Innovation action plan for aluminium in a circular economy

Circular Economy Innovation Network

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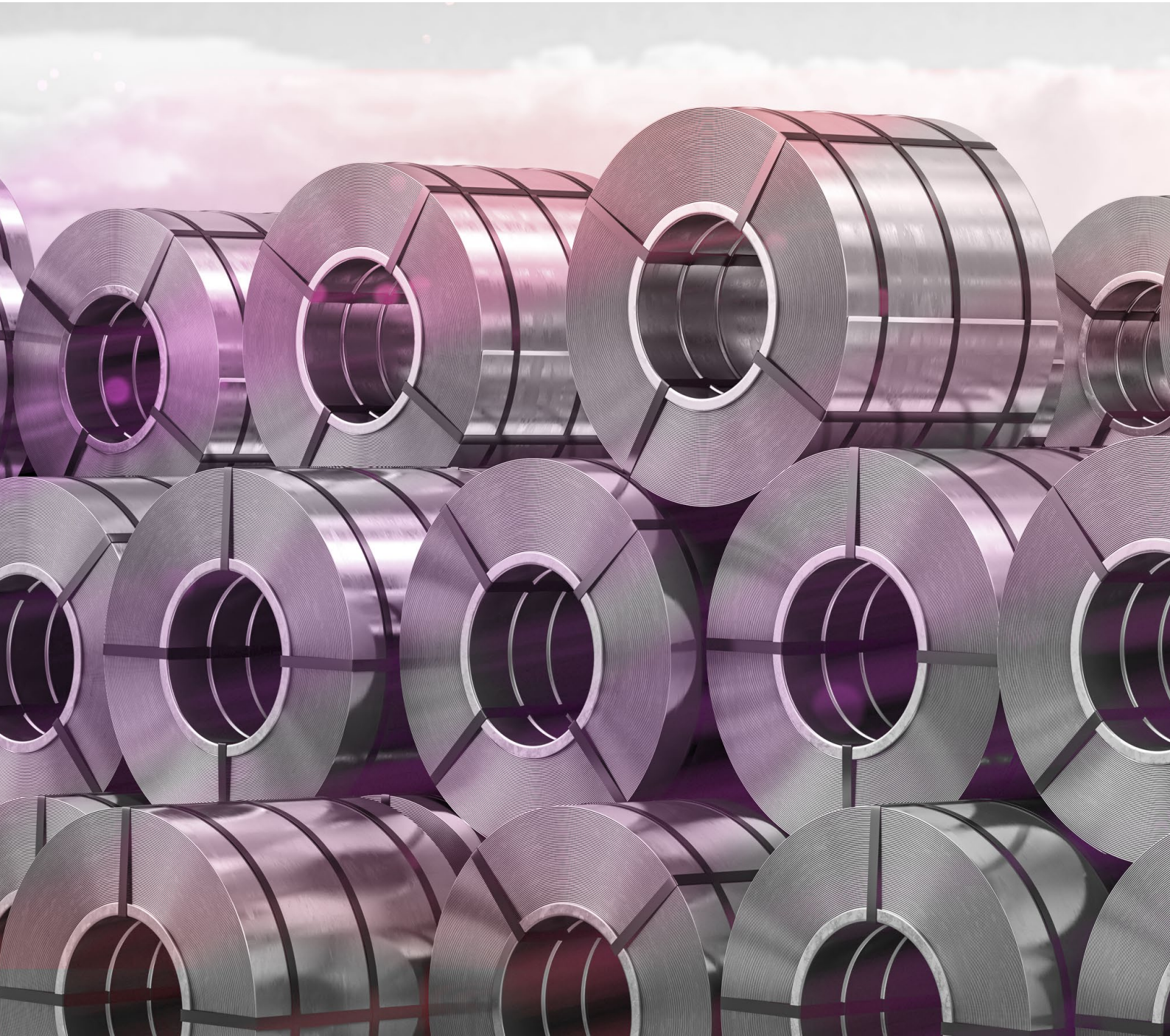

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Introduction

It is widely accepted that a step-change is needed to put the world on track to achieve net-zero emissions by 2050 to meet the 1.5˚C target set out in the Paris Agreement and achieve the Sustainable Development Goals. In the UK, most of what we use and consume flows through a take, make, waste linear economy.

By contrast in a Circular Economy, products or their component parts are recovered or processed in a way that they can be repaired for reuse, resold, refurbished or remanufactured, or reduced to composite elements for recycling.

Circular economy principles are based on a holistic systems thinking approach that seeks to eliminate pollution and waste being emitted from the outset. By adopting a circular economy framework and building collaborative communities aligned to three key principles: Circular Design, Circular Business Models, and Circular Recovery; we aim to inspire industry members to come together to reduce environmental impact and achieve Net Zero goals.

Research shows specialist collaborations produce results that wouldn't be possible when people think and work in isolation, so we are focused on convening sector challenge communities: to collaborate and consult across the value chain to co-create a Circular Innovation Action Plan for each of our target challenges identified by industry stakeholders through a series of consultation interviews, workshops, surveys and literature review.

To date, across the globe, the focus has been concentrated on efforts to mitigate the climate change impacts by a transition to renewable energy, complemented by energy efficiency. Whilst these efforts are critically important, research shows that renewables are likely to address only 55% of emissions[1].

The remaining 45% of emissions result from the way we produce the cars, clothes, food, and the wide range of other products and materials we use in our daily lives.

The Circular Economy Innovation Network focused on aluminium aims to catalyse change for:

1. **Reduction of GHG emissions across participating industries.**
2. **Improved protection for biodiversity and the natural environment from better use of natural resources and prevention of waste leakages into the environment.**
3. **Increased adoption of circular solutions for industry challenges.**

