UKRI NATIONAL INTERDISCIPLINARY CIRCULAR ECONOMY RESEARCH (NICER) PROGRAMME: FINAL REPORT 2025

CE-HUB
UKRI National Interdisciplinary Circular Economy Research

NICER PROGRAMME

University of Exeter

UK Research and Innovation

Contents

Executive Summary: Key Headlines

The circular economy represents a fundamental shift from the traditional "take, make, dispose" linear model to a more sustainable, inclusive, and resource-productive economic system.

Recognising the urgent need for this transition, UK Research and Innovation (UKRI) invested £30M to establish the National Interdisciplinary Circular Economy Research Programme in 2021 to accelerate and scale the UK's transition to a Circular Economy. Comprised of five national circular economy centres and a coordinating CE-Hub, the NICER programme has been at the forefront of providing scientific evidence and leadership to promote the widespread adoption and implementation of circular economy principles and practices. Through its diverse, interdisciplinary and cross-sector research, NICER has produced the evidence base to empower industries, policymakers, and citizens to embrace circular practices and a legacy to ensure leadership of a UK circular economy of the future.

"Technology metals circular economy Roadmap for lithium-ion battery materials system in UK"

"Textiles Circularity Centre launches data driven vision for UK circular clothing economy"

"CE-Hub Directors are nominated as the UK focal point for CircularStep – the UNECE Stakeholder Engagement Platform to accelerate the transition to a circular economy in the UNECE region"

Technology metals Circular Economy Geomodel for mineralisation and minewastes in Cornwall and the first global illustration of new UNRMS framework

The new model enables exploration of lithium, tin and tungsten ore deposits in Cornwall, fundamental enablers of future renewable energy technologies.

The CE-Hub launch the first Circular Economy Data Observatory

A data-science-led approach to model, visualise and demonstrate proof of value from the application of circular economy interventions across all material product-sectoral areas of policy and industry interest. The observatory provides a focal point for data on material flows and stocks alongside linked economic and impact dimensions.

"Scaling up the remanufacture of one medical device was shown to have the potential to save the NHS up to £10M over the next 5 years"

Immersing stakeholders in interdisciplinary research

The Textiles Circularity Centre established the Regenerative Fashion Hub as an important stakeholder engagement platform to immerse citizens, industry and policymakers in circular economy research and envisage a future where they are active actors in CE systems.

"Soil hotels could be just the ticket for precious resource too often lost to landfill"

Six Policy Briefs consolidate ICEC-MCM research findings to discuss how implementation of a Circular Economy can reduce key UK construction industry concerns, including enabling Strategic Supply of materials, Zero Waste (including recovery of valuable Soil and identification of Waste Use Potential) and Net Zero Carbon Emissions; and supporting Biodiversity Net Gain.

"Metal Health Service research has found EPT Boosts Steel Fatigue Life by 100% (low cycle fatigue condition) and up to 300% (high cycle fatigue)"

"System level Life Cycle Assessment & Techno-Economic Analysis Reveals Cost and benefit of Defossilising Green Ethylene"

Electrochemical reduction of CO_2

Circular Chemicals researchers have developed a highly efficient CO_2 electrolysis technology that converts industrial carbon dioxide emissions into valuable chemicals and fuels using a bipolar membrane electrolyser. Achieving over 50% efficiency, this innovation can transform CO_2 into products like carbon monoxide, aiding in the creation of various chemicals.

"Researchers from the Circular Chemicals Centre Win Prestigious Sustainability IChemE Global Award for Industry Collaboration and Pioneering Technologies"

"Big Repair Project Advances 'Right to Repair' Policy for Sustainable Living"

Circular Metals Centre launch the "Circular Business Models for Metals"

This valuable resource reveals 65 circular metal strategies that will be instrumental in empowering businesses to unlock sustainable value.

