Building a more circular Australia

The opportunity of transitioning to a circular economy

pwc

March 2021

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As the world emerges from the COVID-19 pandemic we face the challenge of finding our ‘next normal’. This is both a significant challenge and great opportunity.

> “With this restart, a window of hope and opportunity opens… an opportunity for nations to green their recovery packages and shape the 21st century economy in ways that are clean, green, healthy, safe and more resilient
>
> – UN Climate Chief

PwC’s modelling indicates that Australia could generate $1,860 billion in direct economic benefits over twenty years and save 165 million tonnes of CO2 per year by 2040.

This report explores the opportunity for Australia to adopt the concept of a circular economy, establishing a robust and holistic framework for sustainable growth.

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Foreword

We are in a time of enormous challenge and how we respond will have a great impact on the future of our economy, our society and the planet as a whole.

Australia has experienced rapid economic development and population growth. This has placed pressure on our cities, infrastructure, services and resources that are all based on the prevalent linear economic model of 'take, make, use, waste'.

Australia is depleting its resources at an accelerated rate, whilst generating unprecedented waste and emissions, to the detriment of the region not just environmentally, but socially and economically. There is a growing realisation that climate risk represents financial, environmental and social risk, and that transition towards a lower carbon, more circular economic models represents a historic opportunity.

As Australia emerges from the COVID-19 pandemic we face the challenge of finding our 'next normal'. This is both a significant challenge and great opportunity. Indeed, as the United Nations has implored, this is a chance to 'Build Back Better'.

To address this, Australia has started to explore sustainable solutions, such as alternative sources of energy, curbing excessive consumption, implementing greater efficiency in the built environment, and expanding on existing recycling efforts. However, reversing the current pattern of development requires a truly holistic approach.

In this report, we explore the opportunity for Australia to adopt the concept of a circular economy, establishing a robust and holistic framework for sustainable growth. This involves creating closed-loop material cycles across the production and consumption value chain, and treating waste as a leakage of value to be avoided rather than dismissed.

PwC has defined a framework for circular economic infrastructure, governed by three principles: optimising the consumption of finite resources, maximising product utilisation, and recovering by-products and waste. Given the expansion of urban areas and forecasted growth of our cities, it is only logical that the journey towards circularity should focus on the built environment, transport and housing.

The potential environmental and economic benefit of adopting a circular economy model for Australia has been quantified in this report. Our modelling suggests that Australia could generate $1,860 billion in direct economic benefits over twenty years and save 165 million tonnes of CO2 per year by 2040.

The nations and companies that make early progress towards lower carbon, more circular economic models will be the ones to capture the value articulated in this report from the shift in mainstream capital flows towards a growing emphasis on environmental and social impacts.

PwC has a clear ambition to play a role in this paradigm shift and is uniquely placed to help catalyse and orchestrate the construction of a more 'circular' economy in Australia - that decouples economic activity from the consumption of finite resources, to create an abundant future, without waste.

Part 1

What is a circular economy, and why now?

1.1 Introduction

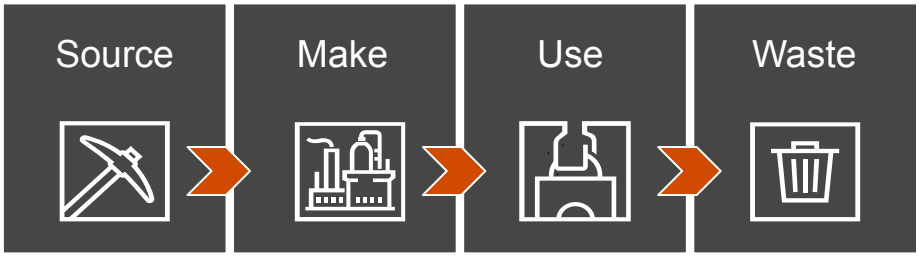
Australia has taken its place among the world's most developed countries and it now faces the resulting challenges – a return to a rapidly growing population post COVID-19 concentrated in cities and a heavy reliance on finite natural resources.

Reflecting today's global economic system, Australia has delivered its growth on a linear model of production that became dominant after the introduction of mass production during the industrial revolution. In terms of economic growth this has been a story of success and prosperity.

However, the transition over the last 200 years to a one-way production model – a linear economy – has caused a strain on finite resources and introduced significant quantities of waste.

The linear economy model involves extracting natural resources to make products that are used for a limited period of time, before being discarded as waste – as shown in Figure 1. Within the same period, the planet's ecosystems have begun to show signs of strain.

Figure 1: Linear economy model



Since the end of the 1940s, technological and social innovation has boosted living standards, which increased consumption, required a greater supply of consumer goods and increased waste. Population growth is leading to increased amounts of waste and emissions. Risks of serious environmental, health, and economic problems are only beginning to emerge.

The linear economy model's dependence on finite resources has also led to their near depletion and to rising and less predictable commodity prices. Companies and economies that rely on scarce natural resources are becoming more exposed to price volatility and are pressured to find alternatives that are both economical and sustainable.

The linear economy model is becoming increasingly unsustainable and there is a need for an alternative economy model that is sustainable.

In contrast, the circular economy has emerged as a more sustainable alternative, and has attracted interest and support from governments over the last two decades, and a growing number of businesses.

A circular economy is an alternative economic model that derives its inspiration from nature's ecological cycle – creating a closed loop of material and energy cycles where all materials operate within a closed system.

A truly circular economy is driven by renewable flows, rather than finite stocks – with two types of material flows:

1. organic material, designed to re-enter and regenerate the environment safely (such as compost)
2. materials, designed to circulate for as long as possible through repair and reuse, without entering the environment for disposal (such as metals, paper and plastic).

The circular economy concept involves various stakeholders including but not limited to manufacturers, distributors, consumers, and governments, and can be applied across all industries. Making the transition to a circular economy means changing the way we source, design, manufacture, distribute, use, and discard materials.

A circular economy model represents a significant opportunity, as well as a challenge.

In a circular economy, every resource moves through in such a way that it becomes food for another process, and in so doing, unlocks vast amounts of previously lost or inaccessible value, to create lasting abundance - for people, economies and the planet as a whole. A move towards this economy now can help organisations address their most immediate needs in new ways that unlock capital and labour to build competitive advantage, create new profit pools and drive innovation. This enables organisation to grow their competitive edge and be fit for long term and sustainable success. Across an entire economy, this move creates an abundance of jobs, systemic resilience and resource security.

The circular economy is often depicted as a series of loops, each representing a different way of managing products that are no longer required by their owners (because they are damaged, defective, or simply unwanted). The loops represent a hierarchy. The closer to the centre the loop is, the less waste and environmental pollution created and the more economic value retained in the product or materials.

Figure 2 Circular economy concept

1. Recycling

Recovering materials from end-of-life products for use as raw materials in another process, excluding incineration to generate energy. This can lead to recovered materials of the same quality, lower quality (down-cycling) or higher quality (upcycling).

