Toolkit for Innovative and Eco-sustainable **Renovation Processes**

Toolkit

Med-EcoSuRe

Mediterranean University as Catalyst for Eco-Sustainable Renovation

The *Toolkit for Innovative and Eco-Sustainable Renovation Processes* has been developed in the framework of the Med-EcoSure project - Mediterranean University as catalyst for Eco-Sustainable Renovation, by the beXLab (building environmental eXperience) Living Lab and research group at the Department of Architecture [DIDA] of the University of Florence.

The Toolkit has been delivered as output of the Med-EcoSuRe project in **November 2022.**

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Introduction

The **Toolkit for Innovative and Eco-Sustainable Renovation Processes** is a comprehensive output produced within the **Med-EcoSuRe project** - *Mediterranean University as Catalyst of Eco-Sustainable Renovation* (financed by the ENI CBC MED Basin Programme 2014-2020) by the research group **beXLab** (building environmental eXperience) settled in the Department of Architecture (DIDA) of the University of Florence (UNIFI).

The Med-EcoSuRe project aimed at generating and implementing innovative and eco-sustainable energy renovation solutions in **Mediterranean higher education buildings**, acting as a beacon of light for the widest renovation of public buildings in the Mediterranean region.

The Toolkit emphasises the benefits of adopting a **Living Lab** methodology to explore **novel forms of collaboration** among **academics, decision-makers and stakeholders** to support **university building and energy managers** in the planning and execution of sustainable retrofit initiatives for higher education buildings, replicable in public buildings (e.g. schools).

The contents of the Toolkit draws from two main levels explored by the project through the Living Lab approach: the regional Mediterranean context and the local one.

At *Mediterranean level*, an intense exchange of experiences occurred within the Med-EcoSuRe initialised cross-border Living Lab - "**Med beXLive**", connecting an excellence **network of experts** in the field of **energy renovation of Mediterranean public buildings**;

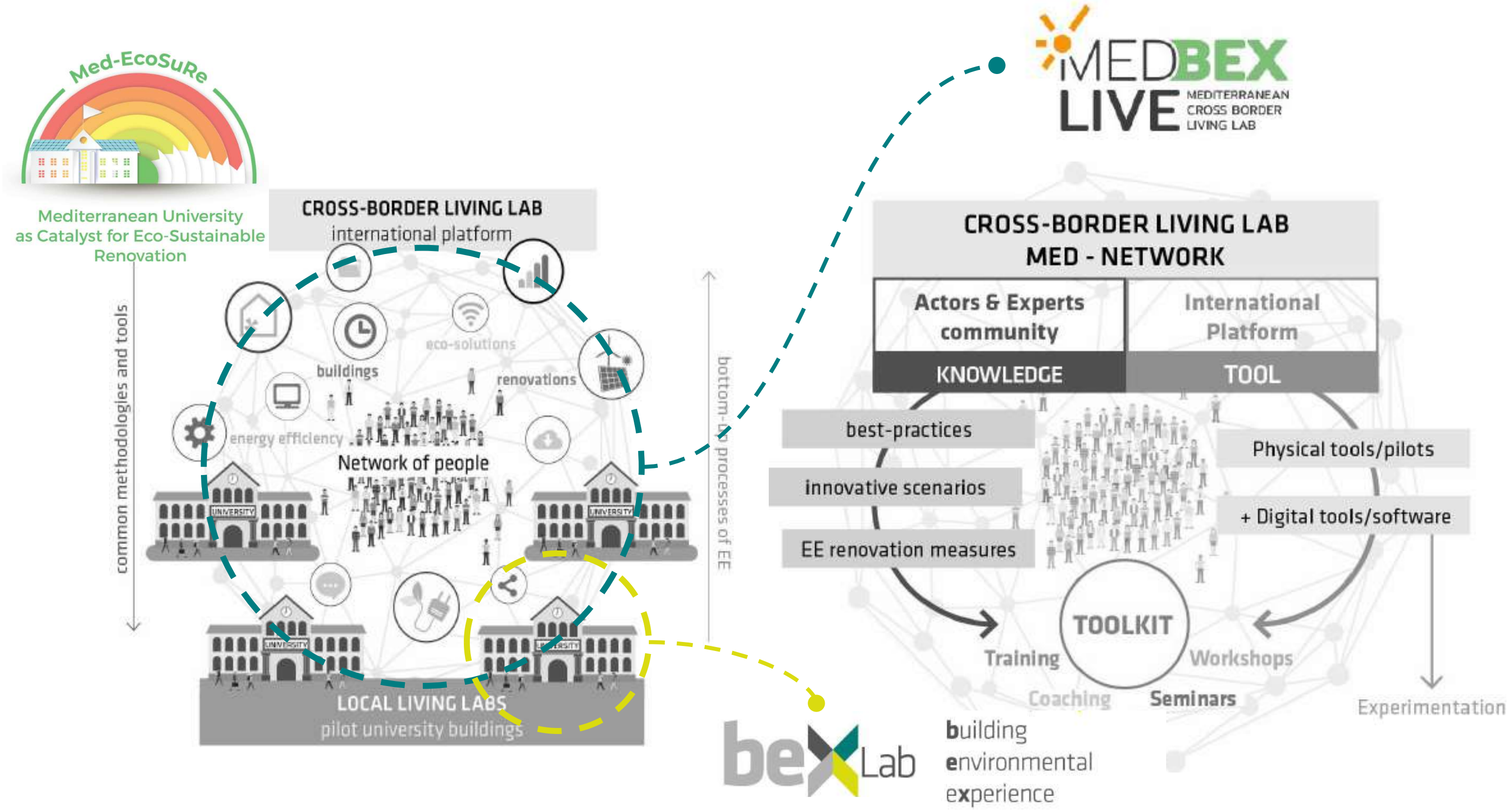
At the *local level*, insights were gained from the experience of a new activated Living Lab in the School of Architecture (DIDA-UNIFI) by the project, the beXLab, where a pilot renovation action has been implemented.

Looking at universities as the most **fertile ground** and appropriate **testing space** to raise open innovation, the project adopted a Living Lab approach as a means to experiment how to overcome the weak implementation and the fragmentation of retrofit processes in Mediterranean public buildings.

For their innate nature of **education, research and technological transfer**, universities are the ideal place for innovation, as innovation hubs, consenting to capitalise the academic knowledge, the know-how and expertise of the local network of stakeholders (companies, public administrations), and offering students the opportunity to actively engage in real-world innovation within the familiar setting of the university building.

The core concept behind the adoption of the Living Lab approach is to exploit **university buildings as living laboratories** not only to trial innovative retrofitting processes, technologies and approaches for **technicians** (university, researchers, students as future ones and stakeholders), but as an occasion to educate the **end-users** community of students towards the sustainable buildings of the future.

The main idea behind the Med-EcoSuRe project is that the implementation of more innovative and eco-sustainable renovations of public buildings in the Mediterranean area can be supported by the creation of university-based Living Labs, where the university community, as a **little society**, can co-experiment innovative processes, strategies and technologies. Exploiting the Living Lab methodology, the retrofit process can be addressed through more collaborative approaches among academics (interdisciplinary teams), decision makers (university building and energy managers), stakeholders (companies, professionals) and with the strategic involvement of end-users, starting from the young generation of students as future technicians/professionals and, above all, citizens. By treating the renovation process as an innovation process, the university community can explore, experiment, and evaluate the best retrofit scenario for the university building.



With the objective to guide the initialization and experimentation of renovation-oriented Living Labs, this Toolkit strives to stimulate more inclusive and collaborative processes in order to overcome bureaucratic and administrative barriers, regulatory and planning issues, institutional, structural and multiple stakeholders bottlenecks slowing and limiting the renovation effort. Moreover, it looks forward to advancing awareness on the benefits deriving from building renovations: economic and financial (e.g. energy cost saving), but also societal (e.g. increased comfort,wellbeing health) and environmental (e.g. carbon savings).

Given that it is mainly written by architects, the Toolkit sustains the value of architectural quality as a combination of aesthetics, appropriateness to the local context and sustainability both for humans and the environment.

What

The Toolkit is a guide to **innovate the renovation process of university/public buildings in the Mediterranean area**, containing **information, procedures, tools and tips** to **co-envision, co-design and co-use energy efficient, eco-sustainable, comfortable and beautiful future buildings.**

Considering renovation as an innovation process, the Toolkit is based on a **Living Lab approach**, opening the renovation to the university, local and global community

Who

The Toolkit is firstly dedicated to **university building and energy managers** willing to innovate the renovation processes of university buildings, but also to **the university and local community of students**, researchers, innovative companies engaged through the Living Lab

How

The Toolkit is organised in **sequential phases** (0 to 5) encompassing the **whole renovation process**, from the initialization of a Living Lab entity to the management of the renovated university building, passing through the acknowledgement of renovation challenges and co-creation of opportunities in collaborative **planning and design** processes

Toolkit Structure

The Toolkit is designed as a comprehensive guide explaining, step by step, how to approach the retrofit of university/public buildings as an innovative process built around the role of people (decision makers, stakeholders and users). It accomplishes this by providing an organised set of methodologies and tools aligned with the most ambitious European Union goals for a green (and digital) transition, and tailored for the Mediterranean socio-climatic and cultural context.

The renovation process has been divided into 5 main phases (knowledge framework, analysis of criticalities, planning and design, intervention and post-management), introduced by a phase zero dedicated to the setting up of the university Living Lab.

For each phase, the Toolkit identifies:

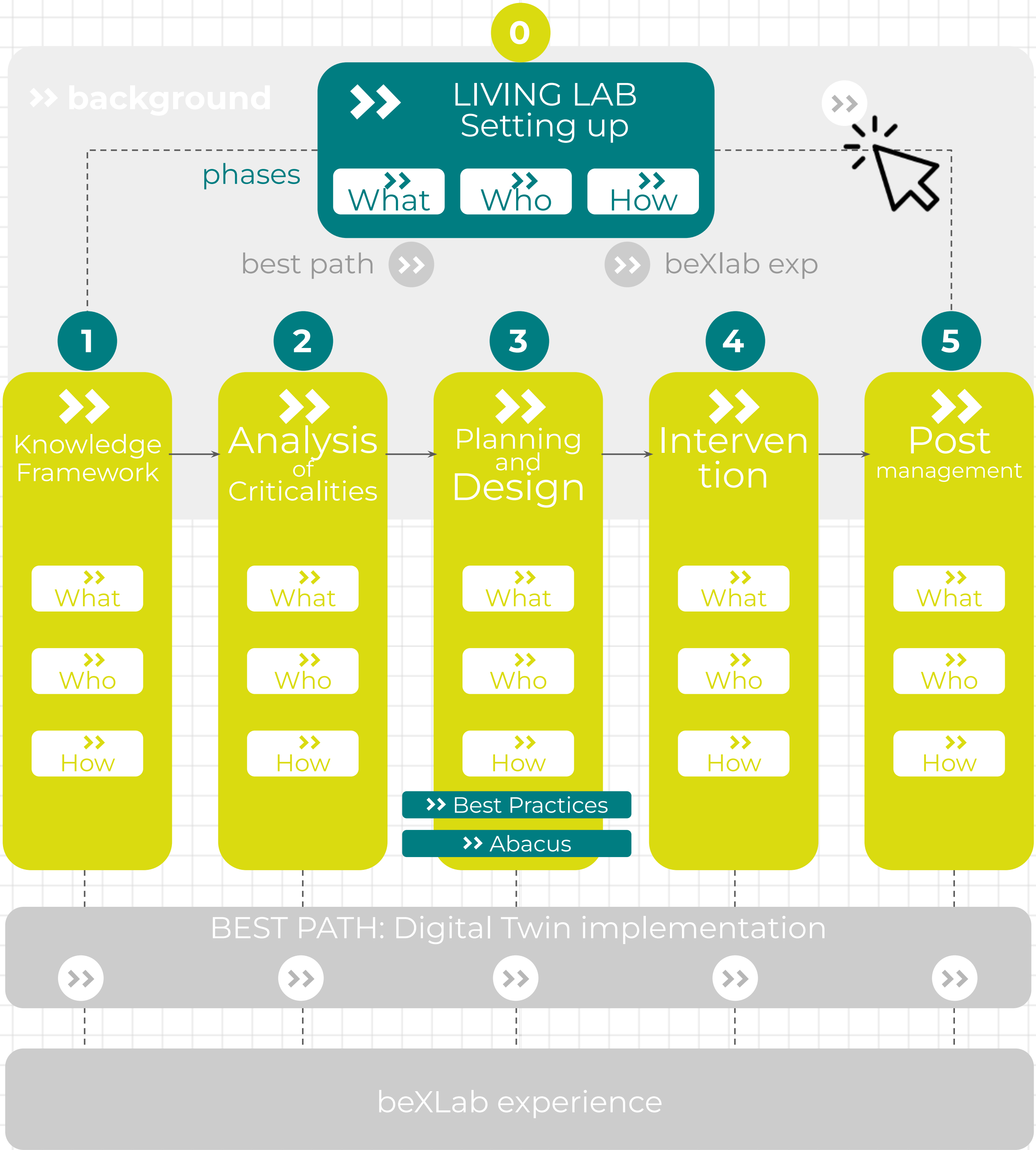
- ➔ activities to be undertaken (what)
- ➔ people to engage (who)
- ➔ methodologies and tools for the implementation (how)

Two sessions run parallels to the progression of the renovation phases:

- ★ Digital Twin BEST PATH - on the digital potential to innovate the renovation process;
- ★ beXLab EXPERIENCE - on the Toolkit application in the real-case pilot renovation action in the School of Architecture of the University of Florence.

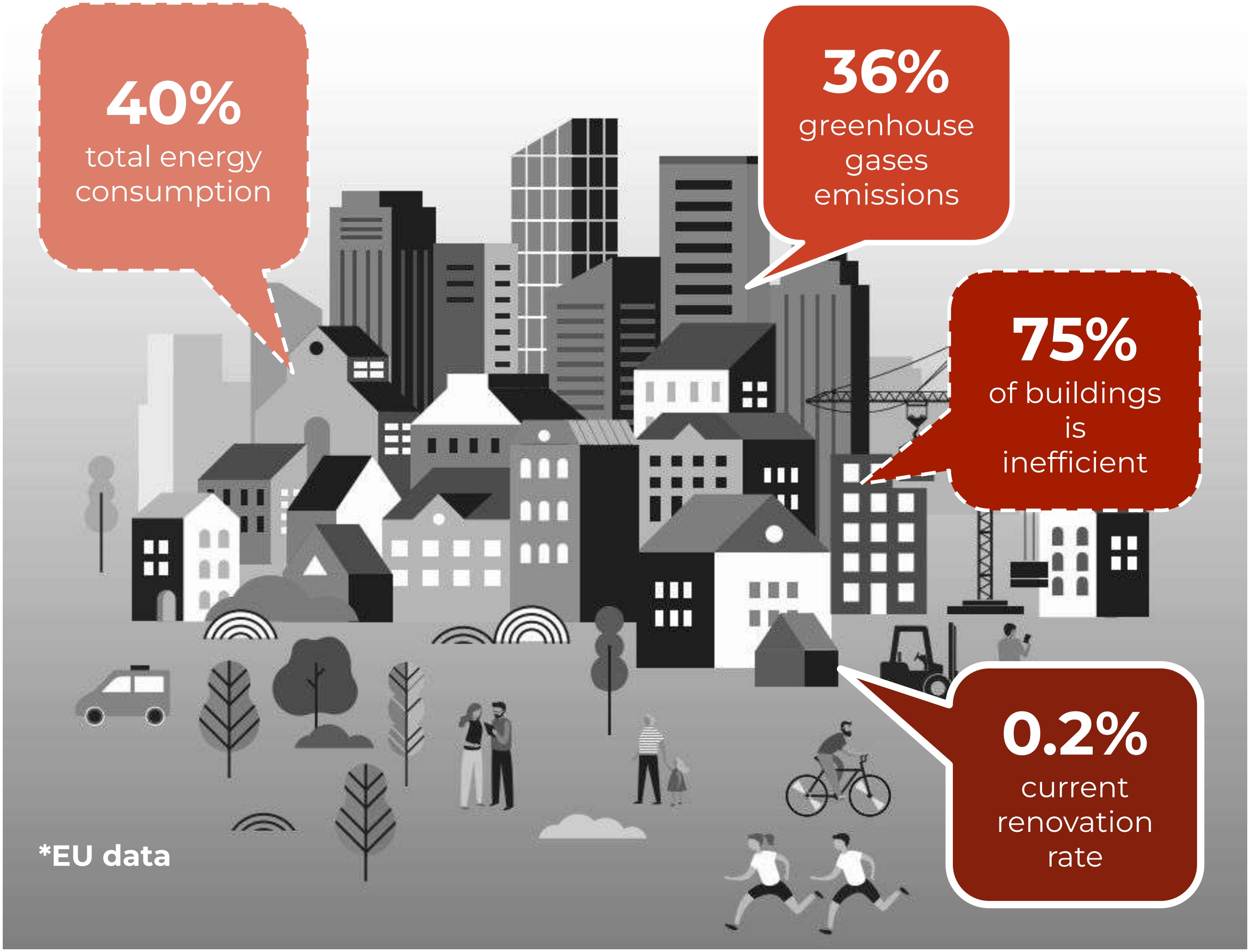
The central renovation phase of "planning and design" has been enriched with two additional resources more focusing on architectural aspects:

- a best-practices catalogue of recently renovated and newly constructed high educational buildings, selected for the innovation of the energy efficiency solutions adopted;
- an Abacus of retrofit solutions for the Mediterranean socio-climatic and cultural context, guiding the selection of the most appropriate renovation strategies, technologies and materials.



0
background
LIVING LAB
Setting up
phases
What
Who
How
best path
beXlab exp
1
Knowledge Framework
2
Analysis of Criticalities
3
Planning and Design
4
Interven tion
5
Post management
What
Who
How
Best Practices
Abacus
BEST PATH: Digital Twin implementation
beXLab experience

Background



40%
total energy consumption
36%
greenhouse gases emissions
75%
of buildings is inefficient
0.2%
current renovation rate
*EU data

Reflecting global trends, in the European Union buildings are responsible for roughly 40% of energy use and 36% of energy-related greenhouse gas emissions, positioning them as the largest energy consumers.

BUILDING ENERGY RENOVATION is the process of intervening on the existing building through the integration of strategies and mix-of-technologies in order to achieve energy efficiency.

Despite the 20 years-old Energy Performance Building Directive (EPBD 2002, recast in 2010, amendment in 2018 and actually under revision), nowadays approximately **75% of the EU building stock remains inefficient**; moreover, low renovation rates determine a **priority**. The evolution of the EPBD across years highlights the progressive attention on the rehabilitation of existing building stocks, with even deeper renovations required to reach nearly zero-energy targets (i.e. buildings requiring nearly zero or very low amounts of energy, covered by renewable energy sources).

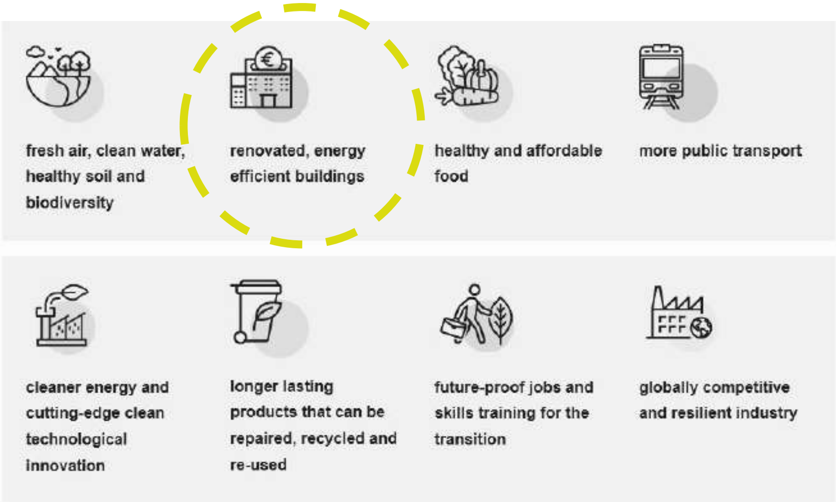
In more recent years, in the context of the ambitious **European Green Deal** aiming to cut 55% of greenhouse emissions by 2030 and to reach **climate neutrality by 2050**, the EU Commission launched the **Renovation Wave** strategy, requiring an anticipated revision of the EPBD to set out how to achieve a zero-emission and fully decarbonised building stock. The strategy emphasises the principle of "energy efficiency first", and addresses the objectives of decarbonization and integration of renewables, life-cycle thinking and circularity, high health and environmental standards, also considering architectural quality and aesthetics. The strategy also expresses the need, and opportunity, to tackle together the **twin challenges of the green and digital transition**, promoting digitally friendly renovations.

The EU approach to building renovations underlines the possibility of taking the maximum contribution from energy rehabilitations, not only in terms of energy savings and environmental impacts (reduction of energy consumption and of greenhouse emissions), but also considering the wider benefits related to health and comfort for occupants, improving living conditions and promoting more sustainable lifestyles. This approach also aligns with the EU Commission initiative **New European Bauhaus**, which fosters creativity and transdisciplinarity in designing sustainable living spaces, inclusive and beautiful.

Occurring in the building lifecycle, the renovation process starts with the acknowledgement of the energy performance levels, as a basis to determine cost-effective improvements scenarios. All buildings have the potential to be renovated for enhanced energy efficiency, eco-compatibility, improved comfort for occupants and architectural quality; discovering and exploiting this potential is the objective of the renovation process. The evaluation of integrated improvement scenarios can be enabled by the adoption of digital technologies, playing a strategic role in supporting more reliable and collaborative renovation processes.

From a practical point of view, the financial investment on energy renovations is secured when the cost of the intervention can be amortised in a proper span of time by the reduction of energy consumptions. The calculation of energy savings is central in the renovation process, requiring the assessment of the energy performance of the existing building and the comparison with the ones achievable in the retrofitted building.


EUROPEAN
GREEN
DEAL

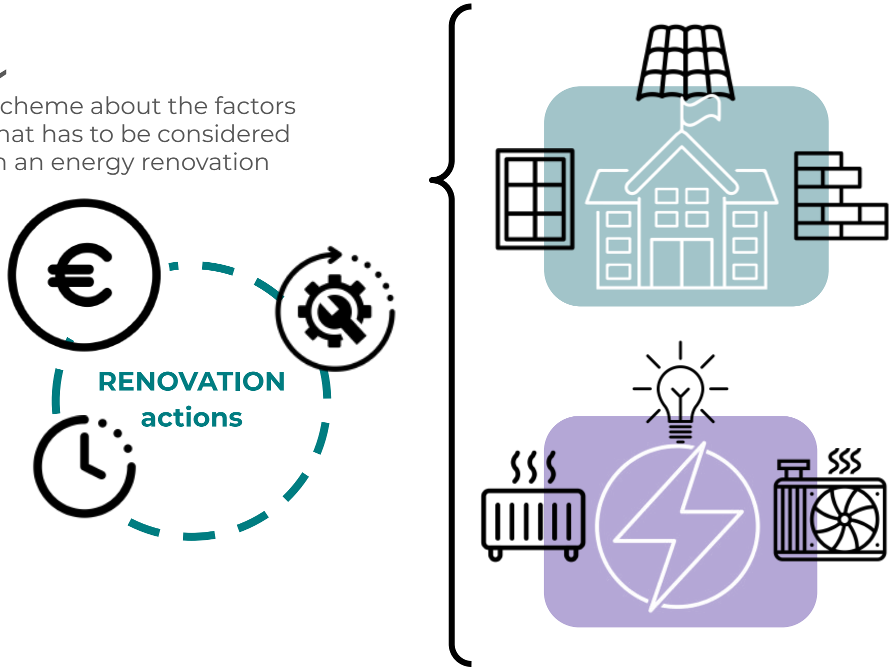

fresh air, clean water, healthy soil and biodiversity
renovated, energy efficient buildings
healthy and affordable food
more public transport
cleaner energy and cutting-edge clean technological innovation
longer lasting products that can be repaired, recycled and re-used
future-proof jobs and skills training for the transition
globally competitive and resilient industry


RENOVATION
WAVE
BUILD
UPON²


#NewEuropeanBauhaus

According to EPBD directive, building energy performance are based on the assessment of the building/plant system, referring to quantitative parameters mainly related to the performance of the envelope (e.g. thermal transmittance) and to the efficiency of the different energy supply systems (heating, cooling, ventilation, lighting and domestic hot water). Focusing on numbers, this approach tends to overlook the contribution of other interrelated aspects, such as the role users' and the architectural quality.

The renovation of university/public buildings typically relies on the expertise of technical officers managing building and energy portfolios, or are outsourced externally to professionals, dedicated companies or ESCO. In both cases, renovations often prioritise economic-financial objectives, aiming to reduce energy expenses swiftly to ensure a prompt return on investment. In practical terms, investing in energy renovations is a sound decision when the renovation costs can be recovered within a reasonable timeframe through reduced energy consumption.



Scheme about the factors that has to be considered in an energy renovation

The Renovation challenge

Outlined by the EU directions, the need to look beyond energy efficiency can be addressed by **co-design processes**, core of the Living Lab approach, leveraging the design culture and creativity to guide the development of more ambitious renovation scenarios valorizing the role, needs and contribution of people.

Aligned with the EU background and directives, four overarching renovation objectives are delineated:

ENERGY
Reduction of energy needs

Renovations primarily aim to diminish the building's energy needs, so that the low energy requirements can be fully satisfied by renewable energy sources.

ARCHITECTURE
Enhancing architectural quality

Renovations present an occasion for aesthetical requalification of existing buildings, with architectural excellence contributing to the communication of sustainability.

ENVIRONMENT
Minimising environmental impact

Ambitious renovations seek to reset the carbon footprint of buildings, mitigating the environmental impacts, starting from the integration of renewable resources.

COMFORT
Elevating comfort and wellbeing

Renovations improve the indoor environmental quality of existing living spaces, contributing to occupants' comfort, wellbeing and health.

go BACK

Transversal to the renovation objectives, and more related to people than to buildings, two interrelated approaches/paths can support more collaborative, inclusive and innovative processes, essential for tackling the complexity of contemporary renovation challenges:

Goals of building renovation projects

TOGETHER

Empowering people's the proactive role and behaviour

Encouraging more collaborative interactions among renovation stakeholders, and engaging end users in the co-design and "aware use" of sustainable university/public buildings, as the best approach;

DIGITALLY

Untapping the digital potential

Adoption of digital technologies (from BIM to Digital Twin) to sustain more collaborative, reliable and sustainable renovation processes, as the best path.

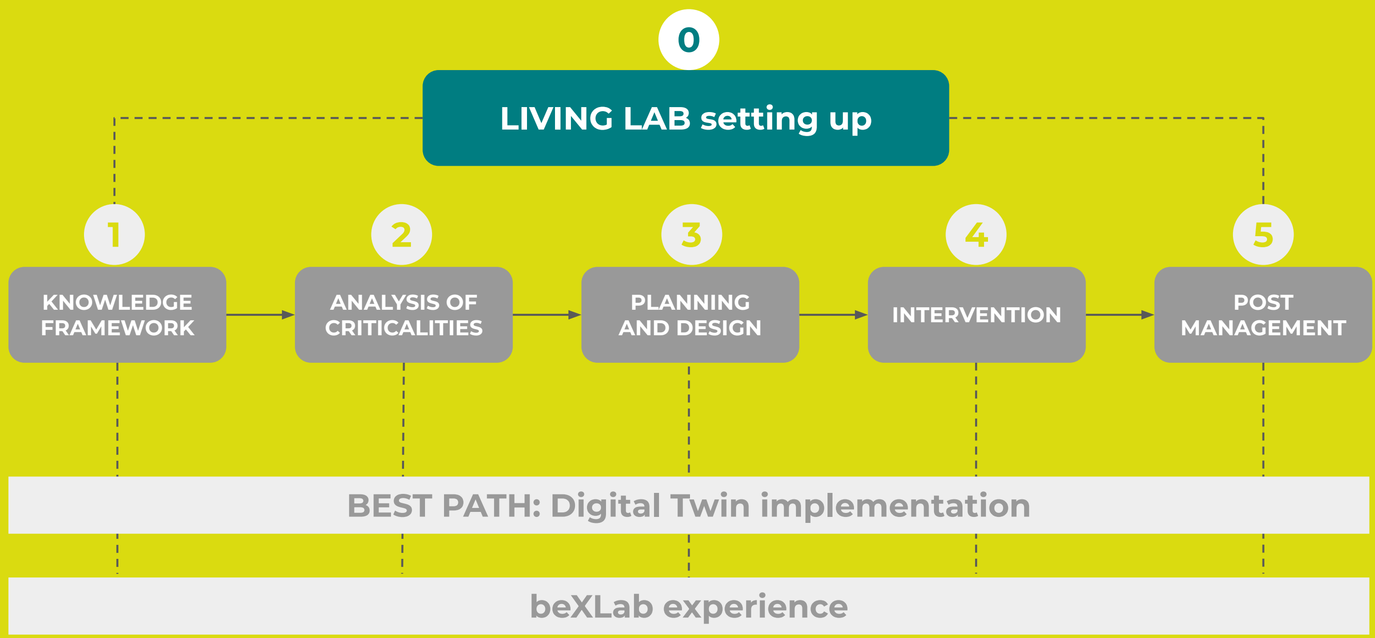
Phase 0
LIVING LAB setting up

The phase zero of the Toolkit provides guidance in the setting up of university-based Living Labs working on the innovation of energy renovation processes in public buildings.

WHAT definition of the Living Lab approach and why it is congenial to innovate the renovation of public buildings

WHO individualization of people to involve in the university LL in order to sustain the innovation process

HOW steps to be followed for the creation of a university LL working on energy renovations.



The main idea behind the adoption of the Living Lab approach to innovate the renovation of public buildings is that working with stakeholders and users in participatory processes can produce more sustainable solutions.

Living Labs (LLs) are defined as **"multi-stakeholder organisations set-up to carry out innovation projects that follow the principles of open and user innovation and focus on real-life experimentation"** [EnoLL- European Network of Living Labs].

In the last decades, LLs are growing worldwide as collaborative platforms for research, development, and experimentation of product and service innovations in real-life contexts, based on specific methodologies and tools, and implemented through concrete innovation projects and community-building activities.

The key guiding principles of the LL approach can be summarised in the following 5 points:

1. **MULTI-STAKEHOLDER PARTICIPATION** {e.g. **University + Local Community**} even if the LL focus is on users, involving all relevant stakeholders is crucial. These include representatives from the public and private sectors, academia and people, following the quadruple helix model;

2. **USER ENGAGEMENT** {e.g. **Students + University Community**} the key to success in any activity is to involve the users since the beginning of the process;

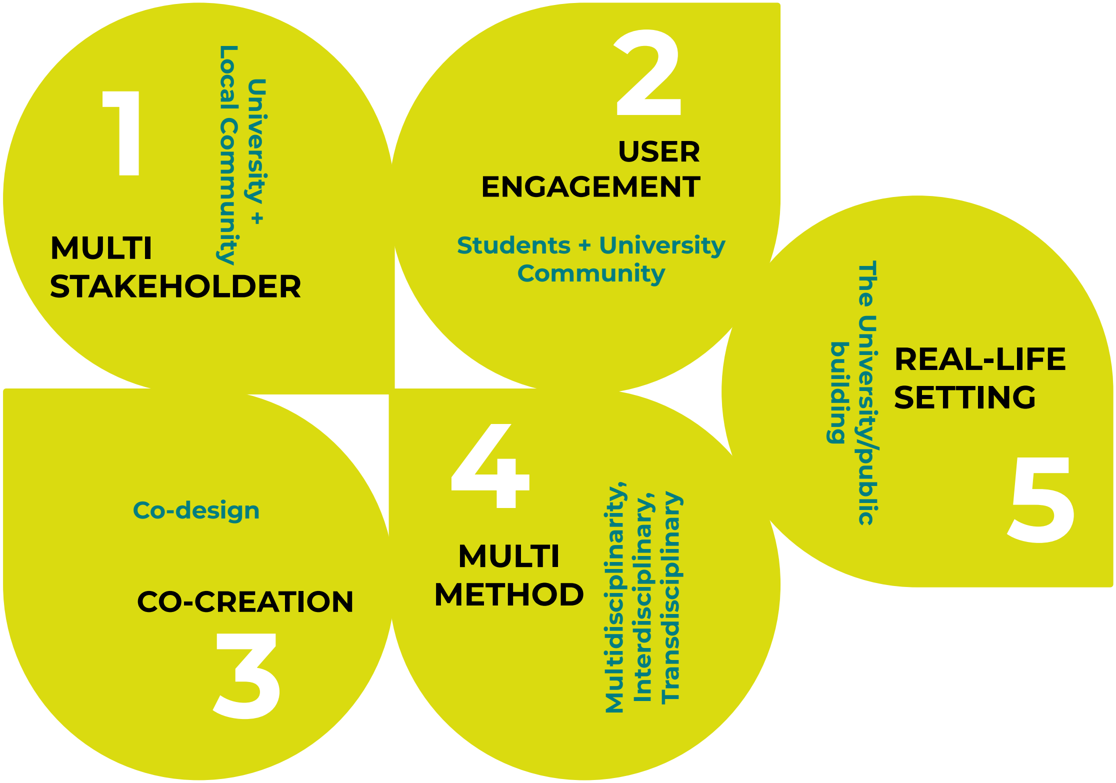
3. **CO-CREATION** {e.g. **Co-design**} traditionally, especially in technology projects, activities are designed as top-down experiments, with users seen as mere factors rather than active participants. There is an increasing recognition that this approach needs to evolve, with users and stakeholders becoming equal contributors and co-creators rather than subjects of studies;

4. **MULTI-METHOD APPROACH** {e.g. **Multidisciplinarity, Interdisciplinarity, Transdisciplinarity**} there is no single LL methodology, but all Living Labs combine and customise different user-centred, co-creation methodologies to best fit their specific purposes;

5. **REAL-LIFE SETTING** {e.g. **the university/public building**} the main characteristic of Living Labs is that activities take place in real-life settings, in order to gain comprehensive insights from the context.

1.There is a wide scientific literature on Living Labs, which is growing in the energy field: in the SCOPUS repository, more than 1200 documents have "living lab" as keyword, with 139 in the subject area of "energy".

Five principles of the LLs



The success of Living Labs is based on the improved c**ommunication and collaboration between the people involved in the process under investigations, whose synergies activate the co-creation of innovation.** Within the LL methodology, at least **four primary roles** uphold the innovation process: promoters, stakeholders, users and customers.

- Promoters: activate the LL;
- Stakeholders: are involved in the Living Lab process, since they are considered useful to contribute;
- Users: are involved in real life testing of the LL proposed solution;
- Customers: beneficiaries from the LL results.

Despite the role differences, individuals may assume various roles simultaneously; for instance a stakeholder might also act as a user and a customer, participating in the development and benefiting from the proposed solution. In the context of LL working on the innovation of the energy renovation process in university/public buildings at least **5 main figures** can be engaged in the co-creation:

- researchers (as promoters)
- building/energy managers (as customers)
- companies and public organisations (as stakeholders)
- students (as users).

All the people involved in the Living Lab can contribute to its success in terms of innovation co-created, and in turn they can benefit from the LL approach in different ways. For each figure involved, the following list describes the roles, their contribution to the Living Lab and the benefits they can achieve from.

PROMOTERS/ENABLERS

Researchers:
The first nucleus of innovators is composed by researchers and experts in the interdisciplinary field of energy renovations (e.g. architects, energy engineers, technical physicists, construction engineers). Thanks to their consolidated theoretical knowledge, developed skills and research experience, they are in charge to select and guide the experimentation of innovative methods and tools coming from the advancements in literature, in order to test them in the real-life context together with stakeholders and users. As a return, researchers can deepen their theoretical investigation and get study cases, with the unique opportunity to experiment in the real-life context of the Living Lab and to have access to a new amount of data. Existing concepts in the different research units involved are merged and evolved to create a starting point toward a common vision, guiding the LL activities. The activation of the LL and its visibility in the university context will stimulate the participation of other disciplinary research groups, representing a fertile ground for interdisciplinary research.

CUSTOMERS

University Building and Energy Managers:
university/public managers (intended as building and energy managers and technicians) are traditionally considered as passive technical or administrative subjects, to whom new approaches and solutions are simply proposed. Thanks to the LL approach, and to the support of researchers, university/public managers can become active players and innovators themselves, contributing to the co-creation and experimentation of emerging ideas, breakthrough scenarios and innovative concepts. University/public managers, and their relative technical offices, are involved in the Living Lab for a double scope: from a side, they can contribute to the LL with their expertise in facility management and, from the other side, they can benefit from the LL with innovative methods and tools to improve their work and get solutions adapted to their specific needs: as beneficiary of the LL results, university managers can be considered as customers.

END-USERS

Students and University Community:
As young and future generations of professionals and citizens, students represent the principal group of end-users of university buildings, daily living university spaces.They are called to co-create innovation giving feedback on the different aspects related to the university building. Students in the disciplinary fields of renovation processes (e.g. architecture, energy engineering, technical physicists) can particularly contribute and take advantage of the LL thanks to their involvement in co-design processes; for this reason, they can also be labelled as customers, since they can acquire new knowledge, competences and skills participating to the LL activities (e.g. workshop). In general, all university students/users can benefit from the engagement in the LL by acquiring knowledge and awareness on energy efficiency and sustainability issues.

STAKEHOLDERS

Public Organisations:
A wide range of public organisations can be involved in the LL according to their role in relation to the energy renovation process (e.g. ownership, administration, authorization, sensibilization). Independently to their focus, public organisations can get increased concern on the issues co-identified by researchers and building/energy managers, augmenting knowledge and awareness for the evolution of policies and practices. The outcomes of the LL can be exploited by public organisations in charge of the management of public buildings stocks to approach in innovative ways their renovation, as the basis for the definition of more sustainable public buildings.

Companies:
Spanning from products to services, large companies, SMEs and startups play an enabling role in the LL, concretising the ideas of innovators through the creation of new soft and/or hard technologies, to be tested in the LL context exploiting the involvement of users. Thanks to the experience in the reference market, companies have the know-how, as well as the tools, to realise the innovation produced in the LL

Companies can contribute to the LL by making available their know-how, experience and tools for the purpose of the LL experimentations (e.g. definition of prototypes); at the same time, they can benefit from the LL to improve their knowledge on innovative technologies for the definition of innovative products and services; finally, companies can take advantages of entering in the excellence and cross-border network of LL, enlarging their geographical area of action.

METHODOLOGY

Living Labs are based on a quasi-experimental approach, with a pre-measurement, an intervention and a post-measurement, where the intervention is equalled to a real-life experiment. The LL methodology follows three main phases of innovation development:

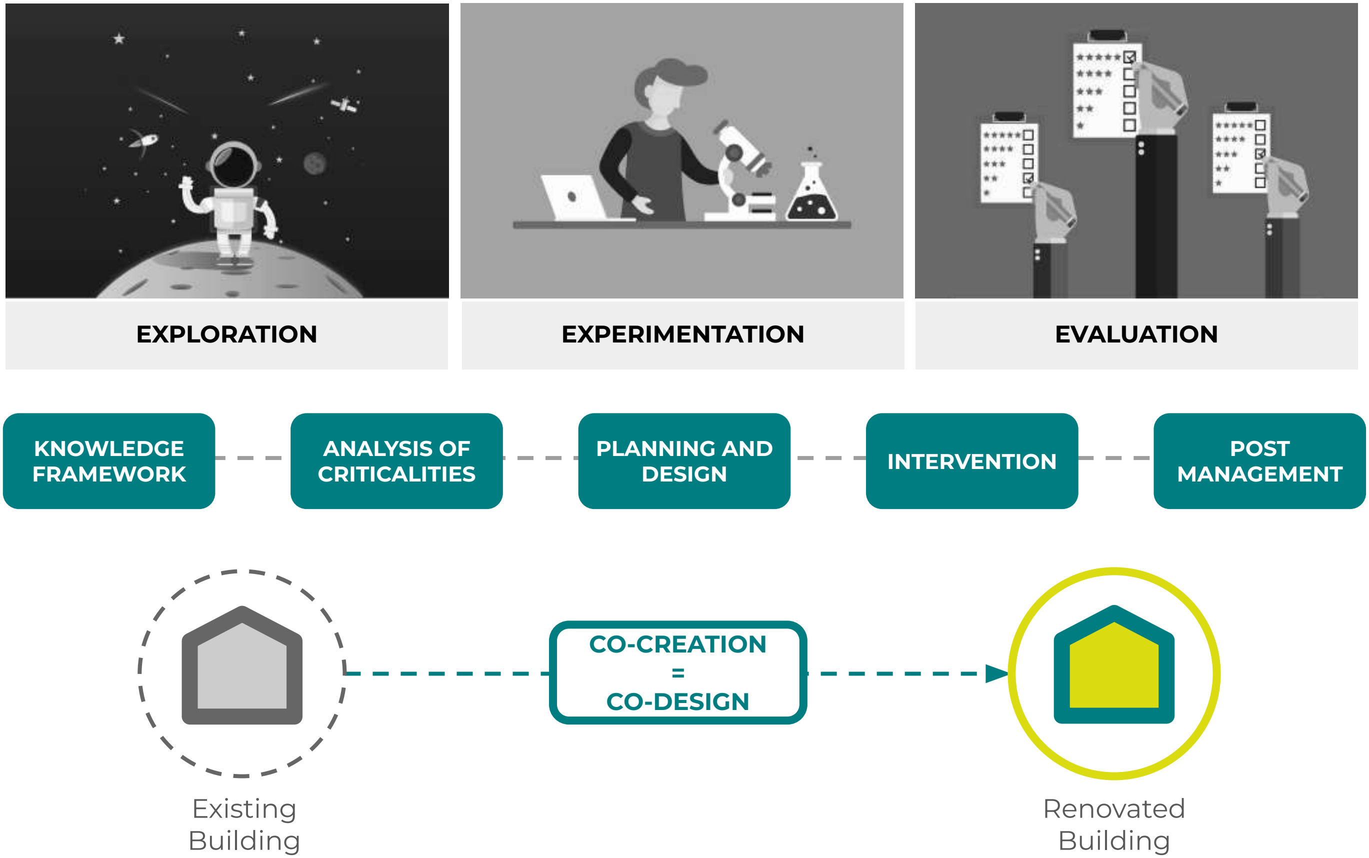
- **Exploration:** getting to know the 'current state' and designing possible 'future states';
- **Experimentation:** real-life testing of one or more proposed 'future states';
- **Evaluation:** assessing the impact of the experiment with regards to the 'current state' in order to iterate the 'future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

In the case of LLs working on building renovation processes, it is possible to assimilate the same renovation to an innovation process, with the three methodological phases coinciding with the acknowledgement and analysis of the existing building (exploration), the co-planning and co-design (exploration) and finally the assessment and dissemination of the implemented renovation measures (evaluation).

1) EXPLORATION: The main goal of this stage is to understand the 'current state', the actual conditions characterising the problem/situation focus of the LL: this means to get an overview of the current habits and practices of targeted users. The objective is to put attention on the current problems, taking into account the specific contexts in which problems occur. Techniques like observation, participation, and in-depth interviews help the comprehension of existing problems and latent needs. This leads to the definition of opportunities for improvement of the 'current state', consenting to envision possible 'future states'. Through brainstorming, ideation and co-creation techniques, all the ideas and options can be materialised into concrete concepts, which will become objects of the co-creation/co-design phase.

In terms of Open Innovation, exploration is defined as purposive inflows of knowledge or technology, aimed at capturing and benefiting from external sources of knowledge to enhance current technological developments. The exploration stage also provides a benchmark of the 'current state', allowing the assessment of potential impacts and effects of the experimentation stage, and consenting to measure the effects of the innovation. Therefore, this stage also can be considered as the 'pre-measurement' before the intervention, which takes place in the experimentation stage.

In building renovation processes, the exploration phase corresponds to the global assessment of the energy and environmental conditions of the existing building, converging in the definition of a complete **"Knowledge Framework"** (Phase 1), as basis for an exhaustive **"Analysis of Criticalities"** related to the building energy, environmental, comfort and architectural aspects (Phase 2), thus revealing the problems to address in the following experimentation phase.



2) EXPERIMENTATION: In the prior exploration stage, some solutions or 'future states' have been materialised into concepts: the experimentation phase puts them to test (by developing and experimenting, for example, with a prototype). What distinguishes the Living Lab approach is its testing within authentic, real-life settings. The degree in which 'real-life' can be attained is linked to the maturity of the design. Prototypes can take on many forms, from tangible MVPs (Minimum Viable Products) to intangible services or experience design prototypes, with the main goal to facilitate the testing of the possible 'future states'. During this stage, innovation is presented as a prototype to the users in the form of a new solution, potentially triggering new habits and improved contexts.

The goal of experimentation is to understand users' reactions and attitudes towards the proposed solution, alongside capturing behaviour, which is possible by having the testing take place in "as-real-life-as-possible" contexts. Depending on the maturity level, interventions can regard proxy technology assessments, user experience testings, or actual field trials.

When a prototype reaches a stable state, experimentation might progress to an actual field trial. Depending on the possibilities, the testing can be short to longer term, involving a few to numerous users, and may encompass specific or comprehensive aspects of the solution. In terms of techniques, one should focus on unobtrusive techniques to capture the concrete user behaviour with the solution ('doing'), rather than solely relying on what people 'say', and/or the contrary, according to the specific experimentation.

Summarising, the experimentation stage puts the designed solution to the test as much as possible in a real-life context, allowing a decision, requiring a return to the exploration stage to iterate the finding of solutions, or whether to proceed to the evaluation stage.

In building energy renovation processes, the experimentation stage corresponds to the "Planning and Design" (Phase 3) of the pilot renovation, and refers to the co-planning and co-design activities aimed to concretise the ideas and solutions identified in the previous exploration phase in defined projects. In this case, the "prototype" is represented by the proper "Intervention" of building renovation on the pilot building (Phase 4), consenting to test the feasibility and improvements brought in by the innovation developed in the LL.

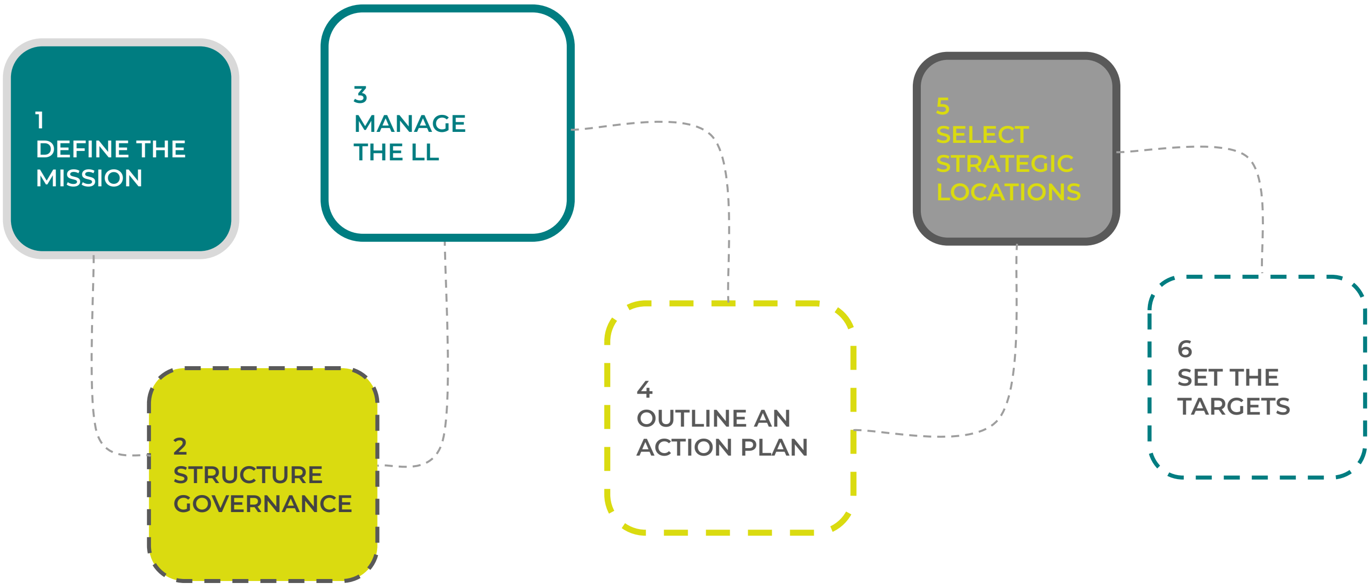
3) The **third and final stage** of the LL's process consists in the evaluation of the innovation produced. While the exploration stage provided a benchmark of the 'current state' in the context and of actual problems, the experimentation stage simulated and envisioned 'future state' through interventions or prototyping. The evaluation is based on the 'post-measurement' of the intervention and the comparison with the 'pre-measurement' benchmark, consenting to quantify the positive impact and added value created by the innovation. In terms of Open Innovation, this stage implies innovation activities to leverage existing technological capabilities outside the boundaries of the LL. Beyond evaluation, the emphasis is on understanding the replicability and the potential market, which can be done through techniques such as market research, toolkits for customization or conjoint analysis for defining a concrete offering, but also the preparation of a coherent communication and marketing strategy. Post-launch activities may include monitoring the actual adoption and usage of the innovation, enabling adjustments or new features to suit the needs of current or prospective user/customer groups.

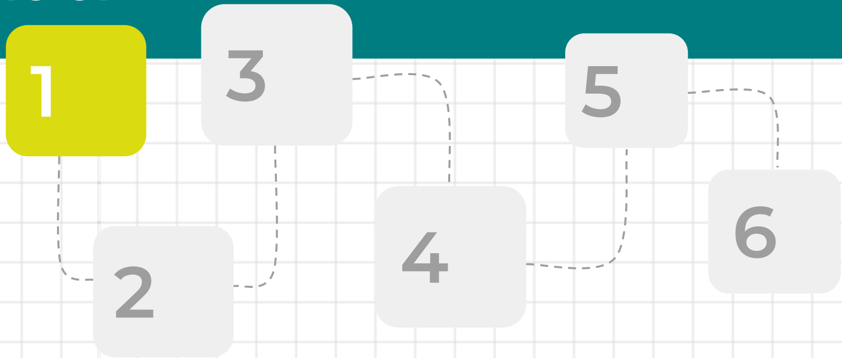
In building energy renovation processes, the evaluation stage corresponds to the post-management of the renovated building (Phase 5), whose improvements can be appreciated thanks to the comparison with the pre-intervention state, also allowing for showcasing the enhancements and encouraging the broader renovation efforts for public buildings.

Activities and Workflow

The Living Lab methodology is designed to revolutionize the refurbishment of university and public buildings by actively involving researchers, building and energy managers, public institutions, local businesses, and students in real-world renovation projects. This innovative approach aims to create a common environment where stakeholders and users can participate in co-design processes, since promoters believe that more effective renovations can be achieved through a collective effort.

For the initialisation of a successful LL working on the energy renovations of university/public buildings, the following **six main activities** need to be implemented:





Activity 1. Define the mission

The foundation of a Living Lab relies on a shared vision among the first nucleus of initiators, intended as a set of guiding principles embodying the essence of the LL, to be shared with all the future participants. The mission serves as a beacon, uniting all current and future participants around common principles representative of the spirit of the LL. Sustainability is an overarching principle inspiring many LLs experiences, driving the exploration of innovative solutions in real-world settings to tackle contemporary environmental and social challenges.

The mission is a brief written/illustrated document identifying the main concepts behind the need to settle a LL, the purpose and the objectives to be addressed, all providing continuity to the LL activities. For this reason, crafting a clear and concise mission statement is crucial.

As a beacon of light, the mission should show the road to maintain over time the core nature of the LL: when a hard decision has to be taken or a controversy emerges, the reference to the mission can be highly beneficial. Also on a daily basis, a well-defined mission can inspire and motivate the activities of the LL, consenting to create a common feeling of belonging. Moreover, the mission serves as a means of communicating the LL essence to stakeholders and users, encouraging their active involvement. Regular evaluation and updates ensure the mission remains relevant and achievable.

back to WORK FLOW

Define the mission

1.
What is the main problem the LL would like to address?

2.
What is the core innovative idea behind the LL?
(a new process? product? or service?)

3.
What is the scope of the LL?

4.
Who are the main beneficiaries?

➜ Four question for the definition of the mission statement

To enhance its impact, the mission statement should be memorable, possibly articulated in bullet points or complemented by compelling visuals. Creating a manifesto, displayed within the physical space of the Living Lab, can reinforce its presence and significance.

The LL mission can be aligned with sustainability approaches already present in the university/public building context (dedicated policies, initiatives, offices), fostering synergies, the convergence of interests and the engagement of new stakeholders.

back to WORK FLOW

beXLab experience

Since the beginning of the beXLab's Living Lab experience in the Department of Architecture (DIDA) of the University of Florence (UNIFI), the first nucleus of promoters/innovators defined a mission, covering the main objectives and approaches of the innovative processes willing to experiment.

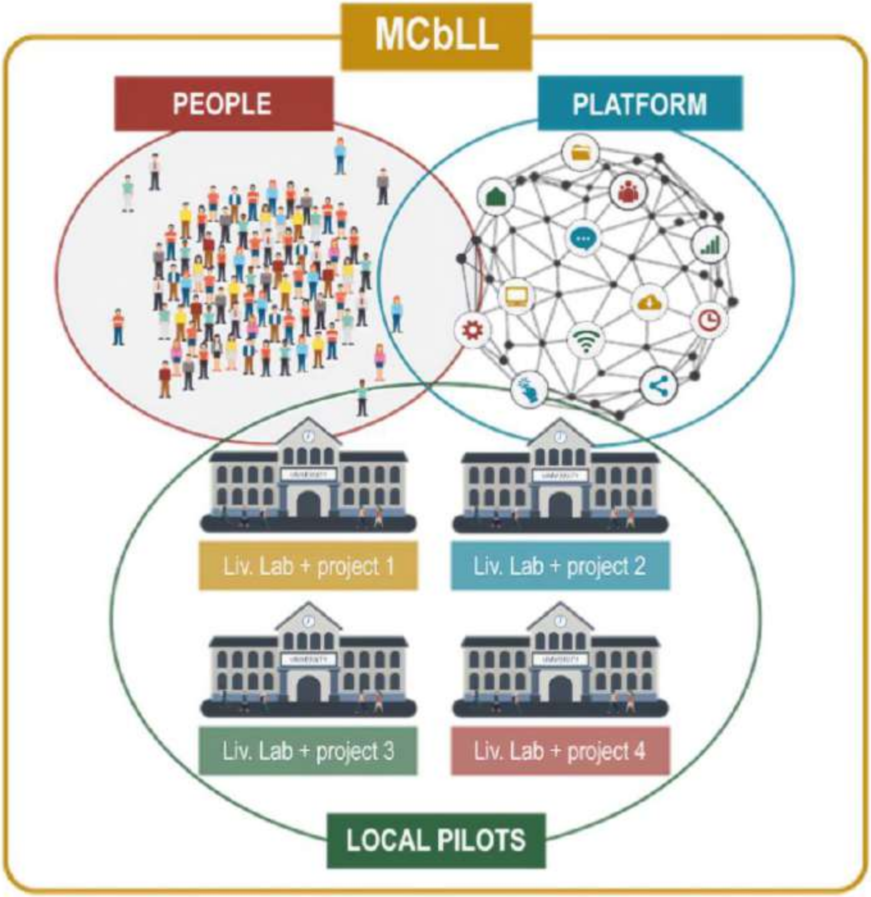
A poster explaining the mission has been created, printed and fixed in the physical space of the Living Lab, in order to always guide participants in the LL activities.

The same name of the initialized Living Lab has been intended as a mission: 'building environmental eXperience' means to give a new value to the role of human experience shaping future sustainable buildings and cities, with the objective of reducing the building environmental impact while improving their environmental quality, as experienced by humans.

- PARTE DI CROSS-BORDER LIVING LAB

beXLab experience

- PARTE DI CROSS-BORDER LIVING LAB

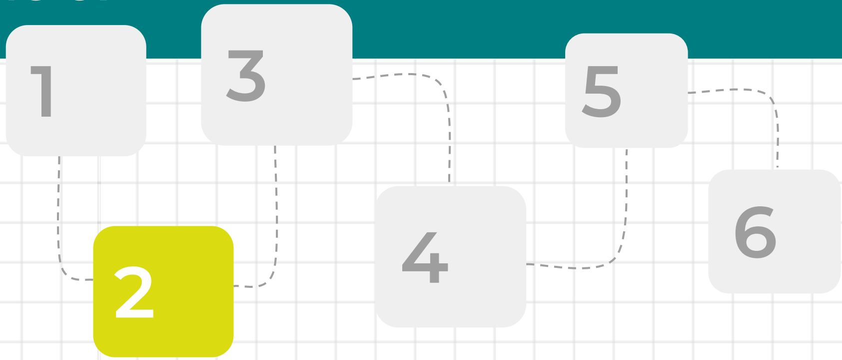


beXLab experience

'building environmental eXperience' is a **collaborative and interdisciplinary Living Lab** helpful to accelerate the **transformation of the urban environment**, contributing to the New European Bauhaus initiative and the objectives of the European Green Deal. A new research path is oriented to **valorize the environmental experience** in built spaces, buildings and cities by enhancing and **stimulating the green and digital transition** experimenting on the **Digital Twins as a predictive tool** integrated with an **inclusive and user-oriented approach**.

4 research fields:

- **LIVING LAB CHALLENGE**
- **GREEN AND DIGITAL TRANSITION**
- **ENVIRONMENTAL WELLBEING**
- **PREDICTIVE DIGITAL TWIN**



Activity 2. Structure governance

Living Lab can occur in two main levels: **local and cross-border.**

Local LLs operate on a real-place, physical area of experimentation, meeting point for innovators, stakeholders and users, where members collaborate and share knowledge directly with each other, without hierarchies, coming together with a shared vision. As demo sites, local LLs adopt participative approaches to fertilize, merge and share the knowledge and know-how among local actors, acting as facilitators to stimulate the collaboration with stakeholders and the engagement of users.

At a strategic level, **LLs can also exist as cross-border networks, connecting in a network different local Living Labs.** As a managed collaboration network, cross-border LLs require to set common tools, methods or even infrastructure to exchange comparable information in order to perform research in a similar way within the various LLs. Collecting, sharing, promoting and implementing local best practices, the network activities are intended to facilitate and achieve the objective to exchange lessons learned. Working on this overarching level, partners of various LLs can conduct research on a larger scale cross-borderly, creating a higher impact on innovation.

In the case of university buildings, it is possible to take advantage of the context by exploiting its inherent knowledge, network and educational objectives to innovate the renovations towards sustainability. Universities can strategically host Living Lab involving the community of innovators (researchers), stakeholders (managers, companies, public administrations) and users (students) for the exploration, experimentation and evaluation of innovative renovation processes.

