HUMAN BEHAVIOUR AND THE CIRCULAR ECONOMY

Social, behavioural, and cultural dimensions of the circular economy transition

Insights and evidence from the NICER Programme

Halid Abu-Bakar [3c], Sharon Baurley [1a], Frank Boons [5g], Fabrizio Ceschin [4d], Fiona Charnley [3c], Ben Cummings [6l], Christopher Dawes [1f], Alessio Franconi [4d], David Harrison [4d], Sumit Hazra [4m], Irene Josa [2b], Samuel King [5e], Feja Lesniewska [2i], Sampriti Mahanty [5g], Jacob Mhlanga [2j], Mark Midownik [4h], Žaneta Muranko [1a], Ryan Nolan [3c], Ricardo O'Nascimento [1a], Marianna Obrist [1f], Bruna Petreca [1a], Danielle Purkiss [4h], Margo Reynolds [3c], Linh Truong [2k], Ramya Venkataraman [2b], Eevee Zayas-Garin [1a]

CE-HUB
UKRI National Interdisciplinary Circular Economy Research

NICER PROGRAMME

University of Exeter

UK Research and Innovation

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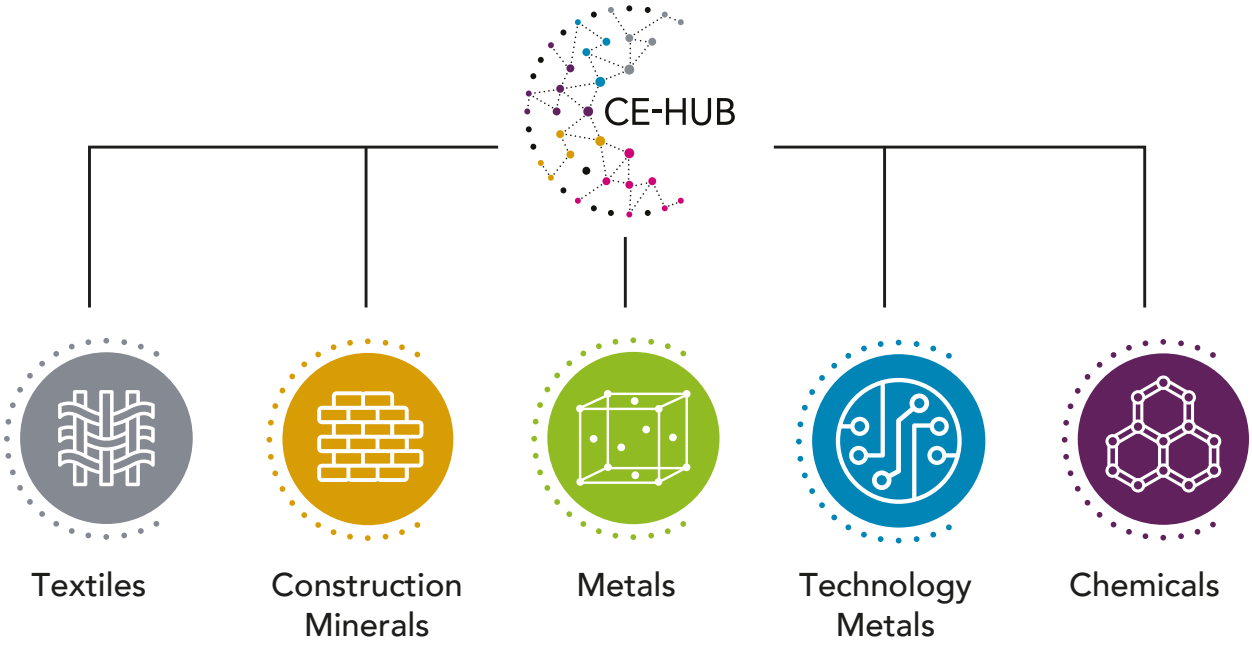
a Materials Science Research Centre, Royal College of Art, London, UK; **b** Department of Civil, Environmental and Geomatic Engineering, University College London, London, UK; **c** Exeter Centre for the Circular Economy, University of Exeter, Exeter, UK; **d** School of Design, Brunel University of London, London, UK; **e** School of Metallurgy and Materials, University of Birmingham, Birmingham, UK; **f** Department of Computer Science, University College London, UK; **g** Alliance Manchester Business School, University of Manchester, Manchester, UK; **h** Department of Mechanical Engineering, University College London, London, UK; **i** Institute for Sustainable Resources, University College London, London, UK; **j** School of Architecture, Building and Civil Engineering, Loughborough University, Loughborough, UK; **k** Loughborough Business School, Loughborough University, Loughborough, UK; **l** School of Chemistry and Chemical Engineering, University of Surrey, Guildford, UK; **m** Warwick Manufacturing Group, University of Warwick, Coventry, UK.

About the National Interdisciplinary Circular Economy Research Programme

The National Interdisciplinary Circular Economy Research (NICER) programme is a £30 million four-year investment from UKRI and the Department for Environment, Food & Rural Affairs (DEFRA) 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 specialty material flow, and the coordinating CE-Hub:

- The National Interdisciplinary Circular Economy Research Hub (CE-Hub), led by the University of Exeter
- The Textiles Circularity Centre (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 DEFRA 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.



