CIRCULÉIRE

REMANUFACTURING INSIGHTS REPORT

CIRCULÉIRE (2024) Thematic Working Group Insights Report

IRISH MANUFACTURING RESEARCH

Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

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Graphic design: Paul McCormack-Cooney, CE Best Practice & Toolkits Lead, IMR.Suggested citation: *Irish Manufacturing Research (2024) CIRCULÉIRE Thematic Working Group Insights Report – Remanufacturing, Ireland*.

Acknowledgements

Irish Manufacturing Research would like to thank the following people without which neither the 2024 TWG, nor this Insights Report would have been possible:

IMR Delivery Team: Agnese Metitieri, Valentina Rangel Leon, Eluise Vaz, Dr Geraldine Brennan.

CIRCULÉIRE Cross-Sectoral Industry Members: see 2024 TWG Participant List

Expert Speakers: Professor Winifred Ijomah, Scottish Institute for Remanufacturing, University of Strathclyde; Dr. David Peck, TU Delft; Dr. Damian Coughlan, University of Limerick; David Fitzsimons, European Remanufacturing Council; Sandra Gleeson, Environmental Protection Agency.

Public Sector Representatives: Alan Kelly (Department of Enterprise, Trade and Employment); Brian Quirke (Department of the Environment, Climate and Communications); Daniel Gannon (Department of Enterprise, Trade and Employment); Sandra Gleeson (Environmental Protection Agency); Siobhan Egan (Environmental Protection Agency)

About CIRCULÉIRE

CIRCULÉIRE, is Ireland's first industry-led national cross-sectoral innovation network dedicated to accelerating Ireland's transition towards a net-zero carbon circular economy. A key objective of the programme is to demystify, de-risk and deliver circular business model innovation.

Want to learn more about CIRCULÉIRE?

Visit our website at www.circuleire.ie or contact circuleire@imr.ie.

Contents

Acronyms

ANSI – American National Standards Institute

B2B – Business to Business

B2C – Business to Consumer

CER/ERC - Conseil Européen de Remanufacture

CRM – Critical Raw Material

DECC - Depa

DPP – Digital Product Passport

ELV - End-of-Life Vehicles

EPA – Environmental Protection Agency

ERN – European Remanufacturing Network

ESPR – Ecodesign for Sustainable Product Regulation

EU – European Union

FDA - Food and Drug Administration

GHG – Green House Gas

GPP – Green Public Procurement

ICT - Information and communication technology

IMR – Irish Manufacturing Research

ISO – International Organization for Standardization

OEM – Original Equipment Manufacturer

PAAS – Product as a Service

TWG – Thematic Working Group

VRP – Value Retention Processes

In support of the Remanufacturing TWG

Winifred Ijomah

Director at Scottish Institute of Remanufacturing, Professor at University of Strathclyde

"Remanufacturing is a triple win formula that is critical for industrial sustainability and our survival on our planet but is underutilised due to a lack of awareness, understanding, and specific tools and techniques.

Activities such as that by Thematic Working Group on Remanufacturing are necessary to increase understanding of the remanufacturing concept and its benefits, which in turn will drive innovations in the discipline."

Dr. David Peck,

Associate Professor at TU Delft

"Irelands Remanufacturing stars are aligning as more and more stakeholders in Ireland and across Europe come together to drive a circular future. In my roadshows and trips around Ireland I have observed for myself that Ireland has the creativity, talent, and entrepreneurial drive to become a leading European remanufacturing hotspot.

I see Ireland seizing the opportunities that circular remanufacturing presents. I have witnessed first-hand a range of companies, knowledge providers and other stakeholders come together across the whole island to drive remanufacturing forwards. This can help deliver not only net zero and materials targets for Ireland and Europe, but also create valuable new jobs and companies.

The great thing is, in 'Remanufacturing Ireland' we do not need to build whole new sectors, we can expand and build upon what is already there. The people, the locations, the products, the materials, the factories, the research and innovation, the passion for a sustainable, circular, net zero, low waste society. Ireland has consistently shown how it can move fast, realise new thinking and help drive Europe sustainably forwards."

Dr. Damian Coughlan

Research Fellow (Remanufacturing for Ireland) at University of Limerick

“Remanufacturing offers companies a Circular Economy strategy with significant economic and environmental benefits. The Thematic Working Group was instrumental in helping participants understand and examine remanufacturing opportunities within their businesses and to explore these opportunities and innovations.”

David Fitzsimons,

Director at European Remanufacturing Council

“The life cycle of products is largely determined by their design. Designing for disassembly allows them to return to use again - better than new. IMR has not only recognized that remanufacturing is going to be key to making sustainable products for a circular economy, IMR is building the networks in Ireland to make it happen. I am delighted to contribute to this work.”

Dr. Gerladine Brennan
Head of Circular Economy at Irish Manufacturing Research (IMR)

"Remanufacturing is a key industrial circular economy business model, which enables the life-extension of components and products by design. While the recognition of remanufacturing in the ESPR regulation is welcomed, its current definition is problematic. It includes a reference to waste as a potential feedstock for remanufacturing, which risks creating the misconception that remanufacturing operates at the material level.

Remanufacturing is a circularity practice which is applicable to product and component levels. It involves the design of products/components for assembly, disassembly and reassembly - to enable life extension whilst guaranteeing performance like new. Remanufacturing is therefore distinct from recycling and other material-level circular economy practices governed by waste regulations. As a Waste Prevention activity, remanufacturing requires a clear regulatory definition that avoids any reference to waste in order to reduce barriers to industrial adoption."

Executive Summary

Remanufacturing is revolutionizing industrial approaches to sustainability and resilience. By restoring **used components and products to like-new condition**, industries can significantly cut down on raw material and energy consumption, leading to lower production costs and reduced environmental impact (Smith, 2023).

In the face of growing pressure to adopt more sustainable practices, remanufacturing is an example of a commercially viable and scalable circular business model that:

- from an **environmental perspective** → ensures material recovery, energy efficiency, reduction of waste, of Virgin Resource Extraction and reduction in greenhouse gas emissions (GHG)

- from an **economic perspective** → enhances supply chain stability, ensures cost savings, competitiveness and profitability, while mitigating risks associated with resource shortages and market fluctuations (Brown, 2021).

Additionally, remanufacturing fosters innovation as pioneers of remanufacturing have developed advanced techniques for efficient remanufacturing (Taylor, 2020), leveraging skills development and promoting job creation.

Remanufacturing can reduce resource extraction and waste disposal by up to 80 per cent compared to the manufacture of a new product and avoid GHG emissions associated with extraction and processing of virgin resources into new products. The savings in carbon dioxide (CO_2) emissions, described in lifecycle analyses (LCAs), range from anywhere between 23 to 87 per cent depending on the product (European Remanufacturing Council, 2024). More specifically, remanufacturing industrial equipment can **reduce the use of raw materials by 80-98%**, making it a highly resource-efficient alternative to producing new equipment (IRP, 2018). Moreover, according to the Automotive Parts Rebuilders Association remanufacturing offsets around 400 trillion British Thermal Units (BTUs) of energy annually (Mccracken High-Voltage, et al., 2016), which is equivalent to powering 6 million cars for a year. Generally, the production cost of a remanufactured product is 40-65 % less than the production cost of a new product (Nasr, 2020).

According to national and international experts engaged in CIRCULÉIRE's 2024 Remanufacturing Thematic Working Group (TWG), the key industrial sectors (Arnout de Pee, 2018) ripe for the scale-up of remanufacturing practices both in Ireland and globally include **renewables, e-mobility, energy-intensive industries, Information and**

communication technology (ICT), Aerospace & Defence, health/med tech, and the built environment.

There is an ongoing debate regarding the definition of remanufacturing particularly in the context of value retention practices. Remanufacturing is often used interchangeably with a multitude of circular practices for example **repurposing, refurbishing, reprocessing, restoration, renovation, remaking, upgrading, rebuilding, and reconditioning.** These practices are aligned in so far as they contribute to keeping components and products in use in the economy – but they differ in terms of the processes and activities they entail.

From a policy perspective, remanufacturing is increasingly recognized globally and in Europe as a key enabler of sustainability and circular economy (CE) goals. At the European level, initiatives such as the ESPR, Right to Repair, and Critical Raw Materials Act are fostering a favourable environment for its growth. There is however, significant debate regarding where remanufacturing fits within the **EU Waste Hierarchy**. Given **ESPR** currently includes a reference to **waste as a possible feedstock for remanufacturing** if remanufacturing's primary focus is to extend the life of components and products before they become waste, **referencing waste creates confusion for industry** as to whether remanufacturing activities fall under the scope of waste regulations and licensing. Alternatively, removing any reference to waste and classifying remanufacturing as a **Waste Prevention** activity (like reuse), would exempt it from waste regulations, reducing barriers to the scale-up of remanufacturing business models. Remanufacturing is also gaining prominence as part of Ireland's interdependent climate-action and circular economy agenda. The Whole of Government Circular Economy Strategy 2022-2023 highlights remanufacturing as a high-value circular economy practice, which delivers both environmental and economic benefits. The **Green Public Procurement (GPP) Strategy and Action Plan 2024-2027** sets ambitious remanufacturing targets, including requiring 80% of public sector ICT procurements to be remanufactured by 2025, enabled by a first of its' kind public procurement framework for remanufactured laptops valued at circa €30 million (DPER, 2024). Other initiatives, such as the **EPA's National Repair and Reuse Partnership Network** established in 2024 offer's a platform to spotlight remanufacturing practices alongside repair and as-is reuse and EPA funded research projects like **Remanufacturing for Ireland** aim to explore the barriers and enablers for scaling-up remanufacturing.

Countries and regions are advancing remanufacturing as a critical component of their circular economy transitions. However, scaling up remanufacturing on the island of **Ireland** will require addressing regulatory barriers, standardizing definitions, and fostering collaboration to unlocking remanufacturing's full transformation potential as an industry-oriented and commercially scalable circular business model.

CIRCULÉIRE TWG 2024 Participants

Irish Manufacturing Research (IMR) would like to thank the following CIRCULÉIRE Members, public sector stakeholders and keynote speakers for contributing their valuable time and sharing insights through their engagement with the 2024 Thematic Working Group series which included a Masterclass, a Spotlight Sectoral Session, an Ideation Workshop and a CIRCULÉIRE Members Policy Roundtable.

Table 1: CIRCULÉIRE Industry Members

ORGANISATIONS		
DeltaQ	Boston Scientific	Farrell Furniture
Masonite	Huhtamaki Cup Print Ltd	Arcology
KnowCarbon	CirTex Ltd	Design & Craft Council of Ireland
Wisetek	Tympany Medical	Well Spent Grain
I am not a Virgin	Second Life Battery Services	Zerobin Group Ltd
WEEE Ireland	Avoca Seafood	Offerre
Votechnik	iQutech	Aughinish Alumina
Freefoam	IFF Plastics	Coca-Cola
Niskus Biotec	J&J Visioncare	
ERP Ireland	Amazon	

Table 2: Public Sector Representatives

NAME	ORGANISATION
Alan Kelly	Department of Enterprise, Trade and Employment
Brian Quirke	Department of the Environment, Climate and Communications
Daniel Gannon	Department of Enterprise, Trade and Employment
Sandra Gleeson	Environmental Protection Agency
Siobhan Egan	Environmental Protection Agency

Table 3: Keynote speakers

NAME	ORGANISATION
Winifred Ijomah	Scottish Institute for Remanufacturing, University of Strathclyde
David Peck	TU Delft
Damian Coughlan	University of Limerick
David Fitzsimons	European Remanufacturing Council
Sandra Gleeson	Environmental Protection Agency

Purpose of this report

The purpose of this document is to capture insights from the Thematic Working Group that CIRCULÉIRE has organised in the first half of 2024. The theme for this conversation was "Remanufacturing" and the Recirculation Strategies," and it focused on innovative approaches to extend the lifecycle of products and materials through the Recirculation Strategies. This comprehensive exploration included:

- a **Masterclass (Session 1)**, that provided foundational knowledge on Remanufacturing, featuring a keynote address by Professor Winifred Ijomah, from Scottish Institute for Remanufacturing. This introductory seminar delved into the concept of Remanufacturing, providing definitions, highlighting the benefits, and distinguishing it from other R-strategies such as Recycle, Reuse, Refurbish, Repair, Refurbishing, and Reprocessing

- a **Spotlight Sectoral Session (Session 2)**, that highlighted industry-specific opportunities and potential challenges, featuring keynotes from Dr David Peck, TU Delft, and Dr Damian Coughlan, University of Limerick. The session offered insights and impact data from best practices and organisations that are frontrunners in Remanufacturing at Irish and European level.

- an **Ideation Workshop (Session 3)**, that fostered creative thinking and collaborative problem-solving around life-extending processes. Session 3 was hosted by CIRCULÉIRE Member iQuTech, that offered the participants a tour of their facilities. The participants were guided on a series of exercises and reflections inspired by the Checklist and the Process map developed under the RemanPath project (https://www.remanufacturing.eu/RemanPath)

- a **Policy Roundtable (Session 4)**, that discussed regulatory frameworks and policy recommendations, featuring keynotes from David Fitzsimons, European Remanufacturing Network and Oakdene-Hollins, and from Sandra Gleeson, Environmental Protection Agency. CIRCULÉIRE industry members and representatives from the public sector and international organisation were able to discuss and reflect on the State of Remanufacturing and the regulatory landscape covering the Recirculation Strategies at Irish and European level.

Through these diverse and engaging sessions, participants gained a deeper understanding of remanufacturing processes and recirculation strategies, contributing valuable insights to the ongoing dialogue on circular economy and recirculation practices.