As real-life places for an user-oriented co-creation of open innovation, **university- based Living Labs can integrate research and innovation processes by experimenting renovation strategies and technologies proposed by innovators, developed with the collaboration of stakeholders and tested by users/students.**

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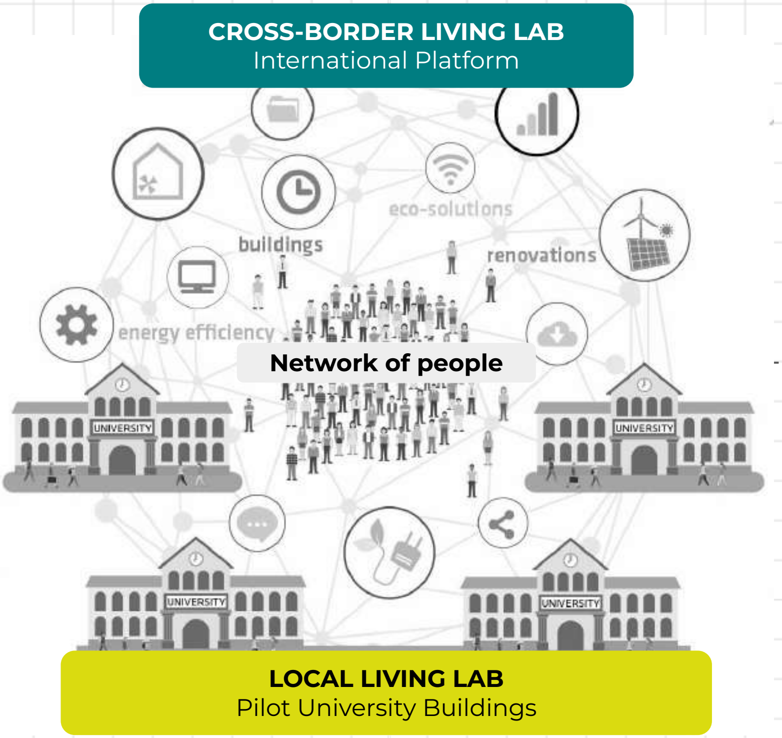
Structure governance

➔ Two levels of Living Labs: **Cross-border** and **Local**



University Living Labs have an educational scope, with both the engagement and the delivery of innovative knowledge to the young generation of students/future designers, managers and users, promoting a culture of sustainability. The internationalization of universities represents a fertile background for the activation of cross-border LLs connecting different universities working on building energy renovations, enabling them to share results and best practices. University-based Living Lab and networks can induce significant and vibrant improvements in the field of building renovation, whose **experimentations in real-university buildings can act as a beacon of light for the wider renovation of Mediterranean public buildings.**

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Structure governance

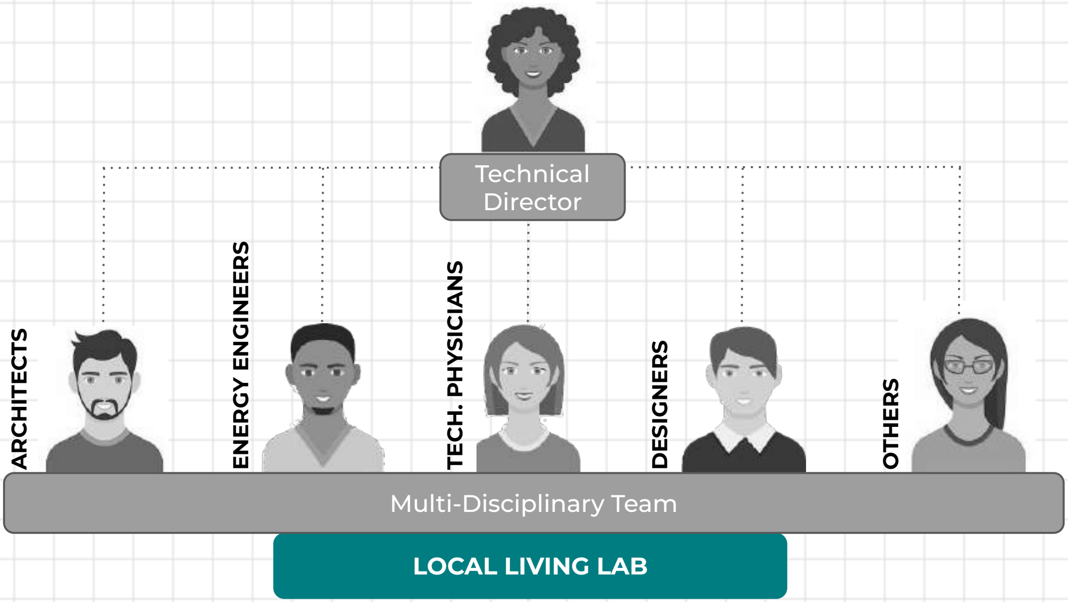
At both levels of implementation, local and cross-border, LLs require **a clear governance and a reliable management.**

Starting from the ground, local LLs are directed by a **Technical Director** and managed by a **Multidisciplinary Team**, composed of researchers and representatives of the university's management body responsible for buildings and energy aspects.

Usually one of the promoters, the Technical Director is in charge of the team coordination, has the scientific responsibility and approves the activities to implement in the LL. She/he is the main reference contact of the LL. Moreover, in case of cross-border implementation, the Technical Director is a member of the Steering Board. The Multidisciplinary Team is responsible both for the management of the relationships with local stakeholders (public organizations and companies), and for the implementation of the LL activities.

The Multidisciplinary Team is composed of at least one researcher for each discipline involved in LL, investigating the renovation process under different points of view. Within the MD Team, the following roles and responsibilities should be covered:

- **Relationships management and communication** (internally with university managers and users, and externally with stakeholders);
- **Physical infrastructure** (pilot implementation, installed technologies);
- **Digital infrastructure** (softwares, tools, Digital Twins, ICT platforms);
- **Scientific production** (protocols, methodologies, reports, papers, conferences).



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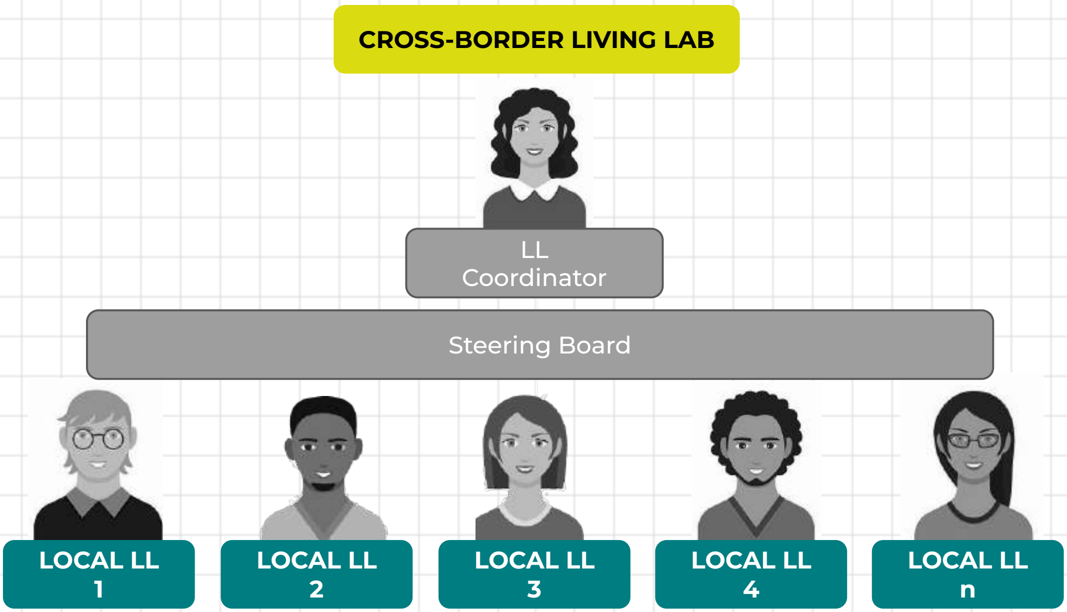
Structure governance

Beyond the scientific experimentations, the **management of relationships and communication** are fundamental for the life of the LL, considering that only a good communication of the LL results can guarantee its future. For their key role in the renovation process, intense relationships have to be maintained with the university managers, for this reason it is important to have an active representative in the team.

New relationships need to be created with an even increasing number of stakeholders, through the activation of conventions with local innovative companies and public administrations, enlarging the territorial basis of the LL. For this reason, the communication of the LL mission and of the ongoing results is fundamental to attract the interest of local stakeholders, letting them to understand the capabilities of the LL and the potential of an involvement. In order to take track of the engaged stakeholders, a matrix of contacts should be created.

Users represent a special target of the LL activities: their active engagement is fundamental to understand the current state and foreseen innovative future ones; moreover, the raising of awareness on building energy efficiency and reducing buildings environmental impacts is crucial. In the case of university building, the peculiar condition of users as students enriches the topics with the educational scope.

At the **cross-border level**, the LL is managed by a **Steering Board**, composed by **representatives of each local LL in the network**, and directed by a **LL Coordinator**, in charge of coordinating the cross-border LL activities between the different local LLs.



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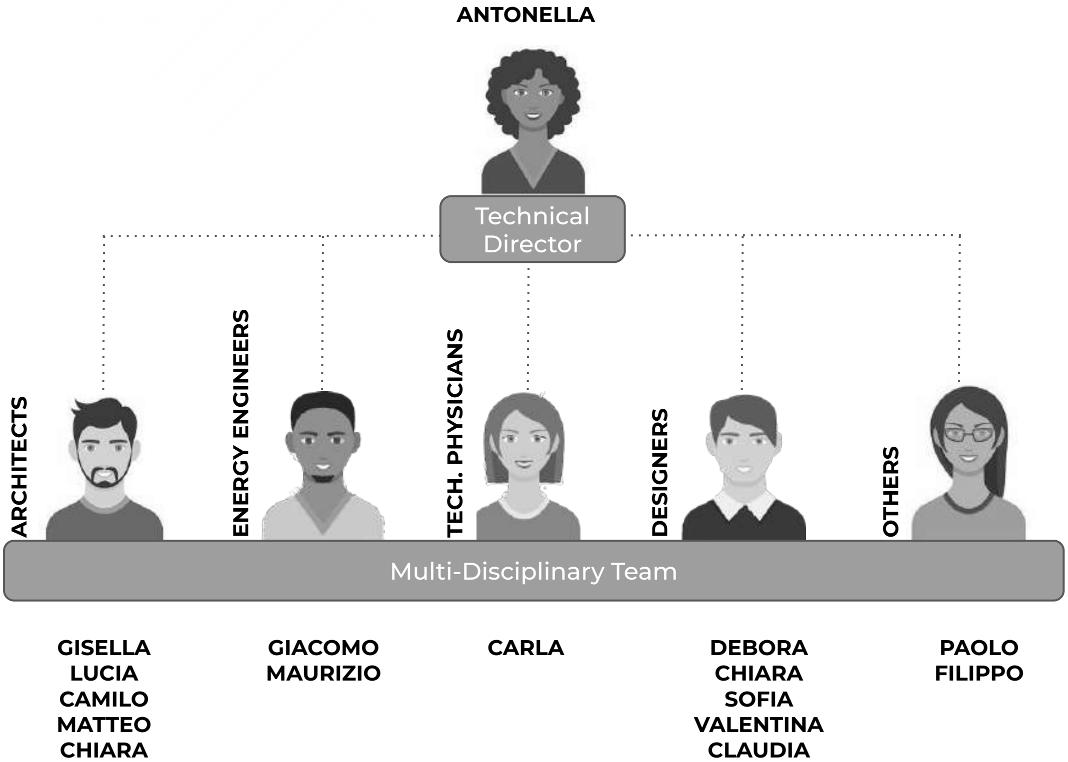
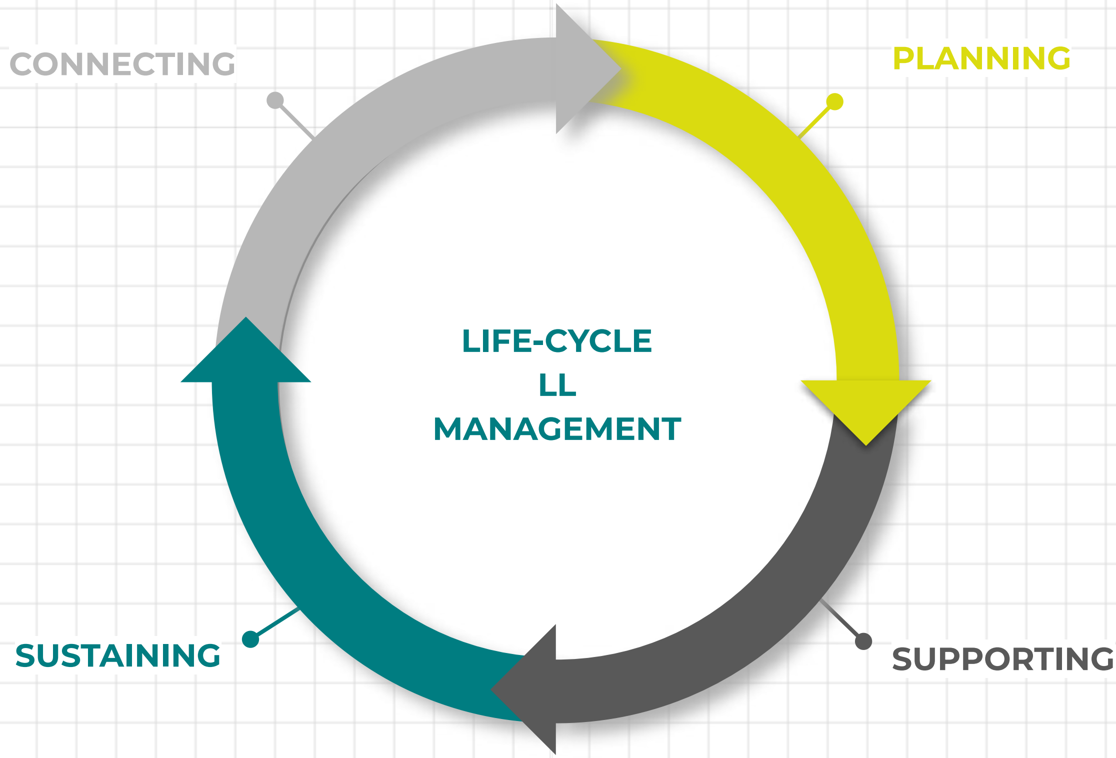
beXLab experience

The LL cross-border implementation provides a wider framework of scopes and activities of the single LLs, requiring them to be harmonized in a bigger scale (national or international), where to intercept new stakeholders.
The development of the cross-border LL is based on the coordination of local LLs, on the management of cross-border relationships and on proper communication, stimulating the creation of new relationships and the involvement of international stakeholders, in order to amplify the network and its impact.



Activity 3. Manage the Living Labs

Both at the cross-border and at the local level, the LL management can be described as a **lifecycle process:**



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Manage the Living Labs

CONNECTING

- agree on common goals and approaches
- identify opportunities for joint innovation
- define intellectual property principles
- explore collaboration opportunities
- enlarge the network by involving new stakeholders
- finalize agreements and contracts

PLANNING

- define an action plan
- valorize the competencies and focus of the single LLs
- elaborate common plans and approaches
- attribute responsibilities and roles
- organize the cross-border LL planning and development
- process
- structure partnerships
- establish a collaboration infrastructure
- plan collaboration activities

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Manage the Living Labs

SUPPORTING

- build a constructive dialogue between local lls
- provide guidance for an harmonic implementation of local lls
- support negotiations
- conduct collaborative testing on co-innovation

SUSTAINING

- communicate the achieved results
- promotion of LL activities
- enlarge the impact of the LL

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beXLab experience

beXLab

INTERDISCIPLINARY

PHYSICAL SPACE

ARCHITECTURE
renovation process and scenario design

ENERGY ENGINEERING
plant and monitoring systems

PROMOTERS
RESEARCHERS

VIRTUAL SPACE

INFORMATION ENGINEERING
data aggregation and analytics

SERVICE DESIGN
data visualization and interaction

PARTICIPATIVE SPACE

STAKEHOLDERS
COMPANIES

CUSTOMERS
BUILDING/ ENERGY MANAGERS

USERS
STUDENTS

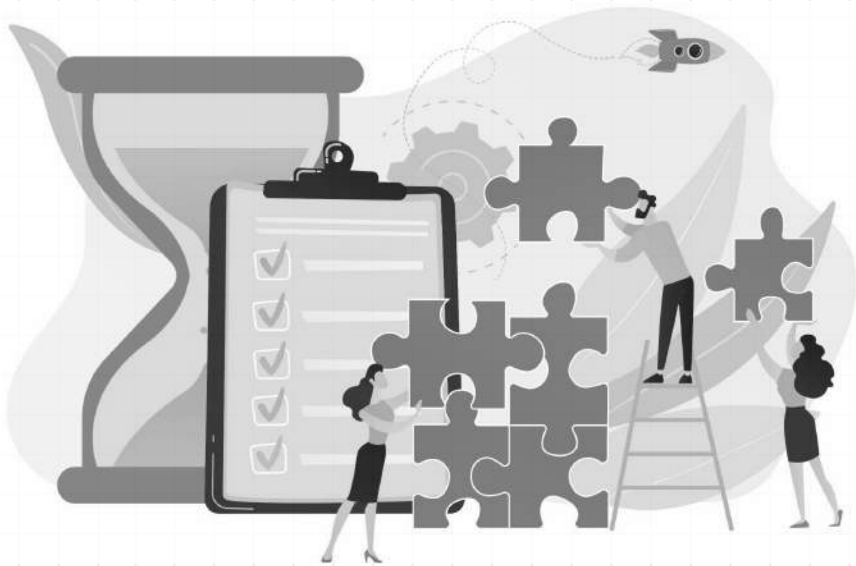
STAKEHOLDERS
PUBLIC ORGANIZATION

Activity 4. Outline the Action Plan

Both at local and cross-border level, the definition of an Action Plan is fundamental to manage the LL activities and to control the achievement of foreseen results, as a tool to support the team working. The Action Plans are defined by the Multidisciplinary Team at local level, and by Steering Board in the cross-border LL implementations.

Coming from the project management discipline, an Action Plan is a document containing a list of steps or activities to be performed in order to achieve defined goals and objectives. It is important to set an Action Plan before the start of the LL activities, since it consents to forecast possible obstacles, foresee efficient answers and at the same time maintain the LL focused on the objectives.

The advantages in the adoption of an Action Plan are the definition of **a clear roadmap to follow** (in line with the mission), the **organization of priorities, the possibility to control the progress with the identification of milestones and deliverables**, also for a continuous monitoring of the LL activities. A good Action Plan clarifies the resources required to reach the LL goals and determines a timeline for the tasks to be performed.



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Outline an Action Plan

1. Define the Objectives

In line with the LL main goals individualized in the mission, specific objectives of the local LL need to be outlined in order to be realistically congruent with competencies and resources. There's a difference between LL goals and LL objectives: the firsts refer to the high-level scope that the LL would like to achieve, while objectives are much more specific, referring to the deliverables and milestones to be completed to achieve the LL goal. In order to be robust, objectives usually have to follow the SMART criteria (specific, measurable, attainable, relevant and timely).

Objectives of the LL are not only related to the renovation process to innovate, but refers to more ambitious objectives of disseminations, sensibilization and training.

2. List the steps
According to the three phases' LL methodology (exploration, experimentation, evaluation), internal steps have to be defined. A step is a group of activities to be performed in a precise sequence in relation to others, in order to achieve the LL objectives and address the main goals. To define an order of priorities, it is important to outline all the foreseen activities and the dependencies among them.

5. Define outputs
Each activity can produce a deliverable and/or a milestone, depending on whether it determines a passage from a step to another. In this case, deliverables are milestones, consenting to keep track of the LL progress.

6. Attribute Roles & Responsibilities
For each activity, roles and responsibilities need to be assigned to LL members according to their competencies.

7. Allocate Resources
Each activity requires an allocation of other types of resources, such as financial and instrumental, all to be defined since the beginning of the LL activities in order to define a reliable budget.

8. Set a Timeline
For a timely achievement of results, there is the need to estimate how long each activity will take to be completed; timeline and/or Pert or Gantt charts can be generated.

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beXLab experience

The cross-border implementation of a Living Lab provides a wider framework of scopes and activities of the single LLs, requiring them to be harmonized in a bigger experimentation, and a relatively bigger scale (national or international) where to intercept new stakeholders.

Activity 5. Strategic Locations

From a more practical point of view, the activation of local LLs requires a pilot-building where to experiment, in the real life context, pilot-renovation processes and where to physically set up the LL.

The selection of the **pilot building/site of the LL** can be guided by the consideration of the most representative characteristics of the wider public building stock of reference (e.g. building type, time of construction, solar exposition, etc.).

The pilot-building has to actually **host living functions**, in order to understand its current state with the presence of users. In the case of university buildings, it should host characterizing functions such as didactics, research and study (special spaces such as specialist laboratories need specific energy and indoor conditions, requiring ad hoc considerations).

It is important to consider the **position** of the pilot-building in relation to the pedestrian flows, in order to valorise the visibility of the pilot-renovation project to be implemented.

Within the pilot-building, at least a room should be available for **research activities**, in order to give to LL members a place to meet and experiment inside the building object of the renovation pilot-action. Moreover, in the light of the educational scope, a good idea could be to consider spaces adaptable for the delivery of **didactic activities**.

The **cross-border Living Lab** requires instead a **virtual place** to be settle: its management can in fact be supported by the creation of a digital infrastructure/platform, where cooperation activities can be organized, information gathered among partners and stakeholders, knowledge and best practices transferred and results organised and provided to the wider public, in order to achieve a bigger impact.

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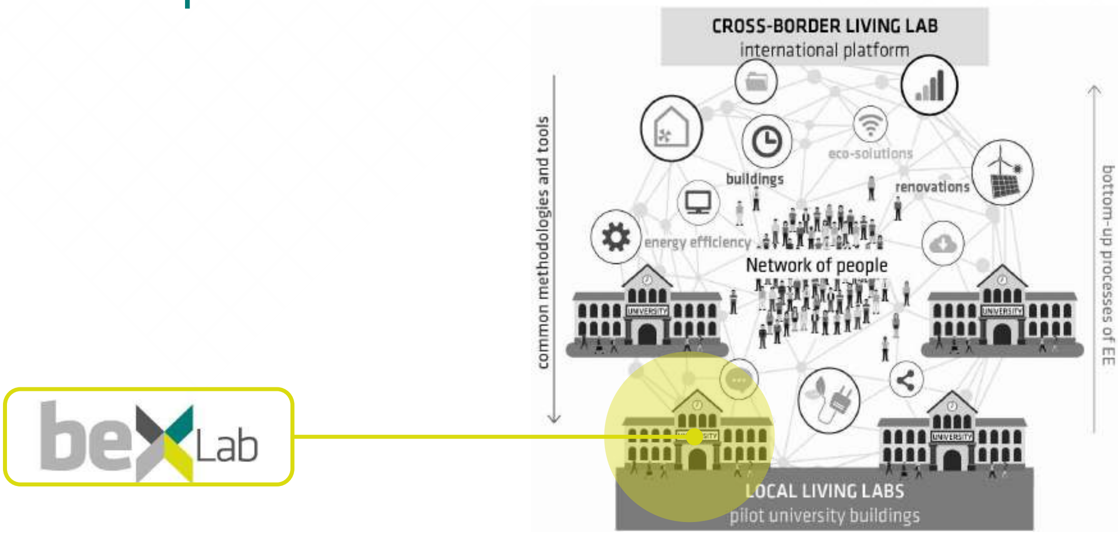
beXLab experience



UNIVERSITY BUILDING TO RENOVATE

PHYSICAL SPACE OF THE LIVING LAB

beXLab experience

BEST-PATH: Digital Twin implementation

LOCAL LIVING LAB

LOCAL LIVING LAB 2.0

Activity 6. Set the Targets

To finalise the setting up of the LL and start with the proper renovation activities, common targets have to be agreed both for the pilot-renovation and for the future renovations of the reference public building stock, in relation to the renovation obectives delineated in the "background" section.

As a 'political' choice, renovation targets express the most ambitious objectives to achieve, resulting in the main challenges to address along the renovation process. The setting of renovation targets is highly influenced by **economic-financial aspects**, but also by the **strategic vision of innovators for the future building.**

Whereas quality targets are primary defined to create a common basis, they can be exploited to quantify the potential improvements in comparison with the conditions of the actual building.

In order to determine the targets, also international or local assessment protocols can be adopteed. Some examples are:

- EU NZEB
- EU Positive building
- National targets
- Environmental Protocolos (Leed, Breeams or local protocols - e.g. ITACA)

Researchers, university managers and stakeholders experts in the renovation field are called to collectively identify reliable targets, to be defined in a quantitative way: more defined are quality targets, easier will be the assessment of the renovation project.

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Set the Targets

NZEB
Nearly Zero Energy Building

U.S. GREEN BUILDING COUNCIL LEED USGBC

ENERGY STAR

INTERNATIONAL WELL BUILDING INSTITUTE WELL™

BREEAM®

NGBS GREEN™
Home Innovation Research Labs

GREEN GLOBES®

LIVING BUILDING CHALLENGE

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beXLab experience

6 KWp

energy production from renewables sources

ENI CBCMED Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA REGIONE AUTONOMA DELLA SARDEGNA

Med-EcoSuRe

Mediterranean University as Catalyst for Eco-Sustainable Renovation

euni well European University for Well-Being

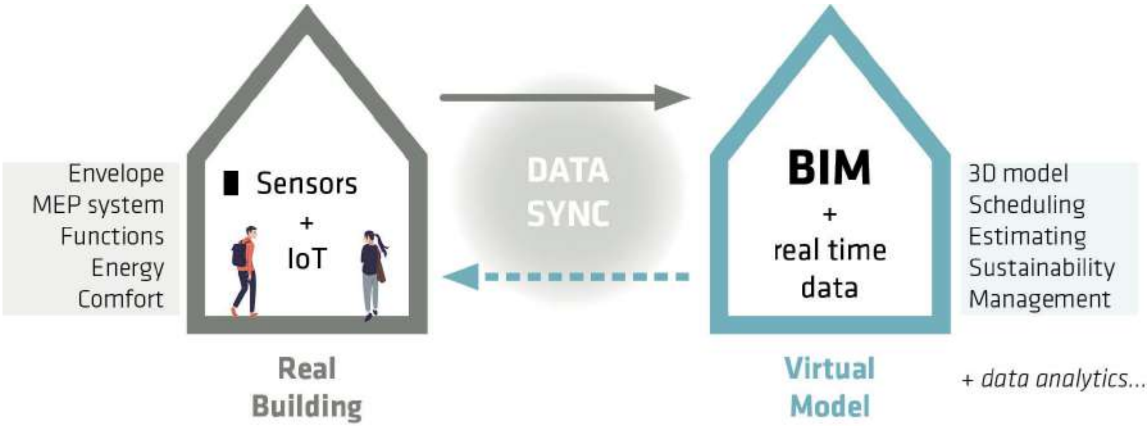
BEST PATH
Digital Twin implementation

The Best Path on Digital Twin implementation describes the processes and procedures required for the usage of the BIM methodology (Building Information Modelling) through a building renovation process. The best path should be used as a general guideline for renovation projects, covering the whole process by describing the BIM delivery process and use at each project phase.

The adoption of BIM for the delivery of renovation projects is intended to significantly support and improve project processes, ensuring quality and a controlled information management since the planning up to the operation stage, covering totally or partially the project life cycle.

BIM methodology and technology can in fact provide a digital asset that can be used to better understand the projects (starting from the buildings themselves) and so to improve the decision making, planning, renovation design and facility management.

Regardless of the size of the project, the application of the methodology can be progressively introduced to develop renovation projects of any building type or facility. The BIM models of each project should contain current, new and updated information supplied via design/construction projects, significant renovations, and/or routine maintenance and operations processes, delivering valuable information to operate, maintain and manage their assets.Building Information Modelling (BIM) is a set of methodologies, technologies and processes enabling multiple stakeholders to collaboratively design, construct and operate a fFacility digitally, in a virtual space.



BEST PATH
Digital Twin implementation

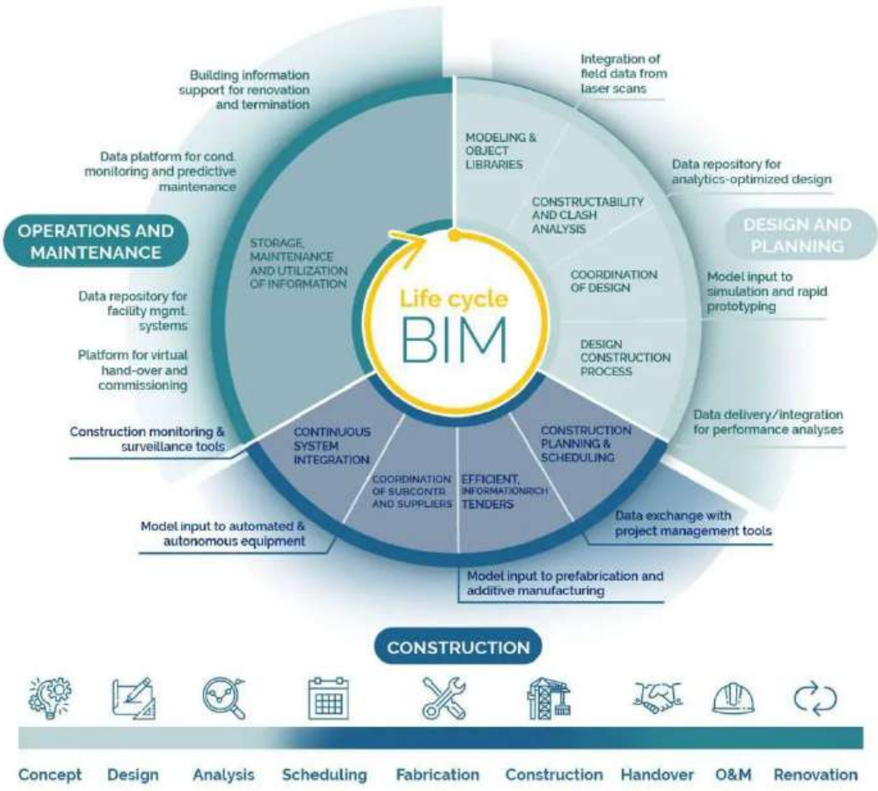
Building Lifecycle

The Building Lifecycle is a step by step process that takes place on every single building of the world, with different procedures. Nowadays this process has been done with no information of the Asset or very little information of the building, without adequate tools and with no methodology.

Considering construction and/or renovation as one of the most common processes of the built environment, it is important to understand how to deal and manage the lifecycle process using building data, applying standards, common methodologies, and planning strategies, and having information management as the guiding thread.

The Building Lifecycle process is dedicated to building managers, willing to improve the construction, renovation and operation processes of buildings. Specifically, the "case study" analyzed as part of the operation/renovation process of a "University Asset".

The Building Lifecycle is divided in 6 phases encompassing the whole life process, starting from the planning and closing with the lessons learned, before starting a new cycle.



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BEST PATH
Digital Twin implementation

To guarantee the cycle and recycle process, it requires organization, procedures, tools, management standards and methodologies.

Building Information Modeling (BIM), appears as the main thread to put together all building lifecycle phases, managing and coordinating building information, up to a Digital Twin implementation.

Building Information Modelling (BIM)

Building Information Modelling (BIM) is a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a Facility in virtual space.

According to the International normative ISO 19650 - BIM refers to the "use of a shared digital representation of a built Asset to facilitate design, construction and operation processes to form a reliable basis for decisions".

What we need to build up now is exactly the “reliable basis” from where to start knowing and understanding current building conditions, but all the information that we are going to collect/produce has to be managed, archived and must be available to everyone at any point in time. The usage information containers for managing information from beginning to end using building information modeling will keep the information reliable and updated through all the building operations and/or lifecycle.

BEST PATH
Digital Twin implementation

European Directives and International normative & standards

1. European Directives

The European parliament determine the importance of the usage of digital information and tools throughout the directive 2014/24 EU on Public Procurement

“For public works, contracts, and design contests, Member States may require the use of specific electronic tools, such as of building information electronic modeling tools or similar. In such cases the contracting authorities shall offer alternative means of access, as provided for in paragraph 5, until such time as those tools become generally available within the meaning of the second sentence of the first subparagraph of paragraph 1.”

Art. 22, c.4

2. International Normative & Standards

At the review of the digital standards in the UK in 2011, as part of the Digital Built Britain the government introduced the normatives and standards to develop construction projects using Building Information Modelling tools. After the British introduction of the normative, other countries around the world started to produce their own standards following the path opened by the UK-PAS 1192.

In 2018 the International Organization for Standardization, after publishing the standards introduced and leaded by Building Smart (open BIM), published the first two parts of the international normative ISO 19659 - Organization and digitization of information about buildings and civil engineering works, including building information modeling (BIM) — Information management using building information modeling.

Up today other parts have been published, organizing without borders the way to manage digital information and processes for the architecture, engineering and construction industry and for the operations, maintenance and management of assets.

BEST PATH
Digital Twin implementation

Best Path - Using digital Information

Following the problems in terms of climate change, air pollution and energy efficiency, we have found that one of the most important problems regarding building management is the lack of information about the organizations of their own assets. This lack of knowledge is more emphasized in the public institutions/organizations and is the main cause of the impossibility to develop action plans to maintain, operate or improve building performance and efficiency.

Nowadays the maintenance strategy is to solve problems once they appear and not to be proactive in preventing and/or planning asset improvement with accurate strategies. This is because to plan we need to know what we have and where we would like to arrive (objectives/requirements), but we cannot define the arrival point without knowing where exactly we are.

1. **Organization acknowledgement**

In order to begin any process the organization needs to be sure exactly where they are, what they are, how they operate, and which are the physical, economical and human resources. Starting from the self-acknowledgement is that they can establish objectives, plan and organize a path or a guideline that takes the organization from one point to another.

2. **Digital data Management**

Developing energy-efficient projects using digital information requires tools that can help planners, designers, managers, and users make the right decisions across a complex set of possible actions and investments. Digital information could be infinite and for that specific reason it is very important to follow standards and apply adequate management and archiving strategies, to maintain total availability and accessibility, from all the stakeholders to the pertinent information.

The “digital twin” as a tool can encapsulate and provide the full range of modeling, analysis, and simulation capabilities needed. In any case working with digital twins requires new skills in modeling, analysis, and visualization, as well as a successful project needs an integrated, multidisciplinary team. Building virtuous collaboration is just as important as having the right technical skills.

BEST PATH
Digital Twin implementation

3. Project phases development

In order to align the project workflow phases (defined in toolkit) with the RIBA “plan of work” stages, we had merged some of them under a more general chapter, following the principles of understanding the project dynamics of the decision making in the implementation of the retrofit processes in university buildings.

The living Lab workflow was organized according to the scheme proposed in the Toolkit, which looks at the retrofit as an innovation and quality process (circular) within the university building's life-cycle, and composed of the following phases:

1. Knowledge Framework (0. Strategic Definition)
2. Analysis of Criticalities (1. Preparation & Brief)
3. Planning and Design (2. Concept Design, 3. Definition Design & 4. Technical Design)
4. Intervention (5. Construction & 6. Handover and Close out)

Post Management (7. In use)

To structure the workflow process for each project section/phase, a subdivision has been structured for data acquisition, activities definition, special project characteristics in the following way:

- People involved in the retrofit process ("the Who")
- Aspects considered for the retrofit ("the What")
- Procedures adopted to address the retrofit ("the How")

Implementing retrofits in university buildings is in fact a complex process, which requires reliable procedures for the coordination of different actors and the integrated consideration of interrelated aspects, such as the conditions of the physical building, its energy behavior and the Indoor Environmental Quality experienced by users.

Phase 1

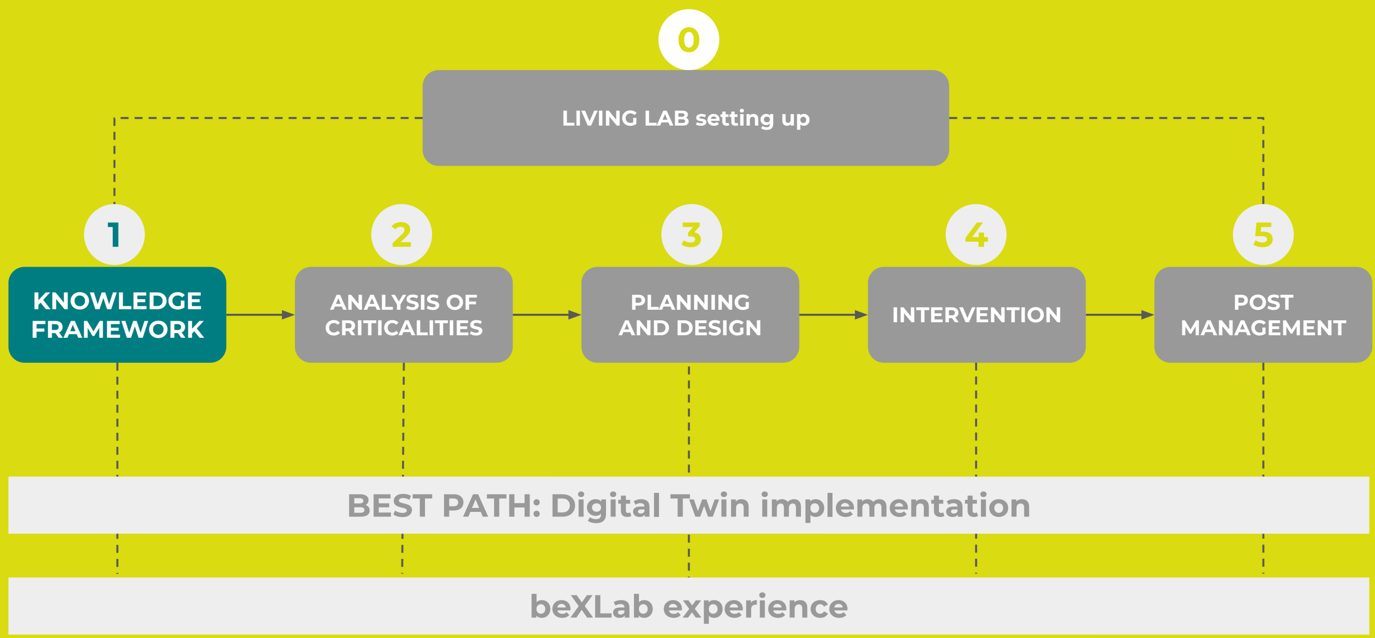
Knowledge Framework

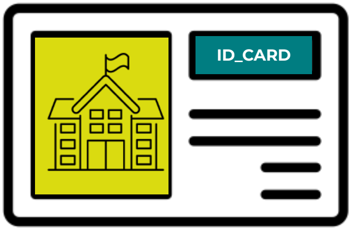
The Knowledge Framework (KF) is an organised collection of data and information describing the real conditions of the pilot-building in relation to the 4 renovation aspects, relevant to analyse its criticalities in Phase 2. It can be defined as a comprehensive picture of the existing building to start a successful renovation project.

WHAT collection of the data and information related to the architectural, energy, IEQ, and environmental aspects

WHO the interdisciplinary group of the LL work together within the university community and with external stakeholders to organize the KF

HOW steps to organize the knowledge on the 4 aspects of building renovations





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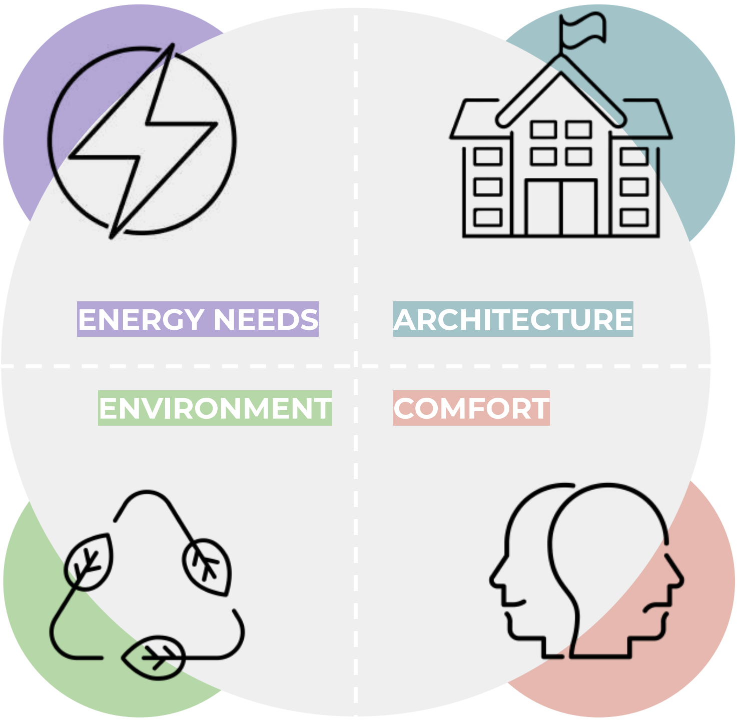


Four types of data are relevant for the definition of the knowledge framework:

1. ENERGY EFFICIENCY

- ➔ Energy supply system: · heating/cooling · ventilation · lighting
- ➔ Distribution in the building, size and typology
- ➔ Effective energy consumptions

2. ARCHITECTURAL QUALITY

- ➔ Physical asset of the building
- ➔ Geometry
- ➔ History and context
- ➔ Actual configuration and destination of use
- ➔ Focus on the building envelope and its performances

3. COMFORT AND WELLBEING

- ➔ Occupancy
- ➔ Space use
- ➔ Perception of comfort in indoor spaces: thermo-hygrometric · visual · acoustic · air quality
- ➔ environment parameters

4. ENVIRONMENTAL IMPACT

- ➔ Renewable energy systems
- ➔ Nature based-solutions
- ➔ Ecological meters
- ➔ Environmental protocols

The main structure of the pilot-building KF is elaborated by **the interdisciplinary group of researchers together with the university managers** with innovative methodologies and tools to overcome the limits/barriers of the current approach to the data management data of the university building stock. In particular, the Living Lab will interact with university managers owning the existing documents with the needed data. In most cases, the completion of the KF is difficult because of missing or fragmented data, also distributed in different offices (administrative, technical, etc), requiring an organised collection and/or the organisation of new survey campaigns.

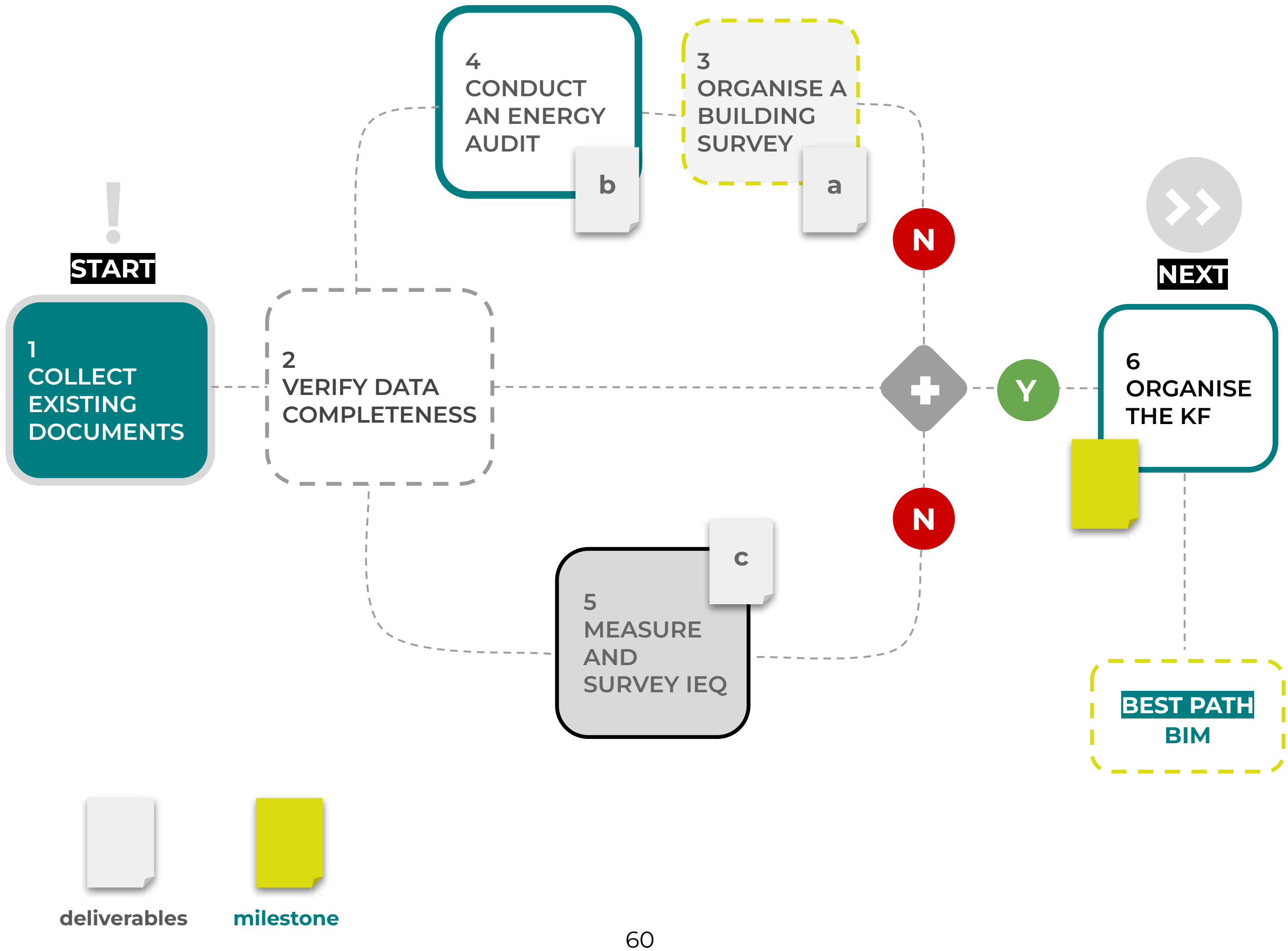
The definition of the KF can take advantage of the university LL, with **students** involved both in the organisation of collected data and in the field work to retrieve the missing information.

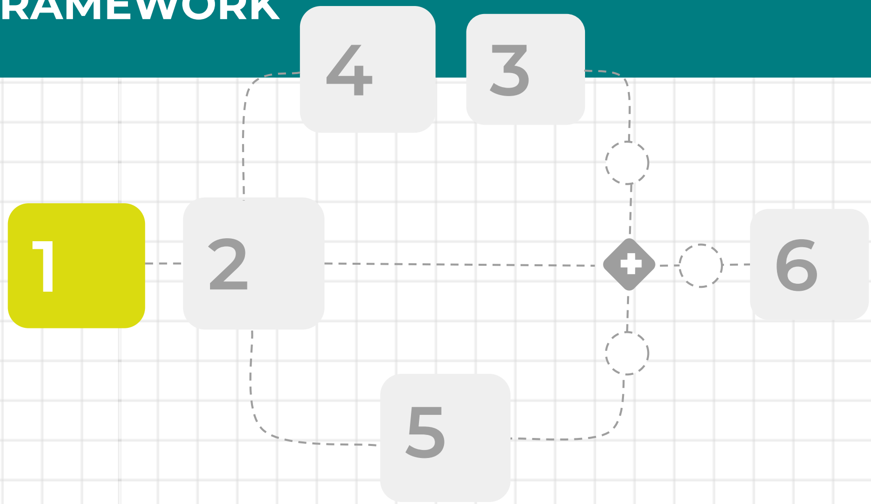
More advanced experimentations in the LL can be created in collaboration with **companies** of innovative technologies supporting the retrieval of architectural data (building survey instruments and softwares), energy data (Escos), IEQ data (monitoring systems, IoTs).

Also **public organisations** can be involved in the construction of the KF, such as public administrations or, in the case of historical buildings, public offices for the management of the local architectural heritage.

Activities and Workflow

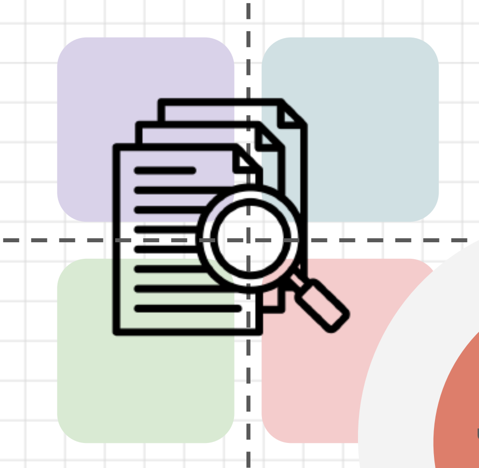
To define the Knowledge Framework, the following sequential (or alternative) activities has to be performed.





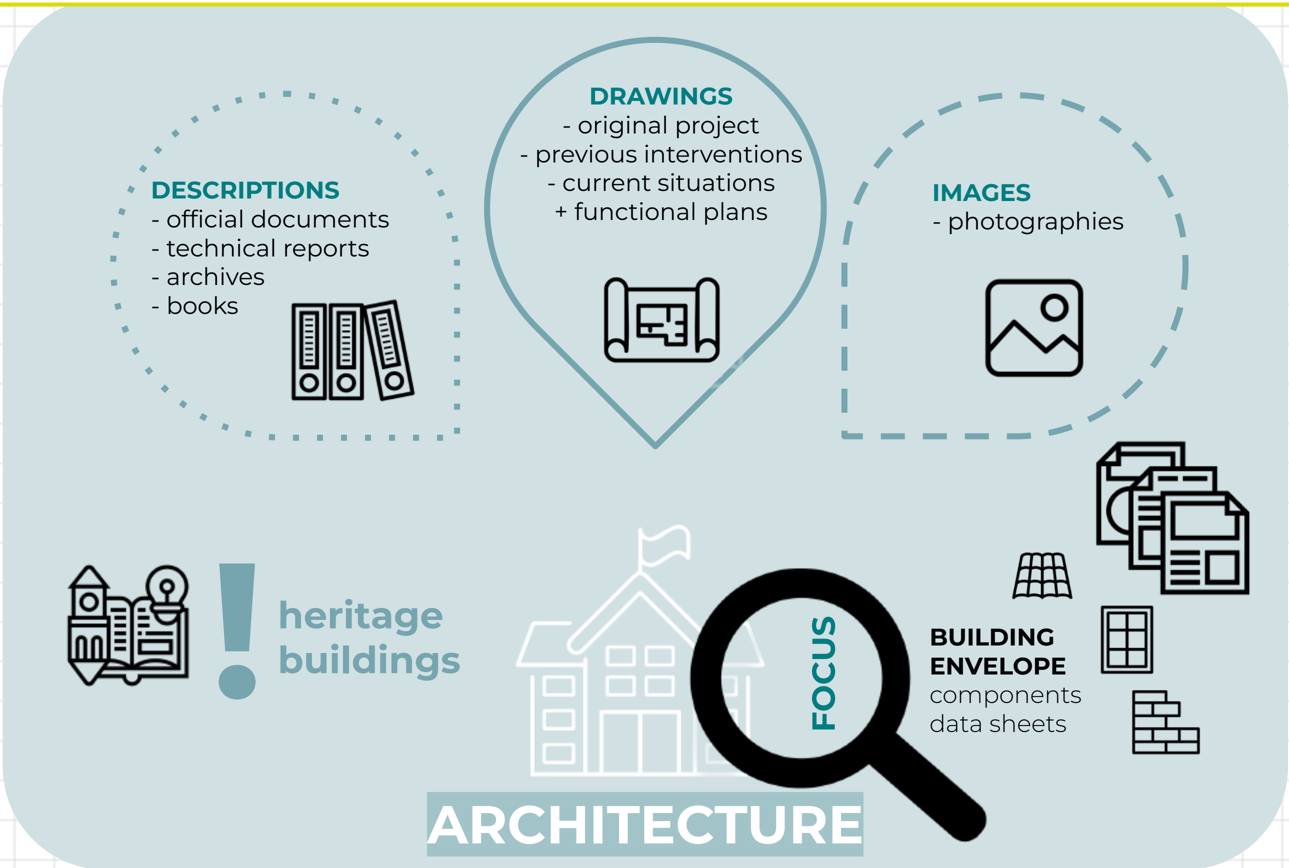
1. Collect existing documents

Considering the four building aspects of architecture, **architectural quality, energy efficiency, IEQ and environmental impact,** the data collection starts from the gathering of existing documents. Most of them should be directly held by the **building and energy managers of the university building**, or other **administrative offices,** others can be obtained by **public authorities** which approved the previous projects.



back to WORK FLOW

Collect Existing Documents



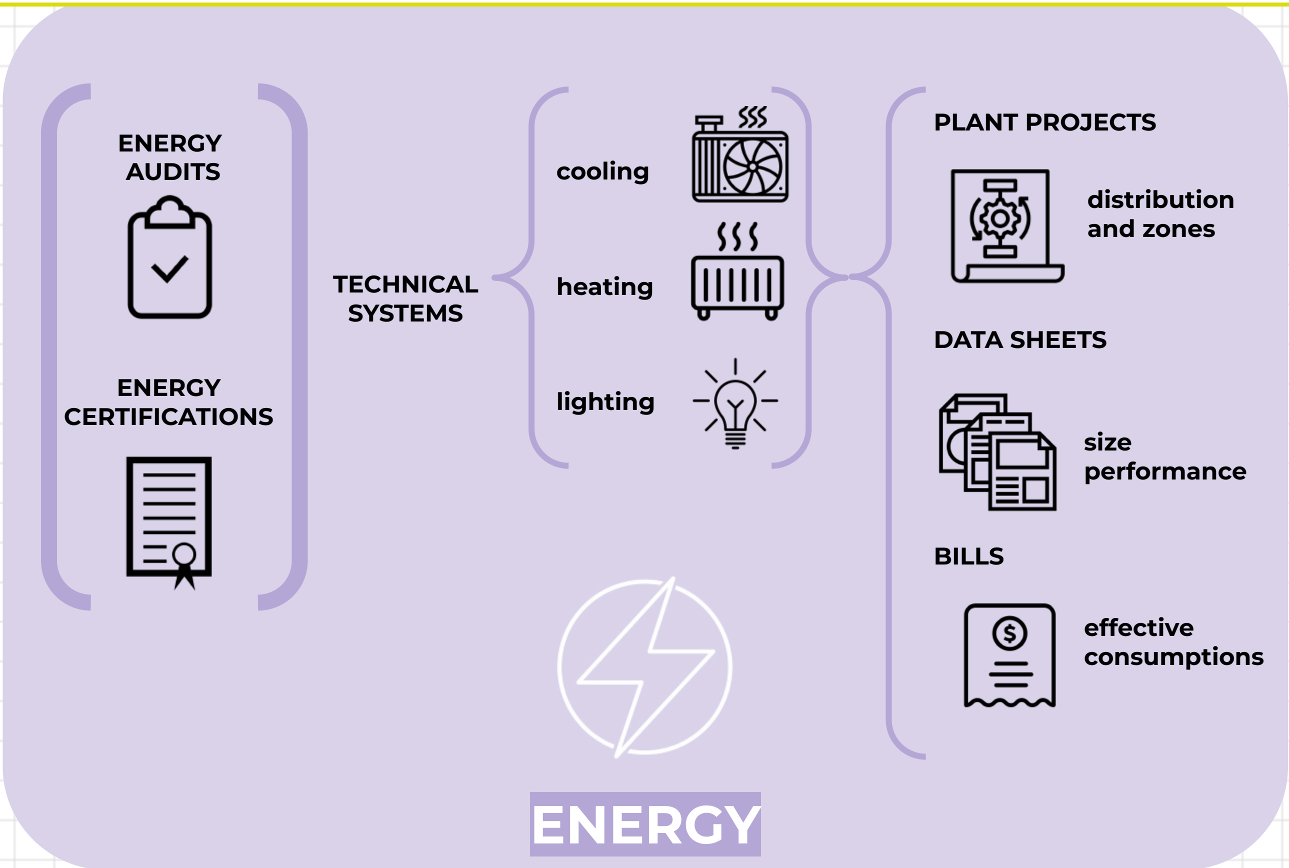
The existing **architectural documents** to start the collection are:

- ➔ Architectural projects (original, actual, and of each intervention)
- ➔ Technical relations (in the case of historical building: archive or literature review)
- ➔ Technical drawings (planimetry, sections, and prospectus)
- ➔ Details of the envelope (stratigraphies and materials)
- ➔ Photographic reports
- ➔ Architectural constraints

EXISTING DOCUMENTS CAN BE:
difficult to find
distributed across offices,
missing...

back to WORK FLOW

Collect Existing Documents

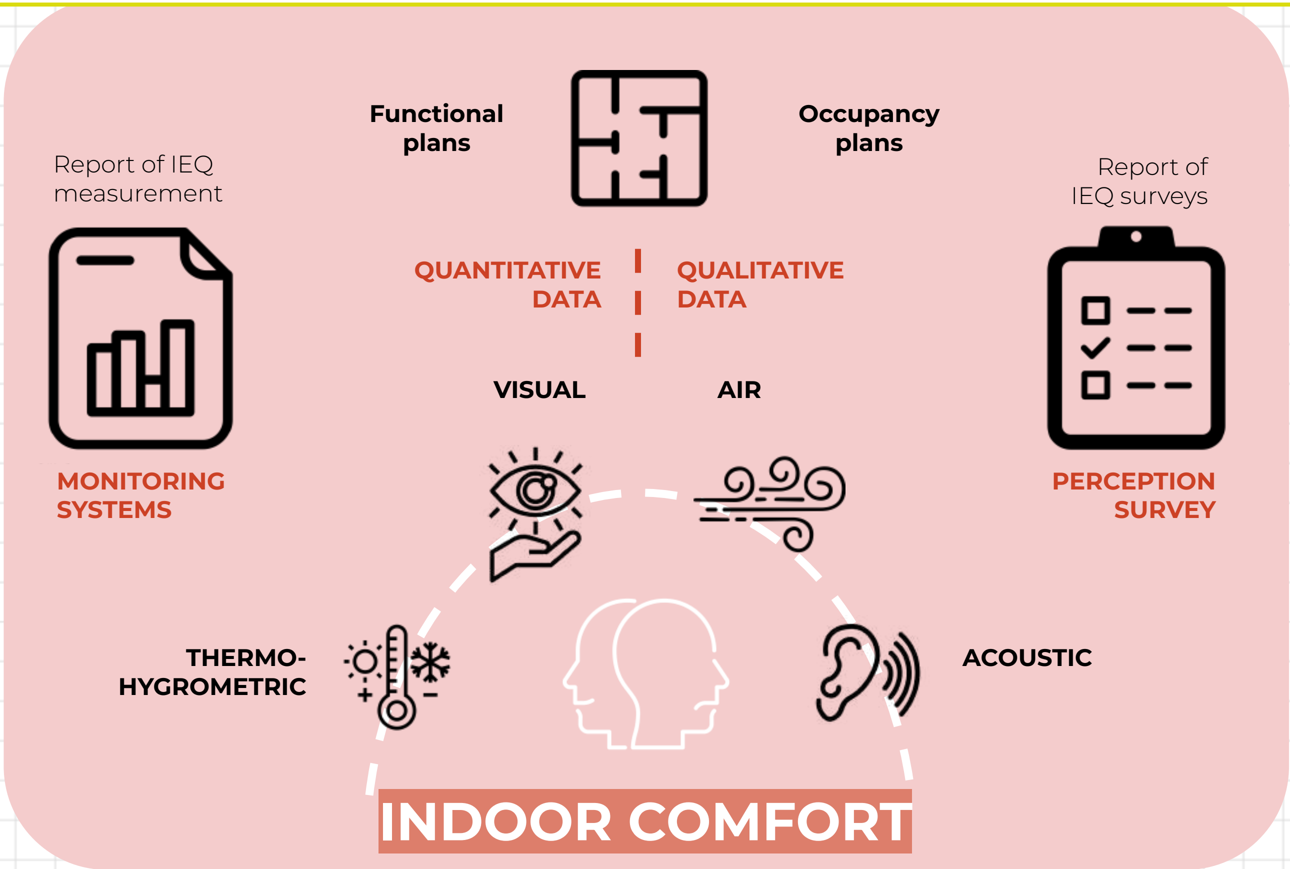


The existing **energy documents** to start the collection are:

- ➔ Energy Audits
- ➔ Energy Certifications
- ➔ Data sheets collection of all the technical system devices
- ➔ Plant System Projects (thermal, cooling, ventilation, electrical)
- ➔ Energy Bills (last 5 years)

back to WORK FLOW

Collect Existing Documents

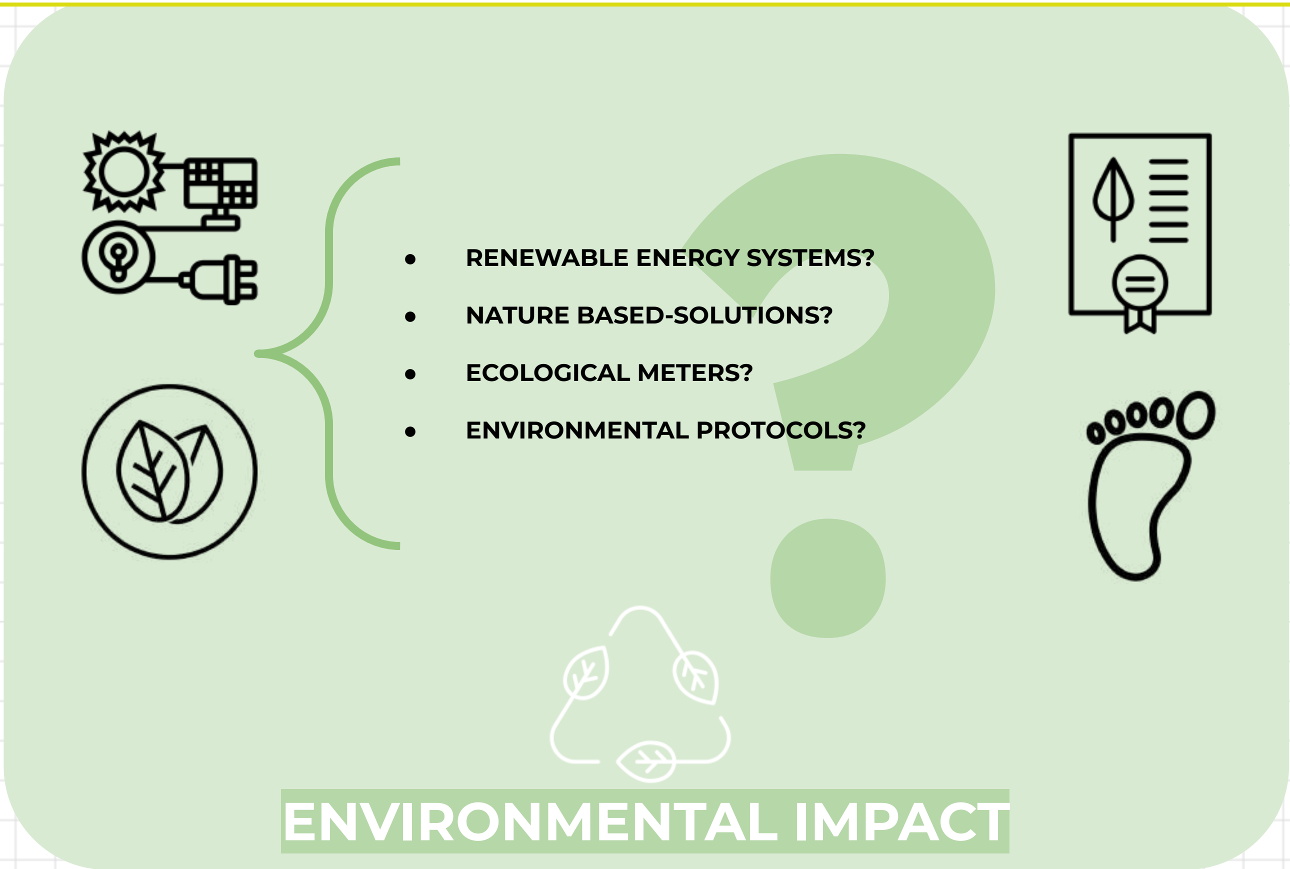


The existing **Indoor Environmental Quality (IEQ) documents** to start the collection are:

