Finanziato dall'Unione europea
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Ministero dell'Università e della Ricerca
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PIANO NAZIONALE DI RIPRESA E RESILIENZA
UNIVERSITÀ DELLA CALABRIA
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What will be done

Publications

Cristian Tolù

Training	graduated with a bachelor's degree in *Building Engineering* in 2021
	graduated with a master's in *Engineering and Construction Techniques in 2023*.
PhD	since November 2023, I have been a PhD student in Civil Engineering with a focus on Architectural Engineering
Research interests	multidisciplinary approach
	digital processes for the management and valorisation of building heritage
Research context	what: light and heavy prefabrication systems
	when: Late 20thCentury
	where: in Italy
	how: knowledge, digitalisation, valorisation, reuse

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Ongoing Research Projects

PRIN 2022

Light prefabrication: knowledge, monitoring and requalification of the architectural heritage of the second half of the twentieth century in the regions of Calabria and Lazio

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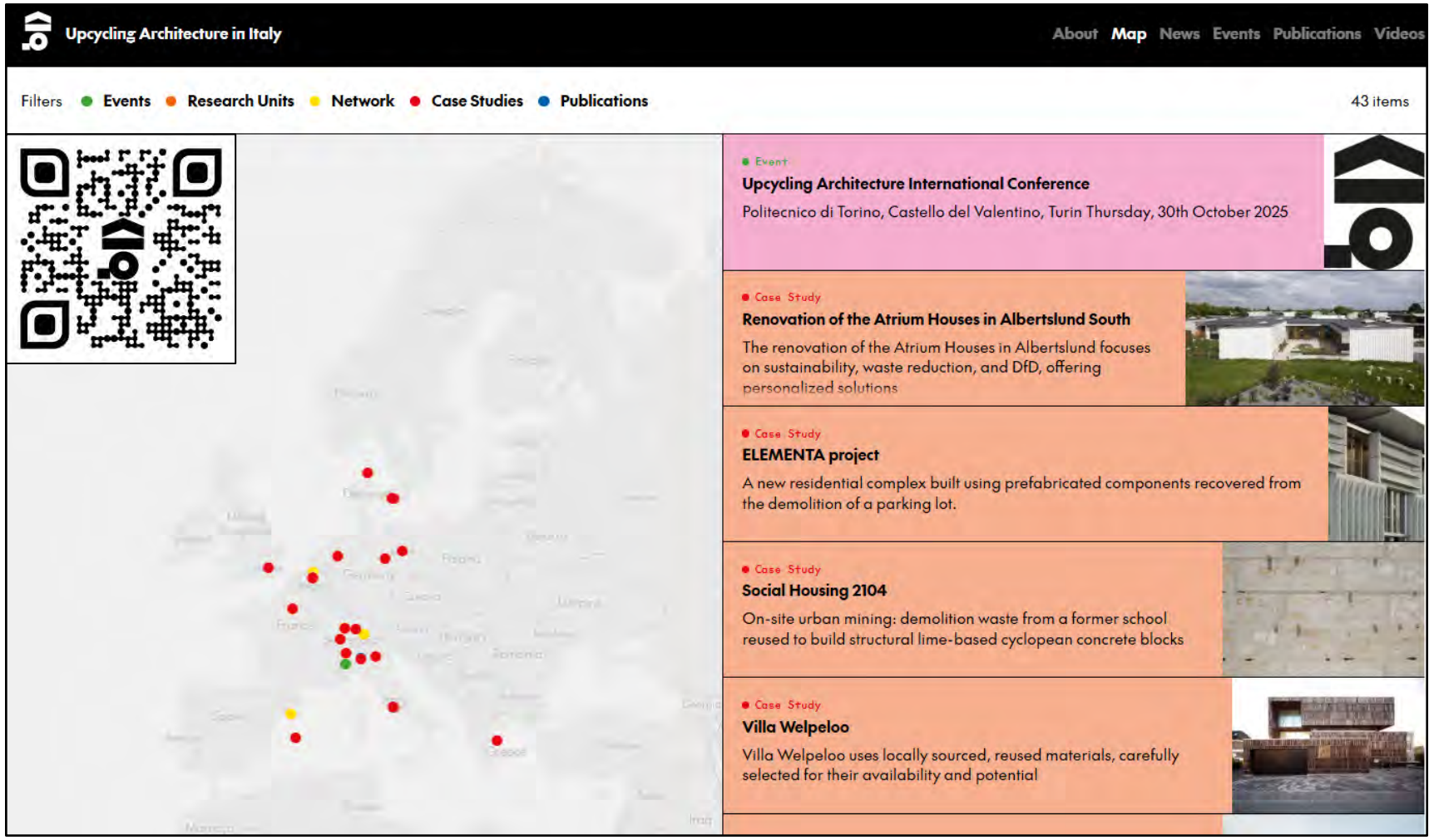
Ongoing Research Projects



PRIN 2022 PNRR funded by European Union – Next Generation EU

Upcycling Architecture in Italy. Forging and Promoting a Renewed Building Culture

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Main goal

- Develop novel path for the actual management and maintenance of prefabricated building heritage (according to the circular economy and heritage preservation);
- Promote disassembly and reuse within heritage preservation and adaptive reuse strategies;

Tools

- BIM-GIS platform for the documentation of the prefabricated building of the late 20th Century;
- BIM-based approach to support the evaluation of the potential disassembly and re-use of the building components;

Method

Phase 1

•Data-mining about main construction systems catalogue of existing buildings at a Regional scale webGIS platform to collect and organize data;

Phase 2

•BIM-based analyses of selected case study assessment of the potential disassembly.

Phase 3 (ongoing)

•Integration of LCA to develop a decisional framework by comparing multiple scenarios.

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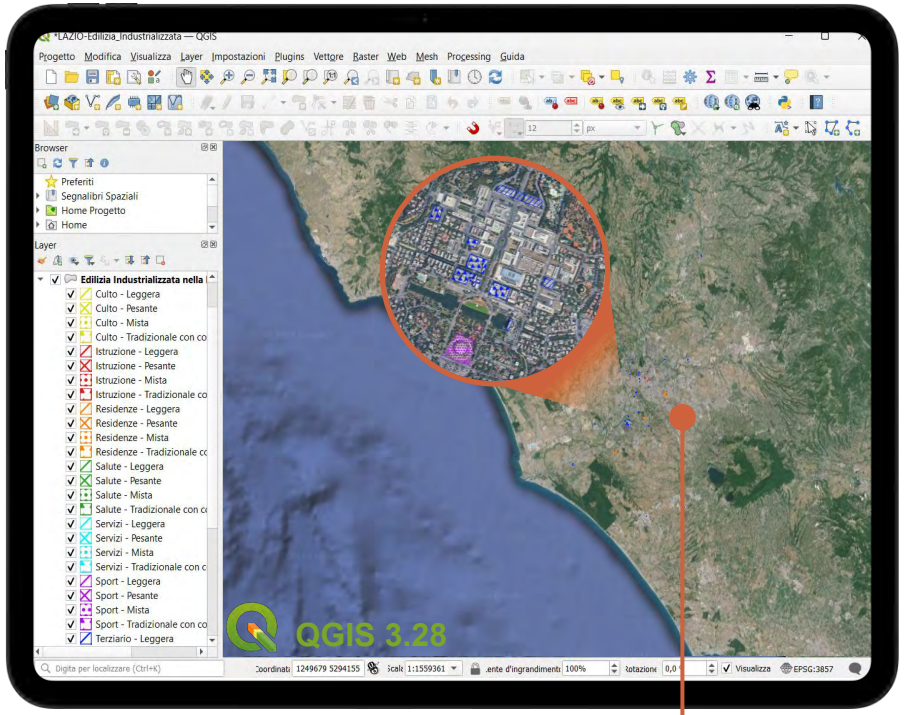
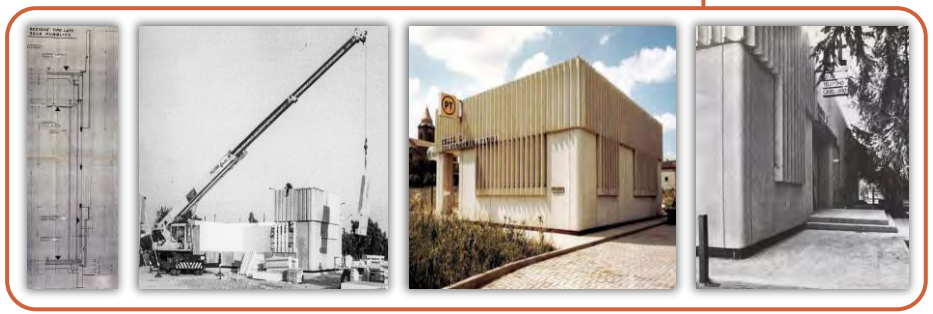
WebGIS to document the prefabricated building stock