Section 1: What is Remanufacturing

1.1 Definition and Status of Remanufacturing

What is remanufacturing?

Defining “Remanufacturing” presents a unique challenge due to the diverse interpretations and applications of the term across various industries and academic disciplines. While remanufacturing generally refers to the process of restoring used products to a like-new condition, there is not a universally accepted or recognized definition of remanufacturing and the specifics can vary significantly, especially across various sectors, where often different terms can be interpreted as remanufacturing. Less commonly used terms that are sometimes used interchangeably, though not always synonymous, include **repurposing, refurbishing, reprocessing, restoration, renovation, remaking, upgrading, rebuilding, and reconditioning**. This complexity in establishing a single, universally accepted definition has important implications. It affects regulatory standards, industry practices, and the development of sustainable manufacturing policies. Understanding these nuances is crucial for stakeholders aiming to navigate the evolving landscape of remanufacturing

1. DEFINITION OF REMANUFACTURING BY ACADEMIA

The concept of remanufacturing has been defined in various ways by different experts and organizations, each adding a unique perspective to the conversation. Professor Winifred Ijomah, in the opening Masterclass session of the CIRCULÉIRE TWG, described remanufacturing as;

> **“...the process of returning a used product to at least its original performance specifications, with a warranty that matches or exceeds that of a newly manufactured equivalent, "like-new" in terms of functionality and durability.”**

This definition underscores the importance of quality and reliability in remanufactured products, ensuring they are as dependable as new ones (Ijomah 2022; BSI 2009). From the perspective of the customer, a remanufactured product should be regarded as equivalent to a new one.

In 1984, **Robert Lund**'s pioneering research (Lund, 1984) has significantly contributed to the emerging academic interest and development of remanufacturing, laying the groundwork for the modern understanding of remanufacturing (Yang, S.S., Ong, S.K., Nee, A.Y.C. (2014).). He defined Remanufacturing

> **"...the process of restoring a used product to a condition where it meets or exceeds the Original Equipment Manufacturer's (OEM) performance specifications, particularly from the customer's perspective."**

Lund's work was instrumental in highlighting the dual benefits of remanufacturing: its economic viability and its potential for environmental sustainability. Back in 1996, Lund called the remanufacturing industry a hidden giant (Lund, 1996). and he initiated a critical conversation about the practice, emphasizing its role in reducing waste, conserving resources, and providing cost-effective alternatives to new products. His research remains a cornerstone in the field (Ijomah, W. (2024) CIRCULEIRE TWG Session 1, Ireland), influencing both policy and practice in sustainable manufacturing.

2. STANDARDS DEFINITION

Standards are developed primarily to set uniform guidelines and requirements within industries, enabling consistency, interoperability, and quality across products, processes, or services. They are established by standardization bodies (like ISO, CEN, or ANSI) and widely used in sectors like manufacturing, technology, and construction to ensure that products and services meet certain quality and safety benchmarks.

The International Organization for Standardization (ISO) has included a definition of remanufacturing on some of its standards. An example of an ISO standard covering remanufacturing is **14009**, which provides terminology and definitions specifically for incorporating material circulation in design and development.

ISO 14009 2020 - 3.2.29 Remanufacturing

> **"...industrial process (3.3.3) which produces a product (3.2.5) from used products or used parts (3.2.6) where at least one change is made which influences the safety, original performance, purpose or type of the product"**

Note 1 to entry: The product created by the remanufacturing process may be considered a new product when placing on the market."

In terms of national standards, the British Standard Institution 8887-2:2009provides one of the most industrially recognised definitions of remanufacturing (British Standards Institution, 2021) Amongst a range of end-of-life options for products, it defines:

BS 8887–220: 2010 The process of remanufacture (Design for manufacture, assembly, disassembly and end-of-life processing (MADE, 2015)

> **"The process of returning a used product to at least to its original performance with a warranty that is equivalent or better than that of a newly manufactured product."**

BS 8887 emphasizes the importance of designing products with their entire lifecycle in mind, particularly focusing on remanufacturing. Key insights include the necessity for products to be easily disassembled and reassembled, which facilitates the recovery and reuse of components. This standard also highlights the economic and environmental benefits of remanufacturing, such as reducing waste and conserving resources. Industries are encouraged to integrate these principles early in the design process to enhance product longevity and sustainability.

Another definition that appears in the British Standards, BS EN45559 "Methods for providing information relating to material efficiency aspects of energy-related products", has recently defined remanufacturing as an "industrial process which produces a product from used products or used parts where at least one change is made which influences the safety, original performance, purpose or type of the product". The definition is based on the one provided by ISO/DIS 14009 (en) (ISO, 2020).

Additionally, the **Kitemark** is a UK product and service quality trade mark which is owned and operated by the British Standards Institution (BSI Group). The Kitemark™ for remanufactured and reconditioned products certifies the remanufacturing or reconditioning processes carried out by suppliers of remarketed items based on the application of BS 8887 series of standards. This certification focuses on the process employed, rather than the end product itself. Kitemark certification confirms that a product or service's claim has been independently and repeatedly tested by experts, meaning that businesses and customers can have trust and confidence in products and services that are BSI Kitemark certified (BSI, 2022).

Furthermore, the **European Remanufacturing Network (ERN)**, an Oakdene Hollins-led, pan-European project funded under Horizon 2020 to understand the shape of remanufacturing in the EU, has also provides its own definition of remanufacturing. The enduring output of ERN is the **Conseil Européen de Remanufacture** (CER, European Remanufacturing Council). This is a fee-paying consortium of early-adopters manufacturers who want to advance the European remanufacturing agenda including

addressing the key priorities from the ERN project. The ERN definition of Remanufacturing is commonly used by industry in the EU defining this practice as as

> **"...the process of restoring a used product to at least its original performance, accompanied by a warranty that is equivalent to or better than that of a new product"**

The European Council for Remanufacturing is vital for the industry as it influences policy, unifies businesses across sectors, promotes economic growth with a goal to triple the sector's value to €100 billion by 2030 (Remancouncil.eu, 2024), supports sustainability through circular economy practices, and facilitates collaboration and innovation.

3. POLICY AND REGULATORY DEFINITION

Remanufacturing has gained significant traction in recent policy discussions across Europe and globally, reflecting its growing importance in advancing sustainability and circular economy agendas. Despite this, a harmonized legal definition remains elusive. Recent efforts by the European Union to define the concept through legislation, such as the *Ecodesign for Sustainable Products Regulation* (ESPR), have not yet achieved consensus. The ESPR includes a definition of remanufacturing but controversially refers to "*waste*" as a possible feedstock for remanufacturing. This risks placing remanufacturing activities under strict waste regulations, requiring businesses to obtain specialized licenses, which could pose significant challenges.

The European Remanufacturing Council has criticized this approach, advocating for the removal of the term *"waste"* from the definition. At the national level, Ireland's *Whole of Government Circular Economy Strategy 2022-2023* provides a broader definition of remanufacturing giving more flexibility to the activity. Irish Manufacturing Research, acting as the Secretariat of CIRCULÉIRE, supports avoiding the use of "waste" in remanufacturing definitions. Instead, it recommends that policy makers classify remanufacturing as a reuse activity under waste prevention. This approach would help to streamline remanufacturing practices and reduce regulatory barriers for businesses. A detailed discussion of these definitions and the associated waste regulation debate follows.

As mentioned above, from a European level perspective, the recently adopted **Ecodesign for Sustainable Products Regulation** (ESPR), which came into force on July 18, 2024, defines remanufacturing in Article 2(16) of (EU 2024/1781), as:

"Actions through which a new product is produced from objects that are waste, products, or components, and through which at least one change is made that substantially affects the safety, performance, purpose, or type of the product."

The inclusion of remanufacturing in such a major regulation highlights its importance for the circular economy. However, this definition has sparked debate, especially because it includes a reference to *"waste"* as a possible source of feedstock for remanufacturing. To understand the controversy surrounding this, it is essential to examine the EU and national waste regulations and their established waste hierarchy. The EU Waste Framework Directive 2008, transposed into Irish law by the European Union (Waste Directive) Regulations 2011(SI No. 126/2011, amended by SI No. 323 of 2020), outlines that the following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:

Figure 1: Waste Hierarchy from Waste Framework Directive - European Commission

According to Article 6 of Ireland's Waste Regulation 2011 (SI No. 126/2011 as amended) **prevention** is defined as:

"Measures taken **before a substance, material or product has become waste**, that reduce:

a) The quantity of waste, including through the re-use of products or the extension of the life span of products
b) The adverse impacts of the generated waste on the environment and human health; or
c) The content of hazardous substances in materials and products. "

This regulation classify **reuse** as form of waste prevention, defining it as:

> "Any operation by which products or **components that are not waste are used again for the same purpose for which they were conceived".**
> (2011 (SI No. 126/2011 as amended by SI No.323 of 2020).

In contrast, "**preparation for reuse**" refers to:

> "Checking, cleaning or repairing recovery operations by which products or components of products **that have become waste** are prepared so that they can be re-used without any other pre-processing".

The distinction between reuse and preparation for reuse is pivotal: reuse occurs before a product and components become waste, while preparation for reuse applies once a product is categorized as waste. This distinction has significant regulatory implications. Once a product/component has become waste—defined *as "any substance or object which the holder discards or intends or is required to discard"* (SI No. 126/2011 as amended by SI No.323 of 2020). —its handling becomes subject to waste activity regulations and requires specific authorizations, as emphasized by the Environmental Protection Agency (EPA) during CIRCULÉIRE's End-of-Waste and By-Products TWG Seminar, which can be accessed here.

Waste regulations play a crucial role in distinguishing activities based on whether materials are discarded. Currently, operations such as reuse, and the handling of by-products are categorized under waste prevention and are not subject to waste regulations. In contrast, activities such as preparation for reuse, recycling, recovery and disposal deal with waste and need to follow waste regulations.

Remanufacturing has not yet been explicitly defined within waste regulations, leading to ambiguity about its classification. The European Remanufacturing Council has been critical of the ESPR's definition and its reference to the term *"waste"*. In their 2023 position paper, they argue:

> "Neither the proposed definitions nor the amendments provide any additional clarity to existing definitions of these terms published elsewhere. **The proposals include incorrect references to 'waste' as a source of feedstock**. Furthermore, the proposed definitions do not acknowledge distinctions between remanufacture and refurbishment that have been adopted at a sector level."
> (ERC, 2023) link: ESPR_ Definitions_ Reman_ March_2023.pdf)

The ERC emphasized:

> "As a minimum, it would be helpful to remove 'waste' from the definitions. It may be even more helpful to step to a higher level and avoid defining both remanufacturing and refurbishment in the ESPR. Instead, describe them both as Value Retention Processes within the circular economy, i.e." (ERC, 2023)

The ERC also criticized the EU's adoption of definitions derived from the U.S. medical devices sector, warning that "the assumption that medical devices terminology can be laid open other product sectors is likely to cause some confusion in the next decade" (ERC, 2023).

At the national level, remanufacturing remains undefined in Irish Waste Regulations. However, Ireland's Whole-of-Government Circular Economy Strategy 2022-2023, published in December 2021, offers a distinct definition:

> "An industrial process where products are disassembled, cleaned, repaired, and reassembled to 'like-new' standards."

This definition does not include the term "waste," aligning more closely with the ERC's point of view of adopting a broader term for remanufacturing.

The table below highlights the different definitions by academia, the British Standards Institute, the European Commission and the one adopted by the Department of Environment, Climate and Communications (DECC) in the Whole of Government Circular Economy Strategy.

ENTITY	DEFINITION: **Remanufacturing is defined as…**	REFERENCE
Professor Winifred Ijomah	**"the process of returning a used product to at least its original performance specifications, with a warranty that matches or exceeds that of a newly manufactured equivalent, "like-new" in terms of functionality and durability."**	CIRCULÉIRE TWG 2024
British Standard Institute	**"the process of returning a used product to at least to its original performance with a warranty that is equivalent or better than that of a newly manufactured product."**	BS 8887–220: 2010
European Commission	**"Actions through which a new product is produced from objects that are waste, products, or components, and through which at least one change is made that substantially affects the safety, performance, purpose, or type of the product."**	Ecodesign for Sustainable Products Regulation (ESPR Article 2(16) of (EU 2024/1781), as
DECC	**"An industrial process where products are disassembled, cleaned, repaired, and reassembled to 'like-new' standards.**	Whole of Government Circular Economy Strategy 2022-2023. Chapter 1. What is the Circular Economy.

The chart above illustrates the different approaches to defining remanufacturing adopted by diverse stakeholders. These varied definitions, as well as the ongoing waste regulation debate, highlights the need for a more consistent and unified approach.

IMR, as the Secretariat of CIRCULEIRE, shares the concerns raised by the European Remanufacturing Council (ERC) regarding the inclusion of the term "waste" in the ESPR definition of remanufacturing. Labelling remanufacturing as involving "waste" could subject these activities to strict waste regulations, requiring businesses to obtain special licenses. This regulatory burden may deter companies from embracing remanufacturing practices, despite their significant environmental and economic advantages.

For this reason, IMR advocates for adopting broader definitions of remanufacturing, such as those provided by the Department of the Environment, Climate and Communications (DECC) in Ireland's *Whole of Government Circular Economy Strategy 2022-2023*. This

definition aligns with the British Standards approach, offering greater flexibility and clarity. Additionally, IMR emphasizes the importance of eliminating the reference to "waste" in any definition of remanufacturing. It recommends policymakers to explicitly categorize remanufacturing as a waste prevention activity, which would help streamline sustainable remanufacturing practices and reduce regulatory hurdles.

