Abstract

Building a sustainable future is a common responsibility that the United Nations Member States stated in 2015 by agreeing on the 2030 Agenda for Sustainable Development. The European Union refers to it while proposing the **Green Deal** to tackle the environmental-related challenges of our times. The objective is accelerating the transition towards a fair and prosperous society, to the best interest of health and well-being of all European citizens. The **role of buildings** in this transition is well-recognized, not only for their untapped potential in terms of energy and emissions savings, but also for their capability to enhance occupants' well-being. Indeed, the effects of indoor spaces on humans' health and well-being is more and more known, and the desired **renovation wave** for buildings must also tackle the challenge of increasing the environmental quality of indoor spaces where people spend 90% of their time. However, **barriers** to intervention are lowering down the process. They also refer to a lack of knowledge/awareness on the status of performance of our building stock and on the potential **co-benefits** brought by its deep renovation (*Chapter 1*).

This **gap** of information must be covered by measuring current and future performance of buildings to support the decision-makers involved in the renovation process. Better and more reliable information would drive political strategies and peoples' choices on how to retrofit and manage buildings in an evidence-based and data-driven manner. Among such evidence, the impacts of buildings on comfort, productivity, health, and well-being cannot be neglected.

The growing availability of **data** due to the digital revolution plays a role - from data, knowledge should 'emerge' in order to become exploitable in tackling health and green challenges. Thus, beside data, methods should be provided to translate them into usable knowledge to the best interest of building transformations towards multiple sustainable goals (*Chapter 2*).

Accordingly, the research presented in this dissertation aims at exploring the potential of different types of building data (simulated, billed, monitored) in identifying **multi-disciplinary methodological frameworks** for building performance evaluation at different scales, ultimately supporting the transition towards a more sustainable future for the built environment. Thanks to six

case studies, **tools** (metrics and methods) are offered to support the decision-making process in retrofit planning and building management to serve, in a data-driven manner, three main objectives: scenario analysis and priorities identification for retrofit planning at the stock level (*Chapter 3*), and development of new models and services to support building management according to a holistic approach (*Chapter 4*). Methods refer to: i) the adoption of the Reference Buildings approach, their modelling and simulation; ii) the exploitation of quadrants-charts and simplified computational flows to define priorities of interventions, preliminarily assessing the financial performance of retrofit measures; iii) the definition of innovative metrics aiming at measuring buildings performance across multiple domains, with a special focus on impacts on people health, productivity, and well-being; iv) the shift from single domains' indicators to the measure of the overall building performance through a single key figure (e.g., euro, performance score, etc.), enabled by the use of monetary and non-monetary economic evaluation tools. Remarks on future development of such methodological approaches are offered at the end of each relevant chapter. Conclusions delineate potentialities for **data usage** and their translation into **understandable metrics**; insights on the **scalability** of buildings performance assessment results; opportunity for **leveraging on co-benefits** to boost renovation and create the buildings of the future; and potentiality for decision-makers and occupants' **engagement** in the process (*Chapter 5*).

Keywords:

KPIs, building data, simulation, simulated data, retrofit, preliminary evaluation, scenario analysis, Reference Buildings, price list, monitored parameters, building management, energy, environment, financial, socio-economic, health, well-being, productivity, Cost-Benefit Analysis, Multi-Criteria Analysis, Multi-Attribute Value Theory, occupants, information services, holistic evaluation, decision-making.