EPSRC Circular Economy community engagement workshops – 24th & 29th March 2022

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Executive summary

A circular economy keeps resources in use for as long as possible, extracting the maximum value from them whilst in use, and recovering products and materials after use. More circular use of resources is crucial to achieving net zero carbon emission targets, as well as reducing waste and pollution harmful to biodiversity, and enhancing resource security. It offers the UK significant economic, social and environmental benefits, including an estimated £10 billion profit increase for manufacturers, a 4.5% reduction in UK GHG emissions alongside a reduction twice this size in GHG emissions embodied in imports[1], and in excess of 200,000 new jobs from only partial implementation[2].

In March 2022 EPSRC ran two virtual workshops open to all researchers with an interest in the circular economy (CE) – including those who already work on CE-relevant research as well as those new to the concepts of CE and circularity. The overarching aim of the workshops was to increase awareness and further develop understanding of the role different engineering and physical sciences (EPS) disciplines play in achieving a circular economy as well as encourage the consideration of resource efficiency and circularity in all EPS research. The agenda included facilitated discussion sessions, talks from keynote speakers and EPSRC staff, and optional "Ask EPSRC" breakout rooms.

Each workshop began with a keynote talk from an external speaker who talked about what the circular economy is and why we need EPS research to deliver it. Following this, delegates engaged in a thought-provoking discussion around what a future circular economy looks like. Next, EPSRC gave a talk on our strategy and approach to circular economy and its place in the context of wider EPSRC/UKRI strategy. Delegates then discussed the EPS research challenges required to realise a future circular economy. The wide range of challenges identified indicates that research for a circular economy stretches across the vast majority of areas that EPSRC supports, with significant links to the rest of UKRI's remit. EPSRC will explore these research challenges further to coordinate with other councils as appropriate, in order to determine how best to support research for a circular economy.

The afternoon sessions focused on embedding considerations of circularity across the EPSRC research portfolio. We began with keynote talks from invited speakers who provided an academic perspective on embedding CE considerations in their research. Delegates then discussed the question "What does circularity and the circular economy mean in your research?" This supported EPSRC to understand more about what the community is already doing in this area and provided peer-to-peer learning for delegates. Following a final talk from EPSRC on funding opportunities for CE research, delegates discussed the ways EPSRC can support high quality, novel CE research, as well as ways of embedding considerations of circularity and resource efficiency in research outcomes.

The workshops demonstrated the enthusiasm in the research community regarding the concept of a future circular economy. The wide range of identified research challenges demonstrated how research for a circular economy stretches across the vast majority of areas that EPSRC and UKRI supports. The Manufacturing and the Circular Economy team at EPSRC will continue to explore opportunities to drive forward priorities and support researchers in this area, for example through targeted community engagement activities. We will consider how to share best practice for CE research with the wider community, embedding consideration across the council's remit. Outputs from these workshops have already fed into the development of the EPSRC delivery plan and will continue to be used to

[1] https://www.creds.ac.uk/wp-content/uploads/CREDS-Resource-efficiency-scenarios-UK-technical-report-web.pdf
[2] http://www.nextmanufacturingrevolution.org/nmr-report-executive-summary; http://www.wrap.org.uk/content/employment-and-circular-economy

develop relevant strategies and priorities, influencing wider EPSRC policy where appropriate.

1. Introduction and objectives

EPSRC held two virtual (Zoom) workshops in March 2022 (24th and 29th) with the aim of exploring the role of engineering and physical sciences (EPS) research in achieving a transition to a circular economy (CE). To maximise engagement with all stakeholders who were interested in attending, EPSRC ran the workshop twice, on different working days in different weeks.

EPSRC aims to actively support the engineering and physical sciences research, innovation and training needed to enable a transition to a more circular economy and the significant benefits this will deliver for both society and the planet. We must embed consideration of and designing for circularity in research and training across the innovation landscape now, so that the systems, technologies, and tools developed to address key priorities – such as the climate crisis and enhancing population health – consider whole lifecycle costs and utilise the resources in the system as efficiently as possible.

With these community engagement workshops EPSRC aimed to increase awareness and further develop understanding of the role different EPS disciplines play in achieving a circular economy as well as encourage the consideration of resource efficiency and circularity in all EPS research. EPSRC was keen to identify community highlights and future priorities to feed into related strategy development and understand barriers to delivering high impact, interdisciplinary research in this area.

The specific objectives for the workshops were:

- Increase the awareness and understanding of the role of EPS research in delivering a transition to a circular economy.
- Increase the awareness and understanding of how to embed circularity in EPS research outcomes.
- Encourage interaction between a wide range of stakeholders and partners with expertise or interest in the circular economy.
- Identify research challenges and opportunities that could be developed as future priorities and develop understanding of the support needed to ensure research in the area delivers maximum impact.
- Increase the understanding of current opportunities (including funding) which can be provided by EPSRC/UKRI for circular economy research.

2. Delegates

This event was open to any and all researchers working in areas directly supporting the transition to a circular economy, as well as those who have an interest in considering circularity in their own research in any area of EPS. A background in circular economy research was not a pre-requisite and applications were actively encouraged from those new to the area or only just beginning to consider how to embed circularity in their research. Colleagues from industry and the third sector were also encouraged to apply.