Overview of the NICER Programme

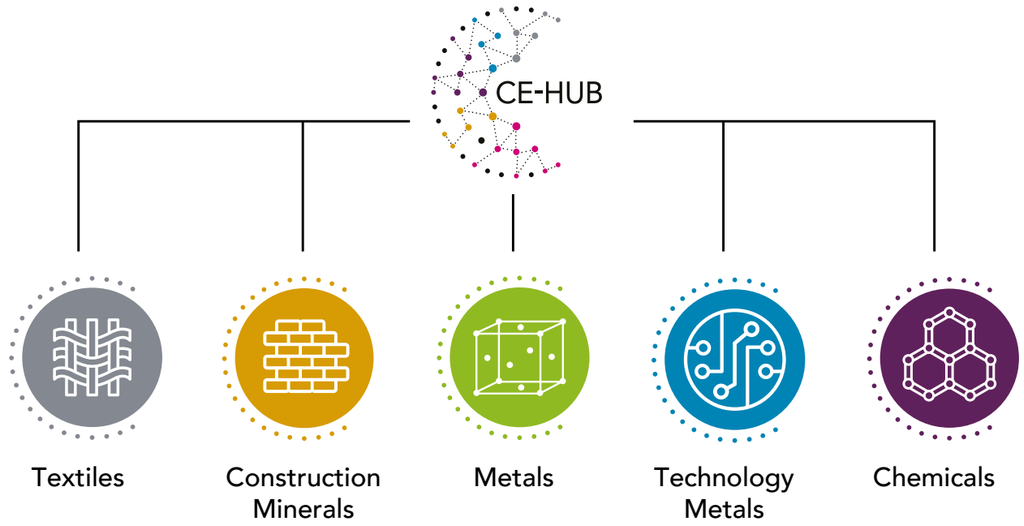
To achieve its objectives the NICER Programme has carried out hundreds of research and impact activities in collaboration with a diverse range of partners. The resulting outputs, case studies, reports, technological developments, tools, approaches and demonstrators have been published and are available through the individual centre websites and the NICER Programme Knowledge Hub. This report provides a snapshot of some of these activities, outputs and impact from across the programme.

About the NICER Programme

The NICER Programme is a £30 million four-year investment as part of the UKRI Strategic Priorities Fund to deliver the research, innovation and evidence base needed to move the UK towards a circular economy. Launched in January 2021 and comprising initially of 34 universities and over 150 industrial partners, NICER is made up of five Circular Economy Research Centres each focused on a specific resource flow, and the coordinating CE-Hub:

- The National Interdisciplinary Circular Economy Research Hub (CE-Hub), led by the University of Exeter
- The Interdisciplinary Circular Economy Centre for Textiles (TCC), led by the Royal College of Art
- The Interdisciplinary Circular Economy Centre for Mineral-based Construction Materials (ICEC-MCM), led by University College London
- The National Interdisciplinary Centre for the Circular Chemical Economy (CircularChem), led by Surrey University
- The Interdisciplinary Circular Economy Centre for Technology Metals (Met4Tech), led by the University of Exeter
- The Interdisciplinary Centre for Circular Metals (CircularMetal), led by Brunel University London

NICER is the largest and most comprehensive research investment in the UK Circular Economy to date. It has been delivered in partnership with industrial organisations from across sectors and UK Government including Defra, DESNZ and the devolved administrations to ensure research outcomes contribute to the delivery of industrial implementation and government policy. A core aim of the programme is growing the Circular Economy community through a significant programme of outreach and collaboration.



1.0 Data and Evidence towards a UK Circular Economy

Data and evidence are fundamental to the successful implementation and operation of a circular economy. Their importance lies in providing insights and information that enable key actions by multiple stakeholders across various stages of the circularity process. Examples include:

Material Flow Analysis:

Data facilitates the tracking and tracing of resources throughout their lifecycle, from extraction to end of use. This enables the identification of waste generation points, optimisation of resource usage, and the development of effective waste reduction strategies. Read our MFA report **here**. Visit the **UK Tech metals Data Observatory**.

