POLITECNICO DI MILANO

Scuola di Architettura Urbanistica Ingegneria delle Costruzioni

Laurea Magistrale – Management of Built Environment

POLITECNICO
MILANO 1863

ENHANCING THE CIRCULAR ECONOMY IN THE CONSTRUCTION SECTOR:

ASSESSMENT OF THE REUSE AND REMANUFACTURING PLAYERS AND APPLICATION TO THE CASE OF OFFICE FIT-OUT

MASTER THESIS

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Academic Year 2022-2023

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Abstract

The circular economy has been presented for more than a decade as the effective way to transform our current linear economic model which consumes non-renewable natural resources and generates waste that the environment struggles to absorb. The construction sector in Europe is one of the largest participants in this model and its transition to circular practices is necessary to meet the waste reduction targets set by EU Member States.

The circular economy in construction and the built environment can be summed up in five words: reduce, reuse, remanufacture, recycle and recover. Nevertheless, the traditional players in the sector are struggling to apply these new principles promoted by the evolution of regulations but blocked by economic, managerial, technical and cultural barriers. Thus, for the past ten years, start-ups and other players have emerged to support the sector towards the massification of circular practices, and especially those of reuse and remanufacturing.

In this thesis, 27 players operating in Western and Northern Europe have been analysed, regarding their organization and the range of services and activities they offer. This analysis resulted in a list of 74 activities related to reuse and remanufacturing practices, including still marginal but innovative services, structured according to their function (consultancy, operations, digital, education). In addition, six categories of actors have been defined according to the nature of the services they offer, and a template has been developed to assess potential new players. All together, the circular economy and reuse players form a local ecosystem able to support traditional players in the management of circular projects.

Nowadays, those local ecosystems, with the services they provided and the type of products they deal with, are best suited to support office fit-out projects. Then, in the last part of the study, starting from the description of a traditional office fit-out management route, a new chronology integrating circular economy and reuse concepts is proposed. Based on the contribution of the specialized players, it highlights how, when and with who they should be applied.

Abstract (Italiano)

L'economia circolare è stata presentata per più di un decennio come il modo efficace per trasformare il attuale modello economico lineare consumando risorse naturali non rinnovabili e generando rifiuti che l'ambiente fa fatica ad assorbire. Il settore delle costruzioni in Europa è uno dei maggiori partecipanti a questo modello e la sua transizione verso pratiche circolari è necessaria per raggiungere gli obiettivi di riduzione dei rifiuti fissati dagli Stati membri dell'UE.

L'economia circolare nella costruzione può essere riassunta in cinque parole: ridurre, riutilizzare, rigenerare, riciclare e recuperare. Pero, gli attori tradizionali del settore faticano ad applicare questi nuovi principi, bloccati da barriere economiche, gestionali, tecniche e culturali. Così, negli ultimi dieci anni, sono emerse start-up e altri attori per supportare il settore verso la massificazione delle pratiche del riuso e della rigenerazione.

In questa tesi sono stati analizzati 27 attori operanti nell'Europa occidentale e settentrionale, per quanto riguarda la loro organizzazione e la loro gamma di servizi e attività. Da questa analisi è scaturito un elenco di 74 attività relative a pratiche di riuso e rigenerazione, comprendenti servizi ancora marginali ma innovativi, strutturate in base funzionale (consulenza, operazioni, digitale, istruzione). Inoltre, sono state definite sei categorie di attori in base alla natura dei loro servizi ed è stato sviluppato un template per valutare potenziali nuovi attori. Tutti insieme, gli attori dell'economia circolare e del riuso formano un ecosistema locale in grado di supportare gli attori tradizionali nella gestione dei progetti circolari.

Oggi quegli ecosistemi locali, con i servizi che hanno fornito e la tipologia di prodotti che trattano, sono i più adatti a supportare i progetti di allestimento degli uffici. Quindi, nell'ultima parte dello studio, partendo dalla descrizione di un tradizionale percorso gestionale di fit-out per uffici, viene proposta una nuova cronologia che integra i concetti di economia circolare e riuso. Sulla base del contributo degli attori specializzati, evidenzia come, quando e con chi dovrebbero essere applicati.

Part I - The circular economy for the built environment

1 Principles of the circular economy

1.1 Towards a definition of the circular economy

Walter R. Stahel, a Swiss architect born in 1946, is considered the father of the notion of circular economy. In his report ***"The Potential for Substituting Manpower for Energy"*** published in 1976 for the European Commission, he established the first bases of a form of circular economy, based on the concepts of service-life extension of goods, reuse, repair, refill, reprogramming, remanufacture and upgrade technology. In a 1982 article ***"The Product-Life Factor",*** he introduced the notion of a "closed loop economy" (figure 1), essential to understanding the very purpose of circularity.

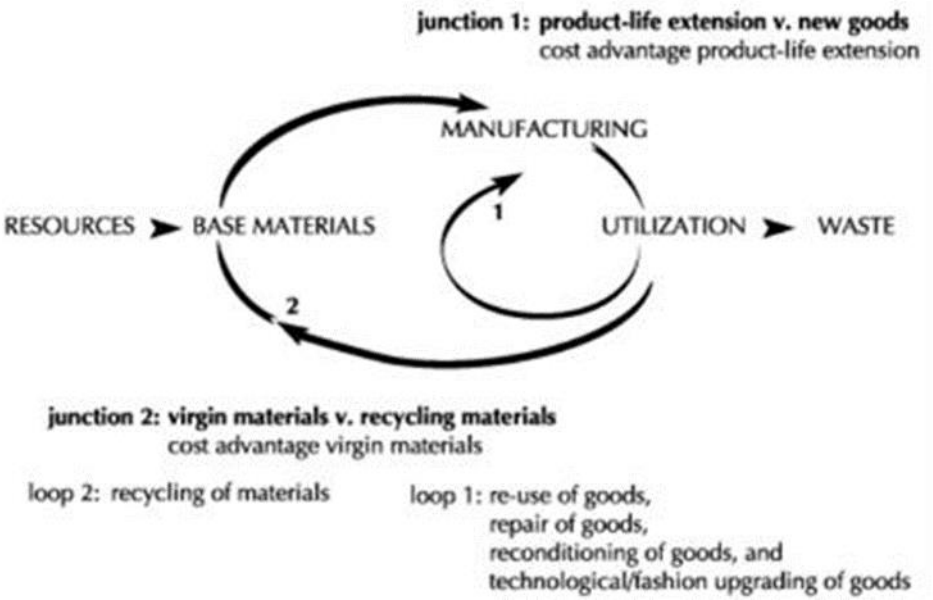


Figure 1 - Concept of closed loop economy (Stahel, 1982)

For Stahel, the concept is "a sensible point at which to start a gradual transition towards a sustainable society in which progress is made consistent with the world's finite resource base". That loop system aims to minimize material, resource and energy flows causing environmental degradation, without restricting economic growth and technical progress.

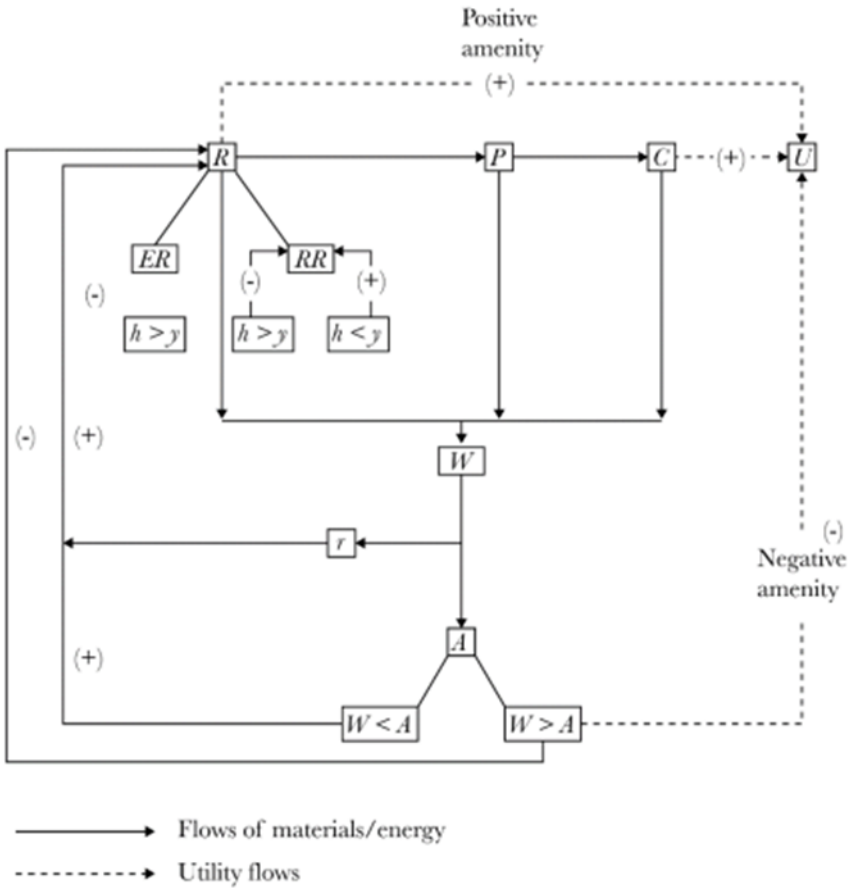
The term « Circular economy » was used and properly defined in the 1990s by Pearce and Turner. They defined the term in opposition to the linear economic model (Pearce & Turner, 1990). They compare the global economic system with a closed thermodynamic model where "everything is an input into everything else", underlying the circular relationship between the economy and the environment, and not just a linear interlinkage.

They developed a "complete picture" of the circular economy within a diagram (Figure 2). In this picture, the model of the closed loop is the ideal to reach. However, they underlined the technical limitations and unfeasibility of recycling 100% of all the waste generated by the system. That

unfeasibility is due to a progressive deterioration of the original material through recycling cycles and an increasing demand for energy to realise more and more recycling cycles.

Then, in the circular economy model, the environment still has to play the role of a waste sink. The environment is assumed to have "assimilative capacity". It allows the environment to reabsorb some wastes and perhaps later, would become useful products. The main example is the compostable wastes that can be absorbed by the soil to regenerate fertile lands.

Finally, even within a circular loop vision, the environment is also seen as a resource provider. Pearce and Turner distinguished two types of resources: exhaustible and renewable. The extraction of exhaustible resources must be limited to prevent the overcoming of natural production performances. However, the conception of renewable resources (accessible and unlimited) allows us to overcome the notion of the "finite resource base" of our planet, used as an argument for a fully closed loop model, defended for example by Stahel.



R	*Resources*	**P**	*Production*	**A**	*Assimilative capacity*
ER	*Exhaustible resources*	**C**	*Consumption*	**r**	*Recycling*
RR	*Renewable resources*	**U**	*Utility*	**h**	*Harvest*
W	*Wastes*			**y**	*Yield*

Figure 2 - The complete picture of the circular economy (Pearce & Turner, 1990)

One of the main criticisms about the circular model developed by Pearce and Turner is that it promotes recycling as the major and dominant process supporting a circular economy.

Finally, one of the latest and more consensual visions of what could be the circular economy has been developed by the Ellen MacArthur Foundation (EMF). In 2013, the Foundation published "***Towards the Circular Economy***". The publication contains the famous "butterfly diagram" (Figure 3) (Ellen

MacArthur Foundation, 2013). It can be seen as a welcome improvement of the former model. The recycling loop becomes one of many other loops such as maintenance, reuse, and remanufacture. Moreover, the diagram is built to represent the environmental impact of each loop: the bigger it is the more it needs energy and work to be executed.

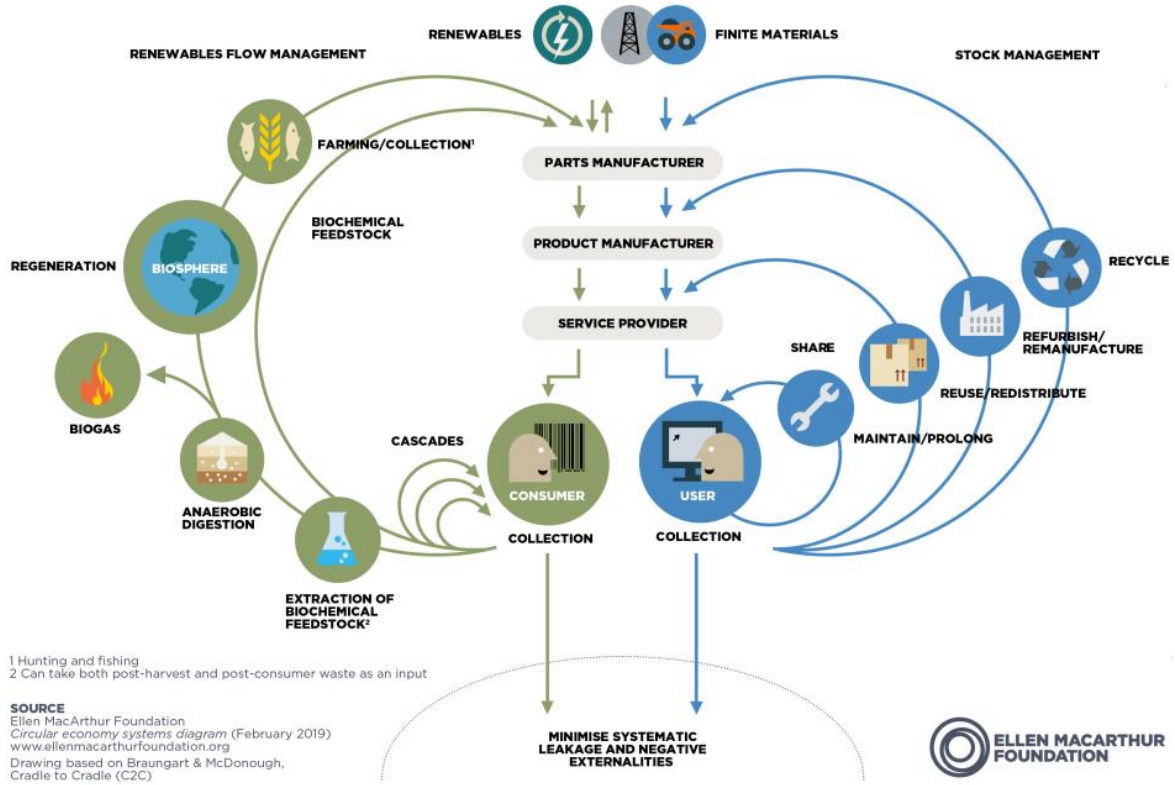


Figure 3 - The butterfly Diagram (Ellen MacArthur Foundation, 2013)

Nowadays, the notion of circular economy is widespread. A study in 2017 identified 114 definitions of the circular economy. They often use a combination of the terms reduce, reuse and recycling, but barely link the circular economy with the concepts of sustainable development and systematic shift. Finally, those definitions also define the circular economy goals of economic prosperity, environmental quality and more scarcely of impact on social equity (Kirchherr, Reike, & Hekkert, 2017).

Then, we can use the definition provided by Kirchherr et al. in the conclusion of their paper, encompassing all the different visions and notions that scholars and other policymakers associate with the concept of circularity. Then, the circular economy can be defined as:

The circular economy

an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso-level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers. (Kirchherr, Reike, & Hekkert, 2017)

Therefore, the circular economy is seen as a major contributor to the achievement of the sustainable development of our society. The circular remains nevertheless a concept focused on the materiality of

such a development (management of the natural resources and the product's life). Therefore, all the actions promoted by a circular model aim in that direction.

1.2 The hierarchy of the re-actions

In the section above, we have seen that the circular processes were presented as loops linking different stages of a product life cycle. Those loops represent diverse ways to deal with products and extend their life. Due to their lexical common characteristic, they are called the "Re-actions", or simply the "Rs", such as in the 2004 Japanese Government's "3R Initiative" (Reduce, Reuse, Recycle). Nowadays, scholars have identified many different re-actions contributing to a circular model. Those re-actions are ranked regarding their impact on a switch to go from a linear economic model to a circular one. One of the most detailed and nuanced descriptions of those re-actions is called the 9R framework. (Potting, Hekkert, Worrell, & Hanemaaijer, 2017). Those different re-actions are defined in Table 1 and dived into three main domains.

Strategies – Re-actions				
Smarter product use and manufacture	R_0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product	***Circular Economy***
	R_1	Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)	
	R_2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials	
Extend lifespan of product and its parts	R_3	Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function	
	R_4	Repair	Repair and maintenance of defective product so it can be used with its original function	
	R_5	Refurbish	Restore an old product and bring it up to date	
	R_6	Remanu-facture	Use parts of discarded product in a new product with the same function	
	R_7	Repurpose	Use discarded product or its parts in a new product with a different function	
Useful application of materials	R_8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality	
	R_9	Recover	Incineration of materials with energy recovery	***Linear Economy***

Table 1 – the 9R framework - Re-actions scale, own elaboration based on (Potting, Hekkert, Worrell, & Hanemaaijer, 2017)

Another version is also used, the 6R framework (Sihvonen, 2015). It is then more accessible to a large audience and provides a useful and potentially common lexical for all the players.

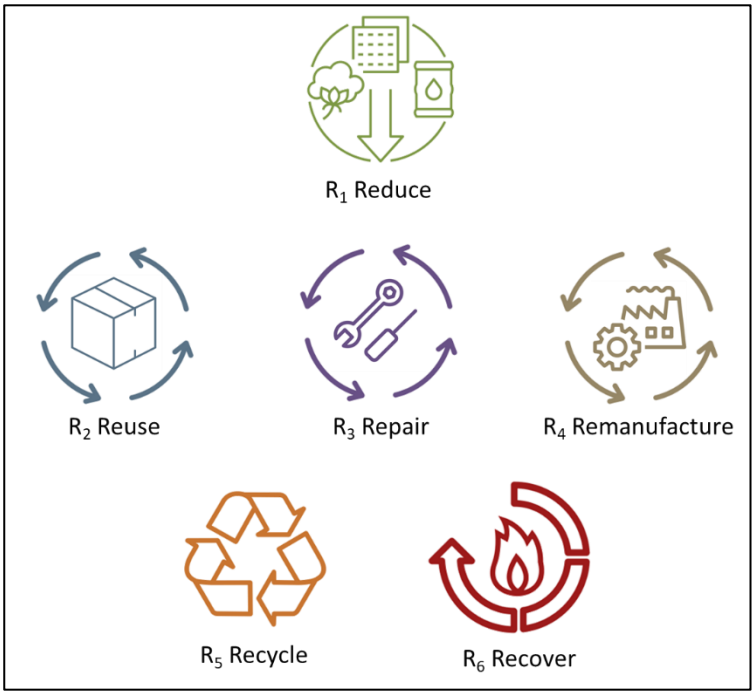


Figure 4 - the 6R framework, own elaboration based on (Sihvonen, 2015)

That framework allows a sufficient level of nuance to be used in the following study. Moreover, when the topic focuses especially on construction products, we will define a final R framework for the thesis.

1.3 Purpose of the circular economy

The European Parliament has described the benefits of developing the concept of the circular economy in our economic model (European Parliament, 2023). It identified three main domains where the circular economy brings benefits:

- **The protection of the environment:**

By slowing down the use of natural resources, the use of lands and then the loss of biodiversity. It will also contribute to the reduction of greenhouse gas emissions, energy consumption and waste production.

- **The reduction of the dependence on raw materials:**

By limiting our need for importations from foreign countries, contributing to our economic imbalance (€35.5 billion in 2021 for EU-27). It will also limit the risks with supply and price volatility of raw materials.

- **Jobs creation:**

By supporting a circular model, it will increase stimulative innovation, domestic economic growth and the development of new sectors in the economy. It will also save consumers money, by providing more durable and quality goods and services.

2 The circular economy in the built environment

2.1 A transition for the construction sector in Europe

By contributing to 9% of the gross domestic product of EU-27 (Eurostat, 2023) and directly employ around 18,000,000 people. Then, the construction sector represents one of the main non-financial sector of the European economy. However, the construction sector presented in those figures includes a wide range of economic activities, going from the extraction of raw materials, the manufacturing and distribution of construction products up to the design, construction, management and control of construction works, their maintenance, renovation and demolition, as well as the recycling of construction and demolition waste.

The construction and the management of buildings, that we could define as the real estate sector, is only a small part of that wide construction sector. Eurostat gives some figures about the construction of buildings:

Main indicators	Value
Number of enterprises	862 950
Number of persons employed	3 227 438
Turnover (€ million)	599 179
Value added (€ million)	143 187
Share in non-financial business economy total (%)	**Value**
Number of enterprises	3.7
Number of persons employed	2.5
Value added	2.2

Table 2 - Key indicators of construction of building in the EU, (Eurostat, 2020)

Therefore, the construction sector and the built environment is considered to be a major contributor to the European environmental impact. Some figures can be given to assess that significant impact (Bonoli, Zanni, & Serrano-Bernardo, 2021). Those figures are highly rough estimations, but give an outlook of the built environment footprint:

Share in the European total (%)	Value
Raw material extraction	50
GHG emissions	36
Energy consumption	40
Waste generation	36

Table 3 - Built environment footprint in the EU (Bonoli, Zanni, & Serrano-Bernardo, 2021)

Thus, a distortion appears between the economic weight of the built environment sector in the European Union and its environmental impact. It highlights the urgent requirement of this sector to evolve and adopt a sustainable transition.

The sustainable development of the built environment must follow diverse and complementary trends:

- **Energy efficiency of the building** to significantly reduce the total energy consumption of the built environment (expected reduction of 80%)

- **Construction of sustainable buildings:** zero-emission buildings, eco-conception, limitation of the urban spread, revegetation
- **Renovation of the stock** to support the energy efficiency of the built environment, but also to improve the general quality of the building (noise reduction, safety, etc.) and to limit the phenomena of vacancy and obsolescence
- **Digitalization** mostly through the generalization of the BIM process in the construction sector, but also through innovative solutions to better manage buildings during their use
- **Circular economy** to decrease the waste generation and the need for raw materials

Therefore, the circular economy applied to the built environment represents a significant topic to develop and structure.

2.2 The circular economy concepts applied to the built environment

The circular economy impacts different aspects of the built environment and the construction sector, from the planning, the manufacturing, the construction, the operative phase to the end of life of the buildings.

In 2014, the French agency for the sustainable development, ADEME, has developed a declination of the circular economy in seven pillars, particularly well-suited for describing how the circular economy concepts can affect the built environment and the construction sector (Table 4).

Production and supply of goods and services	
1	**Sustainable sourcing**: refers to the mode of exploitation/extraction of resources aimed at efficient exploitation of resources.
Example	*Ensure an optimal supply of energy, water, materials (local, bio-sourced, reused, recycled, etc.) for manufacturing of construction products*
2	**Eco-design**: aims, from the design of a process, good or service, to consider the entire life cycle by minimizing environmental impacts.
Example	*Design buildings considering their obsolescence and the depletion of resources (adaptable, reversible, dismountable buildings, etc.).*
3	**Industrial and territorial ecology**: constitutes a mode of inter-company organization through exchanges of flows or pooling of needs.
Example	*Create synergies between projects (pooling of orders, site installations, logistics platforms, etc.).*
4	**Economy of functionality**: favours use over possession and tends to sell services linked to products rather than the products themselves.
Example	*Develop collective services and uses associated with the building and the neighborhood (functional mix, ephemeral occupation, etc.).*
Consumption, demand and behaviours	
5	**Responsible approach**: leads the buyer to make his choice by taking into account the environmental impacts at all stages of the product's life cycle (goods or service).
Example	*Rehabilitation to optimize the use of the existing building (change of destination, densification, renovation rather than demolition/reconstruction)*

6	**Extension of the life cycle**: leads to the use of repair, second-hand sale or donation, or second-hand purchase in the context of reuse or re-use.
Example	*Ensure the reuse and repair and remanufacturing of products and materials coming from deconstruction of buildings*
Waste management	
7	**Recycling and recovery of waste**: aims to use raw materials from waste.
Example	*optimizing waste recycling and site logistics*

Table 4 - the seven pillars of the circular economy applied to the construction sector, own elaboration based on (ADEME, 2014)

Another approach of how the circular economy can be applied to the built environment sector is to consider the traditional life cycle of a building and to add all the concepts of the circular economy that can impact or change this life cycle. The circular economy influences that cycle by two different ways:

- Changing or adding the concepts mobilized for each stage of the building life
- Creating new links between the stages of the building life, generating loops

All those circular strategies applicable to the building life are depicted in the following Figure 5. We find a combination of the concepts described in the seven pillars of the ADEME, and the loops corresponding to the potential re-actions.

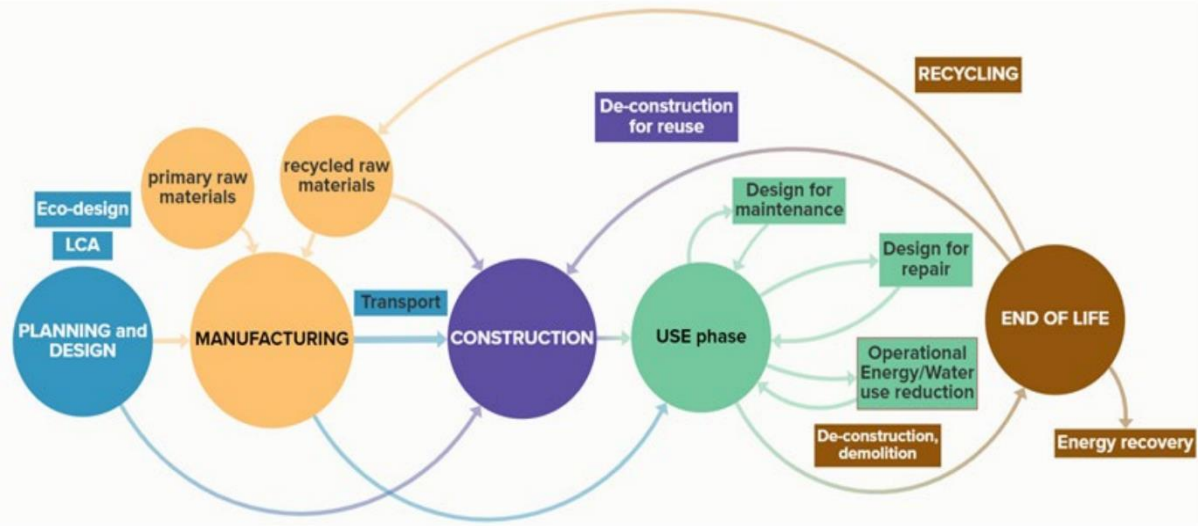


Figure 5 - The circular economy framework for buildings (Saez-de-Guinoa, Zambrana-Vasquez, Fernandez, & Bartolomé, 2022)

In the following sections, a focus will be made on the transition between the use phase, construction and end of life. They basically represent the involved phases in the framework of a refurbishment and fit-out of office spaces, which will be the framework of that study.

2.3 The selective deconstruction and the re-actions

In a "circular" life cycle, products and materials are valued by reinjecting them into the construction process. Thus, we prefer to replace the term "demolition" with that of "selective deconstruction".

The definition provided by the US Department of Housing and Urban Development clearly define the concept of deconstruction, in opposition to the one of demolition:

The selective deconstruction

the selective dismantlement of building components, specifically for reuse, repurposing, recycling, and waste management. It differs from demolition where a site is cleared of its building by the most expedient means. (NAHB Research Center, 2001)

Another vision of selective deconstruction could be that of reverse construction, where building products are dismantled instead of assembled.

Selective deconstruction can be total or partial depending on the scope of the deconstruction or renovation project. In the context of the refurbishment of office space, for example, selective deconstruction affects all furniture and interior fittings and does not intervene on part of the systems, structure or exterior facades. In addition to the total or partial character of a deconstruction, others will prefer to distinguish between structural or non-structural deconstruction.

Selective deconstruction shares the same main objective as classic demolition: the cleaning-out of a space or land to obtain a virgin area ready to welcome a new project. However, selective deconstruction adds other objectives (Küpfer & Fivet, 2021):

- Limit the production of waste
- Retain the intrinsic value of construction products for reuse
- Prefer reuse to recycling of construction products suitable for reuse
- Avoid as much as possible the use of energy recovery by incineration and landfilling

To carry out a selective deconstruction operation, different levers of action can come into play to achieve the objectives:

- Identification of products to be reused by evaluating the various recovery possibilities, in particular by carrying out a resource diagnosis before the operational phase of selective deconstruction

- Dismantling by successive layer of the building to be deconstructed. That is to say by category of products to be dismantled and by site area

- Site management to ensure the proper treatment of all products and waste generated towards their recovery channel, in particular by storing products to be reused in a dedicated space, and by raising awareness and setting up waste sorting in maximum of separate streams

- Management after dismantling of products to preserve their technical characteristics as much as possible, especially during storage and transport

The selective deconstruction will lead to the generation of dismantled products, potentially reusable and of deconstruction waste. To deal with those materials generated, the circular economy promotes the re-actions. Then, for the framework of that study, we define the 4R framework useful for the management of those type of products.

R_0 Reduce

All type of strategies to avoid the consumption of unnecessary or replaceable goods, the extraction of natural resources and the generation of waste (own elaboration)

R_1 Reuse
The repeated use of a product or component for its intended purpose without significant modification. ***(Ellen MacArthur Foundation)***

R_2 Remanufacture
Re-engineer products and components to as-new condition with the same, or improved, level of performance as a newly manufactured one. ***(Ellen MacArthur Foundation)***

R_3 Recycle
Transform a product or component into its basic materials or substances and reprocessing them into new materials. ***(Ellen MacArthur Foundation)***

R_4 Recover
Energy recovery by incineration or other (bio-)chemical processes-based treatments of waste, before landfilling the processes residues. ***(own elaboration)***

For the rest of that study, we will stick to that 4R framework. Some explanations for that choice are here summarized:

- The framework is considered a 4R framework, even if there are five re-actions listed. The R_0 "reduce" action corresponds to a strategy of ^prevention and not one for the management of a product or a waste

- Terms and nuances such as repair, reconditioning, re-purpose, refurbish were not selected to keep a satisfying, understandable and user-friendly common glossary of the re-action

    - Reconditioning can be seen as subcategories of the R_1 action "Reuse", because it involves only light operations on the products (packaging for transport, cleaning) that are necessarily carried out for the reuse of the product

    - Repair and refurbish can be seen as subcategories of the R_2 action "Remanufacture", because they involve significant medication of the products to be as new

    - Re-purpose can be seen as subcategories of the R_3 action "Recycle", corresponding to an operation of up-cycling of the product/waste

- In the idea of share a common language of circular economy, and to support the Ellen MacArthur Foundation, its definition for reuse, remanufacture and recycle have been selected. The ones for reduce and recycle have been elaborated by my own, collecting and summarizing the definitions already existing.

