ENI CBCMED
Cooperating across borders in the Mediterranean

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REGIONE AUTÒNOMA DE SARDIGNA
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Med-EcoSuRe

WP 3 - CROSS BORDER LIVING LAB INITIATIVE

OUTPUT 3.1 - Toolkit of Passive Solutions Design for Higher Education Buildings Retrofitting

Deliverable

LLL Action Plan
Annex I – LLL Action Plan Matrix

The fourth activity of the WP 3 was intended to define the implementation of the Local Living Labs which compose the Mediterranean Cross-border Living Lab.

- Definition of means of collaboration among academics and public bodies (national/regional agencies in charge of EE ...).
- Identification of a set of reference university buildings representing the national higher education building stock
- Signature of Agreement or MOU (memorandum) to share of knowledge and best practices.

Doc. 3.1.4. LLL Action Plan

This document contains a brief description of the methodology adopted to formulate the Action Plan related to the implementation of the Local Living Labs (LLL),which compose the collaborative network of the Mediterranean Cross-border Living Lab. LLL can also create (optional) virtual Local Living Labs (LLL 2.0), developing a Digital Twin of the pilot buildings object of renovation.
The proper LLL Action Plan is reported in the LLL Action Plan Matrix [Annex I], containing the step by step actions to implement for the setting and follow up of Local Living Labs.
The LLL Action Plan is implemented at the local and operational level of the MCbLL by the Technical Coordinator and the Multidisciplinary Team in order to manage the physical Living Lab, site of the pilot project.

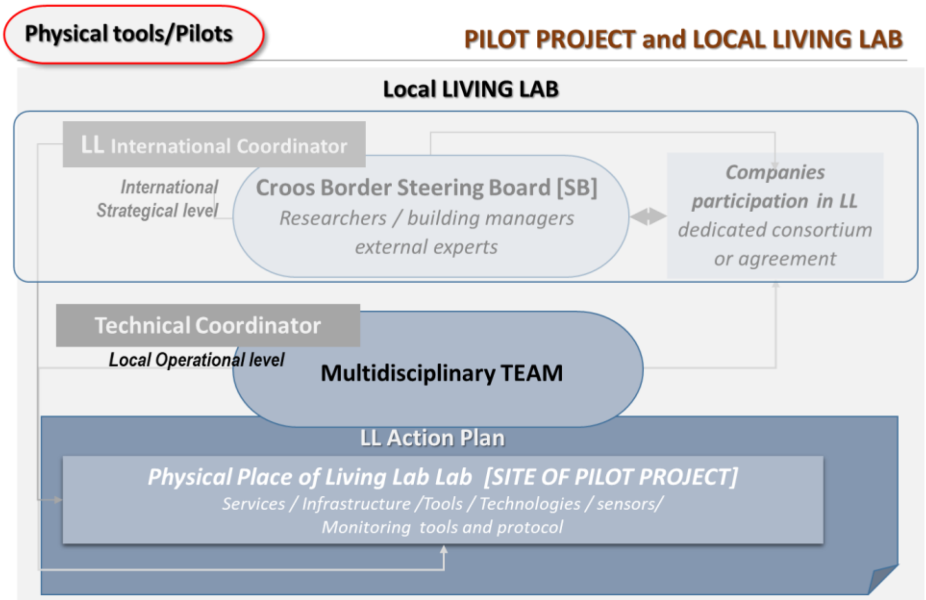

Figure 1 Local Living Lab management

Each University of the Med Eco-Sure partnership is owner of a Local Living Lab, with related instruments and devices. Within the university, a department is the responsible entity of the LLL, comprising its services, infrastructure, tools, and it is in charge of the relationships with other Local Living Labs. The local department is also in charge of constituting dedicated consortiums or agreements for the participation of companies in the LL.