- ➔ Occupancy and maintenance plan
- ➔ Report of IEQ measurements (quantitative data)
- ➔ Report of occupants' surveys (qualitative data)
- ➔ Data sheets collection from monitoring systems

back to WORK FLOW

Collect Existing Documents



The existing **environmental impact documents** to start the collection are:

- ➔ Renewable energy systems' project and data sheets
- ➔ Environmental protocols

back to WORK FLOW

beXLab experience

ARCHITECTURE

➔ COLLECTION OF BUILDING INFORMATION

Santa Verdiana a Firenze
2017
by Farneti & Van Riel

City centre of Florence

heritage buildings

beXLab experience

ARCHITECTURE

➔ COLLECTION OF BUILDING INFORMATION

1395
Convent of Santa Verdiana

1865
Female Prison

1980-1990
New project for the School of Architecture of the University of Florence
(Prof. Arch. Roberto Maestro)

2000
The ground floor of the pilot building is closed to host two new student rooms

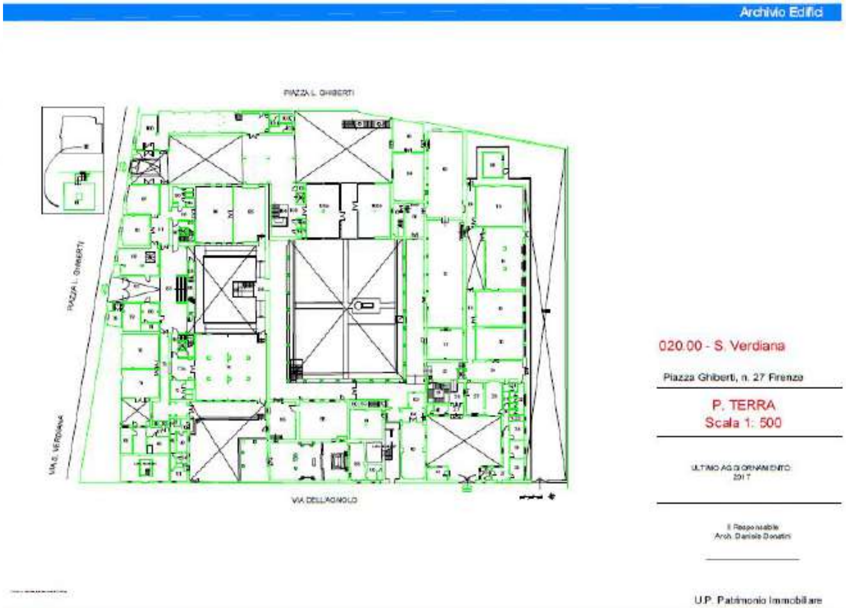
2017
New project for a multifunctional building in the north of the pilot building

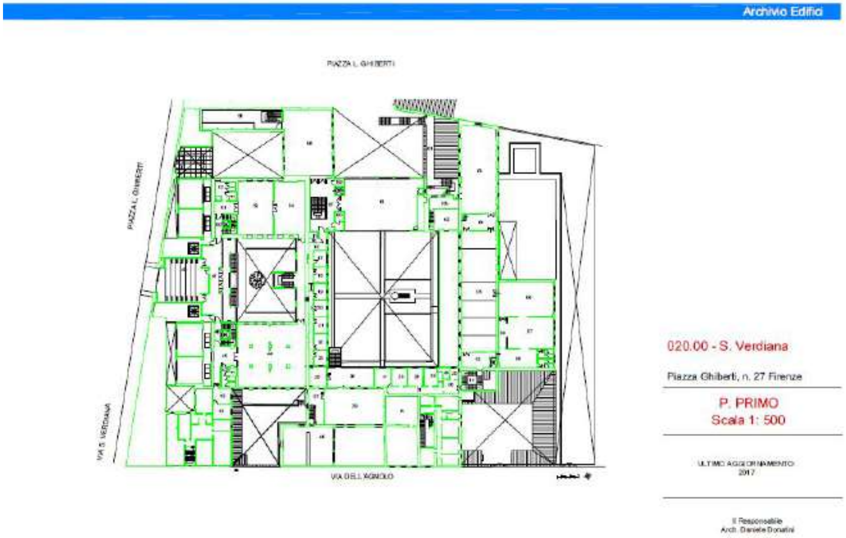
TODAY
New Main Entrance of the School of Architecture, next to the pilot building

beXLab experience

ARCHITECTURE

→ COLLECTION OF DRAWINGS





BUILDING MANAGERS

beXLab experience

ENERGY MANAGERS

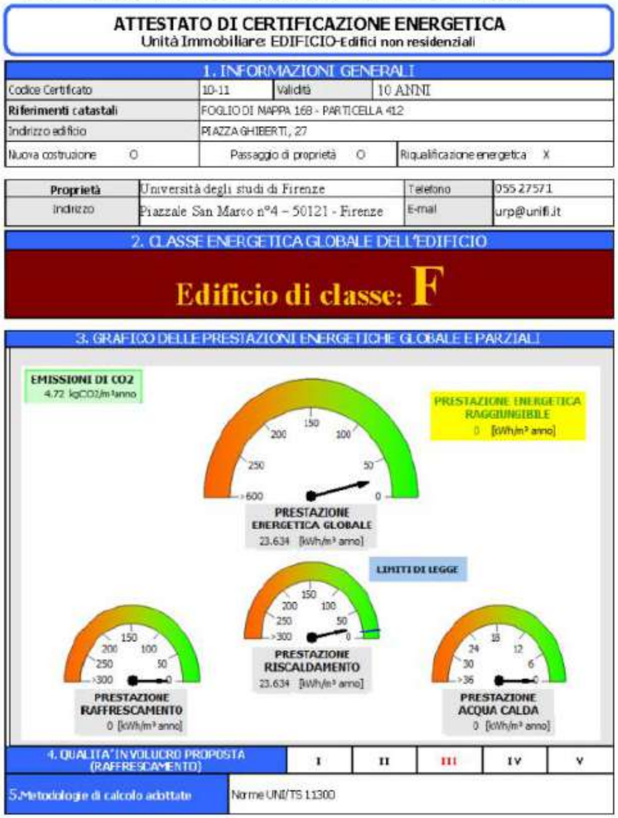
ENERGY

- ➔ ENERGY AUDIT
- ➔ ENERGY CERTIFICATION

ENERGY AUDITS

ENERGY CERTIFICATIONS

A.7. ATTESTATO DI CERTIFICAZIONE ENERGETICA



ATTESTATO DI CERTIFICAZIONE ENERGETICA
Unità Immobiliare: EDIFICIO-Edifici non residenziali

1. INFORMAZIONI GENERALI

Codice Certificato	10-11	Validità	10 ANNI
Riferimenti catastali	FOGLIO DI MAPPA 168 - PARTICELLA 412		
Indirizzo edificio	PIAZZA GHIBERTI, 27		
Nuova costruzione O	Passaggio di proprietà O	Riqualificazione energetica X	

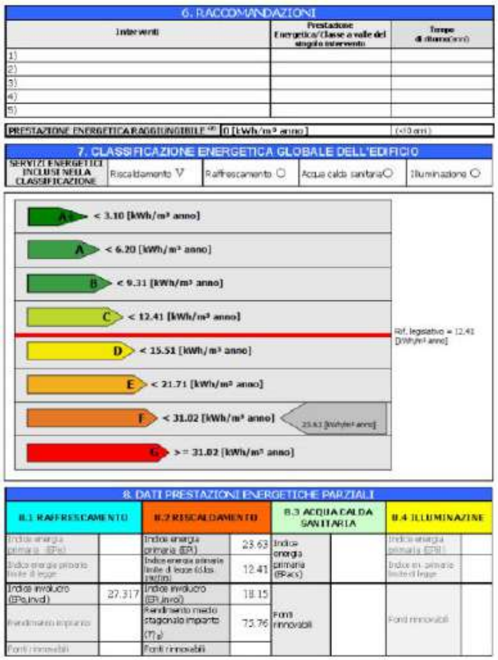
Proprietà	Università degli studi di Firenze	Telefono	055 27571
Indirizzo	Piazzale San Marco n°4 – 50121 - Firenze	E-mail	urp@unifi.it

2. CLASSE ENERGETICA GLOBALE DELL'EDIFICIO

Edificio di classe: F

3. GRAFICO DELLE PRESTAZIONI ENERGETICHE GLOBALE E PARZIALI

4. QUALITA' INVOLUCRO PROPOSTA (RAFFRESCAMENTO)	I	II	III	IV	V
5. Metodologie di calcolo adottate	Norme UNI/TS 11300				



6. RACCOMANDAZIONI

Interventi	Prestazione Energetica/Classe a valle del singolo intervento	Tempo di ritorno (anni)
1)		
2)		
3)		
4)		
5)		
PRESTAZIONE ENERGETICA RAGGIUNGIBILE	0 [kWh/m² anno]	(<10 anni)

7. CLASSIFICAZIONE ENERGETICA GLOBALE DELL'EDIFICIO

SERVIZI ENERGETICI INCLUSI NELLA CLASSIFICAZIONE	Riscaldamento V	Raffrescamento O	Acqua calda sanitaria O	Illuminazione O

8. DATI PRESTAZIONI ENERGETICHE PARZIALI

8.1 RAFFRESCAMENTO		8.2 RISCALDAMENTO		8.3 ACQUA CALDA SANITARIA		8.4 ILLUMINAZINE	
Indice energia primaria (EPe)		Indice energia primaria (EPi)	23.63	Indice energia primaria (EPacs)		Indice energia primaria (EPill)	
Indice energia primaria limite di legge		Indice energia primaria limite di legge (d.lgs 192/05)	12.41			Indice en. primaria limite di legge	
Indice involucro (EPe,invol)	27.317	Indice involucro (EPi,invol)	18.15	Fonti rinnovabili		Fonti rinnovabili	
Rendimento impianto		Rendimento medio stagionale impianto (ηg)	75.76				
Fonti rinnovabili		Fonti rinnovabili					

beXLab experience

ENERGY

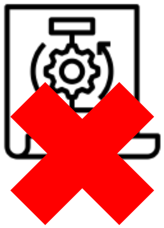
cooling

heating

lighting

PLANT PROJECTS

distribution
and zones



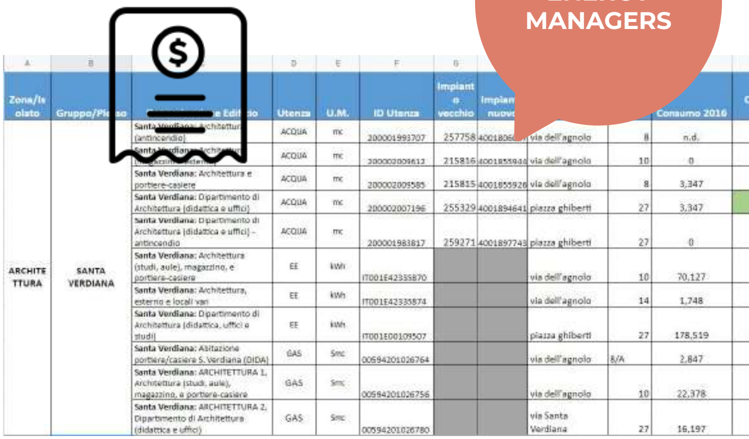
DATA SHEETS

size
performance

BILLS

effective
consumptions

ENERGY MANAGERS



Zona/Isolato	Gruppo/Plesso	[illegible] Edificio	Utenza	U.M.	ID Utenza	Impianto vecchio	[illegible]	[illegible]	[illegible]	Consumo 2016
ARCHITETTURA	SANTA VERDIANA	Santa [illegible] (antincendio)	ACQUA	mc	200001993707	257758	[illegible]	via dell'agnolo	8	n.d.
		Santa [illegible]	ACQUA	mc	200002009612	215816	4001855944	via dell'agnolo	10	0
		Santa Verdiana: Architettura e portiere-casiere	ACQUA	mc	200002009585	215815	4001855926	via dell'agnolo	8	3,347
		Santa Verdiana: Dipartimento di Architettura (didattica e uffici)	ACQUA	mc	200002007196	255329	4001894641	piazza ghiberti	27	3,347
		Santa Verdiana: Dipartimento di Architettura (didattica e uffici) - antincendio	ACQUA	mc	200001983817	259271	4001897743	piazza ghiberti	27	0
		Santa Verdiana: Architettura (studi, aule), magazzino, e portiere-casiere	EE	kWh	IT001E42335870			via dell'agnolo	10	70,127
		Santa Verdiana: Architettura, esterno e locali vari	EE	kWh	IT001E42335874			via dell'agnolo	14	1,748
		Santa Verdiana: Dipartimento di Architettura (didattica, uffici e studi)	EE	kWh	IT001E00109507			piazza ghiberti	27	178,519
		Santa Verdiana: Abitazione portiera/casiere S.Verdiana (DIDA)	GAS	Smc	00594201026764			via dell'agnolo	8/A	2,847
		Santa Verdiana: ARCHITETTURA 1, Architettura (studi, aule), magazzino, e portiere-casiere	GAS	Smc	00594201026756			via dell'agnolo	10	22,378
		Santa Verdiana: ARCHITETTURA 2, Dipartimento di Architettura (didattica e uffici)	GAS	Smc	00594201026780			via Santa Verdiana	27	16,197

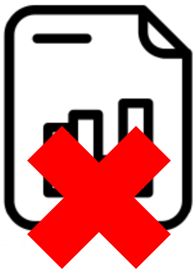
beXLab experience

INDOOR COMFORT

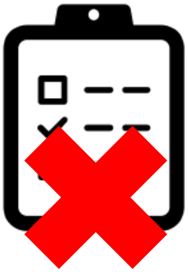
➔ MONITORING SYSTEM
➔ PERCEPTION SURVEY

BUILDING/ ENERGY MANAGERS

Report of IEQ measurement

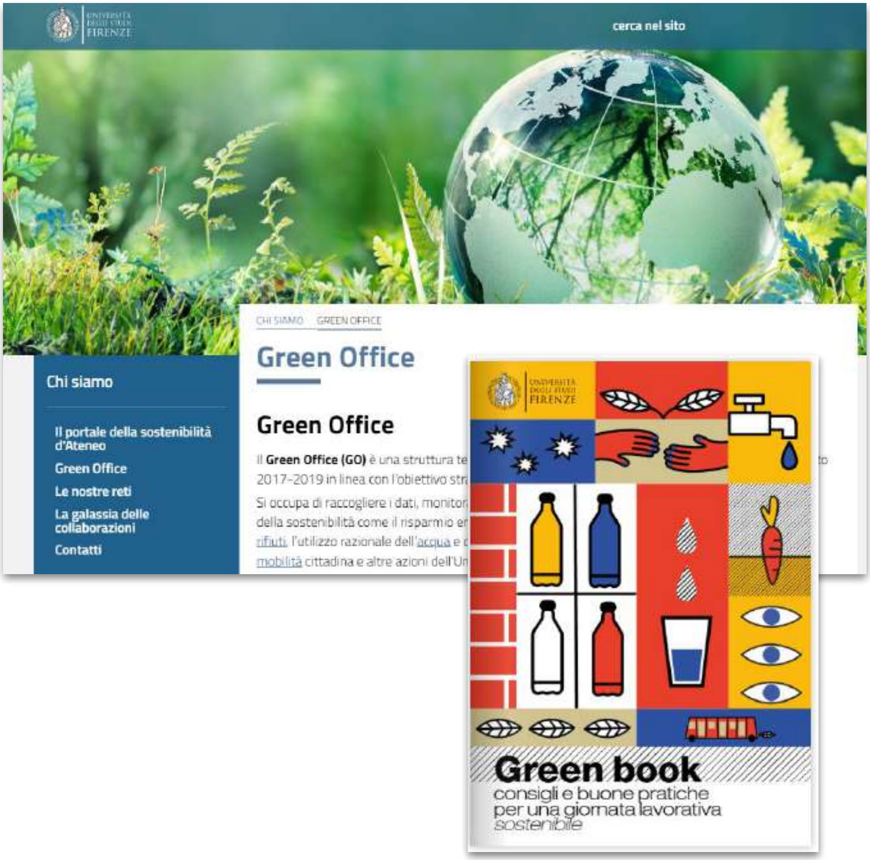


Report of IEQ surveys



beXLab experience

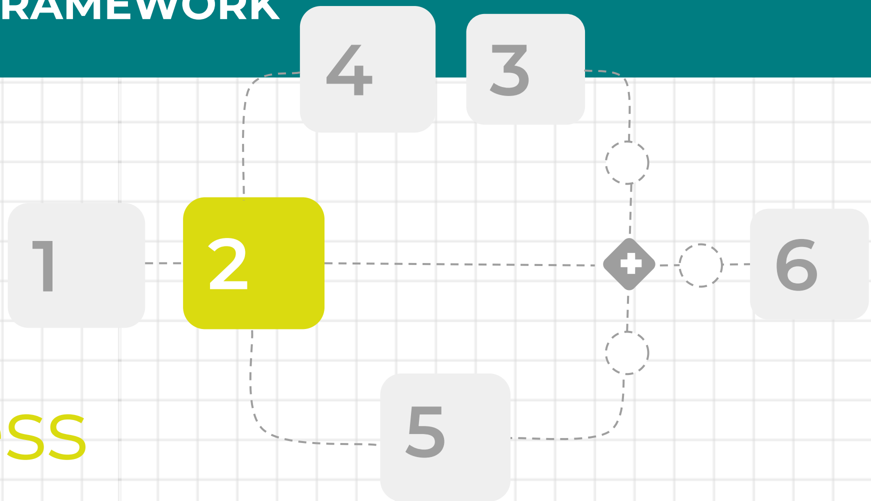
ENVIRONMENTAL IMPACT



ARCHITECTURE renovation process and scenario design

BUILDING/ ENERGY MANAGERS

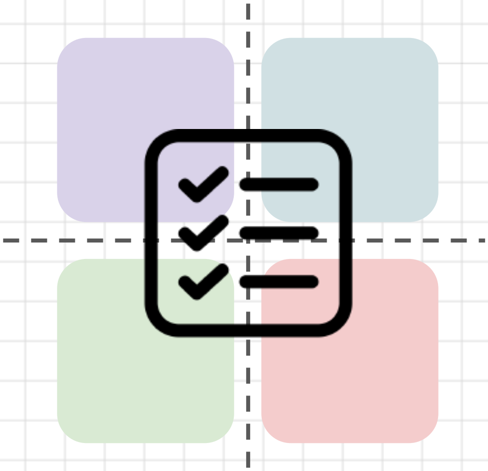
ENERGY ENGINEERING plant and monitoring systems

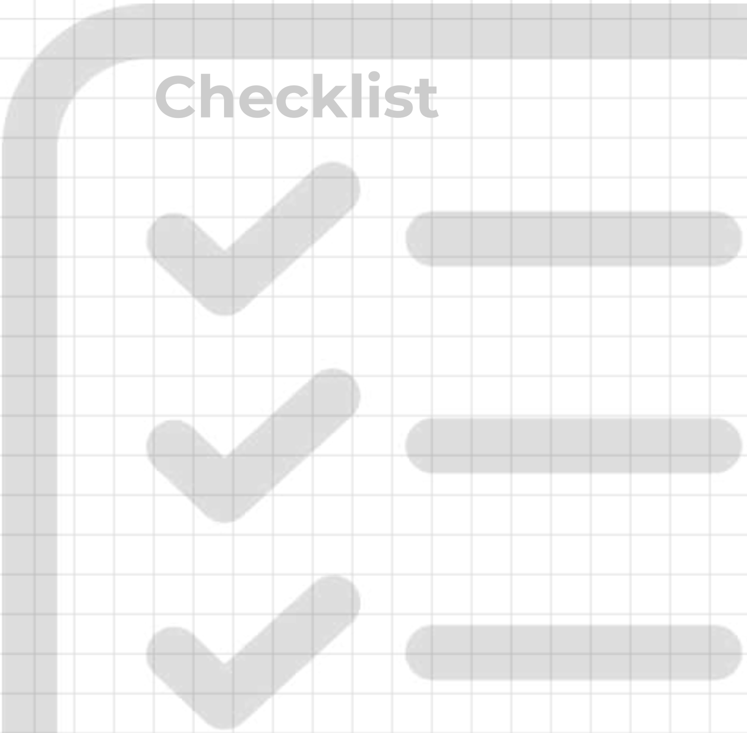


2. Verify Data Completeness

Collected documents have to be analysed in order **to verify the completeness of the data needed** to define the KF, that have to cover all the aspects individualised in the ‘what’.

For the purpose, use the following synthetic **checklists** related to the main 3 aspects.

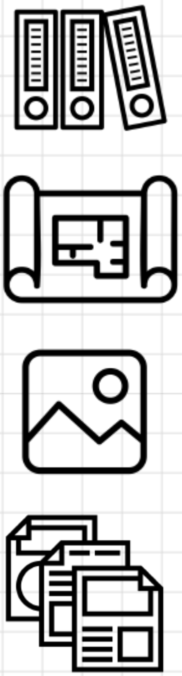




back to WORK FLOW

Verify Data Completeness

REVIEW OF EXISTING DOCS



ASPECTS	TYPE OF DATA	YES/NO
Context	Location	
	Volumetry of the context	
History	Year of construction + transformations	
	Architectural constraints	
Geometry	Plans	
	Sections	
	Elevations	
Physical conditions	Photographic survey	
Functional Configuration	Destination use	
	Functional layout	
Opaque envelope	Surfaces	
	Stratigraphies	
	Materials	
	Thermo-hygrometric properties	
Transparent envelope	Surfaces	
	Materials	
	Thermo-hygrometric properties	
	Visual properties	
	Shading devices	

ARCHITECTURE

back to WORK FLOW

Verify Data Completeness

REVIEW OF EXISTING DOCS

ASPECTS	TYPE OF DATA	YES/NO
Heating system	Size	
	Typology	
	Distribution (plan)	
Cooling system	Size	
	Typology	
	Distribution (plan)	
Artificial Lighting	Number	
	Typology	
	Distribution (plan)	
Energy Consumptions	Consumptions for heating	
	Consumptions for cooling	
	Consumptions for lighting	

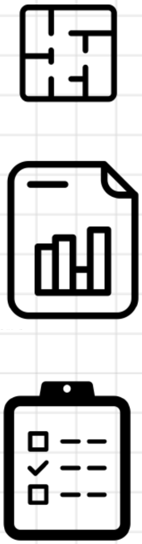
CHECK!

ENERGY

back to WORK FLOW

Verify Data Completeness

REVIEW OF EXISTING DOCS



ASPECTS	TYPE OF DATA	YES/NO
Operative	Destination of use	
	Occupancy rates	
	Hours of occupations	
Thermo-hygrometric comfort	Temperatures	
	Humidity rates	
	Occupants perception	
Visual comfort	Illuminance	
	Daylight factor	
	Occupants perception	
Acoustic comfort	Noise levels	
	Occupants perception	
Air quality	CO2 levels	
	others	
	Occupants perception	

CHECK!

INDOOR COMFORT

back to WORK FLOW

Verify Data Completeness

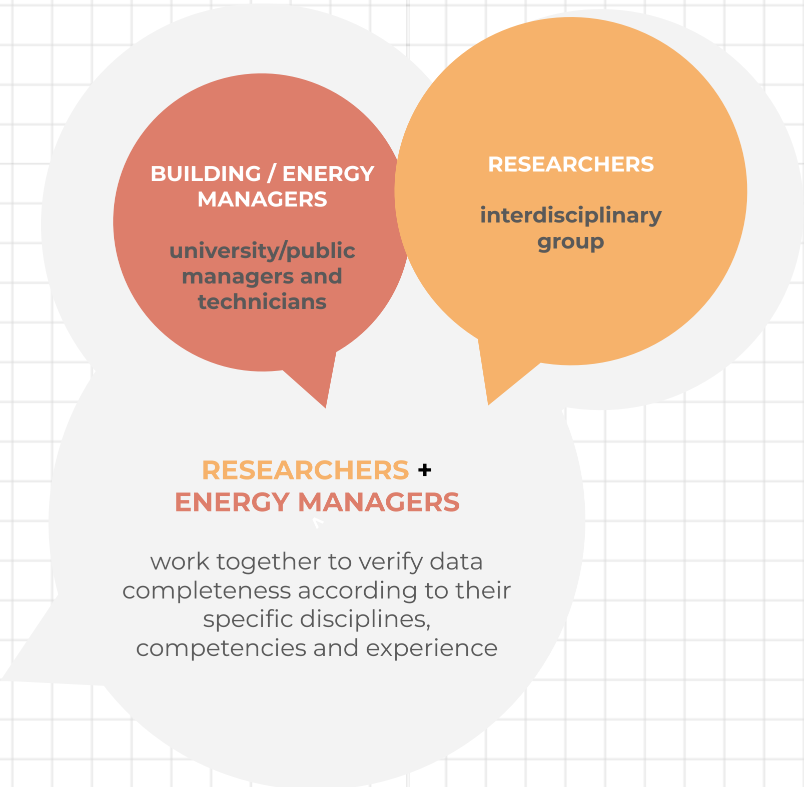
If some data is missing, they have to be collected from the field through the organisation of survey activities.

Missing of architectural data : 3) Organise a building survey

Missing of energy data: 4) Conduct an energy audit

Missing of IEQ data: 5) Perform IEQ measurement

If all types of data are complete, it is possible to move to point 6) Organise the KF.



if all data are collected

back to WORK FLOW

go to AC. 6

Verify Data Completeness

beXLab experience

IEQ

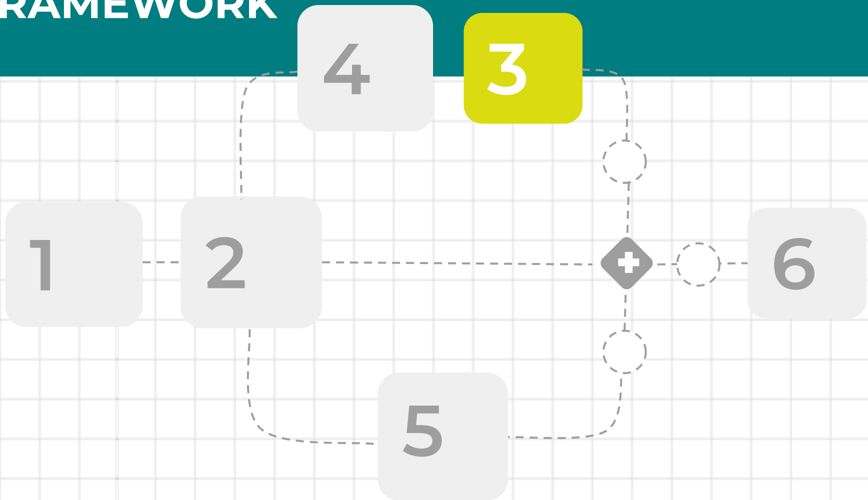
CHECK!

ARCHITECTURE

ASPECTS	TYPE OF DATA	YES/NO
Context	Location	YES
	Volumetry of the context	YES
History	Year of construction + transformations	YES
	Architectural constraints	YES
Geometry	Plans	YES
	Sections	NO
	Elevations	NO
Physical conditions	Photographic survey	YES
Functional Configuration	Destination use	YES
	Functional layout	YES
Opaque envelope	Surfaces	NO
	Stratigraphies	NO
	Materials	NO
	Thermo-hygrometric properties	NO
Transparent envelope	Surfaces	YES
	Materials	NO
	Thermo-hygrometric properties	NO
	Visual properties	NO
	Shading devices	NO

ENERGY

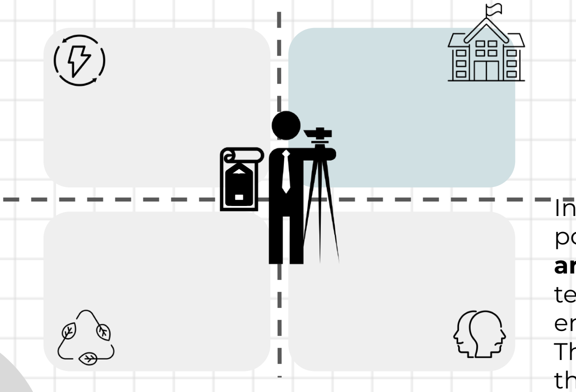
ASPECTS	TYPE OF DATA	YES/NO
Heating system	Size	NO
	Typology	NO
	Distribution (plan)	NO
Cooling system	Size	NO
	Typology	NO
	Distribution (plan)	NO
Artificial Lighting	Number	NO
	Typology	NO
	Distribution (plan)	NO
Energy Consumptions	Consumptions for heating	YES
	Consumptions for cooling	YES
	Consumptions for lighting	YES



3. Organise a Building Survey

When some **architectural data are missing** to complete the KF, it is possible to exploit the LL cooperative approach to organise a strategic building survey to collect the lacking data of the pilot-building, as an occasion to involve all the LL community, starting from the university one:

- **Researchers** (mainly architects) can provide innovative survey methodologies and tools to collect architectural data, with the possibility to experiment and test new technologies in the real-life context (e.g. laser scanners to obtain cloud points, photo-modelling techniques, etc...).
- **Students** can collaborate with researchers to conduct the survey activities, obtaining a fieldwork experience and the opportunity to enter in touch with cutting edge technologies;
- **University managers** can experience innovative methodologies and tools to update their ordinary approach to building surveys.



In the case of historical university building, it should be possible to engage **other departments experts of local architectural heritage**, providing more specific survey techniques, historical knowledge and archive experience to enrich the KF.
The early involvement of local authorities for the definition of the KF (e.g. public administrations or cultural heritage offices) can be useful to open a dialogue on the renovation projects to be authorised.

back to WORK FLOW

Organize a Building Survey

COMPANIES
Measurement Tools, Software House, Developers ...

Can provide innovative tools to collect architectural data from the existing building (e.g. Mobile building survey).

PUBLIC ORGANIZATION
historical building / office for the conservation of the building heritage

Can be interested in deeper architectural data on the pilot-building and can be early involved to smooth the authorization process.

RESEARCHERS + UNIVERSITY MANAGERS

capitalize the activity with a **document on innovative methodologies and tools for building survey**

BUILDING SURVEY
deliv. A

RESEARCHERS
architects

Provide innovative methodologies and tools to collect architectural data from the existing building (e.g. laser scanners to obtain cloud points, photo straightening techniques ....).

BUILDING / ENERGY MANAGERS
university managers

Have experience and can experience innovative methodologies and tools to collect architectural data from the existing building in order to update the current approach to building surveys (if needed).

STUDENTS

Can collaborate with researchers to conduct the survey activities and can learn through didactic activity to acknowledge the state of art of building survey techniques.

back to WORK FLOW

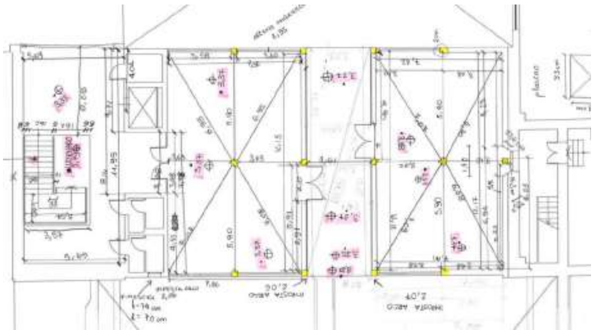
beXLab experience

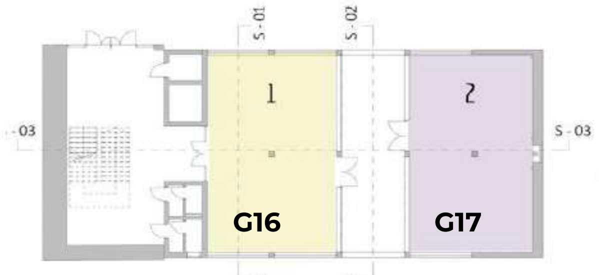
ARCHITECTURE

→ **COLLECTION OF BUILDING INFORMATION**

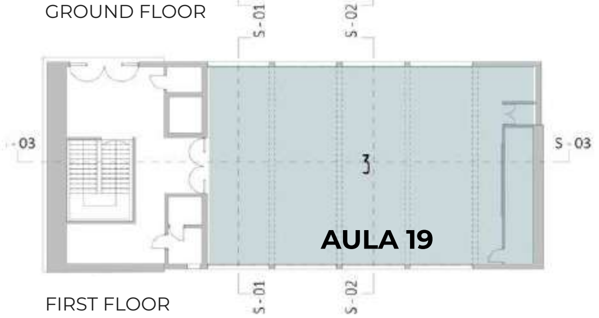
GROUND FLOOR
G16 ~ **beXLab**, **94 mq**
G17 ~ ex professors' room, **90 mq**

FIRST FLOOR
AULA 19 ~ ex aula magna, **213 mq**



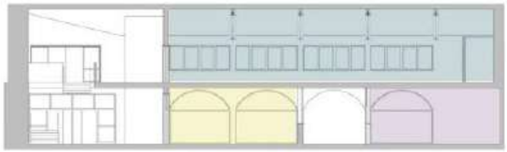


GROUND FLOOR



FIRST FLOOR

Section S-02

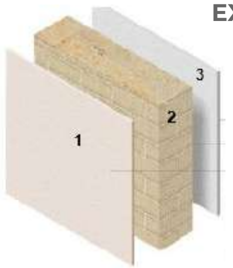


SECTION

beXLab experience

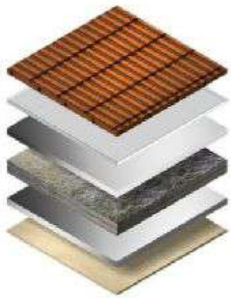
➔ **ENVELOPE**
Opaque

UNKNOWN DATA



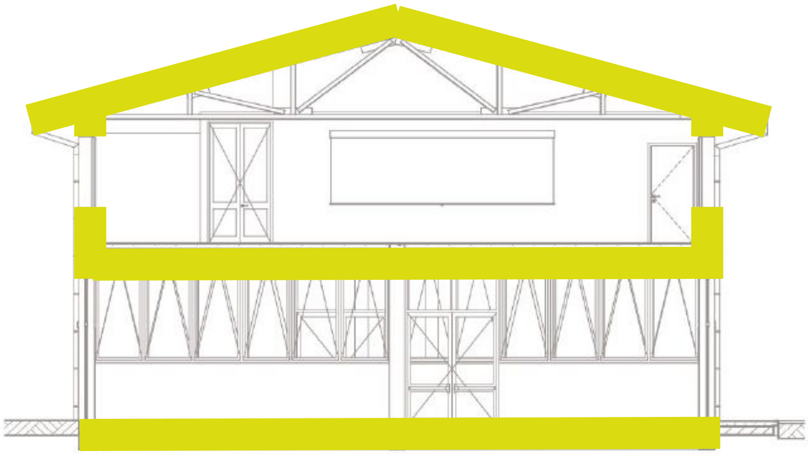
EXTERNAL WALL

1. Intonaco di calce e gesso
2. Tufo
3. Intonaco di calce e gesso

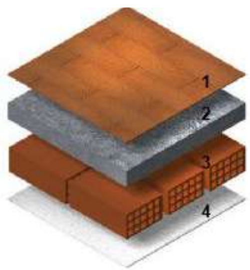


ROOF

1. Tegole in argilla
2. Camera debolmente ventilata
3. Alluminio
4. Pannello in poliuretano espanso (PUR) con rivestimenti flessibili impermeabili ai gas
5. Alluminio
6. Camera non ventilata
7. Legno compensato - 500 kg/m3



INTER-FLOOR SLAB



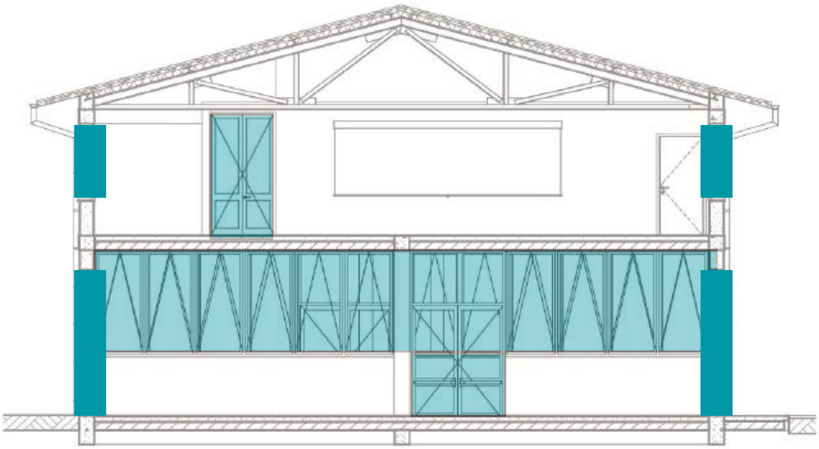
1. Piastrelle in ceramica / porcellana
2. Calcestruzzo - 2200 kg/m3
3. Pignatte in laterizio
4. Intonaco di calce e gesso

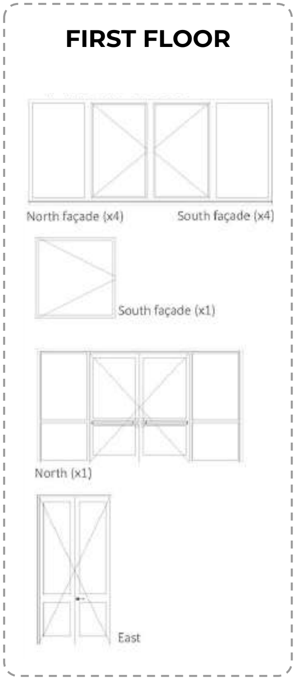
beXLab experience

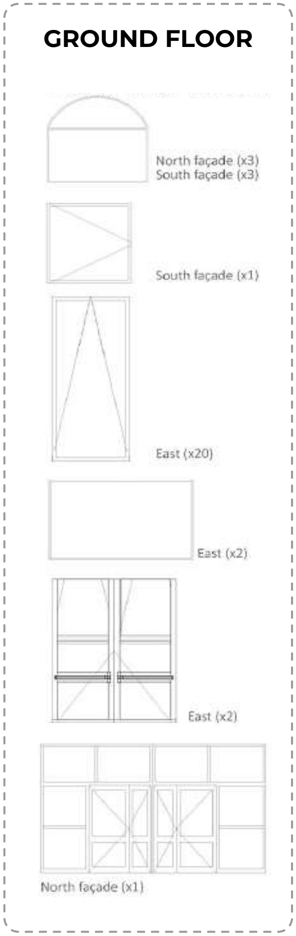
→ **ENVELOPE**
Transparent

UNKNOWN DATA

NB: transparent envelope is prevalent!







beXLab experience

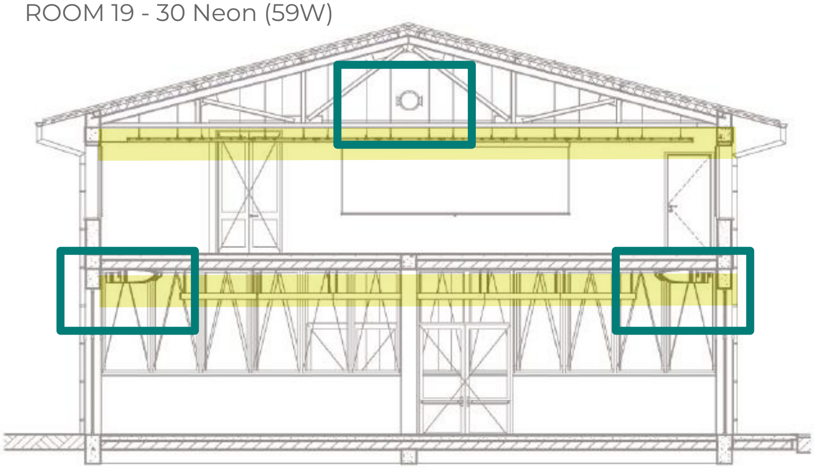
➔ **PLANT SYSTEM**
HVAC and Artificial Lighting

UNKNOWN DATA

HVAC
supply: heat pump
G15 - 4 fancoil
G16 - 4 fancoil
ROOM 19 - tube with 8 splitter

ARTIFICIAL LIGHTING

Ex-aula studenti - 12 Neon (98 W)
Ex-aula pro- 12 Neon (98W)
ROOM 19 - 30 Neon (59W)

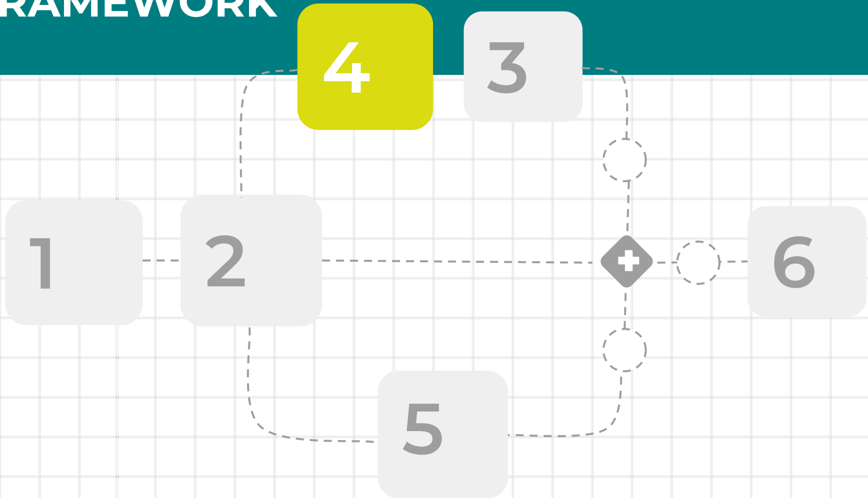


FIRST FLOOR

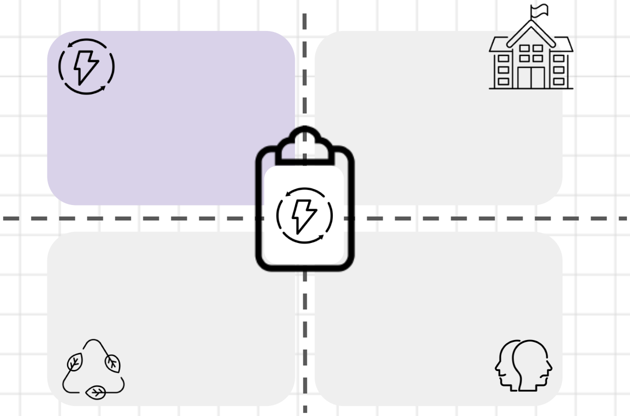


GROUND FLOOR





4. Conduct an Energy Audit



The **lack of an energy audit** of the pilot-building (or older than 3 years) is an occasion to jointly conduct one, together with the LL university community.

Organised by the energy engineers of LL group of interdisciplinary **researchers**, the conduction of an energy audit can be performed together with the university members of the LL (**university managers and students**), as occasion for the experimentation of innovative methodologies and tools.

For example, it is possible to exploit the existing instrumentation (e.g. thermal cameras, spot measurements on plant systems) for a deeper diagnosis of the building.

It is possible to engage **external stakeholders**, experts in energy audit (e.g. ESCOs, energy companies): they are interested in collaborating with the university LL to conduct joint **Research and Development**, but also to attract future professionals (**students**).

back to WORK FLOW

Conduct an Energy Audit

COMPANIES
ESCOs, Software House, Measurement/Monitoring Tools ...

Can provide innovative procedures and tools to speed up energy audits (e.g. ICT platform, app, measurement tools).

BUILDING / ENERGY MANAGERS
university managers

Can collaborate providing their experience or adopting new and experiment ways to approach the real-life energy audit of the pilot building.

RESEARCHERS
Energy Engineer

Provide innovative methodologies and tools to conduct an energy audit (e.g. thermal cameras).

STUDENTS

Are engaged in the real-life energy audit of the pilot-building as a didactic activity, because students can learn how to conduct an energy audit, its tools and techniques.

RESEARCHERS + STUDENTS + ENERGY MANAGERS

Have the opportunity to collaborate with the university community, and can capitalize the activity with a **document on innovative methodologies and tools for energy audit**.

ENERGY AUDIT
deliv. B

back to WORK FLOW

beXLab experience

ENERGY

➔ ENERGY AUDIT DATA COLLECTION FORM
Site data

Building Name	Address	Building square meter (m2)	age of building (years)	Date of last major renovation	purpose of building	Number of floors	Name of utility company
Santa Verdiana - Faculty of Architecture	Piazza Ghiberti 27, 50122 - Firenze	7,105.85 m2 all building	1395	1986	University School for Architects and Designers	3	Consorzio Energia Toscana (CET)

Total Daily Hours of Operation

Sunday	0	Thursday	13	**Months of Operation per Year?**	10
Monday	13	Friday	13	Total Weekly Hours	65
Tuesday	13	Saturday	0	Total Annual Hours	2600
Wednesday	13				

Organization Information

Name of orgnization	**Università degli studi di Firenze**	Name of Contact	Arch. Francesco Napolitano	Position	Technical Office - Director
		contact E-mail	francesco.napolitano@unifi.it	phone number	####

please check all that apply:

- ☐ this building is leased
- ☐ this building is owned
- ☐ the organization recieves monthly bills based on accurate meter readings
- ☐ meters are read regularly by on-site staff
- ☐ bills are compared to monthly meter readings on a regular basis
- ☐ A building automation system or energy management control system is in place and used to track utility data regularly
- ☐ the building is sub-metered
- ☐ the building has automated 15-minute interval or SMART meters

beXLab experience

ENERGY

➔ SAVING ENERGY COMMERCIAL BUILDING ENERGY / AUDIT DATA COLLECTION FORM

Annual Utility Consumption

Building Name	Santa Verdiana - Architecture Faculty UNIFI							
Month	Electricity (KWh)	Electricity cost ($)	Electricity cost ($/KWh)	Natural Gas (MMBtu*/Thermal)	Natural Gas cost ($)	Natural Gas rate ($/MMBtu)	Water (Gallons)	Water Cost ($)
anuary	21419.58	6983.64	0.32604	277.42	6030.85	21.73905991	74496.52	
ebruary	21419.58	6983.64	0.32604	277.42	6030.85	21.73905991	74496.52	
March	21419.58	6983.64	0.32604	277.42	6030.85	21.73905991	74496.52	
April	21419.58	6983.64	0.32604	149.38	2703	21.73942091	74496.52	
May	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
une	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
uly	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
August	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
September	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
October	21419.58	6983.64	0.32604	0	0	21.73942091	74496.52	
November	21419.58	6983.64	0.32604	277.42	6030.85	21.73905991	74496.52	
December	21419.58	6983.64	0.32604	277.42	6030.85	21.73905991	74496.52	
Annual Total=	257034.96	83803.68	0.32604	1536.48	32857.25	21.73927049	893958.24	0

electricity Usage (KWh)	Natural Gas Usage (KWh)	Total energy (KWh)	Energy Use Intensity (KWh/m2)
257035.00	450,292.92	707327.92	99.53953279

* If natural gas is listed on utility bills as CCF or thermal, please refer to conversion table

Calculate the energy use Intensity (EUI) by converting natural gas from Thermal/MMBtu to KWh, as shown below:

– Natural gas usage (Btu)	= total MMBtu × 1,000,000 Btu/MMBtu	= ______	Btu
– Natural gas usage (KWh)	= total Btu ÷ 3,412.14 Btu/KWh	= ______	KWh
– Total energy Use (KWh)	= Electricity KWh + Natural Gas KWh	= ______	KWh
– Energy Use Intensity (KWh/m2)	= KWh/m2	= ______	KWh/m2

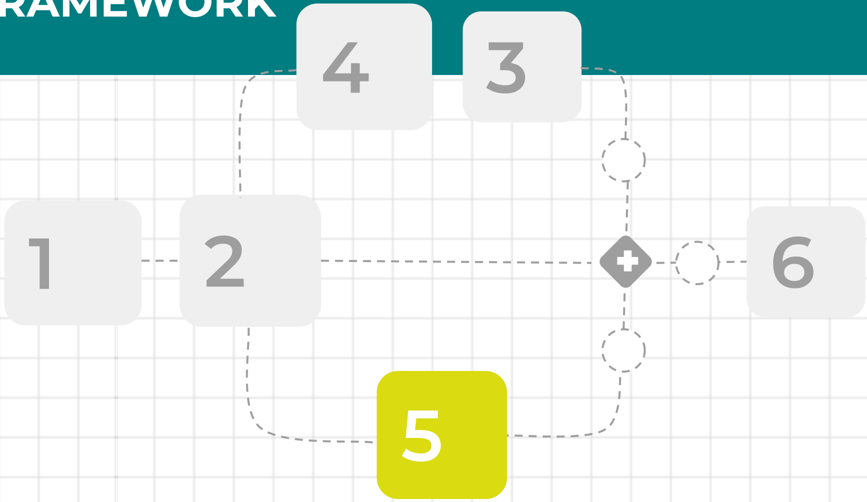
Where another fuel type is being used, please explain where and why it is being used:	Null
Amount of additional fuel type used per year (quantity & units)	Null

beXLab experience

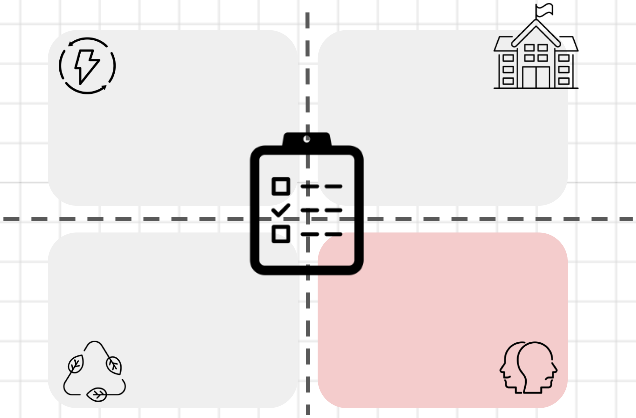
ENERGY

➔ ENERGY AUDIT DATA COLLECTION FORM
Lighting building data

Floor Name or room number	location description (near window, internal office.etc)	lamp type	Ballast type	Wattage	total Number of lamps	Number of Hours light are left on each day	Total KWh/day	how are lights controlled?
Access hall	two sided opening	HAL.	Elect	70	12	13	10.92	Switch
Reception	Internal	FL.	Elect	98	6	13	7.644	Switch
Reception	up light	HAL.	Elect	250	2	13	6.5	Switch
Service room 1	Internal	FL.	Mag.	116	3	1	0.348	Switch
Prof. office 1	Near window	FL.	Elect	98	6	6	3.528	Switch
Prof. office 1	up light	HAL.	Elect	250	2	6	3	Switch
Prof. office 2	Near window	FL.	Elect	98	6	6	3.528	Switch
Prof. office 2	up light	HAL.	Elect	250	2	6	3	Switch
Corridor 1	internal	FL.	Elect	98	2	13	2.548	Switch
Corridor 1	internal	FL.	Mag.	58	4	13	3.016	Switch
WC 1	Internal	FL.	Mag.	116	1	6	0.696	Switch
WC 1	Internal	FL.	Mag.	15	3	6	0.27	Switch
Classroom 12-A	Near window	FL.	Elect	98	22	13	28.028	Switch
Classroom 12-B	Near window	FL.	Elect	98	22	13	28.028	Switch
Classroom 12-B	Blackboard light	FL.	Elect	58	2	8	0.928	Switch
Staircase 1	internal	FL.	Mag.	58	10	13	7.54	Switch
						total KWH/sheet-1	109.522	



5. Measure and survey IEQ



Data on the quality of indoor comfort are usually the most lacounous or missing. Since the objective of better IEQ should be central in the renovation project, the LL activities can be the occasion to build new protocols for the purpose.

Quantitative data can be retrieved by performing a monitoring activity that can be spot or continuous. Spot but periodic monitoring campaigns can be performed by measuring with dedicated sensors' devices, and relative protocol, environmental parameters influencing thermal, visual, acoustic and air quality:

- Thermo-hygrometric (thermoflux meters);
- Lighting;
- Acoustic;
- Air quality;
- CO2 level sensors.

More advanced is the installation of a fixed monitoring system, consenting to retrieve continuous data for a deeper acknowledgement of comfort in indoor spaces. The measurement activities can be supported by the involvement of **technical physicians**, helping to identify the more relevant data, but also the more innovative methodologies and tools.

back to WORK FLOW

Measure and survey IEQ

A comprehensive acknowledgment of the comfort of indoor spaces overcomes the quantitative measurements of environmental factors influencing indoor comfort: **subjective data** can be gathered by the subministration of right-here/right-now IEQ questionnaires to users (mainly **students**), questioning the perception of indoor comfort in all its aspects (visual, thermal, etc).

Surveys on perceived quality and comfort can take the form of longitudinal surveys, consenting to retrieve subjective data over time, useful to combine with monitored continuous environmental parameters.

The Living Lab has an educational scope for **students**. Opening renovations towards a more human-based approach. Filling in the questionnaire, students understand the importance of environmental parameters that influence the indoor comfort.

The external stakeholders are **innovative companies** of monitoring/sensors/IoT systems that can be involved in the LL, providing more innovative tools and methodologies to evaluate the quality of indoor spaces (e.g. measurement devices, sensors, IoT).

For qualitative aspects, the survey activity can benefit from the establishment with the **local departments** of environmental psychology, to provide a deeper understanding of human perception.

Public organisations dealing with health issues can be involved to give importance to the environmental quality of educational spaces, influencing the quality of living, health and wellbeing of the young population.

QUALITATIVE DATA
real perception of indoor spaces by occupants
= USERS' SURVEYS

+

QUANTITATIVE DATA
environmental parameters influencing comfort
= MEASUREMENTS

★ SPOT MEASUREMENTS

★ CONTINUOUS MONITORING

back to WORK FLOW

Measure and survey IEQ

COMPANIES
ESCOs, Software House, Measurement/Monitoring Tools ...

Can provide innovative procedures and tools to speed up energy audits.

PUBLIC ORGANIZATION

can be involved to underline the importance of environmental quality in educational spaces

BUILDING / ENERGY MANAGERS
university managers

Can augment their knowledge on the quality perceived in the university/public building.

RESEARCHERS
architects + engineers + technical physicians + other: e.g. environmental psychologist

Provide innovative methodologies and tools to measure the indoor environmental quality in the existing building.

STUDENTS

as users of the pilot-buildings, can be engaged for the IEQ questionnaires

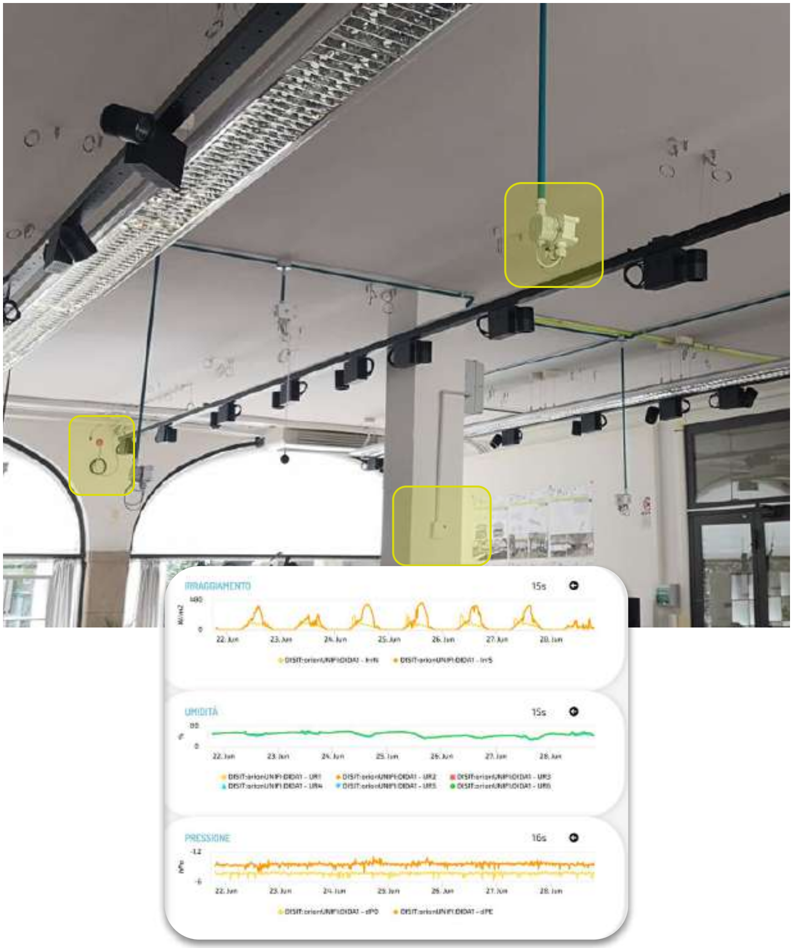
RESEARCHERS + BUILDING MANAGERS

Capitalize the activity with a **document on methodologies and tools to account IEQ**.

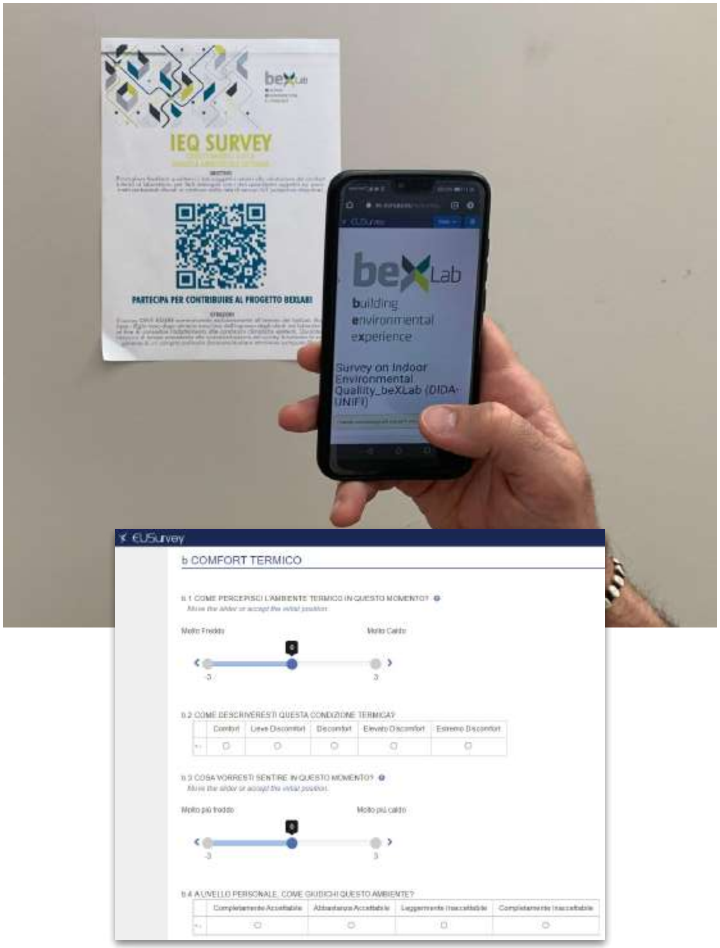
IEQ PROTOCOL
deliv. C

back to WORK FLOW

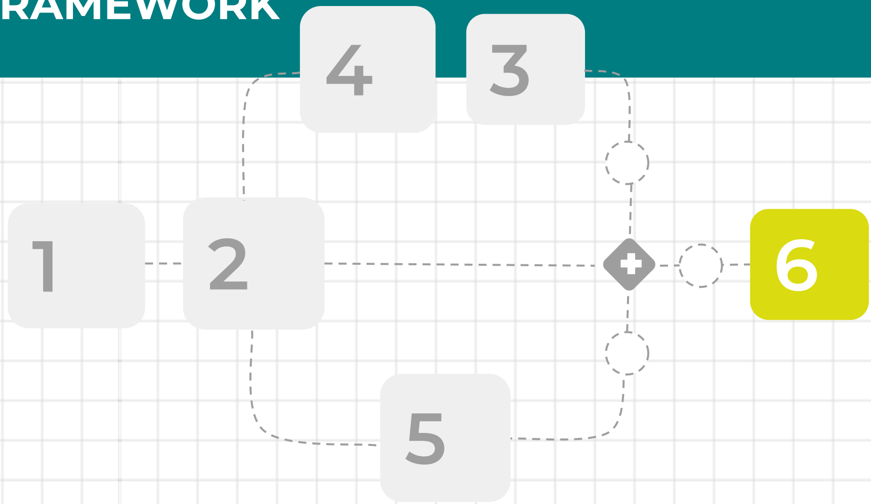
beXLab experience



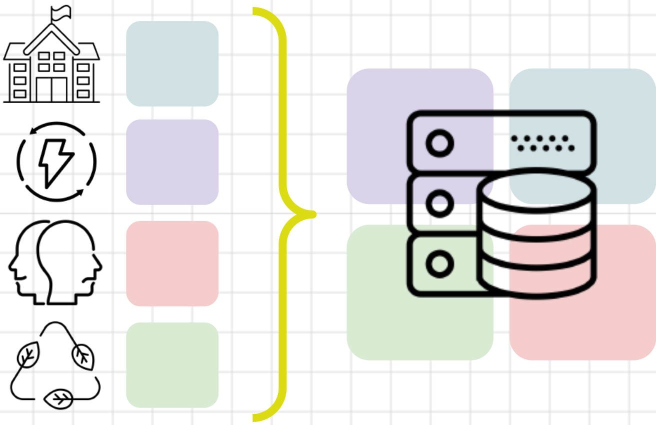
Monitoring System
QUANTITATIVE DATA



Perception Survey
QUALITATIVE DATA



6. Organize the KF



QUALITY PRINCIPLES
TO INDEX AND ARCHIVE

DIFFERENT TYPES OF DATA

All the retrieved data and information from existing documents, survey and measurement activities, have to be structured in an efficient, reliable and implementable form.

