Office of Energy and Climate Change,
NSW Treasury

Circular design guidelines for the built environment

Whole-of-life principles for transitioning buildings, precincts and infrastructure to a circular economy

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NSW GOVERNMENT

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Cover image Sydney Harbour aerial at dawn. © 2012 Ethan Rohloff Photography LLC; Destination NSW.

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Acknowledgement of Country

The NSW Treasury acknowledges that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history.

We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

We celebrate the deep and enduring connection of Aboriginal and Torres Strait Islander peoples to Country and acknowledge their continuing custodianship of the land, seas, and sky.

We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

We reflect on the continuing impact of government policies and practices and recognise our responsibility to work together with and for Aboriginal and Torres Strait Islander peoples, families, and communities, towards improved economic, social and cultural outcomes.

Minister’s message

We are at a turning point in NSW, and we are strongly turning towards a circular economy to help us innovate, grow and create jobs, while ultimately reducing our impact on the environment.

The circular economy presents a huge opportunity for emissions reduction and to make better use of our natural resources, and in NSW, we are leading the nation to embed circularity into the design of buildings, infrastructure and precincts.

In fact, using a circular economy approach in the built environment could deliver $773 billion in direct economic benefits over 20 years, and reduce emissions by 3.6 million tonnes of CO_2e per year by 2040.

> **Integrating circularity into the built environment will create new industries, enable new ventures within the repair, re-use and recycle economy, and provide protection from the rising cost of materials and disposal of waste.**

These are big steps forward, and this is why the NSW Government is designing out waste and pollution and designing in a plan to keep materials in their first life for longer, while smoothing the transition to their second life through reuse and recycling.

Our $356 million *Waste and Sustainable Materials Strategy* (the strategy) is focused on kick-starting the circular economy by reducing waste, supporting recycling, improving resource recovery and lowering emissions.

The strategy will help us make the transition to a circular economy over the next 20 years and includes a commitment to develop circular design guidelines for buildings and infrastructure.

As part of the strategy, these Circular design guidelines for the built environment explain the circular economy principles that will deliver the best outcomes.

I hope these guidelines will encourage industry and government agencies in NSW to adopt smart, innovative, and sustainable design practices to ensure the environment we’re handing to the next generation is better than the one we inherited.

The Hon. James Griffin MP
Minister for Environment and Heritage

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About these guidelines

These *Circular design guidelines for the built environment* (the guidelines) present a comprehensive, whole-of-system approach to implementing circular economy principles throughout all phases of NSW built environment projects.

The guidelines are for built environment professionals and stakeholders in government and industry, including policymakers, industry groups, planners, designers, developers, consultants and facility managers.

The guidelines complement and support the NSW commitment to reducing embodied carbon in construction under the NSW Net Zero Plan Stage 1: 2020-2030. They also set a standard for the new $37 million Carbon Recycling and Abatement Fund to support innovative circular economy approaches that manage waste and materials more efficiently and reduce emissions.

The circular design strategies presented in this guide can benefit all buildings, precincts and infrastructure.

The strategies apply throughout the life cycle of a building, precinct or infrastructure asset, including briefing and design, planning assessment and approval, procurement and delivery, ongoing operation and maintenance, and end-of-life re-use and repurposing.

They are relevant to projects of all types, sizes and locations, and can be tailored in response to the specifics of each project.

Guideline objectives

The guidelines aim to encourage and enable government agencies and industry to take a leading role in adopting smart, innovative, and sustainable approaches to:

- reduce embodied carbon
- minimise the generation of waste
- improve materials efficiency
- increase the circularity of materials.

Overview

The guidelines are divided in 3 parts:

Section 1: Transitioning to a circular economy defines a circular economy approach, explains why we need to adopt this approach, and sets out the policy context for these circular design guidelines.

Section 2: Circular design strategies for the built environment sets out strategies for applying a circular economy approach to built environment design. These strategies can apply to all built environment projects and assets – including buildings, precincts, and infrastructure.

Section 3: Implementing circular design in the built environment demonstrates how these circular design guidelines link to existing sustainability tools and initiatives for the built environment.

The guidance is supported by case studies demonstrating how circular design strategies have been implemented in a range of built environment applications.

1 Transitioning to a circular economy

Defining a circular economy approach

A circular economy approach means shifting away from a ‘take, make, use and dispose’ approach to one that better values resources. This means using materials efficiently and keeping products and materials in use for as long as possible.

We can do this by reducing our use of materials, designing out waste from the outset and using materials and products that are repairable, re-usable and recyclable. At the end of their life, assemblies or components should also be re-used and recycled at their highest value and utility.

A circular economy incorporates more than material flows – its principles can be applied holistically to other resource systems including water and energy. The focus across all resource streams is to eliminate the leakage of value from the system while transitioning from extraction of resources to regeneration of resources.

