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The Role of Design in the CE Transition of the Furniture Industry—The Case of the Italian Company Cassina

Davide Bruno [1,*], Marinella Ferrara [1], Felice D'Alessandro [2] and Alberto Mandelli [3]

[1] Department of Design, Politecnico di Milano, 20158 Milan, Italy; marinella.ferrara@polimi.it
[2] Department of Environmental Science and Policy, Università degli Studi di Milano, 20133 Milan, Italy; felice.dalessandro@unimi.it
[3] Cassina Research and Development Center, Cassina S.p.A, 20821 Meda, Italy; alberto.mandelli@cassina.it
* Correspondence: davide.bruno@polimi.it

Abstract: The literature on circular economy has highlighted the need for more studies focused on investigating the journey of individual companies in the transition toward sustainable processes. This paper addresses this need by focusing on the furniture design industry, showing how the transition requires the re-organization of knowledge regarding materials, processes, technologies, and product quality. This assumption is demonstrated through the design research activity conducted in 2019–2020 as the first part of broader research by Cassina LAB, a collaboration between Cassina Research and Development Centre and POLI.design of Politecnico di Milano. Based on the analysis of the Italian furniture industry between constraints and opportunities, the aim of the research is to identify critical issues and propose sustainable and circular solutions, tailor-made for Cassina. Through this example, the paper contributes to the literature in two ways. First, it adds to the understanding of how companies are adopting the circular economy paradigm. Secondly, it contributes to defining tools to implement new forms of knowledge of materials and re-design processes to deliver products that are compatible with a circular economy model.

Keywords: circular economy; furniture industry; sustainable design; circular materials; Cassina

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1. Introduction

Circular economy (CE) is a concept that has emerged over the last decade as a strategy for global sustainable development and has been adopted by governments and institution policies in Europe [1]. It responds to society's growing interest in environmental issues, which has been long calling for a change in the current linear economic model based on the "*extract-produce-use-eliminate*" pathway [2] to move toward a new paradigm based on the "*produce-consume-recover*", where waste tends to be reduced or eliminated. Developing this new model can reduce the human impact on the environment by saving resources and radically changing the way we produce, use, and interact with the products.

Nowadays, consumers are increasingly paying attention to environmental protection in order to ensure the survival of the planet and future generations. Consumers' purchasing behaviours are strongly influenced by corporate social responsibility [3], both in terms of the overall quality of products and their more environmentally friendly content. Spurred, at least in part, by these findings, a growing number of companies in Europe are approaching initiatives toward CE, seeking a new synthesis between a product's relevance to the consumers and its sustainability. However, despite such examples of good practices, the transition from a linear model to a circular model is still in its early stage.

In all sectors of industrial manufacturing, the adoption of CE is associated with investments in re-organizing processes, using resources in a circular way, and implementing a sustainable design approach (also defined as eco-design). Indeed, design is recognized as a strategic actor of CE [4–8]. It is estimated that approximately 80% of the

environmental impact of products is determined at the design stage [9], and there is a need to change the way materials, products, services, communications, infrastructure, and experiences are designed [10]. Design is called to establish a new relationship between resources and production [11], through a continuous search for innovative solutions that limit industrial waste and improve the use of circular materials at all stages of the value creation process [12,13]. Design must integrate environmental aspects and apply sustainability from the earliest stages of product development [14]. Significant efforts need to be undertaken by companies to accomplish CE [15]. In industrial systems, it means a concerted effort to raise awareness among all actors to promote and facilitate the transition toward new purchasing habits and a new culture of consumption.

In this scenario, this paper aims to contribute to the understating of motivation and the way companies can approach a transition toward the CE paradigm, especially in the furniture sector. Pursuing this intent, the paper focuses on a specific project tailored for a unique company, the leading Italian furniture company, Cassina. It describes the design research conducted in 2019–2020 as the first part of broader research activity by Cassina LAB, a research platform born from the collaboration between Cassina R&D Centre (CRDC) and POLI.design Consortium of Politecnico di Milano. By retracing the topics raised above, the paper is organized as follows. Section 2 focuses on the Italian furniture industry and outlines the critical issues, opportunities, and design strategies for the CE transition. In doing so, the issues addressed with the company are highlighted to define the research objective. In Section 3, after a brief presentation of the company, we unfold the rationale, methodology, and the first part of the research of Cassina LAB toward CE. The paper continues with a discussion and ends with conclusions and some recommendations.

2. The Italian Furniture Industry between Criticalities and Opportunities: Design Strategies in the CE Transition and Elements of a Methodology

The furniture industry plays an important role in the Italian economy due to its value and considerable share in global trade, being one of the leading exporters in the world.

With reference to European furniture production and consumption, Italy (17.5 billion euros) is the most significant furniture producer by value followed by Germany (14.5 billion euros). Similarly, the most significant exporters are Germany (9.5 billion euros) and Italy (9.2 billion euros). The European Member States are major consumers of furniture, estimated at 68 billion euros per year, the largest consumers by value being Germany (16.8 billion euros), the UK (14.2 billion euros), and Italy (10.2 billion euros) (Figure 1).

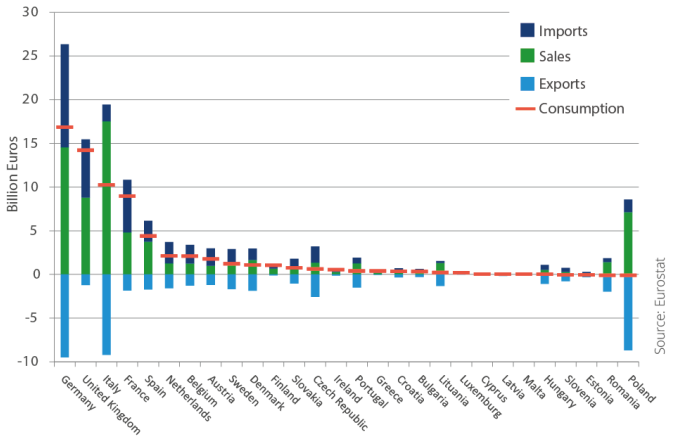

Figure 1. Furniture production, import, and export values by member states. Source: European Commission—Eurostat Prodcom statistics (https://ec.europa.eu/eurostat/web/prodcom) (accessed on 5 April 2022) [16].

The sector gained national importance also for its excellence in design production. Regardless of the size of the companies, they are mainly small and medium enterprises, with all their typical advantages and disadvantages. The sector includes several leading design companies, such as Cassina and a few others that form a competitive reality in the luxury furniture niche and play a strong role as global trendsetters.

According to Federlegno Arredo [17], today environmental sustainability is considered a major competitive advantage for furniture companies, as it promotes the development of innovations that better meet consumer demand.

Environmental sustainability and circularity, embedded in the logic of product design, are the most promising path for innovation in this sector today. Sustainable and circular innovations reduce the environmental impact of production and make it possible to derive added value from consumer changes.

This statement raises some questions: How are companies in the sector operating in this regard? Are Italian furniture design companies adopting sustainable and circular practices?

Recent studies have shown that the Italian furniture industry still shows strong barriers to the adoption of sustainability practices based on a CE model [18–20].

In the European context, the situation is no different than in Italy [21]. It is only in the last three years that furniture industry leaders have shown a growing interest in circular inputs. The reason for this delay has been the lack of regulatory coordination at the EU, national and regional levels [18,19,22]. It was not until 2020 that the EU adopted an action plan [23]. Another major CE barrier is the perception of environmental sustainability as a cost factor [18,19,22]. This is especially true for companies unfamiliar with innovation and design practices and their competitive advantages in terms of savings, medium- and long-term economic benefits, differentiation, and corporate reputation. In this regard, the study "100 Italian Circular Economy Stories" [24] includes a few cases of furniture companies in the "Italian panorama toward CE transition". They have implemented "Circular Inputs" from renewables or previous life cycles (reuse and recycling), low-impact processes, and a "Life Extension" approach to products. In particular, the practices that companies are planning to implement in the next two years are related to energy savings (40%), the development of production processes with low resource consumption (36%), and environmental criteria for the selection of suppliers (33%). Besides Cassina, these few companies are mainly long-established design-oriented companies such as Arper, Fantoni, Fiam Italia, Guzzini, and Magis. They are joined by some start-ups based on environmental sustainability through design. In the following, we will address the main issues and opportunities presented by design strategies in the furniture sector.

Before going into the core of the research we conducted within Cassina LAB, focusing on the company and the production of Cassina, the basic points of our analysis of the furniture sector are mentioned hereafter.

