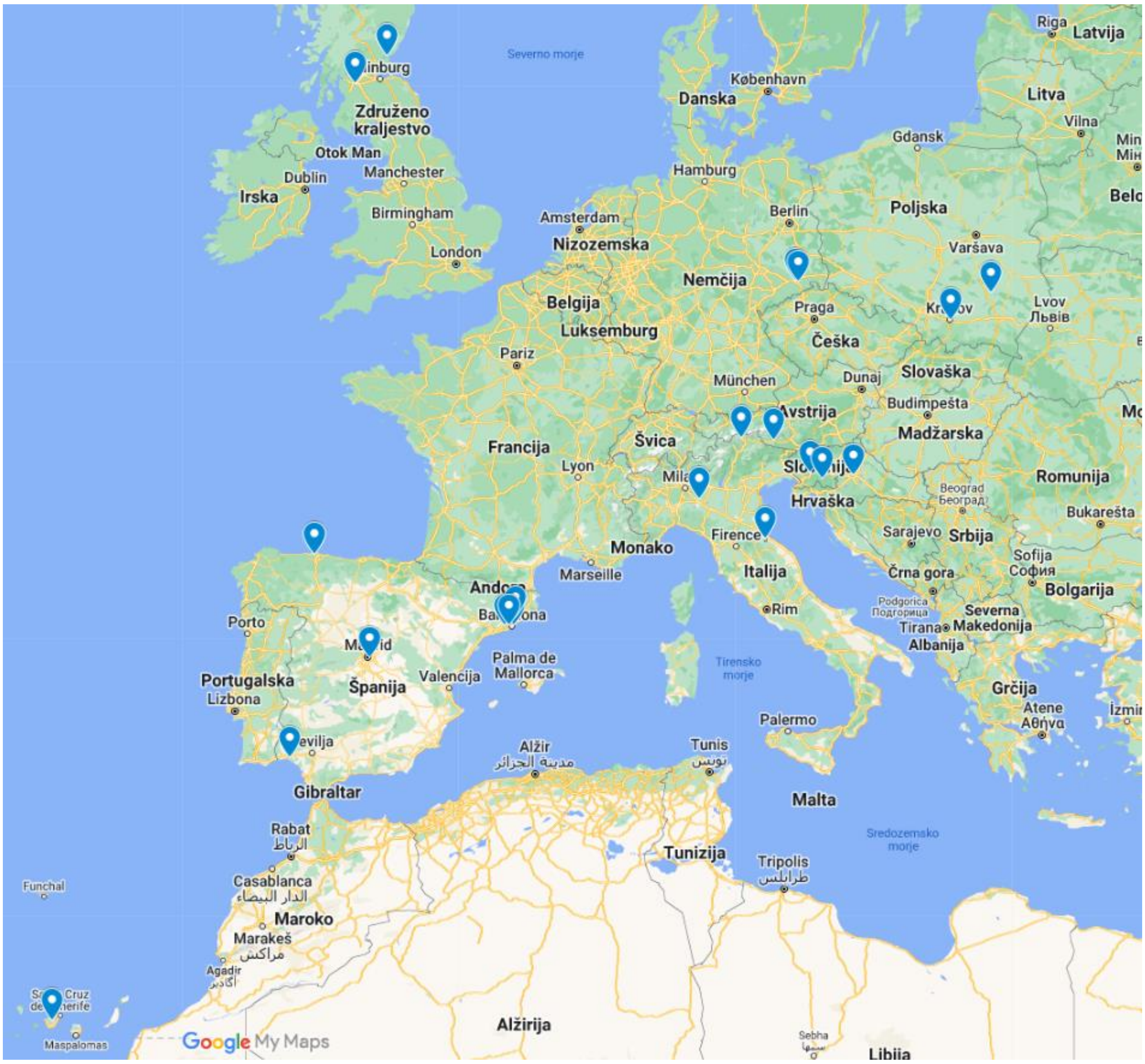


*Figure 14 Geographical locations of possible living labs*

Once the information was received the living lab application manager contacted the applicants to fill in the gaps in the information from the buildings to start with the analysis of the best possibilities for the industrial partners and the MEZeroE project.

In Table 2 it can be seen an overview of the applicants that submit application to the MEZeroE project and the characteristics of the building they proposed. In the table the information gathered from the building owner has been highlighted for the products they are interested in (Dark grey cells: definition of the quantities requested; Light grey cells: only an expression of interest). Pellini SPA was involved only in the second call for buildings since it joined the project late.

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*Table 2 Building application (1 – 13) and interest in industrial partners' products*

| No. | IND partner | Product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Office building | Old house | Public building | Residential bulding | Appartment buildings (3, 200 apartments) | Residential and architecture studio | Office building | Residential building | Tent | Workshop for disabled people, cantine, offices | Workshop for disabled people, cantine, offices | Office building | Security Lodge and Workshop Building |
| | | No. of occupants | 121 | 4 | 100 | 14 | 215 | 4 | 30 | 21 | 1000 | 112 | 80 | 17 | 7 |
| | | Year of construction | 2008 | 1876 | 50 (?) | 1978 | 1975 | 2023 | 1830 | 1985 | 2023 | ~1960 | 2013 | 2021 | 1971 |
| | | Location | Poggio Torriana, Italy | Palleja, Spain | Canary Islands, Spain | Huelva, Spain | Madrid, Spain | Aviles, Spain | Glasgow, UK | Zagreb, Croatia | Lienz, Austria | Dresden, Germany | Dresden, Germany | Logatec, Slovenia | Dundee, UK |
| 1 | Flex&Robust | Flexible structural connectors | | | | | | Interested | | | | | | | |
| 2 | Flexbrick | Integration of PV in an interwoven steel wire mesh | | | | | | | | | | | | | |
| 3 | Focchi | Multifunctional facade system | 400 m² | | | | Interested | | | | | | | | |
| 4 | Heliatek | Glass integrated organic BIPV elements for facade integration | | | | | Interested | 22 m² | | | 100 m² | 2700 units | 300 m² | | 190 m² |
| | | Lightweight, easy-to-install organic BAPV film for existing roofs and facades | | | | | Interested | | | Interested | | | | | |
| 5 | Indresmat | Foamed (bio)polyurethane frames | | | | | | | 52 windows | | | | | | 16 windows |
| | | (bio)polyurethane insulation foams | | | | Interested | | | 190 m² | 220 m² | | | | | |
| 6 | Riko hiše | Sustainable prefab wooden all-in-one envelope components | | 90 m² | | | | | | | | | | | 280 m² |
| | | Sustainable prefab wooden external cladding components | | | | | | 59.84 m² | | | | | | | |
| 7 | Rothoblass | Tailored roof/facade smart membranes | | | | | | 100 m | 190 m² | 110 m² | | | | | 290 m² |
| | | Tailored roof/facade sealing tapes | | | | | | 283 m | | | | | | | |
| | | Tailored roof/facade fastening system | | | | | | Intersted | | | | | | | |
| 8 | Tecnan | Durable advanced functional coatings for self-cleaning and air- purification | | | | | | 620 m² | | | | | | | |
| | | Advanced nanomaterials for energy efficient glazing system | | | | | Interested | 42 m² | | | | | | 200 m² | |
| 9 | Velux | Comprehensive comfort IEQ-based skylights | | | | | | 3 windows | | 2 roof windows | | | | | 8 windows |
| 10 | Window Master | Building integrated natural ventilation solutions | Interested | Interested | | | | 5.40 m² | | | | | | | |
| 11 | Pellini SpA | Integrated microfilm shading device | | | | | | | | | | | | | |
| | | Retroreflective shading device | | | | | | | | | | | | | |