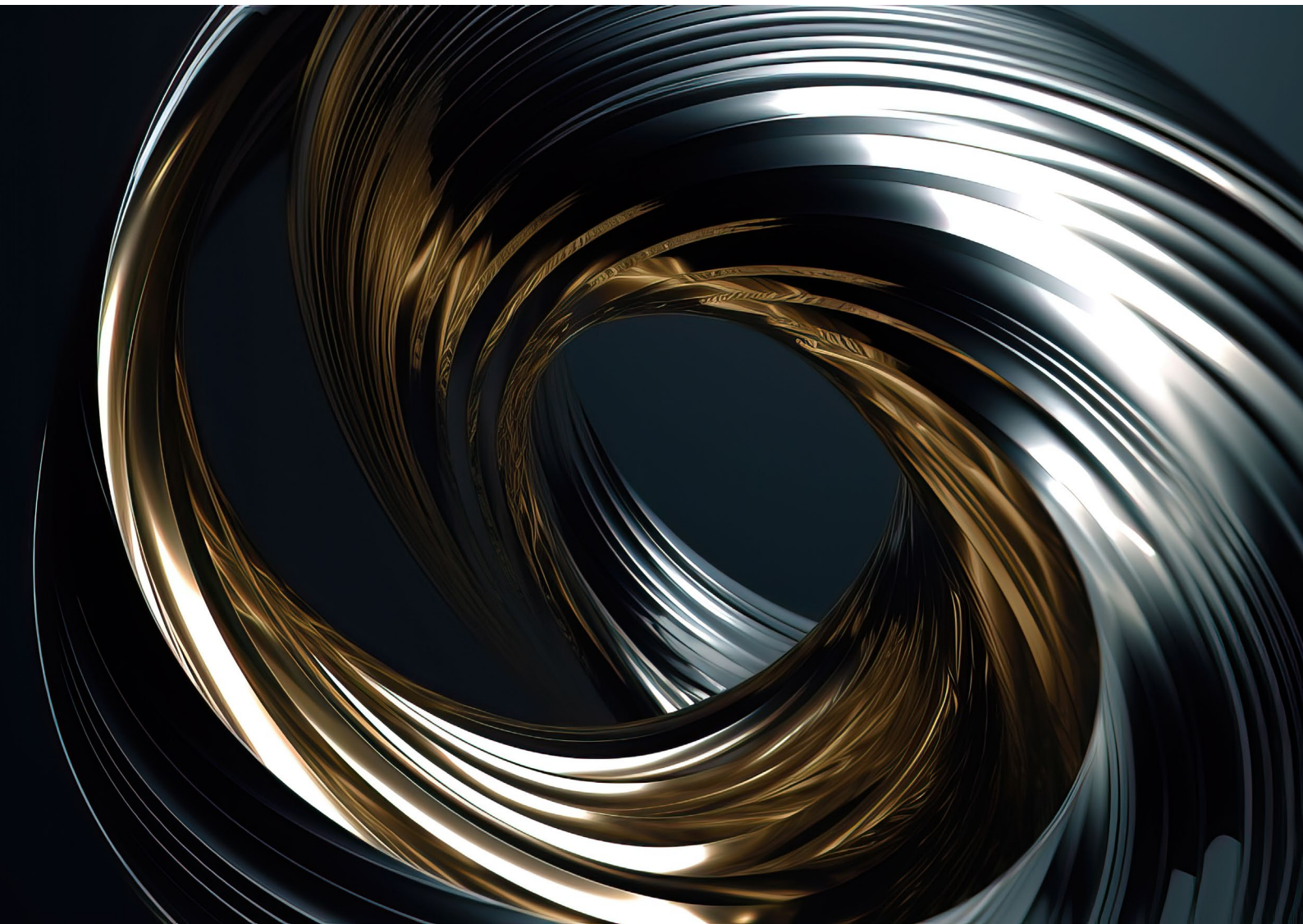
(1) Source: IPCC, Fifth Assessment Report (AR5) and Material Economics analysis.

Aims

The aim of this Action Plan for Aluminium is to outline the key interventions for the aluminium sector to accelerate the adoption of circular economy principles and identify stakeholder groups to lead on the specific actions.

The opportunities are:

- Circular Design: to reduce the environmental impact of aluminium, taking into account the end-to-end cycle to achieve a 'greener aluminium'.
- Circular Recovery: to recover all aluminium and retain its value throughout its lifecycle.
- Circular Business Models: to adopt new ways of working to generate revenue, transform supply chains and do more with less.
- To develop a deeper understanding of the role of circular innovation to deliver environmental, economic and social benefit within value chains and sectors.
- To enhance knowledge sharing collaboration between industry, government and researchers leading to accelerated innovation.
- To develop a greater understanding of the role of policy in driving circular innovation to achieve net zero.



Aluminium Circularity Opportunities in the UK

Aluminium is increasingly important to today's society, as the second most-used metal in the world by mass due to its unique properties, durability, corrosion resistance, and flexibility.

Circular economy for aluminium could boost jobs, generate growth inside planetary limits, stimulate investment, and accelerate the transition towards a lower carbon, resource efficient economy across the UK.

To date, almost all of the primary aluminium that has ever been produced has been extracted through mining the ore bauxite. It takes an average, 4 or 5 tonnes of the clay rock to produce just 1 tonne of aluminium. As with any extractive process, there are significant impacts on the natural environment, including dust pollution, reduced air quality, vegetation loss, forest fragmentation and biodiversity loss, and negative impacts on water resources.

It is well documented that the process is carbon intensive particularly due to the required electricity. Depending on the source of the electricity up to around 16 tonnes of CO2e are produced per tonne of virgin prime aluminium. By comparison, making a tonne of primary aluminium emits more carbon than burning 5 tonnes of oil[2].

However, aluminium has a pivotal role to play in helping to deliver the benefits of a sustainable future as it can be infinitely recycled with minimal levels of degradation and its specific strength offers significant benefits to transportation, logistics, healthcare, engineering etc.

The European Aluminium Association, predict future growth drivers to be:

Automotive: New uses and applications within the automotive sector to reduce vehicle emissions. The increased focus on electric vehicles may also accelerate demand growth as saving weight can help to improve battery life and improve safety.

Construction: The European Green Deal heralds a 'building renovation wave' and with rigorous enforcement of legislation related to the energy performance of buildings, it is expected to create new aluminium solutions adding to those used for facades, window frames, shading devices and HVAC systems (Heating, Ventilation and Air Conditioning). Low-carbon electricity systems also depend on aluminium for many components such as solar panels, wind power plants and high voltage power grids.