2. Remanufacturing

Disassembling products at the component level rather than into separate materials, replacing broken or out-dated parts to make a new product for sale or lease. This avoids a new product having to be manufactured.

3. Reuse

Selling or donating a product in its original form, or with little change, which avoids a new product having to be manufactured. May also include redistribution of unwanted food.

4. Maintenance

Extending the life of a product with its first owner, either via repair or refurbishment service, or by making it easier for users to repair it themselves. This delays the purchase of a replacement product.

5. Redesign

Developing products that use fewer materials or have a smaller environment footprint that are designed to be more durable, or to be offered as a service through a leasing or take-back model. Also includes adaptations to make products easier to maintain, reuse, remanufacture or disassemble and recycle at end-of-life. Aims to tackle the most material impacts, based on lifecycle analysis.

Source: PwC UK, Going Circular: Our 10 Year Journey

1.2 What's the problem?

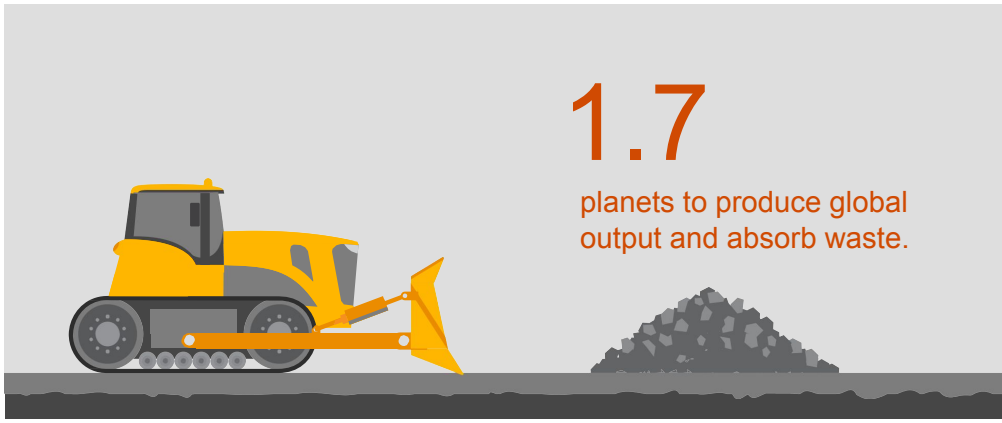
The growth generated through the linear economy model allowed most of the world to access goods and services that have improved our lives.

This has, however, come at the cost of depleting natural resources and environmental damage impacting our planet.

The problems generated through the linear economy model have impacted the planet, the environment, natural resources, industry and the economy – with impacts seen in the following ways.

The planet

Since the 1970s, humankind has effectively been running an ecological deficit in terms of its impact on the environment. This means that the global annual demand for resources has exceeded what the Earth can regenerate each year.



Source: PwC analysis based on Global Footprint Network

Today the global economy uses

This trend is estimated to grow exponentially. If these developments are allowed to continue, the environmental damage caused may become irreversible, or even reach 'tipping points' where self-reinforcing feedback loops produce above-proportionate effects.

The environment

The most fundamental problem caused by the linear economy model is accelerating environmental degradation resulting from economic activity. Multiple other measures point to large-scale environmental damage, showing alarming rates of biodiversity loss, deforestation, land degradation, depletion of stocks of finite resources, disruption of the Earth's freshwater cycle, chemical pollution and climate change, to name just a few examples. Waste and pollution are the main factors leading to this environmental degradation.

Improving Australia's domestic resource recovery capacity and sustainable consumption is critical to avoiding environmental degradation. Every year millions of tonnes of materials are lost to landfill, such as plastics, paper, glass, metals, textiles, masonry, food and other organic materials. These are all potential sources of significant value and resources that are going to waste.

As an example, Australia generates

74

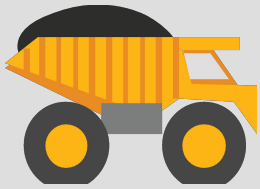
million tonnes of waste per annum

Source: PwC analysis based on Global Footprint Network and National Waste Report 2020

Natural resources

Consuming more resources than the Earth can provide will inevitably lead to shortages of some resources. With half of the global population now middle class or wealthier, the pressure on our planet's resources and ecosystems will be even greater in the future.

90.9%



Of all raw materials do not find their way back into the economy

Source: Global Circularity

Industry and the economy

Price volatility can be associated with three types of scarcity: physical scarcity such as the availability and depletion of stocks; economic scarcity referring to supply and demand; and geographical scarcity referring to who controls the availability of resources. The three types of scarcity are interlinked and all drive the volatility of prices – impacting on businesses and the economy in different ways.

Linear economy models are dependent on abundant resources feeding them, and the negative impacts arising from waste, environmental degradation and scarcity have been borne by the environment and society as a whole.

180%

Percentage increase in commodities prices since January 2000

Source: Australian Bureau of Statistics

Part 2

Why go circular?

The economic perspective

2.1 Summary of results

Circular potential

Concepts of sustainability are not new to policy or business decisions across Australia. In fact, many of the opportunities quantified and explored in the following pages already have government targets or expected take ups without further action – such as government goals for halving food waste, or the expected increase in electric vehicle (EV) ownership.

However, they still lack a holistic approach for increasing circularity in line with the three principles of the circular economy. This section aims to show the quantum of the potential benefits of fully embracing circularity in a coordinated way.

Category of opportunities

To demonstrate the size of the opportunity that going circular presents, we have examined the impact within four key components of a circular economy, as follows:

- A **built environment** based on circular economy principles would optimise land utilisation, and integrate durable, mixed-use buildings designed in a modular way and constructed with recycled and biological materials. Spaces would consume less power and water, and would be highly-utilised thanks to sharing and multi-purposing.
- A circular **mobility** system would be interconnected and shared, electrified, autonomous, and multi-modal. Public transport would make up a large proportion of citizens' mode of travel while individualised mobility would be mostly provided as a service.
- A circular **community** is one that is mindful of resource consumption, use and disposal. It is a community where consumers reduce consumption of energy, water and biomass, extend the life cycle of their assets as long as possible and practice active recycling.
- Australian **industry** working in a circular manner. Businesses transform their business model to be circular, including designing and innovating new products and services.

These categories are used to demonstrate the magnitude of the benefits that could come from embracing the opportunities within each category.

Identifying opportunities

Within these categories, this report does not aim to capture every circular opportunity, but rather demonstrate the magnitude of the benefits that could come from embracing the opportunities in each category. We have quantified only the high impact priority opportunities.

Prioritisation of initiatives based on:

- the potential impact in terms of wealth creation and pollution reduction
- barriers for implementation:
  - **economic barriers** relating to profitability, and capital requirements
  - **technology barriers** relating to lack of technology and infrastructure, for implementation
  - **regulatory barriers** relating to existing policy and regulations.

