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A transition approach for reuse and repair of manufactured products

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Abstract

The landscape of reuse and repair (R&R) activities for manufactured products is vibrant: new European laws, research projects, local initiatives. Our aim is to capture the current and future challenges of the field through an industrial workshop held at the ICED23 conference. A collective reflection was conducted with three French stakeholders: a Product Responsibility Organization, a social and solidarity organization, and a private company producing water-driven dosing pumps. The study results in a multi-level perspective on the R&R value chain and four R&R future scenarios.

Keywords: transition, repair activity, multi-level perspective, circular economy, socio-technical systems

1. Introduction

Within the circular economy context, multiple approaches exist, known as the 'R's. In particular, the framework composed of 9 R's includes the following Rs: Refuse, Reduce, Resell/Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover energy, Remine. (D'Urzo and Campagnaro, 2023). In 2008, the Waste Hierarchy Principle became an integral part of the Waste Framework Directive 2008/98/EC (WFD) endorsed by the European Union. It suggests a specified order of waste management steps, prioritising prevention, reuse, recycling, other forms of recovery (including energy recovery), and, ultimately, disposal. To make these principles a reality, European policies include establishing economic instruments such as landfill charges, Extended Producer Responsibility (EPR) systems, fiscal incentives, etc. Nevertheless, the European economy is surprisingly wasteful and continues to operate a take-make-dispose system. Despite this WFD, the pivotal elements of Reuse and Repair have not yet found a place in the industrial landscape. The lower production costs due to plant relocations makes the Reuse and Repair sector less competitive and perpetuates the proliferation of low-cost products and obsolescence (Raillard, 2021).

This paper focuses on Reuse and Repair activities (R&R), which are crucial to extend the use phase of manufactured products and thus to move toward environmental, economic, and social transitions. Literature on R&R underlines the presence of uncertainties and inconsistencies in defining these terms. (Gharfalkar et al.,2015; Cooper and Gutowski; 2015; Den Hollander et al.; 2017). Den Hollander et al. (2017) define reuse as "*any operation by which products or components that are not waste are used again for the same purpose for which they were conceived*". Repair, on the other hand, is defined as "*the correction of specific faults in an obsolete product, bringing the product back to working condition, whereby any warranty on the repaired product generally is less than those of newly manufactured equivalents and may not cover the whole product, but only the component that has been replaced*" (Den Hollander et al., 2017).

More practically, Tecchio et al. (2019) identified hindrances in the repair industry, grouping them into "consumer choice", where perceived costs hinder repair; "technically infeasible", involving technical obstacles like spare part shortages; and "non-viable", addressing situations where repair is deemed impractical due to functional issues. The repair industry also faces challenges regarding access to original spare parts, tools, product manuals, and expertise. Additionally, competition between larger private enterprises and smaller social economy players for products on platforms like Vinted and Emmaüs in France complicates product reuse. In the industrial realm, the primary focus for companies is often directed towards activities like sourcing raw materials, recycling, and enhancing the durability of components and products to extend the lifespan during the usage phase. However, a shift towards other circular strategies like repair, remanufacture, and reuse is occurring more slowly (Shahbazi and Jönbrink, 2020). This paper delves into the critical importance of integrating R&R practices into industries' business models. Indeed, while the social economy sector widely spreads these practices, industrial sectors still under integrate these issues into their business. Through an industrial research collaborative workshop held at the ICED23 conference and personal expertise, we explore how to frame a systemic transition to R&R as a core activity of the manufactured products value chain. More specifically, through a multi-level perspective, the initial research question can be formulated as: What are the key triggers or expectations to switch to R&R circular models? The second section tackles the background of the reuse and repair of manufactured products, exploring both the legal context and current design practices. The third section outlines the research methodology employed. Section four presents the results, encompassing the value-chain positioning of the three organisations and using a Multi-Level Perspective (MLP) on R&R, projecting onto various scenarios of circular futures. Finally, section five offers conclusions drawn from the research findings and outlines directions for future work.