Bibliographic sources

Archival sources





Linked documents

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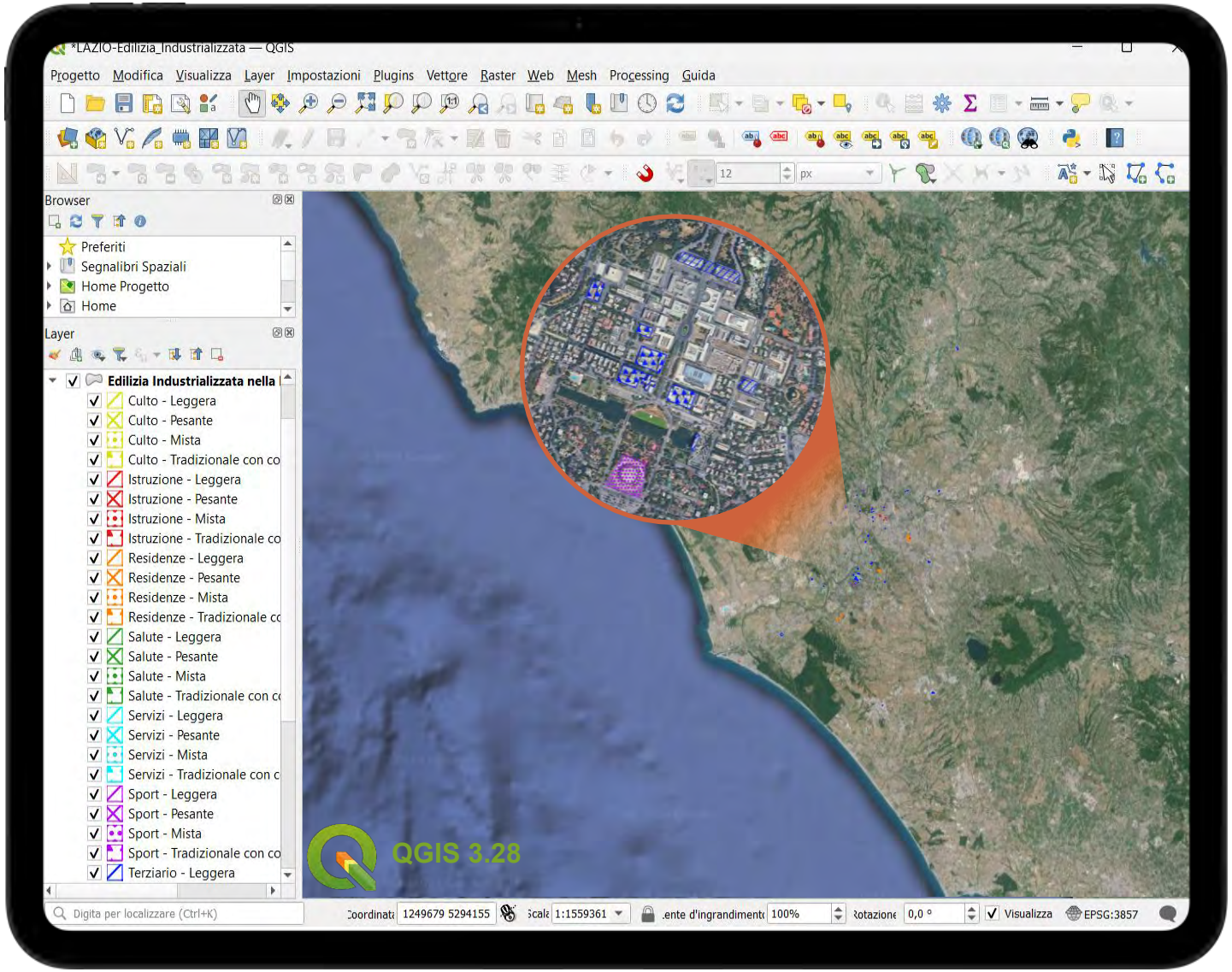

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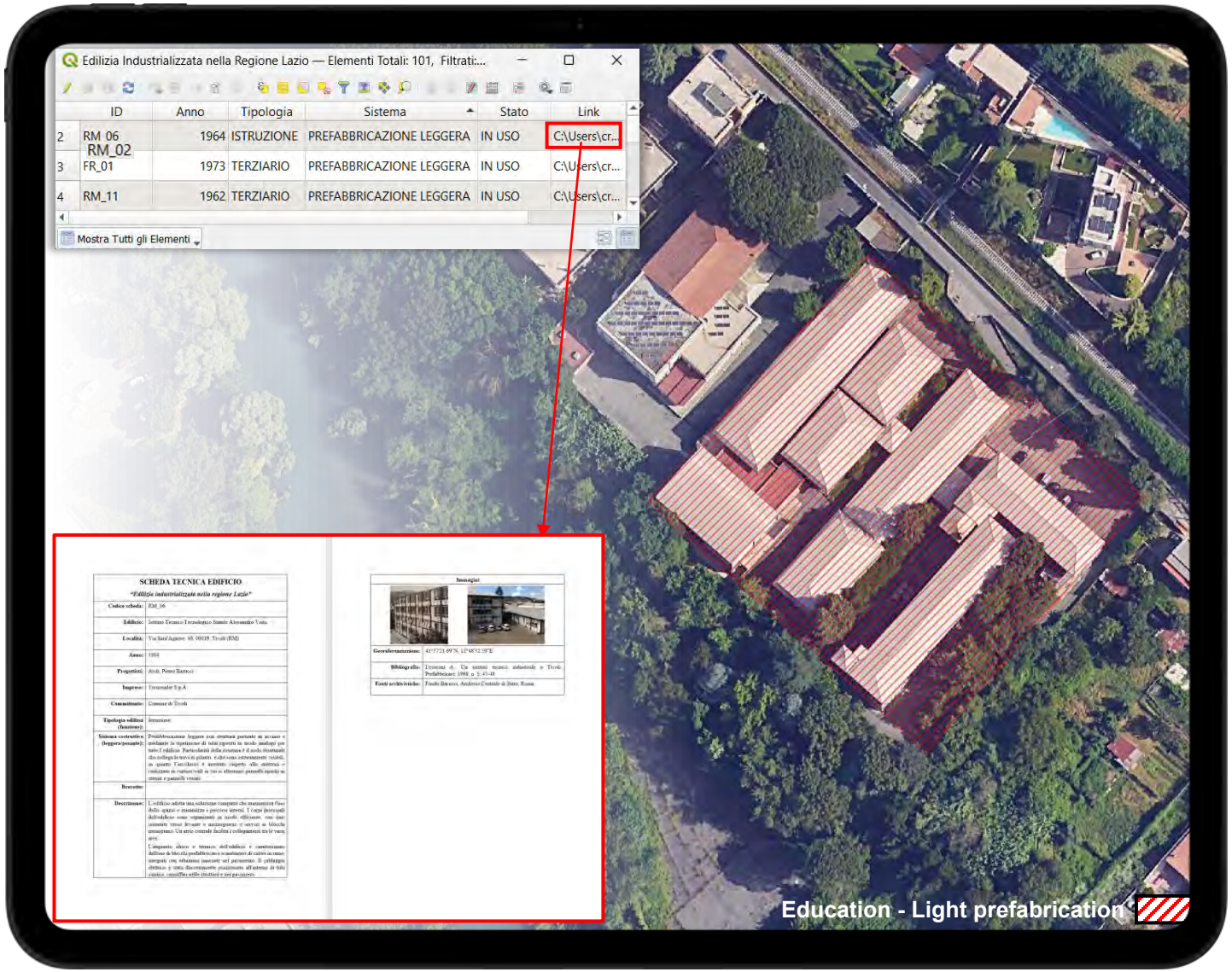