Although this was primarily an EPSRC event this is an inherently interdisciplinary area of research. Applications from those not traditionally in EPSRC remit but currently or hoping to collaborate with those who are to deliver a circular future and/or embed circularity in engineering and physical sciences research and innovation were also welcomed.

Following an expression of interest process, across both days there were a total of 59 attendees from 35 different institutions. A list of delegates can be found in annex 1.

3. Workshop agenda

Session	Description	Led by
Keynote talk 1	What is a circular economy and why do we need engineering and physical sciences research to deliver it?	▪ Keith James, WRAP (24th March) ▪ Sarah Downes, REPIC, and David Fitzsimons, Oakdene Hollins (29th March)
Discussion session 1	What does a future circular economy look like?	EPSRC
EPSRC talk 1	Circular Economy theme and activities	▪ Dr Lisa Coles, Joint Head of Manufacturing and the Circular Economy ▪ Dr Robert Felstead, Deputy Director for Cross-Council Programmes (24th March) ▪ Dr Derek Craig, Deputy Director for Cross-Council Programmes (29th March)
Discussion session 2	What are the engineering and physical sciences research challenges to realise a circular economy?	EPSRC
Networking	Optional "Ask EPSRC" breakout rooms	EPSRC
Keynote talk 2	Academic perspectives on embedding circularity and interdisciplinarity	▪ Professor Marcelle McManus, University of Bath, and Professor Mark Miodownik, University College London (24th March) ▪ Professor Phil Purnell, University of Leeds (29th March)
Discussion session 3	What does circularity and the circular economy mean in the research?	EPSRC
EPSRC talk 2	Funding mechanisms for circular economy research	Naomi South, Portfolio Manager, Manufacturing and the Circular Economy
Discussion session 4	Embedding circular economy principles across the EPSRC research portfolio and action planning	EPSRC

Table 1: Workshop agenda

4. Summary of session outputs

The following has been compiled from the outputs recorded on Miro boards and in notes from the sessions.

4.1 What does a future circular economy look like?

Aim: to facilitate discussion around what a future circular economy looks like, in order to set the scene for later discussion of specific research challenges

Delegates were asked to consider what a future circular economy would look like, being ambitious and considering what we *could* achieve in an ideal world:

Use of resources

A future circular economy will optimise the use of natural resources, including solar and biomass resources. The consumption requirements of the population will be sustained by the available natural resources, with an acceptable buffer to account for black swan events. All negative impacts on the environment will be minimised, not just carbon emissions; considerations of broader environmental metrics will be taken into account – for example, freshwater usage and biodiversity impact. Biological systems will be used more effectively, restoring land and reducing fertiliser use; mining will be more efficient and will ensure local environments are protected. Companies will have a truly positive impact on the environment as opposed to simply mitigating their negative impacts.

Policy and regulations

A future circular economy will sit at the heart of the government's priorities, with a clear political drive and commitment towards circular economy ambitions. Policymakers will make informed and educated decisions based on wider understanding of circularity and sustainability. Carbon will be fully accounted for, especially on imported materials and products, and consumption of local resources will be encouraged by recording all carbon emissions in a product; politicians will have a role to play in making carbon costs more important than money, for example by using tax incentives. The government will put in place clearer and stronger legislation around measurement of circularity and specific targets that organisations are expected to meet (in a similar way to scope 1-3 for GHG emissions). There will be stricter environmental policies which are harmonious across sectors to enable a coherent and transparent approach to circularity throughout the supply chain. In a future circular economy, regulations will encourage more circular practices across industry, including in approaches to waste management, and trade standards will give consumers the confidence to opt for more circular choices. The government will support local councils to deal with a wider range of waste streams, and councils will be provided with metrics for measuring circularity.

Economics

From an economic perspective, a future circular economy will involve a shift away from resource ownership and towards servitisation of materials and products. Using recycled materials will be cheaper than using virgin materials, with pricing linked to durability, availability, and resilience. Economic growth will be decoupled from resource consumption, and companies will recognise that 'economic' and 'sustainable' are not mutually exclusive. Understanding of the trade-off between longer life and product efficiency will inform business decisions, and there will be a greater emphasis on working out unintended consequences before they arise in order to make it easier to choose more sustainable options. Government interventions and incentives will encourage designers to adopt circular economy principles and competitors to work together; penalties will discourage non-sustainable practices, for example manufacturing using virgin materials.

Products and materials

Products in a future circular economy will be designed for reuse, remanufacturing, long life, recovery, disassembly, and redistribution – with recycling as a last resort. We will "make more with less" and maximise durability and efficiency. Materials used will have a lower embedded energy content and all material processes will be as resource efficient as possible. Material passports will be in widespread use to track material flows and stocks. New materials will be designed for circularity and minimised carbon content, and with end-of-life and material recovery in mind from the start. Integration of digital technologies will help save energy and reduce waste in manufacturing processes through application of machine learning techniques and data-driven decision making. Industries will make use of more real-time monitoring and quantification with technology such as digital twins. Recycling and sorting technology and infrastructure will enable circularity of resource flows, and there will be no waste-streams, only by-products.