2. Background - Reuse and repair of manufactured products

2.1. A new legal context the European Union

2.1.1. Right to repair

The European Union's approach to the circular economy primarily priorities technical and economic factors, often overlooking cultural and lifestyle shifts. The EU essentially perceives the circular economy as a path to ”green growth” and decoupling economic growth from environmental degradation is frequently mentioned as a goal with a strong emphasis on resource efficiency and technological advancements, particularly in the realm of waste recycling (Friant et al., 2021).

The European Commission's Circular Economy Action Plan and the future European 'Right to Repair' initiative, as outlined in the "Proposal for Directive on Common Rules promoting the Repair of Goods", presents a new approach to advancing repair strategies (European Parliament, 2023). The term "right-to-repair" encompasses the idea of granting consumers the freedom to repair their products, emphasising that better product quality not only extends product lifespan but also encourages consumers to opt for repair, underscoring the relationship between quality and sustainability (Tecchio et al., 2019). Both community repair associations and environmental non-governmental organisations support it. This future directive represents a key action for end users, business users, and consumers who seek to extend the lifespan of their products and reduce premature obsolescence (Barros and Dimla, 2023) through three primary objectives: establishing design standards that focus on disassembly, repairability, and reliability; ensuring access to spare parts and third-party repair services; providing consumers with information about a product's repairability before purchase. Several key measures are proposed to ensure the implementation of the policy. The 'right to repair' have different implications on the design according to the type of goods’ industry (Saidani et al. 2023) which we discuss later.

2.1.2. Repair incentive

The "Repair Index" was introduced as part of French "anti-waste law for a circular economy" in 2020. It represents a pivotal development in consumer rights and product sustainability. Officially enacted in January 2021, this initiative initially focused on five product categories: smartphones, laptops, washing machines, TVs, and lawnmowers. A first objective of this index is to empower consumers with information

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on a product's repairability at the point of purchase. Secondly, it exerts pressure on manufacturers to market products that are easier to repair, thereby contributing to a reduction in electronic and electrical waste. It consists of five main criteria: (1) the availability of documentation, (2) the disassembly, access, and tools, (3) the availability of spare parts, (4) the price of spare parts, and (5) a last criterion specific to each product category. After one year of deployment of the "Repair Index", the French environmental agency evokes global positive feedback (Bonjean, 2022). This report highlights the influence of the index on consumer choice with an increase in the use of repair services in recent years. In terms of industrial practices, implementing the index also seems to encourage eco-design (even if partially) and seems to increase the accessibility of repair manuals. One of the critical challenges is the data transfer between manufacturers and retailers, which led to tensions due to temporal constraints. The French NGO HOP questions the tool's sensitivity by showing that most displayed grades fall within a satisfactory range. Therefore, HOP suggests reconsidering the scoring system by examining the weighting of different criteria (HOP, 2020). In a study with repair communities, Cavillot (2023) also underlines that other criteria are required to better evaluate the repairability, such as the availability of repair guides, modularity, standardisation, or the lifetime criterion. More globally, not all product categories are currently covered, indicating the need for expansion to encompass a wider array of consumer goods. Further, there is a lack of differentiation within product categories, which can hinder the consumers' ability to make informed choices. Some product models with lower repairability grades remain on the margins of the initiative, prompting questions about the methodology used for calculation. Conversely, products with already high repairability grades, such as washing machines and lawnmowers, have not spurred additional efforts by manufacturers, raising issues about the need for continued incentivisation.

In parallel with the repair index, as stipulated by the "anti-waste law for a circular economy", the "repair fund" was implemented at the end of 2022. In practical terms, consumers can visit certified repair centres to benefit from a guaranteed repair and a fixed repair cost reduction, clearly specified on the invoice. This bonus aims to streamline the repair process and make it accessible to all French citizens, thus extending the lifespan of products.

