State of Play for
Circular Built Environment in Oceania

Countries considered:
Australia and New Zealand

Author: Prof Usha Iyer-Raniga, RMIT University
Organisation: RMIT University

Reviewed by: Dr Scott V. Valentine
Organisation: Director and Senior Circular Economy Specialist, KPMG Australia

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One Planet Network

The One Planet network has been formed to implement the 10-Year Framework of Programmes on Sustainable Consumption and Production (SCP), which supports the global shift to SCP and the achievement of SDG 12. The One Planet network brings together actors from all regions and all sectors to bring together expertise, resources, innovation and commitment towards a shift to more sustainable modes of production and consumption. The network comprises of six programmes: Sustainable Public Procurement, Sustainable Buildings and Construction, Sustainable Tourism, Sustainable Food Systems Programme, Consumer Information for SCP, Sustainable Lifestyles and Education.

Sustainable Buildings and Construction Programme

The Sustainable Buildings and Construction Programme (SBC) aims at improving the knowledge of sustainable construction and to support and mainstream sustainable building solutions. Through the programme, all major sustainable construction activities can be brought together under the same umbrella. The work involves sharing good practices, launching implementation projects, creating cooperation networks and committing actors around the world to sustainable construction. The goal of the programme is to promote resource efficiency, mitigation and adaptation efforts, and the shift to SCP patterns in the buildings and construction sector.

State of Play Reports

The Sustainable Buildings and Construction Programme has been preparing regional reports on the state of play for circular built environment in Africa, Asia, Europe, Gulf Cooperation Council countries, Latin America and the Caribbean, North America and Oceania. In addition to regional outlooks, a global report has been produced to summarise and compare the state of play regarding circularity in different regions. A crucial part of the reports are to not just provide a benchmark but also recommendations on how to move forward towards a sustainable and circular built environment.

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List of acronyms

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
APCO	Australian Packaging Covenant Organisation
ARL	Australian Recycling Label
C&D	Construction and demolition
C&I	Commercial and industrial
CDS	Container deposit scheme
CE	Circular economy
CRS	Container refund scheme
CEA	Circular economy accelerator
DWER	Department of Water and Environmental Regulation
EMF	Ellen MacArthur Foundation
EPA	Environment Protection Authority
EU	European Union
FTE	Full-time equivalent
GDP	Gross domestic product
GHG	Greenhouse gas
GSP	Gross state product
Gt	Gigatonne
HLPF	High-Level Political Forum
IRENA	International Renewable Energy Agency
MSW	Municipal solid waste
Mt	Megatonne
NDC	Nationally Determined Contribution
NSW	New South Wales
PET	Polyethylene terephthalate
SA	South Australia
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
UK	United Kingdom
UN	United Nations
US	United States

Executive summary

This report examines the challenges and opportunities arising from transitioning to a circular economy in Australia and New Zealand. The fact is that as populations rise, material use increases. Historically, we have seen a trend globally whereby material use per person increases as incomes grow. In developed economies, waste has largely been 'out of sight, out of mind'. If emerging economies and least developed countries begin to adopt the same trajectories as those of the developed world, we will be locked into a linear approach and reach a point of no return globally.

As the built environment 'churns' out products and materials through complicated processes of inputs and outputs, the building and construction sector needs to start taking some responsibility for the waste it produces. Throughout Oceania the main streams of waste – municipal solid waste, construction and demolition waste and commercial and industrial waste – are not being mined to the full extent possible. A complex web of issues related to undervaluing the concept of waste itself, market pricing signals, untapped/unexplored market mechanisms, government policy and community education is contributing to the problem.

States in Australia and New Zealand have been forced to confront the waste crisis due to China's 'National Sword' policy. Rather than developing yet another mechanism for waste management, there is an opportunity to leverage the current crisis in order to establish a circular economy based on a resource optimisation strategy. This would need to recognise the importance of an inherently holistic, systemic approach insofar as waste or output from one sector can be food or input for another, as occurs in nature. This requires us to rethink traditional sectoral boundaries and bring industry, government, community and academia together to rethink and develop novel solutions to the problem.

Governments need to lead by providing strong leadership, policy platforms and engagement in research. All industries need to start innovating and working with each other, communities and all levels of government and academia and to identify the 'sweet spots' where possible to develop ground-breaking solutions that can be mainstreamed and upscaled. Communities need to support government, industry and academia by being willing participants in raising awareness of the waste crisis and educational processes needed to support circular economies. Academia should not only engage in research but also incorporate the results of research into day-to-day teaching, arming students with the knowledge they need to face the challenges of the 21st century.

In the Oceania region, greenfield, brownfield and greyfield developments are taking place due to population increases. This requires a planned approach. Given the different lifecycle phases of the built environment, long-term and holistic thinking is required. Virgin material use needs to be reduced and, where possible, materials need to be mined when rebuilding or refurbishing is taking place. Better maintainability, longer shelf life and reusability or even upscaling building products and materials need to be considered at the outset as well as for the ongoing management of buildings. The rhetoric must shift from recycling (downcycling) to reuse/retain/increase value (upcycling). Rather than demolition of buildings, disassembly or deconstruction should be adopted.

Such approaches will reduce environmental impacts and truly decouple growth from environmental degradation. Further, such opportunities will also create jobs as has been shown clearly in the Victorian and South Australian circular economy policy frameworks. Thus, new businesses may be created where material inputs from one sector provide new economic

opportunities at the local level through new supply chains, business innovation, material tracking, product stewardship, prefabrication and digitalisation, to name a few potential areas for development.

If a clear strategy for a circular economy is not developed and implemented now, it will remain a lost opportunity.

1. Introduction

According to a report by the Organisation for Economic Co-operation and Development (OECD, 2019), the forthcoming decades to 2060 will lead to greater resource use due to growing populations and attendant growing incomes. We will also see a global gross domestic product (GDP) increase quadrupling current levels, and per-capita income of around USD40,000 reaching current OECD levels (OECD, 2018, p. 3). As emerging and developing economies grow, production and consumption patterns will also increase, leading to increased material use. Some areas will attract the sharing of services such as bike hire, and Uber and Airbnb services, which will assist in decoupling growth in production levels from material inputs and attendant environmental impacts.

This growth in material use calls for policies and programmes that question the status quo and support a way of doing things that is better than the current business as usual so that forthcoming generations are not faced with the same problems facing current generations in relation to the built environment and associated emissions. The ultimate goal is to set and maintain a trajectory towards low carbon pathways.

The aim of this report is to provide a state of play with respect to circularity in the built environment in the Oceania (Australia/New Zealand) region. Desktop research focusing mainly on grey literature and secondary sources of information was undertaken to provide a broad-brush understanding of policies and programmes, including mandatory programmes as appropriate, and of what constitutes a baseline or starting point to develop a roadmap into the future that supports the aims of decreased material and other resource use. Wherever possible, key global, national and local government sources of published information are used.

The report is divided into sections that facilitate understanding of the key underpinnings of circularity in the built environment for the Oceania region. For Australia/New Zealand, China's National Sword policy (Government of South Australia, 2019) on importing waste from other countries presents a good starting point for the analysis and engaging in further discussion, as this policy has catalysed discussions in these countries about waste arising from three broad streams: municipal solid waste (MSW), construction and demolition (C&D) waste, and commercial and industrial (C&I) waste.

This report commences with an examination of the significance of a circular economy (CE). To better understand how circularity in the built environment can support sustainability and the United Nations (UN) Sustainable Development Goals (SDGs), the impact of the built environment needs to be understood. Following this, the subsequent sections are dedicated to understanding waste. Waste has been considered a driver of thinking on the circular economy in the Oceania region, including on the economic underpinnings and options for recovery. The role of policies and legislation across Australia and New Zealand is also considered. This is followed by an analysis, leading to the discussion and conclusion.

2. Significance of this work

A circular economy may be seen as 'closing the loop' or ensuring that waste does not end up in landfill. The main purpose is to reuse or repurpose waste as material inputs are reused within the system such that there is little or no need to use virgin resources. Upcycling in this context refers to a higher value creation from a lower value or that which is considered to be of no value or to be discarded. This requires not just better understanding of goods and products so that at end of life materials may be extracted for reuse, but also breaking traditional silos so that shared services and shared knowledge can be used to cultivate cross-disciplinary innovation, 'out of the box' solutions and better understanding of living within planetary boundaries. Digitalisation is seen to be a key requirement; but it is noteworthy that a good understanding of materials in the current system and of predicted use of materials in future is also necessary to support circular economies. The built environment may be considered a system in which various inputs (materials or services) are manufactured or produced, and churned through the system, and outputs in the form of waste are created. In this context, material use is significant. Therefore, a solid understanding of materials is a key starting point.

Appropriate material use is key to a successful circular economy. OECD research (OECD, 2018) identifies that globally, material use is expected to double by 2060 based on 2011 figures. In 2011, 79 Gt of materials were used worldwide and by 2060 this is expected to rise to 167 Gt. However, the intensity of materials use will fall by about 1.3% on average annually due largely to greater efficiencies and recycling practices. Recycling is expected to become more competitive. The increase in production and use of materials overall will lead to an increase in environmental impacts. Greenhouse gas (GHG) emissions will rise to about 50 Gt of CO2e by 2060. As a result of increased building and construction activities, particularly in China and India, compared to 2011 figures, related material use will increase. The essential ingredients for the built environment – sand, gravel and limestone – will show a significant increase, leading to attendant rises in GHG emissions, along with growth in the production of iron and steel. Primary materials extraction has a greater environmental impact than secondary materials use, further supporting the argument to move to circular economies.