Considering the current infrastructure for the data management of the university building stock, and critically analysing it together with **university managers** (with the identification of limits and barriers), **researchers** can suggest more innovative methodologies and tools for the data collection.

The **KF has to be consolidated** considering **quality principles** to index and archive the very different types of data and information (documents, drawings, data sheets, etc) for their smoother future retrieval.

From relational databases in local servers to semantic web applications to cloud, the development of the data collection infrastructure can highly benefit from the cooperation with the **information engineering university departments**, providing with the knowledge, experience and tools to improve the efficiency of the information flows.

The activity can also be supported by **local IT companies** (e.g. software houses), or by engaging **local public administrations** already adopting innovative database systems for the management of their building stocks.

back to WORK FLOW

Organize the KF

COMPANIES
Local companies, e.g. Developers / Software House

PUBLIC ORGANIZATION
Local P.O.

Adopting or willing to adopt innovative database systems for the management of their building stock.

RESEARCHERS
information engineers, UX designers

Characterized by interdisciplinarity, consider innovative methodologies and tools

BUILDING / ENERGY MANAGERS
university managers

Has a key role in the process., since they will be the first beneficiaries

RESEARCHERS + BUILDING MANAGERS

Work together to work together to critical analyse the current data infrastructure of the building-stock, indexing and archiving the types of data, finding limits and barriers and the available resources.

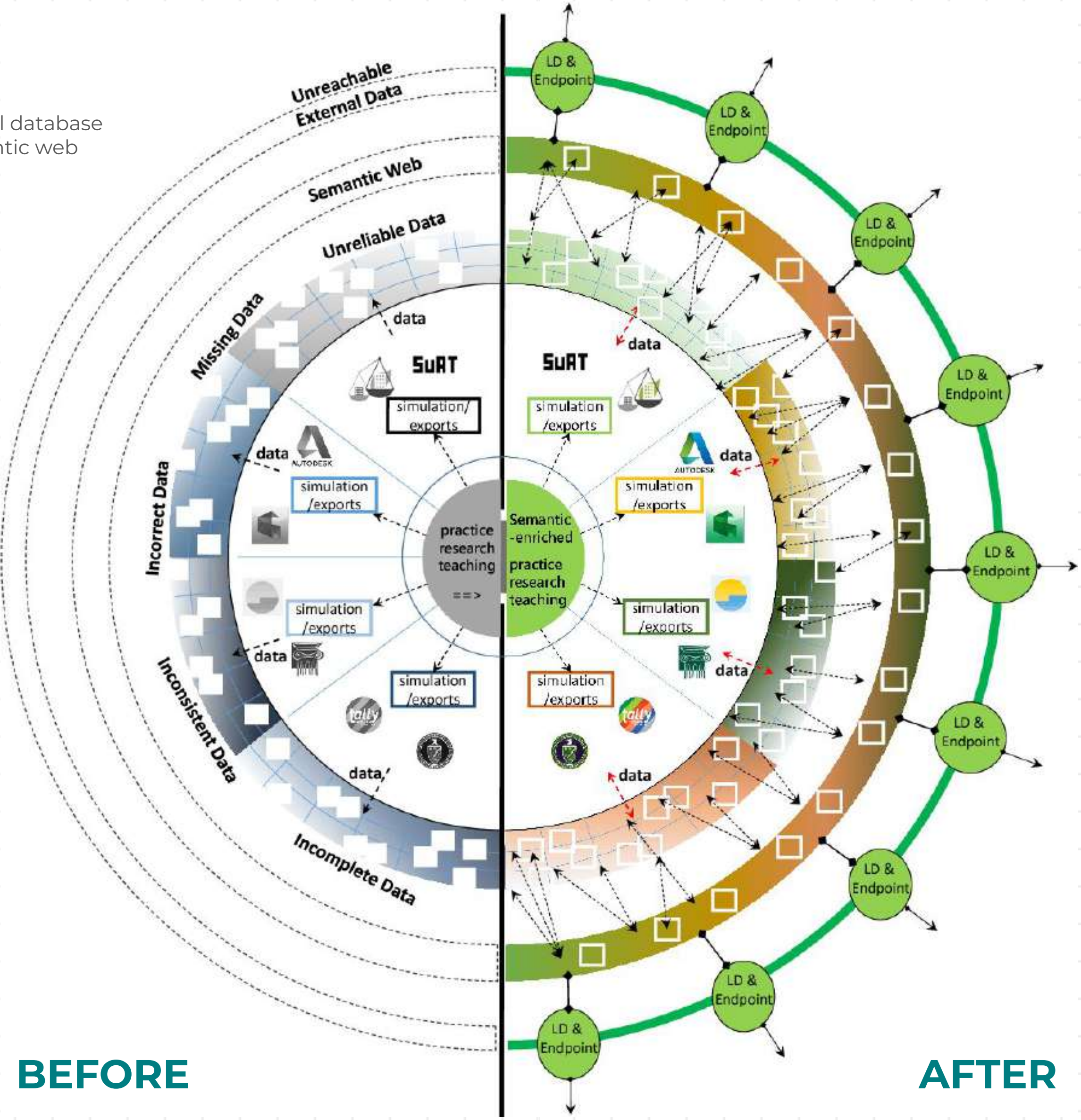
The **final documents** consists in a organized collection of data and information describing the pilot-building in relation to the 4 renovation aspects relevant to analyse its criticalities in Phase 2.

KF milestone

back to WORK FLOW

Organize the KF

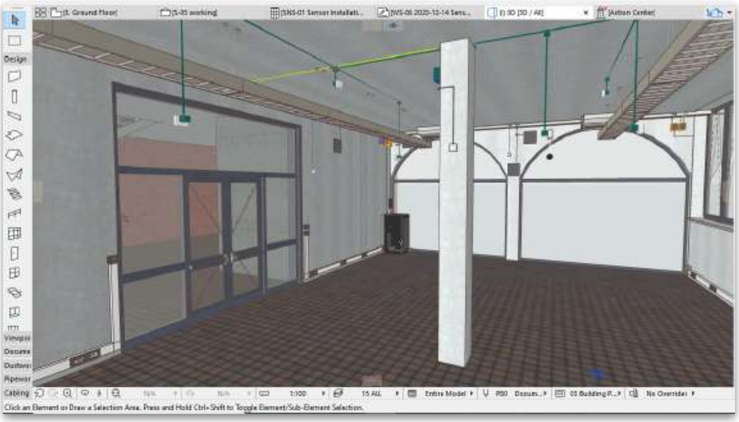
➜
From
relational database
to semantic web

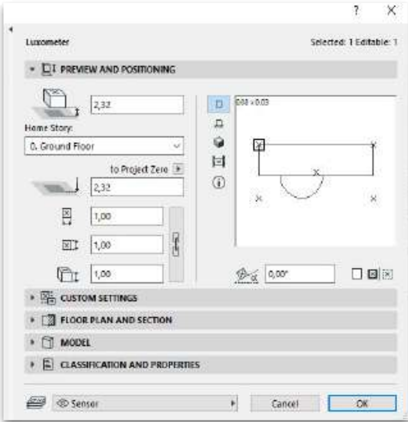


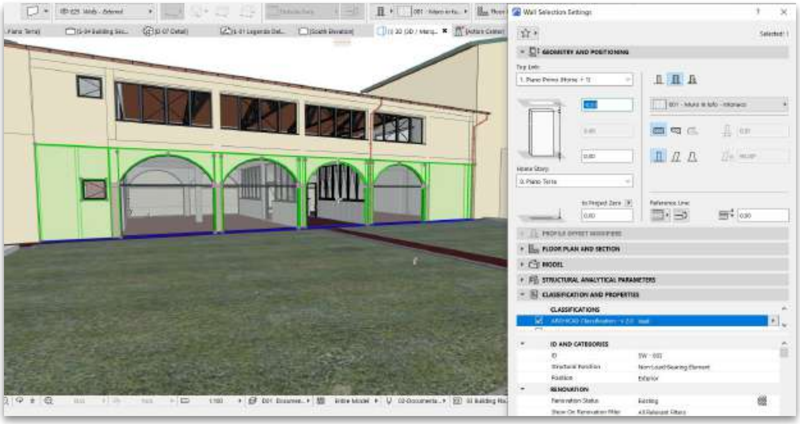
back to WORK FLOW

beXLab experience

→ **BIM ASSET MODEL**







BEST PATH
Digital Twin implementation

In order to develop digital processes the first and most important thing is to dispose of homogeneous and quality information of the asset or assets. This kind of information is not only not available or reliable, in some cases is partially existing or in the worst cases is completely nonexistent, the scenario gets worse when we talk about the public building stock.

That is why the first and most important part to understand the current status and needs of the built patrimony in order to develop projects using digital information is to acquire the information, establish strategies and standards to collect, archive, manipulate and manage the information in a way that is clear and unequivocal for everyone who may require access to the information during the building lifecycle.

Using BIM authoring software to collect and archive information as strategy to collect survey information into Survey BIM Data Model(s) have to be produced to as a repository instrument where to collect the building's current state, they shall contain geometries in the three spatial dimensions, the 2D documentation representative of the project, as well as a series of additional information describing the physical, mechanical, performance and typological characteristics of the building elements and their features.

In the Survey BIM Data Model, the full correspondence between the informative content and the 3D and 2D graphic content must result as the reference base documentation (building ID/information containers) for the single constructive/system components and it will be the starting point for the following retrofit project phases.

As mentioned the important part of this specific task or phase using BIM and Digital information is to collect all the information of the asset, geometrical and non into the same place following quality and granular information standards and have the possibility to collect other assets information using the same methodology and standards inside an organization to enlarge the accessibility and homogeneity of the information for planning and to improve operations and management processes.

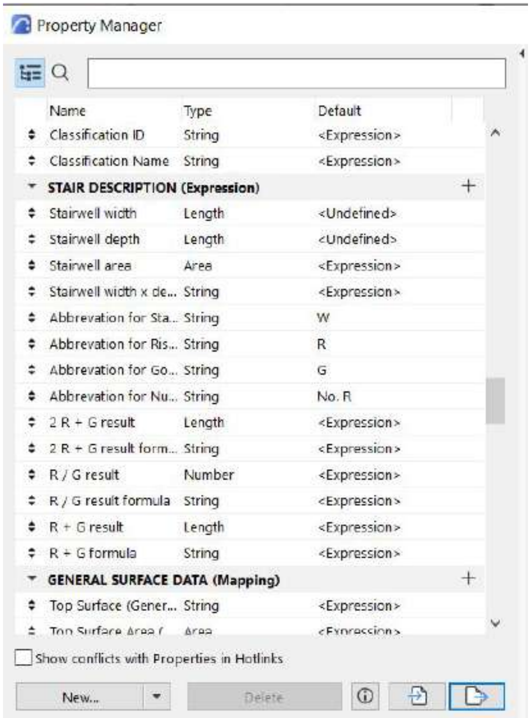
Building information models require a complex understanding of building techniques and technologies, to create a descriptive model and a digital version of a construction process, using the 2D and 3D geometry, objects, and attributes of real building elements, systems and materials.

All information that is or was useful for construction can be saved into Asset Information Models (AIM) and using .IFC files information can be preserved and managed for years and years, if there are organization standards that are over the single human behavior.

BEST PATH
Digital Twin implementation

Some examples of the type of data that could be collected are the following:

- **General Ratings**
  - Fire rating resistance
  - Thermal transmittance
  - Sound transmission
- **Product Info**
  - Model
  - Serial No.
  - Barcode
  - Acquisition Price
- **Manufacturing**
  - Manufacturer
  - Warranty end date
  - Product website
- **Floorings**
  - Fragility ratings
  - Tile dimensions
  - Non-skid surface
- **Wood (materials)**
  - Species
  - Strength grade
  - Appearance grade
  - Moisture content
  - Thickness swelling



All the Building digital information could be too much to be collected and managed so it is important to define the objectives, the reason why collecting information, which type of information and target the collection of the specific information required.

There are only few examples of how detailed the collection of information could be and is why the collection action has to be accurately planned and defined before the survey takes place. There is the possibility to fill 12,000 slots of information by element, multiplied by the amount of elements present on an asset will drive through an enormous quantity of information that is difficult to manage and absolutely useless if it is not collected to be used somehow.

go
BACK

Phase 2
Analysis of criticalities

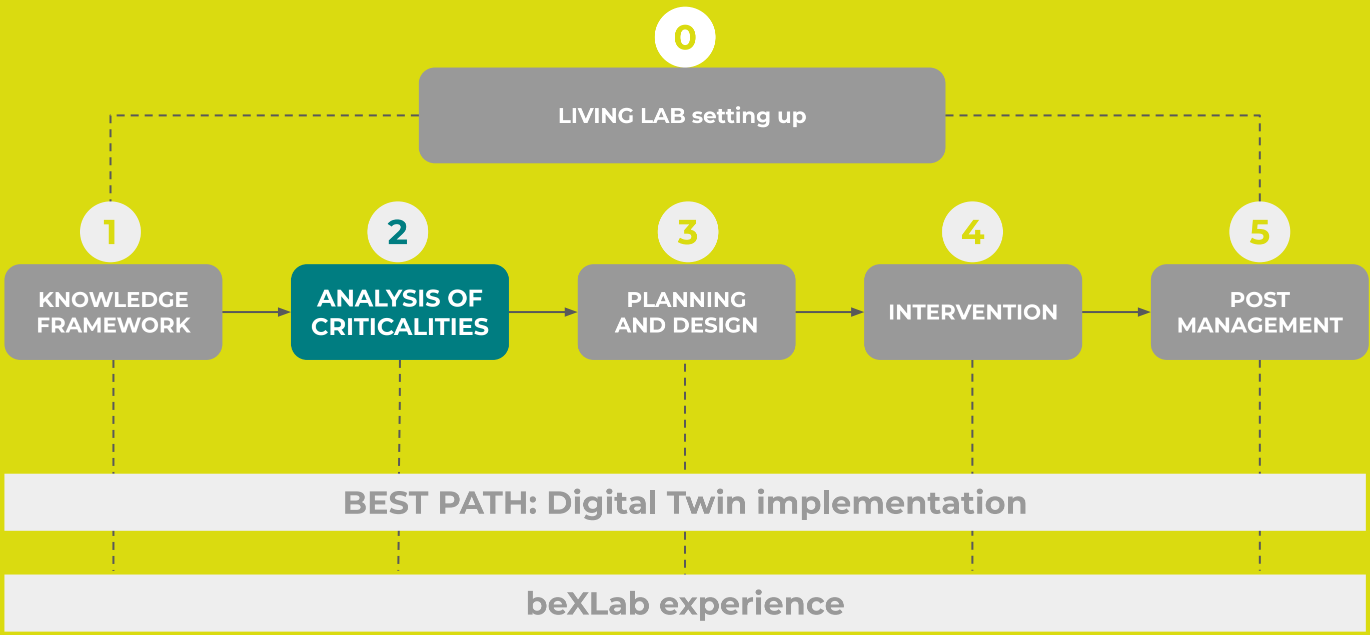
The defined KF in phase 1 is the precondition for the analysis of the criticalities of the pilot-building. Data and information collected in the KF are elaborated to highlight the criticalities that the renovation project has to address in the planning and design Phase 3 to reach the OROs.

As for the definition of the KF, the Analysis of Criticalities can be conducted exploiting the collaboration of all the LL participants from researchers, to external stakeholders, to final users.

WHAT evaluation of the pilot-building's criticalities in relation to the overarching renovation objectives (OROs)

WHO researchers, university building/energy managers, students, companies of innovative products, public organizations

HOW steps to follow to collectively analyse the criticalities of the existing university/public building



The Analysis of Criticalities (AC) is **a comprehensive evaluation of the pilot-building's criticalities in relation to the overarching renovation objectives (OROs), main targets of the renovation project and mission of the LL.**

Criticalities are analysed in a range that span from the verification of minimal requirements by law to the gap with the most ambitious renovation targets.

The AC results in a map and a report of criticalities (deliverables) describing the analysed criticalities, then translated in the Framework of Needs (milestone), input for the planning and design - Phase 3.

Related to the OROs, four main types of criticalities are analysed:

- **Architectural quality**: Inadequacy of the pilot-building physical asset, its spaces, configuration and building elements (with a particular attention on the envelope).
- **Energy efficiency**: Inefficiency of the energy systems (heating, cooling and lighting) and low energy performances
- **Comfort and wellbeing**: Low indoor environmental quality (thermal discomfort, scarce daylight, acoustic disturbances, stale air)
- **Environmental impact**: No energy from renewable sources

The activities of AC are managed by the interdisciplinary group of researchers, with competences covering all the four aspects of the renovation process, but involve all the LL participants, internal to the university context and external.

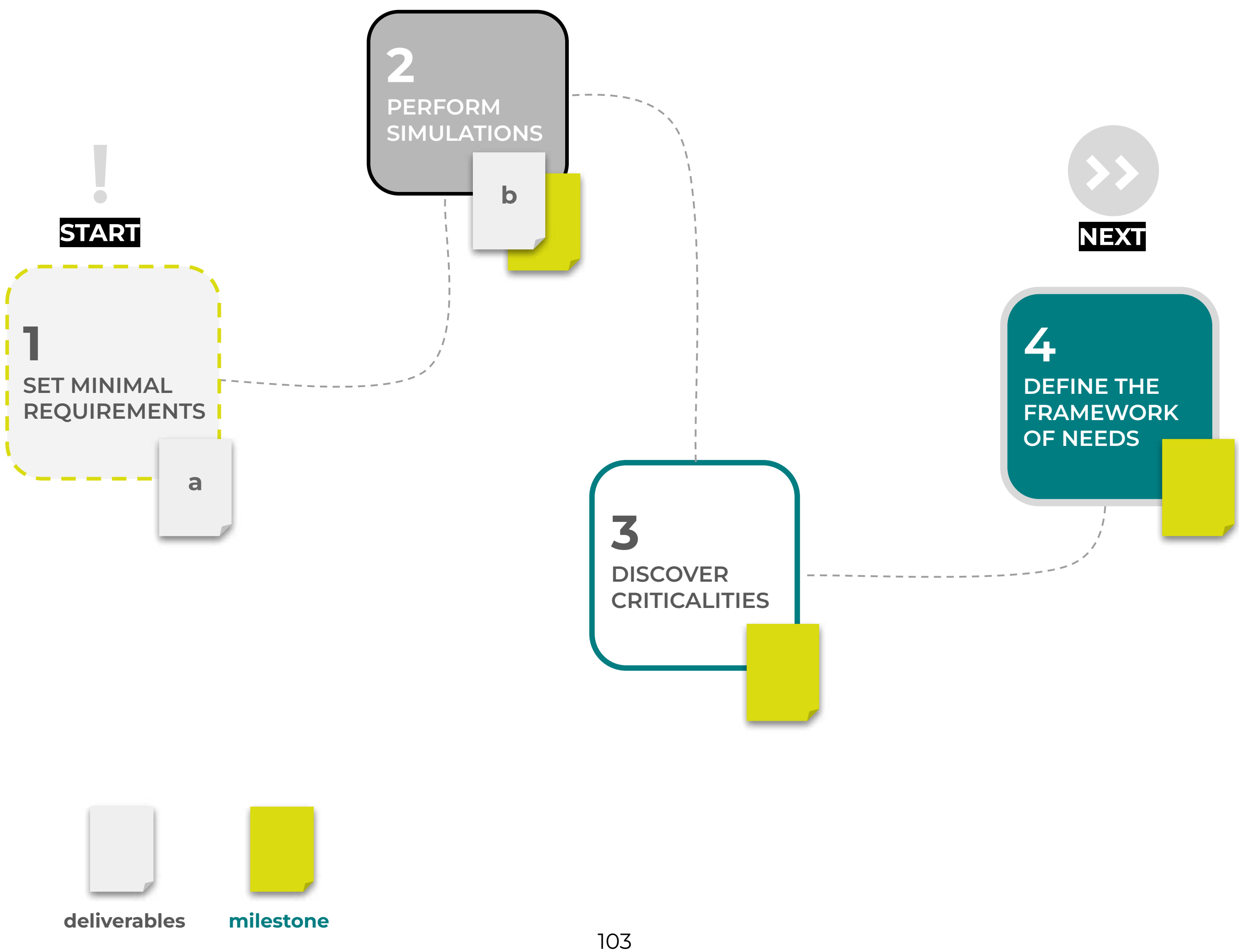
Based on an initial assessment of current methodologies and tools in use by **university managers** to evaluate the criticalities of university building stock, **researchers** are in charge to track the basis to innovate the analysis of criticalities, supported by **stakeholders**.

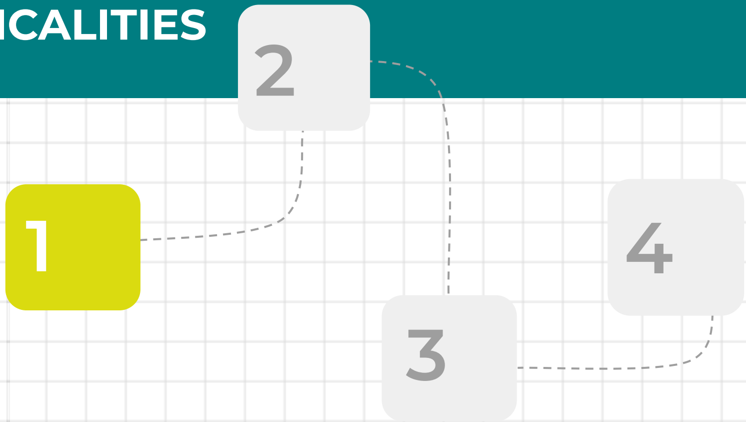
The AC is in fact the occasion to perform integrated analysis on the interrelated aspects of energy efficiency, indoor comfort, architectural quality and environmental impact, by exploiting the interdisciplinary experience on the state of art of the analysis methodologies and tools.

Researchers support university managers in the adoption of more innovative ways to analyse their university building stock, in order to improve their capability to understand the renovation needs.

More advanced experimentations in the LL can be created in collaboration with **companies** or **experts of innovative technologies** supporting the energy and environmental analysis of the building (software houses in the field of energy and environmental simulations).

Activities and Workflow



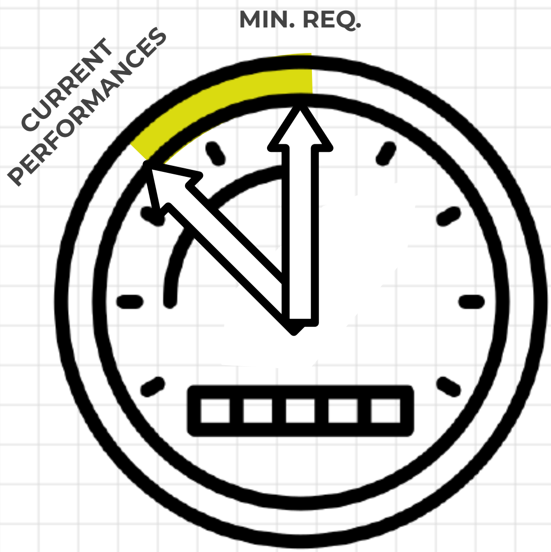


1. Set minimal requirements

The first activity of the AC phase is dedicated to the **collection of all the minimal requirements in force in national or local normatives governing the transformation of university/educational buildings** (if not developed, it is possible to refer to Eu or international standards; e.g. EPBD, ISO).

The definition of minimal requirements is fundamental to discover the pilot-building criticalities, since the renovation project, envisioning more ambitious targets, has to **at least solve the compliance of the pilot-building with existing normative indications**.

Checking the state of art of existing normative is particularly relevant in historical buildings, constructed in a period when no building legislations were in force, but that a proper renovation project should address.



back to WORK FLOW

Set minimal requirements

Aspects	Normative reference	Minimal requirements	Value
A/V ratio	Italian reception of EPBD	A/V	Index (according to location, climate zone and degree days)
Spatial distribution	Italian Law on minimal spatial requirement	Minimal surface for the different activities performed; aeroilluminant ratio	Mq/occupants Index
Opaque envelope thermo-hygrometric performances (walls, roof, groundfloor)	Italian reception of EPBD	Transmittance (U) Thermal Resistance (R) Thermal Displacement (S)	Wmq/K mqK/W hours
Windows thermo-hygrometric performances	Italian reception of EPBD	Transmittance (U) Solar passive contributions	Wmq/K KWh/mq
Energy performances (heating and cooling)	Italian reception of EPBD	Indice di prestazione invernale (EPi) Indice di prestazione estiva (EPe) Indice di prestazione globale (EPgl) energy class	Kwh/m2 year ENERGY CLASS
Plant system ? (heating and cooling)	Italian reception of EPBD 2010	Coefficient of Performances (COP) Rendimento Globale Medio	Index (0-1) Index (%)
Artificial Lighting	Italian reception of EPBD	Lamps efficiency	lumen/watt
Visual quality	National or local (link)	Daylight factor Illumination (natural and artificial)	Index Lux/work floor
Thermo-hygrometric comfort	UNI ISO EN 7730	Air temperature Air speed Average radiant temperature Humidity PMV (Predicted Mean Vote)	X gradi
Acoustic	National or local (link)	Level of Sound Pressure	Decibel
Air quality	National or local (link)	AQI	Index (0-500)
[illegible] energy [illegible] site	Italian reception of EPBD	Energy production Percentage on total energy needs	KWp Index (%)

back to WORK FLOW

Set minimal requirements

Valorizing the LL interdisciplinary approach, a normative review can be organised by **researchers** in order to be implementable (taking into account the evolving normatives) and by **university managers,** who can also support the definition of the normative framework by providing their experience in the local administrative and authorization processes.

RESEARCHERS
architects + engineers + technical physicians ...

Can organize a normative review.

BUILDING / ENERGY MANAGERS
university managers

Can support the definition of the normative framework.

RESEARCHERS + BUILDING MANAGERS

Organize an implementable normative review on minimal requirements influencing building renovation aspects (evolution).

NORMATIVE CHECK
deliv. A

STUDENTS

Can use the deliverable as learning material.

back to WORK FLOW

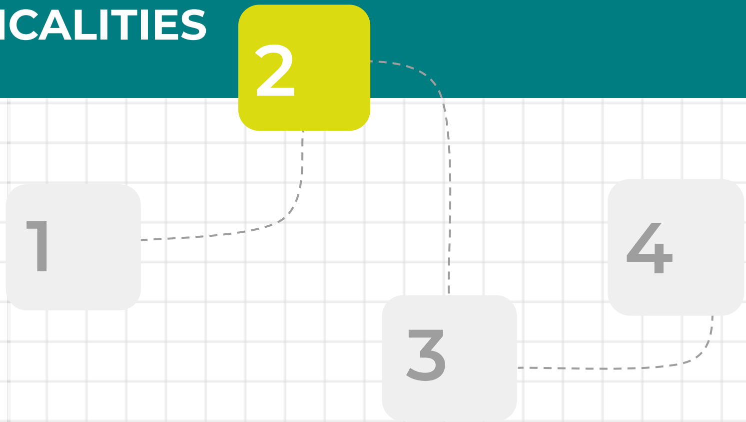
beXLab experience

RESEARCHERS

ARCHITECTURE

ASPECTS	Normative ref.	Min. Req.	Value	Compliance
A/V ratio	D.Lgs. 192/2005 D.M. 26/6/2015 UNI TS 11300 D.Lgs. 48/2020	A/V	Index (according to location, climate zone and degree days)	
Spatial distribution	D.M. 11 aprile 2013 D.M. 259/17 D.M. 21 marzo 2018 D.M. 7 agosto 2017 DPR n. 503/96	- Minimal surface for the different activities performed - aeroilluminant ratio	Mq/occupants Index	
Opaque envelope thermo-hygrometric performances (walls, roof, ground floors)	D.Lgs. 192/2005 D.M. 26/6/2015 UNI TS 11300 D.Lgs. 48/2020	Transmittance (U) Thermal Resistance (R) Thermal Displacement (S)	Wmq/K mqK/W hours	CHECK!
Windows thermo-hygrometric performances	D.Lgs. 192/2005 D.M. 26/6/2015 UNI TS 11300 D.Lgs. 48/2020	Transmittance (U) Solar passive contributions	Wmq/K KWh/mq	

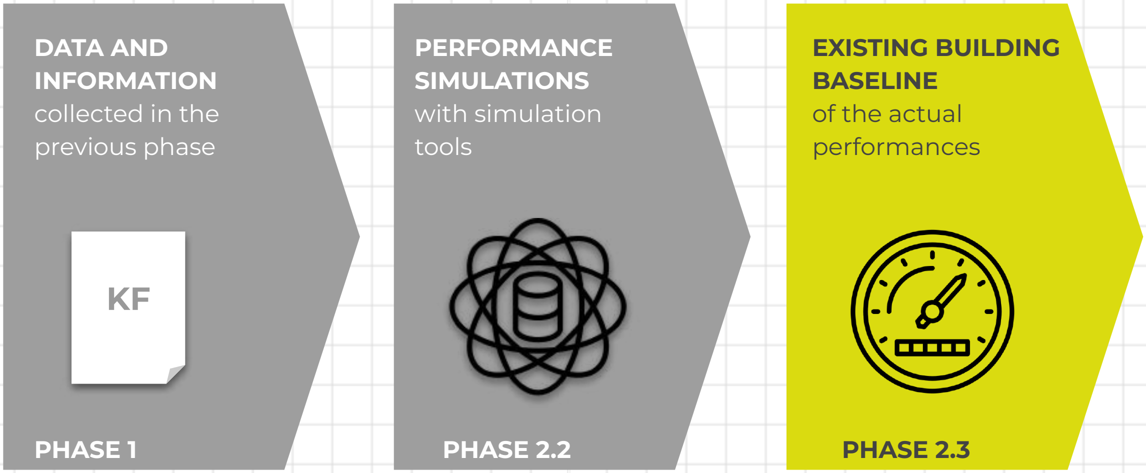
EXAMPLE



2. Perform simulations

A complete assessment of minimal requirements in the previous activity can be compromised if the KF of the pilot-building is not complete; the same normative assessment is an occasion to fulfil the KF in accordance with national and local regulations.

Moreover, normative references to the building performances (e.g. energy) require integrated and complex calculations: for these reasons, **the analysis of criticalities can be supported by the adoption of simulation tools**.



back to WORK FLOW

Perform simulations

A wide range of computational tools, from simple spreadsheets to complex softwares, can offer a **data-based insight** of the pilot-building's conditions in terms of energy efficiency and environmental quality.

Most of the available software is commonly used in professional studios (such as Edilclima, TerMus, Thermolog, Blumatica,Design Builder, Sefaira...) and includes the algorithms according to the national regulations. Even if many possible configurations of the building-plant system can be modelled, some limitations could be addressed.

On the other side, more flexible softwares have been developed at university research level (such as EnergyPlus and TRNSYS), allowing a total customization of the building-pant layout. In the last case simulations need to be run by experts but guarantee higher accuracy.

WIDE RANGE OF SIMULATION TOOLS

COMMERCIAL

rigid / some limitations

user-friendly

include algorithms according to national regulations (e.g. certifications)

VARIOUS ASPECTS

SPECIALISTS

more flexibles / total customization

require experts

usually developed by universities for a deeper analysis

SINGLE ASPECTS

back to WORK FLOW

Perform simulations

One of key factors for reliable results is represented by the time step which simulations are based on: the systems could be studied indeed starting from a monthly scale, up to investigate a more dynamic behaviour.

Standard certifications can be obtained with the first approach and are suitable to define the **building general energy class** and some **IEQ parameters**, for instance aiming a future comparison among different possible interventions. In order to understand a more realistic and detailed situation of the existing, the models has to be studied in function of the external environmental conditions that vary continuously. In this sense, hourly simulations improve the knowledge of the building reactions to different internal and external constraints. Moreover, **dynamic methodologies** let to evaluate the integration of renewable energy and their suitable contribution matching the user demand, during a reference typical year.

Summarising, simulations can be useful tools to achieve:

- Net Envelope's performance;
- Energy consumption and different contributes of active loads and thermal loss;
- Plant sizing;
- Energy performances, according to standard regulation;
- Lighting levels for daylight and artificial devices (with specific softwares such as Relux, Velux, Dialux, Sefaira).

ENVIRONMENTAL CONTEXT ANALYSIS

→ weather data
→ volumetry
→ sun path
→ shadow analysis
→ transparent / opaque envelope
→ external elements

ANALYSIS OF THE DYNAMIC THERMO-HYGROMETRIC PERFORMANCE (OPAQUE ENVELOPE)

→ transmittance
→ phase shift
→ attenuation
→ periodic thermal capacity
→ penetration depth
+ hygrothermal

ENERGY PERFORMANCE ANALYSIS (according to the national regulations)

→ energy class (in rating and score systems)
→ impact of energy gains and losses across the envelope!

DAYLIGHT ANALYSIS

→ daylight factor
→ distribution
→ illuminance
→ natural lighting
→ artificial lighting

back to WORK FLOW

ACTIVITY 2

Perform simulations

In the LL context, the interdisciplinary team of **researchers** define together and for **university managers**, a set of methodologies and tools to evaluate the energy and environmental performances of the university building stock.

Students can be involved in the activity with dedicated training on simulation tools to analyse the energy and environmental criticalities of the pilot building.

Externally, the activity can engage **software houses or experts** in the field of energy and environmental simulations.

RESEARCHERS
architects + engineers + technical physicians ...

Select the best simulation tools according to the different disciplines and competencies.

STUDENTS

Can learn simulation tools as a didactic activity.

RESEARCHERS + BUILDING MANAGERS

DEFINE A SIMULATION PROTOCOL with methodologies and tools to perform building simulations on energy and environmental performance of the existing building (e.g pilot-building).

SIMULATION PROTOCOL
deliv. B

SIMULATION REPORT
milestone

COMPANIES
software houses or experts

Can support the adoption of simulation tools (e.g. software house).

PUBLIC ORGANIZATIONS

Can be interested in deepening the analysis of their building stock (e.g. municipalities).

BUILDING / ENERGY MANAGERS
university managers

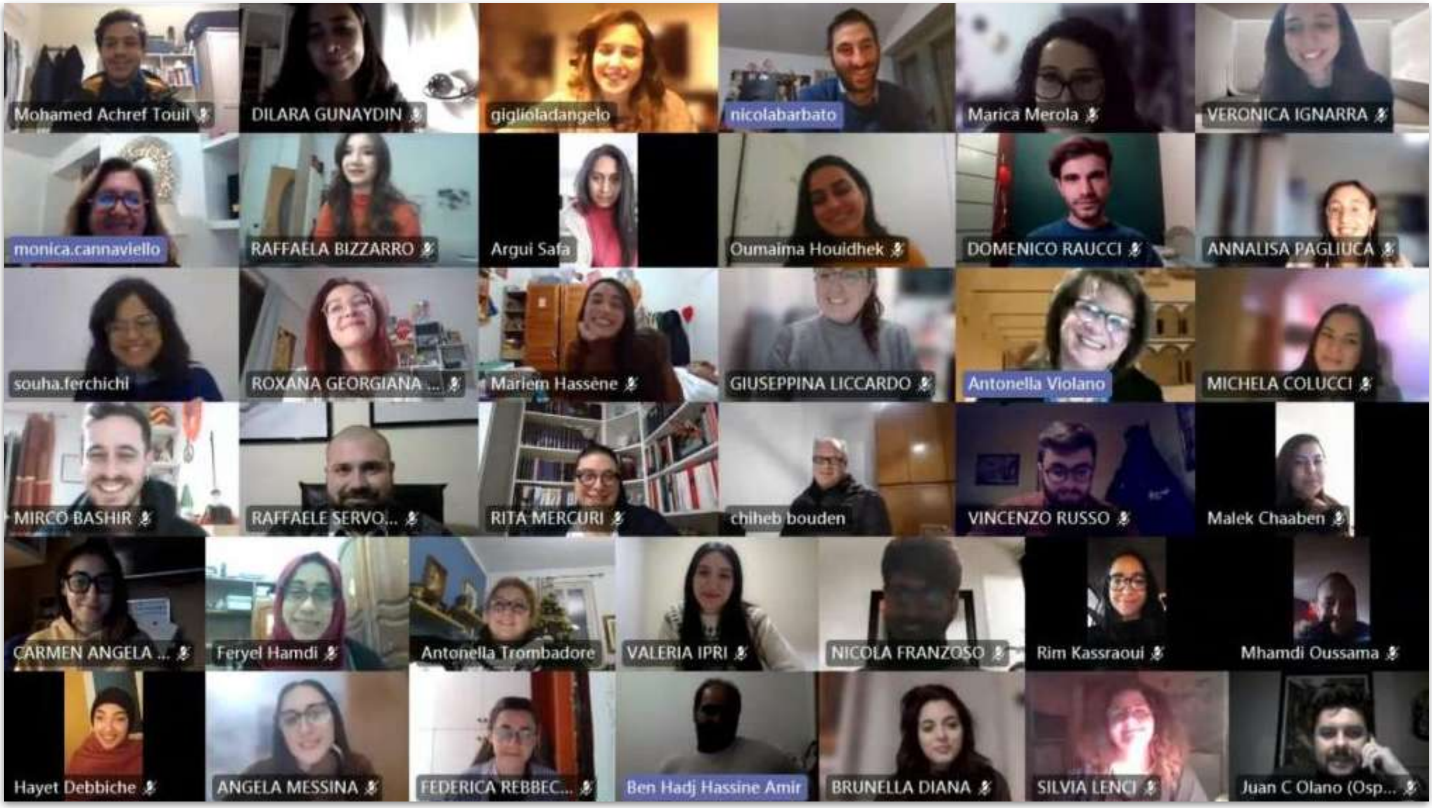
Have experienced and can experience simulation tools.

back to WORK FLOW

beXLab experience

RESEARCHERS
STUDENTS

➔ **CROSS-BORDER LIVING LAB activity**
organised by associated Partner:
University of Campania

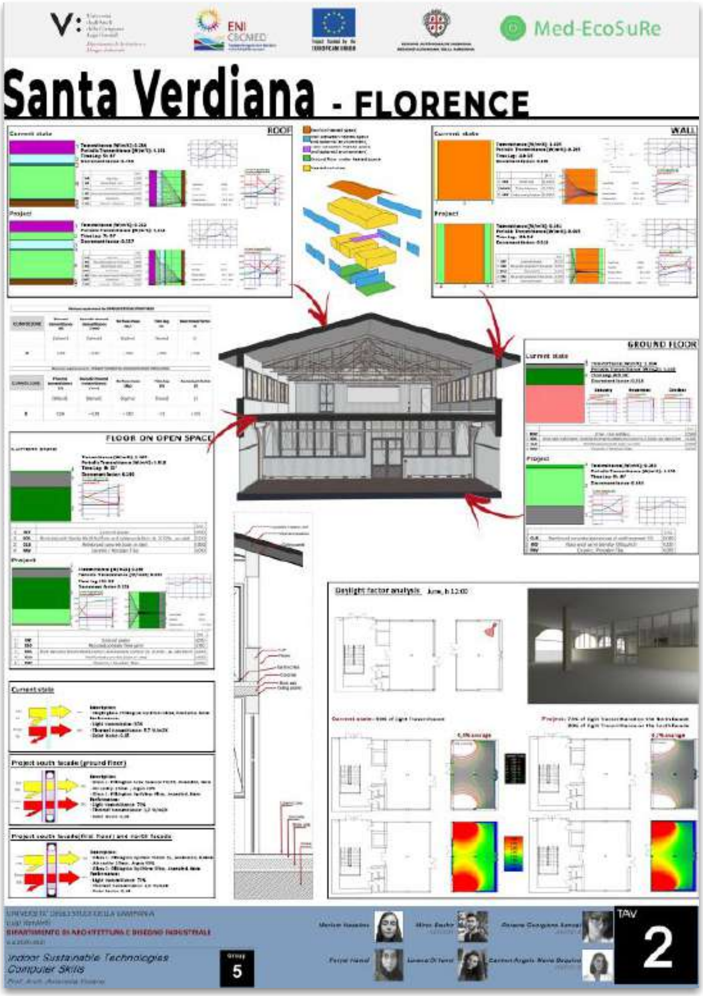


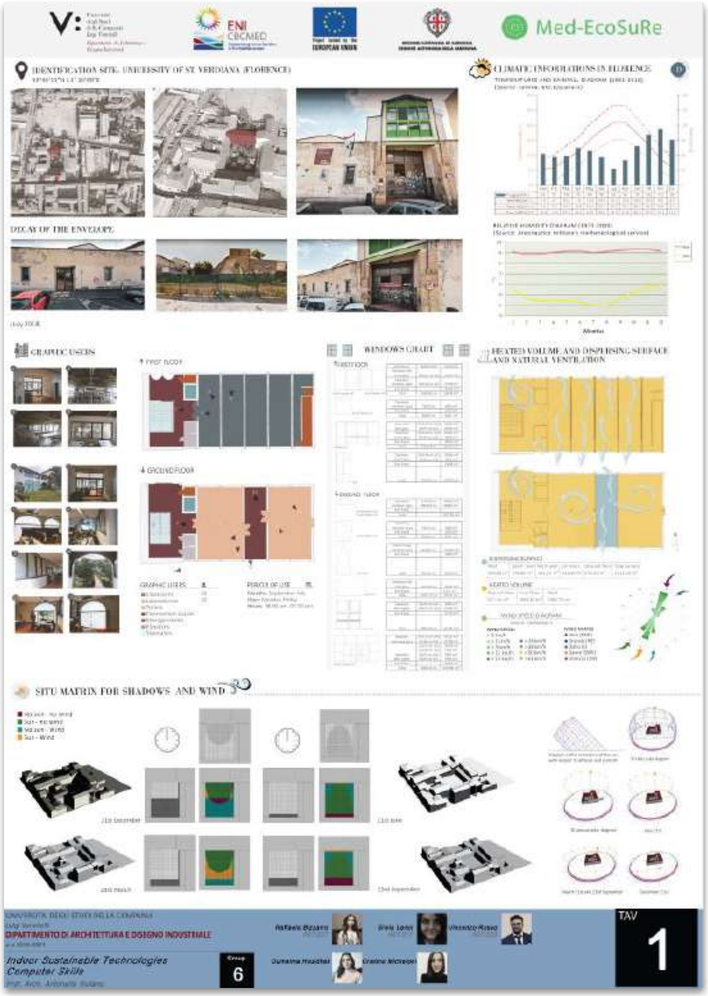
beXLab experience

Eco-oriented and energy efficient technological design of the pilot buildings of Med-EcoSuRe.

SANTA VERDIANA CASE STUDY

➔ **INTERNATIONAL SEMINAR**

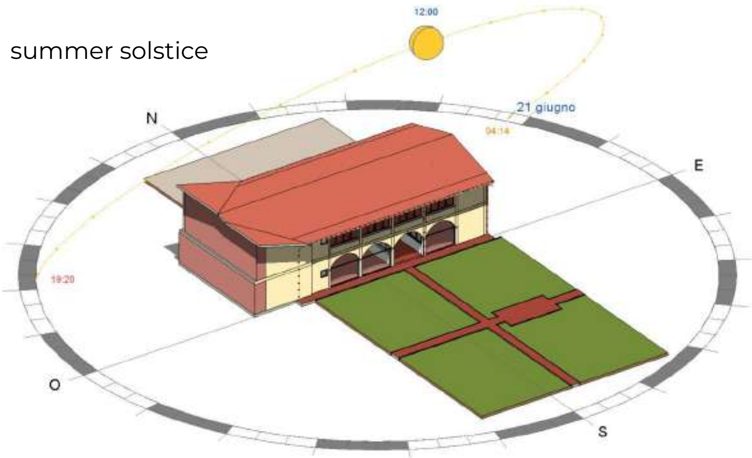


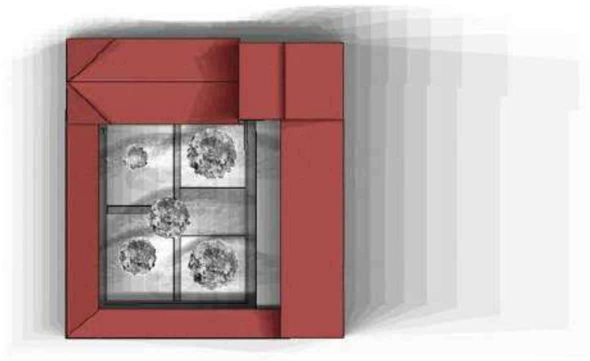


beXLab experience

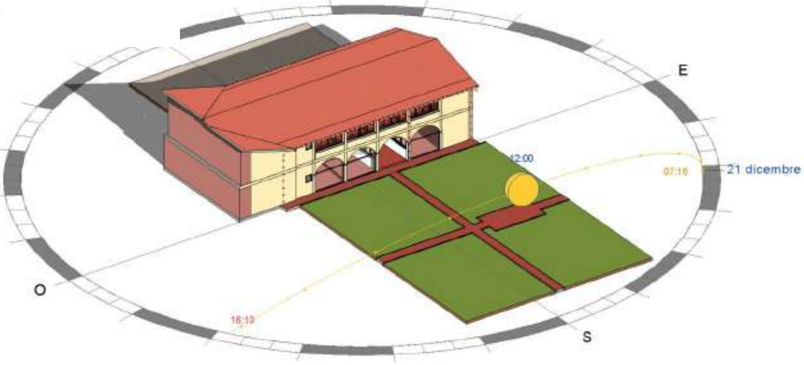
➔ **ENVIRONMENTAL ASSESSMENT**
Orientation / Sun exposure

summer solstice



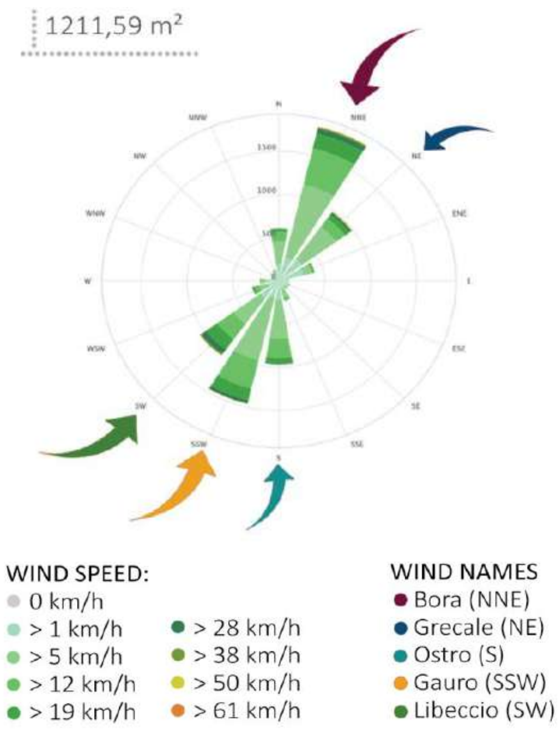


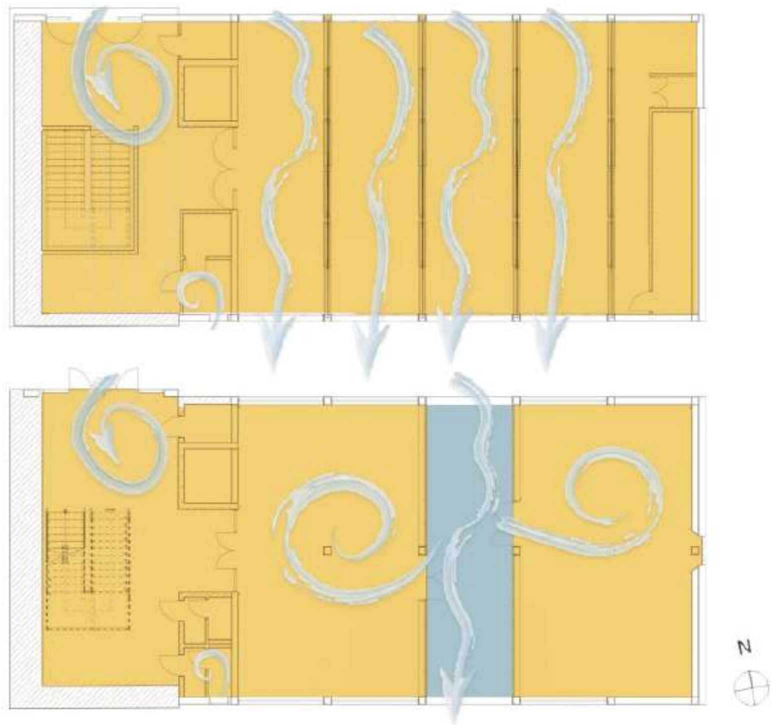
winter solstice



beXLab experience

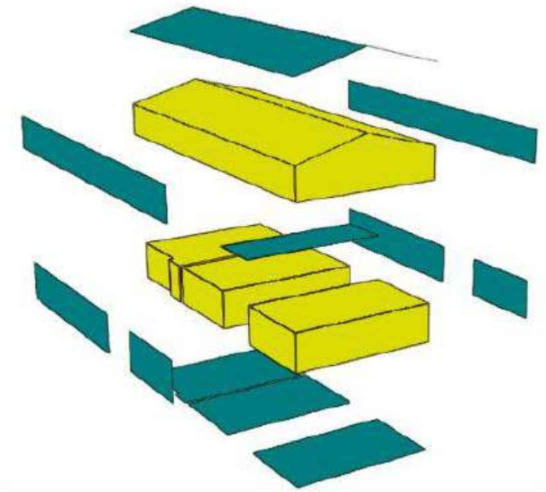
➔ **ENVIRONMENTAL ASSESSMENT**
Main winds and internal ventilation





beXLab experience

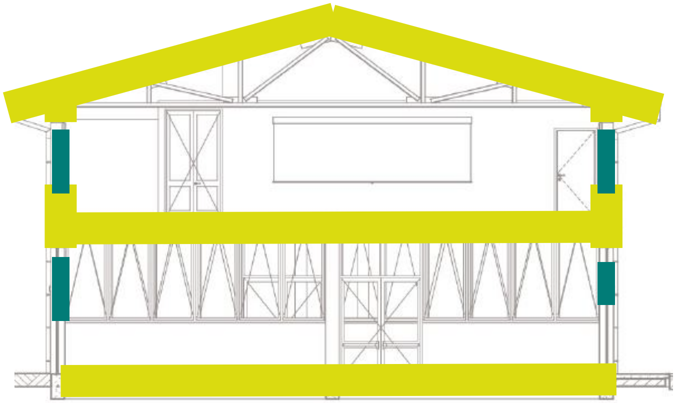
➔ **THERMAL BEHAVIOUR**
Dynamic analysis of envelope performances
| PRELIMINARY MODEL

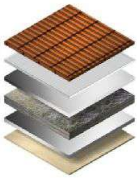


Dispersant Surfaces		Heated Volume		S/V
Type	m^2	Floor	m^3	m^{-1}
Roof	439,81	Ground	977,31	0,62
South wall	178,05	First	989,39	
North wall	181,51	Total	1966,70	
Internal corridor's walls	89,16			
Slab on open space	43,83			
Ground slab	279,23			
Total	1211,59			

beXLab experience

➔ **THERMAL BEHAVIOUR**
Dynamic analysis of envelope performances
| ENVELOPE TRANSMITTANCE CHECK





ROOF

Summer Lag	Trasmittance U	Trasmittance by law
2h 35'	0,357 W/m2K	0,26 W/m2K

INTERFLOOR SLAB

Trasmittance U	Trasmittance by law
1,67 W/m2K	**0,32 W/m2K**

GROUNDFLOOR SLAB

Trasmittance U	Trasmittance by law
1,67 W/m2K	0,32 W/m2K

WINDOWS

Trasmittance U	Trasmittance by law
5,27 W/m2K	1,67 W/m2K

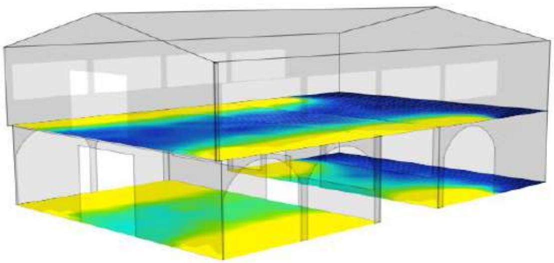
EXTERNAL WALL

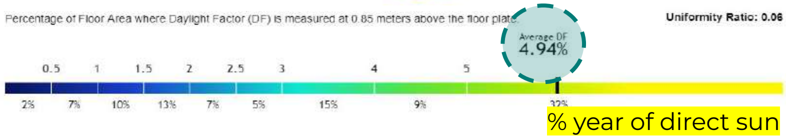
Summer Lag	Trasmittance U	Trasmittance by law
10h 35'	1,53 W/m2K	0,32 W/m2K

beXLab experience

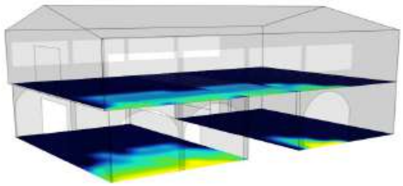
→ **DAYLIGHT ANALYSIS**

Daylight Factor

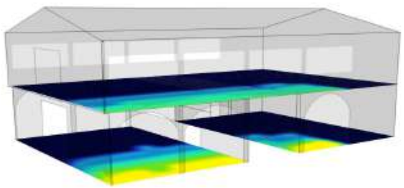




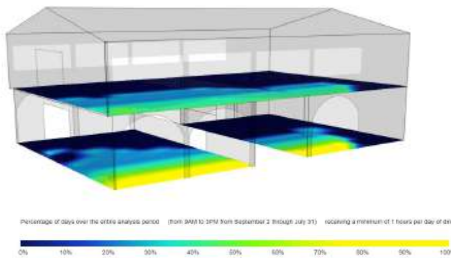
5h



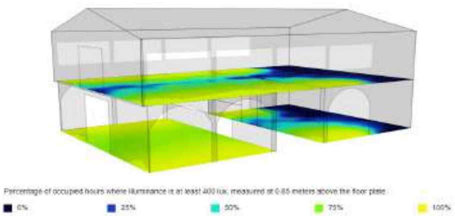
3h



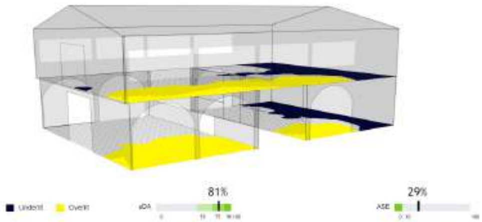
1h



MINIMUM ILLUMINANCE
400 lux

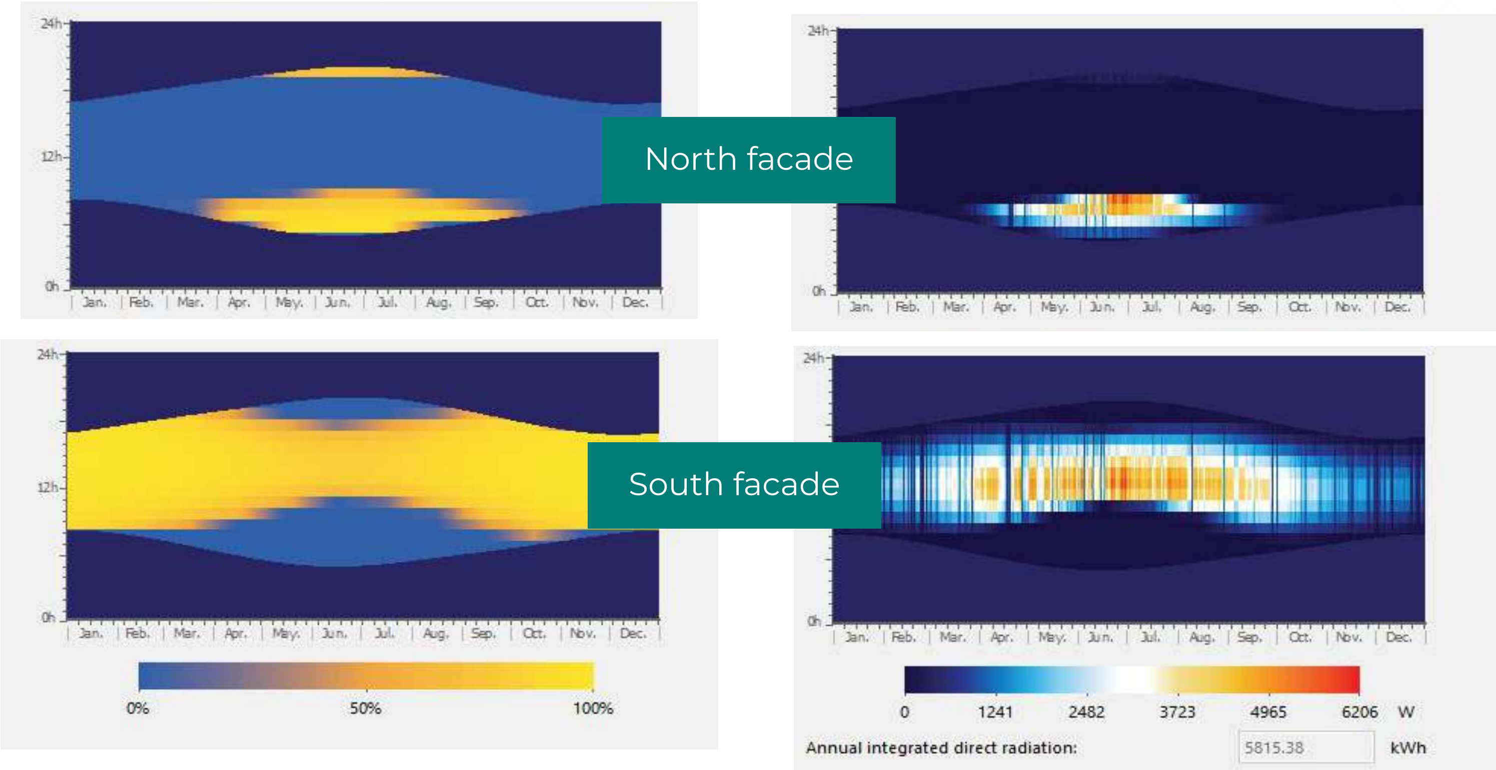


OVERLIT
> 1000 lux



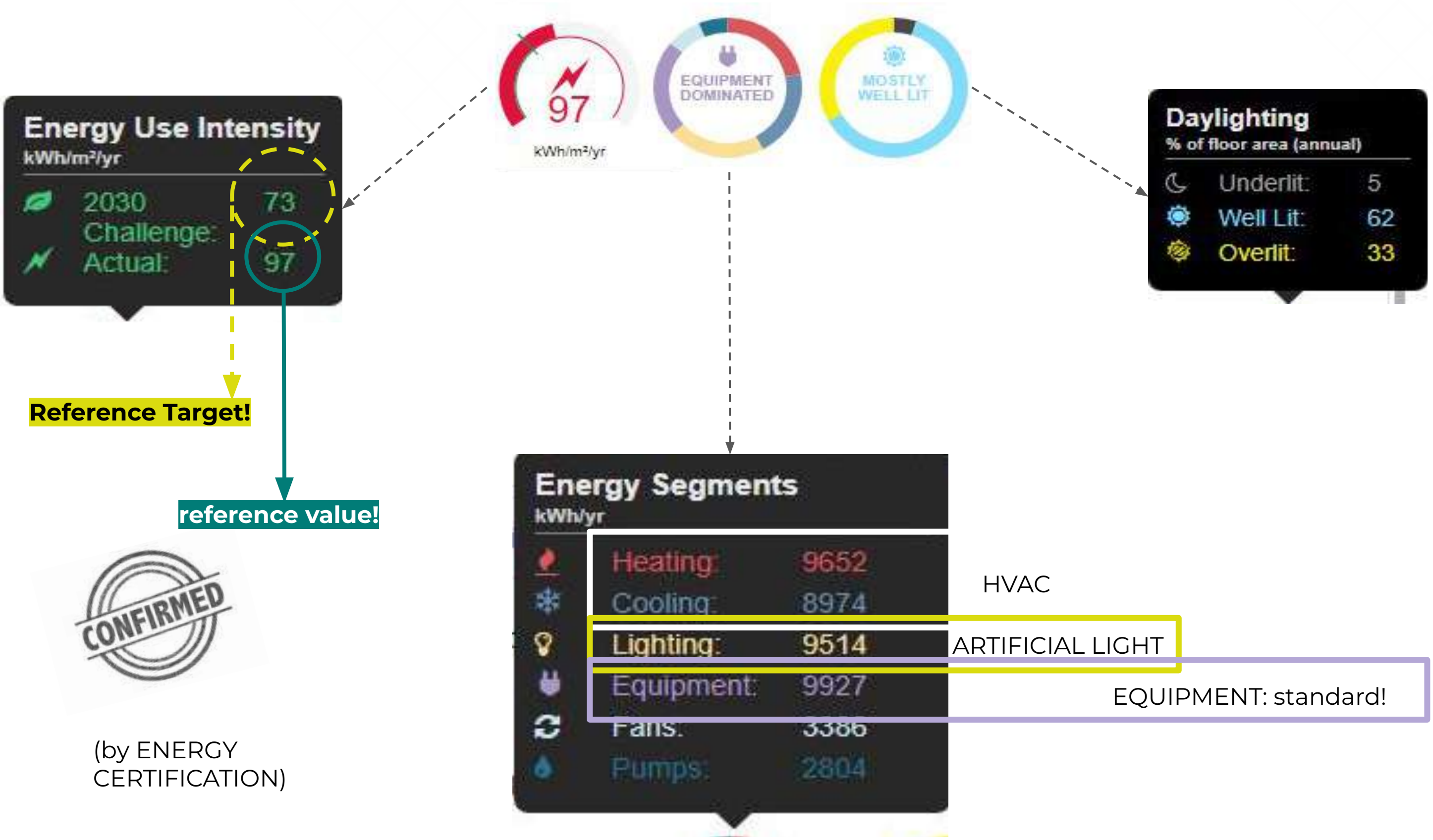
beXLab experience

➔ **SOLAR RADIATION ON THE TRANSPARENT ENVELOPE**



beXLab experience

➔ **SIMULATION OF THE ENERGY BEHAVIOUR**

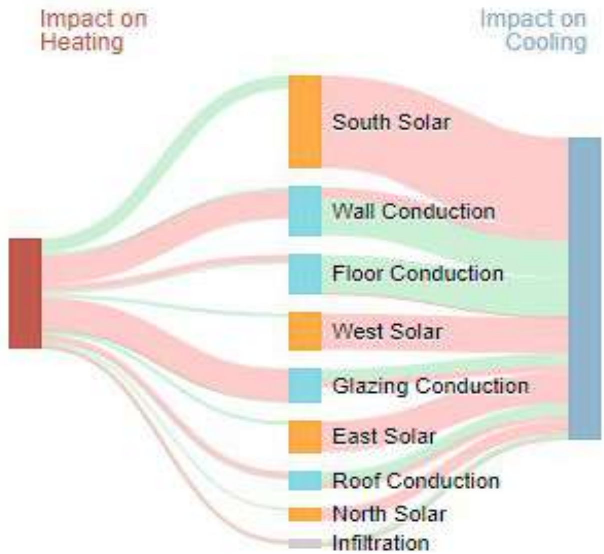


beXLab experience

➔ **ENERGY BEHAVIOUR**
Passive thermal losses / Gains

Thermal energy conduction through the envelope

Thermal energy for irradiation

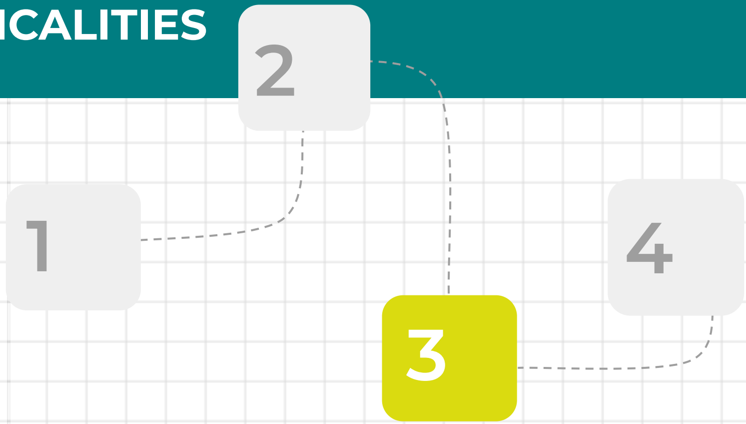


Positive thermal loads

Negative thermal loads

Impact of passive thermal contributions on heating
WINTER PERIOD

Impact of passive thermal contributions on heating
SUMMERTIME



3. Discover criticalities

Pilot-building's criticalities can be discovered by combining and systematising the pilot-building performances retrieved in the KF and/or performed by simulations.