Achieving a universally accepted definition is essential to eliminate conflicting interpretations that could hinder the adoption and growth of remanufacturing practices.

4. RESPONSE TO THE DEFINITIONS DEBATE

The various definitions across academia, industry and regulations, reflect the complexity of remanufacturing and its multifaceted nature. The implications of this diversity are significant and pose various challenges. It affects how remanufacturing is perceived and implemented across different sectors, influencing regulatory standards, industry practices, and consumer expectations.

- Below are some of the initiatives that are taking place in Ireland and some proposals by different actors, which will hopefully provide more clarity and foster a more cohesive understanding of remanufacturing**. Remanufacturing for Ireland (EPA Funded project):** One significant effort is the **"Remanufacturing for Ireland" project, funded by the EPA**, which aims to establish Ireland as a global centre of excellence for remanufacturing. This project seeks to promote resilient jobs within the circular economy by developing a comprehensive roadmap for the sector.

- **EPA's Technical Guidance:** The **EPA** is currently developing a **technical guidance** on reuse and preparation for reuse. Given that much of the debate around the definition of remanufacturing revolves around whether it should be classified as a prevention of waste (reuse activity) or waste activity (preparation-for-reuse), this document is expected to provide valuable insights. It might offer greater clarity on these concepts, helping to provider further guidance on the classification and definition of remanufacturing, and assist companies in navigating the associated regulations more effectively.

- **Proposal for an Umbrella Term:** To address the diversity of practices and terms across sectors, it would be beneficial creating an **umbrella term for remanufacturing-related activities** (Fitzsimons, D. 2024 CIRCULEIRE TWG Session 4, Ireland. This would allow various processes to be categorized under a single definition, providing clarity for regulators, companies, and courts. Such an umbrella term would help harmonize the industry, making it easier to implement and comply with regulations while promoting a unified approach to remanufacturing**.**

- **Multi-stakeholder synergies:** Remanufacturing thrives on the “Triple Helix” model, which integrates academia, industry, and government, as shown in the graphic below. Universities drive innovation and research, while industry provides practical insights and resources. Government supports with policies and incentives. The synergy among these stakeholders enhances remanufacturing’s effectiveness and scalability, creating a robust ecosystem where collaborative efforts lead to greater circular performance and economic viability.

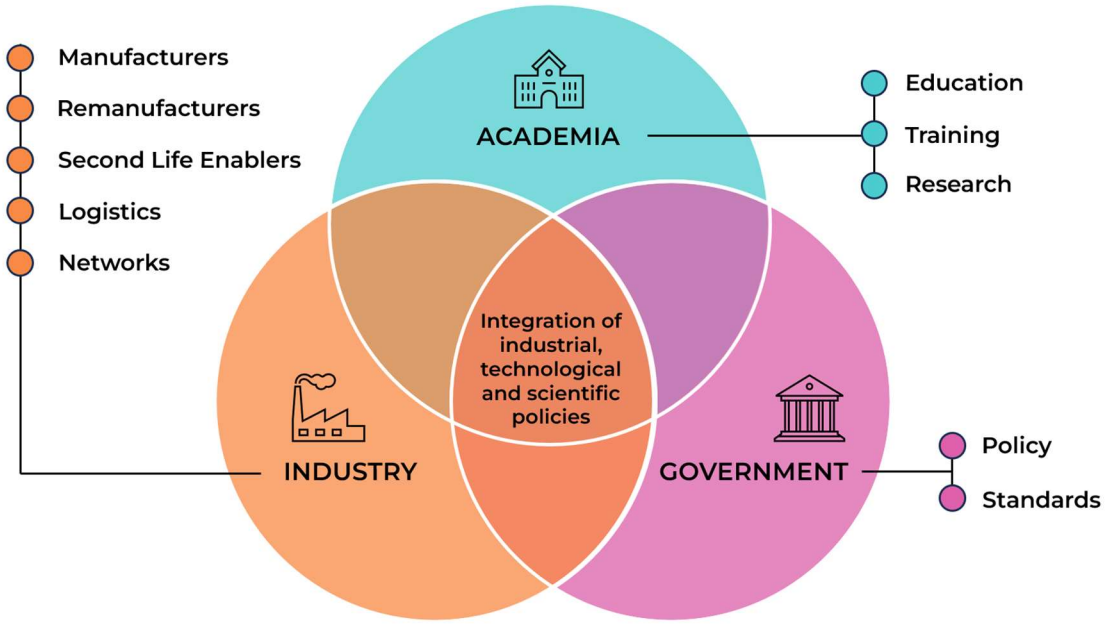
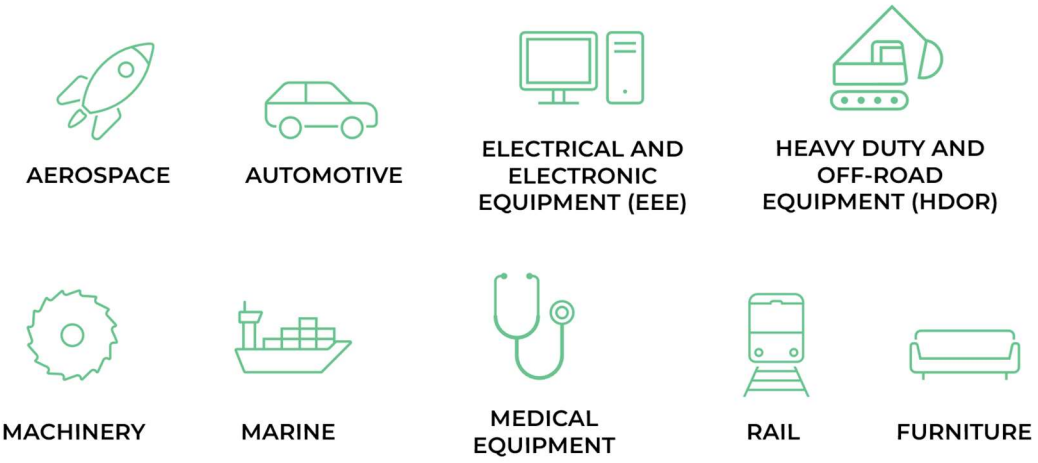


Figure 2: The Triple Helix Model

Current Status of Remanufacturing Market: Sectors and Size

The Remanufacturing industry is expected to play a critical role in advancing the green economy (Ijomah, W. (2024) CIRCULEIRE TWG Session 1, Ireland and supported by Wang Ying's 2013 article, "Remanufacturing to Play Key Role in Green Economy" (Chinadaily.com.cn)). In Europe, the Remanufacturing industry is projected to see substantial growth, with estimates suggesting it could reach €90 billion by 2030. According to a 2015 market study by the European Remanufacturing Council, the industry was valued at approximately €30 billion in 2015, with key sectors like automotive, aerospace, and electronics showing notable potential for expansion (ERN, 2015).

The ERN market study (Parker, Riley, Robinson, Symington, Jansson, et al., 2015) identified nine key sectors for remanufacturing. These sectors are expected to experience significant remanufacturing activities with substantial impact (Parker et al., 2015). The sectors include :



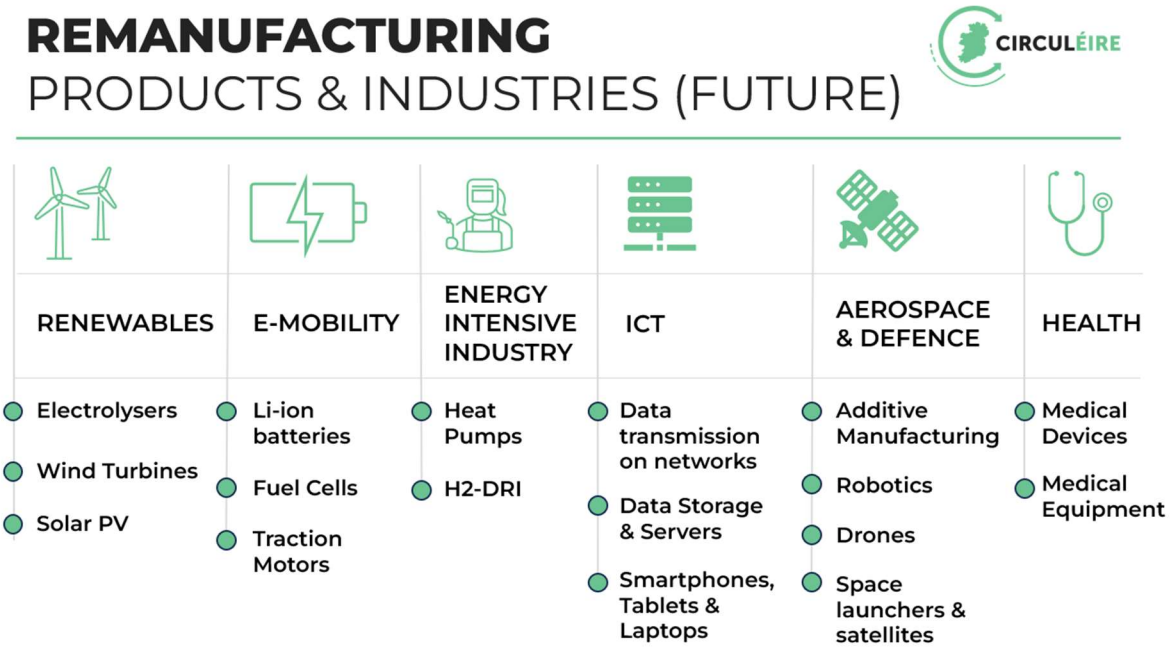
Some examples of products and components that could be remanufactured in the target industries are (Vlaanderen, 2018)

Table 4: Overview of the products that could be remanufactured in target industries. Source: Vlaanderen (2018)

Sectors	Examples products
Aerospace	Helicopters, fixed-wing aircraft and parts such as turbine engines, landing gear, actuators, airframes, engines and fuel systems.
Automotive	Starters, alternators, gearboxes, engines, differentials, brakes and on-board computers.
Electrical and electronic equipment (EEE)	IT equipment: computers, laptops, servers, network switches, routers, modems, receiver stations, and imaging equipment. Electrical parts: power distribution conductors, transformers, switch gear, boards and streetlights.
Furniture	Office chairs, desks, tables, shelves and partition walls.
Heavy duty and off road equipment (HDOR)	Equipment for the construction, mining, agriculture and transport.
Machinery	Wind, gas and steam turbines, valves, compressors, pumps, heat exchangers, food processing equipment, industrial tools and industrial robots.
Medical equipment	Diagnostic, surgical and patient care apparatus.
Marine	Components of large diesel engines, such as cylinder covers, pistons, piston crowns, piston rods, exhaust valves, cylinder covers and connecting rods. Cabin components: for example, re-upholstery, headboards, and new wall, floor and ceiling coverings.
Rail	Locomotive engines, drive motors, axles and traction converters.

Industrial sectors of the future (www.mckinsey.com , 2018) that will increasingly adopt remanufacturing include renewables, e-mobility, energy-intensive industries, ICT, Aerospace and Defense, and health (Coughlan, D. (2024) CIRCULEIRE TWG Session 2, Ireland). These sectors are poised to benefit from remanufacturing due to their high demand for sustainable practices and the need to reduce waste and resource

consumption, particularly Critical Raw Materials (IEA, 2023). The graph below shows products under these sectors



The same Market Study showcased that the value for all manufactured products in the above remanufacturing-intensive sectors was €1.5 trillion in 2015 (ERN, 2015). Specifically, the EU automotive remanufacturing sector is valued between €6-10 billion, with a growth rate of 3.7% per annum, as detailed in Weiland F's 2010 report, "European Automotive Remanufacturing - Technical Trends & Market Developments."

The Remanufacturing Market Study conducted by ERN is approaching its 10-year mark, highlighting the urgent need for an updated, comprehensive and cross-sectoral analysis. Over the past decade, significant advancements and shifts have occurred across various industries, necessitating a fresh, cross-sectoral market study on remanufacturing. This new study would provide critical insights into current trends, technological innovations, and emerging opportunities, ensuring that stakeholders are well-informed and equipped to navigate the evolving landscape of remanufacturing. Addressing these changes can support a better understanding of the market dynamics and foster sustainable growth in this vital sector.

CASE STUDY: BORG AUTOMOTIVE REMAN

BORG AUTOMOTIVE REMAN

ORGANISATION OVERVIEW

BORG Automotive Reman is Europe's largest independent remanufacturer of automotive spare parts, serving the continent's aftermarket with renowned brands like DRI and Lucas. With over 40 years of industry expertise, BORG operates production facilities in England, Poland, and Spain, supported by warehouses across Europe. Employing more than 1,900 people, their circular model minimizes CO_2 emissions and conserves raw materials, aligning with their mission to deliver sustainable automotive solutions.

BUSINESS ACTIVITIES

BORG Automotive remanufactures is the only one in the industry supplying eight different product groups, including starters, alternators, turbochargers, brake calipers, AC compressors, EGR valves, steering racks, and steering pumps. Currently, they remanufacture over two million units across all major brands. With a strong focus on circular economy principles, BORG serves diverse sectors within the automotive industry, helping to reduce environmental impacts and resource dependency within the automotive industry, a sector increasingly prioritizing remanufacturing for sustainability.

REMANUFACTURING APPROACH

BORG Automotive's remanufacturing process includes product recovery, rigorous testing, and reconditioning of components. With advanced production facilities in Poland, the UK, and Spain, they incorporate digital systems and 3D printing for efficient parts replacement. Specialized engineering teams focus on innovations, such as electric and electronic product handling Collaborations with universities and industry networks bolster BORG's R&D, while initiatives like the "Reman Challenge" promotes awareness and expertise among students in automotive remanufacturing.