The analysis of the furniture sector was based on both scientific and grey literature, the latter mainly focusing on the leading Italian manufacturers such as Federlegno Arredo, and organizations that play an important role in promoting CE, such as Symbola.

The analysis allowed us to identify the main critical issues of the industry in terms of ecological transition.

These critical issues come up both before and after the design phase, at points that the classical—and now outdated—design process considered as elements on which design research should not focus. A holistic approach expanded the focus of research to include areas upstream and downstream of the design process. Thus, three critical issues were identified: (1) waste, (2) material issues, and (3) sustainable production. These critical issues were considered by the team as "opportunities" to initiate a broad consultation with the Cassina company to define the objectives of the research and to influence the company's decision-making process.

2.1. The Waste Issue

In general, in the wood furniture industry, of which Cassina is part, three different types of waste are produced during manufacture: (i) sawdust, chips, small pieces of wood, and wooden boards; (ii) waste from production defects or, in very rare cases, unsaleable stock, and (iii) waste from used and discarded products [25] (Figure 2). When analyzing the three types of waste within Cassina, it was found that the first two are efficiently collected and recycled through a service based on partnerships at a regional level. After collection, this type of waste is used as biomass for energy production, or as a resource for other productions, being transformed into wood panels, paper, and paperboard, as already happens in many regions of Europe, with a process that can be directly and easily managed by the furniture industry. Waste material can be transformed into new raw material and reintroduced into the supply chain. The third type of waste is not directly attributable to the company but to consumers. This point has led to a redefinition of the criticality to be dealt with.

In 2017, the environmental impact of furniture waste in the EU28 was 10.78 million tonnes, of which 80–90% were incinerated or sent to landfills [26]. The industry must contribute to finding solutions to this huge amount of waste, which is clearly related to the poor quality of furniture—due to non-durable materials, weak structure, unsuitable shape, and low-quality manufacturing resulting in a short life of the product—as well as furniture made of multiple materials or composites or refined with harmful substances that do not comply with the principle of sustainable design, since they are made of unrecyclable materials, and their components cannot be separated to be repaired, reused, and recycled.

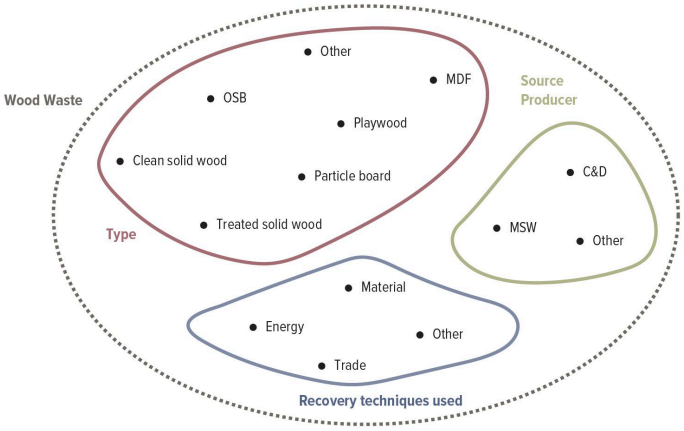

Figure 2. Classification of wood waste.

2.2. The Materials Issue

The use of materials is a key issue in the manufacture of furniture, and, today, is a critical issue.

Among the various adopted materials, particularly critical is the use of adhesives, dyes, coatings, difficult-to-recycle, and unrecyclable materials, which lead to the emission of large amounts of volatile organic compounds as well as waste products that are harmful to humans and the environment [27]. For this reason, especially in the last years, companies have been looking for new certified materials with green chemistry and low environmental impact—such as adhesives that do not contain toxic elements and water-based coatings—avoiding suppliers that use environmentally harmful processes and choosing those with eco-labels. Materials such as wood, metal, and glass represent a common feature in high-value Italian furniture production. During the production phase, they consume a lot of energy but are usually recycled. Similarly, rare raw materials such as leather, marble, and stone present the highest level of CO_2 emission in the extraction phase. These

materials can represent an issue if not used in long-life cycle products. For this reason, among the factors that enable the implementation of CE is the purchase of raw materials with an eye to the preservation of the value of the product at the end of its life cycle. It is in the planning and design phase that the most important decisions about materials and the future of products are made. Business owners must increasingly address critical issues as some products can be designed, re-designed, and recycled. This means choosing recyclable and recycled materials, i.e., circular materials that are easier to recycle in a closed loop, avoiding materials that are more difficult to recycle because, for example, they contain dyes or are mixed with other materials. In addition, as opposed to oil-based, bio-based circular materials can be chosen to become soil nutrients, if they are compostable and biodegradable. In the last few years, many designers have taken up the challenge of circular materials promoting a cultural change [12]. Some brands, thanks to the designers' research, set out to explore new materiality to reduce the production-related environmental footprint, even if it means re-designing processes and developing new materials [12].

2.3. Lasting Production

In the furniture industry, "delaying the end-of-life" is one of the most crucial design strategies [28]. This is nothing new. Thanks to its critical capabilities towards the systems of activities and actions of daily life, design has always been able to orient the production and raise the meaning of products, guiding innovation strategies in different fields. The extension of the life of products involves a dimension linked with materials and the design of structures and shapes that guarantees significant durability. The "design for reliability and longevity" approach uses high-quality materials for high-quality furniture, that maintain their characteristics over time creating personal attachment to the piece of furniture. Moreover, longevity is also a dimension that we could describe as more psychological and anthropological: "design for attachment and trust". This has to do with the ability to reach "meanings and values", i.e., the user's psychological/affective level, making a profound impact [29]. In addition to this strategy, there are other methods to extend the life of products. These are regenerative and restorative design principles: design for ease of maintenance and repair, design for upgradability and adaptability, design for standardization and compatibility, and design for disassembly and reassembly. They enable the reduction of consumption, reuse, and recycling of components and materials. This means for furniture leaders to focus on design solutions that aim to raise and preserve the value of their products at the end of their life cycle. It implies engaging more in circular practices and services, especially in terms of envisioning a longer product life [22] through modular design, thus facilitating component replacement and repair, predictive maintenance, and regeneration.

2.4. Potential Benefits

Conversely to corporate perceptions, an Italian study on the transition to EC [24] reports that companies participating in CE projects, actions, or tools obtained the following benefits:

- 58% of the sample reported benefits in terms of economic savings,
- 47% improved brand reputation,
- 37% competitive advantage,
- 26% have increased customer satisfaction.

Indeed, there are differences across industries, business sectors, the contexts in which they operate, and specific CE actions to which benefits are associated. Anyway, since social responsibility has become a condition for immediate competitive differentiation, companies are increasingly required to incorporate environmental concerns into their business activities. From a corporate perspective, the benefits of all these efforts are a way to reduce conflicts between competitiveness and improved efficiency. As evidenced by current literature, implementing CE has a positive financial impact in the long term, because

saving resources and time increases efficiency. In addition, CE is a matter of environmental responsibility, ethical values, and customer satisfaction [30,31]. The adoption of CE increases the value that a company can generate for the community, as well as its reputation [32]. It increases the possibility of retaining customers over a longer period of time, i.e., developing loyalty.

3. Cassina LAB and the Research Activity

3.1. Cassina: A Design-Intensive Company

Cassina is a renowned international design company, proudly rooted in Italy for over 90 years, that stands out for its authenticity, tradition, and manufacturing excellence. Established in 1927 by Cesare and Umberto Cassina in Meda (Milan), the company has been a protagonist of industrial design in Italy since the 1950s, and today it continues to combine technology and long-standing artisan craftsmanship.

Since 1964, Cassina has undertaken the project "I maestri" to rediscover the roots of contemporary furniture and produce the archetypes of a new way of designing furniture and new aesthetic languages. The collection "I Maestri Cassina" includes pieces by Le Corbusier, Rietveld, Mackintosh, Asplund and Wright, among others. With this project, Cassina demonstrates to be a productive company and also a culture activator that stimulates and educates the public's taste.

With a mindset focused on research, design culture, and furniture innovation, Cassina has been bestowed the prestigious "Compasso d'Oro" lifetime achievement award (1991) by ADI (Italian Design Association). It is considered worldwide as a paradigmatic case of a "design-intensive company", in continuous innovation facing new product design, strengthening its identity [33]. Its uniqueness is rooted in design history, in a deep design knowledge that enables the simultaneous innovation and preservation of its link with the past.