Finally, in the figure 6, the 4R framework is used to better described the connections between the different phases of a building, the ones of a refurbishment project and the ones of product/waste management.

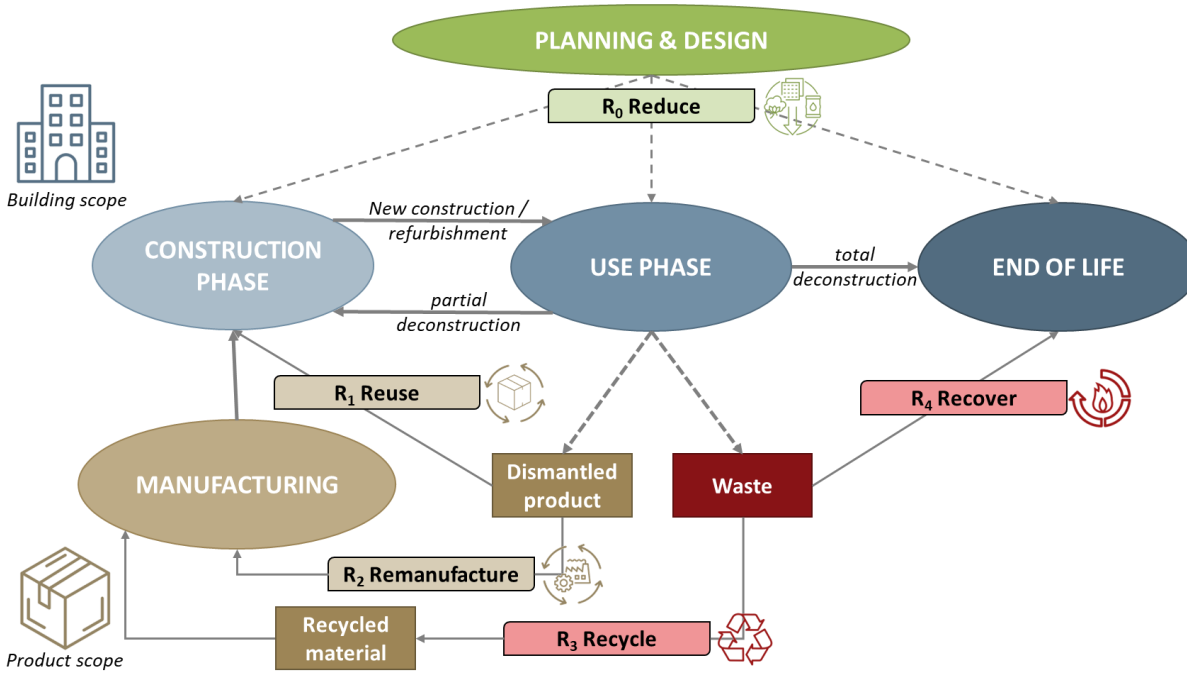


Figure 6 - the 4R framework applied to the selective deconstruction (own elaboration)

3 Development of the circular economy in the built environment

In this section, we will analyse how to develop the circular economy in the construction sector. That development will be described from different aspects:

- **The regulatory framework**

  In Europe, both at the continental level and national levels, directives and regulations have been applied to support the development of the circular economy in general and give some interesting directions for the built environment

- **Private and public initiatives**

  Private companies and public authorities are more and more involved in the experimentations of circular practices in the built environment and in the tenders for new projects.

- **Remanent barriers**

  However, lots of barriers, from diverse perspectives, still hinder the development of circular practices and need to be addressed to expect a better involvement of all the sector players.

3.1 Evolution of the regulatory framework in Europe

To meet the imperative of transformation and conversion of the construction sector towards a circular economy and better recovery of its waste, the European Union and the countries that compose it have implemented various regulations and texts of strategic orientation. For a long time, only the issue of waste management was addressed, in particular, to prevent illegal landfill and its generated pollution.

Nevertheless, an acceleration has been noticed for several years, with the Framework Directive on waste of the European Union, introduced in 2008. Its transcription into national laws, as well as other texts promoted at the national level since then, have reaffirmed the ambitions to develop the principles of the circular economy in construction activities. These different texts then put forward objectives, incentives or rules on the theme of selective deconstruction in particular, in order to achieve a conversion of the sector.

We propose in the following paragraphs to explain the content of these successive regulations, at the EU scale.

The declination of the European regulations for circular economy follows two main tracks:

- **Waste framework directive**

The European Parliament voted on several directives and amendments on waste management over the decades. The first one dates back to 1975, that has been amended in 1991 and 2006. In 2008, a new framework directive has been adopted, and then amended in 2018. Currently, in 2023, the European Parliament is working on a new waste framework directive to better consider the circular economy's objectives on waste management.

- **Circular Economy Action Plan**

In 2015, the European Commission released its first circular action plan, presenting the measure and actions to be applied at the European and national levels to develop the circular economy. A second plan was delivered in 2020. Those action plans imply a modification of regulations at different scales, but also non-regulatory actions to initiate. It set a clear objective of material recovery for the construction and demolition products of 70% by the horizon of 2020.

3.1.1 The Waste Framework Directive (2008)

The Waste Framework Directive of 2008 has introduced several new concepts that are now the basis of the circular economy and has provided the construction sector a new way to consider the waste its activities generated.

1. **the European waste hierarchy**

Figure 7 - The European waste hierarchy (European Parliament)

It highlights the best options to deal with waste. Those different options are then precursors of the re-actions promoted by the circular economy specialists. For the built environment, used to dispose

the waste and products into wastelands, it has been a major challenge to consider this hierarchy. The framework directive has given direction to develop the separate collection of the type of waste. It has been, and it is still a challenge for the construction industry to apply that process to the deconstruction sites. Nowadays, those recycling practices are better managed and included by the deconstruction managers.

2. End-of-waste criteria

End-of-waste criteria specify when certain waste ceases to be waste and becomes a product, or a secondary raw material after having undergone a recovery operation (including recycling). Moreover, the waste product must comply with specific criteria to lose the status of waste:

- the substance or object is commonly used for specific purposes
- there is an existing market or demand for the substance or object
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products)
- the use will not lead to overall adverse environmental or human health impacts

For the built environment, that legal disposition gives a regulatory framework for the operations of reuse and remanufacturing of the deconstruction product waste.

3. Extended producer responsibility (EPR)

> *To strengthen the re-use and the prevention, recycling and other recovery of waste, Member States may take legislative or non-legislative measures to ensure that any natural or legal person who professionally develops, manufactures, processes, treats, sells or imports products (producer of the product) has extended producer responsibility.*
> *(Article 8.1 of the DIRECTIVE 2008/98/EC)*

The framework directive has also introduced in the European legislation the concept of EPR, set in article 8.1. The producer, or product manufacturer can have different responsibilities:

- Accept the returned products or the waste generated at their end-of-life
- Financial responsibility for the management of those waste
- Provide public information on the reusability and recyclability of the product

The Extended Producer Responsibilities Schemes are developed by the member countries of the EU at different paces.

For the built environment, two types of products are already under an EPR scheme in many countries and initiated by the EU:

- Waste of electrical and electronic equipment
- Furnishing waste

Some countries move also forward. For example, France has decided to create an EPR scheme for the construction and deconstruction products, that would be operating in 2024.

In 2018, a new directive amended the waste framework directive of 2008, in the context of the application of the first circular economy action plan of 2015. That directive recalls the main principles. It reinforces the objectives for waste recovery, maximising reuse and recycling. It establishes new

requirements for EPR schemes. It also sets measures to support sustainable production and consumption models by encouraging the design, manufacturing and use of resource-efficient, durable, reusable or at least recyclable products.

Then, since 2023, starting from a focus on the policy options to bring about a more circular and sustainable management of textile waste, the EU has launched discussions to establish a new waste framework directive. Like the amending directive of 2018, that new directive would be inspired by the second circular economy action plan of the European Commission.

3.1.2 The first circular economy action plan (2015)

In 2015, the European Commission adopted its first circular economy action plan. It included measures, declined in 54 actions, to help stimulate Europe's transition towards a circular economy, foster sustainable economic growth and create new jobs.

The action plan established concrete actions, with measures covering the whole life cycle: from production and consumption to waste management and the market for secondary raw materials and reused products. It also had a revised legislative proposal on waste.

In the section about construction and demolition, the Commission stressed that the sector was one of the main waste producers in Europe. The plan sought to identify the drivers and obstacles to the massification of recycling practices in the area. It also encouraged the improvement of the design of buildings and the development of assessment methods for the environmental performances of a building throughout its whole lifecycle. In the end, of the 54 actions identified by the plan, three directly concern the built environment, as explicated in Figure 8.

Construction and demolition	
Pre-demolition assessment guidelines for the construction sector	2017
Voluntary industry-wide recycling protocol for construction and demolition waste	2016
Core indicators for the assessment of the lifecycle environmental performance of a building, and incentives for their use	2017 onwards

Figure 8 - Actions for construction and demolition in first circular economy action plan (European Commission, 2015)

In 2019, the Commission announced that the 54 actions of the plan had been delivered. It led then to the implementation of a new plan.

3.1.3 The new circular economy action plan (2020)

The European Commission adopted the new circular economy action plan (CEAP) in March 2020. It is one of the main blocks of the European Green Deal (adopted in 2019), Europe's new agenda for the sustainable development of the European economy.

This action plan encompasses initiatives along the entire life cycle of products. It targets how products are designed so that sustainability would be the next norm in the EU. It promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented or follows the European waste hierarchy. Finally, a strategic objective is also set, that the resources used are kept in the EU economy for as long as possible.

It is divided into 35 actions, with one specially dedicated to the construction and building sector. The plan would launch a new comprehensive strategy for a sustainable built environment, addressing the issue of energy and resource efficiency, management of construction and deconstruction waste and

digitalization. Thus, the action plan aims to apply circularity principles throughout the whole lifecycle of buildings by different means:

- Improve the sustainability performance of the construction products by the review of the Construction Product Regulation (see section below)
- Improve the durability and adaptability of the built assets by the principles of the eco-design and the development of digital logbooks
- Introduce in public procurements the concepts of whole-life costing and the carbon reduction criteria
- Improve the development of reuse and remanufacturing by levelling up the material recovery targets set in the previous legislation

This action plan, focusing on the environmental and sustainability performance of all types of products in the EU, has led to the preparation of a new regulation (still in progress): the Ecodesign for Sustainable Products regulation (ESPR). That regulation will have a direct impact on the revision of the Construction Product Regulation, by setting new requirements and objectives (Figure 9).

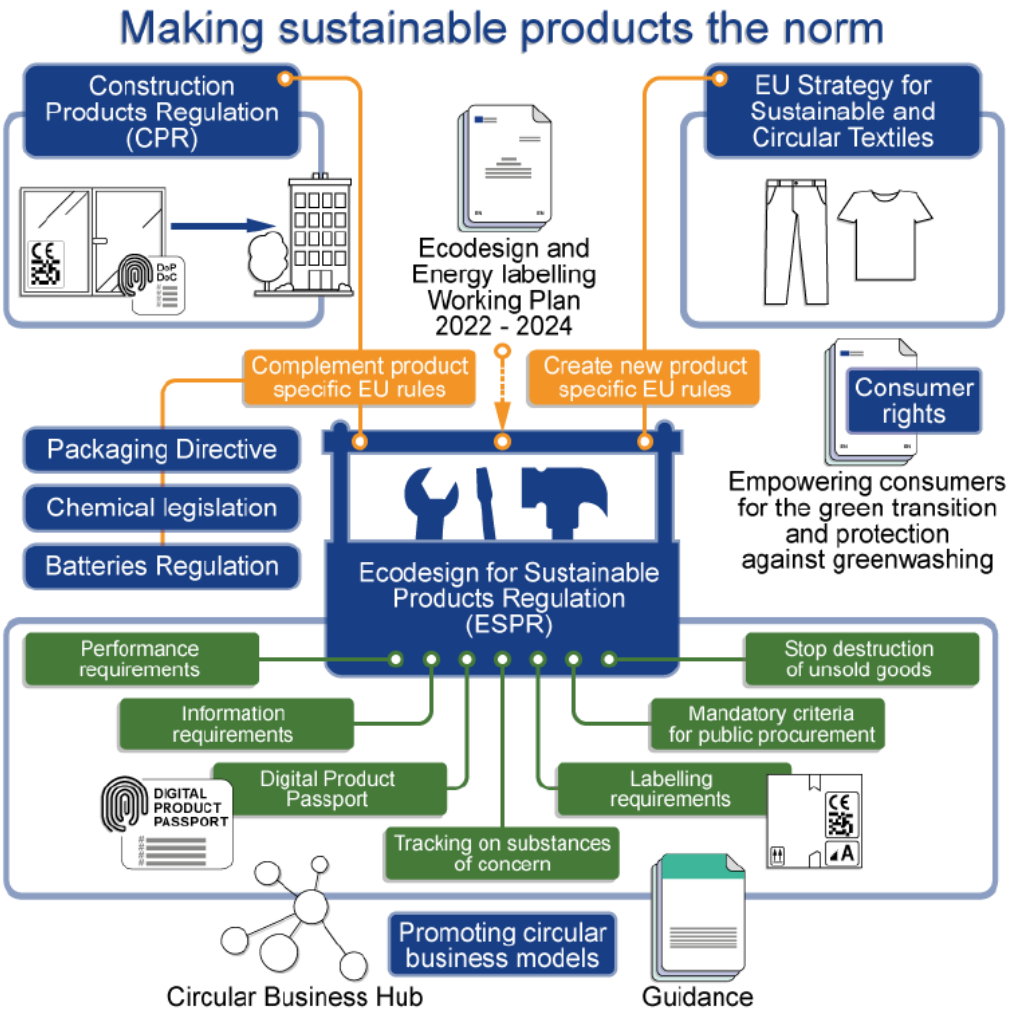


Figure 9 - The Circular Economy Spring Package (European Commission, 2022)

3.1.4 Review of the Construction Product Regulation (WIP)

The Construction Products Regulation (CPR) was first introduced at the European level in 2011. It harmonised rules for the marketing of construction products in the EU. The Regulation aimed to provide a common technical language to assess the performance of construction products. It ensured the publication of reliable information to professionals, public authorities, and consumers, to help them select the optimal product among different countries and manufacturers.

Following the publication of the new circular economy action plan in 2020, the CPR is in the progress of reviewing. The goal is to underline the need for higher environmental and sustainability performances of construction products: energy-efficiency, resource-efficiency, durability, reusability, upgradability, reparability, remanufacturing, and recyclability.

The CPR which mainly regulates the commercialization of construction products in the EU, will seek to improve topics already discussed in the existing CPR. It follows three different objectives. In Figure 10, all the new contributions are highlighted and are explained in the following paragraphs.

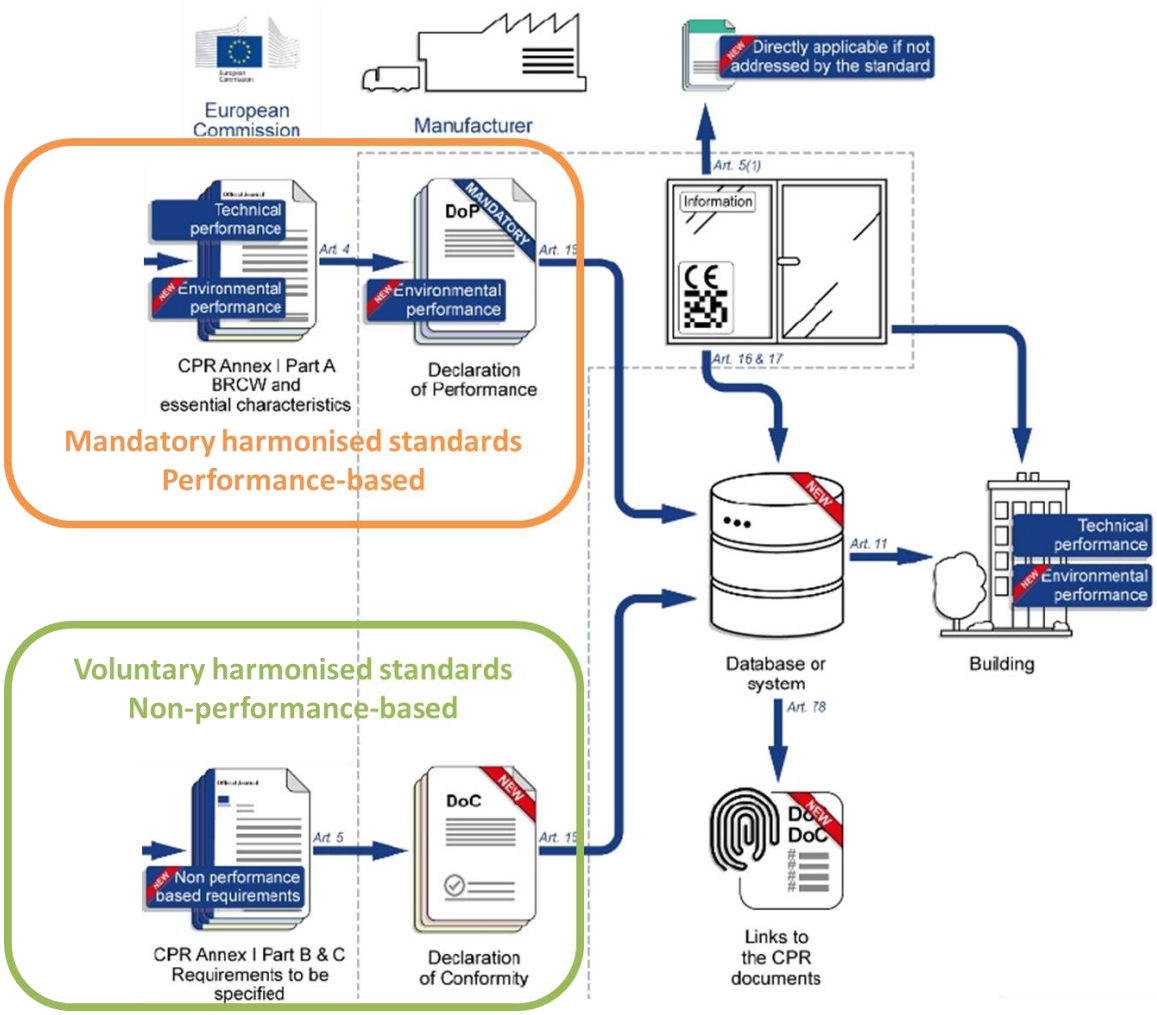


Figure 10 -Evolution of the CPR, the Commission's proposal (European Commission, 2022)

- **Standardization of the construction products**

The objective is an improvement of the current system, based on new definitions and harmonization of the technical specifications and requested documentation. The Declaration of Performance (DoP) completed by manufacturers for all commercialized products is then mandatory.

- **Inclusion of climate change effects**

It includes all the effects associated with the life cycle of the product. The environmental performances described by the standardization of new requirements will be included in the Declaration of Performance. The goal is to reach an accurate environmental assessment at the construction works level.

- **Voluntary addition of non-performance-based requirements**

Some non-performance-based requirements or voluntary additional requirements, related to safety, environment or functioning, can be declared a part of the mandatory DoP, within a Declaration of Conformity. Then, the Commission favourites the voluntary initiatives of the sector for better standardization and promotion of environmental and sustainability requirements.

To conclude, those regulations, with their translation more or less effective in the Member States, illustrate the willingness of Europe to move forward. Starting from an objective of reducing landfilling and better waste management, the EU has progressively adopted the concepts of the circular economy, promoting firstly the recycling of waste and now the reuse of the products. The Eu has also launched a great movement toward a new sustainable conception of product manufacturing, impacting the way construction products are designed and used.

3.2 Involvement of the public and private sectors

In parallel with the evolution of European legislation, more and more public and private initiatives have been launched in the last decade. These spontaneous initiatives can take different forms depending on the type of player involved and the scope of the project:

- Charter of commitment of a local authority
- Selective deconstruction pilot project led by a demolisher or a project manager
- Voluntary certification for a project (ex: Cradle to Cradle C2C)
- Launch of start-ups or associations promoting reuse
- Integration of criteria related to circularity in a public tender apple (share of products to be reused, waste recovery objectives, etc.)

All these initiatives can be driven by different motivations. Some may claim genuine ecological awareness, and others may use these initiatives for their image. In addition, the actors may also want to anticipate changes in the regulations, or thanks to the legitimacy gained by the success of their initiatives, have more influence on the very evolution of the regulations.

For example, at the local level, initiatives led by municipalities or communities also exist to promote the circular economy in the construction sector and encourage selective deconstruction programs. These initiatives take the form of a commitment charter, a roadmap, compiling the best practices that the community undertakes to follow. Thus, the City of Paris has developed a circular economy plan for 2017-2020 with a section dedicated to planning and construction issues. It draws up timetables with the monitoring of pilot projects and the outline governance of a community of actors in reuse, recovery and construction in the Parisian territory. Paris is just one of many municipalities and regions across Western and Northern Europe that implement local strategies for the circular economy and specifically in the construction sector, a domain where they have strong power.

However, private players also can take the lead in the spread of circularity practices. A French example is given in the following paragraph.

A collective example: "Le Booster du Réemploi"

Another virtuous example of that kind of initiative in France is "Le Booster du Réemploi" (Reuse Booster). It has been launched in 2020 by a real estate company willing to massify the reuse practices in the sector. Nowadays, the project gathers 80 companies (Figure 11): investors, developers, promoters, contractors, property companies, facility management companies, public authorities, industrials, technical specialists, architects, reuse players, digital platforms, etc. All those actors, of different sizes, and some being leaders in their domain, work together and help each other to better apprehend the development of reuse and remanufacturing in the sector.

Figure 11 - Reuse booster's main partners (Booster du Réemploi)

That project is based on three main objectives:

- **Ease the prescription of reused products in projects**

To do so, the Booster has several leverages. It serves as a hub to link the different parties of a project. Thanks to its technical specialist partners, it produces also technical sheets on specific topics to ease the practice of reuse, such as technical specifications for the prescription of certain types of reused products (raised floors, sanitary elements, lighting, etc.).

- **Unite the players in a collective dynamic**

The Booster relies on its large community of partners to promote reuse. They all have signed a charter where they engaged themselves to prescribe reused products on their construction and refurbishment projects. They share their feedback on projects and the best practices they developed so that they collectively build common high skills. To encourage this approach and challenge its partners, the Booster also launched two years ago a contest for "circular buildings".

- **Make visible the demand and the supply for reused products**

The Booster is launching a digital platform to structure the demand for reused products. It will not be some kind of marketplace but a tool to make visible the demand of project managers for reuse

products. The platform and the team who manages it will then connect that demand to all the types of supply channels known, such as marketplace, remanufacturers, and deconstruction projects

Therefore, the "Reuse Booster" is a clear example of how public and private players can launch voluntary and collective initiatives before any mandatory regulations. Nevertheless, if that kind of project is essential, it illustrates that nowadays, many obstacles remain to the generalization of the circular economy concepts and processes in the real estate sector.

3.3 The barriers to the development of the circular economy in the construction sector

Even if regulation and voluntary initiatives push forwards the spread and the massification of the circular economy in the real estate sector, many barriers hinder that dynamic. Over time, scholars (Lavagna, Monticelli, & Zanelli, 2022) have identified and analysed those obstacles. They are specific to the issue of reuse and remanufacturing of construction products, being the core of that study. The barriers are presented following different aspects.

- **Technical aspect**

Currently, the buildings renovated or deconstructed are not among the newest. Therefore, the construction products composing them are scarcely designed for disassembly and reuse. Moreover, the construction and assembly techniques often hinder a clean dismantling by being non-reversible. In the future then, dry assembly techniques shall be privileged.

The other main technical issue is the uncertainty on the intrinsic technical characteristics of the product potentially reusable or remanufacturable. Are they still up to date? Can the product be upgraded to meet the current performance requirements? For example, single-glazed windows can be dismantled properly, but their reusability potential is really low due to the requirements on the energy efficiency of the new buildings. It would be then easier to recycle it (not really observed in the actual practices) or upcycle it in a new function (interior partitioning, greenhouses structure, etc.).

- **Economic aspect**

The economic aspects of reuse and remanufacturing practices don't benefit yet from clear and consensual studies to apprehend the second-hand market in the construction sector. Yet, some basic statements can be highlighted to explain the economic barriers to reuse and remanufacturing.

On specific types of construction products, reused and remanufactured goods are cheaper than their equivalent in the new market. For Backacia, a French marketplace, that price gap is between 40% and 80% of the value of the new equivalent. But the heavier and more energy-consumer the remanufacturing operations are, the lower the price gap. For some basic items (basic floor tiles, plaster panels, etc.), already cheap on the market of new, the competitiveness of the reused and remanufactured products is inexistent.

Moreover, at the project scale, economic savings from avoiding waste management fees can be an argument to promote deconstruction over demolition. But the management, labour and planning costs of deconstruction could compensate for those savings. There is then no evidence of the economic advantage of the deconstruction. We could hope that in the future, with the rise of waste management fees and the democratization of selective deconstruction practices, the economic advantage would be more convincing.

- **Informational aspect**

To ensure the reusability of products, the information about them must be managed during their whole life cycle. It includes information from the producer (datasheet, producer's prescription, date of purchase) and the record of all the events and maintenance activities that have occurred during the useful life of the product in a building. The loss of those types of information is an obstacle to assessing with certainty the reusability potential of the product. For example, it can happen that a disassembly notice of the product exists but has been lost over time. The development of the digitalized management of the building's information (through BIM, digital logbook and material passports) is now a convincing solution to overcome the informational barrier.

- **Insurance aspect**

Insurance companies are unwilling to guarantee remanufactured or reused products. It is difficult for them to involve themselves in a sector where standardisation of the delivered product and automation of the processes aren't the norm, and difficult to implement. Indeed, the collected products to remanufacture have different backgrounds (producer, age, events and maintenance operations), and then the remanufacturing operations to carry out are selected case by case.

The technical re-characterization of the products after their remanufacturing is an efficient way to build trust with insurance companies and potential buyers. Nevertheless, that re-characterization can increase the cost of remanufacturing operations, and the remanufactured product loses its economic competitiveness.

- **Regulatory aspect**

At the product scale, the evolution of European regulation has greatly eased the development of reuse and remanufacturing practices (end-of-waste status, upgrading of the waste hierarchy, simplification of the transfer of ownership). Together, they provide a favourable environment for experimentation and the massification of innovative practices in the construction sector.

However, Europe has also adopted strong regulations on buildings' performance. Therefore, products are difficult to reuse in the same function, their technical performances being insufficient with the new buildings' requirements.

Moreover, the objectives of the European Commission and of the Member States on the recovery of materials are still focused on the basic methods of material recovery: recycling and quarry backfill. The objective of the Waste Framework Directive of 2008 (70% of material recovery by 2020 for the construction and demolition waste) hasn't been updated in the amending directive of 2018.

- **Producer's responsibility aspect**

If the product producer isn't concerned by an Extended Producer Responsibility Scheme, he doesn't have any incentives to design durable and reusable products. It is even the opposite case for him from a commercial point of view, the sales of products with a limited useful life ensure the continuity of his activity. To overcome that conflictual situation, EPR policies seem the appropriate regulation to implement. Another and more liberal solution can be proposed. The producer, instead of selling a good, can be more connected to its end-of-life, through tack-back systems. He becomes then more of a service provider than a good producer.

- **Cultural aspects**

Finally, it remains in many players' minds doubts and reluctance to apply circular economy strategies. On the one hand, they can support the recycling sector or basically are not fully aware of the challenges of the moment. That reluctance can impact the two sides of the construction sector.

On the one hand, in the reused and remanufactured product market, the increasing supply faces a really low demand. Nowadays, reusable and remanufactured products' prescriptions in new construction or refurbishment projects are still scarce (scope of the Reuse Booster in France). The main reason for that low demand is the uncertainty on the quality of the products, the available quantities, the warranty and the technical reinstallation.

On the other hand, selective deconstruction projects are more time and work-consuming than a classic demolition project. Moreover, the demolition with the recovery of the concrete and other wastes in the quarry backfill is sufficient to meet the regulatory objectives of material recovery.

Finally, in 2022, a Norwegian study (Knoth, Mamo Fufa, & Seilskjaer) discussed the barriers and success factors to the reuse practices with sector players (manufacturers, architects, environmental consultants, building managers and contractors and public institutions). In Table 5, those different items are recorded within 4 domains.