About the NICER Insight Reports series

The objectives of the NICER programme are to:

1. Accelerate understanding and solutions to enable circularity of specific resource flows,
2. Provide national leadership, coordinate and drive knowledge exchange across the programme as a whole and with policy, consumer, third sector and business stakeholders,
3. Ensure research is embedded with stakeholders by involving businesses, policymakers, consumers and society, the third sector, and other affected groups and communities at every part of the programme.

The transition towards a UK circular economy requires a whole system approach. This means that, in addition to accelerating knowledge at the resource and sector level, there are a number of agnostic system level enablers or drivers that can be applied to accelerate adoption at scale. The purpose of the NICER Insight Report Series is therefore to highlight learning from across the NICER Programme in relation to these system wide enablers.

Introduction

This insight report collates the evidence and insights gained throughout the duration of the NICER Programme on the role of human behaviour in the transition to a circular economy. By synthesising on-the-ground insights and experiences from researchers across NICER with academic literature, we present a view of the challenges and opportunities in implementing circular principles with a particular focus on systems change. In doing so, we highlight the interplay and interdependencies between technological innovation, social dynamics, and economic structures in driving successful change at scale. Through this integration of practical research outcomes and theoretical context, we aim to provide an understanding of the pathways towards a more sustainable and resilient CE, offering new insights for policymakers, businesses, and communities alike.

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.

In what follows, we present nine insights, based on the synthesis of the key learnings from across the NICER programme. These insights also point to the directions of future research, policy, and innovation, with specific focus on the humans in the CE.

Insight A. Understanding of stimuli of human behaviour is critical to inform the design of circular consumption systems. Stimuli are the intrinsic (psychological) and extrinsic (systemic) factors that influence human behaviours performed by the consumer throughout the interaction with a circular offering.

Introduction

It is critical to understand the extrinsic (systemic) and intrinsic (psychological) factors that influence human behaviour to inform the design of circular consumption systems. In the wake of exacerbated and unprecedented systemic global challenges, including, COVID-19, the imminent threats of climate change, cost-of-living-crisis (CoLC), geopolitical disputes, technological disruption and the general inadequacy of global governance structures, human behaviour has been significantly influenced. For example, the CoLC in the UK has resulted in significant household spending cutbacks to focus on essentials (ONS, 2022, 2023). In other cases, as a result of increased climate change awareness, younger generations greatly appreciate the benefits of, and are adopting, more sustainable lifestyles (Biancardi, Colasante and D'Adamo, 2023). In the same vein, intrinsic factors are also significant in determining human interaction with circular offerings. An example being the potential lack of emotional durability of a product (Haines-Gadd, 2018) resulting in consumer resignation to throw away possessions versus repair them. Evidently, understanding these stimuli is crucial to the successful implementation and evaluation of circular consumption systems.

There is a plethora of literature in regard to human behavioural theory (HBT) that is applied to circular systems research (see Parajuly et al., 2020). The Theory of Planned Behaviour is one of the most popular psychological theories, which recognises that the provision of knowledge through educational and persuasive communication can shape a subject's intention to perform a behaviour (Ajzen, 1991; Muranko et al., 2018). Aside from HBT, other bodies of literature, such as sustainable design (e.g. Lockton, 2017) and human resource management (e.g. Dumont, Shen and Deng, 2016), provide critical knowledge that informs effective circular consumption systems design that factors in the influential stimuli of human behaviour.

NICER examples:

In the CE context, there is still fragmentation in studying and addressing human behaviours. However, for a CE to take place we need systematic appraisal. It is critical to design experiments to demonstrate at small scale how circularity can be achieved systematically. The NICER centres have undertaken a number of research projects attempting to address this necessary research.

CE-Hub

The CE-Hub engaged in an investigation in collaboration with The Association of Manufacturers of Domestic Appliances (AMDEA) entitled: *Resource Efficiency of Electrical Appliances in UK Households: Can Consumer Education Help Cut Costs Amid the Cost-of-Living Crisis?* This **study** seeks to understand consumer appliance use and care behaviours in the context of the cost-of-living crisis, post-COVID-19. Specifically, the study attempts to address low levels of consumer knowledge about resource efficiency related to appliance use by testing how consumer education can drive resource efficiency at home. The study was carried out over a 3-month period in seven households in Southwark Borough in London, forming an in-depth understanding of how consumer education can influence consumer behaviours involving domestic appliances, including laundering, cooking, and boiling water. The results of the study suggest that consumer adoption of energy efficient and product life extension behaviours can be influenced by education. The study proposes that industry addresses the intention-action gap with improved and targeted design and delivery of education that motivates and empowers consumers to perform product life extension behaviours on their domestic appliances.

Circular Metals
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. We had 6000 people across the UK take part.

Met4Tech
Met4tech has engaged widely across all themes, working with policy makers and a range of stakeholders via a range of engagement activities. This has included workshops large and small, personal interviews and direct engagement with legal professionals. Met4Tech has engaged directly with government agencies such DEFRA, the Environment Agency (EA) and the Department for Business and Transport (DBT) to understand agency and policy stimuli (e.g. Extended Producer Responsibility) and what might be necessary to trigger these. The centre has also directly engaged with consumers, advertising and media and the wider supply chain to challenge perceptions and existing behaviour whilst seeking to demonstrate and understand the impact that might be felt by the introduction of such policy stimuli.

Insight B. The circular flow of resources emerges from complex interactions between system actors.

Introduction

The transition to a circular economy requires understanding how resources flow through various phases – from origin and production to consumption – and how these flows are influenced by the behaviours of multiple interconnected actors. Rather than focusing solely on individual actors (such as consumers) or isolated innovations, successful circular systems emerge from the interactions between human and non-human actors across wider networks, where participants are influenced by and contribute to collective activities within that system.