Construction in China is expected to stabilise post 2025. However, strong growth in India and growth in Sub-Saharan Africa will counter China's decline. Asia, overall, is expected to experience growth in construction and material use of 2.5% between 2011 and 2025, followed by the Middle East and Africa. The building and construction sector in the United States (US) and Europe will grow at about the same pace by 2060. While globally, agricultural material use will grow by 1.8 times on 2011 figures, construction and utilities will increase by 2.6 times, and industry and services by 3.2 and 3.3 times, respectively by 2060. Also, by this same year, it is expected that recycling will see the highest growth at 3.7 times, while mining will experience a more modest rise at 2.6 times the 2011 growth rate. Income per capita is expected to be 2.7 times more than the 2011 figures while total materials use will grow by 2.1 times. Materials use per day per person will increase from 33 kg in 2011 to 45 kg by 2050 as quality of life increases. The extraction and processing of key metals and the production of concrete will result in a 21% rise in total emissions by 2060 (OECD, 2018). Thus, the impact of the built environment in 2060 cannot be underestimated, even in the Oceania region.

Structural change and technological developments will reduce global materials use intensity by 2060, with construction still seeing the highest use compared to all other sectors. Despite the expected growth in the service economy, the growth and use of materials in the related sectors such as manufacturing by 2050 is set to be 250 Gt. The strongest rise in the use of non-metallic minerals will be in the developing countries and the OECD countries. Biomass is not expected to grow as much during this period and the rate will remain below average economic growth

rates. Fossil fuel use will also increase, but due to the projected trends in energy efficiency, the intensity of fossil fuel use will not be as high based on current trends due to the increased use of renewable energy shifting the focus away from fossil fuels (OECD, 2018).

Recycling is expected to grow faster than mining or material use because the former is currently a mature industry in some parts of the world. In 2017, in the OECD countries France, the United Kingdom (UK), Germany and Italy, recycling rates were a little over 2%, with reprocessing was much lower at 1.5–2%. This is in stark contrast to the rates in some other regions, such as Sub-Saharan Africa (but not South Africa) where recycling rates are at approximately 9.5% and reprocessing is just under 9%. These rates in Sub-Saharan Africa are comparable to those of India, where recycling stands at almost 7% and reprocessing even higher at almost 8% (OECD, 2018, p. 149). Yet there is potential for this to change because where a substantial informal recycling sector exists in developing economies such as in India or Sub-Saharan Africa, these economies will likely follow the same trends seen in the western world such that recycling rates will fall. It is anticipated that an increase in waste materials will lead to an attendant rise in the availability of recyclable materials.

In 2060, global recycling rates will double from 2030 rates, as closing-the-loop processes will become more entrenched and mainstreamed in all economies. As economies mature, the potential for reprocessing materials rises. Between 2017 and 2060, worldwide recycling and reprocessing will multiply their outputs by 3.2% and 2.4%, respectively (OECD, 2018, p. 150). Material intensity (the ratio between the amount of materials used, in weight, and the value of the related economic output – OECD, 2018, p. 36) is expected to decline, primarily in China and India, and by 2060 there will be an overall increase in material use from 2011 figures, reaching 38 Gt in China and 23 Gt in India (OECD, 2018, p. 14). Sand, gravel and crushed rock will see the highest increase in construction materials use during the 2011–2060 period (p. 15). The increased extraction and use of materials will contribute to global increases in GHG emissions, with an expected total emissions projection of 75 Gt of CO2e by 2060 (OECD, 2018, p.17). Based on current trends, concrete alone is expected to be responsible for 9% of total GHG emissions (OECD, 2018, p. 18).

Thus, material extraction, processing and use is central to economic circularity and in the building and construction sector. In Australia and New Zealand, waste has become a catalyst for change and debate in the region due to the introduction of China's National Sword policy. Australia's population (Australian Bureau of Statistics [ABS], 2019a) is expected to increase to between 37.2 and 49.2 million people by 2066 compared to 24.6 million people in 2017. This is based on growth and change resulting from fertility, mortality and internal migration. New Zealand's population as at 31 December 2018 was 4.89 million (Stats New Zealand, 2019a) and has a 90% probability of increasing to 5.29–6.58 million in 2043, and to 5.30–7.88 million in 2068 (Stats New Zealand, 2019a). These increased populations will put more pressure on urban and regional areas and will increase demand for services in the built environment, such as housing and other amenities and infrastructure.

As a result, it is essential to examine and better understand the opportunities arising from the waste crisis in this region. Before considering these issues, however, the next section will examine the role of the built environment and CE.

3. Built environment and CE

The built environment is formed by a range of different yet interrelated disciplines that need to collaborate to deliver on building and infrastructure. The way a built space is used is reliant on numerous factors including the users of the space. More so than other sectors, the built environment sector is perhaps confronted with 'wicked' problems such as the impacts of climate change impacts, and the professionals in this sector are required to contend with issues around adaptation, mitigation, resilience and disaster management, while at the same time endeavouring to achieve resource and related efficiencies from a low-carbon perspective. Responding to some of these problems can lead to tensions; for instance, considering only a mitigative perspective may lead to maladaptive solutions.

The SDGs (UN, 2019) consider the economic, social and environmental dimensions of sustainability, and came into effect in January 2016. The goals support a concerted effort across all scales to bring peace, justice, equity and harmony while also working within the confines of planetary boundaries. They also recognise that sustainability is indivisible. The 17 goals and 169 targets have direct and indirect impacts on the built environment. More specifically, targets 3.9, 6.1-6.4, 6a, 7.1-7b, 11.1, 11b, 12.1-12.2, 12.4-12.5, 12a, 13.1-13.2 and 13b directly impact on the built environment. Indirectly, the relevant targets 1.5, 4.4, 4b-4c, 6.5, 6b, 9.3-9c, 11.2-11.7, 12.6-12.8, 12c, 13.3, 17.6-17.7, 17.9, 17.14 and 17.16-17.18 also impact on the built environment (UN, 2019). Nowhere in these goals, targets and indicators are there any specific references to circular economy. Yet, central to the intent underlying CE are the goals of sustainability and more efficient production and consumption patterns, as outlined in SDG 12.

It has been estimated that, worldwide, 2.5 billion more people will move into urban areas by 2050 (UN, 2015). In terms of the transition to a low-carbon future, the latest International Renewable Energy Agency (IRENA) report (Renner, García-Baños and Khalid, 2019) states that the renewable energy sector has provided 11 million jobs in 2018, a rise from 10.3 million in 2017. Several factors affect how and where jobs are created such as national deployment considerations, government policies, supply chains and trade patterns. The solar sector is still the highest employer, followed by bioenergy and wind. The rise of carbon-neutral/zero-energy policies and programmes in various countries, including Australia, has supported an increase in the use of solar energy. Australia does not lead the pack, but currently follows China, India, the US and Japan. On average, 70% of the electricity demand of urban and residential consumers could be economically met by combinations of rooftop photovoltaic panels and energy efficiency programmes (Makumbe, 2017). In Australia, a good example of this is seen in the efforts undertaken by Burder Industries (Makumbe, 2017). Burder has installed grid-connected rooftop photovoltaic cells, providing 90% of the company's power, thus reducing operating costs by 70%. Supplemented by energy efficiency options, the company has installed a new substation, implemented a power factor correction and adopted practices such as charging battery-powered equipment (including lifts) during the day, when solar generation is at its highest. Burder Industries won the 2015 Clean Energy Council Solar Design and Installation Award for its installation. Such initiatives provide operational savings; however, this alone is not sufficient to ensure a truly low-carbon future. Material use in buildings and construction also needs to be considered, as already stated in the previous section.

The built environment uses materials for buildings and infrastructure and continues to use materials during the process of operation. The role of the built environment as a whole needs to be considered as the built environment may be used as a catalyst for supporting the creation of a circular economy. The world is becoming increasingly urbanised as populations move into cities, as a result of which cities are becoming engines of energy and material use. The three main areas in which we can all support CE are space use, mobility and food. Space use needs to be considered because everyone lives, works and plays somewhere – in some space/s in

the built environment. We also use transport whether personal or public to move from place to place. And we eat and buy food within these spaces to survive.

Low productivity in construction, under-utilisation of some buildings and over-utilisation of others, high energy consumption due to poor designs and inappropriate behaviours, end-of-life waste and the presence of hazardous materials are all barriers to the adoption of CE practices in the built environment (Ellen MacArthur Foundation [EMF], 2015).

A circularity gap report was published in January 2019 by Circle Economy (2019). This report identified that countries can transition to a circular economy by setting comprehensive national policies to drive global action, and where possible by establishing collaborations with relevant stakeholders by opening up traditional borders. There are significant opportunities to scale up the transition to CE, particularly in building and construction (Circle Economy, 2016) and in the food and beverage sector (EMF, 2015). The EMF has identified that industrialised production and the printing of building modules will have a potential economic value of Euros 450–600 million annually by 2035; that reuse and high-value recycling will have a potential value of Euros 100–150 million annually by 2035, as a result of design for disassembly and new business models; and that the sharing and promoting of multipurpose buildings will potentially provide Euros 300–450 million annually by 2035 (pp. 111–20). For the same period, new skills and capabilities will be required for remanufacturing components and new business models, providing opportunities to the value of Euros 150–250 million annually (EMF, 2015, p. 123).

