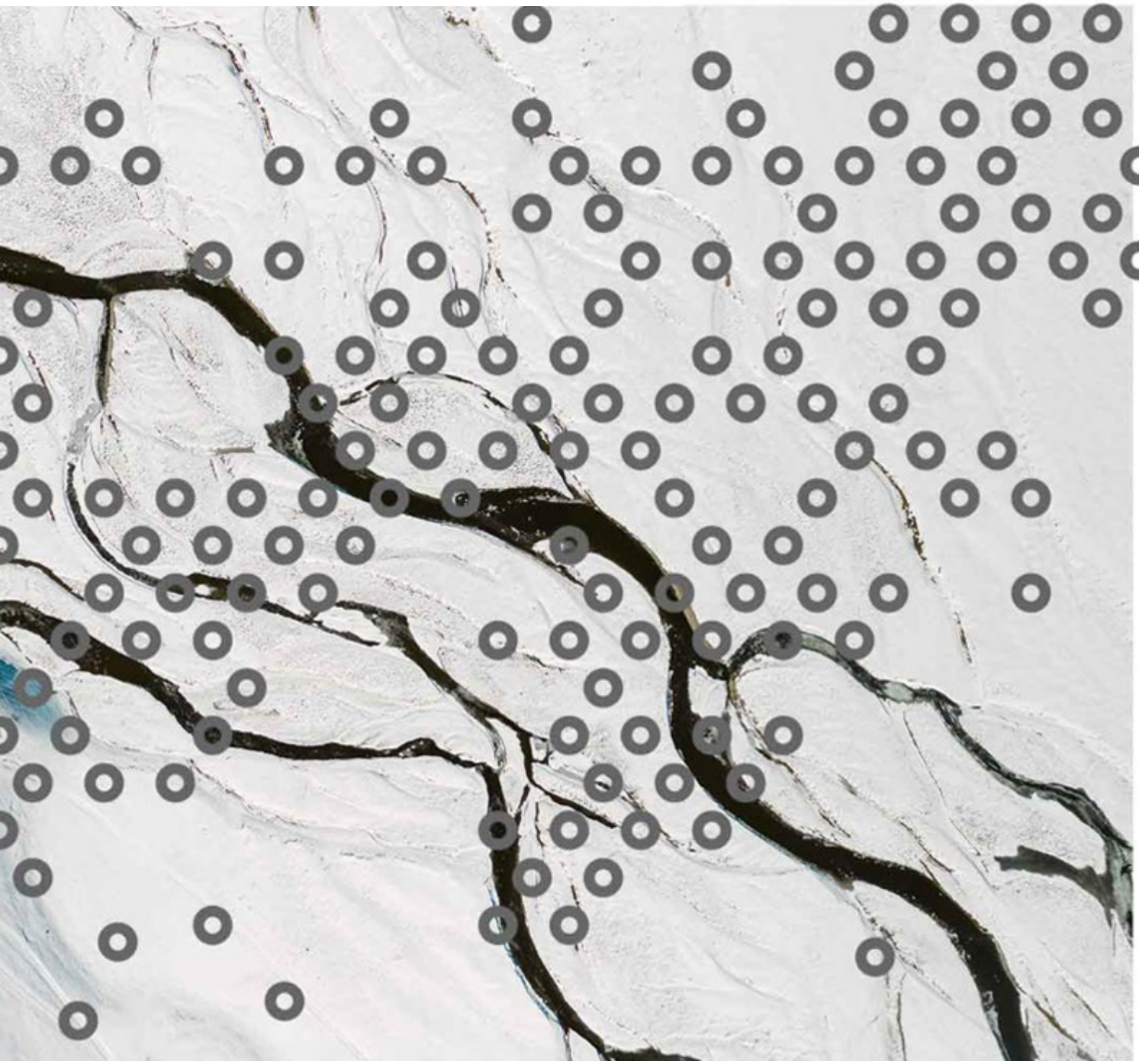

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Report delle attività di ricerca

BEYOND ALL LIMITS

INTERNATIONAL CONFERENCE
ON SUSTAINABILITY IN ARCHITECTURE,
PLANNING, AND DESIGN
11-12, 13 May_2022

edited by
Claudio Gambardella

Università degli Studi della Campania *Luigi Vanvitelli*
Dipartimento di Architettura e Disegno Industriale
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*Dipartimento di Architettura e
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Research activity report

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University communities for the green/digital renovation of buildings

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Abstract

The paper shares the research-design experience behind the retrofit pilot-project of a Mediterranean university building, where beXLab is experimenting Digital Twins in a Living Lab context to innovate the building energy renovation process towards the tracked green and digital transitions. Exploiting the digital to support awareness on the energy and environmental challenges, the paper focuses on the multi-level methodology adopted to engage people in the pilot innovation/renovation process: from managers and decision makers responsible for university building and energy assets (survey) to the university community experiencing the Living Lab spaces, starting from students.
First results are showing that the need to deepen the knowledge on the impact of buildings on the planet and on humans can be addressed only by making people aware of the environmental quality of university spaces, and that digital tools can support this human transition towards a future sustainable buildings and cities.