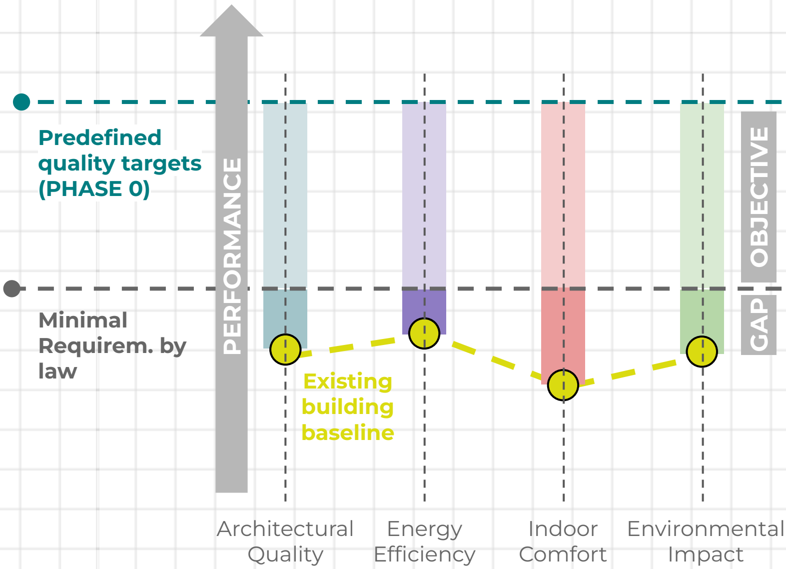
Criticalities emerge from the comparison of the pilot-building performances from one side with the minimal requirements of coming from standards or local normative bodies and, from the other side, with the more ambitious defined targets (defined in relation with the OROs).

The gap between the minimal requirements and the current conditions (existing data and information in the KF or simulations) reveals **a baseline that the renovation project has to address**.

The gap with the more ambitious target (in phase 0) are the more flexible.

Individualised criticalities of the pilot-building are extensively described in the **Report of Criticalities** (deliverable), but also represented in a synthetic/symbolic way through a **Map of Criticalities** accompanying the following phases.

The activity is carried out together by **researchers** and **building/energy managers** and requires a strong coordination.

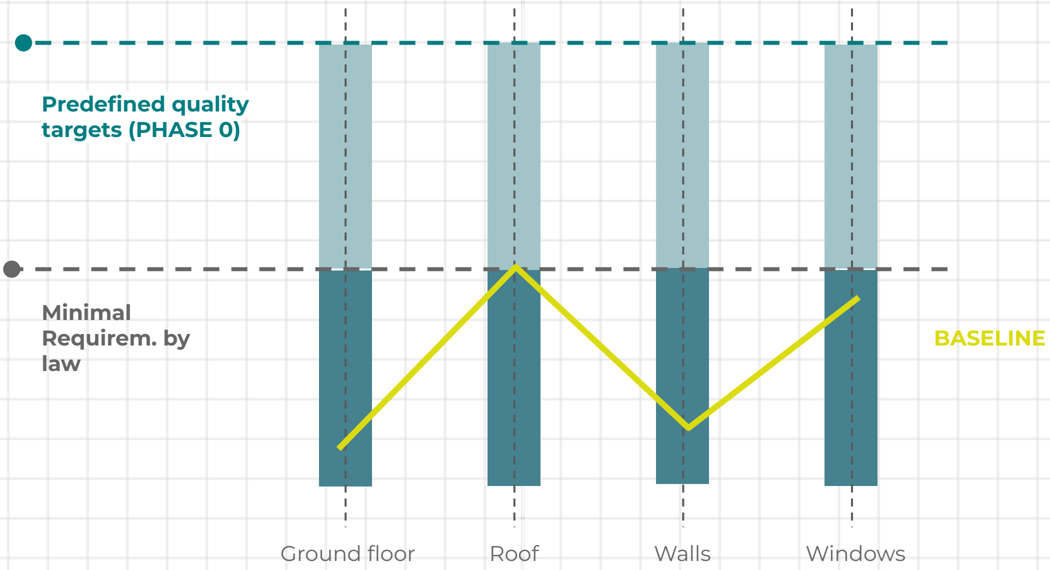


back to WORK FLOW

Discover criticalities

EXAMPLE

Aspects	Performance	Units	Baseline (actual performance)	Min. Requirements	Target value
Opaque envelope (walls, roof, groundfloor)	Transmittance (U) Thermal Resistance (R) Thermal Displacement (S)	Wmq/K mqK/W hours	Y/N	Wmq/K mqK/W hours	Y/N



ARCHITECTURAL ASPECTS

back to WORK FLOW

Discover criticalities

RESEARCHERS
architects + engineers + technical physicians ...

BUILDING / ENERGY MANAGERS
university managers

RESEARCHERS + BUILDING MANAGERS

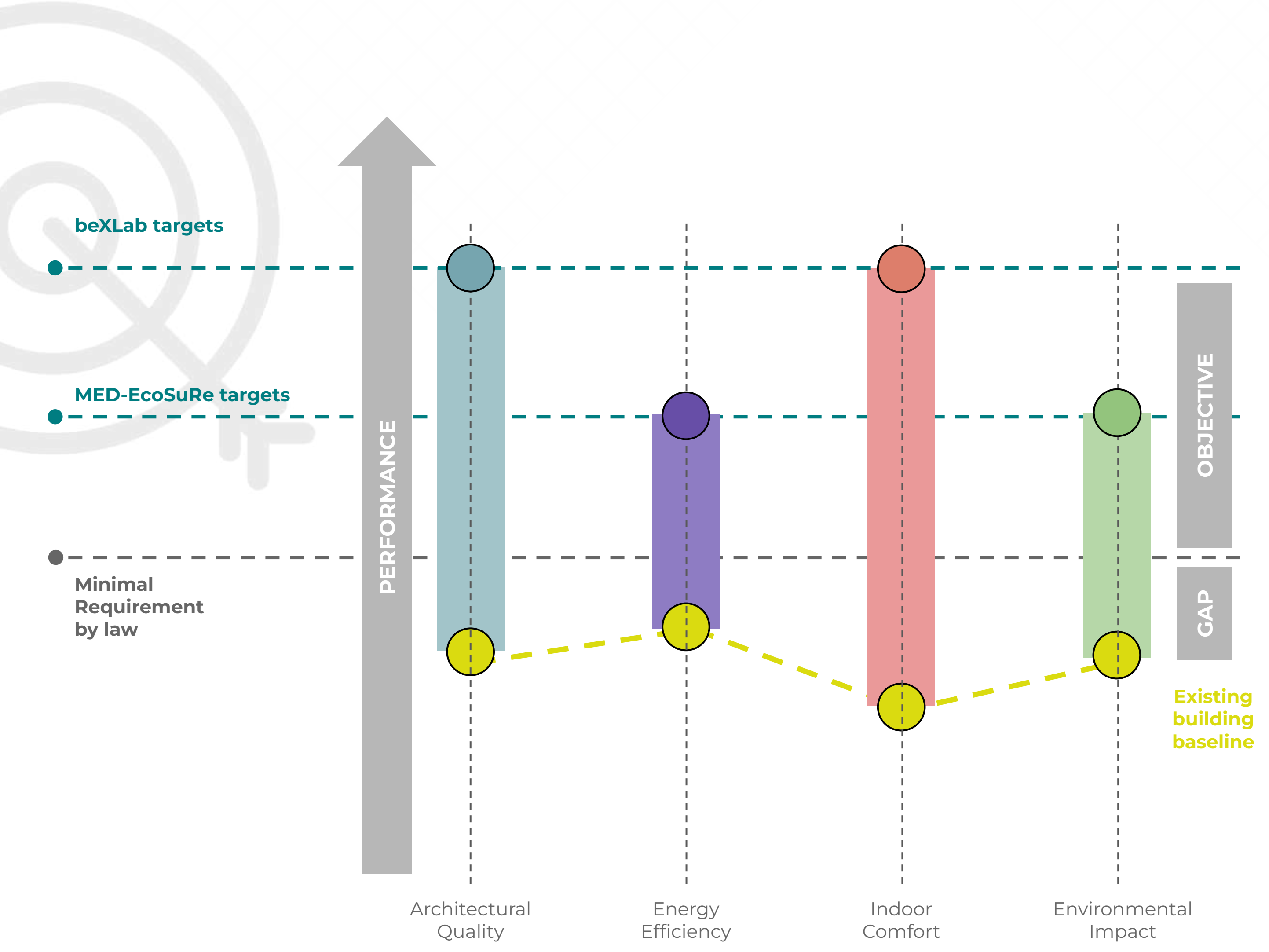
HAVE A STRONG COORDINATION
to account all the aspects and parameters.
They describe the different analysis performed and criticalities emerged.

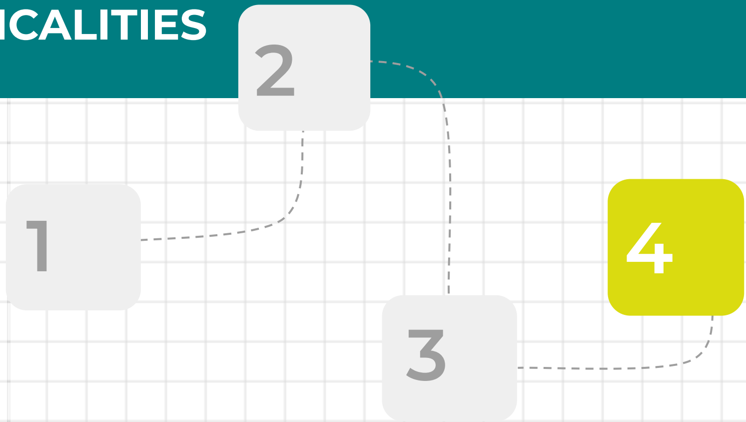
More elaborated is the report, more easier is to find what in the existing building needs to be renovated...

CRITICALITIES REPORT
milestone

back to WORK FLOW

beXLab experience





4. Define the framework of needs

On the basis of the criticalities individualised, it is time to prepare the **Framework of Needs** (milestone), containing all the information to input the design Phase 3.

Needs represent the translation of criticalities in terms of interventions necessary to overcome them.

The Framework of Needs represent a sort of "shopping list" for the design phase, outlining all the interventions to be performed to renovate the pilot-building in order to, from a side, reach the baseline (compliance with minimal requirements), and with a series of interventions to bring the university building towards more ambitious targets of energy efficiency, architectural quality, indoor comfort and EQ.

The framework of needs has as main objective **to pre-identify the key stakeholders** to involve in the design phase, in particular **companies**, divided according to the specific renovation needs to satisfy with innovative solutions.

EXAMPLE

CRITICALITY	NEED	STAKEHOLDERS TO INVOLVE
High transmittance of the opaque envelope	Insulation of the opaque envelope	Insulation of the opaque envelope e.g. Companies of innovative components and materials e.g. Public offices for the authorization process

back to WORK FLOW

Define the framework of needs

RESEARCHERS
architects + engineers + technical physicians ...

BUILDING / ENERGY MANAGERS
university managers

RESEARCHERS + BUILDING MANAGERS

HAVE STRONG COORDINATION AND EXPERIENCE
to account all the criticalities in an organised way and foreseen the renovation needs.

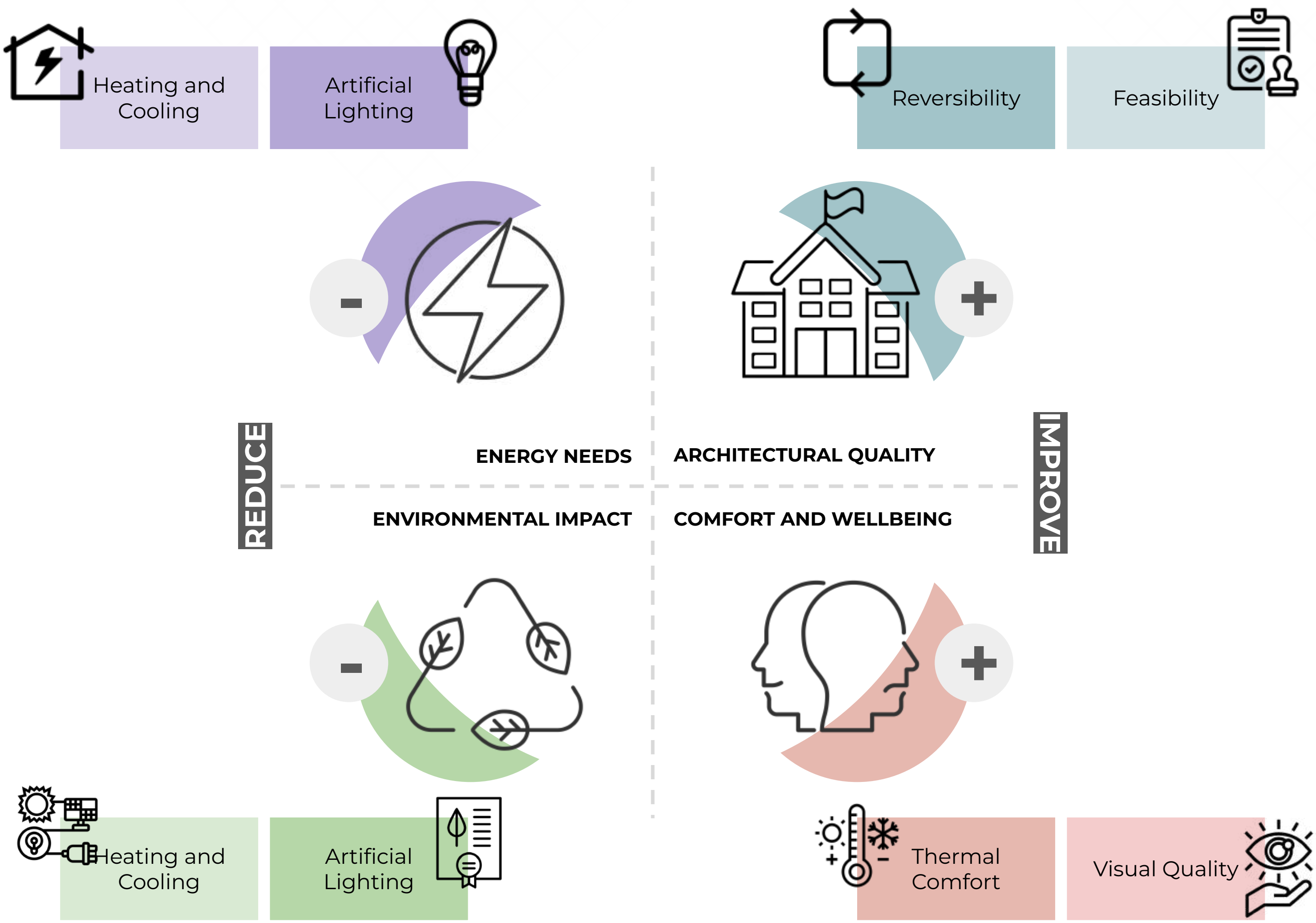
FRAMEWORK OF NEEDS
milestone

COMPANIES

Are identified by the Framework of Needs.

back to WORK FLOW

beXLab experience



BEST PATH
Digital Twin implementation

The raw data collected during the survey process and digitally transformed inside a Survey BIM Data Model(s) must be produced in the phase preceding the "Analysis of Criticalities" phase and must contain all the information required to allow the development of the process accordingly with the organization/project objectives as described/required on the knowledge framework "Data collection checklist".

This phase refers to the elaboration of the data collected in the knowledge framework and the results must highlight the main criticalities of the asset and address the retrofit process. During this phase actions regarding site location, building(s) conditions, whichmight help to understand the current status/characteristics/criticalities, can determine how to implement improvement actions.

Actions as: site analysis; verification of normative compliance / minimal requirements, measurement of indoor comfort conditions; running virtual energy simulations to understand the building performance; comparing quantitative data with qualitative data; determining the gap between the existing situation and predefined target (phase 0); performing a multicriteria analysis; listing indicators and/or defining the framework of needs - are some of the actions that should take place during the phase in order to produce the phase documentation.

The accessibility to quality information from the survey will help to achieve high quality results, after crossing and exchanging information with different digital tools (softwares). To run different types of simulations that can help building managers and /or decision makers to understand clearly the current performance condition of the assets, the maintenance status, the weaknesses and the strengths, these will be the starting points to develop the asset improvement plan.

BEST PATH
Digital Twin implementation

This phase refers to the elaboration, manipulation, management of the data collected in the knowledge framework and the production of results, studies and analysis that highlight and identify the main criticalities of the asset and define the guidelines for the retrofit/efficiency/improvement process.

go BACK

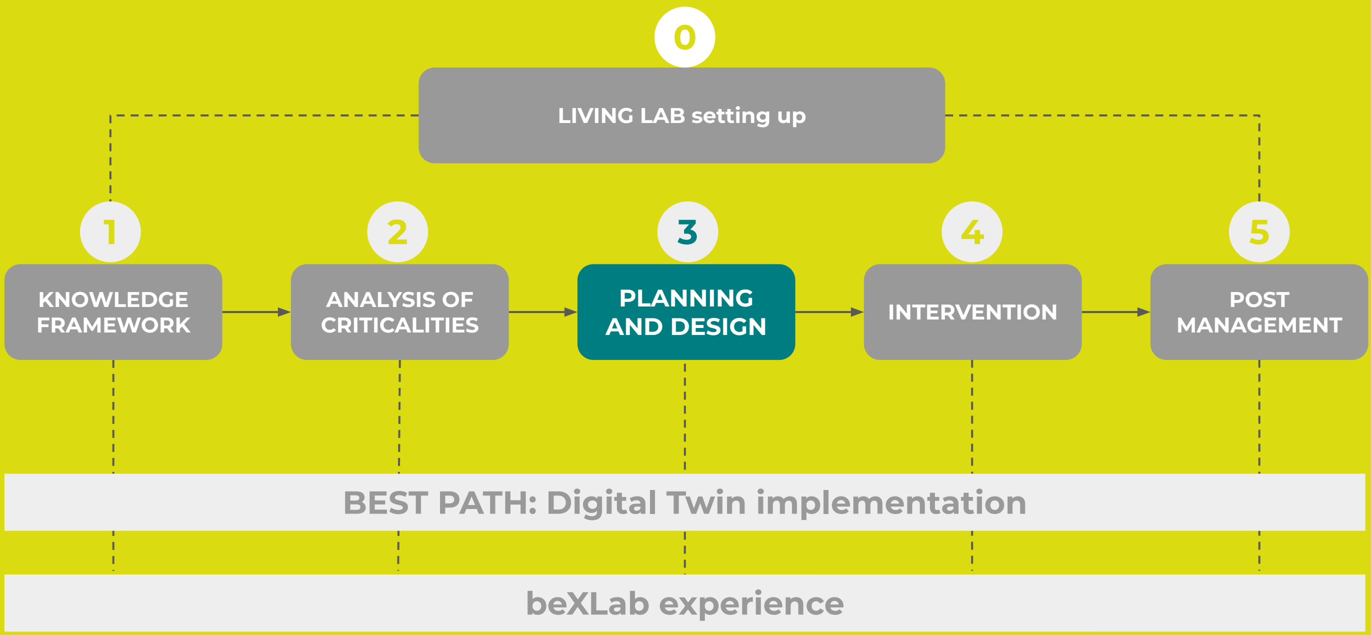
Phase 3
Planning and Design

At the hearth of the renovation process, on the basis of the KF (Phase 1) and of the AC (Phase 2) it is possible to start with the most creative phase of Planning and Design, when the criticalities of the existing building can become opportunities in integrated architectural solutions to intervene on the pilot-building (Phase 4).

WHAT research, integration and test of the best mix-of-technologies to renovate the pilot-building

WHO managed by the interdisciplinary group of researchers (in part. architects), it involves all the LL participants, internal to the university context and external

HOW seven steps to elaborate single projects



PHASE 3

PLANNING AND DESIGN

The Planning and Design phase can highly benefit from the LL environment, with the possibility to activate co-design processes for the definition of the best renovation scenarios, involving stakeholders and users.

Since the beginning of the phase, activities are oriented to search for the **best mix-of-technologies** to satisfy the by exploiting the joint simulations of energy and environmental aspects, while considering the architectural aspects related to the integration of new technologies.

Usually, the simulation of building energy performance is relegated to the late phases of the design process and conducted by specialists for the verification of the preliminary design; the anticipation of simulations in the first phases of the design process, when modifications are highly impacting.

Based on the standard and minimum data-set of the KF, allows to perform preliminary simulations of the energy and environmental performance of the existing building, and to visualise its main criticalities. The analysis of criticalities consents a building-specific calibration of the renovation objectives, with the **definition of key performance indicators**.

Since the early stages of the renovation design process, the BIM asset model, synchronised with performance simulations tools, can act interactively and iteratively as a benchmark to evaluate the improvements deriving from the integration of single/set of renovation technologies in x scenarios, to be assessed on the basis of KPI.

Beyond the BIM-enabled possibility to optimise the pre-design thanks to the interoperability with performance simulation tools, working around a single-shared BIM model fosters the collaboration between designers and specialists, as well as the communication with non-experts, such as owners and end-users, supporting co-design processes.

The Planning and Design phase (P&D) is related **to the search, integration and test** of the best **mix-of-technologies** to renovate the pilot-building.

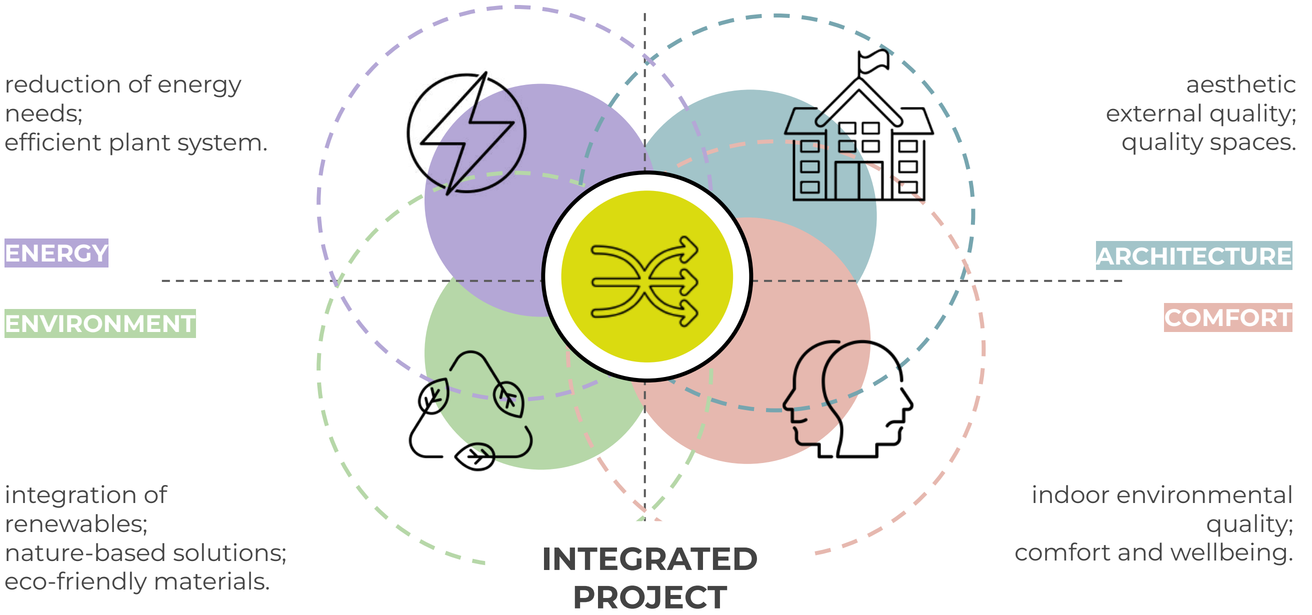
On the basis of the Framework of Needs, the P&D analyses strategies and technologies to solve the recognized criticalities, but also to envision more ambitious outcomes.

The core of the P&D phase is the **definition of different improvement scenarios and a methodology to select the most effective one**, **in relation with the pre-defined quality targets**.

A renovation scenario is described by the four main renovation aspects and the cost related to the strategies and technologies implemented:

- **Architecture**: how renovation strategies and technologies modify the building physical asset
- **Energy efficiency**: how renovation strategies and technologies improve EE
- **Indoor env. quality**: how renovation strategies and technologies improve IEQ
- **Environmental impact**: how renovation strategies and technologies guarantee a low environmental impact?

The P&D regards the definition of **coherent renovation program and projects** (single or partial) for the renovation of the pilot-building in order to reach the OROs.



The P&D phase is managed by the interdisciplinary group of researchers (in part. architects) but involve all the LL participants, internal to the university context and external.

COMPANIES
of innovative technologies

Can supply with innovative components and systems (e.g. eco-friendly materials).

PUBLIC ORGANIZATIONS
associations and NGOs

Interested in innovative and eco-sustainable projects and can contribute to the dissemination activities.

BUILDING / ENERGY MANAGERS
university managers

Acknowledge current approach to design renovation project and experience new approaches.

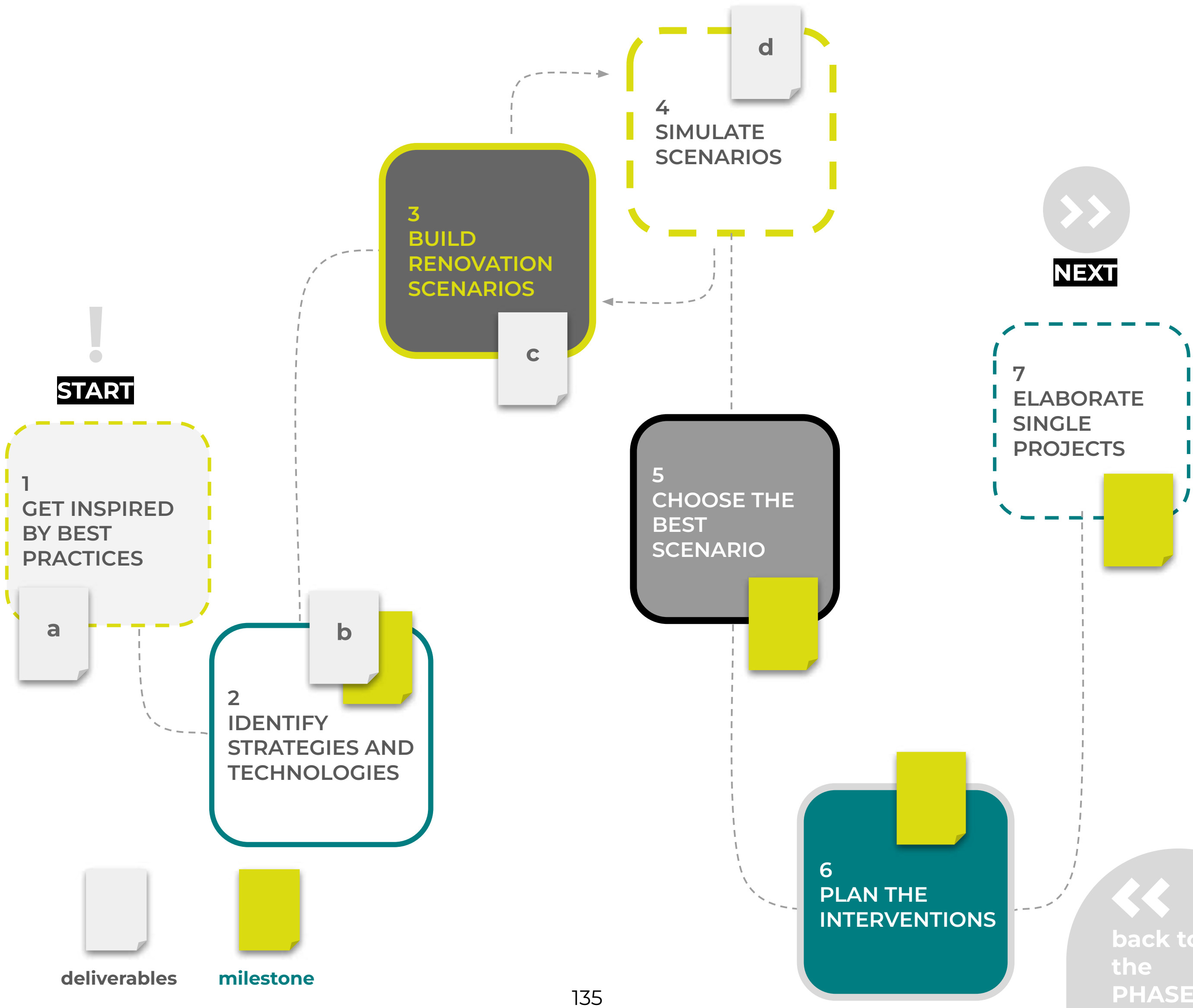
STUDENTS

Engaged in the co-design of innovative scenarios.

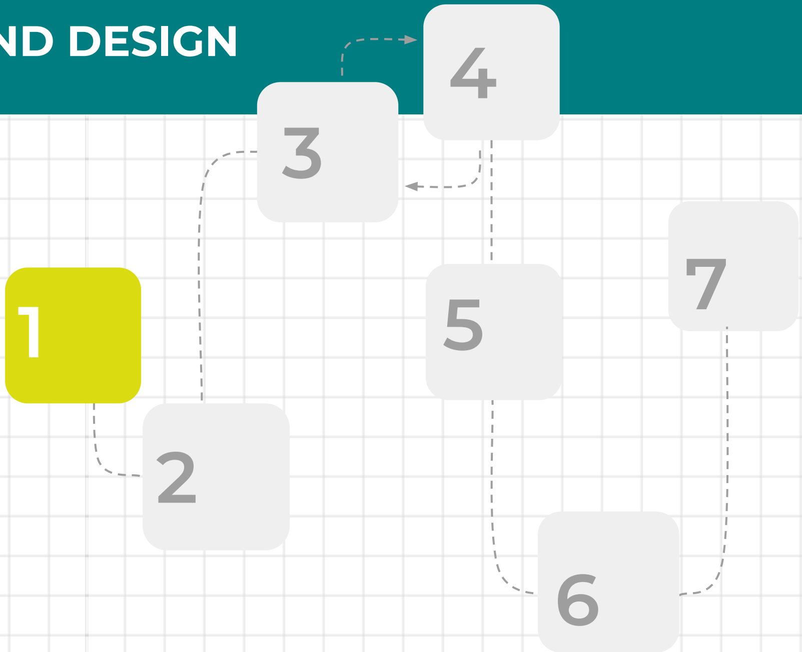
RESEARCHERS
architects, energy engineers, technical physicists, others..

Provide with innovative design methodologies.

Activities and Workflow



back to the PHASE



1. Get inspired by Best Practices

The first activity of the P&D phase has the objective **to give to Living Lab participants an overview of building innovative and eco-sustainable technologies**, **in order to align the vision of the future building**. For this purpose, a collection of best-practices (see Best Practices) related to university building in the Mediterranean European area has been defined, looking both at renovation projects and new constructions. The latters have been inserted considering that, since the major degree of freedom consented to the introduction of more innovative technologies, this potential has still to be untapped in renovation projects.

Considering both qualitative and quantitative data, a set of indicators were defined as basis for the evaluation of the case studies, which allowed for the definition of a baseline for the subsequent comparison between them.

The 18 selected best practices are analysed through the following Performance Indicators.

As regard the envelope:

- VERTICAL OPAQUE CLOSURES (walls);
- HORIZONTAL OPAQUE CLOSURES (roof and ground floor slab);
- GLAZING (windows and transparent elements);
- FAÇADE SOLUTION.

back to WORK FLOW

Which strategies?
Which technologies?

As regard the energy system:

- LIGHTING;
- HEATING VENTILATION & AIR CONDITIONING;
- DOMESTIC HOT WATER;
- RENEWABLE ENERGY;
- BUILDING MANAGEMENT SYSTEM.

In order to allow the user to enlarge the collection, the document defined an approach for all the case studies. It contains two main parts: general data analysis of the university building and performance indicators analysis.

back to WORK FLOW

Get inspired by Best Practices

Starting from the provided **cataloguing methodology**, local LLs can enrich the number of analysed best practices considering local experiences: in this way also the cross-border LL will be enriched.

All the LL participants can benefit from the analysis of best practices to inspire the design phase and new case studies, researchers and students can dedicate the first phases of the design process to enlarge the collection.

RESEARCHERS
architects + engineers + technical physicians ...
Define the methodology to collect best practices

RESEARCHERS + BUILDING MANAGERS + PUBLIC ORGANIZATIONS
Capitalize together the document on best practices collection, in order to implement the cross border platform

BEST PRACTICES COLLECTION
deliv. A

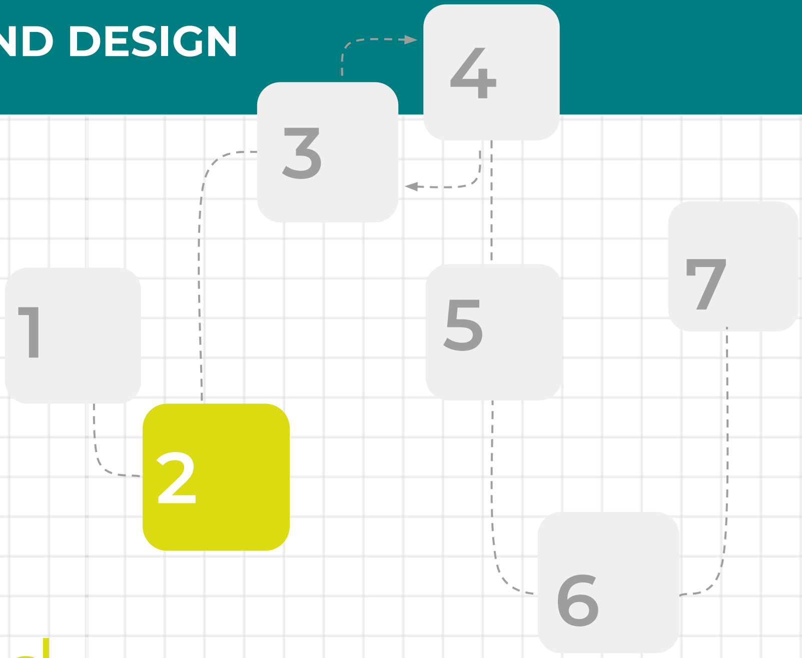
PUBLIC ORGANIZATIONS
associations and NGOs
Can suggest best practices approach.

BUILDING / ENERGY MANAGERS
university managers
Can exploit the collection to motivate more ambitious targets with decision makers.

STUDENTS
Can help in the data collection as a research experience.

COMPANIES
Can suggest best practices.

back to WORK FLOW



2. Identify Strategies and Technologies

The second activity consents a first identification of the renovation strategies, technologies and materials that **can fit the analysed criticalities, by exploiting the Abacus** (see Abacus) **defined for the purpose as a supporting tool.**

The Abacus, in fact, is an organised and navigable selection of strategies for building retrofits in the Med socio-climatic context, correlated with appropriate technologies and materials. Firstly dedicated to high educational/university building, the Abacus can inform the pre-design phase of public buildings' renovation and can stimulate eco-sustainable, innovative, and creative designs of retrofit projects.

When the main strategies and technologies to implement in the renovation project are identified, the activity foresees the engagement of **local companies and experts** to evaluate the appropriateness of the optional technological solutions in relation to the local specific context.
The contact with companies consents to acquire all the information (different products, data sheets, costs), useful to define the different renovation scenarios, but also to stimulate the creation of prototypes and the innovation, with the LL as a R&D accelerator.

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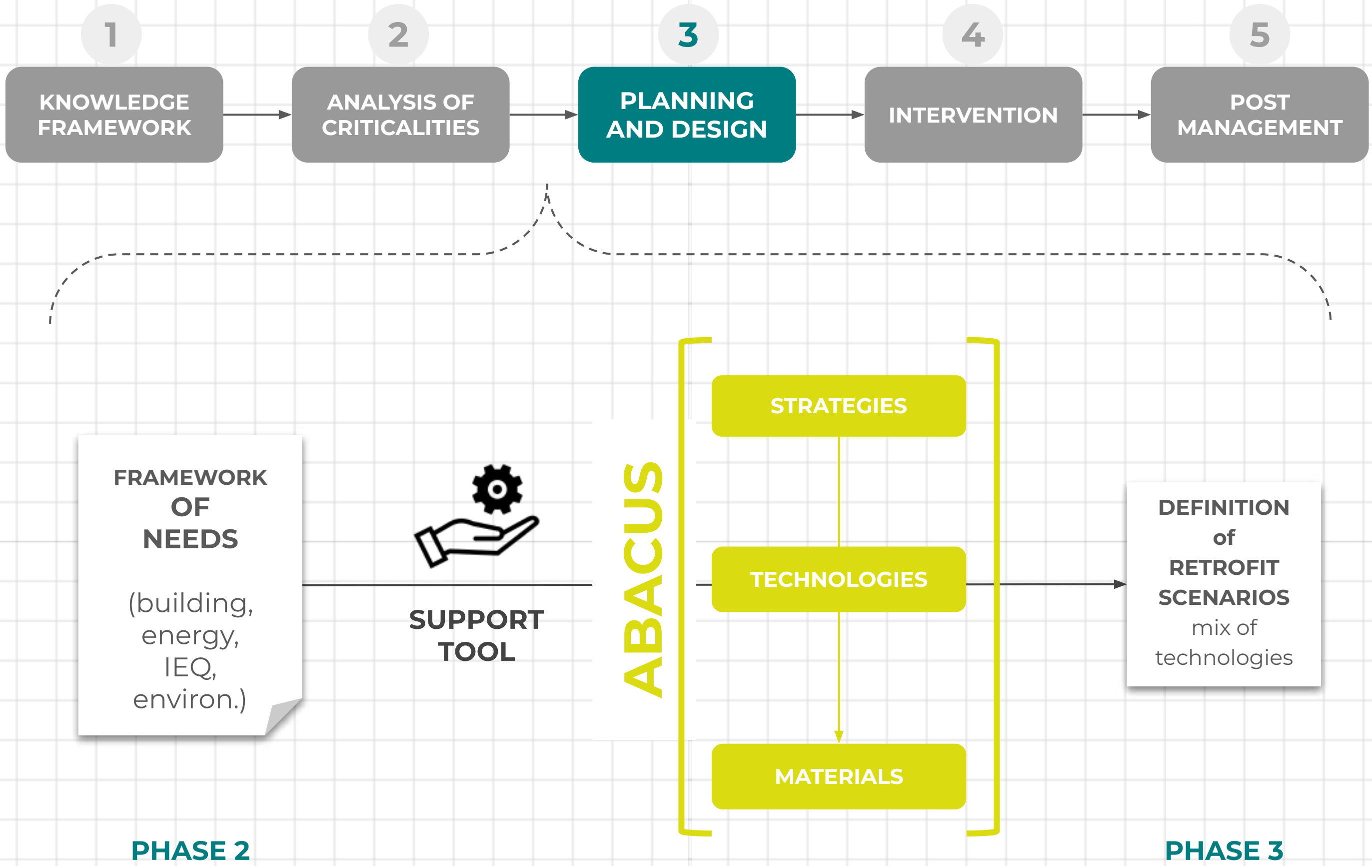
Identify Strategies and Technologies



In the case of historical buildings, in order to identify coherent but innovative technologies, it can be useful to evaluate their appropriateness through a dialogue with the **authorization of local entities**.

Moreover, in order to make the Abacus useful on the local scale, **researchers and students** can enrich the Abacus with more local technologies and materials, on the basis of the provided templates.

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Identify Strategies and Technologies

PUBLIC ORGANIZATIONS
associations and NGOs

Can be interested in the selection of technologies and materials, especially in coherence with historical buildings.

BUILDING / ENERGY MANAGERS
university managers

Can exploit the Abacus and stimulate new prototypes.

RESEARCHERS
architects + engineers + technical physicians ...

Enlarge the Abacus as a supporting tool.

STUDENTS

Help researchers in search and cataloguing as didactic activity.

COMPANIES
local companies

Provide with local technologies and materials (performance/costs*).

RESEARCHERS + BUILDING MANAGERS

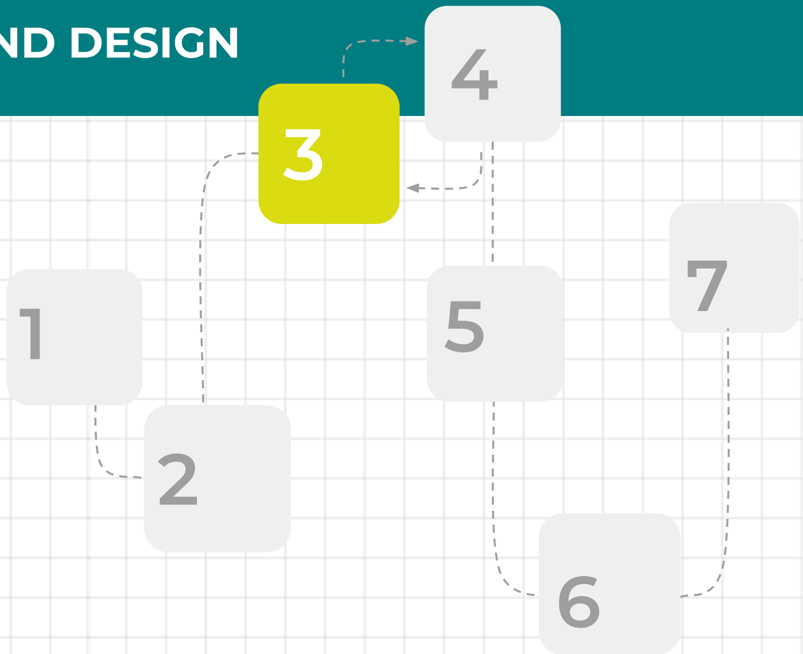
Have strong coordination and experience to identify appropriate strategies, technologies and materials to renovate the pilot-building.

Together with **STUDENTS** and **COMPANIES** can capitalize the Abacus.

ABACUS OF RENOVATION TECHNOLOGIES
deliv. B

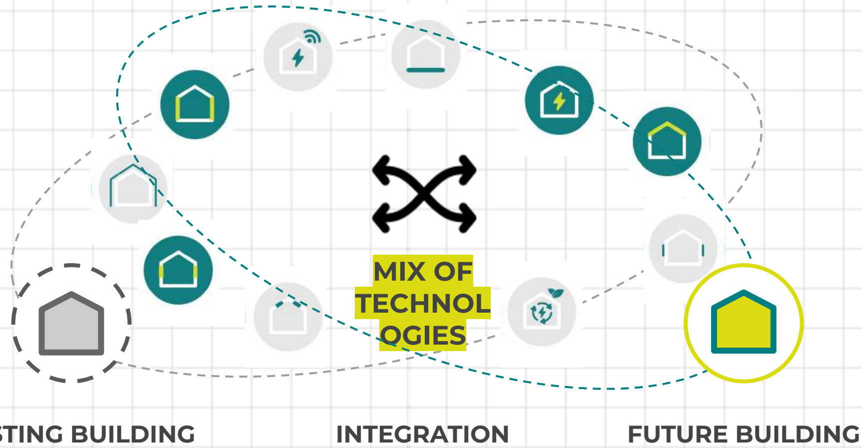
LIST OF RENOVATION STRATEGIES, TECHNOLOGIES, & MATERIALS
milestone

back to WORK FLOW



3. Build Retrofit Scenarios

Once the main strategies and technologies to solve the criticalities of the pilot-building have been identified, it is time to understand how much their integration can improve the overall building performances, in terms of energy efficiency and indoor environmental comfort, but also architectural quality and low environmental impact.
On the basis of the specific criticalities of the existing building, **renovation scenarios are mix-of-technologies to integrate in the existing building in order to reach the baseline, and to address most of the performances foreseen by the predefined quality targets**.



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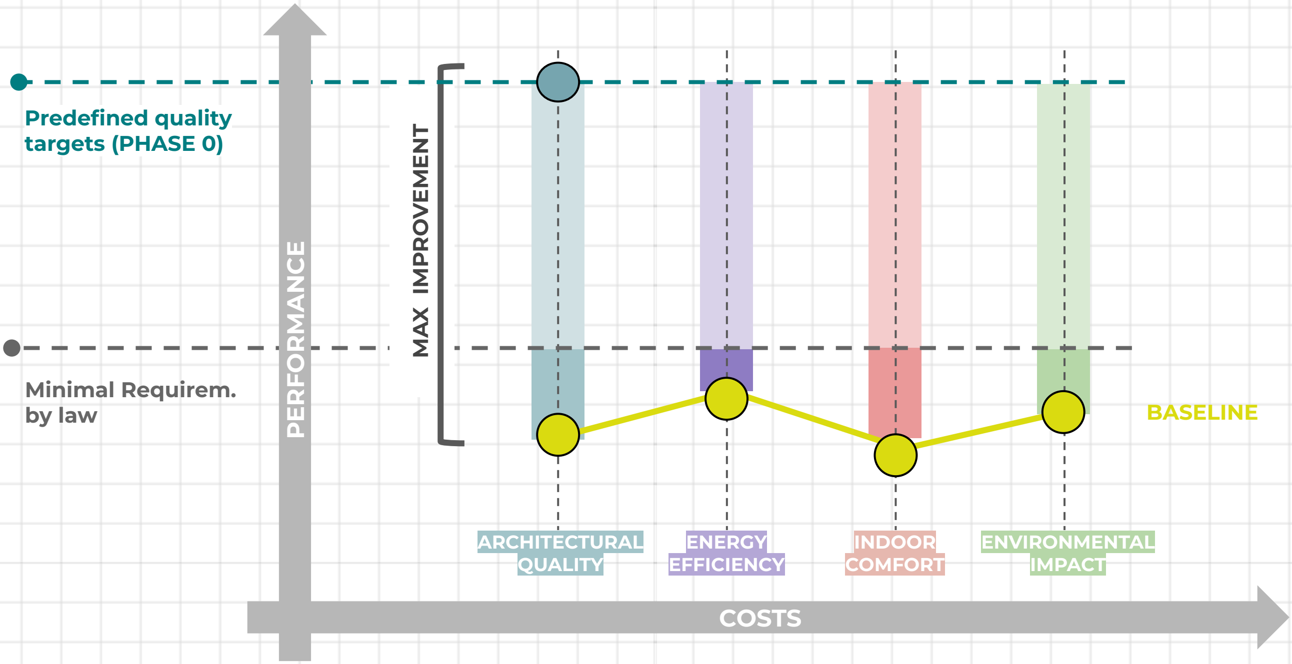
Build Retrofit Scenarios



Renovation scenarios are constructed in relation to the **degree of satisfaction** of the different and pre-defined renovation targets, which can be related to costs or to different renovation aspects to evaluate according to the defined targets, and the performances to reach.

The development of possible scenarios (**what-if scenarios**) is carried out thanks to a methodology that serves to define which are the best solutions (**Best Path Methodology**) in economic, technical and social terms. This methodology allow the possibility to optimise the correspondence of design choices on the basis of predefined criteria (**targets**) and to modulate interventions according to the level of improvement (**range**) decided by the public administration.

To meet the requirements and to develop a broad and inclusive project, an important step is the configuration of three scenarios corresponding to three different 'performance-economic' profiles:

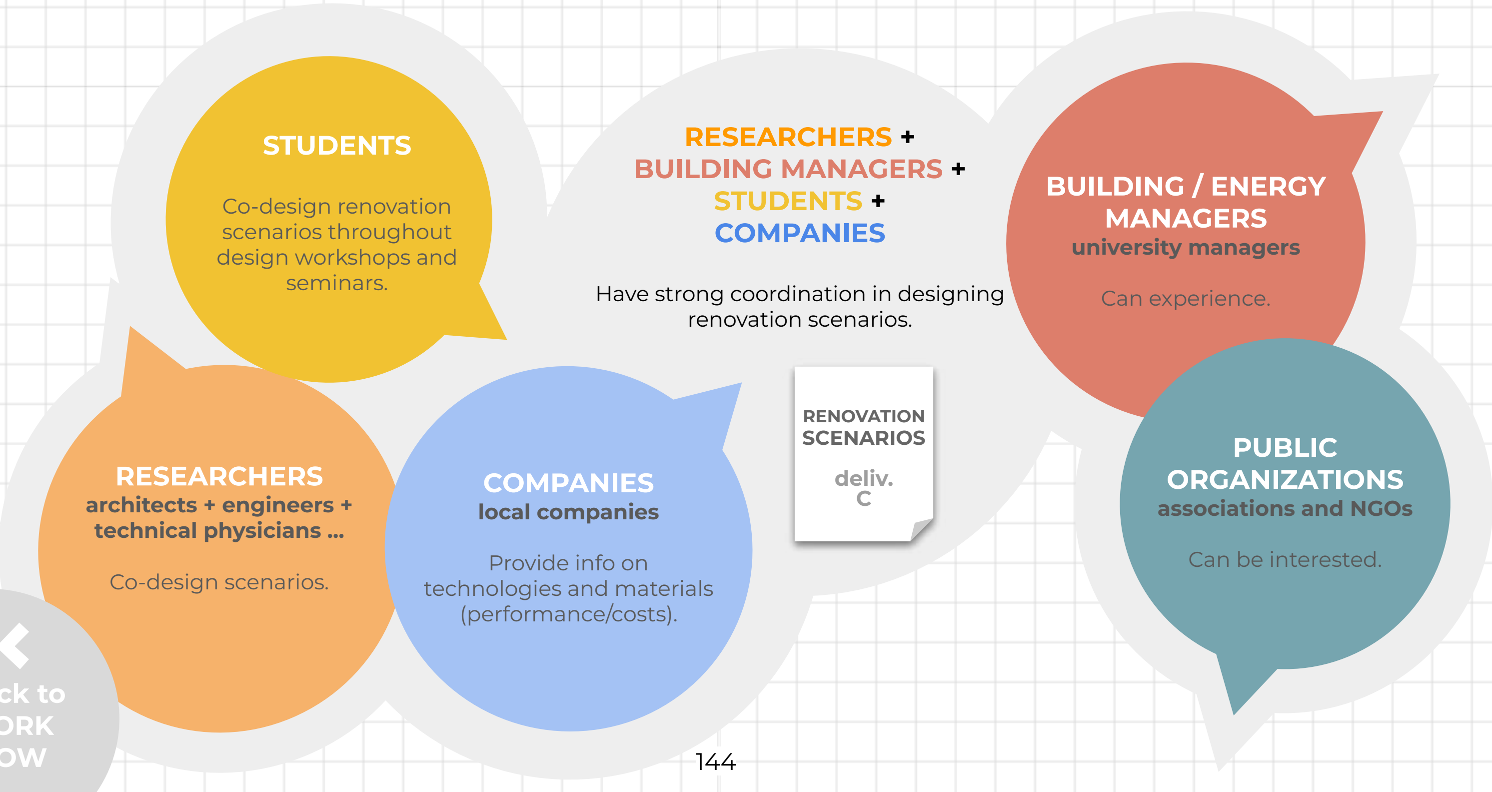
- Low
- Medium
- High

back to WORK FLOW

Build Retrofit Scenarios

It is not necessary that profiles are discordant with each other, but may be consecutive and/or complementary. For example: in the case of heritage buildings, the evaluation of architectural quality has a heavy weight in relation to other targets, since the renovation project has to comply with the existing architectural constraint.
All the three levels examine the design solutions and at the weaknesses that emerged during the analysis of the building and its context. Critical aspects must be turned into strengths in order to reach the final goal and the ambitious targets.

The construction of reliable scenarios in the LL context has the big advantage to merge the knowledge of the interdisciplinary **researchers** group and the experience of **building/energy managers**, as well as the know-how of **stakeholders**, in particular companies providing technical specifications of the different products (technology + material).
This activity of the Phase 3 can be carried out with the suitable choice of supporting tools and professionals. So, the experience of the LL is fundamental for the technical feasibility of scenarios, the definition of scenarios - especially for the architectural aspects - can take advantage from the engagement of students, with the organisation of co-design workshops.



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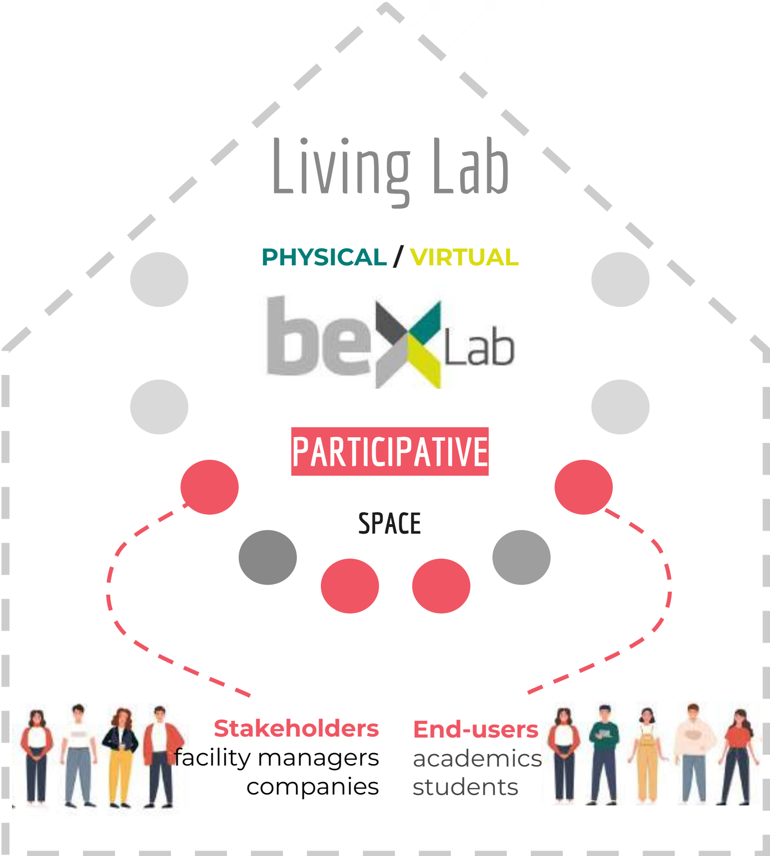
beXLab experience

"a cultural, human centred and positive, “tangible” experience of energy efficiency and environmental quality where people can be aware of the impacts of buildings both on the planet as well as on people in terms of comfort and wellbeing”

#NewEuropeanBauhaus

➔ **DESIGN WORKSHOP & COMPETITION**



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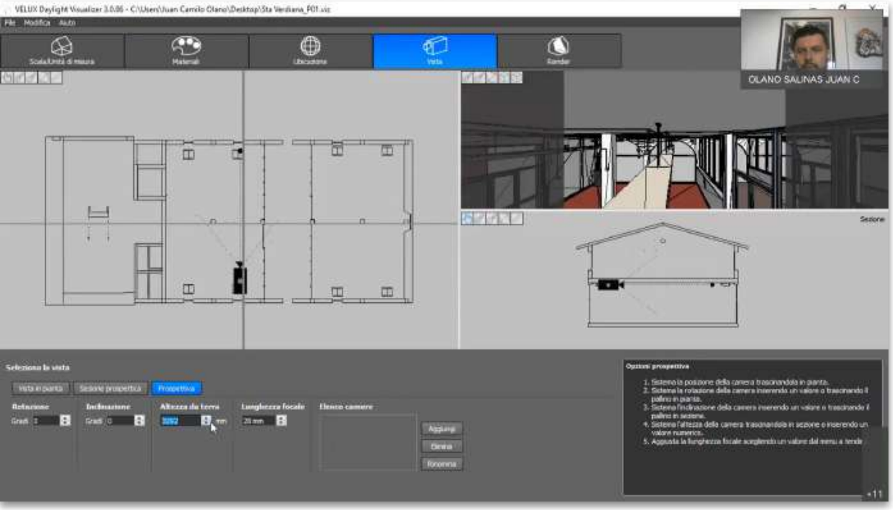
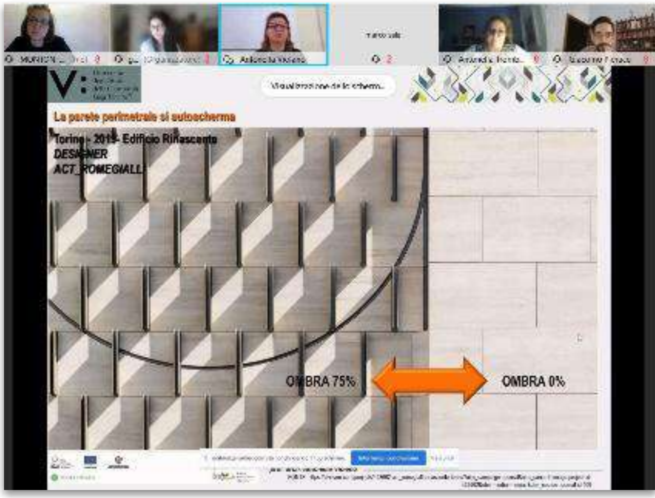
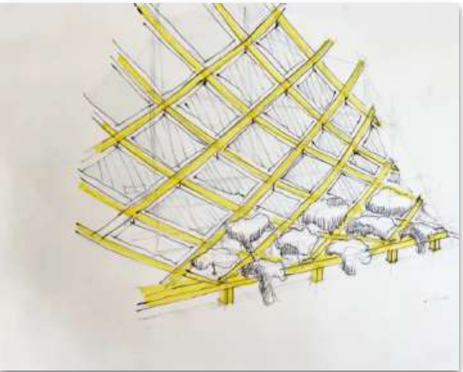
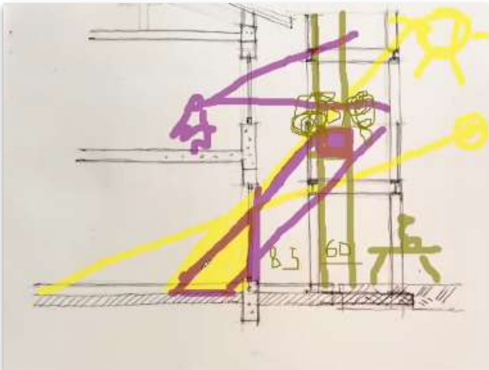
➔ **DESIGN TRAINING WORKSHOP AND COMPETITION**









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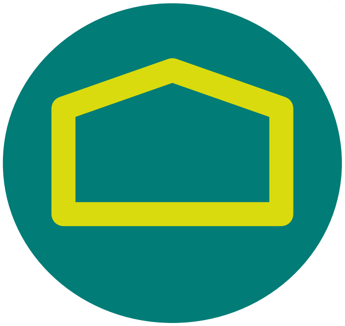
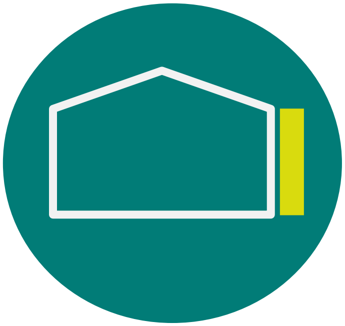
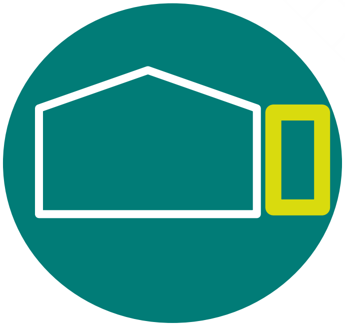
➔ **3 MACRO-SCENARIOS OF INTERVENTION**







1.
ENVELOPE

Direct intervention on the envelope elements (opaque and transparent) by the addiction/substitution of technological solutions

2.
DOUBLE SKIN

Addition of technological and integrated façade solutions, detached about 1 m from the building

3.
TRIDIMENSIONAL

Tridimensional structure in the external space of the building, from which it remains independent.