	Barriers	Driver factors
Mindset and knowledge	• Conservative way of thinking • Lack of collaboration • Reluctancy to take/share risk • Lack of best practices • Lack of knowledge	• Awareness and change of culture • Cooperation and communication • Risk sharing • Pilot projects • Knowledge
Reuse infrastructure	• Lack of functioning market • Costs for extra efforts • Timeline • Lack of storage facilities • Lack of testing framework and infrastructure • Demolition practices for reuse	• Establish infrastructure • Digitalization and standardization
Business framework	• Lack of reuse experts • Need for redesign • Lack or reuse R&D • Linear business model • Lack of market • Lack of incentives • Financial risks	• Including reuse experts in the value chain • Innovative reuse • Creative and innovation capacity • Circular business models • Customer demand • Financial incentives • Funding schemes for reuse in the value chain
Legal framework	• Lack of supporting regulations • Lack of technical documentation • Lack of early planning • Rigid contract/procurement process	• Reuse-friendly regulations and stricter requirements for reuse • Responsibility for documentation; certification agencies • Setting ambitious and achievable goals in the early planning phase • Reuse-focused collaborative procurement process

Table 5 - Barriers and drivers for reuse (Knoth, Mamo Fufa, & Seilskjaer)

Part II - From wastes to products: a new approach

As it was presented in the previous parts, the circular economy applied to the real estate and construction sector has a great deal about waste management. The main idea is to move from a waste vision of the material generated by a deconstruction to a vision of a bank of reusable products. In this part, the same dynamic will be followed, starting from the description of the construction and demolition wastes generated in Europe and the concept of urban mining to the categorisation and the identification of the construction and deconstruction products with the highest reusability potential.

1 Overview of construction waste in Europe

1.1 Assessment of the building construction and demolition wastes

Construction and demolition wastes (CDW) account for 36% of all waste generated in the European Union. It represents about 450-500 million tonnes of CDW produced each year (Interreg Europe, 2022). That figure also includes the infrastructure works.

In the framework of the development of an Extended Producer Responsibility Scheme for building construction and demolition products, the French Agency for the Environment, the ADEME, ran in 2021 a study to better describe the typologies of products and waste generated by the building sector, excluding then all the infrastructure works. That study has been selected because it is one of the most recent ones and is very detailed. At the European level, we suffer a lack of updated information about the nature and amount of those products and wastes generated. The last main study supported by the European Commission goes back to 2011. The figures given by that French study can then give an outlook on the production of construction and demolition waste in the Western countries of the continent.

To start with, a clear definition of what is considered to be a building construction product can be given:

Building construction products

Materials, products and equipment, including decoration, that are manufactured with a view to being incorporated, assembled, used or installed in a durable manner in works or parts of construction works, as well as for the development of plots on which are implanted those buildings.
(ADEME, 2021)

Once used and included in demolition work, those products become waste in a linear economy vision. Traditionally, those wastes are sorted into three categories: inert, non-hazardous, and hazardous. These categories provide a global framework to identify and categorize the different material flows of building construction and demolition wastes (BCDW).

Inert waste

Wastes that do not undergo any significant physical, chemical, or biological transformations when deposited in a landfill.
(European Environment Agency)

Hazardous waste
A term applied to those wastes that because of their chemical reactivity, toxic, explosive, corrosive, radioactive or other characteristics, cause danger, or are likely to cause danger, to health or the environment. (European Environment Agency)
Non-hazardous waste
Non-hazardous waste means waste which is classified neither as hazardous waste nor inert waste. (European Environment Agency)

Altogether, the three categories define a global framework to assess the generation and management of waste. Another way to describe those wastes with more levels of precision is to use the European Waste Catalogue and its Eurocodes. The EWC is a list of waste established by the EU in 2000 to categorize wastes both on their composition and the sector/activity that produce them. Out of the 20 chapters composing the ECW, chapter 17 is dedicated to construction and demolition wastes. The utility of such a catalogue is to provide all Member States with the same framework to assess and compare their production of BCDW. That list of Eurocodes from Chapter 17 is given in Annex A of the thesis.

However, a more quantified overview is needed to better understand the nature of the BCDW generated. Thanks to a compilation of different sources, the ADEME provide a breakdown of those wastes.

Category	Nature	Eurocode	Amount (millions of kg)
Inert waste*	Concrete	17.01.01	17,000
	Clay	17.01.02/03	3,000 to 4,000
	Mixed inert waste	17.01.07	10,000 to 13,000
	Flat glass	17.02.02	200
	Total inert waste		**Around 30,000**
Non-hazardous waste	Metal	17.04	>3,000
	Wood	17.02.01	2230
	Gypsum	17.08.02	600
	Mineral wool	17.06.04	250
	Soft PVC	17.02.03	50
	Rigid PVC	17.02.03	60
	EPS	17.02.03	19,8
	Rigid plastic (PE/PP)	17.02.03	28
	Polyurethan	17.02.03	1 to 13
	Carpeting		30
	Bitumen membrane	17.03.02	80
	Mixed non-hazardous waste	17.09.04	3,400
	Total non-hazardous waste		**Around 9,700**
	Asbestos	17.06.05	570

Hazardous waste	Waste of electrical and electronic equipment	16.02	200
	Specific diffuse waste	17.09.03	100
	Treated wood	17.02.04	<13
	Total hazardous waste		**Around 900**
	TOTAL BCDW		**Around 40,000**
	* *Soils and stones are not included, following the definition of building construction product*		

Table 6 - Annual BCDW in France, based on (ADEME, 2021)

Therefore, inert wastes contribute to three-quarters of the total production of BCDW and concrete alone for 42%.

That predominance of concrete and other inert wastes can be explained by the nature of the source of those wastes, mostly coming from demolition sites (Figure 12). For interior fit-out projects, where the structure of the building is not touched, the proportion of non-hazardous waste can increase and become a major part of the waste generated.

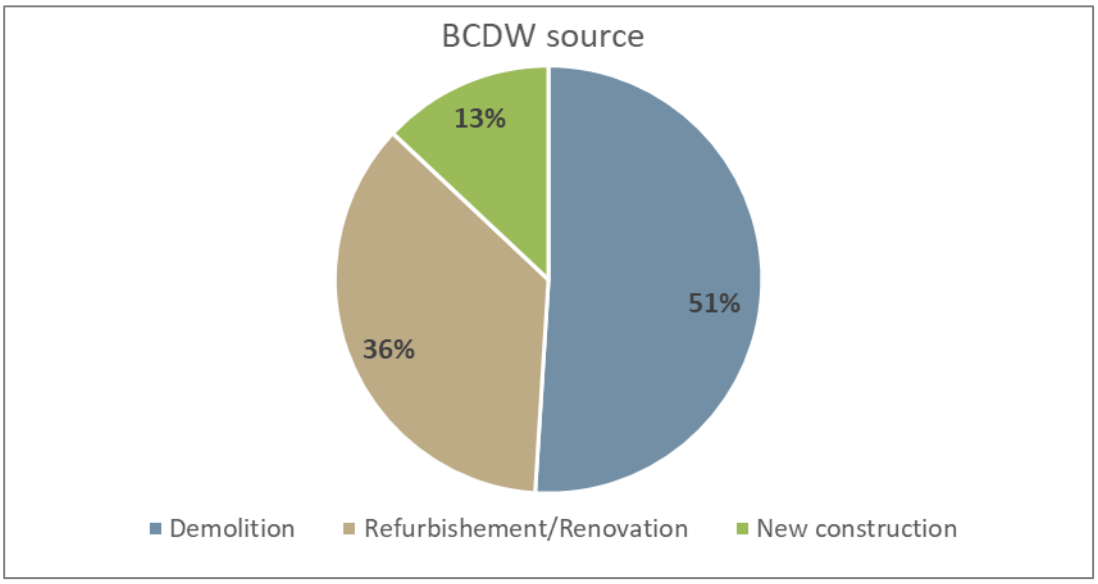


Figure 12 - BCDW source in France, based on (ADEME, 2021)

1.2 Recovery of the building construction and demolition wastes

The objective of the European Union was to reach 70% of material recovery of the construction and demolition wastes in Europe by 2020. According to the Eurostat data and analysed by Slovakian scholars (Spisakova, Mesaros, & Mandicak, 2021), that objective has been achieved successfully at the Europe scale, with a recovery rate of 90%. Only three countries weren't able to reach the 70% goal (Cyprus, Slovakia, and Bulgaria).

But those surprising and satisfying rates can be criticized a bit and do not provide a clear view of the recovery challenges that the sector still has to cope with.

First of all, those data include all types of construction and demolition waste, meaning also waste coming from infrastructure works. Then the predominance of inert waste is even stronger than for BCDW. That causes a distortion of the results for two main reasons.

On the one hand, all those measured rates, along with the European objective of 70%, are based on the weight criterion. Inert wastes are the densest category of waste and then their recovery impacts significantly the total recovery rate.

On the other hand, what is considered to be material recovery is disputable. Indeed, inert waste methods of recovery include both quarry backfilling and road underlay.

- **Focus on quarry backfilling**

  Open-air quarries receive more and more inert waste to backfill excavations. The regulations provide that this backfilling be managed to ensure the physical stability of the backfilled land and must not harm the quality of the soil as well as the quality and proper flow of water. This method has several advantages. Inert waste does not require heavy crushing operations before being deposited, and the reception capacities of these quarries are significant.

  However, this method and its recognition as a recovery process are criticized on several points. Some quarry operators tend to refuse inert waste from construction or demolition. On the one hand, unlike backfilling with used soils, the use of inert waste can reduce the stability of the structure. In addition, some have doubts about the non-toxicity of this waste, which then generated permanent pollution at these sites. On the other hand, quarry backfilling is closer to landfilling than reuse as some people, lobbyists of that practice, try to suggest. Following the re-actions definitions, quarry backfilling can hardly be considered a recovery process:

  - Reuse would suggest that the inert waste would be used for the same function
  - Repurpose or recycling would suggest that the inert waste would be reintroduced in a manufacturing loop

In opposition to the optimistic data presented earlier, the study of the ADEME of 2021 highlights the recovery rate of the construction and demolition waste only for the building sector and thus gives more nuanced results. In Table 7, the recovery rates of different flows of waste for France are presented. The situation can be different for other European countries. Nevertheless, it provides an example of the current progress of the built environment sector in one of the main economies of the EU.

Nature	Recycle	Energy recovery	Total recovery
Mixed inert waste	• 33,3% (production of recycled rubble for concrete or road underlay) • 38,3% (quarry backfilling) • 5% (embankment works)	0 %	**76,6 %**
Metal	90 %	0 %	**90 %**
Wood	41 %	36 %	**77 %**
Gypsum	16 %	0 %	**16 %**
Flat glass	3 % (when not mixed with inert waste)	0 %	**3 %**
Plastics	17 %	9 %	**26 %**

Carpeting	<1 %		2 %	**<3 %**
Mineral wool	<1 %		0 %	**<1 %**
Total IW		76,6 %	0,0 %	**76,6 %**
Total NHW		38,1 %	8,2 %	**46,3 %**
Total BCDW		67,3 %	2,0 %	**69,2 %**

Table 7 - Recovery rate of BCDW in France (in the share of the amount of waste generated), based on (ADEME, 2021)

Thus, according to that study, France has reached a material recovery rate of 67%, meaning that the country almost has almost achieved the European objective of 70% for the building construction sector. Nevertheless, that rate is largely supported by the operations of quarry backfilling (30% out of the 67% registered). By excluding the road underlay output, the material recovery of the BCDW in a close loop (meaning the recycled materials are reintegrated in the manufacturing of building construction products) is minatory in that 67% of material recovery.

Furthermore, by looking more precisely at the different natures of waste, large disparities exist. Thanks to an easy process of recycling and the economic advantage for the waste producers, metal wastes succeed to reach a high rate of recycling. Thus, the total material recovery rate of the non-hazardous waste excluding metal falls only down to 15%. The study argues that this low rate is due to an insufficient collection and sorting of those waste on demolition sites whereas the development of the industrial recycling sector would enable the recycling of larger amounts of those non-hazardous wastes.

The reuse and remanufacturing practices aren't yet developed enough to represent an important share in the recovery methods and then are not mentioned in Table 7. At the global scale of building construction products and wastes, the ADEME estimates that reuse represents less than 1%.

Therefore, the French example underlines the current situation that many European countries experiment:

- High recovery rates are mainly supported by the recovery of inert wastes for other purposes than building construction (quarry backfill and road underlay)
- Metal and wood in a lesser proportion are non-hazardous wastes that benefit from a recycling channel already mature (involvement of the demolition managers, high processing capacity, satisfying territorial coverage, economic advantage)
- Other non-hazardous wastes are scarcely recycled
- Reuse practices are still marginal

Thus, even today, the leading vision remains that the construction sector is producing waste to be eliminated or at best recycled. To further integrate the concepts of the circular economy, a vision of the built environment as a reusable construction product bank.

2 Identification of the reusability potential of construction products

2.1 The concept of urban mining

The concept of seeing the built environment as a potential stock of construction products and materials is part of the circular concept of urban mining. It is defined as follows:

Urban mining

The process of reclaiming compounds and elements from any kind of anthropogenic stocks, including buildings, infrastructure, industries, products (in and out of use), environmental media receiving anthropogenic emissions, etc. The stocked materials may represent a significant source of resources, with concentrations of elements often comparable to or exceeding natural stocks. (Cossu & Williams, 2015)

In its global meaning, the term urban mining also considers other types of products than buildings and their components. It includes vehicles, electrical and electronic equipment, industrial facilities, etc.

The concept applied to the built environment looks at three main indicators (example in Figure 13):

- **The Inflow** (annual): construction products coming from the consumption of natural resources and used for the new construction works in the built environment
- **The Outflow** (annual): construction and demolition waste coming from demolition and refurbishments projects, evacuated of the urban area for recovery or landfilling
- **The Stock in use** (total): represents the total stock of construction products and materials in the urban area, available immediately (in case of deconstruction or renovation) or not

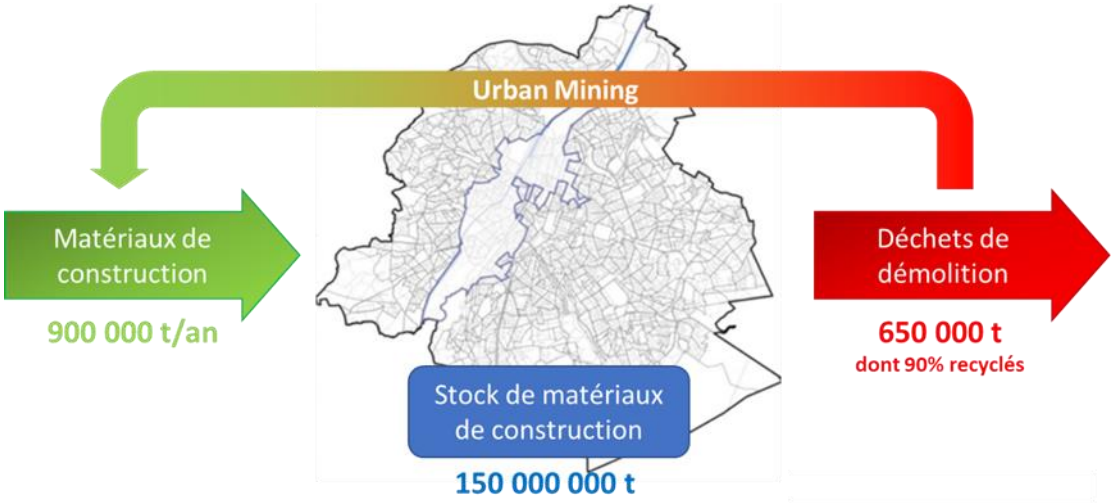


Figure 13 - Example of the Urban Mining concept applied to Brussels (BATIr ULB, 2015)

The assessment of those three indicators enables the establishment of an urban mining potential for a built environment. Some scholars have developed interesting methods to calculate this potential (Arora, Raspall, Cheah, & Silva, 2020), (Lanau & Liu, 2020). In those studies, two methodological aspects are interesting to point out.

The first one is the development of a multi-scale digital methodology to assess the nature and quantity of construction products. Lanau and Liu present the mapping tool (Figure 14) as an "urban resource cadaster", helpful to all stakeholders of urban management:

- It can help to match the supply and the demand for reused material,
- It highlights where the available resource is,
- Architects can have an overview of the local nature of the construction products and incorporate those materials in the design of new buildings.
- Support renovation and demolition companies in the planning of their activity.

The second one concern the estimation of the total stock and the potential to recover it. For Arora et al., it is important to correct the whole urban mining potential with a recovery efficiency rate. That correction corresponds to the loss of available construction products and the impossibility to reuse them, based on several factors, like functional loss associated with age, aesthetics outdated or physical damage, and failure during dismantling or remanufacturing operations.

The two studies together present then the two challenges to the development of the urban mining concept: the acquisition and spread of knowledge about materials and products of the urban area, and the improvement of the recovery and reuse efficiency.

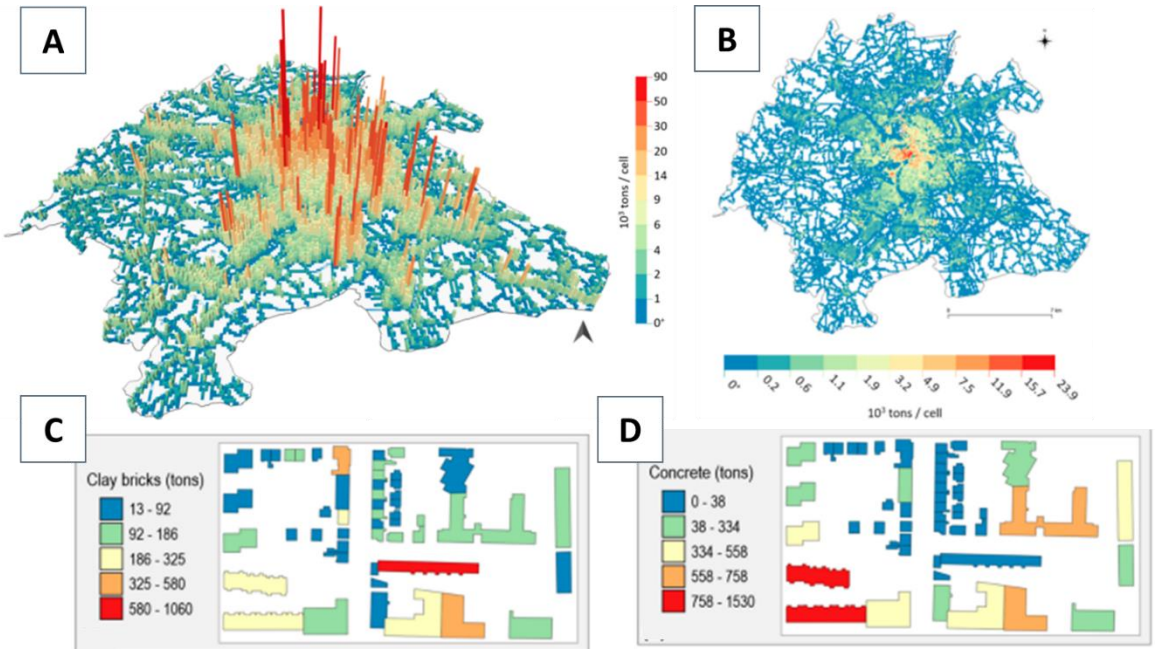


Figure 14 - Urban resources at the city scale (A: total stock, B: clay stock) - Urban resources at the building scale (C: clay bricks, D: concrete), metropole of Odense, Denmark (Lanau & Liu, 2020)

2.2 Categorization of the construction products with high reusability potential

The concept of urban mining and the measurement of its potential remains a macro approach to the reuse and remanufacturing of construction and deconstruction products. From a more practical point of view, and in relation to every type of project management, the building scale is pertinent. Thus, the question is for a deconstruction project, how to move from a waste generation conception to the one of a bank of reusable products.

2.2.1 Lack of a common classification of the buildings' products

The waste can be clearly categorized thanks to the Eurocodes of the European Waste Catalogue, but we still miss a common language to describe the products of a building. That breakdown would be useful to develop synergies between all the parties, both at the national and European levels. Some classifications of the building products already exist, such as the OMNICLASS Table 23 – Products, the UNIFORMAT II classes, the INIES DATABASE in France, etc.

However, by reading through the literature, no classification succeeds to be adopted by a majority of the sector players. Furthermore, those different potential classifications do not share the same scope of buildings' products, some consider technical equipment, some have fewer levels of details, etc.

However, to develop reuse and remanufacturing, some characteristics to describe the building products could be mentioned: location in the building, main function, methods of assembly/disassembly and material composition.

2.2.2 An impossible link between deconstruction products and waste

Finally, using the INIES database main categorise, the French Agency for the Environment has compiled in a matrix the two visions on building components: waste or products, as replicated in Table 8.

	Structure/ Masonry	Facade	Roofing/ Waterproofing	Windows/ Doors	Insulating materials	Partitions/ Ceiling	Floors, walls and ceiling covering	Sanitary equipment	Outdoor equipment	Electronic and electrical equipment
Inert material	x	x	x	x	x	x	x	x	x	
Flat glass		x		x		x		x		
Metal	x	x	x	x	x	x	x	x	x	
Wood	x	x	x	x	x	x	x		x	
Gypsum	x	x			x	x				
Mineral wool		x			x	x				
Soft PVC			x		x	x	x	x	x	
Rigid PVC		x	x	x		x	x	x	x	
EPS		x	x		x	x		x		
Rigid plastic (PE/PP)			x		X	x		x	x	
Polyurethan		x			x		x		x	
Carpeting							x			
Bitumen membrane			x							
Asbestos	x	x			x	x			x	
Hazardous wastes	x	x	x			x	x		x	
EEE waste										x

Table 8 - Link between products functions and waste categories, based on (ADEME, 2021)

This approach highlights the non-existence of links between building product categories and types of material/waste. Thus, it reinforces the distinction deconstruction managers must make between enhancing recycling or enhancing reuse and remanufacturing. For example, the sorting of product/waste in diverse material flows, as promoted as best practice on several guidelines, isn't fit to separate and collect the reusable products on site.

Therefore, the key objectives to consider are the identification upstream of the reusable products, and their management on site, separated of the waste generated and prepared for recycling.

2.2.3 Identification of the high reuse and remanufacture potential product categories

In 2022, The French Technical and Scientific Centre for Construction (CSTB) launched a discussion with 48 sector players to identify the categories of construction products most suited for reused and remanufacture (CSTB, 2022), based on the nomenclature of the "Activités du BTP 2019 de Assurance Construction". Among the players, there were remanufacturers, reuse platforms, contractors, developers, technical specialists and insurers. The idea is to developpe reuse and remanufacturing firstly by supporting the most advanced and promising reusable product channels. That discussion, based on the feedback of the pioneer players, has identified 29 categories, listed in Table 9. That list isn't sorted by reuse and remanufacturing potential.

Main categories	Products
Structure and masonry	**Precast concrete elements** (cellular slabs, pre-slabs, beams, stairs, windowsills, etc.)
	Timber framework, timber frames, timber stairs
	Steel framework, steel frames, steel stairs
	Bricks
	Natural stone rubble
	Pavers, curbs, paving, gravel (from landscaping)
	Roof Tiles
	Slates (natural or non-asbestos fibre cement)
Doors and Windows	**Interior doors** (all materials, giving priority to those without functional fire resistance) - including frames, hardware and handles
	External doors and **windows** (including automatic doors)
Metalwork	**Handrails** (all materials) – mechanically assembled
	Railing/fence/posts/grids/gates/gratings (starting first with the mechanically assembled elements)
Floors	**Raised floors**
	Parquet (nailed or laid floating)
	Flexible flooring (carpet, linoleum, PVC) - excluding glue-down installation
	Tiles (ceramic materials, assimilated materials and natural stone) - excluding glued-down
Walls and ceiling	**Suspended ceilings**
	Removable/mobile/modular partitions
	Stapled or fastened wallcoverings – mechanically fastened /Cladding – excluding support frame
	Plasterboard and/or **recycled wood panels partitions**
	Insulation – excluding glued insulation or with adherent finish
Electrical equipment	**Cable trays**
	Lighting (lamps) and **security lighting**
	Switches and **sockets**, including feeders

	Electrical panels and **circuit breakers**
Other equipment	**Sanitary equipment** (all materials): toilet bowls, urinals, sinks, etc. (Complement: kitchen equipment)
	Sanitary fittings (mixer taps)
	Water radiators (steel/cast iron)
	HVAC technical equipment: heating production, air conditioning, ventilation

Table 9 - the 29 categories of products with high reuse potential, based on (CSTB, 2022)

From that framework, a two-year project has been launched at the end of 2022, to further implement the innovative practices of the sector, to secure them and to receive the insurers' support (Project SPIROU). The project is focused on 10 categories of construction products. For each category, the same methodology will be followed to achieve the goal of "officialization" of the reuse practice:

1. Production of a guide describing all the operations to reuse the product: identification, assessment, dismantling, possible remanufacturing activities, re-characterization, prescription for reinstallation in a new building
2. Evaluation and confirmation of the guide by insurers and technical specialists
3. Capitalization on sector players' feedback
4. Updating of the guide
5. Use of the guide to develop automatic insurance mechanisms and promote product eco-design

The 10 chosen categories of products (Figure 15) for the project have been selected among the 29 ones identified by the CSTB, following different criteria (CSTB; ADEME, 2022): the quantity of available reusable resources, the scarcity of the new equivalent product, the costs related to dismantling and transport, the needs expressed by the sector players, the used methods to assess reusability of the product, the generated risks for the building where the product is reused, the existence of feedbacks, etc.

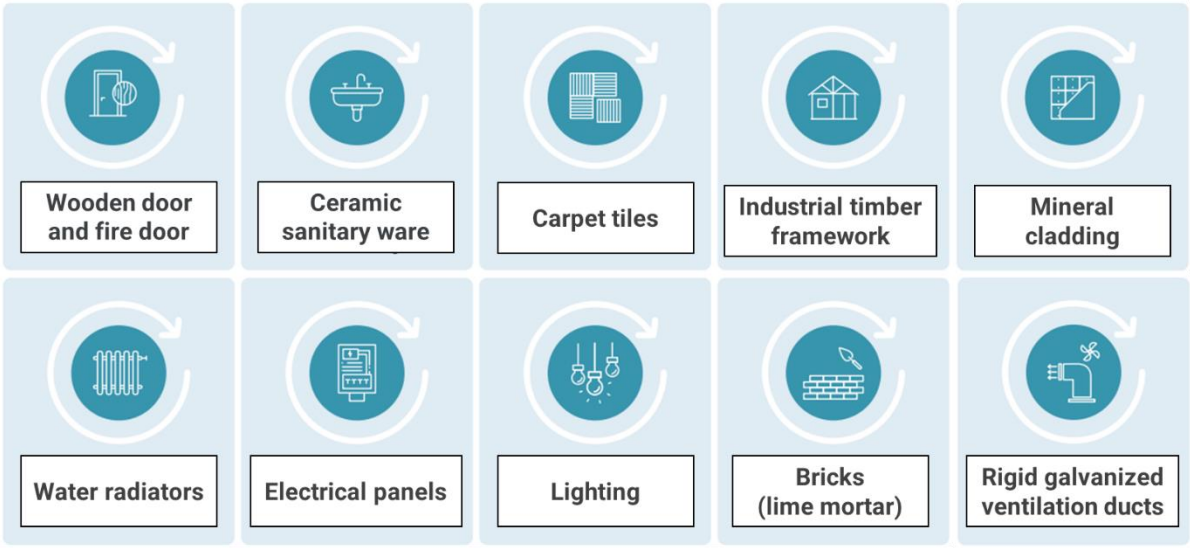


Figure 15 - the 10 selected product categories for the project SPIROU

With those French examples, we have an outlook of the current highest reuse and remanufacturing potentials. The presented categories do not are specific to French architecture, they are common to every type of building all around the world, and more specifically in Europe. However, to that collective knowledge on building products' potential, it is important to keep a case-by-case approach depending on the building to deconstruct.

2.3 The resource diagnosis to assess a building

Norway and France are among the European countries that implement in their regulation a new tool to support reuse and remanufacturing in the construction sector: the resource diagnosis also called the "reuse mapping" by the Norwegian or "diagnostic PEMD" in France (TEK17 regulation in Norway, AGEC 2020 law in France). Many more terms are used: resource audit, reuse audit, reclamation audit, reuse inventory, etc. For the rest of the study, the term resource diagnosis will be used.

The two regulations practically state the same outcomes. They compel any managers of significant renovation or deconstruction projects (more than 1,000 sqm) to produce in the early stage of the project a resource diagnosis.

(ART. 51 LOI AGEC) (FRANCE)

"During significant demolition or renovation of a building, the project planner is required to carry out a diagnosis relating to the management of the products, materials and waste resulting from this work. This diagnosis provides the necessary information relating to the products, materials and waste with a view, as a priority, to their reuse or, failing that, their recovery, indicating the recommended recycling channels and recommending additional analysis to ensure the reusable nature of these products and materials (...)".

The European program FCRBE (Facilitating the Circulation of Reclaimed Building Elements) has defined what is the resource diagnosis:

Resource diagnosis

A resource audit is an operation carried out in buildings scheduled for partial or total demolition. It aims at identifying the building materials and products presenting a high reuse potential. This audit results in a 'resource diagnosis', listing the identified reusable building elements. The resulting inventories present information on the materials and products' characteristics such as dimensions, quantities, conditions, environmental impact, technical characteristics, disassembly recommendations, etc. (FCRBE, 2020)

Resource audits are presented as a key activity to support in the earliest possible stage the reuse of building products, by following several purposes:

- Providing building owners and designers of new projects with data on reusable products
- Serving as a decision tool for discussing the reclamation and the destination of the products
- Advertising the availability of potentially reusable products to other interested parties
- Indicating to the demolition contractor which products need to be carefully dismantled

Three different levels of diagnosis are identified by the Interreg-Europe program, sorted by the scope of work of the audit (and then its cost):

1. A "specific" audit of the building focused only on the identification of specific items with high economic value (mainly historical products, architectural antiques, and specific technical equipment). That type of diagnosis is light on technical and environmental issues and only assesses the residual value of the high economic potential products and the existence of a market for them.
2. A "light" audit, considering all the building products, but only assesses the reuse potential of the common reclaimed products. The audit is often carried out by the potential reclaimer of

those kinds of products (remanufacturers, reused material sellers, etc.) The economic goal for the building owner is to reach the break-even point or more.