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*Table 3 Building application (14 – 26) and interest in industrial partners' products*

| No. | IND partner | Product | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Warehouses | Residential building | Kindergarten and a primary school | Single-family house | University and research | Industrial building | Modular house | Structural research lab | Industrial | Research laboratory | Chimney | Residential | Offices and meeting rooms |
| | | No. of occupants | 15 | 36 | 215 | 4 | 540 | 15 | 1 to 4 | 3 to 13 | 4 | 4 | / | 3 | 20 |
| | | Year of construction | 2000 | 1965 | 2016 | 1972 | 1988 | 1973 | 2022 | 1968 | 1980 | 1900s | 1900s | 1980 | 2020 |
| | | Location | Barcelona, Spain | Barcelona, Spain | Barcelona, Spain | Pielaszów, Poland | Barcelona, Spain | Barcelona, Spain | Ribnica, Slovenia | Cracow, Poland | Sant Sadurni d'Anoia, Spain | Cracow, Poland | Cracow, Poland | L'Ametlla del Valles | Codogno, Italy |
| 1 | Flex&Robust | Flexible structural connectors | | | | PUFJ - 125 l + FRPU - 8 m² | | | | 60 m | | Interested | | | |
| 2 | Flexbrick | Integration of PV in an interwoven steel wire mesh | Interested | 108 m² | 350 m² | 60 m² | | | | 67 m² | 108 m² | | Interested | | |
| 3 | Focchi | Multifunctional facade system | | | | 9 m² | 250 m² | | | | | | | | |
| 4 | Heliatek | Glass integrated organic BIPV elements for facade integration | | 376 m² | | Interested | 35 units / 280 m² | | | | | | | Interested | |
| | | Lightweight, easy-to-install organic BAPV film for existing roofs and facades | | | | | | | | | | | | | |
| 5 | Indresmat | Foamed (bio)polyurethane frames | | | | 12 windows | 25 windows | 10 - 12 windows | | 5 windows | | 7 windows | | 4 windows | |
| | | (bio)polyurethane insulation foams | | | | 155 m² | 165 m² | | | | | | | | |
| 6 | Riko hiše | Sustainable prefab wooden all-in-one envelope components | | | | | | | 100 m² | | | | | | |
| | | Sustainable prefab wooden external cladding components | | | | 6 facade walls | | | | | | | | | |
| 7 | Rothoblass | Tailored roof/facade smart membranes | | | | 145 m² | | | | | | | | | |
| | | Tailored roof/facade sealing tapes | | | | | | | | | | | | | |
| | | Tailored roof/facade fastening system | | | | | | | | | | | | | |
| 8 | Tecnan | Durable advanced functional coatings for self-cleaning and air- purification | | 1000 m² | | 110 m² | | | | | | | | | |
| | | Advanced nanomaterials for energy efficient glazing system | | 200 m² | | | 165 m² | | | | | | | | |
| 9 | Velux | Comprehensive comfort IEQ-based skylights | | | | 4 roof windows | 30 m² | | | | | | | | |
| 10 | Window Master | Building integrated natural ventilation solutions | | | | 12 windows | 35 units / 280 m² | | | | | | | | |
| 11 | Pellini SpA | Integrated microfilm shading device | | | | | | | | | | 1 item | | | |
| | | Retroreflective shading device | | | | | | | | | | | | | Interested |

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The characteristics of the buildings that have applied to become living labs in MEZeroE project are summarized in the next chapters (part of the information collected during the process of requesting living labs).

## 7.1 Year of construction

The year of construction of the buildings that applied can be seen in Figure 15. As defined previously in this chapter, 26 buildings applied to the request.

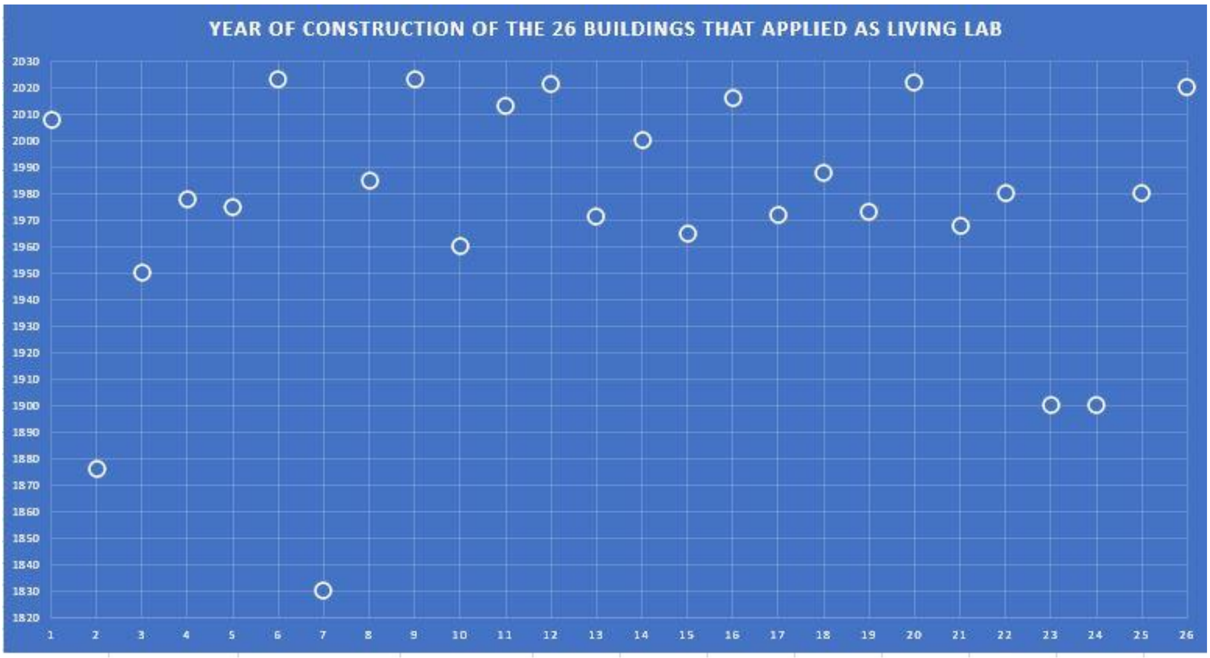


*Figure 15 Year of construction of the buildings that applied as living labs*

One building was built before 1900 (1830). A significant number of buildings, specifically 16, were constructed between 1900 and 1970, with notable years including 1920, 1930, 1940, and several during the 1950s and 1960s. There are 5 buildings built between 1970 and 2000. Additionally, 4 buildings were constructed in the 21st century, spanning from 2000 to 2020, with the latest one built in 2020. This variety in the age of the buildings provides a comprehensive spectrum for evaluating the implementation of living labs in buildings with diverse characteristics. Moreover, the inclusion of newer buildings allows for an assessment of the requirements and challenges when integrating living labs into contemporary construction practices.