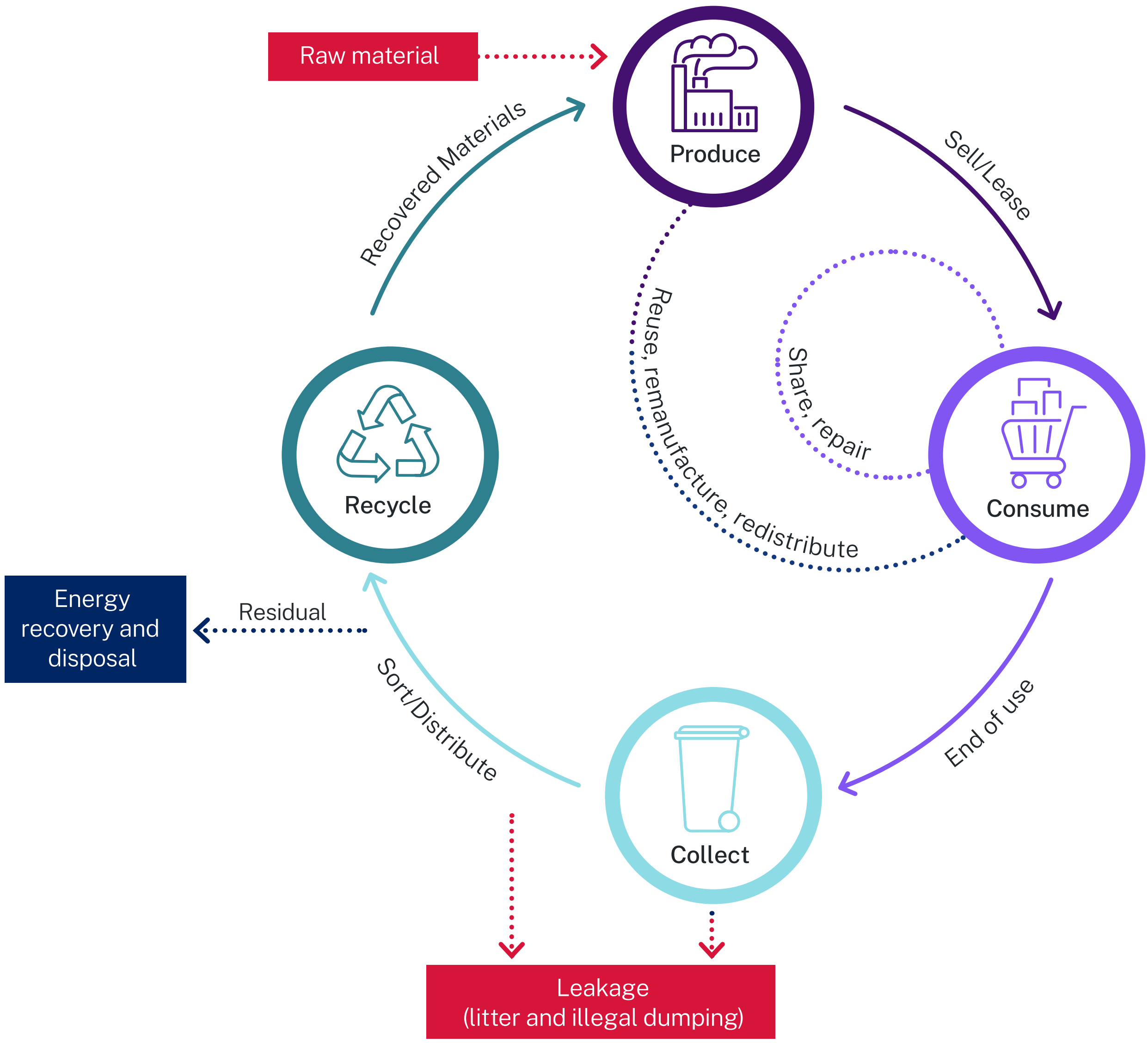


Figure 1 The circular economy (DPIE 2021)

Why we need to adopt this approach

Maximising the use and value of resources brings major economic, social and environmental benefits. It contributes to innovation, growth, job creation and prosperity, while reducing our impact on the environment.

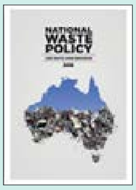
Analysis has shown that incorporating a circular economy approach into the built environment could reduce emissions by 3.6 million tonnes of CO_2e per year by 2040. It could deliver $773 billion in direct economic benefits over 20 years[1].

Integrating circularity into the built environment will create new industries. It will help facilitate the development of ventures within the repair, re-use and recycle economy, and provide protection from the rising cost of materials and disposal of waste.

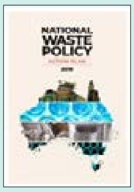
This new approach will also help projects meet sustainability reporting requirements and emissions obligations, boost their sustainability ratings, and ultimately contribute to making urban and regional areas more liveable, resilient and sustainable.

NSW policy context for these circular design guidelines

National Policy



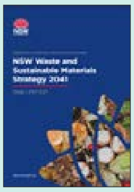
The **2018 Australian National Waste Policy** identified avoidance of waste, improved resource recovery, and increased use of recycled material and products as critical in Australia's shift toward a circular economy.



The **2019 National Waste Policy Action Plan** sets targets and actions for implementing the National National Waste Policy. National targets to ban the export of waste, to reach 80% average resource recovery rate from all waste streams by 2030, and to significantly increase governments' and industry's use of recycled content.

State Government Policy

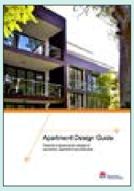
The **NSW Circular Economy Policy Statement** will help guide NSW Government decision making as we transition to a circular economy. It sets the ambition and approach for a circular economy in NSW, and provides principles to guide resource use and management.



The **NSW Waste and Sustainable Materials Strategy 2041** provides a long-term strategic focus for a transition to a circular economy over the next 20 years. Backed by $356 million in funding, the Strategy outlines the government's actions over the next six years to deliver on its long-term objectives of reducing carbon emissions through better waste and material management.

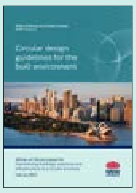
State Government Planning Framework

From 1 October 2023, NSW will mandate the reporting of embodied emissions as part of the **Sustainable Buildings State Environmental Planning Policy** (SB SEPP) and associated Environmental Planning & Assessment Act regulations amendments. This will increase our understanding of how materials are used in buildings and support development of future benchmarks and targets for a variety of buildings, from homes to child-care centres to hospitals.



The **Apartment Design Guide** supports design and place in the NSW planning system with regard to residential design for apartment development.

Circular design guidelines for the built environment



The **Circular design guidelines for the built environment** will promote waste reduction and materials circularity in the built environment. It is a readily implementable guide that will enable government agencies and industry to take a leading role in adopting smart, innovative, and sustainable approaches to reduce embodied carbon and improve materials efficiency.

Figure 2 Policy context for the guidelines

United Nations Sustainable Development Goals

In 2015, world leaders adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs). A circular economy supports progress towards SDGs 9 and 12:

- Goal 9 – Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
  - Develop quality, reliable, sustainable and resilient infrastructure and promote inclusive and sustainable industrialisation
  - By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes.
- Goal 12 – Ensure sustainable consumption and production patterns
  - By 2030, achieve the sustainable management and efficient use of natural resources
  - By 2030, substantially reduce waste generation through prevention, reduction, recycling and re-use.

The guidelines will help to realise these SDGs by providing a pathway for improving the sustainability of the State's infrastructure through efficient resource use.

National Waste Policy and Action Plan

Australia's *National Waste Policy: Less waste, more resources 2018*[2] identifies waste avoidance, improved resource recovery and increased use of recycled materials and products as critical in Australia's shift towards a circular economy.

The *National Waste Policy Action Plan 2019*[3] sets national targets and actions for implementing the National Waste Policy. These include targets to reduce the generation of waste per capita by 10% by 2030, reach an average resource recovery rate of 80% by 2030, and significantly increase government and industry use of recycled content.

The guidelines will help achieve these targets by outlining strategies which aim to reduce waste generation, improve recycling and increase recycled content in construction.

NSW Circular Economy Policy Statement

The *NSW Circular Economy Policy Statement – Too Good to Waste*[4] sets the ambition and approach for transitioning to a circular economy in NSW. It identifies 8 focus areas to guide government action to support the transition pathway, including:

- circular design
- sustainable procurement
- supporting re-use and repair.

These guidelines provide practical strategies for how to achieve the above focus areas within built environment design.

NSW Waste and Sustainable Materials Strategy

The *NSW Waste and Sustainable Materials Strategy 2041*[5] articulates 3 key principles for achieving a circular economy:

Design out waste and pollution

Keep products and materials in use

Regenerate natural systems

Figure 3 Principles for achieving a circular economy

The strategy provides a long-term focus for making the transition to a circular economy over the next 20 years. Backed by $356 million in funding, the strategy outlines the government's actions through until 2027 to reduce carbon emissions through better waste and material management.

The strategy includes a commitment to develop circular design guidelines for buildings and infrastructure.

NSW Net Zero Plan Stage 1

Circular design also supports the vision and targets set by the NSW Government in *Net Zero Plan Stage 1: 2020 – 2030*[6] to fast-track emissions reduction in NSW.

The NSW Government has recently announced targets to reduce emissions by 70% by 2035, compared to 2005 levels. This supports its goal to achieve net zero emissions by 2050, together with its 50% reduction target by 2030.