The ReSOLVE framework used by Arup (2016) and the EMF and McKinsey & Company (2016) adopts Regenerating, Sharing, Optimising, Looping, Virtualising and Exchanging as key parameters to support circularity in the built environment. Each element of the framework may be used across all scales of the built environment. ‘Regenerating refers to regenerating and restoring natural capital, where safeguarding, restoring and increasing the resilience of an ecosystem are prioritised. Sharing involves maximising asset utilisation, pooling the use of assets and reusing/adapting assets. Optimising system performance, prolonging an asset’s life, decreasing the use of resources and implementing reverse logistics are the main aims underpinning the move to optimise. Looping refers to keeping products and materials in cycles and prioritising inner loops such that remanufacturing and refurbishing products and components and recycling materials are prioritised. Virtualising involves displacing resource use with virtual use, replacing physical products and services with virtual services, replacing physical with virtual locations and delivering services remotely. This is where shared business models become particularly critical. Exchanging is about using new business models, including flexible design and use, and leasing and performance-based models to ensure flexible and optimised user-focused designs. This also includes using alternative material inputs in buildings, providing service-centric models, and using advanced technology where appropriate’ (Iyer-Raniga, 2019).

Not only are new building materials and advanced techniques of construction required, but also new business models so that the socioeconomic system can support circularity approaches. Iyer-Raniga (2019) has applied this framework across various building lifecycles and interactions with key policy frameworks such as zero-energy policies for selected case studies, and analysed the learnings from selected case studies, as well as the impacts across emerging markets.

At the building level, there are opportunities to support CE practices. The use of flexible volumes supported by modular construction can adapt current spaces for other types of use. For instance, warehouses being converted into apartments are an example of change of use from industrial to residential. Working from home or teleworking in locations close to home reduce or eliminate altogether the need for mobility. Building design and construction impacts the use of resources during and post construction and operation. Energy, water and waste all impact

the operation of a building and good design can lead to reduced energy use, provided that occupants adopt expected behaviours. The use of smart construction such as prefabrication; durable, eco-friendly materials, including local materials; smart technologies in spaces; and modular and other value engineering techniques all support good design and construction. Planning or placing the building appropriately within the site, and using approaches such as pedestrian-oriented, transit-oriented and medium- to high-density developments all support smart building ecosystems, particularly when they include appropriate nature-based and wider mobility solutions (EMF, 2015).

3.1 Oceania SDGs and Nationally Determined Contributions (NDCs)

Australia has made a commitment to respond to and report to the High-Level Political Forum (HLPF) on the SDGs (Australian Government, 2018). In the 2018 report to the HLPF, SDGs 1, 8, 11, 12, 14 and 15 were reported. Australia's intended NDC set in August 2015 is an extension of the current targets to 2020. The Emissions Reduction Fund and the Australian Government's direct action policy is supporting businesses and the community to reduce emissions. Australia will reduce GHGs by 26–28% below 2005 levels by 2030. Against 2005 levels, Australia's targets represent projected cuts of 50–52% in emissions per capita by 2030 and 64–65% per unit of GDP by 2030. Over 23% of Australia's electricity is expected to come from renewable sources by 2020 (Government of Australia, 2015).

In New Zealand, the SDGs administered by the government are focused on supporting Small Island Developing States (SIDS), improving donor coordination in the Pacific, strengthening the impact of domestic and international policy positions, supporting regional approaches in the Pacific and developing economic and social policies that promote effective implementation of the SDGs. In the process, among other priorities such as improving its economy, New Zealand aims to promote the elimination of fossil fuel subsidies and of fisheries subsidies and focus on ocean issues (Ministry of Foreign Affairs and Trade New Zealand, 2020). As part of the country's contributions towards ratifying the Paris Agreement, one of New Zealand's NDCs is to reduce GHG emissions by 30% below 2005 levels by 2030 (Ministry for Environment New Zealand, 2020a). This is building on a current target of 5% below 1990 levels by 2020, either by reducing emissions throughout the economy or purchasing international units to make the shortfall. New Zealand's emissions have increased more than that of other developed countries since 1990 and low-cost opportunities to reduce emissions are needed.

4. Waste as the driver

The World Resources Forum held in Sydney in 2015 estimated the value of CE in Australia to be at AUD26 billion per year by 2025 (Florin et al., 2015). Waste is defined as any material that has no further use or value to the previous owner in its existing state, leading to it being discarded. Dealing with waste management generally involves waste collection and transfer, sorting, recycling and reuse, and finally disposal. Private organisations and local government are usually responsible for the associated collection and transportation.

Figure 2 provides a glimpse of waste in mass generated by OECD countries in the Asia-Pacific region. While this report is concerned with Australia and New Zealand, data from relevant countries such as Japan and South Korea are reported for comparison as these countries have much larger populations than Australia and New Zealand. New Zealand's figures are much smaller in comparison to Japan and South Korea due to high population numbers and densities. Such differences in population size need to be considered when comparing the data on waste.

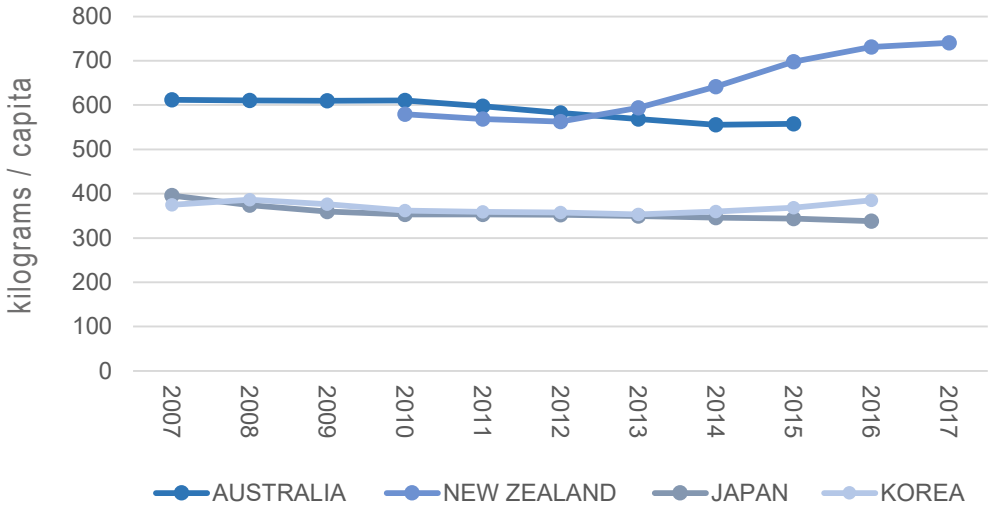


Figure 1: Municipal waste data (kg/capita) across Australia, New Zealand, Japan, and South Korea, 2007-17

Data source: OECD 2017

Graphics: Ninni Westerholm

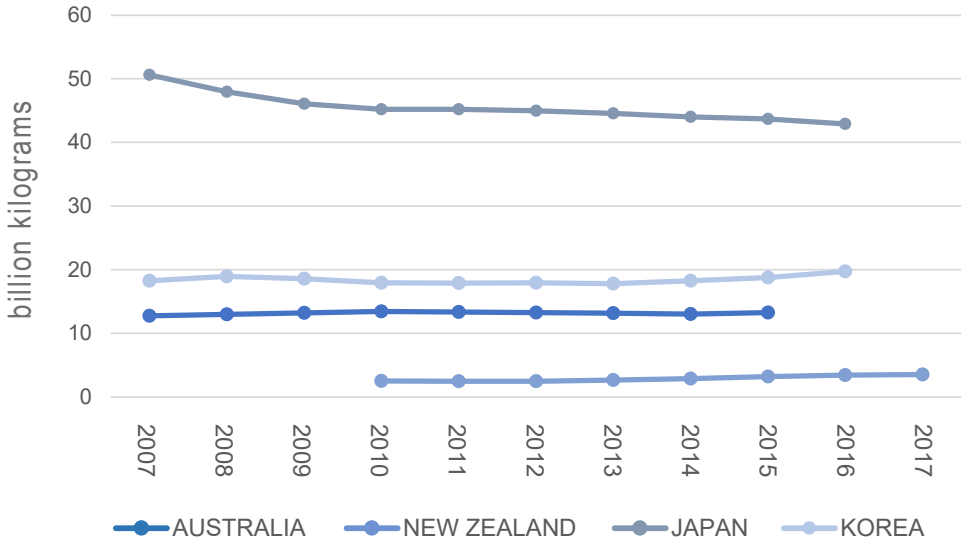


Figure 2: Municipal waste data (billion kg) across Australia, New Zealand, Japan, and South Korea, 2007-17

Data source: OECD 2017

Graphics: Ninni Westerholm

The remainder of this section focuses on waste in Australia and New Zealand. As explained earlier, waste includes municipal solid waste, construction and demolition waste and commercial and industrial waste. In Australia, solid waste collection services include the collection and removal of waste in the domestic, commercial and industrial sectors (2911 Solid waste collection services) (ABS, 2011). Portable toilets, bins and other receptacles for hire are also included in waste collection services. In addition, waste collection services cover bin hire and waste collection; garbage collection in domestic waste; hazardous waste and solid collection services; industrial waste collection services; metal barrel and skip hiring and associated waste collection; night soil collection services; portable toilet hiring and waste collection services; rubbish collection services such as skips hire; solid waste collection services; solid waste haulage services at a local level; and waste, solid waste, and collection service.