IMPACT DATA

BORG's circular approach results in substantial environmental benefits, including significant reductions in CO_2 emissions and energy savings. Remanufacturing has a lower environmental impact compared to the equivalent newly produced spare parts. The results from life cycle assessments (LCA) conducted on their 8 product groups show that on average, 60% less CO2eq is emitted, 42% less energy (MJ) is consumed, and there is a 70% lower depletion of nature's non-renewable raw materials (Sb-eq).*

LINK TO WEBSITE: Remanufacturing Explained

Additionally, according to the Ellen MacArthur Foundation's 2012 report titled "Towards the Circular Economy Vol. 1: an economic and business rationale for an accelerated transition," (Ellen MacArthur Foundation, 2013). a subset of the EU manufacturing sector could realize net material cost savings worth up to $630 billion per annum by 2025 through activities such as product development, remanufacturing, and refurbishment. The four key regions estimated to account for some **70 % of remanufacturing value in Europe** are Germany, the UK & **Ireland**, France and Italy.

In comparison, the U.S. remanufacturing sector comprises over 73,000 companies, generating combined annual sales of $53 billion. This data (Ijomah, W. (2024) CIRCULEIRE TWG Session 1, Ireland) highlights the robust nature of the remanufacturing industry in the U.S. The United States serve as a notable example where remanufacturing has long been a profitable business (Peck, D. (2024) CIRCULEIRE TWG Session 2, Ireland), even before sustainability became a mainstream agenda. This demonstrates the economic viability and potential profitability of remanufacturing.

In **Ireland**, the remanufacturing industry is anticipated to experience significant growth. The abovementioned target industries and products illustrate the broad applicability of remanufacturing across various industries. Remanufacturing in Ireland is expected to offer substantial economic benefits, including significant cost savings and efficiency improvements (Peck, D. (2024) CIRCULEIRE TWG Session 2, Ireland).

Rematec and the International Conference on Remanufacturing (ICoR 2025)

The ICoR conference series was established in 2011 as the 1st International conference for remanufacturing academia. Rematec is one of the world's most established exhibition for the remanufacturing industry. ICoR and Rematec have run conjointly since 2017 to bring academics and industry together as that fusion of knowledge and expertise is necessary to optimise remanufacturing, mainstream it, and ensure its future sustainability in spite of technological and geopolitical instability. The 7th International Conference on Remanufacturing will take place **8-10 April 2025** at the RAI, in Amsterdam, the Netherlands, in conjunction with Rematec.

1.2 Benefits of Remanufacturing

Environmental benefits

Remanufacturing offers substantial environmental benefits, making it a key component of sustainable industrial practices. These benefits include :

- **Materials Recovery**
  A significant portion of the materials and value added during the initial

manufacturing process is recovered. For instance, remanufacturing automotive parts results in approximately 88% savings in materials compared to producing new components. This process also leads to a 53% reduction in CO_2 emissions and requires 56% less energy (Gong, Q., et alt, 2022).

- **Energy Efficiency**
  Remanufacturing consumes 50-80% less energy compared to traditional manufacturing (Sundin, E. and Lee, H.M., 2012). This reduction in energy use not only lowers production costs but also decreases the environmental footprint associated with energy consumption. Additionally, remanufacturing reduces the energy required for extracting, processing, and treating end-of-life products (Gong, Q., et alt, 2022).

- **Reduction of Virgin Resource Extraction**
  By reducing the need for mining critical materials, remanufacturing mitigates associated human rights and environmental issues. This practice helps preserve natural habitats and reduces the environmental degradation caused by mining activities (Ibid).

- **Waste Reduction**
  Remanufacturing significantly reduces environmental degradation by preventing waste from entering ecosystems. Approximately 85% of a product that would have been landfilled can be reused, thereby reducing landfill space usage (Sundin, E. and Lee, H.M., 2012). This is particularly beneficial in small countries where landfill space is limited.

- **GHG Emission Reduction**
  Remanufacturing can lead to up to a 98% reduction in CO_2 emissions compared to manufacturing new products (Russell, J.D., Nasr, N.Z. and UNEP International Resource Panel, 2018). This substantial decrease in greenhouse gas emissions supports global efforts to combat climate change. For example, under the Climate Action Plan, the Irish government has committed to reducing emissions by 51% across all sectors of the economy by 2030 and to becoming net zero by 2050 (Gong, Q., et alt, 2022).

- **Circular Economy**
  Remanufacturing is a prime example of circularity, giving products a new life instead of destroying or landfilling them. This practice conserves resources for longer periods and reduces the environmental impact of production and disposal. By keeping products in use for as long as possible, remanufacturing supports the principles of a circular economy, promoting sustainability and resource efficiency.

CASE STUDY: REvolve

REvolve
The Sustainable Automotive Supply-Chain Solution

ORGANISATION OVERVIEW

REvolve is a technology-driven supply chain solution that simplifies the sourcing of green auto parts. Developed through a partnership between Ted4Parts (a vehicle recycling service) and Mackessy Technology, REvolve connects vehicle recyclers with consumers, including insurers, repairers, and fleet managers, in Ireland and the UK. It supports circular economy practices by facilitating high-quality reuse of undamaged Original Equipment Manufacturer (OEM) parts, contributing to sustainable vehicle repair and resource savings.

BUSINESS ACTIVITIES

Every year 6 million cars reach end of life status in the EU and an estimated of 8 to 9 million tonnes of waste is generated from the disposal of End-of-Life Vehicles (ELVs). REvolve enables the automotive industry to source green auto parts, providing a sustainable alternative to new parts and reducing waste. The platform links green auto parts suppliers (vehicle recyclers) with consumers (insurers, repairers, fleets) ensuring graded, quality-assured parts that meet Vehicle Remarketing Association (VRA) standards. This approach supports the circular economy by reintroducing usable vehicle components, reducing landfill waste and new resource demand.

RECIRCULATION STRATEGIES

REvolve's circular approach utilizes a digital platform to source and supply graded, undamaged green auto parts. Vehicle recyclers disassemble ELVs, inspecting and grading parts to meet VRA standards, then provide them for reuse. This system ensure that good quality parts are available for vehicle repairs, minimizing new part production requirements. This circular approach minimizes landfill waste, preserves natural resources, and supports Ireland's compliance with EU environmental standards for ELVs.

IMPACT DATA

REvolve's reuse of vehicle parts results in significant environmental savings, avoiding an estimated 35.3 gigajoules of energy and 1,887 kg of CO_2 emissions per vehicle. REvolve includes carbon savings reporting for clients, reinforcing transparency and sustainability. For example, An Garda Síochána, Ireland's police force, saved 38,477 kg of CO_2 by procuring 551 reclaimed parts, achieving on average 94% reduction in net CO_2 through REvolve.

LINK TO FULL CASE STUDY: CIRCULÉIRE

Economic benefits

Remanufacturing not only supports environmental sustainability but also offers significant economic advantages, making it a strategic choice for businesses aiming to enhance profitability and competitiveness.

1. **Cost Savings**
   Production costs are reduced by 20-80% through remanufacturing (Boorsma, N., et alt, 2022), primarily due to lower labour, energy, materials, and disposal expenses compared to traditional manufacturing. Remanufacturing has been recognized as a highly profitable business venture (Louis and Ijomah 2002). These savings benefit both the remanufacturer and the customer, as remanufactured products are typically priced at 40-80% of the cost of new products (Gong, Q., et alt., 2022)

2. **Competitiveness**
   Remanufacturing makes businesses more competitive by reducing costs and enhancing marketing from a sustainability perspective. In conventional manufacturing, product testing is statistical, meaning only a sample of products are tested. In contrast, remanufacturing requires every product to be tested and fully operational to be fit for sale, ensuring higher quality and reliability (CRR, 2014).

3. **Profitability**
   Remanufacturing is highly profitable, with profit margins often reaching around 20%. This profitability stems from the ability to sell remanufactured products at approximately 40% lower prices than new products while still maintaining substantial profit margins (J. V., Duberg, et alt., (2023). United States serves as a notable example where remanufacturing has long been a profitable business, even before sustainability became a mainstream agenda

4. **Supply Chain Stability**
   Remanufacturing avoids supply chain disruptions by reducing dependence on raw materials, thus enhancing supply chain stability. This stability is further supported by the ability to reuse and recycle components, which mitigates the risks associated with raw material shortages and price volatility (S. Zhao, et alt., 2022)

5. **Energy Savings**
   The process of remanufacturing uses up to 85% less energy compared to manufacturing new products, leading to substantial reductions in carbon emissions (MITEI, 2010).

CASE STUDY: iQuTech

ORGANISATION OVERVIEW

iQuTech, a carbon-negative company founded in 2009 by John Kennedy and Mark O'Sullivan, is a European leader in returns management for Tier 1 manufacturers across sectors like consumer electronics, telecom, and aerospace. With hubs in Ireland, Poland, and the Czech Republic, iQuTech uses its Blocworx software to help companies like Eir achieve efficient, sustainable operations through custom returns and recirculation processes, supporting ESG goals

BUSINESS ACTIVITIES

iQuTech partners with leading OEMs to provide sustainable, circular economy solutions. As an example. through its collaboration with Eir, iQuTech established a closed-loop system that recovers, repairs, and redistributes electronic products. This solution keeps products in circulation, lowering both environmental impact and operational costs by minimizing new stock needs.

RECIRCULATION STRATEGIES

iQuTech's work with Eir focuses on establishing a closed loop returns management system. All Eir products, from modems to set-top boxes, are routed to iQuTech for inspection, repair or refurbishment and redistribution. Around 50% of returned items require no repairs. . In up to 90% of return, faults are cosmetic that can easily be repaired or refurbished. Unsalvageable items are dismantled, and their parts are recycled into other supply chains. This system not only maintained supply resilience during COVID-19 but also reduced emissions by minimizing logistics and new production.

IMPACT DATA

Before partnering with iQuTech, Eir annually had around 240,000 electronic units either sent to landfills or left unused in customers' homes. They disposed of 12 tonnes of electronic waste weekly, replacing items with new units. Now, with iQuTech processing 80,000 units every month, Eir reintroduces refurbished products to customers. Each saved unit, valued between $15–$60, strengthens Eir's market position and supports their goal of achieving zero emissions by 2050.

LINK TO WEBSITE: https://iqutech.com/

Social Benefits

Remanufacturing offers a range of social benefits that contribute to economic stability and community well-being, making it a vital component of sustainable development.

1. **Job Creation**
   Remanufacturing creates more low/semi-skilled job opportunities, providing employment for a broader segment of the population (Gong, Q., et alt., 2022).

2. **Price Reduction**
   Lower product prices make goods more accessible to low-income individuals, enhancing affordability and inclusivity (CRR, 2014).

3. **Skill Development**
   The remanufacturing process fosters the development of new skills and expertise, contributing to workforce development and personal growth (www.nibusinessinfo.co.uk., n.d.)

4. **Community Revitalization**
   By establishing remanufacturing facilities, communities can experience economic revitalization through increased local employment and business opportunities (Karvonen, I., et alt., 2015).

5. **Environmental Awareness**
   Remanufacturing promotes environmental consciousness by encouraging the reuse of materials, which can lead to a more sustainable and eco-friendly society (Fofou, R.F., et alt., 2021).

CASE STUDY: Rype Office

ORGANISATION OVERVIEW

Rype Office is a UK-based company specializing in remanufactured, sustainable office furniture. Focused on reducing waste and emissions, Rype Office helps businesses create eco-friendly workspaces. They are committed to the circular economy, offering Net Zero Carbon furniture and comprehensive office decarbonization solutions for clients looking to implement sustainable practices.

BUSINESS ACTIVITIES

Rype Office designs and provides sustainable, remanufactured office furniture using locally sourced materials, saving clients money while reducing greenhouse gas emissions and waste. They have also created furniture designs using materials like post-consumer waste plastic. Their customers include businesses and institutions aiming to reduce environmental impact through carbon-neutral office solutions. Rype also supports social initiatives, partnering with local communities to create jobs, particularly for disadvantaged groups, in support of their circular and social value commitments.

REMANUFACTURING APPROACH

Rype's circular economy approach involves remanufacturing office furniture to Net Zero Carbon standards, which includes sourcing, reusing, and refurbishing materials to reduce waste. They use their Blocworx technology to monitor quality and track environmental savings, making significant carbon reductions in each project. They partner with organizations like the Merthyr Tydfil Institute for the Blind and Connection Crew to enhance social impact while achieving high environmental standards.

