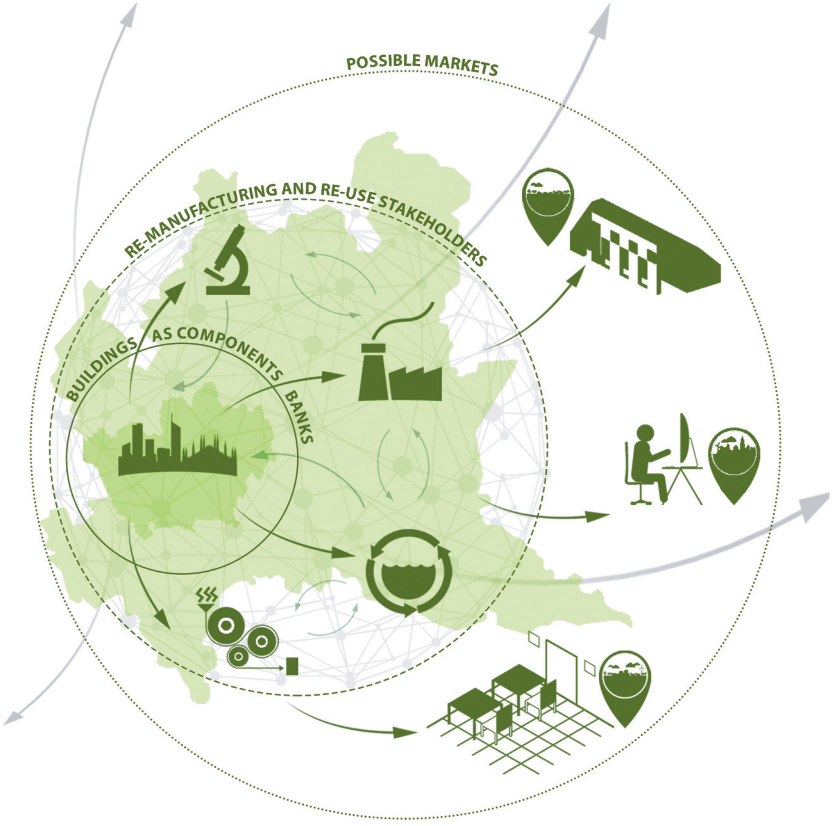
Re-manufacturing networks for tertiary architectures

Innovative organizational models towards circularity

edited by Cinzia Maria Luisa Talamo



Ricerche di tecnologia dell'architettura
FrancoAngeli

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diretta da Giovanni Zannoni (Università di Ferrara)

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The book presents the results of the project "*Re-NetTA (Re-manufacturing Networks for Tertiary Architectures). New organizational models and tools for re-manufacturing and re-using short life components coming from tertiary buildings renewal*", developed at Politecnico di Milano (2018-2021) and supported by Fondazione Cariplo, grant n° 2018-0991 (Call "Circular Economy for a sustainable future 2018").

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Part III – Insights

1. Circular economy and tertiary architecture

by *Monica Lavagna, Carol Monticelli, Alessandra Zanelli*

1.1 Circular strategies: fragmented practices and lack of stakeholder awareness

The principles of circular economy are based on theoretical issues developed in the Sixties-Seventies (Boulding, 1966; Commoner, 1971; Stahel and Reday, 1976; Stahel, 1982), about closing the loop and the extensions of product life cycle through material exchange (reuse, recycling) and strategies planned from the beginning, with a particular focus on design.

In the 2000s, to face the problem of the increasing resource consumption and the growing cost of raw materials, some international bodies (UNEP, 2006; EMF, 2013; 2014; 2015; EEA, 2016; 2017) relaunched these principles, under the concept of circular economy, with the aim to replace the current linear economic model.

In recent years, the circular economy has become an important objective, in particular of policies (EC, 2014; 2015; 2020) and has been promoted by various environmental action plans, programs, roadmaps and local initiatives, especially in Europe (but not only). The construction sector is a "priority area", as it is the producer of the highest quantity (36%) of waste (Eurostat, 2020) and the consumer of about 50% of all extracted materials (EC, 2020).