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➔ **I MACROSCENARIO OF INTERVENTION**
| ENVELOPE

#	Retrofit strategies	Ex. technological solutions
1	**Thermal insulation of the opaque envelope**	Internal insulation, external. etc...
2	**Fixture Substitution**	Thermal Break fixtures, smart windows, double glasses, etc...
3	**Sun Radiation Control**	Solar shadings, fixed, mobile, horizontal, vertical, etc...
4	**Sun Reflection**	Reflective Shelf
5	**Production of energy from renewable sources**	PV integration, thermal panels, etc...
6	**Sunlight entrance**	Skylight, sun pipes, etc...

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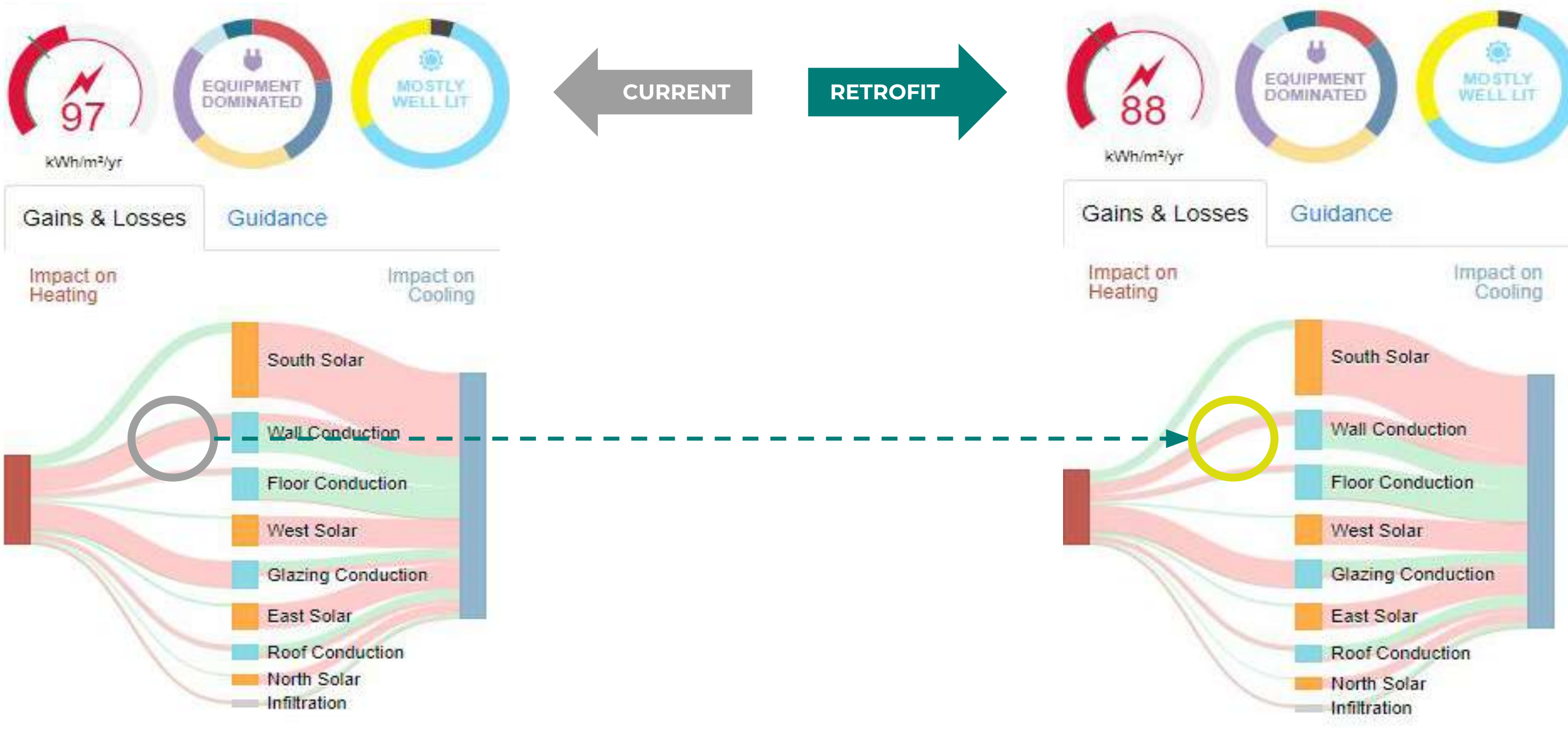
Retrofit strategies	Ex. technological solutions
Thermal insulation of the opaque envelope	internal insulation of external walls with 8cm panels of wood fiber (160 kg/m3)



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➔ **I MACROSCENARIO OF INTERVENTION**
Single Strategies Evaluation

Retrofit strategies	Ex. technological solutions	Simulation of post-retrofit energy use
insulation of the opaque envelope	internal insulation of external walls with 8cm panels of wood fiber (160 kg/m3)	**88 kWh/m2 yr** ✗
fixtures substitution	fixtures with performance in line with the prescription by law	**80 kWh/m2 yr** ✗
sun radiation control	schermature solari mobili con lamelle orizzontali (10 cm) su superfici vetrate	**90 kWh/m2 yr** ✗

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➔ **I MACROSCENARIO OF INTERVENTION**
Technological mix

Retrofit strategies	Ex. technological solutions	Simulation of post-retrofit energy use
insulation of the opaque envelope	internal insulation of external walls with 8cm panels of wood fiber (160 kg/m3)	**70 kWh/m2 annui** ✓
fixtures substitution	fixtures with performance in line with the prescription by law	
sun radiation control	schermature solari mobili con lamelle orizzontali (10 cm) su superfici vetrate	
sunlight entrance	openings of skylights in the roof (first floor)	

energy use:
97 KWh/m2 yr

← **CURRENT**

RETROFIT →

reference target:
73 KWh/m2 yr

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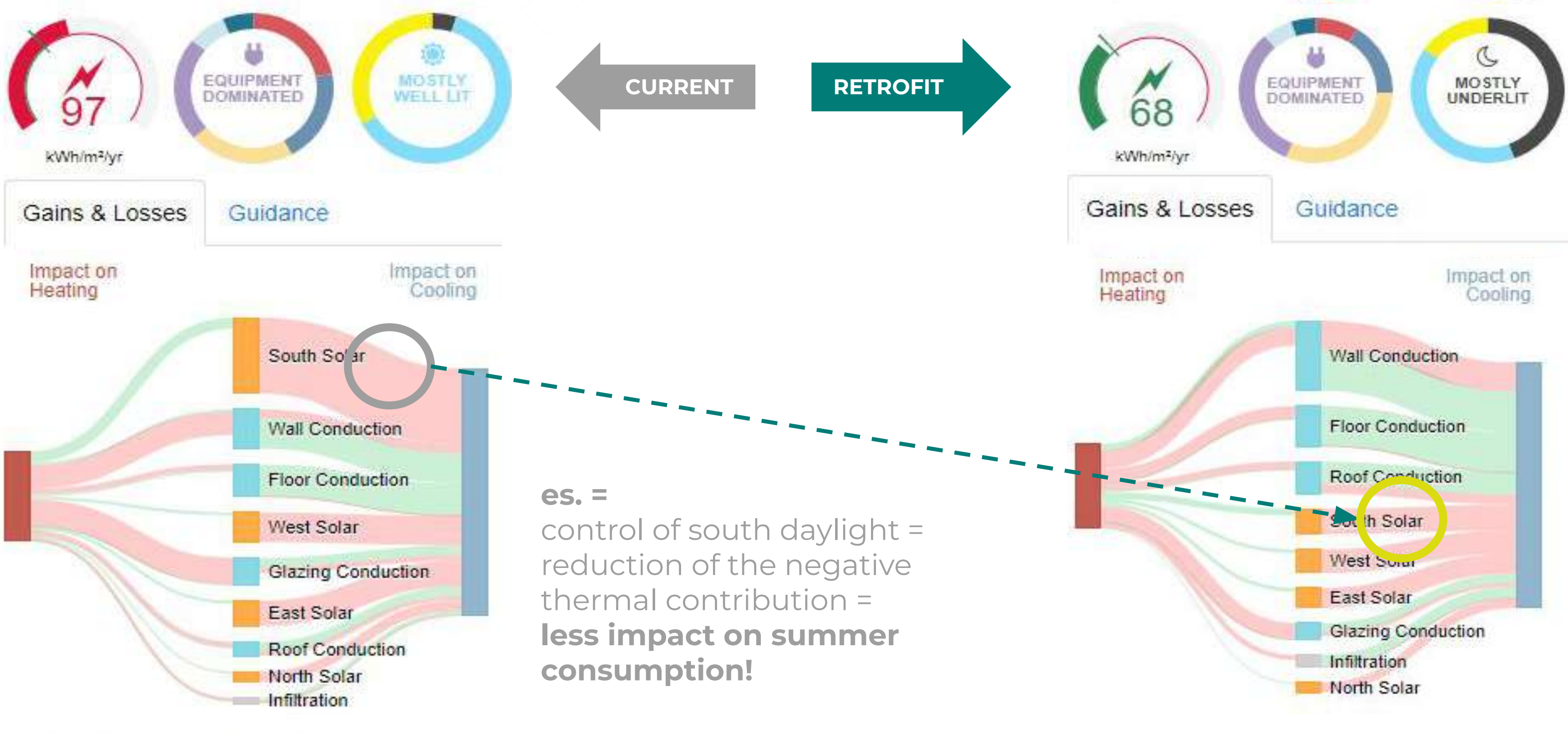
➔ **I MACROSCENARIO OF INTERVENTION**
Technological mix



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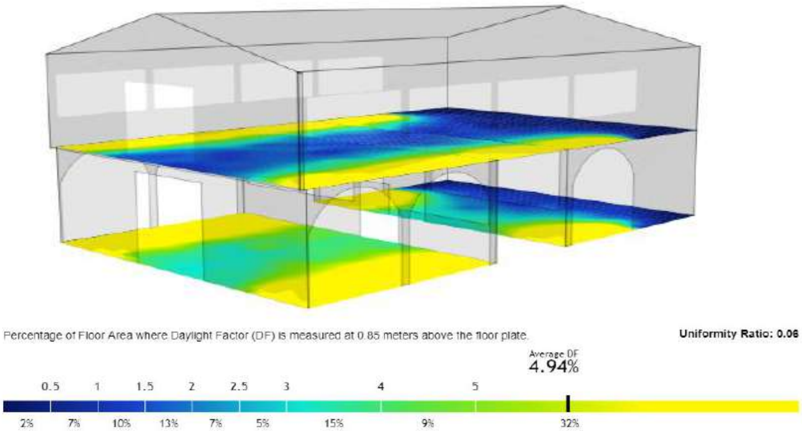
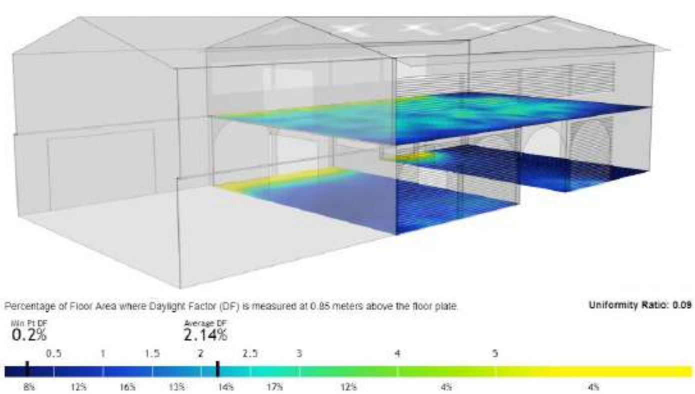
➔ **I MACROSCENARIO OF INTERVENTION**
Technological mix

DAYLIGHT ANALYSIS

CURRENT | RETROFIT





Daylight factor

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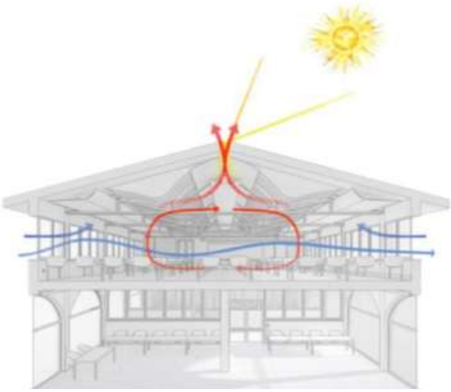
➔ **I MACROSCENARIO OF INTERVENTION**
SKYLIGHT, PROJECT 1



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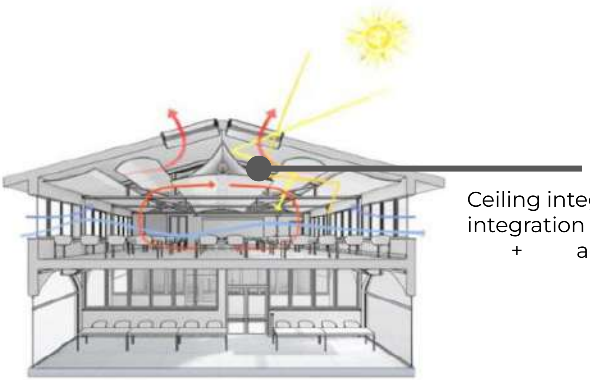
➔ **I MACROSCENARIO OF INTERVENTION**
SKYLIGHT, PROJECT 2



Ceiling integration:
integration of the plant thermal system
+ acoustic control

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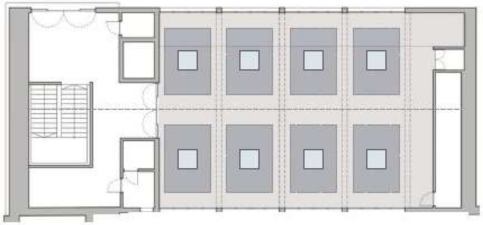
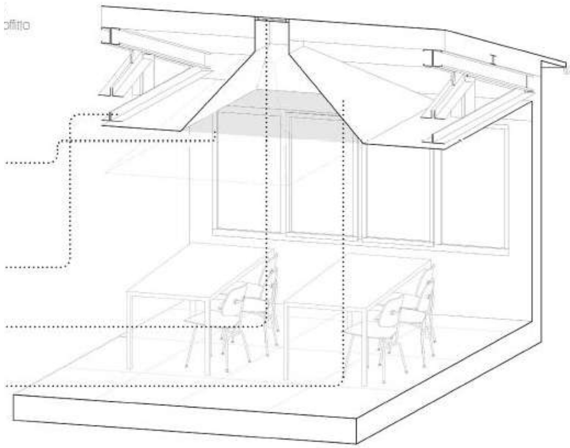
➔ **I MACROSCENARIO OF INTERVENTION**
SKYLIGHT, PROJECT 3

Roof scheme

Skylights, 80x80 cm
Diffusing surfaces
countertop





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➔ **II MACROSCENARIO OF INTERVENTION**
| DOUBLE SKIN

#	Retrofit strategies	Ex. technological solutions
1	**Control of solar radiation**	Permanent, movable, horizontal or vertical solar shading, materials, etc ...
2	**Green integration**	Vertical green walls, climbing plants, etc...
3	**Solar reflection**	Reflecting and absorbing surfaces, etc...
4	**Energy production from renewable sources**	Photovoltaic panels (different types)

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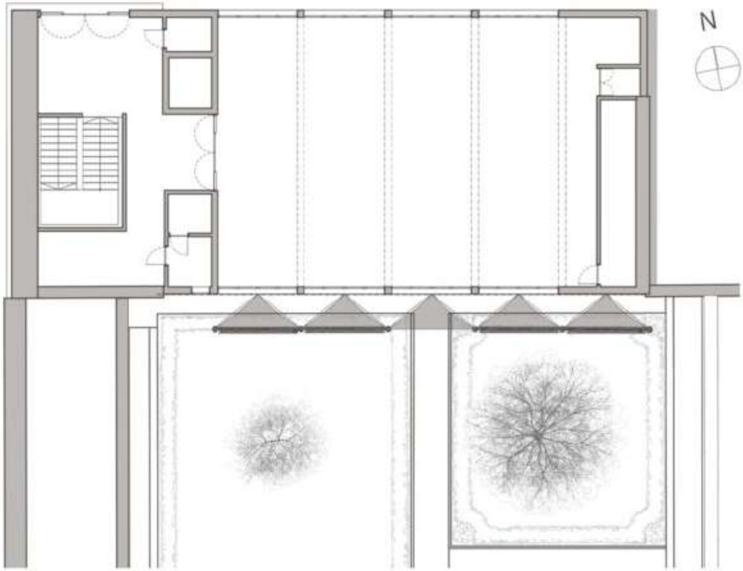
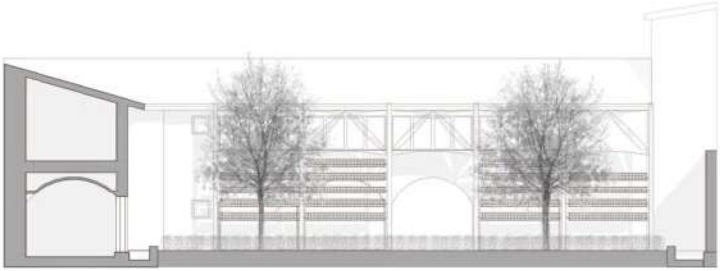
➔ **II MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 1





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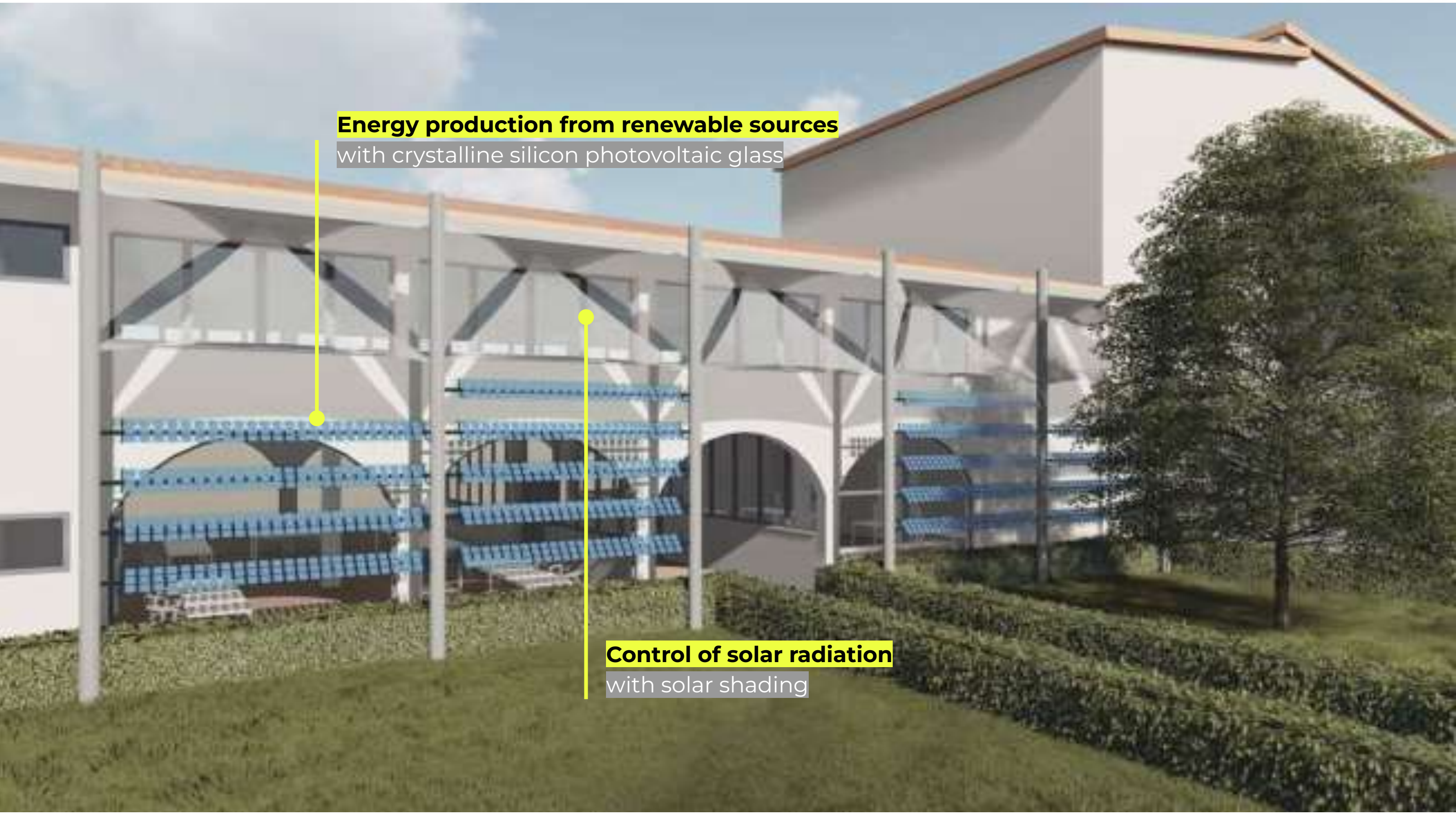
➔ **II MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 1

Triangular sails



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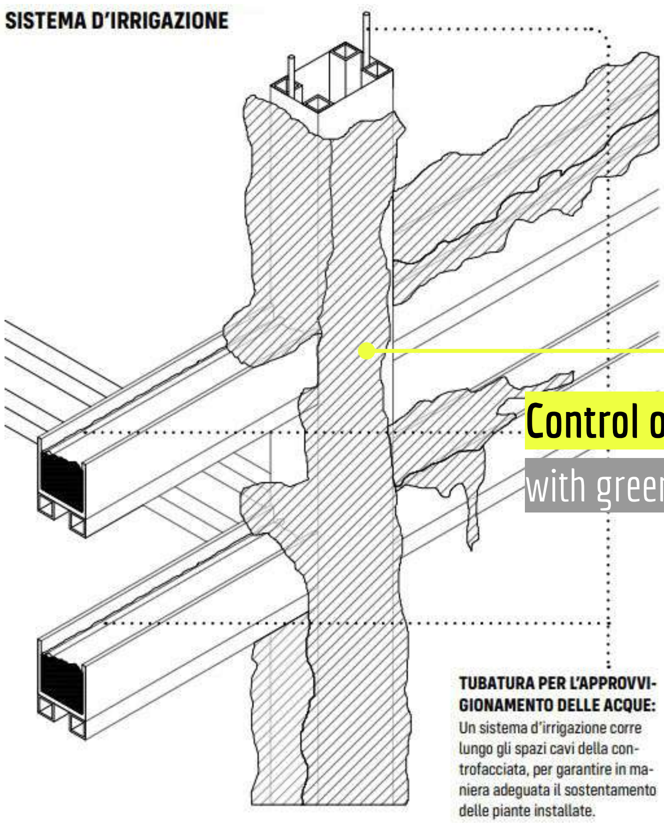
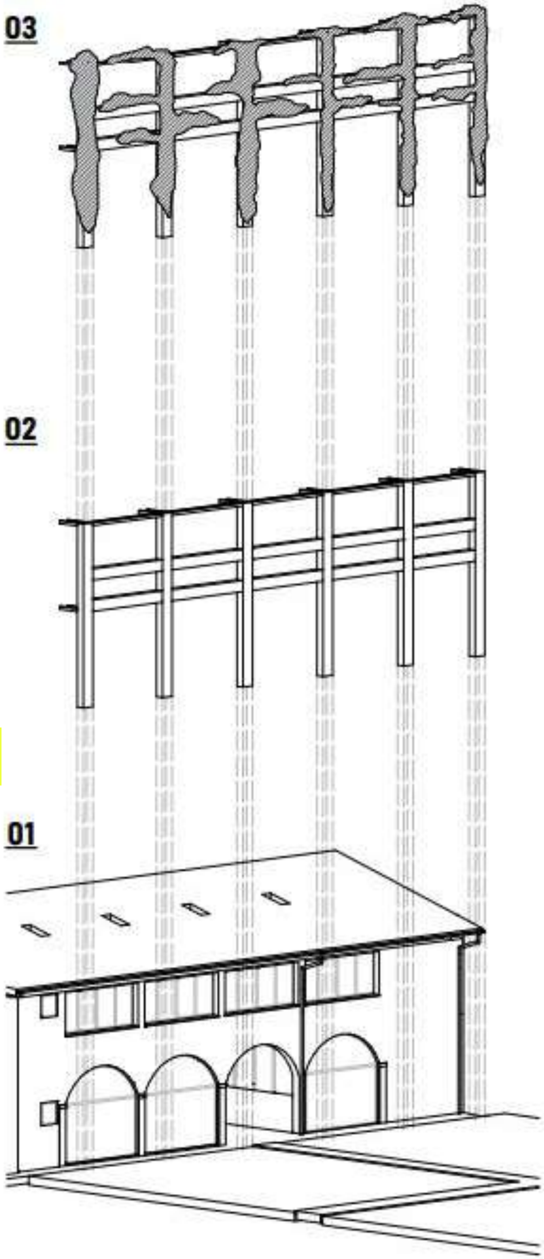
➔ **II MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 2

Assonometry and irrigation detail



Control of solar radiation
with green elements



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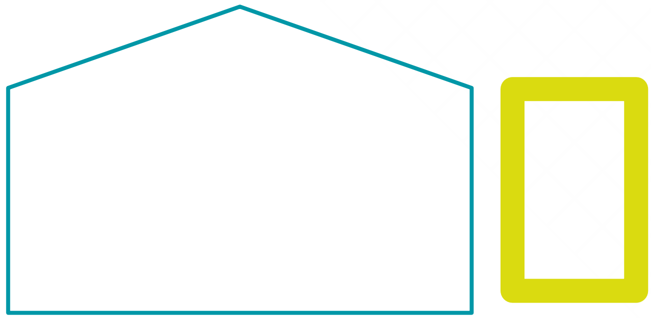
➔ **II MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 2

beXLab experience

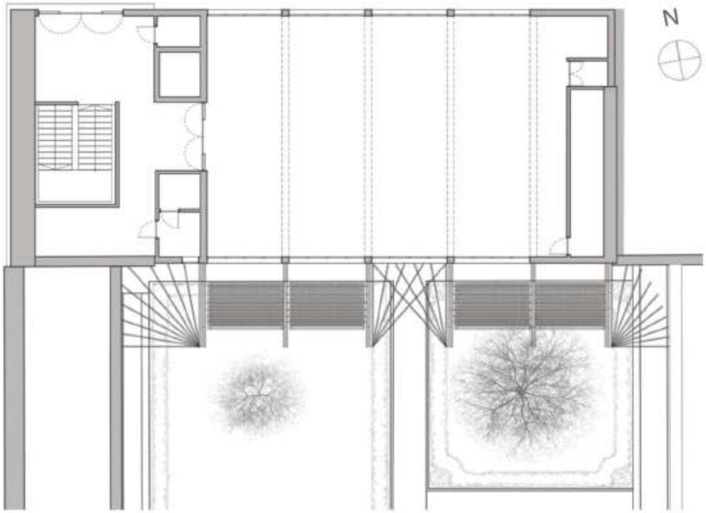
➔ **III MACROSCENARIO OF INTERVENTION**
| TRIDIMENSIONAL

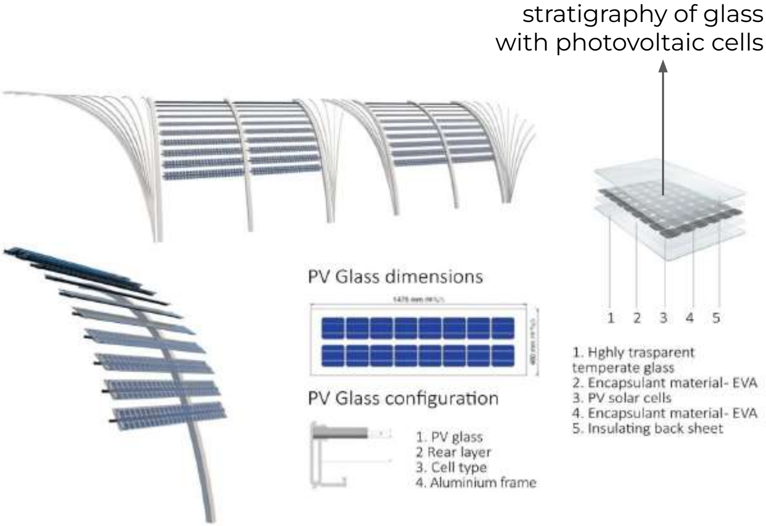


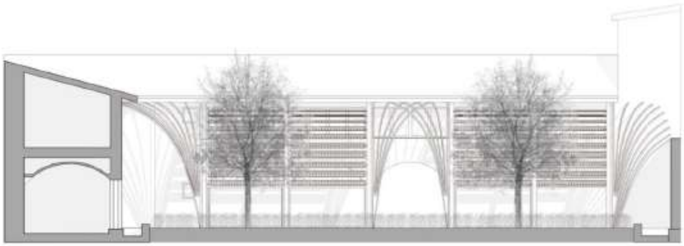
#	Retrofit strategies	Ex. technological solutions
1	**Control of solar radiation**	Permanent, movable, horizontal or vertical solar shading, materials, etc ...
2	**Green integration**	Vertical green walls, climbing plants, etc...
3	**Solar reflection**	Reflecting and absorbing surfaces, etc...
4	**Energy production from renewable sources**	Photovoltaic panels (different types)
5	**+ Design of new external/covered spaces**	Covered lightweight construction (different technologies and materials)

beXLab experience

➔ **III MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 1







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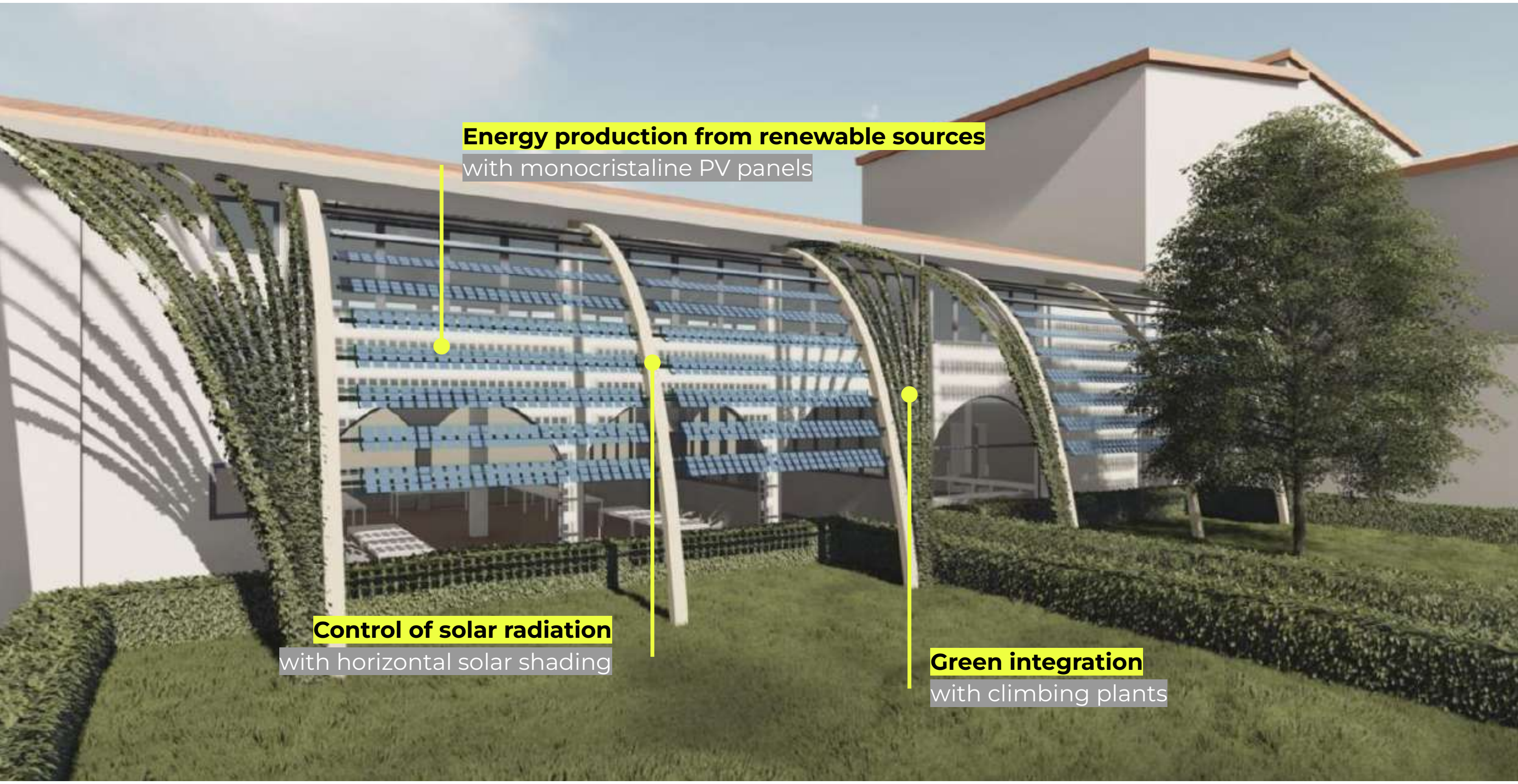
➔ **III MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 1



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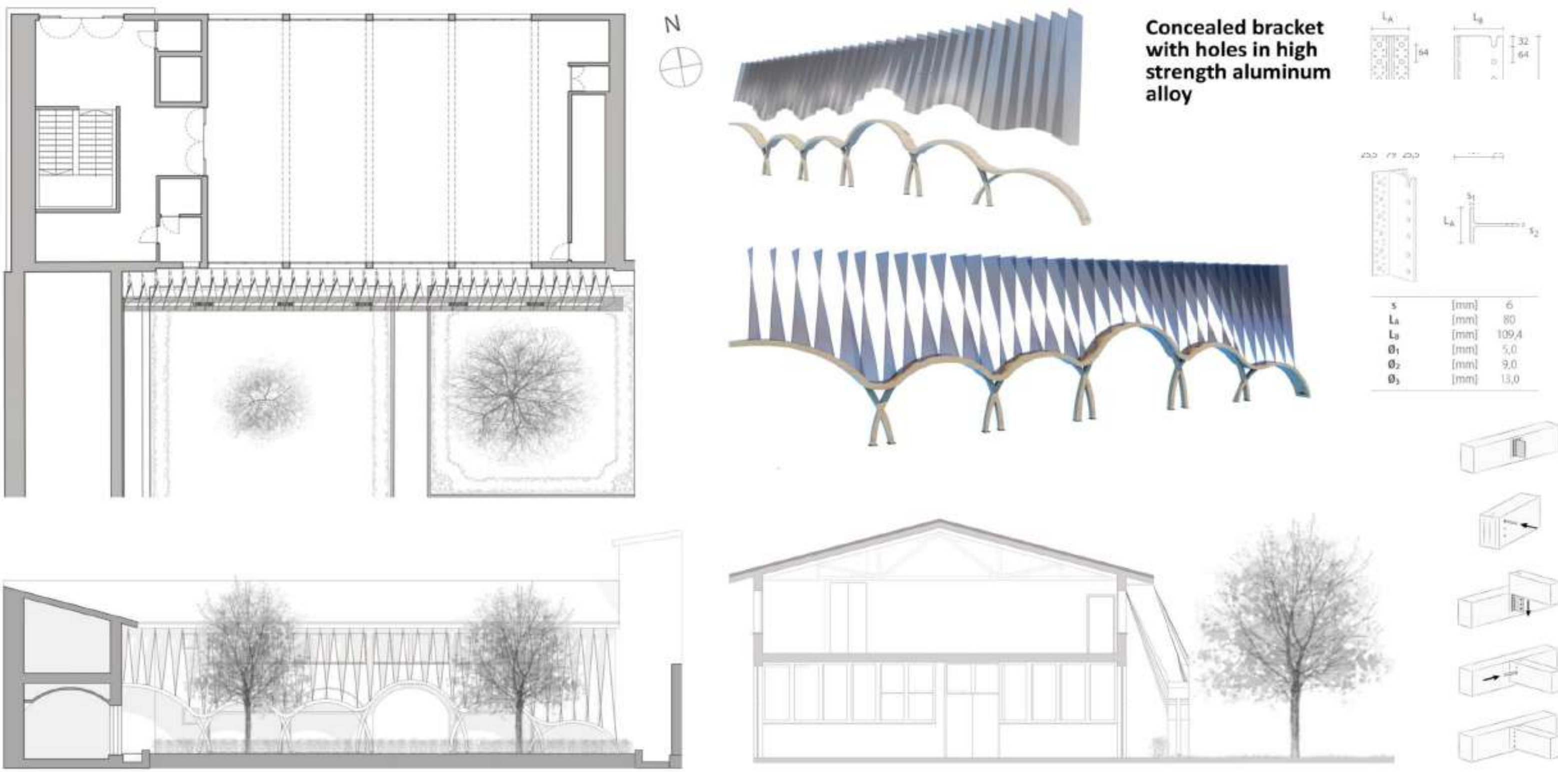
SOUTH FACADE, PROJECT 2



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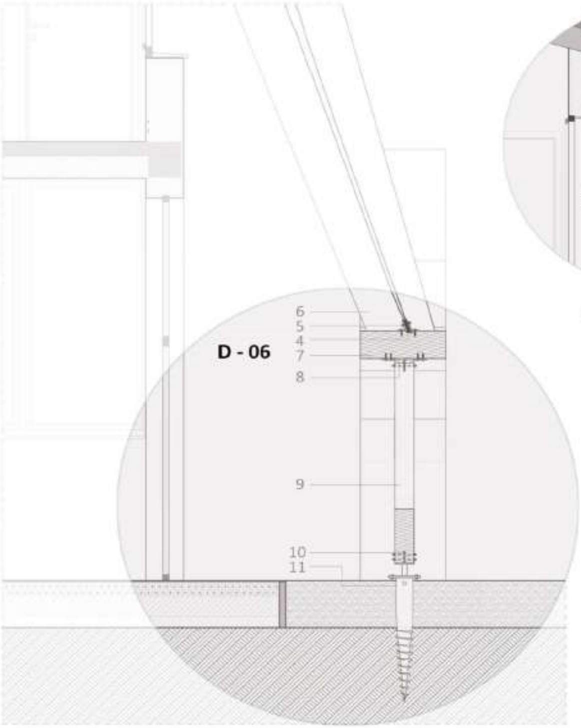
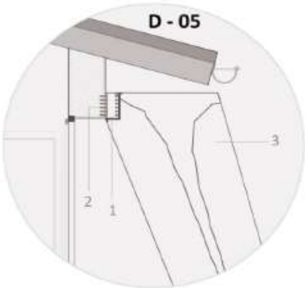
→ **III MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 2





Detail of guide for panel insertion

D - 05
Attachment to the tuff wall:
1. Retractable aluminum bracket
2. BSD self-drilling plug
3. HAVER metallic fabric panel

D - 06
Panel-wooden element connection and ground connection:
4. Bolted inclined L plate
5. Guide for panel insertion
6. HAVER metallic fabric panel
7. Wave shaped wooden element
8. Bolted T-bracket
9. Shaped wooden element 16x16cm
10. Bolted T post base with internal core
11. Foundation screw

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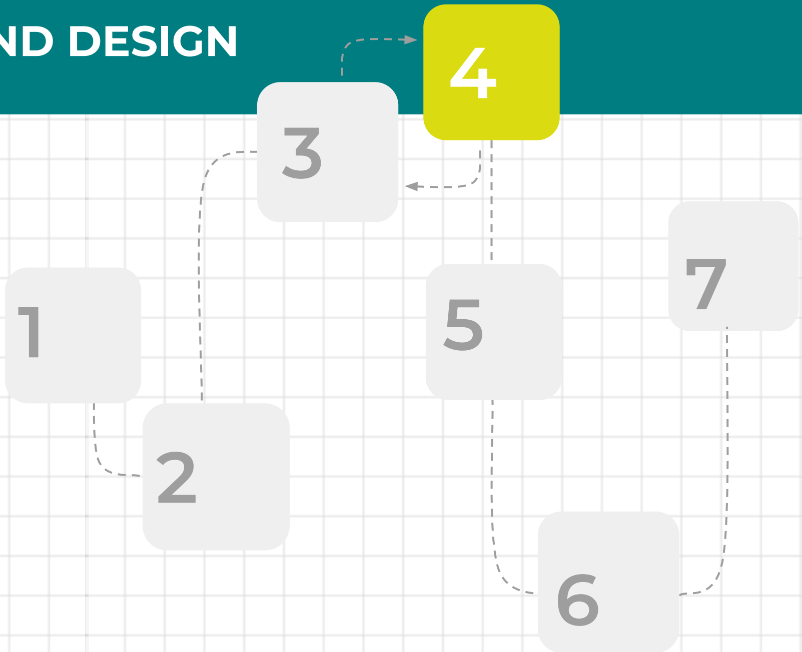
➔ **III MACROSCENARIO OF INTERVENTION**
SOUTH FACADE, PROJECT 2



4. Simulate Scenarios

As for the analysis of criticalities the adoption of simulation tools can give a deeper insight to the environmental and energy performances of the building, in this phase it is useful to predict the future renovated building.
In the design phase the simulation approach is enlarged to the **architectural aspects** of the future building, with the possibility **to visualise the transformation of the existing building** with the integration of the renovation technologies according to the different scenarios.
Since the early stages of the design phase, it is possible to exploit the simulations performed in the AC to act **interactively and iteratively** as a benchmark to evaluate the improvements deriving from the implementation of the different scenarios.

According to the different types of simulation performed, it is possible to appreciate the improvements from the integration of single/set of renovation technologies in comparison to the current conditions.

In particular it is possible to evaluate the performances of the mix-of-technologies in relation to:

- Architectural quality;
- Energy efficiency;
- Indoor environmental quality: improvement of visual quality, thermo-hygrometric comfor;
- Environmental impact: (es. Energy production from new renewable sources, LCA calculation of the construction systems and building materials).

With the activity of scenario building, **simulations are an iterative process**: if the simulated performances of the mix-of-technologies of a scenario do not match with the foreseen targets, it is necessary to formulate the mix-of-technologies.

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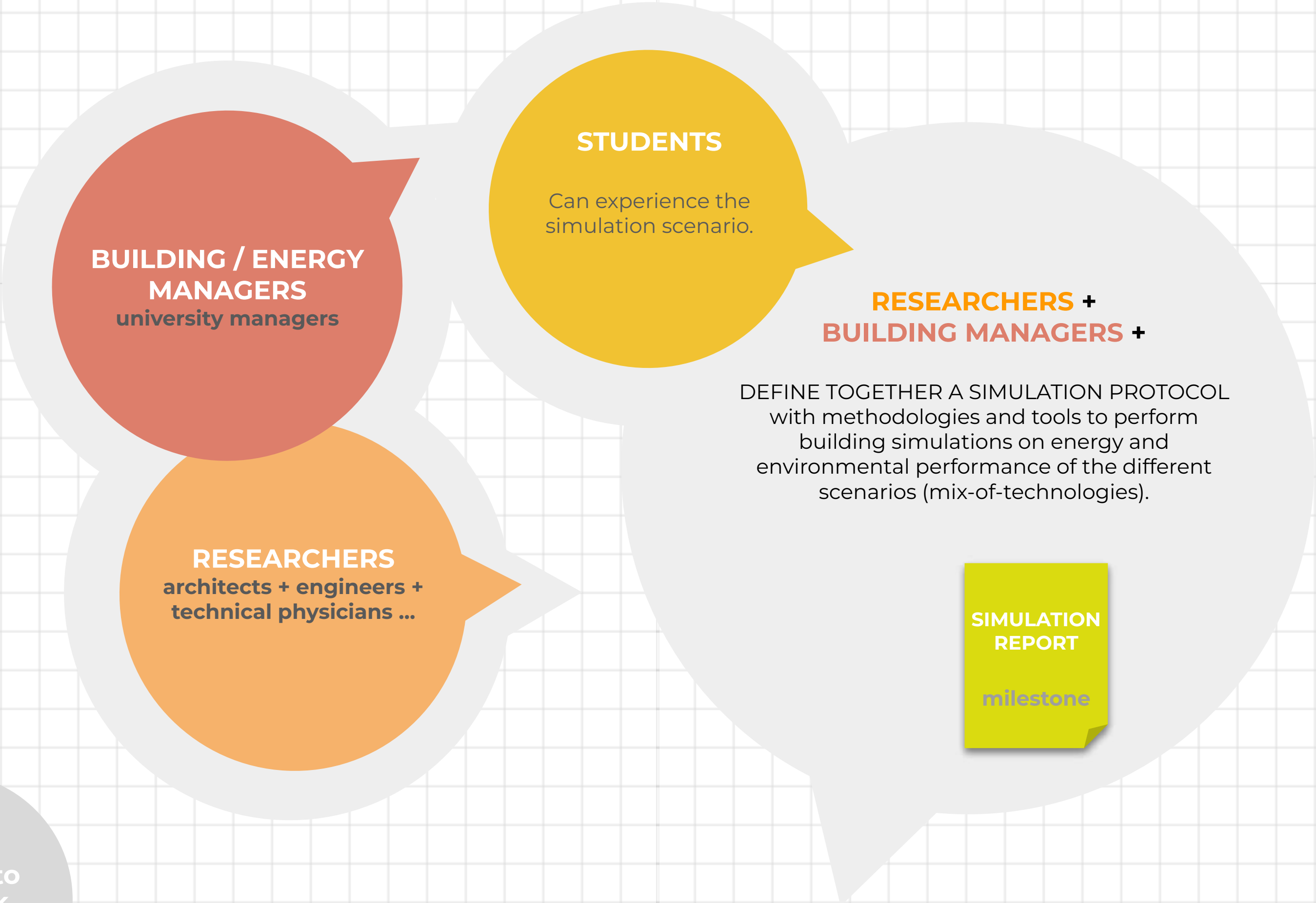
Simulate Scenarios

For each scenario, it is possible to visualise all together the architectural, energy and environmental aspects of the new building, in relation to the costs.

As for simulations in the AC phase, the simulation of renovation scenarios is managed by researchers according to their disciplinary background. In the LL context the activity can benefit from the experience of stakeholders, as simulation tools companies, and involve students as an occasion of didactic.



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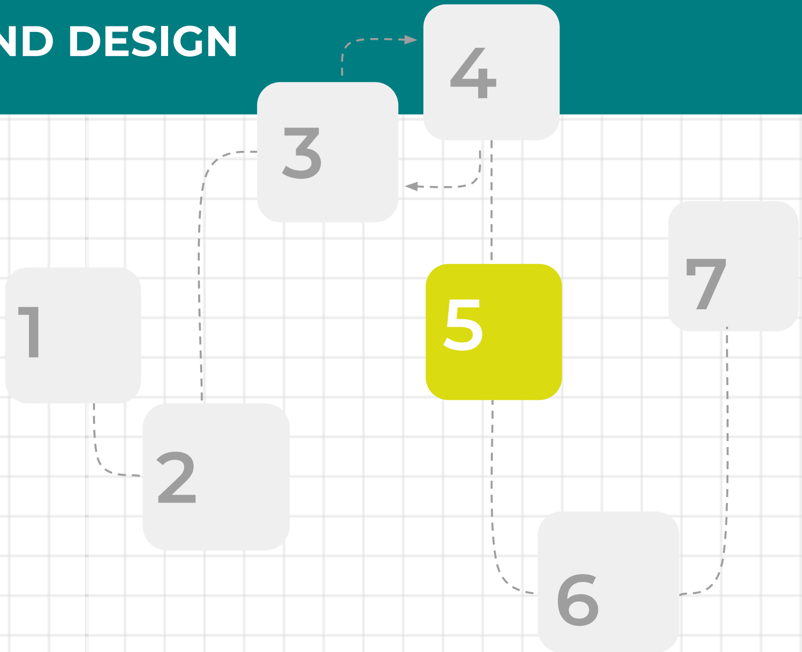


5. Choose the Best Scenario

In this step, the targets (criteria) previously used for the definition of quality requirements will be taken into account and different scores will be given according to the satisfaction degree of the common needs.

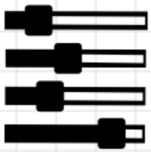
The three design levels (low, medium and high), in this case, are not in conflict with each other and they are especially useful with regard to the economic aspect, which is known to be crucial for wide-ranging planning.

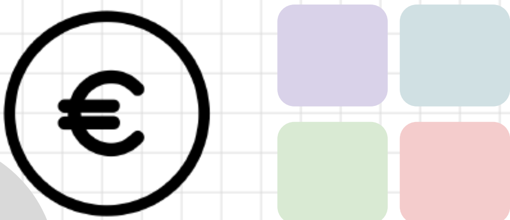
COST-BENEFIT ANALYSIS

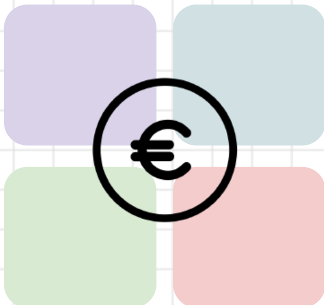
focus on the budget

MULTI-CRITERIA ANALYSIS

effectiveness in achieving goals







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Choose the Best Scenario

The selection of the best scenario is carried out adopting **two different comparative evaluations**, based on the single criterion methods (monetary approach) and the multi-criteria methods (non-monetary approach): Cost-benefit analysis (CBA) and Multi Criteria analysis (MCA).
Both methodologies present some prickly points; MCA, for instance, is not considering public expense efficiency at all, but only its effectiveness in achieving the SM goal. On the contrary, critics often consider CBA not appropriate in managing intangible impacts, which are more relevant to policies and strategies at this scale for achieving SM and urban quality of life.

Multi Criteria Analysis

Usually, a decision-making problem has more than one goal to reach, and there is always a trade-off between the different goals, advocated by different interest groups or stakeholders. The MCA is a tool for reaching a specific goal through the selection of alternative projects that allows to take into account several criteria and the stakeholders' opinions. The alternative projects always have a significant social, economic, environmental impact. Therefore, the inclusion of multiple stakeholders in the decision making process is widely acknowledged. Within the MCA, the objectives to reach must be specified and corresponding attributes or indicators must be identified. The actual measurement of indicators needs not to be in monetary terms, but it is often **based on scoring, ranking and weighting of a wide range of qualitative impact categories and criteria** (such as for example, architectural quality).

When there are implicit constraints, the multi-criteria analysis will consist of choosing an alternative among a set of finite and known options. The analysis will be based on the attributes that describe the options, and the importance of the criteria involved in the decision process.

Analytic Hierarchy Process (AHP) is a three-stage method: (i) building the hierarchy; (ii) weighting the indicators by a pair-wise comparison, and (iii) calculating the final value for the alternatives.

The goal which needs to be reached is at the top of the hierarchy; the primary criteria are settled in the second level, and they are followed by the subcriteria on the third level. In the following level there might be additional subcriteria, while at the bottom level of this "probability tree" (Tudela et al., 2006) there are the discrete options under consideration. The elements of the hierarchy can relate to any aspect of the decision problem — tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood — anything at all that applies to the decision at hand. The stakeholders, public and private, might take part to the construction of this hierarchy. Once the criteria and subcriteria have been settled, a set of weights is required to proceed with the analysis.

These weights represent the relative importance of the criteria, subcriteria and attributes belonging to a specific nest in the hierarchy. According to the original procedure developed by Saaty, these weights are obtained from pair-wise comparison matrices, for each nest in the hierarchy. Once weights are available, the hierarchical structure is collapsed, following a folding back procedure. For each option under study, there will be a final weight. These final weights are used to rank the options.

back to WORK FLOW

According to a widely accepted sustainability rating systems (see for example, GBTool, SBTool and Itaca Protocol), each indicator has then been measured by a quantitative score tied to a performance scale of values, which ranges from 0 to +2 (0 = deficient performance; 1 = ordinary practice, which is the minimum acceptable performance; +2 = good performance).

Cost Benefit Analysis:

Firstly, the CBA is **based on monetisation and inter-temporal discount**. Money is the measure unit used as a common numerary to reduce all costs and benefits associated to an investment or a policy. Apart direct monetary costs in perfect markets (e.g. untaxed cost of energy) whose monetisation is trivial, also non-market goods and goods traded in an imperfect market are quantified. The first ones (e.g. time or environmental costs) are translated into the common numerary by means of the willingness to pay or by deriving prices from substitute markets (hedonic prices method). The second ones are translated into their opportunity cost by subtracting taxes (e.g. fuel prices) and by looking at the direct effect only (e.g. shadow price of labour cost).

Once all relevant effects of an investment are quantified, the concept of intertemporal discount is used to translate future costs and benefits to present day by means of a social discount rate. This way, the future can be compared with present. For example, it offers a way to compare a cost of 1€ to be paid now to obtain a future benefit of 1,1€. Similarly, in financial CBA, the discount rate is the financial one. trivial, also non-market goods and goods traded in an imperfect market are quantified. The first ones (e.g. time or environmental costs) are translated into the common numerary by means of the willingness to pay or by deriving prices from substitute markets (hedonic prices method). The second ones are translated into their opportunity cost by subtracting taxes (e.g. fuel prices) and by looking at the direct effect only (e.g. shadow price of labour cost). Once all relevant effects of an investment are quantified, the concept of intertemporal discount is used to translate future costs and benefits to present day by means of a social discount rate. This way, the future can be compared with the present. For example, it offers a way to compare a cost of 1€ to be paid now to obtain a future benefit of 1,1€. Similarly, in financial CBA, the discount rate is the financial one.

The key concept of CBA technique is the **surplus**. It is made of consumers' surplus, plus producers' surplus, plus, if the case, Government surplus. Surplus is defined as the difference between the willingness to pay/sell of users/producers for a good (which is the combined effect of perceived utility and income distribution) and the effort needed to obtain such good (the monetary cost or any other kind of effort). A scheme generates a variation of surplus, between the situation "with" and "without" it. Following this concept, CBA essentially compares among trade-offs: total benefits must exceed the total opportunity cost of consumed resources (labour, time, monetary costs, etc.) to make a project feasible. Otherwise, social cost exceeds social benefits and the scheme should be rejected.

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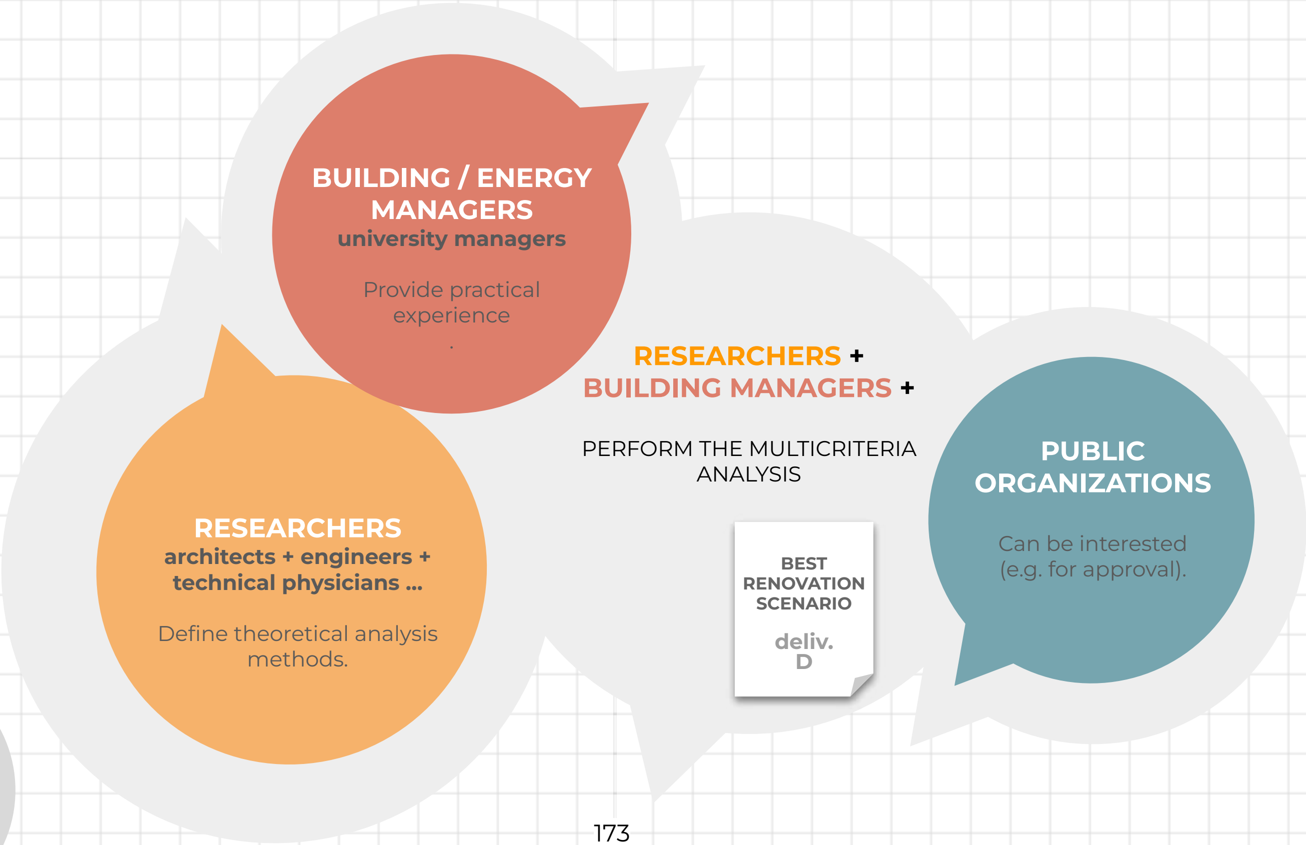
Choose the Best Scenario

Questa fase risulta fondamentale anche per operare un sistematico monitoraggio dell'area di intervento e, volendo, anche dell'intero parco edilizio pubblico, che in questo modo può essere aggiornato e revisionato; anche in base al cambiamento dello scenario finanziario (soprattutto per quanto riguarda le amministrazioni comunali e regionali, il cui ricambio è molto veloce) sarà possibile modificare in tempo reale le risposte progettuali per adeguarsi alle nuove necessità (e disponibilità monetarie).