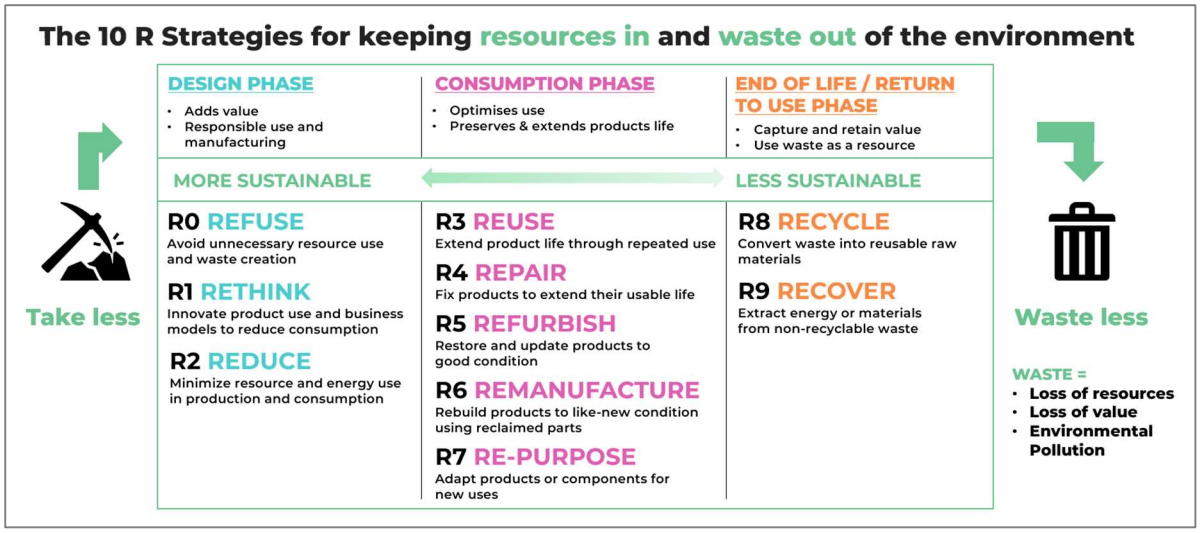
IMPACT DATA

Rype Office reports an 80% reduction in greenhouse gas emissions and waste for clients using their services, with financial savings through remanufactured products. Their commitment to Net Zero Carbon by 2050 aligns with the UN Race to Zero pledge, emphasizing environmental stewardship and cost efficiency.

LINK TO WEBSITE: https://www.rypeoffice.com/about-us/

1.3 Differences between recirculation strategies

Remanufacturing involves restoring a product to its original specifications, often with performance and reliability that match or exceed that of a new product. This process differs from other recirculation strategies, even if all of them retain value within the economic system and are thus referred to as **value-retention processes (VRPs)**. This term highlights their impact, which encompasses both economic and environmental objectives. The impact is evaluated based on material savings, energy savings, emission reductions, cost benefits, and employment opportunities (IRP, 2018).



Clarifying the differences between various value-retention processes is crucial to

- **Avoid uncertainty and misalignments**
  ensures that stakeholders, including manufacturers, consumers, and policymakers, have a clear understanding of each process's unique benefits and limitations;
- **Data-informed decisions making**
  help organisations in making informed decisions about resource allocation, regulatory compliance, and sustainability goals;
- **Enhance market transparency**
  Allowing consumers to make more environmentally conscious choices;
- **Unlock full circular potential**
  Support the development of more effective strategies for circular economy initiatives, promoting resource efficiency and reducing environmental impact.

As per the abovementioned definition, remanufacturing involves taking used products and restoring them to a like-new condition, often with performance levels equivalent to or better than the original. This process includes disassembly, cleaning, repairing, replacing worn parts, and reassembling the product. Remanufactured products typically come with warranties similar to new products, ensuring reliability and

performancehttps://link.springer.com/chapter/10.1007/978-3-030-81799-2_1. This strategy is more resource-intensive than repair or reuse but offers significant benefits in terms of quality and longevity.

Three business models are used in remanufacturing:

- an OEM takes responsibility for the return and reuse of its own product
- an OEM appoints an approved third party to carry out the preparation for reuse to OEM specifications
- third parties independently refill, reuse and also remanufacture cartridges and printers

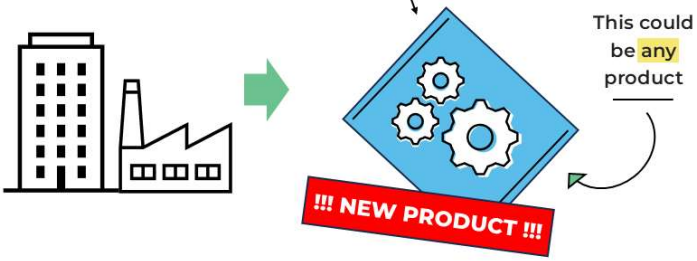
REMANUFACTURING IN PRACTICE

CIRCULÉIRE

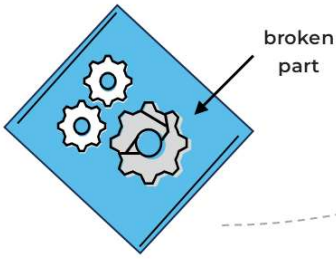
DEPENDING ON THE INDUSTRY, THIS IS ALSO REFERRED TO AS...

- REPURPOSING,
- REPROCESSING,
- RESTORING,
- RENOVATING,
- REMAKING,
- UPGRADING,
- REBUILDING,
- RECONDITIONING
- OR
- REFURBISHING,

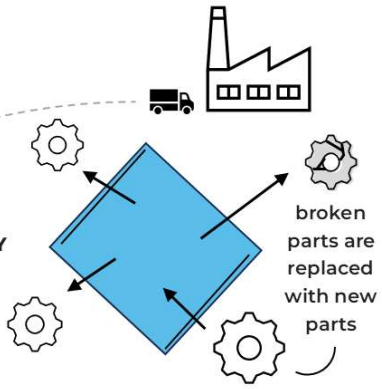
1 A COMPANY MANUFACTURES A PRODUCT AND SELLS, OR LEASES IT TO A CUSTOMER



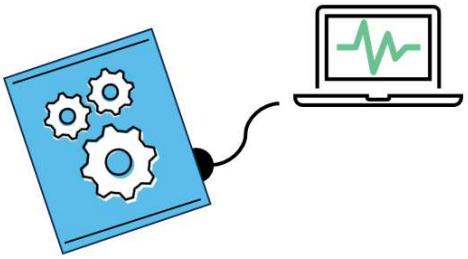
2 EVENTUALLY THE PRODUCT MAY BECOME WORN OR PARTS MAY BREAK



3 THE PRODUCT IS RETURNED TO THE MANUFACTURER OR REMANUFACTURER WHERE IT IS DISSASSEMBLED, INSPECTED AND ANY BROKEN OR WORN PARTS ARE REPLACED



4 THE PRODUCT IS REASSEMBLED, STRESS-TESTED AND IF APPLICABLE ANY FIRMWARE OF SOFTWARE UPDATES ARE APPLIED



3 THE 'NEW' PRODUCT IS THEN OFFERED WITH A 'GOOD-AS-NEW' OR A 'BETTER-THAN-NEW' WARRANTY

! THE REMANUFACTURED PRODUCT IS NOT THE SAME AS THE OLD PRODUCT – IT IS TECHNICALLY TREATED AS A NEW ONE

! REMANUFACTURING IS MADE MORE POSSIBLE WHEN A PRODUCT IS DESIGNED FROM THE OUTSET TO BE REMANUFACTURED

To understand the various strategies for extending the life cycle of products, it is essential to explore the main differences between remanufacturing and other recirculation methods such as repair, reuse, refurbish, repurpose, and recycling.

R3 - REUSE

Reuse refers to the practice of using a product again for the same purpose it was originally designed for, without significant alteration. This strategy is highly efficient in terms of resource conservation, as it extends the product's life cycle with minimal additional energy or material input (Hildenbrand, J., et alt., 2021) . However, reuse does not address any wear and tear or potential defects that may have developed over time, which can limit the product's reliability and performance compared to remanufactured items.

R4 - REPAIR

Repair involves fixing specific faults in a product to restore it to working condition. This process typically addresses only the defective part, and the warranty usually applies solely to the repaired component. Consequently, the overall functionality and warranty of the product may be reduced compared to its original state (Yuanjun Laili, et alt., 2021). Repair is often a quicker and less resource-intensive option but does not guarantee the same level of performance or longevity as remanufacturing.

R5 - REFURBISH

Refurbishing involves restoring a product to a good working condition by repairing or replacing certain components. Unlike repair, refurbishing often includes a more comprehensive overhaul to improve the product's performance and extend its lifespan (European Circular Economy Stakeholder Platform, 2021). However, refurbished products may not meet the same quality standards as new or remanufactured items, and their warranties are typically shorter. The Basel Convention defines refurbishment as a process that should increase or restore a product's performance to meet applicable technical standards (Ibid).

R7 - REPURPOSE

Repurposing entails using an end-of-life product for a different purpose than originally intended, often with minimal intervention. This strategy is creative and can significantly extend the utility of products that might otherwise be discarded (Hildenbrand, J., et alt., 2021). However, repurposing does not necessarily restore the product to its original functional level, and the new application may not fully utilize the product's potential, unlike remanufacturing, which aims to restore the product to its original or even better condition.

R8 - RECYCLING

Recycling breaks down a product into raw materials, which are then used to create new products. This process requires significant energy and resources to convert materials back into a usable form (Yuanjun Laili, et alt., 2021). While recycling is crucial for managing waste and conserving raw materials, it often results in materials of lower quality than the original, which can be less desirable for designers. In contrast, remanufacturing restores products to a functional level equivalent to the original, maintaining high quality and performance standards (Ibid).

Each recirculation strategy has unique characteristics and operational nuances that must be considered to achieve the best results. By comprehensively analyzing and integrating these differences, organisations can tailor a recirculation approach that maximizes effectiveness and sustainability. Recirculation strategies, when used in conjunction, can significantly enhance system efficiency and performance.

CASE STUDY: Wisetek

ORGANISATION OVERVIEW

Wisetek Solutions, founded in 2007 by Sean Sheehan, specializes in reverse logistics and Information Technology Asset Disposition (ITAD). Wisetek has expanded globally, with facilities in Ireland, the USA, UK, Thailand, and a partner network spanning 145 countries. Wisetek's mission aligns with circular economy principles by focusing on maximizing equipment re-use and minimizing waste. Today, the company employs 450 people worldwide and leads in sustainable IT solutions.

BUSINESS ACTIVITIES

Wisetek provides comprehensive reverse logistics and ITAD services, offering companies an end-of-life solution for IT assets by refurbishing, reusing, or responsibly recycling equipment. The company primarily serves large corporations with significant IT infrastructure needs, helping extend IT assets' lifecycle and supporting sustainable practices. The sector's demand for such services is crucial, with global IT sales reaching $3.5 trillion in 2020. Wisetek processes over 250,000 IT units annually, maintaining re-use rates between 40-70% depending on equipment type, reinforcing the importance of CE for environmental impact reduction.

RECIRCULATION STRATEGIES

Wisetek's recirculation strategies includes cataloguing, testing, refurbishing, and reselling IT equipment, utilizing processes designed for CE. Equipment undergoes detailed inspection and testing, with up to 30% reused directly and an additional 10-15% refurbished before re-entry to secondary markets. Remaining components are dismantled, processed, and recycled to recover valuable materials like rare earth metals. Data erasure and chain-of-custody management ensure secure asset disposition. Wisetek also collaborates with the industry to maintain high environmental and operational standards, overcoming logistical and regulatory challenges in global CE.

IMPACT DATA

In 2019, Wisetek achieved significant environmental milestones, such as a reduction of 24,409,105 lbs in greenhouse gas emissions and diverting 524,154 lbs of toxic materials from landfills. These results stem from processing 18,228,910 lbs of IT materials, underscoring the environmental benefits of Wisetek's circular approach. Using tools like the ITAD industry environmental impact calculator, Wisetek has quantified its contribution, demonstrating both cost savings and improved sustainability for its partners.

LINK TO FULL CASE STUDY: CIRCULÉIRE

Table 5: Comparison between different Value Retention Processes (Contribution of remanufacturing to Circular Economy, European Topic Centre Waste and Materials in a Green Economy. Source: Gustavsson et al. (2021)

		Reuse	Repair	Refurbish-ment	Remanu-facturing
Waste/non Waste	Can the used device be waste?		✓	✓	✓
	Can the used device be non-waste?	✓	✓	✓	✓
Input	Can used products get a life extension?	✓	✓	✓	✓
	Can old parts be sources of life extension?		✓	✓	✓
	Can parts/components partly be bought new?		✓	✓	✓
Purpose	Does a new device have same purpose?	✓	✓	✓	✓
	Is the purpose of the new device at least the one that was originally intended?			✓	✓
Actors	Who mostly carries out the product's life extension?	user, OEM*, third party	user, OEM*, third party	OEM*, third party	OEM*, third party
Process steps	Is repair and refurbishment necessary?	✓			
	Is fixing faults included?		✓	✓	✓
	Is replacing defective components included?		✓	✓	✓
	Is disassembly and reassembly Included?		✓	✓	✓
	Is it a standardised industrial process?				✓
Warranty and performance	Is it brought up to date to a specific quality level to a satisfactory level?		✓	✓	to at least original quality
	Is its performance and/or functionality increased or restored?			✓	✓
	Is it placed on the market as an 'as-new' product?			more aesthetic than functional	✓
	Is a warranty given or are applicable standards or regulatory requirements met?			✓ less valuable than for reman products	✓

✓ = *not clearly defined or definitions contradictory*

* OEM: original equipment manufacturer

Source: Gustavsson et al. (2021)

IDENTITY LOSS

In Remanufacturing used goods are disassembled into pre-determined groups of components. These parts, that originally constitute the identity of the product, are then repaired and ready for reassembly into a new product. The original product identity, linked to the original components, is lost - the operation is comparable to the process for new product manufacturing. The shape and added value of the remanufactured product are preserved, serving the same purpose as during its original life cycle.