There are many strategies for applying the circular economy, based on closing the cycles of production and consumption in the technosphere, in order to reduce the flows of resource consumptions and waste emissions, to and from the ecosphere. The strategies currently applied at European level are very diverse and fragmented, but they can be grouped into three areas (Giorgi *et al.*, 2022): i) resource and waste management, with an end-ofpipe approach mainly linked to solving the problems of end-of-life waste; ii) design for circularity (e.g. design for disassembly), with an upstream approach and a vision extended to the life cycle; iii) circular business models and networking of operators, with a management and value chain approach.

Current practices, especially in the construction sector, are mainly oriented towards waste management and recycling (Giorgi *et al.*, 2017), which is the least optimized solution in the hierarchy of circular actions, but also the most promoted by the current European legislative framework. Moreover, downcycling activities, such as the reuse of aggregates for the construction of road foundations, deriving from the need to solve the problem of managing construction and demolition waste at the end of the building service life, are the most practiced. This is also a consequence of a strongly focused approach on the material level, while the building level is rarely considered (Pomponi and Moncaster, 2017).

Instead, the primary objective of the circular economy, in the original inspiring principles, should be value conservation, based on the extension of product life, not simply understood as an extension of the use of materials over several lives (through recycling), but possibly as an extension of the use (through multiple use cycles) of products and construction systems as they are (reuse) or with few adaptations (re-manufacturing), maintaining their value over time. Examples of these kinds of applications in the built environment are only pilot cases (CE100, 2016; ARUP, 2016) and not current practice.

The difficulty for the construction sector to prolong the maintenance of the economic value is the main reason that hinders the implementation of more effective circularity strategies. The practice of downcycling is caused by the fact that demolition activities at the end of the building life return materials that are mostly inert, of little value and difficult to recycle, due to the constructive characteristics of the existing building stock. The potential to identify a residual economic value in the building products is generally poor, due both to the low value of the building materials, and to the degradation state of the elements at the end of the building's life (being generally very long). This discourages disassembly operations, which would favour the potential reuse of products, but are very expensive because they are manual, favouring demolition. Moreover, disassembly is a scenario that is difficult to apply to buildings that had not been designed and built to be disassembled (and, therefore, not characterized by reversible constructive solutions).

Despite being a circularity strategy, recycling can become a legitimation for accelerating consumption, without guaranteeing a solution to the scarcity of raw materials for the construction sector, and with unsustainable energy and environmental costs.

Reuse and re-manufacturing are rarely practiced in the construction sector and are more widespread in industrial sectors, where end-of-life products still have good residual performances and high economic value, and service life cycles (of use) are short. In the construction sector, these practices are hampered by the low economic value of the products and by the long times of use (typically decades), which discourage operators from taking on the management of the useful life of the products and the end of life.

However, there are also areas of temporary use in the construction sector, in particular in tertiary buildings (offices, reception facilities, exhibition areas, commercial spaces, temporary shops), characterized by functional and/or aesthetic obsolescence (of image/branding), that lead to disposal of products which still have a high residual value and which could become interesting opportunities for experimenting reuse and re-manufacturing (Talamo *et al.*, 2021).

Implementing these practices, however, requires a control of the entire process along the life cycle and appropriate networking of operators.

Circular practices in the construction sector are currently very fragmented and there are still few supply chains and organizational models that permanently involve operators in circular practices. This derives from the fact that the flows of products, that can be reused or regenerated, are not constant (especially if we refer to those disposed by the existing assets and which have not been designed to be reused), so the activation of a stable supply chain becomes difficult. The variability of the products, the fragmentation of supply (linked to the individual construction/demolition sites) and the variety of possible operators involved or available, make complex the logistics and the management of processes and responsibilities. The consequence is to manage the reusable products and constructive systems case by case, thus failing to activate stable supply chains.

The lack of circular supply chains is also motivated by the lack of awareness on the side of operators of the potential for generating value from circular practices, in particular related to reuse and re-manufacturing, and the re-evaluation of resources that would otherwise be wasted. The construction of new organisational and business models based on circularity, which modify ownership relationships, transaction methods, and extend the responsibility of the producer to the entire life cycle, creating a lasting relationship with the customer, can demonstrate to operators the economic advantages of circularity and open up new market opportunities.

