

Design for Disassembly as a Circular Building Design Strategy: Environmental, Economic and Social assessment for residential buildings

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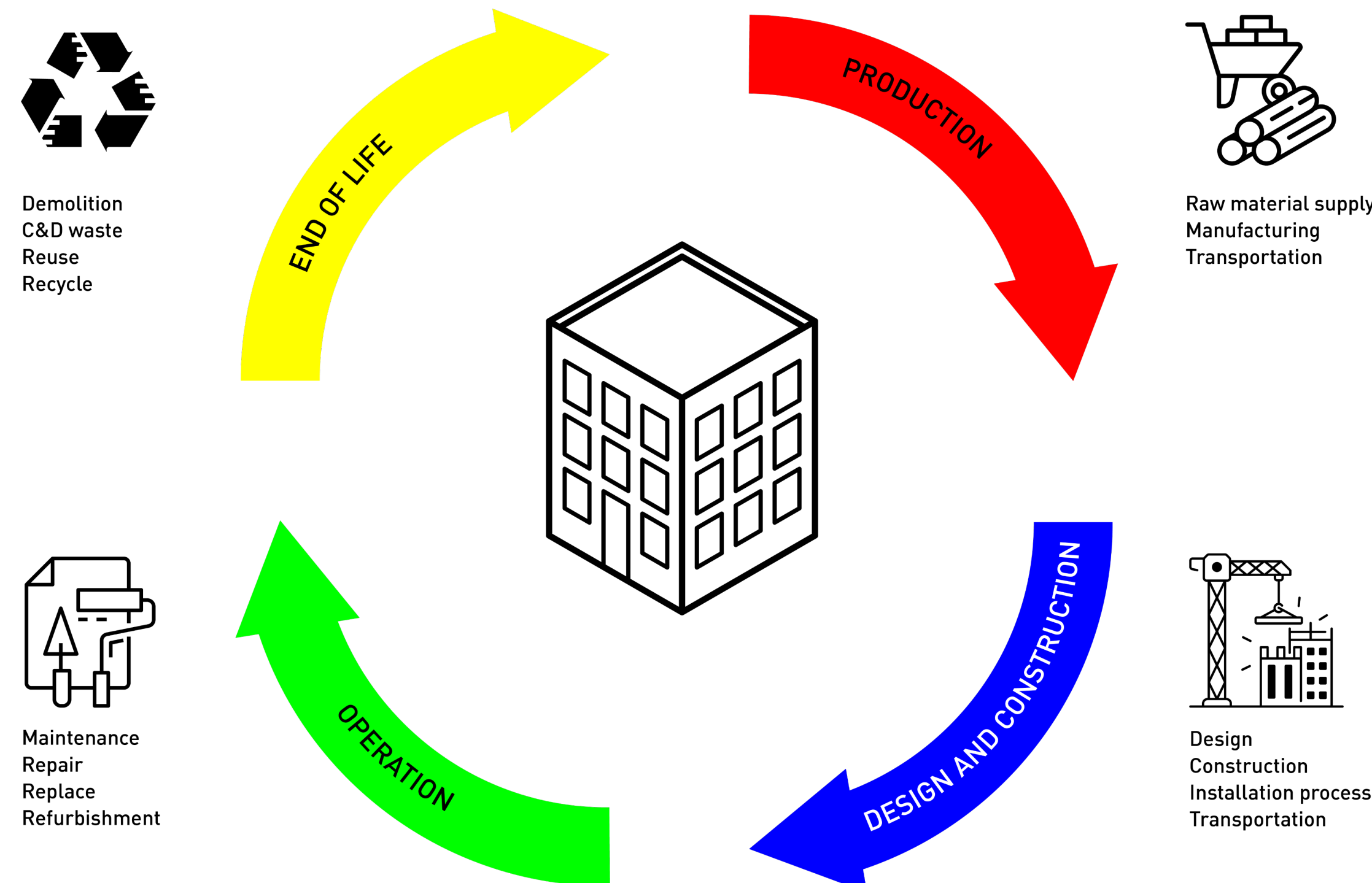
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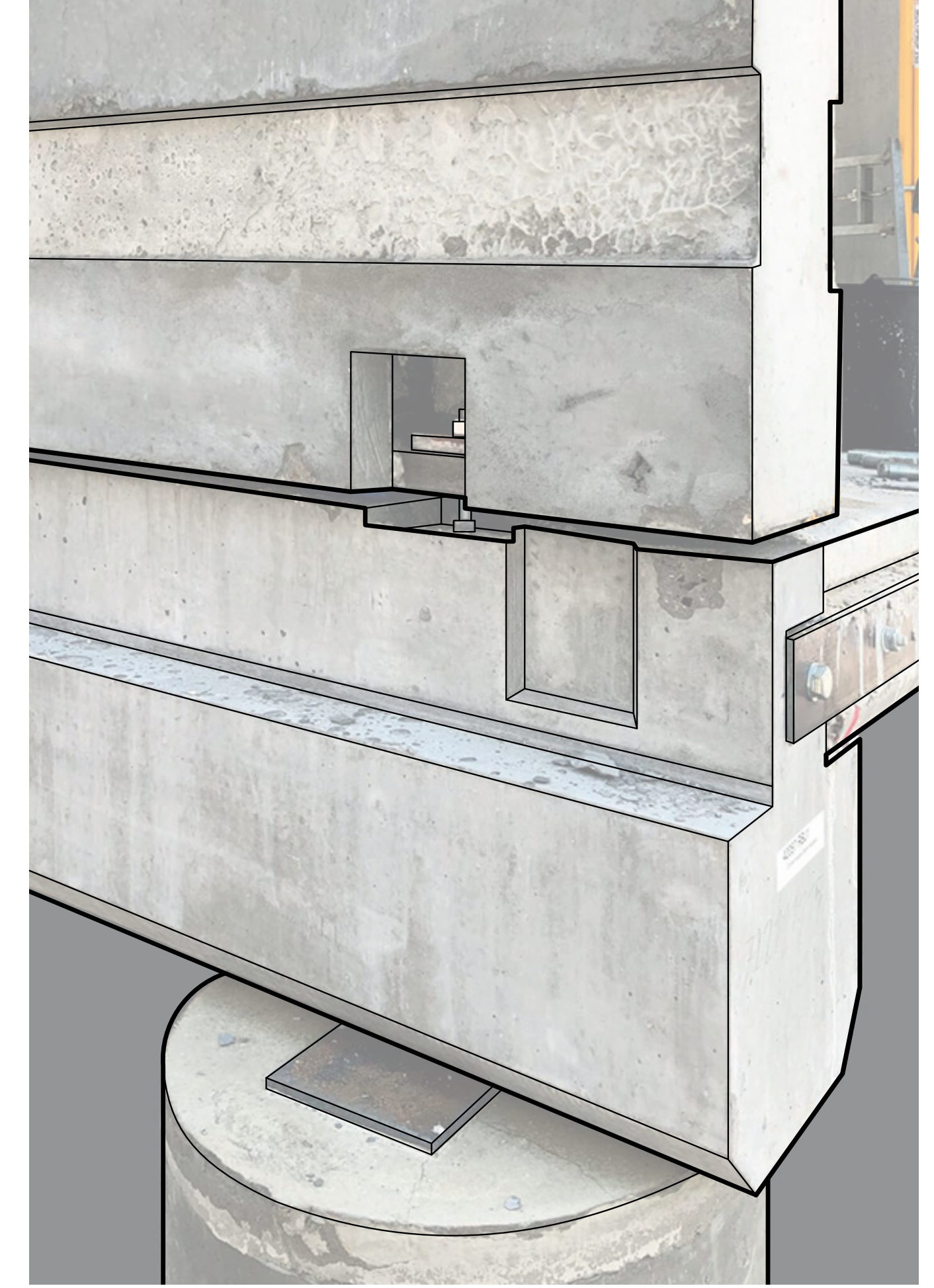
1. Background