Materials used in the built environment are a significant source of carbon emissions. For instance, just the production of steel, aluminium and cement produce an estimated 7–9% of annual global greenhouse gas emissions[7]. The built environment is also a major contributor to NSW landfill waste[8].

For NSW to meet its carbon emission reduction targets, the built environment sector must decouple growth from its consumption and disposal of finite resources. The circular design strategies in this guide present opportunities to substantially reduce carbon emissions associated with new developments.

Sustainable Buildings State Environmental Planning Policy

Adopting circular design strategies can significantly reduce upfront embodied carbon in residential and non-residential buildings. From 1 October 2023, NSW will mandate the reporting of embodied emissions as part of the State Environmental Planning Policy (Sustainable Buildings) 2022 (SB SEPP) and associated Environmental Planning & Assessment Act regulations amendments. Embodied emissions reporting will apply to all development in NSW where the SB SEPP applies. Residential buildings will report through the BASIX Materials Index incorporated into the BASIX online tool. Non-residential buildings will be required to report embodied emissions with the Development Application and Construction Certificate. This mandatory reporting will increase our understanding of how materials are used in buildings and support development of future benchmarks and targets.

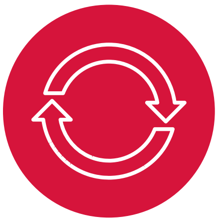
2
Circular design strategies for the built environment

The design strategies presented in this guide build upon the circular economy principles in the *NSW Waste and Sustainable Materials Strategy 2041*.

Circular economy principles

Design out waste and pollution

Minimising waste generation, maximising materials efficiency and reducing the harm that can be caused by waste can be achieved by taking a circular approach to design. Circular design strategies that can achieve these objectives include designing buildings and components for longevity, designing buildings to be adaptable for multiple uses, and using products and materials that have a low risk of incurring harm to the environment and human health.



Keep products and materials in use

Within a built environment context, keeping materials in use can be achieved by selecting products with re-used or recycled components, repurposing existing assets and materials on site, and using tools, such as a materials database, to promote end-of-life repurposing.

It is also important to consider how products and materials can be kept in use at their highest value and utility. This ensures the resources, energy and embodied carbon within the product or material are preserved.

Regenerate natural systems

A circular economy approach means we move away from an economic system which involves the extraction of natural resources, to a model where nature is regenerated. Reducing the need to extract virgin materials, through circular design strategies, means that more natural areas can be preserved.

Buildings, infrastructure and precincts can also be designed to preserve and regenerate local natural ecosystems, including by incorporating green infrastructure into design.

As with all design decisions, there may need to be trade-offs. For example, waste minimisation needs to be balanced against safety, structural strength and longevity as well as whole-of-life embodied energy and carbon emissions. As life cycle assessment and supply chain management is advanced, implications and multi-criteria analysis of design decisions can be better assessed.

Circular design strategies

The following design strategies for the built environment provide practical ways to implement the circular economy in buildings, infrastructure, and precincts:

1. Design for longevity
2. Design for flexibility and adaptability
3. Design to maximise materials circularity and enable disassembly
4. Design for materials efficiency
5. Design for best practice operational waste management
6. Re-use existing assets or materials
7. Select products with recycled content
8. Select products that are designed for disassembly
9. Select products and materials that have an identified end-of-life use
10. Select low-impact materials
11. Incorporate green infrastructure
12. Maintain a materials database
13. Procure products as a service

In the following pages, each design strategy is discussed in further detail to guide the implementation of circular economy principles into projects.

The circular design plans in the Appendix can help you plan and document how circular design strategies will be implemented throughout a project.

1.
Design for longevity

Design to maximise the potential life span in which an asset, or components of an asset, performs a required function under intended conditions of use and maintenance.

Aims

- Extend the useful life of buildings, precincts and infrastructure.
- Preserve the value of materials and their embodied carbon.

Outcomes

- Life span is prolonged.
- Major refurbishment and repair programs are rarely needed.
- Use of new materials is reduced.

Actions

- Use durable, long-lasting materials, rather than materials that require recurrent replacement or refurbishment.
- Design for easy maintenance, repair and upgrading.

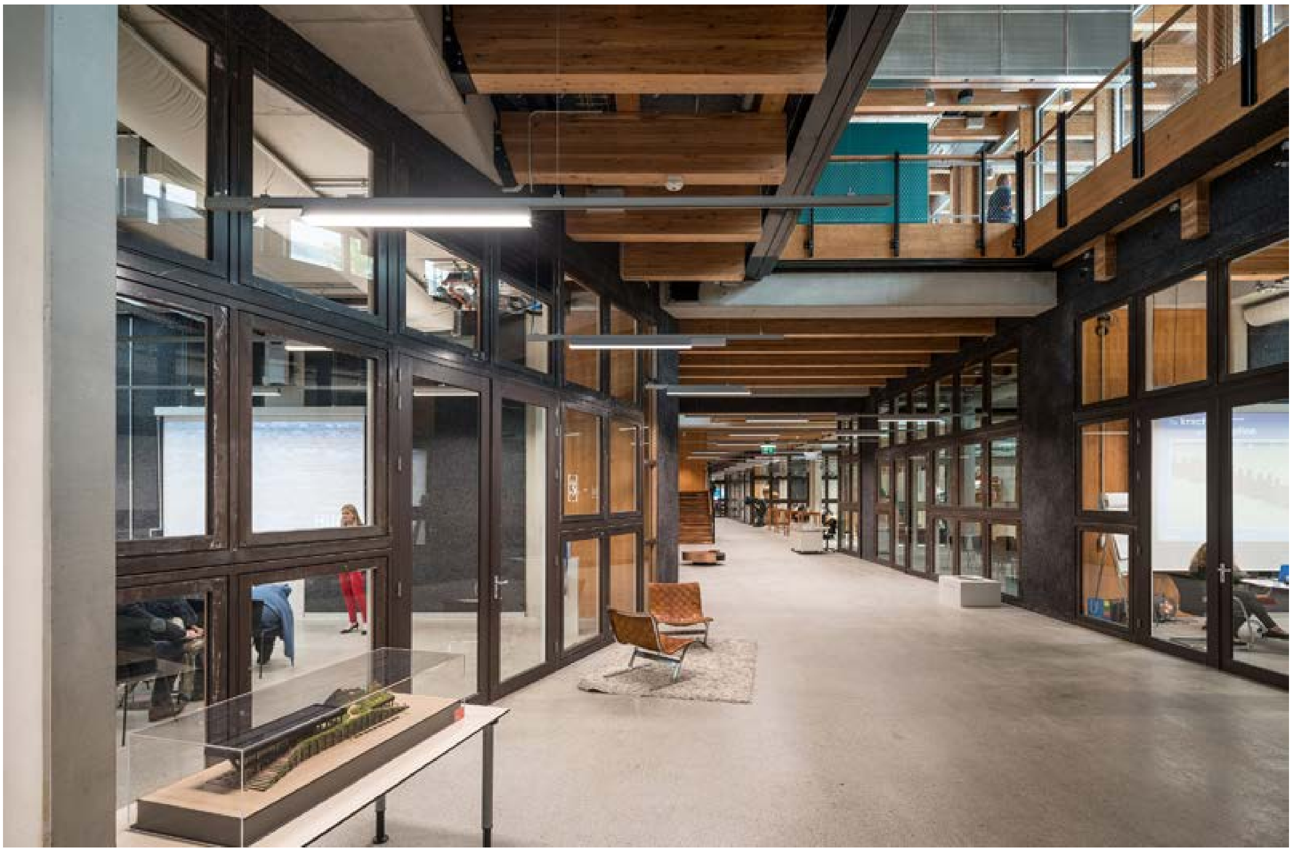
Best practice example

Leppington and Edmondson commuter car parks, Australia.