2.2. Current R&R industrial and design practices

Tyl et Allais (2021) identified a dominant top-down approach to facilitating reuse and repair in the design process in the scientific literature. It delves into strategies for enhancing end-of-life stages, such as disassembly, upgradability, and modularity (Pialot et al., 2012; Cooper, 2013), shaped on large-scale business models and technical solutions (Bridgens et al., 2018). D'Urzo and Campagnaro (2023) introduced the Design-led Repair & Reuse framework to focus on small and medium-sized organisations which engage in transformative and low-technology activities such as R&R, benefiting local development and creating job opportunities. Cooper and Gutowski (2017) identified types of reuses and a framework for evaluating design for reuse options: "design for simple repair" (including durability and easy access to worn components), "design for sub-assembly upgrade" (including modularity and easy disassembly) or "design for component reuse" (including easy to disassemble and standardised components and joints). More recently, the CIRCit project identified and mapped different strategies in a “circular strategies scanner” (Shahbazi and Jönbrink, 2020): For instance, "design for repair and maintenance" and "design for reuse". While sharing common design principles, these exhibit subtle differences in core concepts and practical implementation. "Design for reuse" needs all components to ensure uniform durability; in contrast, "design for repair" does not necessitate identical component lifespans, as its primary focus is on the ability to remove and replace faulty parts. Unfortunately, repair in the social and solidarity economy (Repair cafés for instance) is facing specific barriers which are still not taken over by industry (Masclet et al., 2023). In the realm of business models, embracing circular economy practices a harmonisation between market dynamics, legal frameworks, and product characteristics that facilitate the extension of product lifespans (Bakker et al., 2014). Repair is often hailed as a critical element in the circular economy, as it extends the lifespan of products and fosters a closed-loop system (Terzioglu, 2017).

3. Research method

The initial empirical basis for the paper was the industrial workshop on sustainable innovation proposed and organised by the three first authors for the ICED23 conference (July 2023 in Bordeaux, France),

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titled "How to make reuse and repair a core industrial process?". The scientific objective of the workshop was to investigate how to support designers and companies in effectively integrating reuse and repair practices into their industrial processes. For the selection of industrial case studies, the objective was to enroll three different types of French organisations connected to the repair and reuse of manufactured products. Various company statuses and sizes were expected to reflect the R&R landscape. Crossed with availability constraints, representatives of one private company, one Product Responsibility organisation (PRO), and one social economy association accepted to give their testimony and co-animate the workshop (Table 1). Three groups of participants (from academia and industry, N=15) who attended the ICED23 conference volunteered to join the 2.5-hour workshop. After a presentation of each case study, three questions were framed by the industrial speakers as follows.

- For the pump manufacturer: *How to handle the pumps' end-of-life*?
- For the PRO: *How can we overcome the barriers in practice and enable the transition towards more durable EEE products?*
- For the social economy association: *How to deal with the strong technical and economic constraints inherent to the reuse and repair of digital equipment?*

Documents included personal notes from the facilitators, paperboard notes, and presentations made by the industrial speakers. Post-workshop reflections led by the authors of this paper were organised around the following research questions: *How to frame a transition to reuse and repair as a core activity of the manufactured products value chain*? The follow-up analysis is based on two stages:
(1) An in-depth **analysis of three industrial case studies using the multi-level perspective** (MLP) framework (Geels, 2011). The MLP framework has been praised (but also criticised) for a fruitful analysis of socio-technical transitions to sustainability since the 2000s. It was recently applied to define transition pathways for recycling systems (Salmenperä, 2021; Heiges and O'Neill, 2022). Our choice of the MLP is related to its ability to capture transition involving multiple actors, embodied in the framework under Niche, Socio-technical Regime and Socio-technical Landscape (Geels, 2011). The main interest for our case is as follows: beyond a reflection on a single technology in focus, it is about interactions between technology, policy, business, and culture, which is absolutely in line with the review on R&R activities.
(2) As a result, based on the outcomes of the discussions in groups with the participants, a proposition of **four distinct R&R scenarios** addressing the challenges of reuse and repair based on the circular futures framework (Bauwens et al., 2020). In this part, we do not intend to generate a single vision but different alternatives for R&R, because we hypothesise multiple directions can be taken towards sustainability, notably depending on the type of governance. For this purpose, we rely on scenario planning tools and techniques, precisely the 2*2 matrix approach, for its understandability among designers. Bauwens et al. (2020) delivered an interesting narrative for four generic scenarios for a circular economy, which we can easily adapt and customise to R&R, generalising the roles of PRO, private companies, and social economy companies. Two critical uncertainties (governance and level of high or low-technology innovation) shape the four scenarios called Planned circularity, Bottom-up sufficiency, Circular modernism, and Peer-to-peer circularity.