The building and construction sector accounts for about **37%** of global **CO₂ emissions**, **25%** of global **waste generation**, and **30%** of global **raw material extraction**. As a result, this sector has a **significant impact** on the environment. Given the goals set out in the Paris Agreement for **decarbonization** and raw material extraction, introducing the **Circular Economy (CE)** to the building and construction sector can reduce its environmental impact. At the European level, CE is promoted by the **Circular Economy Action Plan**, which is a component of the **European Green Deal**. **Circular Economy practices** (Reuse, Recycle, Repurpose, Reduce, etc.) can be applied throughout all stages of the building life cycle, from the production of materials and components to the end-of-life phase. The **design phase** of a building is crucial as the choices made in this phase determine the majority of its impacts. A design approach based on **circular economy principles** facilitates the recovery of resources, reducing both environmental impact and costs. For example, among the **circular design strategies**, **Design for Disassembly (DfD)** is gaining momentum. It is a strategy that relies on **dry connections and prefabrication**, allowing for the **complete disassembly** of building components without damaging them. However, there is a lack of empirical studies about the impact of DfD on **environmental, economic, and social sustainability** of buildings. Environmental assessments have been conducted, but results are heterogeneous, and not comparable. Economic and social assessments have been largely unaddressed.

Building Life Cycle



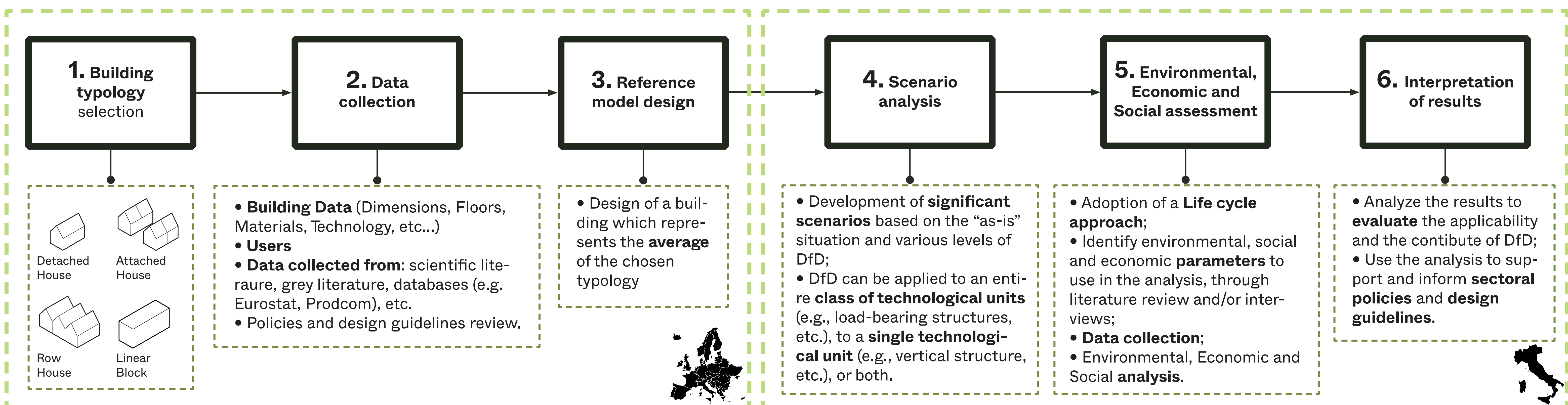
Graphic elaboration by G. Montalbano



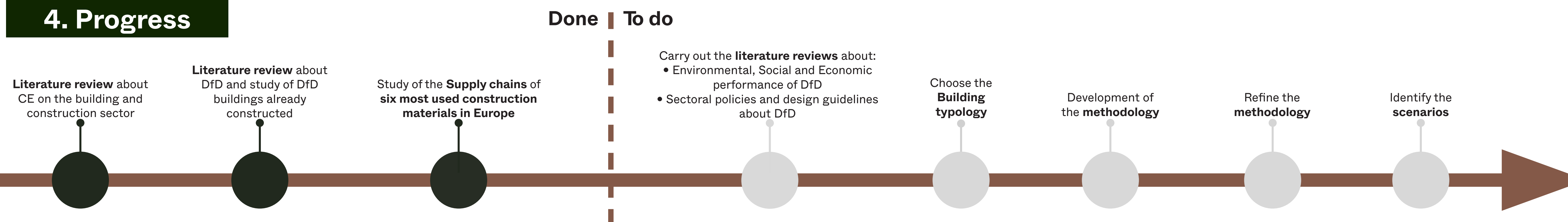
2. Objectives

- To understand the current and potential application of **Design for Disassembly** strategy and its contribution to the **Environmental, Economic and Social** performance of residential buildings design.
- To support and inform **sectoral policies and design guidelines**.