3. An "exhaustive" audit searching for innovative reuse possibilities for the maximum number of products. The diagnosis can also integrate more detailed technical, economic and environmental specifications (carbon savings, residual value, disassembly ability, etc.) and different reclamation and recovery scenarios. That type of audit is surely more expensive and time-consuming than the two first ones.

In the framework of a detailed and exhaustive audit, some factors are essential to assess the reuse potential of the building products. For each factor, the auditor (carrying out the audit) must answer several questions, as presented in Table 10 below.

Factor	Questions to assess the reusability of a product
Condition	• Is the product in good general condition? • Are there noticeable damages? • Does it need a remanufacturing process?
Quantity	• Is the batch large enough to attract potential reclaimers?
Standardization	• Are the batch homogenous? • Is the product of standard size?
Authenticity and value	• Is the product (or new equivalents) scarce? • Is it from a famous brand, designer, architect, etc.? • Is there historical/cultural value? • Does the product present noticeable aesthetic qualities?
Economic value	• Is there an existing demand in the market? • Is it more price competitive than the new equivalent or alternative? • Will it be possible to cover the cost of labour required?
Facility of dismantling	• Can the product be dismantled without damaging it? • Is dismantling technically feasible (dry assembled)? • Is the product easily and safely accessible?
Manageable logistics	• Is the product easy to handle? • Can the product be safely stored, transported, remanufactured and reinstalled? • Is there a remanufacturer channel for this type of product?
Carbon savings and durability	• Does the new equivalent's production generate a heavy environmental impact? • Does the product still present a long useful life?

Health and Safety	• Is there any presence of hazardous substances in the product? • Do the dismantling operations present health and safety risks?
Performance	• Is there any original producer technical datasheet of the product? • Is the product still compliant with current technical standards? • Does the product still present acceptable technical performance?

Table 10 - Factors and concerns to assess the reusability of a product, based on (FCRBE, 2020)

Finally, after having identified the products with reuse potential, the auditor must produce the resource diagnosis. the FCRBE program has proposed a possible template to structure the information collected during the first due diligence of the building, along with some desk study. The template is divided into two parts:

- **General context information**
  - Project reference
  - Dates: of the diagnosis' release, of the site visit(s)
  - Contracting authority: name, address, tel/mail, additional information
  - Auditor information: name, address, tel/mail, additional information
  - Building owner information: name, address, tel/mail, additional information
  - Audited building information: name, address, contact in situ, additional information (type, function, location, context, etc.)
- **For each coherent batch of product: general description**
  - Identification: ID code for the batch, product group and product name
  - Picture of the product
  - Quantity (or estimation): given the commonly used units for that product
  - Dimensions and mass: for logistic issues
  - Location in the building: useful for planning the dismantling operations and avoiding confusion
  - Condition: comments on the general condition of the product, describing potential damages
  - Other remarks: freedom of the auditor to add any comments on the product

Furthermore, a third template is proposed for a deeper analysis of a homogenous batch of products, to better assess its reuse potential. That "element sheet" is divided into different sections:

- **Element identification and description**
  - brand, technical denomination, product reference, producer references
  - Information on the date of production and implementation
  - technical performances (mechanical, acoustic, thermal, reaction/resistance to fire)
  - aesthetical description: colour, finishings, homogeneity
  - detailed description of its components, materials
  - specific value: historical, aesthetical, economic, scarcity, etc.
- **Context**
  - Detailed localisation data with complementary pictures
  - Record of past events that occurred in the building or the concerned building's area
  - Building/WIP project description
  - Logistical feasibility: ease of being handled, stored, transported, etc.
- **Assembly**
  - Assembly method of the product
  - Dependence on the connected building elements

    - Dismantling risks: for the product, the building and the workers
- **Environmental benefits**
    - *Possibility:* Run a Life-Cycle-Analysis
- **Hazardous substances**
    - Cross-checking with other audits (asbestos survey, waste audit)
    - Results of specific tests (example: lead test)
- **Additional documents**
    - All related documents providing a more detailed description of the item
- **Suggested applications**
    - Suggested reuse applications (giving examples from past projects)
    - Potential complementary studies required
    - Potential remanufacturing/re-installations recommendations

The level of detail obtained thanks to the carrying out of an "element sheet" requires more study from the auditor: economic feasibility study, LCA study, dismantling tests, technical studies, chemical tests, etc. However, that level of detail is not necessarily required for all the products identified in the resource diagnosis. It would be mainly required for batch products with apparent high reuse potential, on request of the building/project managers. Moreover, it provides essential information for potential buyers, or designers willing to integrate those products in their projects.

Finally, the resource diagnosis is focused on the identification of high-reuse potential products in the building. But all products and materials are not reusable and then will become wastes after the deconstruction or refurbishment. Therefore, experts and public regulators share the idea to associate the resource diagnosis with the waste diagnosis, to have a global foresight of the circular impact of a deconstruction project (merging expected reuse and remanufacturing goals and expected waste recycling rate). In France, the regulatory discussion on the resource diagnosis, which should be effective by the end of the year 2023, has decided that association. In Annex B of the thesis, the still work-in-progress template of the future "diagnostic PEMD" is reproduced.

Objectives of the study

The resource audit is one of the first main steps to conduct a deconstruction or refurbishment project. However, during all the phases of the project, from the strategy planning to the closing of the project, many activities and actions have to be carried out to implement, execute and monitor circular economy and reuse/remanufacturing objectives.

The production of a resource diagnosis is a good example of the new skills and knowledge required for this kind of project. Nowadays, traditional players (project managers, developers, contractors, developers, architects, etc.) express the need to be supported to integrate circularity in their projects.

Therefore, the thesis supports several complementary objectives:

- **Analyse and assess the circular economy and reuse players**

To run successfully a project integrating circular and reuse objectives, project managers should be assisted by a set of expert collaborators. These specialist players build together local ecosystems that can provide a wide range of activities and services useful for project and building managers.

Therefore, the identification and assessment of these new expert players are essential to better understand their added value to a circular project, their specialization, their innovative practices and models, etc.

The objective would be then to categorize the circular economy and reuse players and develop a methodology to assess those players.

- **Identify the key activities to carry out for a refurbishment project**

Through the assessment of circularity and reuse experts, the second objective is to identify the key activities and processes that project managers should consider and add to the "traditional" management of a deconstruction or refurbishment project. Those new activities can be seen as additive and time-consuming tasks for project management, but they can also be integrated coherently with traditional and mandatory steps of the deconstruction and refurbishment project.

The activities and actions related to the circular economy and reuse strategies will be identified and listed along with the analyse of the specialist experts.

- **Application to the case of a fit-out of an office space**

Finally, the two first objectives and their results would be applied to a specific type of project: the refurbishment of office space. That precise kind of project is well suited to implement circular and reuse strategies for several reasons: the scope of the work includes high reuse potential products, all the parties are professional and are incited to develop skills and knowledge about reuse and remanufacturing practices and management, office spaces are commonly located in large cities where a local ecosystem of specialist players is more likely to be developed and mature.

Part III - Circular economy and reuse players: business models and activities supporting the sector

1 Introductory presentation of those players

The launch of an operation of selective deconstruction and renovation of office spaces is still today a project presenting many barriers, explained in the state of the art.

Nevertheless, for several years, many companies, start-ups or associations have been formed to support and develop the circular economy in general and the construction sector. The range of services offered is vast, ranging from the development of digital tools to the implementation of materials reuse methods, including consulting services throughout the project.

Subsequently, the term **player of the circular economy and reuse** will designate any start-up, company, association, institutional or private project, online platform, etc. working on the themes of the circular economy in the construction field and providing useful and relevant support to the traditional players in the Real Estate sector.

However, several issues hinder these new actors' contribution to the shared objective of developing circular economy practices in office space renovation projects.

1.1 Variety of players in the circular economy

The circular economy is an important topic affecting all sectors of the economy. Today, start-ups are playing the supporting role for companies in their transition to a circular operating model: reduction of CO2 emissions, energy saving, reduction of waste production (in production lines or in office activities), awareness of environmental issues, introduction to the principle of eco-design and waste valorization.

However, the services offered by this type of non-specialist start-ups, while useful to the spread of circular economy topics among all the sectors, do not respond in a relevant way to the more specific needs and expectations of real estate and construction players.

Yet today, thanks to a great diversity of actions and good communication, these "generalist" circular economy start-ups can present themselves as key players, despite the strong limits of the solutions they can provide for deconstruction projects. This is currently the case in the Milan region, for example, where this type of actors covers a large part of the media space.

We can therefore judge the relevance of using a player in the circular economy and reuse by the care he takes to develop services entirely dedicated to the construction sector.

1.2 Need for a quality ecosystem

As with any construction or demolition project, the addition of circularity objectives and a fortiori material reuse objectives requires the presence of quality local players. All the players working locally (the scale of action may vary depending on the size of the organization) form what will be called the **ecosystem**.

Obviously, the maturity of these ecosystems varies greatly between countries, regions and even cities. We can understand by the concept of maturity different factors:

- The number of players operating around the project concerned
- The competence and the maximum level of activity of these players
- The notoriety and the level of trust for these players
- The diversity and innovation of the services offered
- The local presence of other construction projects integrating similar objectives
- Legislative and regulatory support for the activity of these players

For a project manager, in-depth knowledge of his local ecosystem and the services it can provide is an essential condition for successfully carrying out a renovation or deconstruction project.

2 Objectives of the players' analysis

In this chapter, the main objective is therefore the most exhaustive description possible of the players of the circular economy in the construction sector.

This main objective is broken down into several complementary sub-objectives:

1. Identify and structure all the services and activities offered by these players
2. Understand their model and their development by picking several indicators
3. Establish a glossary defining and categorizing these players according to their core business
4. Develop a Template to apprehend and evaluate the proposal of a new identified player

2.1 Identify the services and activities provided

The range of services offered by circular economy players is vast. Each actor only offering part of the set of possible services sought. It is therefore interesting to identify all these services to better understand the role and the contribution of each player.

In addition, the sector is currently in full evolution and innovation is permanent. This produces a significant inflation in the number and diversity of services offered.

Therefore, the objective is also to further structure the list of activities and services provided by circular economy players in the construction field. To do this, a taxonomy of these activities, on several levels will be built. It will make it possible to identify the main areas of action of these start-ups or other types of organization, and to group together under common themes the activities similar or complementary.

2.2 Understand the model of the players

The main objective of understanding these players relates to their action. Nevertheless, without turning into an advanced economic study, it is interesting to identify some indicators to better understand the model and the development of these players.

The information collected will be used to determine the age of these organizations, their area of action, their size and their sources of funding. Together, they will provide insight into the level of maturity of these organizations and their business strategy.

2.3 Categorize and define those players

The current growth and diversification of circular economy players in the construction sector makes it difficult to understand this ecosystem, how it works, and which type actors could be useful for a given project.

Thanks to the analysis of the services provided by these organizations, it will be possible to identify similarities and similar proposals between different players. Thus, the objective is to categorize these actors, and to group together actors whose core business is similar under a common and clearly defined name.

This need for characterization is imperative to consolidate and universalize circular economy practices in construction. The lack of vocabulary to designate the actions to be taken and the actors who carry them out are major obstacles to the effective management of deconstruction and renovation projects.

2.4 Establish a template to assess new players

As has already been said, more and more players are entering this new sector of the circular economy. In addition, one can remember the key action of clearly identifying the local ecosystem of players who can provide support for a deconstruction or renovation project.

This study therefore proposes to develop a Template to assess a selected player, with several objectives:

- Identify the market area of the player
- Understand the range of services provided
- Check its real involvement in the specific sector of the circular economy in construction, applied to office spaces
- Evaluate the contribution and added value of this actor in the sector, through the category in which it can be classified

To do this, the Template will be designed around the list of activities proposed by the analysed player, and then who would help to categorize it.

However, this sector is still in the process of innovation and transition. The Template must therefore be flexible. It must be able to consider and integrate new proposals, services or different and innovative models that could emerge in the near future.

3 Methodology followed

3.1 Main principles and steps

To complete the four objectives mentioned above, the selected strategy is the systematic review of many start-ups and other kinds of organizations operating in the sector of circular economy in the construction industry.

This systematic review follows several steps, of which the methodology would be explained below:

1. The identification and selection of the players to be analysed
2. The statement of some economic and operational indicators
3. The review and the listing of all the services provided

This method will lead to the generation of two tables:

- a table listing all the analysed players, along with some indicators and a brief description
- a matrix with all the listed services and activities in rows and the players in columns to find out who does what

The next step is to structure the listed activities and build a multi-level taxonomy. It would be mainly determined through cross-relationships between the listed activities and the independent professional domains, such as IT, consulting, manufacturing, …

After having better understood the panel of activities provided, a correlation matrix between all the activities will enable the possibility to identify similarities among some players in terms of offered services. Then, a glossary of players' categories will be established, using the most common terms found in the literacy, but by adding a clear definition.

Finally, by merging all the previous results together, a template to assess other start-ups will be imagined, based on the layout of a checklist.

3.2 Review of a sample of the circular economy and reuse players

3.2.1 Identification and selection of the reviewed players

The selection of start-ups and other types of organizations took place in two stages:

1. Identification and research of potential candidates
2. Filtering and selection of the most relevant ones

The search for players that could potentially fall within the scope of the study followed different leads and sources, listed below:

- Players already identified during previous personal research studies or internships, mainly based in France and Belgium
- List of players and case studies presented by my tutors for this study, mainly concerning Italian or Northern European actors
- Players presented in articles or studies on the theme of the circular economy in construction
- Players presented in case studies of deconstruction or renovation operations, who through their expertise have helped the project managers to achieve circularity objectives
- Players in connection with other players already analysed, either because their action is complementary and they highlight their partnership, or because one of the players is a spin-off organization of the other

Subsequently, faced with many potential candidates that could be analysed, certain filters and elimination mechanisms were necessary to retain only the most relevant players for the purpose of this study.

The first filter is a geographic one. The selected players must be located in Western Europe. The condition of belonging to the EU has not been kept, since Norway, a non-EU member country, is a breeding ground for circular economy players in the construction industry. Relative care was also taken to represent as many different countries as possible, although the disparities in the development of this theme of the circular economy in construction can be great between these countries, and therefore the number of potential players can significantly vary.

The second filter concerns the core business of the actors identified. As it has been said, the term circular economy encompasses a wide variety of domains and levels of circularity (hierarchy of the Re-actions). For this study, the selected start-ups had to focus on the themes of selective deconstruction, reuse, and digital or managerial support to carry out these operations.

Many of the preliminary identified start-ups focused on construction waste recycling processes. Today, they are certainly the best organizations able to capture major investments, thanks to increasingly innovative processes that are easily transposable to an industrial scale. Thus, despite their success and their contribution to the development of the circular economy and recycling practices in construction, they were not selected for this study, focused on more closed loops.

In addition, other identified actors were also not retained due to the lack of collectable information about them. That lack of information could be due to:

- The absence of an organization's website
- A website that is too underdeveloped or too uncluttered
- The presentation of services that are too simplistic or incomplete
- Lack of customer testimonials or presentation of case studies

Fortunately, it should also be noted that the language barrier for the study of certain start-ups operating in Northern Europe has not generated difficulties. Some of these start-ups offer an English version of their website. For the others, I would like to congratulate and thank the quality of web pages' translation services offered by the Chrome internet browser, developed by Google.

3.2.2 Economic and operational indicators

To better understand these start-ups and their level of maturity, a few economic and operational indicators have been identified. The list of these indicators is as follows:

- *Country*: country of origin where the player has started
- *Date of creation*: year of foundation of the organization
- *Location:* City(s) where the main offices of the organization are located
- *Market area*: area in which the actor operates, which can range from a region to a group of countries
- *Number of employees*: give a range of the size of the organization
- *Sources of income*: explains the different means of the organization to generate income

These indicators were chosen because they are the easiest to obtain. Indeed, to obtain comparable data between the different players, it is necessary to obtain all the information sought for each.

Thus, other economic indicators such as annual turnover, fundraising, etc. could not be selected because the information remained unfindable or too unreliable for many actors.

The two main sources for finding information were the "About Us" sections of the actors' websites and, in case some information was still missing, their LinkedIn profile. In case of conflict between these two sources (often concerning the date of creation or the number of employees), preference was given to information found on the organization's own website.

Regarding the number of employees, the accuracy of the information collected may vary from one organization to another. Some clearly indicate it; others simply give a range. In addition, in this kind of structure, the variable part of interns and fixed-term contracts can be quite significant, which generates a frequent fluctuation of the exact number of employees in an organization. Finally, the interest in recording the number of employees is to obtain an overview of the size of a structure, and not to have data that can be used to the nearest unit.

For all these reasons, a categorization by range of number of employees has been decided. It follows the different categories also used by the LinkedIn network, presented in Table 11.

Code	Nb. of employees	Code	Nb. of employees	Code	Nb. of employees
A	1	**D**	51 - 200	**G**	1001 - 5000
B	2 - 10	**E**	201 - 500	**H**	5001 - 10000
C	11 - 50	**F**	501 - 1000	**I**	10001+

Table 11 - Company size codes (source: LinkedIn)

Finally, the last category concerns the sources of income of the players. During the analysis, recurring sources of income were identified, and are thus presented in the form of a checklist:

- **Consultancy fees**: concerning all consulting services provided to project managers, also including the realization of resource diagnosis
- **Sales of products**: income related to the direct sale by the player of reused or remanufactured products
- **Commissions on sales**: commissions taken by the player, having enabled the sale of reused or remanufactured products between two parties
- **Users' subscription**: monthly or annual subscription of customers to the tools or services offered by the player (often concerning the digital field)
- **Dismantling operations:** fees received for total or partial dismantling operations on a site, carried out by the player
- **Remanufacturing operations:** fees received to remanufacture products on behalf of a customer
- **Subsidies:** Subsidies from other actors (public organisms, parent companies, associations of professionals in the sector)
- **Training:** income generated by a training offer proposed by the player
- **Certifications:** revenue generated by certification services requested by customers

Each player can combine different sources of income, given the diversity of the services it offers. Nevertheless, the explanation of these sources of income is only indicative and gives an idea of how this kind of start-ups can create wealth and profit on this theme of the circular economy in the construction. A more advanced study of the amounts generated, the return on investment, or the analysis of this type of economic indicators would be needed to better assess the economic viability of the model supported by all these players.

3.2.3 Review and listing of the activities of the players

For each analysed players, I've been through the available documentation findable on internet, mostly using their own website, offering different kind of information containers:

- Service presentation in specific sections of the website
- Start-up presentation on the section "About us"
- Video presentation of the firm
- Founder interview video in media or podcasts
- Free access to the online tools they can offer
- Demo request for contents requiring a subscription
- Press articles presenting the player or a case study
- Testimony of a client
- Case study presentation

The process was to analyse one by one each selected players and progressively build a matrix by adding new activities in rows and new players in columns, and by putting a cross to stress out that a given player carries out a given activity. The list of activities has then increased progressively through the review of a growing number of players.

An interest was taken not to lose in this first part of that study too much detail on the specificities and originalities of each activity proposed by the different players. The difficulty then was not to get lost in too fine a level of detail, which would generate too many activities to list when the differences between some could not be so significant.

For example, concerning the realization of the resource diagnosis, the services of realization of this so-called general diagnosis of a building have been grouped together in a single activity, without considering the different particularities that certain players can offer compared to others (photos,

methods for calculating quantities, precision in the description of the state of these materials, possibilities of reuse, etc.). On the other hand, the service of carrying out a general resource diagnosis of a building was distinguished from a service offering a more detailed resource diagnosis focused on a certain type building product, considering more technical, environmental and economic issues.

In addition, some players communicate effectively and accurately about the nature and methods of the activities and services they provide. This made it possible to list new, ever more precise and innovative activities, which greatly contributed to the quality of that whole activity identification process.

Other start-ups are more discreet about their process (which is understandable in a logic of corporate secrecy). Thus, it is possible that certain specific activities, or using innovative tools, have not been listed, despite the analysis of those start-ups.

In the end, out of all the activities listed, some are offered by many players, while other activities are only offered by a single one. Nevertheless, I chose to keep these unique activities in the list. This choice was motivated by two main reasons:

- **The innovative and promising nature of these activities**: In a logic of permanent evolution of the sector, it is more interesting to highlight emerging practices, new trends, which are rare today, but which could develop and spread rapidly among more actors.
- **The possibility of these activities to ensure an income** for the actor who offers them: certain activities such as catalogues of training for reuse jobs remain an important source of income, even if they do not directly impact the proper conduct of a project.

After the systematic review of all the services offered by the analysed players, we obtain a substantial list of activities that can be provided by the players of the circular economy and reuse in the construction sector. This list remains raw, non-hierarchical and difficult to understand.

3.3 Structuring the list of all the offered services and activities

The list of activities obtained by reviewing the players analysed is disorderly. Each activity was added to the list when it was identified for the first time during the review.

To order and structure this list, two approaches are used:

1. An approach by sector of activity
2. A chronological approach

3.3.1 The functional approach

This approach aims to categorize activities according to their field of activity. To do so, we are grouping together activities with similar traits:

- Use of the same types of tools
- Similar positioning vis-à-vis the customer (service provided, independent activity, free access)
- Close commercial proposal
- Similar objectives of the activities
- Complementary objectives of the activities
- Positioning in the same management phase of a project

The grouping of the different activities was done from the bottom up. Really close activities are grouped together. We then constitute homogeneous sets of a few activities (two to five elements). Then, again, these groups are brought together in different sections corresponding to different sectors. For this structuring, four areas are distinguished:

- **Asset/Project management assistance:** all consulting, support, planning, management assistance activities, assisting project managers throughout the refurbishment project
- **Operational and technical activities:** all manual or material activities mainly related to the management of remanufactured products, from their removal to their reinstallation
- **Digital tools development:** set of digital tools developed by players of the circular economy and reuse to facilitate, improve, connect the different practices of all the sector players
- **Educational activities and support**: set of activities dedicated to the production of educational content, in different forms and intended for different categories of the population, from the public to specialized players

These four domains form a coherent partition of all the activities listed and therefore make it possible to classify them in a list at three levels: Domain / Topic / Activity.

3.3.2 The chronological approach

Another classification of the listed activities has been considered. It is a question of distributing the activities according to the chronological order of the management of a project:

- **Building optimization:** including building management and renovation strategy planning
- **Deconstruction project:** first phase of the renovation project, corresponding to the planning and cleaning operations
- **Product remanufacturing:** intermediate phase of remanufacturing and management of deposited and reusable products, in order to ensure their proper implementation
- **Fit-out project:** second phase of the project, following the deconstruction operations and finalizing the renovation project with the delivery of a new usable space
- **Independent activities:** sets of training activities and production of educational content, useful throughout the project

Thus, the logic of this approach is the opposite of that of the functional approach. We start from the main phases of a project to gradually dive into the details and then be able to position the activities listed in the relevant places within the chronology.

In the end, this approach makes it possible to classify the activities following a chronological order in a list at four levels: Phase / Stage / Step / Activity.

3.4 Categorization of the players

To categorize the players into different categories, two methodologies have been followed, since the first one's output didn't provide useable data to process with.

The first idea was to use the matrix obtained with the activities provided by the different players analysed. We wanted to identify the activities frequently provided together by the same player. The mathematical model to assess those possible association of activities would be a correlation matrix:

- We start from the matrix A with activities in rows and players in columns, a x in $[A]_{ij}$ signifying that the player j provides this activity i
- Another matrix A' is generated, replacing the void by 0 and the x by 1, so that each activity I followed a binary random variable X_i
- Excel tools then efficiently help to generate a correlation matrix R, calculating every correlation coefficient between two activities

The correlation coefficient r_{ij} between activity I and activity j is calculated thanks to the formula:

$$r_{ij} = \frac{E((X_i - E(X_i))(X_j - E(X_j)))}{\sigma(X_i)\sigma(X_j)} \in [-1;1]$$

The correlation coefficient is number between -1 and 1 giving an overview of the dependence between the provision of two activities, following the rules in Table 12:

Scale of correlation coefficient	Level of correlation between activities
$\mathbf{0 < |r_{ij}| \leq 0,19}$	Very low
$\mathbf{0,2 < |r_{ij}| \leq 0,39}$	Low
$\mathbf{0,4 < |r_{ij}| \leq 0,59}$	Moderate
$\mathbf{0,6 < |r_{ij}| \leq 0,89}$	High
$\mathbf{0,8 < |r_{ij}| \leq 1,0}$	Very high

Table 12 - Correlation coefficient's interpretation

Then the idea was to link together activities sharing high correlation coefficients into clusters. The clusters then follow two rules:

- Each activity is at least correlated with another activity within the clusters
- No activity is correlated with an activity of another cluster

These processes have been run for two thresholds of correlation factors, and the results are presented in Table 13. The first threshold of 0,5 didn't give usable data, because 85% of the activities were gathered into the same cluster.

Threshold	Number of clusters	Average size of clusters	Number of isolated activity
$\mathbf{0,5 < |r_{ij}|}$	3	23 (one counting 63 activities)	6
$\mathbf{0,6 < |r_{ij}|}$	11	6 (from 2 to 15 activities)	13

Table 13 - Correlation matrix method's results

The second threshold has delivered a satisfying number of clusters, with an average size of 6, but with a standard deviation of 4,25. The obtained results were then not homogeneous. Moreover, looking at the different activities composing a given cluster, we could assume that activities only carried out by one player are responsible for the merging of different clusters into one, blurring the different sectors of activities.

A second method was used, in the same idea of the correlation matrix, but with formula different, considering the "popularity" of the activities. The dependence matric created follows the formula:

$$D_{i1,i2} = \frac{\sum_j (A'_{i1} \times A'_{i2})}{Min(\sum_j A'_{i1}; \sum_j A'_{i2})}$$

The dependence coefficient between activity i1 and activity i2 gives the proportion of time the activities are carried out together, given their occurrences. The activities with a number of occurrences below 15% of the number of players analysed were not considered.

Nevertheless, the same results are observed as with the first method:

- Setting low thresholds (under 0,8) generates too big clusters
- Setting high thresholds (above 0,85) generates clusters coherent and useful, but isolates a high number of activities (60% of the activities considered)

Finally, by setting a threshold at 0,85, we obtained only two clusters. They are coherent (similar or complementary activities grouped together) and are comparable to sections of the functional breakdown structure of the list of activities.

Therefore, it has been decided to base on that functional breakdown structure the categorization of the players of the circular economy and reuse.

At the end, six categories of players have been defined, based on the second level of the activities' functional breakdown structure. Two rules are followed to categorize the players:

- On the one hand, each category has its own rules to determine if a player fits into it or not.
- On the other hand, each player can fit into several categories

The categories and their precise rules of determination would be precise in the section 4.3.

3.5 Elaboration of the template to assess new players

The template aims to be useful for the assessment of new players and has been developed as a table thanks to Excel tools. The final version is presented in the section 4.4 and in Annex E.

A first draft has been imagined at the very beginning of the players review and was designed to facilitate that very review (Figure 16). It was mainly based on the first intuitions I could have. However, it was rushed to design such a template and to already imagine the assessment checklist. That first template was criticisable on several points:

- Too short: the review of a player using this template led to the loss of much information
- Not exhaustive: Entire fields of activities were missing in the checklist
- Not adaptable: the template wasn't suited to accept innovative and different solutions provided by a new player

Key words			
Principal activities			
audits and support			
Resource diagnostic	*Digital tools (BIM oriented)*	*Consulting and management support*	
Materials			
Dismantling	*remanufacturing*	*storage*	*transport*
Commercial support			
Linking/marketplace	*Outlet research*	*Material research*	*Product sales*
Location		**Market area**	
Economic indicators		**Digital development**	
Executive summary			

Figure 16 - First draft of the assessment template

The elaboration of a definitive version of an assessment template for new players was then best suited after the review of many players, and after activities and players categorization. Therefore, the template can be seen as a merging of all the different topics mentioned above. Then, it has been

constructed around different sections: presentation of the player, categories of the player, Activities carried out by the player.

In the presentation section, a wide blank is left to allow the writer to have some liberties to sum up and precise the activities and the particularities of the player. For example, if a player is remanufacturer specialized in wooden products, it would be explained in this paragraph. Moreover, a checklist of the economic and operational indicators can be filled.

Next, a table present the six categories of players identified. Thanks to the established rules and excel formulas, the table would automatically be filed, thanks to the section on the activity.

Finally, the functional breakdown structure (FBS) of the activities has been recycled to design a checklist of activities carried out by the analysed player. However, that FBS is quite long in its original form, and then, is not the best suited to design a useful and efficient checklist. So, it has been decided to keep only the first two levels of that FBS (Domain and topics). It keeps a satisfying level of details to precisely assess a new player, it remains 25 different check boxes in the final checklist. Furthermore, for each of those 25 sets of activities, a small description is added to be clear on the scope of each line.

Moreover, to keep the template adaptable to innovative and new activities that could be discovered, the end of the template is empty. The writer can then add at the end of the sheet, within the same layout of the checklist, new activities and their description.

All those design decisions have been taken to obtain a useful template to assess new players, with a satisfying level of detail, within two pages.

4 Results of the player's review

4.1 Presentation of the analysed players

For this study, 27 players of the circular economy in the construction sector have been identified, selected and analysed. They all operate in Western and Northern Europe. In the following Table 14, all the players are presented, and then some global observations will be discussed.

