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Remanufacturing for Ireland (ReManIre)

Authors: Damian Coughlan, Colin Fitzpatrick, Jason Power and Alan Ryan

Lead organisation: University of Limerick

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Rialtas na hÉireann
Government of Ireland

Environmental Protection Agency

The EPA is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: Implementing regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.

Knowledge: Providing high quality, targeted and timely environmental data, information and assessment to inform decision making.

Advocacy: Working with others to advocate for a clean, productive and well protected environment and for sustainable environmental practices.

Our Responsibilities Include:

Licensing

- Large-scale industrial, waste and petrol storage activities;
- Urban waste water discharges;
- The contained use and controlled release of Genetically Modified Organisms;
- Sources of ionising radiation;
- Greenhouse gas emissions from industry and aviation through the EU Emissions Trading Scheme.

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- Drive the implementation of best practice in regulated activities and facilities;
- Oversee local authority responsibilities for environmental protection;
- Regulate the quality of public drinking water and enforce urban waste water discharge authorisations;
- Assess and report on public and private drinking water quality;
- Coordinate a network of public service organisations to support action against environmental crime;
- Prosecute those who flout environmental law and damage the environment.

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- Implement and enforce waste regulations including national enforcement issues;
- Prepare and publish national waste statistics and the National Hazardous Waste Management Plan;
- Develop and implement the National Waste Prevention Programme;
- Implement and report on legislation on the control of chemicals in the environment.

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- Engage with national and regional governance and operational structures to implement the Water Framework Directive;
- Monitor, assess and report on the quality of rivers, lakes, transitional and coastal waters, bathing waters and groundwaters, and measurement of water levels and river flows.

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- Publish Ireland's greenhouse gas emission inventories and projections;
- Provide the Secretariat to the Climate Change Advisory Council and support to the National Dialogue on Climate Action;
- Support National, EU and UN Climate Science and Policy development activities.

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- Design and implement national environmental monitoring systems: technology, data management, analysis and forecasting;
- Produce the State of Ireland's Environment and Indicator Reports;
- Monitor air quality and implement the EU Clean Air for Europe Directive, the Convention on Long Range Transboundary Air Pollution, and the National Emissions Ceiling Directive;
- Oversee the implementation of the Environmental Noise Directive;
- Assess the impact of proposed plans and programmes on the Irish environment.

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- Coordinate and fund national environmental research activity to identify pressures, inform policy and provide solutions;
- Collaborate with national and EU environmental research activity.

Radiological Protection

- Monitoring radiation levels and assess public exposure to ionising radiation and electromagnetic fields;
- Assist in developing national plans for emergencies arising from nuclear accidents;
- Monitor developments abroad relating to nuclear installations and radiological safety;
- Provide, or oversee the provision of, specialist radiation protection services.

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- Provide independent evidence-based reporting, advice and guidance to Government, industry and the public on environmental and radiological protection topics;
- Promote the link between health and wellbeing, the economy and a clean environment;
- Promote environmental awareness including supporting behaviours for resource efficiency and climate transition;
- Promote radon testing in homes and workplaces and encourage remediation where necessary.

Partnership and Networking

- Work with international and national agencies, regional and local authorities, non-governmental organisations, representative bodies and government departments to deliver environmental and radiological protection, research coordination and science-based decision making.

Management and Structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

1. Office of Environmental Sustainability
2. Office of Environmental Enforcement
3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

Remanufacturing for Ireland (ReManIre)

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What did the research aim to address?

The ReManIre project, funded by the Environmental Protection Agency and led by the University of Limerick, explores how Ireland can position itself as a global centre of excellence for remanufacturing. Remanufacturing is defined as the industrial process of returning a product to at least its original performance with a warranty equivalent to or better than new. It is increasingly recognised as a vital circular economy strategy that can strengthen supply chain resilience, reduce carbon emissions, conserve materials and energy, and create high-quality employment. Against the backdrop of rising climate pressures, geopolitical instability and material scarcity, the European Union has prioritised circularity and industrial decarbonisation, making remanufacturing an important component of future competitiveness.

The study uses the Triple Helix model of University, Industry and Government to gather national and international perspectives from stakeholders through a state-of-the-art literature review, detailed stakeholder mapping, twenty-six semi-structured interviews and a follow-up survey. Findings show that the potential of remanufacturing in Ireland is substantial, but several barriers restrict its wider adoption. Awareness and understanding of remanufacturing remain limited across many sectors, and cultural attachment to linear business models continues to dominate decision-making. Regulatory uncertainty also poses challenges, particularly where waste classifications, medical device regulations and inconsistent interpretations of EU rules lead to confusion for manufacturers and remanufacturers. Many organisations report difficulties accessing product information and technical data from Original Equipment Manufacturers, whose intellectual property practices and business models can inhibit third-party remanufacturing. Economic and market barriers—including high labour costs, limited takeback systems and inconsistent access to used products ("cores")—further constrain scaling efforts. A shortage of skills and the lack of dedicated educational pathways in design for remanufacture and lifecycle engineering also limit capability growth.

What did the research find?

Despite these challenges, the report identifies strong drivers that position Ireland for significant progress. EU policy, most notably the Circular Economy Action Plan and the Ecodesign for Sustainable Products Regulation, explicitly supports remanufacturing, while Digital Product Passports, IIoT technologies and advanced analytics open new opportunities for traceability, diagnostics and sustainable product design. Stakeholders emphasise that Ireland's experience in high-value manufacturing, coupled with growing public-sector interest in green procurement and the introduction of frameworks such as the OGP's remanufactured laptop initiative, provides a solid foundation for market development. The increasing pressure on critical raw materials is also heightening interest in circular resource strategies across industry.

The project finds strong consensus that a coordinated national approach is needed. Stakeholders highlight the importance of developing a national policy framework that clarifies definitions, harmonises regulation and supports cross-border flows of remanufactured goods. They also identify a clear need for a national centre of excellence to provide shared testing facilities, demonstration capabilities, skills development, applied research and industry support. Such a centre would act as a focal point for collaboration and capability building across academia, government and industry. Priority sectors where Ireland could gain early advantage include medical devices, ICT and electronics, e-mobility and batteries, heavy machinery and renewable energy technologies.

How can the research findings be used?

Overall, the report concludes that remanufacturing offers Ireland a strategic opportunity to enhance industrial resilience, reduce environmental impact and capture significant economic value. By addressing regulatory barriers, strengthening education and skills, supporting business model innovation and establishing a centre of excellence, Ireland can accelerate the adoption of remanufacturing and contribute meaningfully to Europe's broader transition toward a competitive, climate-neutral and circular industrial landscape.

Project code: 2022-GCE-1134

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Remanufacturing for Ireland (ReManIre)

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EPA Research Report

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Prepared by

University of Limerick

Authors:

Damian Coughlan, Colin Fitzpatrick, Jason Power and Alan Ryan

ENVIRONMENTAL PROTECTION AGENCY
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699
Email: info@epa.ie Website: www.epa.ie

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This report is based on research carried out/data from September 2023 to August 2025. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Project Partners

Dr Damian Coughlan
Department of Electronic & Computer Engineering
University of Limerick
Castletroy
Limerick
Ireland
V94 T9PX

Professor Colin Fitzpatrick
Department of Electronic & Computer Engineering
University of Limerick
Castletroy
Limerick
Ireland
V94 T9PX
Email: colin.fitzpatrick@ul.ie

Dr Jason Power
School of Education
University of Limerick
Castletroy
Limerick
Ireland
V94 T9PX

Dr Alan Ryan
School of Engineering
University of Limerick
Castletroy
Limerick
Ireland
V94 T9PX

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Executive Summary

Remanufacturing is defined as the industrial practice of returning a product to at least its original performance with a warranty that is equivalent to or better than that of a newly manufactured product. Remanufacturing is a key industrial circular economy business model that has been implemented across several industrial sectors and it is championed for its economic, environmental and societal benefits. Remanufacturing enables product-level efficiency by reducing materials and energy requirements and lowering emissions and waste, thus building resilience and resource efficiency. Remanufactured products often have higher profit margins and longer lifetimes than those of the original manufactured items, reducing the need to extract virgin raw materials. Remanufacturing creates new skill sets and employment. The growing impacts of climate change, geopolitical conflicts and the COVID-19 pandemic have shown how sensitive our supply chains are to external factors that can cause disruption to energy supply and access to materials. In response to these challenges, the European Commission has prioritised initiatives such as the Clean Industrial Deal to transform Europe's industrial sectors by decarbonising, boosting competitiveness, ensuring energy security and promoting circularity and driving innovation.

The research was conducted using the Triple Helix model of innovation pillars (university, industry and government). Stakeholders from all areas of remanufacturing were interviewed to gather insights and opinions on how we can support remanufacturing activity in Ireland.

The outcomes of this research identified the following themes: regulation is seen as a barrier to and enabler of remanufacturing; collaboration across the island of Ireland is key to building momentum; education and skills are needed to bridge gaps in knowledge of remanufacturing; and government support through policy and funding is key to advancing remanufacturing in Ireland. The main recommendations from this report are as follows: create a centre of excellence to advance remanufacturing; create policies to promote remanufacturing and support Irish businesses in line with European Union policy; and create a roadmap to support remanufacturing in Ireland through further stakeholder engagement across industry, government and education.

The research outcome proposes the development of a roadmap for remanufacturing in Ireland and the creation of a centre of excellence with inputs from all stakeholders to provide a resource for opportunities for companies to test and build out their remanufacturing capabilities through funding, education or collaboration. The advancement of remanufacturing is seen as a key enabler in delivering a more competitive and resilient Ireland and European Union.

1 Introduction

1.1 Background

The definition of remanufacturing as used by the European Remanufacturing Council is “the industrial process of returning a product to at least its original performance” and, according to British Standard 8887-2, remanufacturing is defined as an industrial practice of “returning a product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product” (Parker *et al*., 2015).

Remanufacturing has been identified as a circular business model for industry that has been practised for many years in the automotive and aviation industries and several other sectors (Nasr *et al*., 2018). Remanufacturing can also be described as a value retention process, and this process can create net-positive outcomes by enabling product-level efficiency, with reductions in materials and energy use and in emissions and waste generation (Nasr *et al*., 2018). The process steps for remanufacturing include disassembly, cleaning, repair and replacement of damaged or worn components, reassembly and testing, with the remanufactured product being of the same quality and coming with the same warranty as that of a new product (European Remanufacturing Council, 2017a).

However, remanufacturing has yet to fulfil its potential across the European Union (EU) (Karvonen *et al.*, 2017). The European Remanufacturing Council estimates that there is the potential to create significant economic and environmental benefits in the EU (Parker *et al.*, 2015). There are several important barriers to and drivers of the implementation of remanufacturing at the local, national and international levels (Matsumoto *et al.*, 2016). Added to this is the lack of a formal definition of remanufacturing and what the activity entails; there is ongoing debate on whether it is classified as a waste prevention activity or a waste activity, as this can pose a significant threat to remanufacturing by categorising the activity under waste regulations. The waste hierarchy (Figures 1.1 and 1.2) is the foundation of existing European legislation such as the Ecodesign for Sustainable Products Regulation and the Waste Electrical and Electronic Equipment Directive.

The Remanufacturing for Ireland (ReManIre) project is funded by the Environmental Protection Agency (EPA) under its green and circular economy research funding scheme, with funding awarded to the University of Limerick in 2024. The purpose of this project is to provide a roadmap to support Ireland’s development as a global centre of excellence for remanufacturing while promoting resilient jobs as part of the circular economy. The project undertakes a combination of desk study and primary data collection to gather data using the Triple Helix model of innovation, with the aim of understanding the success factors for and barriers to remanufacturing,

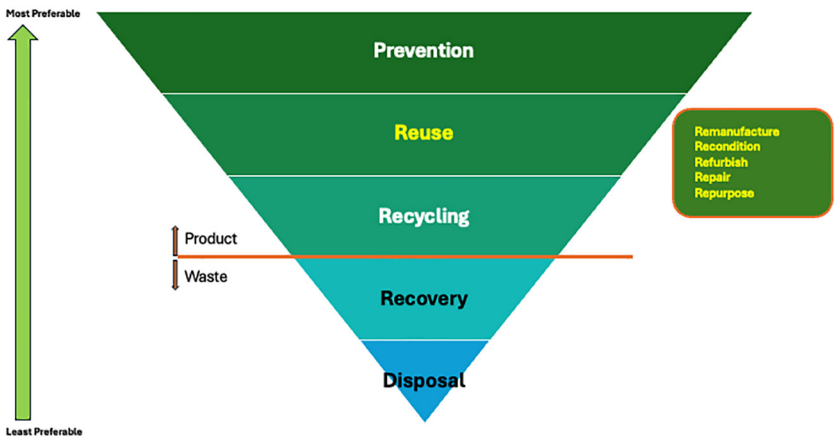

Figure 1.1. The waste hierarchy.

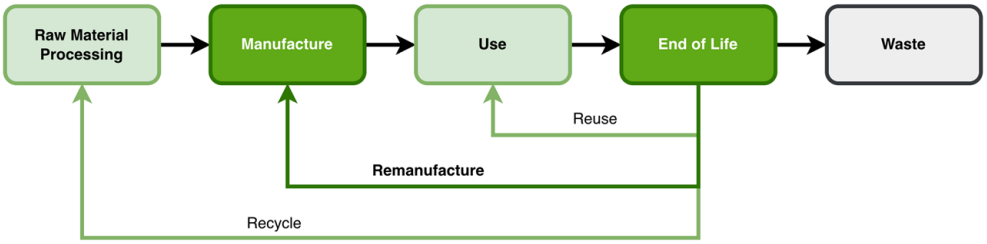

Figure 1.2. Remanufacturing and the circular economy.

and to gather opinions on and insights into how a remanufacturing sector can be supported in Ireland. The output of the project will be focused on supporting policymakers and business supports that can create the conditions for remanufacturing to thrive. The roadmap for remanufacturing will be informed by stakeholder experience and feedback to map out a pathway for remanufacturing in Ireland and to align with and support the EU and Member States in future endeavours.

The roadmap is being developed using the Triple Helix model of innovation, which refers to a set of interactions between university, industry and government pillars to foster economic and social development through innovation and entrepreneurship. The Triple Helix model seeks to align the relationships between university (education and research), industry and government to rapidly advance sustainable industrial development. Within the context of the project and using the Triple Helix model, a preliminary stakeholder mapping exercise was completed, as shown in Figure 1.3. Recirculation strategies such as reuse, repair and remanufacture through product lifetime extension and new circular business models are stated to be highly promising for achieving certain targets (Marini *et al.*, 2024).

The Whole of Government Circular Economy Strategy 2022–2023 (DECC, 2021) defines remanufacturing as an industrial process where products are taken apart, cleaned, repaired and reassembled to a like-new condition so that they can used again. Remanufacturing has been identified as having economic, environmental and societal benefits. The economic benefits range from cost savings through lower production costs for energy and materials to value retention by preserving the embedded value from production and extending product lifetimes and increased market access by offering lower cost products. The environmental benefits are seen in the reduction in materials and energy use, which reduces the carbon footprint and also reduces the demand for virgin raw materials and minimises waste. The societal benefits can be seen in the creation of employment and the provision of good-quality products for different market tiers, and in business model innovation such as product service systems.

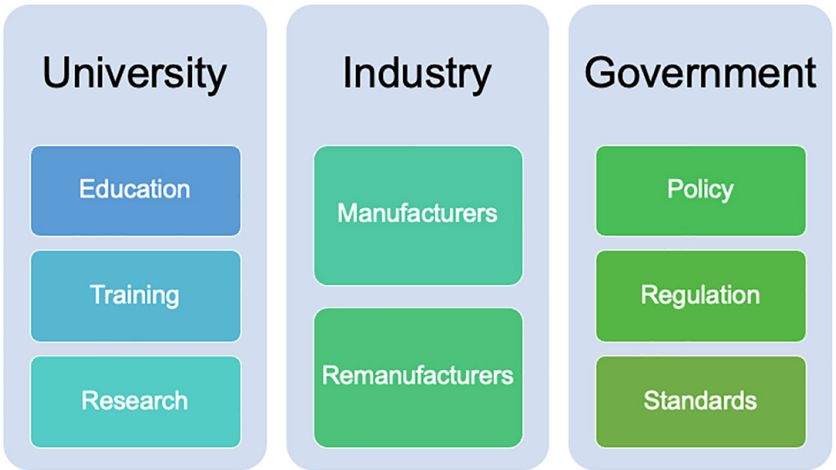

Figure 1.3. The Triple Helix.