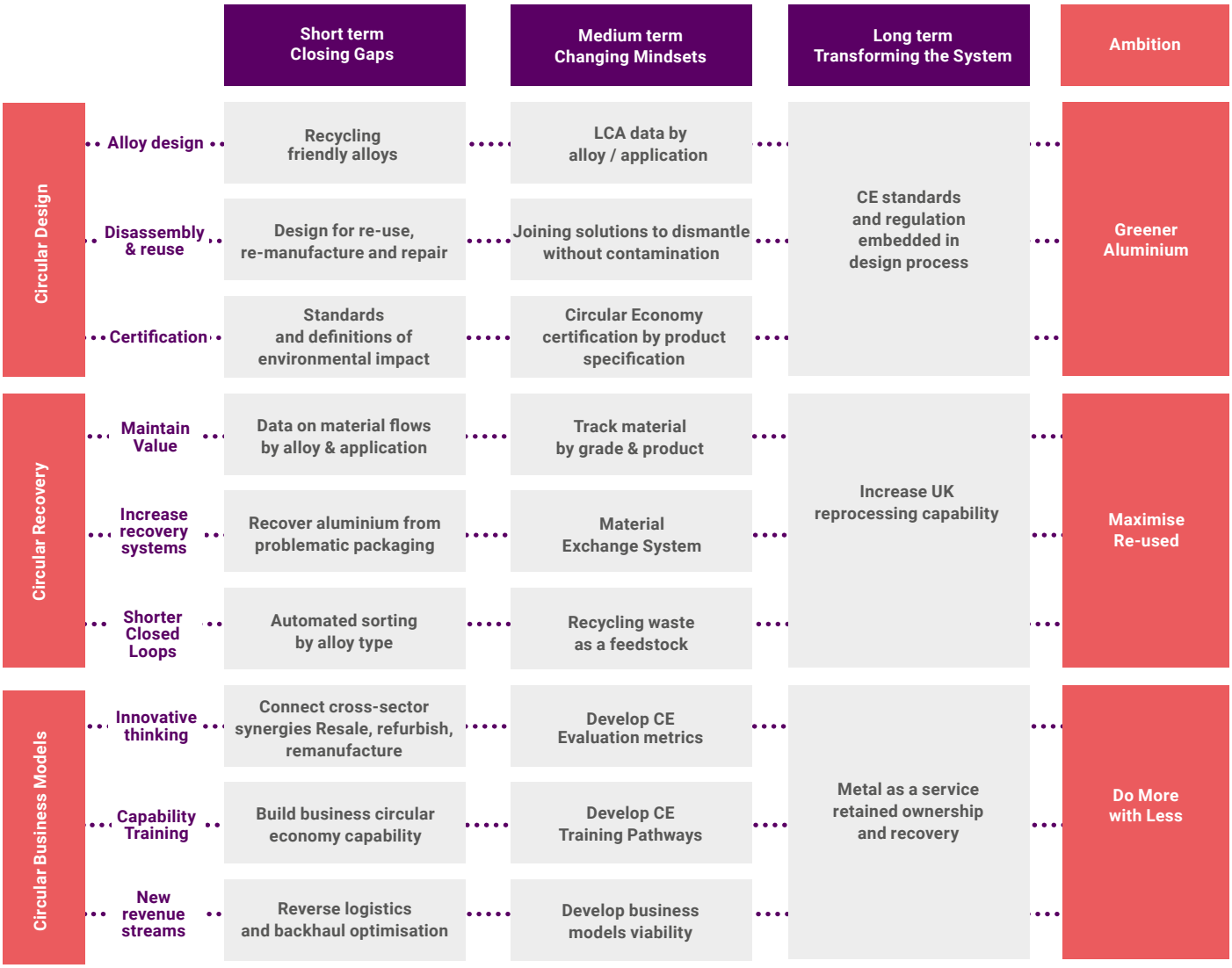
Packaging: The pressure on non-recyclable and non-recoverable packaging has increased since the adoption of the EU Single Use Plastics Directive in 2019. The UK's Department for Environment, Food and Rural Affairs [DEFRA] directive on beverage containers, including aluminium beverage cans, need to be collected and recycled at rates 90% or higher. Composite (laminated) packaging must be redesigned in order to make it suitable for sorting and recycling.

(2) Europa JRC Technical Report - Sustainability aspects of Bauxite and Aluminium

Recycling can help to reduce the amount of natural virgin resources but it does not address the root causes of climate change, which include greenhouse gas emissions from burning fossil fuels and other human activities. The recycling infrastructure itself generates waste and has an environmental impact through transportation, material processing, cleaning, shredding, re-forming, particularly because in the UK and Europe it is predominately powered by fossil fuels. The Circular Economy framework focus efforts toward the smaller, tighter inner loops where products and materials can be repaired, refurbished, remanufactured and resold, enabled by circular design principles.

While recycling is an important part of reducing our impact on the environment, it is not a solution to climate change on its own.

Summary of opportunities based on consultation with UK industry, government and academia



Importance of Renewable Energy Sources

Aluminium is a particularly electro-intensive industry. The falling costs of variable low carbon power represent an opportunity; however, significant challenges remain, as aluminium smelters require constant power inputs.

Greater development of other complementary power technologies such as batteries and hydrogen are being explored. UK wind energy is led by Scotland, with plans for 27GW off wind capacity to be built in the next decade. Whilst the CEIN programmes do not focus on energy, renewable sources of energy are a critical factor and pivotal to reduction of scope 1, 2 and scope 3 emissions. Energy sources are not in scope for the production of this action plan since other Innovate-UK KTN initiatives are focused in this area.

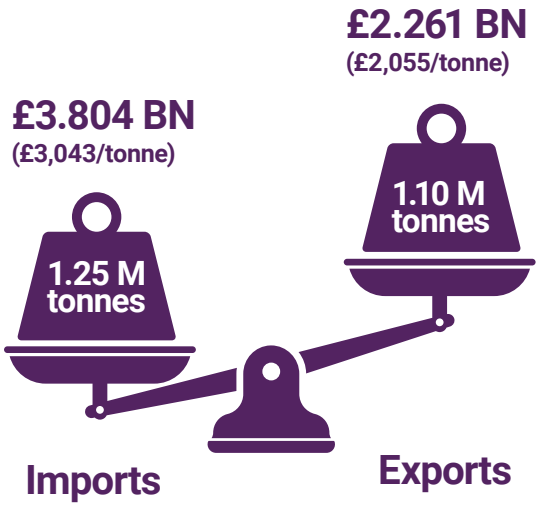
Landscape Assessment

The UK government outlines its plans to achieve the 2050 goals[3] by:-

- Accelerating the transition towards a regenerative growth model that gives back to the planet more than it takes.
- Advancing towards growth within planetary boundaries by reducing its consumption footprint.
- Doubling its circular material use rate in the coming decade.

The circularity of aluminium is focused on recycling, however, currently there is limited capacity in the UK. Therefore, large quantities of scrap aluminium material is sent overseas, typically to the EU, for reprocessing. For example, in 2018, 100,141 tonnes of aluminium packaging were collected for recycling in the UK, 95% of it was exported to Europe for onward use. The reprocessed aluminium is then imported in a higher value state. As illustrated in the image to the right, based on figures from by the ALFED UK/EU Trade Negotiations Position Paper[4].

UK aluminium imbalance between imports of high value products and exports of lower value products.



In effect, the UK imports aluminium at almost 50% higher value than it exports. While significant investment is required to develop the UK reprocessing capability, there is a substantial opportunity to capture and improve on the value of the aluminium in the UK.

(3) 2050 Build Back Greener Report, https://www.gov.uk/government/publications/net-zero-strategy
(4) https://alfed.org.uk/policy-areas/trade/alfed-uk-eu-trade-negoitations-position-paper-february-2020/

Government Policy and Regulations

Various governmental policy measures and regulations are in place which are designed to deliver reduced environmental impact and increase circularity of materials. The nature of these measures depends on the industry and type of organisation.