For most of the categories of opportunities, quantifying the high priority opportunities gives a sense of the quantum of benefits.

The one exception to this is industry. This is for two reasons. The first is that information on both the impact and potential barriers is internal within businesses. This varies greatly based on the type of business and the industry in which they operate. The second is that the largest opportunities in this category will come from innovations that are not yet known. The true potential is in industry redesigning what they produce and this will only happen at a large scale when the attitudes of circularity are embraced.

Quantifying impact

For the identified priority opportunities, we have sized the potential for twenty years from 2021 to 2040 in terms of:

- direct benefits (savings to households, industry and governments and positive externalities)
- reduction of CO2 emissions.

Direct benefits have been used to measure against investment or costs of implementing policy changes from a government perspective. This helps understand the investment that could be made and still generate a positive cost benefit ratio in total economic terms.

All the benefits captured in this report are presented as an incremental above the business as usual that a circular economy could deliver. This recognises that progress will be made in many of these areas without policy or attitude change. This allows us to demonstrate the true benefit of doing things differently, above and beyond what is already happening.

It is important to note that these forecasts are all made on a pre-COVID-19 basis, with any particular COVID-19 impacts called out qualitatively.

Direct benefits

Direct benefits presented by state and category are shown below and explored in more detail across the following pages.

	Cumulative benefits to 2040 (billions $)	Average benefit (2021-2040) as proportion of GSP
NSW	648	3.48%
VIC	285	2.08%
QLD	705	6.54%
SA	67	2.04%
WA	109	1.36%
TAS	20	2.05%
NT	10	1.21%
ACT	17	1.33%
Australia	1860	3.25%

	High priority opportunities	Quantified benefits	

Built environment	Modular construction
	3D printing
	Sharing space
	District cooling
	High value recycling and reuse
		$ material savings
		$ labour savings
		$ electricity savings
		% faster time to market
		* CO2 reduction
			$773 billion
			
			20 year cumulative benefits

Mobility	Intermodal Transport Systems
	Electric Vehicles
	Autonomous Vehicles
		$ accident reduction
		$ congestion savings
		$ fuel savings
		% lives saved
		* CO2 reduction
			$111 billion
			
			20 year cumulative benefits

Community	Energy consumption and purchasing attitudes
	Sorting and recycling
	Food waste reduction
		$ electricity savings
		$ increased value of recycling
		* CO2 reduction
			$175 billion
			
			20 year cumulative benefits

Industry	Increased use of renewable energy in production
	New markets for value add product such as green steel
		$ electricity savings
		$ increased potential market
		* CO2 reduction
			$801 billion
			
			20 year cumulative benefits

2.2 Built environment

A circular built environment could generate $773 billion in direct economic benefits over twenty years and save 3.6 million tonnes of CO2 per year in Australia by 2040

2.2 Built environment

Built environment benefits

Our analysis suggests that, if city planning, modes of construction and real estate management implement the circular economy opportunities below, this could generate direct benefits of $85 billion in 2040, or an average of 1.31% of gross domestic product (GDP) each year for the next 20 years.

A circular built environment optimises land utilisation, and integrates durable, flexible, and modular spaces. It is designed to facilitate closed loops of water, nutrients, materials, and energy, and is constructed through sourcing bio-based and recycled materials.

However, the National Waste Database shows that construction and demolition created over 23 megatonnes of 'core waste' in 2018-19.[1] This is roughly the same amount as all other commercial and industrial core waste combined. Additionally, what is already built is not used as efficiently as it could be if it was managed under circular principles.

Embracing circular opportunities in the built environment is not just about how we design and build for the future, but also retrofitting and encouraging better use in the environment we already have. Incorporating circular opportunities in the built environment during the construction and throughout the asset life of buildings allows for optimal usage of construction materials, reduced utilisation of finite resources, and substantial reductions in waste.

The current COVID-19 situation has demonstrated how fundamentally our assumption about the built environment can change with regards to teleworking (which is an example of circular use in the built environment, but has not been quantified in this report).

1. Australian Government (2020) National Waste Report 2020

Built environment opportunities

The following opportunities were identified for making our built environment more circular. The five shown in bold are those that are deemed to be high priority and have associated benefits quantified:

- Urban planning to optimise land utilisation (e.g. use of brownfield sites)
- Use of biological and non-toxic elements in architecture (i.e. sustainable building materials with a biological origin can contribute to designing smarter buildings)
- **Industrialised production of modules** (i.e. modular production off-site for rapid assembly on-site)
- **3D printing of building modules**
- Equipment/materials sharing platform (i.e. supply and demand of equipment/materials can be aligned)
- **Sharing of building space** (e.g. multi-use building)
- Increased teleworking to reduce need for office floor space
- Building and infrastructure for effective energy, nutrient and material cycle (e.g. **district cooling**, insulation, solar water heating systems, building management systems)
- Selective demolition/refurbishing of existing buildings
- **High-value recycling and re-use of construction modules** (i.e. deconstruct vs. demolish) and material (e.g. steel)
- Looping of organic construction material to biosphere

Modular construction

Wider adoption of modular construction is an example of circularity in the built environment. Modular construction and prefabricated buildings involve off-site production and then on-site assembly of building units. This technique increases construction process speed, enhances quality and consistency of output, and reduces material wastage.

Modular construction reduces on-site material and labor costs and allows for faster delivery. During the construction phase alone, the usage of modules can bring savings of up to 15% in material costs and close to 75% in labour costs.[2] This in return for a slight increase in capital and operating expenditure compared to conventional construction methods.

Modular and prefabricated buildings are not new concepts, however wider adoption of the opportunity could bring about significant savings and economic benefits. The challenge is to increase the adoption of modular construction across the infrastructure and built environment sector.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	8358	68,176
VIC	5566	45,401
QLD	6925	56,486
SA	1208	9857
WA	3346	27,294
TAS	276	2250
NT	479	3908
ACT	559	4563
Australia	26,717	217,935

3D printing of modules

3D printing technology allows for printing and assembly of houses and building spaces in a reduced timeframe. It involves only a fraction of the typical associated costs and construction material and can cut down on transport requirements.

With increased adoption, 3D printing in the Australian construction sector can save labour and material costs. The technology allows for construction at a fraction of the cost and reduces material consumption significantly. While 3D printing adds ~12% in associated capital and operating expenditures, it results in ~20% material savings and ~32% labour savings.[3]

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	1791	14,609
VIC	1148	9361
QLD	1618	13,197
SA	264	2155
WA	763	6223
TAS	59	480
NT	96	780
ACT	126	1029
Australia	5864	47,834

2. Strategy& (2019) Putting GCC Cities in the Loop
3. Ellen MacArthur Foundation (2015) Delivering the Circular Economy: Toolkit for policymakers

Sharing and multipurpose use of space

Embracing circular opportunities in the built environment is not just about how we design and build for the future, but also retrofitting and encouraging better use in the environment we already have.