The EU has initiated and developed a body of work to implement more sustainable and circular economy practices in the single market through the likes of the Clean Industrial Deal and the Ecodesign for Sustainable Products Regulation, the latter setting out a proposal for digital product passports. The Draghi report identified the key pillars to secure the future of European competitiveness and highlighted three vital components to boost the EU's competitiveness: closing the innovation gap, decarbonising our economy and reducing dependencies (Draghi, 2025). Remanufacturing is an important strategy in this respect, as it drives innovation, creates quality jobs, helps reduce carbon footprints and reduces dependency on virgin raw materials.

1.2 State-of-the-Art Review

1.2.1 Introduction

The impacts of climate change have become one of the main risks for many people on our planet. The impact of human activities on our planet has dictated that we change our methods and our management of these activities. The rapid industrialisation that has taken place over the past 200 years has committed many countries to a course that threatens to further damage life on Earth. In response to the increasing impacts of climate change, countries and governments have sought to minimise these impacts by implementing policies that encourage and force more sustainable practices.

Repositioning our activities on this planet to address climate change requires both mitigation and adapting our current approach to our activities.

Recent events such as the COVID-19 pandemic and the outbreak of war in Ukraine have presented a glimpse of a future where supply chains are no longer resilient and where events outside our control can impact the economies and well-being of many.

Manufacturing is estimated to account for 20%, or one-fifth, of worldwide emissions, according to the United Nations (UN). These emissions, coupled with our extensive extraction of mineral resources, have led to a crisis point where our planet's climate has been adversely affected by human activity.

Manufacturing throughout the globe has been impacted by supply chain disruption caused firstly by China implementing a quota system on raw material extraction and export, instead favouring its supply of domestic markets, and, secondly, by the COVID-19 pandemic in 2019, which placed further stress on an already tentative global supply chain. The ongoing illegal invasion of Ukraine by Russia has placed further strain on material and food supply chains as well as dispersing citizens to other countries. The EU has been developing policy in recent years to advance the more efficient use of energy, water and materials, establishing legislation to drive EU Member States to adopt measures to secure their economies and consolidate sustainable and resource-efficient practices.

The EU has developed the European Green Deal, which aims to make the EU climate neutral. The main components of the strategy are no net emissions of greenhouse gases by 2050, decoupling economic growth from resource use, and leaving no person or place behind in this transition (European Commission, 2019). The REPowerEU plan was introduced in 2022 to reduce energy dependency on Russia in the wake of the invasion of Ukraine and to strengthen economic growth, security and climate action (European Commission, 2022).

The Green Deal Industrial Plan was developed for industry in Europe to increase technology development, manufacturing production and use of resource-efficient products. This deal was designed to complement other efforts to transform industry, such as the Circular Economy Action Plan (European Commission, 2020).

The Green Deal Industrial Plan is based on the following key foundations: a simplified regulatory environment, access to funding, enhancing skills and open trade to ensure resilient supply chains (European Commission, 2023). Under the Green Deal Industrial Plan, the Net-Zero Industry Act and the Critical Raw Materials (CRM) Act have been developed to formalise the EU's commitment to net zero emissions and secure its future.

The Net-Zero Industry Act will create a simpler and predictable legal framework for net zero industries through establishing a more secure supply of clean energy (European Commission, 2023).

The CRM Act will allow the EU to identify raw materials that are strategically important for manufacturing and

clean energy technology and to diversify the supply chain, thus lessening the reliance on one source (Watkins *et al.*, 2023). The CRM Act will also seek to identify and recover materials in use in Europe and reduce the dependence on imports.

The Circular Economy Action Plan was introduced to provide a sustainable product policy framework to increase circularity in products by mandating and expanding the remit of the Ecodesign Directive. This legislative initiative will help increase product reuse, repair and durability while addressing the use of hazardous materials, increasing energy and resource efficiency and increasing the content of recycled material in products. It will enable remanufacturing and a reduction in carbon and environmental footprints, and restrict single use and premature obsolescence (European Commission, 2015).

The circular economy has a key part to play in the transition of industry towards energy and resource efficiency. Remanufacturing has an important part to play in the transition to climate neutrality and as a sustainable strategy for companies to reduce the need for new materials, reduce energy use, extend product lifetime and create a circular value chain for their products.

In 2024, the Circle Economy Foundation was commissioned by the Department of Environment, Climate and Communications (now the Department of Climate, Energy and the Environment) to provide a detailed analysis of the materials flows in Ireland and its carbon footprint, and to create a circularity baseline (Circle Economy, 2024). The report identified that Ireland has a large material footprint and a technical cycling rate of 2.7%, which is much lower than the global average of 7.2% (Circle Economy, 2024). This report also identified opportunities for Ireland to increase its circularity rate by advancing R-Strategies (for circularity) such as remanufacturing.

Parker *et al.* (2015) published the *Remanufacturing Market Study*, which sought to provide a comprehensive overview of the European remanufacturing industry. The report estimated that in 2015 the remanufacturing industry was worth over €29 billion and employed close to 200,000 employees, with over 7000 firms actively involved. The main remanufacturing activities at this time were taking place in the aerospace, automotive, heavy-duty/ off-road equipment, and electronics and electrical equipment sectors (Parker *et al.*, 2015). The recently published Ecodesign for Sustainable Products Regulation has positioned all forms of reuse, from refurbishment to remanufacturing, as the prime movers in driving more sustainability in products (European Commission, 2024).

The definitions of reuse, based on the waste hierarchy (Lansink, 2015, p. 24), and of remanufacturing have been open to some debate, and they have been characterised using different terms such as reconditioning and refurbishment. Figure 1.4 presents the definition of each R-Strategy and the differences in the product lifetime extension group.

Remanufacturing has been defined as a value retention process, as it can create a competitive advantage through a reduction in environmental impact and costs (Nasr *et al.*, 2018; Kurilova-Palisaitiene *et al.*, 2023). Remanufacturing has been practised for several decades and has become a formalised product and value recovery process in many industries (REMADE, 2023).

Remanufacturing as a value retention process has been in operation for many years in the following sectors: aerospace, automotive, electrical and electronic equipment, heavy-duty and off-road equipment, furniture, machinery, marine, medical equipment and rail (Parker *et al.*, 2015). However, remanufacturing has been gaining traction in many new industries, from consumer electronics to renewables (wind turbines, solar photovoltaic, electrolysers), e-mobility (lithium-ion batteries, fuel cells, traction motors), heat pumps and medical devices.

1.2.2 Barriers to and drivers of remanufacturing

A literature review was undertaken to understand the common barriers to and drivers of remanufacturing, and the subsequent themes have been identified. These themes are important, as they can become enablers of or barriers to companies that want to adopt more sustainable practices such as remanufacturing.

The European Remanufacturing Network conducted a remanufacturing market study in 2015. This was a comprehensive study that estimated the current levels of activity across the EU and conducted surveys with companies throughout Europe that undertake

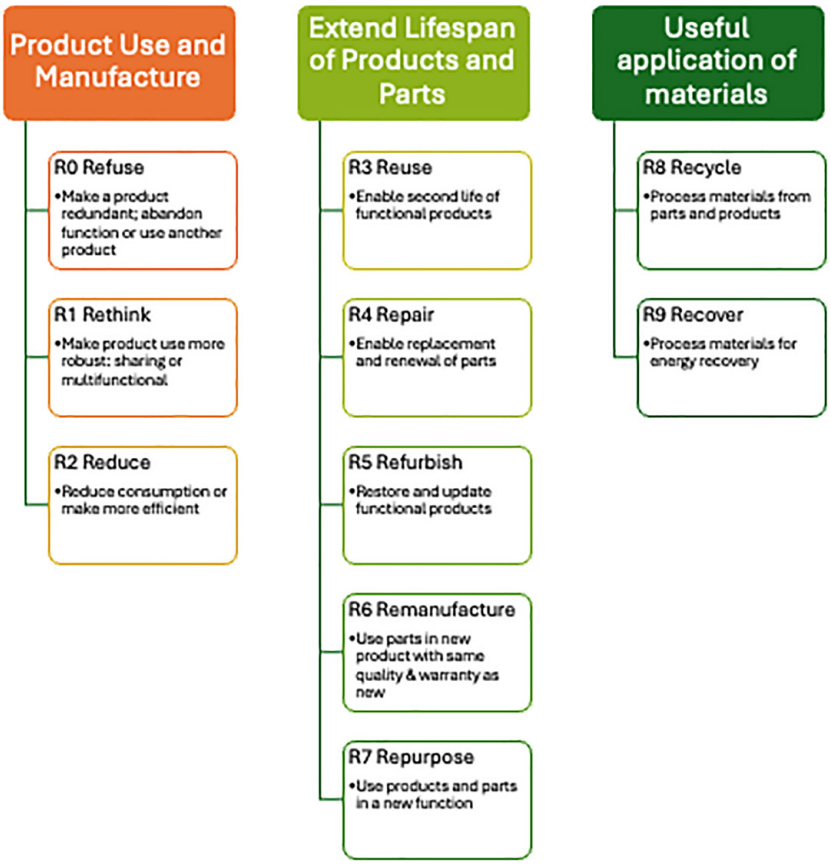

Figure 1.4. R-Strategies.

remanufacturing (Parker *et al*., 2015). The resulting report states that 70% of remanufacturing value in the EU is based in Germany, France, the UK, Ireland and Italy, with Germany accounting for one-third of activity (Parker *et al*., 2015). The study also identified the key remanufacturing sectors in Europe and undertook a deep analysis of the sectors, activities, market size, and opportunities and barriers. The main sectors for remanufacturing in Europe are the automotive, aerospace, electrical and electronic equipment, furniture, heavy-duty and off-road equipment, machinery, marine, medical equipment and rail sectors (Parker *et al*., 2015). The study conducted surveys among industries and identified motives such as higher profit margins, environmental responsibility, strategic advantage and increasing market share, and barriers such as customer recognition, volume and availability of "core" components, the quality of core components and high labour costs (Parker *et al*., 2015).

Remanufacturing practices in Ireland have been examined by CIRCULÉIRE's (Ireland's national platform for circular manufacturing) Thematic Working Group, which gathered the opinions of network members and companies throughout the island of Ireland to understand national barriers to and drivers of remanufacturing (Metitieri *et al*., 2024). This report highlighted barriers such as those related to regulations, intellectual property, logistics and market structure, and drivers such as resource scarcity, supply chain resilience and policy developments (e.g. green public procurement) to accelerate remanufacturing activity (Metitieri *et al*., 2024).

1.2.3 Policy, regulation and standards

Policy, regulation and standards are essential to drive change and to adhere to more sustainable practices. There is, however, a significant lack of remanufacturing-specific policies and legislation in the EU, although there are frameworks based on the circular economy that do specifically mention remanufacturing as a circular economy strategy along with reuse, repair and refurbishment. Remanufacturing has been defined variously as refurbishment, reconditioning and reprocessing, which has caused issues, with different definitions being used by governments and industries. There are policies in

place across the globe that support remanufacturing through either guidelines or standards.

Policies and regulations

The frameworks in the EU are based around the European Green Deal, which is a series of strategic measures by the European Commission to enable Europe to become climate neutral by 2050. The European Green Deal is a policy framework that covers climate, energy, industry and the circular economy, among other things, to make Europe more resource efficient and competitive. The Clean Industrial Deal is a vital component of the European Green Deal and has been created to address the rising challenges of energy security and decarbonisation by boosting demand for clean products, financing the clean energy transition, and advancing circularity and access to materials, with the aim of 24% of materials being circular by 2030. The Circular Economy Action Plan has been designed to promote more sustainable practices for consumers and industry, with a focus on high-impact sectors such as electronics, batteries, construction and textiles.

Remanufacturing has been identified by the European Commission as an important circular economy business model and important to the future prosperity and security of the EU (European Commission, 2020). The Circular Economy Action Plan identifies remanufacturing as a key sustainability principle to advance circularity (European Commission, 2020). The Ecodesign for Sustainable Products Regulation has been enacted by the EU to advance circular practices for specific products. Remanufactured products are considered to be new products and will come under the regulation's requirements (European Union, 2024).

Standards

Standards are understood to be a driver of remanufacturing, as specific standards provide evidence of quality and reliability for products and instil confidence in consumers and purchasing departments.

Standards in remanufacturing and the circular economy have become much more prevalent, and this is providing more clarity around these practices and increasing awareness of the quality and warranty benefits of these types of products and components.

The European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute are the three standards organisations that are officially recognised by the EU. CEN represents the national standardisation bodies of 34 European countries. CENELEC is responsible for developing technical standards for ecodesign and energy legislation. CENELEC has created the Joint Technical Committee (CEN/CLC/JTC 10 on Material Efficiency for Ecodesign) to develop a suite of eight standards in areas such as extending product lifespans and facilitating the reuse of components, which are key components of remanufacturing (CENELEC, 2025). The International Organization for Standardization (ISO) has developed a suite of standards around the circular economy and its principles and terminology (ISO 59004:2024) and on business models and value chains (ISO 59010:2024), and it is currently developing a standard for circularity performance assessment (ISO 59020). The UK has developed standards on remanufacturing-specific activities, for example British Standard 8887-220, and the USA has remanufacturing-specific standards such as ANSI RIC001.1-2016. Both of these standards clearly define remanufacturing and its core activities and processes. Standards have been identified as being a key enabler of remanufacturing.

1.2.4 Ireland

The EU Circular Economy Act was enacted into law in 2022 and was Ireland's first piece of legislation to define the circular economy and create a statutory basis for future circular actions (Government of Ireland, 2022). While there is no specific reference to remanufacturing, it does refer to specific circular strategies. The National Waste Management Plan for a Circular Economy, published in 2024, outlines a series of national targets, with target 4 centred on preparation for reuse and repair/remanufacturing (Local Government Ireland, 2024a). However, the document states that there is no current legislation or supporting dataset available to assist the development of preparation for reuse and repair targets and that there is a need to establish a clear regulatory regime to help develop this target. The National Waste Management Plan for a Circular Economy does state that "it is proposed to consider

a roadmap for the remanufacturing target in parallel with repair" (Local Government Ireland, 2024b). Supporting circular strategies through legislation and data is of key importance to building a foundation for remanufacturing and resilience in Ireland. A lack of policy and legislation has not stopped other countries from leading the charge to more sustainable practices based on the circular economy and green public procurement. In Ireland, the Department of the Environment, Climate and Communications published the Green Public Procurement Strategy and Action Plan 2024–2027 and included the first sectoral target for information and communication technology (ICT) procurement (DECC, 2024). The target states the following: "By 2025, a minimum of 80% of ICT end user products (desktop computers, portable computers and mobile phones) procured by public sector bodies under new contract arrangements are certified to EPEAT Gold Standard (or equivalent), TCO Certified (or equivalent) or will have been remanufactured". The same document states that construction products should be procured provided that they are designed in such a way that reuse, remanufacturing and recycling are facilitated. The Office of Government Procurement also developed a Remanufactured Laptops Framework that will enable the public sector to purchase remanufactured laptops, which will reduce the cost of laptops and minimise their carbon footprint (CFIT, 2024).

The EU Medical Devices Regulation (MDR) was introduced in 2017, with an article on the reprocessing of single-use devices (SUDs), such as catheters, that enables the reprocessing and remanufacture of medical devices once the processor assumes the same obligations as the original equipment manufacturer (OEM). This regulation was transposed into Irish Law in Statute Instrument 261 and enables the provision of reprocessing, but other EU Member States have interpreted the MDR differently, which has led to difficulties in harmonising legislation across the EU.

The U.S. Food and Drug Administration (FDA) in the USA has issued guidance on remanufactured and reprocessed medical devices and allows companies to determine whether they are required to meet regulatory responsibilities.

The number of specific remanufacturing policies is gradually increasing as this activity is scaled up across all sectors, with the Government of Ireland's Whole of Government Circular Economy Strategy, published in February 2026, representing another milestone in this domain.

1.3 Manufacturing in Ireland

Manufacturing in Ireland is a key component of the success of the Irish economy in recent years, generating substantial economic benefits (Ibec, 2025). According to the Industrial Development Agency (IDA) and Enterprise Ireland, manufacturing activities are categorised into the following sectors: built environment, medical devices, pharmaceuticals, renewables, electronics and semiconductors. Ireland has had a diverse range of manufacturing activities since it transitioned from an agriculture-based economy to an industry-based economy. Government support and the setting up of the IDA encouraged foreign direct investment. Software services have largely taken the place of electronics and ICT manufacturing in Ireland. According to the most recent report on manufacturing in Ireland by the Irish Business and Employers' Confederation (Ibec), manufacturing accounts for 11% of total employment in Ireland, generates €13.4 billion in wages and employment taxes annually and contributes over €10 billion in corporation tax, while also accounting for €208 billion in exports in 2022 (Ibec, 2025).

