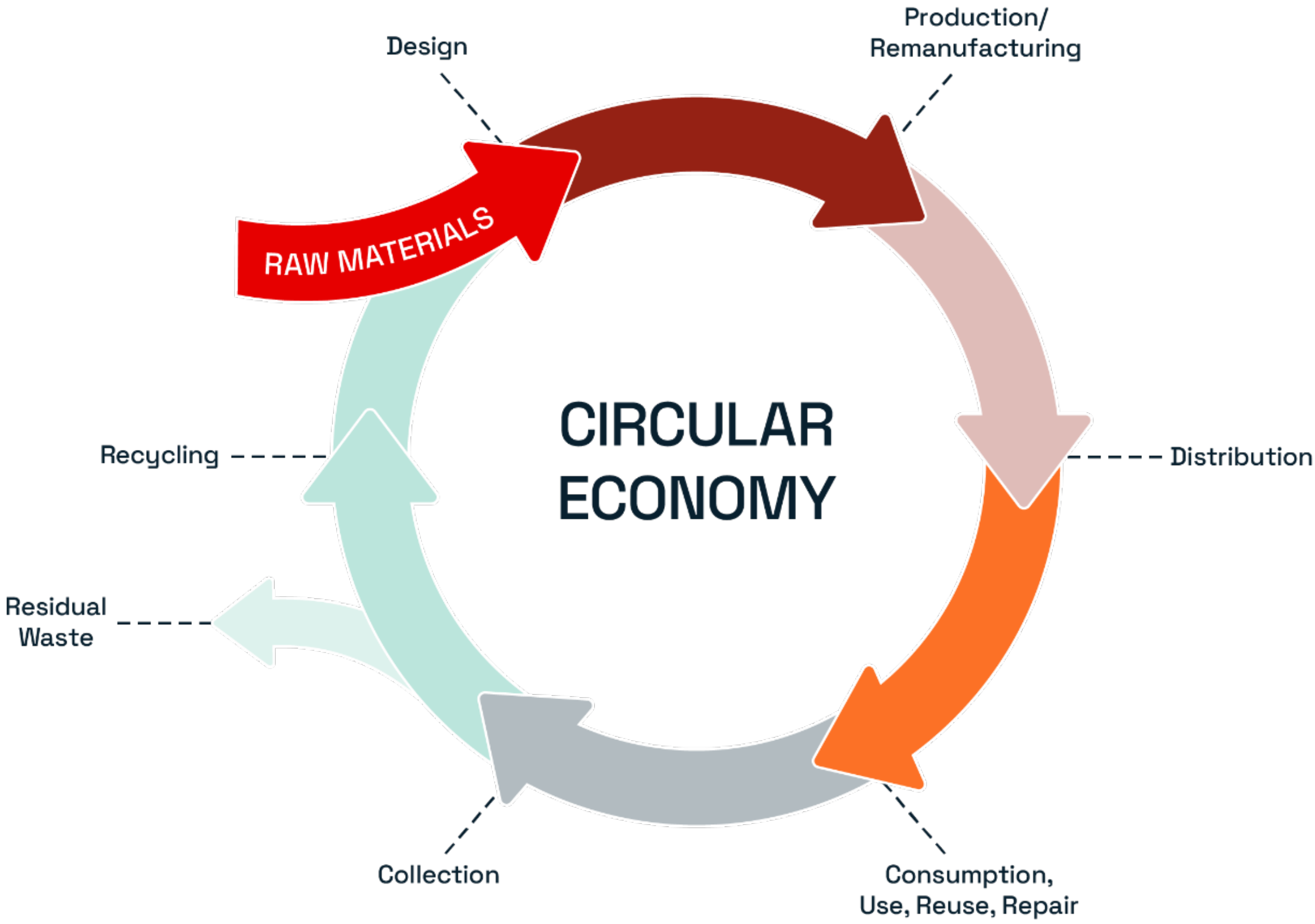
Explainer: Circular Economy

What is a circular economy?

A circular economy is an innovative process model that prioritises sustainable and efficient use of resources, making it highly relevant to the engineering profession. Unlike the traditional linear model of "take, make, dispose," the circular economy seeks to maintain the value of resources within the system for as long as possible (Figure 1).