Sharing and multi-purposing of spaces is key to maximising the use of the buildings we already have, and also reduces the need for new building construction.

Multi-purposing applies mainly to commercial spaces through co-working (offices shared by workers from multiple organisations). It can also apply to residential spaces being used as an alternative to traditional hospitality spaces. Digital applications can also facilitate the sharing of spaces and allow versatile utilisation throughout asset lifetime.

It is acknowledged that while COVID-19 may have accelerated the adoption of some circular ideas in the built environment (such as teleworking), it may slow others, like sharing. Public health measures are likely to reduce this opportunity in the short term and influence longer term attitudes. However, we do not believe this eliminates the potential of sharing (although processes and policies may look different). In the medium term, as organisation realise their built environment requirements have been disrupted by COVID-19, the potential for sharing with a smaller footprint may increase.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	360	3,776
VIC	289	3,032
QLD	219	2,302
SA	43	455
WA	86	907
TAS	12	123
NT	5	56
ACT	19	203
Australia	1,034	10,855

District cooling

Energy efficiency in operations of the built environment offers many circular opportunities. These include use of high performance insulation, optimisation of natural light, use of solar water heating, design to ensure energy and water efficiency coupled with use of renewable sources of energy.

District cooling is one opportunity that offers great potential to increase energy efficiency where cooling can consume significant energy. This has already been adopted in the Australian context. Brisbane was the first city to adopt a district cooling network, with energy savings ranging between 10% to 30% for individual buildings as well as C02 emissions reductions of up to 24,000.[4]

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	458	3697
VIC	423	3422
QLD	289	2347
SA	102	832
WA	187	1468
TAS	20	174
NT	11	84
ACT	32	252
Australia	1521	12,276

4. Brisbane City Council (2017) Clean and Green Strategy 2017-2030

High value recycling and reuse of modules

As mentioned, construction and demolition currently produces the same amount of core waste as all other industry sectors combined. Approximately 65% of that is currently recovered.[5] There is scope to reduce waste through reuse, and to increase the recycling rate of that waste that is produced.

At the point of end-of-use, disassembly should be favored ahead of demolition. The resulting high-value recycling reduces waste, and captures value that would otherwise be destroyed. This process can save up to 30% of material costs, while increasing associated labour costs by only approximately 5%.[6]

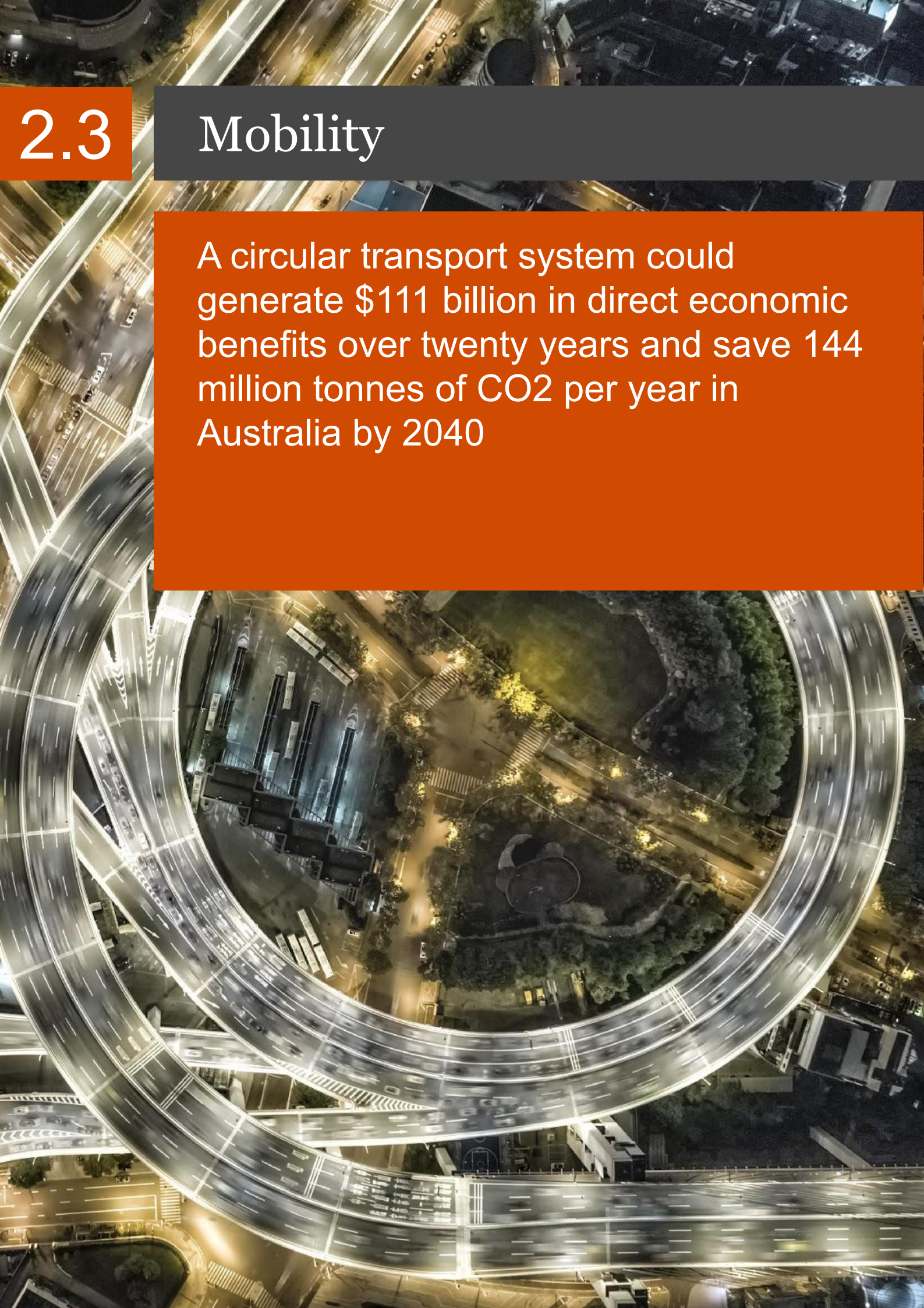
Recycling of construction modules also reduces the demand for virgin, non-renewable resources, and the energy needed to extract and process them.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	17,672	170,642
VIC	12,911	124,674
QLD	10,050	97,049
SA	3109	30,021
WA	4228	40,825
TAS	992	9580
NT	317	3061
ACT	818	7894
Australia	50,097	483,747

5. Australian Government (2020) National Waste Report 2020
6. Ellen MacArthur Foundation (2015) Delivering the Circular Economy: Toolkit for policymakers

2.3 Mobility

A circular transport system could generate $111 billion in direct economic benefits over twenty years and save 144 million tonnes of CO2 per year in Australia by 2040



2.3 Mobility

Mobility benefits

Our analysis suggests that a more circular mobility system could generate direct benefits of $13 billion in 2040, or an average of 0.19% of GDP each year for the next 20 years. These benefits span economic, social, and environmental value by reducing congestion, traffic accidents, and fuel consumption, along with the costs associated with them. It can also achieve a substantial reduction in CO2 emissions, by up to 144 million tonnes in 2040 (compared to business as usual projections).