The UK was the first G20 country to mandate reporting of climate related risks and opportunities under TCFD 2025 (Taskforce on Climate Relate Financial Disclosure) for business to demonstrate an understanding of how climate related risks, and subsequent carbon reduction plans are built into a company's strategic planning approach, something now highly valued to investors, and stakeholders. A component pillar is Streamlined Energy and Carbon Reporting (SECR)[5] introduced as legislation to replace the Carbon Reduction Commitment (CRC) Scheme.

SECR requires obligated companies to report on their energy consumption and associated greenhouse gas emissions. It is expected that this obligation will become more stringent and cover more companies with time such that all organisations will need to commit to a net zero plan.

The UK Government mandates all Central Government Departments, their Executive Agencies and Non Departmental Public Bodies to apply Procurement Policy (PPN 06/21) when procuring goods, services or works with a contract value above £5 million per annum meaning suppliers must submit a robust carbon reduction plan that identifies goals and timelines before a tender can be reviewed for consideration.

(5) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850130/Env-reporting-guidance_inc_SECR_31March.pdf

In September 2021, the government introduced a number of legislative measures to tackle greenwashing, mandating that companies provide accurate and transparent information about the environmental impact of their products and services, including the ability to impose fines and bring legal action against companies that engage in greenwashing. This directive, together with the Green Claims Code, aims to help businesses understand and comply with their existing obligations under consumer protection law. The Competition & Markets Authority guidance covers a wide range of topics, including legal operating framework, carbon footprints, recycled content, and biodegradability, and provides clear standards for companies to meet when making environmental claims.

Carbon Border Adjustment Mechanism (CBAM) is an emissions tariff applied to goods with a high risk of carbon leakage from countries which are not members of the EU Emissions Trading System (ETS) as a mechanism to accelerate a reduction in carbon footprint. This legislation will have impact on UK business importing and exporting to Europe as it will apply to aluminium, as well as other industrial materials such as iron, steel, ammonia and cement.

The European Union's implementation of CBAM is focused on reducing the risk of carbon leakage as it strengthens its Emission Trading System and is likely to affect market price and metal trade flows.

Importers will need to declare and purchase CBAM certificates to cover the greenhouse gas emissions associated with the production of the imported aluminium products, starting with a transition phase from October 2023 to 2026 after which it is proposed that importers will start paying carbon adjustments.

The UK Department Energy Security & Net Zero Carbon Border Adjustments consultation process seeks to address carbon leakage and support decarbonisation across emissions and is likely to result in greater emphasis on data collection, reporting and inherently procurement policy.

Environmental claims must :-

1. Be truthful and accurate.
2. Consider the full life cycle of the product or service.
3. Be clear and unambiguous.
4. Not omit or hide important relevant information.
5. Be fair and meaningful.
6. Be substantiated.

Ongoing Initiatives

There are several ongoing programmes to address some of the challenges with transforming the UK metals industry to more sustainable and circular practices. The focus and scope of each of these programmes are different and an overview is provided in table below.

Innovate UK KTN have been actively engaged with each of these programmes to ensure alignment of the action plan with these programmes where possible. These programmes offer potential sources of funding support and/or collaboration to facilitate the action towards circularity of aluminium in the UK.

Overview of initiatives in the UK relevant to circular economy in metals.

		Resource Efficiency programmes				
		Circular Metal	PRISM	i-SPACE	Transforming Foundation Industries Challenge	ECONOMISER
	Programme lead	Brunel University London	Materials Processing Institute	Swansea University Metals	Innovate UK	Foundation Industries Sustainability Consortium (FISC)
Theme	Circular economy	Metals	Metals	Metals	Multi-material	Multi-material
	Process optimisation				Multi-material	Multi-material
	Alternative fuels				Multi-material	Multi-material
	New materials development	Metals			Multi-material	Multi-material
	Digital technologies		Metals		Multi-material	Multi-material
	Decarbonisation		Metals		Multi-material	Multi-material

Note: Multi-material includes metals, glass, cement, ceramic, paper and bulk chemicals.

Circular Design

From choosing the material type, considering the way products and services interact with people and systems through to end-of-life disposal, Design is a critically important pillar of Circular Economy systems.

The aluminium sector has the opportunity to reduce environmental impact through improved design.

Alloy design - In 2021, there were over 600 registered aluminium alloy types in the Aluminium Association system. While only a small proportion of these alloy types are in widespread use, the variety of compositions and alloying elements complicates segregation and sorting. The 1000 series are relatively pure, containing at least 99% aluminium, and are most easily recycled. Whereas the 7000 series contains greater quantities of other alloying elements, e.g. zinc, which affects their recyclability. In the near-term, the alloy compositions should be aligned to the compositions in the recovered material flow to maximise the recycled content without detriment to the material properties and performance. Longer term, consideration should be given to the number of alloy iterations to assess if proliferation is a barrier to an effective and efficient sorting and recycling process.

Product design – the specification of alloys in product design is often based on the existing design rather than considering the required performance. Multiple alloy types in single products leads to contamination of the alloys and downcycling of the material. If the number and type of alloys used for a given product or application were rationalised in the design process (e.g. single alloy body in white), it could ease recovery of the material and open up opportunities for tighter circular processes, e.g. reuse or remanufacturing. This approach to the design process will be incentivised if the designer and producer has a greater vested interest in the recovery of the material, which could be achieved through legislation or business model innovation.

Design for life - Both products and materials can be designed and developed to tolerate damage and maintain performance. Research is underway into methods to rejuvenate alloys. Microscopic damage to the material can be detected and diagnosed during service. Physical stimuli can then be applied to reverse the damage, including electrical current treatment[6], ultrasonic vibration[7] and others. Another route is to design the alloys such that weak points in the material are strengthened as the damage occurs, which can be termed self-healing[8]. While these approaches are at early stages of development, they represent a significant opportunity to reduce the demand for primary resources and move towards greater resource efficiency.

(6) C.-L. Liang et al: Mater. Charact., v145, p545, 2018 https://www.sciencedirect.com/science/article/abs/pii/S1044580318318886
(7) R. Zhang et al.: Intl. Journal of Fatigue, v153, https://doi.org/10.1016/j.ijfatigue.2021.106463
(8) R. Lumley, Self Healing Materials, v100, 2007, https://doi.org/10.1007/978-1-4020-6250-6_11

Design for recovery - it is recommended that designers consider the in-country end of life management before specifying a material type, particularly where the prevalent end of life solution is thermal incineration, resulting in a further minimised material recovery. Evaluating the implications of specifying a long-life durable material, such as aluminium, for short-term applications requires consideration of Life Cycle Assessment [LCA] and environmental scores to account for the wider impact of energy, emissions, water, pollution and others. In consumer goods, the material flow can be as short as 8 weeks, therefore action taken now can improve design for recycling efficiencies in the near term, however in automotive and construction industries changes to design specification may take decades before the asset is available for recovery and re-use, meaning a variable systems approach could be beneficial.