Changing attitudes

In a future circular economy, a paradigm shift will have resulted in the obsolescence of consumerism. The public will make choices based on how long things last; there will be more emphasis on "low material-intensive" activities for work and leisure, and perceptions towards re-used products will have changed. The vision is a highly informed and educated public persuaded of the benefits of a circular economy, and therefore more likely to accept new technologies and legislations. Circular economy educational material will be utilised at all levels, including at early stages, and consumption of materials and carbon content will be understood by the majority of society. Access to circular economy in products and services will be inclusive and equitable; collaborative decision making by local communities will result in more jobs, improved local economies, and better quality of life for all.

4.2 What are the engineering and physical sciences research challenges to realise a circular economy?

Aim: to facilitate discussion around key research challenges either fully in EPSRC's remit or with engineering and physical sciences (EPS) relevance/involvement.

Delegates were asked to discuss the EPS research challenges that need addressing in order to transition to a circular economy. Delegates were encouraged to consider: the current state-of-the-art; how EPS research can contribute to filling the knowledge gap; which research disciplines and other stakeholders need to be involved; and what EPSRC/UKRI can do to accelerate impact.

Materials for a Circular Economy

Discussions were varied and wide reaching, encompassing research challenges across the spectrum of EPSRC's remit, as well as several cross-cutting challenges incorporating topics across UKRI's remit. Delegates used Miro boards to capture the discussion and these can be found in annex 2.

One of the key identified themes most relevant to EPS research was the challenge of materials for a circular economy. This is a wide-reaching issue with research challenges at every stage of a material's life. Delegates discussed the importance of developing new, more circular materials which are designed for reuse and recycling, as well as exploring the possibilities of producing more materials from existing waste streams or designing materials which are self-healing and self-repairing in order to extend their life. Delegates also recognised the need to improve the circularity of existing materials and avoid over-reliance on new 'miracle materials' without addressing the issues we already have. Delegates identified research challenges in tracking materials throughout their lifetime, for example by using material passports, as well as minimising the use of materials wherever possible to reduce the amount currently in the system. Several end-of-life research challenges were identified, including the difficulties in sorting and separating materials, as well as challenges in reuse, repurposing and recycling materials.

Cross-cutting challenges

Delegates also identified several research challenges which are more cross-cutting by nature and stretch into other areas of UKRI's remit. Some of the key such challenges are highlighted in Fig. 2.

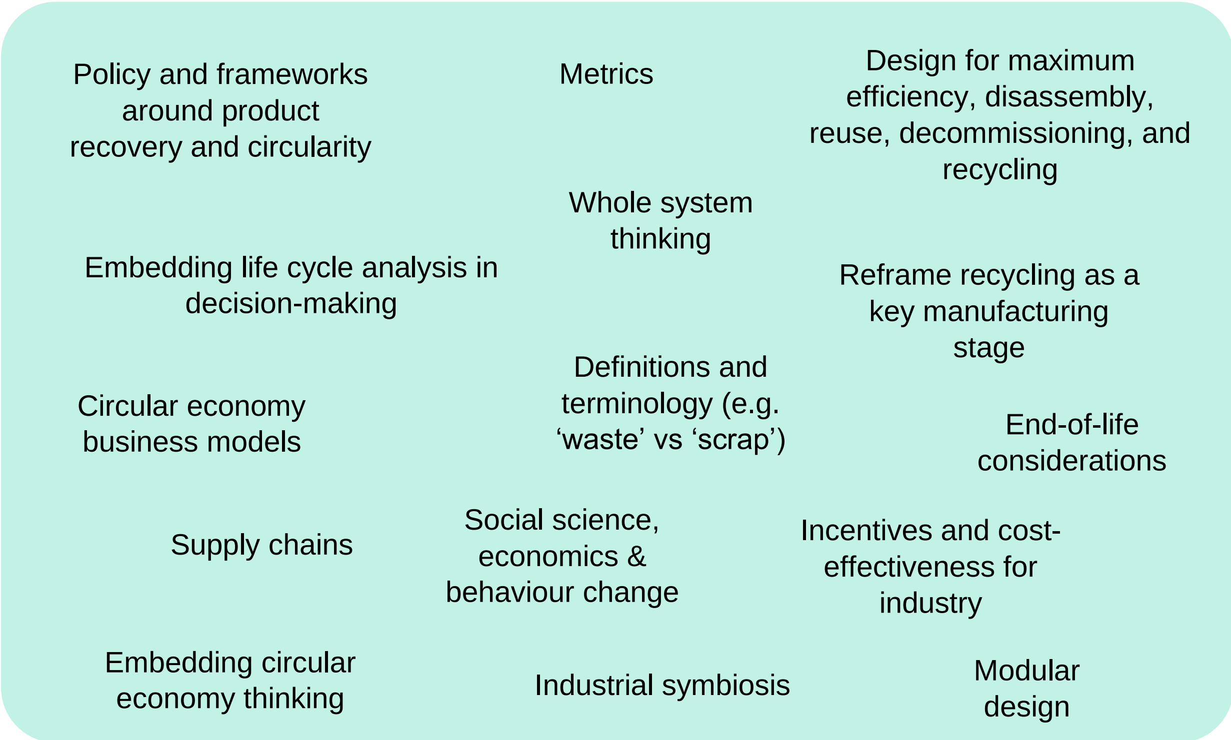

Figure 2: Cross-cutting challenges

4.3 What does circularity and the circular economy mean in your research?

Aim: to facilitate sharing of best practise with regards to embedding circularity in research outcomes.