Supply chains in a circular economy are inherently socio-technical systems that span across places, where networks of people participate in carrying out processes through their interactions, collectively benefiting from their activity within the system. The circular flow of resources emerges from these whole system behaviours rather than from isolated actions. This necessitates consideration of how various actors perform behaviours collectively and in relationship with each other, driving the production and exchange of resources, information, and value in complex circular economy systems.

Complex systems perspectives applied to CE transition (Odabasi et al., 2023) emphasize the need for social innovation (Manzini, 2015) and collaborative efforts that extend beyond individual actions and isolated technological advancements. This requires addressing issues through multi-layered approaches that analyze how resources, information, and value are created and exchanged in relationships between actors (Latour, 2007).

Institutional actors, including customers, government bodies, policymakers, businesses, industry groups, NGOs, academic institutions, and international organizations, play critical roles in creating novel cultures and markets necessary for CE adoption. Their roles range from creating conducive regulatory environments and providing financial incentives to driving innovation, educating stakeholders, and facilitating collaboration. The emergent properties (Georgiou, 2003) of a system result from these co-constitutive relationships between diverse and complementary actors, producing system-level outcomes that could not be achieved by individuals in isolation.

NICER examples:

TCC

The TCC proposes the concept of the Social Production Network (SPN), based on understanding of complex systems, distributed manufacture, and social production function (Ormel et al., 1999). In this model, human actors (including wearers and stakeholders) and non-human actors (such as technologies, products, and materials) interact as interconnected components of a whole system. These systems demonstrate the ability to self-organize in towns in ways that facilitate circularity – a quality that emerges from many actors' behaviours across the system rather than isolated efforts of individual actors.

These systems are place-based, meaning the entire system's behaviour depends on the specific attributes, capacities, and capabilities of actors that vary across locations. The local focus supports small businesses, individual designers, innovators, and makers, promoting co-creation as a new way of acquiring clothing outside the vast linear global supply chain. System transformation is driven or constrained by multiple factors bounded by where these networks exist, including human behaviour, culture, policy, and broader macroeconomic and environmental influences. For the list of TCCs research and tools related to the SPN visit the Regenerative Fashion Hub website (2024).

ICEC-MCM

In construction supply chains, the flow of material across the value chain enables various actors to interact with products, making collaboration an essential component (Velenturf & Jopson, 2019; Pedreño-Roja et al., 2020; Rumo, 2021). Understanding the roles of contractors, administrators, end-users, and local communities across resource flow stages is vital in designing effective circular systems. These human actors, whether acting individually or collaboratively, engage in behaviours that are intricately woven into a system-wide behaviour chain.

Collaboration creates shared value and benefits across the supply chain and becomes a systematic way through which customers or partners capture value within a closed loop system. During the plasterboard circular economy business model (CEBM) canvas workshop held by the ICEC-MCM, stakeholders across the plasterboard lifecycle phases agreed that collaboration was the fundamental enabler for circular economy business models.

Met4Tech

Met4Tech has engaged directly with government agencies such as DEFRA, the Environment Agency (EA), and the Department for Business and Transport (DBT) to understand agency and policy stimuli and what might be necessary to trigger these. The centre has also directly engaged with consumers, advertising and media, and the wider supply chain to challenge perceptions and existing behaviour while seeking to demonstrate and understand the impact of policy stimuli.

Implications for Practice

The evidence from across NICER CECs demonstrates that:

1. Successful circular systems require orchestrated action between multiple actors rather than focusing solely on individual behaviour change
2. Place-based considerations and local contexts significantly influence how circular systems develop and operate
3. Collaboration and partnership are fundamental enablers for circular economy business models
4. Policy, governance, and collaborative behaviours are key requirements that enable circular transformations
5. Data sharing and information flow between actors is crucial for system functionality

Understanding these complex interactions is essential for designing effective interventions and policies that can support the transition to a circular economy at scale.

Insight C. The community assumes a pivotal role in fostering participation in a CE. Community activities bolster circular practices and alternative economies while instilling a sense of belonging; they cultivate an environment for learning and the exchange of innovative ideas.

Introduction

The integration of communities within the circular economy represents a pivotal focus in sustainability and economic research, highlighting the essential role communities play in implementing its principles to extend the life cycle of products and minimise resource extraction and waste. This approach contributes to environmental preservation while enhancing human wellbeing, a multifaceted concept where community involvement is crucial for fostering a sense of belonging and mutual support (Jewitt et al., 2024).

Community-led initiatives that drive the adoption of alternative economic models and innovative practices reinforce the circular economy's emphasis on recycling, sharing, leasing, and reuse. These efforts are critical for reimagining business operations and consumer behaviours and highlight the indispensable role of social entrepreneurs in moving sustainability beyond simple waste management (World Economic Forum, 2023). Moreover, the transition towards a circular economy requires significant reskilling and upskilling, offering communities the chance to achieve economic and social growth. For instance, the Dutch government's Circular Skills Program aims to bridge the gap between vocational education and the demands of the circular economy, particularly in construction, by identifying skill shortages and promoting educational reforms.