Nowadays, increased competition, highly complex consumer needs, rapid advances in technology, and last but not least, the need to circularly rethink the creation of value are stressing the furniture industry. Cassina is aware of the necessity to reply to the driving forces of the current changes, implement a CE model, and adequate methods to manage the resulting changes. In its pursuit of research and development and experimentation with new materials and processes, the CRDC identified in the Politecnico di Milano Design System the expected collaboration for its transition to a more sustainable product model as well as innovative design solutions.

3.2. Cassina LAB, Scope and Vision of the Research

Cassina LAB is a partnership between CRDC and POLI.design of Politecnico di Milano. It was launched in 2019 with the aim of improving the quality and the value of the interior design experience, in terms of psycho-physical well-being, by seeking mindful and healthier, more environmentally friendly solutions and alternatives to the existing products by researching innovative materials and design of products and furnishing systems.

The aim of Cassina LAB is a balance between the responsibility of manufacturers and the needs and desires of consumers. The latter are more and more linked to the awareness of the importance of the ecological transition as well as the environmental sustainability of production. This example could encourage and support further collaboration between industry and academia and assist other SMEs in their transition toward CE.

Today's concept of well-being is inherently linked to the health-promoting quality of interiors, offering a range of psycho-physical benefits according to the idea of comfort, new functionality, and the users' sensitivity to sustainability for themselves, society, and the environment.

Thus, the aim of the research contributes to broadening the vision of CE and the theoretical considerations linking them not only to environmental and social benefits that

seem distant from the consumers but also to benefits that feel immediate to them, i.e., their physical and mental health.

The methodology proposed by the research team explores and experiments with new research methods of circular design along a supply chain that includes suppliers, craftsmanship, and technicians devoted to quality, as well as expertise in long-lasting products.

With a company tradition that has always placed the culture of design at its core, the launch of Cassina LAB means that the company is taking on the challenge of expanding its mission in the coming years, in line with the principles of sustainability and CE [34].

Cassina's green pathway requires the right choice and use of renewable technologies and materials. The company is a prominent expert in the application of traditional materials, but it needs to update its knowledge by exploring new circular, environmentally friendly resources and tools for research and development.

Circular materials [12] can reuse original materials and flow into a "technical cycle" in which inorganic materials or synthetics can be continuously reused without losing their properties or value, and without causing harm or waste [35]. Furthermore, new bio-based materials can be incorporated into the "biological cycle" at the end of their life. Organic nutrients or materials can be reintroduced into the biosphere without harm or waste, as they degrade naturally thus providing a food source for the broader system [35,36]. Despite these general principles, not all bio-based materials are highly sustainable for the environment and people. Most are not suitable for the furniture industry because of their limited durability. Material and energy flows, production cycles, and manufacturing techniques in industrial systems are questioned for understanding how these systems interact with the environment.

3.3. The Research in a Nutshell

From a CE perspective, Cassina is called upon to move towards more sustainable production models that use material resources in a circular flow with a regenerative and reparative design approach [37]. The main goal is not only to minimize the "cradle-to-grave" flow of materials but to develop a cyclical industrial "cradle-to-cradle" metabolism [35]. The latter is capable of moving waste materials to a new cradle so that they can maintain their status as resources: in short, to keep the quality of resources as high as possible over time. Environmental sustainability requires an intensive process of "recirculation of resources in loops of reuse": recycling, renewing using clean energy, and eliminating waste [38]. This requires a far-reaching restructuring of companies and production processes to drastically reduce the environmental footprint [39–41] and achieve sustainability through design, adopting strategies to improve the circularity of the production system [42], and developing new collaborative business models [43].

To rapidly move towards this goal, Cassina LAB promotes the identification of an updated supply chain for the use of cleaner and circular materials, and works on alternatives that take into account durability, salubrity, and aesthetics, as well as environmental impact, to meet the challenges of climate change and the Sustainable Development Goals [44].

Specifically, the research project has been mainly oriented to:

- Explore innovative and sustainable materials for new and existing Cassina products.
- Research and innovation related to new furniture materials are moving towards sustainability, CE, and well-being in order to create a healthy environment, protect nature and improve the quality of life.
- Create new knowledge and share new research methods and tools for sustainable innovation, to implement best practices that impact all business decisions. Hence, designing a new database of innovative and sustainable materials creates a unique digital materials library.
- Develop innovative product concepts and technologies to ensure unprecedented qualities linked to objects and spaces' sustainability for new lines of luxury

furnishing systems (residential, office, hotel, and healthcare spaces), consistent with the characteristics and expectations of Cassina design, in line with the tradition (brand identity) of the company.

The latter is beyond the scope of this paper. Thus, we postpone the description of the development of innovative product concepts to a future publication.

3.4. Methodology

Today, we still need to further develop our knowledge and expertise in order to fully understand the potential role of CE in empirical research [45].

The most widely used methodology is the empirical study of the past, present, and future behaviour of companies, together with the analysis of the constraints that hinder the path to CE in different contexts (geographical and industrial sectors).

Based on the analysis of the literature and the in-depth study of critical issues that arise around the circular economy of furniture, the design research team was created with a multi-discipline approach. The team, made of industrial design researchers, a material design researcher, a product designer, a design facilitator, and two process engineers, collaborated with the CRDC team (marketing experts, production engineers, and the curator of Cassina's historical archive) and focused on how to address critical issues and turn them into opportunities for positive change in terms of circularity, product quality and value, as well as business benefits (see Section 2.4).

Both extensive consultations with management and a series of discussions with CRDC executives and technicians were initiated on these issues. In particular, a series of interviews were used to collect data on the supply chain, materials, components, and production processes at the company's manufacturing site, and waste and scrap disposal.

Data collection was a back-and-forth process between the researchers and the CRDC staff, with changes made according to feedback in a "systematic combining" approach.

At this stage, we also used some of the tools typically adopted by companies associated with the Circular Transition Indicators (CTI) framework developed by the World Business Council for Sustainable Development (WBCSD) (https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Circular-transition-indicators) (accessed on 10 December 2021).

The collected data were analyzed for a diagnosis of critical issues, which was followed by creative sessions, design, assessment, and feedback.

The procedure was based on a step-by-step approach and an iterative process to be performed cyclically for data collection, analysis, diagnosis, co-defining circularity solutions, and testing. According to Garcés-Ayerbe et al. [15], a company's circular economy is a step-by-step process in which actions are implemented progressively, beginning with activities that involve control measures and ending with the implementation of preventive practices.

The CRDC staff worked on the project as co-researchers, as they were involved in the analysis and in some creative sessions. They also facilitated organizational learning for both the company and the researchers, so that the new knowledge was transferred from one side to the other.

In summary, the steps of the methodology can be described as follows (Figure 3):

1. Exploratory phase (data collection, extensive consultation with the company, focus on critical issues and diagnosis);
2. Design phase (creative sections/problem solving and design);
3. Prototyping;
4. Release.

Efforts have been made to encourage the participation and collaborative engagement of Cassina employees and to promote organizational learning related to the selection of materials and finishes, and to the design and development of circular products.

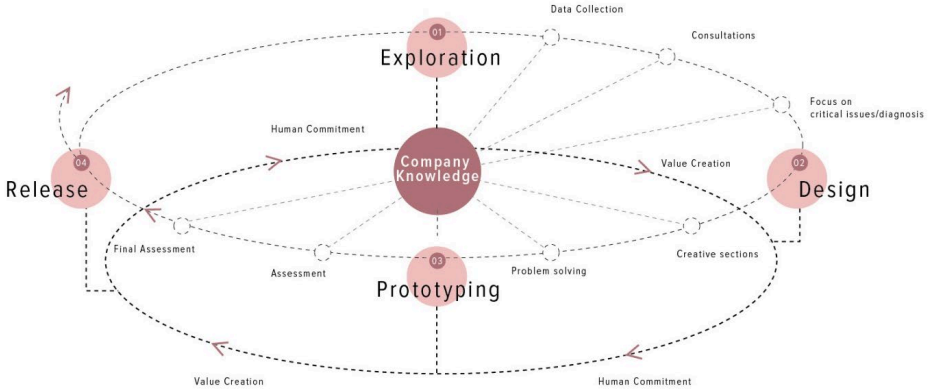

Figure 3. Circular design process developed by the research team.

3.5. Critical Materials and Circular Materials

A large part of the research focused on the material issue and critical materials [46].

A model in which the CE of materials must be managed, and a product must be either recycled or biodegraded at the end of its life, requires deep knowledge in terms of materials to be used (composition, compatibility, recyclability, the corresponding industrial processes, and, eventually, composting capacity). A lack of understanding of the materials and processes would create a knowledge barrier in the transition process toward CE. This barrier is a major obstacle to the development of sustainable and circular products.