Table 1. Industrial stakeholders at the ICED23 workshop

Organisation name	**Public/Private Profit/Non-profit**	**Area of activity**	**Target products-Scope**
Dosatron	Private - Profit	Manufacturing and selling industrial dosing solutions	Water-driven dosing pumps
ecosystem	Private - Non-profit	Product Responsibility organisation	Consumer goods - Electric and Electronic Equipment
Emmaüs Connect	Association - Non-profit	Combat digital exclusion and give inclusive access to digital practices	Digital devices (smartphones, laptop computers)

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4. Results

4.1. Value-chain positioning of the three organisations

The three organisations are first represented from a value chain perspective. An interesting vision of such a value chain is proposed by (Orée, 2015). On a traditional lifecycle of a product, seven pillars of circular economy are represented: sustainable supply, sustainable logistics, ecodesign, industrial and territorial ecology, responsible consumption, reuse/reemployment/repair, and recycling.

Dosatron is a company producing fully mechanical water-driven dosing pumps. It has engaged significant efforts since 2012 to make its products: (1) Less footprinting: Life Cycle Assessment calculations included in the design of products through three impact categories: climate change, water consumption, and fossil resources depletion; (2) More repairable: development of a repair index consisting of four criteria: a disassembly index based on a functional approach (identification of vital functions that might wear during use) and including the time to replace and the weight of the concerned components; the documentation of all "wear" functions; their after-sales availability; and finally the price (the price of the most expensive function <XX% of the pump price); (3) More recyclable: almost every material used is recyclable; mixed-materials sub-assemblies are demountable; systematic material labelling. Dosatron performed these actions voluntarily as its activity is a niche market with no specific regulation. However, despite this long-term work, this SME selling product worldwide (95% of products are sold outside of France) faces numerous issues that limit the impact of its actions. In particular, the limited access to end-users reduces the effective repair or recycling of products. Also, these water-driven dosing pumps may be used in contact with chemicals that may require specific and destructive disposal of the product. Moreover, products are small and thus involve low plastic volume, making them harder to collect. Finally, the company aims to develop a global repair and recycling branch to promote circular practices, which is quite challenging for an SME. For these reasons, Dosatron is mainly positioned on the ecodesign pillar in Figure 1.

Emmaüs Connect is a social economy association created in 2013 and part of the international Emmaüs movement developed in the 1950s in France by Abbé Pierre to fight exclusion, poverty, and poor housing. Emmaüs Connect aims to combat digital exclusion and give inclusive access to digital practices. One particular action is to promote access to digital devices like smartphones, tablets, and laptops through repair and reuse. A whole value chain called LaCollecte.tech was created by Emmaüs Connect to (1) collect used devices donated by companies (33k devices collected in 2020), (2) repair re-usable devices (58% of the collected devices) through a partnership with more than 20 social reintegration organisations, and (3) sell refurbished equipment to precarious people at low prices (10k devices sold in 2020). Challenges faced by Emmaüs Connect are multiple. The first one concerns reusing devices: high variation in the quality of collected devices; difficulties in dismantling equipment; compatibility between components; access to spare parts (mainly on the Asian market); profitability of repairing (if the time needed to repair one device exceed one hour, it is not profitable). The second category concerns reusing spare parts: non-processed practices (primarily based on some people's know-how); difficulty in testing every spare part; digital second-hand spare parts are not valuable enough to ensure a solid and profitable supply chain; difficulty in creating and maintaining reliable databases. Moreover, one recent significant issue is the competition with private businesses developing second-hand markets (for example, Back Market company) and limiting access to the available reservoir of used devices. For all these reasons, Emmaüs Connect is mainly positioned on the reuse/reemployment/repair pillar in Figure 1.