Communities play a vital role in behaviour change through role modelling and peer influence. There is a need for more widespread infrastructure, physical and logistics in neighbourhoods or online, to facilitate reuse, remaking, reskilling and upskilling. Without this, actions taken within community settings are not sufficiently visible to have an impact. Moreover, distance and access issues also pose practical inconvenience. For example, unused and underutilised spaces in locations with high footfall such as highstreets may be good avenues to facilitate behaviour change. The role of online communities should not be missed, the proven success of the sharing economy is another evidence for the connection across community members that is beneficial for circular principles.

The role of communities in advancing the circular economy is linked to several theoretical frameworks, notably systems thinking, distributed manufacturing, the concept of the second industrial divide, and industrial symbiosis. Systems thinking offers a holistic approach to understanding the interconnectedness and interdependencies within the circular economy, emphasising the importance of community engagement in creating sustainable systems (Meadows, 2008). Distributed manufacturing, on the other hand, decentralises production processes, allowing communities to localise production and reduce environmental impact through shorter supply chains (Johansson et al., 2015). This concept aligns with Piore and Sabel's (1984) discussion on the second industrial divide, which advocates for a shift towards flexible production systems supporting community-based, adaptable manufacturing ecosystems. Finally, industrial symbiosis, a concept where waste from one process becomes the input for another, creating a network of mutual benefits (Chertow, 2007), relies on community collaboration to optimise resource use and reduce waste.

NICER examples:

TCC

The TCC developed a concept for community-led, localised networks for extending the life of clothes. During the Regenerative Fashion Hub (RFH, 2024) exhibition, we demonstrated this concept in a real-world setting by engaging and immersing publics in different ways. We invited local menders, upcyclers, designers, etc. to exhibit their work which is already pushing circularity forward and we showed how these initiatives can work together in dialogue with TCC's own design research and innovations. Guest exhibitors' real-life examples of circular practices resonated with the public. Their work added a layer of familiarity to the exhibition, helping visitors connect with the concepts and ideas being presented. This was taken further by offering guided tours of the exhibition space, which was a way of engaging visitors directly and personally introducing them to our research, which prompted discussions during the visits.

Furthermore, we ran various studies to collect primary qualitative data from members of the community whose work in textiles can inform sustainable transitions. The exhibition, whether at RCA or RichMix was designed to be in dialogue with the neighbouring community. The choice of RichMix as a venue, situated on a vibrant high street, was particularly significant. Its location and accessibility standards made the exhibition more open to the general public, inviting passersby to engage with the work. Hosting numerous events in the space further broadened its reach and created opportunities for making new connections.

Through this work developing and running the RFH alongside relevant publics, we have a richer understanding of how a community can drive circular transitions while enhancing its resilience, diversity of skills and wellbeing. It is in the best interest of communities to foster initiatives that span distributed manufacture, intergenerational skills exchange and spaces for care and repair. Therefore, the theme of community should always be at the centre of CE research.

Insight D. The adoption of CE systems necessitates new behaviours that require effort (physical, cognitive, and emotional) from the actors and system support to effectively implement these behaviours.

Introduction

The adoption of Circular Economy (CE) systems indeed necessitates new behaviours that require significant effort – physical, cognitive, and emotional – from the actors involved, as well as robust system support to effectively implement these behaviours. Existing approaches to changing consumer behaviour are primarily normative, relying heavily on educational and behavioural messaging, interventions such as nudges, and efforts to shift beliefs, decisions, and habits away from 'bad' consumption towards pro-environmental 'good habits' that support long-term sustainability goals. However, these methods have shown limited impact.

Therefore, the transition to CE systems demands a multifaceted approach that goes beyond normative strategies. It requires a combination of physical infrastructure, cognitive tools, and emotional support to help individuals and organisations adapt to and maintain new, sustainable practices. This holistic approach is essential for overcoming the limitations of traditional behaviour change methods and achieving the desired environmental and social outcomes.

Normative methods such as changing labels, providing information, using scare tactics, or trying to instil a sense of 'sacrifice' have not been particularly effective (Wilk, 2022; Bly, Gwozdz & Reisch, 2015; Jackson, 2009). These strategies often fail to address the deeper, more ingrained behaviours and the complex motivations behind consumer choices. Additionally, the 'double dividend' concept, which suggests that reducing material consumption benefits both the environment and individuals, does not hold true in practice (Jackson, 2005b; Chamberlin & Callmer, 2021). This indicates that simply reducing consumption is not enough; there must be a comprehensive support system in place to facilitate and sustain the new behaviours required by CE systems.

The behaviour of other actors is also critical for orchestrated action to support the transition to a CE. Research is beginning to reveal the different barriers and drivers that different actors face in this transition, including businesses (Tan et al., 2022), and particularly SMEs (Ahmadov et al., 2023).

NICER examples:

TCC

The Consumer Experience strand of TCC created a conceptual model designed to link consumer wellbeing with circular practices in the textile industry, focusing on how consumers' emotional, physical, and psychological wellbeing can drive more sustainable behaviour in relation to garment use, reuse, and recycling. The framework organises wellbeing in three main categories: Feeling well, Doing well, and Being well. Feeling well refers to the hedonic aspects of wellbeing like sensory comfort, pleasure, attachment, and feelings of community. Doing well emphasises eudaimonic wellbeing, including personal growth, creativity, and learning. Being well focuses on the objective dimensions of wellbeing, including affordability and access to sustainable products and services.