Delegates discussed examples of previous work and best practice, as well as challenges they had faced and advice for peers who are new to the concept of circular economy (CE).

Fig. 3 highlights the range of research relating to circularity being undertaken by delegates.

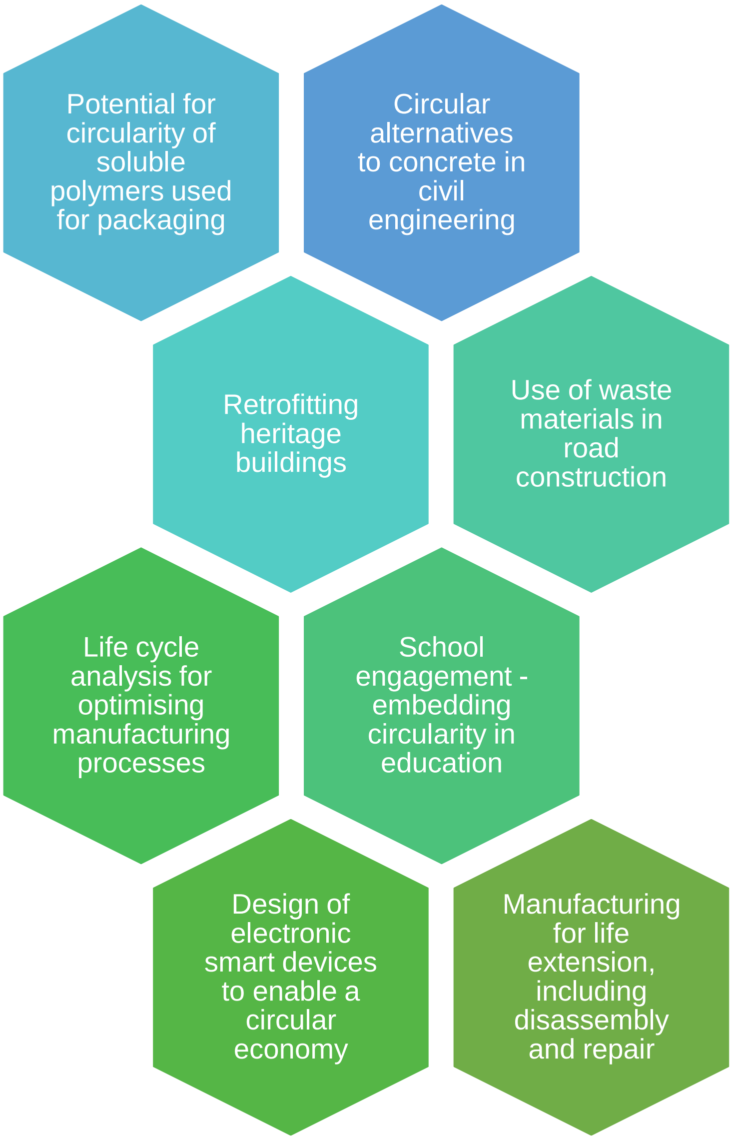

Figure 3: Delegates' answers to the question "What does circularity and the circular economy mean in your research?

The following points are some of the common challenges experienced by delegates working in circular economy:

- Difficulties with how to **define circularity** in projects – it's a complex concept and it can be difficult to embed life cycle principles in decision making.
- The **interdisciplinary** challenge of bringing experts together from a range of backgrounds and working with multiple departments who all use their own terminology.
- Working with **stakeholders and industry partners** who prioritise cost, performance and behaviour instead of sustainability aspects.
- Considering **unintended consequences** – for example, making a material more circular but also more carbon-intensive.

Fig. 4 highlights delegates’ key pieces of advice to those starting to consider circularity in their research.