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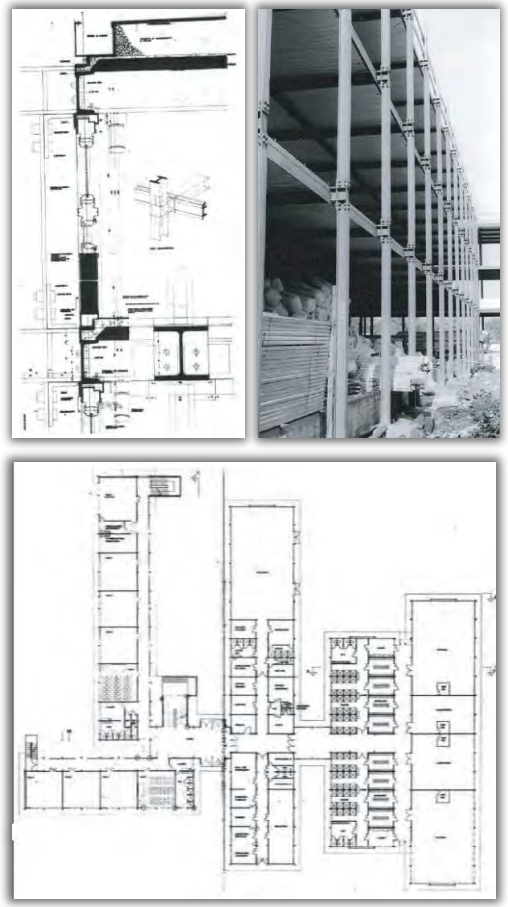
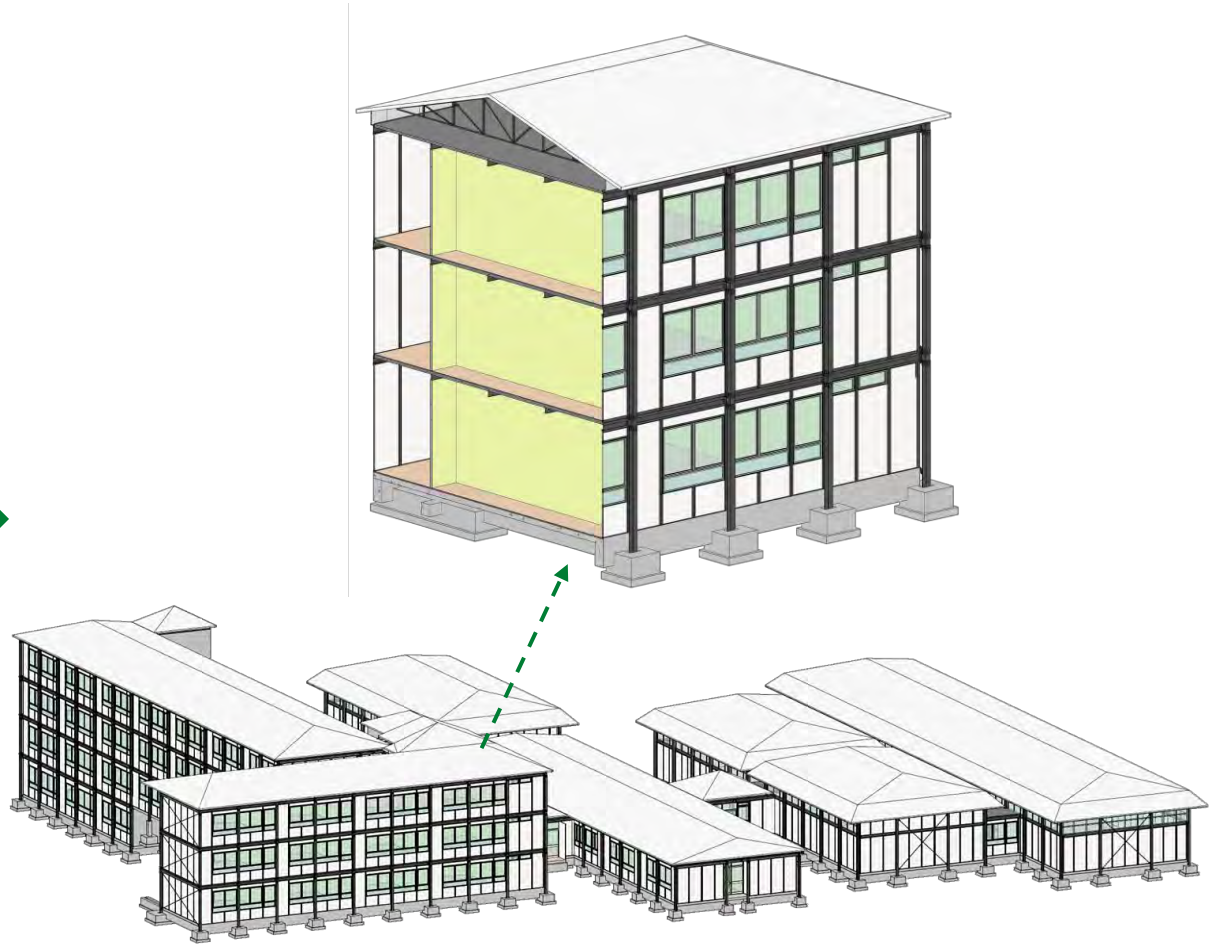
BIM-based analyses of a case study

The **construction of the BIM** exploiting philological approach → the model to collect and organise the historical and technical data framework derived from the analyses of the original design documents





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BIM-based analyses of a case study

The **update of the BIM** exploiting onsite survey → the model has been update to the actual state exploiting on-site survey

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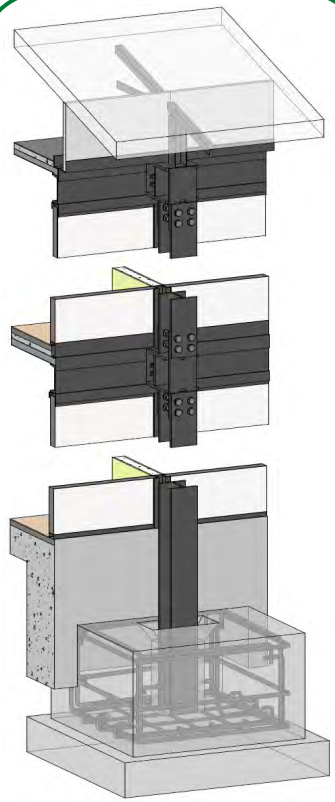
BIM-based analyses of a case study

The **use of the BIM** as an **analytical tool** to assess the potential disassembly→ for each building component, a set of disassembly parameters is coinceived (according to DfD ISO 20887:2020)

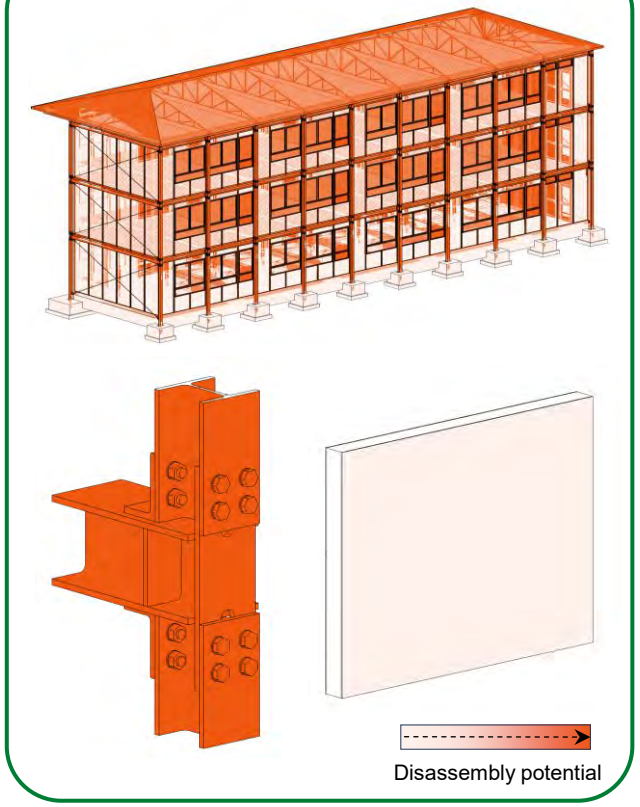
BIM (LOD G)