Effort plays a significant role in the Doing well dimension of the framework. It is related to eudaimonic wellbeing, which is about achieving meaningful, long-term through active engagement and purposeful actions. Through the WB framework, effort is not seen as a burden but as a positive and necessary investment in achieving personal satisfaction. For example, the WB framework acknowledges that making choices such as repairing clothes, co-creating products or researching more sustainable material options, require effort. However, this effort can lead to a sense of accomplishment and empowerment, contributing to the consumer's wellbeing. The effort put into sustainable practices also fosters skills and competence, giving individuals a sense of mastery. This personal growth supports eudaimonic wellbeing and encourages ongoing participation in circular practices, reinforcing healthier consumption behaviour. Effort is integrated in the WB Framework as a positive driver for individual fulfilment and circular behaviour.

Insight E. Actors in a CE system have dynamic roles, meaning that each actor can position themselves as having multiple roles/functions in the system.

Introduction

To fully understand the dynamic roles of different human actors in circular economy (CE) systems, it is necessary to have a comprehensive understanding of their involvement in all stages of resource flow, starting from the source, through production, and up to consumption. Adopting a comprehensive viewpoint is essential in developing efficient circular systems that are both environmentally friendly and considerate of all stakeholder engagements and actions across the whole lifespan of a product. Research indicates that in the field of CE, human actors play an active role as agents who actively direct and control the allocation of resources (**Padilla-Rivera et al., 2020**). These actors involved in this system-wide behaviour chain encompass a range of participants, including as suppliers, manufacturers, users, and recyclers. Each actor has distinct roles and responsibilities that together contribute to the functioning of the system. This behaviour chain is an integral part of the larger framework of CE, where the role of each actor is interconnected with others, highlighting the need for collaboration and interdependence (**Bals et al., 2022**). This perspective is highlighted in studies that address the social aspects of CE, emphasising that human actors are crucial in transitioning from traditional linear models to circular models. These actors are not passive; instead, they engage actively in designing, implementing, and managing systems that aim to maximise the sustainability and efficiency of resource use across different phases of the product life cycle (**Padilla-Rivera et al., 2020**). Moreover, the concept of 'regime-niche' actors as catalysts in CE transformations further underscores the dynamic roles these human actors play. These individuals or groups often spearhead innovations and system changes that are necessary for the effective implementation of CE principles. They do this by initiating and managing transitions towards more sustainable practices, often overcoming significant systemic and institutional barriers (**Fogarassy et al., 2020**).

Additionally, the engagement of these actors in a CE is not static but evolves over time. Actors throughout the supply chain are increasingly seen not just as participants but as co-creators in the value generation process. This perspective shift is highlighted by the role of "circular stakeholder engagement practices", which aim to align interests, create a shared vision, and build relationships based on trust. Such engagement is crucial for sharing risks, accessing resources, co-constructing knowledge, and political decision-making, which are vital for implementing and scaling CE initiatives (**Fobbe et al., 2022**).

NICER examples:

Circular Metals

Our study examines three case studies of different organisations to investigate the complexities associated with implementing circular business models. Our research aims to create a tool that assists organisations in adopting a progressive, strategic framework, allowing them to anticipate and strategise for the long-term transformation of their operations towards sustainability and circularity. An initial analysis of the first case study has shown a substantial obstacle: the requirement for changing customer behaviour for the effective implementation of a circular business model. The finding underscores a significant conflict between organisational goals and consumer behaviours, indicating that internal initiatives alone are inadequate. There is a pressing need for external involvement and educational programs to synchronise customer perceptions and behaviours with the principles of circularity. This highlights the complex constraints of adopting circular models, where success depends on both internal organisational modifications and the capacity to influence and adjust to external stakeholder behaviours.

TCC

As we advocate for localised textile supply chains that are community-driven and have the wellbeing of their communities as their core aim, we have developed a number of tools to co-design these systems with existing actors (Regenerative Fashion Hub, 2024). Focus group discussions amongst participants reveal that, in order for these systems to become increasingly aligned with CE principles, wearers need to become more involved in various processes to maximise clothing reuse. For example, maintenance, custodianship or co-creation are processes which could extend the life of garments and which could be promoted at local level through settings such as repair cafes, libraries and markets. This would also require existing businesses to adopt multiple roles/ functions to fulfil the self-sufficiency of local and distributed circular supply chains.

Met4Tech

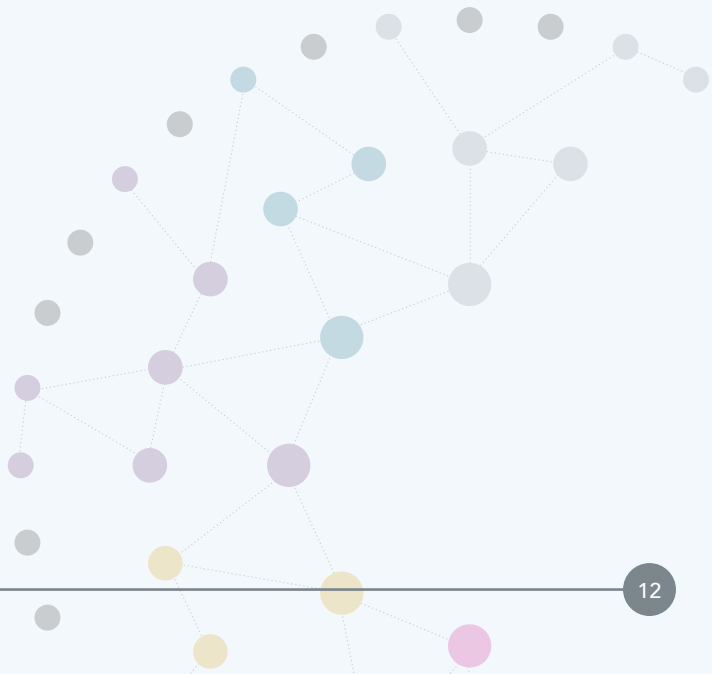
Met4Tech has supported numerous small businesses to explore alternative business and sales models, including the potential to act as both supplier of new items, collector of end of life (EOL) items and distribution hub to enable effective reuse and recycling through partners. A good example of this is the Innovate CR&D funded project focussed on Tyre Pressure Monitoring System (TPMS) sensors. The EU legislates that a TPMS system must be fitted to all new vehicles manufactured from 2014, initially this used an indirect system (non tyre specific) but over time transitioned to direct monitoring (tyre specific sensing). With an average life span of five years and with four sensors to each vehicle (1 per tyre) weighing an average of 28 grams per sensor, this has the potential to generate approximately 840 tonnes of waste to landfill annually. The distributor supported in this example is a national distributor of new sensors and has developed a model to collect EOL sensors from customers, identify those with a second life to be put back into the market and recycle those which are truly EOL. Similarly, the customer also fulfils a collection and segregation role, effectively separating the valve stem from the sensing unit, enabling more efficient recycling processes downstream.

