



PhD in INGEGNERIA GESTIONALE / MANAGEMENT ENGINEERING - 40th cycle

**INTERDISCIPLINARY Research Field: MODULARITY AS ENABLER OF EFFICIENCY,
CIRCULARITY AND INCLUSIVITY IN RESIDENTIAL BUILDINGS**

Monthly net income of PhDscholarship (max 36 months)

€ 1500.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

Interdisciplinary PhD Grant

The PhD research will be carried out in collaboration with research groups of the PhD programme in **"ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING"**.

See <https://www.dottorato.polimi.it/?id=422&L=1> for further information.

In recent decades, at the European level, there has been a push to improve the productivity of the construction sector while simultaneously reducing its environmental impact. Retrofitting interventions on residential buildings are often extremely expensive and therefore only accessible to a limited portion of population. Consequently, retrofitting rates are too low. Reaching the targets set by the Union necessarily requires addressing the aspect of inclusivity, which encompasses several issues (such as low incomes, precariousness, and the need for frequent relocations). Furthermore, to date, retrofitting of existing buildings occurs through technologies that have not been developed to be circular. Circular economy promotes sustainability in material usage through efficient resource utilization. The adoption of circular practices implies maximizing the reuse of existing materials and/or components and reducing waste. Current retrofitting practices are designed to improve current energy performance, leaving unanswered



	<p>questions about what will happen to the building sector in the future or the waste generated during the retrofitting process.</p> <p>Modularization, with its characteristics of increasing functional unity and decreasing costs, is a candidate to be a winning solution for finally achieving buildings that combine efficiency, inclusivity and circularity. The objective of this research is to study how modularity can become an enabler of efficiency, circularity and inclusivity in residential buildings. In that context, modularity can tackle the complexity of retrofit projects and their high cost making retrofit accessible to a wider segment of the population, creating an inclusivity solution.</p> <p>Modular systems or those based on the concept of modularity are spreading mainly in Northern Europe for new constructions, while they are much less developed for retrofitting existing buildings. Exploring modularity in retrofitting presents an opportunity to bridge this gap and leverage the benefits of modular construction techniques in retrofitting the existing building stock, answering the need to reduce the greenhouse gases emissions of the built environment.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research will entail qualitative methods belonging to the field of social sciences (e.g., open and semi-structured interviews, Delphi and world café for data collection, thematic and content analysis, Gioia method for data analysis) together with techniques belonging to the architectural engineering field (e.g., case study analysis, performance-based analysis, and post-occupancy evaluation), combining them in an innovative way. The epistemological approach is based on a "systemic approach": the system consists of a building, or a group of buildings, seen as an "organism" in its lifecycles. The research will analyse modular and reversible retrofitting scenarios for the organism, to evaluate how modular systems can create a virtuous circle.</p> <p>The research will focus on leveraging polar case studies to investigate success and failure cases of modularity in retrofitting, particularly as a driver for enhancing efficiency, circularity, and inclusivity. By leveraging on value theories as a robust theoretical lens for framing the</p>



	<p>research, the aim is to elucidate the diverse impacts of modular implementation on various stakeholders, ranging from end-users to construction and manufacturing firms engaged in the retrofitting projects.</p> <p>Through a series of multiple case studies involving industry players, the aim is to investigate diverse scenarios of modular production process implementation. Similarly, the research will delve into various approaches to internal development of proprietary standards within the retrofitting sector, with an emphasis on the level of mass customisation. In particular, we will investigate the role of modularity as an enabler for circularity, and assess its implications on supply chain dynamics.</p>
<p>Educational objectives</p>	<p>The candidate will develop a set of skills essential for conducting rigorous research in management, with a specific focus on the field of social science, particularly project management, and architecture, particularly management of residential buildings. The candidate will acquire hard skills through participation in doctoral courses covering topics such as energy efficiency, retrofitting, artificial intelligence in the built environment, and circular economy. These courses provide foundational knowledge and practical insights essential for navigating the complexities of research in these areas.</p> <p>The candidate will also learn the scientific approach to research, methodologies for data collection and analysis, scientific writing and other dissemination strategies. Additionally, the candidate will learn to apply theoretical frameworks to their research, critically evaluating existing theories and applying them to real-world management issues.</p> <p>Furthermore, the candidate will learn soft, interpersonal skills and network development, establishing connections within both the professional and scientific communities through collaborations and participation in academic events, conferences and seminars.</p> <p>Moreover, the candidate will have the opportunity to enhance their teaching abilities as they serve as tutors for laboratories and management courses, guiding students through practical applications, and providing constructive feedback. The candidate will learn to mentor and</p>



	<p>supervise thesis projects, learning how to guide research processes.</p>
<p>Job opportunities</p>	<p>The European Commission estimates that by 2030, annual investments of 275 billion euros will be needed for the energy transition of the building sector, opening diverse opportunities for the candidate. Given the magnitude of projected investment and the increasing interest in the field, the demand for professional figures in the retrofitting sector, with a focus on circularity and inclusivity, is rising. The skills acquired throughout present an opportunity to contribute as an expert in modular retrofitting solutions for residential buildings within the construction and building sector. The candidate can offer valuable insights into enhancing existing structures with circular and affordable retrofitting techniques. Likewise, manufacturers specializing in retrofitting modules or broader construction applications may find value in the insights gained during the research, facilitating enhancements in internal production processes and module designs. These companies can streamline their operations and deliver more adaptable solutions to the market.</p> <p>Furthermore, the expertise acquired could open opportunities for engagement with consulting firms for the implementation of modularity across products and processes.</p> <p>Practical applications are advising on strategic planning or optimizing production workflows, with a holistic understanding of the supply chain dynamics and a specific emphasis on fostering circularity.</p> <p>Opportunities also exist in university research, research centres, and applied research, considering the topic of sustainable construction and energy efficiency.</p> <p>Additionally, expertise in this area is valuable for informing public policy and regulations and for helping governments promote circular and inclusive practices in the retrofitting sector. These opportunities are crucial for driving systemic change and achieving ambitious energy and climate targets.</p>
<p>Composition of the research group</p>	<p>1 Full Professors 1 Associated Professors</p>



	0 Assistant Professors 0 PhD Students
Name of the research directors	Giorgio Locatelli, Ornella Iuorio

Contacts	
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information	
<p>Access to a desk within the department is required to conduct research. In addition office 365 and software for qualitative research such as NVivo and Atlas, and REVIT and Rhino for design research.</p> <ul style="list-style-type: none"> •Teaching and tutoring: "If coherent with the development of their doctoral program, the PhD candidate will have the opportunity to be involved in: teaching activities, tutoring to master students, tutoring to PhD candidates for administrative processes". •Italian knowledge (e.g. borsa co-finanziata da ente italiano): "The interaction with key stakeholders requires a fluent knowledge of the Italian language". <p>Funding for educational activities: 6.100,00 Euros for three years.</p>	