Grazie alla valutazione è quindi possibile decidere il livello di intervento su piccola o grande scala; attraverso un processo di coinvolgimento della cittadinanza e conoscenza (tramite incontri e dibattiti) si procede alla identificazione dello scenario più conforme e completo (aspetti esigenziali prestazionali) da poter portare avanti.

Questo progetto (PILOT PROJECT) permetterà la conoscenza e l'acquisizione dei sistemi di studio, indagine e ricerca al fine di poter delineare una metodologia consolidabile e quanto più possibile versatile, che potrà essere replicata e arricchita per i processi futuri.



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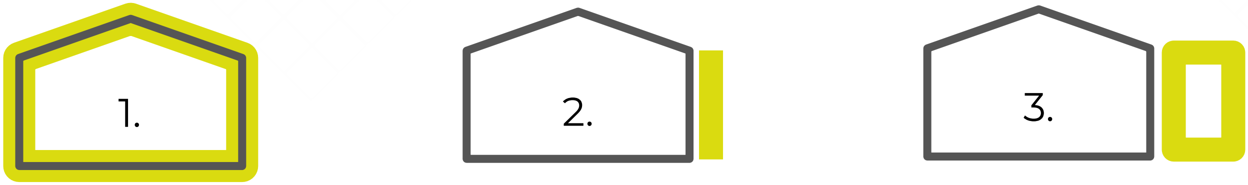
beXLab experience

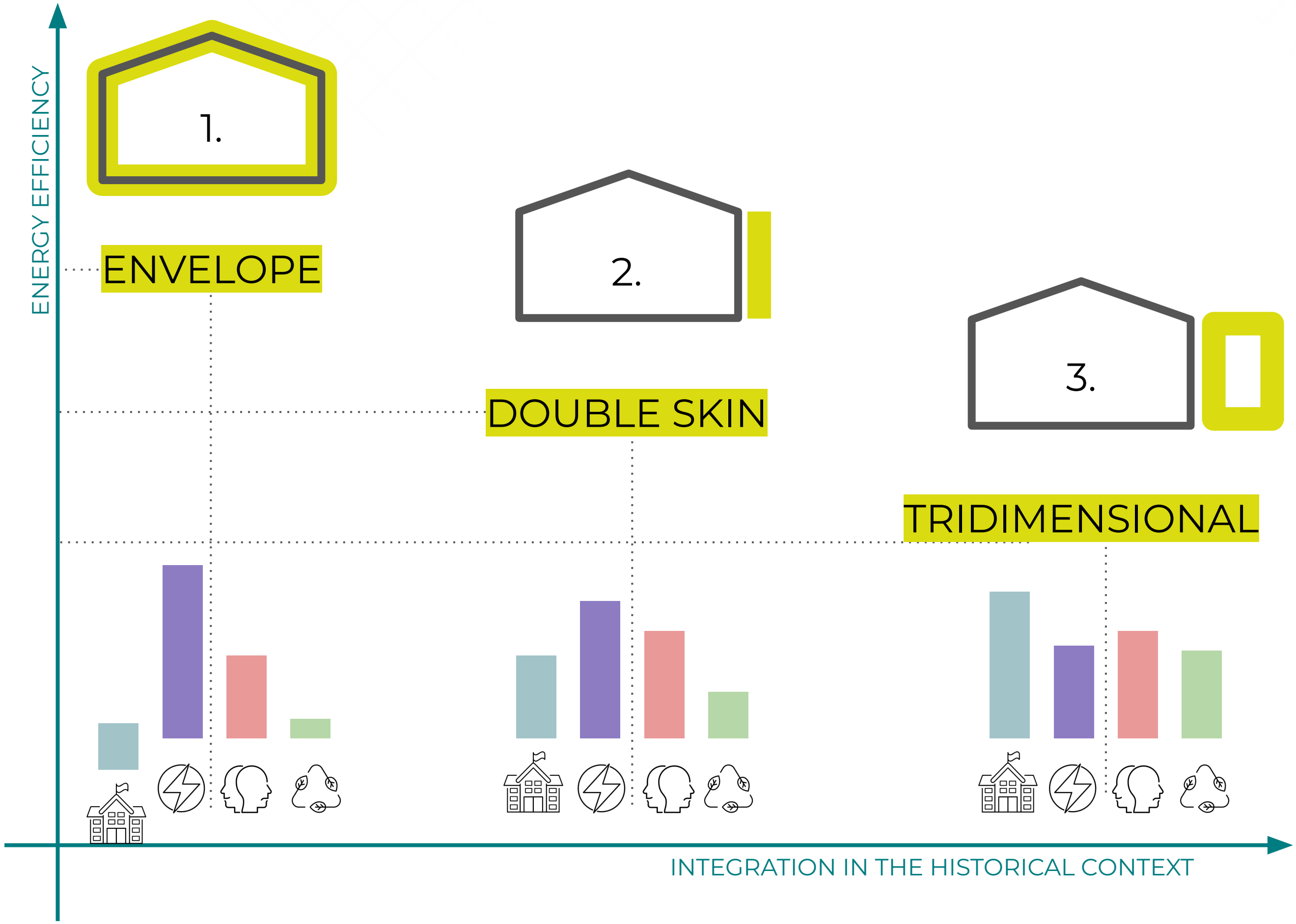
➔ **3 MACRO-SCENARIOS OF INTERVENTION**
QUALITY TARGET



ENVELOPE | DOUBLE SKIN | TRIDIMENSIONAL

beXLab experience

➔ **3 MACRO-SCENARIOS OF INTERVENTION**
FIXED BUDGET



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➔ FINAL SCENARIO OF INTERVENTION

ENVELOPE

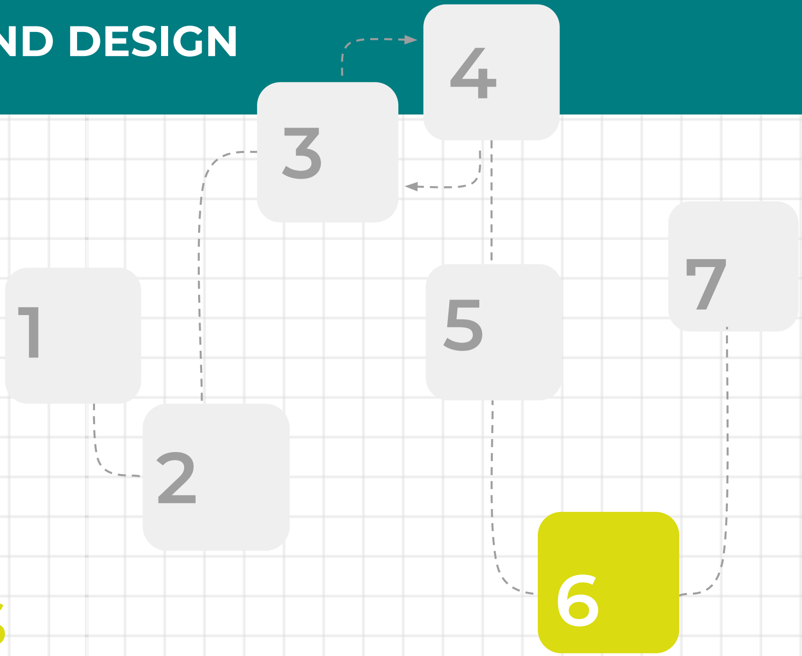
SKYLIGHTS

- ➔ visual improvement
- ➔ better natural ventilation
- ➔ reduction of energy needs for artificial lighting
- ➔ renewable energy production

TRIDIMENSIONAL

3D STRUCTURE

- ➔ reversibility
- ➔ not touching the existing building!
- ➔ shading system/daylight control
- ➔ thermal improvement (summer period)
- ➔ reduction of energy for cooling
- ➔ renewable energy production



6. Plan the interventions

Once the best scenario has been identified, it is time to plan the foreseen interventions.
The activity regards the optimization of the economic resources to invest in the renovation project in the temporal dimension. According to times and costs, it is possible to adopt to main approaches: Whole-building approach or Staged approach.

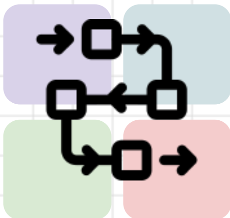
Whole-building approach

ONE INTERVENTION

financial-economic resources

interventions' program

Staged approach



SERIES OF INTERVENTIONS

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Plan the interventions

A **whole-building approach** to energy efficiency upgrades focuses on the retrofits of multiple building systems.

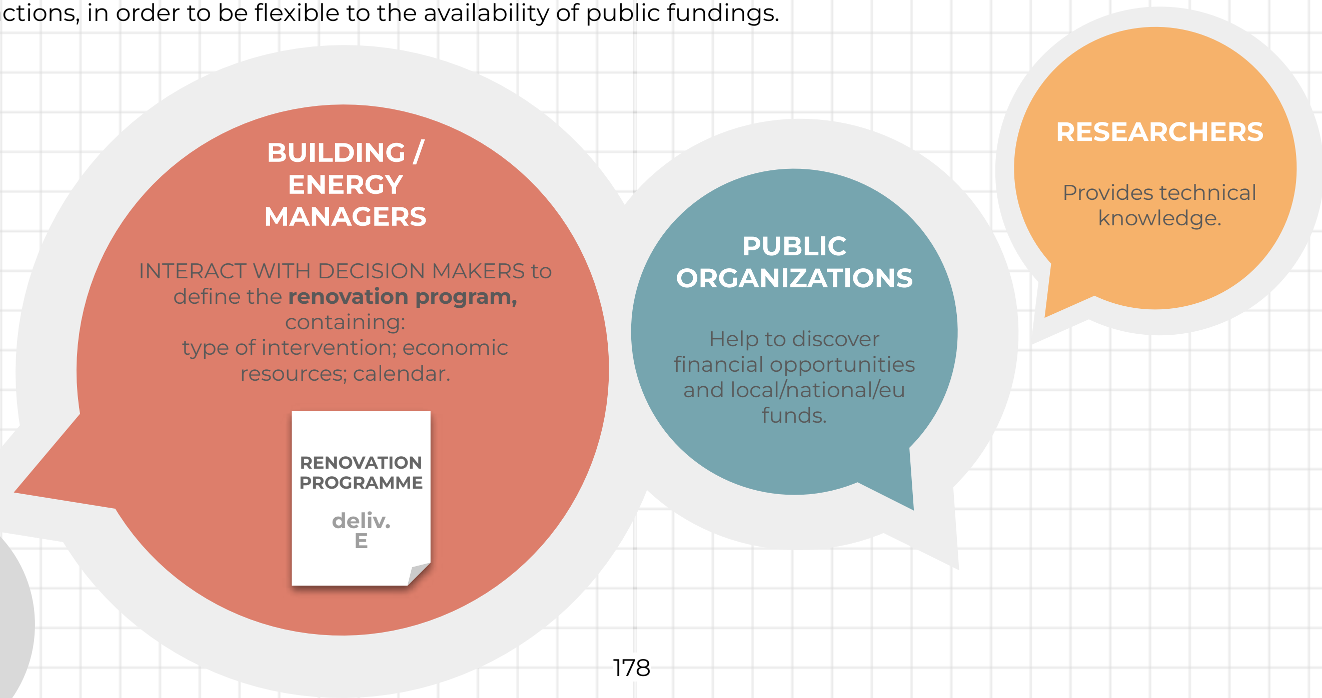
The key to the **staged upgrade approach** is to complete improvements to building systems in the order that reflects the influence of one system on another. For example, waste heat from lighting systems adds cooling loads to spaces that must be met by the cooling equipment during the summer. By first upgrading the lighting systems, future cooling system improvements can be properly sized and better optimised in a subsequent stage of the project.

The different retrofit strategies and technologies can in fact **be implemented in time**, considering the economic aspects (e.g. possibility to intercept public or dedicated funds). According to the availability of the economic resources, it is possible to distribute different retrofit interventions in time. This operation requires to consider the specificity of each retrofit action and the link with the others.

The activity can be mediated by **researchers**, but requires a strong coordination between the university offices in charge of the economic management (search of funds) and the **building/energy managers.**

Moreover, the LL provides with the technical knowledge (researchers) and know-how (companies) to evaluate the technical feasibility and convenience to incorporate or unbundle the different interventions.

On the basis of the different retrofit actions foreseen in the selected scenario, a renovation program can be defined highlighting the possibility to distribute the different interventions in time, and the sequentiality of actions, in order to be flexible to the availability of public fundings.



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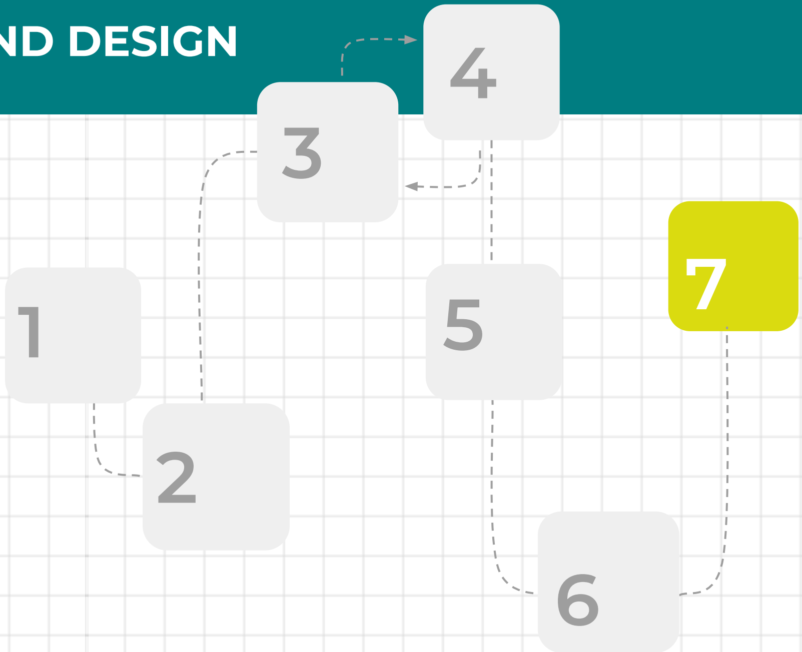

7. Elaborate Single Projects

The final activity of the P&D regards the elaboration, approval and finalisation of the whole or single projects foreseen in the renovation program.

According to the procedures foreseen at national or local level, the renovation has to be drafted with an increasing deepening of data and information, from the preliminary to executive project, in order **to be approved by competent authorities**. According to the mix-of technologies, the renovation project can be architectural and/or related to plant systems.

The LL environment can highly support the definition of renovation projects, which can be finalised by researchers with the collaboration of:

- **Building/energy managers** can provide information of the authorization procedures and legal/administrative aspects;
- **Students**: can be involved in the definition of a real-case renovation project, allowing them to experience renovation projects.

Moreover, the collaboration with **stakeholders** already involved in the previous activities support the definition of the renovation project, providing specific technical information, performances and costs of the different technologies.

Also the previous contact with **public organisations** can highly benefit this project delivery activity, smoothing the authorization process.

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Elaborate Single Projects

RESEARCHERS + BUILDING MANAGERS + COMPANIES

Work together for the renovation project.

RENOVATION PROJECT
deliv. F

RESEARCHERS
architects + engineers + technical physicians ...

Develop and finalize the project according to their competencies.

BUILDING / ENERGY MANAGERS
university managers

Inform about procedures and legal/administrative aspects.

COMPANIES
local companies

Give detailed information. e.g. construction systems, processing, products, technologies and materials.

PUBLIC ORGANIZATIONS
associations and NGOs

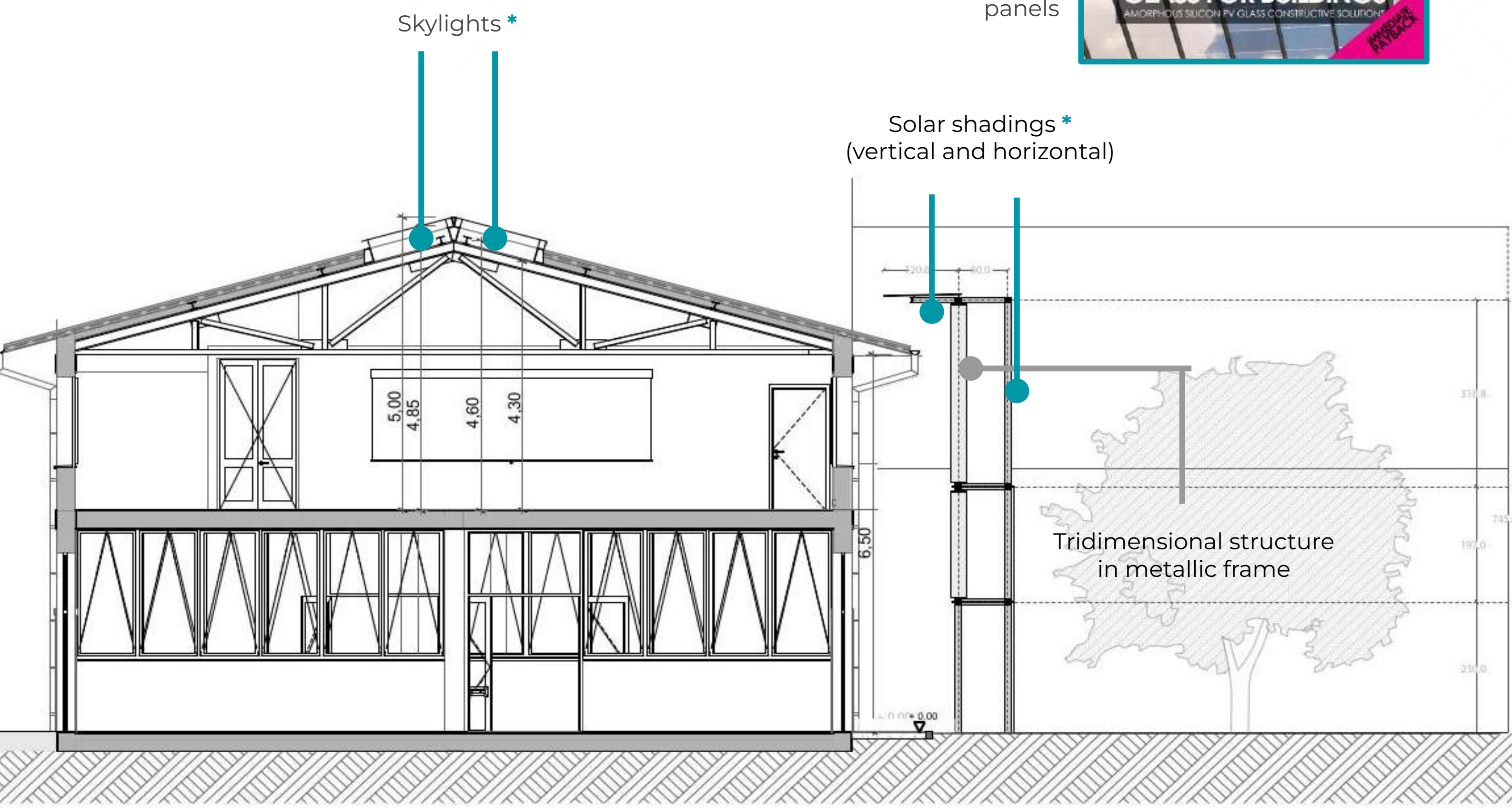
Will approve the document.

back to WORK FLOW

beXLab experience

➔ **FINAL SCENARIO OF INTERVENTION**
TECHNICAL DRAWINGS

*** Technological solution**
Amorphous silicon PV double glass panels



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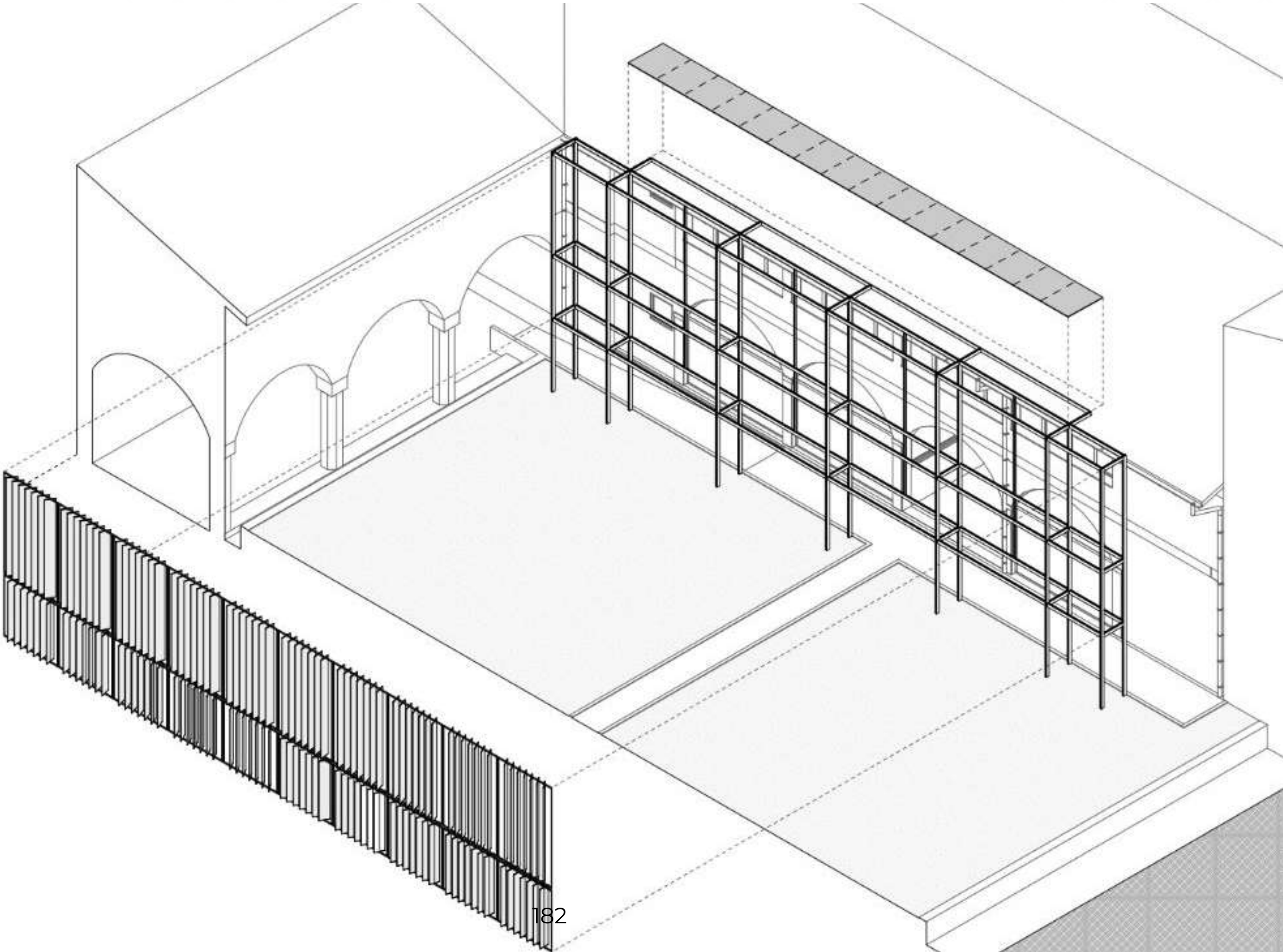
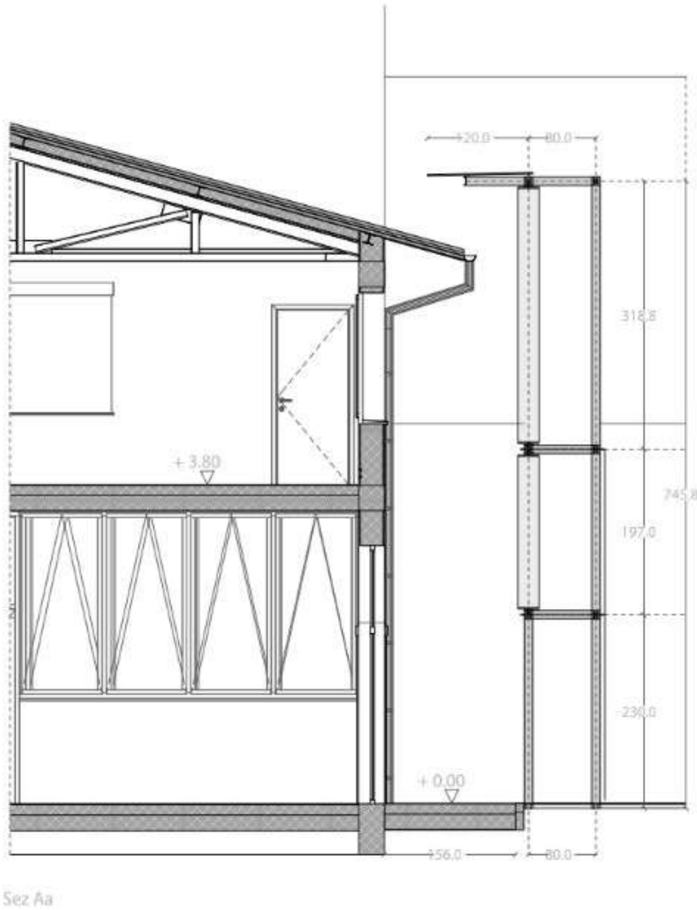
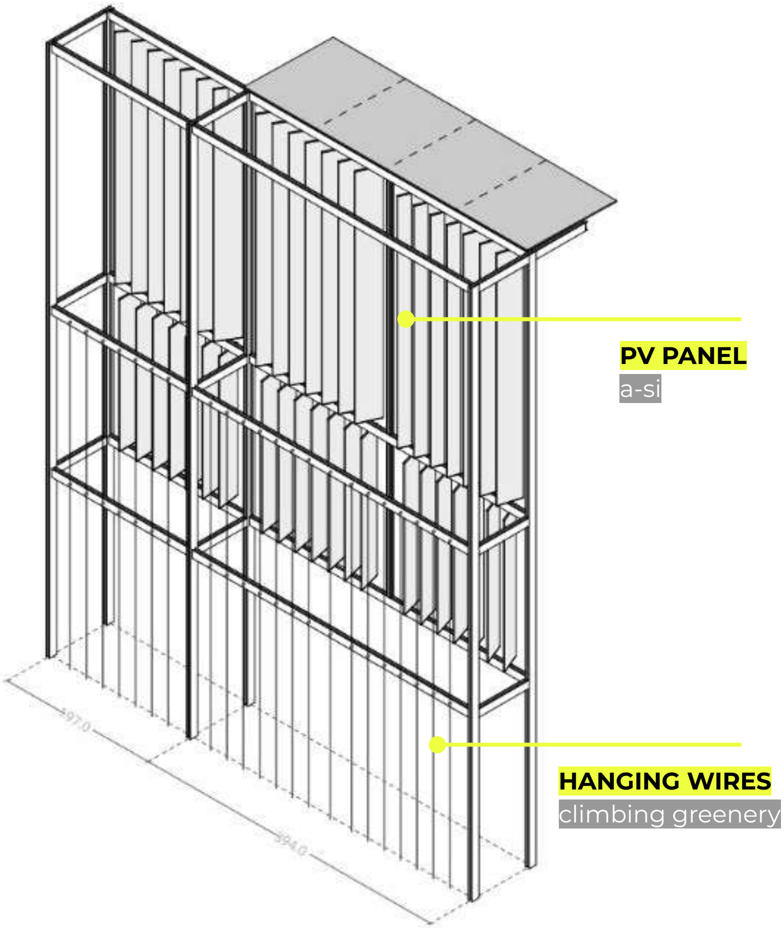
➔ **FINAL SCENARIO OF INTERVENTION**
AXONOMETRY



beXLab experience

➔ **FINAL SCENARIO OF INTERVENTION**
DETAIL OF THE 3D STRUCTURE





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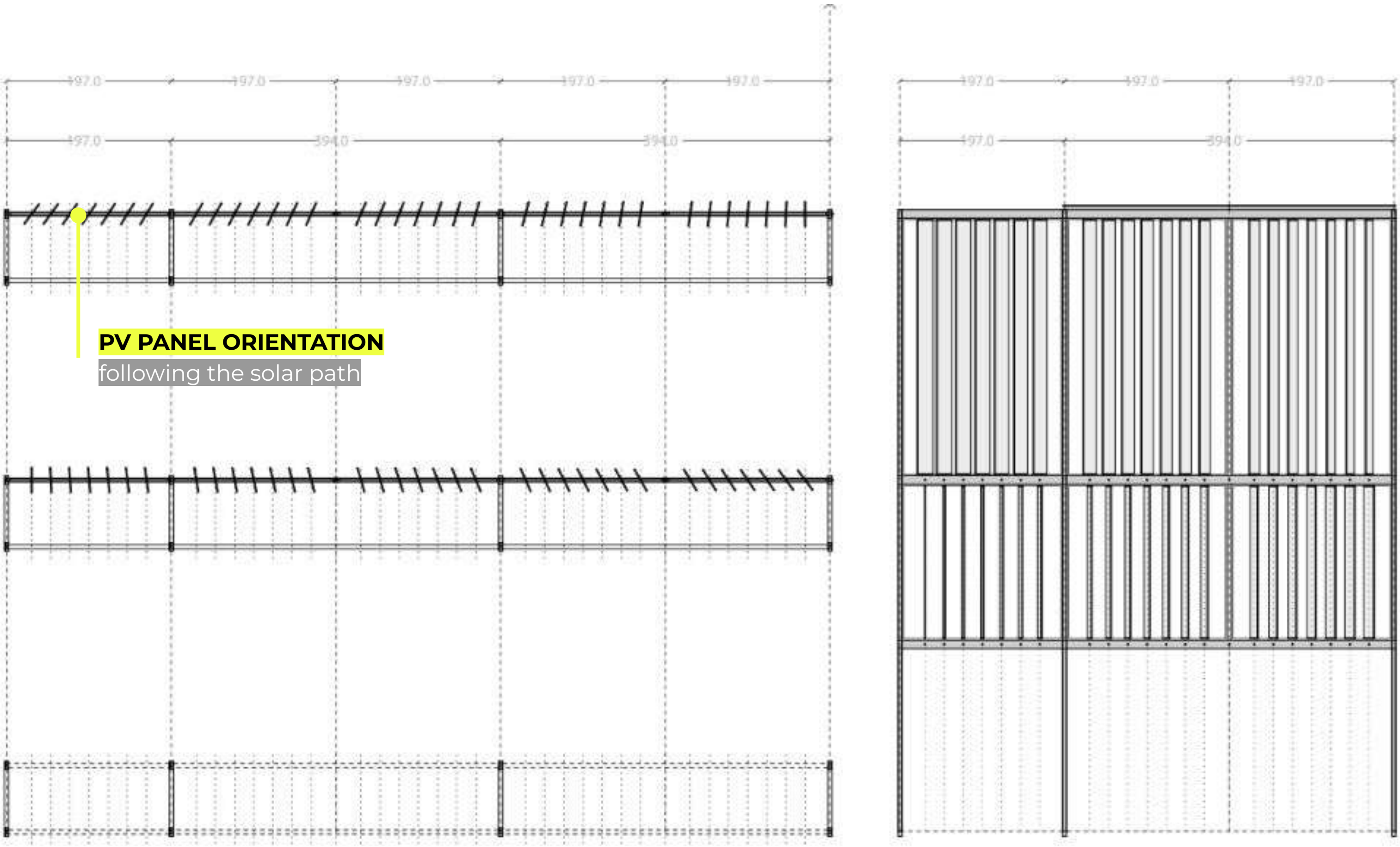
➔ **FINAL SCENARIO OF INTERVENTION**
DETAIL OF THE 3D STRUCTURE



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→ **FINAL SCENARIO OF INTERVENTION**
RENDERING

beXLab experience

➔ **FINAL ARCHITECTURAL SOLUTION**

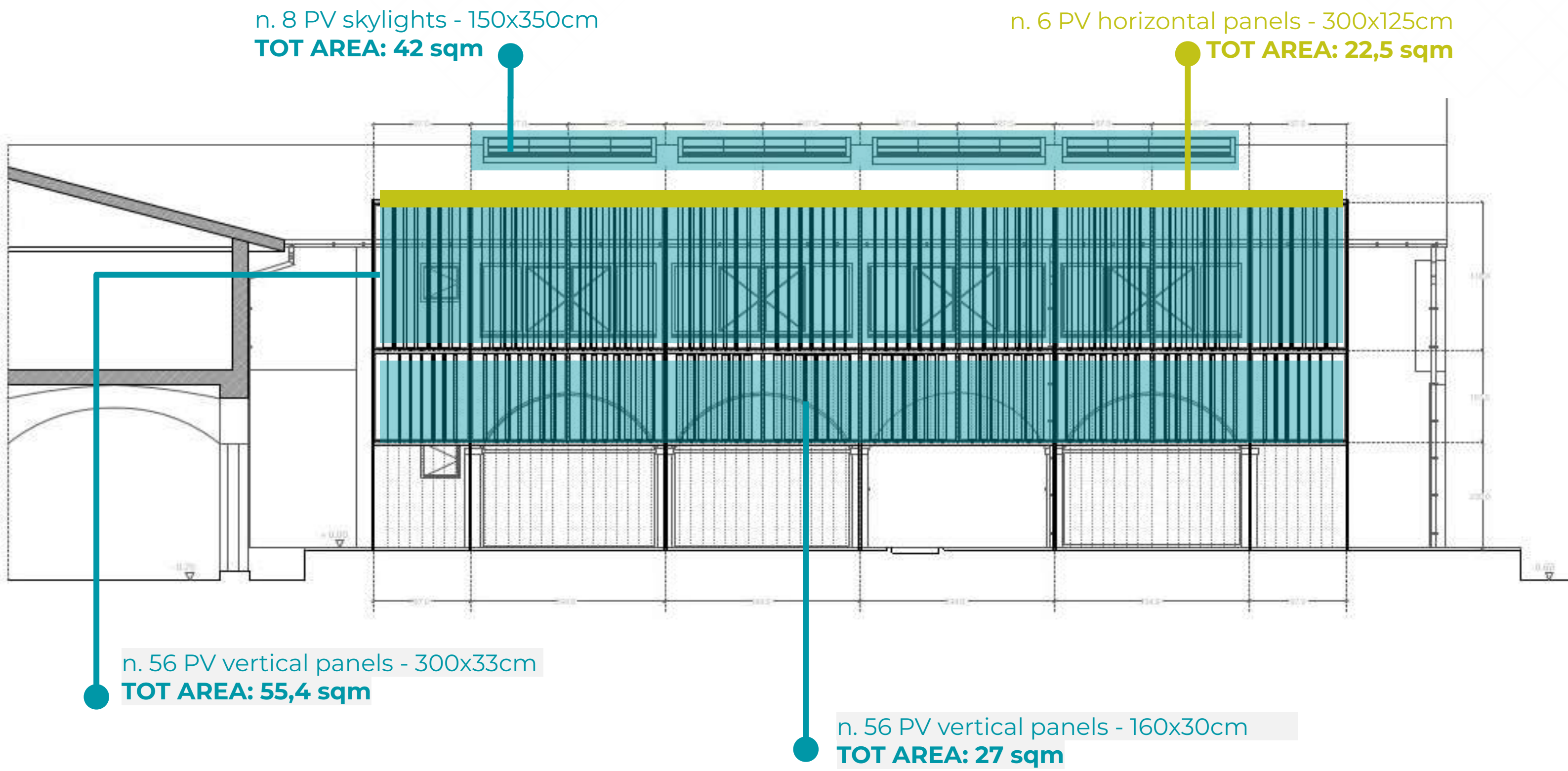
In collaboration with

- architectural design colleagues for the definition of the final architectural solution;
- Solartys and ONYX for the evaluation of the PV integration;
- UNIFI Technical Office for the presentation to the SABAP;

APPROVED!

beXLab experience

➔ **FINAL ARCHITECTURAL SOLUTION**
3D STRUCTURE / SOLAR SHADING + ENERGY PRODUCTION
South Façade of the Pilot building



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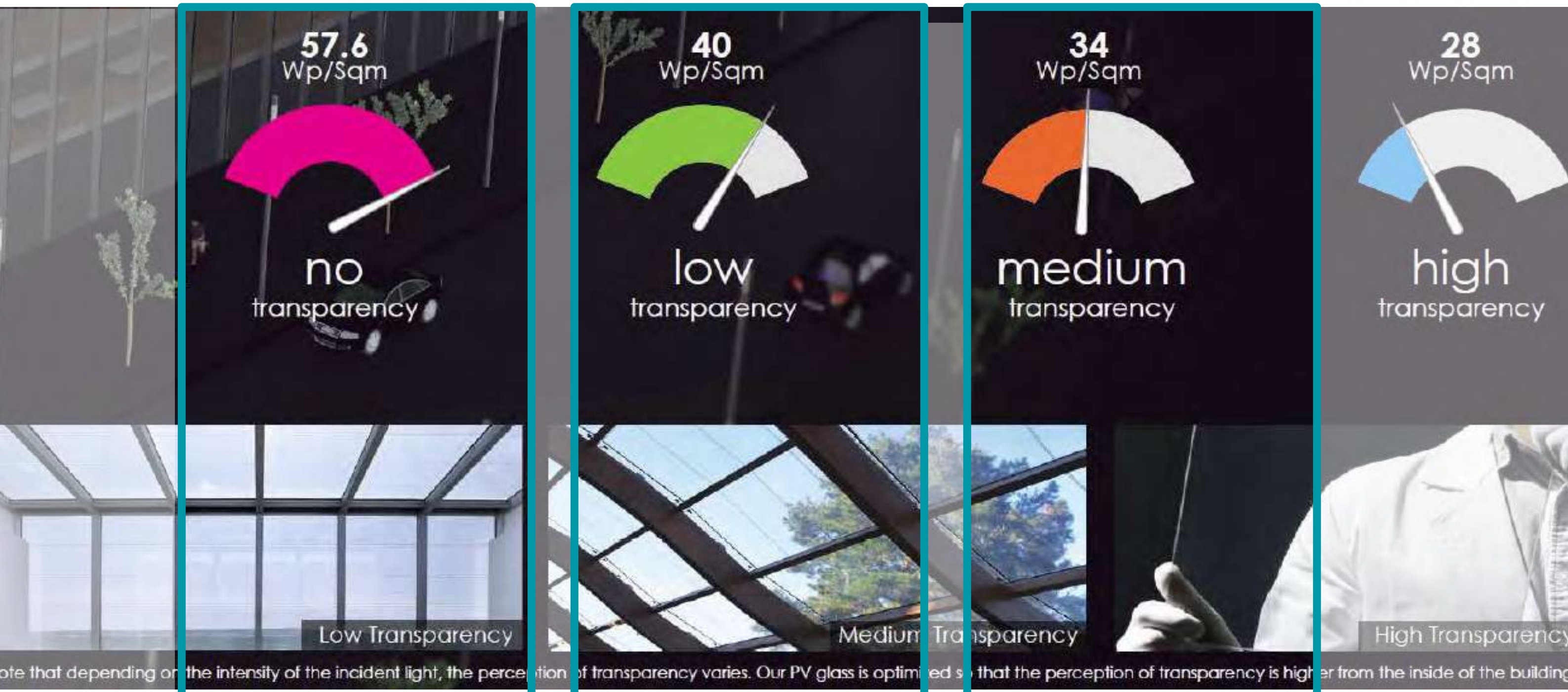
➔ **FINAL ARCHITECTURAL SOLUTION**
ENERGY PRODUCTION

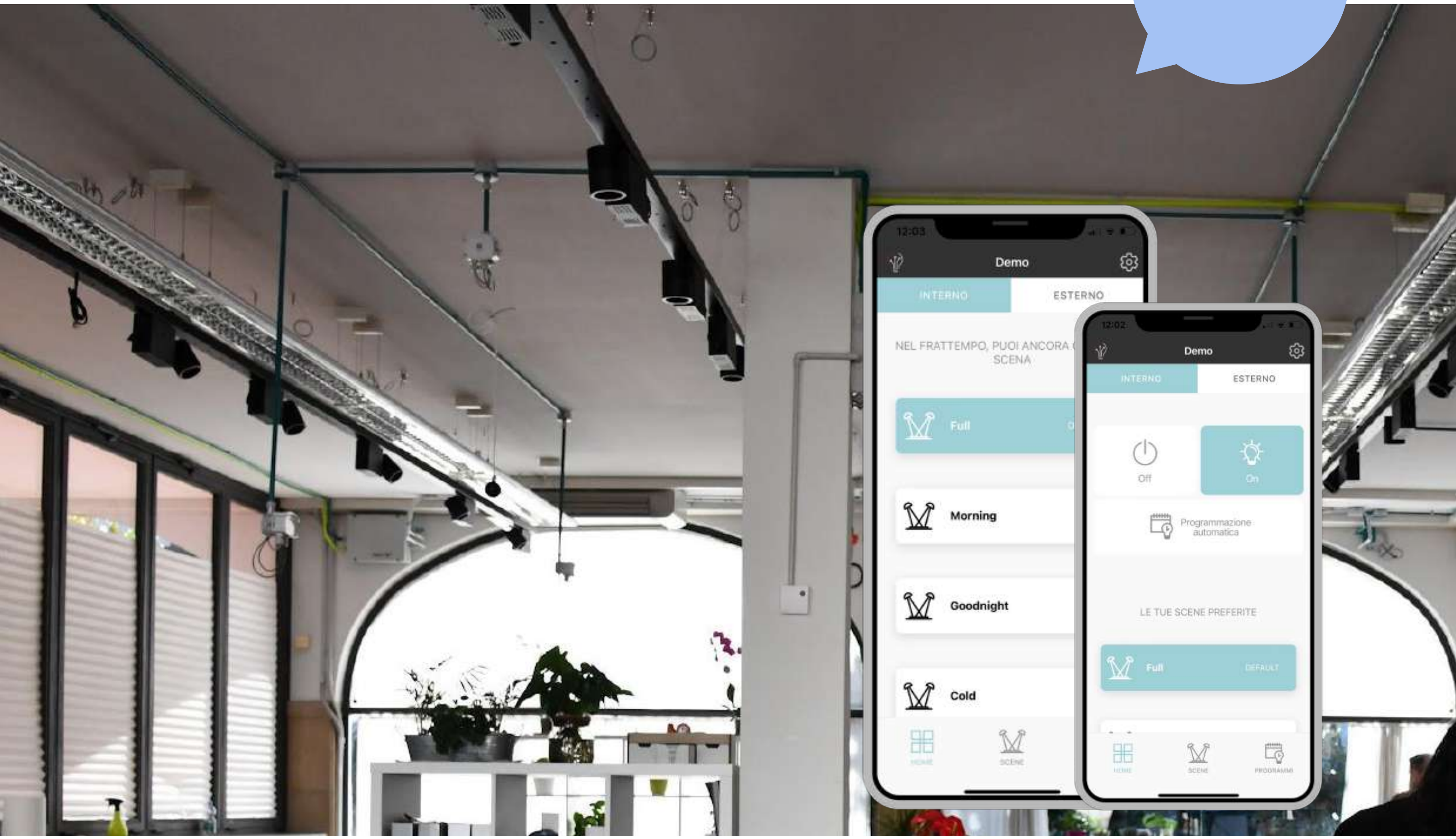


horizontal panels	skylights + vertical panels (ground floor)	vertical panels (upper floor)	**Total production = 6 KWp**
1,3 KWp	**2,8 KWp**	**1,9 KWp**	

beXLab experience

COMPANIES

➔ **FINAL ARCHITECTURAL SOLUTION**
LED LIGHTING SYSTEM



BEST PATH
Digital Twin implementation

The phase is dedicated to the architectural exploration of different mix of retrofitting technologies, in order to define different intervention scenarios, to be evaluated together with the economical part.

1. CONCEPT DESIGN

Starting from the Analysis of criticalities documentation and with a real knowledge (physical measurements) of the current condition of the building, building design scenarios should be developed following the idea to solve building criticalities and weaknesses and to improve energy performance and indoor quality comfort and well-being.

The phase refers to the elaboration of retrofit/refurbishment design scenarios and the respective digital evaluations/simulations in terms of energy performance, solar radiation control, natural/artificial illumination, indoor comfort & well-being and spatial functionality. During this phase the best design solution(s) or combination of strategies will be evaluated in terms of cost effectiveness to determine the best project approach that must contain high integration design, effective/efficient energy performance and indoor quality improvement, efficient usage of natural resources and high cost-effective balance.

The aim at this stage is to prepare the architectural concept incorporating strategic engineering requirements, energy performance strategies, comfort and well-being solutions all aligned to a cost plan and outline project strategies.

2. PROJECT DEFINITION

Starting from the results of the concept design (preliminary design) documentation, the phase aim is to undertake the design process into a complete development/refinement of all the different disciplines and elements/details that are part of the project up to a definitive state.

This phase refers to the design review, structural analysis, MEP analysis, energy efficiency simulations and cost exercises to test architectural concepts resulting in spatially coordinated and comfortable design aligned to updated cost plan, project strategies and specifications.

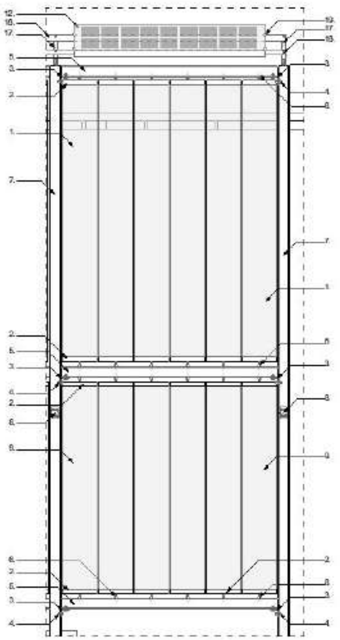
3. TECHNOLOGICAL DEFINITION

This phase starts with the authorized set of documents and the relative BIM authoring models containing geometrical and alpha-numerical information regarding the definitive project.

BEST PATH
Digital Twin implementation

In the evolution/production of the executive (construction) BIM Model(s), must guarantee the full correspondence between the informative content and the 3D and 2D graphic content, the detailed installation instructions, dimensions, levels, finishes and hyperlinks to the product/appliances/furnitures/materials technical sheets and to any reference documentation required to assure the compliance of the construction process with the designed project (to ensure that the "traditional" documentation, intended as a collection of the entire documentation and 2D tables of the Executive Project, is linked to the 3D Model through, for example, the use of links or URL parameters, in relation to the real possibilities and in adherence to what is described in the *Best Path*).

The entire Data Mode and the Product Information Management (PIM) shall include the entire directory tree, and links to data sheets and documentation shall not refer to web addresses, so as to ensure availability even in the absence of connection and/or modification of URLs, and so as to allow PIM to reconstruct the Data Model also on platforms different from the one used for the regulation of the construction process.



	LEGENDA
1.	Pannello Fotovoltaico a-Si semitrasparente dim. 300 x 2400 mm - Colore grigio
2.	Sistema di fissaggio panello fotovoltaico (tipo **Ninfa 90 o Ninfa 120**) - Colore acciaio satinato
3.	**Nodo n°1 Trave - Pilastro** / Staffa di collegamento bullonata - profilo ad "L" 80x80mm - Colore bianco
4.	Bullone M 16 passante con dado per collegamento struttura
5.	Trave - HEB 100 - verniciatura a polvere colore bianco
6.	Bullone/Dado per fissaggio panelli fotovoltaici
7.	Pilastro - HEB 100 - verniciatura a polvere colore bianco
8.	**Nodo n°2 Pilastro - Pilastro** / Piastra di collegamento struttura forata per bullonatura passante - verniciatura a polvere colore bianco
9.	Pannello Fotovoltaico a-Si semitrasparente dim. 300 x 1900 mm - Colore grigio
10.	**Nodo n°3 Pilastro - Trave** / Piastra di collegamento struttura con foro per bullone - verniciatura a polvere colore bianco
11.	Bullone M 16 passante con dado per collegamento struttura
12.	Pannello Fotovoltaico "Cristalline PV" dim. 1650 x 850 mm - installazione a 15°
13.	**Nodo n°4 Pilastro - Trave inclinata** (15°) - profilo metallico rettangolare 100 x 50 x 4(s) mm - verniciatura a polvere colore bianco. Collegamento con struttura verticale con saldatura in fabbrica previa alla verniciatura.
14.	Plinto - prefabbricato in cls dim. 110 x 50 x 80(h) cm. Finito a vista con esporgenza di 5 cm s.l. del cortile
15.	**Nodo n°5 Pilastro - Plinto** / Piastra di collegamento struttura con forometrie per bulloni/tirafondi. Piastra saldata al pilastro con saldatura in fabbrica previa alla verniciatura - verniciatura a polvere colore bianco
16.	Bullone M 16 di espansione o dado e tirafondi ancorati, per fissaggio struttura alle fondazioni
17.	Triangolo strutturale in tubullare rettangolari saldate (60 x 30 x 3 mm) per installazione di paneli PV inclinati angolo 15°
18.	Profilo metallico forato per ancoraggio di staffe/agganci tradizionali per panelli PV - dim 40 x 40 mm
19.	Staffa/aggancio tradizionale per paneli PV
20.	Trave - IPE 100 - verniciatura a polvere colore bianco

go BACK

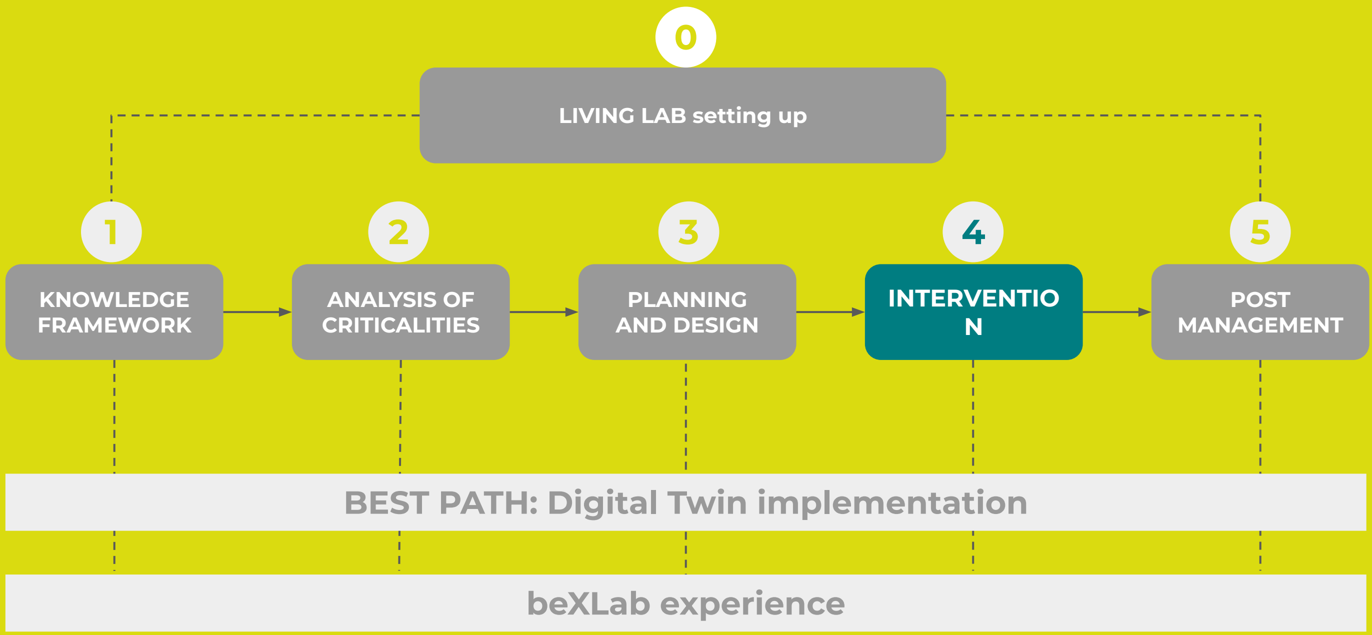
Phase 4
Intervention

On the basis of the executive and approved retrofit project, as a result of the Planning and Design Phase 3, the renovation process moves to the intervention phase, related to the construction works to integrate the mix-of-technologies on the existing pilot-building, delivering the renovated building to the post-management (Phase 5).

WHAT is the set of activities spanning from the approval of the renovation project to its full realisation through the construction works

WHO is managed outside the LL environment, as the main actor in this phase is the stakeholder/contractor in charge

HOW four steps to hand-over (delivering the renovated building from the contractor to the client)



The Intervention Phase (4) is the set of activities spanning **from the approval of the renovation project to its full realisation and the construction works** to physically renovate the existing building through the integration of the selected mix of technologies.

Considering the other typologies of building works, the retrofit may be more complicated, not only because it insists on an existing building, but because the construction site can be in part occupied. Also in the case of moving out the building functions, time is a critical element with severe cost implications.

In order to optimise the construction process, the phase foresees a deep planning to ensure that activities are carried out in a sequence that is effective in terms of costs, time and technical feasibility.

In contrast with the other renovation phases, the Intervention is managed by stakeholder/contractor in charge of the renovation works on the existing building, which are actors outside the LL.

Yet all the actors involved in the LL are engaged in the majority of the activities related to the intervention phase, in line with the LL mission to support innovative renovation processes.

COMPANIES
contractors, suppliers, workers

Provide with construction materials and work.

BUILDING / ENERGY MANAGERS
university managers

Carry on procedures to select and delivery construction works.

PUBLIC ORGANIZATIONS

STUDENTS

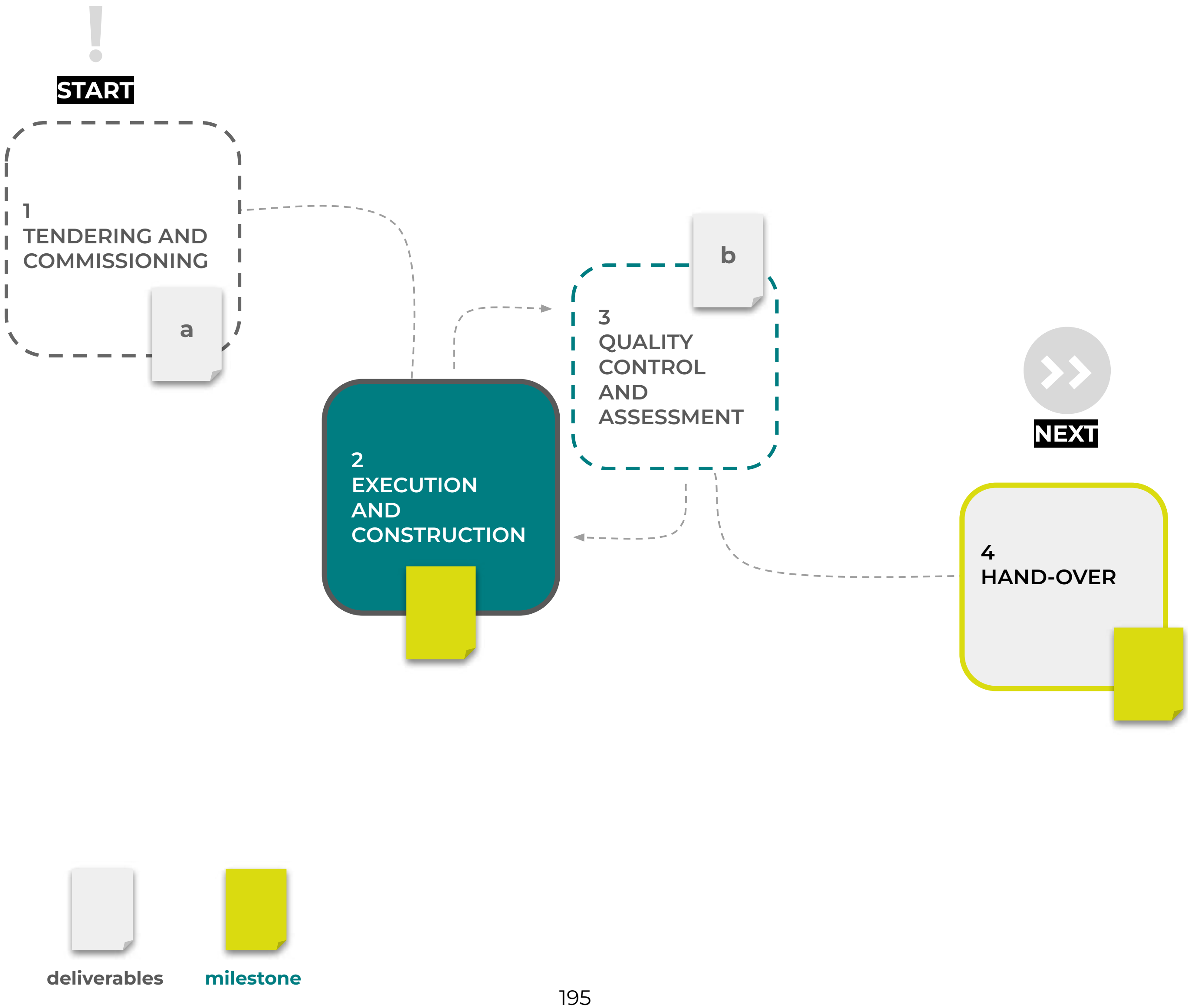
Can experience the construction site and understand the construction process.

RESEARCHERS
architects, energy engineers, technical physicists, others..

Can support the evaluation of the tenders process orienting to the targeted quality. They can document and valorise the implementation of the renovation.

e.g. collecting pictures, videos, etc.

Activities and Workflow



1. Tendering and Commissioning

On the basis of the executive renovation projects, the intervention phase starts with the selection of the best procedures for the tendering of the renovation works. Tendering is the activity of selecting the contractor who will construct the works to renovate the existing building, according to the defined renovation project.

The selection of experienced, competent contractors and other energy professionals is critical to the success of major retrofit projects.

Legally obliged in the public sector, it foresees the formal, structured procedure for generating competing offers from different potential suppliers or contractors looking to obtain an award of business activity in works, supply, or service contracts.

There is an increasing tendency for suppliers to be aggregated into single contracts, for example, integrated supply teams on public projects may include: the main contractor, designers, sub-contractors, suppliers, facilities managers.

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Tendering and Commissioning

According to national or local legal requirements, usually related to the amount of works and expenses, the process for securing tenders may take **three different basic forms**:

- Open tendering
- Selective tendering
- Negotiated tendering

According to the process, tendering **can be carried out in**:

1. **Single-stage tendering**. It is used when all the information necessary to calculate a realistic price is available when tendering commences. An invitation to tender is issued to prospective suppliers, tenders are prepared and returned, a preferred tenderer is selected and following negotiations they may be appointed (main adopted for retrofit).

2. **Two-stage tendering**. It is used to allow early appointment of a supplier, prior to the completion of all the information required to enable them to offer a fixed price. In the first stage, a limited appointment is agreed to allow work to begin and in the second stage a fixed price is negotiated for the contract.

STATEMENT OF WORK

It defines with sufficient details the renovation project in order to allow contractors to determine if they can provide services.

According to the dimension of the renovation project, the document can contain:

- technical drawings
- specifications

A good idea to create well-defined procurement documents is to organise a **BIDDER'S MEETING** to ensure that contractors have a **clear and common understanding** of the specific requirements of the renovation project

back to WORK FLOW

Tendering and Commissioning

Several procurement-related documents may need to be prepared, including a statement of work and a contract template, which can be considered as the main delivery of the activity.

A statement of work defines the project scope in sufficient detail to allow prospective contractors to determine if they can provide the services. For a major retrofit project, it may also be accompanied by drawings and specifications. In addition to creating well-defined procurement documents, holding a bidders' meeting is a constructive way to ensure that all prospective contractors have a clear and common understanding of the project requirements.

Due to the complexity of renovation projects, it is advisable to embed a commissioning process, a process of aspiring that all systems and components are designed, installed, tested, operated, and maintained according to the operational requirements. The commissioning process is the integrated application of a set of engineering techniques and procedures to check, inspect and test every operational component of the project: from individual functions up to complex amalgamations.

Commissioning activities in the broader sense are applicable to all phases of the project from the basic and detailed design, procurement, construction and assembly until the final handover, sometimes including an assisted operation phase. The main objective of commissioning is to affect the safe and orderly handover of the unit from the constructor to the owner, to guarantee its operability in terms of performance, reliability, safety and information traceability.

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. Before being awarded this title, however, a ship must pass several milestones. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems, and staff have successfully completed a thorough quality assurance process.

This bureaucratic-commercial activity can highly benefit from the LL environment, with building/energy managers supported in the preparation of the tendering documents by researchers, in order to optimise the delivery.

Thanks to the previous involvement of production companies (of renovation technologies and materials), the collection of the technical and economic data to prepare the tendering and carry out the commissioning can be optimised.