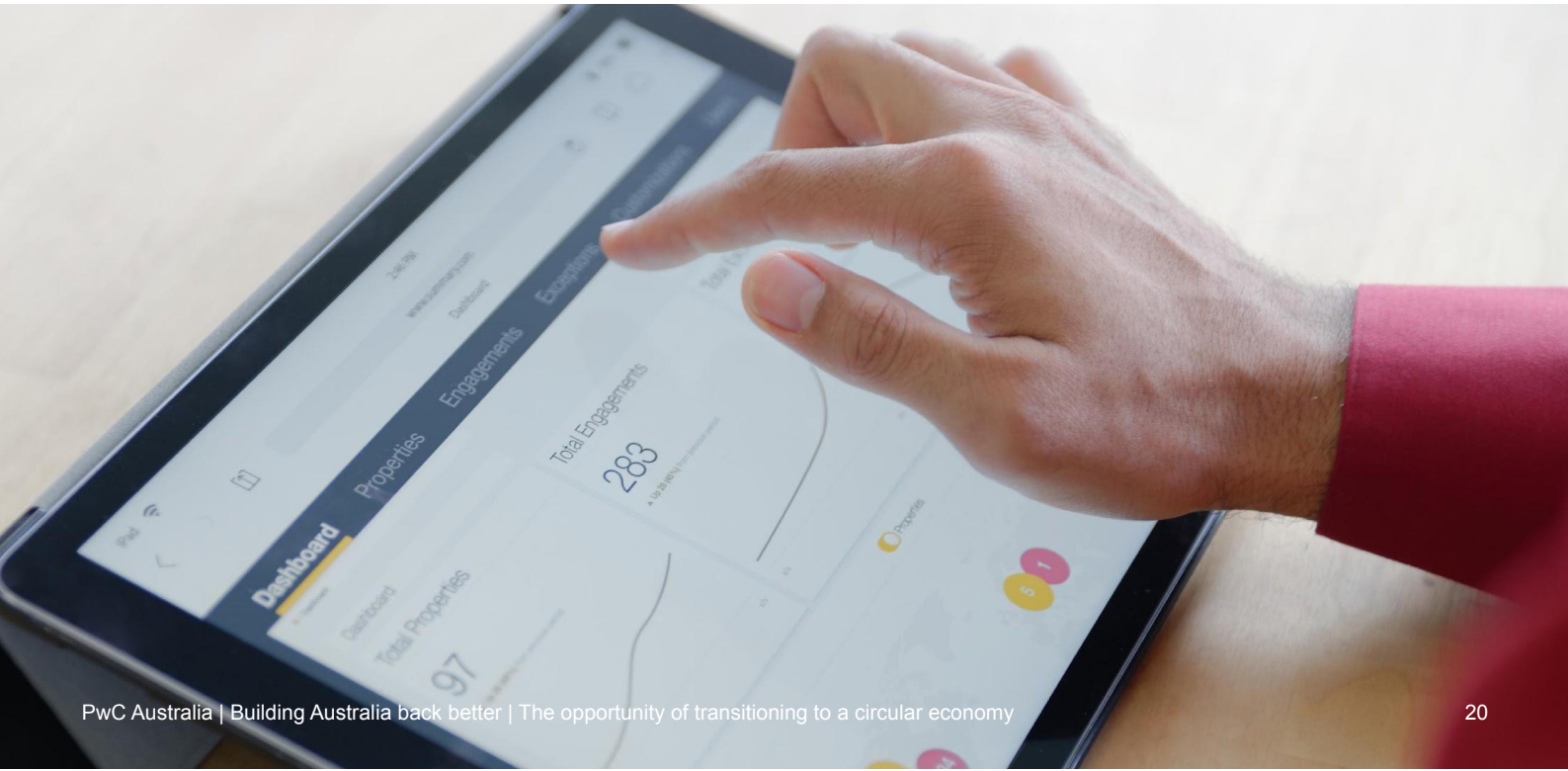
A circular mobility system provides interconnected and ubiquitous public transportation solutions. It provides safe, clean, and energy-efficient alternatives to the traditional petrol-based cars, and promotes ride sharing.

A circular mobility system requires technology improvements, public infrastructure investments and a shift in community attitudes. However, this is a lower area of potential benefits because of the amount of attention that this area receives by policy markers, making the business as usual case already ambitious in efficiency and benefits.

Mobility opportunities

The following opportunities were identified for making our mobility system more circular. The first three, shown in bold, are those that are deemed to be high priority and have associated benefits quantified:

- **increased use of personal electric vehicles**
- **increase adoption of connected and autonomous cars**
- **increased use of intermodal transportation systems**, through a system-level integration of all transport modes, combined with last mile connectivity
- use of clean and renewable energy sources across all transport modes
- increased usage of shared personal and transit transportation systems
- increased car repair and used parts sale
- predictive transport asset maintenance through smart asset management systems for cars and public transport modes.



Autonomous vehicles

Autonomous driving is becoming increasingly closer to a reality in our personal transport systems. The technology is being advanced by both traditional automotive industry and technology giants.

With increased adoption, autonomous vehicles could improve the mobility system through reduction in congestion by 50% by closing space between cars and reducing accidents by 90% through avoiding human error.[7]

These benefits will come with increase purchase costs of vehicles, but will still result in net direct benefits in the long term, as prices of the vehicles come down through advancements and production scale, as shown below.

These benefits are expected to be the furthest away of those examined in this report, with mass production not expected to start until 10 to 15 years from now. Therefore the benefits are generally only realised in the last few years of those examined. Governments can start now in creating the right conditions for their adoption.

Electric vehicles

Electric vehicles (EVs), including battery-powered, hydrogen-powered and plug-in hybrid vehicles, are expected to grow rapidly in Australia, as they are worldwide.

EVs can reduce pollution and car-associated fuel consumption, and as part of a city system, electric vehicles can support renewable energy production. EVs are also safer, due to their lower speed, lack of combustion risk, and the integration of basic automation features that help to prevent accidents.

Additionally, operations and maintenance costs of EVs are lower than those of petrol and diesel vehicles (as electricity is cheaper than fuel and EVs require less maintenance as they have fewer moving parts).

As with autonomous vehicles, these benefits do initially come with an increased purchase price for electric vehicles. However, these prices are already falling rapidly thanks to continuing reductions in battery prices.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	232	491
VIC	166	341
QLD	129	267
SA	39	79
WA	75	155
TAS	7	13
NT	6	13
ACT	5	10
Australia	659	1,3710

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	3087	27,254
VIC	3122	27,144
QLD	2312	20,222
SA	688	6247
WA	1240	10724
TAS	217	2,013
NT	75	659
ACT	150	1304
Australia	10,892	95,567

7. Swinburne University of Technology (2017) “Self-driving cars could dramatically reduce the road toll,” Swinburne University of Technology, Sep. 26, 2017

Intermodal public transport

A connected, multi-modal transportation system with sufficient capacity, speed and comfort provides the fundamental basis for a circular mobility system.