"CE means different things to different people – set **clarity** on shared understanding at the beginning."	**"Early thinking** on adoption and end user acceptance is critical to implement early in project design and concepts."	"Recognise **stakeholders** who need to be incorporated and the interactions needed for circularity."
"Research is like a jigsaw puzzle – develop fundamental technologies which are **puzzle pieces of the whole picture** but can be used to develop further sustainable technologies."	"Think of the resources needed for manufacturing different products and the **impacts of changing the design."**	"The **social aspects** of CE are just as critical as the environmental, economic, and sustainable aspects."
"When developing new materials, rather than focusing purely on properties make sure you also consider **end of life**."	"Start thinking about circularity **sooner rather than later**."	"When engaging with different stakeholders it is important to realise and appreciate **differences in terminology** as CE is an emotive topic."
"Think of the **full lifecycle** of the product."	"Material transfer is always a big problem. Keep an **inventory of materials** into and out of the project."	"Do dive in, but make sure you are **connecting with the wider community** at the same time. There is a decade of work done here that will be helpful."
"Consider the **economics of the replacement** before you start."	"Look to **regional solutions** for short loop recycling and retain value in products."	"Have a **wide interdisciplinary team** with different perspectives."
"**Don't assume that everyone 'gets it'**; it is worth checking that everyone understands what CE is and what outcome you are trying to achieve."	"One size doesn't fit all; there are **multiple approaches to CE** that apply to different lifecycle stages and product types."	"Teams require a mix of experts with specific knowledge and those that are good at systems thinking to see the whole picture - **zoom in and out**."

Figure 4: Delegates’ advice to those starting to consider circularity in their own research

4.4 Embedding circular economy principles across the EPSRC research portfolio

Aim: to facilitate discussion around increasing the amount of high-quality, high-impact circular economy (CE) research we fund and encouraging broader consideration of circularity across the rest of the portfolio.

Delegates discussed ways of embedding circular economy principles across the EPSRC portfolio through two lenses: supporting research into transitioning to a future circular economy; and embedding considerations of circularity in research outcomes across the wider portfolio. (For further clarification on the scope of the discussion, please see annex 3.) Delegates felt the following stakeholders should be involved in wider discussions around these topics:

- Expert groups and learned societies, including economists, social sciences & behavioural researchers, environmental scientists, designers, non-CE researchers.
- Policymakers and government, including DEFRA, BEIS, and regulatory bodies.
- Industry and end-users; catapults and SMEs.
- Other funders, including all UKRI councils, and international funding bodies.

4.4.1 Supporting high quality, novel circular economy research

Delegates discussed the ways EPSRC can encourage and support high quality, novel circular economy research and maximise its impact. This focussed on research which is specifically targeted towards transitioning to a future circular economy, considering how this can be better supported through EPSRC's existing funding mechanisms (responsive mode, fellowships, etc).

What does an effective circular economy research project look like?

Delegates suggested that a successful CE research project consists of **interdisciplinary, holistic, and integrated research** based on systems understanding of the problem, and **considers all aspects** of the research question. It includes a whole life-cycle consideration of both the problem and the solutions explored. It looks beyond a specific material stream or product, to wider impacts across disciplines and sectors. It also considers individual consumer and citizen aspects, to a level of detail beyond just researching current preferences; it considers barriers to implementation throughout its duration. A 'good' CE project has a strong motivation, a novel problem to tackle, a well-designed research framework, and appropriate industrial applications.

Additionally, an effective CE research project puts **outcomes and impacts** at the heart of the research. It sets realistic end goals, with clear impacts and ambitions in mind from the start. It has a long-term vision, with an emphasis on value; it considers environmental and social impacts, as well as sustainable development goals, at all stages. A 'good' CE research project measures sustainability metrics in a way that makes sense and is appropriate to the research being undertaken. It involves all relevant **stakeholders**, including end users, policy makers, and industry. It considers their perspectives and concerns and ensures it can provide tangible and adoptable solutions for stakeholders.

How can EPSRC support and encourage these features?

Delegates suggested that EPSRC could emphasise the importance of circular economy by making it a **strategic priority**, therefore offering a clear vision of what is needed in this area. CE is an interdisciplinary area by nature and so requires EPSRC to **work closely with other UKRI councils**. EPSRC could also continue to engage with the community by running

further workshops and similar activities focussed on embedding circular economy thinking in more specific research areas. CE research projects require **wider access to stakeholders** and this is something EPSRC could look into facilitating, as well as providing more accessible information on current CE research projects to help researchers connect with those already working in this space.

Delegates felt that for CE projects, which are often interdisciplinary by nature, **reviewer selection** is of the utmost importance. They suggested there needs to be a balance between reviewers with expertise in the specific research area being studied, and reviewers with wider expertise in circular economy. Reviewers could be carefully briefed on sustainability and circularity to ensure they assess proposals appropriately.

Delegates suggested that EPSRC could **highlight the importance of interdisciplinary projects** and offer targeted support to the community in preparing such proposals. EPSRC could also explore the potential for **long-term investments in circular economy research**, to complement existing investments like the NICER programme. There could also be potential for EPSRC to play a role in **bringing together researchers** working in circular economy in order to catalyse new collaborations.

4.4.2 Embedding considerations of circularity and resource efficiency in research outcomes

Delegates discussed ways of embedding circular economy thinking in research outcomes across EPSRC's portfolio. This session was not focussed on doing research in a circular way (e.g. equipment repair, minimising lab waste etc) but instead on making sure **research outcomes are sustainable** in terms of circularity and resource efficiency, e.g. designing for end of life, minimising the use of virgin materials as consumables, considering where the research will end up and whether that will contribute to a future circular economy. (Please see annex 3 for further clarification on the scope of this discussion.)

What does embedding circularity in research outcomes look like in practise?