## 7.2 Buildings typologies

The buildings typology can be seen in Figure 16. The typologies have been divided as follows:

- Tertiary: the majority of the buildings that applied for the living labs are buildings with activities mainly done in office spaces. There are some differences in the buildings as some of them are pure offices and other ones have other activities like workshops buildings or warehouses. This last one has been included here to not have one building with one specific typology. Anyway, it will be treated specifically as its activities can be a little different from the others.

- Educational: Inside this typology there can be found buildings with kindergarten and primary school and buildings related to university and research. Many differences can appear between primary school and university, but we have considered them in one typology. Obviously, the requirements for each living lab will differ but this will be analysed as part of the process of implementation.
- Residential: Residential buildings with different characteristics: old houses, different dimensions from small houses to big residential buildings.
- Mixed: buildings with a mix between office and residential or other buildings with different activities inside them (workshop, canteen, offices, etc.)

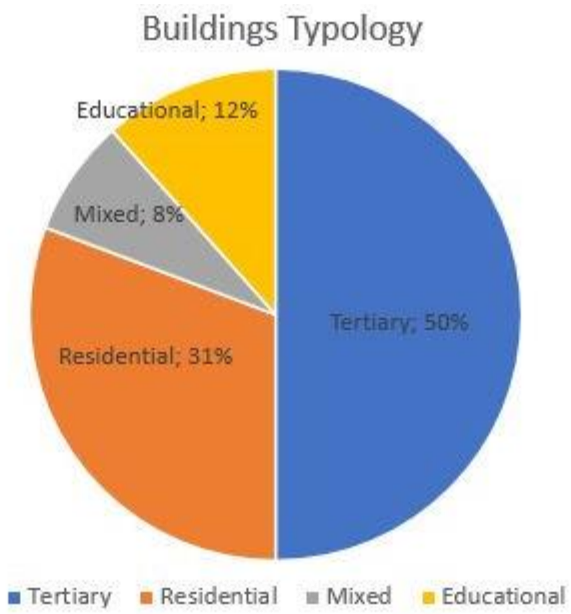


*Figure 16 Buildings typology for the living labs*

As it can be seen in the Figure 16, the percentage of each typology is as follows: Tertiary buildings are the 50% of the buildings that applied to the project request, 31% of the buildings can be included in the residential typology. With these numbers almost the 81% of the buildings can be included in these two typologies. 12% are educational buildings and another 8% can be included in mixed typology buildings. These numbers give the project different possibilities to test the “living lab” approach. Probably some of these buildings don’t finish the process but with a number of 26 applicants the project can have enough possibilities to continue with the work without problems.

## 7.3 Number of occupants in the buildings

Another important point that needs to be measured as part of the process to define the living labs is the number of occupants that the applicants have. As it can be seen in Figure 17 almost all the buildings are below 100 occupants. We have one building with around 1000 occupants, but this number will need to be treated carefully as the living lab will reach less people. It is important to mention that the living labs process will not refurbish the entire buildings in the majority of cases. They will be done actions that refurbish and implement the solutions of the project in specific parts of the building. This will imply that the people affected will be less that the one showed in the Figure 17, but this number is interesting to study the context of each building.

As also defined in Figure 17, we have one building with around 500 occupants or users, two with occupants around 200 persons and the rest of them are below 100 persons.

The total amount of occupants that will be in some contact with the living lab reach the amount of 2600 persons with all the considerations that have been mentioned previously.

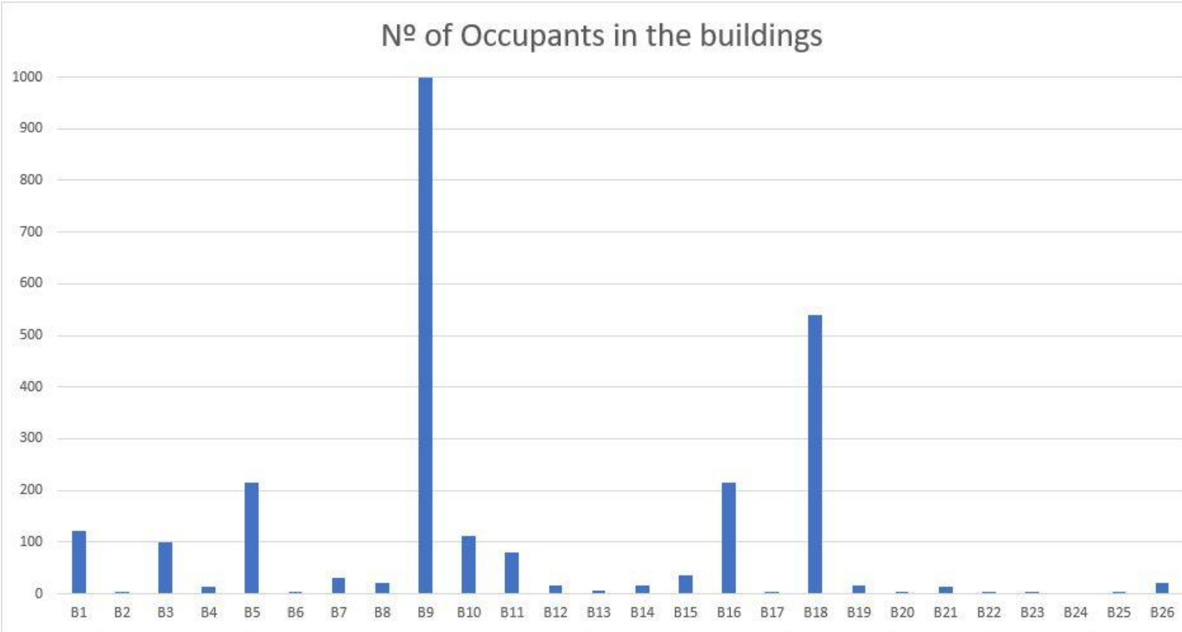


*Figure 17 Number of occupants in the buildings that applied for living labs*

## 7.4 Façade typologies

Other important element to be defined by the applicants to the living lab implementation was the façade typology of the building where the living lab will be implemented.

As it can be seen in Figure 18 the façade typologies were as follows:

- Concrete/bricks (16 buildings): the majority of the buildings. This is a traditional way of construction of many residential buildings. Structure in concrete and walls in different type of bricks with different layers including the insulation.
- Sandwich panels (2 buildings): Different configurations of sandwich panels defining the external walls of the building with the structure in different materials (concrete or steel). More used in tertiary buildings.
- Ceramics: panels based in ceramic materials that cover the entire façade using the ventilated façade typology.