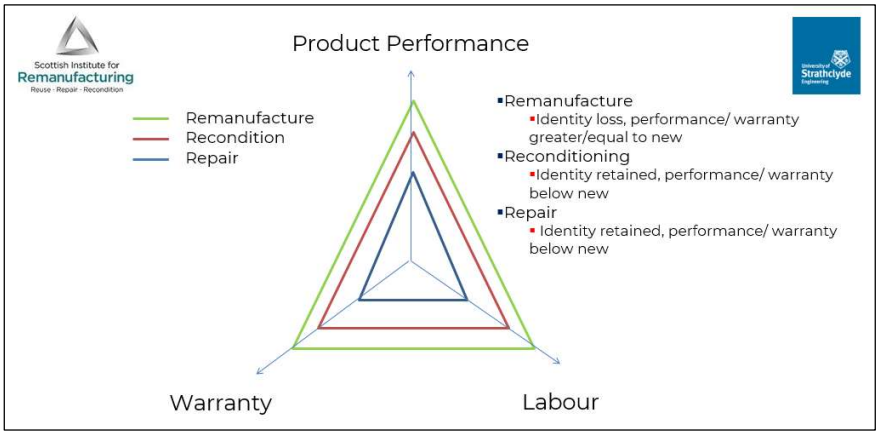


Figure 3: A hierarchy of secondary market processes (Ijomah W, 2002; BSI, 2009)

CASE STUDY: Tympany Medical

ORGANISATION OVERVIEW

Tympany Medical is a Galway-based medical technology company that develops sustainable ear, nose, and throat endoscopes. Endoscopy uses camera technology to improve the visualisation of hard-to-reach areas during surgery. Focused on reducing waste, the company created the Solascope, a sterile, reusable panoramic endoscope. By rethinking endoscope design, Tympany aims to lower the environmental impact of medical devices while improving surgical visibility.

BUSINESS ACTIVITIES

The healthcare sector produces a lot of waste and contribute 4%-5% of global greenhouse emissions (Rodriguez-Jimenez et. al., 2023). If healthcare were a country, it would be the fifth largest emitter of greenhouse gases on the planet. Single-use medical supplies account for about 80% of the industry's carbon footprint. Currently, discarded products that are disposable rather than reusable make up 85% of global medical waste. Tympany Medical addresses the environmental challenge posed by single-use medical devices. With traditional endoscopes, procedures require multiple scopes and extensive sterilization, generating significant waste. Tympany's Solascope device minimizes waste by encapsulating the core components, allowing for reuse, which reduces both environmental impact and costs associated with medical waste disposal.

RECIRCULATION APPROACH

Tympany medical has developed the next generation of endoscope called Solascope. The Solascope introduces a groundbreaking encapsulation technology, allowing its complex internal components to be reused across procedures. Solascope's inbuilt lens-cleaning feature maintains a clear surgical view, enhancing efficiency. Through an integrated manufacturing and remanufacturing model, Tympany advances circular economy principles in medical devices, setting a new industry standard in waste reduction and reusability.

IMPACT DATA

The Solascope's design reduces reliance on single-use devices, cutting costs of hazardous waste disposal, which can average €1,530 per tonne. This innovation also reduces the number of scopes required per surgery from 4 to 1, significantly cutting medical waste. Tympany Medical's approach not only lowers expenses for healthcare providers but also minimizes environmental impact, making the circular economy a tangible reality for medical devices

Link to full case study: CIRCULÉIRE

Section 2: Policy developments supporting remanufacturing

Remanufacturing is increasingly being highlighted and promoted in policy discussions across the world signalling its rising role in advancing sustainability and circular economy efforts. Countries like the USA and China have been early adopters of remanufacturing related policies, setting notable examples. For instance, the USA's **Federal Vehicle Repair Cost Savings Act of 2015** promotes remanufacturing by requiring federal agencies to use remanufactured vehicle parts, such as engines and alternators, to maintain government fleets. This approach is designed to reduce costs while maintaining quality and performance standards. Similarly, since 2000 China has included remanufacturing in its Government's **Five-Year Plans, highlighting it's importance for China's economy and circular economy goals.**

2.1 European Policies

Despite the absence of a uniform definition, remanufacturing is increasingly being recognized in European circular economy policies. Legislation such as the Ecodesign for Sustainable Products (ESPR, 2024), the Right to Repair and various initiatives under the Green Deal, and related policies shaping a favourable environment for the growth of remanufacturing in Europe. Below is a list of recent European policies that support or create enabling conditions for the advancement of remanufacturing:

- **ESPR**
  The Ecodesign for Sustainable Products Regulation (ESPR) is set to revolutionize product standards in the EU by including requirements for product durability, reusability, and reparability—all crucial for remanufacturing. Additionally, the regulation mandates a **Digital Product Passport** (DPP) to enhance product transparency and traceability, which could significantly facilitate and boost remanufacturing, refurbishment, and other recirculation strategies.

- **Fit for 55**
  The "Fit for 55" plan (Consilium, 2022) is an EU initiative aimed at reducing

greenhouse gas emissions by 55% by 2030, aligning policies with the European Green Deal's climate goals. It highlights the role of energy transition technologies (Ibis) and digital technologies in driving demand for remanufactured products. Additionally, *the concept of "open strategic autonomy" in this plan underscores the importance of reducing reliance on external resources, further encouraging remanufacturing*.

- **Right to Repair**
  The Right to Repair addresses the environmental and resource impacts of premature disposal of consumer goods. Premature disposal produces 261 million tonnes of CO_2-equivalent emissions, consumes 30 million tonnes of resources, and generates 35 million tonnes of waste annually in the EU (Spinaci, S., 2023). By supporting the repair and reuse of products, the initiative promotes a shift of consumer's behaviour towards repair and reuse, *which could help normalize remanufactured goods and enhance the remanufacturing industry.*

- **Critical Raw Materials Act**
  The Critical Raw Materials Act is an EU initiative designed to secure a sustainable and resilient supply of critical raw materials essential for green and digital transitions. The Critical Raw Materials Act provides indirect support to remanufacturing by aiming to diversify EU raw material imports, reduce strategic dependencies, and improve circularity. By 2027, EU member states are required to adopt measures to increase the collection of waste products containing critical raw materials (CRMs) and promote the reuse of CRM-containing products. This creates opportunities for remanufacturing businesses to extend the life of products with CRMs, helping the EU meet sustainability targets.

- **Net Zero Industry Act**
  The Net Zero Industry Act aims to boost the EU's manufacturing capacity for net-zero technologies, indirectly benefiting remanufacturing by promoting circular economy practices. The proposal sets a benchmark for the manufacturing capacity of strategic net-zero technologies to meet at least 40% of the EU's annual deployment needs by 2030. The benchmark provides predictability, certainty and long-term signals to manufacturers and investors and allows them to track the progress. By prioritizing sustainable production and incentivizing closed-loop processes, the act encourages manufacturers to adopt remanufacturing as a way to reduce waste, lower carbon emissions, and ensure a steady supply of critical components. Additionally, it includes provisions to foster innovation and investment in technologies that extend product life cycles, which aligns well with remanufacturing goals.

CASE STUDY: Vanguard AG

ORGANISATION OVERVIEW

Vanguard AG, founded in 1998 and based in Berlin, is a leading European medical remanufacturer, specializing in restoring single-use medical devices to “as new” quality. With a mission to support circular economy principles in healthcare, Vanguard’s advanced technology and rigorous quality standards have made it a trusted partner for over 1,000 European healthcare institutions, reducing both costs and environmental impact.

BUSINESS ACTIVITIES

Vanguard provides remanufacturing for complex medical devices, including cooled ablation catheters and 3D mapping catheters, serving hospitals and medical institutions across Europe. Their remanufacturing process aligns with the healthcare sector’s need to reduce waste and costs, as medical device remanufacturing can cut expenses by up to 50% compared to purchasing new equipment. Vanguard’s sustainability commitment supports a healthcare model that’s efficient, cost-effective, and environmentally responsible.

REMANUFACTURING APPROACH

Vanguard uses certified state-of-the-art remanufacturing processes to ensure the functionality and safety of refurbished devices, fully compliant with EU regulations. Their approach minimizes waste, conserves resources, and reduces greenhouse gas emissions. Vanguard collaborates with the AMDR (Association for Medical Remanufacturers) to promote high standards across the industry, ensuring that remanufactured devices provide safe, high-quality alternatives to new products

IMPACT DATA

Vanguard’s operations avoid 275 tons of medical waste annually, saving approximately 59,340 kg of CO_2 emissions. Their remanufacturing efforts support both environmental sustainability and cost savings, offering healthcare providers access to high-quality, eco-friendly devices that are economically advantageous.

Link to website: https://www.vanguard.de/en/vanguard-ag/

2.2 National Policies: Spotlight on Ireland

In Ireland, remanufacturing is increasingly featured in circular economy and sustainability policies. The previously mentioned **Whole of Government Circular Economy Strategy 2022-2023**, not only included a definition of remanufacturing but also highlighted it as a specialised example of the circular economy, driven not only by environmental concerns but also by the high value of the remanufactured components.

The **Green Public Procurement (GPP) Strategy and Action Plan 2024-2027 (**www.gov.ie. (2024) is also a key driver in the uptake of remanufacturing in Ireland. By leveraging the significant purchasing power of public sector bodies, which spend an estimated €18.5 billion (EPA, 2024) annually on goods, services, and works (www.cso.ie. 2021), the GPP aims to reduce consumption and emissions throughout the lifecycle of products.

The **GPP Strategy and Action Plan 2024-2027** mandates that by 2025, 80% of ICT products procured by public sector bodies should be certified as remanufactured or meet equivalent standards. A new public procurement framework has already enabled public bodies to purchase remanufactured laptops, which enabled the recent procurement of **60,000 remanufactured laptops by the Government of Ireland over the next four years**. This initiative (Circular Computing, 2024), part of a circular public procurement framework and implemented in collaboration with Circular Computing (Circular Computing, 2024) and GreenIT (OGP Portal, 2024), is expected to save 19 million kg of CO_2e, 72 million kg of earth minerals, and 11 million litters of water, while also achieving a cost saving of €15 million. In this contract all laptops meet the BSI Kitemark standard for “Remanufacturing”. Such measures underscore the GPP’s potential to drive significant environmental and economic benefits (www.gov.ie, 2020), making remanufacturing a cornerstone of Ireland’s transition to a carbon-neutral and circular economy.

CASE STUDY: Circular Computing

ORGANISATION OVERVIEW

Circular Computing is a UK-based company specializing in remanufactured laptops that meet the BS 8887 standard. They set their mission with a simple thought: "*How can we remanufacture a laptop to be like new? - "new" meaning not simply a cosmetically improved finish but an intense focus on the performance and reliability of the laptop too"*. In 2015 they opened the world's first purpose-built laptop remanufacturing factory, with the goal of providing sustainable computing options by extending laptop lifecycles.

BUSINESS ACTIVITIES

Circular Computing remanufactures laptops from leading brands like HP, Dell, and Lenovo. With a rigorous 5+ hour remanufacturing process and a 360-point quality check, they serve business, education, and government sectors, helping clients reduce Scope 3 emissions while achieving eco-friendly IT setups.

REMANUFACTURING APPROACH

Their remanufacturing process involves detailed inspection, component replacement, and cosmetic reconditioning. Certified by the BSI Kitemark, they ensure each remanufactured laptop meets or exceeds new-product standards. Every laptop is disassembled into individual parts and repainted by advanced robotic systems to match colours and finishes of the original new product. Screens are fully dismantled, with at least one part replaced which guarantees no scratches or pressure marks. Each laptop undergoes Aiken testing and a minimum 3-hour stress test to guarantee high performance and reliability.

IMPACT DATA

Through Circular Computing's unique remanufacturing process, 99% of original laptop materials are reused, while the remaining 1% is recycled into pallets, ensuring zero waste. With over 180,000 spare parts in inventory, this approach reduces e-waste and cuts costs by up to 40% compared to new models, significantly lowering carbon footprints. Circular Computing's laptops meet stringent quality standards, offering clients financial savings and environmental benefits, and helping them report reductions in Scope 3 emissions.

Link to website: https://circularcomputing.com/

Furthermore, the **National Waste Management Plan for a Circular Economy 2024-2030** further emphasizes remanufacturing, including it in one of its targets.

The **Remanufacturing for Ireland Research 2023-2025** project, funded by the EPA, aims to provide a strategic roadmap to position Ireland as a global centre of excellence for remanufacturing.

Additionally, in early 2024, the EPA established **a National Repair and Reuse Network** comprising 13 members from various engaged in repair and reuse activities. The network goal is to facilitate knowledge sharing and engagement to support and scale reuse and repair activities in Ireland. IMR, acting as the Secretariat of CIRCULEIRE and as a member of this network, considers that remanufacturing should be explicitly included within the remit of this network. As discussed in Section 1(3), IMR believes that remanufacturing should be classified as a reuse activity under waste prevention in the waste hierarchy. Including remanufacturing within the network would enhance synergies between stakeholders, support sectoral development, and contribute to Ireland's ambition of becoming a global leader in remanufacturing.

In conclusion, both European and Irish policies increasingly recognize the critical role of remanufacturing in advancing circular economy goals. However, significant regulatory barriers remain, particularly concerning the definition of remanufacturing and its classification under waste regulations. Clear and consistent classification, such as recognizing remanufacturing as a reuse activity, and its inclusion in initiatives like the EPA's National Repair and Reuse Network, are essential steps to fostering collaboration, innovation, and growth within the sector.

CASE STUDY: Orangebox

ORGANISATION OVERVIEW

Founded in 2002, Orangebox is a Welsh company specializing in workplace furniture, designing adaptable, modern pieces for global markets. With over 450 employees, they focus on “smartworking” solutions, catering to organizations that value sustainable, flexible, and ergonomic office environments. Their approach aligns with industry trends toward environmentally friendly and adaptable office spaces.