NAME OF THE PLAYER		
LOGO	Presentation	Foundation date
		Country
		Location
		Market area
		Company size code
CIRCULARITY		
	Circularity is one the main Italian start-up promoting circular economy. It has developed a platform where users can collaborate with all type of actors implicated in the value chain of products and registered on the platform (manufacturers, transporters, recycling plants, future users of reused materials). Circularity also offers a wide range of support for firms in the development of their circular economy approach: consultancy services, sustainable certifications, or webinars.	2018
		ITALY
		Milan
		Italy
		C
MOEBIUS		
	Mobius-Réemploi's core business is consulting in reuse processes and remanufacturing of raised floors. It has succeeded to elaborate a full industrial process for the remanufacturing of that of product, enabling to sell it with certification and insurances.	2017
		FRANCE
		Paris
		Ile-de-France
		C

CYCLE UP		
	Cycle Up is certainly the most famous French marketplace dedicated to reused construction products. Its strength is largely based on its faculty to propose to its clients and its users different levels of support: realization of a resource diagnostic, free announces on the platform or managed by Cycle Up, possibility to store the products into Cycle Up's warehouses, help to find on the market reused materials, … Originally operating in the Parisian region, Cycle Up has developed since 2021 a territorial strategy across all the country, by opening new offices in different important cities.	2017 FRANCE Paris, Rennes, Lyon, Toulouse France C
BACKACIA		
	BACKACIA is a French marketplace. Its core business is to provide an online platform to link sellers and buyers of reused products all around France. The firm also provide consulting services to support circular strategies on dismantling projects.	2016 FRANCE Paris France B
STOCKPRO		
	STOCKPRO is an online marketplace dedicated to new products coming from surplus (on site or from factories). The core business on the firm is to help subscribers to manage their stocks, their sales, and others logistical issues.	2018 FRANCE Paris France C
UPCYCLEA		
	My UPCYCLEA is a digital tool aiming to better monitor the circularity of a real estate portfolio, based on several digital options: bank of product passports to assess circularity indicators of buildings, monitor the bank of potential reusable products, source ex-situ reusable products, BIM synchronization, search of valorization paths, ...	2016 FRANCE Paris France, Benelux C
ARTICONNEX		
	ARTICONNEX is a startup operating in the West of France. It has three warehouses where the firm collects reusable (or new but not used) materials, remanufactures them if needed, and sell them physically on site. Manly focus on wood products, the firm proposes also other categories of products easily reusable.	2018 FRANCE Nantes Bretagne, Pays-de-la-Loire C
ECO'MAT38		
	ECO'MAT38 is a dismantler and remanufacturer operating in the Grenoble's region in France. It collects reusable products mainly from sites where it has been also the dismantler and/or the auditor. The warehouse serves as a remanufacturing place but also as a physical shop.	2015 FRANCE Grenoble Rhone-Alpes C
TRICYCLE		
	TRICYCLE is a collection of several brands, specialized in diverse topics of CE: cleaning out, remanufacturing, sales of remanufactured products, transformations, etc. Together, they offer a full services package to dismantling projects with valorization and reuse objectives. TRICYCLE OFFICE is one of the brand specialized in valorisation (resale, remanufacturing and transformation) of office furniture.	2009 FRANCE Paris France D

MINEKA		
	MINEKA is an association working to enhance reuse in the region of Lyon. It collects products from dismantling and construction site (reusable material or surplus of construction) and resales them in its warehouse shop. It also provides consulting services for project managers, along with specific trainings.	2016 FRANCE Lyon Rhone-Alpes C
PROCLUS		
	PROCLUS is a French start-up offering a full-service program to take care of technical electrical components from a detailed and specific resource diagnostic, dismantling operations, remanufacturing processes and resale.	2022 FRANCE Paris France B
OPALIS		
OPALIS	OPALIS is a business directory, recessing firms reusing and remanufacturing construction products around Benelux and France. It has been developed mainly by ROTOR. Thanks to a digital interface, users can search products using maps, or material filters. However, most of the remanufacturers are specialized in old materials. The website also offers documentation for each category of material, containing: description, dismantling and installation advises, test to run, indicative prices, requirements, ...	2019 BELGIUM Brussels Belgium, France, Luxembourg, Netherlands B
ROTOR DC		
RotorDC	ROTOR is originally a architects collective, having develop an association to support the sale of remanufactured products. Having its warehouse near Brussels, ROTOR DC aims to offer to dismantlers a location to remanufacture and sale products with good potential of reuse. In bigger projects, ROTOR can be more involved, helping to manage some operations on site (audit, cleaning out, strategy elaboration)	2014 BELGIUM Brussels Brussels region C
BUILD CIRCULAR		
build circular .brussels	BUILD CIRCULAR is a program launched after the pandemic to support companies in the construction sector in a circular transition, in the Brussels region. The program provides many trainings and awareness workshops in destination to contractors (small or big). On their website, one can find a business directory of firms in the region having already integrated circular practices.	2020 BELGIUM Brussels Brussels region B
RELIEVE FURNITURE		
Relieve Furniture	RELIEVE FURNITURE is an online marketplace dedicated to office furniture. The material transaction is realized between the donator and the buyer, on their own term. RELIEVE team helps the donators and the buyers by providing a useful online marketplace to purchase products, but also by helping donators to better manage the sale of their products and enhancing the trust of the potential buyers.	2020 BELGIUM Brussels Brussels region, England B
BATITERRE		
BATITERRE	BATITERRE is a remanufacturer operating in the Brussels region. Collecting different kind of products on dismantling sites, it sells them in its physical store, after remanufacturing operations. An online catalogue is also available.	2020 BELGIUM Brussels Brussels region B

CORNERMAT		
	CORNERMAT is one of the organization created by RETRIVAL (an environmental organization operation for the circular economy and the management of waste on construction site since 1997). CORNERMAT acts as a remanufacturer and/or seller of reusable products, both on a physical and digital platform.	2019 BELGIUM Charleroi Wallonia B
CIRCONFLEXE		
	CIRCONFLEXE is a start up mainly providing consultancy service to support building owners in the dismantling operations they can realize. They are focused on enhancing the reuse of materials, and thanks to their members' network, they can help and manage the sales of those products.	2022 BELGIUM Liège Wallonia B
MADASTER		
	MADASTER is an online platform providing tools to its users to manage their real estate portfolio in terms of material knowledge, circularity and CO2 storage. The platform aims to be flexible, and IA aided to generate the most accurate data, using users' inputs (BIM, Excel), manufacturers' data, IA predictive tools.	2017 NETHERLANDS Laren Austria, Belgium, Germany, Netherlands, Norway, Switzerland C
LOOPFRONT		
	Loopfront presents itself as a collaborative platform aiming to support circular economy and reuse in the construction. By a system of subscription, customers have access to digital tools to help them managing their resource survey on all their projects. Digital tools available on the platform help to generate reports (CO2 savings, waste, financial), product passport, automation in the reuse processes management (dismantling, storage, transport).	2018 NORWAY Oslo Norway, Sweden, Ireland, Germany C
RESIRQEL		
	RESIRQUEL is a team of consultant promoting the resource audit (or reuse mapping as they call it) before demolition. They offer consultancy services for dismantling operation, realize audits and also provide training to realize themselves a reuse mapping.	2013 NORWAY Oslo Norway B
REHUB		
	REHUB is a marketplace requiring at least a free registration to be used, and a payable version to unlock all the tools of the platform such as reserved or buy item online, access to technical and logistic support, CO2 savings reporting, etc.	2019 NORWAY Oslo Norway B
SIRKEN		
	SIRKEN is operating all around Norway, thanks to a network of warehouses. Contractors generating products surplus or reusable products can deposit them on the closest warehouse. The product would be sold both through an online marketplace and physical shops. The start-up also realized reuse mapping before deconstruction projects. Furthermore, SIRKEN has also designed outdoor furniture, resulting from upcycling processes.	2020 NORWAY Skatval Norway B

MATERIA		
M	MATERIA provides digital tools to enhance reuse processes during a deconstruction project, such as material passport for a reuse mapping, providing also quality data for the main marketplaces in Norway.	2022 NORWAY Oslo Norway B
MATERIAL MAPPER		
Material Mapper	MATERIAL MAPPER is primarily a mapping tool operating in 12 municipalities across Norway, referencing the future refurbishment/dismantling projects within the next years. It gives to all players data about the type and amount of potential reusable products which would be generated. Linked with other players (auditors, transporters, marketplace, testers), the start-up also plays the role of a hub to centralize all users' needs.	2020 NORWAY Oslo Norway B
RESTADO		
restado	RESTADO is the main marketplace for reused products sales in Germany. The platform works both for private and professional sellers or buyers. The platform only enables the connection between sellers and buyers and does not provide other types of support.	2016 GERMANY Berlin, Stuttgart Germany B
CONCULAR		
Concular	CONCULAR is a pioneer start-up in the field of circular economy in the construction sector in Germany, since 2012. Nowadays, the range of the services provided is wide: consulting services for dismantling projects or the for the circular management of a portfolio, digital tools to support that circular management and projects, a marketplace to connect buyers and sellers of reused products.	2012 GERMANY Berlin, Stuttgart Germany C

Table 14 - Presentation of the 27 analysed players

That list of players can be analysed from different points of view:

- **Geographical:** (Figure 17) the players come from 6 countries both located in Western and Northern Europe. Only Norway doesn't belong to the EU. France and Belgium are overrepresented, due to their progress in the development of the circular economy in the construction sector, the former knowledge I had about those players and due to the relative size of France compared to other smaller countries in the list.

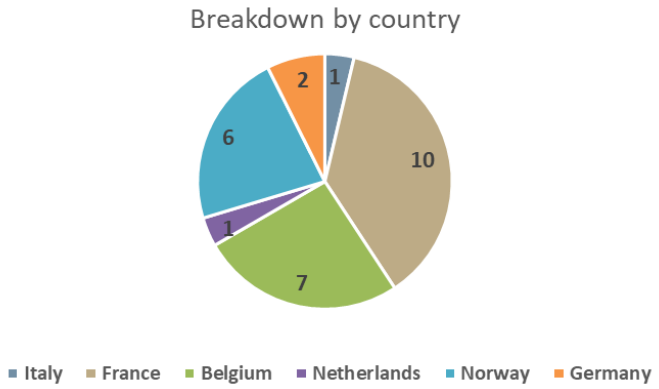


Figure 17 - Distribution of the players among countries

- **Historical:** (Figure 18) Only 5 players have been operating before 2016. Starting from 2016, we can find several firms created each year. I didn't find organisation created. A first hypothesis would be the backlashes of the COVID pandemic. However, that hypothesis isn't based on any strong

evidence, and we must keep in mind that there are only 27 analysed players, it isn't sufficient to give general figures on the whole sector.

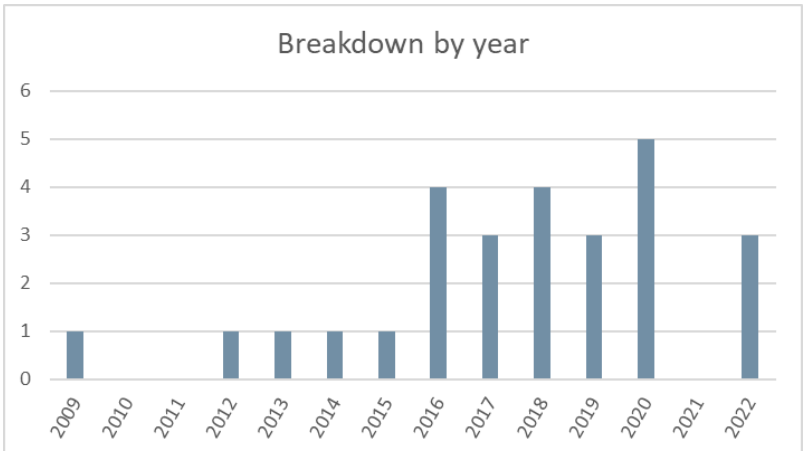


Figure 18 - Number of analysed players by year of foundation

- **By size:** (Figure 19) The players are mostly startups. It is then natural to face small organizations. A slight majority of them are composed by less than 10 employees, the others counting between 11 and 50 employees.

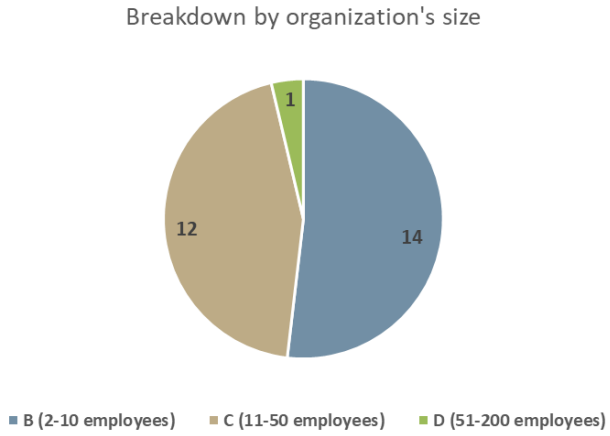


Figure 19 - Distribution of players by number of employees

- **By source of income:** (Figure 20) the Sources of revenue for the players are diverse. They illustrate the faculty of the player to generate profit from different type of activities. They don't rely one specific source, which is encouraging for the development, the strength of the sector.

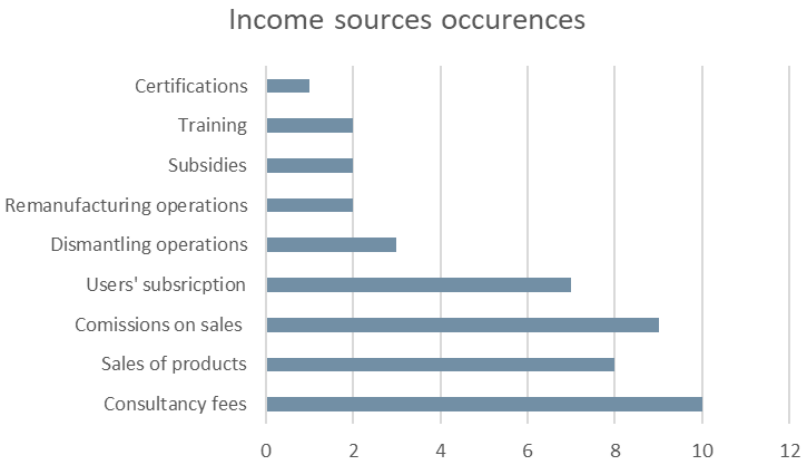


Figure 20 - Players' sources of income

4.2 Breakdown structure of the activities

The review of the 27 selected players has led to the creation of an unstructured list of 74 activities. Before establishing a breakdown of that list, some figures about the players' review outputs can be given (Table 15). The whole matrix of that review is put in Annex C.

Average number of activities carried out by a player	**11**
Standard deviation of the number of activities carried out by a player	5,2
Average number of occurrences of an activity	4
Standard deviation of the number of occurrences of an activity	3,4

Table 15 - Statistical analysis of the reviewed activities

With an average number of activities carried out by a player of 11 (representing 15% of the 74 listed activities), one can say that the players are quite specialized in some fields and are quite complementary to offer a total set of 74 activities. Only one player offers less than 6 activities and 3 players more than 16 activities. Then, with a standard deviation of 5, we consider that the analysed players have a similar level of activity.

By looking at the activities, we find an average number of occurrences around 4. This low average translates the willingness to have listed innovative, specialized and rare activities only offered by a limited number of players. Figure 21 gives the "popularity" of the activities, meaning the proportion players carrying out the same activities. 45% of the activities are provided by less than 10% of the players, illustrating again the diverse and specialized offer of services in the reuse and circular economy field in construction. The two activities carried out by more than 41% of the players concern case studies presentation and writing articles on the circular economy and reuse topics. It is then not surprising that they such a popularity among the players.

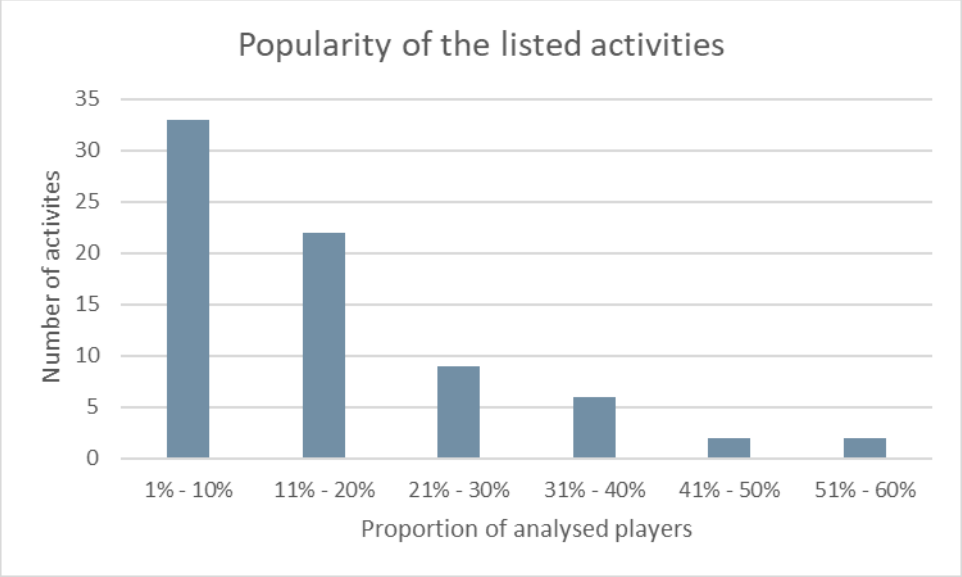


Figure 21 - Number of activities carried out by a proportion of the players

In the following Table 16, the functional breakdown structure (FBS) of the activities is presented. It is the most important one, serving after or the categorization of the players and the elaboration of the assessment template. The chronological breakdown structure is reported on Annex D. the FBS is divided into 4 domains, having around 7 topics each. In the topic's sections, the activities are presented with a definition, to better understand their scope and their objectives.

1 Asset/Project management assistance

1.1 Resource diagnosis

1.1.1 Execution of a resource diagnosis of a building, in preparation for a refurbishment project

The player carries out on behalf of the project manager a resource diagnosis of the space to be renovated, following a site visit, with estimation of the quantities, evaluation of the quality of the products and materials and possible recovery scenarios.

1.1.2 Execution of a resource diagnosis focused on specific products (technical, economic, environmental aspects)

The player carries out on behalf of the project manager a resource diagnosis focused on a certain type of product for which he is a specialist. It provides qualitative data to finely judge the technical reusability of products and its economic and environmental viability.

1.1.3 Execution of resource diagnosis of a set of building

The player carries out on behalf of the asset manager a resource diagnosis of a real estate portfolio, following a site visit, with estimation of the quantities, evaluation of the quality and availability of the products and materials and possible use or recovery scenarios.

1.1.4 Creation of a digital inventory of material and products available or potentially reusable in a building

The player creates on behalf of the asset manager a digital resource inventory of a real estate portfolio, using its internal digital inventory tools. The player provides also to the asset manager the skills, tools and knowledge to use the digital resource inventory.

1.2 Deconstruction planning assistance

1.2.1 Planning of circular strategies and objectives at the initiation of a refurbishment/deconstruction project

The player supports project management in understanding the challenges of circularity and reuse, the planning of coherent strategies within the framework of the project, with the establishment of quantified objectives (quantity to reused and/or recover).

1.2.2 Scenarios analysis to enhance the circularity of a project and/or of the management of a building

The player supports the project management in the establishment of scenarios describing different levels of objectives, recovery strategies, products to be reused. The scenarios are evaluated and prioritized.

1.2.3 LCA study to assess reusable product's life cycle

The player runs an LCA for certain products identified in the resource diagnosis. For this type of product, either in large quantities, or of particular interest, the choice of recovery method is determined using the LCA.

1.2.4 Redaction of specific technical requirements in tender's texts

The player writes on behalf of the project manager the technical clauses in the tender documents related to the careful dismantling, on-site storage and removal from the site of the products identified to be reused/remanufactured.

1.3 Fit-out planning assistance

1.3.1 Feasibility study to integrate reused products in a refurbishment/fit-out project (reuse ex- or in-situ)

The player supports the project management in the integration of remanufactured/reused products in the new fit-out project. These products can come directly from the same site (reuse in-situ) or can be identified on other sales channels (reuse ex-situ).

1.3.2 Search for a local ecosystem of players to support a circular project

The player accompanies the project management in the search for local actors of the circular economy and reuse, in order to know the local ecosystem in detail. The actor can present his own network, often already well known and accustomed to working together.

1.4 Environmental assessment of a project/asset

1.4.1 Environmental assessment and/or closing report of a project (avoided waste, energy savings, CO2 savings)

The player evaluates on behalf of the project manager the environmental assessment estimated (at the initiation of the project) or achieved (in the closing of the project). The aspects studied can be CO2 savings, water savings, amount of waste generated, ...

1.4.2 Circularity certification for projects or buildings

the player has developed new certifications to assess the compliance of a project with the challenges of the circular economy. Under request of the project management, he can evaluate the project and potentially issue a certification.

1.5 On-site deconstruction assistance

1.5.1 On-site supervision of operations related to selective deconstruction and reuse

The player supports the actors of the deconstruction site to ensure the achievement of the circularity objectives decided in the project planning. This covers the management of the products to be deposited and remanufactured, relations with the external actors solicited, ...

1.5.2 On-site management of subcontractors in charge of the dismantling of reusable products

The player is in charge of finding contractors specializing in the selective removal of products to be remanufactured, and of managing them on the site, working alongside the demolisher in charge of the main/structural deconstruction operations.

1.5.3 On-site presentation of best practices to dismantle/store/sell reusable products

The player promotes best practices on the deconstruction site to ensure the selective removal, storage and management of products to be reused. This can be awareness meetings for workers, learning deconstruction methods, sorting on site, space management.

1.6 Remanufactured products sale assistance

1.6.1 Production of commercial advertisements of reusable products on behalf of the product owner

The player produces commercial advertisements for dismantled products for sale on marketplaces. He collects as much data as possible (photos, quantities, condition, product reference, data sheet) and also shares his marketing knowledge to enhance the sales.

1.6.2 Management of sales of reusable products on behalf of the product owner

the player takes care of the sales on behalf of the owner of the products to be reused resulting from the deconstruction. They identifies possible sales channels, manages commercial announcements, exchanges with potential buyers, manages logistics issues.

1.6.3 Setting up of temporary showroom/shop on the dismantling site for reusable and dismantled products

the player organizes the installation of a showroom on the deconstruction site, for the duration of the project in a dedicated space on the site. The dismantled products are sold there for direct sale to visitors, both private and professional.

1.7 Remanufactured products purchase assistance

1.7.1 Search of reusable product source for a fit-out project

The player searches for local sources of remanufactured products on behalf of the project manager, as part of a fit-out project with the objective of integrating such products. They verifies the correspondence between the identified lots and the project's requirements.

1.7.2 Assist buyers in the purchase of reusable products in a specific product catalog

The player offers a whole catalog of remanufactured/reused products (remanufacturer store or marketplace). They offers potential buyers personalized support in the selection of products corresponding to their requirements.

2 Operational and technical activities

2.1 Dismantling operations

2.1.1 On-site dismantling operations focused on specific products

The player takes care of selective dismantling operations for a specific type of products identified in the project planning. They has developed specific skills to best deal with the dismantling, storage and transport of these specific products.

2.1.2 Full interior cleaning-out operations

The player is in charge of all the cleaning-out operations of the building to be deconstructed. It ensures the dismantling and storage of products identified to be remanufactured/reused and the sorting of waste on site into different flows for specific recycling/recovery.

2.2 Installation operations

2.2.1 Installation of remanufactured products at the destination site

The player, whether he himself is the reseller of the remanufactured product, or a contractor, takes care of the installation of the remanufactured product, according to the specific indications linked to such a type of product.

2.3 Logistics activities for reusable products

2.3.1 Transport of products between sites/warehouses/remanufacturing centers

The player recovers from the deconstruction site the products previously dismantled and stored on site. They transports them to the destination site: warehouse, remanufacturing center or other construction site.

2.3.2 Storage of products between two sites in warehouses, on behalf of the product owner

The player stores reusable products in its warehouses, dismantled on a deconstruction site. These products still belong to the deconstruction manager and are temporarily stored awaiting in-situ reinstallation or sale to another site.

2.4 Remanufacturer's purchase activities

2.4.1 Independent purchase of reusable products to remanufacture

The player, whose main activity is the remanufacturing of products, searches for new sources of products to be remanufactured, entering into a relationship itself with the deconstruction projects having not necessarily initially planned a dismantling and reuse of their products .

2.4.2 Purchase or acquisition, and storage or reusable products to be remanufactured

The player, whose main activity is the remanufacturing of deconstruction products, recovers (very often free of charge) dismantled and reusable products on the request of the deconstruction managers.

2.4.3 Purchase or acquisition, and storage of surplus new products, coming from construction/manufacturing sites

The player whose main activity is the resale of reusable products recovers (very often free of charge) new and unused products from surpluses from construction sites or manufacturing sites on the request of the production sites managers.

2.5 Remanufacturing activities

2.5.1 Conditioning operations of reusable products

The player conditions the reusable products. This includes activities of cleaning, minor repairs and packaging of products. In the end, the processed products are saleable as reusable.

2.5.2 Remanufacturing operations of reusable products

The player remanufactures reusable products. This includes activities of cleaning, restoration equivalent to new, qualification and packaging of products. In the end, the processed products are saleable as remanufactured.

2.5.3 Remanufacturing operations of products in the service of the product owner

The player remanufactures reusable products. This includes activities of cleaning, restoration equivalent to new, qualification and packaging of products. All those activities are carried out at the service of the product owner, planning an in-situ reuse of the products.

2.5.4 Transformations operations of collected products, with a change of their functions

The player remanufactures products non-reusable in their primary function. This includes activities of cleaning, transformation, requalification and packaging. The processed products are reusable in a new function, or in the same function with a lower level of requirement.

2.5.5 Up-cycling of construction waste to produce new products (office and outdoor furniture)

The player requalifies construction waste (element in wood, metal, non-reusable products, etc.) and up-cycles them by transforming them into new construction and/or furniture for office or outdoor spaces.

2.6 Remanufacturer's sales physical activities

2.6.1 Permanent store management dedicated to remanufactured products

The player manages a physical store where they sells remanufactured or reused products, remanufactured by themself or collected from other remanufacturers.

2.7 Management of technical, administrative and insurance topics

2.7.1 Documentation provision for traceability of reused and remanufactured products from one site to another

the player ensures the traceability of the reusable/remanufactured products for which he is responsible as transporters, storers or remanufacturers, etc. Traceability between the different sites (deconstruction, warehouse) is reported on documents or invoices.

2.7.2 Management of technical verification operations for remanufactured products

The player ensures the technical viability of the remanufactured products. To do this, he tests the technical characteristics of the product with laboratory partners and checks their compliance with the standards.

2.7.3 Warranty of remanufactured products sold

The player guarantees the remanufactured or reused products that it sells. To do this, he obtained the support of insurers, either through a professional relationship of trust, or through proof of the technical characteristics of the product.

3 Digital tools development

3.1 Marketplace

3.1.1 Marketplace for reused/remanufactured products, without platform teams' assistance for sellers

The player has developed a marketplace (online platform) dedicated to the sale of reusable or remanufactured materials. Each user, buyer or seller, acts independently on the platform, creating and managing sales ads, arranging the logistical issues of the transaction.

3.1.2 Marketplace for reused/remanufactured products, with platform teams' assistance for sellers

The player has developed a marketplace (online platform) dedicated to the sale of reusable or remanufactured materials. Users, buyer or seller, can be supported by marketplace teams to manage sales ads, arrange logistical issues, search for specific products.

3.1.3 Marketplaces' reused products advertisements compiler

The player has developed a marketplaces' product advertisements comparator/compiler tool. With geographical and product typology filters, the compiler facilitates the specific search for reusable or remanufactured products.

3.2 Remanufacturer's online sales

3.2.1 Online store of a remanufacturer, with delivery services

The player, whose main activity is the remanufacturing of deconstruction products, sells them on an online store. He then ensures himself, or through the intermediary of a partner transporter, the delivery of the products sold to the destination site.

3.2.2 Online store of a remanufacturer, with online reservation or purchase and physical withdrawal

The player, whose main activity is the remanufacturing of deconstruction products, sells them on an online store. It does not ensure the delivery. Products are reserved/purchased online and withdrawn by the buyer from the remanufacturer's warehouses.

3.2.3 Link of commercial advertisements with the online marketplaces

The player, whose main activity is the remanufacturing of deconstruction products, publishes ads for their remanufactured products on marketplaces and other third-party seller sites.

3.2.4 Link of commercial advertisements with mainstream and generalist marketplaces (eBay, social networks)

The player, whose main activity is the remanufacturing of deconstruction products, publishes ads for their remanufactured products on generalist and mainstream marketplace (ex: eBay, Amazon) and social networks marketplace (ex: Facebook).

3.3 Tools to improve advertisement quality on marketplace/online store

3.3.1 CO2 savings indicator

The player indicates in the sales advertisements of remanufactured or reused products the mass of CO2 emissions saved for the purchase of this product, in comparison with its treatment as waste and the purchase of a new product.

3.3.2 Smart pricing tools

The player has developed a pricing tool for the sales advertisements of remanufactured or reused products, considering the cost of the remanufacturing process but also the price of new equivalent products to remain competitive.

3.3.3 Alert mechanisms on specific remanufactured/reused products flows for potential buyers

The player has developed alert and announcement mechanisms (through mails mostly) to inform potential buyers looking for a particular type of remanufactured product of its arrival on the store platform.

3.3.4 Provision and exportation of material passport to online marketplaces

The player has developed material passport generation tools, synchronizing producer and owner data, exported and serving to generate reusable product advertisements on the marketplace, with high quality data.

3.3.5 Newsletter presenting new reusable and available product arrivals on the platform

The player, whose main activity is the management of a marketplace or an online store, regularly sends its registered members a newsletter presenting the new arrivals of remanufactured/reused products on the platform.

3.3.6 Connection service with carriers or storage companies

The player, whose main activity is the management of a marketplace or an online store, offers its users, both sellers and buyers, direct contact with transporters and storers who are partners of the platform, to facilitate logistical operations between the parties.

3.4 Research tools for specialist professionals

3.4.1 Interactive map/directory to search for transporters, storers and waste/reusable products recoverers

The player has developed an online directory, making it possible to search for actors in the logistics and reuse of deconstruction products. These directories are also presented in the form of interactive maps to better assess the local ecosystem.