In this phase, construction companies participating in the tendering are involved in the LL, in order to understand the LL mission and the importance of quality targets, in particular the environmental impact. For this reason, specific requirements can be inserted in the tender regarding the accomplishment of low environmental impact of construction sites.

back to WORK FLOW

Tendering and Commissioning

BUILDING MANAGERS + COMPANIES

Work together to stipulate a contract.

CONTRACT

deliv. A

RESEARCHERS
architects + engineers + technical physicians ...

Can propose innovative tendering* introducing more qualitative procedures, not only the percentage of discount.

COMPANIES
suppliers and constructors

Participate to the tender.

BUILDING / ENERGY MANAGERS

Organize, launch and evaluate the tender.

back to WORK FLOW

1 2 3 4

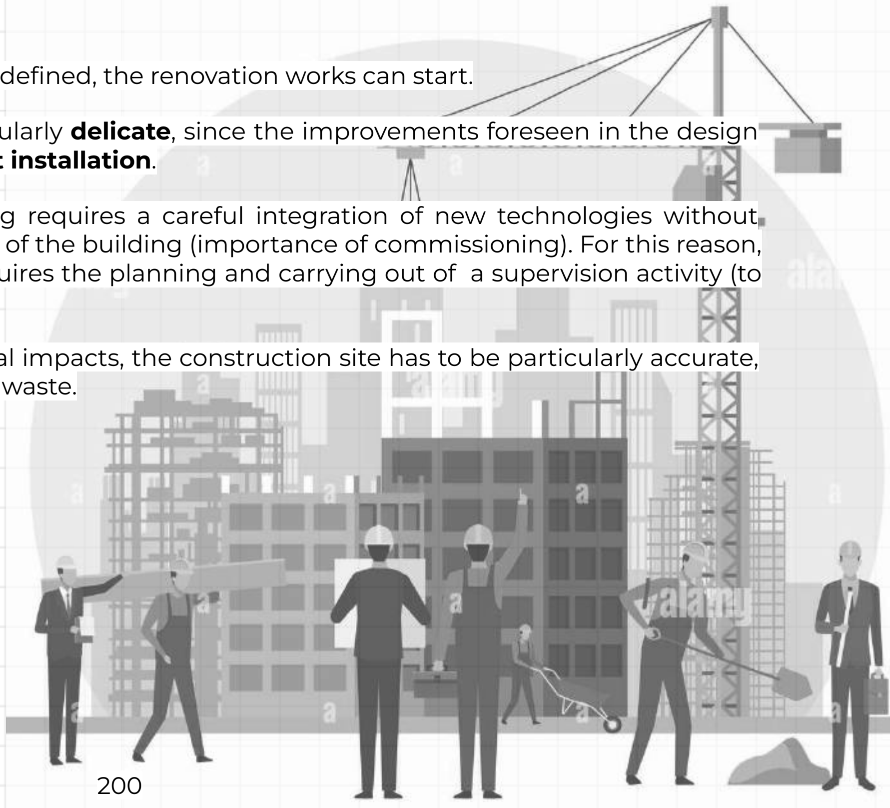
2. Execution and Construction

Once contractors and the procurement are defined, the renovation works can start.

The execution of renovation works is particularly **delicate**, since the improvements foreseen in the design phase can be compromised by an **incorrect installation**.

Moreover, working on the existing building requires a careful integration of new technologies without compromising the other functional aspects of the building (importance of commissioning). For this reason, the mitigation of the construction risks requires the planning and carrying out of a supervision activity (to follow).

Considering the target of low environmental impacts, the construction site has to be particularly accurate, for example with a proper management of waste.



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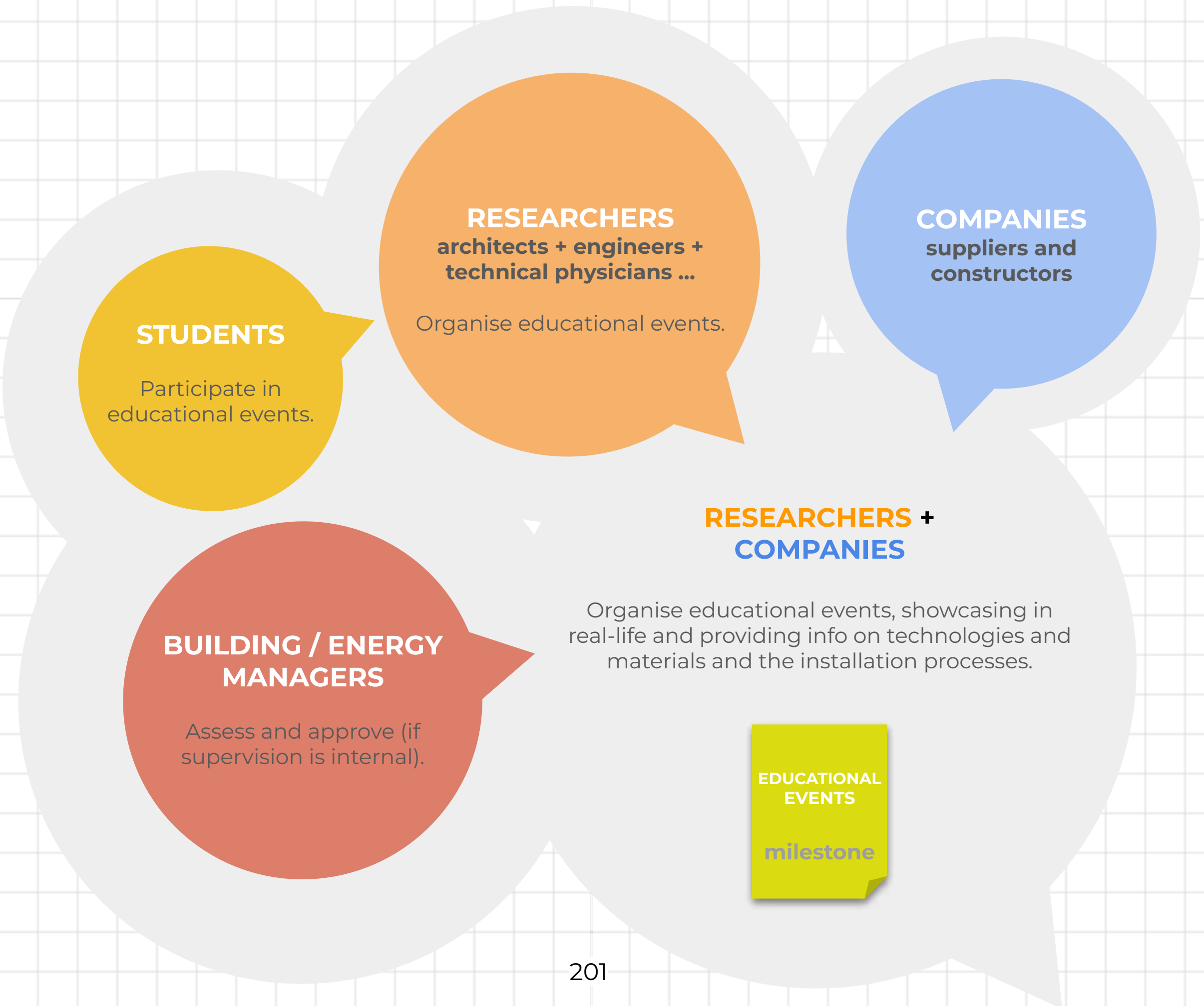
Execution and Construction

The activity is an occasion to valorize the LL objectives: the same construction site can become a didactic occasion to young generations of students and workers, with the possibility to assist to the construction process related to the integration of innovative renovation technologies.

The possibility to document the pilot-project realisation (e.g. with time-lapse) and to interview specialised workers or companies providing technologies and materials can give prominence to the renovation process.



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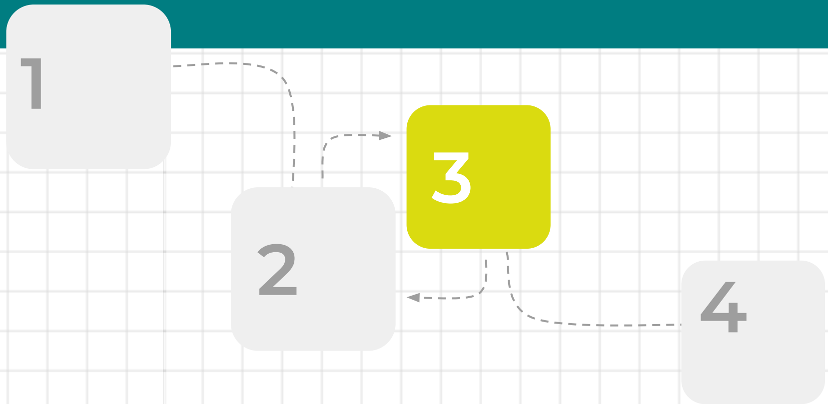

3. Quality Control and Assessment

Along the construction process, the control activity is carried out to ensure the correct realisation of the renovation project.

The activation of a commissioning process is the best path to guarantee that the renovated building respects all the requirements and reaches all the targets of the design phase, with controlled performances.

The activities comprise both visual inspections, to check the work is being carried out as agreed using specified materials and dimensions, and tools, to test the performances (e.g. air tightness testing, thermography to check insulation quality and air tightness).

Equipment such as renewable technologies, boilers, thermal stores and heating systems require adequate commissioning and testing to ensure that they are doing what they are expected to do.

These systems require in fact a correct installation and are tested according to standards and recorded checks to ensure that systems interact effectively with each other (a.g. PV panels and electric system connection).

The activity regards the recognition and report of defects in installations, check and record that the retrofit works conform to quality, standards and compliance with the retrofit design and manufacturers' instructions.

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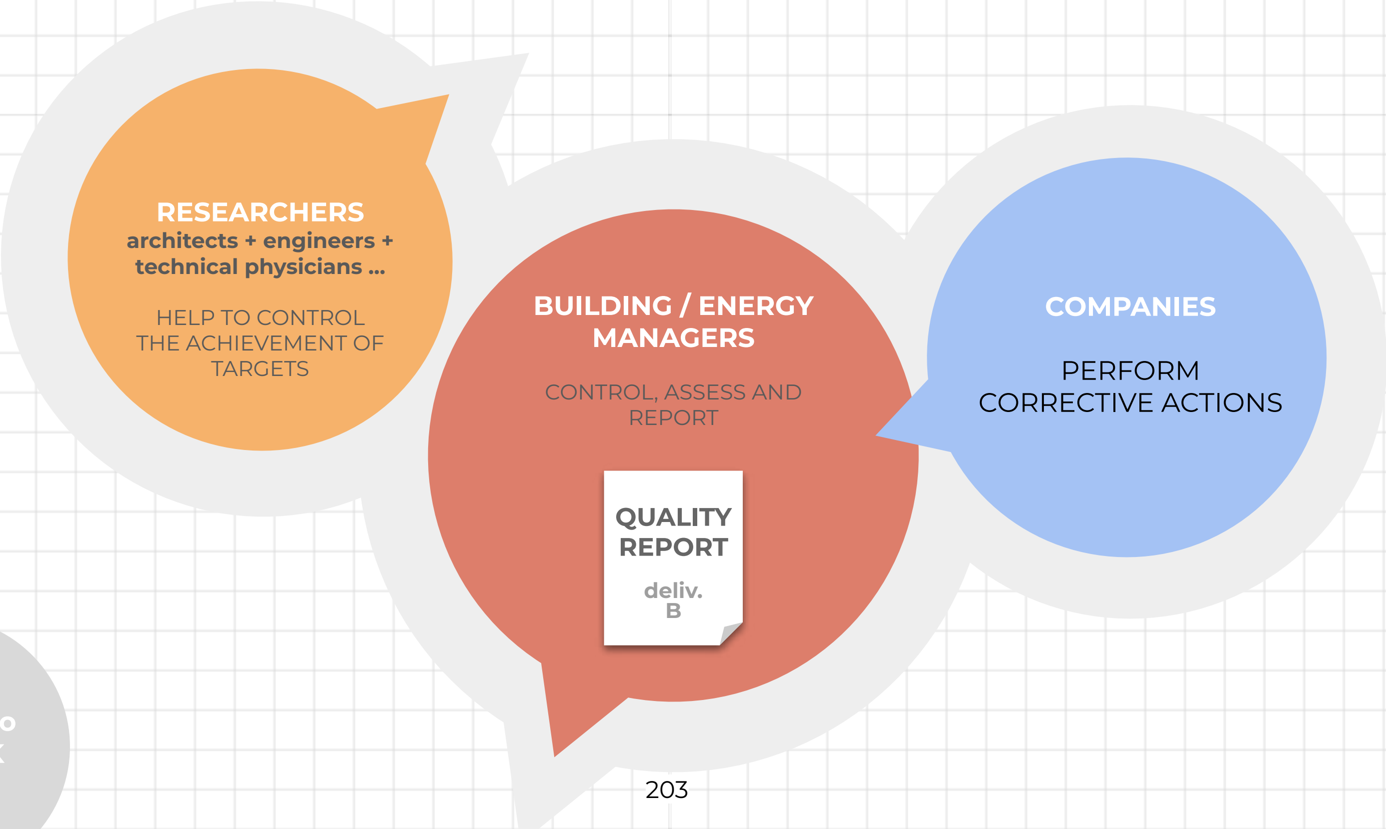
Quality Control and Assessment

The main objective of the activity is that the whole-renovated building "put through its paces" before "sign off".

If discrepancies from the approved project are detected, the activity also foresees the definition of recommendations, recording and implementation of corrective actions, requiring the renovation process to come back to the activity one (execution and construction).

Quality control also verifies that maintenance plans are in place before the handover and that those carrying out the maintenance are qualified and aware of any special features of the renovation technologies.

Quality controls and acceptance tests are carried out by the delegated construction supervisor.



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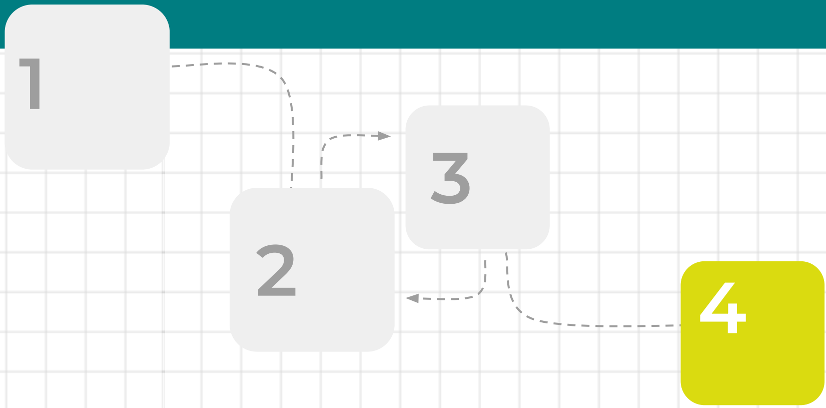


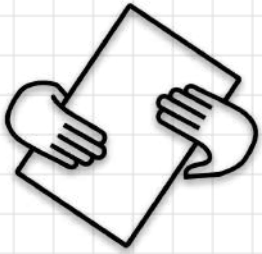
4. Hand-Over

The last activity of the intervention phase is the management, monitoring and evaluation of the project handover.

Handing over is the activity of delivering the renovated building from the contractor to the client (in our case the university).

HANDOVER CHECKLIST

before the completion of construction works...



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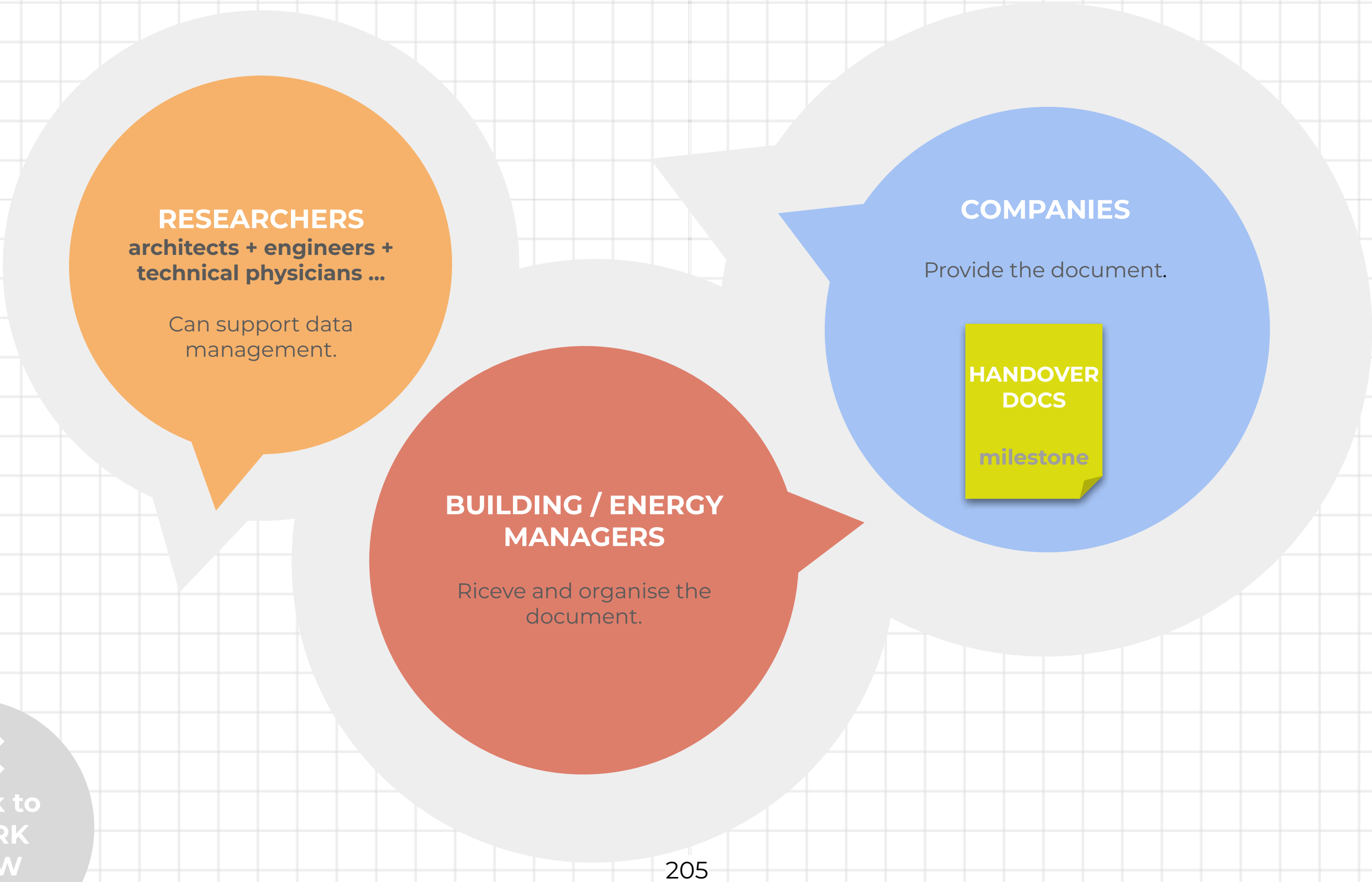
Usually, this activity is underestimated, since the finishing of works is the moment in which both actors would like to close the process. Instead, in retrofit processes the handover is crucial, since the university building/energy managers need to know exactly how to use, check and maintain the specialist renovation systems and products that have been installed.

Developing a handover checklist before the renovation project is completed is the best option, in order to ensure that all the data sheets, user manuals, instructions, warranties and guarantees are collected before the contractor leaves.

All the documents related to the installed renovation technologies are collected together in the “as-built report”, representing the milestone of this phase and activity.



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BEST PATH
Digital Twin implementation

The phase is dedicated to the construction (refurbishment) and the delivery of the building project. At this point the construction details and shop drawings of the definitive scenario will be developed to guide the construction company through all the process of architectural exploration of different mix of retrofitting technologies, in order to define different intervention scenarios, to be evaluated together with the economical part.

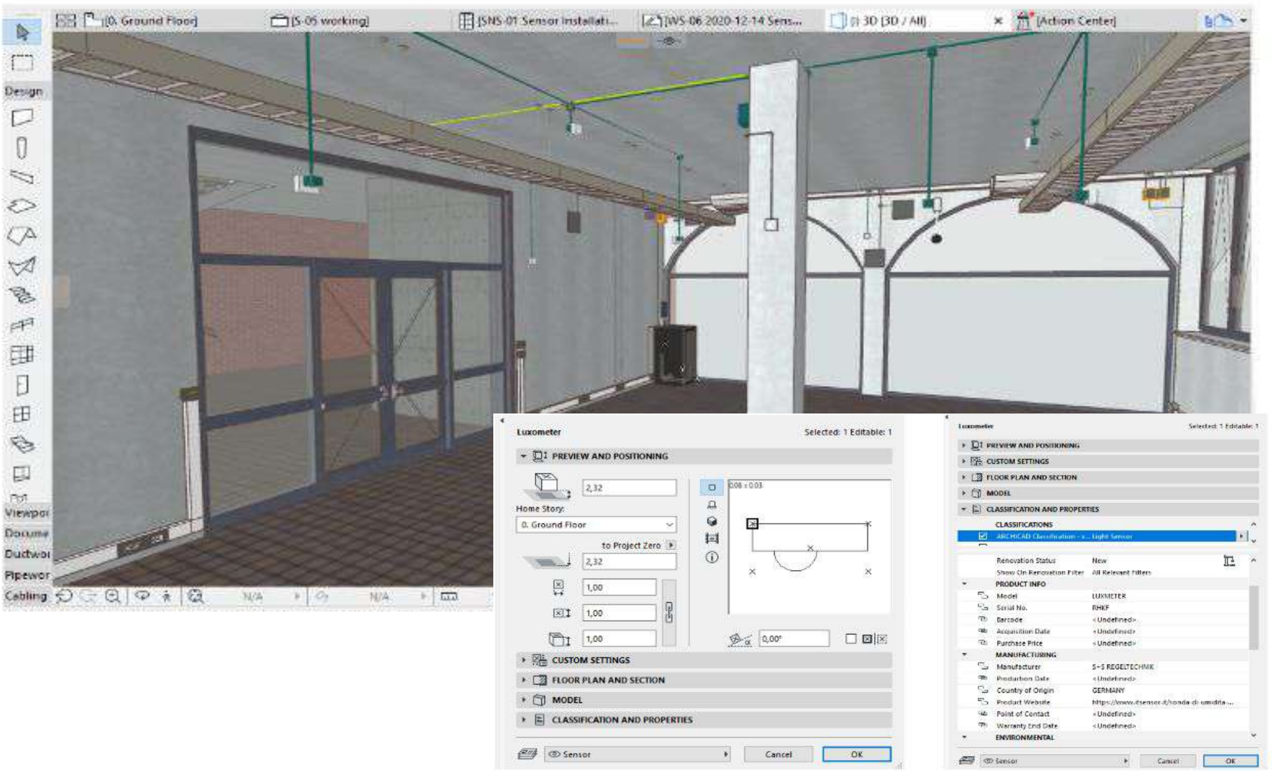
1. CONSTRUCTION

During the construction phase, the Construction company or the General Contractor shall implement all the necessary strategies and resources in order to manage the building information and keep the Data Model constantly updated accordingly recording variations to the 3D and 2D graphic contents, Metadata (non-graphic information), "traditional" documentation, 4D (time schedule) and 5D (cost plan) contents.

The Project Information Model (PIM) must contain all the information related to the single material/product energy performance (architectural, structural, MEP, etc..), that should reflect the characteristics of what came from the project simulations during the definition phase and will be tested during the commissioning phase.

The Construction BIM Data Model or PIM shall be updated with all information useful to build up and resulting variations during the construction phase, in order to represent a valid tool for analysis and verification of construction progress and procedures. After the validation of the Data Model by the Construction Management, it will be possible to obtain, at the end of the works, an As-Built BIM Data Model or Asset Information Model (AIM) that will include all the necessary information of what has been realized useful for the following and longest building phase Operation & Maintenance (O&M) and if requested for the Facility Management of the asset.

BEST PATH
Digital Twin implementation



In consideration of what has been said above, the PIM can be considered an Asset Information Model, because the Construction PIM will be enriched during the construction, specially with non geometrical information, in order to become the information container of the As-Built Process.

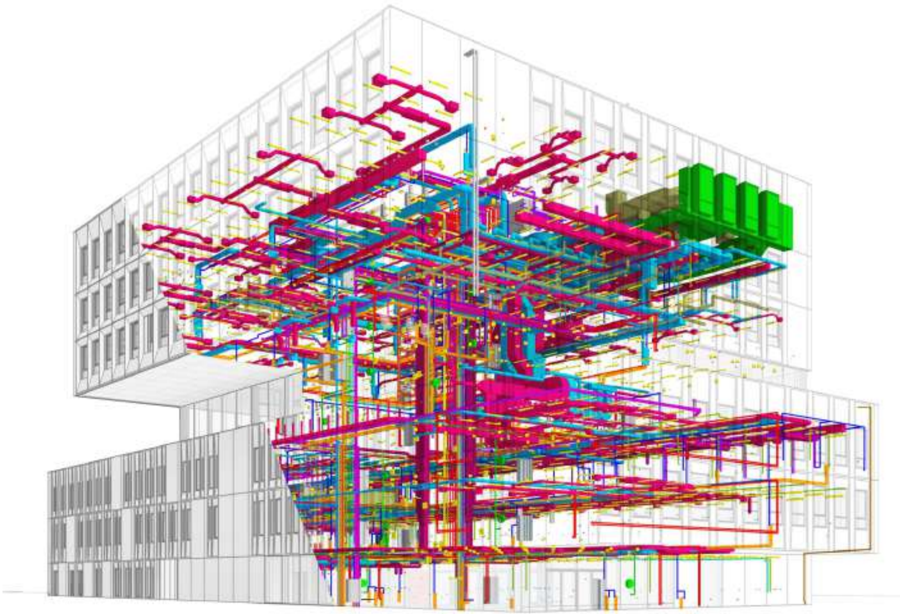
For the building delivery a series of planned tests will take place to guarantee the real performance and functionality of the construction process. All these tests will be properly documented and included as part of the delivery/handover documentation.

BEST PATH
Digital Twin implementation

2. HANDOVER

After all the commissioning tests and when all the systems and construction matters satisfy all the planned requirements and are properly functioning the handover process will take place.

The As-Built BIM Data Model is not only part of the documentation that must be submitted, but the most important one since it must contain all Asset (As-Built) information, containing links to technical data sheets, compiled parameters, volumetric and spatial data, and be characterized by a level of correspondence such as to recognize the BIM Data Model in relation to what has actually been built, produced, modified and installed, during the construction phase. Therefore, the As-Built BIM Data Model shall contain all necessary information of what has been produced and the characteristics of the construction elements installed for the subsequent conduction and management of Facility Management in order to design strategies for the management of the buildings.



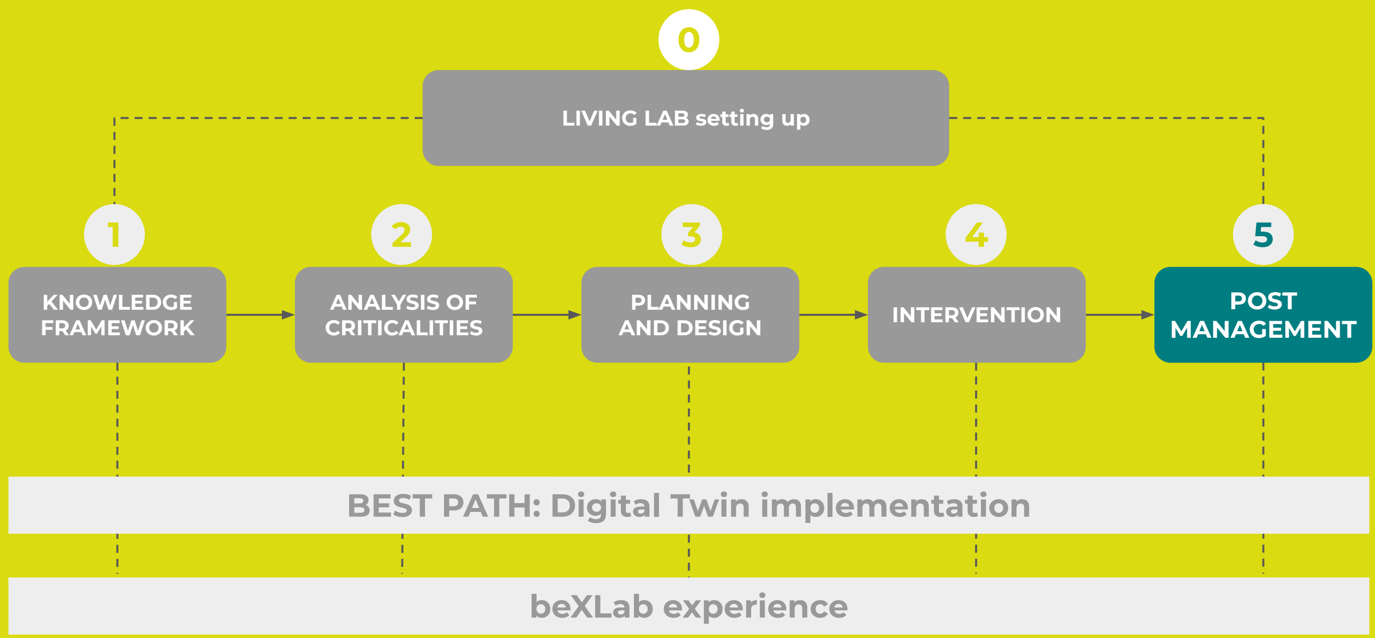
go BACK

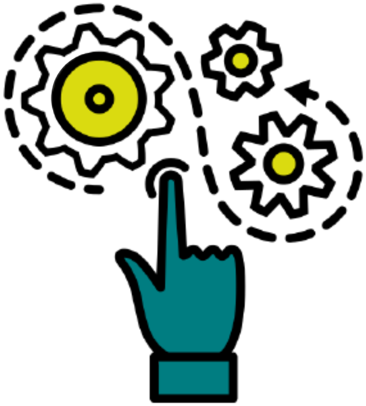
Phase 5
Post management

The renovation process does not finish with the end of the renovation works, since the effectiveness of the renovation has to be verified in the renovated building.

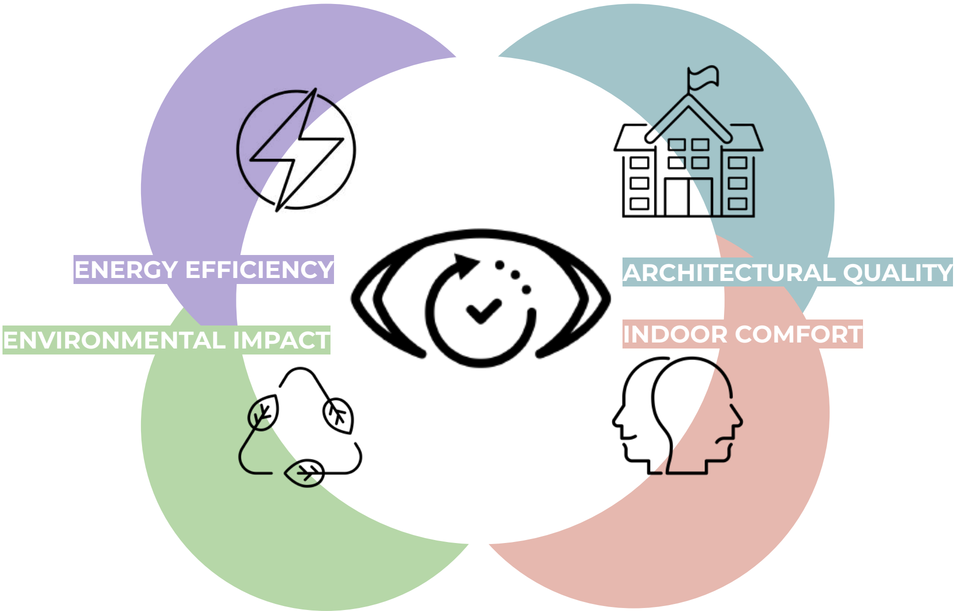
With the handover of the renovated building concluding the intervention phase 4, the post-management phase refers to the future life of the renovated building, in terms of improved management and operation.

WHAT	starting moment for the new life of the renovated building where new ways of management are required to maintain the improved performance in time
WHO	individualisation of people to involve in the university LL in order to sustain the innovation process
HOW	three steps to follow proper monitoring of the renovated building





The Post-Management Phase (PM) is the starting moment for the new life of the renovated building where, since new technologies have been integrated, **new ways of management are required to maintain the improved performance in time**.



BUILDING / ENERGY MANAGERS
university managers

Play a central role and innovate the current practices.

PUBLIC ORGANIZATIONS
associations and NGOs

Can be involved to valorise the experience.

COMPANIES
contractors, suppliers, workers

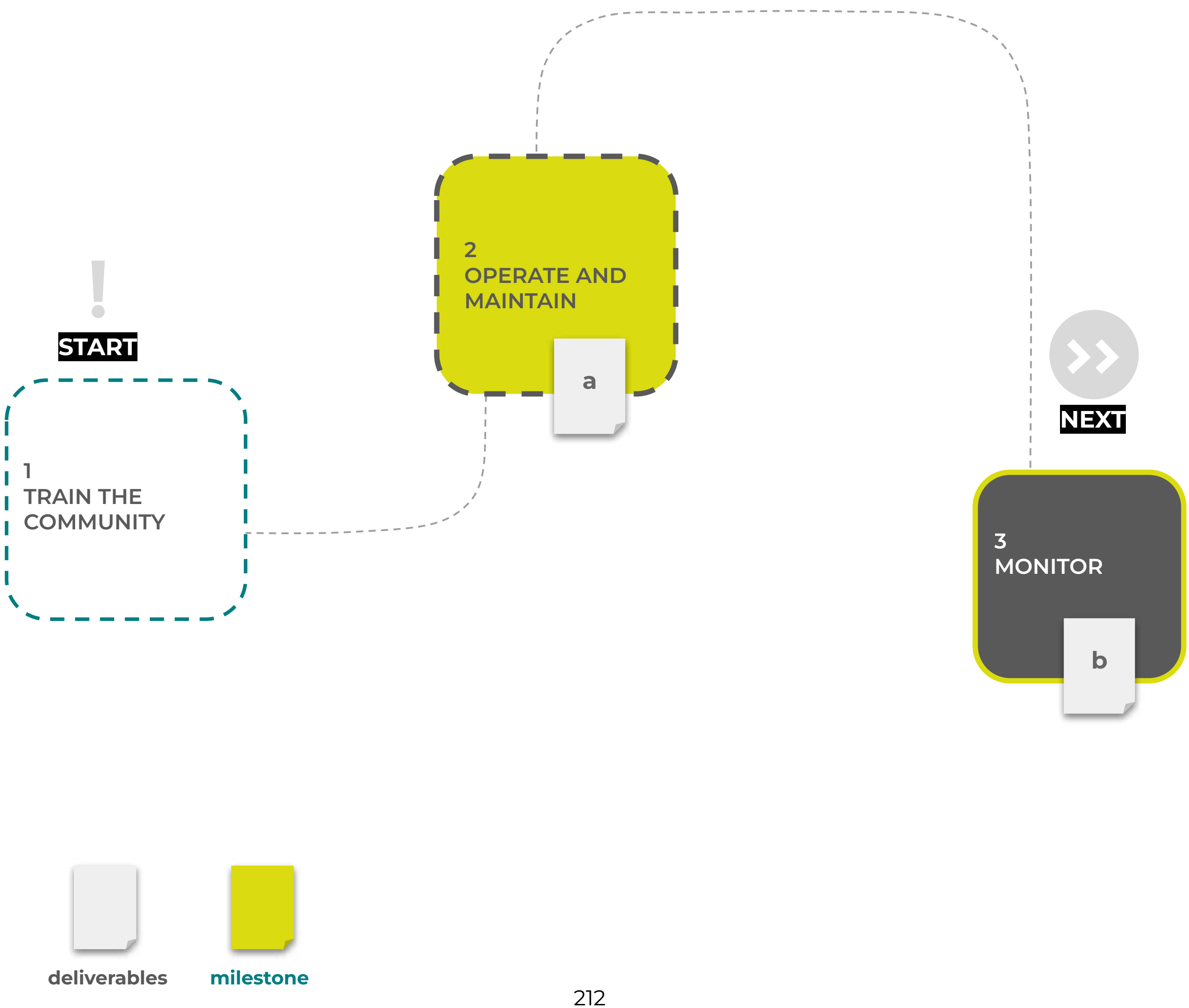
Can provide innovative tools for the management of the renovated building.

STUDENTS

Are engaged in the new life of the renovated building.

RESEARCHERS
architects, energy engineers, information engineering, user experience designers, others

Can support the adoption of new procedures.


START
1
TRAIN THE COMMUNITY
2
OPERATE AND MAINTAIN
a
NEXT
3
MONITOR
b
deliverables
milestone

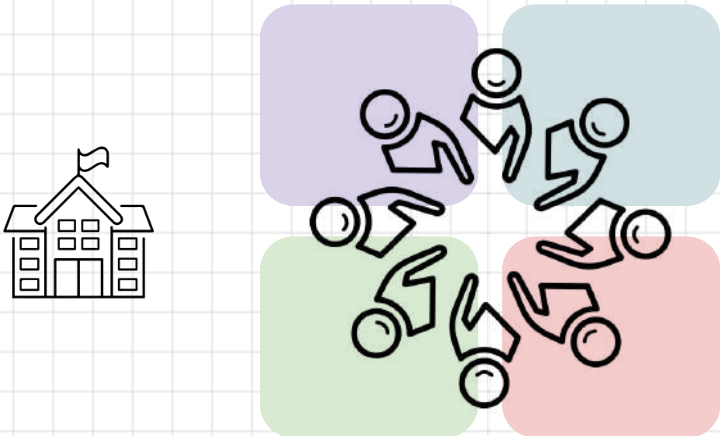
1. Train the Community

Developing **highly trained staff** is essential to maximise the performance of the completed retrofit. Beyond the investment in equipment and technologies, an **adjustment in behaviour** is needed in all the people managing and living the university building to realise the full benefit of the renovation.

The activity has the objective to make the university staff **aware of the new functioning of the building**, in order to fully capture the renovation potential and to be confident in performing the post-management activities.

The **training activity** regards all the new systems, processes or technologies introduced by the renovation project, but also the following activities to perform in this final renovation phase.

By undertaking a needs assessment for relevant facility staff, it is possible to identify capacity gaps and develop a customised training program.



New strategies
New technologies
...
new way of living the building...!

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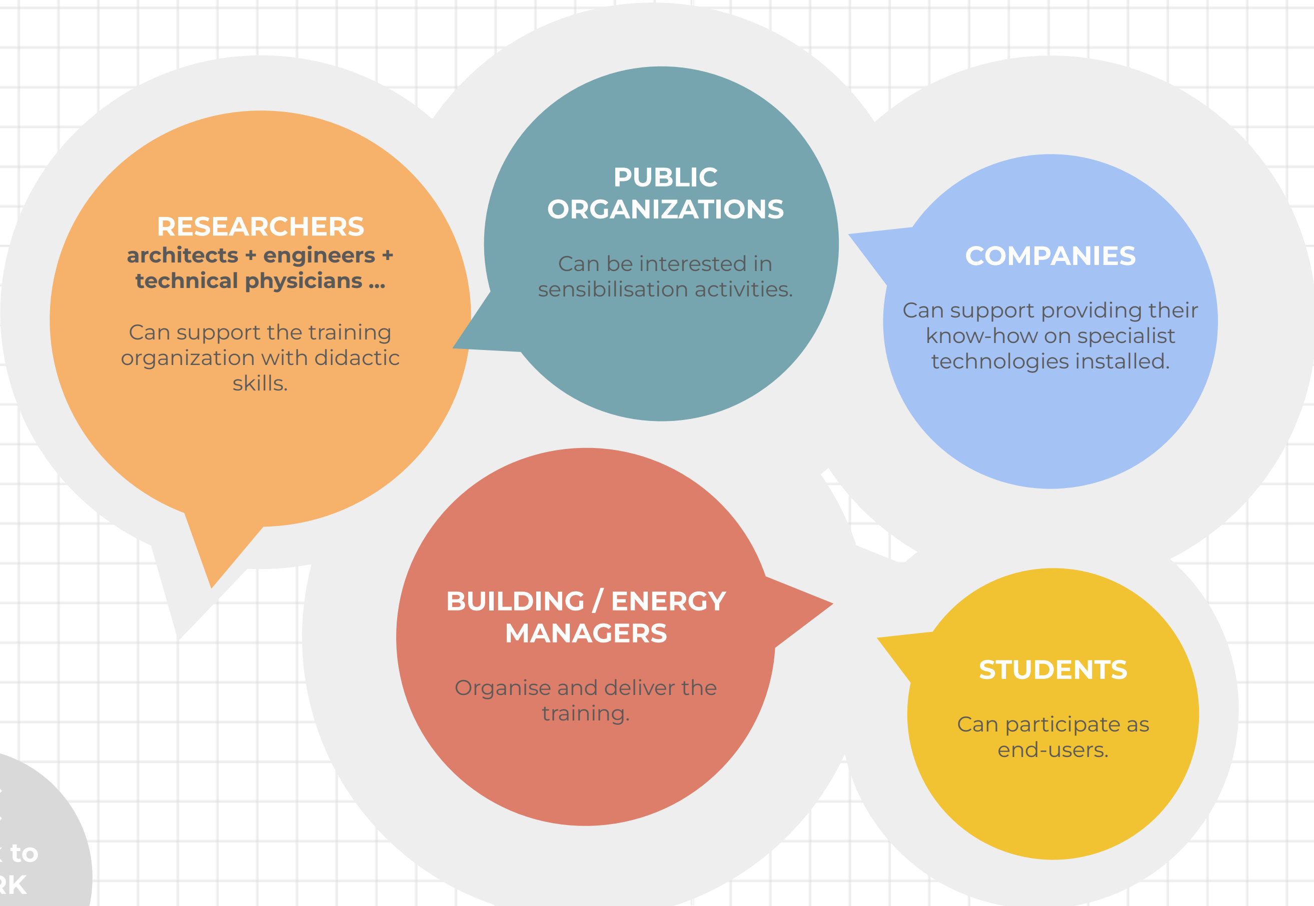
train the community

The training activity can be conducted together by researchers (for their training skills and competence on the innovative renovation technologies installed) and building/energy managers (for their representative role in the university staff).

The activity can also benefit from the collaboration of companies of the specific technologies installed, who can provide in depth training.

According to the typology of renovation strategies adoption, also students as users can be involved in the post-management training, in order to let them be aware of the new functioning of the renovated building.



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1 2 3

2. Operate and Maintain

Operations and Maintenance (O&M) is the combination of mental (operations) and physical (maintenance) activities that are required to keep the renovated building and its energy systems functioning at peak performance.

O&M APPROACHES			
REACTIVE	'adjust when it breaks'	saving now	not saving in long time
PREVENTIVE	'program testing to maintain or replace'	regular intervals	saving in long-term
PREDICTIVE	'monitoring systems and equipments'	when alert	saving in long-term

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Operations focus on the **control and performance optimization of equipment, systems, and assemblies**. Proper operations help ensure that equipment produces the required capacity when needed, and that it produces this capacity efficiently. Maintenance typically refers to routine, periodic physical activities conducted **to prevent the failure or decline of building equipment and assemblies**. Proper physical care helps ensure that equipment maintains its required capacity and that assemblies maintain their integrity.

O&M is an activity that almost all facility management staff engages in, but the nature of that engagement varies.

Some engage in reactive O&M, primarily responding to complaints and breakdowns, while those with a well-planned comprehensive O&M program work proactively to prevent complaints and failures. Implementing a comprehensive O&M program with limited resources is a common challenge. All too often, a lack of funding, time, manpower or even training prevents holistic and optimised O&M. Dedicating the resources can be advantageous, though, as a well-run O&M program can achieve the following (U.S. Department of Energy, 2010):

- Whole building energy savings of 5% to 20%
- Minimal comfort complaints
- Equipment that operates adequately until the end of its planned useful life, or beyond
- Design levels of indoor environmental quality
- Safe working conditions for building operating staff.

Optimizing a building's O&M program is one of the most cost-effective approaches to ensure reliability and energy efficiency, as a building's O&M practices can often be significantly enhanced with only minor initial investments (U.S. Department of Energy, 2010). Through low cost improvements and operational tweaks, such as those implements as part of an EBCx process, a building's energy use can be reduced while maintaining or even improving occupant comfort (Landsberg, Lord and Carlson, 2009).

When planning for energy upgrades, a building needs to evaluate how each retrofit will impact its O&M program, and if current O&M practices are adequate. Additional training or resources may be required to maintain the systems and/or assemblies affected by the upgrade, or to maintain the benefits associated with the upgrade. For standard retrofits, the O&M program may not be affected since these retrofits usually replace systems and components with similar but more efficient systems and components. However, even in these instances it's important to evaluate the sufficiency of the current O&M program and consider devoting additional planning and resources to maintain the performance and benefits of these retrofits.

Continua qui: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20761.pdf

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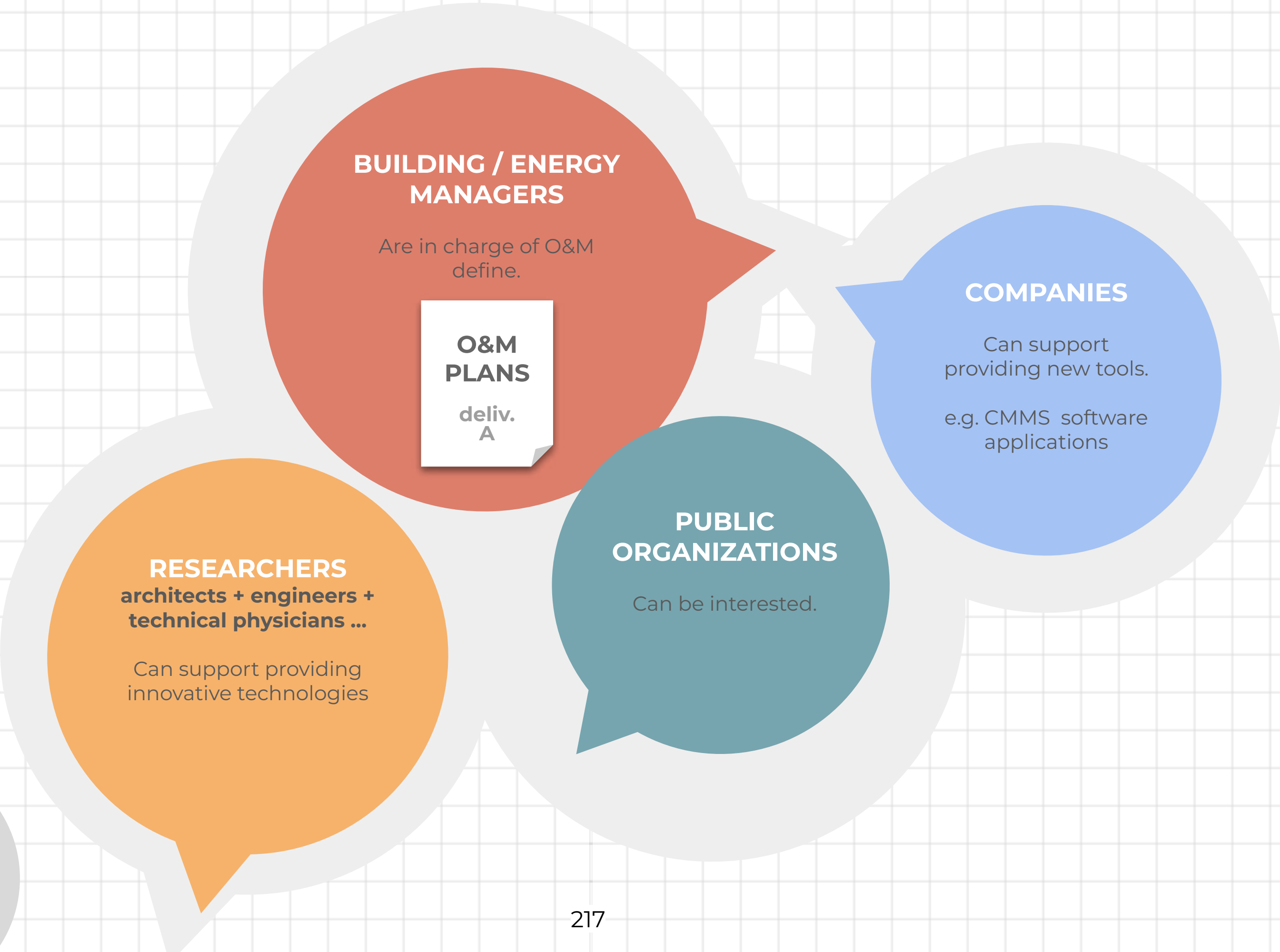
Building management systems (BMS) or building automation systems (BAS) provide control of the building systems. These typically include heating, ventilating, air-conditioning and refrigeration (HVAC/R), electrical power, lighting, fire suppression and alarm, and security systems, etc. Building controls also have the ability to monitor and control systems to improve performance, conserve energy, conserve water, and control lighting. The greater control provides the ability to improve a buildings performance, environmental impact, and the user / occupant's environment. Direct digital controls (DDC) with real time monitoring and history provide the ability to acquire system data real time or with trend-logging, or trending, (over a predetermined period of time) to observe performance, issues / troubles, and identify possible improvements to operations and maintenance.



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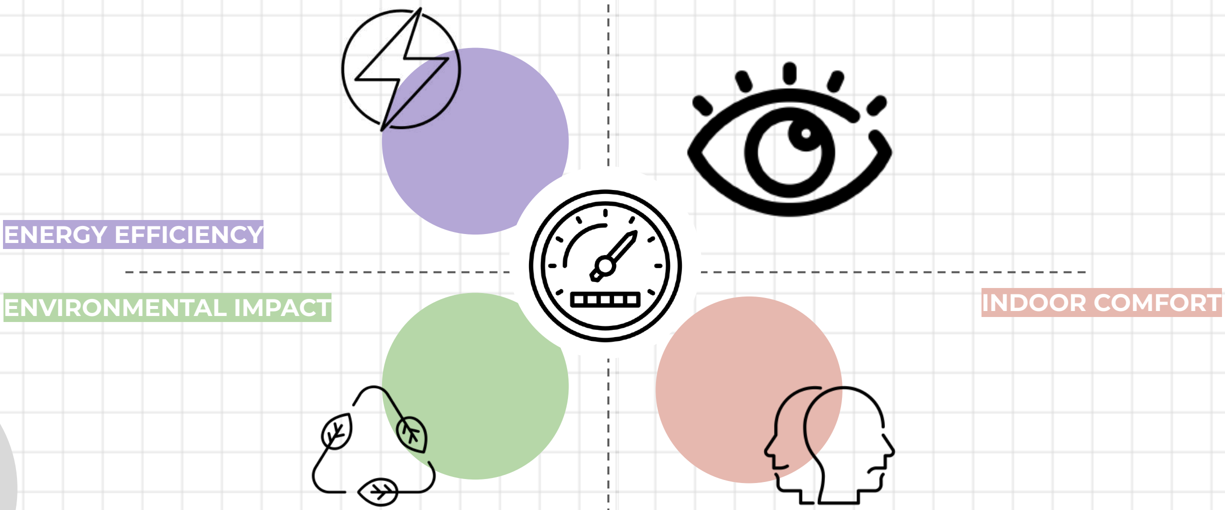
3. Monitoring

The monitoring activity is based on the idea that it is not possible to manage what it is not possible to measure.

Tracking energy use data provides the basis for setting and revising energy performance targets and allows to prove the benefits of the renovation project. This can be done thanks to the pre-intervention monitoring of the building quality, in terms of energy efficiency and indoor environmental quality (see phase 1 - Knowledge Framework).



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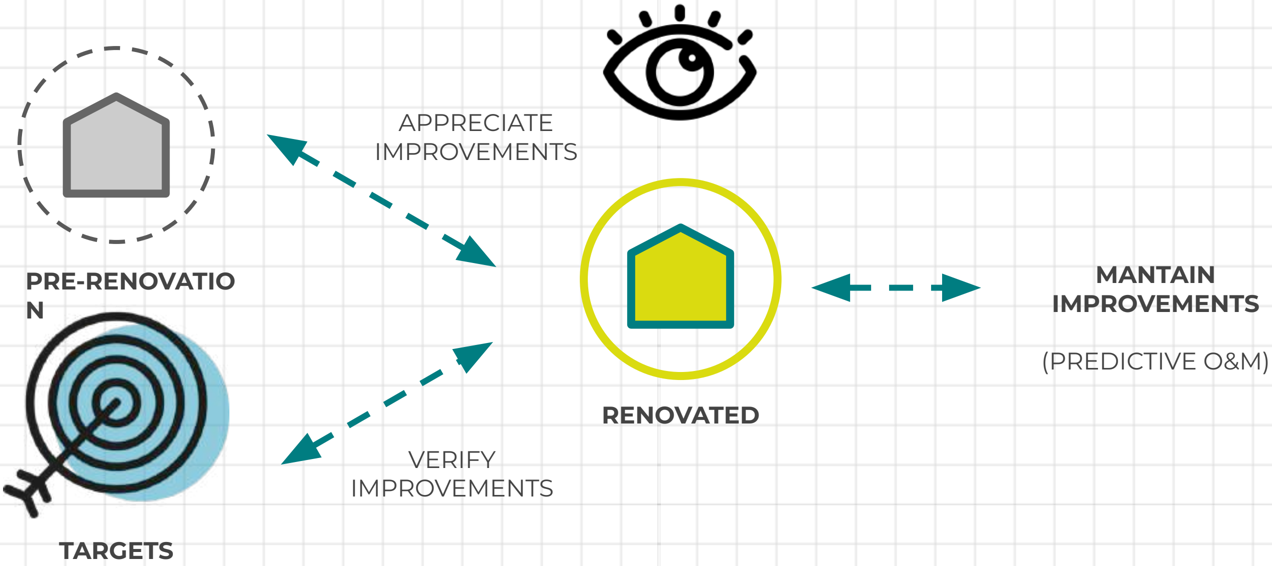
Monitoring



After measures are implemented, they require periodic monitoring to ensure that their benefits are realized over time. Sufficient resources and strategies must be put into place to ensure that measurements are recorded and analysed on a periodic basis. Energy data can be monitored at the facility level by using utility meters and at the system level, such as your chiller plant, by using submeters.

Historical energy data can be used to develop baselines for your building, as well as for individual projects. The most basic method of tracking performance is to add monthly energy billing data into ENERGY STAR Portfolio Manager.

For larger, more complex major retrofit activities, project-level savings can be assessed through measurement and verification by following the International Performance Measurement and Verification Protocol (IPMVP). If your organization has entered into an energy performance contract, the ESCo may be responsible for measurement and verification activities.

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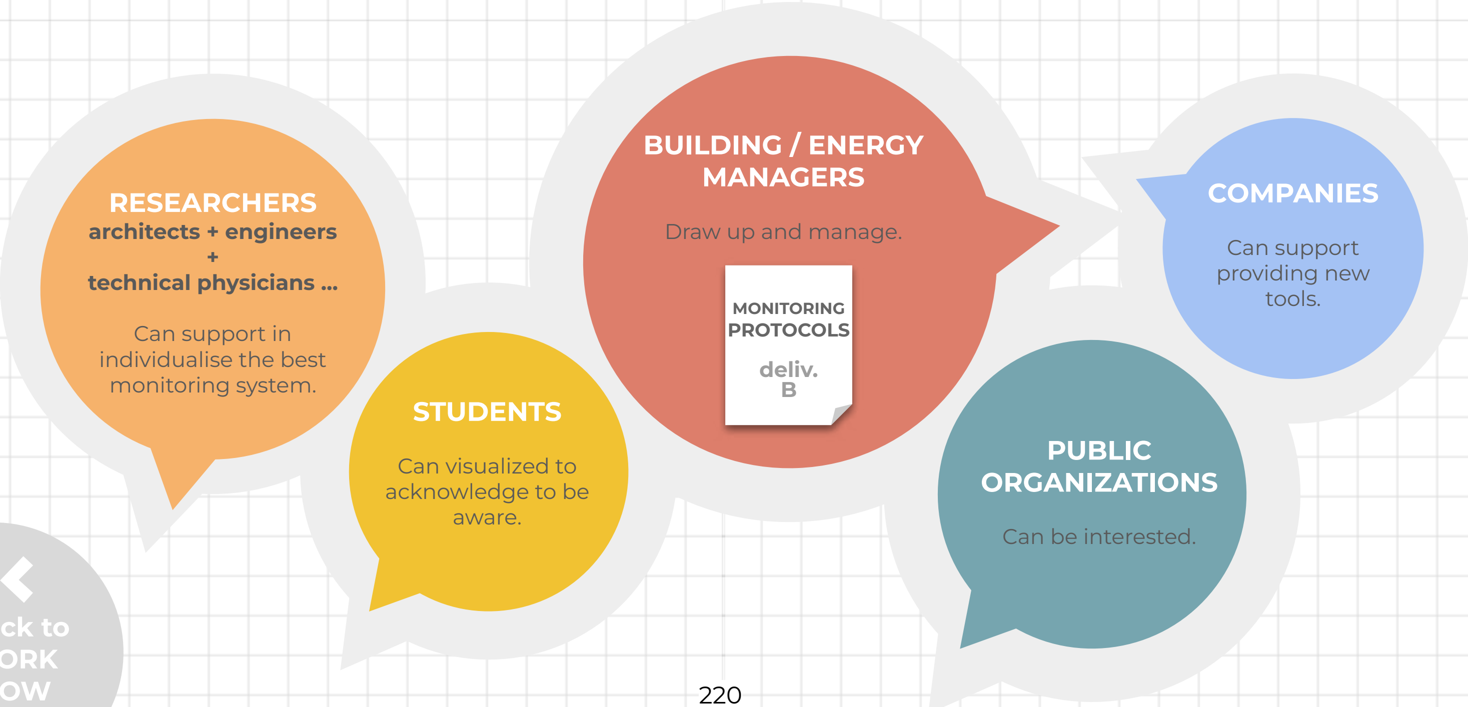
Monitoring

Forecast future energy consumption trends based on your planned major retrofit measures. Monitor your actual energy consumption against the baseline you established using Portfolio Manager and your forecast. Variances should be investigated and explained. Continue to benchmark your organization's performance over time by comparing your facilities to other similar Canadian facilities using Portfolio Manager.

Basic monitoring might include: • monitoring energy use and carbon dioxide emissions to validate predicted performance and provide feedback to occupants • interviews with tenants before and after works to compare qualitative experience and identify usability issues. More sophisticated monitoring might include: • temperature and humidity monitoring of habitable space to quality-assure internal conditions • temperature and humidity monitoring of building fabric to check it is performing as expected • air tightness testing over a period of years – to check longevity • measurement of electrical consumption – to check for creep on appliance efficiency or "standby" wastage • measurement of water usage – to identify waste of cold and hot water

Building automation systems optimise the energy consumption of buildings. Many of these systems are complex, and building operators may require specialised training to realise the full benefit of an automation system. Energy managers may require training on monitoring and tracking to ensure that they can perform their roles effectively.



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BEST PATH
Digital Twin implementation

For the O&M phase the Asset Information Model (AIM) will be implemented for the facility and/or asset management, undertaking post occupancy monitoring and evaluation of the building energy performance, interior comfort and well-being in real time (digital twin).

During this phase all the matters regarding occupation profile, energy performance, energy savings, wellbeing and interior comfort must be monitored, registered and evaluated to properly understand the building conditions. Conditions that will determine future improvement interventions or refurbishment strategies for the building itself or other buildings part of the property assets of the institution.

To keep track of the modifications, evolutions or small modifications due to the routine and extraordinary Maintenance processes, it is very important to constantly update the Asset Information Model as part of the maintenance protocol. This because the O&M phase is the longest one of all the building lifecycle and many years may pass before any new intervention on the building and with the time happens that many persons may pass through the processes as well and if there is no documentation of what has been modified on the building, all the information produced and monitored through the years will have a big lack of consistency and the most valuable resource could be considered lost.

Important documents that should be produced and reviewed periodically are:

- Lessons learned report;
- Performance reports;
- Energy savings reports;
- Environmental and indoor quality conditions reports;
- Occupation profile reports.

Conclusions

in conclusion, the best path BIM technology-based offers numerous advantages such as:

- increased efficiency and productivity
- reduced margin of error
- reduced processing time
- decreased costs
- greater interoperability
- excellent sharing among the actors of the process
- the possibility by the client to virtually monitor the evolution of the project, to control and verify the building lifecycle, such as the operation and the routine and extraordinary maintenance.

In essence, the introduction and usage of the new technologies, methodologies, tools depends on the will to set a new mindset and a new way of working.

Everything is in the hands of the team leaders and the ability to change human resources goodwill.

Digitalization and record of information is a very valuable tool that can change the way to approach refurbishment or new construction projects, following the principles of sustainability and energy efficiency, always looking into a cost effective direction.