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- Stone (1 building): combined with wood quite common in old buildings.
- Tensile (1 building): very specific of temporal buildings.
- Steel + panels (1 building): different layers of materials combined with structure in steel.
- Curtain wall (2 buildings): profiles of aluminium and glass panels. Very typical of office buildings across Europe.
- Wooden (2 buildings): usually combined with bricks. Very common in old buildings.

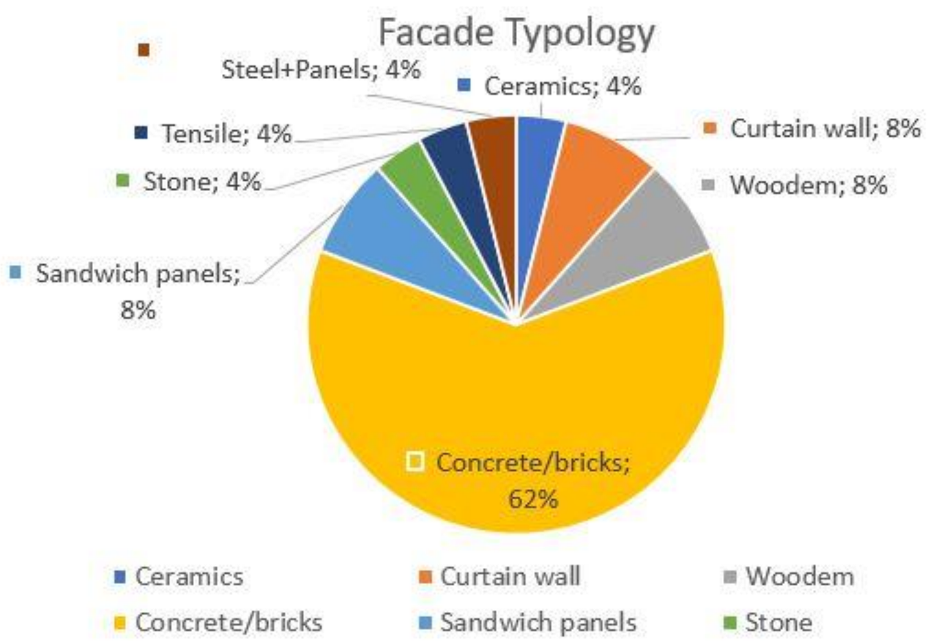


*Figure 18 Façade typology of the buildings that applied to living labs (Number of buildings with each typology)*

## 7.5 Ownership

The ownership of the buildings that have applied to the process has also taken into account as it is very important to avoid problems during the implementation and use of the living lab. The less persons or companies involved the less problems for the process. In Figure 19 can be seen the different type of ownerships that have the building which sent information to be used as living labs:

- Total (77%): the applicant defined that they have the complete ownership of the building so the activities proposed will have only one contact.
- Community (12%): there is a community of persons or owners who need to agree with the intervention.
- Non defined (12%): some of the applicants don't leave clear this concept and this information is under collection.

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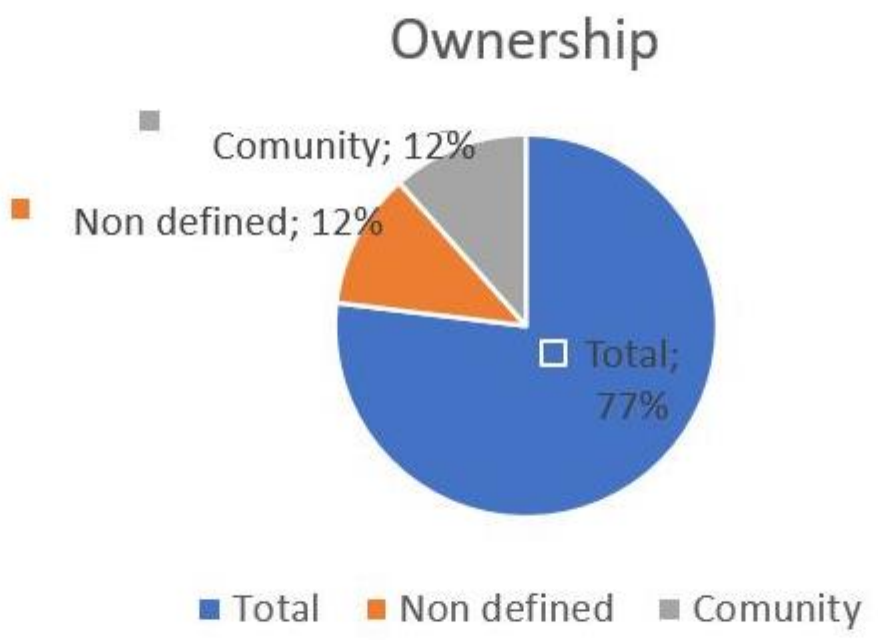


*Figure 19 Ownership of the buildings that applied to living labs*

## 7.6 Micro-location

The location of the buildings related to their geographical zone has been defined Figure 20, but it is also quite important to know the detailed position of the building related to its context to be able to analyse other details or avoid problems during the activities to be done during the project.

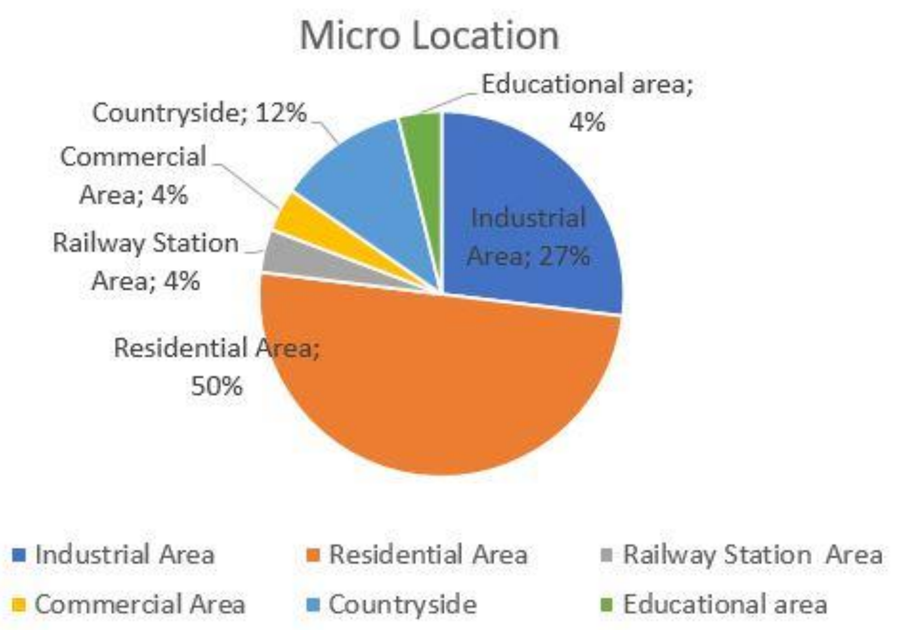


*Figure 20 Micro Location of the buildings that applied to living labs*

The typologies of micro location defined until this moment were as follows:

- Residential area (13 buildings): the majority of the buildings are included in this typology. It is related to buildings located in urban areas with many buildings of the same characteristics close to them. It is also a very big typology as many cities differ considerable from others based on the country, the geographical position (flat areas or mountain areas), etc. Due to this, it is necessary to analyse the position of the building related to its context.
- Industrial area (7 buildings): areas sometimes close to the urban areas but with specific characteristics and requirements. Here the buildings usually are placed with more distance between them with surrounds more similar to a countryside but with a high level of urbanization.
- Educational areas (1 building): closer to the urban areas than the industrial areas, with many open surroundings (in general), buildings with some space between them but that include many approaches depending on the country and the surroundings.
- Countryside (3 buildings): buildings placed in the countryside. Usually with a lot of distance between them and without urbanized areas in the surroundings.
- Commercial areas (1 building): areas with many typologies of buildings, high presence of cars in the surroundings usually close to the cities highly urbanized and with open surroundings
- Railway station areas (1 building): areas close to railway station spaces with some times problems of sounds and vibrations with similar characteristics to the industrial areas.

# 8 Deployment of the Living Labs

From building applications, we are moving to living laboratories. Based on all received applications, industrial partners' interest and product availability, consortium meetings and building owners' willingness to participate 11 living labs are active in May 2024:

- office building in Poggio Torriana, Italy,
- residential and architectural studio in Aviles, Spain,
- office building in Logatec, Slovenia,
- kindergarten and primary school in Barcelona, Spain,
- industrial building in Barcelona, Spain,
- modular house in Ribnica, Slovenia,
- industrial building in Sant Sadurni d'Anoia, Spain,
- research laboratory in Cracow, Poland,
- chimney in Cracow, Poland,
- residential building in L'Ametlla del Valles, Spain,
- office building in Codogno, Italy.

Living labs are numerated in order as the applications arrived and they are not re-numbered if somebody drops-off.

Main activities unfolding in each of the living lab are: performance of baseline measurements (measuring the parameters before the product installation), product installation and performing measurements after the product is installed to determine the difference introduced by using a new product. Estimated timeline for the participating living labs is presented in Table 4.

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*Table 4 Estimated timeline for baseline measurements, product installation and measurements after product installation in the 11 active living labs*

| Date | | 1 | 8 | 14 | 18 | 21 | 22 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Office building | Residential and architecture studio | Office building | Kindergarten and a primary school | Industrial building | Modular house | Industrial | Research laboratory | Chimney | Residential | Offices and meeting rooms |
| No. of occupants | | 121 | 4 | 17 | 215 | 15 | 2 | 4 | 4 | / | 3 | 20 |
| Year of construction | | 2008 | 2023 | 2021 | 2016 | 1973 | 2022 | 1980 | 1900s | 1900s | 1980 | 2020 |
| Location | | Poggio Torriana, Italy | Aviles, Spain | Logatec, Slovenia | Barcelona, Spain | Barcelona, Spain | Ribnica, Slovenia | Sant Sadurni d'Anoia, Spain | Cracow, Poland | Cracow, Poland | L'Ametlla del Valles | Codogno, Italy |
| 2023 | 1 | | | | | | | | | | | |
| | 2 | | | | | | | | | | | |
| | 3 | | | | | | | | | | | |
| | 4 | | | | | | | | | | | |
| | 5 | | | | | | | | | | | |
| | 6 | | | | | | | | | | | |
| | 7 | | | | | | | | | | | |
| | 8 | B | | | | | | | | | | |
| | 9 | | | | | | | | | | | |
| | 10 | | I | | | | | | | | | |
| | 11 | | | | | | | | | | | |
| | 12 | | | | | | | | | | | |
| 2024 | 1 | | | | | | | | | | | |
| | 2 | | | | | | | | | | | |
| | 3 | I | | | | | | | | | | |
| | 4 | | | | | | | I | B | | | |
| | 5 | | | | | B | | | | | | |
| | 6 | | M | | | | | | | | | B |
| | 7 | | | | I | | | | | | B | |
| | 8 | | | | | | | | I | | | |
| | 9 | | | | | | | | | | | I |
| | 10 | | | B | | | M | M | | | I | |
| | 11 | | | | | | | | | | | |
| | 12 | | | | | I | | | | | | |
| 2025 | 1 | | | | | | | | | | | |
| | 2 | M | | I | | | | | | | | |
| | 3 | | | | | | | | | | | |
| | 4 | | | | | | | | M | | | M |
| | 5 | | | | | | | | | | M | |
| | 6 | | | | | | | | | | | |
| | 7 | | | M | | M | | | | | | |
| | 8 | | | | | | | | | | | |
| | 9 | | | | | | | | | | | |
| | 10 | | | | | | | | | | | |
| | 11 | | | | | | | | | | | |
| | 12 | | | | | | | | | | | |

## 8.1 Living lab no.1 – Poggio Torriana, Italy

Living lab no. 1 is an office building in Poggio Torriana, Italy where next products will be installed:

- Focchi's multifunctional prefabricated facade.

Office building that was built in 2008 will be renovated and a new office space will be constructed. Building was already renovated in 2016 and since 2018 upgraded for building automation. The building is used by 121 occupants. Renders of the newly build part are shown in Figure 21.

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*Figure 21 Renders of the newly build part of the office building in Poggio Torriana, Italy – Living lab no. 1*

## 8.2 Living lab no. 8 – Aviles, Spain

Living lab no. 8 is a residential and architectural studio in city center of Aviles in Spain where next products will be installed:

- Tecnan's durable advanced functional coating for self-cleaning and air purification and advanced nanomaterials for energy efficient glazing system,
- Rothoblaas's smart membrane and sealing tapes,
- Flex&Robust flexible joints.

The building to be reconstructed was initially built in 1895 and is located in the historic center of Aviles. The aim of renovation is to obtain passive house certificate and all used materials must be in line with that. There are 4 occupants in the house shown in Figure 22.

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*Figure 22: Construction site in Aviles, Spain in October 2023 – Living lab no. 8*

## 8.3 Living lab no. 14 – Logatec, Slovenia

Living lab no. 14 is a Fire research laboratory in Logatec, Slovenia where next product will be installed:

- Tecnan's advanced nanomaterial for energy efficient glazing system.

Office building, shown in Figure 23, is attached to the test hall built in 2021 is exposed to overheating since there are lots of windows oriented towards South with no infrared protection and no outer shading. The renovation is tackling this by applying infrared barrier coating on the windows in the office part of the Fire laboratory. There are 20 occupants using the building during the workdays.

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*Figure 23: Office building in Logatec, Slovenia – Living lab no. 14*

## 8.4 Living lab no. 18 – Barcelona, Spain

Living lab no. 18 is a kindergarten and primary school in Barcelona, Spain where next product will be installed:

- Flexbrick's integrated PV in an interwoven steel wire mesh.