This system relies on the availability of public transport and on a digital interface to manage the provision of a transport related services and let people shift between personal, shared, and public transportation in an optimised mobility system.

This expands customer travel choice and supports greater efficiency in how our transport services are provided leading to increased use of public transport systems.

This can reduce travel in personal vehicles with associated emissions and accident risk and reduce overall congestion. Intermodal commuting is often used to combine the strengths of various transportation options, and reduce dependence on the car.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	782	7,013
VIC	367	3,305
QLD	193	1,691
SA	66	602
WA	125	1,106
TAS	5	44
NT	10	83
ACT	8	72
Australia	1555	13,916

2.4 Community

Circular communities could generate $175 billion in direct economic benefits over twenty years and save 16.7 million tonnes of CO_2 per year in Australia by 2040

2.4 Community

Community benefits

Our analysis suggests that circular behaviours adopted in our community could generate direct benefits of $15 billion in 2040, or an average of 0.29% of GDP each year for the next 20 years.

Circular strategies at the household level will generate multiple benefits. It minimises the usage of finite resources; reduces costs associated with excessive consumption of electricity and purchase of food; extracts greater value from recycled waste; and substantially reduces CO2 emissions.

More than the other categories examined, creating a circular community, one that is mindful of resource consumption, use, and disposal is most dependent on individual attitudes, rather than broad investments or policies. Governments can influence, but not guarantee, these attitudes through the provision of information, setting incentives through policy and reducing costs of these behaviour through supportive recycling infrastructure.

Community opportunities

The following opportunities were identified for realising circular benefits in our community. The first three, shown in bold, are those that are deemed to be high priority and have associated benefits quantified:

- **Improving energy consumption attitudes** (e.g. turning off AC when not in use, unplugging appliances when not in use, sourcing low-energy consumption fittings)
- **Sorting and recycling of materials** (e.g. water, organic, plastic, glass, paper, metal)
- **Reducing avoidable food waste**
- Sourcing products made of bio-based, recycled material
- Increased focus on household appliance repair
- Sharing of durable assets (e.g. lawnmower, tools)
- Extending water use cycle (e.g. using grey water for greening and landscaping)

Community energy attitudes

Adopting efficient energy consumption behaviours is essential to reducing associated energy wastage. These include turning off the lights in vacant rooms, adjusting the air-conditioning thermostat, and unplugging appliances that are not in use, coupled with adoption of proven technologies (such as light sensors and home automation) and conscious selection of energy efficient fittings and appliances.

Fittings that consume little energy, such as LED lights, can bring savings of up to 70% to 90% in electricity consumption and associated CO2 savings.[8] Similarly, water-efficient fittings can reduce water consumption by more than 60% for showers and faucets.[9]

Awareness on efficient energy consumption behaviours coupled with adoption of proven technologies are necessary to reduce the associated energy wasted.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	2187	21,405
VIC	3029	29,094
QLD	1089	10,557
SA	578	5840
WA	637	6091
TAS	119	1224
NT	53	513
ACT	61	591
Australia	7754	75,315

8. International Energy Agency (2020) Lighting, IEA, Paris https://www.iea.org/reports/lighting
9. Australian Government (2020) Your Home - Reducing Water Demand

Food waste

Preventing the generation of organic waste represents another significant opportunity. Reducing avoidable food waste reduces the energy and resources required to produce food that is never consumed, reduces the emissions from transporting that food and then reduces the requirement to process that waste.

The savings could be achieved by a number of consumer and retail activities such as right-sizing the shopping basket and buying per unit, better awareness on optimal food preservation practices, optimised ordering and pricing at retail stores, and smart packaging for incrementing shelf-life.

In addition to the value associated with the wasted food, reduced food waste leads to significant greenhouse gas savings at all stages of the cycle (less transport, less cold storage, less landfill).

Australia already has high goals for reduction of avoidable food waste. Australia has set a goal to halve its food waste by 2030, aligning with the UN's Sustainable Development Goal 12.3.

Efficient recycling

Recycling rates of household waste current vary state to state. Not only is there potential to increase these rates, but also ways to more efficient capture the true value of recyclable materials if they are sorted and treated effectively.

A transition towards increased recycling of materials can achieve significant value and reduce landfilling practices.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	1258	18,033
VIC	1716	24,104
QLD	1469	20,814
SA	490	7287
WA	649	9050
TAS	199	3038
NT	29	413
ACT	26	364
Australia	5836	83,102

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	897	8002
VIC	420	3626
QLD	242	2104
SA	119	1070
WA	139	1191
TAS	19	172
NT	2	18
ACT	38	330
Australia	1876	16,513

10. Australian Government (2017) National Food Waste Strategy

2.5 Industry

Industry benefits

Our limited analysis of potential benefits from circular industry suggests direct benefits of $801 billion in 2040.

Circular industry adopts conscious policies in the way they work, in the energy they consume and they waste they produce. But circular industry also provides the next wave of innovation to promote a future circular economy. Circular organisations will design the products and services that will we require to keep advancing in a circular journey.

Industry opportunities

As discussed above, the identification of circular opportunities will depend on the innovation and attitudes of the organisations in industry. Therefore, we have included just two known opportunities in our analysis, anticipating that there will be many more to be identified in the future:

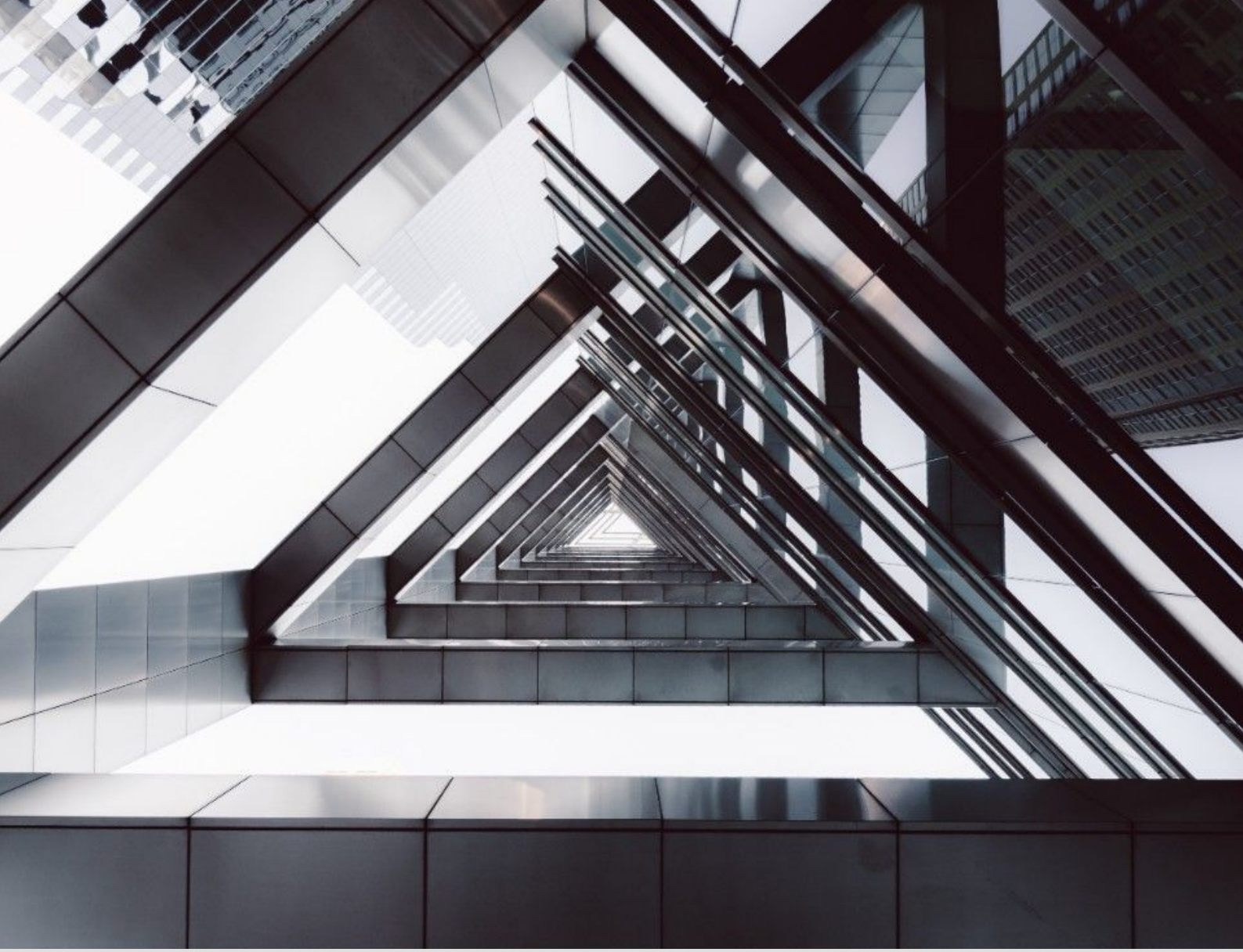
- the manufacturing industry switching to renewable energy sources over coal and gas
- production of green steel in Australia replacing some iron ore exports for manufacturing overseas.

Manufacturing use of renewables

Grattan Institute research shows the potential savings if Australia's manufacturing industry used renewables to replace their coal and gas energy use.[11]

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	232	491
VIC	166	341
QLD	129	267
SA	39	79
WA	75	155
TAS	7	13
NT	6	13
ACT	5	10
Australia	659	1,369

11. Grattan Institute (2020) Start with steel: A practical plan to support carbon workers and cut emissions



Green steel

‘Green steel’ or steel that is produced using renewables and efficient practices presents a large opportunity for Australia.

The direct benefit estimate below shows the export opportunity of green steel, netted from the resulting reduction in exports of iron ore.

	Benefits in 2040 (millions $)	Cumulative benefits to 2040 (millions $)
NSW	21,485	294,349
VIC	0	0
QLD	34,377	470,959
SA	0	0
WA	0	0
TAS	0	0
NT	0	0
ACT	0	0
Australia	55,862	765,308

Part 3

A way forward - going circular

3.1 Embracing the challenge

To set in motion the transition to a circular economy and reap the potential benefits, an integrated and comprehensive national framework is required to ensure government and industry contribute toward a solution.

The challenge is to now reinvent our economy to grow our standard of living without depleting natural resources and harming the natural environment.

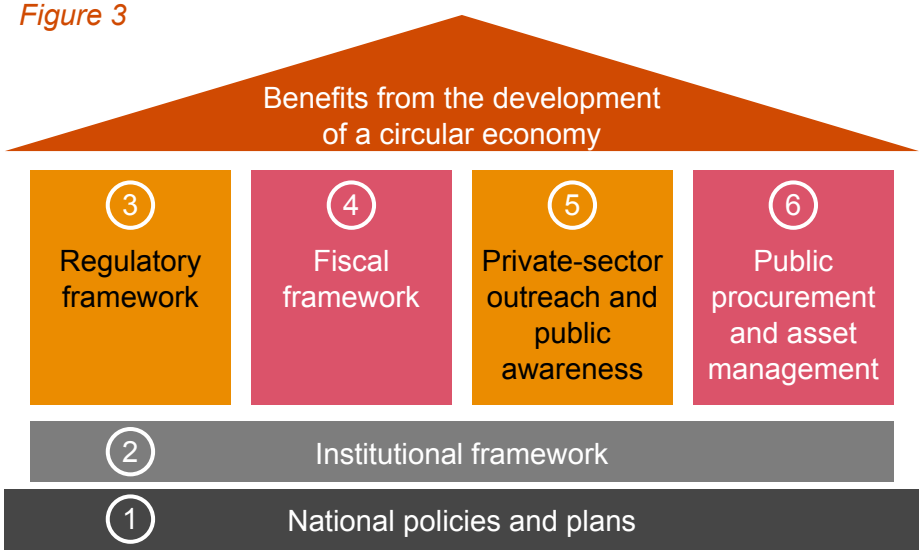
In order to address this challenge, at a high-level, there are three ways to drive change:

1. **stopping certain activities**, or the use of certain products, and finding substitutes or new technological solutions
2. where technological solutions or substitutes do not exist, or are not sufficient, **efficiency improvements** should lead to decoupling of resource use and economic growth
3. where neither stopping certain activities or generating efficiency improvements is enough, processes would need to **go fully circular** by closing all loops and eliminating all negative externalities in order to avoid an ecological collapse.

Australia has already started on this journey, protecting the environment by banning certain activities and in some cases decoupling them from economic growth. Concepts of sustainability are not new to policy or business decisions across Australia. For instance all levels of government have committed to reduce, reuse and recycle the goods and products we no longer need, and set dedicated targets to reduce waste by 2030.

However, we still lack a holistic approach for incentivising circularity in Australia. Figure 3 illustrates the key pillars required to facilitate Australia's transition towards a more circular economy.

Figure 3



In order for the benefits articulated in this report, government and industry should focus on four actions to drive change.

1. A national circular economy framework

Despite circular economy principles underpinning the national waste policy, the focus of that policy is waste, and not a plan targeted to the end-to-end nature of transitioning to a circular economy. To compliment waste and energy policy, governments should integrate their efforts in a comprehensive national framework that will ensure all relevant stakeholders contribute toward a solution.