In line with the need to improve design skills in circular manufacturing and align with theories of environmental sustainability and circularity guidelines researchers, designers and innovative brands have moved towards a deep exploration of materiality over the past decade [12,47]. In addition to individual initiatives, now universities and institutions are also getting involved in this trend. New circular materials and technologies have been developed through recycling primary materials or using organic waste (forest, fruits, vegetables, coffee grounds, etc.) jointly with bio-resins or the bio-culture of microorganisms (mycelium, algae, bacteria, etc.). Several bioplastics (https://bioplasticseurope.eu/) (accessed on 15 June 2021) and bio-based materials are now available on the market and have started to be used more widely. This development has radically innovated materials and the knowledge on them in a process still in progress. The increasing, emerging knowledge requires an alignment of the manufacturing structures.

During the creative section, we identified a solution to build, share and update new knowledge to equip SMEs with a useful and flexible tool such as a materials library. The Cassina Material Library concept has been designed as a digital and physical tool to include the materials traditionally used by the company, as well as new materials and technological innovations with a specific focus on circularity.

The explanatory bubble diagram in Figure 4 shows the exploratory research approach aimed at (i) identifying and investigating both the materials traditionally used in the furniture industry, focusing on the specific case of Cassina (Step I), and (ii) innovative solutions with a focus on circular material, considering their level of circular sustainability (Step II).

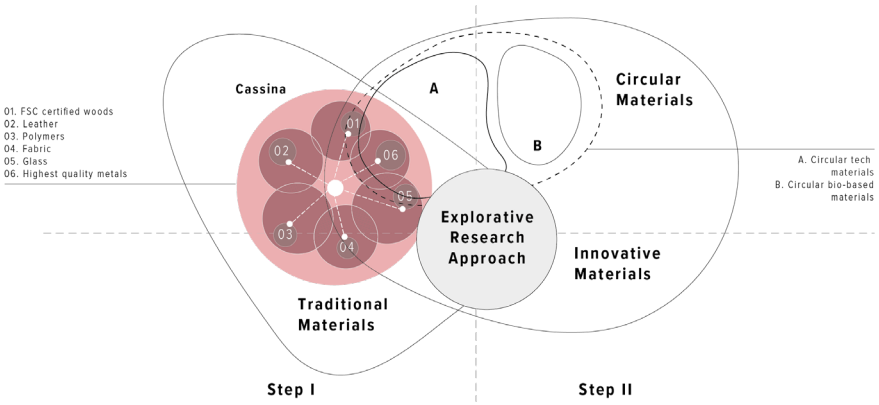

Figure 4. Explorative research approach scheme.

Step I identified that Cassina prides itself on the use of authentic, high-quality, and long-lasting and certified materials—such as FSC-certified woods, leather, fabrics, glass, polymers, and the highest-quality metals. A new tool has been created for the design and product development teams (internal use), that need to make the best material decisions to improve product performance, reduce costs, and minimize risks. Each of the different materials is inserted into a circular diagram (pie chart) that makes the properties of the materials (density, specific gravity, Young's modulus, stiffness, and strength) easy to read and compare. The tool is useful for evaluating alternative materials characterized by similar properties and for selecting the most effective materials in consideration of their recyclability. Users can use the new tool in the early stages of product design when multiple materials are considered, and numerous details must be defined. The tool is based on the "radar charts" introduced by [48] as a technique for visualizing a qualitative comparative analysis. Specifically, the circular diagram (pie chart) uses a radial layout where nodes are placed at varying distances from the origin, with the distance representing the magnitude of the associated condition/property. A line is then drawn to connect the nodes, creating a shape that can be used for comparison (Figure 5).

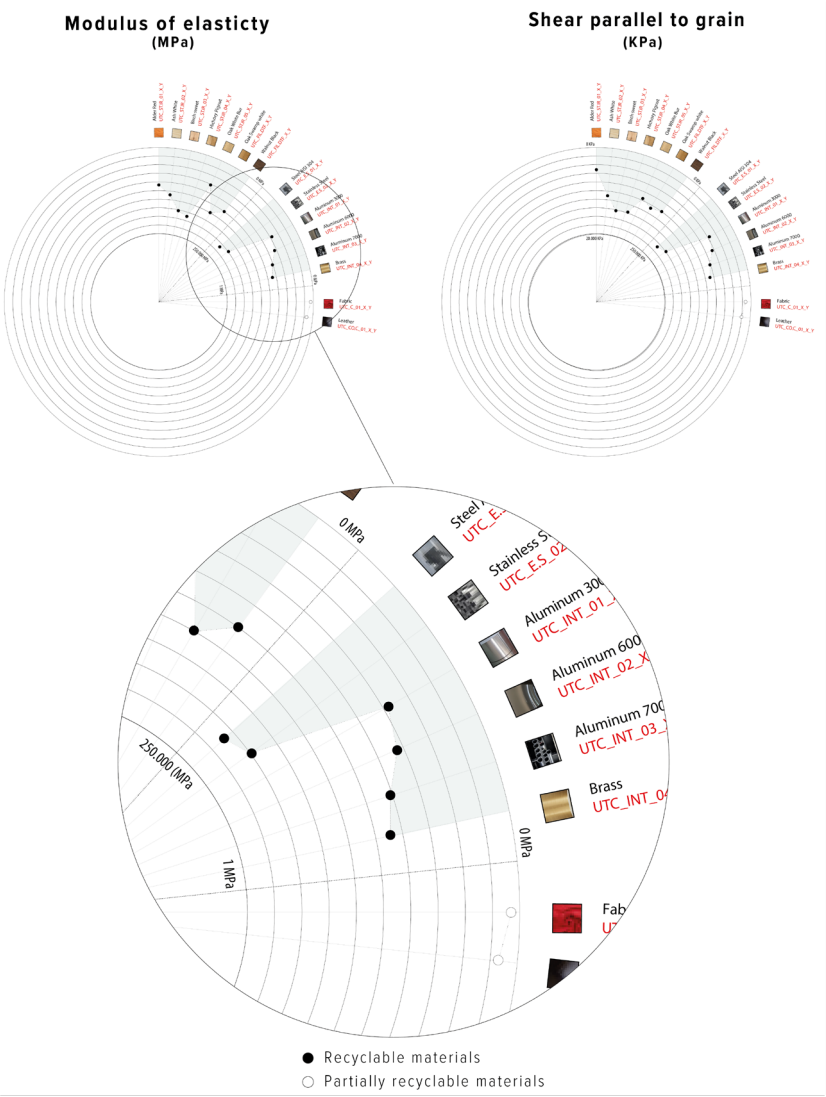

Figure 5. Comparative circular diagrams. In this practical example, the selection of certain materials based on their mechanical properties is shown. Knowledge of these material properties makes it possible to evaluate the wear of materials over time and select them accordingly.

In line with the company's vision to combine history with the future, Step II of the research activity explores materials and suppliers that move towards sustainability, circularity, and well-being to create a healthy environment, protect nature, and improve the quality of life. The research focused on the identification of innovative circular materials.

The "Table of Materials", as shown in Figure 6, summarizes the results of the exploratory phase for the materials library. The "Table of Materials" is organized on different levels. The first level corresponds to the "sector of origin" (mainly aeronautics, medical, and marine), typically representing leading sectors in the development of advanced materials. We referred to this first data to identify and select the circular materials on the second level. On the third level, these selected materials have been classified based on their main features/characteristics (e.g., high-performance, comfort). Overall, about 40 materials have been selected.

For each material in the library, the following was provided: the name of the material, a picture of it, the manufacturing company, and a detailed string of the material code ID, which includes (i) the material's intended use (e.g., structure, upholstering, lining), (ii) the primary production process, (iii) the secondary production process, (iv) the energy value for production, (v) the energy value for disposal, (vi) the energy value for recycling, (vii)

the CO_2 footprint, (viii) the recycling rate (from 1 to 7), and composting capacity. More information provided by the producer is listed in the technical sheet stored in the digital archive. It is necessary to point out that finding this information is not always easy, because not all companies use the same indicators yet. This is the reason why the digital materials library is under construction.