3.4.2 Interactive map/directory to search for remanufactured product stores

The player has developed an online directory, making it possible to search for construction product remanufacturers (possibly owning a warehouse-store). These directories are also presented in the form of interactive maps to better assess the local ecosystem.

3.4.3 Interactive map/directory to search for contractors willing to use and install reused/remanufactured products

The player has developed an online directory, allowing you to search for (sub)contractors willing to implement reused/remanufactured products in a fit-out project. These directories are also presented in the form of interactive maps to better assess the local ecosystem.

3.4.4 Interactive map/directory to search for future deconstruction/refurbishment projects

The player has developed an interactive online map, listing future refurbishment/ deconstruction projects in an area, with the possibility of having an overview or access to their resource diagnosis.

3.4.5 Map generation tools to assess the typologies of a products used in an area

The player has developed an interactive online map, presenting the types of products most present in an area. This map is improved thanks to research work on the subject, or by resource diagnosis feedback.

3.5 Digitalization of product passport and resource diagnosis

3.5.1 Importation and digitalization tools of a resource diagnosis

The player has developed an interface allowing to import a resource diagnosis carried out on another medium. The digital interface makes it possible to systematically compile useful information for each material/product analysed, and to establish a product passport.

3.5.2 AI aided tools to generate product passport for a digital resource diagnosis

The player has developed tools to help create material passports as part of the digitization of resource diagnostics. AI assistance can be used to check or estimate quantities, find producer information, suggest recovery methods, etc.

3.5.3 Provision of a library of commercial products passport (with environmental, technical specifications)

The player has developed a product passport library, analysing and evaluating marketed construction products, under environmental (carbon footprint, water consumption, etc.) and circular (use of recycled materials, re-employability, etc.) aspects.

3.6 Tools for managing inventories and resources of buildings

3.6.1 Management tools of the inventory, dormant stock and flows between different buildings of a single user

The player has developed tools to help manage digital inventories of resources in stock or installed in the user's buildings. The use of QR codes and the systematic reporting of operations on the user interface improve the traceability and reusability of products.

3.6.2 Compilation tools to merge products or building passports, and to manage the total inventory of products in a portfolio

The player has developed tools for compiling product passports, digital inventories and resource diagnostics to centralize in a single interface all the management, logistics and recovery operations for products of a real estate portfolio.

3.6.3 AI aided tools to establish best scenarios to recover and valorise products and waste on a dismantling site

The player has developed AI-assisted tools to establish recovery scenarios for products identified in a resource diagnosis. The algorithm can help find potential remanufacturers, recycling centers, carriers, etc. and estimates cost, CO2 savings according to the scenarios.

3.7 Reporting tools based on user's assets digital data

3.7.1 Generation and exportation of environmental reports

The player has developed reporting tools on the digital user's interface used for digital inventories or resource diagnosis. The reports generated can then assess the environmental performance of the organization in its management of a portfolio or a project.

3.7.2 Generation and exportation of compliance reports for certification or regulations

The player has developed reporting tools on the digital user's interface used for digital inventories or resource diagnosis. The reports generated are specific to answer regulation/certification requirements, using users' data input on the digital interface.

3.7.3 Establishment and calculation of a circularity index for a project or a building

The player has developed a circularity index/score and a calculation method. Using user data entered on the digital platform, the index can be calculated automatically on request.

3.8 BIM related tools

3.8.1 Matching tools between BIM model and online marketplace to search for reusable products suitable for the project

The player has developed a linking tool between the BIM model of a construction/fit-out project and marketplaces and online stores of reused/remanufactured products to search for and identify products suitable for model, to integrate as soon as possible in the project.

3.8.2 BIM extraction tools to obtain a digital inventory of available and reusable products in a building

The player has developed a tool for converting a BIM model of an existing building into a materials inventory / building resource diagnosis, in anticipation of a refurbishment/deconstruction project.

4 Educational activities and support

4.1 Production of educational content

4.1.1 Writing articles or files on circular economy and reuse issues

The player makes available on its website or through newsletters some articles, reports, white papers, or files on topics of the circular economy in construction, not necessarily directly related to the activities and achievements of the organization.

4.1.2 Organization of webinars on circular economy and reuse issues

The player organizes webinars to train and raise awareness of the general public and sector players on the challenges, objectives and processes of the circular economy in the construction field.

4.1.3 Delivery of courses/MOOC on circular economy and reuse issues

The player organizes courses (mainly held online) or MOOCs to train and raise awareness among the general public and industry players about the challenges, objectives and processes of the circular economy in the construction field.

4.3.4 Presentation of the organization's achievements

The player makes available on its website or through newsletters the achievements of its organization, the testimonials of satisfied customers, the explanation of case studies, the total impact of the organization on environmental and circular objectives (ex: CO2 savings).

4.2 Production of technical documentation

4.2.1 Production of technical documentation to assist reuse processes

The player writes and offers technical sheets to explain and facilitate reuse and remanufacture operations. This can be guides for dismantling/reassembly of specific product types, product condition verification processes, remanufacturing techniques.

4.3 Training offer

4.3.1 Training offer for project manager

The player offers certified trainings dedicated to project managers to train them in the integration of strategies and objectives of circular economy, promotion of reuse in their deconstruction/refurbishment projects.

4.3.2 Training offer for resource auditor

The player offers certified trainings dedicated to future resource auditors to train them in carrying out a resource diagnosis of a building: the due diligence process, quantities estimation, state assessment, knowledge about recovery methods, etc.

4.3.3 Training offer for workers on site

The player offers certified trainings dedicated to workers on (de)construction sites to train them in selective deconstruction practices, management of worksite spaces and sorting of construction waste, sober management of resources (water, electricity, oil, gas).

Table 16 - Functional breakdown structure of the activities

4.3 The categories of players

After having structured and categorise activities, the categories of players have been established using the functional breakdown structure. Six categories have been identified:

- **Resource auditor:** players executing a resource diagnosis of the building before a deconstruction project. They are trained to better assess the quality, the quantities and the potential recovery methods of the products in a building.
- **Circularity & Reuse consultant:** players assisting asset and project managers in the circular management of their assets/projects. They draw strategies and best scenarios to improve the overall environmental impact of the project, but more precisely to enhance the processes for reuse and remanufacturing. They are helpful in all the stages of the project: project planning, operations on-site, sales or purchase of remanufactured/reused products, fit-out planning, project closing.
- **Remanufacturer:** players carrying out activities of remanufacturing of products from deconstruction project. They can run operations of conditioning, cleaning, repairs, transformation, up-cycling, technical testing. They also ensure the sales of those remanufactured products. Moreover, they can carry out other logistic operations on those products, form dismantling on site to transport and re-installation.
- **Marketplace:** players developing and managing an e-commerce website where reused/remanufactured products are provided by multiple third parties. They can also assist sellers and buyers in their transactions.
- **Digital solution developer:** players developing digital tools, platforms or services to enhance and ease reuse, remanufacturing, circularity processes in the management of a refurbishment project, to manage the inventory/diagnosis of resources of an asset, to assist players in their IT development
- **Circularity trainer:** players providing trainings dedicated to project managers, resource auditors or workers on-site or other "traditional" players, on the topic of selective dismantling and reuse

For each category of players, precise rules have been established to characterize a given player, based on the functional breakdown structure of the activities, on three levels: domain/topic/activity.

The characterisation of an analysed player follows the steps:

1. If the player carries out at least one activity on a given topic, it is considered that the player is dealing with that precise topic
    - Example: if the player can assist the project planner in the "*writing of specific technical requirements in tender's texts*" (Activity 1.2.4), he is considered to be dealing with the "*deconstruction planning assistance* topic" (Topic 1.2)
2. To be characterised as a **Resource auditor**, the topic 1.1 "*execution of a resource diagnosis*" must be delt with
3. To be characterised as a **Circularity & Reuse consultant**, at least two out of the topics 1.2 "deconstruction planning assistance", 1.3 "Fit-out planning assistance", 1.4 "*Environmental assessment of a project/asset*", 1.5 "*On-site deconstruction assistance*", 1.6 "*Remanufactured products sale assistance*" and 1.7 "*Remanufactured products purchase assistance*" must be delt with

4. To be characterised as a **Remanufacturer**, at least two out of the topics 2.4 "Remanufacturer's purchase of reusable products", 2.5 "Remanufacturing activities", 2.6 "*Remanufacturer's sales physical activities*" and 3.2 "*Remanufacturer's online sales*" must be delt with
5. To be characterised as a **Marketplace**, the topic 3.1 "*Marketplace management*" must be delt with
6. To be characterised as a **Digital solution developer**, at least one out of the topics 3.4 "*Research tools for specialist professionals*", 3.5 "*Tools for the digitalization of product passports and resource diagnosis*", 3.6 "*Tools for managing inventories and resources of buildings*", 3.7 "*Reporting tools based on user's assets digital data*" and 3.8 "*BIM related tools*" must be delt with
7. To be characterised as a **Circularity trainer**, the topic 4.3 "*Training offer*" must be delt with

Those characterisation rules might seem awkward, but they have been based on the characterisation process of the 27 players analysed (Figure 22). These rules prevent the players to multiplicate the categories where they can fit. Thanks to this, the average number of categories suited for each player is slightly above 2. Only the startup CycleUp covers all the six categories.

	CIRCULARITY	MOEBIUS	CYCLE UP	BACKACIA	STOCKPRO	UPCYCLEA	ARTICONNEX	ECO'MAT38	TRICYCLE	MINEKA	PROCLUS	OPALIS	ROTOR DC	BUILD CIRCULAR	RELIEVE FURNITURE	BATITERRE	CORNERMAT	CIRCONFLEXE	MADASTER	LOOPFRONT	RESIRQEL	REHUB	SIRKEN	MATERIA	MATERIAL MAPPER	RESTADO	CONCULAR
Resource diagnostician		x	x	x	x			x		x	x		x					x			x		x		x		x
Circularity & Reuse consultant	x	x	x	x						x			x		x			x			x						x
Remanufacturer		x	x	x			x	x	x	x	x		x			x	x						x				
Marketplace			x	x	x	x							x		x					x		x	x			x	x
Digital solution developer	x		x	x	x	x				x		x		x					x	x				x	x		x
Circularity trainer			x							x				x							x						

Figure 22 - characterisation of the 27 analysed players

4.4 The assessment template for new players

Thanks to all the previous results of the players review, a template for the assessment and the understanding of new players have been elaborated.

The compromise was to elaborate a template with a significant level of detail (enabling the understanding of the player's activities and model) and to succeed to create a user-friendly template, as a checklist (to be quick in the analysis of a new player and to obtain uniform information sheets about the analysed players).

It results in a template holding on a double-sided sheet, mainly as a checklist. The first paragraph for presentation is free-to-write. It enables to write done some specifications and a resume of the player, its model, its activities and its corporate culture. It is also a good way to remind us of the role of an already analysed player by reading it. On the next two pages, the template is given (Figure 23).

Concerning the structure of the checklist, the choice was either to use the level2 of the functional breakdown structure of the activities, or a classification of the activity topics based on the rules of characterization of the players mentioned in the section above. However, that last possibility is complicated, because not all the topics of the FBS were used to establish the characterization rules (some topics are independent or related to several categories of player). Therefore, the functional breakdown structure has been preferred. Nevertheless, the characterisation rules are implemented in the template, to automatically characterise the analyse player (a "X" appears to check the appropriate categories).

Finally, using principally the location indicator and the player categories, we could imagine the generation of an interactive map to look for players of the circular economy and reuse in our area, filtered by the specific type of players we need for a project.

NAME OF THE PLAYER

PRESENTATION

FOUNDATION	COUNTRY	LOCATION	MARKET AREA	COMPANY SIZE	TURNOVER

PLAYER CATEGORIES		
RESOURCE DIAGNOSTICIAN	CIRCULARITY CONSULTANT	REMANUFACTURER
MARKETPLACE	DIGITAL SOLUTION DEVELOPER	CIRCULARITY TRAINER

ACTIVITY FIELDS CARRIED OUT		
1 Asset/Project management assistance		
1.1	**Execution of a resource diagnosis/digital inventory** *Realisation of a resource diagnosis for a deconstruction project, or complete generation of a digital inventory to assist the management of the resource of a building*	
1.2	**Deconstruction planning assistance** *Assistance and consulting services to plan strategies of reuse and selective dismantling, set objectives and assess the feasibility of circular scenarios for a deconstruction project*	
1.3	**Fit-out planning assistance** *Assistance and consulting services to plan strategies of integration and research of remanufactured products and remanufacturers for a fit-out project*	
1.4	**Environmental assessment of a project/asset** *Certification and reporting services to assess the circularity of a project/asset, along with other environmental aspects (CO2 savings, waste reduction, etc.)*	
1.5	**On-site deconstruction assistance** *Assistance and consulting services to support project management on-site: supervision of dismantling operations, promotion of best practices, relation with subcontractors, etc.*	
1.6	**Remanufactured products sale assistance** *Assistance services to support deconstruction management in the sales of dismantled products: production of commercial ads, relation with potential buyers, sales on-site*	
1.7	**Remanufactured products purchase assistance** *Assistance services to support fit-out management in the search for remanufactured/reused products, from the identification of local sources to the selection of specific products*	
2 Operational and technical activities		
2.1	**Dismantling operations** *Execution of selective dismantling operations on a deconstruction site, from specific operations for certain types of products, to the complete cleaning-out of the building*	
2.2	**Installation operations** *Execution of operations of installation into a fit-out project of remanufactured/reused products*	
2.3	**Logistics activities for reusable products** *Execution of logistics operations for reusable and manufacturable products, including transport and storage*	
2.4	**Remanufacturer's purchase of reusable products** *Remanufacturer's activities to search for, collect and acquire reusable/manufacturable products, along with products coming from production surplus*	

2.5	**Remanufacturing activities**	
	Remanufacturer's activities of cleaning, conditioning, remanufacturing, transformation and up-cycling of reusable/manufacturable products	
2.6	**Remanufacturer's sales physical activities**	
	Management of permanent and physical store dedicated to remanufactured/reused products	
2.7	**Management of technical, administrative and insurance topics**	
	Management of the administrative issues around remanufactured products: traceability documentation, technical verification in laboratories, warranty of the sold products	
3 Digital tools development		
3.1	**Marketplace management**	
	Development and management of an online marketplace dedicated to the sales of reused/remanufactured products, linking sellers and buyers	
3.2	**Remanufacturer's online sales**	
	Development and management of an online store where a remanufacturer sells directly its products, or set reservation system linked with a physical store	
3.3	**Tools to improve advertisement quality on marketplace/online store**	
	Development of tools and digital services on marketplaces and online stores to enhance, ease and improve the sales of reused/remanufactured products	
3.4	**Research tools for specialist professionals**	
	Development and management of online directories and interactive maps to search for specialist professionals: recovery players, remanufacturers, reusable products sources, etc.	
3.5	**Tools for the digitalization of product passports and resource diagnosis**	
	Development of digital solutions to carry out inventories/resource diagnosis of a building and to generate product passports	
3.6	**Tools for managing inventories and resources of buildings**	
	Development of digital solutions to manage the resource inventory of a building: flows recording, real estate portfolio's inventory overview, recovery scenarios' establishment	
3.7	**Reporting tools based on user's assets digital data**	
	Development of digital solutions for environmental reporting in the management of a real estate portfolio, also including compliance reports (for certifications or regulations)	
3.8	**BIM related tools**	
	Development of digital tools to link the BIM environment with the circular economy and reuse field, to generate resource inventories or integrate reused products	
4 Educational activities and support		
4.1	**Production of educational content on circular economy topics**	
	Provision of articles, courses, MOOC, webinars, case studies on the topic of the circular economy in the construction sector, dedicated for the general public or the sector players	
4.2	**Production of technical documentation for reuse/remanufacturing**	
	Production of technical sheets on reuse and remanufacturing operations: guides for dismantling, conditioning, verification processes, remanufacturing techniques	
4.3	**Training offer**	
	Offer and management of certified trainings dedicated to project managers, resource diagnosticians or workers on-site, on the topic of selective dismantling and reuse	
+ Other activity fields		

Figure 23 - Final version of the player assessment template

4.5 Discussions

The different results presented in the sections above highlight the diversity of the ecosystem of players in the circular economy and reuse and their contribution to help the built environment to move toward a sustainable and circular model. The range of their services is wide and covers all the different steps of the management route of a built asset. Furthermore, the template produced in the framework of the study can then be useful tool to assess the contribution of new players in the sector and identify innovative solutions.

Nevertheless, this study has also revealed some current limitations of the ecosystem of those players:

- **Visibility of the players**

The players face difficulties to be visible outside the channels dedicated to the promotion of the circular economy. There are few articles in the general and the built environment specialized press to present their activities. Some players however, like MOBIUS, succeed to develop a strong communication strategy and then benefit from a leader status.

- **Geographical disparities**

The market areas of the players are not homogeneous among the Western and Northern Europe. France is overrepresented in the list of analysed players for this study because the background knowledge about them was already strong. But it has been difficult to find pertinent players in Italy for the precise topic of reuse and remanufacturing for example. The same problem was meet with countries like Spain and Portugal (the language barrier could be also a factor).

The geographical disparities are also observed within a country, or players tends to operate in large cities. A possibility is also that there can be many small remanufacturers operating in all the territories, but their visibility could be weak.

- **Assessment of their services**

The template and the identification of several categories of players aimed to provide a clear description of the different type of services delivered by the players of the circular economy and reuse. However, the different methods used in the study have failed to separate the areas of actions of the players to identify recurrent patterns.

Indeed, currently, the players can provide themselves a wide range of services that enable them to fill into different categories (marketplace and reuse consultant for example). On the one hand, that multi-disciplinarity shows the skills that those players have developed and their willingness to provide a full-integrated solution package. But on the other hand, it shows also that the specialization into one type of service doesn't generate sufficient profit for the player.

Then, the template and the categorisation of the players and their activities are a first step to an overall method to assess local ecosystems. It will require other tools to give a complete understanding of the ecosystem, such as a research methodology to find local players and a rating score to evaluate the complementarity of the identified players in a given area.

Finally, we could wonder for which type of projects could local ecosystems of reuse and remanufacturing players be involved. On the one hand, as we have seen in the second part of this study, the categories of products better suited for reuse and remanufacturing and benefitting from

mature networks of remanufacturers and resellers are mostly internal and finishing products. For example, Mobius a French remanufacturing start-up, is specialized in the remanufacturing of raised floors, thanks to an industrialized process recognized by insurers. Other typically easy-to-reuse products are carpet tiles, standard-size doors, lighting, partitions frames, sanitary equipment, etc. The structural elements of a building don't benefit todays from organized and recognized reuse and remanufacturing channels (expected steel and timber frameworks). On the other hand, the reuse and remanufacturing players' services, especially consultancy and digital solutions, have been designed to support sector professionals for large projects rather than support individuals in their private projects. Indeed, remanufacturers and marketplaces are more interested in dealing with large quantities of a same product. Moreover, digital inventory and reporting tools are more suited for professionals managing buildings and portfolios and submitted to more intensive regulatory requirements.

Therefore, it appears that office fit-out projects, concerning internal and finishing products and managed by sector professionals, are well suited to integrate high circularity objectives and involve the circular economy and reuse players.

Part IV - Integrate circularity and reuse: application to office fit-out

1 Overview of the concept of office fit-out

1.1 The different layers of a building

Following Stewart Brand's conception (Brand, 1994), a building can be divided into different six "shearing" layers (the 6 S), distinguished by their expected lifetime (Figure 24):

- **Site:** includes the geographical setting of the building, linked to the surrounding urban environment. Contrary to the building, the site is eternal.
- **Structure:** includes foundations and load-bearing elements, it mainly be considered to be the building itself, having the longest expected lifetime (up to 300 years).
- **Skin:** includes the exterior faces of the building, it corresponds to the envelope of the building, and could be replaced every 25 years or so, for technical or aesthetical motivations.
- **Services:** includes lifts, HVAC system, utilities, plumbing, etc., services are the "blood" or the "working guts" of the building. Their expected lifetime varies from 7 to 15 years.
- **Space plan:** includes the interior layout (partitions, ceiling and floor finishings, doors, etc.), its expected lifetime can highly vary depending on the building function.
- **Stuff:** includes all the removable objects (furniture, everyday objects) and can be changed on a frequent basis (daily, monthly, yearly)

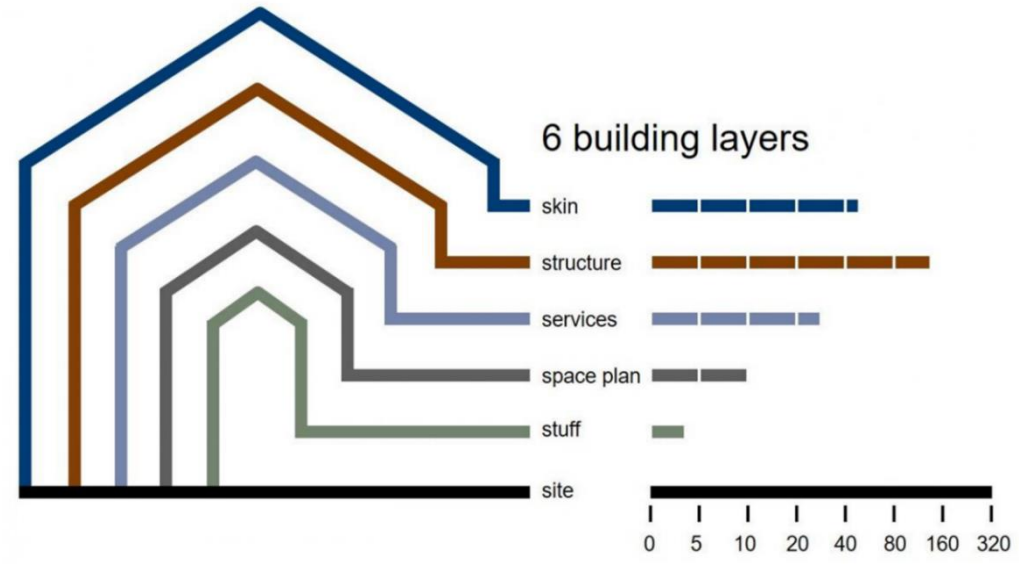


Figure 24 - The 6S model, based on (Brand, 1994)

That conception of the building and its different layers has a great impact on the eco-design of a building. Regarding their different expected lifetime, elements of each layer should be removable without damaging the layers of a higher expected lifetime.

1.2 Characterization of a fit-out

Building renovation or refurbishment are two terms with the same general meaning, applicable to a large range of operations.

Building refurbishment
Refurbishment includes any building works that modify the building or space, aiming to increase its economic value or social desirability, update it to current standards, improve its performance, or adapt it to a different use. (Casas-Arredondo, 2021)

Therefore, following the area of the interventions, a refurbishment can be partial if it concerns only a part of the building, total if the whole building is being renovated.

Another way to categorize the refurbishment projects is to consider their impact on the different layers of the building. Thus, the fit-out of a building can be defined thanks to that layer model. Commonly, a fit-out intervenes on the third last layers: stuff, space plan, services, and sometimes also to the skin layer.

Building fit-out
Building fit-out is the process of (removing and) installing interior building materials and components, which may include floor, wall and window coverings, partitions, doors, furniture, equipment, and sometimes mechanical and electrical (M&E) services. (Casas-Arredondo, 2021)

The first operation of a building fit-out corresponds to the removal of the actual layers. That deconstruction phase can also be named “strip-out”. The second phase corresponds to the very definition of a fit-out. For office spaces, it is defined as:

Office fit-out
the development of an office space with the purpose of aligning its functionality with the requirements of the people who use it: it’s making sure a space does what its occupants – or owners - need it to do. (OKTRA, 2023)

In the EU, non-residential buildings account for 25% of the total European building stock (D'Agostino, Cuniberti, & Bertoldi) and office buildings represent a quarter of the non-residential building (23%). Thus, office buildings only account for 6% of the buildings in Europe, which can seem insignificant compared to residential buildings.

However, some figures illustrate the environmental impact of the frequent fit-out of office spaces. Those spaces are willing to receive a fit-out operation frequently, between 2 and 10 years (Rossi & Deepak, 2009) and between 25 and 30 years for a deeper refurbishment including the skin of the building (Rey, 2004). Moreover, for an office fit-out project, some estimate that the greenhouse gas emissions are 74,5 kgCO2eq per square meter (Liljenström & Malmqvist, 2016) and that the fit-out of 100 square meters generates an amount of 6,3 tonnes of demolition and construction waste (BBP, 2015).

Therefore, office fit-out activities would benefit from a change of practices, adding more concepts of the circular economy, to reduce its environmental impact.

1.3 Interest in applying circular economy strategies to office fit-out

As some scholars have demonstrated, the buildings dedicated to tertiary activities offer a favourable framework to develop and massify the practices of reuse and remanufacturing (Atta, et al., 2022). Some reasons support that vision, based on the fact that office building interiors are renovated on a frequent basis, with a short time of use compared to other building functions.

On the one hand, the components dismantled during those operations keep high residual economic value and technical performance and are dry assembled. They possess then a high reuse potential and can benefit from a large market potentially interested in those types of products.

On the other hand, newly renovated spaces, willing to integrate more circular economy concepts, can adopt new strategies such as the selection of products eco-designed and easily reusable or of reused and remanufactured products, the rigorous management of the information about the building products during their whole useful life.

Then, office spaces can be the laboratory for the development of reuse and remanufacturing practices. The circular management of the fit-out operations is also a way for concerned firms (tenants, landlords, contractors, property managers, etc.) to green their image and be voluntary actors in the environmental transition through more circularity.

2 The traditional management of office fit-out

In this section, we will describe how a traditional office fit-out is managed: what are the different types of office fit-outs? What are the main steps? Who is involved? Traditional project management could include environmental certifications, but we will see in a second step how circular economy and reuse aspects could be integrated.

2.1 The different categories of office fit-out

Office fit-outs are sorted into different categories, depending on both the outcome of the project and the decision maker. Commonly, three categories are defined:

- **Shell and core (or base build):**

Figure 25 - Example of shell and core (source: RAP interiors)

corresponds to the outcome of a strip-out operation, when the three last layers of the office building have been removed (stuff, space plan and services), leaving apparent all the structural elements. However, the space remains weather-proofed. At the shell and core stage, the blank space is ready to receive any fit-out design. That stage can be undergone by various types of actors: a landlord willing to provide an empty space in the market, a leaving tenant compelled to apply the "make good" obligation in the contract, or a tenant undergoing the full refurbishment of an office space.

- **Category A fit-out (Cat A):**

Figure 26 - Example of Cat A fit-out (source: RAP interiors)

Category A fit-outs refer to basic fit-outs operations undergone by the building landlord. The output of this type of fit-outs includes the installation of services: mechanical, electrical and plumbing services, basic lighting systems, fire security systems, and HVAC systems; but also includes some basic elements of the space plan, such as raised floors or suspended ceilings. Category fit-outs provide a white canvas for tenants to establish their own design for the layers space plan and stuff. Category A fit-outs correspond to most of the spaces put in the market of the office lease.

- **Category B fit-out (Cat B):**

Figure 27 - Example of Cat B fit-out (source: RAP interiors)

Category B fit-outs correspond to the final result of a complete fit-out operation. It answers the needs of the tenant (end user of the space) and differs from Cat A by adding partitioning, upgrading the services equipment, finishes, fittings, IT and audio-visual equipment, furniture, etc. It creates the final functional layout of the space (meeting rooms, workstations, coffee corners, etc.) and provides an office space ready to use.

However, those two types of complementary fit-out processes, a landlord providing a Cat A fit-out and a tenant undergoing then a Cat B fit-out, correspond to the traditional model where the tenant signs a fixed and long-term lease contract. Today, with the development of home-working and then co-working spaces, especially since the COVID-19 pandemic, tenants are looking for shorter-term contracts offering more flexibility.

Therefore, a new category of fit-outs has emerged, known as Cat A+, undergone by landlords willing to adapt to the new trends of the office lease market. Basically, the Cat A+ fit-out offers fully furnished spaces, with all services included. They are not made for a specific tenant but furnish a sufficient high-quality space for any new tenants to use them directly. Cat A++ fit-out is also called “Built to Lease” or “Plug and Play”.

2.2 Processes and players for an office fit-out

For the following sections, we will only consider a full operation consisting of stripping out an office space and its fit-out, undergone by a single decision maker (tenant or landlord) to provide a Cat B (or Cat A+) office fit-out. That timeline has been established through the compilation of different timelines provided and explained by fit-out companies (Oktra, DALE Office Interiors, Echospace, Centric Office, ODG Group, Overbury, Lindner, Morgan Lovell). The stages are presented in the paragraphs below and are represented in Figure 28.

1. **Planning**

In this phase, the tenant foresees the end of the current office lease. After discussions with the involved stakeholders (landlord, tenant, employees) and the identification of their needs and expectations, the first choice would be to renegotiate (stay in the same building) or relocate (find a new office space).

In case of relocation, the tenant should contact a property agent to ease the search for a new building. The property agent provides its expertise in the lease market and its trends but also can provide legal support to negotiate the contracts and the lease obligations.

Parallelly, an internal team is built to manage the whole process, with an internal project leader to manage the project, gathering all employees’ requirements. The team draws up a budget forecast with the support of the financial division and established the concepts and goals for the

Moreover, to better establish the goals and requirements for the new office fit-out, some specialist consultants can be involved. They assess the current organization’s operations and services and offer areas of improvement to enhance the organization’s performance. Those consultants are mainly ICT services specialists and workplace specialists. Workplace consultancy services often include furniture and storage audits, staff engagement workshops, time and space studies, information technology reviews, space utilisation analysis, staff interviews, online surveys, etc.

Finally, at the end of that stage, the two outputs are the selection of the new office space to occupy and the full understanding of the workplace’s requirements.

2. Design

After having assessed the organization's needs, the internal project team appoints a fit-out partner and/or architect/interior designer team. The fit-out partner can also play the role of the designer or can advise the project team along the whole fit-out process.