These car parks have been designed for longevity by keeping adaptable design in mind. The ground level has been designed so it can readily be converted into commercial or retail space, and the structural design allows for 2 additional floors to be added. The roof has been designed to support disassembly and reinstallation when the future expansion occurs. This helps to extend the useful life of the structure, preserve the value of its materials, and allow for ease of maintenance, repairs and upgrades.

2.
Design for flexibility and adaptability

Design to balance the needs of the present with how those needs might change in the future, and design for the ability to change through frequent reconfiguring.



Aims

- Extend the ability of buildings, precincts and infrastructure to respond to evolving needs.
- Preserve the value of materials and their embodied carbon.

Outcomes

- Life span is prolonged, and premature end of life avoided.

Actions

- Allow for easy alteration, upgrading and disassembly of components.
- Accommodate multiple uses, different uses and change of use.

Best practice example

Circl Pavilion, The Netherlands.

The pavilion has been designed to be flexible and adaptable. Automated walls, movable furnishings and multifunction floor configurations allow open plan areas to be easily reconfigured in a few minutes. The space can be configured for a variety of uses including dance events, markets, meetings, exhibitions and film screenings. The structure incorporates re-used materials assembled with dry fixings for ease of dismantling and re-use.

3.
Design to maximise materials circularity and enable disassembly

Design using materials, products and connection systems that allow for easy re-use and recycling of materials, products and components at end of life. Design to allow an assembled structure or product to be taken apart without destroying its constituent materials or components.

Aims

- Improve re-use and recycling of materials, products and components from buildings, precincts and infrastructure.

Outcomes

- Materials, products and components are re-used and recycled.
- Demolition waste is reduced.
- Waste disposal costs are reduced.

Actions

- Plan for deconstruction, re-use and recycling from the outset, such as via modular design.
- Use connection systems that support easy disassembly.
- Use materials that are easily re-used or recycled.
- Avoid potentially harmful or composite materials.

Best practice example

Bradfield 'first building', Australia

Bradfield City Centre's 'first building' will be used as an advanced manufacturing research, development and training facility. Due to open in 2023, it will support the advanced manufacturing sector in the Western Parkland City.

The 'first building' has been designed with Country and culture in mind, and embodies sustainability. It will be net zero at opening, and has been designed for disassembly and to minimise waste across its life cycle. The design preferences locally sourced, low-embodied carbon building materials and uses pre-fabricated low-waste components. The building will incorporate passive design, solar panels, green roof and battery technologies to deliver the energy requirements for the building and reduce its operational footprint.

4.
Design for materials efficiency

Materials efficiency means 'doing more with less' – this involves design and construction methods that use lower amounts of materials and reduce waste.

Aims

- Maximise the efficient use of materials.

Outcomes

- Use of materials (and associated environmental impacts) is reduced, and material costs are reduced.
- Repair and refurbishment of components is easier.

Actions

- Minimise material offcuts during construction and installation.
- Optimise functionality of structural elements.
- Use off-site prefabrication and standard modules and material sizes, including pre-cast concrete.

Best practice example

Modern methods of construction in schools, Australia.

School Infrastructure NSW is delivering school buildings using modern methods of construction. These projects make use of off-site and modular construction and standardisation of building components. Schools Infrastructure NSW is reporting that projects are delivered more quickly and efficiently, reducing carbon emissions and waste and promoting innovation.

5.
Design for best practice operational waste management

Design to ensure that waste and recycling storage and collection systems maximise re-use and recycling and allow for ease of access by both users and waste service providers.

Aims

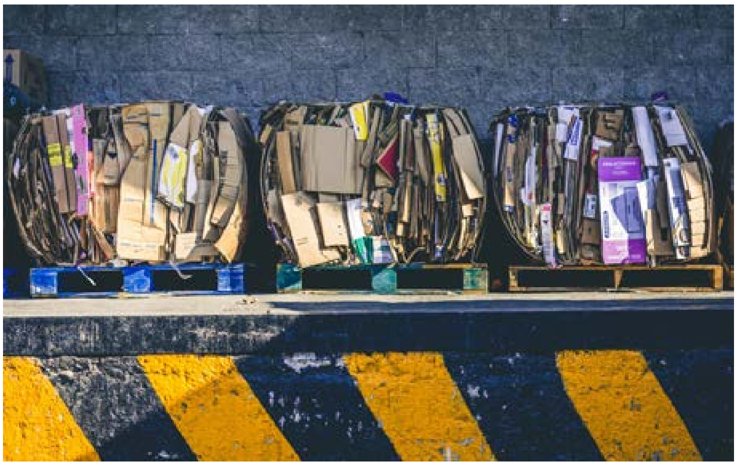
- Encourage clean separation of waste streams.
- Maximise opportunities for re-use and recycling of materials.

Outcomes

- Waste to landfill is reduced.
- Waste disposal costs are lower.
- Greenhouse gas emissions are reduced due to less organics waste to landfill.

Actions

- Provide appropriate space and equipment for separating and storing waste.
- Provide appropriate access for waste removal.
- This will be different depending on the type of development and its intended use. For example, individual bin storage areas versus the use of chute systems or separate basement storage areas. Mobile bins, bulk bins or bin lifting equipment can also make it easier to collect waste.
- The NSW Government provides separate guidance on designing for waste management and recycling[9,10].



Best practice example

Green commercial leases at Barangaroo South, Australia

Green lease clauses require tenants to design fit-outs to separate a minimum of 5 waste streams, use only compostable packaging, and not use plastic bags. 80% of operational waste is diverted from landfill across 20 waste streams.

6.
Re-use existing assets or materials

Incorporate existing structures, products and materials on the project site into the new development.

Aims

- Re-use existing assets or materials at their highest value and utility.
- Reduce demolition waste.
- Reduce the need for virgin materials.

Outcomes

- Natural resource depletion is reduced.
- Costs are lower due to reduced volumes of both waste and new materials.
- Greenhouse gas emissions are reduced.

Actions

- Find opportunities to retain existing assets and structures.
- Salvage and recondition existing components, using fewer resources to deliver the same or improved function.
- Ensure appropriate separation of potential sources of contamination.
- If they can't be used on site, transfer materials to another project.

Best practice example

Quay Quarter Tower, Australia

This commercial office and retail development incorporates two-thirds of the structure of an existing building located on the site (66% of columns, beams and slabs and 95% of structural walls). This ensured 50% of the resources required for the new tower were directly re-used from the existing building, saving over 7,500 tonnes of CO_2e emissions and reducing the cost by $130 million compared to a full demolition.