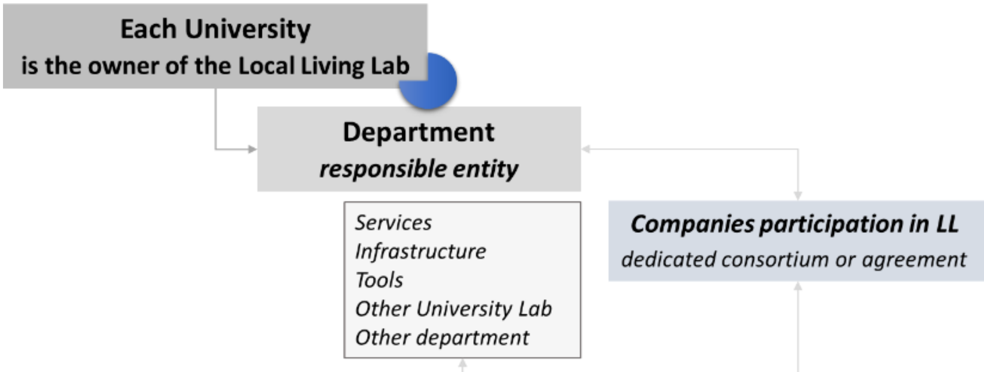

Figure 2 Ownership and responsibility of the LLL

As Living Labs, the Local Living Labs of the MCbLL use a quasi-experimental approach. This includes a pre-measurement, an intervention and a post-measurement, where the intervention is equaled to the real-life experiment. Three main phases can be distinguished in the innovation development:

- **Exploration:** getting to know the 'current state' and designing possible 'future states'
- **Experimentation**: real-life testing of one or more proposed 'future states'
- **Evaluation**: assessing the impact of the experiment with regards to the 'current state' in order to iterate the 'future state'.

The first phase within a Living Lab project can be labelled as 'exploration'. In terms of the New Product Development (NPD) process, this consists of moving from idea towards concept or prototype of the solution. In the language of entrepreneurs, this is the 'problem-solution fit' stage, as you identify the problem and fit your solution as good as possible with the problem. The main goal of this stage is to understand the 'current state'**.** This means getting an overview of the current habits and practices of users you want to target. A specific focus is put on the current problems they still face, taking into account the specific contexts in which these problems occur. This stage also can be considered as the 'pre-measurement' before the intervention, which takes place in the experimentation stage.

The second stage of the development process can be labelled as 'experimentation'. In the previous stage a certain solution or 'future state' materialized into a concept, this stage puts it to the test by developing and experimenting with a prototype. Specific for a Living Lab approach is the 'real-life' setting in which the testing takes place. In the experimentation stage, the innovation itself is presented as a prototype to the users in the form of a new solution, which potentially triggers new habits and new contexts of use. The goal of this 'intervention' is to understand user reactions and attitudes to the proposed solutions, and to also capture behaviour, which is made possible by having the testing take place in "as-real-life-as-possible" contexts. When a prototype is stable enough, the experimentation can take the form of an actual field trial. Summarizing, the experimentation stage puts the designed solution to the test, as much as possible in a real-life context, and allows a decision to be made on whether to head back to the exploration stage to iterate your solution, or whether to proceed to the evaluation stage.

The third and final stage consists of evaluating the innovation. As the exploration stage provided a benchmark regarding the ‘current state’ of the end-users, the experimentation stage simulated an envisioned ‘future state’ by means of an intervention. The evaluation stage enables to generate a ‘post-measurement’ of the intervention and compare it to the ‘pre-measurement’ benchmark, illustrating potential impact and added value created by the innovation. In terms of Open Innovation processes, this stage is aimed at exploitation. Exploitation entails purposive outflows of knowledge or technology, implying innovation activities to leverage existing technological capabilities outside the boundaries of the organization. By combining the pre- and post-measurement of the intervention, it should be possible to quantify the value proposition. This stage can also consist of the post-launch activities, where actual adoption and usage of the innovation is monitored in order to re-design or add new functionalities according to the needs of existing or new market groups.

For the implementation of Local Living Labs, the Action Plan considers the following actions:

- Selection of the good location in the University building where implement the LL
- Develop parametric survey /analyze or integrate the Energy Audit
- Homogenizing data of Energy Audit [common criteria for Med –EcoSuRe case studies]
- Contribute to define Baseline
- Contribute to Define and Finalize Common Protocol of monitoring
- Develop monitoring [spot – dynamic – seasonal]
- Manage sensor/devices and tool for energy data collecting
- Implementing pilot actions / selecting technologies and materials
- Interaction with energy manager /companies /stakeholder
- Implementing training activities and coaching

Local Living Lab 2.0 (optional)

An innovative idea for the development of Local Living Lab within the MCbLL is to combine physical and virtual data of the pilot buildings with a Digital Twin. The main purpose is to stimulate advanced participatory process, supporting with a BIM software the facility management and maintenance, enhancing their capability to plan and implement sustainable retrofitting scenarios, analysing and evaluating /technologies/performance/cost among the different Mediterranean climatic contexts.

The Digital Twin of the pilot building enters in the dynamics of the Mediterranean Cross-border Living Lab, adding an innovative approach to deal with the information occurring in the design, construction and management of the pilot buildings, supporting integrated processes that will enrich the Toolkit.