2921 Waste treatment and disposal services (ABS, 2011) consist of units mainly engaged in the treatment or disposal of solid, liquid and other types of waste (including hazardous waste). The operation of landfills, combustors, incinerators, compost dumps and other forms of waste treatment, including waste facilities and transfer stations but excluding sewage treatment facilities, are part of this regulation. This includes garbage disposal services, treatment and disposal of hazardous waste, landfills operation, operation of other treatment facilities, rubbish dumps or tips operation, sanitary disposal services, and septic tank pumping or cleaning services other than repairs and maintenance.

2919 Other waste collection services (ABS 2011) consist of units mainly engaged in the collection and haulage of domestic, commercial or industrial liquid waste and other waste types, except for sewerage systems. This category includes collection services for hazardous and industrial waste that are not solid waste; liquid waste collection and haulage services; oil collection services and septic tank waste collection services except repairs and maintenance; and waste collection services not classified elsewhere.

2922 Waste remediation and materials recovery services (ABS 2011) consist of units mainly engaged in the remediation and clean-up of contaminated buildings and mine sites, mine reclamation activities and removal of hazardous materials such as asbestos and lead paint, and other toxic material abatement. Also included are asbestos removal services, hazardous material removal, lead paint abatement, materials recovery station operations, materials separation and sorting operations, mine reclamation, remediation and environmental services, toxic material abatement and waste remediation.

In Australia, the regulation of waste is the responsibility of the state and territory governments. To increase the rates of recycling, new materials and products must be created such as creating tiles from agricultural waste, and applications tested and mainstreamed so that there are opportunities for market uptake. However, regulation and legislation in itself is not sufficient, as this represents the ‘floor’ or minimum standards rather than best practice or ‘ceiling’ standards. Thus, while legislation and regulation may be used as an incentive to ensure consistent standards across the whole industry it does not support innovation, entrepreneurship and best practice in the industry.

Self-regulation may be adopted to support industry to engage and provide profitable solutions in an ever-changing market, while also bringing the laggards of the industry up to par, making it easier for industry as a whole to achieve the aims of resource efficiency and attendant pollution reduction. In this context, product stewardship can support the production, supply and use of products from cradle to cradle, rather than from cradle to gate. Industry product stewardship provides the necessary framework for transparency and tracking of materials and has been mandated by the Product Stewardship Act 2011, which is used across all states and territories (Edge Envrionment Propriety Limited, 2012; State of Victoria, 2019).

Australia has increased its recycling rates from 7% in 1996 to 58% in 2016–17 (Ritchie, 2019). Australia's waste in 1996–97 totalled 22.7 Mt with a recycling rate of 7%, equating to 1.5 Mt – thus, 21.2 Mt ended up in landfill. In 2016–17, Australia's total waste was 54.4 Mt, 31.7 Mt (58%) of which was recycled. As a result, in recent times, the amount of waste going into landfill has been approximately 21.7 Mt (Ritchie, 2019). The latest figures (from 2016–17) indicate that Australia produced 20.4 Mt of construction waste, 13.8 Mt of household waste, 12.7 Mt of waste generated from electricity, gas and waste services and 10.8 Mt of waste produced by manufacturing (ABS, 2019b). The proportion of construction waste was the largest, at about one third of the total.

As Australia does not yet have a mature energy from waste industry, these recycling figures give cause for optimism. The Australian kerbside recycling system is quite robust and reflects best practice as opposed to that of New Zealand. However, policy settings in the Australian context still have a long way to go, particularly compared to the European Union (EU). The reduction in waste to landfill is largely due to consumption patterns per capita and population increases. Landfill prices in the various states and cities in Australia are not the same: they are higher in Sydney, Canberra, Adelaide and Melbourne (in order from highest to lowest), while Brisbane, Darwin, Hobart and Perth make up the bottom four with the lowest-rate levies.

China has been the primary destination for waste exports from Australia and New Zealand. Other destination countries in the region are Malaysia, Indonesia, Vietnam, Thailand and India. Two main groups of materials were affected by the import ban introduced by China in January 2018: mixed paper grades and plastics scrap with a maximum 0.5% contamination limit. Fibre grades of approximately 1.1 million tonnes of cardboard were generated in 2017, of which 638,000 tonnes went to China (Blue Environment, 2018; MRA Consulting, 2018). In January 2018, China imported about 2.5 million tonnes of fibre, 45% of which came from the US and 30% from the EU.

In comparison, New Zealand recycles approximately only 28% of its waste, with 15.5 million tonnes of waste discarded (Recycle NZ, 2020) and 300,000–350,000 tonnes of waste exported (MRA Consulting, 2018). New Zealand's resource recovery sector comprising collection, sorting and processing has investments in excess of NZD3 billion, with a turnover of approximately NZD1 billion annually. The sector employs between 15,000 and 20,000 staff (New Zealand Government, 2018).

The next section briefly examines plastics.

4.1 Plastics

Globally, the New Plastics Economy Global Commitment by the EMF and the UN supports businesses, governments and other organisations to address pollution caused by plastics and to transform the global plastic system. In Australia, the Australian Packaging Covenant Organisation (APCO) has been working closely with government and industry to reduce the impact of plastics on the environment. The Sustainable Packaging Guidelines, Packaging Sustainability Framework and Annual Reporting Tools are all available to support, develop and monitor packaging products in Australia. APCO's packaging recycling label programme incorporates the Australian Recycling Label (ARL) to assist consumers to better understand how to recycle products appropriately. This is now available in New Zealand as well (Circular Economy Accelerator [CEA], 2018).

Studies by the EMF indicate that only 14% of plastics globally are collected for recycling, with the rest being dispersed as garbage into the environment predominantly across land and water, including oceans. About 95% of plastic packaging material value is lost to the economy, to the value of USD80–120 billion annually (EMF and McKinsey & Company, 2016, p. 17). New Zealand exported NZD13.1 million worth of plastics overseas in 2017 (Stats New Zealand, 2019b). Plastics generally end up in landfill, are incinerated or escape into oceans, land and urban areas. Due to inadequate waste management infrastructure, plastics end up in the environment and cause untold damage to land and oceans, rivers and other water bodies.

With respect to plastics, New Zealand exported 41,000 tonnes in 2017. Other countries/regions such as the US, the UK, Europe, Japan, Mexico and Canada contributed a total of 14 million tonnes per annum in 2016, of which 7.35 million tonnes went to China (Brooks, Wang and Jambeck, 2019). Many businesses in New Zealand have signed the NZ Plastics Packaging Declaration committing to 100% reusable, recyclable or compostable packaging by 2025. Some businesses have also signed up to the New Plastics Economy Global Commitment led by the EMF alongside the UN. The Sustainable Business Network NZ has created the Circular Economy Accelerator (CEA), which provides events, publications and other resources as a platform for collaboration and innovation.

A system-wide approach to solving the plastics issue has led to the development of a CE approach for New Zealand where lifecycles are maximised, usage optimised at the end of life, and all materials are reutilised. Alongside the work undertaken for the EMF (World Economic Forum, EMF and McKinsey & Company, 2016), New Zealand's strategies in relation to plastics focus on the fundamental redesign of problematic plastic packaging and the elimination of plastics where possible, moving from single-use to multi-use models and recycling using 100% reusable, recyclable or compostable packaging, and using recycled content only by 2025 (CEA, 2018). To achieve these goals, New Zealand needs to reduce the types and complex formats of plastic packaging used, increase the number of processing facilities in New Zealand, improve the labelling of plastic packaging and implement consistent collections across the country. To support these outcomes, the New Zealand business community needs to undertake an audit of full plastic packaging, redesign packaging to enable better recycling quality and value, and support suppliers that are able to provide packaging with recycled content. For the packaging sector, implementing a standards-based national labelling system for recycling, compostable and recycled content, expanding markets for recycled content and expanding product stewardship schemes to include rigid plastics are needed. In turn, governments need to increase the waste levy to incentivise change, invest in onshore recycling facilities, initiate a system for accurate data collection for plastic packaging, develop bold plastic packaging strategies, facilitate collection and recycling processing nationwide, use its own procurement policies to drive the market, and provide direct research and development (R&D) funding for research into viable alternatives to single-use plastics.

New Zealand banned single-use plastic bags in mid-2019. New Zealand businesses have committed to using 100% reusable, recyclable or compostable packaging in their operations by 2025.

On 2 March 2020, the National Plastics Summit was held in Canberra, Australia. In addition to a number of global and Australian businesses committing to reducing the use of plastic, particularly in packaging, the ANZPAC Plastic Pact was signed with the EMF's Global Plastics Pact Network. ANZPAC will support the development of initiatives aimed at ensuring that at least 70% of all plastic packaging is being recycled or composted by 2025. This initiative is being led by APCO (Australian Government, 2020). This signals a broad commitment from the Australian and New Zealand governments and the business communities in these countries to tackling the problem of plastics, which has the potential to be expanded into the Oceania region.