7.
Select products with recycled content

Preference products that contain recycled content to keep materials circulating within the economy.

Aims

- Reduce extraction of virgin materials.
- Reduce embodied energy of materials and components.

Outcomes

- Natural resource depletion is reduced.
- Greenhouse gas emissions are lower.

Actions

- Use products and materials with high recycled content, such as concrete with cement substitutes, recycled asphalt pavements or fit-out products with recycled materials.
- Preference selection of products:
  - with low environmental impact and minimal energy requirements for recycling that are recommended under certification schemes
  - with end-of-life uses or good recyclability, such as products with take-back or stewardship schemes.

Best practice example

M1 Pacific Motorway Tuggerah to Doyalson, Australia

A section of the M1 Pacific Motorway built in the 1980s has had its useful life extended and the value of its materials preserved during a recent upgrade. 200,000 tonnes of the old, cracked surface of the M1 was collected, processed in a mobile crushing plant and then reincorporated into the new road layers. This project saved time and money, while reducing the environmental pressures associated with sourcing new concrete (including extraction, transport and increased embodied emissions).

8.

Select products that are designed for disassembly

Select products and connection systems that allow an assembled structure or product to be taken apart without destroying its constituent materials or components.

Aims

- Minimise waste to landfill.
- Improve re-usability and recyclability.

Outcomes

- Waste management costs are reduced.
- Natural resource depletion is reduced.
- Greenhouse gas emissions are lower.

Actions

- Specify materials and products that are easy to disassemble into component parts, including through using prefabricated, modular components.
- Use specifically engineered and smart materials, adhesives, layers and parts.

Best practice example

Het Diekmann Vocational School, The Netherlands

The building is clad using an innovative, dry, brick-stacking system (ClickBrick) that requires no mortar, enabling easy disassembly. All bricks are fixed by stainless steel clips and wall ties hence becoming re-usable and recyclable. A remodel of the facade in 2016 removed 18,000 bricks to create space for window frames. Approximately 6,000 bricks were re-used directly in a follow-up project.

9.

Select products and materials that have an identified recovery pathway

Select products and materials that can be re-used or recycled once they reach end of life.

Aims

- Minimise waste to landfill and associated costs.
- Encourage innovation, research and development to generate technology, systems and demand that will support markets for re-used and recycled materials.

Outcomes

- Re-usability and recyclability is improved.
- Greater opportunities are created, and feasibility, market awareness and demand is improved for re-used and recycled products, structural components and materials.
- Natural resource depletion is reduced.

Actions

- Support new and existing markets for re-used and recycled materials, structural components and products by:
  - selecting materials and products that have an identified end-of-use market (existing or emerging)
  - incorporating requirements for recycled content (that are recyclable at end of life) within design and procurement specifications.

Best practice example

One Market Plaza, United States of America

The project team on this San Francisco development engaged a ceiling panel supplier to dismantle and recycle the old ceiling panels instead of sending them to landfill. The recycled materials were used to manufacture new panels to be used in this project. The new panels are also part of a ‘take back scheme’ arrangement to ensure future circularity.

10.
Select low-impact materials

Select products and materials that will have low impact on the environment and human health.

Aims

- Reduce impacts on human health and the environment, including reducing the toxicity and embodied energy of materials and components.

Outcomes

- Health and wellbeing are improved.
- Hazardous waste management at end of life is reduced.
- Embodied emissions related to transport are reduced.

Actions

- Use materials with minimal impact on the environment or human health, including materials that:
  - have low embodied energy
  - have a low potential to harm the environment or human health
  - are locally sourced
  - have minimal disposable packaging
  - are traceable back to their origin.
- **Tools for selecting materials and suppliers** in Section 3 provides suggestions on where to find information to support selection of low-impact materials.

Best practice example

The Biological House, Denmark

The house is constructed using boards made from upcycled biocomposite materials: composites made from biological ingredients such as plant fibre ‘waste’ from agriculture. Raw materials used to construct the building won’t end up as waste but can be fed into new closed loops.

11.
Incorporate green infrastructure

Incorporate the network of green spaces, natural systems and semi-natural systems – including waterways, bushland, tree canopy, green walls and roofs, green ground cover, parks and open spaces – that support sustainable communities.

Aims

- Reduce environmental footprint.
- Reduce negative impacts of built assets on natural ecosystems.
- Maximise the abundant co-benefits and value of green elements such as tree canopy, habitat and natural drainage systems.

Outcomes

- Life span of built assets is extended.
- Management of stormwater and flood safety is improved.
- Urban landscapes that sequester as much carbon as possible.
- Urban areas are cooler in hot weather, as heat-island effects are reduced.
- Operational efficiency and cost savings are greater.
- Health and wellbeing is improved.
- Urban habitat is improved and extended.

Actions

- Incorporate green infrastructure into building and landscape design by:
  - retaining and enhancing existing ecological elements within the landscape
  - providing green cover such as planting on roofs and walls
  - using green infrastructure, permeable materials and water-sensitive urban design to better manage stormwater and drainage
  - adopting sustainably sourced organic materials that can be processed with organic waste streams.

Best practice example

Blacktown Showground water-sensitive urban design redevelopment, Australia

Redevelopment of the showground has created an integrated environment where water plays a major role. Water flows through the retention system and vegetated wetlands, under a boardwalk and alongside picnic shelters and a café. The children's playground includes a waterplay area reinforcing the importance of water in the landscape. The community food gardens also use recycled water to support vegetation plots. Improved water efficiency and addition of a non-potable water supply has resulted in an 80% reduction in potable water use. The area is also significantly better at detaining high flows and reducing flood risks.

12.
Maintain a materials database

Keep a record of products, systems and materials within a built asset, including planning for end of life.

Aims

- Keep materials in use at their highest value and utility.
- Reduce use of virgin materials in new buildings, precincts and infrastructure.

Outcomes

- Re-use and recycling of existing materials is greater, due to:
  - improved understanding of where materials are located within a structure
  - improved understanding of materials' life span and how they are joined with other materials, assisting with disassembly, re-use and recycling
  - higher confidence regarding materials' properties and integrity.

Actions

- Establish a digital inventory of the structures, products and materials that make up an asset to support re-use and recycling of materials and components.
- Use the inventory to identify repair, re-use and recycling options.
- Ensure procedures are in place to update the inventory throughout the procurement, delivery and operation of the asset.

Best practice example

Venlo City Hall, The Netherlands

Components in the building have been documented in a materials database (or 'materials passport') that describes the materials and provides an end-of-life plan, such as how to disassemble then recycle or return them to the manufacturer.

13.
Procure products as a service

Procure products or systems needed in the built asset through a ‘products as a service’ model, where the customer pays for the performance and outcomes of a product rather than owning it.

Aims

- Support asset longevity and reduce opportunities for obsolescence.

Outcomes

- Waste to landfill is reduced.
- Potential life span of materials is increased.
- Maintenance of buildings and infrastructure is more cost-effective.