Standards and definitions - The terminology and definitions in use at present are inconsistent and varied, so that it is difficult to clearly communicate the environmental credentials of a given product and hence to illicit a commercial advantage from adopting circular practices. First aligning definitions and terminology, then designing consistent certifications will help communicate the benefits of circular practices to customers. Aluminium has the potential to lead the way in defining and certifying the environmental credentials of the material to increase value of UK production.

Strategic Themes

Design Actions	Suggested ownership	Timeline for action
Recycling friendly / scrap tolerant alloys Design and develop alloy specifications aligned to the composition of recovered material. Work in this area exists but needs to be across multiple alloy applications and sectors to increase adoption. This will require collaboration up and down value chains for different applications.	Industry, recyclers, producers, OEMs, Academia	Short term
Design for re-use, re-manufacture and repair Increase awareness and adoption of state-of-the-art design for re-use, re-manufacture and repair across industries. Work with designers and product specifiers to generate sector design guidelines for aluminium products.	Academia, Industry, Innovate UK KTN	Short term
Standards and definitions of environmental impact Standardise the terminology and metrics used to determine the environmental impact of aluminium. Currently different terminology is used across the sector, including specifications provided by customers, for example some use percentage recycled content while others use embodied carbon. A consistent approach helps articulate the benefit of using aluminium over other materials, encouraging industry to adopt more sustainable practices and promote UK production.	Trade bodies, Industry, Academia, Standards organisations, NGOs	Short term
Circular Economy certification by product specification Develop and define certification indicating the circularity of aluminium products, on labelling for example. The certification clearly communicating the circularity and environmental impact of aluminium products to end-users and encourage demand for more circular materials.	Industry, Academia, Standards organisations, NGOs	Short term
LCA data by alloy / application Develop a modular and consistent life cycle assessment (LCA) for aluminium products. Existing LCAs are inconsistently applied so difficult to compare. The LCA needs to consider the full life of the product and as such can articulate the benefits of circularity.	Academia, Industry, Trade Bodies	Medium term
Joining solutions to dismantle without contamination Identify improvements in joining solutions to enable increased dismantling without contamination. Joining solutions exist however are not widely adopted and many products are shredded prior to reprocessing, significantly decreasing the value of the material and increasing carbon footprint.	Academia, Industry	Medium term

***Timeline (Short 0-2yrs, Medium 3-5yrs, Long 5yrs+)**

Circular Recovery

Focusing on retaining all assets across value chains and procurement policies can result in reduced amounts of new feedstocks needed, lowering costs and mitigating risk across supply chains. This is particularly pertinent for aluminium where primary production has a significant environmental impact.

The aluminium sector has the opportunity to reduce environmental impact through increased adoption of closed loop recovery to maximise value retention.

According to researchers Mulhall and Braungart, across the globe, businesses throw away hundreds of billions worth of valuable materials because they are not designed for recovery. What is gained on the front end through convenient bonding is lost on the back end through destructive mixing of materials that degrades their quality.

Maintain value – Digital tools can fundamentally enable circular systems. Several OEMs are adopting materials passport - a means of tracking materials throughout the material flow - to encourage material recovery. The data could be used to gain greater understanding of the flow of the alloy types and facilitate connections between waste handlers and potential users of the materials and products to maintain the value of the material.

Natural capital accounting - Scrap aluminium volumes and price fluctuate according to market demand, the opportunity to move away from weight-based towards impact-based targets and reporting, focusing initially on carbon and natural capital accounting will improve data collection leading to development of innovative digital solutions for tracking scrap and residual waste.

Closed loop - Recycling is an important business model for metals including aluminium. However, a significant percentage of the UK recycling is carried out in open loops, whereby the alloy types are not segregated and the recyclate may be used in other, lower value, applications. As opposed to closed loop recycling, where the recyclate is used for the same or similar application (see Figure 1). This resource-efficient system enables material recovered to retain its inherent properties and is not subject to changes. This is limited by the accumulation of impurities along both the production and recycling processes.

Closed loop examples -

- Hydro, a Norwegian aluminium producer, has stated it's committed to a circular economy approach. The company has implemented a closed-loop recycling system for aluminium, which enables it to recycle scrap aluminium from its own production processes as well as from external sources.

- Novelis, a US company also based in the UK and Europe, produces rolled aluminium products for a variety of industries. The company is committed to a circular economy approach and is a successful example of operating a closed-loop recycling system for aluminium, which enables it to recycle its own scrap as well as scrap from external sources.

- Ball Corporation is a US-based company operating in the UK that produces metal packaging. The company has implemented a closed-loop recycling system for aluminium cans, which enables it to recycle cans from its own production processes as well as from external sources.

Separation and sorting - Ongoing developments in laser-based and x-ray analysis techniques has improved separation and sorting to reduce contamination. However, some products remain challenging. This is exemplified by composite materials in which aluminium accounts for a low percentage of the overall product, making the metal difficult and expensive to recover, often leading to downcycling into lower value products. Developing and deploying sorting and purification methods at scale would facilitate widespread closed loop recycling.

Purification - Aluminium's low melting point, high oxygen affinity and high reactivity compared to its contaminants makes it difficult to separate molten aluminium from impurities. Methods for removing elements from molten aluminium include: filtration, electromagnetic separation, electrolysis, fluxing and gravity separation. These techniques are subject to commercial constraints in the UK due to their

Recycling waste - Innovation being developed in the UK include the use of dross and salt slag resulting from recycling process, as a feedstock for other processes[10]. Valuable metals recovery can be carried out by a multistage electrometallurgical method developed by Zuo et al[11]. Other methods which are currently under development include salt-free plasma technology[12]. The current export of salt slag from the UK is a lost resources that involves transportation of a hazardous waste due to the UK's current lack of infrastructure.

Infrastructure - there is an opportunity for the UK to benefit from the increased demand for recovered aluminium by increasing the required infrastructure. As previously mentioned, the UK imports aluminium at almost 50% higher value than it exports. UK communities do not currently have access to consistent standardised recycling processes and those that do may not have adequate infrastructure to process all recyclable materials. Even when recycling programs are available, people may not always participate. For example, they may not sort their recyclables properly or may throw recyclable materials in the trash out of convenience, acknowledging the role of behaviour change, communication and education is a key factor. In addition, repair and remanufacture can open up new economic opportunities but the required infrastructure needs to be developed.