Keywords

Green/digital transition, inclusive multidisciplinary approaches, digital twin, living laboratory, involvement toward awareness.

1. Introduction

In the era of the recognized irreversibility of human activities on the planet's health, buildings 'quality plays a strategic role, due to their enormous impacts on environmental sustainability, both in terms of energy consumptions and life-cycle carbon-footprint, as well as on human's health and wellbeing, also reminded by the pandemics experience.
The need to regenerate the built environment is made explicit in the commitment from the global scale, with the interrelated UN Sustainable Development Goals, to the EU policies and programs, starting from the Green Deal (EU commission 2019) to the Renovation Wave, evolving the Nzeb concepts towards positive energy buildings, also influencing with more ambitious targets the transformation of existing buildings, representing the most critical challenge.
Yet, if the green direction is traced and the requirements provided, the implementation in existing building projects and practices is still full of bottlenecks, also starting from the scarce digitalization of the building sector. Parallel to the Green, the Digital transition is considered an opportunity to enlighten the still *too grey* building processes with a new amount of shareable data and information for a "smart-sustainable" decision making across the whole building life cycle.
The pivotal role of people in such a context is well highlighted in the New European Bauhaus initiative, aiming at the promotion of participative co-design processes to inclusive envision collectively, towards beautiful future buildings and cities.
These are the challenges and aspirations of the experience shared in this paper, based on the settlement of a co-creation space in an university building in Florence, for the definition and implementation of innovative and eco-sustainable retrofit processes.

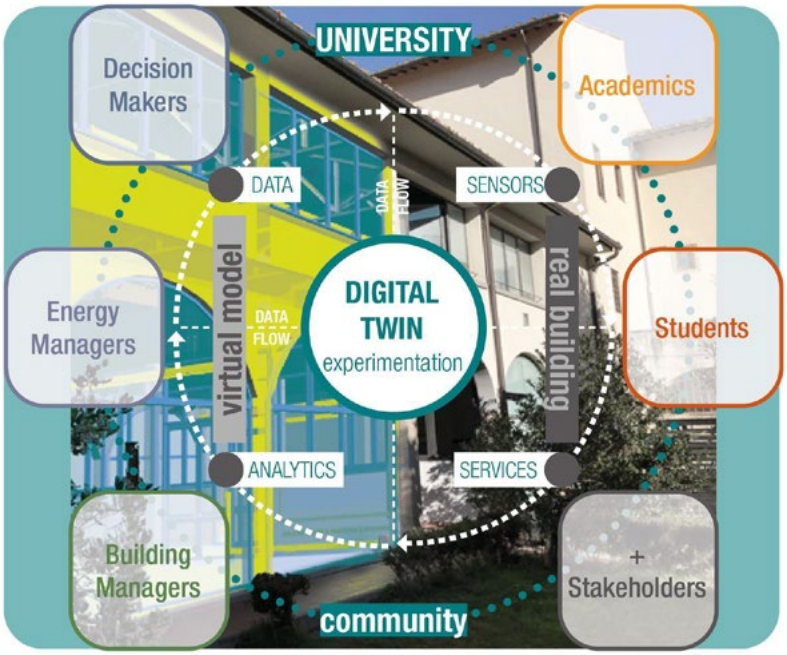

Fig 1. Twinned methodologies and actors participating in the retrofitting and awareness process.

2. Objectives

The paper shares the research-design experience of the pilot-project in the international research project Med-EcoSuRe, with the aim of describing the methodologies adopted and the promising first

Focusing on the unique Mediterranean socio-climatic context, the research project has the main objective to foster the role of universities as catalysts of innovative and eco-sustainable renovation processes in public buildings, by introducing a more collaborative approach for decision support (Trombadore et al. 2022).