Life cycle assessment (LCA):

Life cycle assessment (LCA) is a powerful tool for evaluating the impacts of a product or service throughout its entire lifespan and can be used to assess the benefits of various circular strategies, such as product design for disassembly, and component or material reuse or recycling. Environmental LCA by the ICEC-MCM showed that the use of cleaner fuels can decrease carbon emissions of cement, concrete, and a reinforced concrete building by up to 35%, 37%, and 29%, respectively. See further insight from across the programme **here** and read our 'reusefully' case study on pre-demolition LCA **here**.

Process Optimisation:

Data informs the design of products for circularity by providing insights into material properties, product lifecycles, and waste streams. This "design for circularity" approach promotes disassembly, repair, and recycling, maximising resource efficiency. Furthermore, data sharing across the supply chain facilitates collaboration and optimisation of logistics for waste reduction. Read our case study on RoundRack **here** – A Material Impact Tool for the circular textiles economy.

Policy Development and Monitoring:

Reliable data is crucial for evidence-based policymaking and the development of regulations that support the circular economy. This includes setting targets, providing incentives, and promoting innovation. Data also allows for the monitoring of progress towards circular economy goals and informs adaptive management strategies. Read our **Case study on Extended Producer Responsibility (EPR) sandbox for the UK fashion industry**.

Business and Citizen Empowerment:

Providing stakeholders with data on the environmental impact of products and services empowers them to make informed business and purchasing decisions. This can drive demand for circular products and encourage businesses and citizens to adopt circular practices. **Read our report on Human Behaviour and the Circular Economy.**

NICER CE DATA OBSERVATORY

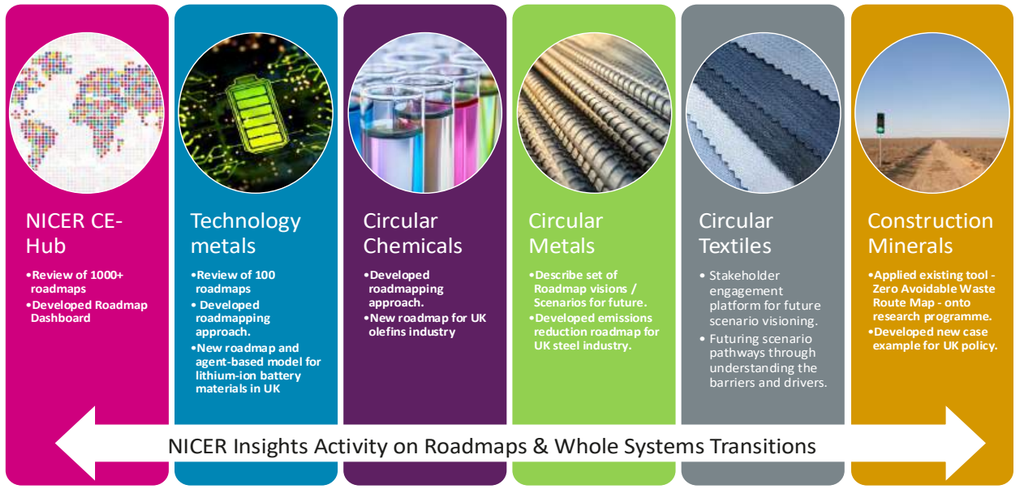
The circular economy data observatory (CE-DO) was initiated by the CE-Hub to build a common and consistent framework for evidencing the impact and outcome of CE interventions and transformations. CE-DO 1.0 was developed through the programme incorporating material flow visualisation and source data from the CE-Hub and three of the NICER Centres. The project demonstrated proof of value to government policy teams, reducing costs of data collection, **increasing the value of existing data** and providing results across multiple policy needs and questions. From this starting point additional analysis has been performed to identify multi-billion pound losses in material value and significant economic opportunity and value creation for CE intervention. A CE-DO 2.0 has been developed through additional Defra funding to build additional case examples and proof of value for material flows including plastics and glass. This current work is embedded with Defra policy analysis and delivery teams.