The design phase is composed of different steps: space concept planning, preliminary design, service design, and then final design. While drawing the final design of the project, some aspects should be considered: the brand and the company culture, the well-being and productivity of the employees, the compliance with design regulations, the functions integrated into the new space plan and the sustainability of the project (linked with certifications objectives and the company's green credentials).

Concurrently with the design steps, the technical programme runs (OKTRA, 2023). It assesses the different challenges that the project meets such as financial control, schedule planning, building performance specifications, statutory approvals, fire safety regulations, health and safety agreements, and contractual agreements.

3. Construction

The construction phase starts with the transitional step of the tender procurement to appoint a contractor. The process can be longer if negotiations are opened with contractors for rebid of over budget.

After having appointed a contractor and received the permits, the construction operations start, following the different traditional steps:

- Site set-up and preliminary work: preparation of the site to provide an efficient, healthy and safe site for workers and operations
- Demolition and strip-out of the existing elements non-useful for the new project
- First fix and build: raised floors, HVAC systems, hard ICT systems, partitions framework
- Second fix and finishes: lighting, partitions finishes, floors, ceilings and wall finishes, sanitary (and kitchen) installation
- FF&E: furniture, fixtures and equipment installation
- Final clean and handover: space ready to use, test and certification of end of works, operation and maintenance manual provision

However, the FF&E is often separated from the rest of the contractor's missions. With the help of the fit-out partner, an FF&E procurement can be run to select a manufacturer or an independent consultant serving as the intermediary.

4. Operation

Following the handover of the completed fit-out, the company organises the moving-in of the organization, with all the technical support needed (communication redirection, closing of the former lease contract, certification obtention, etc.).

The newly renovated space is now occupied and used by the collaborators. Within this operational phase, traditional operations of maintenance, information management and optimization are carried out by a facility management company.

Nowadays, a new procurement route is more and more acclaimed by fit-out companies: the Design & Built method. The principle is that the project manager performs only one tender to select a "design-builder". That player provides altogether the missions of fit-out consultancy, design and construction.

That new method presents some benefits for the project manager, like greater cost certainty, time-saving (around 33%), more synergies and expertise sharing between architects, engineers and contractors and less risk-taking, resource consumption and expertise knowledge requirements for the company undergoing the fit-out project.

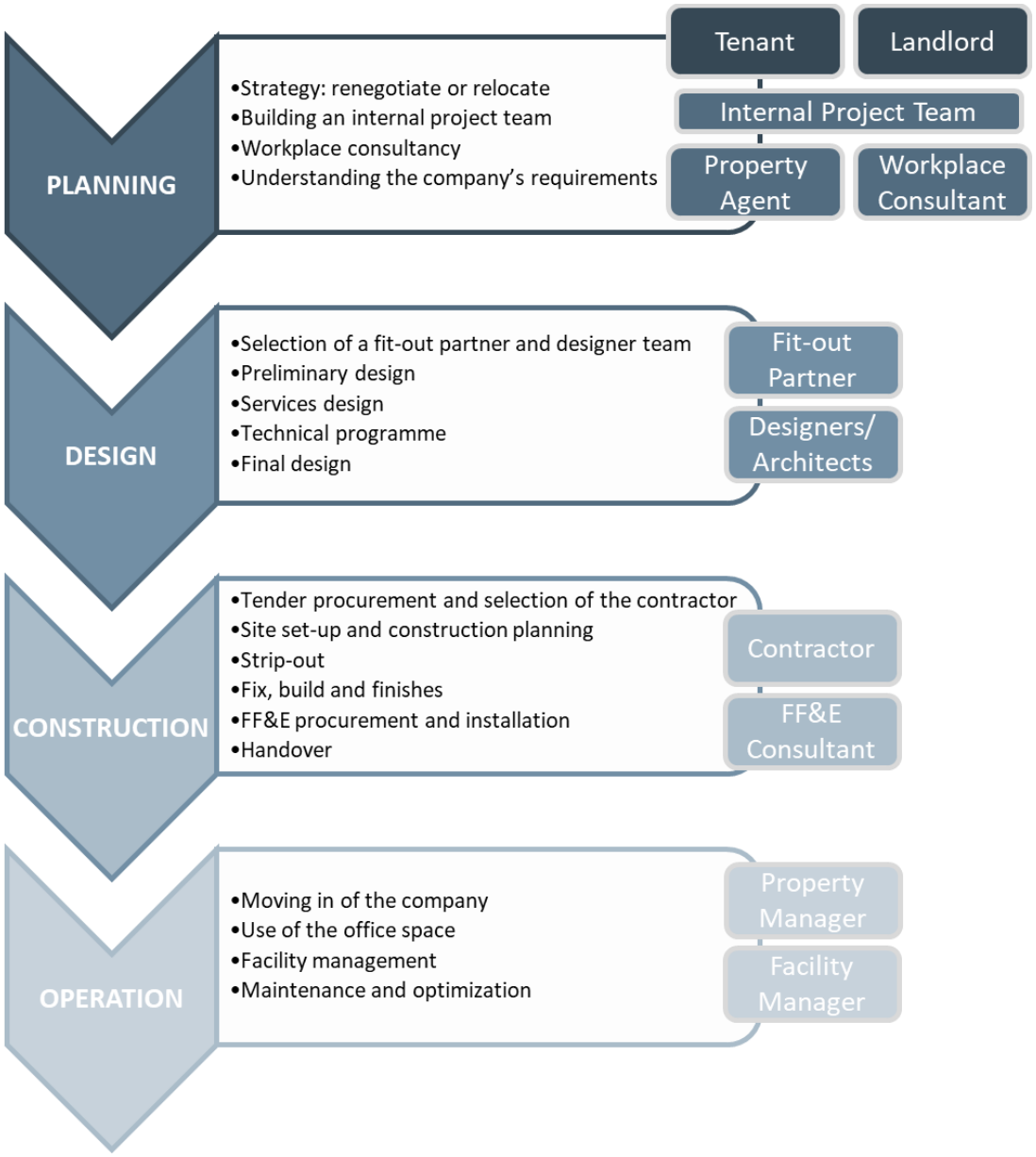


Figure 28 - Timeline and involved player in the traditional procurement route of an office fit-out (own elaboration)

2.3 Certification for office fit-outs

There are nowadays several popular certifications and rating tools for assessing the sustainability, environmental and well-being aspects of an office fit-out project. In the following paragraphs, the main ones are presented.

- **LEED Interior Design & Construction**

LEED is a US certification which stands for "Leadership in Energy and Environmental Design". LEED Interior Design & Construction (LEED ID+C) is the rating system developed to assess a fit-out project.

The LEED scoring system is decomposed into 35% related to climate change, 20% to direct impact on human health, 15% to water resources, 10% to biodiversity issues, 10% to the green economy and 5% to community and natural resources.

- **BREEAM Refurbishment and fit-out**

The BREEAM ("Building Research Establishment Environmental Assessment Methodology") Refurbishment and fit-out is a UK certification which provides a framework to deliver fit-outs projects to a high-performing and sustainable standard, support commercial success, and create positive environmental and social impact.

The BREEAM RFO is focused on the assessment of ten main issues: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution and innovation.

- **SKA Rating**

SKA Rating is a UK rating system developed by RICS (Royal Institution of Chartered Surveyors) to assess fit-out projects within the framework of sustainability best practices criteria. Thanks to an easy-to-use online tool, the rating system can fit several purposes: an informal self-assessment of the environmental aspects of the project, a quality-assured assessment thanks to the involvement of a SKA assessor, a guideline for the implementation of best practices and a benchmark to compare the environmental performance of different fit-outs scenarios.

Based on a set of hundred "good practices", SKA Rating covers topics like energy and CO2 emissions, waste, water, materials, pollution, well-being and transport.

- **Fitwel**

Fitwel is a certification system developed by the US Centers for Disease Control and Prevention in collaboration with building design experts. It assesses the health and well-being features of the building. It covers design and construction strategies evaluation but also the assessment of operational strategies.

The Fitwel credit system assesses the building and the project considering seven health impact categories: surrounding community health, reduction of morbidity and absenteeism, social equity for vulnerable populations, the feeling of well-being, access to healthy foods, occupant safety and increase physical activity.

However, the most popular certifications for office fit-outs focus mainly on global sustainability and the social impact of the project. Nowadays, there are no leader certifications to assess the circularity of a fit-out project. The circular economy concepts are one of the many criteria for environmental certification like LEED or BREEAM.

3 Integration of circularity in office fit-out

3.1 Followed methodology

The objective of this section is to determine how it is possible to integrate to fit-out projects the circular economy concepts and especially the 4R framework (reduce, reuse, remanufacture, recycle, recover). To do so, several topics and results previously established were merged to propose a specific planning of such a project.

Then the materials used to draw the planning are:

- The set of categories of players of the circular economy and reuse identified in the previous part

- The listed activities provided by those players and contributing to a circularly managed office fit-out project
- The traditional management route of an office fit-out project
- Chronologies of deconstruction/construction project proposed in the literature (OREE & CSTB, 2022), (FCRBE, 2020), (Casas-Arredondo, 2021)

The starting point is to use the traditional procurement route of an office fit-out represented in **Erreur ! Source du renvoi introuvable.**, and reuse the four main phases: planning, design, construction and operation, and to confront it with the chronological breakdown structure of the players' listed activities, and the proposed chronologies provided in the literature.

The obtained chronology is designed to present only the very specific actions and steps required to enhance reuse and remanufacturing practices in the project. The other environmental and ESG topics (energy and CO2 savings, water consumption, management of recycling and recovery of wastes generated, impact on biodiversity, social equity, well-being) are not considered. However, in a general case, obviously those topics should be additional key objectives for any sustainable fit-out project.

The next step is to identify the involved players for each entry of the planning, both traditional and reuse specialist. Currently, the two profiles are still differentiated, because we consider that circularity and reuse practices are still underdevelopment and that classical players have not developed yet the required skills to manage the issues related to circularity and the 4R framework.

3.2 Chronology of an office fit-out project within the 4R framework

3.2.1 Listing of the players

For that chronology, 12 players are involved in, some all along the project and others only for specific actions at a certain stage of the project. 7 of those players are considered "traditional":

- Landlord of the building
- Tenant, managing the whole project thanks to its internal project team
- Fit-out partner
- Design team
- Contractor
- FF&E consultant
- Facility manager

The 5 other players are the ones identified in the previous part of the thesis:

- Circular economy and reuse consultant, which would be named CE&2R consultant (2R refers to reuse and remanufacture)
- Resource auditor
- Remanufacturers
- Marketplaces
- Digital solution providers

We would like to point out that the last three players are written in their plural form. Indeed, for a single project, more than one remanufacturer and marketplace can be involved, regarding the type of construction products they deal with, the availability of those products, etc. Digital solution providers, due to the wide range of tools they offer, can also be several to called for a project.

The chronology is illustrated in

3.2.2 Description of the chronology

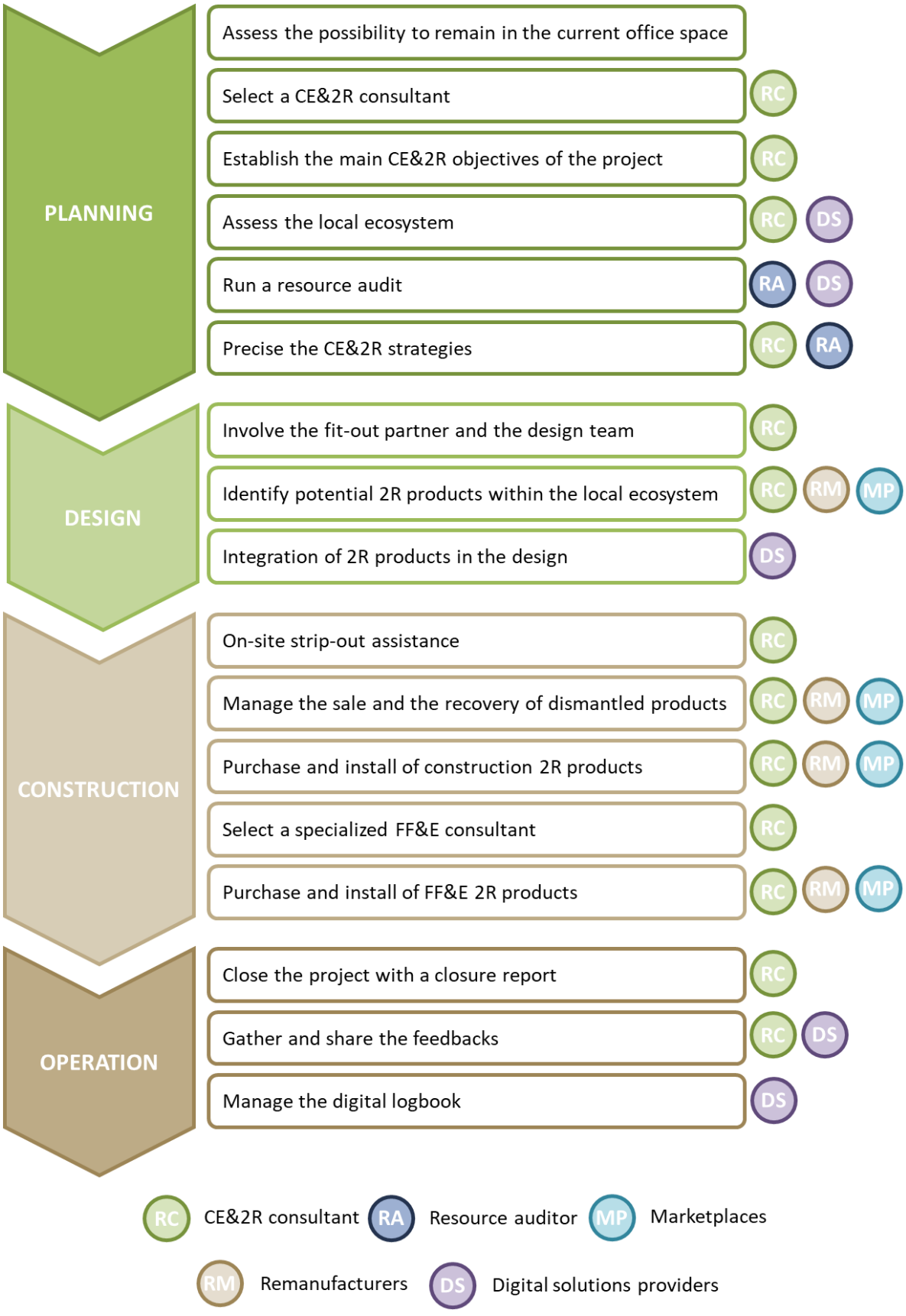


Figure 29 - Chronology of a fit-out project focused on the CE&2R steps (own elaboration)

3.2.2.1 Planning phase

Assess the possibility to remain in the current office space

The first decision the project owner can take to enhance the circularity of a fit-out process is to question its utility. If the current occupied office still fit the tenant needs and if the property owner is willing to renegotiate a new lease contract, choosing to renounce to a fit-out project is the most circular option, corresponding to the maximum level of the re-actions: "R_0 Reduce". It hinders the non-essential consumption of resources, energy, water, etc.

However, the option to remain in the same office is often impossible to select for different reasons: the refusal of the landlord to renegotiate or the need of the company to change its workplace to meet business development objectives (unsatisfying location, enhance the workplace fit-out efficiency, change the size of the occupied space, meet new requirements).

Select a CE&2R consultant

The internal project team launching a fit-out project is willing to integrate to the project circular economy objectives. Therefore, to support it, the team will look for a circular economy consultant, specialized in the management of reuse and remanufacturing processes.

The selection of CE&2R consultant as the earliest stage possible is a key to fully integrate circular economy concepts within the project, and the consultant would bring its expertise for all the remaining steps to carry out.

Establish the main CE&2R objectives of the project

With the expertise of the CE&2R consultant, the project team establishes the main objectives in term of reducing, reusing and remanufacturing. They can refer to certification requirements.

There are diverse ways to express the CE&2R objectives, such as a target rate or amount of product to dismantle and to recover in the reuse or remanufacture loops or a target rate or amount of product to integrate to new fit-out.

In this step, the main strategies are also established, giving an overview of the requirements, people, processes and costs related to the CE&2R objectives.

Assess the local ecosystem

The reuse consultant has the expertise and knowledge about the ecosystem of players of the circular economy and reuse in the area of the fit-out project. Regarding its characteristics, the reuse consultant should be able to assess the maturity and the potential contribution of the ecosystem to the project.

This assessment enables also to have a first overview of how the CE&2R objectives can be achieved, by pointing out the potential synergies with other players, but also the obstacles the project might face due to a lack of specific players.

Run a resource audit

The selection of a resource auditor is the first outcome of the previous assessment of the local ecosystem. The resource auditor will then produce a resource diagnosis to identify and assess the reuse potential of the products installed in the office space to refurbish. Case by case, further desk studies can be conducted to precisely the reuse potential of some products.

The resource diagnosis is positioned early into the chronology due to its importance for the rest of the project. It serves as basis for the selection of reuse and remanufacture scenarios for the project and as

product bank for the design team. Furthermore, its early publication sheds light on the reusable products on site which could interest potential buyers.

Precise the CE&2R strategies

The assessment of the local ecosystem, the resource diagnosis and the further desk study provide quantitative and qualitative material to precise the CE&2R strategies and scenarios to adopt for the project and to achieve the circular objectives.

The CE&2R strategies can be for example the selection of identified batch of products to reuse in the new fit-out project, the sale of another batch to a specialist remanufacturer, the collaboration with a specific marketplace to sale small quantity of reusable products, etc.

3.2.2.2 Design phase

Involve the fit-out partner and the design team

Like for a traditional procurement route, a fit-out partner and a design team are selected for the project. However, in collaboration with CE&2R consultant, those two main partners should be selected also regarding their interest for and knowledge about reuse and remanufacturing practices. If they are not expert on the topic, the reuse consultant can also assist those partners to integrate circular processes in their activities for the project (knowledge sharing, best practices explanation).

Identify potential 2R products within the local ecosystem

To assist the design team in the integration of remanufactured or reused (2R) products in the design of the new fit-out, the reuse consultant provides the design team the different sources of reused and remanufactured products within the local ecosystem (marketplace, remanufacturers' shop, future deconstruction project). At this step, the goal can be either to already select the 2R products to purchase or have an overview of the market and its products "bestsellers".

Integration of 2R products in the design

In the basis of the market insight provided by the reuse consultant, the resource diagnosis, and following the project's objectives and strategies, the design team integrate remanufactured and reused products in its design project.

The prescription of 2R products is more difficult compared to new equivalents (issue on quality, warranty, quantity, dimensions, etc.). It requires flexibility and adaptation from the designers, architects and engineers.

3.2.2.3 Construction phase

On-site strip-out assistance

During the strip-out operations carried out by the contractor, the reuse consultant provides assistance on site. It overviews the execution of the dismantling and recovery of identified products to be reused and trains the workers on site to the best practices. In case, the reuse consultant manages the coordination between the general contractors and specific subcontractors in charge of the dismantling of given products.

Manage the sale and the recovery of dismantled products

In parallel with the progressive strip-out operations, dismantled products are sold or given to third parties (remanufacturers, marketplaces, other construction projects) and evacuated of the site. The logistics issues, such as conditioning, transport, transaction, date and traceability documentation are

discussed between the reuse consultant and the contractors from one side and third parties from the other side.

The contractor or the reuse consultant, depending on tender's documents specifications, registers all those transactions to check the achievement of the CED&2R objectives and strategies.

Moreover, for the products identified in the resource diagnosis and integrated in the design of the new fit-out, the contractor should ensure the good condition storage and reconditioning of these products.

Purchase and install of construction 2R products

During the construction and fit-out operations, considering the schedule and the availability of identified 2R products in the market, the contractor with the assistance of the reuse consultant purchases these products and registers all those transactions to monitor the achievement of the CED&2R objectives and strategies.

The contractor also ensures the good installation of the purchased 2R products, respecting remanufacturers or guidelines' indications and collect all the technical documentation related.

Select a specialized FF&E consultant

As for the selection of the fit-out partner and the design team, the FF&E (furniture, fixtures and equipment) consultant is charge of the purchase of the FF&E should also be sensitive to the circular economy and 4R concepts.

The FF&E consultant would collaborate with remanufacturers specialized in remanufactured office furniture, or at least, eco-designed products (low natural resources use and easily reusable). Moreover, it could also have expertise in the second-hand market for this kind of products.

Purchase and install of FF&E 2R products

The FF&E consultant and the contractor, regarding the CE&2R objectives and the design prescriptions, purchase furniture, fixtures and equipment in the reused, remanufactured and eco-designed product market (marketplaces, (re)manufacturers).

The contractor also ensures the good installation of the purchased 2R FF&E products, respecting remanufacturers or guidelines' indications and collect all the technical documentation related.

3.2.2.4 Operation phase

Close the project with a closure report

At the end of the project, a closure report is necessary to assess the achieved circularity of the project. It confronts the obtained results with the preliminary objectives and compare the resource diagnosis and its conclusion to the actual reuse or remanufacturing of the products.

In case of differences between results and objectives, all the involved parties should be able to explain the limitation and barriers they have faced, or in contrary the opportunities that have occurred during the project which have helped to achieve the project goals.

Gather and share the feedbacks

In parallel with the closure reporting, all the parties involved share their feedbacks. Contrary to the closure reporting, feedback sharing gives more space to personal opinions, promotions of best practices, tips or advice for future projects.

Then, the feedbacks should be communicated to the general public, to participate in the levelling up of all the sector and to give the example for other project managers and players.

Manage the digital logbook

After the handover of the new fit-out, a digital logbook should be monitored. It gathers all the information of the products in the building (remanufactured or new) like technical specification, producer information, traceability, chronology of the events, dismantling notice, maintenance manual.

The record and the update of the logbook provides a useful tool to enhance the maintenance of the building components (participating in the Reduce re-action) and their reuse and remanufacture potential in the next fit-out project of the office.

Using digital solutions, the management of that digital logbook and of the inventory is user-friendly and can be one the main circular mission for facility management.

Conclusion

The circular economy in the construction and built environment sector is currently being structured. The movement started decades ago by committed academics and architects and has since been supported by the European Union in the evolution of its regulation. The traditional players in the sector, developers, building managers, general contractors, architects, engineers, are mostly aware of the need to evolve their practice towards more circularity, and sobriety in the consumption of natural resources and the production of waste. However, persistent barriers prevent a clear transition of the entire sector.

However, studies and pioneering projects have highlighted good practices, particularly about reuse and remanufacturing. The building product categories that are the easiest to reuse and remanufacture have been identified. They mainly concern interior and non-structural elements and are easily found in office spaces. In addition, the resource diagnosis has become an essential tool for analysing the reuse potential of the existing built environment to be deconstructed or renovated.

To support traditional sector players and consolidate circular practices in deconstruction and renovation projects, an ecosystem of specialized players has formed in recent years. The study of their model and their activities has made it possible to better understand the added value of these actors in the management of deconstruction and renovation projects. The analysis of 27 of these actors made it possible to generate a list of 74 activities divided into 4 sections: project assistance, technical and operational activities, digital tools development and educational support. In addition, to better define these actors in the future, a template based on the list of activities has been developed and six different categories of actors have been defined: resource auditor, circular economy and reuse consultant, remanufacturer, marketplace, digital solution developers and circularity trainer.

Therefore, the categories of products with a high potential for reuse on the one hand and the structure of the ecosystem of reuse and remanufacturing players on the other hand have justified the relevance of integrating circular economy practices with ambitious goals to office fit-out projects. In this study, a chronology of specific circular actions has been added to the classical one. It also precise which CE&2R players should be involved in, so that project managers understand how they can mobilize the local ecosystem of the CE&2R players.

This thesis has deliberately focused on reuse and remanufacturing, yet only part of the overall concept of circular economy, with the improvement of recycling, the eco-design of new products and the reduction of our need for goods consumption. Today, after having finished the work for this thesis, I have the feeling that the construction sector is on the threshold of the transition towards more circularity, in line with other environmental issues and digitalization. We must now act collectively, in a practical way, to apply all these principles to finally consolidate reuse and remanufacturing in real, useful and efficient projects.

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EUROPEAN WASTE CATALOGUE: CHAPTER 17

17 CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)

17 01 concrete, bricks, tiles and ceramics
- 17 01 01 concrete
- 17 01 02 bricks
- 17 01 03 tiles and ceramics
- 17 01 06 mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing hazardous substances
- 17 01 07 mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06

17 02 wood, glass and plastic
- 17 02 01 wood
- 17 02 02 glass
- 17 02 03 Plastic
- 17 02 04 glass, plastic and wood containing or contaminated with hazardous substances

17 03 bituminous mixtures, coal tar and tarred products
- 17 03 01 bituminous mixtures containing coal tar
- 17 03 02 bituminous mixtures other than those mentioned in 17 03 01
- 17 03 03 coal tar and tarred products

17 04 metals (including their alloys)
- 17 04 01 copper, bronze, brass
- 17 04 02 aluminium
- 17 04 03 lead
- 17 04 04 zinc
- 17 04 05 iron and steel
- 17 04 06 tin
- 17 04 07 mixed metals
- 17 04 09 metal waste contaminated with hazardous substances
- 17 04 10 cables containing oil, coal tar and other hazardous substances
- 17 04 11 cables other than those mentioned in 17 04 10

17 05 soil (including excavated soil from contaminated sites), stones and dredging spoil
- 17 05 03 soil and stones containing hazardous substances
- 17 05 04 soil and stones other than those mentioned in 17 05 03
- 17 05 05 dredging spoil containing hazardous substances
- 17 05 06 dredging spoil other than those mentioned in 17 05 05
- 17 05 07 track ballast containing hazardous substances
- 17 05 08 track ballast other than those mentioned in 17 05 07

17 06 insulation materials and asbestos-containing construction materials
- 17 06 01 insulation materials containing asbestos
- 17 06 03 other insulation materials consisting of or containing hazardous substances
- 17 06 04 insulation materials other than those mentioned in 17 06 01 and 17 06 03
- 17 06 05 construction materials containing asbestos

17 08 gypsum-based construction material
- 17 08 01 gypsum-based construction materials contaminated with hazardous substances
- 17 08 02 gypsum-based construction materials other than those mentioned in 17 08 01

17 09 other construction and demolition wastes
- 17 09 01 construction and demolition wastes containing mercury
- 17 09 02 construction and demolition wastes containing PCB (for example PCB-containing sealants, PCB-containing resin-based floorings, PCB-containing sealed glazing units, PCB-containing capacitors)
- 17 09 03 other construction and demolition wastes (including mixed wastes) containing hazardous substances
- 17 09 04 mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03

RÉPUBLIQUE FRANÇAISE
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cerfa

Formulaire de diagnostic portant sur la gestion des produits, équipements, matériaux et des déchets issus de la démolition ou rénovation significative de bâtiments

Le formulaire est émis par le Ministère de la Transition Écologique[1]. Il est accompagné d'une notice pour vous guider, à chaque étape, dans le remplissage et vous informer de vos obligations déclaratives. Les chiffres entre parenthèses renvoient vers la section d'aide au remplissage de la notice.

En tant que maître d'ouvrage vous devez transmettre ce formulaire rempli au Centre Scientifique et Technique du Bâtiment (LIEN PLATEFORME; plateforme.PEMD@cstb.fr) **avant l'acceptation des devis ou la passation des marchés.**

1 - L'opération

Adresse de l'opération :
Adresse (numéro et voie) : _____
Code postal : _ _ _ _ _ Commune : _____

Date estimée de début du chantier : M M / A A A A
Date estimée de fin du chantier (optionnel) : M M / A A A A

L'opération est-elle (1) : ☐ Une démolition ☐ Une rénovation significative ☐ Les deux

Nombre de bâtiments concernés par la démolition : _____
Surface totale de plancher à démolir : _____ m²
Nombre de bâtiments concernés par la rénovation significative : _____
Surface totale de plancher à rénover : _____ m²

Typologies principales des bâtiments (2) :

- ☐ Maison individuelle
- ☐ Logement collectif
- ☐ Commerces
- ☐ Bureaux
- ☐ Bâtiment industriel
- ☐ Établissement de santé
- ☐ Établissement d'enseignement
- ☐ Café, hôtel, restaurants
- ☐ Infrastructures destinées aux sports, loisirs
- ☐ Infrastructures destinées aux transports
- ☐ Autre : _____

Date d'obtention du permis de construire du bâtiment le plus ancien (et non la date d'obtention du permis de construire de cette opération) : M M / A A A A
ou à défaut l'année de construction (approximative si la date précise n'est pas connue). S'il s'agit d'un lot, indiquez la date de l'année du bâtiment qui a la plus grande surface de plancher.

Depuis cette date, y a-t-il eu au moins une rénovation importante, une opération de décontamination (ex : désamiantage) ou une autre intervention importante ? :

☐ Oui ☐ Non ☐ Ne sait pas

1. Article 51 de la loi du 10 février 2020 relative à la lutte contre le gaspillage et à l'économie circulaire.
Plus d'informations sur legifrance.gouv.fr

2 - Le maître d'ouvrage

Si personne physique :
Nom d'usage : _____
Prénom : _____

Si personne morale :
Raison sociale : _____
Numéro de Siret ou Siren : _ _ _ _ _ _ _ _ _ _ _ _ _ _

Adresse :
Numéro et voie : _____
Code postal : _ _ _ _ _ Commune : _____

3 - Le diagnostiqueur

Si personne physique :
Nom d'usage : _____
Prénom : _____

Si personne morale :
Raison sociale : _____
Numéro de Siret ou Siren : _ _ _ _ _ _ _ _ _ _ _ _ _ _

Adresse :
Numéro et voie : _____
Code postal : _ _ _ _ _ Commune : _____

Assurance souscrite par le diagnostiqueur :

☐ **Je déclare qu'en cas de sinistre l'assurance souscrite couvre les activités du diagnostiqueur et que le montant de la garantie est d'au moins 300 000 € par sinistre et 500 000 € par année d'assurance.**

Nom de la compagnie d'assurance : _____
Numéro de police : _____
Date de validité : du J J / M M / A A A A au J J / M M / A A A A

Pouvez-vous justifier des compétences du diagnostiqueur à la demande de l'administration (3) ?