(10) https://im-mining.com/2020/11/16/rio-tinto-signs-ultromex-treat-landfill-aluminium-salt-slag/

(11) https://www.sciencedirect.com/science/article/abs/pii/S0921344921003773

(12) https://www.sciencedirect.com/science/article/abs/pii/S0921344902000101

Open Loop vs Closed Loop

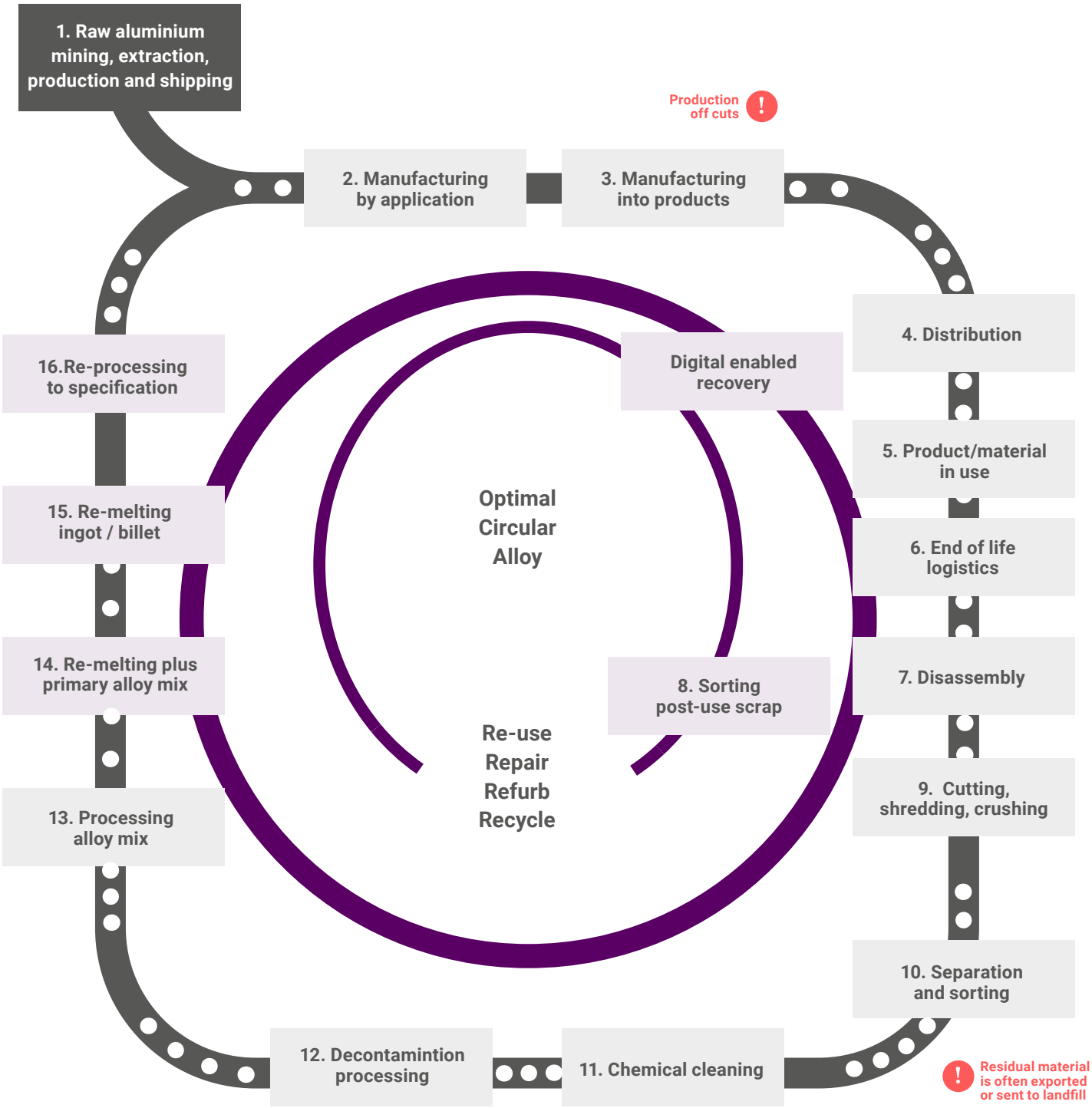


Figure 1. Open Loop vs Closed Loop process with reduced circularity leads to additional investments in energy, time, cost and prevents benefits from shorter, tighter closed loops.

Diagram created by Lorraine Bennett Runton + Christopher Pilgrim

Strategic Themes

Recovery Actions	Suggested ownership	Timeline for action
Data on material flows by alloy & application Collate data on the flow of aluminium material by alloy grade and application. Determine which grades and applications exhibit higher recovery rates to identify best practice and opportunities to close loops and improve recovery.	Industry, Academia	Short term
Recover aluminium from problematic packaging Develop economically and environmentally sound method to recover aluminium from laminate flexible packaging to avoid landfill or incineration.	Industry, Academia, Resource sector	Short term
Automated sorting by alloy type Develop and adopt method to enable scrap material to be sorted into alloy type. Recent progress has significantly improved sorting capability but further development is required to reduce contamination and facilitate closed loop recycling.	Industry	Short term
Track materials by grade & product Develop digital ledger (passport) to track and trace materials down to the grade and application. Use systems to identify opportunities for extended material life at highest value state.	Industry, Academia, Digital technology providers	Short – Medium term
Materials exchange system Coordinate multiple systems which capture material tracking data and secondary materials. Design a holistic system which encourages and facilitates the reuse or remanufacture of aluminium products.	Industry, Academia, Resource sector, Digital technology providers	Medium term
Recycling waste as a feedstock Research and scale-up methods to recycle waste products from aluminium recycling, including salt slag and dross, to reduce environmental impact and improve resource efficiency.	Industry, RTO, Government	Medium term
Increase UK reprocessing capability Identify opportunities to increase aluminium reprocessing capability in the UK (including repair and remanufacture) to reduce reliance on exports and imports. Work is already underway in this area, but further investment is required.	Government, Industry, Investors	Medium – Long term

***Timeline for action (Short 0-2yrs, Medium 3-5yrs, Long 5yrs+)**

Circular Business Models

Circular business models define how an organisation creates and delivers value to a wide range of stakeholders, while eliminating waste and environmental damage as its materials and products move around the economy.

Circularity can offer commercial opportunities to generate incremental revenue, transform relationships with existing customers, and attract new customers, at the same time as protecting supply chains against rising costs of prime materials and mitigating resource shortages.

Aluminium has the potential to lead the way in defining and certifying the materials environmental credentials to increase value of UK production while doing more with less.

Increase resilience - For the majority of business, the current focus is to prioritise a series of short term returns on investment, however adopting circular business models can help protect supply chains against rising costs of prime materials and offer greater resilience. In a volatile global market, the UK industry cannot compete on ever increasing unit volumes at ever reducing unit price. The opportunity for aluminium is adopt business models to do more with less increasing resilience and effective circular material flows.