Ecosystem is a Producer Responsibility Organisation (PRO), French eco-organism that deals with Waste of Electrical and Electronic Equipment (WEEE). According to European and French laws, it is a private non-profit company approved by public authorities and financed by more than 4,000 producers of EEE with a mission of general interest. Its objectives are to organise the collection, depollution, and recycling of household and professional WEEE, lamps, tubes, and small fire extinguishers and extend these equipment's lifetime through reuse and repair. In 2020, ecosystem collected and treated more than 600,000 tons of household WEEE. One recent mission of ecosystem assigned by the French government was to create the "repair fund", i.e. an incentive system to promote out-of-warranty repair of EEE, with a 410 million € envelope for six years. This system was launched in December 2022, and it includes communication to the public and labelling of professional repair actors that are allowed to apply a repair fund

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(public subsidy from 15 to 60€ per device, depending on the equipment family) to their clients. The feedback shows that more than 43,000 refund demands have been submitted after six months and that the most repaired devices are washing machines, dishwashers, and cell phones. Regarding the reuse of EEE, ecosystem works with multiple partners (social economy organisations, retailers, municipalities) to sort devices. Re-usable devices are sent to social economy associations like Emmaüs Connect, but they only concern 1.5% of the collected WEEE. For these reasons, ecosystem is mainly positioned on the recycling pillar and is growing on the reuse/reemployment/repair pillar in Figure 1.

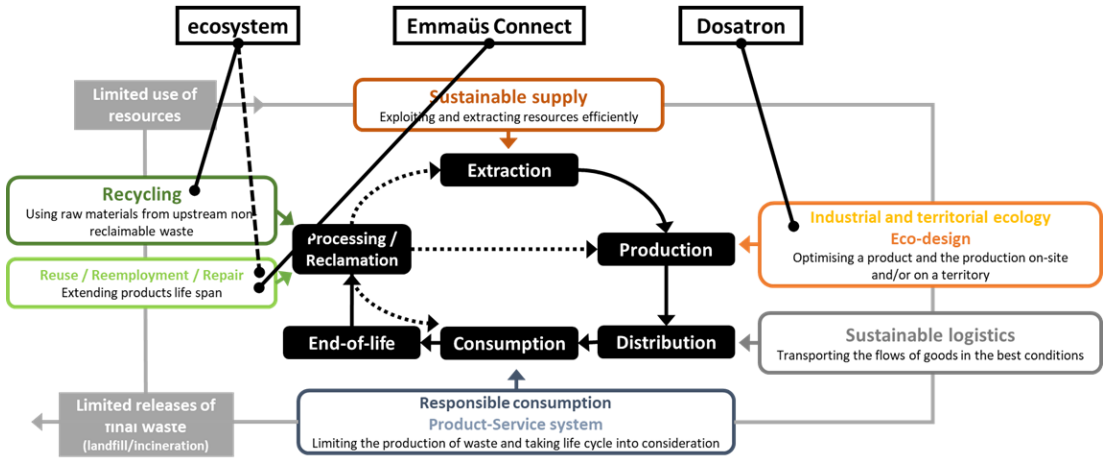

Figure 1. Positioning of the three organisations on a circular value-chain

4.2. A Multi-Level Perspective (MLP) on reuse and repair

In a broader systemic perspective, the three organisations described in the previous section illustrate three different types of stakeholders and positioning of R&R activities on the value chain of manufactured products, i.e. products issued from industrial processes. This section considers this full life cycle of manufactured products, notably including design, manufacturing, and end-of-life activities, as a socio-technical system involving multiple stakeholders: public authorities, Producer Responsibility Organisations (PROs), producers, NGOs and social economy organisations, consumers… Based on Geels' (2011) definition, the initiated progressive adoption of R&R activities by all the actors of this socio-technical system is a socio-technical transition as it involves alterations in the overall configuration of the system, entailing technology, policy, markets, consumer practices, infrastructure, cultural meaning, scientific knowledge. In that sense, the Multi-Level Perspective framework (Geels 2011) illustrates this ongoing transition and clarifies the stakes that will allow us to reflect on possible R&R futures in the next section. From an R&R perspective, the current state of this socio-technical system is represented in Figure 2.