☐ Oui ☐ Non

4 - Le diagnostic

Date de la dernière visite de l'opération : J J / M M / A A A A

Les bâtiments ou parties de bâtiments visitées par le diagnostiqueur :

Les parties de bâtiments non visitées :

Raisons pour n'avoir pas visité ces parties :

Le diagnostic a-t-il identifié des vices ou des désordres apparents dans des composants des bâtiments ?

☐ Oui ☐ Non

Si oui, le rapport de diagnostic fournit-il des indications sur les précautions de démolition ou de rénovation ?

☐ Oui ☐ Non

Documents consultés :

☐ Dossier des Ouvrages Exécutés (DOE) des bâtiments existants
☐ Plans
☐ Diagnostic amiante
☐ Diagnostic plomb
☐ Diagnostic termites
☐ Autres :

5 - Tableaux déclaratifs

Le diagnostic PEMD se fait à l'échelle de la parcelle et non des bâtiments. Dans le cas où l'opération concerne plusieurs bâtiment, vous devez donc faire la somme des PEMD concernés par l'opération.

Tableau 1 - Caractérisation des produits, équipements et matériaux (PEM) identifiés comme potentiellement réemployables (4)

Remplissez ces colonnes							Cochez la case pour indiquer si ces informations sont renseignées dans votre rapport de diagnostic (12)				
Catégorie (5)	Quantité disponible (6)	Dimensions (7)	Type principal d'assemblage (8)	Âge estimé (9)	État de conservation ou de fonctionnement estimé (10)	Suspectez-vous la présence de substances dangereuses dans ce PEM ? (11)	Localisation et fonction du PEM dans le bâtiment (13)	Analyses préconisées pour vérifier la réemployabilité	Photographie	Informations techniques disponibles (14)	Précautions de dépose, transport et stockage (15)
						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐
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						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐

Remplissez ces colonnes							Cochez la case pour indiquer si ces informations sont renseignées dans votre rapport de diagnostic (12)				
Catégorie (5)	Quantité disponible (6)	Dimensions (7)	Type principal d'assemblage (8)	Âge estimé (9)	État de conservation ou de fonc-tionnement estimé (10)	Suspectez-vous la présence de substances dan-gereuses dans ce PEM ? (11)	Localisation et fonction du PEM dans le bâtiment (13)	Analyses préconisées pour vérifier la réem-ployabilité	Photo-graphie	Informations techniques disponibles (14)	Précau-tions de dépose, transport et stockage (15)
						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐
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						☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐

Tableau 2 - Diagnostic déchets (16)

Remplissez ce tableau pour l'ensemble des éléments (considérés dans ce tableau comme des déchets) qui seront déposés lors du chantier, y compris les PEM identifiés comme potentiellement réemployables dans le tableau 1.

Déchets inertes (DI)

Identification des déchets				**Destination (18)**	**Valorisation (19)**				**Élimination**		**Condition techniques**
Catégorie	**Code déchet**	**Quantité estimée (17)**		**Le diagnostic identifie-t-il les filières et exutoires possibles ?** cochez pour oui	**Valorisation matière**			**Valorisation énergétique**	**% incinération sans valorisation énergétique**	**% non valorisable, à enfouir**	**Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ?** cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
Mélanges bitumineux (sans goudron)				☐							☐
Terres non polluées (hors terre végétale)				☐							☐
Béton				☐							☐
Pierre				☐							☐
Tuiles et ardoises				☐							☐
Briques				☐							☐
Carrelages et faïences				☐							☐
Mélange de DI listés ci-dessus sans DND				☐							☐
Déchets inertes (DI): Si votre DI ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											

Déchets non dangereux non inerte (DNDNI) 1/3

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
Plâtre											
Plaques et carreaux				☐							☐
Enduit et support inerte				☐							☐
Bois											
Bois A (emballages, palettes)				☐							☐
Bois B (peints, meubles)				☐							☐
Métaux											
Cuivre				☐							☐
Aluminium				☐							☐
Ferreux				☐							☐
Zinc				☐							☐
Autres, non ferreux: Si votre DND métal ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Plastiques											
PVC				☐							☐
PS				☐							☐

Déchets non dangereux non inerte (DNDNI) 2/3

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
PP				☐							☐
PE				☐							☐
Autres plastiques: Si votre DND plastique ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Matériaux isolants											
Laines minérales				☐							☐
Isolants biosourcés				☐							☐
Autres matériaux isolants: Si votre DND isolant ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Revêtements de sol											
Moquette				☐							☐
Linoléum				☐							☐
Autres revêtements de sol : Si votre DND sol ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Complexes											
Panneaux sandwich				☐							☐
Complexes plâtre + isolant				☐							☐
Complexe d'étanchéité sans goudron				☐							☐
Autres matériaux complexes: Si votre DND complexe ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Divers											

Déchets non dangereux non inerte (DNDNI) 3/3

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
Fenêtres et autres ouvertures vitrées : bois/alu/pvc et simple vitrage ou double vitrage				☐							☐
Mélange de DND listés ci-dessus				☐							☐
Végétaux				☐							☐
Terre végétale				☐							☐
Autres matériaux ou déchets non dangereux (DND): Si votre DND divers ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											

Déchets d'équipements

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
Équipements sanitaires (lavabos, éviers, WC…)				☐							☐
Génie climatique (chauffage, climatisation, ventilation)				☐							☐
Équipements de chauffage, climatisation ou frigorifiques contenant des fluides frigorigènes dangereux				☐							☐
Conduits de fluide et canalisations				☐							☐
Câbles				☐							☐
Équipement divers (ascenseurs, armoires TGBT, …)				☐							☐
Déchets d'Equipements Electriques et Electroniques (DEEE)											
Luminaires (tubes fluorescents, néons, lampes à décharges, lampes à LED)				☐							☐
Electroménagers				☐							☐
Autres DEEE contenant des substances dangereuses: Si votre DEEE contenant des substances dangereuses ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											
Autres DEEE non dangereux: Si votre DEEE ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											

Déchets dangereux (DD)

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
Amiante *(précisez)* • • •				☐							☐
Mélange bitumineux contenant du goudron				☐							☐
Complexe d'étanchéité contenant du goudron				☐							☐
Peintures contenant des substances dangereuses				☐							☐
Bois traités contenant des substances dangereuses (Bois C)				☐							☐
Terres contenant des substances dangereuses				☐							☐
Dechets dangereux DD: Si votre DD ne se trouve pas ci-dessus, veuillez compléter le tableau annexe en fin de document											

Tableau annexe

Identification des déchets				Destination (18)	Valorisation (19)				Élimination		Condition techniques
Catégorie	Code déchet	Quantité estimée (17)		Le diagnostic identifie-t-il les filières et exutoires possibles ? cochez pour oui	Valorisation matière			Valorisation énergétique	% incinération sans valorisation énergétique	% non valorisable, à enfouir	Le diagnostic identifie-t-il les conditions économiques et techniques nécessaires à la valorisation ou l'élimination ? cochez pour oui
		Masse (tonnes)	Volume (optionnel)		% réutilisation (sur site ou hors site) (20)	% recyclable	% remblayage, comblement de carrière	% à incinérer avec valorisation énergétique			
				☐							☐
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		CIRCULARITY	MOEBIUS	CYCLE UP	BACKACIA	STOCKPRO	UPCYCLEA	ARTICONNEX	ECO'MAT38	TRICYCLE	MINEKA	PROCLUS	OPALIS	ROTOR DC	BUILD CIRCULAR	RELIEVE FURNITURE	BATITERRE	CORNERMAT	CIRCONFLEXE	MADASTER	LOOPFRONT	RESIRQEL	REHUB	SIRKEN	MATERIA	MATERIAL MAPPER	RESTADO	CONCULAR	Number of occurrences of the activity
1	**Asset/Project management assistance**																											
1.1	**Resource diagnosis**																											
1.1.1	Execution of a resource diagnosis of a building, in preparation for a refurbishment project		x	x	x				x		x			x								x		x		x		x	10
1.1.2	Execution of a resource diagnosis focused on specific products (technical, economic, environmental aspects)											x																	1
1.1.3	Execution of resource diagnosis of a set of building																		x									x	2
1.1.4	Creation of a digital inventory of material and products available or potentially reusable in a building					x																						x	2
1.2	**Deconstruction planning assistance**																												
1.2.1	Planning of circular strategies and objectives at the initiation of a refurbishment/deconstruction project	x	x	x	x	x					x			x					x			x						x	10
1.2.2	Scenarios analysis to enhance the circularity of a project and/or of the management of a building	x	x											x														x	4
1.2.3	LCA study to assess reusable product's life cycle	x																				x						x	3
1.2.4	Redaction of specific technical requirements in tender's texts		x								x			x					x									x	5
1.3	**Fit-out planning assistance**																												
1.3.1	Feasibility study to integrate reused products in a refurbishment/fit-out project (reuse ex- or in-situ)		x								x																	x	3
1.3.2	Search for a local ecosystem of players to support a circular project										x																		1
1.4	**Environmental assessment of a project/asset**																												
1.4.1	Environmental assessment and/or closing report of a project (avoided waste, energy savings, CO2 savings)		x		x						x	x							x			x				x		x	8
1.4.2	Circularity certification for projects or buildings	x																											1
1.5	**On-site deconstruction assistance**																												
1.5.1	On-site supervision of operations related to selective deconstruction and reuse		x	x							x			x					x			x							6
1.5.2	On-site management of subcontractors in charge of the dismantling of reusable products		x	x	x						x								x				x						6
1.5.3	On-site presentation of best practices to dismantle/store/sell reusable products															x						x							2
1.6	**Remanufactured products sale assistance**																												
1.6.1	Production of commercial advertisements of reusable products on behalf of the product owner			x	x											x			x										4
1.6.2	Management of sales of reusable products on behalf of the product owner			x	x														x										3
1.6.3	Setting up of temporary showroom/shop on the dismantling site for reusable and dismantled products								x							x													2
1.7	**Remanufactured products purchase assistance**																												
1.7.1	Search of reusable product source for a fit-out project		x	x							x																		3

		CIRCULARITY	MOEBIUS	CYCLE UP	BACKACIA	STOCKPRO	UPCYCLEA	ARTICONNEX	ECO'MAT38	TRICYCLE	MINEKA	PROCLUS	OPALIS	ROTOR DC	BUILD CIRCULAR RELIEVE FURNITURE	BATITERRE	CORNERMAT	CIRCONFLEXE	MADASTER	LOOPFRONT	RESIRQEL	REHUB	SIRKEN	MATERIA	MATERIAL MAPPER	RESTADO	CONCULAR	Number of occurrences of the activity
1.7.2	Assist buyers in the purchase of reusable products in a specific product catalog														X													1
2 Operational and technical activities																												
2.1	**Dismantling operations**																											
2.1.1	On-site dismantling operations focused on specific products								X	X		X		X			X											5
2.1.2	Full interior cleaning-out operations									X							X											2
2.2	**Installation operations**																											
2.2.1	Installation of remanufactured products at the destination site									X																		1
2.3	**Logistics activities for reusable products**																											
2.3.1	Transport of products between sites/warehouses/remanufacturing centers		X	X				X	X	X	X	X				X	X	X										10
2.3.2	Storage of products between two sites in warehouses, on behalf of the product owner													X				X					X					3
2.4	**Remanufacturer's purchase activities**																											
2.4.1	Independent purchase of reusable products to remanufacture		X					X								X												3
2.4.2	Purchase or acquisition, and storage or reusable products to be remanufactured		X	X	X			X	X	X	X	X				X	X											10
2.4.3	Purchase or acquisition, and storage of surplus new products, coming from construction/manufacturing sites							X	X		X																	3
2.5	**Remanufacturing activities**																											
2.5.1	Conditioning operations of reusable products		X	X	X			X	X	X	X			X		X	X	X										11
2.5.2	Remanufacturing operations of reusable products		X					X	X	X		X		X		X	X											8
2.5.3	Remanufacturing operations of products in the service of the product owner											X		X														2
2.5.4	Transformations operations of collected products, with a change of their functions								X																			1
2.5.5	Up-cycling of construction waste to produce new products (office and outdoor furniture)									X													X					2
2.6	**Remanufacturer's sales physical activities**																											
2.6.1	Permanent store management dedicated to remanufactured products							X	X	X	X			X		X	X						X					8
2.7	**Management of technical, administrative and insurance topics**																											
2.7.1	Documentation provision for traceability of reused and remanufactured products from one site to another	X	X	X	X			X	X	X	X				X	X				X		X		X		X		14
2.7.2	Management of technical verification operations for remanufactured products		X	X							X	X										X					X	6
2.7.3	Warranty of remanufactured products sold		X	X								X																3

		CIRCULARITY	MOEBIUS	CYCLE UP	BACKACIA	STOCKPRO	UPCYCLEA	ARTICONNEX	ECO'MAT38	TRICYCLE	MINEKA	PROCLUS	OPALIS	ROTOR DC	BUILD CIRCULAR RELIEVE	FURNITURE	BATITERRE	CORNERMAT	CIRCONFLEXE	MADASTER	LOOPFRONT	RESIRQEL	REHUB	SIRKEN	MATERIA	MATERIAL MAPPER	RESTADO	CONCULAR	Number of occurrences of the activity
3	**Digital tools development**																												
3.1	**Marketplace**																												
3.1.1	Marketplace for reused/remanufactured products, without platform teams' assistance for sellers			x	x	x										x					x		x	x			x	x	9
3.1.2	Marketplace for reused/remanufactured products, with platform teams' assistance for sellers			x	x											x													3
3.1.3	Marketplaces' reused products advertisements compiler						x																						1
3.2	**Remanufacturer's online sales**																												
3.2.1	Online store of a remanufacturer, with delivery services		x	x								x		x				x											5
3.2.2	Online store of a remanufacturer, with online reservation or purchase and physical withdrawal			x				x	x	x	x			x			x	x											8
3.2.3	Link of commercial advertisements with the online marketplaces											x																	1
3.2.4	Link of commercial advertisements with mainstream and generalist marketplaces (eBay, social networks)					x																							1
3.3	**Tools to improve advertisement quality on marketplace/online store**																												
3.3.1	CO2 savings indicator		x	x	x	x			x		x	x				x							x						9
3.3.2	Smart pricing tools					x																							1
3.3.3	Alert mechanisms on specific remanufactured/reused products flows for potential buyers				x							x						x	x										4
3.3.4	Provision and exportation of material passport to online marketplaces																								x	x			2
3.3.5	Newsletter presenting new reusable and available product arrivals on the platform																		x								x	x	3
3.3.6	Connection service with carriers or storage companies		x		x	x					x					x							x			x	x		8
3.4	**Research tools for specialist professionals**																												
3.4.1	Interactive map/directory to search for transporters, storers and waste/reusable products recoverers	x																											1
3.4.2	Interactive map/directory to search for remanufactured product stores												x																1
3.4.3	Interactive map/directory to search for contractors willing to use and install reused/remanufactured products										x				x														2
3.4.4	Interactive map/directory to search for future deconstruction/refurbishment projects																									x			1
3.4.5	Map generation tools to assess the typologies of a products used in an area																			x						x			2
3.5	**Digitalization of product passport and resource diagnosis**																												
3.5.1	Importation and digitalization tools of a resource diagnosis			x	x		x														x				x			x	6
3.5.2	AI aided tools to generate product passport for a digital resource diagnosis					x														x	x				x				4

		CIRCULARITY	MOEBIUS	CYCLE UP	BACKACIA	STOCKPRO	UPCYCLEA	ARTICONNEX	ECO'MAT38	TRICYCLE	MINEKA	PROCLUS	OPALIS	ROTOR DC	BUILD CIRCULAR RELIEVE FURNITURE	BATITERRE	CORNERMAT	CIRCONFLEXE	MADASTER	LOOPFRONT	RESIRQEL	REHUB	SIRKEN	MATERIA	MATERIAL MAPPER	RESTADO	CONCULAR	Number of occurrences of the activity
3.5.3	Provision of a library of commercial products passport (with environmental, technical specifications)						X												X									2
3.6	**Tools for managing inventories and resources of buildings**																											
3.6.1	Management tools of the inventory, dormant stock and flows between different buildings of a single user					X														X								2
3.6.2	Compilation tools to merge products or building passports, and to manage the total inventory of products in a portfolio						X												X								X	3
3.6.3	AI aided tools to establish best scenarios to recover and valorise products and waste on a dismantling site						X																					1
3.7	**Reporting tools based on user's assets digital data**																											
3.7.1	Generation and exportation of environmental reports						X												X	X				X			X	5
3.7.2	Generation and exportation of compliance reports for certification or regulations																										X	1
3.7.3	Establishment and calculation of a circularity index for a project or a building						X																				X	2
3.8	**BIM related tools**																											
3.8.1	Matching tools between BIM model and online marketplace to search for reusable products suitable for the project			X			X																	X				3
3.8.2	BIM extraction tools to obtain a digital inventory of available and reusable products in a building																		X								X	2
4	**Educational activities and support**																											
4.1	**Production of educational content**																											
4.1.1	Writing articles or files on circular economy and reuse issues	X					X	X		X					X					X	X		X		X	X	X	11
4.1.2	Organization of webinars on circular economy and reuse issues	X																										1
4.1.3	Delivery of courses/MOOC on circular economy and reuse issues	X																										1
4.3.4	Presentation of the organization's achievements		X	X	X	X		X	X		X		X		X	X				X	X		X			X	X	15
4.2	**Production of technical documentation**																											
4.2.1	Production of technical documentation to assist reuse processes												X															1
4.3	**Training offer**																											
4.3.1	Training offer for project manager			X							X				X						X							4
4.3.2	Training offer for resource diagnostician			X											X						X							3
4.3.3	Training offer for workers on site														X													1
	Number of activities carried out by the player	9	21	23	16	10	9	11	14	12	22	13	3	13	6	10	8	10	13	6	8	10	6	7	6	7	6	20	

ACTIVITY CHRONOLOGICAL BREAKDOWN STRUCTURE

1 Building optimization

1.1 Assessment of a building

1.1.1 Environmental and circular assessment of a building

1.1.1.1 Generation and exportation of environmental reports

1.1.1.2 Generation and exportation of compliance reports for certification or regulations

1.1.1.3 Establishment and calculation of a circularity index for a project or a building

1.1.1.4 Circularity certification for projects or buildings

1.1.2 Assessment of the resource available in a building

1.1.2.1 Execution of resource diagnosis of a set of building

1.1.2.2 Creation of a digital inventory of material and products available or potentially reusable in a building

1.1.2.3 BIM extraction tools to obtain a digital inventory of available and reusable products in a building

1.1.2.4 Provision of a library of commercial products passport (with environmental, technical specifications)

1.1.3 Management of the resource available in a building

1.1.3.1 Management tools of the inventory, dormant stock and flows between different buildings of a single user

1.1.3.2 Compilation tools to merge products or building passports, and to manage the total inventory of products in a portfolio

1.2 Refurbishment project planning

1.2.1 Setting up circular strategies

1.2.1.1 Planning of circular strategies and objectives at the initiation of a refurbishment/deconstruction project

1.2.1.2 Scenarios analysis to enhance the circularity of a project and/or of the management of a building

1.2.2 Understand the local ecosystem

1.2.2.1 Search for a local ecosystem of players to support a circular project

1.2.2.2 Interactive map/directory to search for future deconstruction/refurbishment projects

2 Deconstruction

2.1 Deconstruction phase design

2.1.1 Resource diagnosis

2.1.1.1 Execution of a resource diagnosis of a building, in preparation for a refurbishment project

2.1.1.2 Execution of a resource diagnosis focused on specific products (technical, economic, environmental aspects)

2.1.1.3 Importation and digitalization tools of a resource diagnosis

2.1.1.4 AI aided tools to generate product passport for a digital resource diagnosis

2.1.2 Valorization scenarios for products

2.1.2.1 LCA study to assess reusable product's life cycle

2.1.2.2 AI aided tools to establish best scenarios to recover and valorise products and waste on a dismantling site

2.1.3 Writing tender's texts

2.1.3.1 Redaction of specific technical requirements in tender's texts

2.2 Deconstruction operations

2.2.1 On-site assistance

2.2.1.1 On-site supervision of operations related to selective deconstruction and reuse

2.2.1.2 On-site management of subcontractors in charge of the dismantling of reusable products

2.2.1.3 On-site presentation of best practices to dismantle/store/sell reusable products

2.2.2 Dismantling activities

2.2.2.1 On-site dismantling operations focused on specific products

2.2.2.2 Full interior cleaning-out operations

2.3 Recovery of dismantled and reusable products

2.3.1 Finding a way to evacuate dismantled products

2.3.1.1 Interactive map/directory to search for transporters, storers and waste/reusable products recoverers

2.3.1.2 Connection service with carriers or storage companies

2.3.1.3 Setting up of temporary showroom/shop on the dismantling site for reusable and dismantled products

2.3.2 Evacuation of dismantled products

2.3.2.1 Transport of products between sites/warehouses/remanufacturing centers

2.3.2.2 Storage of products between two sites in warehouses, on behalf of the product owner

3 Product remanufacturing

3.1 Collection of reusable products

3.1.1 Acquisition by a the remanufacturer

3.1.1.1 Independent purchase of reusable products to remanufacture

3.1.1.2 Purchase or acquisition, and storage or reusable products to be remanufactured

3.1.1.3 Purchase or acquisition, and storage of surplus new products, coming from construction/manufacturing sites

3.2 Remanufacturing operations

3.2.1 Conditioning

3.2.1.1 Conditioning operations of reusable products

3.2.2 Remanufacturing

3.2.2.1 Remanufacturing operations of reusable products

3.2.2.2 Remanufacturing operations of products in the service of the product owner

3.2.3 Transformation

3.2.3.1 Transformations operations of collected products, with a change of their functions

3.2.3.2 Up-cycling of construction waste to produce new products (office and outdoor furniture)

3.3 Sales of remanufactured products

3.3.1 Remanufacturer's store

3.3.1.1 Permanent store management dedicated to remanufactured products

3.3.1.2 Online store of a remanufacturer, with delivery services

3.3.1.3 Online store of a remanufacturer, with online reservation or purchase and physical withdrawal

3.3.2 Assisted sale on behalf of the dismantler and product owner

3.3.2.1 Production of commercial advertisements of reusable products on behalf of the product owner

3.3.2.2 Management of sales of reusable products on behalf of the product owner

3.3.2.3 Marketplace for reused/remanufactured products, without platform teams' assistance for sellers

3.3.2.4 Marketplace for reused/remanufactured products, with platform teams' assistance for sellers

3.3.2.5 Newsletter presenting new reusable and available product arrivals on the platform

3.3.3 Digital tools to enhance the sales

3.3.3.1 CO_2 savings indicator

3.3.3.2 Smart pricing tools

3.3.3.3 Provision and exportation of material passport to online marketplaces

3.3.3.4 Link of commercial advertisements with mainstream and generalist marketplaces (eBay, social networks)

3.3.3.5 Link of commercial advertisements with the online marketplaces

3.3.4 Technical and insurance issues

3.3.4.1 Management of technical verification operations for remanufactured products

3.3.4.2 Warranty of remanufactured products sold

3.3.4.3 Documentation provision for traceability of reused and remanufactured products from one site to another

4 Fit-out project

4.1 Fit-out design

4.1.1 Integration of remanufactured products

4.1.1.1 Feasibility study to integrate reused products in a refurbishment/fit-out project (reuse ex- or in-situ)

4.1.1.2 Matching tools between BIM model and online marketplace to search for reusable products suitable for the project

4.2 Purchase of remanufactured products

4.2.1 Assistance in the search of remanufactured products

4.2.1.1 Search of reusable product source for a fit-out project

4.2.1.2 Assist buyers in the purchase of reusable products in a specific product catalog

4.2.1.3 Alert mechanisms on specific remanufactured/reused products flows for potential buyers

4.2.2 Source of remanufactured products

4.2.2.1 Marketplaces' reused products advertisements compiler

4.2.2.2 Interactive map/directory to search for remanufactured product stores

4.2.2.3 Map generation tools to assess the typologies of a products used in an area

4.3 Fit-out operations

4.3.1 Installation of remanufactured/reused products

4.3.1.1 Interactive map/directory to search for contractors willing to use and install reused/remanufactured products

4.3.1.2 Installation of remanufactured products at the destination site

4.4 Project closing

4.4.1 Environmental and circular reporting

4.4.1.1 Environmental assessment and/or closing report of a project (avoided waste, energy savings, CO2 savings)

5 Independent activities

5.1 Resource available on request

5.1.1 Training

5.1.1.1 Training offer for project manager

5.1.1.2 Training offer for resource diagnostician

5.1.1.3 Training offer for workers on site

5.2 Documentation permanently available

5.2.1 Educational documentation

5.2.1.1 Writing articles or files on circular economy and reuse issues

5.2.1.2 Organization of webinars on circular economy and reuse issues

5.2.1.3 Delivery of courses/MOOC on circular economy and reuse issues

5.1.1.4 Presentation of the organization's achievements

5.2.1.4 Production of technical documentation to assist reuse processes

NAME OF THE PLAYER

PRESENTATION					
FOUNDATION	COUNTRY	LOCATION	MARKET AREA	COMPANY SIZE	TURNOVER

PLAYER CATEGORIES		
RESOURCE DIAGNOSTICIAN	CIRCULARITY CONSULTANT	REMANUFACTURER
MARKETPLACE	DIGITAL SOLUTION DEVELOPER	CIRCULARITY TRAINER

ACTIVITY FIELDS CARRIED OUT		
1 Asset/Project management assistance		
1.1	**Execution of a resource diagnosis/digital inventory**	
	Realisation of a resource diagnosis for a deconstruction project, or complete generation of a digital inventory to assist the management of the resource of a building	
1.2	**Deconstruction planning assistance**	
	Assistance and consulting services to plan strategies of reuse and selective dismantling, set objectives and assess the feasibility of circular scenarios for a deconstruction project	
1.3	**Fit-out planning assistance**	
	Assistance and consulting services to plan strategies of integration and research of remanufactured products and remanufacturers for a fit-out project	
1.4	**Environmental assessment of a project/asset**	
	Certification and reporting services to assess the circularity of a project/asset, along with other environmental aspects (CO2 savings, waste reduction, etc.)	
1.5	**On-site deconstruction assistance**	
	Assistance and consulting services to support project management on-site: supervision of dismantling operations, promotion of best practices, relation with subcontractors, etc.	
1.6	**Remanufactured products sale assistance**	
	Assistance services to support deconstruction management in the sales of dismantled products: production of commercial ads, relation with potential buyers, sales on-site	
1.7	**Remanufactured products purchase assistance**	
	Assistance services to support fit-out management in the search for remanufactured/reused products, from the identification of local sources to the selection of specific products	
2 Operational and technical activities		
2.1	**Dismantling operations**	
	Execution of selective dismantling operations on a deconstruction site, from specific operations for certain types of products, to the complete cleaning-out of the building	
2.2	**Installation operations**	
	Execution of operations of installation into a fit-out project of remanufactured/reused products	
2.3	**Logistics activities for reusable products**	
	Execution of logistics operations for reusable and manufacturable products, including transport and storage	
2.4	**Remanufacturer's purchase of reusable products**	
	Remanufacturer's activities to search for, collect and acquire reusable/manufacturable products, along with products coming from production surplus	

2.5	**Remanufacturing activities**	
	Remanufacturer's activities of cleaning, conditioning, remanufacturing, transformation and up-cycling of reusable/manufacturable products	
2.6	**Remanufacturer's sales physical activities**	
	Management of permanent and physical store dedicated to remanufactured/reused products	
2.7	**Management of technical, administrative and insurance topics**	
	Management of the administrative issues around remanufactured products: traceability documentation, technical verification in laboratories, warranty of the sold products	
3 Digital tools development		
3.1	**Marketplace management**	
	Development and management of an online marketplace dedicated to the sales of reused/remanufactured products, linking sellers and buyers	
3.2	**Remanufacturer's online sales**	
	Development and management of an online store where a remanufacturer sells directly its products, or set reservation system linked with a physical store	
3.3	**Tools to improve advertisement quality on marketplace/online store**	
	Development of tools and digital services on marketplaces and online stores to enhance, ease and improve the sales of reused/remanufactured products	
3.4	**Research tools for specialist professionals**	
	Development and management of online directories and interactive maps to search for specialist professionals: recovery players, remanufacturers, reusable products sources, etc.	
3.5	**Tools for the digitalization of product passports and resource diagnosis**	
	Development of digital solutions to carry out inventories/resource diagnosis of a building and to generate product passports	
3.6	**Tools for managing inventories and resources of buildings**	
	Development of digital solutions to manage the resource inventory of a building: flows recording, real estate portfolio's inventory overview, recovery scenarios' establishment	
3.7	**Reporting tools based on user's assets digital data**	
	Development of digital solutions for environmental reporting in the management of a real estate portfolio, also including compliance reports (for certifications or regulations)	
3.8	**BIM related tools**	
	Development of digital tools to link the BIM environment with the circular economy and reuse field, to generate resource inventories or integrate reused products	
4 Educational activities and support		
4.1	**Production of educational content on circular economy topics**	
	Provision of articles, courses, MOOC, webinars, case studies on the topic of the circular economy in the construction sector, dedicated for the general public or the sector players	
4.2	**Production of technical documentation for reuse/remanufacturing**	
	Production of technical sheets on reuse and remanufacturing operations: guides for dismantling, conditioning, verification processes, remanufacturing techniques	
4.3	**Training offer**	
	Offer and management of certified trainings dedicated to project managers, resource diagnosticians or workers on-site, on the topic of selective dismantling and reuse	
+ Other activity fields		