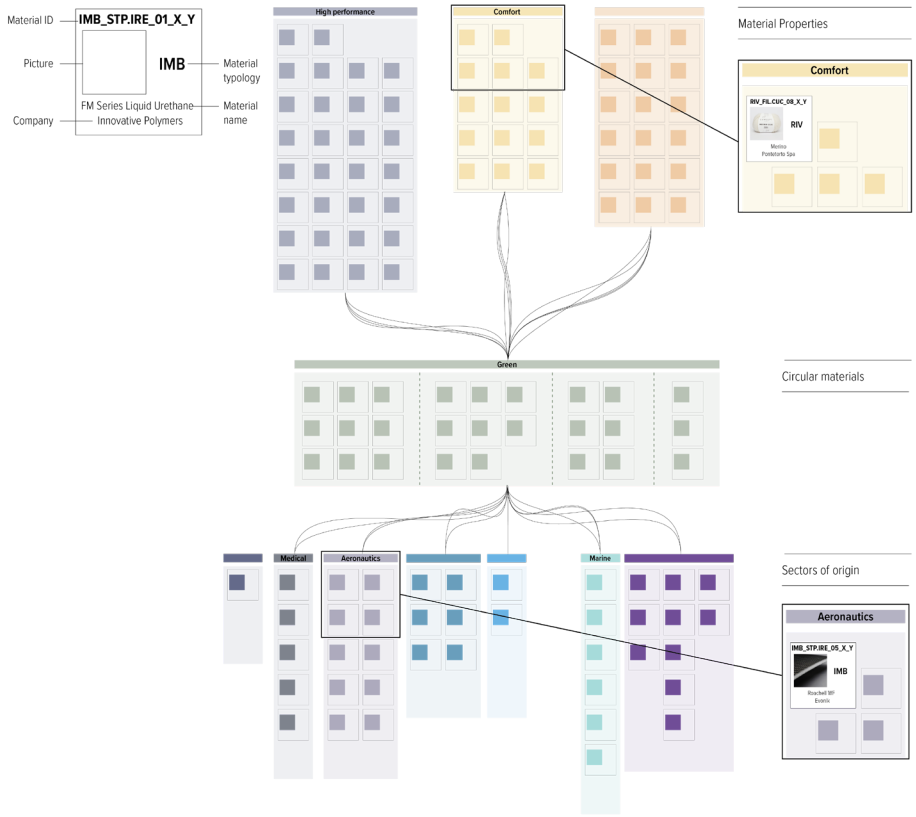

Figure 6. Table of new materials.

This first result is preparatory to the creation of a unique Cassina Digital Materials Library, which will serve as a central repository for materials, where all the information about any material can be cross-referenced with others and each material can be identified through various parameters and search keys. The digital materials library will give the company's designers and manufacturers complete visibility and control over the materials they use to complete the design. The result is a faster product development cycle with fewer inefficiencies and errors.

3.6. Re-Design of One of Cassina's Existing Products

Thanks to a conscious approach to updating knowledge of materials and alternative production processes, Cassina LAB wants to promote CE, and well-being, without sacrificing performance, durability, or comfort.

The exploratory phase was followed by an experimental phase for the re-design of a product on the catalogue. In this phase, the Soriana 944 model was chosen among all that have made the history of Italian design, to be prototyped in a renewed, more sustainable version with lower environmental impact.

In this paper, the re-design of this armchair is described as a representative case of the research phase aimed at integrating circular materials in production, replacing the

original materials that cannot guarantee the same environmental sustainability and recyclability, without sacrificing the authentic aesthetics and comfort of the original design.

In 1970, the Soriana upholstered series by Afra and Tobia Scarpa (1969) was awarded the Compasso d'Oro for the masterful complexity achieved with an extremely simple and coherent design, and technical details (Figure 7). On the one hand, Soriana's design recalls the series of furniture with metal frames and loose upholstery created by Le Corbusier and Charlotte Perriand in the 1920s. On the other hand, this design deliberately abandons the composure of the same structural elements and twists the idea of external structure in favour of the tension and expression of soft materials [49,50]. The designers took advantage of a novelty at that time, the polyurethane foam upholstery technique that was destined to revolutionize the manufacture of sofas and armchairs. They create an armchair that does not require internal supports but derives its shape from the vice-like grip of the metal structure that embraces it (Figure 8).

Over the years, Soriana has become one of the most sought-after upholstered furniture for interior design projects around the world. The armchair is now in the collection of the New York MoMA.

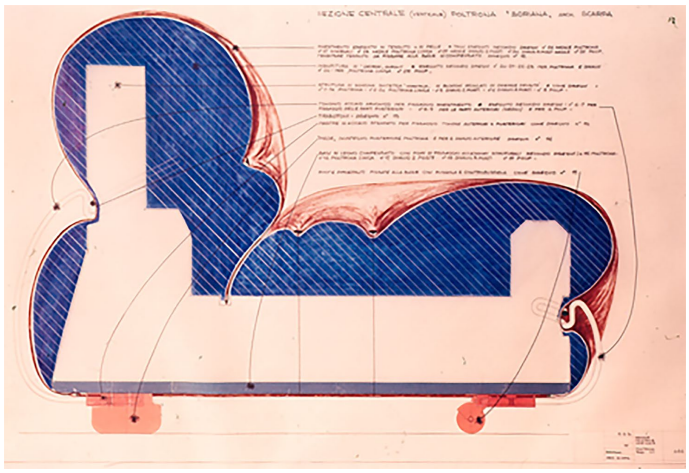

Figure 7. Soriana armchair cross-sectional original drawing.

As a first step, critical issues related to environmental sustainability have emerged from the analysis of the materials that currently make up Soriana. We know how critical this issue is for upholstery products that use polymeric foams extracted from petroleum, coal, or natural gas, i.e., all non-renewable resources, as raw material. Specifically, the support was made of fabric bags filled with EPS (Expanded Polystyrene) microspheres of various densities, whereas the internal volume was created by various layers of polyester-based gauzed cotton wadding. The production of these materials contributes to an increase in CO_2 emissions and, at the end of their life, results in hardly-disposable waste. When they degrade, they decompose into toxic microparticles for flora and fauna and even for humans. The current solution to this problem is to replace them with similar materials derived from recycling waste materials. The "Table of Materials" was then used to identify and evaluate possible alternatives. The final decision was made in the Cassina laboratory with Tobia Scarpa, who evaluated the consistency of the chair and guaranteed that the result would not alter the original design. Thus, the Soriana 944 model was relaunched in 2020 in a renewed ecological version. Specifically, new circular materials and finishing processes have been identified with the goal of creating a lower environmental impact (Figure 9).

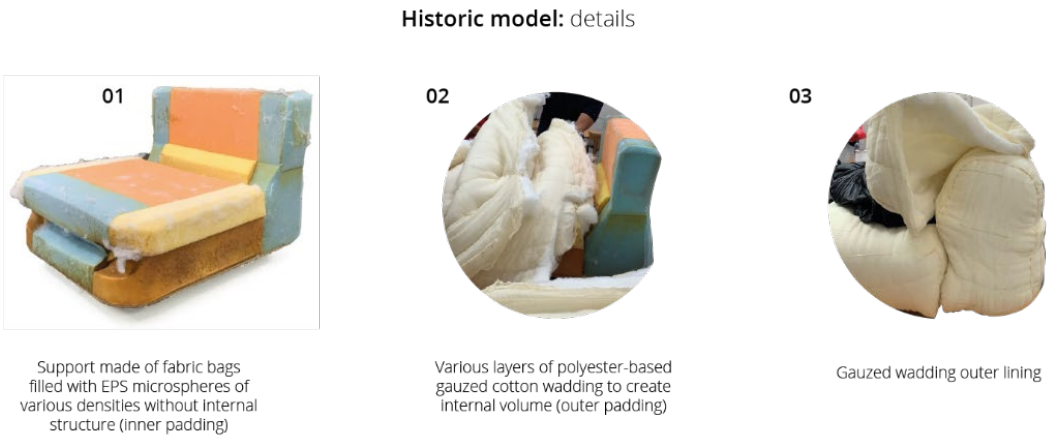

Figure 8. Soriana's constructive details and materials in its original version (1969–2019).

Figure 9. Soriana 944 in its renewed ecological version.

Figure 10 shows a cross-sectional drawing of the Soriana 944 model used to specify the materials in its renewed ecological version. The bold black line marks the volume of upholstery, in both the inner and outer padding, made with ecological materials. Considering Soriana's structure and shape, it is clear how the use of sustainable materials has increased to nearly 100%.