4.2 Economic underpinnings for CE through waste

In the EU, the shift to CE is expected to add 900 billion Euros to the economy and create an extra 3 million jobs by 2030, which will result in higher GDP in the EU arising from an increase in consumption but more manageable GHG emissions (EMF, 2015). Australian government analysis indicates that 9.2 full-time equivalent (FTE) jobs are created for every 10,000 tonnes of material recycled, compared to 2.8 jobs per 10,000 tonnes of material sent to landfill (Otter, 2018). The business proposition is simple: businesses save money, and can then reinvest and grow their business to support new and better ways of doing things. CE relies on keeping products and materials in the system for longer, leading to a greater reliance on repair, refurbishment or leasing of products and shared services. In turn, this supports local employment through the creation of jobs in sorting facilities or community-based repair centres and includes supporting people with special needs to gain employment. This is explored further in section 7.4. The next section focuses on waste generated in Australia and New Zealand and opportunities for recovery.

5. Waste generated and options for recovery

OECD (2019) research has indicated that, by 2060, the volume of materials used globally is expected to double and that the emissions associated with their use and management are expected to contribute to 65% of global GHG emissions. With respect to the building and construction sector, the use of plastics in infrastructure through reuse of printer cartridges and the reuse of glass bottles for road base are now being trialled with some success. The use of recycled rather than virgin aluminium can reduce electricity and water consumption by over 90% (Sebaie et al., 2006). Studies conducted by the European Commission (2015) have indicated that a reduction of GHG emissions by 450 million tonnes by 2030 is possible.

Australia's National Waste Policy has been responding to SDG 12 in particular, dealing with sustainable consumption and production. The reports produced on the state of waste (Commonwealth of Australia, 2018) show that improvements in waste management in Australia are possible. Australians generate 67 million tonnes of waste per annum, which equates to 2.7 tonnes of waste per person. Australia recycles 37 million tonnes of waste per annum and recovers about 58% of all waste generated. Energy is recovered from 2 million tonnes of waste annually. Waste management and other related waste services add a total value of AUD12.6 billion per annum. For every 10,000 tonnes of waste recycled, 9.2 jobs are created (as opposed to 2.8 jobs created for every 10,000 tonnes that go to landfill). Waste is responsible for 2% of all GHG emissions in Australia.

Looking at the trends from previous years, in the 2014–15 period Australia produced about 64 million tonnes of waste. Almost 60% of this was recycled. If fly-ash is excluded, waste generation per capita increased by an average of almost 1% per year in the same period. In 2014–15, per capita, Australia produced the equivalent of 565 kg of municipal waste, 831 kg of construction and demolition waste, 459 kg of fly-ash and 849 kg of other commercial and industrial waste (Pickin and Randell, 2016).

Generally, Australia is recycling and recovering waste but we are still not doing enough. More recycling is needed as the waste generation per capita increased by an average of 1% a year to 2015 (Pickin and Randell, 2016). Australia is generating less municipal waste per capita, but experiencing increases in commercial and industrial waste, and construction and demolition waste. Overall, in 2014–15, masonry, organic waste and fly-ash represented nearly two-thirds of the waste stream; while paper, cardboard, glass and fly-ash in the waste stream are generally declining. Masonry materials from demolition are increasing while waste metals, organics and

plastics appear to be reducing in the waste streams. Over 10 million tonnes of Australia's 20.4 million tonnes of construction and demolition (C&D) waste has found its way back into road base as a recycled product (Commonwealth of Australia, 2018).

New Zealand's Waste Minimisation Act 2008 was developed by the Ministry for Environment in 2008 following the introduction of the government's Waste Strategy in 2002 (CRN Aotearoa, 2002). The 2002 strategy was based on three main goals: economic – increasing material resources efficiently; environmental – reducing environmental damage from the generation and disposal of waste; and social – lowering the costs and risks of waste to society. Legislation in New Zealand is set up by the federal government and is supported by two tiers of government: local and territorial. The local governments enable democratic decision-making and action by and on behalf of communities. Regional councils sit at the top tier and are concerned with environmental resource management, flood control, air and water quality and pest control and may be involved in public transport, regional parks and bulk water supply. Territorial authorities form the second tier of governance supporting the councils and are responsible for a wide range of local services including roads, water supply and sewerage, libraries, parks, recreation services, local regulations, community and economic development, and town planning (Local government New Zealand, 2020). Councils and territorial authorities are directly elected by the residents of the region, district or city.

As waste management forms the basis for resource recovery, this is explored further in the next section.

6. Policies/legislation/regulation on waste in Oceania

Australia has developed policies on circular economy that are based largely on waste. Since local administration is undertaken by the states rather than the federal government, each state's approach is described briefly below. It should be noted that, generally speaking, Australia's CE platform has been built upon the waste management strategy of each state and territory. In contrast, New Zealand manages its policies at the federal level, with the councils and territories working in alignment with the federal government.

This section covers approaches to CE, waste to energy options, understanding current waste recovery profiles and waste management strategies.

6.1 Approaches to CE

Approaches to CE in Australia and New Zealand are presented individually below as each state/territory across Australia and New Zealand has a local or regional approach.

6.1.1 Australian Capital Territory

The Australian Capital Territory's CE platform is linked to its waste management strategy. The goal of the strategy is to drive innovation to achieve zero waste through a resource recovery programme and by supporting the shift to a carbon-neutral Canberra by 2050. The waste management strategy relies on less waste being generated, a full resource recovery programme, a clean environment and a carbon-neutral waste sector in the Australian Capital Territory (ACT Government, 2018).

6.1.2 New South Wales

The New South Wales policy statement on CE was announced in early 2019. The policy identifies that a common language for discussions on CE is an essential starting point. It is based on seven principles that support industry and the community by developing a framework for implementing initiatives over the product lifecycle to ensure long-lasting design, maintenance, repair, reuse, sharing and transformation of products into services, remanufacturing and recycling. The intent of the New South Wales approach is also to consider implementing a 20-year waste strategy co-led by the New South Wales Environment Protection Authority (EPA) and Infrastructure New South Wales.

The policy paper defines CE in the following terms: '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' (State of New South Wales and EPA, 2019, p. 3).

Below are listed the seven principles underpinning New South Wales's CE approach (State of New South Wales and EPA, 2019):

1. Sustainable management of all resources – This principle refers to using resources sustainably so that future generations do not miss out by replacing raw materials with recycled products. This will ensure that virgin materials are not mined and will also reduce the environmental impact of associated emissions.
2. Valuing resource productivity – This principle refers to recognising the value of economic prosperity and the more effective use of resources by minimising the use of virgin materials and recognising that resources have inherent value that may support multiple cycles of use and reuse.
3. Designing out waste and pollution – This principle refers to innovating product design that supports long-term use, reuse, remanufacture and resource recovery so that all users can support such measures to keep the products and materials in the system for as long as possible without having to send them to landfill. This discourages waste being diverted to landfill and extends the lifespan of the existing landfill. Increasing service offerings will also prevent products from being diverted to landfill while increased remanufacture and repair minimises the amount of resources used, leading to a reduction in the attendant waste.
4. Maintaining the value of products and materials – This principle refers to increasing the repairability of products and the recyclability of materials used in the creation of products, which will keep products in use for longer, enhancing their lifecycle. A focus on sharing/shared services moves away from individual use and developing local markets will support local jobs and local communities.
5. Innovating new solutions for resource efficiency – This principle refers to innovative business models and services across different sectors that can assist in capturing value and how the use of technologies can increase resource efficiency and support reuse and the development of new products that will be in demand in the marketplace through upcycling.
6. Creating new circular economy jobs – This principle refers to the new jobs that may arise from innovative business models and from the creation of new manufacturing, service and resource recovery opportunities. Encouraging repairs and refurbishments will support jobs and the local economy through new skill creation and enhancement.
7. Fostering behaviour change through education and engagement – This principle refers to moving away from linear economy needs to support appropriate behaviour change in communities and individuals, through education and engagement.

6.1.3 Northern Territory

A specific CE policy has not yet been set up by the Northern Territory Government. The government's waste management strategy has been updated to reflect a new regulations framework focused on waste reduction and reuse, which represents a key underpinning for a transition to a CE. The industry recovers secondary resources, thereby supporting waste management practices that enable reuse.

6.1.4 Queensland

Queensland has a specific policy for CE. However, CE principles have been initiated and supported by the Queensland Government (Queensland Government, 2020). The strategic priorities of reducing the impact of waste on the environment and communities, transitioning to a CE and building economic opportunities are supported by a change strategy that involves a strong legislative and policy framework, good governance, effective compliance management, partnerships and collaboration supporting a sound knowledge platform and a comprehensive education programme. Queensland has set up the Circular Economy Lab, an experimental and collaborative platform with a mission to accelerate the development of a circular economy in Queensland. The intention of the lab is to establish a collaborative innovative platform and support uptake of CE through a seed fund (Business Models Inc., Coreo, Queensland Government, 2020).