Manufacturing in Ireland plays a vital part in the success of the Irish economy; however, increasing global competitiveness allied with concerns about climate change are pushing Irish companies to evolve and adopt digitalisation and sustainability strategies. The potential of remanufacturing for industry in Ireland requires further investigation in terms of how it can be supported and how to create a competitive advantage for industries in Ireland.

1.4 Emerging Trends

1.4.1 Digitalisation

Digitalisation is a well-defined emerging trend that is becoming a key driver of sustainable practices. The European Commission has enabled the uptake of digital product passports to trace and measure the impacts of materials and processes over a product's life cycle. Electric vehicle (EV) batteries are set to become the first product to require a digital product passport.

1.4.2 Design for remanufacture

"Design for remanufacture" is an important strategy within the ecodesign philosophy when products are being designed, as it requires a full understanding of a product's life cycle and the interventions to prevent premature disposal and increase its use phase (EMF, 2013). The opportunity to build in design for remanufacturing principles can extend a product's lifetime through better disassembly, reparability and modularity. The principle of design for remanufacture has been in operation in many sectors, such as the aerospace and automotive sectors, for many years. Additive manufacturing is enabling companies to produce cost-effective and high-quality parts for their products.

1.4.3 Logistics

Supply chain challenges have been very evident since the COVID-19 pandemic and there is now a better understanding of how global supply chains work and the risks associated with them. The logistics of taking back and recovering products and materials have presented a huge challenge for remanufacturing and similar practices, but the advent of traceability software and hardware technology has enabled manufacturers to trace their products and return valuable components and materials. The advances in traceability through the use of software and Internet of Things devices can drive further remanufacturing capabilities.

1.5 Research Gaps and Opportunities

The emerging trends highlight further areas of research to advance remanufacturing through the gains being achieved through design and technology.

There are, however, several other research gaps, which were highlighted previously in the section on barriers to remanufacturing in this report (section 1.2.2). These barriers, from implementing design for remanufacturing to regulatory issues and complexity issues across the production and supply chains, all need further investigation. Since a report by the European Environment Agency assessing remanufacturing's contribution to the circular economy (EEA, 2021), there have been further developments in addressing these issues in light of digitalisation and the demand for CRM and other raw materials.

The European Remanufacturing Council was created after an EU Horizon 2020 call to develop a remanufacturing sector in Europe in 2015. The European Remanufacturing Council has been a key enabler in terms of highlighting the research gaps and opportunities for remanufacturing in the EU.

Digitalisation can provide a very real opportunity for companies to drive efficiencies in their operations and allow information from their products' life cycles to create a more sustainable product lifespan. Fofou *et al*. (2021) reviewed life cycle strategies that can enhance remanufacturing and identified opportunities for Industry 4.0 innovations, such as design for remanufacture, product service systems, "remaining useful life", closed-loop supply chains and smart manufacturing, to complement and enhance remanufacturing opportunities. Kurilova-Palisaitiene *et al*. (2018) identified several challenges associated with the remanufacturing process, such as a lack of material requirements planning system, poor core information, a lack of core material and insufficient quality management practices. They suggested that a lean approach to the remanufacturing process would reduce these challenges (Kurilova-Palisaitiene *et al*., 2018).

Several gaps and challenges for remanufacturing have been identified in the literature, but many of these challenges have been addressed across industries where remanufacturing has been practised for many years, notably in the automotive, aerospace and heavy machinery/off-road equipment sectors. The rapid transitions occurring in manufacturing practices as a result of advances in technology can also create opportunities for remanufacturing to become more efficient, to reduce complexity and to improve clarity on product use and takeback. Kim *et al*. (2024) stated that remanufacturing can benefit from technologies such as the Industrial Internet of Things (IIoT) and digital product passports, as they can facilitate real-life monitoring, and machine learning can be used to detect anomalies and defects and to optimise processes and other opportunities through the use of new technologies (Kim *et al*., 2024).

The demand pressures for CRM and other materials due to geopolitical and supply chain disruption is positioning remanufacturing as a cost-effective and sustainable opportunity to reduce the need for virgin raw materials. The increasing demand for CRM is

being driven by the clean technology sectors and existing legacy industries such as ICT and electronics.

The emerging trends of digitalisation, design for remanufacture, and logistics and takeback, coupled with advances in smart manufacturing, can address and unlock the potential of remanufacturing for Ireland.

There are opportunities for companies to gain more insights into and become more involved in remanufacturing, both nationally and through the EU. In Ireland, there are opportunities for funding through the IDA and Enterprise Ireland's innovation vouchers. There are several initiatives in Europe that address the funding of remanufacturing; for example, the EU Horizon Europe Cluster 4 (Made in Europe) funding call has a specific focus on remanufacturing. There are other funding mechanisms that have had remanufacturing topics included in their scope, from Interreg Europe to the Circular Cities and Regions Initiative. The ability to connect companies based in Ireland to funding opportunities and collaborations is an important aspect in furthering the country's ambitions for remanufacturing.

2 Methodology

2.1 Introduction

The ReManIre project uses as its foundation the Triple Helix model of innovation whereby the nexus of university, industry and government is used for collaboration and the benefit of industry and innovation (Ranga and Etzkowitz, 2013). The project will identify stakeholders from each pillar and seek their opinions on how a roadmap can be developed for remanufacturing to thrive in Ireland.

The objective of the ReManIre project is to provide a roadmap to support Ireland's development as a global centre of excellence for remanufacturing while promoting resilient jobs as part of the circular economy. To develop this further, the objective is posed as a research question in four parts.

The research question is as follows: How can Ireland develop a roadmap to become a global centre of excellence for remanufacturing to drive sustainable manufacturing and create employment through the Triple Helix lens? The first steps that are needed to achieve the objective are detailed in the four questions and responses below.

1. What are the current enablers of and barriers to remanufacturing in the literature?

- A state-of-the-art review was undertaken to understand the current enablers of and barriers to remanufacturing globally and specifically in the EU. This literature review identified the key drivers for remanufacturing and the sectors in which it has been adopted, such as second life enablers, logistics and networks. The government pillar contains the sub-groups of policymakers, regulation and standards.

2. What are the expert opinions on how Ireland and the EU can contribute?

- Through this review, the process of mapping stakeholders began using the lens of the Triple Helix pillars of university, industry and government. The Triple Helix model identifies that the interactions of the three pillars are key to fostering and developing innovation (Etzkowitz and Leydesdorff, 1997, p. 184) and, in this case, to promoting and supporting remanufacturing in Ireland. The university pillar will be divided into the sub-groups of education, training (vocational) and research. The industry pillar contains the following sub-groups: manufacturers and remanufacturers.

3. What would a centre of excellence for remanufacturing look like?

- A centre of excellence is defined as a place or an organisation that is known for doing a particular activity very well and that is involved in new developments and new ways of working, etc.[1]

4. What would a roadmap look like?

- A roadmap for developing a centre of excellence to support remanufacturing would provide a series of steps and stages over a period of time to develop the building blocks for a centralised hub.

2.2 Stakeholder Identification

A process of stakeholder identification was undertaken to identify experts and interested parties in remanufacturing in Ireland. The Triple Helix lens was used to identify the pillars of university, industry and government, and stakeholders were identified through business networks and by contacting stakeholders who are actively involved in remanufacturing research, practice and policy.

The university pillar incorporated all activities from the education, research and training sectors and identified experts across remanufacturing and the circular economy. The industry pillar mapped sectors in which remanufacturing is predominant. The mapping captured remanufacturing activity (OEM, contract, third party), logistics and networks activities. The government pillar mapped and identified stakeholders

1 https://dictionary.cambridge.org/dictionary/english/centre-of-excellence (accessed 24 May 2026).

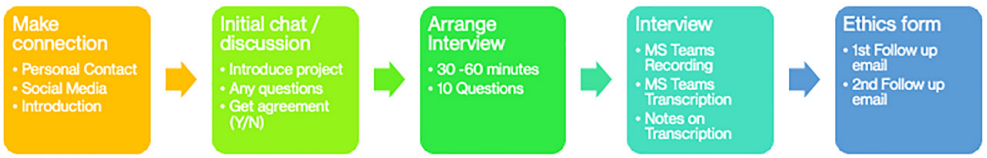

Figure 2.1. Interview process flow. MS, Microsoft.

that are involved in policy, funding, standards and regulation activities.

Following on from the stakeholder mapping and identification, stakeholders were contacted through personal connections, business networks and direct communication.

2.3 Stakeholder Interviews

The stakeholder interviews were conducted after the completion of the stakeholder mapping exercise to source suitable interviewees (Figure 2.1). A total of 26 stakeholders across the university, industry and government pillars were interviewed (Figure 2.2). The majority of interviewees were from the EU and the UK. The stakeholder interviewees came from a variety of domains in the ICT, medical devices, reverse logistics, e-mobility, renewables, electronics, public service, business supports, trade associations, consultancy, academic and research sectors. The stakeholder

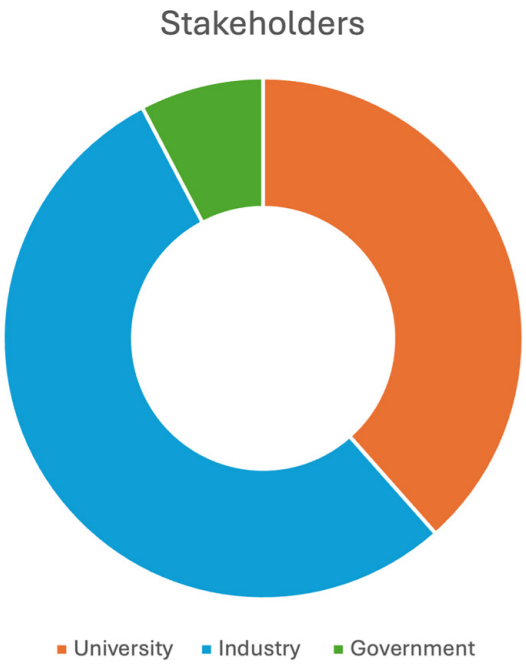

Figure 2.2. Stakeholder interview distribution.

interviews featured participants from Ireland, the UK, France, Belgium, Germany, the Netherlands, Sweden, Denmark and the USA.

All interviews were undertaken in accordance with guidance provided by the University of Limerick's Ethics Board. The interviews consisted of a preliminary introductory discussion on the project, followed by a semi-structured interview to canvas insights and opinions from the stakeholder. The semi-structured interview consisted of 10 questions based on the stakeholder's work background, their organisation's operations and their opinions on the future of remanufacturing in relation to their work.

All interviews were conducted using the University of Limerick's Microsoft Teams software, which provided a transcription of each interview. The interview transcriptions were reviewed after the interview session to clarify any discrepancies based on the video recording. The duration of the interviews ranged from 20 to 60 minutes. All interviews were recorded for transcription purposes and all video recordings will be erased on completion of the project.

The semi-structured interviews were analysed following best practice:

- all participants were pseudonymised;
- interviews were transcribed by Microsoft Teams and reviewed;
- coding of interviews was conducted using NVivo software:
  - data were examined to identify common topics, ideas or patterns,
  - data were collected into codes and categories,
  - codes and categories were organised into themes;
- deductive analysis was conducted.

The interview questions were based around the following structure: background, organisation operations and future trends. The questions below are examples of those provided to stakeholders:

Background:

- Q1. Can you describe your role and what your company does?
- Q2. How many employees do you have?

Operations:

- Q3. What sector do you operate in and where is it located?
- Q4. Can you give an example of your remanufacturing/refurbishing activity?
- Q5. What are the biggest barriers to your current remanufacturing activities (regulatory, access, market structure, collection infrastructure, customer market, technological, administrative)?
- Q6. Who are your main competitors?

Future:

- Q7. How can we best support remanufacturing in Ireland? (roadmap)?
- Q8. What would a centre of excellence for remanufacturing look like in your opinion?
- Q9. What do you believe are the best enablers to advance remanufacturing in Ireland and beyond?
- Q10. What supports would you like to see in place to support remanufacturing?

2.4 Stakeholder Survey

After completion of the stakeholder interview stage, a structured follow-up survey was developed to capture domain-specific perspectives and identify any focal points that may yield further information.

A series of three surveys was designed, one for each Triple Helix pillar: university, industry and government. The survey questions were based on location, role, familiarity with remanufacturing, and stakeholder group, and there were targeted survey questions for each pillar.

The industry stakeholders were asked a series of questions based on the following:

- remanufacturing activities;
- types of products and components;
- key drivers (opinion);
- the top three barriers to remanufacturing;
- the supports needed to enable remanufacturing.

The university stakeholders were asked a series of questions based on the following:

- primary area of research;
- research projects activity;
- research gaps;
- barriers that limit impact or collaboration;
- the roles of academia and research in advancing remanufacturing.

The government stakeholders were asked a series of questions based on the following:

- policies or instruments that exist to promote remanufacturing;
- policy barriers to remanufacturing;
- government interventions to support remanufacturing;
- alignment of national and EU policy.

The final section of the survey was based on a roadmap for remanufacturing and asked questions based on the following:

- the top three priorities for a roadmap;
- priority sectors;
- critical enablers at the national and EU levels;
- long-term success in remanufacturing.

Chapter 3 presents the outcome of the survey and discusses the results, along with the results of the stakeholder interviews.

3 Findings

3.1 Themes

A thematic analysis was conducted using NVivo software to code, categorise and group themes together. The dominant codes were then categorised and grouped into themes. The findings presented in this chapter capture the most popular insights, with further discussion on their meaning and interpretation of the data. The eight themes that were created are awareness, culture and social factors; remanufacturing practice and circularity; skills, training and education; market and economic conditions; policy, regulation and governance; industrial engagement and collaboration; technology, innovation and digitalisation; and strategic planning and support structure.

3.2 Awareness, Culture and Social Factors

The first main theme is awareness, culture and social factors. This theme relates to the current standing of remanufacturing in the context of the circular economy and wider circularity strategies, and the barriers that exist to remanufacturing due to a lack of understanding of its benefits for suitable products and components. This theme is grouped into two categories: (1) awareness and perception and (2) culture and behaviour. The role of remanufacturing and the emergence of the circular economy are new concepts to many people, and raising awareness is a key area.

3.2.1 Awareness and perception

This category relates to the limited awareness around remanufacturing and circularity, and perceptions among stakeholders about what is needed to develop an understanding of remanufacturing and its advantages.

Figure 3.1 presents the frequency of codes by respondent, with the most dominant codes being the need to develop a collaborative environment and the need to address education on remanufacturing across all areas. Other dominant codes relate to the need for more awareness and how to upscale remanufacturing, along with examples of best practice from other sectors and countries. Emissions reduction and CRM were highlighted as important areas that remanufacturing can help address and this needs to be aligned through more effort on awareness (Lilley, 2009).

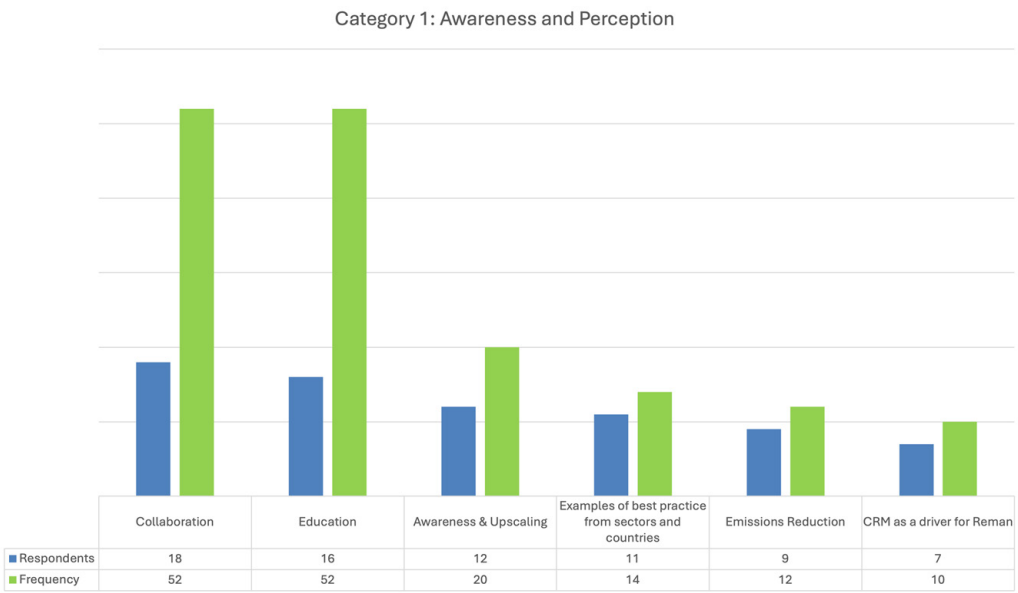

Figure 3.1. Awareness and perception. Reman, remanufacturing.