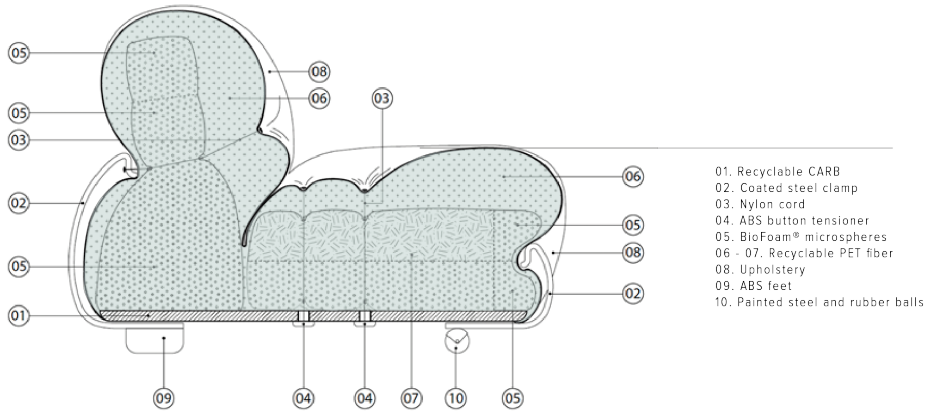

Figure 10. Soriana 944 model cross-sectional drawing indicating the constituent materials in its ecological version: 01—recyclable CARB certified poplar multilayer panel, low-level formaldehyde offgassing; 02—powder-coated steel clamp; 03—nylon cord for topstitching; 04—ABS (Acrilonitrile Butadiene Stirene) button tensioner. Inner padding: 05—in BioFoam® microspheres. Outer padding: 06/07—in 100% recycled blown PET fibre recovered by PlasticBank®. Upholstery: 08—in a selection of fabrics and leathers from the Cassina Collections. Feet: 09—in ABS. Wheels: 10—in eco-friendly painted steel and rubber balls.

In particular, the inner padding is made of BioFoam® microspheres, a 100% bio-based PLA (Polylactide Acid) foam, the first organic-based patented foam composed of biopolymers obtained from natural resources, made from Synterra® PLA by Synbra Technology (Etten-Leur, The Netherlands). It is physically and mechanically comparable to expanded polystyrene (EPS) and was specifically developed to serve as a feedstock for shape moulding. This material is durable and suitable for long-term use. It is certified as industrially compostable according to EN 13432 and is Cradle-2-Cradle^{SM} Silver certified. All BioFoam® components comply with the European Directive EC1994/45/EC regarding the absence of heavy metals and mutagenic and carcinogenic substances, and therefore also comply with the European Directives 2002/95/EC and 2000/53/EC. BioFoam® has a very low carbon footprint compared to other materials and is even better than EPS, which is a very good insulation material (Figure 11).

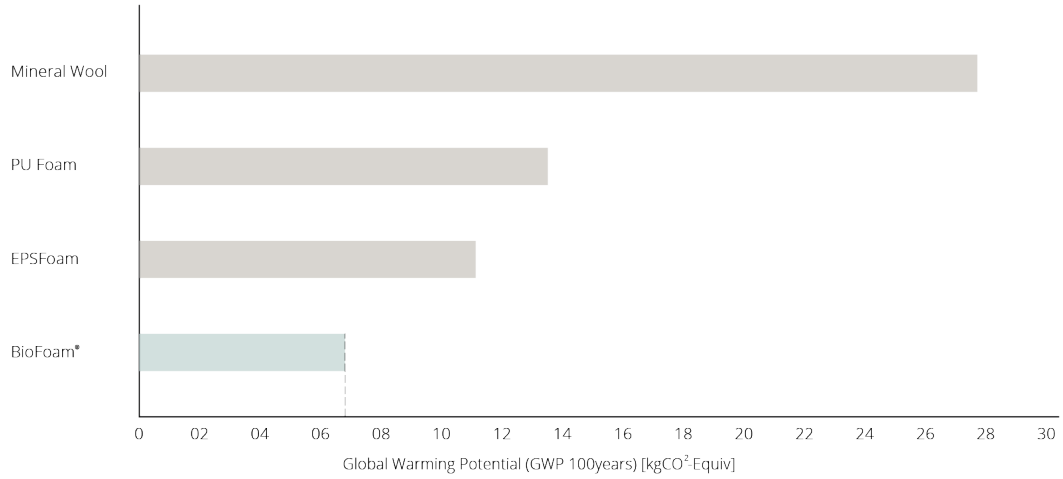

Figure 11. BioFoam® vs. competitors' materials CO_2 footprint. From BioFoam technical sheet.

The new Aerelle® Blue filling fibre was chosen for the outer layer of the padding. Aerelle® Blue is produced by ADVANSA Marketing GmbH (Hamm, Germany). Aerelle®

Blue is a 100-percent recycled plastic fibre made from PET (polyethylene terephthalate), mainly recovered from the oceans by PlasticBank® (Vancouver, BC, Canada). PlasticBank® is a for-profit social enterprise that is turning plastic into gold by revolutionizing the world's recycling systems to create a regenerative, inclusive, and circular plastic economy (Figure 12).

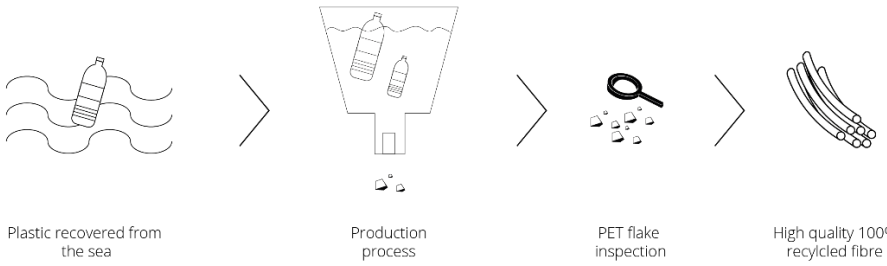

Figure 12. Circular process of the recycled plastic fibre made from PET.

The same material is used for the padding of the cover that wraps around the structure like a soft quilt. For the new version, Cassina has introduced a selection of colour combinations that combine the fabrics with the metal vise. This is no longer chromed but painted in different colours to be more eco-friendly.

4. Discussion—The Role of Design for CE

At this stage, the research conducted within Cassina LAB is a small project in the wide range of possible actions towards CE. The research focuses on facilitating the company with a methodology that, step by step, guides the transition toward a more sustainable and circular model. It defines a methodology and a tool to systematize the new knowledge of materials for sustainable, circularity-friendly choices, and to convey the relevant information to the consumers.

This multi-disciplinary project allows verification of how design can play an active role in facilitating a company transition. Although the presented design process and results are tested only on the furniture sector, the research approach and methodology are generalizable and can be applied to many other product categories and sectors. Design research and development have proved to be key competencies in the EC transition.

After completing the first phase of Cassina LAB research, we can first compare what we have achieved in terms of design with the typical design process. Secondly, we can add some considerations to the most current guidelines [45,46,51] and methodologies [52] from the literature.

The Cassina LAB research flows in line with pre-existing concepts. Many of the activities with which we approached the research are consistent with sustainable design, skillfully unfolded by Vezzoli and Manzini [28].

Sadly, in the past companies have not shown much interest in applying sustainable solutions to manufacturing. Today, as the CE is an umbrella concept that may operationalize sustainable design [53], industrial design must fill the gap to sustainable development. The introduction of the concept of CE better meets the language of entrepreneurs. At the same time, the CE paradigm introduces clearer goals about waste metabolism and industrial symbiosis, which are more decisive concepts. In the large CE framework, the design process expands upstream and downstream with respect to its classic and consolidated extension/dimension.

At this stage, the Cassina LAB research is limited to the upstream expansion of the design process. This requires more analysis, research, and tools to make preliminary choices for the re-design of existing products and the design of new circular products. The

research has focused on the flows of recourses, mainly materials and waste, and company knowledge. It implements the concept of materials circularity (degree of recyclability, compostability, and biodegradability) and associated industrial processes (low-intensity, carbon footprint, and water footprint) and services of circularity (recovery and upcycling of waste). This extension of the process makes design an actor of change reducing the harmful impacts of products and productions. This implicates reducing the toxicity and harmfulness of substances entering products and the emission of hazardous substances leaving the environment, which is ultimately measured in terms of global warming and the greenhouse effect, with significant benefits for management, users, society, and the environment.

The research does not propose the involvement of actors at meso and macro levels (i.e., eco-industrial parks, cities, provinces, and countries) but identifies new suppliers at micro levels.

In the literature on CE, little attention has been paid to the design process, practical methods, and tools. However, the design competencies have a big chance to lead the research process, facilitate companies to implement their new knowledge and add value to re-designed products.