1.2 Rapid obsolescence and temporary use: opportunities for circularity in tertiary buildings

Many industrial sectors are developing practices of circularity, based on re-manufacturing and reuse, for items characterised by short life spans, and enabling virtuous organizations of relationships between the operators of the entire production-use-reuse-regeneration process (Atta *et al.*, 2020; see Chapter 3). Starting from the need to experiment virtuous circular paths for building elements through re-manufacturing and reuse, considered as winning and low environmental impact strategies in the perspective of a regenerative circular economy (CER, 2020), the main objective is to foresee the range of possible winning applications in the field.

In the construction sector, the tertiary sector (public and private offices, accommodation facilities, commercial structures, exhibition spaces, shops) is characterised by: i) the strong presence of prefabricated and dry assembled building elements and products, ii) products and materials with high economic and performance value, iii) products often replaced after short life cycles (10-15 years) (Peters *et al.*, 2017), due to the frequent renewal of the fit-out (for functional reasons, spatial layout or corporate identity) typically implemented in such specific contexts. These features are similar to the ones that facilitate the application of reuse and re-manufacturing in the industrial sectors.

Additionally, in recent times some trends, which determine an acceleration of the modifications and the replacements inside tertiary buildings, have been consolidated. In particular, the use of buildings as a service (hoteling, temporary shops, co-working and various forms of sharing), corresponding to new use models and to a high degree of temporary use of the spaces, is generating frequent renewals as a consequence of recent changes in usage patterns. This process is empowered by the shortening of leases, the transformation of the Real Estate market and business models and, last but not least, the most recent requirements of organisational and spatial transformability and rapid and reversible rearrangement upon the exiting pandemic emergency. In the last twenty years, the workspaces have evolved from individual offices to open spaces, to accomplish the need for collaboration. The rise of smart working has further modified the use of office spaces. This opened the way for the hybrid use of shared spaces like hoteling, hot desking (non-reservation-based hoteling) and free address seating. After the pandemic period, the design of offices and other tertiary spaces is still changing with different rules and needs. The consequence are frequent changes in space layout.

The commercial spaces have also evolved over the last twenty years, with the spread of temporary forms such as temporary shops and "pop up" store. Due to the short leases, retail is also characterized by frequent change in the commercial destination of shops, which involves substantial renovations of the interiors in relation to the type of commercial activity and branding image. Finally, shops typically tend to renew their image frequently, to attract attention.

In the current practice, these renovations mean the demolition and the disposal in landfills of elements (finishes, internal partitions, flooring, false ceilings, fittings, systems and furnishings), which are still in good condition and have a high percentage of residual performances. These are building products that could be recovered, reused or re-manufactured. The typical partitions for tertiary interior design are characterised by modular products, special joints and dry and easy assembly, that guarantee their integrity during disassembly and a durability overcoming the first cycle of use.

The environmental advantage of re-manufacturing emerges especially for short-term buildings or their elements, where the dismantled products can ensure a satisfying level of residual performances: the functional obsolescence is rarely corresponding to the physical decay and this aspect should be verified at the end of the functional life cycles of the products themselves.

The following observations underline the reasons for focusing on buildings of the tertiary sector as a possible sector of interest for re-manufacturing strategies:

- the huge number of buildings used for various tertiary destinations (public and private offices, accommodation facilities, exhibition facilities, retail, temporary shops, etc.);
- the presence of an unused tertiary building stock waiting to be revitalized, whose number increased during the pandemic emergency of the last two years, due to the paradigmatic change of the "non-use" of the offices and their management;
- the frequent cycles of renewal and reconfiguration of the interior spaces following a series of needs, that determine a fast functional obsolescence and frequent reshaping;
- the consequent availability of significant quantities of disused elements and products (in particular interior finishing materials, panels, tiles, services, equipment and furnishings). Most of these elements, typically designed and produced for tertiary building, are dry assembled (therefore easily to disassemble), composed of high-value (high embodied

energy content) materials, generally supplied with manufacturer technical datasheets and manuals (therefore easily traceable);
- the presence in this sector of operators (e.g. facility managers) who deal with the management of spaces, the monitoring of interventions during the use phase and the planning of the end-of-life (e.g. for restyling), and who can become key players in conjunction with the re-manufacturing operators;
- the predisposition of this sector to experiment product-service formulas applied to building elements and products, taking into account the short cycles of use and the interest of clients for leasing than ownership (e.g., successful practices relating to furnishings).

