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Australian Academy of Science and ARC Centre of Excellence in Synthetic Biology joint submission to the *Opportunities in the Circular Economy* inquiry

The Australian Academy of Science and ARC Centre of Excellence in Synthetic Biology welcome the opportunity to contribute to this inquiry examining opportunities in the circular economy. By focusing on comprehensive strategies to prioritise waste minimisation, advanced recycling, and remanufacturing[i] technologies, there are opportunities to support Australia's journey to net-zero emissions and create resilient, sustainable industries.

This submission focuses on the circular economy opportunities that come from science—and synthetic biology in particular. Synthetic biology is the application of engineering principles to biology. It involves rationally designing and constructing biological systems and devices and re-designing existing natural biological systems, usually based on DNA-encoded instructions, and applying them to address key problems.

To scale up the adoption of circular economy principles, this submission identifies the following opportunities:

- Establishing **a national framework for resource-efficient waste circularity** to provide a consistent definition of 'waste' across jurisdictions and strengthen regulatory frameworks to incentivise the use of waste as a resource.
- **Deepen collaboration between government, academia, and industry** to define research missions and drive circular and bioeconomy[ii] growth. Aligning with global best practices and leveraging funding programs, tax incentives, and research and development (R&D) support will strengthen industry-research partnerships in green manufacturing, de-risk opportunities, and attract private investment.
- Investment in **advanced recycling infrastructure and localised waste management systems** to process hard-to-recycle materials, such as electronic waste and batteries, support real-time tracking platforms to enhance waste recovery and create skilled local jobs.

Waste can be used as a feedstock for synthetic biology. Science can transform waste into a valuable resource that drives innovation and economic growth. By treating waste as a valuable resource and addressing infrastructure gaps, Australia can progress towards more sustainable industry practices and advance circular economy initiatives.

A national framework for resource-efficient waste circularity

A national framework is needed to address and resolve legislative inconsistencies and drive meaningful progress towards net zero emissions.

Treating waste as a standalone element limits its potential. To fully realise its value, waste should be considered across the sectors of the government's Industry Net Zero Plan and be embedded within key sectors, such as alumina and aluminium, chemicals and plastics, and iron and steel industries.

In addition, inconsistent definitions of 'waste' across Australian states and territories hinder cohesive efforts toward building a circular and bioeconomy, delaying progress and regulatory approvals.

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[i] 'Remanufacturing' is the process of restoring used or worn-out products to like-new or better-than-new condition through disassembly, repair, replacement of components, and reassembly.

[ii] The bioeconomy is an economy built on the sustainable use of biological resources, such as plants, animals, microorganisms, and organic waste, to produce food, materials, chemicals, and energy. It harnesses biotechnology and advanced technologies to develop innovative products and services from renewable sources.

A national framework for resource-efficient waste circularity would:

- Provide clear strategies and measurable goals for circular economy and bioeconomy initiatives.
- Standardise definitions of 'waste' and streamline regulatory approvals.
- Establish waste as a core element of industrial processes rather than a by-product, promoting sustainable industrial practices.

The framework should seek to align with other plans, such as the European Union's Circular Economy Action Plan.

Australia should recognise waste as a core resource for a sustainable circular economy

Science plays a critical role in developing advanced recycling and remanufacturing technologies. Scientific research and innovation, such as chemistry, synthetic biology, materials science, and condensed matter physics, are unlocking the potential of waste streams that are currently difficult to recycle, such as electronic waste (e-waste), batteries, photovoltaic (PV) modules, and tyres. These technologies reduce dependence on natural resource extraction by enabling the recovery of critical minerals from end-of-life products. [1] Without these solutions, valuable resources will continue to be discarded or incinerated, limiting Australia's progress toward sustainability and weakening its industrial and sovereign resilience.

Prioritising waste as a feedstock strengthens the link between recycling and manufacturing, helping Australia transition to a closed-loop economy while minimising environmental impacts. Australia should:

- Recover and reuse high-value resources through advanced recycling processes.
- Recognise and quantify the value of materials currently seen as low or no-value waste.
- Identify new opportunities at the intersection of recycling and manufacturing.
- Invest in a science-driven approach to drive technological innovation, maximise resource use and promote sustainability.
- Implement performance frameworks for monitoring and measuring progress and environmental impact. These frameworks should measure success based on the effective recovery and reuse of waste and design for circularity.