To do this, the Italian team set up the university Living Lab (Nina et al. 2014) inside the Department of Architecture of Florence DIDA, in order to stimulate the collaboration and information exchange between the actors involved in the retrofit of the pilot case study, starting from building and energy managers/decision makers, but encompassing the whole university community (academics and their natural network of stakeholders, e.g. innovative companies), to finally involve students/users of common spaces.

In line with the EU objectives of a sustainable Renovation Wave merging the Green and Digital transitions, the Italian team is working on the most promising digital technologies for the building sector (from BIM to sensors and IoTs), sustaining their wide adoption for more reliable retrofit processes based on a new amount, quality and variety of data (e.g. existing and future building analysis and scenarios simulations), but also as an occasion to trigger more innovative and sustainable building lifecycles (e.g. operation and management).

Embracing the NEB initiative for more inclusive and participative co-design processes, the ultimate objective of the Living Lab is to create 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 themselves, in terms of comfort and wellbeing. This co-creation space has been settled in the strategic university setting, where future generations of citizens, decision makers and technicians are growing up.

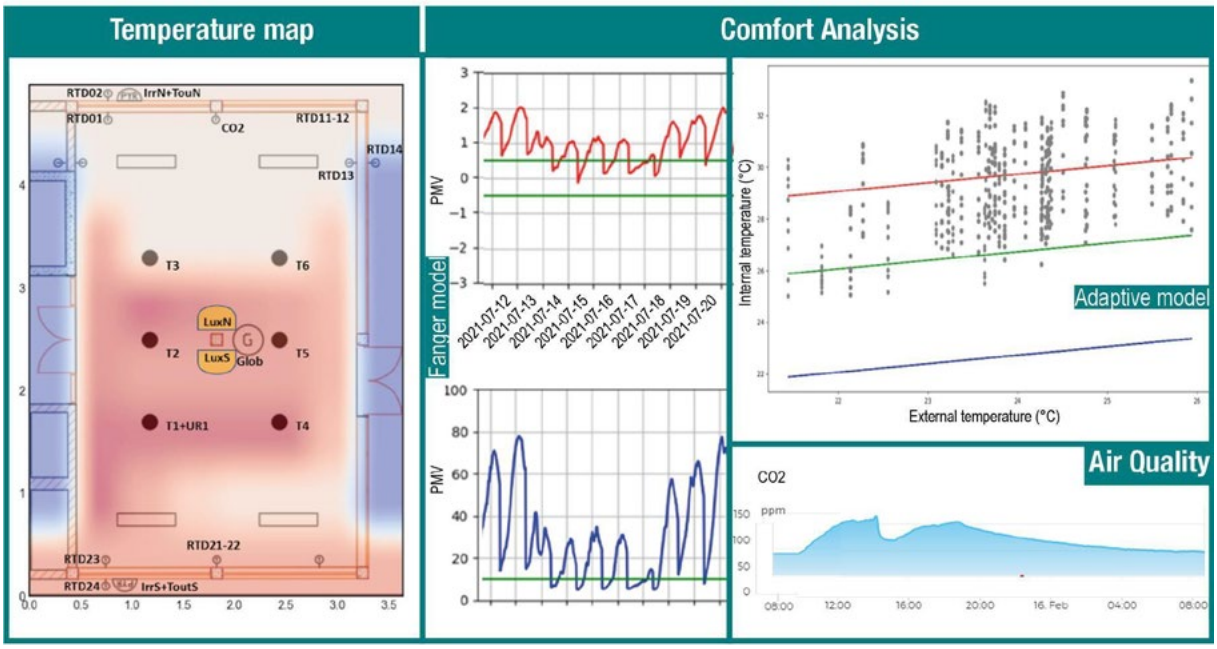

Fig 2. Data processing derived from lab measurements concerning thermal comfort and air quality.

3. Methodology

Considering the retrofit of an university building as a strategic innovation process, the research team promoted a multi-level Living Lab methodology, with a Mediterranean university network of excellence which operates locally inside university pilot-buildings, for a collaborative exploration, experimentation and evaluation of innovative and eco-sustainable retrofit schemes.

The innovative core of beXLab is the experimentation of predictive Digital Twins (Khajavi et al. 2019): the pilot-university building has been equipped with a real-time environmental monitoring systems (sensors and IoTs) and twinned with a virtual BIM-based building model for the calibration of energy and environmental quality simulations on the existing building and for the definition of the best "*mix-of-technologies*" retrofit scenarios (Trombadore et al. 2020).