3.2.2 Culture and behaviour

The culture and behaviour category contained two dominant codes relating to customer behaviour and cultural attitudes (Figure 3.2). The customer behaviour element relates to issues such as existing practices where take–make–dispose linear models are prevalent and can prove difficult to move away from. There may be some types of products that consumers perceive have health and safety issues, but the scientific evidence has stated otherwise. The cultural attitudes element relates to a reluctance to change or to adopt new practices and business models. Respondents highlighted this as a barrier to adopting remanufacturing. An example was provided where the culture of an organisation can prevent change, as moving to more circular models of business requires an element of risk and innovative practices, and can challenge existing processes, from design to logistics and workflows.

3.3 Remanufacturing Practice and Circularity

The remanufacturing practice and circularity theme groups issues and challenges in OEM engagement, product design and business model development.

3.3.1 Original equipment manufacturer engagement

OEM engagement is increasing, according to an industry stakeholder, who suggested that although there was once resistance, they are now exploring remanufacturing and seeing the value.

Many respondents highlighted issues with OEM engagement in remanufacturing and said that barriers exist, especially in third-party remanufacturing, even though the products meet the required standards. An example was provided whereby certain medical devices can be remanufactured by a third party, but the resale market is often reduced, as the OEM has built a legacy relationship that prevents the exchange of new scientific methods that provide evidence of the safety of remanufactured devices (Figure 3.3).

3.3.2 Product design

The product design category responses highlighted the need for organisations to understand their products and their life cycles to identify opportunities for remanufacturing and circularity. There are other issues related to implementing design for remanufacture, product performance and product design that are necessary to understand in the absence of information on the product life cycle. One stakeholder suggested that understanding the opportunities for the remanufacture of medium-lived complex goods, high-value goods and high-material-intensity goods can overcome barriers to this activity. Current advances in technology through digitalisation can create a better understanding of the life cycle. Issues with the original product design may inhibit the ability to remanufacture and affect product performance and longevity (Figure 3.4).

Figure 3.2. Culture and behaviour.

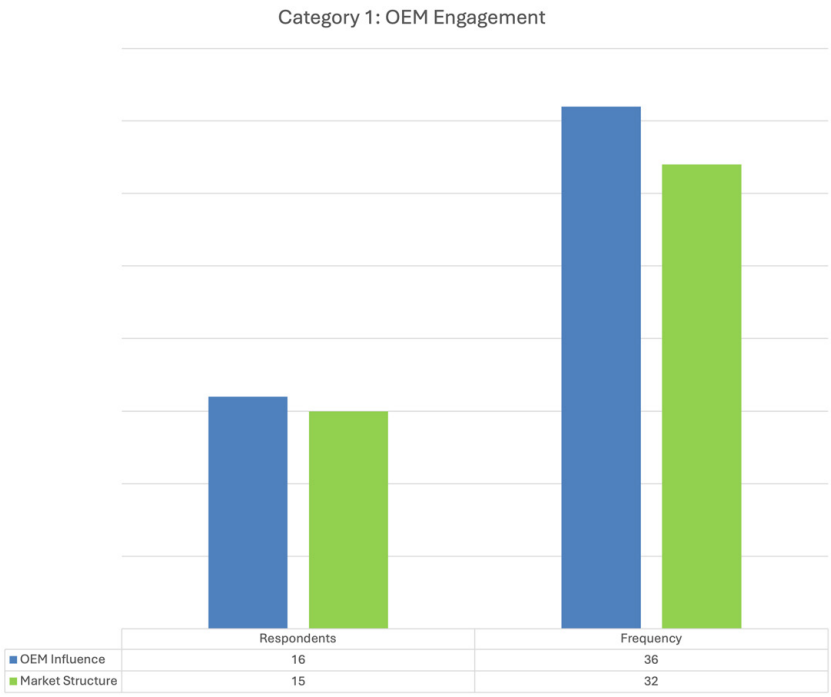

Figure 3.3. OEM engagement.

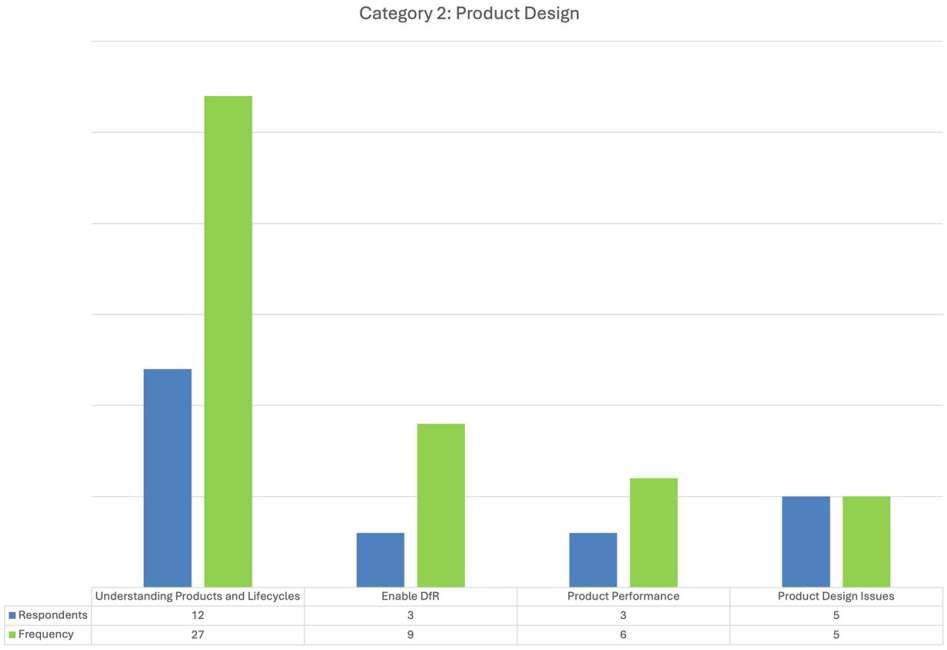

Figure 3.4. Product design. DFR, design for remanufacturing.

3.3.3 Business model development

To implement a circular strategy such as remanufacturing, a change in business model is required. This in turn requires an understanding of the economic incentives and benefits, how remanufacturing fits into the company strategy, and how to scale the strategy (Figure 3.5).

3.4 Skills, Training and Education

Skills, training and education are important for creating a better understanding of remanufacturing and circular business models. The categories under this theme are training and knowledge transfer, and education gaps.

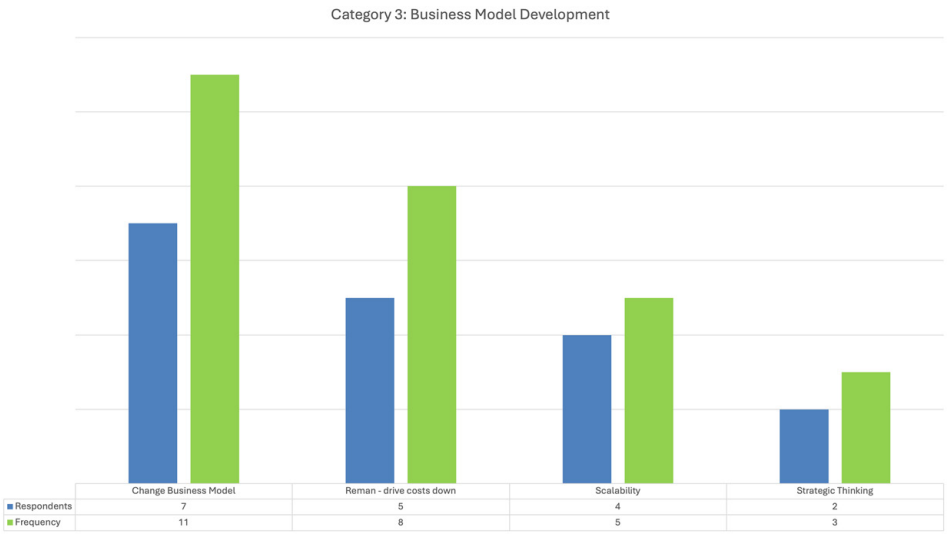

Figure 3.5. Business model development. Reman, remanufacture.

3.4.1 Training and knowledge transfer

Responses in the training and knowledge transfer category pointed to a lack of knowledge with regard to products and their life cycles and remanufacturing as a circular strategy in industry. A lack of skilled people was also mentioned by stakeholders (Figure 3.6).

3.4.2 Education gaps

The education gaps category consisted of two sub-categories highlighting the need for specific remanufacturing-focused education to understand the complexities of remanufacturing and recirculation strategies, and the lack of formal training in undergraduate courses (Figure 3.7). Opportunities to increase skills and address training needs are required in Ireland, according to stakeholders.

3.5 Market and Economic Conditions

This theme is based on the structure of existing markets and current economic conditions that may enable or prevent remanufacturing activity.

3.5.1 Market activation

The market activation category relates to the issues of current consumer behaviour and attitudes to

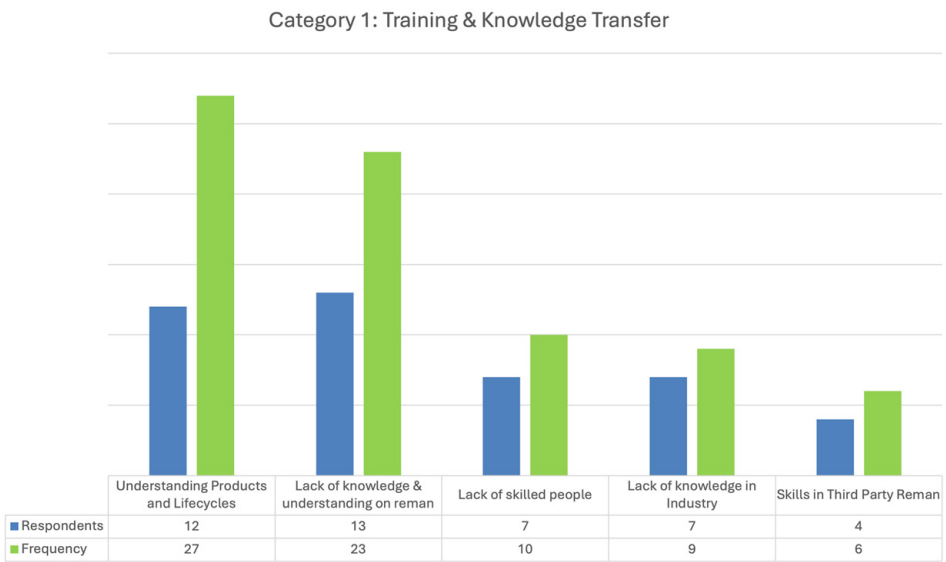

Figure 3.6. Training and knowledge transfer. Reman, remanufacturing.

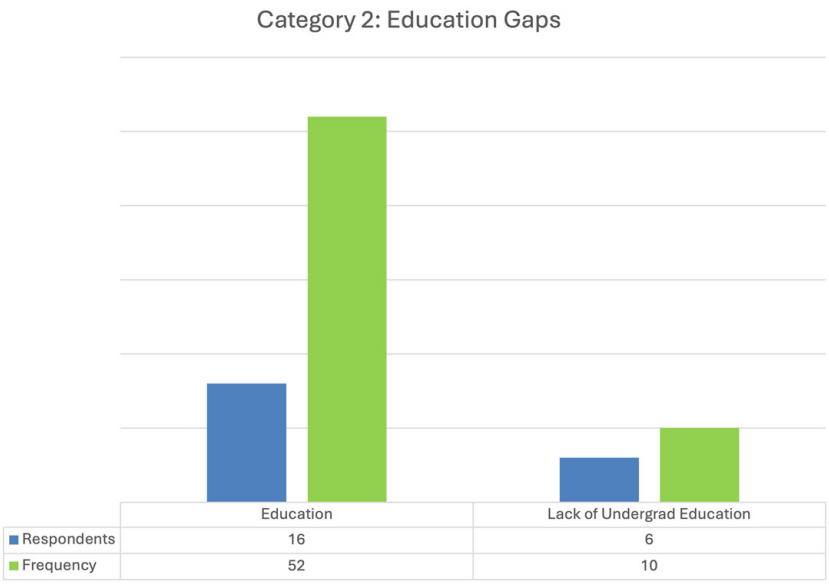

Figure 3.7. Education gaps.

remanufactured products, and understanding if there is a market for remanufactured products, based on the demand for such products. The opportunity may be there, but there may not be enough volume to fulfil the opportunity, because of either a lack of takeback or no transparency in logistics (Figure 3.8).

3.5.2 Costs and funding

In the category of costs and funding, the need for funding to be available either internally or externally to enable innovation for remanufacturing was highlighted. The impact of cost and budgetary constraints was also noted as a barrier to furthering remanufacturing, and the cost of labour was highlighted as a concern (Figure 3.9).

3.6 Policy, Regulation and Governance

Policy, regulation and governance are important areas to understand, as they can seriously impact certain industries and organisations on their journey to remanufacturing.

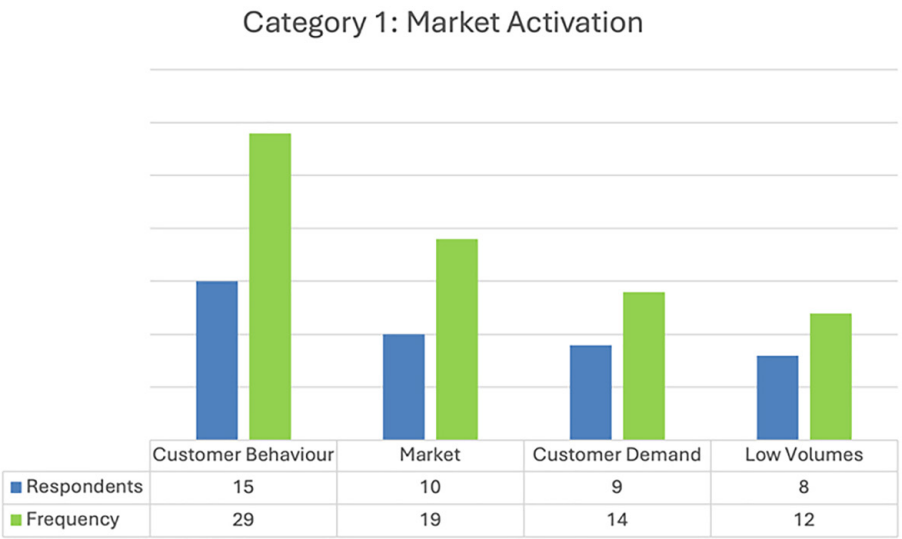

Figure 3.8. Market activation.

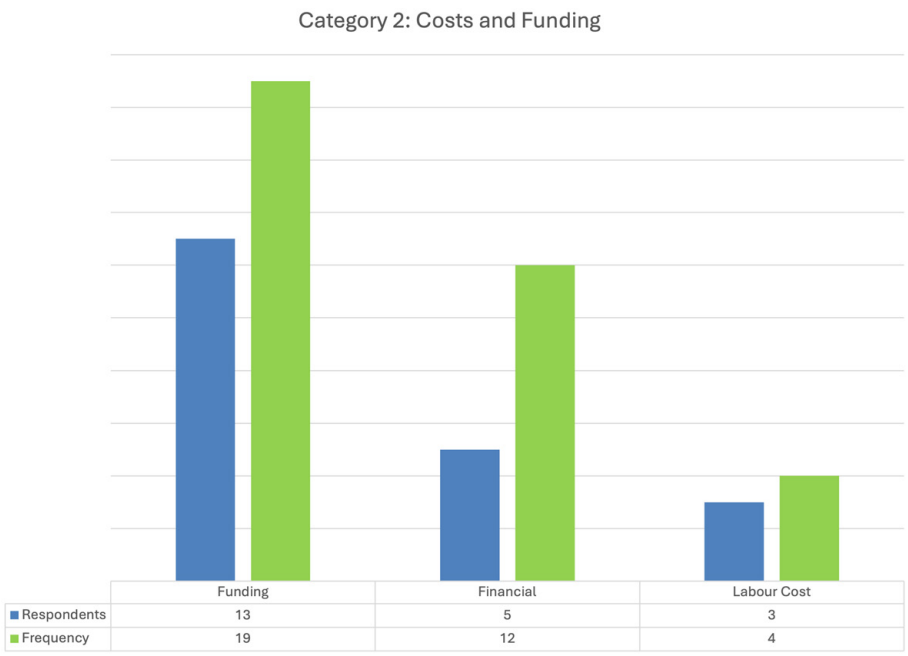

Figure 3.9. Costs and funding.