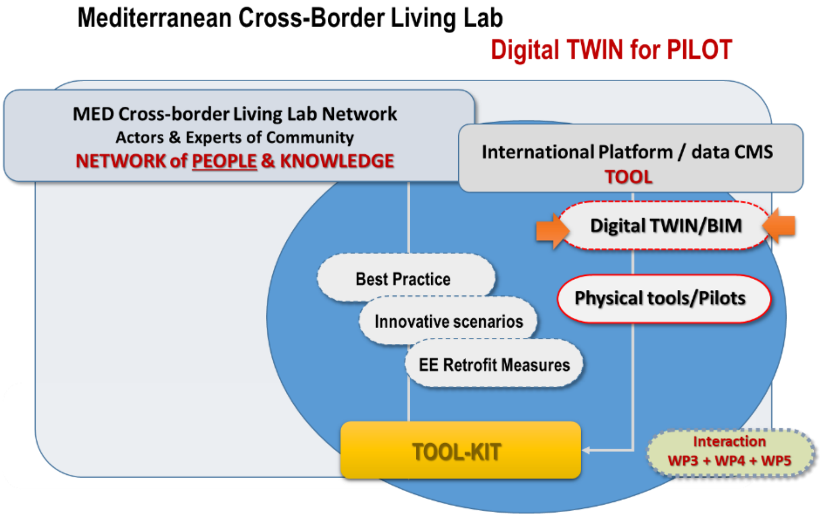

Figure 3 Digital Twin within the MCbLL

The management of the Digital Twin is parallel to the management of the physical place of the Local Living Lab, requiring the attention of the Technical Coordinator and the Multidisciplinary Team, who are in charge of the modelling of the Digital Twin of the LLL in order to create virtual scenarios of solutions and performances, also supporting IOT data management and behaviour evaluation.

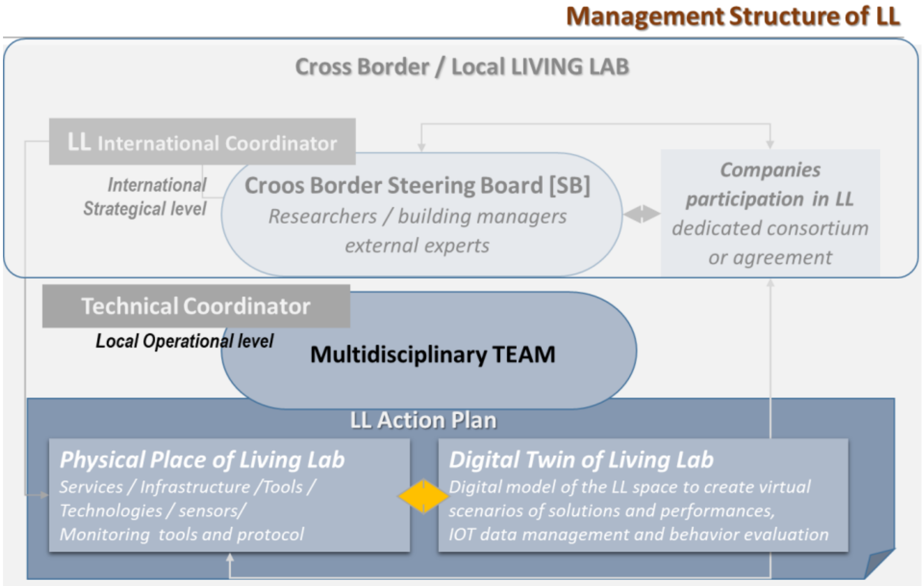

Figure 4 Management of the Digital Twin

The Digital Twin is defined by the BIM Dictionary as "a set of digital assets – models, documents and data sets - that mirror a physical asset for part/whole of the Asset Life Cycle. In the Construction Industry, a Digital Twin typically refers to a data-rich 3D model – of a building for example - that represents, reacts to, and can cause changes in the Physical Twin, the actual building. Through Asset Coupling, the connection between the two twins can be either one-way or two-way, synchronous or asynchronous, depending on their Coupling Level. Higher coupling – through two-way connectedness of BIModels with live sensors, cameras, scanners and Building Management Systems - allows a twin to adjust itself according to the information received from the other. As a simple example, opening a door in one, will open the door in the other. More useful examples include (1) the ability to utilise the Digital Twin to monitor and control the mechanical and environmental performance of its Physical Twin; and (2) the real-time synchronisation of digital assets to match any changes in corresponding physical assets".