The Virolai Petit kindergarten, shown in Figure 24, was built in 2016 in Barcelona. The building is attached to the sport hall. The building will go under renovation during school summer break of 2024 where new extension of one more floor will be built allowing incorporation of new technologies, especially in the facade areas. The building hosts 215 occupants, mostly children.

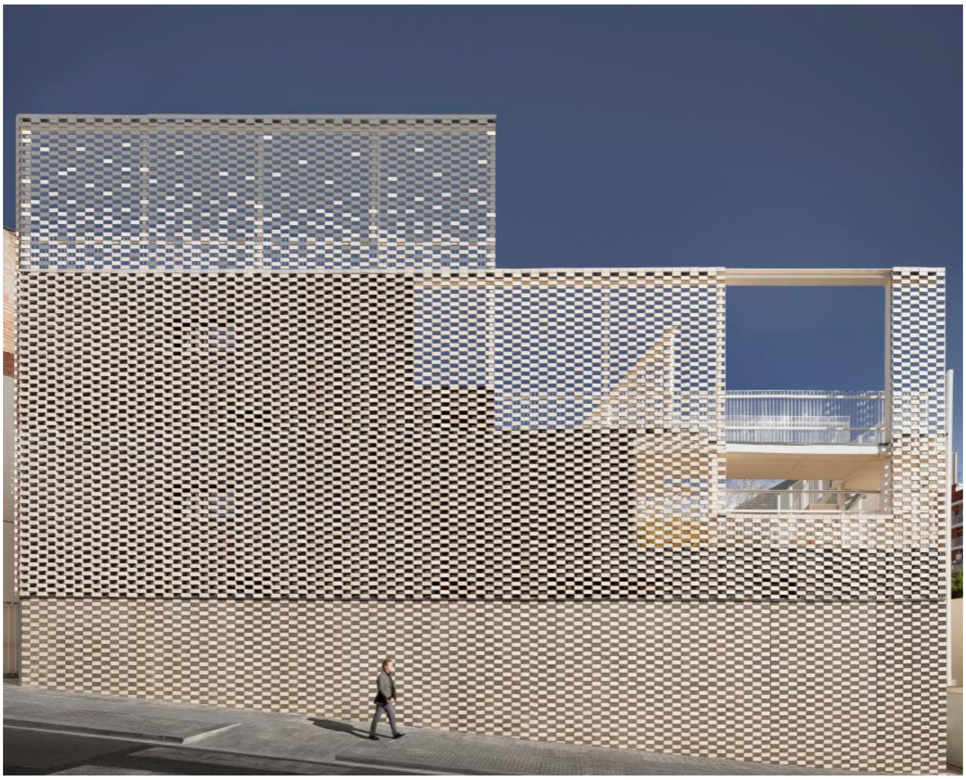

*Figure 24: Kindergarten and primary school before renovation in Barcelona, Spain – Living lab no. 18*

## 8.5 Living lab no. 21 – Barcelona, Spain

Living lab no. 21 is an industrial building in Barcelona, Spain where next product will be installed:

- Indresmat's foamed (bio)polyurethane frames.

Industrial building in Figure 25 was built in 1973 and it has 15 occupants during the workdays. Planned intervention is to remove the windows in the facade of the building by replacing an old, fixed windows of single pane glass. This intervention will be performed in the context of a rehabilitation of the facade for safety reasons and taking the opportunity to decrease the energy demand and its usage.

*Figure 25: Industrial building in Barcelona, Spain – Living lab no. 21*

## 8.6 Living lab no. 22 – Ribnica, Slovenia

Living lab no. 22 is a modular house in Ribnica, Slovenia where next product will be installed:

- Sustainable prefab wooden all-in-one envelope components.

A modular house shown in Figure 26 is a newly built facility and allows for different ways of use. It can be a temporary modular office, a holiday facility or part of a larger structure that consists of several similar modules. It represents a solution to improve sustainability, as it mostly contains easily renewable materials (wood, mineral wool). The modular house consumes very little energy for its operation, it is possible to become completely self-sufficient. It can be occupied by 1 to 4 occupants.

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*Figure 26 Riko hiše's modular house in Ribnica, Slovenia – Living lab no. 22*

## 8.7 Living lab no. 24 – Sant Sadurni d'Anoia, Spain

Living lab no. 24 is an industrial building in Sant Sadurni d'Anoia where next product will be installed:

- Flexbrick's integrated PV in an interwoven steel wire mesh.

The planned intervention is to renovate the image and use of the existing control building in the company's complex by enhancing the exterior space including a sunscreen to allow exterior use by providing shade and sun control as well as electricity production. This intervention is a part of already ongoing renovation. The use of active photovoltaic cells in the outside pergola will actively contribute in reducing carbon footprint by generating energy for the users and improving sustainability of the building by decreasing energy use. The building with partly installed product is shown in Figure 27.

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*Figure 27 Control building in Sant Sadurni d'Anoia with partly installed integrated PV in an interwoven steel wire mesh – Living lab no. 24*

## 8.8 Living lab no. 25 – Cracow, Poland

Living lab no. 25 is a research laboratory of the Cracow University of Technology in Cracow where next products will be installed:

- Flex&Robust's flexible structural connectors,
- Indresmat's foamed (bio)polyurethane frames,
- Pellini's integrated microfilm shading device.

The planned modernization of the building shown in Figure 28 involves replacing windows and strengthening the building's bearing construction by filling the cracks with a flexible structural connector. The aim of the renovation is to modernize the external envelope, improve thermal and internal comfort parameters of the building envelope and building interior. The laboratory is occupied by 4 employees.

*Figure 28 Research laboratory of Cracow University of Technology before the renovation – Living lab no. 25*

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## 8.9 Living lab no. 26 – Cracow, Poland

Living lab no. 26 is a chimney within the Cracow University of Technology complex in Cracow where next product will be installed:

- Flexbrick's integrated PV in an interwoven steel wire mesh.

The planned intervention is including the installation of a curtain with integrated photovoltaics in an interwoven steel wire mesh on the existing free-standing, historic chimney shown in Figure 29. The intervention will be carried out in the context of testing the effectiveness of photovoltaics built into the Flexbrick curtain in Polish climate conditions, referring to the historic character of the chimney. The building is not inhabited.

*Figure 29 Historical chimney in the complex of Cracow University of Technology in Cracow – Living lab no. 26*

## 8.10 Living lab no. 27 – L'Ametlla del Valles, Spain

Living lab no. 27 is a residential building in L'Ametlla del Valles where next products will be installed:

- Indresmat's foamed (bio)polyurethane frames,
- Indresmat's (bio)polyurethane insulation foam.

The planned intervention for the residential building shown in Figure 30 is focused in improvement of the facade and installing new windows.

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*Figure 30 Residential building in L'Ametlla del Valles, Spain before renovation – Living lab no. 27*

## 8.11 Living lab no. 28 – Codogno, Italy

In an industrial building of Living lab no. 28 offices and meeting rooms will be used for product installation:

- Pellini's retroreflective shading device.