Delegates suggested embedding circularity involves ensuring projects have a clear demonstration of **how outcomes create or move towards circularity**; durability and end of life is considered for all new technology being developed. Examples include: a reduction in virgin material extraction; maximisation of resource utilisation in the design of new technology; waste minimisation; avoidance of structures or bonding methods which are difficult to separate. Embedding circularity in research outcomes involves finding **new 'sustainable' solutions** that are 'easier' than traditional solutions, with the aim of making it desirable to adopt new solutions. The aim is for researchers to **think about end of life from the start**, considering the impact of new materials and technologies in the discovery stage as opposed to later in the development stage. However, it is important to recognise that there are diverse views on circularity and sustainability, and these will differ depending on the research field or sector.

A key factor in embedding circularity is **evaluation** throughout the project – i.e. measuring the impacts (environmental and otherwise) of the research being carried out at all stages. Embedding circularity involves **collaboration** with multiple stakeholders, from scientists and engineers to industry and policymakers. **Business models** should be considered, along with considerations of design principles for different industry sectors.

How can EPSRC support and encourage these approaches?

Delegates felt that EPSRC could play a role in encouraging researchers to adopt a **whole systems approach**, promoting the expectation that CE sits across all sectors of research.

The potential for including CE requirements for funding could be explored – for example, requiring all projects which create new products or materials to credibly address what happens to them after the use phase; or requiring the use of demonstrators for expected outcomes. Delegates also suggested EPSRC could have a role to play in providing **examples of best practice** in embedding circularity – for example, by creating a **CE forum** to bring together representatives from groups working in aligned areas and link research projects together to enable transfer of ideas.

Delegates asked if there was a possibility for EPSRC to explore incorporating sustainability in **assessment criteria**. Potential options suggested by delegates were: adding CE or sustainability metrics into criteria; asking for LCA or techno-economic evaluation to be included in proposals; requesting an optional paragraph explaining any circularity/sustainability aspects of the proposal; developing guidance for assessing 'national importance' criterion to include CE aspects. Even if CE aspects are not formally assessed, delegates felt that requiring them to be **addressed in the proposal** would still put CE at the forefront of the research community's minds.

4.5 Action planning

To finish the day delegates were asked "What will you do differently as a result of this workshop?" Fig. 5 overleaf lists delegates' answers.

Figure 5: Delegates' answers to the question "What will you do differently as a result of this workshop?"

5. Next steps

It is clear that there is enthusiasm in the research community regarding the concept of a future circular economy; this will be invaluable in driving the UK towards a more sustainable and resource-efficient future. The wide range of research challenges identified in section 4.2 indicates that research for a circular economy stretches across the vast majority of areas that EPSRC supports, with significant links to the rest of UKRI's remit. The Manufacturing and the Circular Economy team will consider how these challenges could best be supported by EPSRC. We will work with the other EPSRC themes (and other parts of UKRI where appropriate) to explore specific areas in more detail. For example, we have an ambition to run a workshop focussing on ICT and the circular economy in 2023.

The workshop discussions highlighted the vast range of experience and backgrounds of delegates, suggesting that this is an area of work which transcends career stages and disciplinary boundaries. The conversations about what circularity means in delegates' own research were highly engaging and proved useful both for EPSRC to understand more about what the community is already doing in this area, and for other delegates who are just beginning to include considerations of circularity and the circular economy in their research. The Manufacturing and the Circular Economy team will consider our role in sharing best practice for circular economy research with the wider community. We will also use the outputs identified in section 4.4 (embedding circular economy principles across the EPSRC research portfolio) to feed into theme strategy and influence wider EPSRC policy where appropriate.

Annexes

Annex 1 – delegates list

24th March	
Name	Organisation
Mark Jolly	Cranfield University
Frans Muller	University of Leeds
Shangtong Yang	University of Strathclyde
Charith Perera	Cardiff University
Nick Voulvoulis	Imperial College London
Karishma Jain	University of Cambridge
Julia Stegemann	University College London
Joseph Butterfield	Queen’s University Belfast
Santosh Kumar	Diamond Light Source
Kai Xu	Middlesex University
Mahmoud Shaffie	University of Kent
Tanvir Hussain	University of Nottingham
Andy Moores	CIRIA
Zhenyu Zhang	University of Birmingham
Stephanie Ordonez Sanchez	University of Strathclyde
Paul Timms	Loughborough University
David Bucknall	Heriot-Watt University
Ling Min Tan	University of Sheffield
Amir Badiee	University of Lincoln
Ningtao Mao	University of Leeds
Aoife Foley	Queen’s University Belfast
Luciano Batista	Aston University
Riccardo Maddalena	Cardiff University
Andrew Abbott	University of Leicester
Pete Holliman	Swansea University
Danielle Densley Tingsley	University of Sheffield
Mohamed Afy-Shararah	Cranfield University
Deborah Adkins	University of the West of England
Felician Campean	University of Bradford
29th March	
Name	Organisation
Anju Massey-Brooker	Royal Society of Chemistry
Claire Potter	University of Sussex
Jose Luis Casamayo	University of Sheffield
Marco Aurisicchio	Imperial College London
Michael Shaver	University of Manchester
Michael Stead	Lancaster University
Bao Nguyen	University of Leeds
Megan Woodworth	Big Atom
Sandy Rodger	Cranfield University
Chun-Yang Yin	Newcastle University
Eral Bele	University College London
Koon-Yang Lee	Imperial College London
Magdalena Titirici	Imperial College London
Orla Williams	University of Nottingham
Pedro Rivera-Diaz-del-Castillo	Lancaster University
Ross Minty	University of Strathclyde
Alejandro Gallego Schmid	University of Manchester