Deepen collaboration between government, academia and industry to drive circular and bioeconomy growth

Developing missions for sustainable resource management and reuse research, co-designed with government, academia and industry, could be a vehicle for collaboration on defined challenges. Faster pathways to market for university-led R&D can accelerate Australia's transition to a resource-efficient economy. However, financial constraints and complex regulatory frameworks continue to hinder the translation of innovations from the laboratory to large-scale industrial applications. Precision fermentation and bio-manufacturing, which offer transformative potential, require efficient commercialisation pathways to ensure they are scaled effectively.

Without streamlined and bespoke support, Australia risks losing high-impact scientific innovations and skilled resources and organisations to international markets, weakening its global competitiveness in the zero-waste and sustainable materials management sectors.

Utilising new and existing funding mechanisms can strengthen industry-research collaboration and streamline pathways from laboratory research to industrial application. Programs like the Australian Research Council Centres of Excellence and Australia's Economic Accelerator support knowledge generation and accelerate knowledge translation and commercialisation into new technologies and capabilities.

Responding to Australia's environmental and waste management challenges requires adopting sustainable, environmentally responsible practices to reduce reliance on raw material extraction and address the waste and emissions associated with these processes.[2] R&D opportunities for Australia include:

- Reducing waste at the extraction stage by improving resource efficiency through advanced, science-based mineral processing technologies that recover valuable metals and prevent them from entering waste streams.
- Investing in technologies that minimise emissions from extraction processes by applying high-purity refining techniques and innovative technological methods.
- Maximising the remanufacturing potential of extracted materials by employing high-tech recycling methods that conserve resources and extend material lifecycles.

Advancing circularity through sustainable consumption, product design and stewardship

The circular economy goes beyond waste management, offering a pathway to tackle excessive resource consumption. Products must be designed with circularity in mind—using high-level circular economy strategies like rethink and reduce to avoid putting materials into circulation unnecessarily, extend material lifecycles and lessen waste management challenges.

Poor design restricts recycling and reuse opportunities, contributing to landfill growth and environmental degradation. Many products, such as lithium-ion batteries and soft plastics, are not designed for efficient recycling, leading to significant waste at the end of their lifecycle.

Prioritising sustainable consumption and design choices can reduce resource dependency and environmental impacts. Shifting toward circular product design would align Australia's industrial practices with long-term sustainability goals and position recycling as a supportive, rather than standalone, strategy. This shift can be achieved by:

- Strengthening national product stewardship through Extended Producer Responsibility (EPR) schemes to ensure producers take responsibility for the entire lifecycle of their products.
- Incentivising producers to design products that are easy to recycle or repurpose by integrating bioproducts and materials developed through advanced synthetic biology.
- Establishing collection points and schemes, such as the Construction Plastics Recycling Scheme.

Integrating life cycle assessments in innovation

Adopting systems thinking and system dynamics approaches to integrate life cycle assessments (LCAs)—which evaluate the environmental impacts of green materials—in technology development must be prioritised to ensure that R&D efforts contribute effectively to a green economy, with a focus on reuse and recycling and support sustainable decision-making.

Embedding LCAs into the design of new materials and processes will enable the industry to align innovations with resource-efficient economic principles while minimising the long-term environmental impacts of their operations. This transparency is essential to align research with national sustainability goals and establish a robust framework to assess the genuine environmental benefits of emerging 'green' technologies.

Investment in advanced recycling infrastructure and localised waste management systems

Insufficient recycling infrastructure and inadequate technologies limit Australia's ability to recycle and recover valuable materials, leading to low recycling rates and increased reliance on waste exports.

Current recycling systems struggle to efficiently separate and recover metals, plastics, polymers, and other valuable materials, driving reliance on new material production, which is often cheaper than recycling. The lack of well-developed markets for recycled products further compounds the issue, creating an economic and environmental gap.

A real-time waste-tracking platform would provide valuable data on the types and quantities of waste generated across industries. This data would support policy development, enable researchers and research organisations to develop targeted remanufacturing solutions, and build transparency for stakeholders.

Building circularity through local infrastructure

Waste management options vary by location, with distance and population size influencing access to waste and resource recovery facilities, and resource recovery rates. Increasing local waste management infrastructure reduces transport costs and generates local employment. Regional circular waste management supports a decentralised approach, minimising environmental impacts and transport costs while promoting sustainable social and economic development.

To discuss or clarify any aspect of this submission, please contact Mr Chris Anderson, Director Science Policy at Chris.Anderson@science.org.au.

References

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2. CSIRO. Sustainable Materials Management. (2020). https://research.csiro.au/circulareconomy/sustainable-materials-management/