A dedicated and comprehensive circular economy strategy is a crucial step in the transition toward a circular economy. As part of this strategy, policymakers at all levels should agree and define priority initiatives to spearhead the transition. At the national level, this includes achieving resource efficiency and increasing the use of renewable inputs into product design. Similar frameworks can be seen in France, the Netherlands, and Scotland, among other countries.

2. Developing market dynamics and incentives for change

Private sector investment has rapidly shifted mainstream investment towards sustainability-focused companies in recent years. This shift in the market is born out of the growing understanding that climate risk presents investment risk, but also a historic investment opportunity.

The nations and companies that are the early movers towards lower carbon, more circular economic models will be the ones to capture the value from these new and growing markets. This includes the rapid growth of the ESG (Environment, Social and Governance) investment sector.

However, as discussed in Part 1 of this report market failures exists and in the presence of a market failure, free markets will not produce efficient or socially optimal outcomes. This is why governments also need to step in to regulate activities that otherwise lead to excessive negative externalities.

Resource scarcity is a problem that cannot be solved by the free market. In a free market economy scarcity will lead to higher prices for raw material and energy inputs, which in turn will force companies to improve their resource efficiency and innovate.

Higher prices will also create incentives for collection and re-use, which creates markets for second hand materials. Unfortunately, the majority of markets operate with market failures resulting in negative externalities for society as a whole.

Taxes or levies on polluting activities are one way for governments to make companies assume the external costs of their production activities. In addition to this, incentives that create positive externalities could be explored, for example innovative ideas that reduce the negative impact on the environment could be subsidised.

3. Creating markets for second-hand products and materials

For a circular economy model to work, markets for second-hand products and materials must exist. A challenge today is that not all second-hand materials are price competitive. The price of virgin input materials may be too low and the markets for recycled materials may be too small. A potential solution, could be through industry driving change through looking for new ways of turning waste into new input materials.

By incentivising the types of economic activity that help nature's ecosystems rather than deplete them, national and supra-national legislation has the power to protect the environment and accelerate the transition to a circular economy.

4. Focus on infrastructure and the built environment

Australia's cities contain 68% of the national population, with this expected to reach 74% by 2066.[12] In addition, Australia is entering a decade of unprecedented levels of investment in infrastructure and city-shaping projects. This is demonstrated by the Australian Government's $110 billion investments in transport infrastructure across Australia over the next 10 years.

The unprecedented levels of investments in infrastructure in Australia, presents a significant opportunity for government and industry to implement the circular economic principles and strategies into infrastructure. The following page presents PwC's Circular Infrastructure Framework, exploring the strategies to deliver circular cities and infrastructure in Australia.

12. ABS (2018) Projected population, Australia, 2017–2066

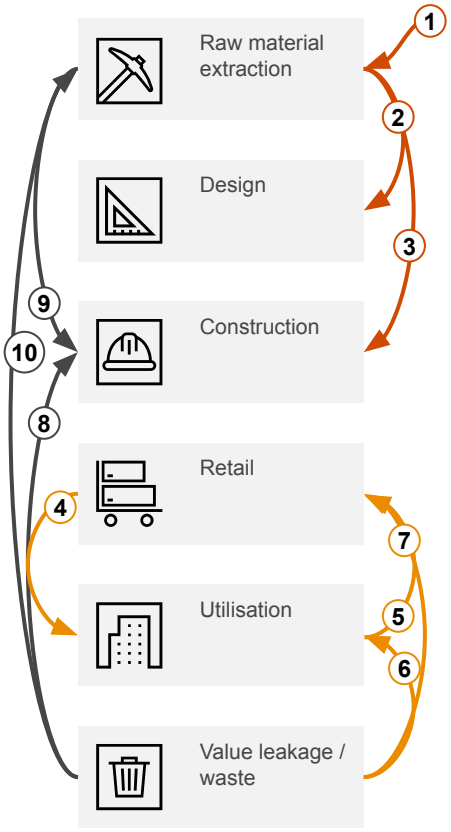
3.2 The road to circular infrastructure

PwC's Circular Infrastructure Framework

3 principles and 10 corresponding strategies

Principles		Circular strategies
Prioritise renewable inputs	1. Circular sourcing	Replace construction materials with renewable, bio-based, or recycled materials
	2. Sustainable design	Design infrastructure and buildings for disassembly
	3. Resource efficiency	Optimise usage of raw materials to minimise waste in the construction process (e.g. opting for prefabricated components or modular construction)
Maximise product use	4. Product as a service	Provide a service in areas that were traditionally sold as products (i.e. a developer pays a periodic fee for the use of a product rather than purchasing the product outright, for example modular facades)
	5. Sharing/ virtualising	Sharing or multi-purposing of assets (sharing of commercial and residential space through co-working and co-living)
	6. Usage optimisation/ maintenance	Increase the performance and efficiency of product to maximise its life span
	7. Reuse/ distribution	Purchase and sell second-hand materials
Recover by-products and waste	8. Refurbishing/ remanufacture	Remanufacture or refurbish existing buildings/ components for new usage, rather than down-cycling
	9. Recycling from manufacturing	Down-cycling waste or by-products from construction to be used for another product
	10. Recycling from consumption	Recycle discarded materials after demolition/ deconstruction

Infrastructure lifecycle



The anticipated pipeline of infrastructure in Australia expected to be deliver over the next decade presents a significant opportunity for government and industry to rapidly implement circular economic principles and strategies into the built environment. This is crucial as the construction and demolition sector in Australia currently accounts for 31% (23 metric tonnes) of the waste in Australia.[13] This is partly due to the nature of sector, but also because of the conventional design and construction methods currently adopted leading to significant waste.

As illustrated in this report, there are significant benefits generated by government and industry transitioning toward a circular economy. The framework above presents a pathway to a more circular infrastructure and built environment in Australia.

Incorporating circular opportunities throughout the asset life of infrastructure and the built environment creates value for the economy, provides opportunities for industry to create new revenue streams, products and services, and better outcomes for our environment.

13. Australian Government (2020) National Waste Report 2020

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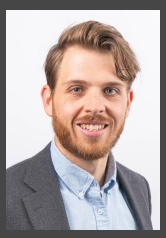

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PwC commits to net zero by 2030

PwC announced a science-based commitment to achieve net zero greenhouse gas (GHG) emissions by 2030.

Our net zero ambition will require us to reduce our total GHG emissions by 50% in absolute terms over the next decade. We'll achieve this by driving energy efficiency improvements in our offices and reducing the GHG emissions associated with our business travel.

PwC's commitment to net zero builds on our 2018 environment ambition to drive efficiencies, go 100% renewable, and offset 100% air travel emissions from FY19 and residual energy use by FY22. It is also an extension of our commitment to be carbon neutral, which we have continued since 2008.

We recognise that healthy environmental ecosystems are of great importance to First Nations populations globally and acknowledge Aboriginal and Torres Strait Islander peoples' profound spiritual connection to land. To find out more visit www.pwc.com.au

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