DISASSEMBLY PARAMETERS

Parameters Categories	Parameters	Definition	0 (low)	1 (medium)	2 (high)
Structure	Obsolence	Parameter calculated as the sum of the following 5 parameters that assess the obsolescence state of the element.	0-3	4-6	7-9
	Steelwork erected after 1970	Steel from 1970 was considered as part of the Eurocode programme and the development of product and design standards (SCI P427)	pre 1970	1970-2007	post 2008
	Significant section loss due to corrosion	Loss exceeding 5% of the element thickness is considered significant (SCI P427)	loss >5%	3-4%	0-2%
	Signs of fire exposure	Proven through a visual inspection. Components exposed to uncontrolled flames cannot be reused (SCI P427)	exposed	not exposed	
	Evidence of plasticity observed in the steel surface or corrosion protection	Proven through a visual inspection. Plasticized components cannot be reused (SCI P427)	>l/300	l/250<l <l/300	<l/250
	Steelwork subjected to fatigue	Knowledge derived from the history of the building. Components from bridges, cranes or those subjected to seismic actions cannot be reused (SCI P427)	seismic zone 3-4	seismic zone 2	seismic zone 1
	Safety of disassembly	Proven knowledge about the construction materials, identifying potential hazardous substances (ISO20887)	proven existence of hazardous substances (documentary basis)	visual ispection	proven absence of hazardous substances (documentary basis)
	Consistency of original design principle to DfD principle	Proven knowledge about the original design choice in terms of ease of access, independence, reversible connections	visual assessment of construction details	knowledge about the historical-technical context (literature)	proven knowledge about the original design choice (documentary basis)

DISASSEMBLY POTENTIAL



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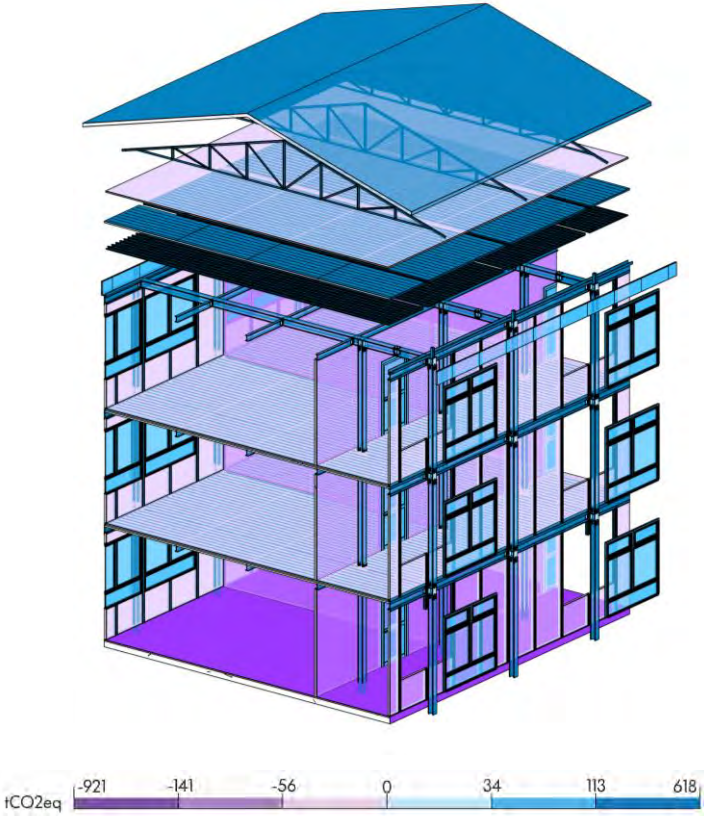
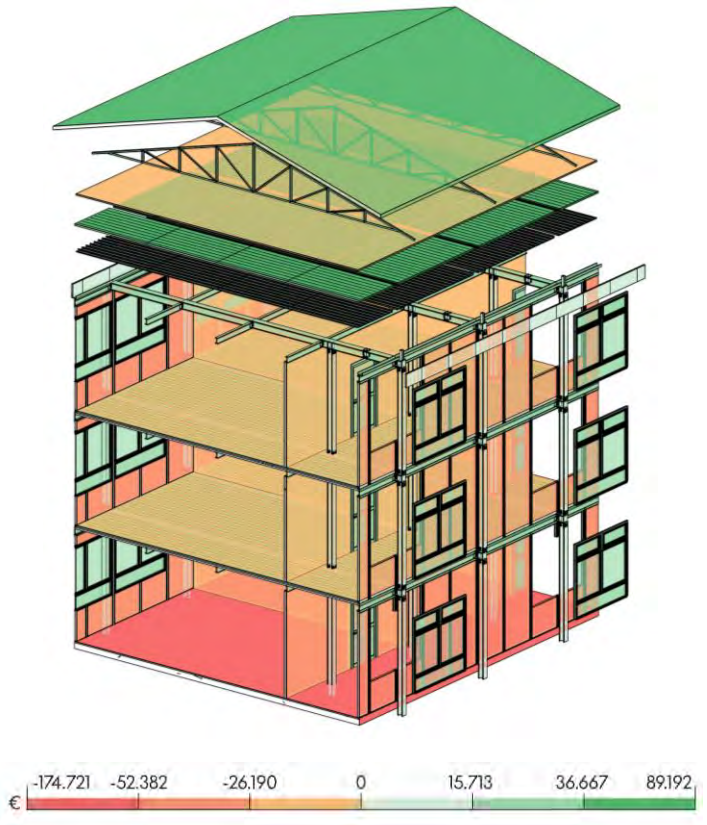
The **use of the BIM** as **tool for design future scenarios**

ECONOMIC AND FINANCIAL IMPACTS



Representation of tCO2eq emissions, in accordance with the Greenhouse Gas Protocol (GHG). The purple color indicates the emitted CO2eq, while the blue color represents the avoided CO2eq.



Representation of disposal costs associated with each construction element. Red indicates incurred costs, while green represents avoided costs.

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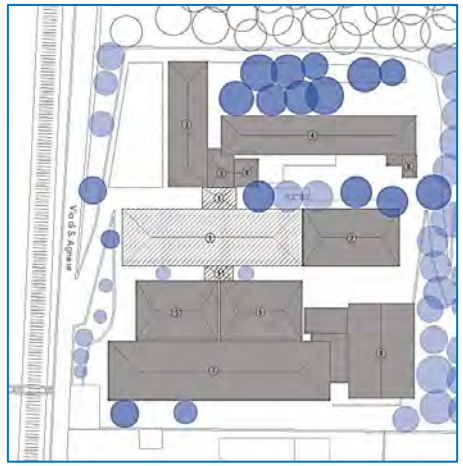
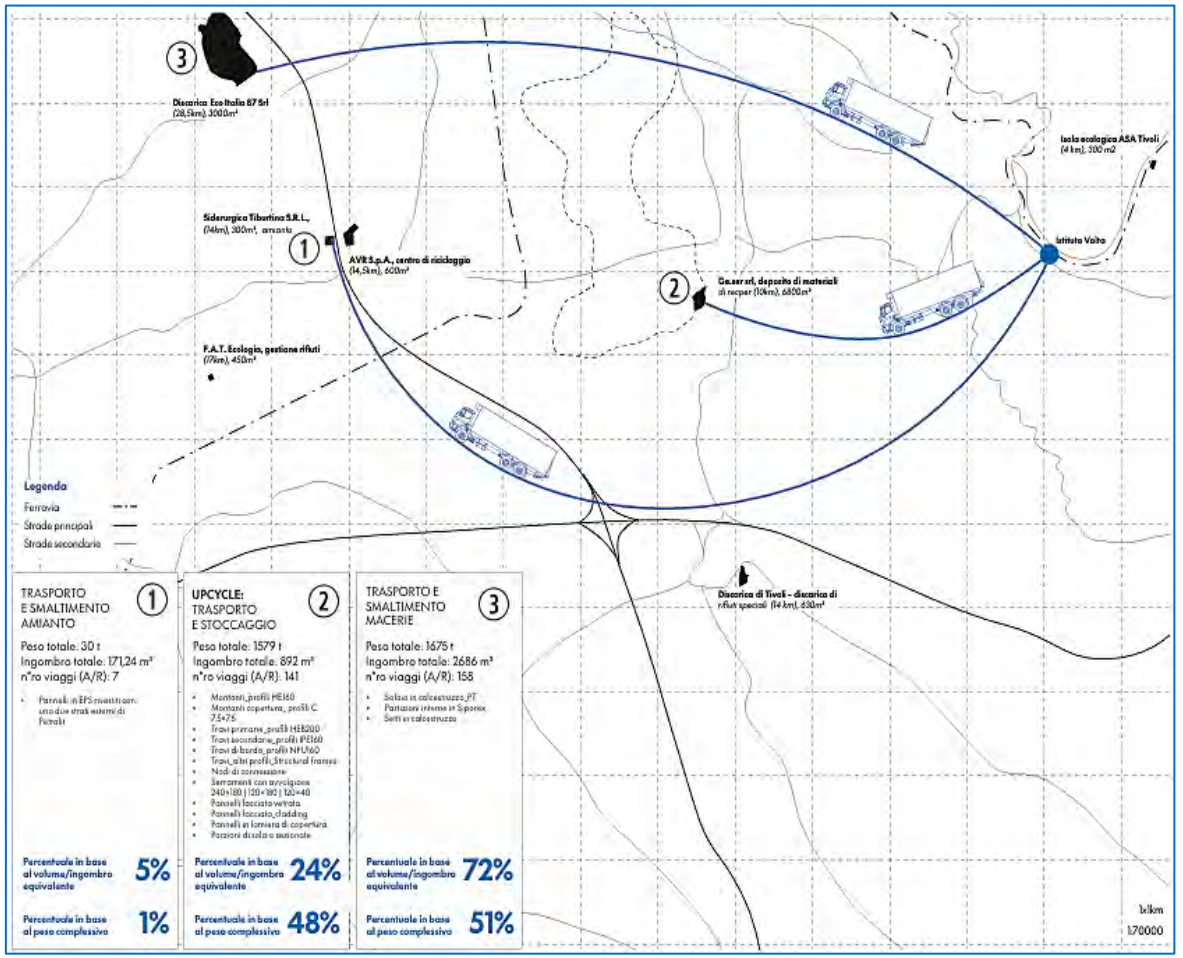
CONSTRUCTION SITE