3.6.1 Regulatory barriers and enablers

Regulation can act as both a barrier and an enabler for organisations on their journey to drive forward circularity. For example, regulations on medical devices are not harmonised across the EU, so each Member State has their own transposed legislation limiting or allowing products to be reprocessed or remanufactured. A similar issue relates to end of waste regulations and tax burdens, which can impact the adoption of circular business models such as remanufacturing (Figure 3.10).

3.6.2 Standards and certifications

In this category, standards and certifications were highlighted as a means to drive adoption of circular practices through adherence to internationally recognised standards and certifications in areas such as quality and health and safety (Figure 3.11).

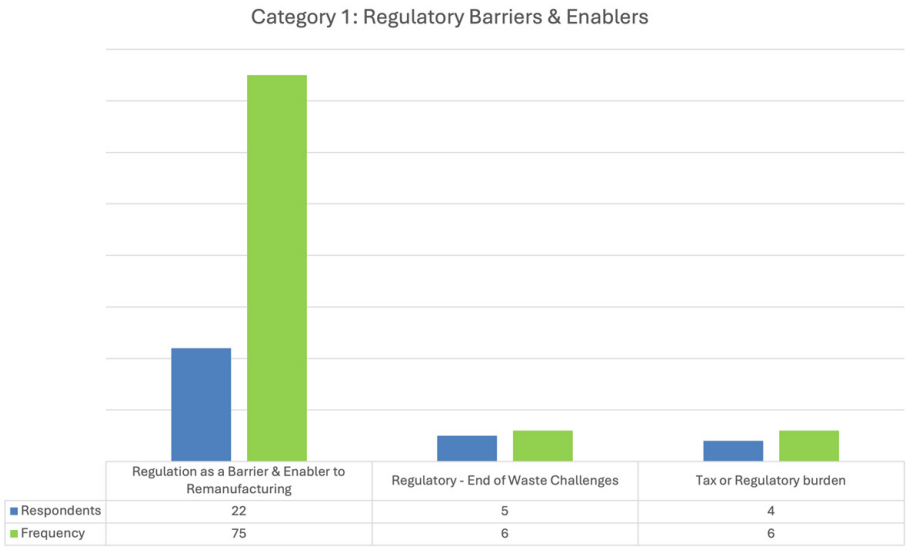

Figure 3.10. Regulatory barriers and enablers.

Figure 3.11. Standards and certifications.

3.7 Industrial Engagement and Collaboration

Industrial engagement and collaboration is a vitally important area to drive sustainability and resilience in Ireland's industrial sectors. Collaboration between the various stakeholders and sectors is key to growing areas like remanufacturing.

3.7.1 Industry collaboration

The codes that were prioritised in this category relate to collaboration between stakeholders such as industry and academia for research purposes, and the requirements of innovation, which need support across all pillars and sectors. Collaboration between organisations and their service partners and distributors is also a key area to drive innovation. The opportunity for organisations in Ireland to learn from future trends in remanufacturing is essential to build in resilience and align with best practice elsewhere in the EU (Figure 3.12).

3.8 Technology, Innovation and Digitalisation

Technology, innovation and digitalisation is an important area, as the drive towards improved technology and digitalisation can be an enabler of innovation and a driver of remanufacturing.

3.8.1 Technology enablers

Technology enablers such as digitalisation have been highlighted as a means to improve remanufacturing, for example through analysing use-phase data and the opportunity to test products and processes to make them more sustainable. A key takeaway from the interviewees is that there may be challenges in applying new technologies to current products (Figure 3.13).

3.8.2 Data and tools

The main takeaway from this category is that current supply chain issues such as access to CRM may enhance circular strategies but will also restrict access to materials that may be required for current production. Data are also required to provide support for remanufacturing in terms of measuring carbon footprints and life cycle analysis. Another issue raised by respondents was that digitalisation may hinder the remanufacturing process (Figure 3.14).

3.9 Strategic Planning and Support Structure

The theme of strategic planning and support structure relates directly to the role of a centre of excellence for remanufacturing in Ireland. Interviewees were

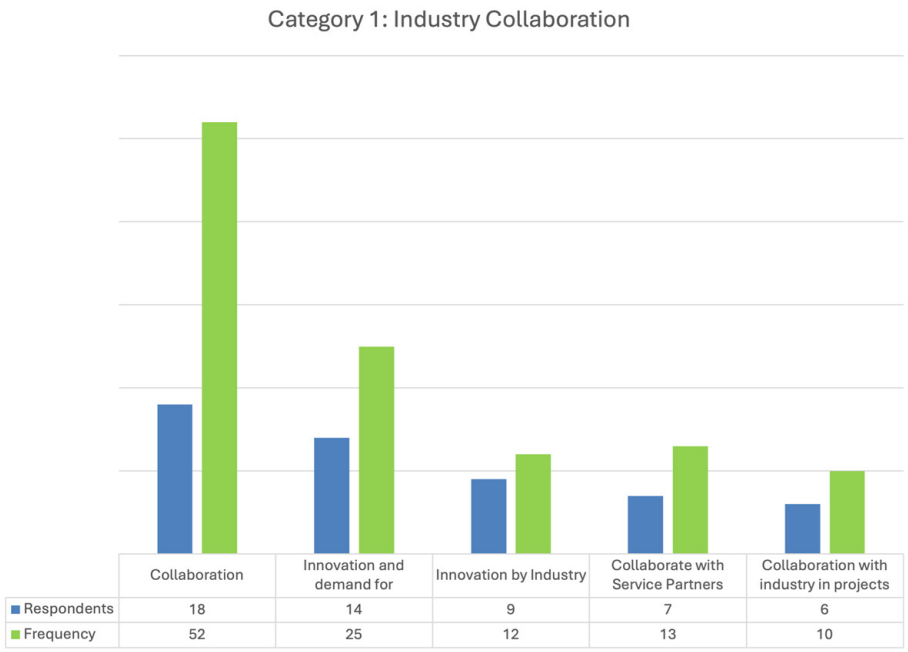

Figure 3.12. Industry collaboration.

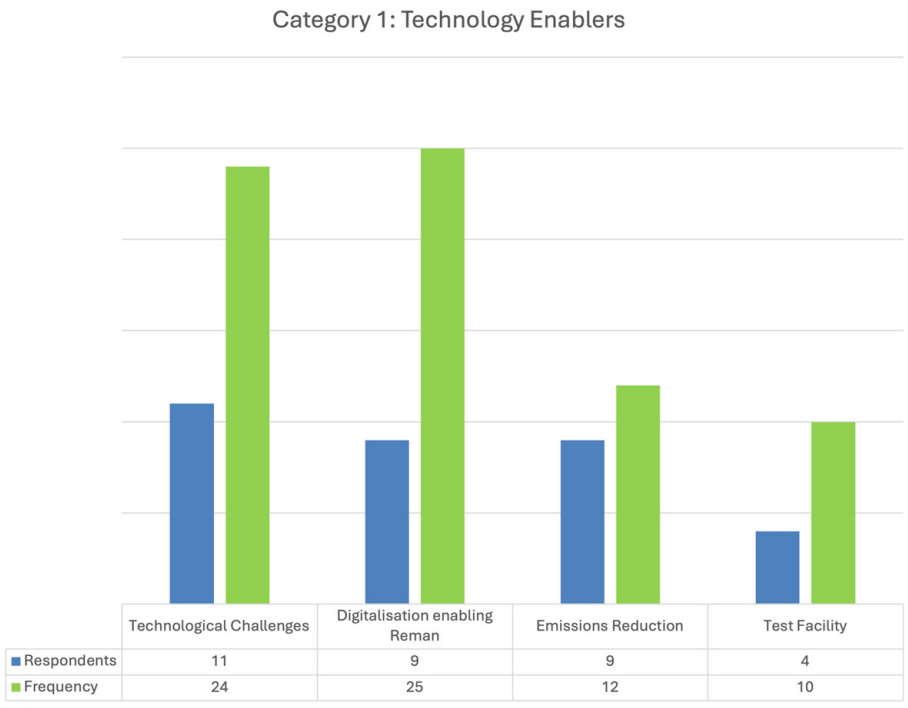

Figure 3.13. Technology enablers. Reman, remanufacturing.

questioned on what they think a centre of excellence should focus on to initiate and support remanufacturing in Ireland. The analysis of this theme will provide the foundations for a roadmap for remanufacturing in Ireland.

3.9.1 Future of remanufacturing

Stakeholders highlighted the following needs for the future of remanufacturing in Ireland in the context of a centre of excellence: collaboration, education, government support, understanding products and life

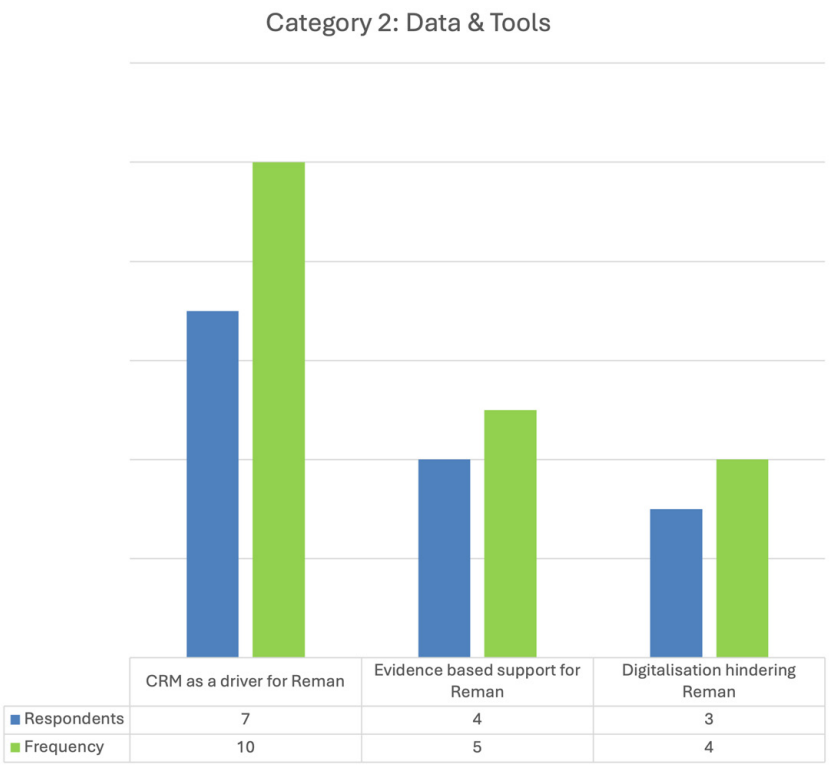

Figure 3.14. Data and tools. Reman, remanufacturing.

cycles, digitalisation enabling remanufacturing, the demand for innovation, understanding technology challenges, capacity building through training, and increasing knowledge and awareness of remanufacturing. A stakeholder suggested that a regional approach to remanufacturing could provide economies of scale and market building (Figure 3.15).

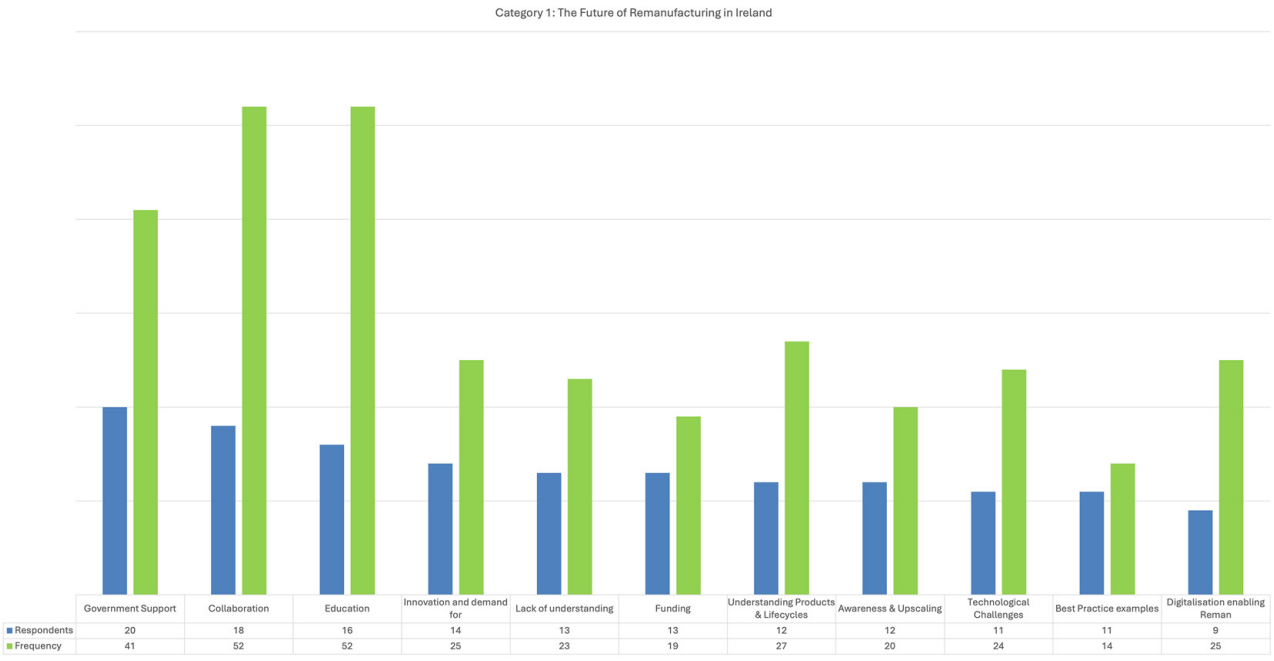

Figure 3.15. The future of remanufacturing. Reman, remanufacturing.

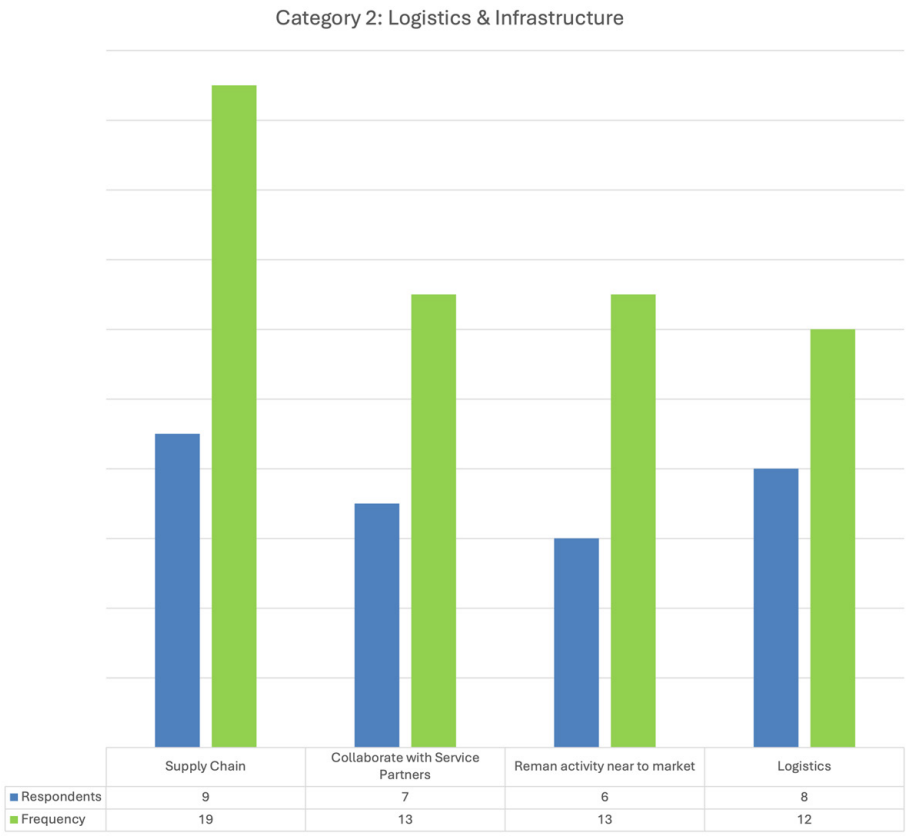

Figure 3.16. Logistics and infrastructure. Reman, remanufacturing.

3.9.2 Logistics and infrastructure

Logistics and infrastructure is understood to be an important area for remanufacturing. Understanding supply chains is key to this, and this can be made easier through collaboration with service partners and distributors (Figure 3.16). It is worth noting that remanufacturing activity close to the market is an important activity to encourage remanufacturing. The logistics of recovering products for remanufacture is key to valorising any opportunities from remanufacturing (Dowlatshahi, 2005).

3.10 Stakeholder Surveys

A follow-up survey was forwarded to all participants of the interview process. The survey was based on the insights gathered from all stakeholder interviews and the subsequent themes, together with a horizon scanning exercise on how to progress and support remanufacturing in Ireland and further afield.