BUSINESS ACTIVITIES

In response to the estimated 3 million items of office furniture sent to UK landfills each year, Orangebox launched its "re-made" service to extend the life of their products. This service provides refurbished furniture with the same reliable performance but with a significantly reduced carbon footprint. Currently, "re-made" covers all soft seating and task chairs, with plans to expand to other items in the future.

REMANUFACTURING APPROACH

Orangebox begins each "re-made" process by gathering detailed information about the items, sometimes via a site audit. Once the project scope and costs are agreed upon, items are collected and refurbished at their South Wales HQ within 4–8 weeks. All re-made items are supported by an Orangebox warranty (5 years). Upon request, Orangebox can provide clients with carbon savings estimates, highlighting the environmental benefits of choosing remanufactured products over new ones.

IMPACT DATA

Orangebox’s “re-made” service reduces the carbon footprint of furniture by up to 91%. They source 45% of components within 10 miles of their HQ, and over 90% from mainland Europe, minimizing transport emissions. Replaced parts are recycled locally, ensuring nothing goes to landfill. Additionally, collections are coordinated to backfill existing deliveries, reducing transport impact.

Link to website: Sustainability - Orangebox

Section 3:
Drivers, & perceived barriers to Remanufacturing

3.1 Enabling factors for Remanufacturing and potential challenges for industry

Remanufacturing plays a crucial role in advancing the circular economy by promoting sustainability and resilience across industries. Here are some key factors highlighting its role as a cornerstone of future industrial practices:

- **Innovation Driver**
  It drives innovation as companies develop advanced techniques to refurbish products efficiently, fostering technological advancements and improving product quality (Scottish Institute for Remanufacturing, 2024).
- **Circular Design**
  Remanufacturing is driven by circular design principles, encouraging the creation of products that can be easily disassembled, repaired, and reused. This extends the lifecycle of products and reduces waste (Jensen, H.H. (2024).
- **Scalable Industrial Solution**
  It offers a scalable business model that can be applied across various sectors, making it a versatile solution for sustainable industrial practices (Bhawna, et alt., 2024).
- **Producer Responsibility**
  Remanufacturing aligns with extended producer responsibility, urging manufacturers to design products with multiple-use lives in mind, thereby reducing environmental impact (Vinay, et alt., 2024).
- **Resource Efficiency**
  By restoring used products to like-new condition, industries can significantly cut down on the consumption of raw materials and energy, leading to lower production costs and reduced environmental footprint (Ishii, et alt., 2020).

- **Waste Management**
  This process helps manage waste effectively by keeping valuable materials in circulation for longer periods, which is a core principle of the circular economy (Jensen, H.H. (2024).
- **Supply Chain Stability**
  Remanufacturing enhances supply chain stability and reduces vulnerability to resource shortages and market fluctuations, providing a buffer against economic uncertainties (www.zerowastescotland.org.uk., 2015).

3.2 Key Drivers/Opportunities for the Development of Remanufacturing

The development of remanufacturing is driven by several key factors and opportunities

A. **Resource Scarcity and Critical Raw Materials**
B. **Economic and Market Factors**
C. **Supply Chain Disruptions and Resilience**
D. **Regulatory/Policy Developments**

A: RESOURCE SCARCITY AND CRITICAL RAW MATERIALS

One of the most pressing drivers for remanufacturing is the increasing scarcity of critical raw materials, particularly in Europe. Raw materials are vital to the economy, supporting a robust industrial base and the production of goods integral to everyday life and modern technologies. However, the number of critical materials has more than doubled, rising from 14 in 2011 to 34 in 2023 (Europa.eu., 2023) and the access to these materials is increasingly uncertain, creating significant pressure on manufacturing industries. This scarcity is exacerbated by the concentration of these materials in non-European countries, creating a dependency that heightens supply risks for the EU. Remanufacturing offers a viable solution that helps to mitigate these risks by reducing the need for new raw materials, thereby addressing both supply chain vulnerabilities and resource shortages. (Peck, D. (2024) CIRCULEIRE TWG Session 2, Ireland).

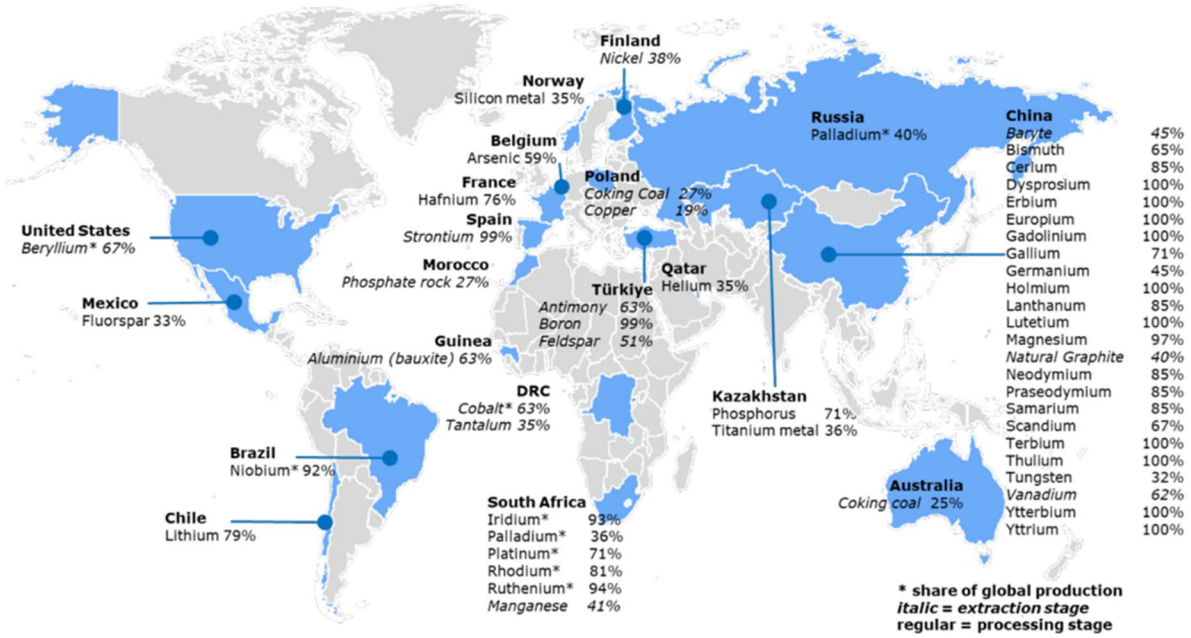


Figure 4: Main EU suppliers of individual CRMs. European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M., Veeh, C., Study on the critical raw materials for the EU 2023 – Final report, Publications Office of the European Union, 2023

Recognizing this need, the EU has introduced the Critical Raw Materials Act, which aims to strengthen all stages of the critical raw materials value chain, diversify imports to reduce strategic dependencies, enhance the EU's capacity to monitor and mitigate supply disruptions, and improve circularity and sustainability. The Act will create an enabling environment, offering opportunities for remanufacturing to play a key role in achieving the targets outlined within the Act (Peck, D. (2024) CIRCULEIRE TWG Session 2, Ireland).

B: ECONOMIC AND MARKET FACTORS

Economically, remanufacturing is particularly attractive for high-value products where the cost of remanufacture is significantly lower than producing new items. In sectors like aerospace and automotive, the high initial cost of products creates substantial opportunities for remanufacturing. However, the cost of remanufacturing must remain competitive; for example, in the aerospace sector, if remanufacturing costs exceed 65% of the cost of a new product, it is often deemed "beyond economic repair." (Ijomah, W. (2024) CIRCULEIRE TWG Session 1, Ireland).

C: SUPPLY CHAIN DISRUPTIONS AND RESILIENCE

The supply chain disruptions experienced between 2020 and 2022 highlighted the strategic importance of remanufacturing. During this period, companies with in-house or approved third-party remanufacturing operations gained a competitive advantage by being able to supply components and final products when new ones were not available. This experience underscored the role of remanufacturing in enhancing business

resilience and mitigating the risks associated with supply chain disruptions (Fitzsimons, D. (2024) CIRCULEIRE TWG Session 4, Ireland).

D : REGULATORY/POLICY DEVELOPMENTS

As evidenced in Section 2, policy frameworks at a European Union and national level, are increasingly promoting remanufacturing as part of a broader shift towards sustainability. Legislation such as the Ecodesign for Sustainable Products (Europa.eu., 2024), the Right to Repair, Fit for 55, the Critical Raw Material Act and the Net Zero Industry Act at a EU level and then GPP Strategy and Action Plan as well as Circular Economy Strategy in Ireland are creating a landscape that is favourable for the development of remanufacturing in Europe (Peck, D. (2024) CIRCULEIRE TWG Session 2, Ireland and Fitzsimons, D. (2024) CIRCULEIRE TWG Session 4, Ireland).

3.3 Key Challenges/barriers for the Development of Remanufacturing

REGULATORY AND ACCESS BARRIERS

COMPLEX REGULATIONS

Navigating the often unclear or insufficiently developed regulatory landscape for remanufacturing can be challenging due to varying standards and compliance requirements across regions, with a lack of specific laws and standards governing remanufacturing.

Intellectual Property (IP) and Design Rights

Uncertainties around IP and design rights ownership in remanufactured products can deter companies from investing in remanufacturing processes.

COLLECTION AND LOGISTICS

Efficient Collection Systems

Establishing efficient systems for collecting used products is crucial. Inconsistent collection mechanisms can hinder the steady supply of cores (used products) needed for remanufacturing.

Logistics Chain

Managing the logistics of transporting used products to remanufacturing facilities can be complex and costly. Logistics still need improving, with real-time route optimization by third-party services that could enhance efficiency for both domestic and international collections.

MARKET STRUCTURE AND CUSTOMER PERCEPTION

Market Dynamics

The current market structure often favours new products over remanufactured ones, limiting market opportunities for remanufactured goods. The current cost structure in manufacturing often does not account for resource constraints and environmental impacts, focusing instead on raw material and labour costs.

Customer Perception

There is a prevalent snobbery against used goods, with many customers perceiving remanufactured products as inferior in quality. This perception can hinder market acceptance and demand.

TECHNOLOGICAL AND EFFICIENCY CHALLENGES

Technological Expertise

A lack of understanding and expertise in remanufacturing techniques, including advanced technologies, tools and business models, can impede progress.

Limited knowhow and skills, as many companies lack a deep understanding of remanufacturing processes and often confuse it with repair or reengineering.

Efficiency

Achieving the same level of efficiency in remanufacturing as in manufacturing new products remains a significant challenge.

Design limitations

Products are frequently not designed with remanufacturing in mind, making it difficult to disassemble and reassemble them efficiently.

ADMINISTRATIVE AND STRUCTURAL BARRIERS

Administrative Hurdles

Administrative processes related to remanufacturing can be cumbersome, adding to the operational burden.

Structural Barriers

Rapid technological evolution and high wages in certain regions can create structural barriers to the widespread adoption of remanufacturing.

Investment Constraints

Small and medium-sized enterprises (SMEs) often struggle with funding to invest in the necessary tools and technologies, making it difficult to scale their remanufacturing operations.

DEFINITIONS AND INDUSTRY PRACTICE

Commercial and regulatory discrepancies

Different sectors use varied terminology to describe similar processes. For instance, the medical equipment sector often uses the term “refurbishment” instead of “remanufacturing,” which complicates regulatory compliance and market communication.

Language and terminology variations

Translating terms like remanufacturing into different languages can alter their meaning, leading to discrepancies in global practices and standards.

“Spray and Pray” operators

Small companies that claim to remanufacture products without fully disassembling or refurbishing them. This practice raises issues of non-compliance and the misuse of the term “remanufacturing,” undermining the credibility and standards of the industry.

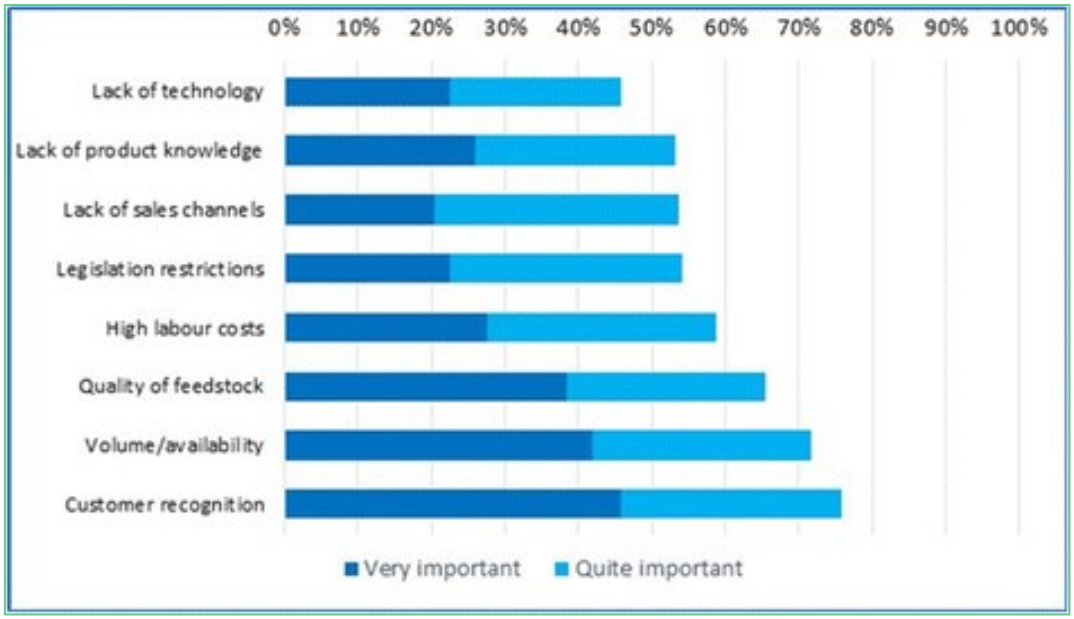


Figure 5: Barriers seen as ‘quite’ or ‘very’ important (Percentage of respondents) from in “European Remanufacturing Network market study”, 2015

Addressing these barriers requires a multi-faceted approach involving regulatory reforms, technological advancements, market education, and strategic investments. By overcoming the most pressing challenges (Figure 5), the industry can unlock the full potential of remanufacturing, contributing to a more sustainable and resource-efficient future.