Alice Moncaster	Open University
Mercedes Maroto-Valer	Heriot-Watt University
Yanlu Zhao	Durham University
Antonios Kanellopous	University of Hertfordshire
Chrysoula Litina	National Highways
Helen Mitrani	Newcastle University
Rebecca Lunn	University of Strathclyde
Alexei Winter	University of Sheffield
Claire Davis	University of Warwick
Gill Thornton	Liberty Powder Metals
Jagroop Pandhal	University of Sheffield
Konstantinos Salonitis	Cranfield University
Manuela Pacella	Loughborough University

Table 6: delegates' list

Annex 2 – Miro boards for section 4.2

Initial research challenges identified by applicants (collated post-workshop by EPSRC staff according to research area):


sorting and segregation systems
separation of multi-materials
robust materials for reuse economy
Minimise material use and increase efficiency
What do with unusable materials post-life, concrete
changing material use; removing non-recyclable materials (e.g. civil sector - removing concrete, also plastics)
New methods to encourage stakeholders in the early stages of value chains to reduce material consumption
Advanced Materials
Waste materials passports
identifying ways to produce critical raw materials from wastes for security of supply
assessment of residual life of materials or products
Multi use materials - designed for recyclability, reuse, monitoring.
Combine items to right
identifying waste streams
Using waste resources and conversion to advanced materials and chemicals
Adapt current materials to make them more circular
Example is fibreglass - how create substitutes that do same function, what do with current waste streams. What are sideffects of using new material.
Also: e.g. rubber tyres as aggregate and microplastics
Biobased feedstock for materials -> a simple way to circumvent recycling issues?
Recycling composite plastic materials
Innovative repurposing of materials and components
Develop new materials which are more circular
Waste streams as a source of raw materials
Developing materials that self-sense the most appropriate next lifecycle
Materials recovery (particularly from existing waste) - physical, biological, and chemical approaches
Material tracking across multiple lifecycles
Development of 'bio-based' or 'circular' materials that have the same functionality as man-made materials
Purity of raw material and waste
We don't always have information on the materials contained within existing assets to understand what and how materials can be reused
Self-healing, self-repairing materials

Manufacturing

- Making materials that can be used in current manufacturing processes
- Decision making frameworks for selecting the appropriate point for Remanufacturing / repair / etc
- Zero waste facilities (manufacturing, production, recycling)
- Technologies for local manufacturing
- Huge background in manufacturing technology
- alternative ways of making products to allow reuse/recycling
- narrowed additive sets to enable safer recycling
- Products without waste materials
- Regulations and standards not up to speed with novel manufacturing processes or materials
- Rebranding recycling as a key manufacturing stage

Energy

- Data as circular resource (energy use/C02 emissions)
- Recycling of Li batteries
- Energy use to drive CE
- Is there a CE take on EV charging - eg interchangeable cassette batteries?
- Replacing fossil fuels with renewable (sustainable) raw material sources
- Which CE strategies deliver carbon reductions, and when in their lifespan do they do so
- Symbiotic relationships to ensure net zero and no waste

Healthcare Technologies

- How can pharma provide effective drugs which do not carry over and persist in the environment

Physical Sciences

How can pharma provide effective drugs which do not carry over and persist in the environment

Changed appoach to contaminants. Eliminate at source rather than use them and then need to "dispose" of them

Recycling/ recovering catalysts

Functional polymers in formulated products: e.g. detergents, shampoos, beauty care, adhesives, inks, paints all have these polymers: yet there isnt an integrated infrastcutre from cradle to grave to drive circularity in this space

Chemical Particularly those in formulated products that have not made the agenda for funding

Electrocatalysis as a powerful tool for sustainable chemicals and fuels

Efficient and safe solvent recycling in pharma/high value chemical manfaucture

Using recycled materials without compromising quality and durabilitiy (i.e. rCB, catalysts, solvents)

Physics-centred research (less AI)

Reversible materials chemistry

Engineering

Durability and resilience of innovative materials, developed under CE frameworks

Performance of re-used, recycled materials, especially in safety-critical applications

Separation of different materials from a single product

Progressing the recyclability/repairability of composite materials

Recycling technologies and infrastructure

Durability vs recyclability

technologies for disassembly (for asset / infrastructure)

Creating engineering designs that are durable but also flexible enough to be repaired & recycled

New materials and technologies are needed to decarbonise cement/concrete sectors

To analyse how engineeringcan contribute to a circular and regenerative bioeconomy

Reuse of materials: data collection/sharing for enabling reuse in appropriate applications

Developing clean cycles, so that accumulation of pollutants doesn't create risks to humans or the environments. We can decontaminate our materials by recovering hazardous components, but there is an energy cost...