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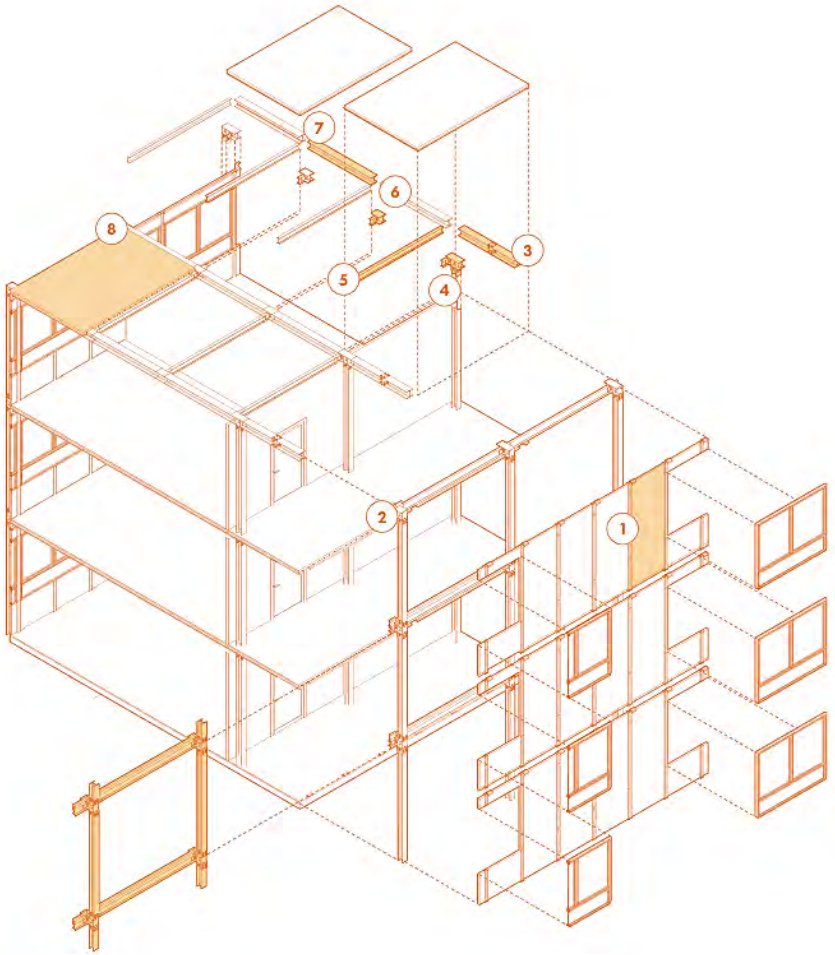
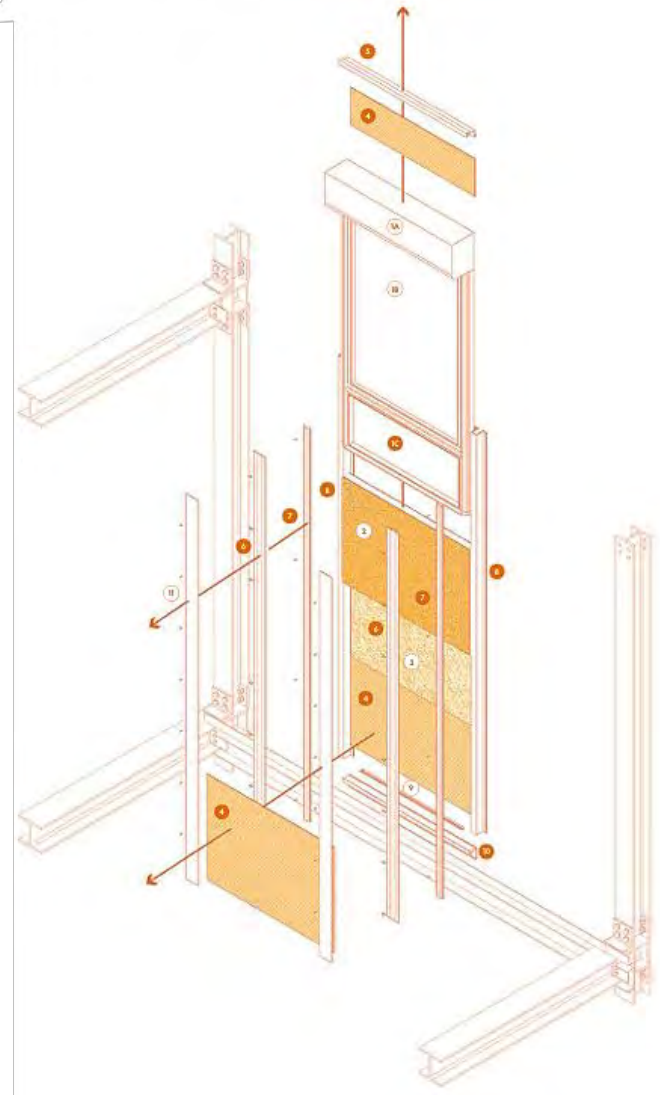
DISASSEMBLY PROCESS