Actions

- Where possible, lease infrastructure and services from providers that incorporate take-back, re-use, repair, refurbishment and recycling as part of their business model.
- Incentivise ongoing maintenance and longevity of products.

Best practice example

M-use® elevator, international

Mitsubishi offers a unique model for elevator leasing where the supplier owns and maintains the product at a fixed annual cost for the duration of the agreed period. When the current use of the elevator ends, the supplier is responsible for dismantling and re-using each elevator, where possible, or recycling the components.

3
Implementing circular design in the built environment

Collaborating through all project phases

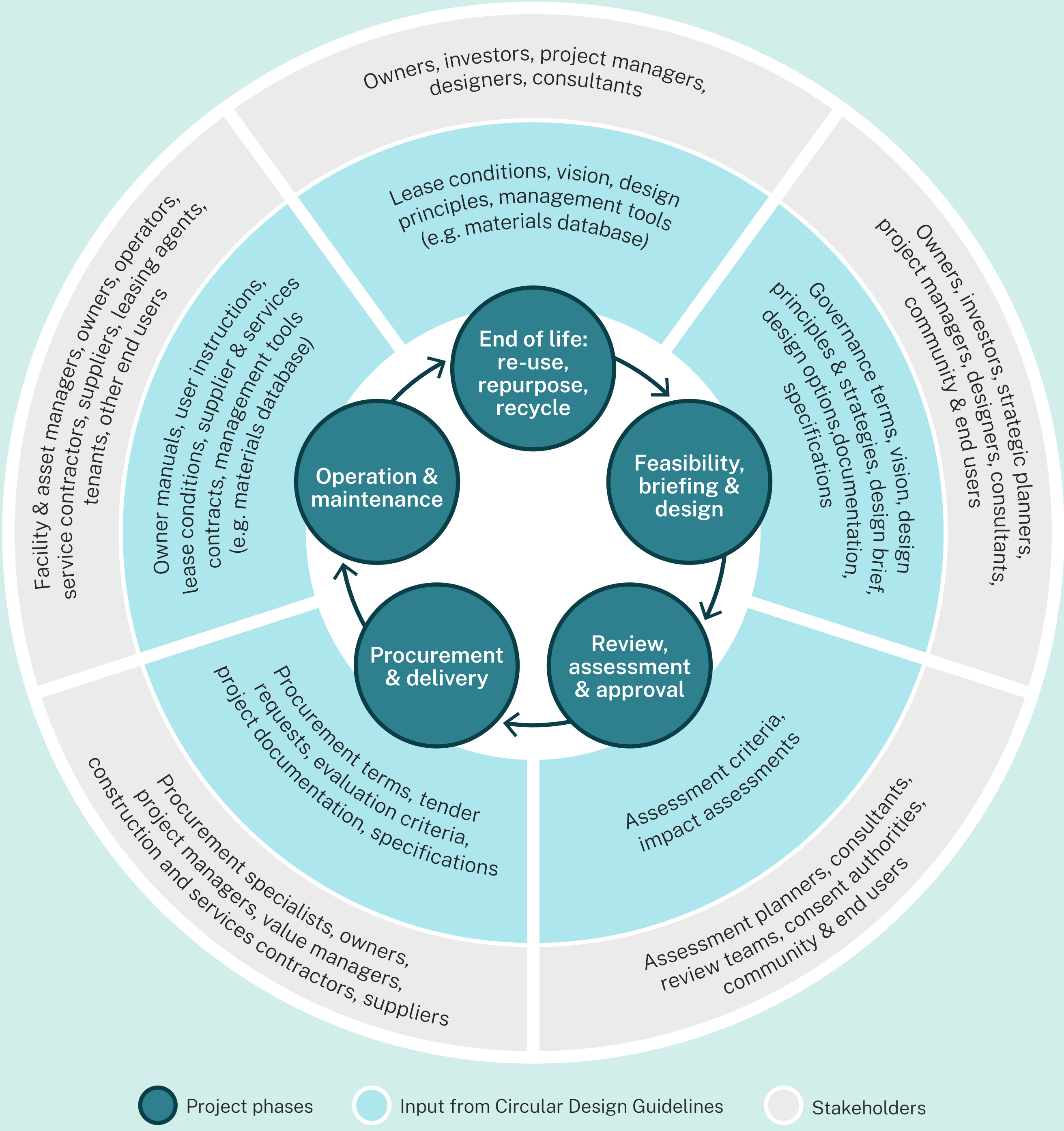


Figure 4 Phases and stakeholders contributing to the circular economy

Circular design strategies can be integrated and provide direction throughout the life cycle of an asset. For maximum benefit, circularity should be considered at the earliest project planning stage and reviewed throughout project delivery and into operations. At each phase in the development and life of an asset, stakeholders can add value by collaborating to identify and review opportunities for supporting the circular economy through design, procurement, delivery and ongoing maintenance and operations.

Tools for selecting materials and suppliers

Preference suppliers involved in product stewardship or take-back schemes

Product stewardship and take-back schemes make producers more responsible for managing the environmental impact of products throughout their life cycle. They encourage producers to reduce waste, re-use and recycle materials and extend the life span of their products.

Choosing suppliers involved in product stewardship or take-back schemes offers stakeholders a straightforward way of achieving circular design outcomes relating to waste avoidance and materials recovery.

The NSW Government supports the development of national product stewardship schemes: see **Product stewardship schemes and priorities**.

Look for environmental certification, labels and declarations

Environmental certification, labels and declarations can provide information and assurance relating to circular economy outcomes for the selection of materials and products.

The International Organization for Standardization (ISO)[11] sets out the principles and criteria for 3 key types of environmental labels and declarations that can be used to improve the reporting and transparency of environmental impacts in supply chains.

The following certification and labelling schemes and declaration types can be used to demonstrate lower impact materials and transparent measurement and reporting of environmental impacts associated with products.

Table 1 Environmental certification labelling and declarations

Environmental certification or declaration type	Purpose	Example certification scheme
ISO14001 certification	Specifies requirements for an effective environmental management system (EMS)	N/A
Type I Environmental labelling (ISO 14024:2018)	For eco-labelling schemes where there are clearly defined environmental performance criteria for products	Good Environmental Choice Australia (GECA), Global GreenTag
Type II Self-declared environmental claims (ISO 14021:2016)	For products and services where there are neither criteria nor labelling schemes	N/A
Type III Independently verified environmental product declarations (EPDs) (ISO 14025:2006)	Quantification of environmental impacts and performance using a life cycle approach	International EPD System, EPD Australasia
Other – independent schemes	To demonstrate certain environmental performance criteria or chain-of-custody criteria have been met	ISEAL Alliance, Forest Stewardship Council (FSC), Best Environmental Practice PVC, Australian Paint Approval Scheme (APAS)

Deploying digital engineering

Digital engineering is the adoption of technologies that optimise the collection and use of relevant data about a project or asset throughout the life cycle of the asset.

Digital engineering supporting circular design includes:

- using 'digital twins' and data analytics as decision-support tools
- using materials databases (databases of materials and products relating to a built asset).

This can benefit asset owners and operators over the long term, as well as project architects, engineers and delivery teams.