Figure 1: Conceptual diagram illustrating principles of a circular economy



Historically, the definition of circular economy has been inconsistent, reflecting its adaptability to different economic, social and environmental needs, however, circular economy is universally guided by three key principles:

1. **Designing out waste and pollution:** Engineers play a crucial role in eliminating waste and pollution from materials and products. This involves rethinking product design to minimise waste generation and prevent environmental contamination from the outset.
2. **Preserving and enhancing material value:** The circular economy focuses on retaining the highest possible value of materials and products through recovery, repurposing, and innovative engineering solutions. This includes designing for disassembly, modularity, and incorporating recycled materials into new products.

3. **Conserving natural resources and regenerating nature:** A core principle of the circular economy is the conservation of natural resources. Engineers can contribute by developing processes that minimise the use of virgin raw materials and by designing products and systems that actively regenerate natural ecosystems.

Success Story #1: Sustainable Buildings Research Centre – University of Wollongong

The Sustainable Buildings Research Centre, located at the University of Wollongong Innovation Campus, has achieved Living Building Challenge 'Living Certified' status – a great example of circular economy success in the built environment. The Centre has delivered a range of circular initiatives including:

- A large proportion of reused building materials, including disused telegraph poles, railway tracks, pieces and bridges and components of a demolished house.
- A high proportion of environmentally certified materials.
- Use of non-toxic building materials.
- Dematerialisation in design.
- Close to 100 per cent diversion of construction waste from landfill.
- 100 per cent on-site renewable energy generation.

What are the challenges of moving towards a circular economy?

Transitioning to a circular economy in Australia is not without its challenges. Australians use the third most raw materials per person in the OECD and rank near the bottom for how efficiently we use these materials[1] and are only one of five G20 countries without a national circular economy framework[2]. Several barriers stand in the way of a circular economy transition.

- **Lack of National policy framework:** The existing policy environment is configured towards a linear economy that follows a model of resource extraction, production, use and waste. This traditional economic model is at odds with the reduce, reuse, refurbish, repair and recycle model required by a circular economy, making it difficult to implement circular practices on a large scale.
- **Regulatory and standardisation gaps**: Outdated waste definitions, inconsistent regulations across states and territories, and the absence of national standards for circular economy practices hinder progress.
- **Lack of capability:** Insufficient understanding of material origin or the skills and resources to conduct lifecycle analysis (LCA). This can also be exacerbated by a lack of partner networks for the procurement of circular materials.
- **Lack of data**: The absence of a central data hub for circularity hampers product certification, and creates a gap for the comparison between circular products.
- **Siloed procurement**: Fragmented procurement processes reduce economies of scale, purchasing power, and the effectiveness of circular practices.
- **Market barriers**: Stigma over secondary materials and consumer preferences limit the adoption of circular practices.
- **Innovation and research needs**: A shortfall in targeted research and innovation, particularly in areas like material substitutions, waste minimisation, and emissions abatement technologies, stalls advancements in circular economy practices.
- **Uncertain pathways from research to commercialisation**: Newly created circular products face challenges in scaling up to commercial viability.

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[1] OECD (2024), "Material resources: Material resources", *OECD Environment Statistics* (database), https://doi.org/10.1787/data-00695-en (accessed on 19 August 2024).
[2] DCCEEW (2024), "Circular Economy Ministerial Advisory Group: Final Report", available online (accessed 11 December 2024).

- **Technical and process limitations**: Designing products and processes that are both efficient and easily recyclable and reuseable presents many technical challenges.
- **Traditional business models:** Many industries are still focused on short-term profitability rather than long-term sustainability. Further, there is a lack of accountability for the environmental costs of a product across an asset's lifecycle, which is required to incentivise structural change.

Success Story #2: Collie Green Steel Mill in Western Australia

Western Australia is set to become home to the country's first green steel recycling mill in Collie, expected to begin operations in 2026. Green Steel Western Australia's $400 million facility will process 400,000 tonnes of scrap steel annually, converting it into long steel products such as rebar, with minimal environmental impact.

The electric arc furnace technology will be powered by renewable energy, cutting carbon dioxide emissions by an estimated 562,000 tonnes per year compared to traditional methods. It highlights how engineering innovation can support circular economy principles by reusing existing materials and reducing reliance on raw resources like iron ore.

The project is estimated to generate over 200 local jobs and 600 construction jobs, contributing to the economic transition of Collie, historically a coal and energy hub. It exemplifies how green manufacturing can foster regional economic resilience while promoting sustainable engineering practices.