1.3 The challenge to implement circular models in the context of tertiary architectures renewals

The application of circularity in the construction sector requires a change of perception: the costliness of raw materials led to the shifting of the focus of the supply chain from the ecosphere to the technosphere. This means that materials stored in buildings are potential resources, waiting to be reused at the end of their life. Consequently, resources should be monitored throughout their life cycle, in a cradle-to-cradle perspective.

Several studies expressed this concept both at city level and at building level. Hence, the birth of the concept of urban mining, which means to thinking of the cities and buildings as a mine of materials. Resources are stored in the anthropogenic stock embedded in our buildings. The upgrading of this vision is to consider not only the building materials, but also the building products and elements that can be reused.

In line with this concept, the European project "Building as Material Bank" (Peters *et al.*, 2017) suggests that buildings can be seen as "banks" of products and materials. This concept open to new strategies and business models for lengthening the service life of building products, preserving their value over time. To allow these changes, the design approach has to consider more than one life cycle of the products/elements, towards reuse, re-manufacturing and repurpose.

A good practice we can pursue is to create an inventory of materials and products available within buildings, whose economic value is real-time updating, following the market's variations. One of the most virtuous initiatives of survey under development is the Madaster platform conceived by Turntoo (Rau, 2019): it contributes to spread awareness of the value of building products over time and of the benefits (also economic) coming from their management at the first end-of-usage towards reuse.

However, the activation of these processes means the satisfaction of some necessary conditions, related to the overcoming of the current technical, organizational/managerial, regulatory, information and cultural barriers.

First of all, there are flows of waste materials and elements which come out from building not designed for disassembly and reuse/regeneration: they have high potentials to be regenerated, but their heterogeneity and non-continuity create considerable problems, from a technical point of view, in the reworking activities. These last ones have to be carried out on a case-by-case basis. Furthermore, this aspect hinders the activation of a stable supply chain. The immediate foreseen consequence for driving this rework towards is a shift back to an artisanal and non-industrial processes, for the ability to manage the re-manufacturing with an higher level of flexibility.

Secondly, the difficulties during the recovering of the products stored in the current buildings derive from the current use of non-reversible construction techniques, which necessarily involve demolition at the end-of-life. Designing them in the logic of dry assembly and constructive reversibility (design for disassembly), in order to enable the recovery of parts without breakages or irreparable losses, helps to overcome this barrier.

A third important aspect is the management of information during the life cycle of the products. The loss of information related to the properties of the product and the lack of a register of the actions on the product over time leads to difficulties in reuse at the end of the first life. The technical information of products, related to characteristics and performances, has to be integrated with technical specifications (defined by the manufacturer) concerning the whole life cycle, related to the installing and assembling process, the maintenance needs and the disassembly process, where it is possible. These information have to be stocked and implemented over time, in order to detail new specifications about the products, related to the actual conditions of assembly-use-disassembly (e.g. the number of maintenance interventions during the lifetime, the replacements of some parts, the repainting). For such purposes, tools as Building Information Modelling and Material Passport are potential for facilitating the re-manufacturing chain in order to collect and manage information over time.

Linked to this aspect, the guarantee of performance after the re-manufacturing phase is the main critical point for the circular process based on reuse/re-manufacturing/repurposing: the operator have to re-ensure a new certification of a product not knowing precisely the degradation stage after the first usage cycle. A possibility is the material "re-characterization" and testing of its performances, but it is a much more expensive process in comparison to the recycling industrial process, where the production process is checked. One possible leverage for overcoming this problem, although probably not enough to solve the problem, could be the traceability and the registration of the material properties and the technical specification of the product and of the maintenance actions, monitored over the multiple life cycles.