MATERIAL FLOW ANALYSIS OF LONDON TEXTILES

The TCC used a combination of Material Flow Analysis (MFA) and Life Cycle Assessment (LCA) to study the environmental impact of UK's fashion industry. This involved examining the entire life cycle of clothing, from fiber extraction to post-consumer waste. They also used **scenario modeling** to evaluate the potential benefits of "circular strategies" like reducing consumption and promoting secondhand markets. The study found that these strategies could reduce greenhouse gas emissions by over 30%. Alarmingly, 40% of post-consumer clothing ended up in landfills or incinerators, and a significant portion was exported. The study highlighted that most of the environmental impact (87% of greenhouse gas emissions) originates from imported clothing. Read our paper on **A Material Flow Analysis of the UK Clothing Economy**.

LEADING THE WAY

The NICER Programme has contributed to and developed multiple Circular Economy Roadmaps as pivotal strategy documents to influence and support future policy and regulation. This has included the CE-Hub Roadmap Dashboard, the Circular Chemicals Roadmap, the Technology Metals CE roadmaps for rare earth magnets and lithium-ion battery materials, scenarios for reducing the environmental impacts of the UK clothing economy and the Zero Avoidable Waste Route Map.



See our **CE-Roadmap Dashboard** and read our report on **Roadmaps and Whole System Transitions**.

2.0 Circular Economy Technologies

Key Stages of a Circular Economy

PREMANUFACTURE TECHNOLOGIES

Production of green hydrogen using the reaction of liquid aluminium with water steam, and an embodiment of this method. Hydrogen production using the reaction of aluminium with water is important from the viewpoint of Net-Zero challenges as it is emission-free. The benefits are both environmental and societal. Moreover, as aluminium and water are abundant on Earth, this way of hydrogen production may become the mainstream in the future energy harvesting.

Breakthrough CO_2 Electrolysis Technology Converts Emissions into Valuable Fuels and Chemicals with Over 50% Efficiency. This technology aims to reduce fossil fuel reliance and promote a circular economy, thus contributing to the UK's decarbonisation goals and enhancing sustainable chemical production.

Revolutionising Metal Refining: Al-Ti-B Grain Refiner Efficiency Soars from 40% to 95%. This, for the first time, has overcome the inconsistency problem associated with Al-Ti-B grain refiners and will confer significant economic benefits in the casting industry. In addition, this will enhance enormously the ability to recycle aluminium alloys effectively without reducing quality, i.e. without low value down-cycling.

PRODUCTION TECHNOLOGIES

TCC's bio-based process for recycling of biowaste. By transforming biobased waste into new biobased materials, the intention is to add value to end of life materials and produce circular materials that can then be designed to re-enter and remain in the material stream as high value textiles.

Biomaterial start-up collaborating with Cranfield University/TCC – outcomes will lead to a reduction in food landfill waste; improvement of natural dyes to be able to replace synthetic dyes; minimisation of the need for pre-treatment techniques, which tackles heavy metal pollution.

Development of novel melt spinning and jet casting processes for the production of Alloys and Rare Earth Permanent Magnets (REPMs). Development and commercialisation of HPMS technology will recover Rare Earth Alloys which can be manufactured into new REPMs with a 90% energy saving when compared to those from primary sources**.**

CONSUMPTION TECHNOLOGIES

Non-linear ultrasound measurements technologies: These diagnostic techniques allow for earlier and more precise detection of potential issues, facilitating interventions that can pre-emptively address fatigue before it leads to significant damage. The ability to diagnose metal fatigue and rejuvenate metallic components during service can extend their service life by a factor of 3; such service life extension is expected to be more significant with further development of more effective technologies.

A fully developed Metal Health Service will provide a solid foundation for transforming the current product-based metals industry to a largely service-based industry.

Multisensory Virtual Reality (VR). Farfalla is a Virtual Reality (VR) experience that immerses consumers in the future of retail, empowering them to see themselves contributing to textile circularity. Through hands-on activities, users explore bio-based textiles in a multisensory environment, fostering learning and optimism.