The survey was forwarded to all stakeholder interviewees in June 2025 and a total of 13 respondents completed the survey, which is a 50% response rate. The responses to all survey questions are presented below (Figures 3.17–3.21 and Table 3.1).

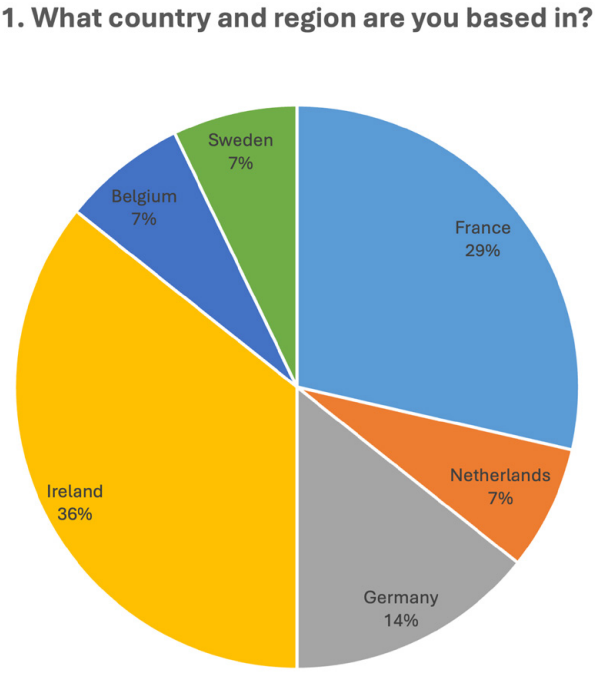

Figure 3.17. Country location.

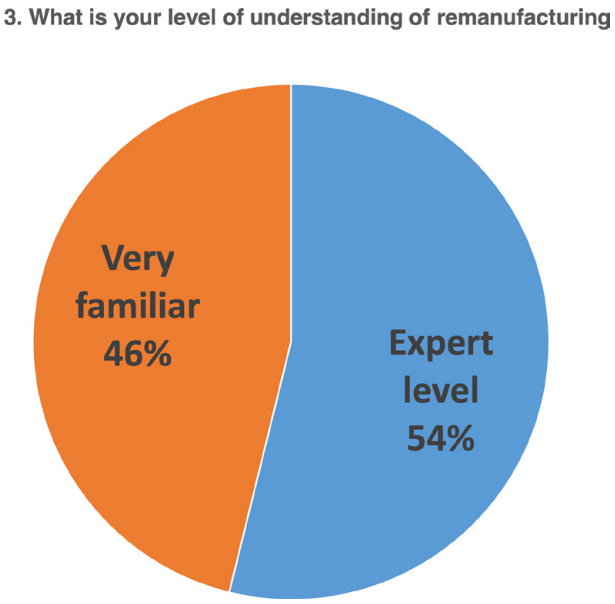

Figure 3.18. Level of understanding.

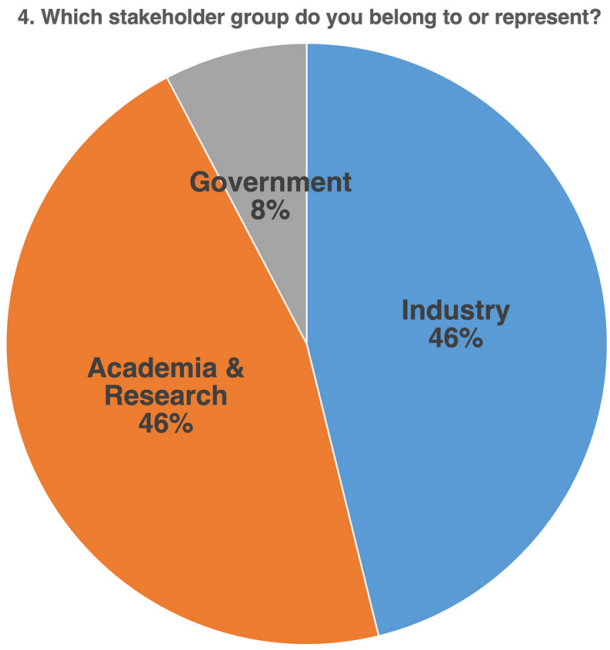

Figure 3.19. Stakeholder group.

3.10.1 General survey questions

1. What country are you based in?

   The majority of stakeholders were based in Ireland (36%) followed by France (29%) and Germany (14%).

2. What is your role or function in your organisation?

   The respondents replied as follows:

- five respondents worked in professor-level roles in academia and research;
- four respondents worked in director-level roles;
- two respondents worked in manager-level roles;
- one respondent worked as a business owner;
- one respondent worked in a coordinator role.

3. What is your level of understanding of remanufacturing?

   The survey respondents said that they have a high level of knowledge around remanufacturing, with 46% being very familiar and 54% having an expert level of knowledge.

4. Which stakeholder group do you belong to or represent?

   The respondents were largely from industry and academia/research, with only a small percentage from government.

3.10.2 Industry stakeholder questions

1. Is your organisation currently involved in remanufacturing?

   Five respondents were involved in remanufacturing, while one respondent was working as a remanufacturing consultant.

2. What types of products/components do you remanufacture or support?

   Three respondents worked in the medical devices industry, one respondent worked in electromechanical products, while another worked in the ICT, micro-mobility, telecoms and battery remanufacture sector. The final respondent represented companies in remanufacturing across all sectors, from ICT to automotive and electrical products, etc.

3. What are the key drivers of remanufacturing in your sector?

   The key drivers of remanufacturing that were highlighted were cost savings, sustainability targets and customer demand.

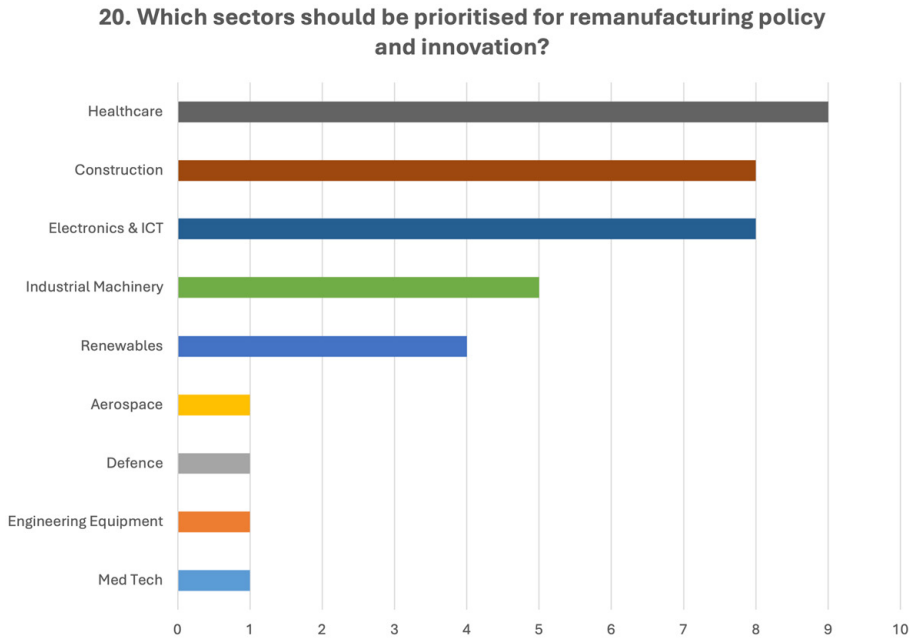

Figure 3.20. Priority sectors. Med Tech, medical technology.

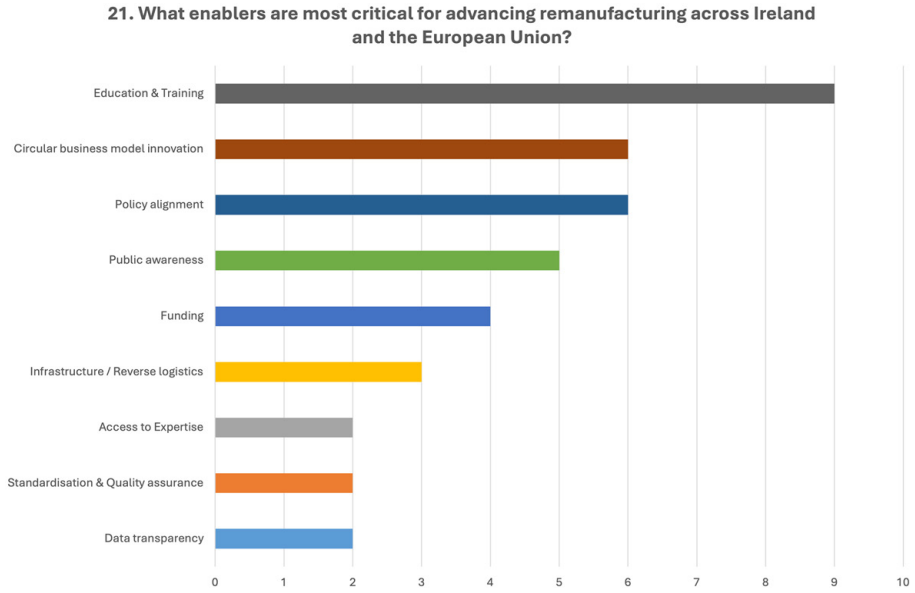

Figure 3.21. Critical enablers across Ireland and the EU.

4. What are the top three barriers to scaling remanufacturing in your organisation?

   The respondents noted several barriers to scaling remanufacturing. These barriers can be categorised under the following headings:

- **perception** – customer understanding of remanufacturing versus second-hand goods, intellectual property issues, the perception that remanufacture is inferior to new, existing suppliers and sales teams that are reluctant to change;
- **OEM** – access to OEM data, OEM interference and resistance, forced obsolescence;
- **regulatory** – regulation, certification duration and availability, cheap and new products, administrative burdens moving product across borders, compliance with device collections;
- **takeback** – recovering core components for remanufacture, market fragmentation.

5. What kinds of support (policy, funding, technical) would enable your remanufacturing activity?

   The respondents to this question gave the following answers:

- policy and funding;
- unified EU regulation and certification availability;
- funding, technical support on materials and recovery;
- legal support for circular procurement and extended producer responsibility (EPR) to recognise and promote remanufacturing;
- incentivising circular procurement practices in healthcare;
- healthcare and public sector support for remanufacturing.

3.10.3 University (academic/research) stakeholder questions

1. What is your primary area of research related to remanufacturing?

   Design for remanufacturing was highlighted as the main area of research activity, along with sustainable manufacturing, remanufacturing to slow CRM flow rates and enhancing adoption of remanufacturing technologies.

2. What research projects or networks are you involved in related to remanufacturing (if any)?

   The respondents stated that they were involved in a variety of national, European and international projects related to remanufacturing, from working with the European Remanufacturing Council, EIT RawMaterials, EIT Manufacturing, Rematec Amsterdam and Horizon Europe, to involvement with remanufacturing-specific conferences, such as the International Conference on Remanufacturing, and working on national projects in France (Circular), Sweden (REMARKABLE, SCANDERE, Innovate for Remanufacturing) and Ireland (under the Disruptive Technologies Innovation Fund and Research Ireland).

3. What are the most urgent research gaps in the field of remanufacturing in your opinion?

   The stakeholders under the university pillar highlighted the following areas where research is most urgently required:

- the link between remanufacturing and CRM flows and improved recycling rates;
- more empirical studies and applied studies from industry, case studies and research policy papers, life-cycle assessments and sustainability assessments;
- more best-practice exemplars;
- automation for remanufacturing and quantifying and reducing impact of remanufacturing;
- access to data to drive decisions;
- how to upscale remanufacturing activity.

4. What barriers limit research impact or collaboration in remanufacturing?

   The respondents identified the following as barriers that limit research impact and collaboration:

- misaligned priorities;
- lack of funding mechanisms;
- policy fragmentation;
- power imbalance between OEMs and other remanufacturing stakeholders;
- access to data;
- expertise;
- intellectual property concerns;
- ability to change.

5. What role should academia and research organisations play in advancing remanufacturing in the next 5–10 years?

   Respondents put forward the following suggestions:

- create a network of European remanufacturing centres, aimed at supporting companies to experiment and prove the value of remanufacturing;
- develop defence remanufacturing;
- develop remanufacturing business models;
- create regional and local innovation hubs that are open to a wide range of people within the community, with a focus on social innovation impacts;

- implement demonstration projects, training, technical support and industry research projects;
- pave the way for the next generation of remanufacturing, which is more sustainable and human centred;
- support industry;
- propose simulation and modelling to assess and pilot remanufacturing value chains from different perspectives (technical, economic, environmental and social).

3.10.4 Government stakeholder questions

1. What policies or instruments currently exist in your region related to remanufacturing or the circular economy?

   The "Buying Greener" government guidance document was highlighted, as it states that remanufactured ICT equipment should be considered in public sector procurement (DECC, 2024).

2. What are the main policy barriers to promoting remanufacturing in your area?

   A lack of policy was identified as the main barrier to promoting remanufacturing.

3. What government interventions are most effective for supporting remanufacturing?

   The following government interventions were identified as the most effective for supporting remanufacturing: standards on remanufacturing, public procurement requirements, and fiscal incentives or tax breaks.

4. How aligned is remanufacturing with national or EU circular economy goals in your view?

   Most respondents agreed that remanufacturing is highly aligned with national and EU Circular Economy goals.

5. What should be the top three priorities in a national remanufacturing roadmap?

   The three priorities for a national remanufacturing roadmap identified by respondents are presented in Table 3.1.

6. Which sectors should be prioritised for remanufacturing policy and innovation?

   The sectors that respondents felt should be prioritised are presented in Figure 3.20. Each respondent selected three industries where they think a remanufacturing policy and innovation should be prioritised.

7. What enablers are most critical for advancing remanufacturing across Ireland and the EU?

Table 3.1. Priorities identified by survey respondents

Respondent	Priority 1	Priority 2	Priority 3
1	Regulation	Fiscal incentives	Education
2	Quantify remanufacturing activity	Barriers – technical, investment and business models	National network of remanufacturing centres
3	Legislation	Promote green procurement	Secure supply chains
4	Applied research	Change customer perception	
5	Funding mechanisms	Resource mapping for post-consumer products	Policy mechanisms
6	Product demand – standards	Promote green procurement	Emissions reductions
7	Drive greater adoption	Best-practice exemplars	Funding for research and implementation
8	Awareness	Reskilling	Integration of artificial intelligence
9	Priority for remanufactured products	Procurement policies	Incentives for remanufacturers
10	Procurement – remanufacture first	Regulatory harmonisation	Prevent anti-remanufacturing practices
11	Public support for remanufacture	Prevent anti-competitive practices	
12	Economic, legal and technical support for remanufacturers		
13	Identify opportunities	Clarity on regulations	Promote remanufacturing to the public

Most respondents highlighted education and training as the most critical enabler, followed by circular business model innovation and policy alignment.

8. What does long-term success in remanufacturing look like for your organisation/sector?

   The response from each stakeholder on what success will look like for their organisation or sector was as follows:

- "a bunch of opportunities";
- "a national network of remanufacturing centres which collaborate across the European Union";
- "remanufacturing is 100% of our business, increased uptake";
- "remanufactured products are indistinguishable from and are as acceptable as new products except they are labelled as remanufactured";
- "ongoing support and funding (including social bonds) for all enterprise – making it easy and worthwhile and easy to do 'remanufacturing'";
- "sales in Europe exceeding €100 billion by 2030";
- "greater re-use of materials, reduced reliance on virgin material extraction";
- "remanufacturing adoption by SMEs [small and medium-sized enterprises] and large companies";
- "remanufactured products bought before a new product if it is equivalent";
- "favourable procurement for remanufactured before buying new to reduce cost, waste, emissions and build resilience into the supply chain";
- "all hospitals routinely looking at remanufactured devices as a 100% alternative to OEM devices";
- "a higher degree of collaboration from different stakeholders";
- "existence of national or regional centres dedicated to remanufacturing, where companies could find remanufacturing experts on product/process/business".