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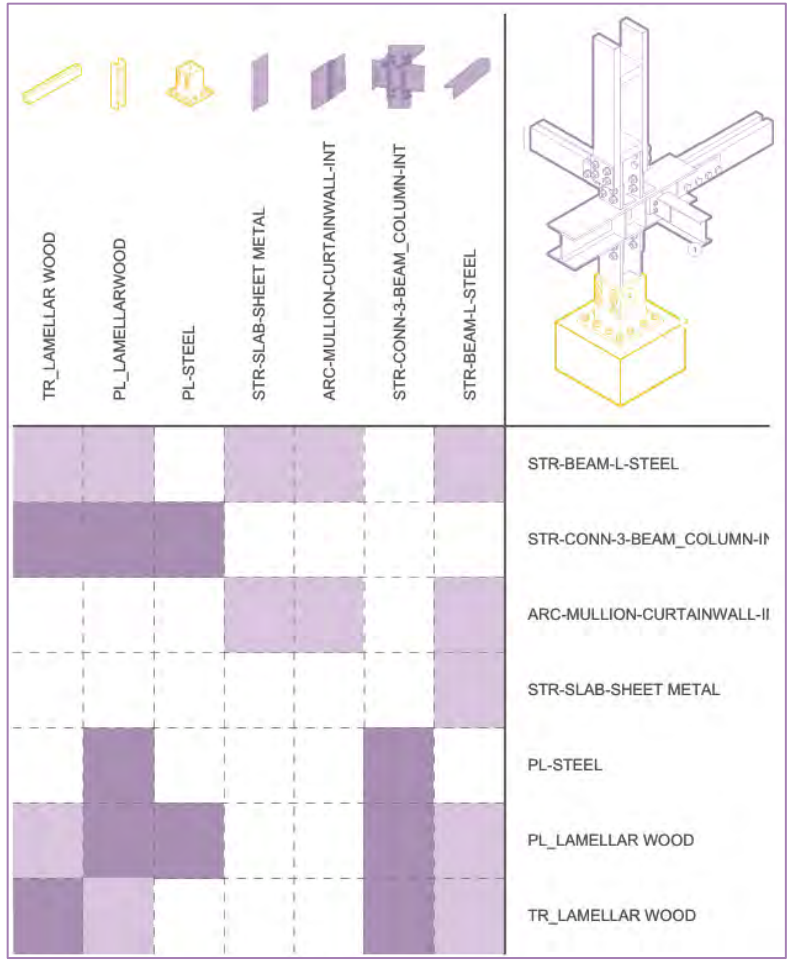
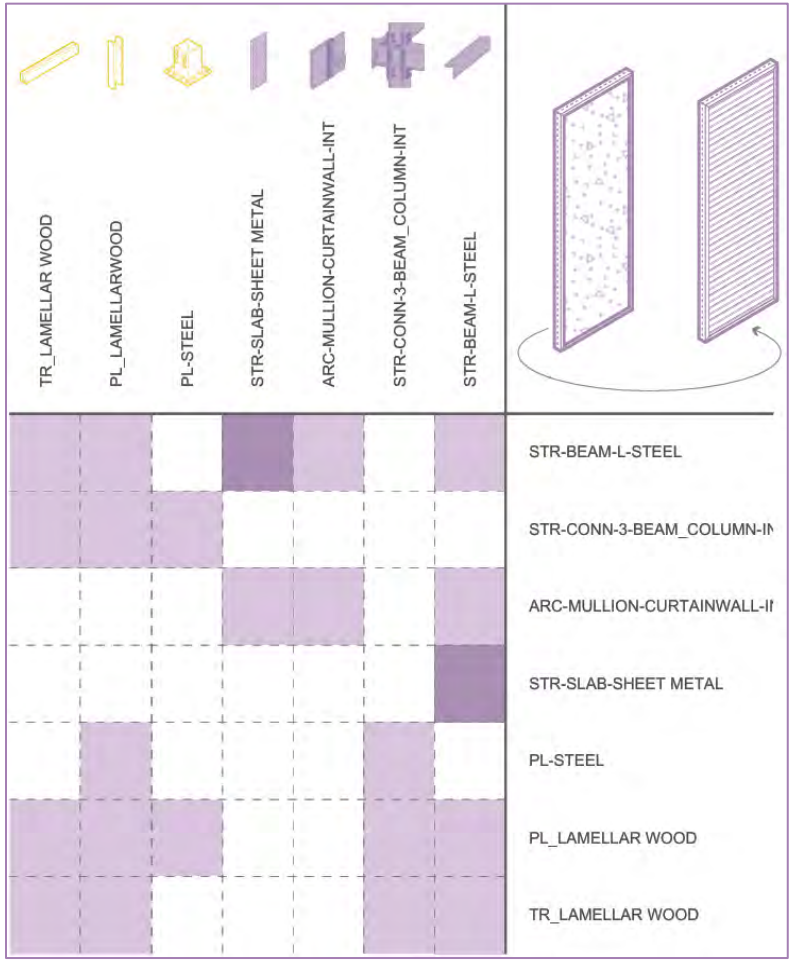
POSSIBLE RE-ASSEMBLY (RE-USE)





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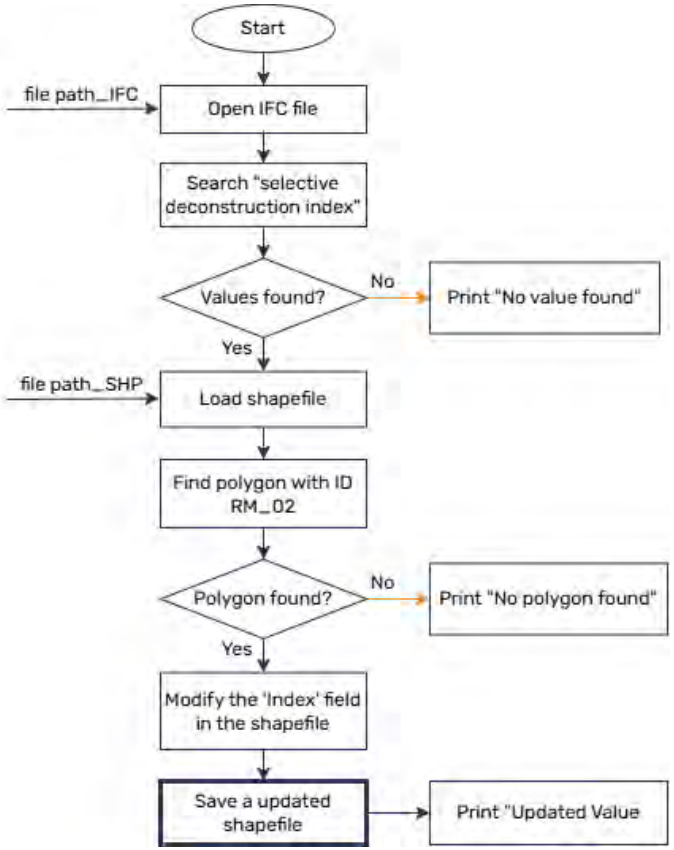
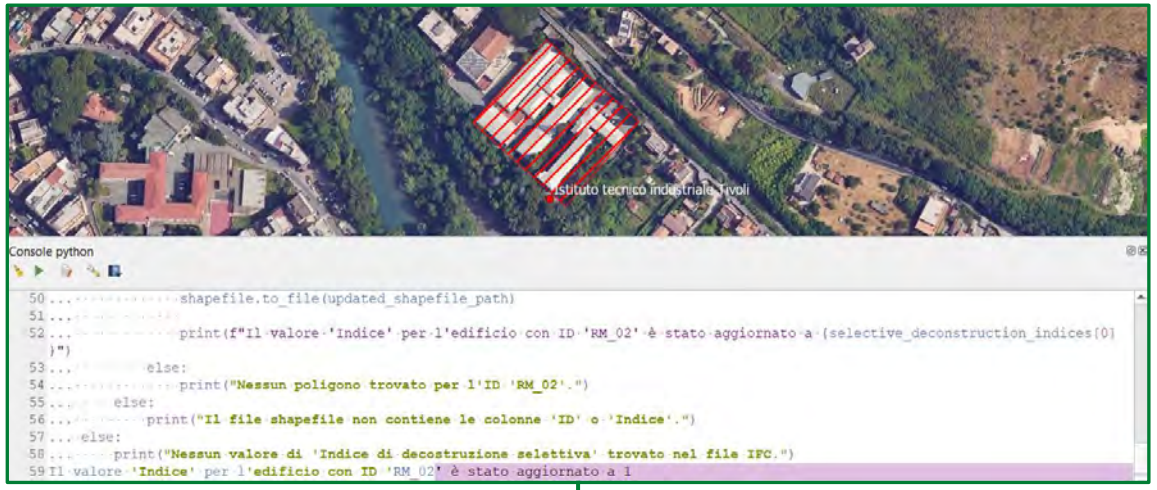
Integration of BIM results in the webGIS platform





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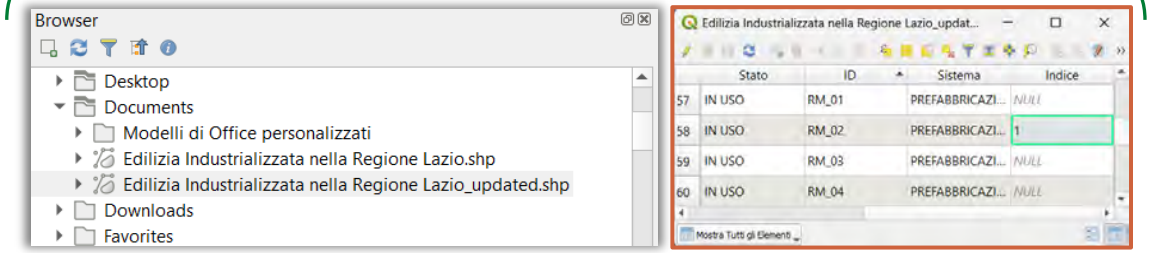