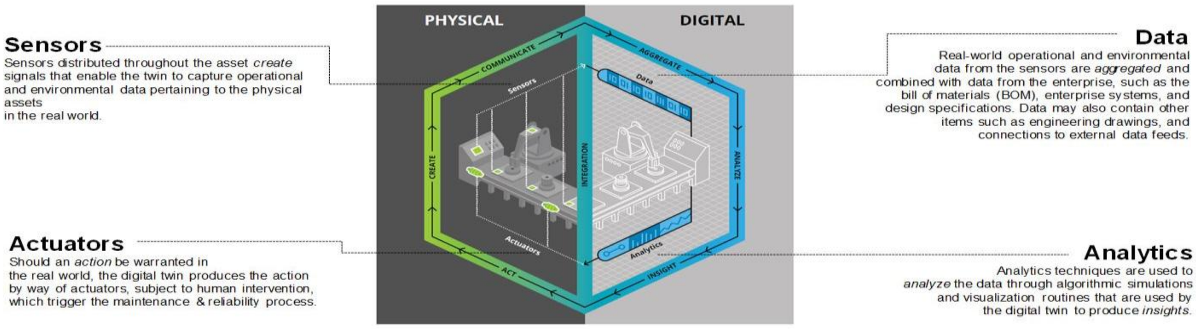

Figure 5 Representation of theDigital Twin

“At its simplest, a digital twin can be defined as a digital representation of a real-world asset or group of assets. However, digital twins potentially offer a much richer capability to model and analyse real-world systems and how they change over time. Digital twins are not based on any one technology. They require a combination of capabilities for data management, analytics, simulation, visualisation, and information sharing. Machine learning and advanced analytics combined with an understanding of real-world conditions (such as energy flows, environmental conditions, and material attributes) means digital twins can provide new insights into the behaviour of assets and infrastructure under current and future conditions. The ability to visualise this data in 2D and 3D models and over time makes the information accessible to many levels of user[1].”

The **Digital Twin of the Local Living Labs** has the objective to process, computing, obtain analytics and manage the information related to the physical pilot buildings and its renovation. In particular, the elaboration of the LLL Digital Twin permits to manage information on:

- 3d survey
- Historical LL operational data
- Real time LL operational data – monitoring elaboration
- Real time environmental data – monitoring implementation
- Data processing - data analytics – IOT data modeling
- Dynamic energy modeling
- End users data and feedback / behavior monitoring
- Energy retrofitting scenarios modeling and evaluation /stakeholder involvement
- Data visualization / communication /interaction
- Implementing training activities and coaching

[1]Woods, E. &Freas, B. (2019). Creating Zero Carbon Communities: The Role of digital Twins. Available at: https://www.iesve.com/support/white-papers/digital-twin-white-paper.pdf