By leveraging renewable energy and advanced recycling technology, the Collie mill demonstrates a path toward decarbonising the steel industry, setting an example for future heavy industry projects in Australia.

What are the solutions to achieving circularity?

Governments at all levels have a role to play in crafting a regulatory environment that facilitates circularity in every aspect of the Australian economy. An example of government action is the Circular Economy Ministerial Advisory Group (CEMAG), which was established to provide advice to the Australian Government on the transition to a more circular economy. CEMAG have proposed the following policy solutions to support a circular economy in Australia in their final report to the Minister.

- **Establish a National Circular Economy Framework to integrate into existing policy:** Australia's transition to a circular economy (including targets, indicators and a market vision) should integrate with other sustainability-related policy work (for example, the Net Zero Sector Plans and mandatory climate-related financial disclosures).
- **Standardise regulation:** Develop and deploy a Circular Economy Act to harmonise inter-jurisdictional regulations and standards.
- **Leverage government procurement to increase investment:** The government has substantial procurement power and can lead by example to encourage and de-risk private equity investment, for example, via the Environmentally Sustainable Procurement Policy and Reporting Framework.
- **Build capacity:** Identify skills gaps in circular economy, support a Commonwealth-backed broker for a transition to a circular economy and integrate circular economy into the Sustainable Finance Taxonomy and Green Bonds Framework.
- **Support applied science and research to commercialisation pathways:** Commission studies for the measurement, evaluation and reporting of circular economy and identify future economic opportunities.

Success Story #3: Samsara Eco – Climate Repair via Infinite Plastic Recycling

Samsara Eco is pioneering a method to break plastics down into their fundamental components, offering an innovative recycling solution that helps cut emissions by minimising plastic waste in landfills. In collaboration with the Australian National University, Samsara has developed a process that enables the endless recycling of plastic using enzymes, which break the material into its core components, allowing it to be remade repeatedly.

This method involves modified enzymes that swiftly degrade plastic into smaller molecules, ensuring that the recycled material retains the same structural quality as new plastics. The technology is particularly effective for recycling difficult plastic mixtures, such as coloured, multilayered, and composite plastics.
According to Samsara, one tonne of recycled plastic saves 5,774 kWh of electricity; 2,593 litres of oil; 98 million btu (British thermal units) of energy and 23 cubic metres of landfill.

How can engineers help support the transition?

Engineers are critical to the guiding three principles of the circular economy. Implementing these principles in engineering practice can be achieved with the following strategies:

- **Challenge business-as-usual procurement and project processes**: Engineers can advocate for and implement procurement practices prioritising sustainability, such as specifying low-impact materials, requiring lifecycle assessments, and integrating circular economy principles into project scopes. Engineers can drive systemic change and influence supply chains towards sustainable outcomes by questioning traditional approaches and championing innovative solutions.
- **Reducing raw material use:** Engineers can reduce the reliance on new raw materials by using innovative and recycled materials in design and manufacturing processes and designing for utility efficiency (e.g. energy and water).
- **Designing out waste and pollution, and for longevity and reusability:** Engineers are at the forefront of creating products that are durable, repairable, and free from toxic components or hazardous processes. This approach extends the lifecycle of products and materials, ensuring they remain in use for as long as possible.
- **Maximising recycling and refurbishment:** The engineering sector can lead in reusing, recycling, and refurbishing materials. This includes developing technologies and processes that make recycling more efficient and less resource-intensive.
- **Reducing environmental impact:** Engineers can significantly reduce the environmental impact of products and processes by designing systems that prevent greenhouse gas emissions, and other pollution and minimise material loss. Engineers Australia's *Carbon Measurement Fundamentals for Engineers*[3] is an essential tool for measuring, understanding and mitigating embedded carbon.
- **Upskilling and partnership:** Engineers have a vital role in building capacity for a circular economy by pursuing professional development in sustainable design, materials innovation, and life-cycle analysis. Partnering with organisations, and allied professionals, allows engineers to demonstrate and advocate for the benefits of circular practices, fostering innovation, knowledge-sharing, and systemic change.

The circular economy presents a strategic opportunity for engineers to contribute to a more sustainable and resilient future, where resources are efficiently managed, and environmental impact is minimised.

[3] Engineers Australia (2024), Carbon Measurement Fundamentals for Engineers, Version 1, accessed 18 October 2024.