Create jobs - According to the Green Alliance August 2022 report, 'Levelling up Through Circular Economy Jobs', the remanufacturing sector could and should be supported to grow rapidly in the coming years. Some 300,000 jobs could be created in remanufacturing by 2035, by Green Alliance's calculations. Remanufacturing involves returning a product to its original state or better and supplying the customer with a warranty. This model is already growing in popularity for electronics and electrical appliances. When repair, reuse and recycling are factored in, up to 150,000 additional jobs could be created by 2035. The report emphasises how all regions could benefit leading to a requirement for increased sector focus on training and people development to enable a skilled workforce where capability gaps exist.

Value resources - International Federation of Accountants challenges chief financial officers and investors to rethink of how material resources are valued, with externalities properly priced in, and to be open to a more balanced approach to financial value creation in the longer term[13].

(13) https://www.accountingforsustainability.org/abn-climate-action.html

Transaction to contract - The traditional ownership model is being challenged with many new entrants to the sharing market. In transport, in white goods, in freight, the trend is growing towards a preference to pay for assets or services on demand via transactional purchasing for immediate use or through long-term contracts[14]. Whilst this is not a new concept, many OEMs do have retained ownership and take back models. Phillips Healthcare has greater control of product life extension and through repair, maintenance and recovery services while new revenues are generated including those from refurbished equipment sales, simultaneously reducing embedded carbon and avoiding recycling or landfill. While the exact impact of the capital equipment value chain on emissions requires further research, some figures estimate up to 6.5% of global emissions to be attributable to capital equipment activities. Capital equipment manufacturing consumes 7.2 billion tons of raw materials globally each year—including half of all metal ores consumed globally[15].

Servitisation - Circular economy business models are designed to create sustainable economic growth. One such model is the concept of "product as a service," where instead of selling a product, a company provides a service that delivers the benefits of the product without the customer having to own it. However, this requires tracking the movement and origin of these products and materials to ensure their sustainability and ethical sourcing.

- Rolls Royce talk publicly about refining design principles and adapting operations not only to make the most of all the machined-off pieces ensuring metals are not mined unnecessarily, but also re-considering the need for metals to be heated up twice or re-shaped again, thus saving energy and resources, as well as the cost of not buying it twice. The company deliberately seeks to find innovated solutions in collaboration with its SME supply chain sharing knowledge and systems through its REVERT scheme[16].

- Renault already embrace the principles of re-using and reconditioning parts and only recycling them when their useful life is fully exhausted. Renault has implemented a closed-loop recycling system and is exploring ways to extend the life of its vehicles through repair and refurbishment. For end-of-life vehicles, the components are recycled, which enables the company to recycle up to 85% of the materials used in its vehicles.

- Volvo has implemented a circular business model for its vehicles, which involves leasing its vehicles to customers and taking them back at the end of their useful life for refurbishment, resale, or recycling.

(14) PWC https://www2.deloitte.com/content/dam/Deloitte/us/Documents/consumer-business/us-cb-the-rise-the-sharing-economy.pdf

(15) PACE, Accenture & Circle Economy. (2021). Circular economy action agenda: Capital equipment. (pp. 1-46, Rep.). The Hague: PACE. Retrieved from: https://pacecircular.org/sites/default/files/2021-02/circular-economy-action-agenda-capital-equipment.pdf)

(16) https://www.edie.net/circular-economies-and-scenario-analysis-how-rolls-royce-is-innovating-for-zero-carbon-operations/ http://www.r2piproject.eu/wp-content/uploads/2018/08/Rolls-Royce-Case-Study.pdf

Digital tools - Digital Ledger technology can provide a tamper-proof and immutable record of the journey of a product or material from its origin to its current state. This record can include information on the materials used, the production process, and the environmental impact of the product. By having this information stored on a blockchain platform it becomes accessible to everyone in the supply chain, making it easier to verify the authenticity and sustainability of a product or material. This creates transparency and trust among stakeholders, which is essential for building a circular economy. Material or product passports can incentivise sustainable practices by creating a traceable system that rewards those who follow sustainable practices, such as using recycled materials, with higher ratings and reputations. This can encourage more businesses to adopt sustainable practices, leading to a more circular and sustainable economy.

Aluminium as a service

In the case of aluminium, an "aluminium as a service" business model could involve a company leasing aluminium products to customers and providing maintenance and repair services, rather than selling them outright. The company would retain ownership of the aluminium products and be responsible for their end-of-life management.

The concept of using metal as a service for the circular economy is still in its early stages. Examples of companies and initiatives that are exploring this approach include:-

- The Circular Retrofit Lab is an initiative in the UK that is exploring the use of metal as a service for building retrofits. The initiative involves leasing metal components, such as structural beams and façade panels, to building owners and then taking them back at the end of their useful life for reuse or recycling.

- Material Economics is a consulting firm that specializes in circular economy strategies. The firm has proposed the concept of "steel as a service," which involves leasing steel components to customers and then taking them back at the end of their useful life for reuse or recycling.

- Steelcase, a furniture manufacturer, has implemented a circular business model for its products. The company leases its furniture to customers and takes it back at the end of its useful life for refurbishment, resale, or recycling. The company also uses recycled steel in its products and has implemented closed-loop recycling systems for steel components.

Collaboration

Collaboration along the supply chain is necessary to achieve circular business models. While demand for low embodied carbon materials is increasing from specifiers, this needs to be translated into procurement contracts to incentivise business model and technical innovation.

(15) https://www.accountingforsustainability.org/abn-climate-action.html

(16) PWC https://www2.deloitte.com/content/dam/Deloitte/us/Documents/consumer-business/us-cb-the-rise-the-sharing-economy.pdf

Strategic Themes

Business Model Actions	Suggested ownership	Timeline for action
Develop business models viability Build evidence base for circularity of aluminium. Based on market demand widening access to knowledge in sectors where access to recovery and re-use of metal is known to be difficult and costly.	Business, Industry Bodies, RTOs	Short term
Connect Cross-sector Synergies Employ innovate thinking within public private partnerships for collaboration across the value chain identify opportunities for re-sale, refurbish re-manufacture.	Business , Government, Industry Bodies	Short term
Build Business Capability Convene regional centres to identify Circular Economy expertise with sector specific learning programmes to harness synergies and knowledge dissemination.	Governnment, Public Bodies, Industry Bodies, RTOs	Short term
Reverse logistics and backhaul optimisation Identify supply chain efficiencies for system collaboration across the value chain for shared movement, reducing back-haul, improving operating margins and reducing carbon from vehicle movement.	Industry, Industry Bodies, RTOs	Short – Medium term
Training Pathways Establish a training/ vocational programme that would lead to improved skills and capability for employees and students in the metals and aluminium sector, potentially leading to increased capacity and efficiency.	Trade bodies, Industry, RTO, Academia	Medium term
Develop CE Evaluation metrics Build a viability model to assess the UK opportunity for retained metal ownership by identifying the sectors and industries for pilot studies that would inform the sector as a whole.	Trade bodies, Industry, Government	Medium term
Metal as a Service Build a viability model to assess the UK opportunity for retained metal ownership by identifying the sectors and industries for pilot studies that would inform the sector as a whole.	Industry, RTO, Academia	Medium – Long term

***Timeline for action (Short 0-2yrs, Medium 3-5yrs, Long 5yrs+)**

Measurement and Evaluation

Strategies built into business operations such as life long guarantee, take-back logistics, buy back, repair components, and sale of refurbished products require careful consideration through revenue modelling, but without embedding evaluation metrics it will be difficult to accurately reflect the areas for adjustment and investment. The key performance indicators below offer potential for data and insights.