PROs (like ecosystem) are both landscape and regime actors as they share close links with both public authorities and producers; they also partner with social economy actors to promote reuse.

Most producers (product design & manufacturing companies) are global regime actors with no particular interest or initiatives in R&R activities (business as usual).

However, some producers are niche actors who developed ambitious and voluntary initiatives in R&R activities. For instance, Dosatron's business model is fully compatible with the current socio-technical regime but sets a transition experiment (Van Den Bosch, 2010) as it is a small-scale initiative with "a high potential to contribute to transitions; innovation projects with a societal challenge as a starting point for learning aimed at contributing to a transition". Another example is the one of SEB[1], an international house appliances manufacturer, pioneer in repairability. Focusing on price and availability of spare parts, the company operates a wide network of approved repair centres, relying on professional technicians and keeping hands on the spare parts manufacturing for the sake of safety and quality.

[1] https://www.groupeseb.com/en/reparability

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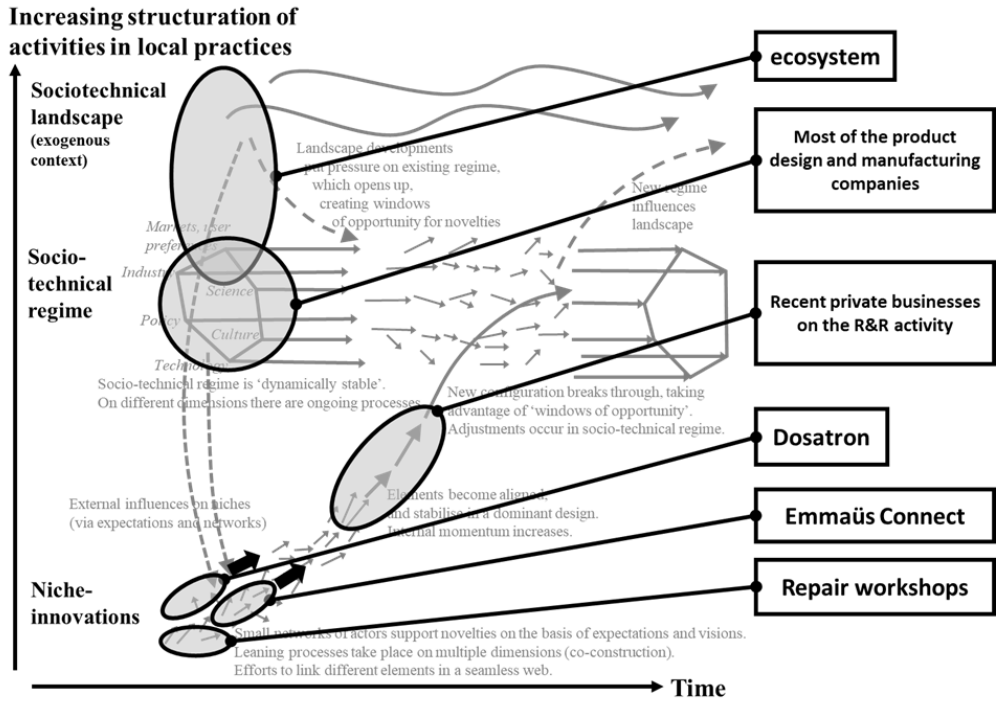

Figure 2. MLP framework with R&R actors based on Geels (2011)

Social economy organisations working on R&R activities are niche actors. Due to their size, they have no opportunities to reach the internal momentum to initiate the global transition and modify the socio-technical regime in place; they mainly act at a lower, more local level by raising awareness and performing craft or semi-industrial R&R activities (like repair workshops). They are primarily involved in the reuse sector and rarely in repair activities. Some are gathered in networks (RREUSE in Europe, "Réseau des ressourceries" in France). Some of these actors are, however, bigger and act actively to be involved in the initiated transition (like Emmaüs Connect), notably to preserve their reservoir of used products and influence landscape and regime evolutions (through public advocacy, for example, or competing solutions like Label Emmaüs, an online platform to sell refurbished products).