Digital twins

A digital twin is a virtual representation of a physical entity and can be used for various applications and scales and across project phases. For example:

- planning – informing land-use assessment and planning studies
- design development – monitoring potential impacts on adjacent properties, providing contextual information on project surrounds
- delivery – planning and monitoring logistics, environmental impacts
- operations – using real-time or near real-time data to monitor, analyse and report on an asset.

Digital twins can support circular design in various ways including:

- simulating assembly and disassembly methods before physical works begin
- identifying products and components requiring maintenance or replacement, including their location and relationships within an asset
- using operational data on performance and asset condition to inform new and replacement builds
- identifying elements of existing assets suitable for re-use and recycling.

Materials databases

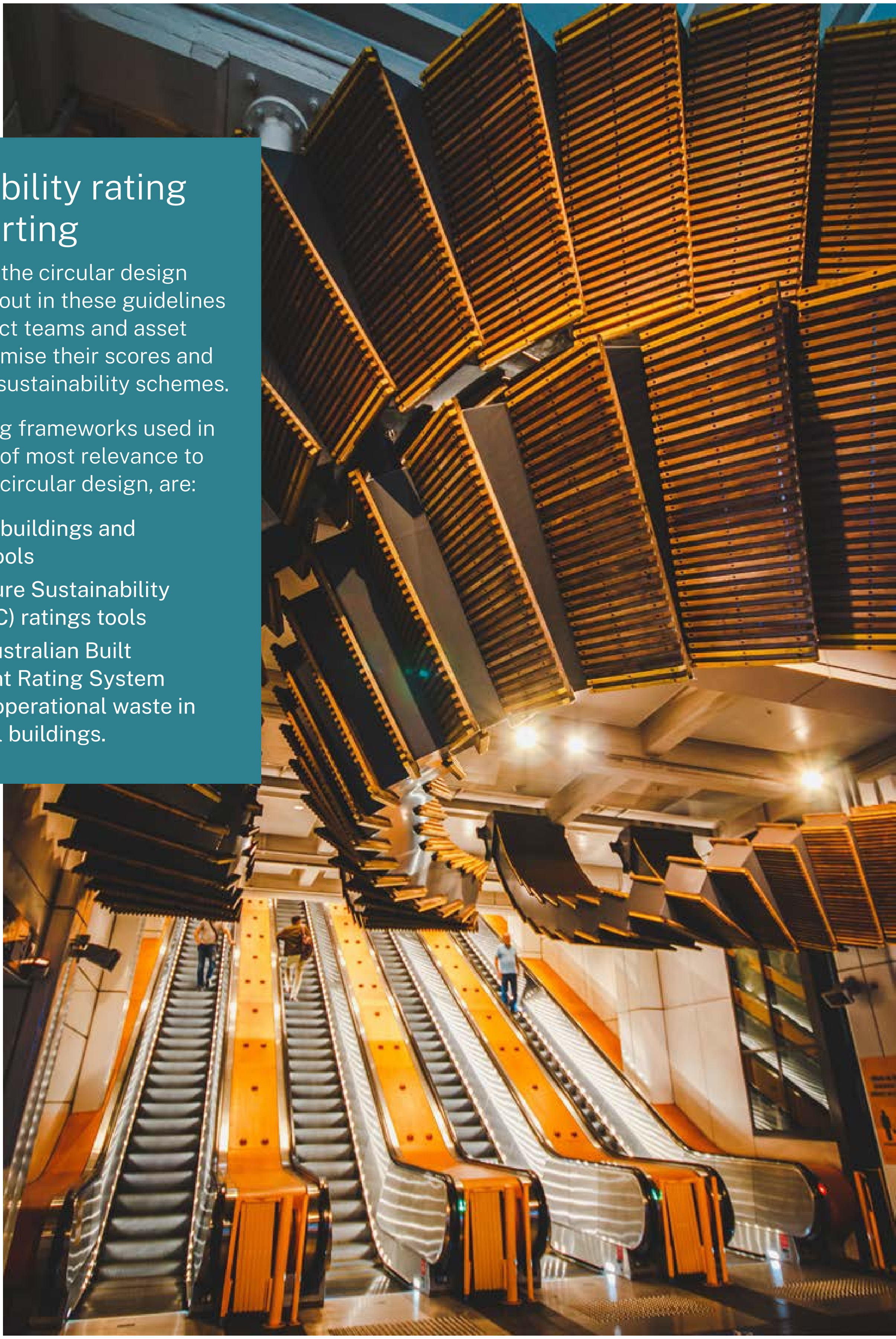
A materials database (also called a 'materials passport') is an inventory of the products, materials and structural components that make up an asset. The database can provide consistent 'track and trace' information on the origin, composition, repair and dismantling options of a building element, as well as handling requirements for the end of its service life.

Using a digital inventory enables analytics, sharing and reporting of data, and supports end-of-life planning for re-use and recycling of materials.

The information required to build a materials database can be progressively generated throughout the design, procurement and delivery process. This information model is then maintained throughout the operation of the asset, to ensure the data remains valid for the next phase in the asset life cycle.

Digital Built NSW

Digital Built NSW will support adoption and use of whole-of-life digital engineering across the built environment, leveraging international and national standards, policies and frameworks to ensure universal application to NSW Government infrastructure.



Sustainability rating and reporting

Implementing the circular design strategies set out in these guidelines can help project teams and asset managers optimise their scores and ratings under sustainability schemes.

The main rating frameworks used in Australia, and of most relevance to implementing circular design, are:

- Green Star buildings and precincts tools
- Infrastructure Sustainability Council (ISC) ratings tools
- National Australian Built Environment Rating System (NABERS) operational waste in commercial buildings.

Green Star buildings and precincts tools

The Green Building Council of Australia (GBCA) administers a suite of Green Star rating tools for use on building and precincts, including Green Star Communities, Green Star Performance, Green Star Interiors and Green Star Buildings[12].

Green Star Buildings is the first tool to be released under the Future Focus program, a major overhaul of the tools, and the most aligned with circular design strategies.

Table 2 Examples of Green Star Buildings credits that are aligned with circular design strategies

Green Star Buildings key credit	Criteria	Relevant circular design strategies
Responsible construction	The builder diverts a minimum threshold of construction and demolition waste from landfill	Design for materials efficiency Re-use existing assets or materials
Responsible procurement	The builder's procurement process follows ISO 20400 *Sustainable Procurement – Guidance*	All – sustainable procurement processes can be used to drive circular economy outcomes
Responsible products (structure, envelope, systems, finishes)	A minimum threshold of each product category meets a responsible product value which can be achieved through re-used products, EPDs, FSC certification, ISO14001 certification, best environmental practice PVC	Re-use existing assets or materials Select products with recycled content Select low-impact new materials
Upfront carbon	The upfront embodied carbon emissions of the project are measured and reduced by a minimum threshold	Design for materials efficiency Re-use existing assets or materials Select products with recycled content Select low-impact new materials
Life cycle impacts	The project demonstrates a 30% reduction in life cycle impacts when compared to standard practice	All – life cycle assessment is a key tool for measuring and assuring outcomes from applying circular design strategies
Leadership challenge: circular economy	The project team identifies and implements circular economy principles and initiatives The project team demonstrates an increase in circularity	All – this leadership challenge rewards the implementation of circular economy principles and initiatives

ISC rating tools

The Infrastructure Sustainability Council (ISC) administers a suite of rating tools focused on infrastructure assets, including the IS (Infrastructure Sustainability) Planning tool, IS Design & As Built tool and IS Operations tool[13].