Insight F. Niche innovation adoption by small networks of people can be used as a CE transition strategy. Emerging socio-technical systems invariably start with early adopters who accelerate the transition process. Industries can leverage this phenomenon to effectively organise actors and behaviours as they transition towards embracing CE principles.

Introduction

The transition to a circular economy requires changes in our socio-technical systems, which include a combination of economic, cultural, technological, regulative, organisational, and institutional innovations. The Multi-Level-Perspective (MLP) model (Geels 2002, 2004) is often used to make socio-technical system innovations easier to understand. It looks at how three levels interact to show how transitions happen: the existing system or currently dominant socio-technical regime (meso level), innovative niches (micro level), and the landscape of events that affects the regime and niche (macro level). Niches are particularly important because, as protected spaces 'isolated' from the influence of the dominant regime, they can act as incubation rooms where radical innovations can be tested, become more mature, and potentially challenge and change regime practices (Geels, 2002). The transition to a circular economy is further characterised by co-evolutionary processes, where the interplay between economic, cultural, technological, regulative, organisational, and institutional subsystems mutually influences and reinforces each other, driving the dynamics of transformative change and shaping the trajectory of transitions (Grin, Rotmans, Schot, 2010). Several concepts referring to socio-technical experimentation have been developed, including: *social experiments* (Verheul & Vergragt, 1995), *experiments in Strategic Niche Management* (Hoogma, 2000; Kemp, Schot, & Hoogma, 1998), *transition experiments* (Rotmans et Al., 2000; Van den Bosch, 2010), and *bounded socio-technical experiments* (Brown et al., 2003). More recently, design scholars have started exploring how design can play a role in designing such socio-technical experiments (e.g. Ceschin, 2014, Gaziulusoy & Ryan, 2017).

Looking specifically at **actors** and **behaviours**, it is clear that the transition to a circular economy requires: 1] the involvement of a wide range of actors, including businesses, users, public authorities, governments, research centres, NGOs, etc.; and 2] fundamental changes in culture (the sum of norms and values), practices (the sum of routines and behaviours), and institutional structures (rules, regulations, power structures) (Rotmans & Loorbach, 2010).



NICER examples:

Circular Metals

Visions and roadmaps: 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.

Long-term circular businesses: The Circular Metals Centre is currently collaborating with a range of businesses to envision how their medium/long-term business strategies can shift towards circularity. This entails supporting them in conceiving solutions that integrate business model, supply chain and product-service design aspects. This involves taking into account all the actors in the value chain, as well as their required changes (in culture, practice).

Circular Economy Centre for Mineral-based Construction Materials (ICEC-MCM)

Modular buildings: The Centre is exploring how the concept of 'modularity' can be integrated more radically and effectively in building design. This would improve and facilitate the process of decommissioning and reuse of components. This entails changes in behaviour and practice of a range of actors including engineers, architects and constructors.

Researchers at the ICEC-MCM demonstrated through a specific example (Kitayama & Iuorio, 2023) of a building component that it is possible to deconstruct and reuse lightweight exterior infill walls using current technologies in order to facilitate modularity and the practice of designing for deconstruction. Comparative life cycle assessments (LCAs) of linear vs. circular building components showed reductions in CO2e emissions between 6-27% depending on the type of circular scenarios assessed (Kitayama, Iuorio, Josa, Borrion & Black – *manuscript under review*).

Met4Tech

We developed four overarching **scenarios** that were discussed in an early workshop to discuss potential ways in which the system around techmetals could develop. Our insight was deepened through ***learning histories*** of the use of three key techmetals. These preliminary approaches, which we discussed in meetings that cut across academia and practitioners, served as a starting point for two more comprehensive approaches:

Roadmapping: A key to guide the process of developing niches to challenge the existing regime is to engage in a collective process where system actors deliberate on the steps to develop and scale up their system innovation. As we have seen many roadmaps that focus on specific circular economy strategies, we adopted a systemic approach that challenged participants to explore a more holistic solution space. This also helped to look at the interrelations between different circular strategies, seeking to exploit synergies and avoid blockages.