Component tracking and evaluation of 'fit for purpose' for reuse

Technologies to track and trace materials in value chains from extraction to consumption and back

Sorting technology for materials at recycling centres

Retrofit to extend life but using low carbon and recycled materials

Durability/long term performance of "greener alternatives"

Alternatives to shredding

De-bondable glues

Automated disassembly

How do we incentivise business? LCA hasn't - too many arguments against BAU

To analyse the potential trade-offs and rebound effects associated to the implementation of circular economy strategies

Thinking beyond CE in specific product lines and integrating different industrial sectors (waste to resource)

How to drive industrial symbiosis

Industry-focussed

Make circular processes/technology cost effective for industry

Focus on emerging industries

Another challenges would be how to balance the sustainability and profitability for a company

Approach to certification that is more inclusive of circularity

supply networks

Thinking beyond CE in specific product lines and integrating different industrial sectors (waste to resource)

Material and/or product passports to enable traceability and reuse at scale

Facilitate link to other fields (e.g. social sciences)

interdisciplinary collaboration across different sectors of the economy

Interdisciplinary thinking

Interdisciplinary project proposals across the whole value chain will need necessary to address these challenges at a systems level.

Manufacturing, construction, developers, architects, but also social sciences and economists

The challenges are at the interfaces of disciplines, and how to really integrate whole systems approach thinking.

How do we release the real strengths of bio-processing to interface with techno-based approaches - different timescales

Interdisciplinary calls which allow to explore problems holistically, using a truly systems approach

Holistic approach across whole life cycle

Design

Design for disassembly and design for reuse

Product Design for recyclability

Efficiency of design

Building multifunctionality without detrimentally affecting recyclability

design for recycle - material, components and system

alternative design approaches to allow reuse

Designing robust modular structures

Modular design of new technologies

How do you make something last for 50 years but which can be recycled?

Integrated design tools for selection of the optimal material for a circular economy

Design of devices made with advance materials with a view to unmaking without having to use energetically intensive processes

Designing for decommissioning

ensure research projects include circular economy thinking and analysis

Incorporate systems thinking into CE research

Embedding circular economy thinking

Incorporating policy into EPS research to help guide the CE direction?

Measuring the level of circularity and sustainability

LCA needs to be adapted to CE

Explore CE business models

Supply chain readiness and disruptive business models

Supply chain readiness and disruptive business models

Technologies and consumption models supporting the development of new business models

Development of new business models

Development of the right metrics for assessing CE readiness

Development of the right metrics for assessing CE readiness

Economics research more actively encouraged as part of interdisciplinary research

Policy / frameworks

Approach to certification that is more inclusive of circularity

Bridging top down (tech/manufacturers/policy) with bottom up (users/citizens/activists)

frameworks to enforce product recovery like bottle deposit scheme

Annex 3 – scope of discussion for section 4.4.2

In the final facilitated session of the workshop, delegates discussed ways of embedding circular economy thinking in research outcomes across EPSRC's portfolio. This session was not focussed on doing research in a circular way but instead on making sure **research outcomes are sustainable** in terms of circularity and resource efficiency.

For example, delegates were encouraged to discuss topics like:

- Designing with end-of-life in mind from the very beginning
    - Considering the potential for repair, reuse/redistribution, remanufacturing, recycling
    - Can waste products be used as feedstocks for other work?
- Avoiding the use of virgin materials in designing new technologies/products – e.g. using recycled or recovered materials instead
- Considering how their research will be used by consumers – can it be used in a circular way?
- Factoring in a whole systems approach – how can resource flows be tracked? How does the research link up with economics, behaviour change, etc to enable a circular economy?
- Incorporating life-cycle assessment (LCA) of feedstocks and materials throughout the project
- If they were to make something more circular, would that affect who uses the research? Would it make affect considerations of impact?

Delegates were encouraged to think about where their research will end up, and whether that will contribute to a future circular economy (even if it's not directly addressing the engineering and physical sciences challenges identified in the morning). The aim was to embed considerations of circularity and resource efficiency in **WHAT** the research is, not **HOW** they are doing it. For example, EPSRC considered the following topics **out of scope** for this discussion:

- Capital equipment sharing and end-of life (e.g. reuse, resale, decommissioning)
- Minimising and recycling of lab waste and consumables
  - E.g. eliminating the use of single-use plastics
- Business travel considerations
  - Minimising international travel (i.e. conferences)
  - Working from home and the carbon emission implications of this
  - Online meetings in favour of in-person meetings
- Carbon emissions while carrying out research
  - Carbon footprint calculators (e.g. EPSRC imposing carbon restrictions in the JoR)
  - Green electricity and eliminating the use of fossil fuels
  - Green buildings and campus emissions

While the examples above are important issues to discuss, these (and other factors) are being considered as part of a wider piece of work by the EPSRC environmental sustainability team and were therefore out of scope for this workshop.