Private businesses dedicated to R&R activities have emerged in the last decade (for example, Back Market, Murphy, Vinted…). They are profit companies that may threaten social economy organisations, but they are also visible to the public and have an active role in the transition.The transition has been initiated by multiple factors such as landscape developments (European Union, French government) through new regulations and initiatives (repair index, repair fund, right to repair…), a progressive awareness of the public and the companies about R&R issues by public authorities, PROs and NGOs (like Zero Waste, Right to Repair Europe, HOP…), and the emergence of these new private businesses dedicated to R&R.

After the transition, the updated socio-technical system (manufactured products value chain with massive adoption of R&R activities) is still uncertain and will depend on multiple factors. For example, niche actors may evolve or not towards regime actors, or current regime actors may monitor their transition by developing internal activities or by collaborating with dedicated R&R actors like private businesses of social economy organisations. An approach based on circular futures is proposed in the next section to structure the reflection on the possible scenarios.

4.3. Projecting four scenarios of reuse and repair futures

This section is elaborated based on the four circular scenarios produced by Bauwens et al. (2020), the literature review and items collected during the collective reflection from the ICED23 workshop. The four scenarios are customised and developed from an R&R perspective to draw possible futures for R&R activities, emphasising the roles of the different stakeholders. Each scenario can be seen as a

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different landing field for the MLP initial situation developed in section 4.2. Five criteria are considered for detailing scenarios: technology, organisation, data management, policies, business mode, and user relationship. The four reference scenarios are built around two orthogonal axes: governance (centralised/decentralised) and technology (low-tech innovation/high-tech innovation). Governance still makes sense regarding R&R activities, but it is worth noting that centralised governance may be interpreted as led by national public authorities or large companies. On the other hand, local initiatives and actors including social economy organisations and citizens organise a decentralised governance. Regarding technology, low-tech and high-tech innovations are reinterpreted here as the capacity for end-users or R&R professional actors to perform repair activities based on generic tools and processes or not, as well as more or less inclusion of digital tools for performing the repair activities.

The first scenario, termed "**Planned R&R**" (adapted from Bauwens' "Planned circularity" scenario), envisions a robust regulatory framework imposed by public entities to promote reuse and repair (through Producer Responsibility organisations like ecosystem, for instance). The focus is on orchestrating a planned and legally regulated approach to circularity, where strong governmental regulations drive businesses toward practices that prioritise R&R. This scenario involves developing incentives for businesses and market stakeholders to actively engage in R&R. Central to this vision is the establishment of a centralised organisation structured around repair funds, like current developments in France and largely dominated by conventional economy actors. The repair process is technologically supported, and the responsibility shifts from end-users to specialised actors and businesses. It represents a departure from the traditional linear economy model, signalling a strategic shift towards a more circular and sustainable economic paradigm.

In the second scenario, termed "**Bottom-up R&R**" (adapted from Bauwens' "Bottom-up sufficiency" scenario), the focus shifts towards empowering local initiatives and actors in the social economy (like Emmaüs Connect, for instance), such as R&R workshops, repair cafés, as pivotal contributors to fostering R&R. Informed citizens and consumers play a substantial role by actively engaging with localised structures. The informal network is especially important in the household appliances and digital devices sectors. In repair cafés, citizens develop retro-engineering and strategies to repair all devices. This scenario encourages the donation or purchase of reused products, creating a strong link between individuals and grass-roots organisations. Small and light infrastructures dominate, developing their policies and avoiding unnecessary technologies. The scenario promotes small-scale repairs tailored to the specific needs of these local initiatives. The business model is centred on reuse, promoting a sustainable circular economy, and prioritising the local community. The economic scale is intentionally kept local, sometimes even favouring exchange or local currency, and promotes a more community-oriented consumption and production model. Citizens, both initiators and active participants, become integral parts of the success of this scenario, forming a collaborative network that supports and sustains the concept of sufficiency.