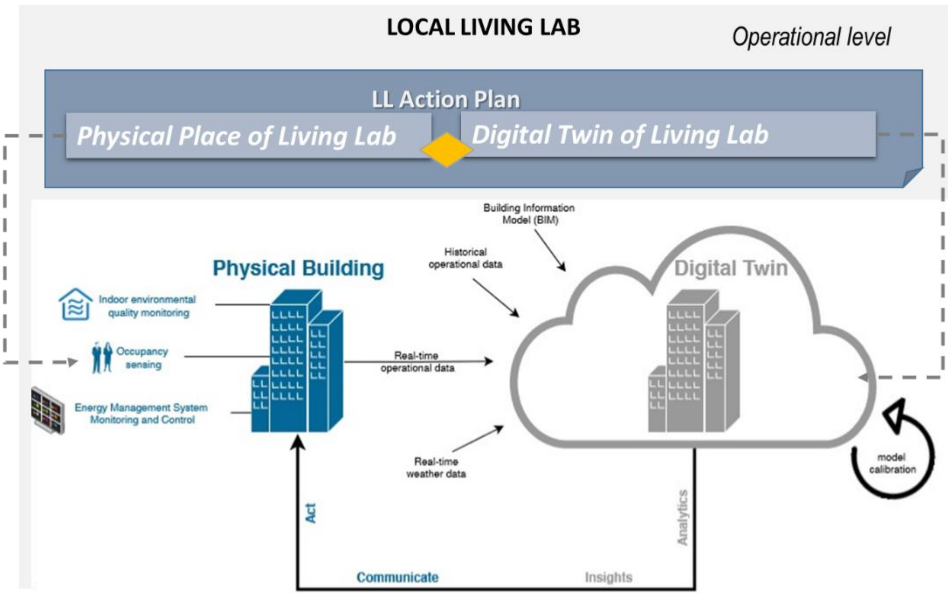

Figure 6 Digital Twin of the Local Living Labs

BIM technology has a great potential for further improving building efficiency. It might also deliver a broader, more holistic view that can support building management, as well as help in estimating total cost of ownership over the entire building lifecycle. For this to happen, more work is needed to integrate even more information on energy and operating characteristics. This is possible because the BIM model can include (or reference) all information on the building's structure and contents with the potential to receive all active data from sensors and any other IoT enabled devices. A digital twin can be used to analyze the building's behavior and ultimately define new control scenarios, adjusting the performance to the target.
The Digital Twin can be a static model, visual and geometric, presenting the global architecture, structure, and systems of the building, resulting in the sum of an architectural model, a structural model, a mechanical model, an electrical model, an energy model and a space model. Moreover, it is possible to enhance BIM possibilities, bridging with BEM [Building Energy Modelling], obtaining a Digital Twin as an operating and performance model. The Digital Twin has the potential to support building operation, if the static model is augmented with other types of information:

- Dynamic data coming from any sensor, meter, or smart equipment
- Construction and commissioning data (e.g. configuration, settings, etc.)
- Consistently updated product documentation

The Digital Twin of the pilot buildings represents predictive-control method that permits energy design and simulations. The building energy performance tools can be divided in two parts:

1. Design tools: these are meant to size the optimal mechanical and electrical systems, taking into consideration the worst-case scenarios
2. Simulation tools: these include dynamic simulation typically over a one-year duration. They will take three parameters into consideration: the building envelope, the equipment, and the control scenario. They are used to assess the energy demand, indoor environmental quality, carbon dioxide emission, payback periods of energy saving measures.

The different stakeholders can leverage the model specific to their usage and needs. This will result in benefits for all of them:

- Facility manager –The context provided by the model (place, technical geometry) is key information for operation, diagnostics, and maintenance
- Maintenance manager – active data on equipment status, alarms, and performance history can help reduce response time and enable predictive maintenance
- Asset manager – Space organization information can complement occupation ratio and energy consumption per zone to improve asset management
- Energy manager– Energy consumption per zone, floor, tenant, or equipment can help in allocating and optimizing costs

Summarising, combining actual building performance data with the as-built model can help inform future design decisions. This can include optimizing retrofits of the same building or optimizing overall design for similar new builds.

Annex I: LLL Action Plan Matrix

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Annex I - LLL ACTION PLAN MATRIX (UNIFI)

#	ACTIONS	Responsible	Contribution	Description	Resources	Milestones	Check	Notes
1	**COMPOSITION OF THE MULTIDISCIPLINARY TEAM**	Technical Coordinator		Selecting the components of the MT and determining their roles	Research fellows, researchers	Multidisciplinary Team	V	
2	**SETTING UP OF THE LOCAL LIVING LAB**	TC, Multidisciplinary Team		Selecting the physical meeting point of the LLL	Co-working rooms within the university site of the pilot building	Local Living Lab	V	
3	**IDENTIFICATION OF STAKEHOLDERS**	TC, MT		Exploring the national and local potential stakeholders	National and local research, mailing lists, contacts		V	
4	**IDENTIFICATION OF BEST PRACTICES**	MT	Students		Desk research		V	
4	**SELECTION OF THE PILOT BUILDING**	TC, MT	University officers, building managers,	Identifying the building object of renovation	University buildings	Pilot Building	V	
5	**DIGITAL TWIN (OPTIONAL)**	MT	University officers, software houses, experts	Setting up of the digital model of the pilot building (information enrichment)	Survey tools for existent building, BIM software	Digital Twin of the pilot building	V	
6	**ENERGY AUDIT**	MT	Esco, university officers	Reporting the pilot building energy behaviour	Facility management documents	Energy audit of the pilot building	X	
7	**MONITORING**	MT	Energy experts	Monitoring the building behaviour with physical measures and users' perception	Sensors, users (interviews)	Perceived and real behaviour of the existing pilot building	X	
8	**PROJECT**	TC, MT		Designing a project for the renovation of the pilot building	BIM software	Integrated design solution for the renovation of the pilot building	X	
9	**SIMULATIONS**	TC, MT	Experts, software houses	Simulate various renovation scenarios	Energy software	Scenarios simulations	X	
10	**REALIZATION**		Construction companies	Construction works on the pilot building	Construction	Renovation of the pilot building	X	
11	**POST-INTERVENTION MONITORING**	TC, MT	Energy experts	Monitoring the building behaviour with physical measures and users' perception	Sensors, users (interviews)	Perceived and real behaviour of the renovated pilot building	X	
12	**COMMUNICATION AND DISSEMINATION**	TC, MT	Communication Lab (eventually)	Communication of LLL activities and results to all the stakeholders	Mailing lists, printed materials	Constant contact with stakeholders	V	