Table 3 Examples of ISC Rating Scheme credits that are aligned with circular design strategies

IS Rating Scheme key credit	Aim	Relevant circular design strategies
Sustainable procurement (all credits)	To reward the assessment and selection of suppliers, goods and/or services that both contribute to achieving the project/asset's sustainability objectives and manage the material sustainability risks and opportunities in the supply chain	All – sustainable procurement processes can be used to drive circular economy outcomes
Rso-1 Resource efficiency strategy and management	To reward development and implementation of a resource efficiency strategy and associated action plans	All – requires a resource efficiency strategy and resource efficiency action plan that are specifically aligned with circular design strategies
Rso-4 Resource recovery	To reward the sustainable management of resource outputs (waste)	Design for materials efficiency Re-use existing assets or materials Select products and materials that have an identified end-of-life use
Rso-5 Adaptability	To reward design and planning for deconstruction, disassembly and adaptability of future infrastructure	Design for longevity Design for flexibility and adaptability Design to maximise materials circularity and enable disassembly Select products that are designed for disassembly Maintain a materials database
Rso-6 Material life cycle impact measurement and reduction	To reward design and practice that reduces life cycle environmental impacts of materials	All – credit uses a life cycle assessment process to measure and demonstrate a reduction in material impacts
Rso-7 Sustainability-labelled products and supply chains	To reward procurement of materials that have sustainability labels or are from sustainable supply chains	Re-use existing assets or materials Select products with recycled content Select low-impact materials

Measuring outcomes

Life cycle assessment

Life cycle assessment (LCA) is a method that can be used to measure the potential environmental impacts (e.g. greenhouse gas emissions, embodied energy, resource depletion) across the whole of life of an asset, from material acquisition through production, use and end of life.

LCA can be applied to products and materials but also at a larger scale to buildings, precincts and infrastructure. It can be used to compare design options and measure and report on the outcomes of applying circular design strategies. It can also be used to quantify the tonnage of material flows and the embodied carbon and waste of products.

Circularity assessment

Newly developed metrics have been created to measure the circularity of selected materials and products. These can assess circularity before and after circular design interventions. The Material Circularity Indicator (MCI) from the Ellen MacArthur Foundation[15] and the Circular Transitions Indicator (CTI)[16] are 2 well-known examples of circularity assessment tools.

NABERS Waste

NABERS is used to measure the environmental performance of Australian buildings and tenancies, including energy efficiency, water usage, waste management and indoor environment quality.

The NABERS Waste tool[14] measures how well a building manages operational waste generation and recycling, and supply chain management. The tool tailors its service to accommodate different types of buildings and provides data and insights to help improve operational waste management practices.

Circular design strategies relating to operational waste avoidance and materials re-use are directly relevant to improving buildings' performance against the NABERS Waste tool.

Glossary

By-product	Substance or object resulting from a production process, the primary aim of which is not the production of that item[17].
Circular economy	A circular economy values resources by keeping products and materials in use for as long as possible. Maximising the use and value of resources brings major economic, social and environmental benefits. It contributes to innovation, growth and job creation, while reducing our impact on the environment[4].
Digital engineering	Digital engineering is a convergence of data software technologies, such as building information modelling (BIM), geographic information systems (GIS) and other related systems, for driving better businesses, projects and asset management outcomes.
Digital twin	A digital twin is a virtual representation of a physical object or process, connected to real-world data.
Embodied carbon	Greenhouse gas emissions associated with materials and construction processes throughout the whole life cycle of a building or infrastructure. It is calculated as the sum of upfront embodied carbon, in-use embodied carbon, and end-of-life embodied carbon, measured by CO_2e.
Embodied energy	The total energy necessary for an entire product life cycle including virgin material extraction, transport, manufacture, assembly, installation, maintenance, repair, disassembly, replacement, deconstruction and composition. This includes renewable and non-renewable energy. Embodied energy does not correlate to embodied carbon.
Life cycle	Consecutive and interlinked stages of a product or service system, from design, acquisition of raw materials, production, distribution, use and end-of-life management[18].
Life cycle assessment	An analysis of the environmental and/or social impacts of a product, process or a service for its entire life cycle. It looks at the raw material extraction, production, manufacture, distribution, use and disposal of a product[18].
Materials database	An inventory of the products, systems and materials contained within an asset. Also known as a 'materials passport'.
Materials circularity	The degree to which products and materials are kept in use within the economy at their highest value and utility, including through re-use and recycling, saving extraction of virgin materials.

Materials efficiency	The efficient use of materials to deliver a product or a service. Generally described as 'doing more with less'.
Modular design	Design that applies standardised elements for materials and products, enabling a reduction in construction waste and easier re-use at end of life.
Operational waste	Waste produced within built assets once operational. It typically includes waste produced by users of domestic, commercial, industrial, government and public premises.
Prefabrication	The manufacture of building components prior to transporting to a project site.
Product as a service	Business model where the customer pays for the performance and outcomes of a product rather than owning it. Also known as 'goods as a service'.
Product stewardship scheme	Product stewardship schemes place responsibility on those who produce, sell, use or dispose of products to reduce the product's impact on the environment and human health.
Recyclability	The ease with which a material can be recycled in practice and at scale[19].
Recycled content	Material that has been through a recycling process.
Recycling	Set of processes (including biological) for converting materials, that would otherwise be disposed of, into useful materials or products[20].
Refurbish	Return a product to good working order. This can include repairing or replacing components, updating specifications and improving cosmetic appearance.
Re-use	Reallocation of products or materials to a new owner or purpose without significant modification, but potentially with some repair.
Smart materials	Materials that sense and react to environmental conditions or stimuli e.g. mechanical, chemical, electrical, or magnetic signals[21].
Take-back scheme	Used or unwanted items returned to the point of purchase, or other designated point, by the end user, to ensure such items are re-used, or recycled.
Virgin materials	Materials that have not yet been used in the economy.
Waste	A discarded, rejected, unwanted, surplus or abandoned substance. (From the definition of waste within the NSW *Protection of the Environment Operations Act 1997*. The full legal definition can be found within the Dictionary of the Act)[22].

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Appendix

Circular design plan

A simple planning template – like the following – can help you to propose and document how circular design principles will be implemented throughout a particular project.

Design strategy	Project phase	Aims	Actions
Design for longevity			
Design for flexibility and adaptability			
Design to maximise materials circularity and enable disassembly			
Design for materials efficiency			
Design for best practice operational waste management			
Re-use existing assets or materials			
Select products with recycled content			
Select products that are designed for disassembly			
Select products and materials that have an identified end of life use			
Select low-impact materials			
Incorporate green infrastructure			
Maintain a materials database			
Procure products as a service			

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