Sustaining this core-experimentation, some practical methodologies were already set up in order to involve the university community in the definition of innovative and eco-sustainable retrofit processes, as soon as the living laboratory was created. They could be divided as follows:

1. *A survey for university building and energy managers/decision makers of Mediterranean universities*: it was carried out to understand the current practices for the refurbishment of public buildings stocks, and in particular the collaboration barriers. A detailed questionnaire was proposed in order to map the existing and to underline the "who-does-what" process in the management chain from the service offices to the highest decision levels. Moreover, the quality of available information was addressed aiming at demonstrating the importance of uniformity, standardisation and facility of keeping it shareable;

2. *Development of tools for the cross-elaboration of different measurement data for the internal comfort and wellbeing*: those post processing methods are necessary to aggregate multiple different data set-up (indoor and outdoor parameters obtained by sensors) and convert them into suitable information which represents the basis for the future analysis. A clear

Fig 3. Architectural solutions proposed during the design workshop

understanding of the output from experimentation, brings the digital twin model to be finalised and validated, leading the way to the re-design step. On the other side, the possibility of rendering the data in a more comprehensible form is the key for educational initiatives towards awareness and virtuous processes.

3. *A design workshop organised to engage university students in the co-design of the architectural solution for the retrofit of the pilot building*: the experience aimed at involving the main end-users of university spaces/students in the design phase of the university pilot-building retrofit project. Sharing the knowledge framework and analysis of criticalities on the pilot building, architectural students were introduced to the most traditional/innovative retrofit strategies and technologies for the Med area (i.e.. nature-based passive and active solutions - PV), and involved in the co-design of architectural solutions for their integration in pilot-building.

4. *A long-term survey has been drawn up to continuously retrieve subjective data from the university community on the environmental quality of the pilot building:* a questionnaire was compiled according to EN ISO 10551:2019 [4] and shared within the research group, at first. Thermo-hygrometric, lighting and acoustic issues were investigated from the point of view of the opinions related to the perception of environments as a function of personal activities and characteristics. These subjective contributes are continuously collected and are going to be compared with the objective parameters which are derived by direct measurements on site. The whole data matching will define a comprehensive view of the pilot (before-after the retrofit) in the BIM system.

4. Results and future works

The multi-level and multi-disciplinary methodology to innovate the retrofit process is an ongoing process that will last for years, beyond the pilot retrofit would be accomplished, e.g. keeping under control the monitoring phase for the building, for the user needs and behaviours, the operational maintenance of the Digital Twin system and forecasting replicability in other contexts.
The steps followed up to now have already highlighted some crucial, critical points, but also some opportunities.
First of all, a lack in the information about the existing is noticed at all the levels of the building management chain in the Mediterranean area. Fragmented data are present in different and non-homogeneous forms; the access is difficult as well as the capacity to fix a clear framework of the context of interest. Digitization processes have not started yet or they are partial anyway.
For these reasons the set-up of beXLab represented a breaking point, collecting a large part of missing information through direct measurements and especially promoting the building investigation within all its aspects.
Some data processing tools have been configured in order to derive robust information about e.g. the thermo-hygrometric characteristics and the air quality inside the laboratory, as shown in fig. 2. The implemented automathics algorithms merge the various sensors outputs and translate them to the common indexes for evaluating internal comfort such as the Predicted Mean Vote and the Predicted Percentage of Dissatisfied according to UNI-EN-ISO 7730 (2005).
In addition to the scientific contribution, the methodologies adopted allowed to involve people in the spirit of collaboration and innovation of the Living Lab, "forcing" them to become aware of the environmental quality of the university spaces and their current (managers) and future (students) role.
In the spirit of the NEB, the engagement of students in the co-design process permitted them to deepen their knowledge and understanding of current sustainability challenges (i.e. energy efficiency) and innovation opportunities to tackle them (i.e. digital technologies), also considering the architectural aesthetics of the retrofitted buildings.

5. Conclusions

Addressing the Med-EcoSuRe objectives, the described research-design experience suggested the need of going beyond buildings renovation to rethink human behaviours firstly, and that the green and digital transitions should be blended in a virtuous circle opening building issues to people (through the concept of inclusion, participation, awareness).
The complexity of the contemporary challenges for the built environment can be approached by combining quantitative and qualitative data in a more integrated way, not to define standard solutions, but to build a wide range of possible scenarios in which society can reflect its diversity, aspirations and desires. This requires a new capability of active “sensing” buildings, their environmental sustainability and comfort/wellbeing, as prerequisite for the construction of a common awareness which can support human-based and culturally appropriate building renovation processes.

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