In the building full replacement of glazing units and openable windows will be done. The building is shown in Figure 31.

*Figure 31 Office building in Codogno, Italy before the renovation – Living lab no. 28*

# 9 Results & Discussion

The main results obtained in this deliverable and in the work performed in task 5.3 are as follows:

- **Definition of the living lab laboratory**: during the work that has been done in this task and implemented in this deliverable, it has been advanced in the specific definition of the living lab that will be used in the project. Due to this connection the definition started to be more real and connected to the real buildings that will be used in the project. It is part of the work that will be done in the next months to define in detail the different configurations of living labs that will be developed on each of the buildings that applied to this process.
- **Information needed to set up the living laboratories**: as part of the process followed an initial definition of the information needed to know if a living lab is possible has been done.

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Some of this information still hasn't been obtained as it requires a higher level of detail, but it is important to know as much as possible all the components that can influence in the implementation. Later it will be assessed if some of this information would be included or not.

- **Definition of the testing protocol**: An initial testing protocol has been defined and now this testing protocol will be implemented in all the applicants that finish the process. This work will serve to optimize the protocol and see if the level of detail and the figures and steps defined are useful or some of them can be improved.
- **Living lab possibilities**: a campaign to collect different living labs across Europe with different characteristics and possibilities has also been done as part of the process. 26 buildings have passed the first step and now the process is entering in more detail to understand the way living labs can be implemented on them. Part of this process will be done by matching these buildings with the possibilities of the industrial partners to provide components to be tested in enough quantities. This process has started making a first match between industrial partners and buildings to advance in the configuration of each living lab. This process connected to the better definition of the testing protocol will be the first part of the process to have buildings with project components to be assessed during the next monitoring period.

# 10 Risks and interactions

## 10.1 Risks/problems encountered

From the risks defined in the proposal related to this WP and deliverable

1. **Risk 1: Objectives are too challenging.**
    - The implementation of the living labs is a challenging activity as a big part of the activity needs to be done by external partners to the project but taking into account the amount of living labs proposed in this task (26) it is considered that the implementation can be achieved in an important part of them enough for the project. This sentence also based in the level of commitment demonstrate until this moment.
2. **Risk 2: Authorisation time is longer than the foreseen and delays in living labs.**
    - The process until now is following the deadlines defined in the project. Now, it is the crucial moment in which the real implementation in the living labs starts. This real implementation can imply that some of the living labs applications cannot be used but as the number is enough the project counts that it will be possible to demonstrate the developments performed.
    - Real implementation will also test the way the protocol is useful for avoiding problems. A high detail initial protocol is estimated that will be useful for avoiding problems during the implementation and have enough buffer time to solve the expected problems.
3. **Risk 3: Results do not reach the market**
    - One of the results of the WP5 is the validation of the way living labs will be implemented and that the information obtained from them is useful for the market. The element that needs to be validated is the process performed and the results obtained. This is something that will be seen during the monitoring process and different measurements (sensors, data obtained) will be established if the results are not the ones expected. It is necessary to take into account that during this process users of the building will be involved, and their answers

will give important feedback of the type of results obtained and if it is necessary to modify the approach.

## 10.2 Interconnections with the other deliverables

This deliverable is included in WP5 “Market uptake: demonstration of solutions in Living Labs conditions”. This WP has four deliverables:

1. **D5.1 Living lab plan**: define the entire work related to living labs and establish what will be done as part of the process.
2. **D5.2 Intermediate report on members activities**: draft version of the activities performed (structure of the living labs, interests, trends, etc.) until M25.
3. **D5.3 Report of the development of the fully deployed and virtual LLs**: this report that includes the deployment of the living labs in the buildings that applied to become living labs with the different steps (protocol, requirements, etc.)
4. **D5.4 Report of the deployment of the LLs**: Final explanation of the work performed to implement the LLs.

In the Figure 32 the interconnection with the deliverables of the WP5 and with the work done in the other WPs of the project is shown.

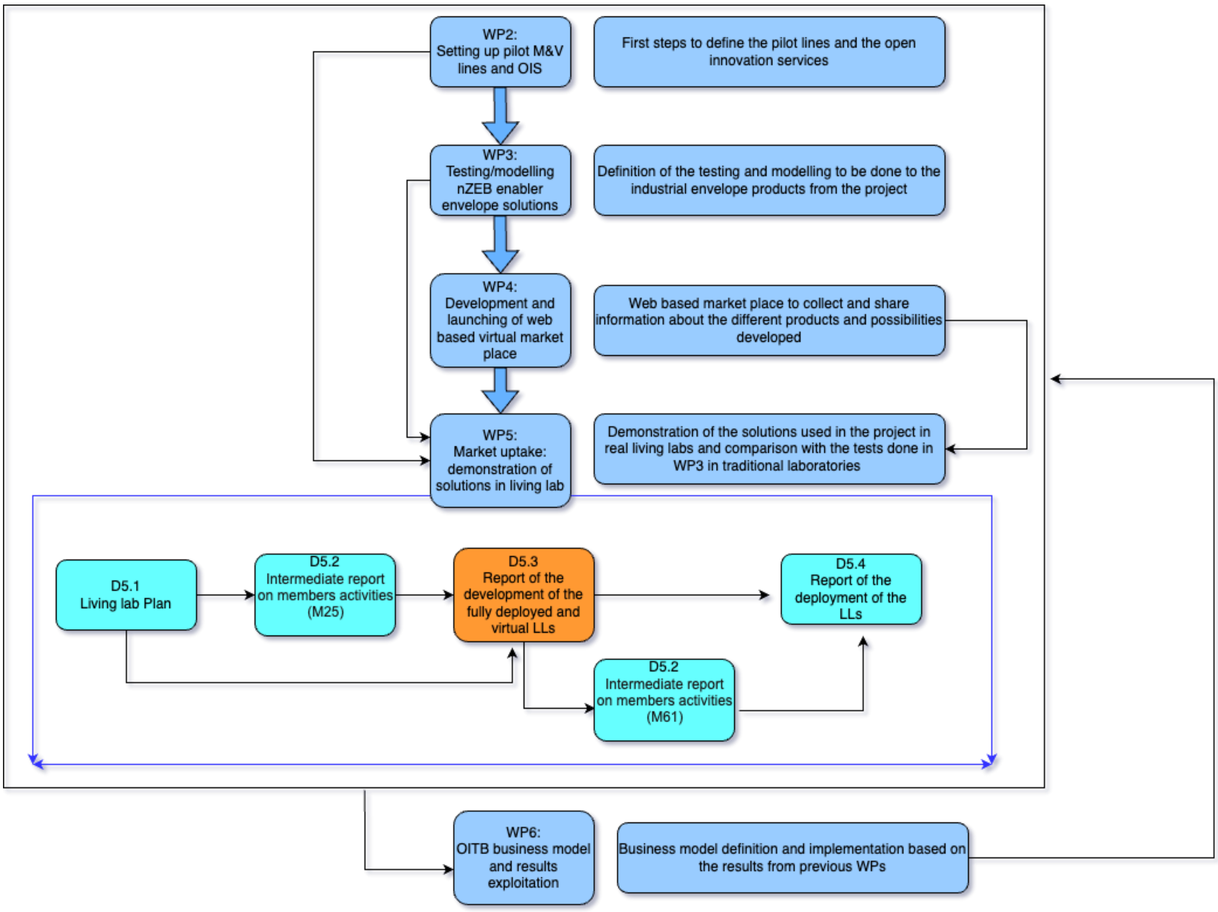




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*Figure 32 Interconnection with other deliverables*