Responsible innovation: We consistently challenged consortium partners to adopt principles and techniques of responsible innovation. While challenging, we managed to generate some of the deliverables in a way that reflects the AREA principles: Anticipation, Reflexivity, Engagement and Action. This requires us to engage with system actors that represent the spectrum of interests in developing our solutions. Responsible innovation specifically seeks to uncover and then prevent unintended negative consequences to result from the establishment of routes of circulation and associated innovations. As such, it functions as a method to improve the likelihood that transitions deliver on sustainability dimensions.

Insight G. Policymakers must work closely with local system actors to understand how they can drive and enable formation of a network the shared goal of which is community wellbeing and circularity.

Introduction

Policy making is an iterative process. Good policy making is designed systematically to include actors who are impacted by policy changes including civil communities as much as business and government at all levels. (Mazzucato et al 2020) Policy to transition to a circular economy has largely been the domain of technical and business actors and more recently government, mainly central government.(Fitch-Roy, Benson, and Monciardini, 2021) This is particularly the case where circular economy policy is being designed with high emitting industries such as cement, steel and chemicals. (Kovacic, Strand and Völker, 2020)

Transforming circular economy policy making in and between sectors at all levels requires investment in initiatives to identify actors, build trust between different groups, exchange knowledge and collectively engage in systematic processes to develop shared futures that are just and sustainable. For a country such as the UK with its dynamic constitutional relationship between central government (the State) and devolved powers (both nations – Scotland, Wales and Northern Ireland as well as cities and counties) it can be difficult to build resilient multilevel policies across and between different actor communities.

NICER examples:

ICEC-MCM

In research conducted by ICEC-MCM specifically for the Scottish government consultation on the 2023 Circular Economy Bill researchers found tensions between economic trade law which is centralised and environmental laws which are devolved, along with planning and procurement laws (also devolved) which could undermine a sustainable transition to a circular economy which is acceptable to all actors at all levels of governance. (Dougan et al, 2022) Moving beyond such a situation needs a concerted effort by all levels of government to build collaborative narratives which go beyond long standing national/sovereign models of governance. (Kautto and Lazarevic, 2020) The pathway ahead for circular economy encompasses also a radical transformation in approaches to policy making and governance.

Met4Tech

Researchers at the University of Birmingham (UoB) have seen the adoption of its' Hydrogen based Rare Earth Permanent Magnet recycling technology into the Mineral Security Partnership, an international collaboration between 14 countries and the EU to drive public and private investment in the responsible critical minerals supply chains globally. It does so by working with host governments and industry to drive targeted diplomatic and financial support for strategic projects along the value chain. This is founded on a series of principles and commits to only support projects that meet high ESG standards, promoting local value addition and uplifting communities.

In addition to this, the project has worked closely with international policy, standard and advisory groups, ensuring that a wider and often local perspective is considered when devising international standards and legislation, effectively seeking to minimise and prevent unintended consequences for local communities regardless of geographic location.

CE-Hub

Human behaviour underpins the design and implementation of CE roadmaps, shaping how systems, stakeholders, and industries adopt and operationalise circular practices. The success of these roadmaps depends on their ability to embed behavioural insights into systemic frameworks, aligning individual, organisational, and societal actions with CE principles. Typological frameworks reveal the varying behavioural demands across governance levels: national roadmaps require widespread societal engagement for large-scale interventions, regional and municipal strategies depend on context-specific behavioural adaptation, and sectoral roadmaps necessitate organisational shifts towards practices such as remanufacturing and design-for-circularity. Behavioural readiness often determines the scalability and efficacy of upstream interventions like reduction and reuse, which are less established than downstream activities like recycling. Addressing these gaps requires robust mechanisms within roadmaps to measure and adapt to behavioural trends, employing systems-thinking paradigms to synchronise incentives, enhance compliance, and sustain engagement.

Insight H. Human wellbeing can be achieved through engagement with circularity at a personal, interpersonal and community level.

Introduction

The active involvement of various human actors, ranging from local communities to government authorities, plays an important role in fostering a profound sense of responsibility and connection to the circular model. It is crucial to recognise that circular practices extend beyond individual actions and permeate societal structures.

For instance, existing literature underscores the symbiotic relationship between wellbeing and repair within the circular economy framework. Repair, as a behavioural aspect, not only serves as a means to extend the lifespan of products but also becomes a source of satisfaction for individuals. The act of fixing things, whether it be a household appliance or a clothing item, instil a sense of accomplishment and contributes to a positive psychological impact.

NICER examples:

ICEC-MCM

One example is in the realm of construction, like retrofitting structures. Rather than opting for rebuilding structures, repairing and refurbishing existing structures can be done. This not only aligns with sustainability goals but also fosters the preservation of culture as these restoration projects keep part of the original structure's spirit. For instance, repairing a local playground or a historic building not only preserves tangible assets but also strengthens the social fabric. This not only reduces waste but also forges stronger place connections. At ICEC-MCM, Social Life Cycle Assessment (S-LCA) was used to analyse the impacts of a circular economy strategy at different levels, ranging from individual (workers, users) to collective (local community, society).