3. Research Design



4. Progress



5. Complementary activities

CO₂NSTRUCT - Modelling the role of circular economy construction value chains for a carbon-neutral Europe research project funded by the European Union's Horizon Europe research and innovation programme

- Study of the Supply chain of six construction materials
- Application of CE practices in the production of materials

Research on **bio-based materials** and their application in constructions

- Focus on **Raw Earth**;
- Study of the **Rammed Earth** construction technique;
- Environmental sustainability evaluation

Research on **temporary housing units in post-disaster scenarios**

- Focus on the **sustainability** of temporary housing units;
- Study of the **relation** between Design for Disassembly, Circular Economy and temporary housing units.

6. Activities and Publications

Educational Activities: courses and seminars

- English for Research Publication and Presentation Purposes | 30 h | Johanne Spataro | CLI UNIPI
- 3D surveying and semantic digital modeling: scan-to-bim and artificial intelligence | 10 h | Valeria Croce | DESTeC UNIPI
- Conservation of the 20th Century industrial heritage: a research project about the grain silos from the Thirties in Italy | 8 h | Stefania Landi | DESTeC UNIPI
- Sustainable actions for built heritage | 4 h | Veronica Vitello | DESTeC UNIPI
- Tutoring and supplementary teaching activities**
- UNIPI | Fondo Giovani academic year 2022/2023 | Course: Laboratorio Integrato di Progettazione Architettonica 2 | Module: Architettura Tecnica 2 | Prof. Giovanni Santi | 15 h
- UNIPI | Fondo Giovani academic year 2023/2024 | Laboratorio Integrato di Progettazione Architettonica 2 | Module: Architettura Tecnica 2 | Prof. Giovanni Santi | 10 h
- ENA Marrakech | academic year 2023/2024 | Course: Architecture et techniques pour la construction durable | Prof. Giovanni Santi
- ENA Marrakech | academic year 2022/23 | Workshop "Architecture and Light Technologies in the Digital Era" | 22-26 May 2023 | Prof. Giovanni Santi | 15 h
- International Summer School "The City and the Water: Floating architecture. Architectural and landscape design for the valorisation of the waterfront of Pisa" | 31 August - 9 September 2023 | Prof. Giovanni Santi | 10h

Conferences

- FORTMED International conference on Fortifications of the Mediterranean Coast | Pisa, 23-25 March 2023
- Colloqui.ATE 2023 In Transition: challenges and opportunities for the built heritage | Bari, 14-16 June 2023
- International Online Conference on Buildings Design, Construction, and Operation | Online, 24-26 October 2023
- The Future of Hides, a New Frontier: The Worldwide Development Of The Food Sector In A Synergic Connection With The Tanning Industries" | Milan, 18 September 2023

Publications

- Billi, D.; Croce, V.; Montalbano, G.; Rechichi, P. La Torre degli Upezzinghi a Caprona: analisi storico-archivistica e rilievo digitale per la documentazione dell'evoluzione temporale. In *Bevilacqua, M.G.; Ulivieri, D. Defensive Architecture of the Mediterranean. Proceedings of FORTMED 2023, Pisa, 23-25 March 2023*, Pisa, Pisa University Press, pp. 391-399.
- Montalbano, G.; Santi, G. Environmental sustainability of the building process: the F.A.D. method as a way of understanding best practices in circularity. In *Fatiguso, F.; Florito, F.; De Fino, M.; Cantatore, E. Colloqui.ATE 2023 In Transition: challenges and opportunities for the built heritage*, Bari, 14-16 June 2023, Bari, Edicom, pp. 1713-1728.
- Montalbano, G.; Santi, G. Lightweight Technologies in Sustainable Architecture: The Importance of Connections in Disassembly. *JCEA*, 2023, 17(2), (ANVUR Scientific Journal)
- Montalbano, G.; Santi, G. Creative Frugality as a Sustainable Circular Pattern in Architecture and Building Construction. | *Engineering Proceedings* | Accepted | To be published.
- Montalbano, G.; Santi, G.; Najem, K. Rammed earth construction: a circular solution for sustainable building | *LATAM ISEC proceedings* | Accepted | To be published.
- Montalbano, G.; Santi, G. Sustainability of Temporary Housing in Post-Disaster Scenarios: A Requirement-Based Design Strategy | *Buildings (ANVUR class A)* | Under review.