The regulatory framework plays an important role in this respect. While on the one hand the European directives are oriented towards circularity, there are still many regulatory barriers that hinder the recovery of materials and products at the end of their life. Furthermore, there is still a lack of a regulatory framework dedicated to second-life products (in particular certification schemes, guarantees and the transfer of ownership). Finally, the strong regulatory restrictions on performance of buildings often hinder reuse (due to the lack of knowledge on the residual performance of the products), imposing "downcycling" of the function and application of the reused product. If this latter aspect cannot be overcome, the regulatory framework should instead be updated to allow the application of circular practices.

The ownership and thus responsibility of products and elements are other relevant aspect to be considerered. The current product sales practice and the lack of responsibility of the producers with respect to the useful life and end of life does not stimulate the design of durable products, designed to be reused, because the interest of the producer is to guarantee himself the continuity of production and sale on the market. To overcome this situation, a possible approach is the introduction of new contractual opportunities among manufacturer and end user (product-service formula): the producer retains ownership of the product during the entire life cycle (with the extension of producer responsibility and a "take-back" formula at the end of life), providing the customer with building products as a service.

This perspective requires the activation of new supply chain organizations and the development of new organizational models, which provide for the involvement of the producer/distributor of the product, but which can then expand to new operators who deal with re-manufacturing and the second life of the product.

Starting to filling the gap, to apply new business models developed on the product-service or on the leasing/renting model is necessary to define the relationship among producers-installers-users-maintenance technicians-dismantlers (e.g. related to logistic, technical skills, management skills, responsibility, ownership of the product). This leads to the need to define new organizational models and possible re-manufacturing network.

One of the conditions for structuring possible new re-manufacturing networks could be the identification of new interface figures among the many operators of the circular process (production, use, disposal, re-manufacturing, market of re-manufactured products). This aspect allows to generate new professional figures, skills and jobs.

Finally, the cultural barrier is the last one. The second-hand market has fluctuating successes in other sectors. Specifically in the construction sector, this sensitivity is still very variable. The momentum of this market would certainly be strengthened by awareness-raising actions on some win-win key points: for the demand, the reduction of costs related to the "ownership" of building components related to temporary uses, thanks to temporary access (leasing) to customizable fit-outs (building product as a service); for the supply, both the reduction of production costs through the reuse or regeneration of materials and products, and new business opportunities related to rental rather than sale.

Among all the aspects dealt with, the economic lever is certainly the one that can drive change. For this reason, the research work presented in this book focuses on this aspect (value retention) and on the need for new organizational models of the supply chain.

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This book deals with re-manufacturing, recondition, reuse and repurpose considered as winning strategies for boosting regenerative circular economy in the building sector. It presents many of the outcomes of the research *Re-NetTA (Re-manufacturing Networks for Tertiary Architectures). New organisational models and tools for re-manufacturing and re-using short life components coming from tertiary buildings renewal*, funded in Italy by Fondazione Cariplo for the period 2019-2021.

The field of interest of the book is the building sector, focusing on various categories of tertiary buildings, characterized by short-term cycles of use.

The book investigates the most promising strategies and organizational models to maintain over time the value of the environmental and economic resources integrated into manufactured products, once they have been removed from buildings, by extending their useful life and their usability with the lower possible consumption of other materials and energy and with the maximum containment of emissions into the environment.

The text is articulated into three sections.

Part I BACKGROUND introduces the current theoretical background and identifies key strategies about circular economy and re-manufacturing processes within the building sector, focusing on tertiary architectures. It is divided into three chapters.

Part II PROMISING MODELS outlines, according to a proposed framework, a set of promising circular organizational models to facilitate re-manufacturing practices and their application to the different categories of the tertiary sectors: exhibition, office and retail. This part also reports the results of active dialogues and roundtables with several categories of operators, adopting a stakeholder perspective.

Part III INSIGHTS provides some insights on the issue of re-manufacturing, analyzed from different perspectives with the aim of outlining a comprehensive overview of challenges and opportunities for the application of virtuous circular processes within building sector. Part III is organized in four key topics: A) Design for Re-manufacturing; B) Digital Transformation; C) Environmental Sustainability; D) Stakeholder Management, Regulations & Policies.

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La passione per le conoscenze