The research process has raised awareness of critical issues, and has implemented a method to diagnose and solve the supply chain criticality; it has provided a new tool to check the material circularity. This tool serves to better support the designers working with it and guide the choice of materials during the design and development phases of existing and new products.

The Cassina Material Library was conceived as a flexible (and expandable) tool that allows the management and the designers who collaborate/work with the company to make material choices with full awareness and responsibility, and to communicate them clearly to the public so that they can better understand the value of the product.

However, it must be noted that valid substitutes do not currently exist for all materials. Scientific research must continue to advance to ensure increasingly innovative and sustainable solutions.

At the moment, with regards to the circular design process of products, we can only add some thoughts. The assessment made during the analysis phase, starting from the critical aspects of the sector, leads to the conclusion that what Cassina has achieved in the past is in line with the current guidelines for the circular product. Cassina's production is based on the high-quality design of products that have withstood time and the ravages of time, continuing to be appreciated and have become sought-after collectables. They are unlikely to be found in landfills. In addition, Cassina offers a repair service for its products that meets the requirements of the circular economy.

The choice, therefore, fell on a pilot action to re-design one of Cassina's existing and historic products. The Soriana 944 armchair by Afra and Tobia Scarpa, produced by Cassina since 1970, remains one of the most desirable upholstered items for interior design projects around the world, proving that design creates tangible and intangible qualities that can be improved to be appreciated even more by consumers and users.

There are many other tasks for CE design, and some of them will be addressed in the next research steps. At this stage, we can say that circular design contributes in terms of:

- Reducing the risks of material criticality;
- Supporting knowledge with tools that can promote circularity;
- Reducing the environmental impact of projects through the selection and use of recycled/recyclable bio-based materials and production processes;
- Updating knowledge within the company, especially for what refers to materials and production processes, with implications for human capital empowerment;
- Developing new recyclable products and re-designing existing products based on recyclability;

- Maintaining or increasing the quality standard of products, as a design is sought that preserves the added value of a (historical-cultural) product as long as possible and adds the new values of recyclability and psycho-physical comfort;
- Extending the life cycle of furniture in the form of reuse, even if the latter is not yet a priority over recycling, incineration, and landfill, and its environmental impact must be accurately and adequately quantified;
- Increasing the aesthetic value is mentioned as an important feature that contributes to extending the life of the product, thus improving the efficiency of material and energy consumption.

5. Conclusions

There is still an impasse and many obstacles in the perception of SMEs in the transition to CE. Therefore, this paper aims to contribute to the literature on CE transition in order to understand how, at a company level, design competencies, approaches, methods, and tools can contribute to identifying a pathway towards the CE paradigm.

Conversely to common corporate perceptions, investing in CE and design pays off in the long run, also in terms of corporate reputation and innovation.

A system in which the "circularity" of materials must be managed, and a product must be either recycled or biodegraded at the end of its life requires a profound knowledge of the composition and compatibility of materials. A lack of understanding of the composition and compatibility of materials, processes, and product components would create a knowledge barrier in the transition process. Not only this barrier stands in the way of the implementation of advanced materials and new technologies, but it also becomes a major obstacle to the development of sustainable products. CE transition represents a great opportunity for "Made in Italy" which can count on its ability to develop innovative and long-lasting products that arise from an economy increasingly oriented towards circularity.

This paper contributes to gaining an insight into the path toward CE of a design-intensive company, proving that this transition must start with a re-organization process of the knowledge of materials, technologies, and product quality through the improvement of design competencies on environmental sustainability and circularity. Moreover, from the re-organization of knowledge new tools and new qualities of the design process can emerge, that can ensure innovation from circularity. This assumption is demonstrated through the case study of the design research activity carried out by Cassina LAB thanks to the scientific cooperation between Cassina's R&D centre and POLI.design of Politecnico di Milano. In the following, the main conclusions are given as key points.

- The research results have revealed that the collaboration process, involving both internal (industrial) and external (academic) researchers, has not only led to the expected objectives but has also fostered a cultural change towards innovation inside the company itself. Therefore, this experience has allowed for the extraction of key transferable learning topics, opening a new research realm for the application of new design methods and tools.
- The definition of a new tool and the method changes emerging from the design research has allowed the implementation of new organizational forms of knowledge on materials and design processes to deliver products that are compatible with a circular economy at the end of their life. Within this set of methods and tools, the creation of a unique "Cassina Materials Digital Library" based on circularity will provide a central repository for materials allowing designers and manufacturers to cope with a faster product design process with lowered inefficiency.
- Thanks to the research carried out by Cassina LAB, innovative recycled and recyclable materials will be continuously applied to the design development of existing products as well as new products to offer a conscious approach with sustainable, high-quality, and durable alternatives.

As an avenue for further research in the field of CE, Cassina LAB is working on the creation of a vademecum of upcycling procedures to allow the correct design for assembly, disassembly, and sub-assembly of products and/or systems. This involves ensuring that the parts can be dismantled to be reused or recycled at the end of their life cycle.

Design plays a big role in helping SMSs transition with a methodology that guides them step by step. Design can provide new tools and methods for verifying the circularity of materials, as well as methods for diagnosis and solving supply chain issues. These can better support professional designers and guide material choices during the design and development phases of existing products.

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References

1. European Commission. Circular Economy, 2016. Available online: http://ec.europa.eu/environment/circular-economy/index_en.htm (accessed on 1 July 2021).
2. Dokter, G.; Thuvander, L.; Rahe, U. How circular is current design practice? Investigating perspectives across industrial design and architecture in the transition towards a circular economy. *Sustain. Prod. Consum.* **2021**, *26*, 692–708.
3. Smith, N.C. *Morality and the Market: Consumer Pressure for Corporate Accountability*, 1st ed.; Routledge: London, UK, 1990.
4. De los Rios, I.C.; Charnley, F.J.S.; Sundin, E.; Lindahl, M.; Ijomah, W. Skills and capabilities for a sustainable and circular economy: The changing role of design. *J. Clean. Prod.* **2017**, *160*, 109–122.
5. Liedtke, C.; Baedeker, C.; Borrelli, L.M. Transformation Towards a Sustainable Society—Key Intervention Areas. *Innov. Energy Res.* **2015**, *4*, 1–10.
6. Ceschin, F.; Gaziulusoy, I. Evolution of design for sustainability: From product design to design for system innovations and transitions. *Des. Stud.* **2016**, *47*, 118–163.
7. Crabbè, A.; Jacobs, R.; Van Hoof, V.; Bergmans, A.; Van Acker, K. Transition towards sustainable material innovation: Evidence and evaluation of the Flemish case. *J. Clean. Prod.* **2013**, *56*, 63–72.
8. Gaziulusoy, A.I.; Brezet, H. Design for system innovations and transitions: A conceptual framework integrating insights from sustainability science and theories of system innovations and transitions. *J. Clean. Prod.* **2015**, *108*, 558–568.
9. European Commission. Ecodesign Your Future: How Ecodesign Can Help the Environment by Making Products Smarter, 2014. Available online: https://op.europa.eu/en/publication-detail/-/publication/4d42d597-4f92-4498-8e1d-857cc157e6db (accessed on 14 November 2020).
10. Moreno, M.; De los Rios, C.; Rowe, Z.; Charnley, F. A conceptual framework for circular design. *Sustainability* **2016**, *8*, 937. https://doi.org/10.3390/su8090937.
11. Korhonen, J.; Honkasalo, A.; Seppälä. Circular Economy: The Concept and its Limitations. *Ecol. Econ.* **2018**, *143*, 37–46.
12. Ferrara, M. Circular Material for Creative Industries: The Emerging Bioplastics. In *Material Designers. Boosting Talent towards Circular Economies*; Clèries, L., Rognoli, V., Solanki, S., Llorach, P., Eds.; MaDe: Milan, Italy, 2021; pp. 52–59. Available online: http://materialdesigners.org/wp-content/uploads/2021/03/MaDe-Book-1.pdf (accessed on 14 November 2020).
13. Karlsson, R.; Luttropp. C. EcoDesign: What's happening? An overview of the subject area of EcoDesign and of the papers in this special issue. *J. Clean. Prod.* **2006**, *14*, 1291–1298.
14. Landeta-Manzano, B.; Arana-Landín, G.; RuizdeArbulo, P.; DíazdeBasurto, P. Longitudinal Analysis of the Eco-Design Management Standardization Process in Furniture Companies. *J. Ind. Ecol.* **2016**, *21*, 1356–1359.