4 Conclusions

4.1 Key Findings from Stakeholder Interviews

The findings from the stakeholder interviews and surveys present a representation of the current thoughts and trends in the area of remanufacturing. The stakeholder interviews identified eight themes, and the high-level findings are presented for each theme below:

1. **Awareness and culture.** Remanufacturing remains a niche activity for industries and companies and much more needs to be done to build awareness of this activity and its potential benefits. The definition of remanufacturing is still not clear to many, and building awareness will be an important aspect of growing this circular business model. Stakeholders stated that the linear model of production is dominant and that companies need to examine opportunities to become more circular to stay resilient and improve sustainability. Customer behaviour is also a key challenge and there is a body of work in raising awareness among product end users that there are advantages to creating a demand for remanufactured goods.
2. **Remanufacturing and circularity.** Remanufacturing is an important piece in the jigsaw for OEMs seeking to reduce their material and energy use; however, third-party remanufacturers find it increasingly difficult to seize opportunities. Regarding product design, companies need a better understanding of their products' life cycles to understand how they can design for remanufacture and make the necessary changes. Companies need to implement circular business models to stay competitive, but they need support to help make this happen.
3. **Skills, training and education.** A lack of understanding and knowledge on remanufacturing is holding back change. Further work is needed to address the skills gap and to provide appropriate training and education to relevant parties through academic, continuous personal development or vocational channels.
4. **Market and economic conditions.** Stakeholders pointed out that current market conditions may prevent remanufacturing activity from taking place, and the absence of core products and the availability of logistics for takeback need to be addressed. To initiate remanufacturing is a complex and difficult process, and more work needs to be carried out to enable companies to subsidise costs and labour.
5. **Policy, regulation and standards.** The absence of policy, regulation and standards can hinder progress on remanufacturing. Policy harmonisation was identified as being a key driver for increasing remanufacturing. Existing regulations can inhibit remanufacturing by classifying products and components as waste, and care needs to be taken to not make recycling a more favourable activity. Standards have been highlighted as an important driver to provide evidence and rigour for circular products.
6. **Industrial engagement and collaboration.** Engagement and collaboration is a key driver of remanufacturing, and the development of research activity that is aligned with industry goals is paramount to its adoption.
7. **Technology, innovation and digitalisation.** Technologies such as IIoT, additive manufacturing and artificial intelligence (AI) can address problems across the manufacturing and remanufacturing ecosystem. The digital product passport will also address many of these issues and create a more transparent playing field.
8. **Strategic planning and support structure.** This theme was identified in relation to developing a centre of excellence. The many product manufacturing, service and distribution challenges will require intervention to support remanufacturing activity locally, nationally and internationally. To protect companies undertaking activities in Ireland, we need to build a pathway to address these concerns and build in resilience and resource efficiency to protect our economy.

The stakeholder interviews offered very interesting insights into how we can support companies that are interested in engaging and identifying opportunities in remanufacturing. The stakeholders raised many interesting points and highlighted challenges and opportunities for more collaboration to encourage remanufacturing. These points are as follows:

- What is the role of EPR schemes? As they are responsible for managing the end-of-life stage of products and opportunities within the circular economy, there could be a role for EPR schemes to enable remanufacturing.
- Economic opportunities for the circular economy are not always near term, which needs to be considered in terms of funding, etc.
- Clear definitions of circular economy business models and where they are applicable are required.
- Coordinating and linking up actors and entities to discover remanufacturing is required.
- New ways are needed to convene stakeholders and to innovate and collaborate.
- Remanufacturing and manufacturing facilities are required to test tooling, products and processes.
- Cross-border collaboration activity is required.
- What does Ireland need to do for remanufacturing? How can interested parties be identified?
- Patchwork legislation should be removed, as harmonisation of legislation can increase remanufacturing.
- Products need to be validated for a number of reuse/remanufacture cycles.
- There is growing support for sustainability among governments.
- The provision of safe and secure services for post-consumer products is needed (EPR).
- Remanufacturing requires innovation.
- Digitalisation can drive remanufacturing activity (emissions reduction).
- The Chinese government is scaling up remanufacturing.
- Remanufacturing provides an outlet to resell and at a much-reduced price.
- Ireland can support remanufacturing through its digital skills to create a framework for remanufacturing.

4.2 Key Findings from Stakeholder Surveys

The stakeholder surveys were a follow-on body of work to gather further opinions and insights across the pillars of the Triple Helix. A total of 13 respondents completed the surveys, out of a potential 26, which is a response rate of 50%. The survey responses provided the following data:

- Respondents came from a selection of European countries: Ireland (36%), France (29%), Germany (14%) and Belgium, Sweden and the Netherlands (7%).
- The majority of respondents have high-level roles in their organisations.
- There was a very high level of understanding of remanufacturing across all respondents.
- Respondents represented industry (46%), academia/research (46%) and government (8%).

In the industry pillar stakeholder group, five respondents were directly involved in remanufacturing, while one respondent worked as a remanufacturing consultant. The respondents came from a variety of sectors, from the medical devices sector to the ICT, telecoms and batteries sectors, and from a remanufacturing trade association. The respondents stated that the key drivers of remanufacturing are cost savings, sustainability targets and customer demand. The respondents stated that the main barriers to remanufacturing, from their experience, are perception, OEM activity, regulatory burdens and the takeback of core products. The respondents stated that the supports they need for their operations are policy implementation and harmonisation across the EU, easier certification processes (CE mark), funding mechanisms, technical support for recovery of materials and products, further enhancements to green public procurement (in healthcare and the public sector), and using EPR to recognise and promote remanufacturing.

In the university (academia/research) pillar stakeholder group, respondents stated that design for remanufacture is one of the main areas of research, along with sustainable manufacturing, the link between CRM and remanufacturing, and technologies to improve remanufacturing. The respondents stated

that they were involved in research activity across the EU, nationally and internationally. The survey respondents identified the following areas where further and urgent research is needed: how CRM and remanufacturing are aligned, how automation can support remanufacturing, and how to upscale remanufacturing. The following are also required: more empirical and applied studies (case studies), more best practice exemplars and access to data.

According to this cohort, the main barriers to remanufacturing are misaligned priorities, lack of funding mechanisms, policy fragmentation, OEM influence, access to data, access to expertise, intellectual property concerns and an organisation's ability to change. To overcome these barriers and advance remanufacturing, the stakeholders identified the following actions: develop a network of European remanufacturing centres to support industry at the regional or local level, develop defence remanufacturing, establish demonstration projects with industry to showcase remanufacturing activity, and develop simulation and modelling activities in value chains for remanufacturing.

In the government pillar stakeholder group, the respondents stated that policies such as the Green Public Procurement framework are instrumental in adopting remanufactured products and that further polices like this are needed to promote remanufacturing. Remanufacturing is aligned with EU and national goals and can be supported through the use of standards to promote remanufacturing and through fiscal incentives such as tax breaks.

The final part of the survey gathered stakeholder opinions on what would be their top three priorities for the development of a roadmap for a centre of excellence. The complete list of responses is presented in Table 3.1 and includes:

- mapping remanufacturing activity;
- mapping post-consumer resources;
- education, awareness and perceptions;
- regulation, legislation and standards;
- funding (research, implementation, AI);
- best-practice activity (case studies, pilot projects);
- green public procurement;
- a support centre for remanufacturing.

The respondents stated that the following sectors should be prioritised for remanufacturing opportunities: healthcare, construction (built environment), electronics and ICT, industrial machinery and renewables. The most critical enablers for advancing remanufacturing across Ireland and the EU are education and training, circular business model innovation, policy alignment, public awareness and funding.

With regard to what long-term success in remanufacturing might look like across all organisations, respondents suggested the following: opportunities across the value chain; a national network to support remanufacturing with expertise on products, processes and business; remanufacturing adoption across all sectors; reduced reliance on virgin raw materials through reuse and recovery; remanufactured products being selected first based on cost, sustainability and quality; and further collaboration between entities.

5 Spotlight on Remanufacturing

5.1 Introduction

This chapter provides examples of remanufacturing activity in the form of case studies and country studies to highlight the ongoing work to scale up remanufacturing.

Remanufacturing in Europe is primarily based in the automotive, aerospace, electrical and electronic equipment, heavy-duty and off-road equipment, machinery, marine and medical equipment sectors (EEA, 2021). The European Environment Agency identified that remanufacturing markets did not grow significantly between 2015 and 2021, but there are signs of interest across industry, primarily due to an increasing understanding of resource scarcity, the adoption of circular economy business models and the increasing advances in digitalisation, with current remanufacturing rates of approximately 5% in the main sectors and 10% in the aerospace sector (EEA, 2021).

Interest in remanufacturing is growing, and it has been defined in the new EU Batteries Regulation. Remanufacturing has been highlighted as a strategy to enable EV batteries to become more sustainable and improve circularity and to scale remanufacturing (European Union, 2023). The regulation also implements the use of digital product passports for EV batteries.

The case studies highlighted here show that Ireland has the opportunity to support remanufacturing in these sectors through circular procurement in the form of directives, supporting current manufacturing and future industries.

5.2 Case Studies

The case studies presented here are only a small selection of what is happening across Ireland and the EU and globally. The case studies cover the ICT, medical device, life sciences and renewables sectors.

5.2.1 Information and communications technology – Circular Computing and GreenIT

In Ireland, the Department of the Environment, Climate and Communications published the Green Public Procurement Strategy and Action Plan 2024–2027 (DECC, 2024), which set a sectoral target for remanufactured devices. The Office of Government Procurement developed a framework for remanufactured laptops, and a consortium comprising the IT asset disposition company GreenIT, based in County Kildare, and the UK-based Circular Computing won the contract to become a supplier of remanufactured laptops to the public sector. This has been welcomed across the EU as a potential game changer in terms of integrating remanufactured devices into the public sector.

5.2.2 Medical devices – Zehnacker and Vanguard AG

Medical devices are often designated as SUDs by the OEM and are disposed of after one application. The healthcare sector has very high rates of emissions due to the prevalence of SUDs. The hygienic recovery and sterilisation of these SUDs through reprocessing has been shown to be safe and compliant while reducing emissions and cost (Benedettini, 2022). The remanufacture and reprocessing of medical devices is an important strategy in driving down costs, improving sustainability and reducing carbon footprints. Zehnacker is a German-owned company based in Ireland that provides decontamination and sterilisation services to the healthcare sector in Ireland. It has partnered with Vanguard AG, a German company that reprocesses and remanufactures medical device equipment (CE marked, in line with the MDR) at its facilities in Germany. Zehnacker provides a service for hospitals throughout Ireland whereby it collects electrophysiology catheters and certain surgical devices for reprocessing by Vanguard AG, thus helping to reduce costs and emissions from the healthcare sector.

5.2.3 Healthcare – Cytiva

Cytiva is an equipment provider for the life sciences and biopharma industry. The company has a worldwide customer base and has developed a remanufacturing arm as part of its operations. Cytiva provides a range of instruments, from bioreactors to

imaging systems, as part of their remanufacturing portfolio. All equipment is provided with a 1-year “same as new” warranty.

5.2.4 Renewables – Ørsted

The renewables sector is one of the fastest growing industries worldwide and Ørsted is one of the largest providers of renewables in the form of wind turbines. The average lifespan of renewable wind energy equipment is between 20 and 25 years; however, the blades and gearboxes can have a much-reduced lifespan, and end-of-life strategies are now becoming more prevalent. Ørsted contracts much of this work to local third-party or contract remanufacturers.

5.3 Country Study on Remanufacturing

An important aspect of understanding remanufacturing is learning from existing endeavours. Scotland and Denmark offer prime examples of publicly and privately funded endeavours to initiate and support remanufacturing. Scotland and Denmark are similar in size to Ireland, with comparative populations and industries.

5.3.1 UK

The Centre for Remanufacturing and Reuse was established in 2007 to promote remanufacturing and reuse in the UK; the centre is now operated by Oakdene Hollins Ltd, which was a precursor to the European Remanufacturing Council.

The Scottish Institute for Remanufacturing (SIR) began as a collaboration between the University of Strathclyde, Zero Waste Scotland and the Scottish Funding Council, and was approved for funding by the Scottish Government in 2014. The purpose of the institute is to help stimulate and support the remanufacturing community in Scotland. It is notable as being only one of six centres of excellence for remanufacturing globally.

The main objective of SIR is to drive collaboration between industry and academia by supporting funding opportunities and knowledge transfer through education and training and expertise, to build and sustain circular business models.

SIR works with companies involved in remanufacturing in the automotive, renewables, ICT and marine sectors. It also collaborates with academic networks, industry groups and policy and standards development to further the adoption of remanufacturing. Professor Winifred Ijomah from the University of Strathclyde is the primary investigator and technical director of the institute.

Remanufacturing is an important part of the UK manufacturing landscape. The ReMake Value Retention Centre is a £10-million funded research centre led by the National Manufacturing Institute Scotland and the University of Strathclyde, in partnership with the University of Sheffield and the University of Exeter, where the focus is on high-integrity sectors critical to national infrastructure (ReMake Value Retention Centre and University of Exeter, 2025). The University of Brighton leads the Remanufacturing Catalyst for the South East programme. Established in 2024, six universities, industry partners, local government and the University of Brighton’s Manufacturing Technology Centre are involved in the programme, which aims to help companies move towards net zero and the circular economy (University of Brighton, 2024). There are other collaborations in the UK involving the University of Birmingham, Coventry University and Loughborough University, and there are many companies directly involved in remanufacturing, including in the aerospace (Rolls Royce), electronics and ICT (Hewlett Packard) and automotive sectors.

5.3.2 Denmark

reManuFactory is a collaboration between the Technical University of Denmark (DTU) and the Danish Industry Foundation (Industriens Fond), established following a call to create a national competency centre for remanufacturing. reManuFactory is intended to be a strategic focal point for the circular transformation of Danish industry by drawing on the expertise of DTU institutes. This collaboration is being supported by private capital from the Danish Industry Foundation.

The Danish Industry Foundation has sought to develop circular production to promote more sustainable and resilient industry in Denmark. This effort includes a total of 13 funded projects to kick-start circular production. reManuFactory will initially focus on electronics, mechanics, plastics

and metals. The centre will be developed and run from DTU and will use its laboratory facilities and research-based consulting expertise to collaborate on projects with small and large companies. The process of implementing remanufacturing is complex and creates demands in areas such as logistics and design. The centre will support Danish companies in examining how they can adopt remanufacturing and become more resilient. reManuFactory is being led by Professor Tim C. McAloone at the Department of Civil Engineering and Mechanical Technology at DTU. The centre will be supported with DKK 37 million (€50 million) and will run until 2028 (DTU, 2025). DTU was founded as a polytechnic college in 1829 and changed its name to DTU in 1994. The Danish Industry Foundation was established in 1898 and is a philanthropical foundation. It is made of up of a secretariat and a board of directors who oversee the foundation's equity of €650 million (Industriens Fond, 2025).

5.3.3 USA

The Golisano Institute for Sustainability is based at the Rochester Institute of Technology (RIT) in New York State, where one of its research focus areas is remanufacturing and resource recovery. Its research themes include "Design for X", life-cycle engineering, condition assessment, cleaning and repair, and validation. The institute provides test beds and laboratories for further research for industry.

RIT is a member of the REMADE Institute, which is a public–private partnership and a consortium of industry, academia, trade organisations and national laboratories that is funded by the U.S. Department of Energy's Advanced Materials and Manufacturing Technologies Office (a sub-office of the Office of Energy Efficiency and Renewable Energy) to increase manufacturing competitiveness, strengthen national supply chains and accelerate the circular economy, with funding of $10 million (U.S. Department of Energy, 2025). The REMADE Institute is led by RIT's Golisano Institute for Sustainability. The primary goals of the REMADE Institute are to reduce energy use and emissions through minimising the use of primary materials in energy-intensive industries; reduce the use of primary feedstocks by increasing the use of secondary feedstocks, resulting in cost and energy savings; and develop technologies to transform material reuse, remanufacturing, recovery and recycling. REMADE members represent a wide variety of companies across the aerospace, automative and heavy machinery and off-road sectors.

5.4 Opportunities for Remanufacturing in Ireland

5.4.1 Medical devices

Ireland is the second-largest exporter of medical devices in Europe (Ibec, 2025) and is a global "MedTech" hub, with 450 companies employing 42,000 people to deliver €12.6 billion in MedTech exports across the world. Over 50% of these companies are contract design, development, manufacturing and logistics services companies (Ibec, 2025). The opportunities arising in the MedTech and healthcare sectors to create products with longer lifetimes and to reduce the use of SUDs can provide an opportunity for remanufacturing to be a solution and change this linear life-cycle model. The advances in materials, design, cleaning and sterilisation may provide further opportunities to address the lack of sustainability of these products.

Medical devices can be categorised as high-value items that have a significant cost implication for hospitals while also being categorised as SUDs that are disposed of after their first use. Although many of these devices are unsuitable for several life cycles, there are many devices that are suitable for reprocessing or remanufacturing, such as electrophysiology catheters, while maintaining health and patient safety standards.

The opportunity for remanufacturing of medical devices is based on Article 17(2) of the MDR, which outlines a provision allowing for the reprocessing of SUDs). Ireland has adopted this position in Statutory Instrument 261 (Government of Ireland, 2021). The MDR states that if you process SUDs in Ireland, you will act as the legal manufacturer of the SUDs and you must fulfil applicable MDR requirements, such as CE marking (HPRA, 2025). A recent systematic review and meta-analysis of reprocessing of single-use medical devices conducted by the Health Research Board in Ireland stated that reprocessing results in direct and indirect cost savings and that reprocessing has the potential to reduce global warming impacts

but may exacerbate human health impacts (McGrath *et al*., 2023). The National Health Service in the UK has recently provided guidance on the inclusion of reprocessed and remanufactured medical devices (NHS, 2024) and, in the USA, the FDA has issued guidance on the remanufacturing of medical devices (FDA, 2024).