TCC

The textiles sector faces a challenge to support consumers to transition from overconsumption into custodians of garments. Responding to the limited understanding of ways to dissociate the usage of material resources from human wellbeing and economic development, the TCC developed a wellbeing framework to understand the factors that constitute human wellbeing and to apply this understanding strategically in evolving circular consumer experience offers. It provides a platform for design and evaluation of circular experiences that support the adoption of circular practices whilst providing long-term wellbeing. The Wellbeing Framework for Circular Consumer Experiences supports the objectives of the TCC by examining consumer wellbeing as a route to the social health benefits of circularity, promoting new cultures of consumption that catalyse sustainable behaviour, and as a consumer-focused tool to support the move towards zero waste through a focus on enabling responsible and personalised engagement with consumption, reuse, and recycling. For example, TCC developed FarFalla, an immersive (Virtual Reality) multisensory experience that provides a fresh approach, showing that the wellbeing dimensions '**engagement**', '**bodily & sensory**', '**learning**' and '**enjoyment**' are key to fostering circular behaviour. FarFalla immerses consumers in the environmental impact of garments, using scents and haptics to visualise resource use, and enables creative engagement with regenerated materials. It transforms circularity into a rewarding, communal activity, and an effective way to motivate consumers, disseminate science, and drive deeper conversations about textile circularity.

Circular Metals

The results of the Big Repair Project highlighted that participants reported feeling positive when they fix appliances, indicating wider 'social value' with regards to health and wellbeing. In the UK, social value is defined as a broader understanding of value beyond money as the main indicator of value where "social value measurement goes beyond financial or economic value and tries to capture social impact in the round". Social Value is considered to embrace complexity and whole-systems analysis. Positive net social impact is the outcome of social value. Social impact is fundamentally about isolating and measuring direct cause-and-effect relationships between a specific set of activities and outcomes. One of the outcomes of the Big Repair Project was to define more clearly how to measure the social value of repair activities and how they can be quantified in monetary terms (Big Repair Project, 2024).

Insight I. "CONSUMERS"? What do we call ourselves in CE?

Introduction

In the context of the Circular Economy (CE), the traditional role of consumers is evolving into more dynamic and participatory roles, often described with terms like prosumers and prosumption. Prosumers, a blend of producer and consumer, engage actively in the production and recycling processes, contributing to a more sustainable life cycle of products (Toffler, 1980). This involvement ranges from DIY repairs to active participation in recycling initiatives, which enhances both short-term and long-term well-being by fostering a sense of accomplishment and environmental responsibility (Schor, 2010). The concept of prosumption signifies a shift towards more collaborative consumption patterns where consumers are no longer passive recipients but active participants in the product life cycle. This can include behaviours such as sharing, leasing, and recycling, which are integral to the CE model (Ritzer & Jurgenson, 2010). Such engagement not only promotes environmental sustainability but also supports economic resilience by reducing waste and resource use.

Alternative hedonism, a concept introduced by Soper (2008), suggests that individuals can derive pleasure and satisfaction from sustainable consumption practices. This perspective challenges traditional consumption-driven happiness by promoting well-being through sustainable living and reduced consumption. On the other hand, custodian stewardship emphasises the role of individuals as caretakers of resources, ensuring their preservation and responsible use for future generations (Brown, 2016). In addition, the literature about neurodiversity within CE adoption can focus on the importance of inclusive practices that cater to the diverse cognitive and neurological needs of individuals. This ensures that CE practices are accessible and beneficial to all segments of the population, promoting equity and inclusivity (Walker, 2014). The "liberty of things" concept advocates for the freedom to use, modify, and repurpose products, empowering consumers and fostering innovation within CE frameworks (Womack, 2018).

NICER examples:

TCC

In the NICER programme, the importance of human actors (all actors in the system and/or user citizen) in CE was underlined the need for behavioural changes and the development of a collective identity in several recent studies, such as, developing the TCC wellbeing framework, focusing on the language of circularity and terminology for awareness and clarity on CE adoption. The awareness, learning and consistency should be improved for circular behavioural changes.

ICEC-MCM

In the case of secondary construction materials, especially mineral-based products, "customers" are organisations rather than individuals. Clients, as key stakeholders in construction projects, have a substantial influence on the adoption of recycled or non-virgin materials. The impact derives from demand generation, awareness, the availability of information and alternative options, economic incentives and the secondary materials adoption is influenced by collaboration and partnership, setting standards and benchmarks for ensuring accountability. From an individual perspective, secondary materials preferences and sustainable awareness can somehow affect the decision making of construction clients, however, there is limited evidence for this association.

Met4Tech
While the circulation of techmetals involves actions to be taken by users/consumers, in our work we delved into a related issue, which is that consumers are also citizens that can articulate their consent or concern about the provision of critical metals. While 'consumers' expect products that contain such metals (such as batteries) to be available in a reliable way, as citizens they might contest the activities to provide for such materials to take place close to home. In our work we engaged with this dual role specifically in relation to the prospect of mining lithium in Cornwall. This case exemplifies how circulation of materials where security of supply is of importance, the impacts of resulting local systems of supply and circulation are directly felt by consumers. In this work we used approaches to involve the community in developing the prospect of mining activities.

Circular Metals
In the Big Repair Project we explored future scenarios where the lifespan of electronics and appliances was extended through the act of repair. This **repair economy** is inherently local and provides a counter-balance to the necessary highly efficient global manufacturing economy. The local nature of repair, the jobs it creates and the social and environmental awareness it promotes provide high social value. We all have multiple identities, we are mums, dads, daughters, sons, cousins; we are also neighbours, gardeners, sports people; we are workers, managers and customers; our economic identities don't need to be pinned down to a single identity: 'consumer'. They can and should embrace recycler, repairer, custodian and care-taker. Our work shows these contribute to the local and global economy but at the moment these identities are suppressed by the dominance of consumerism as the driver of economic growth.

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