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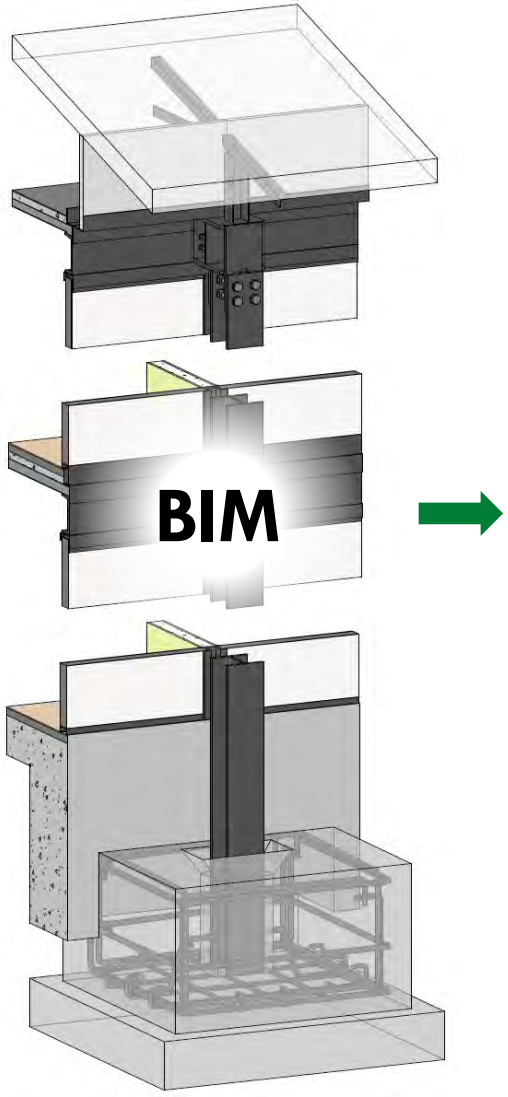
LCA-BIM based approach – Reuse Scenarios



3D-01 | LCA-17-materials

<LCA-17-materials>

A	B	C	D	E	F
Family	Type	Number	Material: Name	Material: Area (m²)	Material: Volume (m³)
Cast-In-Place Stair	Monolithic stair	5	Concrete	274,8173	18,2308
Floor	ARC-SLAB-FINISHING FLOOR	3	Concrete	1889,5596	56,6875
Floor	ARC-SLAB-FINISHING ROOF-	6	Concrete	2934,4163	88,0325
Floor	ARC-SLAB-FLOOR-200 mm	2	Concrete	3009,4525	496,5597
Foundation Slab	15 cm	2	Concrete	7,3350	1,1003
Monolithic Run	Structural deep 120 mm	5	Concrete	274,8173	18,2308
STR-BEAM-RECT-CONCRETE	15x30 cm	9	Concrete	7,9268	0,3558
STR-BEAM-RECT-CONCRETE	25x60 cm	6	Concrete	29,5300	2,0256
STR-BEAM-RECT-CONCRETE	35x35 cm	194	Concrete	970,6933	80,5675
STR-BEAM-RECT-CONCRETE	35x65 cm	47	Concrete	661,8352	67,3057
STR-FOUND-COLUMN-CONCRETE	35x35x30 cm	6	Concrete	3,9900	0,2205
STR-FOUND-COLUMN-CONCRETE	35x35x42 cm	21	Concrete	17,4930	1,0805
STR-FOUND-COLUMN-CONCRETE	35x35x100 cm	12	Concrete	19,7400	1,4700
STR-FOUND-COLUMN-CONCRETE	35x35x130 cm	6	Concrete	12,3900	0,9555
STR-FOUND-COLUMN-CONCRETE	35x35x168 cm	16	Concrete	41,5520	3,2928
STR-FOUND-COLUMN-CONCRETE	35x35x190 cm	10	Concrete	29,0500	2,3275
STR-FOUND-COLUMN-CONCRETE	35x35x198 cm	8	Concrete	24,1360	1,9404
STR-FOUND-COLUMN-CONCRETE	35x35x220 cm	2	Concrete	6,6500	0,5390
STR-FOUND-COLUMN-CONCRETE	35x35x278 cm	12	Concrete	49,6440	4,0866
STR-FOUND-COLUMN-CONCRETE	35x35x308 cm	8	Concrete	36,4560	3,0184
STR-FOUND-COLUMN-CONCRETE	35x35x398 cm	18	Concrete	104,7060	8,7759
STR-FOUND-COLUMN-CONCRETE	35x35x410 cm	8	Concrete	47,8800	4,0180
STR-FOUND-COLUMN-CONCRETE	35x35x440 cm	2	Concrete	12,8100	1,0780
STR-PLINTH-CONCRETE	Type A	62	Concrete	396,7558	34,8502
STR-PLINTH-CONCRETE	Type B	136	Concrete	1257,9031	129,4856
STR-PLINTH-CONCRETE	Type D	1	Concrete	20,7993	2,7221
STR-PLINTH-CONCRETE-E_F	Type E	3	Concrete	118,7957	16,9806
STR-PLINTH-CONCRETE-E_F	Type F	21	Concrete	593,0101	74,1762
STR-PLINTH-STAIRS-CONCRETE	Type stairs	2	Concrete	68,5600	8,2320
Concrete: 651				13258,1711	1178,6660

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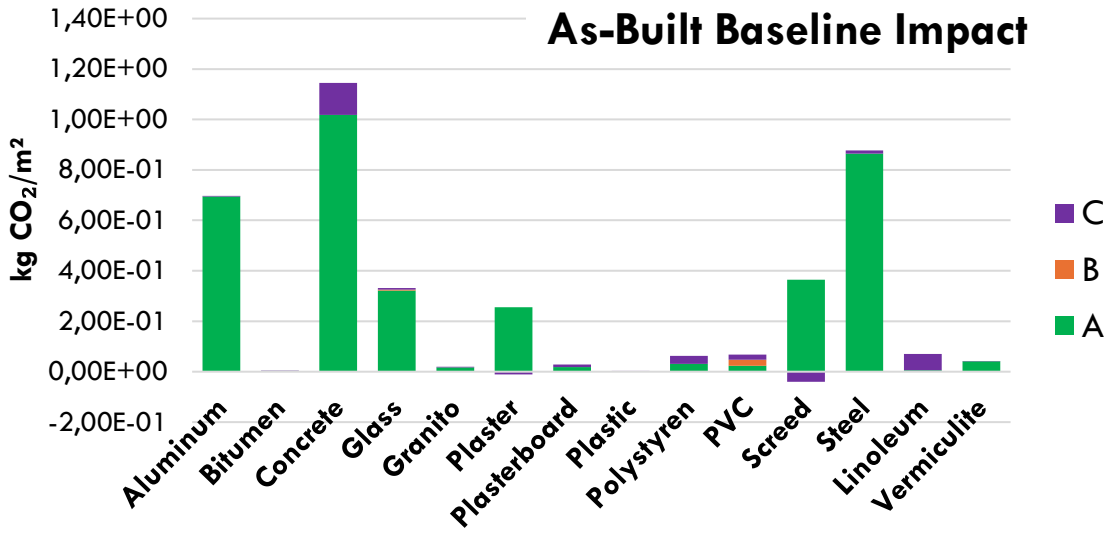
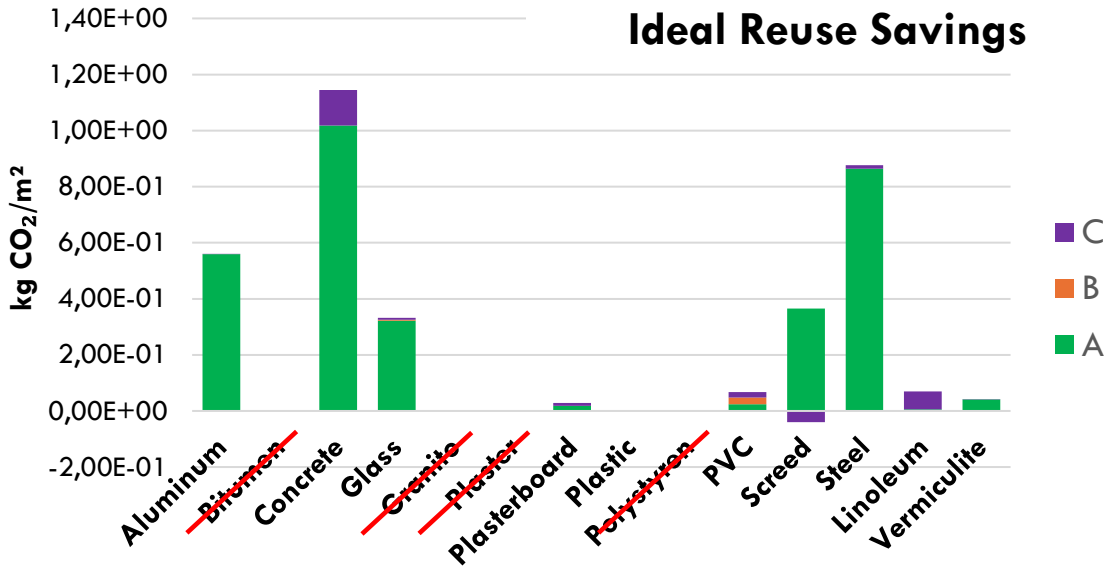
LCA-BIM based approach – Reuse Scenarios