Method for monitoring the in-service use of heavy-duty off-road vehicles that will identify its level of wear and tear at the end of life. This method is able to predict to a greater than 95% certainty how the vehicle was used and therefore the wear and tear on the vehicle, which in turn will help to decide its post-end of life processing, whether it is reuse, remanufacture or recycling.

RECOVERY TECHNOLOGIES

Electro-Pulse Treatment (EPT) has been developed to rejuvenate and recover fatigued metallic components. EPT can rejuvenate and recover high strength steel, extending fatigue life by 100% in a low cycle fatigue condition, and by 300% in a high cycle fatigue regime.

Domestic Scrap Steel Recycling. Computer vision-based object detection method for steel scrap sorting developed to facilitate the sorting process. This method identifies various materials on a moving conveyor belt, such as steel, copper, and fabrics.

Lightweight exterior infill wall panels for multistorey buildings were designed by ICEC-MCM, with specially adapted connectors to enable their deconstruction and reuse in a new building, and shown to reduce CO_2 emissions and virgin material extraction.

REPURPOSE TECHNOLOGIES

TCC repurposed Augmented Reality (AR), a popular technology commonly used in fashion retail to enhance sales, and applied it to promote circular economy principles. Specifically, TCC used AR to improve consumer awareness of biobased materials. The Biofibre Explorer is an AR application designed to showcase the fabrication process of TCC-biobased circular textiles.

Toolbox for sustainable metal recycling provides a suite of innovative technologies that use fewer chemicals and less energy, which companies can consider for recovering valuable technology metals from a range of products and complex materials (i.e. batteries, electronics, magnets, etc.).

DATA RELATED TECHNOLOGIES

The ICEC-MCM developed a computer model to analyse resource flows over their whole life cycles from extraction to end-of-use, and estimate missing data using Bayesian statistics. This new **Bayesian Material Flow Analysis (BaMFA) model** can help understand the quality of data collected by government and industry about resource use, and make data collection more efficient.

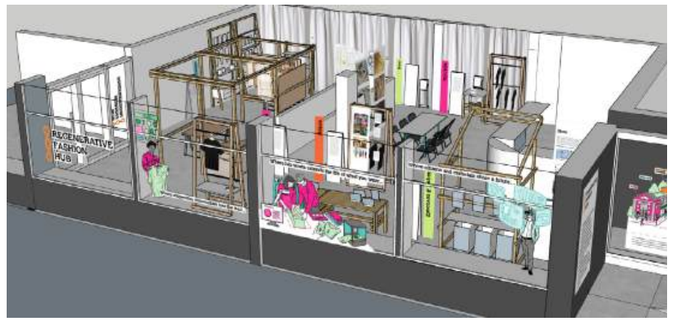
The first Regional Computational General Equilibrium Model of the UK economy was developed to examine the macro economic impacts of circular economy measures adopted by the UK construction industry.

For further information read our report on Technology Innovations in the Circular Economy.

3.0 Influencing Integrated Implementation

TEXTILES CIRCULARITY CENTRE *REGENERATIVE FASHION HUB* STAKEHOLDER-ENGAGEMENT PLATFORM

The Textiles Circularity Centre (TCC) showcased a community-led approach to extending the life of clothes through their Regenerative Fashion Hub exhibition. By collaborating with local menders, upcyclers, and designers, the exhibition demonstrated circular practices in action and fostered public engagement through tours and discussions. The accessible location and diverse events broadened the reach of the exhibition, creating opportunities for connection and learning. This initiative highlighted the importance of community-centered approaches to circular economy research, emphasising the value of skills sharing, localised manufacturing, and care/repair spaces for enhancing community resilience and well-being.



TCC Regenerative Fashion Hub

2
London high street activations

Visited by
1,233 people; 191 consumers
and
102 businesses participated in research activities

10
week duration

RESEARCH AND DEVELOPMENT FUNDING

Seed funding schemes are crucial for driving innovation in the circular economy, as they provide much needed resources and support for stakeholders to develop and implement circular solutions. Throughout the NICER Programme, we have been able to provide funding for cutting-edge feasibility research as well as collaborative research & development (CR&D) projects led by industry practitioners with HEI partners.