6.1.5 South Australia

South Australia was the first state in Australia to quantify the benefits of CE, which it did in 2017. The state used macroeconomic modelling to show that interdependencies between 78 sectors can keep materials in the economy. South Australia's Government sees a CE as a self-sustaining system that is driven by renewable energy and designed to keep materials circulating in the economy as much as possible so that maximum value is extracted while the resources are in use, and at end of life, thereby regenerating products and materials. Two types of material flows have been identified as relevant: an organic flow of materials that produces energy through composting and leaves behind material with high nutrient value that can support future growth; and material flows such as metals, fibres and plastics that can be repaired and reused so that they do not end up in landfill or as waste. Green Industries South Australia (2019) acts as a catalyst to stimulate investment in new industries and key sectors, materials and regions in South Australia.

The business models underpinning South Australia's CE are collaborative consumption models through which the private or public sharing of models supports the reduction of structural waste, such as cars not being used 90% of the time or office spaces being shared. The creation of jobs and a reduction in GHG emissions are seen to be the main advantages compared to a business-as-usual scenario.

6.1.6 Tasmania

In 2017, work undertaken on behalf of the Local Government Association Tasmania identified opportunities for moving to a circular economy in the state. The role of policy and strategy at both the state and national levels and their alignment was considered important, alongside leadership and governance, particularly in government organisations, to lead and champion the reuse of waste in the system. Also seen as important was the need to provide greater transparency around the performance of waste management and the resource recovery system.

Tasmania has a well-advanced system of renewables forming the basis of its electricity production, with 90% of power coming from renewables. Tasmania became the first jurisdiction in Australia to achieve net zero emissions in 2015–16 (Department of Primary Industries, Parks, Water and Environment, 2020).

The new waste strategy for Tasmania is aligned with principles underpinning a circular economy (Department of Primary Industries, Parks, Water and Environment, 2020). Discussions related to a circular economy in Tasmania commenced with the draft discussion paper released by the Department of Primary Industries, Parks, Water and Environment in June 2019. The discussion paper identified the areas of tourism development, higher education, the bio-economy sector, renewables and emissions reduction, public health and jobs as presenting opportunities to be tapped.

6.1.7 Victoria

Victoria's CE policy is structured around resource efficiency. Recycling Victoria, introduced in 2020, is Victoria's 10-year action plan to engage with and support Victoria's circular economy (Victorian Government, 2020a). Reducing waste, creating thousands of jobs and fundamentally transforming the recycling sector are all key priorities outlined with a budget support of AUD300 million. The plan began with a discussion paper centred on minimising resource use, and avoiding waste and pollution, underpinned by good design and efficient practices. Pollution to soil, air and water as well as other impacts such as litter, noise and odour are expected to be eliminated by the adoption of thinking and practice based on CE (State of Victoria, 2019).

As Victorians are anticipated to produce 40% more waste in 2050 compared to current trends, a four-bin waste and recycling system will be rolled out in partnership with councils in 2021. From the current system of green bins for garden organics, food and food organics and red bins for general waste to landfill and yellow co-mingled recycling for paper, cardboard, plastics, metals and glass, the new recycling system will include a four-bin system. This will involve a bin for co-mingled recycling for paper, cardboard, plastics and metals; a bin for general waste to landfill; a food and garden organic bin; and a bin for glass (a new purple bin) (Victorian Government, 2020a).

In addition, by 2022–23 a new container deposit scheme (CDS) will be set up, as has been implemented in South Australia for glass, aluminium and PET (polyethylene terephthalate) plastic beverage containers. The government is supporting these additional options for recycling with AUD129 million to transform recycling and to support local councils (Victorian Government, 2020b). Such actions are also expected to reduce litter, create new jobs, and see more plastic, aluminium and glass containers used in new recycled products.

Recycling Victoria (Victorian Government, 2020b) supports kerbside reform, reliable and transparent recycling oversight, new rules to cut down waste, reducing business waste, investing in infrastructure to support increased recycling, providing support to communities and councils across Victoria, supporting behaviour change to reduce waste and supporting products to stay longer in the system. It is anticipated that this will boost Victoria's economy by up to AUD6.7 billion, create more than 3900 new jobs and establish new skills, help businesses grow in ways that create new innovative jobs and grow the repair sector, drive greater resource recovery and improve social inclusion, while also providing savings, facilitating GHG abatement and setting the foundation for a strong recycling system for Victorians (Victorian Government, 2020b, p. 5).

6.1.8 Western Australia

The vision for Western Australia is to become a 'sustainable, low-waste, circular economy in which human health and the environment are protected from the impacts of waste' (Waste Authority, 2018, p. 6). The Western Australian Government's policy objectives include adopting a waste culture that includes avoiding, recovering and protecting waste from being downcycled, while also protecting the environment. The government recognises that the creation of a circular economy in Western Australia has the potential not only to support economic outcomes but also to drive investment in infrastructure and jobs. Longstanding sustainability concepts, including lifecycle thinking and resource efficiency, underpin the circular economy platform for Western Australia.

6.1.9 New Zealand

As a small country, New Zealand's federal policies on waste and a circular economy provide a clear direction for the country. Research undertaken by the CEA within the Sustainable Business Network (2018) shows that design is a primary driver for a CE. Designs need to ensure that unnecessary and unwanted materials are used while also increasing longevity, repairability and upgradability; supported by market demand so that solutions for a CE may be scaled and considered valuable. In addition, business models are required that incorporate sharing economies to reduce resource use; establish improved infrastructure to support reprocessing, reverse logistics and the like; and support technology that tracks materials and ensures there is value capture. Policies that support and implement regulatory frameworks for CE and accelerate transitions to upscale and mainstream are also considered to be critical features of a CE in New Zealand. New Zealand has also examined how indigenous knowledge can inform and guide the shift to a circular economy (Ministry for the Environment, NZ, 2020b).

6.2 Waste to energy

Energy from waste technology has been used in other parts of the world, predominantly in the EU. Waste to energy is about converting waste into energy or using waste as a source of fuel. Organics can be easily converted into fuel, usually in the form of gases or biofuel that can be used for cooking or lighting or powering appliances. About 5.3 million tonnes of food for human consumption is wasted every year (Waste Authority, 2018a).

Organics often form a significant proportion of waste that can be diverted easily from landfill at the household level and also at the local government level. Food disposed to landfill produces methane and negates the ability to use such organics for composting or other purposes. The technology used for such conversions is also important as GHG emissions may result from the process of bio-organic conversion and operation.

6.2.1 Australian Capital Territory

The waste sector in the Australian Capital Territory produces around 3% of GHG emissions in the territory but has the potential to play an important role in improving the ACT's emissions profile (ACT Government, 2011a). The rate of resource recovery in the ACT was over 70% in 2003–04, representing the second-highest per-capita rate in the country (at over 2.5 tonnes per ACT resident in 2009–10).

The potential for converting waste to energy supports the use of alternative fuel sources in the ACT, away from the current fossil fuel–based sources, particularly if bio-organic sources of fuel are used. Establishing a carbon-neutral waste policy in the ACT will also require methane capture from landfill in the initial stages with a view to minimising and eventually eliminating organic waste to landfill, expanding bioenergy generation and investigating new technologies around waste to energy, increasing recycling, and supporting energy-efficient waste collection and transport solutions (ACT Government, 2011a).

6.2.2 New South Wales

The New South Wales Government's policy has established a framework that separates requirements for low-risk waste proposed for thermal treatment from those for all other wastes. Energy from waste is about ensuring that human health and the environment are protected and avoiding unnecessary resource consumption, resource recovery and disposal. Higher-value resource outcomes are maximised, air quality and human health are protected, 'mass burn' is avoided and scope for industry innovation is supported. Thermal treatment provides an opportunity to recover energy from waste, offset the use of non-renewable energy sources and avoid the methane produced from landfill. Incineration facilities and such other facilities that do not support provide genuine energy recovery are excluded (State of NSW and EPA, 2015).

Eligible waste fuels include various options that pose a low risk to human health such as biomass, recovered waste oil, landfill gas and biogas. Depending on the type of waste stream, there are limitations on the proportion of residual waste that can be used for energy recovery. For instance, in the case of mixed municipal waste, a processing facility can receive recyclables, and food and garden waste where these have been collected separately by councils and there is no limit by weight of the waste stream received at a processing facility. In the case of construction and demolition waste, a processing facility may only use 25% by weight of the waste stream. These measures are to encourage that source-separated materials be put back into the system as much as possible.

6.2.3 Northern Territory

There are no specific waste to energy policies in the Northern Territory. That said, the Shoal Bay Waste Management Facility in Karama, Holmes (City of Darwin, 2020), opened in 2005, owned and operated by Landfill Management Services and supported by the City of Darwin, and has been using landfill gas to power homes. The gas is a combination of carbon dioxide and methane and is derived from the decomposition of organic waste deposited in landfill. It is connected to the local electricity grid. Therefore, although there are no recent policy frameworks, Shoal Bay is still serving the needs of the Northern Territory.

6.2.4 Queensland

The Queensland Government aims to develop a AUD1 billion bio-futures industry by 2026 (Queensland Government, 2018). Energy recovery technology has also been considered, which is expected to contribute to powering Queensland with 50% renewable energy by 2050.