Section 4: Insights & Conclusions

> **"Remanufacturing is an intensive, standardized industrial process that provides an opportunity to add value and utility to a product's service life. Repair, refurbishment, and other VRPs are maintenance processes that typically occur outside of industrial facilities and provide an opportunity to extend the product's useful life."**

RE-DEFINING VALUE THE MANUFACTURING REVOLUTION
Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy. IRP (2018)

In an era marked by increasing environmental awareness and resource scarcity, remanufacturing emerges as a critical strategy for achieving a more sustainable and circular economy and promoting supply chain resilience (Ijomah, W. (2024) CIRCULEIRE TWG Session 1, Ireland.). Remanufacturing extends the lifecycle of products and ensures that valuable materials are reused rather than discarded (Ibid). The role of remanufacturing will only become more significant, making it a cornerstone of future industrial practices.

4.1 Insights for industry

1. **REMANUFACTURING AS AN INNOVATION DRIVER**
   Remanufacturing significantly drives innovation by encouraging organizations to invest in research and development to continuously improve processes and technologies. The remanufacturing process inherently involves multiple feedback loops and rigorous testing, fostering continuous improvement. For instance, in the aerospace industry, remanufacturing jet engines involves advanced diagnostics and precision engineering, leading to innovations that enhance engine performance and reliability. And more, Caterpillar's remanufacturing program has been highly successful, allowing the company to rebuild machinery and components to like-new condition, which maximizes productivity and reduces costs by up to 60% compared to new products (Klaidman, 2021),). Similarly, GE Healthcare's GoldSeal™ program refurbishes medical imaging devices, providing cost-effective and reliable solutions for healthcare providers. By establishing robust feedback mechanisms to learn from customer experiences, companies enhance product quality and service, making

remanufacturing a key component of their innovation strategy. This continuous cycle of improvement not only boosts operational efficiency but also positions companies at the forefront of circular business models. Additionally, remanufacturing can reduce production costs by up to 60%, demonstrating its economic and environmental benefits. This dual impact underscores the importance of remanufacturing as a driver of industrial innovation and circularity (see the Case Studies featured in this Report).

2. **RECIRCULATION STRATEGIES WORK BEST IN CONJUNCTION**

Using recirculation strategies in combination will help derisking the transition and testing phases by **ensuring flexibility**, with different strategies applied based on the condition and value of the returned products, allowing for more adaptable and responsive operations; **mitigating risks**, if one strategy faces challenges, others can compensate, maintaining overall system stability; and **increasing market acceptance**, gradually introducing refurbished and remanufactured products alongside repaired and reused items, building consumer trust and acceptance, smoothing the transition to a circular economy. By understanding the value retention distinct strategies, businesses can make informed decisions about managing their products' end-of-life stages, balancing resource efficiency, cost, and product performance. See iQuTech Case Study in Section 1.2 for a real life example.

3. **EARLY SYSTEMIC INTERVENTION: DESIGN FOR REMANUFACTURING**

Overcoming barriers to implementing remanufacturing requires a multifaceted approach, starting with the design phase. Products should be designed with their future remanufacturing potential in mind, which involves creating designs that facilitate easy assembly and disassembly. **Design for Remanufacturing (**Boorsma, 2022) is inherently complex, as it requires balancing features that make a product both easy to take apart and put back together, which are often opposing characteristics. Despite these challenges, investing effort in this area is crucial for the long-term viability of remanufacturing (See Tympany Medical Case Study in Section 1.3). For example, Caterpillar has successfully integrated design for remanufacturing into their product development, allowing for efficient disassembly and reassembly of heavy machinery components. This approach not only extends the lifecycle of their products but also significantly reduces waste and production costs. By focusing on early systemic intervention, companies can enhance their remanufacturing capabilities and drive innovation.

4. **REMANUFACTURING AND SERVICE-BASED MODELS ARE MUTUALLY BENEFICIAL**

Transitioning from traditional product ownership to a **Product as a Service (PaaS)** model, where customers pay for usage rather than ownership, can significantly enhance remanufacturing efforts. This model ensures a consistent return flow of used products, which are essential for remanufacturing processes. For instance,

companies like Xerox have successfully implemented PaaS models, resulting in a 30% reduction in material costs and a 25% increase in product lifecycle (Xinlan, et alt., 2024). By adopting service-based business models, such as leasing or PaaS, companies can create a sustainable cycle of product use and reuse. Furthermore, fostering partnerships with suppliers and customers can strengthen the remanufacturing ecosystem, driving mutual benefits and promoting greater circularity.

5. PRIORITIZING HIGH VALUE PRODUCTS

Organisations should conduct a detailed cost-benefit analysis to ensure remanufacturing is economically viable, focusing on high-value products where significant savings can be achieved (see Section 1.2 above for insights on the Benefits of Remanufacturing and see BORG Case Study in Section 1.1) and organisations can recover and retain high-value products, components and harvest materials for higher quality recycling. Furthermore, providing strong customer support and warranties can build trust and confidence in remanufactured products, highlighting their advantages for high-value goods. Incorporating customer-service-supported VRPs into a company's operations can enhance and deepen valuable customer relationships while also expanding into new and diverse market segments.

6. WARRANTY IS KEY: QUALITY CONTROL AND GLOBAL STANDARDS TO WIN CUSTOMERS BIAS

Remanufacturing is the only reuse process that can provide the same warranty as a new product, as it ensures the same functionality as the original (see The Orange Box Case Study in Section 2.2). Industry should invest in implementing rigorous testing procedures to guarantee that remanufactured products meet or exceed original performance standards. Obtaining certifications to validate the quality and sustainability of your remanufactured products play a key role in boosting acceptance from B2B and B2C customers. For instance, Caterpillar, a leader in the remanufacturing industry, offers the same warranty on their remanufactured engines as they do on new ones. This practice has significantly increased customer trust and satisfaction, leading to a 20% rise in sales of their remanufactured products over the past five years (Alqahtani, A.Y. and Gupta, S.M., 2017). Additionally, studies have shown that remanufactured products with robust warranties can reduce customer hesitation and increase purchase likelihood by up to 30% (Otieno, W. and Liu, Y., 2016).

4.2 Insights for public sector

1. **DRIVING REMANUFACTURING ADOPTION THROUGH TARGETED POLICIES AND CLEAR GUIDELINES**

   Remanufacturing is increasingly recognized in Europe and national policies as a key enabler of circular economy. Recent policy developments are creating a favourable environment for the promotion of remanufacturing practices as commercially scalable circular business model.

   Setting specific targets and requirements for remanufacturing, sends strong signals to industry which can accelerate implementation. For example, **in the automotive sector**, regulations such as the End-of-Life Vehicles (ELV) Directive in the European Union mandate that a significant percentage of vehicle components must be reused or recycled (Golinska, P., Kawa, A., (2011). This directive encourages remanufacturing practices. Additionally, the Federal Vehicles Repair Cost Savings Act in the United States encourages the use of remanufactured parts in federal vehicles to cut costs and support environmental goals (Rematec.com, 2016). See Revolve Case Study on the automotive sector in Section 1.2.

   Developing clear standards and guidelines that are embraced by both industry and public sector is essential to supporting remanufacturing adoption. Standards and industry guidelines can serve as benchmarks for best practice and provide clarity for businesses adopting remanufacturing business models. **In the med tech sector**, the U.S. Food and Drug Administration (FDA) has specific guidelines for remanufacturing medical devices. These guidelines require entities to comply with stringent quality system regulations, including registration, adverse event reporting, and marketing submissions (Federal Register, 2024). The FDA's focus is on ensuring that remanufactured medical devices meet the same safety and effectiveness standards as new devices (Food and Drug Admnistration, 2024). See Vanguard Case Study in Section 2.1 on the med tech sector.

   Ongoing efforts aim to create more consistent policies and guidelines that balance economic viability, environmental sustainability, and regulatory compliance. Industry must stay updated on evolving policies, regulations, and standards relevant to remanufacturing, such as the EU Ecodesign for Sustainable Products Regulation, Ireland’s Green Public Procurement Action Plan, and British Standards. Staying informed ensures compliance and enables businesses to capitalize on available incentives and opportunities.

2. **CLARIFYING THE ROLE OF REMANUFACTURING IN THE WASTE HIERARCY**

   One of the key debates surrounding remanufacturing is its classification within the waste hierarchy. As mentioned in Section 1.3, Irish Manufacturing Research, acting as the Secretariat of CIRCULÉIRE, advocates for remanufacturing to be classified as a

waste prevention activity (like reuse) focused on life-extension of components / sub-assemblies and products rather than a waste activity associated with materials. This approach would exempt remanufacturing from the regulations associated with waste management, reducing regulatory hurdles that could deter businesses from adopting these practices. Providing clear regulatory guidance and reducing burdens can encourage more companies to integrate remanufacturing into their operations, either as a core activity or a new business avenue, thereby supporting the growth of remanufacturing practices.

3. **PUBLIC PROCUREMENT AS MARKET BUILDER**

   Green Public Procurement will play a key role in the mainstreaming of remanufactured goods illustrated by the Government of Ireland's 2024 procurement framework for remanufactured laptops worth an estimated €30m (www.gov.ie, 2024). In this contract all laptops meet the BSI Kitemark standard for "Remanufacturing". Raising awareness about the benefits of remanufacturing through targeted campaigns leveraging GPP initiatives can help shift perceptions and make remanufactured products more attractive to both businesses and consumers. By educating stakeholders and promoting the positive impacts of remanufacturing, the public sector can foster a more supportive environment for the implementation of these practices from businesses, ultimately leading to greater acceptance and adoption. See Circular Computing Case Study in Section 2.2 about GPP.

4. **URGENT NEED FOR AN UPDATED REMANUFACTURING MARKET STUDY**

   The Remanufacturing Market Study conducted by ERN is nearing its 10-year mark, underscoring the urgent need for an updated, comprehensive, and cross-sectoral analysis. Over the past decade, significant advancements and shifts have occurred across various industries, necessitating a fresh market study on remanufacturing. Technological innovations, such as advancements in automation and digitalization, have transformed remanufacturing processes, making them more efficient and cost-effective. Additionally, the growing emphasis on sustainability and circular economy principles has increased the demand for remanufactured products across sectors. For example, in the automotive industry, remanufacturing has not only reduced waste but also significantly cut down on energy consumption, saving up to 85% of the energy required to produce new parts. See Revolve Case Study in Section 1.2 and BORG Case Study in Section 1.1 for real life examples of the savings. A new cross-sectoral market study would provide critical insights into current trends, technological innovations, and emerging opportunities, ensuring stakeholders are well-informed and equipped to navigate the evolving landscape of remanufacturing. An updated cross-sectoral analysis, with sectoral insights, is essential for understanding market dynamics and fostering scale-up of remanufacturing.

5. SYNERGIES IN AND BEYOND THE SUPPLY-CHAIN TO FOSTER REMANUFACTURING

Remanufacturing necessitates robust synergies within supply chains to be truly effective. This involves organizing a comprehensive logistic system that ensures the safe and reliable take-back, processing, and resale of products. Collaboration with various stakeholders across the value chain, including suppliers, manufacturers, and distributors, is essential to streamline these processes. A prime example of successful remanufacturing is Caterpillar's Reman program, which has significantly reduced waste and lowered costs by reclaiming and refurbishing used parts. Additionally, promoting a triple helix approach—leveraging the interaction between academia, industry, and government—can drive innovation and policy support. For instance, the European Remanufacturing Network (ERN) exemplifies how such collaboration can enhance remanufacturing practices, leading to economic and environmental benefits. In Ireland, the EPA-led **National Repair and Reuse Network,** which includes representatives from government, industry, and academia, facilitates knowledge sharing and engagement to support and scale reuse and repair activities in Ireland. Explicitly Including remanufacturing within the scope of this network partnership would enhance collaboration among stakeholders. By fostering these synergies, remanufacturing can play a key role in advancing a circular economy, reducing resource consumption, and minimizing environmental impact.

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CIRCULÉIRE

About CIRCULÉIRE

CIRCULÉIRE, is Ireland's first cross-sectoral industry-led circular

innovation network dedicated to accelerating Ireland's transition towards a net-zero carbon circular economy. A key objective of the programme is to demystify, de-risk and deliver circular business model innovation for Irish industry.

Irish Manufacturing Research (IMR) is the secretariat of CIRCULÉIRE – which was co-designed and co-funded by the Department of Environment, Climate and Communications (DECC), the Environmental Protection Agency (EPA) and EIT Climate-KIC between 2020-2022. In November 2022, DECC announced sole continuation funding for CIRCULÉIRE from 2023 onwards.

Want to learn more about CIRCULÉIRE? Look at www.Circuléire.ie **or contact** Circuléire@imr.ie

CIRCULÉIRE

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IRISH MANUFACTURING RESEARCH

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