15. Garcés-Ayerbe, C.; Rivera-Torres, P.; Suárez-Perales, I.; Leyva-de la Hiz, D.I. Is It Possible to Change from a Linear to a Circular Economy? An Overview of Opportunities and Barriers for European Small and Medium-Sized Enterprise Companies. *Int. J. Environ. Res. Public Health* **2019**, *16*, 851.
16. European Commission—Eurostat Prodcom Statistics. Available online: https://ec.europa.eu/eurostat/web/prodcom (accessed on 5 April 2022).
17. FederlegnoArredo. *Rapporto Ambientale 2010*; FederlegnoArredo: Milan, Italy, 2010.
18. Barbaritano, M.; Bravi, L.; Savelli, E. Sustainability and Quality Management in the Italian Luxury Furniture Sector: A Circular Economy Perspective. *Sustainability* **2019**, *11*, 3089. https://doi.org/10.3390/su11113089.
19. Savelli, E.; Barbaritano, M.; Bravi, L. Circular Economy and Quality Management within the Furniture Sector: An exploratory study. In Proceedings of the 1st Conference on Quality Innovation and Sustainability, Valença, Portugal, 6–7 June 2019.
20. Barbaritano, M.; Savelli, E. Design and sustainability for innovation in family firms. A case study from the Italian furniture sector. *Piccola Impresa/Small Bus.* **2019**, *1*, 20–43. https://doi.org/10.14596/pisb.342.
21. Silvius, G.; Ismayilova, A.; Sales-Vivó, V.; Costi, M. Exploring Barriers for Circularity in the EU Furniture Industry. *Sustainability* **2021**, *13*, 11072. https://doi.org/10.3390/su131911072.
22. Mura, M.; Longo, M.; Zanni, S. Circular economy in Italian SMEs: A multi-method study. *J. Clean. Prod.* **2020**, *245*, 118821**.** https://doi.org/10.1016/j.jclepro.2019.118821.
23. European Commission 2020. Circular Economy Action Plan. The European Green Deal, 2020. Available online: https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en (accessed on 10 February 2022).
24. Fondazione Symbola—Enel. 100 Italian Circular Economy Stories, 2021. Available online: https://www.symbola.net/ricerca/100-italian-circular-economy-stories/ (accessed on 19 January 2022).
25. European Biomass Industry Association (EUBIA). Absorbing the Potential of Wood Waste in EU Regions and Industrial Bio-based Ecosystems—BioReg. D.1.2: State of the Art Technical Report, 2017. Available online: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bf188114&appId=PPGMS (accessed on 4 April 2022).
26. European Environment Bureau (EEB)—Eunomia Research & Consulting. Circular Economy Opportunities in the Furniture Sector, European Environmental Bureau, 2017. Available online: https://eeb.org/wp-content/uploads/2019/05/Report-on-the-Circular-Economy-in-the-Furniture-Sector.pdf (accessed on 11 November 2021).
27. Azizi, M.; Mohebbi, N.; De Felice, F. Evaluation of sustainable development of wooden furniture industry using multi criteria decision making method. *Agric. Agric. Sci. Procedia* **2016**, *8*, 387–394.
28. Vezzoli, C.; Manzini, E. *Design per la Sostenibilità Ambientale*; Zanichelli: Bologna, Italy, 2007.
29. Chapman, J. *Emotionally Durable Design: Objects, Experiences and Empathy*, 2nd ed.; Routledge: London, UK, 2012.
30. EIO. *A Systemic Perspective on Eco-Innovation. Eco-Innovation Observatory*; European Commission, DG Environment: Brussels, Belgium, 2013.
31. Martos-Pedrero, A.; Cortés-García, F.J.; Jiménez-Castillo, D. The Relationship between Social Responsibility and Business Performance: An Analysis of the Agri-Food Sector of Southeast Spain. *Sustainability* **2019**, *11*, 6390.
32. Masi, D.; Kumar, V.; Garza-Reyes, J.A.; Godsell, J. Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. *Prod. Plan. Prod. Plan. Control* **2018**, *29*, 539–550.
33. Magistretti, S.; Dell'Era, C.; Frattini, F.; Messeni Petruzzelli, A. Innovation through tradition in design-intensive family firms. *J. Knowl. Manag.* **2020**, *24*, 823–839.
34. Cassina. The Cassina Manifesto, 2021. Available online: https://www.cassina.com/content/dam/ld/cassina/company/manifesto/02_details/Manifesto.pdf (accessed on 22 February 2022).
35. McDonough, W.; Braungart, M. *Cradle to Cradle: Remaking the Way We Make Things*; North Point Press: New York, NY, USA, 2002.
36. Scott, J.T. *The Sustainable Business: A Practitioner's Guide to Achieving Long-Term Profitability and Competitiveness*; Routledge: London, UK, 2013.
37. Ellen McArthur Foundation, Circular Economy in Detail, 2016. Available online: https://archive.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail (accessed on 14 October 2021).
38. Clark, J.H.; Farmer, T.J.; Herrero-Davila, L.; Sherwood, J. Circular economy design considerations for research and process development in the chemical sciences. *Green Chem*. **2016**, *18*, 3914.
39. Prendeville, S.; Sanders, C.; Sherry, J.; Costa, F.; Harlow, R.R. Circular Economy: Is it Enough? Ecodesign Centre, 2014. Available online: https://pdfs.semanticscholar.org/943c/814c3300b69a06bd411d2704ec3baa3a0892.pdf (accessed on 20 October 2021).
40. Loiseau, E.; Saikku, L.; Antikainen, R.; Droste, N.; Hansjürgens, B.; Pitkänen, K.; Leskinen, P.; Kuikman, P.; Thomsen, M. Green economy and related concepts: An overview. *J. Clean. Prod.* **2016**, *139*, 361–371.
41. Geissdoerfer, M.; Savaget, P.; Bocken, N.M.P.; Hultink, E.J. The Circular Economy—A new sustainability paradigm? *J. Clean. Prod.* **2017**, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048.
42. Winkler, H. Closed-loop production systems—A sustainable supply chain approach. *CIRP J. Manuf. Sci. Technol.* **2011**, *4*, 243–246.
43. Lieder, M.; Rashid, A. Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *J. Clean. Prod.* **2016**, *115*, 36–51.
44. Sustainable Development Goals. Available online: https://sdgs.un.org/goals (accessed on 7 February 2019).

45. van Dam, K.; Simeone, L.; Keskin, D.; Baldassarre, B.; Niero, M.; Morelli, N. Circular Economy in Industrial Design Research: A Review. *Sustainability* **2020**, *12*, 10279. https://doi.org/10.3390/su122410279.
46. Babbitt, C.W.; Althaf, S.; Cruz Rios, F.; Bilec, M.M.; Graedel, T.E. The role of design in circular economy solutions for critical materials. *One Earth* **2021**, *4*, 353–362. Available online: https://www.sciencedirect.com/science/article/pii/S2590332221001202 (accessed on 7 March 2022).
47. Ferrara, M. Shifting to Design-driven Material Innovation. In *Ideas and the Matter. What Will We Made of and What Will the World Be Made of?* Ferrara, M., Ceppi, G., Eds.; List-Lab: Campbell, CA, USA, 2017; pp. 173–185.
48. Meuer, J.; Rupietta, C.; Backes-Gellner, U. Layers of coexisting innovation systems. *Res. Policy* **2015**, *44*, 888–910.
49. Masiero, R.; Maguolo, M. (Eds.) *Afra e Tobia Scarpa Architetti 1959–1999. Tobia Scarpa Architetto 2000–2009*; Mondadori Electa: Rome, Italy, 2009.
50. Oropallo, G. Scarpa, Afra and Tobia. In *The Bloomsbury Encyclopedia of Design*; Bloomsbury Academic: London, UK, 2016; Volume 3.
51. Shahbazi, S.; Jönbrink, A.K. Design Guidelines to Develop Circular Products: Action Research on Nordic Industry. *Sustainability* **2020**, *12*, 3679. https://doi.org/10.3390/su12093679.
52. Prieto-Sandoval, V.; Torres-Guevara, L.E.; Ormazabal, M.; Jaca, C. Beyond the circular economy theory: Implementation methodology for industrial SMEs. *J. Ind. Eng. Manag.* **2021**, *14*, 3. https://doi.org/10.3926/jiem.3413.
53. Blomsma, F.; Brennan, G. The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *J. Ind. Ecol.* **2017**, *21*, 3. https://doi.org/10.1111/jiec.12603.