# 11 Conclusions

This deliverable has established a comprehensive approach for defining the living lab testing protocol, detailing the necessary information collection, roles, responsibilities, and the protocols for proper implementation. The technologies to be used and methods for obtaining and utilizing data from the living labs were also outlined. The protocol is designed to be adaptable, considering the unique characteristics and requirements of each case. A significant milestone in this phase of the project was the interest shown by 26 applicants willing to implement innovative products in their buildings and to provide monitoring data and results from the living lab activities. One of the primary challenges has been educating the applicants about the implications of participating in this project, especially since most are not typically engaged in research activities. This included explaining the concept of a living laboratory and its relevance to future activities and the status and requirements for installing industrial products in their buildings.

**Key Findings**

- Interest and Participation: The expression of interest from 26 applicants highlights a positive engagement with the project's objectives.
- Protocol Adaptability: The proposed protocol's ability to be tailored to specific building characteristics ensures flexibility and relevance to various scenarios.
- Educational Efforts: Significant effort was required to inform and align applicants with the project's goals and processes, emphasizing the importance of clear communication and understanding.

**Limitations**

- Applicant Understanding: The initial unfamiliarity of most applicants with research activities posed a challenge, necessitating extensive explanatory efforts.
- Data Collection and Analysis: Variations in building characteristics require a flexible yet robust data collection and analysis approach, which can be complex and resource-intensive.
- Implementation Constraints: Real-world constraints such as authorization times, warranties and the practicalities of implementing the living labs in existing buildings can impact timelines and project outcomes.

**Recommendations**

- Enhanced Communication: Develop comprehensive communication strategies and educational materials to better prepare future applicants and streamline the onboarding process.
- Protocol Optimization: Continually refine and optimize the testing protocol based on feedback and results from initial implementations to improve efficiency and effectiveness.
- Resource Allocation: Ensure adequate resources, including time and technical support, are allocated to address the complexities and constraints identified during the implementation phase.

- Cross-Project Integration: Leverage insights and data from this project to inform and support activities in related work packages, such as WP2 and WP3, fostering a more integrated and synergistic approach across the project.

By addressing these key findings, limitations, and recommendations, the project can enhance the effectiveness of the living labs, ensuring that they provide valuable insights and data for the development and implementation of innovative building technologies.

**Next steps**

The future work to be done in this WP shall focus on the details of each of the applicants to filter the most valuable and interesting ones and to finally demonstrate the type of data that can be obtained with this approach when we compare with the data obtained from testing and a laboratory. It is important to remark the possible constrains that could arise due to the requirements asked to the project products and the changes that will be necessary to do to comply with these requirements. This information will also be very interesting for the activities performed in other work packages like WP2 and WP3. Moreover, and as a part of the work to be performed, the implementation of the protocol on each of the living labs and the different information required to do it will be carried out.

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# Annex A

**Agreement for the Provision of Products within EU Horizon 2020 project no 953157**

This Agreement ("Agreement") is entered into as of DD/MM/YYYY ("Effective Date") by and between [Industrial partner], situated at [Address] ("Provider" or "Party A"), and [Counterparty name], situated at [Address] ("Recipient" or "Party B").

1. **Scope of Work**

Party A agrees to provide a list of products as specified in Exhibit A attached hereto ("Products") to Party B as part of the European Project no. 953157, “Measuring Envelope products and systems contributing to next generation of healthy nearly Zero Energy building” ("Project").

2. **Payment**

No payment shall be required for the Products as they will be covered by the funds allocated within the Project.

3. **Technical Documentation**

Party A provides all necessary technical documentation related to the Products to enable the proper understanding and utilization by Party B on the company’s website and through the documentation accompanying the products delivered.

4. **Delivery of Products and Transfer of Risks**
   1. Party A shall deliver the Products to the specified location as agreed upon by both parties.
   2. The risk of loss or damage to the Products shall transfer from Party A to Party B according to the INCOTERMS indicated in the order confirmation and invoice.

5. **Liability and Claims**
   1. Each party shall be liable for any damages or losses resulting from its own negligence or willful misconduct.
   2. Neither party shall be liable for any consequential, incidental, indirect, special, or punitive damages.
   3. Party A guarantees the products supplied will not suffer from defects, lack of quality and/or non-conformity for a period of xx months from delivery to the customer, reserving the right to repair or replace. Party A will be able to perform the warranty within a reasonable time period, taking into account its own organization. In case of defect, lack of quality, non-conformity of the product, Party B shall notify Party A within 8 days from their discovery, with adequate documentation.

The warranty provided does not cover the effects of wear or damage that may arise after delivery due to improper or careless use, excessive stress, use of inappropriate materials or effects of external agents, not provided for in the contract. Should Party B or third parties make any modifications or repair work that are not appropriate, the warranty shall have no value either directly or on the effects thereof. PPE products and anchoring devices in general are subject to periodic review under Party B's responsibility, as per the documentation attached to the product which the customer undertakes to comply with.
If, in carrying out operations that are presumed to be under warranty, it turns out that the damage does not fall under Party A’s warranty, Party B shall bear the costs of such operations.

6. **Confidentiality**

Both parties agree to treat any information received from the other party as confidential and to take all necessary measures to prevent unauthorized disclosure.

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7. **Privacy and Ethics**

The privacy policy and the code of ethics available at [Webpage of the Industrial partner or other source] apply to this Agreement. Both parties shall adhere to applicable privacy laws and ethical standards indicated therein in the handling and use of any confidential information, personal data, or other sensitive information exchanged during this Agreement.

8. **Term and Termination**

This Agreement shall commence on the Effective Date and continue until the completion of the Project, unless terminated earlier by mutual agreement or for cause, upon the occurrence of any of the following events: material breach of any provision in this Agreement; insolvency; violation of applicable laws, regulations or ethical standards in connection with the performance of its obligations under this Agreement; failure to meet project milestones.

9. **Governing Law**

This Agreement shall be governed by and construed in accordance with the laws of [Country].

10. **Entire Agreement**

This Agreement constitutes the entire understanding between the parties and supersedes any prior agreements or understandings, whether oral or written.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement as of the Effective Date.

| | |
|---|---|
| **[Industrial partner]** | [**Counterparty name**] |
| By: _____________________________<br>[Industrial partner's representative, Title] | By: _____________________________<br>[Counterparty representative, Title] |
| Date: ___________________________ | Date: ___________________________ |

**Exhibit A**: List of Products [Include a detailed list of the products to be provided, including specifications, quantities, and any other relevant details.]