The biological technologies that can be used include the conversion of organic wastes, or of bio-solids from wastewater treatment plants; the fermentation of organic waste with high sugar content; and solid fuel production through MSW, C&I and C&D streams. The chemical technologies include liquid fuel production other than advanced thermal treatment such as individual waste streams like tyres, waste oils, plastics and solvent. For thermal technologies, incineration and advanced thermal treatments are available options. In the case of incineration

potential feedstock is mixed MSW, C&I and some C&D waste, and woody biomass; and for advanced thermal treatment, options are pre-sorted MSW, C&I and some C&D waste such as plastics and tyres.

Each of these options leaves residues such as bottom ash, fly-ash, wastewater, and solid and liquid residues, and provides outputs such as heat, electricity, alcohols and combustible liquid fuels (Office of Resource Recovery, Department of Environment and Science, State of Queensland, 2019).

The Queensland Government has developed eight principles for waste to energy. Principle 1 states that a risk-based approach will be used to guide and manage the development of energy from waste infrastructure. Principle 2 is about the Queensland Government applying the waste hierarchy consistently, and that energy from waste does not undermine recycling and that disposal should not undermine appropriate energy recovery. C&D waste does not lend itself (as a result of its composition) to waste to energy unless wood waste is part of C&D waste. The Queensland Government recognises under Principle 3 that energy recovery is only appropriate for residual wastes that are not practical or economically viable to recycle. As recycling improves over time, Queensland's transition to a CE will enhance capacity in the composition of residual waste; thus, energy from waste facilities need to be designed to accommodate this change. Principle 4 relates to the composition of residual waste and to ensuring that waste to energy policies are designed to accommodate change so that as recycling rates increase other options may be considered. Principle 5 states that for genuine energy recovery to be achieved, waste to energy facilities must meet a minimum energy efficiency threshold that is consistent with international best practice. Principle 6 states that Queensland should adopt international best practice standards for managing the environmental impacts for waste to energy technologies. Principle 7 states that Queensland needs a clear, consistent and well-informed assessment process for new waste technologies, while Principle 8 ensures that communities impacted by the proposed facilities must be engaged appropriately and transparently.

6.2.5 South Australia

South Australia has a strong track record in waste management and resource recovery. The government's 2011–15 strategy built on the previous five-year strategy (2005–10) in ensuring that challenging targets are set for all three main areas of waste streams: MSW, C&I and C&D. Waste to energy supports zero waste to landfill, but a balance needs to be struck between energy from non-renewables and circular economy principles. The government's intent is not only to be the regulator but also to provide support mechanisms and economic incentives while addressing market failures and perceived barriers to development. Three bioenergy projects have been set up in the state dealing with biomass and forest residues (Warren et al., 2013).

The South Australian Environment Protection Authority (EPA SA) has developed a standard for the recovery of energy when refuse-derived fuel is used in industrial processes (EPA SA, 2020). The government recognises that there are technologies that can deliver environmental benefits and offer economic opportunities. A waste to energy opportunities discussion paper eliciting feedback from SA stakeholders was developed in 2017 (EPA SA, 2017) and has formed the basis of the main strategy adopted by the government to date.

6.2.6 Tasmania

A waste to energy plant fully funded by the Tasmanian Regional Infrastructure Fund was commissioned to be built under a deal signed with a majority of the Tasmanian councils in 2002. It was expected to handle 200,000 tonnes of MSW a year, enough to power approximately 17,000 homes per annum, a first of its kind in Australia (Energy News Bulletin, 2020). Other energy from waste options considered may be pursued with further R&D of attendant policies and guidelines. In Tasmania, approximately 244,000 tonnes of organic waste was generated in 2010–11, of which about 75% was landfilled (Tasmanian Government, 2020).

Some of the options considered for bioenergy are to incentivise its generation from forestry residues. Tasmania has undertaken an audit of organic waste detailing sources, stockpiles, production per annum, and estimated future production. In addition, the project will identify locations, quantities, specifications and ownership of the full range of biomass materials with bioenergy potential (Tasmanian Government, 2017).

6.2.7 Victoria

In Victoria, the foundational platform for waste to energy is to mine as much waste as possible back into the system and away from landfill into energy production. As part of Goal 3 under Victoria's circular economy goals, waste to energy options are considered as a means to recycle more resources. Pursuing an 80% waste landfill diversion target by 2030, waste to energy facilities will focus largely on organic processing. Infrastructure facilities need to be in place to plan and support waste to energy facilities. Investment in the building of waste to energy facilities to support energy production and dissemination at a precinct scale is built into the plan. Research funding is also supporting this front.

Any technology that converts waste into energy such as heat, electricity, gas and liquid fuels is supported by the Victorian Government, including best practice options. Biological waste to energy conversions such as anerobic digestion are also considered in the mix and constitute the main reason for continuing with the organic and food waste bin in the state (Victorian Government, 2020b). The government plans to closely monitor developments in the waste to energy area so as to divert waste from landfill other than the residual waste that cannot be used elsewhere in the system. Therefore, thermal waste to energy will be capped at 1 million tonnes each year until 2040, effected through regulation (Victorian Government, 2020b, p. 36). This will be reviewed in 2030.

6.2.8 Western Australia

As yet there are no specific waste to energy programmes in Western Australia. But the state recognises that organics offer an opportunity. Under the Western Australian Government's objective of 'Recover', from 2020 there is a target to recover energy from residual waste (West Authority, 2018b). In the government's waste hierarchy, energy recovery is considered the penultimate least preferred option for the disposal of waste. Material recovery is still preferred over energy recovery; and it is considered for residual waste only if the option is to send the waste to landfill.

6.2.9 New Zealand

In New Zealand, new legislation specifying enhanced roles and functions as part of the government's package on sustainability has been considered by the Ministry for Environment (Ministry for Environment New Zealand, 2007). The ministry is considering issues of waste to energy as part of its suite of waste management initiatives.

The next section examines the waste recovery profiles of the different countries.

6.3 Waste recovery profile

Existing waste generation and recovery profiles provide a benchmark for understanding how far the various states and territories in Australia and New Zealand have to go to reach their goals of resource recovery or a zero-waste society.

6.3.1 Australian Capital Territory

In the ACT the highest proportion of waste generated is C&D, followed by garden waste, commercial waste and household waste, and then wood waste and bio-solids. Construction waste reached a high of 285,000 tonnes in 2009–10 (ACT Government, 2011, p. 11). The ACT's waste strategy covers household, C&D and C&I sectors, as well as garden and timber waste. The main focus in relation to these waste streams is to reduce the amount of waste generated per capita; reduce the amount of total waste going into landfill by more than 80% by 2015, 85% by 2020 and 90% by 2025; and improve recovery from organic waste by 2020. In addition, the ACT Government wants to lead Australia in low rates of litter and illegal dumping and to double the amount of energy generated from waste.

6.3.2 New South Wales

Going forward from 2019, for the 2021–22 period the NSW Government's targets are to avoid and reduce the amount of waste generated per capita in the state and to focus on increasing the recycling rates to 70% for MSW and C&I, and 80% for C&D waste (NSW and EPA 2019). The NSW Government is underpinning its waste strategy with CE principles. The use of data, investment, innovation, collaboration, skills development and engagement will all be used to support circular design and operations. Some of the focus areas in this are innovation; procurement; high-quality, consistent recycling; valuing organics; mainstreaming product stewardship; responsible packaging; supporting reuse and repair; and circular design thinking.

6.3.3 Northern Territory

In the Northern Territory, the waste management and secondary resources industry provides infrastructure and services to the community. The services include the collection, processing, recycling and disposal of waste. The waste industry has contributed to the economy in the Northern Territory through both job creation and overall turnover. In the period 2017–18, the industry processed, recycled and disposed of more than 517,000 tonnes of resources from waste streams. Of this, 34.3% was recovered and diverted from landfill (Behrens, 2018). Industry was involved in waste collection and transfer, sorting of waste, recycling and disposal to landfill.

6.3.4 Queensland

In 2017–18 period, Queensland produced nearly 11 million tonnes of waste, and the waste volume increased at a much higher rate than the increase in population for the same period. This is partly due to the fact that Queensland has no waste levy and low landfill gate prices have led to waste being brought into the state. About 37% of the increase in waste was the result of waste being brought in from other states and territories in Australia. The amount recovered during this period was 4.9 million tonnes or around 45% of the total waste generated in Queensland (Queensland Government, 2019a), meaning that 55% of the waste was landfilled, clearly demonstrating the state's poor resource recovery performance, and confirming the trend of more waste going to landfill. Overall, the levels of resource recovery were more or less consistent over this 2017–18 period.

Sending hazardous materials such as asbestos to landfill is unavoidable unless technology can come up with better solutions that support hazardous extraction and reuse. Using the baseline of 2018, waste diversion in Queensland overall was at 45.4% away from landfill, consisting of 32.4% MSW, 47.3% C&I and 50.9% C&D waste. In 2025, the MSW diversion is expected to increase to 55% of 2018 levels, 70% in 2030, 90% in 2040 and 95% in 2050. C&I waste is expected to increase from a current 47% to 65% in 2025, 80% in 2030, 85% in 2040, and then remaining at 85% through to 2050. C&D waste is expected to move from a baseline of 51% in 2018 to 75% in 2025 and to be maintained at 85% in 2030, 2040 and 2050 (Queensland Government, 2019a).