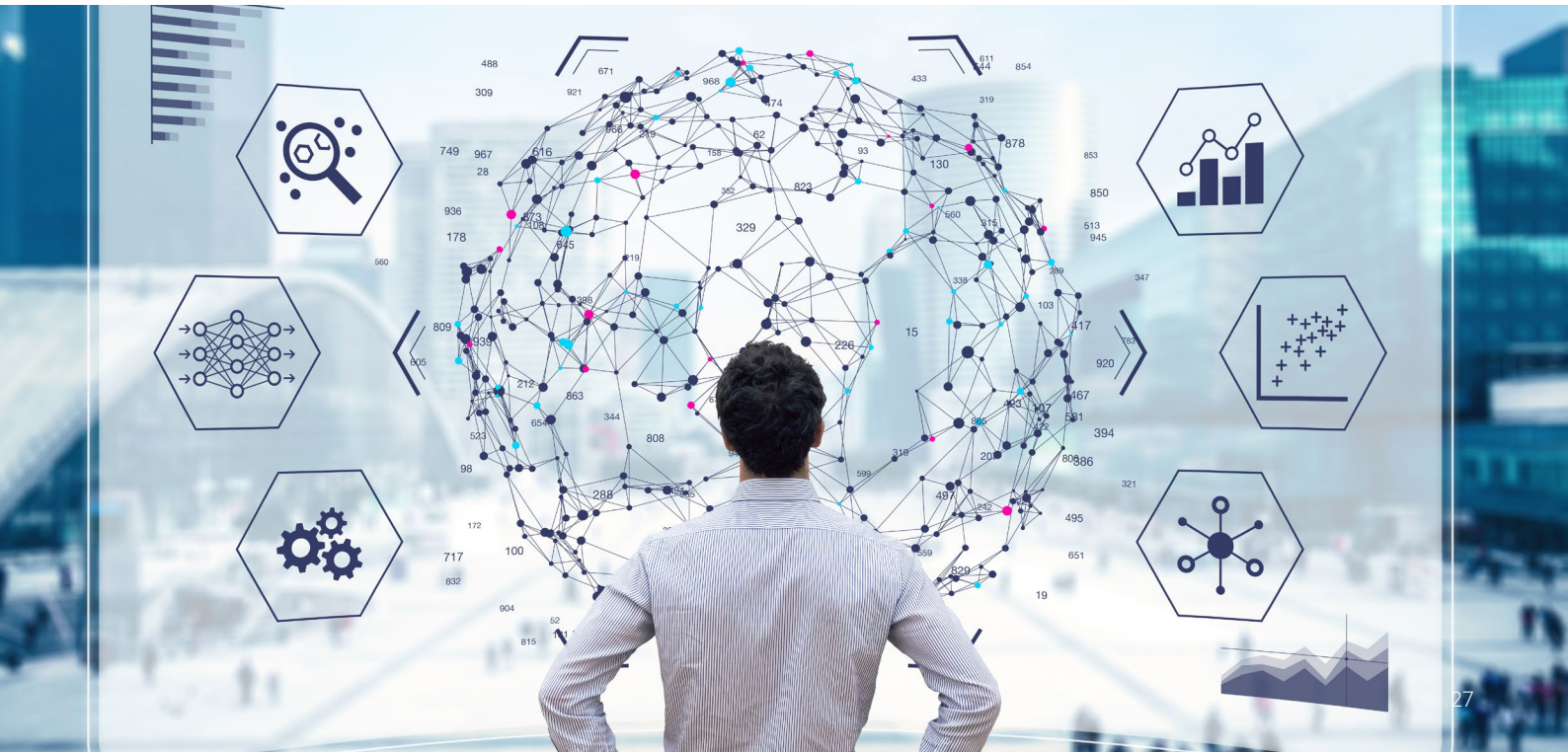
Waste Elimination: focusing on measuring the phased reduction of surplus resources. It can include metrics such as the percentage decrease in total waste generation, reduction in energy, water, materials, scrap etc, measured as value, volume and percentage.

Product Life Extension: measuring the extension of product lifetime, enabled by design in order to reduce the need for new production and resource consumption. It can be measured by indicators such as the average lifespan of products, the percentage increase in the adoption of sharing, rental, servitisation models, or the reduction of product obsolescence.

Closed-Loop Systems: assessing the extent to which circularity is achieved across the value chain, where materials and assets are retained at the highest value for as long as possible. It can be measured by indicators like the percentage of products designed for repairability, and infinite recyclability without degradation, or the increase in remanufacturing and refurbishment.

Material Circularity: evaluating which materials remain in the value chain through recycling and reusing processes. It can be measured by percentage reduction of virgin material consumption and increase in recycled content, and percentage of recyclability across borders ensuring responsible end of life management.

It is important to note that the specific choice of KPIs may vary depending on the industry, sector, or organization implementing circularity across holistic inter-connected systems. These KPIs provide a starting point for measuring progress towards a circular economy but should be tailored to the specific context and goals of the organization or project.



Looking ahead

Aluminium Action Plan: Next Steps

Aluminium is a valuable technical resource, increasingly crucial to modern society. It has multiple applications in enabling technologies for the future, therefore, demand is set to increase dramatically. This action plan offers a pathway to optimise resource use within the Aluminium industry. The Innovate UK KTN Circular Economy Innovation Network will continue to champion the move towards a circular future for the Aluminium sector and the delivery of this action plan by the Aluminium Community.

Join the Innovate UK KTN Circular Economy Innovation Network

The Circular Economy Innovation Network is open to all organisations across the UK, from large companies, SMEs and start-ups, to academics and researchers. Be part of our collaborative communities working towards: Circular Design, Circular Business Models, and Circular Recovery. Together we can enable more resilient industries, inspire innovative businesses to create value through circular economy principles, andinvolve talented people to create vibrant and successful ecosystems,for a positive impact on the UK's economy, environment, and society environment, and society.

Find out more

You can find all our industry reports, future thinking, events and information at our website.

Read more

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Connecting for
Positive Change.

Innovate UK

This is an independent paper reflecting the views of the Circular Economy Innovation Network team at Innovate UK KTN. This programme aims to enable more resilient industries to work together, connect, collaborate, and share experiences to achieve Net Zero through circular innovation.

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