In the third scenario, termed "**Industry-led R&R**" (adapted from Bauwens' "Circular modernism" scenario), the model closely aligns with current production and consumption patterns. This scenario places the responsibility for R&R squarely on proactive businesses (such as SEB, Dosatron) that seek to pivot a portion of their model towards these emerging activities. These enterprises not only establish their standards but also retain the expertise and repair skills internally (working with labelled repairers), keeping control over most of the product life cycle. Companies take a hands-on approach to integrating circular practices into their core operations. They actively organise and participate in the R&R ecosystem, creating a self-sustaining cycle that extends the life of their products. This approach not only fosters a culture of responsibility within the business sphere but also contributes to a paradigm shift where circularity is seamlessly integrated into mainstream production and consumption practices. The focus is on internalising repair capabilities, aligning them with corporate standards, and developing a more sustainable and circular business model.

The fourth scenario, termed "**Peer-to-peer R&R**" (adapted from Bauwens' "Peer-to-peer circularity" scenario), revolves around digital technology, collaborative economy, and do-it-yourself (DIY) approaches. The emphasis is on leveraging digital platforms and collaborative tools to create a decentralised network of actors involved in R&R. Both traditional profit businesses and those from the social economy contribute to this network, forming a web of interconnected initiatives. The economic model is built upon sharing information – through open design and appropriate licensing -, resources, skills, and experience,

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fostering a collaborative ecosystem beyond traditional economic boundaries. The connection between producers, actors in R&R, and end-users is facilitated. Autonomy is achieved by the capability of producing tools and spare parts thanks to digital means. Technology plays a pivotal role in the dynamics of this scenario, aligning with the paradigm of "Distributed Economy" – a model that intertwines locally networked initiatives. The four scenarios stand as prototypic and archetypal futures, but we will probably witness the rise of several mixes that intertwine the multiple dimensions of each scenario.

5. Conclusions and future work

The paper's research question was the following: how to frame a systemic transition to reuse and repair as a core activity of the manufactured products value chain? Starting from an industrial workshop gathering scholars and speakers involved in R&R (associations, companies, and Product Responsibility Organisations), this paper discusses potential trajectories to integrate R&R as crucial production and consumption systems activities. To do so, the Multi-Level Perspective and the circular futures framework were considered and adapted. Four scenarios emerged, looking at the governance and the technology in the production and consumption systems. The scenarios also encapsulate the authors' experiences (such as the RECYLUSE project on repair workshops (Tyl and Allais, 2021)).

Among the four scenarios, "Planned R&R" advocates for a robust regulatory framework imposed by public entities, while "Bottom-up R&R" focuses on empowering local initiatives and actors in the social economy. "Industry-led R&R" closely aligns with current production and consumption patterns, placing responsibility on proactive businesses. Lastly, "Peer-to-peer R&R" fosters digital technology, collaborative economy, and DIY approaches, emphasising the creation of a decentralised network of R&R actors through digital platforms and tools. This work attempts to imagine the future of R&R and must be seen as a proxy to support discussion among researchers, public and private actors. It underlines that repair-oriented approaches challenge the traditional industrial ecosystem, and reshape the dynamics of production and consumption. It calls for designers to engage closely with new stakeholders, both from the private and public sector, in a more territorial approach, complementing sectoral results on repair, see for instance (Saidani et al., 2023).

Some limits of the study serve as future perspectives. First, the scenarios need to be further consolidated and illustrated. Subsequent work will cross-reference the scenarios with larger national projections, e.g. those of ADEME 2050 (Thiriot, 2022), to identify other trends and perspectives. Secondly, another focus group must be planned with participants representing the R&R sector (for example, repair workshops or networks, companies, public actors, and local waste management offices...) to confront the scenarios with their expertise and analyse their weaknesses and opportunities.

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