5.4.2 Built environment

The built environment is a key area for decarbonisation due its high energy demand and materials usage. The built environment comprises residential, public and commercial buildings and infrastructure in Ireland. It was responsible for 11.1% of greenhouse gas emissions in 2022 (Government of Ireland, 2024) and is worth over €11 billion to the Irish economy (ResearchAndMarkets.com, 2024). Energy efficiency has been a key driver in reducing emissions in this sector, but there are opportunities to develop more circular practices in this area. The advent of new technologies such as inverters, heat pumps and automation in the built environment is one of many areas in which remanufactured products, parts and components can reduce the overall burden on this sector. The rapid advancement of construction methods and technology is providing an opportunity for companies to drive sustainable practices to reduce their carbon footprint and increase adoption (IGBC, 2025). The new technologies, from retrofit to digitisation, that are becoming standard in the built environment have been supported by projects such as the Digital Academy for the Sustainable Built Environment, which is a hub for courses and micro-credentials in Ireland across energy, the circular economy and digitalisation.

5.4.3 Renewables – wind energy

Ireland's location at the edge of the European community places it in a unique position to exploit its geography to benefit from the prevailing winds both onshore and offshore. The nascent wind energy sector is expanding throughout the island of Ireland, with a strong uptake of onshore wind farms. The Government of Ireland has committed to a target of at least 5 GW of grid-connected offshore wind by 2030 and to investing in floating offshore wind deployment (Government of Ireland, 2023). The government has also committed to developing Ireland's local and global offshore wind supply chain. This industrial strategy is anchored on four core pillars: offshore wind supply chains; research, development and innovation; future demand and end use for renewable energy; and balanced regional economic development opportunities (DETE, 2024).

The ability to quickly develop an offshore presence for wind energy will be a key challenge in the coming years. Ireland's ability to decarbonise its electrical grid could make it an attractive and competitive location for companies to operate from. The support required to help service and maintain wind farms in onshore and offshore locations can provide an opportunity to develop a remanufacturing sector in line with the renewables industry. Scotland's wind energy sector has been recognised as an example of international best practice in terms of innovation, current activity, and capacity and investment (DETE, 2024). Companies such as Renewable Parts have become key players in the remanufacture of wind turbine components, thus reducing the cost to wind farm operators and the carbon footprint (Scottish Environment Business Awards, 2019).

5.4.4 Manufacturing

Manufacturing accounts for 220,000 jobs in Ireland, and exports worth €22 billion in 2023 (Ibec, 2025). The manufacturing sector represents 20% of Ireland's material footprint and 17% of its carbon footprint, making it the third-largest contributor after the built environment and services (technology) sectors (Circle Economy, 2024). The drive to make manufacturing more sustainable can create the conditions for a remanufacturing sector to thrive through innovation and circular jobs. The geopolitical pressures that exist will put pressure on the availability of materials and their supply chains, and therefore new circular business models will be needed. The addition of automation and technological advances such as additive manufacturing may provide an opportunity for companies to remanufacture industrial equipment and machinery to build resilience and efficiency in the manufacturing sector.

The pharmaceuticals sector is a key driver of Ireland's economic wealth through exporting and employment. The equipment required for the pharmaceutical sector

is maintained to high standards of quality and safety, in accordance with EU and FDA regulations. There may be opportunities to remanufacture the equipment in this sector once it has become obsolete due to regulatory restrictions.

5.4.5 Digital services

Ireland has developed a very strong and dynamic digital services sector from its initial foundations in the electronics industry, which has led to Ireland's current position at the forefront of the digital and software industry. The development of software services to advance sustainability is pivotal to measuring and understanding the operational efficiency of all our sectors. The Irish government has created the Disruptive Technologies Innovation Fund to drive collaboration between research and industry, to develop novel technologies to transform business across ICT, AI and manufacturing. The potential of AI to enhance and drive sustainability is a priority area of research for the EU (Eager *et al.*, 2020). The government and the EPA have highlighted how Ireland's digital sector can help accelerate the transition to a circular economy through various solutions such as value chain management, value chain transparency, dematerialisation and enabling waste-to-resource matchmaking.

5.4.6 Research centres

Research centres play a key role in maintaining Ireland's competitive advantage across the global manufacturing landscape. Traditionally, research centres in Ireland have been established with specialities and knowledge developed in universities and colleges. Ireland has a rich history of collaborating with industry to achieve notable successes and to keep it on the front foot during challenging times.

In Ireland, several research centres and universities provide cutting-edge research across the Irish manufacturing sector. Research in remanufacturing in Ireland has thus far been limited and needs to be increased to sustain Ireland's and the EU's economies and to build in resilience. By providing opportunities for research to companies based in Ireland and the EU, we can offer a competitive advantage and solidify Ireland's role in the EU. A research centre focused on remanufacturing can harness our existing knowledge and skill sets to add value to small and medium-sized enterprises and multinational corporations, and to other services, from logistics to service and distribution. The Irish Manufacturing Research's national platform for circular manufacturing (CIRCULÉIRE) has led the way in promoting the circular economy and has adopted and developed the initial stages of investigating remanufacturing in Ireland.

6 Recommendations

6.1 Introduction

The recommendations outlined in this chapter reflect the results of the stakeholder interviews and surveys. They are supported by the themes identified in the state-of-the-art literature review and in research trends and attitudes towards remanufacturing in Europe and in a global context. Developing a plan to initiate and support remanufacturing is possible, as it has been undertaken in other countries. The main recommendations are to:

- create a centre of excellence to advance remanufacturing;
- define policies based on remanufacturing and support Irish businesses in line with EU policy;
- create a roadmap to support remanufacturing in Ireland through further stakeholder engagement.

6.2 Centre of Excellence for Remanufacturing

Several centres of excellence for remanufacturing have been created and developed, including in the UK, Singapore, the USA, South Korea, China and Germany (Scottish Institute for Remanufacturing, 2025).

SIR is hosted at the University of Strathclyde and was funded by the Scottish Funding Council and Zero Waste Scotland, with an initial investment of £1.3 million over 3 years. It has since received additional support from Zero Waste Scotland to continue its activities in stimulating and supporting the remanufacturing community in Scotland.

The Advanced Remanufacturing and Technology Centre is a public–private partnership between the Singapore Agency for Science, Technology and Research and Nanyang Technological University that provides a collaborative platform to bring industry, public research institutes and academia together (Pepin, 2018). The main research themes are focused on next-generation manufacturing, autonomous manufacturing, net zero manufacturing and resilient value chains. The net zero manufacturing theme covers remanufacturing process technology and smart remanufacturing systems.

The REMADE Institute is a public–private partnership funded by the U.S. Department of Energy's Advanced Materials and Manufacturing Technologies Office and is a partnership of industry, academia, trade organisations and US national laboratories. The REMADE Institute is led by RIT. RIT is home to the Centre for Remanufacturing and Resource Recovery.

In 2017, China designated the city of Hejian in Hebei province as the home of the National Remanufacturing Industry Demonstration Base. The remanufacturing activities based in and around Hejian city are focused on the automotive and oil and gas industries (European Remanufacturing Council, 2017b).

Karvonen *et al.* (2017) meanwhile developed a series of recommendations for policymakers and industry to further remanufacturing through the creation of a European centre of excellence.

A centre of excellence for remanufacturing in Ireland could mimic best practice from the centres highlighted above and create ties to further strengthen its reach. A centre of excellence should be a focal point for collaboration and networking on the island of Ireland. Establishing a one-stop shop for circularity and manufacturing would be a key driver for advancing sustainable practices and create easy access to support for industry. A centre of excellence should be a resource for all stakeholders, where remanufacturing activities are presented, explored and initiated through policy and funding. Providing access to training and education on remanufacturing and other recirculation strategies should be a key function of a centre of excellence. There is an opportunity to incorporate a remanufacturing centre of excellence into the existing portfolio of CIRCULÉIRE and Irish Manufacturing Research, in line with government policy to create a centre of excellence for circular innovation as part of Action A66 in the public consultation on the Whole of Government Circular Economy Strategy 2026–2028.

6.3 Developing a Remanufacturing Policy

A structured and consistent set of policies to support remanufacturing should be developed in line with current best practice and in line with Ireland's ambitions and targets to achieve net zero by 2050.

The opportunities to build resilience and sustainability into manufacturing will be key to keeping Ireland resilient and at the forefront of technology advancement in the coming years. Circular economy policy has identified the importance of all R-Strategies in achieving net zero, but a new focus is needed to develop specific policies related to remanufacturing. We have seen the ability of green public procurement to drive change by using a top-down approach in the public sector. The next steps should include mandatory targets to further incentivise the uptake of remanufactured products.

Policy development should concentrate on current activities in Ireland as well as potential future industries driven by the transition to cleaner energy. Government policy should be directed towards supporting all industries across the manufacturing, service and distribution sectors in Ireland.

A national data collection framework on remanufacturing activity and its environmental and economic value would be an important foundation in helping to develop further policy to support this activity.

This report highlights that remanufacturing should take place close to market to reduce the carbon footprint and overall impact of remanufacturing. Ireland is ideally placed, due to its geographical position as an island on the edge of Europe, to develop and trial specific remanufacturing activities. The island of Ireland contains many skills and competencies across manufacturing, logistics, software and innovation that can bring innovation and change and lead by example. Ireland can leverage its role as an EU Member State to add value and be used to promote remanufacturing.

6.4 Roadmap for Remanufacturing

A roadmap to outline the journey to support remanufacturing in Ireland will be an essential tool in aligning the needs of all stakeholders and aligning with government and EU strategy while incorporating Ireland's unique position in Europe and its skill sets.

A standard strategic roadmap requires the identification of strategic objectives, the development of initiatives, the definition of actions, the setting of timelines and milestones, understanding dependencies and risks and, finally, the regular process of reviewing and refining the roadmap. Creating a roadmap would begin with mapping remanufacturing and potential adjacent activity in Ireland. The opportunity to quantify this activity would enable a centre of excellence to meet the specific needs of these companies. Further stakeholder engagement would be beneficial to understand the localised barriers that companies may face, be it technology related or supply chain complexity.

Barrie *et al*. (2024) conducted a study on national circular economy roadmaps that focused on global roadmaps, calls to action and operational strategy. Thirty roadmaps were identified, offering qualitative vision with focused areas and actions to be undertaken. The research categorises remanufacturing under circular resource management (Barrie *et al.*, 2024). Ireland's roadmap for the circular economy, *The Circular Economy Programme 2021–2027*, was created and led by the EPA to outline the national plan to transition to a circular economy (Environmental Protection Agency, 2021, p. 16). The key points of this document are to provide leadership, knowledge and expertise to help promote circularity across all sectors in Ireland. The programme identifies several priority areas, from packaging to textiles, batteries and electronics. Remanufacturing has been identified in this roadmap and the development of a specific roadmap for remanufacturing will be a key part of this programme. Finland prepared one of the first national roadmaps to a circular economy in 2016 under the leadership of the Finnish innovation fund Sitra. Following on from this success, Sitra developed a guide on developing this type of roadmap (Järvinen and Sinervo, 2020). This guide identified a number of steps for creating a roadmap (Figure 6.1).

We can adapt these steps for a roadmap for remanufacturing in Ireland. In addition, it is necessary to further set out and understand the needs of industry through stakeholder engagement and to further understand the barriers and enablers in Ireland. A roadmap for remanufacturing should map and address the needs of all sectors in their adoption and understanding of remanufacturing. The next steps after

Figure 6.1. Circular economy roadmap structure. Based on Järvinen and Sinervo (2020).

this foundational research and prior to developing the roadmap would encompass the following:

- Groundwork and preconditions. Map activities in Ireland in remanufacturing or a related activity, such as repair, refurbishment, reprocessing and reconditioning, to understand the industrial scope and potential stakeholders.
- Stakeholders and participation. Identify key stakeholders in industry, academia and research, and government, and create a steering group to strengthen participation.
- The situational picture. Consolidate the information gathered in the first two steps to understand the current state of remanufacturing in Ireland.

Following this foundational stage, the roadmap can be further developed by setting out the vision and goals, selecting focus areas, planning actions to achieve the roadmap goals, compiling and publishing the roadmap, executing and implementing the roadmap and, finally, evaluating and revising the goals (Figure 6.2).

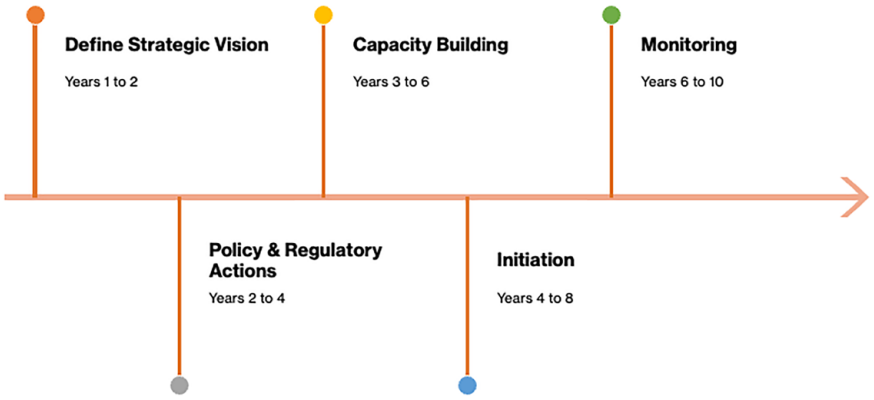

Figure 6.2. Roadmap process.

An example of what a roadmap process might look like is documented here:

- Strategic vision. Develop Ireland as a centre of excellence for remanufacturing within the context of supporting Irish, European and global manufacturing. Identify activities in remanufacturing that play to Ireland's strengths and skills. Address opportunities to increase R-Strategies across industry.
- Policy and regulatory actions. Develop policy to support remanufacturing in Ireland and to support organisations, either through further green public procurement or through understanding the opportunities presented by legislation and developing test beds using specific funding mechanisms to enable organisations to de-risk.
- Capacity building. Create awareness of remanufacturing among all stakeholders, from industry to consumers. Identify and enable further learning through online courses, webinars and industry forums.
- Initiation. Engage with the three pillars of the Triple Helix and further develop a strategy to help all stakeholders in Ireland initiate remanufacturing activities through pilot projects, partnerships or collaborations.
- Monitoring. Measure and capture data from remanufacturing activity and feedback from stakeholders to identify areas of strength and areas of weakness where additional support is needed.

The outcome of this project is to provide a roadmap that will enable Ireland to develop as a global centre of excellence for remanufacturing while promoting resilient jobs as part of the circular economy. The strategic vision is to create a centre of excellence for remanufacturing in Ireland, to create employment and build in resilience to manufacturing. This can be achieved by assessing the current landscape in Ireland, defining the opportunities that may exist and aligning the vision with national policy. The first stages of the strategic vision have been captured in section 1.2 and suitable sectors have been identified in Chapter 5. However, following on from this initial research, a further study is vital to identify suitable sectors for remanufacturing. A key action of the strategic vision is aligning national and EU policy, including the EU Circular Economy Act, the Whole of Government Circular Economy Strategy 2026–2028 and various policy items, such as the Clean Industrial Deal, the Ecodesign for Sustainable Products Regulation and digital product passports. The strategic vision can be further enhanced with stakeholder engagement.

The ReManIre project can be seen as the first piece of the puzzle in the development of a strategic roadmap for the development of Ireland as a centre of excellence for remanufacturing. Ireland is an ideal test bed for assessing and implementing remanufacturing practices and solutions owing to its highly developed ecosystem for technology coupled with its high level of academic and research facilities for industry. This project has outlined and developed the first steps of the strategic vision by examining the current state of the art and identifying opportunities for sectors in Ireland.

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Abbreviations

AI	Artificial intelligence
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CRM	Critical raw materials
DTU	Technical University of Denmark
EPA	Environmental Protection Agency
EPR	Extended producer responsibility
EU	European Union
EV	Electric vehicle
FDA	U.S. Food and Drug Administration
ICT	Information and communication technology
IDA	Industrial Development Authority
IIoT	Industrial Internet of Things
ISO	International Organization for Standardization
MDR	Medical Devices Regulation
OEM	Original equipment manufacturer
ReManIre	Remanufacturing for Ireland
RIT	Rochester Institute of Technology
SIR	Scottish Institute for Remanufacturing
SUD	Single-use device

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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