The CE Hub's Flexible Fund supported high-impact research in CE, encouraging proposals that include regional studies, interdisciplinary collaborations, and early career professionals from academia, industry, and government. The NICER CR&D fund was delivered in partnership with Innovate UK and enabled SMEs to undertake experimental development projects to address the challenges of transitioning to a circular economy in collaboration with academic partners. Read our funded project **case studies** and our report on **Small and Medium Enterprises and the Circular Economy** to find out more.

10
cutting edge feasibility studies were funded by the CE-Hub, distributing a total of
£500k

Case studies
were produced for all projects to provide information on their journey and outcomes.

32
projects were supported by Innovate UK providing a total of £2.5 million in funding to SMEs

These case studies have been published on the Knowledge Hub and have been
downloaded approximately 150 times

CIRCULAR VALUE CHAINS

The CE-Hub has played a pivotal role in bringing together stakeholders from across value chains to identify and implement opportunities for circular innovation. Specifically, the CE-Hub has focused on the Sectors/Areas of **Healthcare**, **Solar PV**, **Defence and Security**, **Electrical Appliances**, Digital Technology and **Hospitality**. The CE-Hub's work has led to significant outcomes. For example, over 12 months the CE-Hub brought together over 80 stakeholders from across the Healthcare sector to analyse and demonstrate how and where circular innovation can be effectively applied. Key outcomes include major contributions to the Department for Health and Social Care (DHSC) **Design for Life Roadmap** outlining the government's plan to build a circular economy for medical technology to increase resilience, drive growth, realise cost savings and improve sustainability. The team have secured £1.8M EPSRC funding to continue the research through the Digitally Enabled Circular Healthcare Innovation (DECHI) Programme.

4.0 Behaviour Change and Policy Influence

Human behaviour plays a pivotal role in the successful transition to a CE. Individual and collective actions, from consumer purchasing decisions to corporate strategies, directly impact the adoption and effectiveness of circular principles. Understanding and influencing these behaviours is crucial, as they shape consumption patterns, drive demand for sustainable products, and determine the success of new initiatives such as reuse and recycling.

Behavioural insights can inform policy design, product development, and communication strategies, helping to overcome barriers to circular practices. Moreover, fostering a 'circular mindset' among individuals and organisations is essential for creating a culture that supports long-term systemic change. As such, addressing human behaviour is not just one component of CE discourse, but a fundamental driver of its realisation and success.

THE BIG REPAIR PROJECT

6,000
people across the UK took part

The **Big Repair Project**, led by UCL Plastic Waste Innovation Hub and an initiative of the UKRI Interdisciplinary Centre for Circular Metals, investigated household maintenance and repair practices for electrical and electronic equipment (WEEE) in the UK. The project examined how the UK's 'Right to Repair' law, introduced in July 2021, impacts product longevity and waste reduction. With approximately 2 million tonnes of WEEE discarded annually in the UK, the project studies the complex ecosystem of actors involved in repair, and engaged citizens, independent SMEs, in-house repairers, and community repair cafes.

Through surveys and repair logbooks, the research identified barriers to repair, including regulatory misalignment and accessibility issues around spare parts, repair services, and technical information. The project set out to investigate the efficacy of Right to Repair legislation and support the UK's broader environmental and circular economy objectives. Data is shared through an interactive UK Google Map and open access reports, making repair experiences and challenges visible to policymakers and the public.

WELLBEING FRAMEWORK

The TCC **developed a framework** that examines how a holistic approach to consumer wellbeing can provide social benefits through circularity, foster new consumption cultures that promote sustainable behaviour, and serve as a consumer-driven tool to advance towards zero waste through responsible and personalised participation.