3,91E+00	A	B	C
Aluminum	6,95E-01	0,00E+00	1,96E-03
Bitumen	3,54E-03	0,00E+00	7,88E-05
Concrete	1,02E+00	0,00E+00	1,26E-01
Glass	3,22E-01	2,94E-03	7,11E-03
Granito	1,72E-02	0,00E+00	2,26E-03
Plaster	2,56E-01	0,00E+00	-1,15E-02
Plasterboard	1,86E-02	0,00E+00	9,51E-03
Plastic	1,24E-03	0,00E+00	3,75E-06
Polystyren	3,04E-02	0,00E+00	3,22E-02
PVC	2,38E-02	2,38E-02	1,99E-02
Screed	3,65E-01	0,00E+00	-3,97E-02
Steel	8,64E-01	0,00E+00	1,26E-02
Linoleum	6,02E-03	0,00E+00	6,39E-02
Vermiculite	4,09E-02	0,00E+00	1,22E-03



3,45E+00	A	B	C
Aluminum	5,87E-01	0,00E+00	1,65E-03
Bitumen	0,00E+00	0,00E+00	0,00E+00
Concrete	1,02E+00	0,00E+00	1,26E-01
Glass	3,22E-01	2,94E-03	7,11E-03
Granito	0,00E+00	0,00E+00	0,00E+00
Plaster	0,00E+00	0,00E+00	0,00E+00
Plasterboard	1,86E-02	0,00E+00	9,51E-03
Plastic	1,24E-03	0,00E+00	3,75E-06
Polystyren	0,00E+00	0,00E+00	0,00E+00
PVC	2,38E-02	2,38E-02	1,99E-02
Screed	3,65E-01	0,00E+00	-3,97E-02
Steel	8,64E-01	0,00E+00	1,26E-02
Linoleum	6,02E-03	0,00E+00	6,39E-02
Vermiculite	4,09E-02	0,00E+00	1,22E-03

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Next points

- Compare different reuse scenarios in order to define a decisional framework and method;

I	II	III
ADAPTIVE REUSE (Renovation)	**PARTIAL REUSE + MARKET**	**RELOCATED ADAPTIVE REUSE (Renovation)**
Position On-site	**Position** On-site	**Position** Suggested site
Structure Structural retrofitting	**Structure** Structural design	**Structure** Structural retrofitting
Skin Skin renovation (new)	**Skin** New skin design	**Skin** Skin renovation (new)

- extend the integration of parameters to include those most relevant to selective deconstruction and Life Cycle Assessment (LCA) into the webGIS platform
- develop an optimized workflow for data exchange and platform integration
- validate the method with other case studies (on going – post offices, more than 1000 in Italy)

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Personal introduction

Projects

Research objectives

What has been done

What will be done

Publications

Cristian Tolù

Publications

ReUSO 2024

XII° ReUSO Edition
Documentation, Restoration and Reuse of Heritage
Bergamo, Italy
29-31 October 2024

Valorizzare il patrimonio della prefabbricazione leggera in Italia: una piattaforma digitale a supporto della "decostruzione selettiva"

Enhancing the heritage of light prefabrication in Italy: a digital platform to support "selective dismantling"

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Abstract: This paper focuses on the design and test of an experimental digital platform aimed at managing 20th-century industrialized buildings, especially those featured by the adoption of light prefabrication systems, supporting the innovative approach of "selective dismantling" and the reuse of building components. The platform integrates Geographic Information System (GIS) technology with philological Heritage Building Information Modeling (HBIM) procedures. The prototype is tested on the case study of the industrialized building stock of the Lazio Region in Italy, providing an insight into the full functionalities of industrialized school buildings of the 1960s, featuring load-bearing steel structures and light panels. The study remarks on how the platform effectively organizes and displays the historical-technical data derived from bibliographic analyses, supporting the technically and historically consistent preliminary assessment of the buildings in terms of selective dismantling" and reuse of building components.

Keywords: Upcycling, Building Industrialization, BIM, GIS

1. Introduzione

In Europa, nella seconda metà del Novecento, la prefabbricazione è lo strumento per affrontare le esigenze di una rapida urbanizzazione, attraverso l'industrializzazione edilizia. Oggi, la maggiore parte degli edifici prefabbricati, costruiti tra il 1950 e il 1980, sebbene all'avanguardia all'epoca [1,2], non è più rispondente alle necessità d'uso: il patrimonio della costruzione industrializzata rappresenta, quindi, un'importante settore per l'applicazione dei processi, innovativi e sperimentali, di riqualificazione del costruito.
Alla luce delle più attuali direttive in materia di sostenibilità ambientale e di economia circolare, i processi di gestione e riqualificazione del costruito comprendono anche le pratiche di "decostruzione selettiva", riuso e riciclo delle componenti edilizie [3,4]: il patrimonio della costruzione industrializzata del secondo Novecento – rispondendo ai criteri di standardizzazione, coordinamento modulare e assemblaggio – si presta particolarmente all'applicazione massiva di tali processi di decostruzione, smontaggio e riuso. In particolare, il segmento della costruzione industrializzata caratterizzata dall'applicazione di tecniche di

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PRIN PNRR 2022

Upcycling Architecture in Italy

Design Workshop
Risultati
Results

a cura di/edited by:
Alberto Bologna
Josep Maria Garcia-Fuentes
Ilaria Giannetti
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Roberto Germanà

BSA 2024

Building Information Modeling (BIM) and Building Energy Modeling (BEM): Interoperability and Interactive Data Representation for the Energy Management of the Existing Buildings

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Abstract
The text discusses the potential for energy efficiency improvements in existing buildings, emphasizing the importance of digital modeling and Building Performance Simulation (BPS) methods to achieve Net Zero Energy Building (NZEB) standards. The integration of Building Information Modeling (BIM) and Building Energy Modeling (BEM) approaches is highlighted as crucial for enhancing energy efficiency. The proposed workflow involves four steps: i) collection of building data throught documental analysis and on-site surveys; ii) the construction of a BIM model and its production in Industry Foundation Classes (IFC) standards, including thermo-physical parameters; iii) the developing the BEM model; iv) the creation of a Virtual Reality (VR) interactive environment. The methodology is tested on an office building at the University of Rome Tor Vergata, built in the 1980s. Key outcomes include verifying data interoperability, optimizing energy simulation processes, and enabling interactive exploration of energy data through VR techniques. This integrated approach reduces errors, time, and costs, while also serving as a decision-making support tool for building managers and an educational tool for energy design awareness. The study presents a scalable workflow for energy building management and lays the groundwork for innovative digital twin development for buildings and structure.

1. Introduction

In Europe, the 20th Century existing buildings stock, constructed using industrial-derived techniques and materials, need to undertake massive assessment of the energetic performances. Looking to Italy, the 75% of residential sector building stock was constructed before the 2000, avoiding detailed consideration about energy consuptions, and only the 2% was built after the 2010, according to recent environmental criteria (Gevorgian et. al, 2021). The enanchment of the energy performance of this buildings stock – achieving Net Zero Energy Building (NZEB) standards (European Commission, 2020) – can significanly contribute to global efforts to mitigate climate change (Fonseca Arenas, 2024).
This pursuit represents a significant research endeavor and requires a multidisciplinary approach and a continuous updating of research tools.
In particular, the process benefits from the combination of a solid knowledge base of the building, obtained through documental analysis and on-site surveys, with advanced digital modelling, to organize information, to support Building Performance Simulation (BPS), and to facilitate the visualization of data. In this field, one promising approach is the integration of Building Information Modeling (BIM) and Building Energy Modeling (BEM) methodologies (Spiridigliozzi, 2019). By combining these approaches, we can leverage the wealth of building technology data provided by BIM with the detailed energy simulation capabilities of BEM. This integration allows for a holistic assessment of a building's energy performance and facilitates informed decision-making throughout the design,