METALS 2050 REPORT

The Circular Metals Centre developed visions of how circularity could be embedded in the metal sector by 2050. These visions span across the whole metal value chain and were co-created with 30 experts from academia, business, and government (through a combination of interviews and co-design workshops). Subsequently, transition roadmaps were co-created, to identify the key milestones required to achieve those visions. Overall, visions and roadmaps clearly show that the transition to a circular economy for metal requires the involvement of all societal actors. In addition, the transition roadmaps identify, for each of these actors, the key changes in culture and practice.

30
experts

KNOWLEDGE HUB

The **CE Knowledge Hub** reflects an interdisciplinary approach, integrating a range of content from academic rigor to practical tools. It offers resources for policy makers, businesses, and academics, blending knowledge from insight and spotlight reports, case studies, digital articles, and interactive tools. The Hub's content strategy balances in-depth academic research with accessible resources, catering to a broad audience that includes policymakers, industry leaders, and researchers across sectors, thereby encouraging collaboration and cross-pollination of ideas.

Over 5,000
document downloads

14,000+
unique users

Legacy

The NICER Programme's impact extends far beyond the duration of its funding. Through its diverse initiatives and groundbreaking research, NICER has created a lasting legacy that will continue to shape the UK's circular economy landscape for years to come.

National and International Leadership

Worlds first UN-recognised International Centre of Excellence on Sustainable Resource Management in the Circular Economy

Lead by key academics in the CE sector, including multiple NICER program leads, the UK has established the worlds first UN-recognised International Centre of Excellence on Sustainable Resource Management in the Circular Economy (ICE-SRM CE). In collaboration with key industry partners, the UN and Defra backed centre is developing cutting edge solutions to support green transition and sustainable resource management. The centre will be developing, enhanced data collection and material flow modelling, technical innovation, and bespoke policy recommendations that will inform government and industry approaches to the circular economy.

CE-Data Observatory

The scope, results and impact of the CE-DO continue to be extended, tested and evaluated with Defra, wider government policy teams and other economic actors. A new CE-DO 3.0 is under development as a cross-cutting project with the UN Centre for Circular Economy, aiming to integrate CE with the UN Global Resource Management Framework and aligned with emerging global standards and guidance on measuring circular economy.

Empowering Communities and Building Capacity

UKRI Critical Minerals Accelerating the Green Economy Centre

Met4Tech's focus on critical minerals has led to the creation of a dedicated £4.5M centre at the University of Exeter that will help experts address the challenges faced in sustainably securing fresh and innovative access to critical minerals.

Institutionalised Knowledge and Expertise

The UK Technology metals Observatory

This resource, hosted at the BGS, provides UK data and case studies on tech metals and their products needed to achieve the UK's net zero ambitions by 2050, and complements studies by the UK's Critical Minerals Intelligence Centre. Links here.

Future Availability of Raw Materials in Europe

Linking to the work of the ICEC-MCM in relation to construction and demolition waste, UCL is collaborating with 27 partners on the €14.1M Horizon Europe FutuRaM project, working to understand stocks and flows of construction materials and other mineral wastes in Europe, and to develop and demonstrate the United Nations Framework Classification for Resources.

Digital Innovation and Circular Economy Network+

This new £2.5M EPSRC Network brings together researchers from 9 UK universities and a wealth of industrial and government partners to accelerate a digitally enabled circular economy.

Skills Development

The workshops, webinars and host of tools, case studies and other educational resources developed by the NICER Programme are being embedded within educational programmes and executive training to equip individuals and businesses with the skills and knowledge needed to thrive in a circular economy.

Digitally Enabled Circular Healthcare Innovation

Building on the work of the NICER Programme, researchers have secured £1.8M EPSRC funding to collaborate with partners across the healthcare sector to embed circular innovation within the production, use and reuse of medical technology.

Stakeholder Engagement Platforms

By facilitating dialogue and collaboration between diverse stakeholders, including industry, policymakers, and civil society, NICER has fostered a shared understanding of the challenges and opportunities associated with the circular economy.

Fostering Innovation and Collaboration

CE-HUB

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