Examining the year 2017–18, local governments in Queensland sent 340,000 tonnes of paper and packaging to recyclers, and 1.4 million tonnes of organics were processed into products such as soil, potting mixes and mulch. In addition, 1.24 million tonnes of mixed domestic waste was picked up weekly through kerbside collection. Local governments have also had to contend with 6000 tonnes of illegal waste, costing them AUD18.4 million in 2017–18 (Queensland Government, 2018).

As this report's focus is the built environment, C&D waste is discussed here further, in particular because relevant data is available for Queensland. During 2017–18, the highest recovery was attributed to concrete, with 1,851,243 tonnes recovered. This is followed by asphalt, with 360,146 tonnes recovered, and ferrous scrap metal at 283,726 tonnes. Bricks and tiles were recovered, to the volume of approximately 84,066 tonnes. The materials least recovered include other construction and demolition materials at 226 tonnes, non-packaging plastic at 2,151 tonnes and non-packaging glass at 7,370 tonnes (Department of Environment and Science, Queensland Government, 2018). Clearly, there is a huge opportunity for waste recovery in the state. About 50.9% (nearly 2.7 million tonnes) of C&D waste was recovered, out of the total 5.3 million tonnes. The 2.69 million tonnes of construction and demolition waste recovered in 2017–18 was a 477,000-tonne (21%) increase from 2016–17. This also included a 375,000-tonne increase in the amount of concrete recovered and a 42,000-tonne increase in the amount of bricks and tiles recovered (Department of Environment and Science, Queensland Government, 2018).

6.3.5 South Australia

The UN acclaimed SA's waste and resource management as best practice in 2010 (UN Habitat, 2010, cited in Lifecycles et al., 2017). South Australia's recycling rate of 80% (in 2013–14) is indeed good (as the state is seeking to recover all its waste), but there is still room for improvement that can support a full and complete transition to CE. The proportion of recycled material use is still only at 4%, which means that a lot more needs to be done to convert waste into value (or potential value) (Lifecycles et al., 2017).

South Australia's waste management practices have also been supported by a strong renewable platform for wind and solar (40%), the highest in Australia in 2014 (Climate Council of Australia, cited in Lifecycles et al., 2017). The waste sector has an annual turnover of around AUD1 billion, contributing more than AUD500 million to the gross state product (GSP), and has attracted over AUD6.5 billion in investment (Lifecycles et al., 2017).

6.3.6 Tasmania

Opportunities for Tasmania to improve its resource recovery rates involve targeting priority materials common across other states, including organics and materials from the C&D sector; optimising kerbside systems; and upgrading local government infrastructure to ensure that best practice is followed. Collecting appropriate baseline data has been identified as critical because, without data, monitoring, reporting and setting targets will be difficult. The definitions of the type of materials, quantities/units of measure and opportunities for recovery (as opposed to waste ending up in landfill) have been identified.

As set out in an issues paper produced by the Tasmanian Government (Tasmanian Government, 2020), introducing a waste levy by 2021; introducing a container refund scheme by 2023; achieving a 50% average recovery rate from all waste streams by 2025 and 80% by 2030; reducing the waste generated per Tasmanian by 5% by 2025 and 10% by 2030; ensuring that 100% of packaging is reusable, recyclable or compostable by 2025; and reducing the volume of organic waste sent to landfill by 25% in 2025 and 50% by 2030 have all been recognised as key actions and targets. In addition, governance structures and waste and recovery infrastructure plans have also been considered.

6.3.7 Victoria

Four million tonnes of materials are still sent to landfill each year in Victoria (State of Victoria, 2019). In 2012, it was estimated that Victorian businesses spent (wasted) AUD5.4 billion on materials that were discarded during production (Sustainability Victoria, 2014). Minimising food waste alone would allow Victorian households to save over AUD2000 per year (QDOS, 2018). More organic waste collection could lead to the recovery of up to 650,000 tonnes of food and garden waste each year (Victorian Government, 2020b). Small businesses could reduce their overall costs, staff time and energy costs, as seen in the case of Maton Guitars (Sustainability Victoria, 2015), which used out of the box thinking to produce its musical instruments. Another study has shown that improved practices and design standards could add USD266–404 to the value of every tonne of mixed plastic packaging collected (EMF, 2017), thereby impacting the supply chain and reducing inefficiencies post use. Such approaches to enhancing value have been supported by the EMF and McKinsey & Company (2016), where 95% of plastic packaging material value was lost after just one use due to poor design and behaviour. GHG emissions reduction in Victoria for a circular economy has the potential to provide a 40% reduction in waste and attendant CO2e based on 2017–18 figures by 2050 (State of Victoria, 2019).

Despite having the second-highest resource recovery rate in the country, Victoria is expected to be managing 20 million tonnes of waste per annum by 2046, up from 20 million tonnes of material per year (State of Victoria, 2019; Sustainability Victoria, 2018). To keep up with international trends, particularly in other leading OECD countries, Victoria needs to drastically reduce its waste generation (OECD, 2015; APCO et al., 2018). The government is aiming for an 80% average resource recovery rate from all waste streams following the waste hierarchy by 2030 (Victorian Government, 2020b). Manufacturing jobs and jobs arising from the waste sector are expected to contribute to Victoria's economy and still lead R&D (The Victorian Connection, 2018; Department of Economic Development, Jobs, Transport and Resources, 2017).

In Victoria, around 43% of waste is generated from C&D activities (State of Victoria, 2019), highlighting a big opportunity for waste reduction and materials recovery in this sector. Building and infrastructure design can easily use recovered materials and the construction technology used can easily support recovery at demolition; sustainable innovation precincts can also be used to showcase successful demonstration projects. Sometimes, decision-making at the building level may not make economic sense, in which case precinct-level planning such as shopping centres and other public spaces makes more economic sense. A good example of a recyclable house is that designed by Quentin Irvine in Beaufort, Victoria (O'Farrell et al., 2018, cited in State of Victoria, 2019), using materials that would otherwise have ended up in landfill. Thus, legislation, economies of scale, knowledge and skills, better understanding of resource considerations, behaviour change, among other considerations, are all important.

6.3.8 Western Australia

Western Australia has the highest rate of waste production of all the Australian states and territories (excluding fly-ash, due to its resource base driven economy of mining). In 2014–15, Western Australia had a resource recovery rate of 48% and disposed of the second-highest amount of waste to landfill in the country (1358 kgs per annum, excluding fly-ash) (Waste Authority, 2018b). During the nine years to 2014–15, the total volume of waste generation in Western Australia increased by about 20%, or 2.1% annually, due to population increases; but on a per-capita basis the waste decreased marginally by 0.3% per year and waste to landfill decreased, coinciding with increases in resource recovery. In the decade to 2014–15, waste disposal in Western Australia dropped by 24% on a per-capita basis or 3% per year on average (Waste Authority, 2018a).

In Western Australia, the materials from waste streams include C&D waste, organics, metals, paper and hardboard, glass, plastics, textiles and hazardous waste. By weight, all these materials except hazardous materials make up more than 90% of the state's waste stream. C&D constitutes around 50% of Western Australia's waste stream and 45% of all materials are recovered for recycling (Waste Authority, 2018a). These numbers highlight a great opportunity to support more efficient building practices and maximise the recovery of waste.

Metals represent 20% of all materials recovered for recycling by weight, representing a huge opportunity to upscale, whereas paper and cardboard represent only around 10% of materials used for recycling. Yet paper and cardboard are high-value materials for recycling as they are immediately absorbed into the supply chain. Glass is another material that can easily be brought back into the supply chain. Plastics, other than single use plastics, possess high economic value, especially when contamination rates are low, and can be absorbed back into the supply chain. Textiles also have high embodied energy content and can be brought

back into the supply chain easily to avoid being sent to landfill as waste. Hazardous waste, while representing only a small proportion of waste, can cause untold damage upstream and downstream if not well managed. Its safe disposal is therefore paramount (Waste Authority, 2018b).

6.3.9 New Zealand

New Zealand sent an estimated 3.156 million tonnes of solid waste to municipal landfills in 2006, in contrast to the 2.03 million tonnes of waste sent to landfill in 1982. This increase may be the result of increases in the country's population and GDP. At least 2.4 million tonnes of material were diverted from landfill for beneficial use in 2006 (Ministry for the Environment, NZ, 2019a).

A waste review undertaken by the government in 2006 flagged a need for enhanced data collection and improvements in waste monitoring and reporting. Supported by findings from a report produced by the OECD (OECD, 2007), a clear direction has been set for New Zealand. This includes decoupling GDP from municipal waste. A need to develop a comprehensive waste management framework that departs from the current fragmented approaches, more engagement with and legislative support for materials recovery, recognition of the limited viability of local markets, and redressing the lack of waste management information and awareness-raising are all steps that have been identified as important.

The legislation in relation to waste management introduced by the Ministry of Environment New Zealand in 2007 includes that waste minimisation and recovery activities be specified in the waste management plans of government authorities. Legislation covering product stewardship schemes to encourage producers, retailers and consumers to accept responsibility for environmental impacts was also considered as backstop legislation. Waste management plans are also to be set up to minimise, recover and recycle waste, supported by the legislation.

6.4 Waste management strategy

Waste management strategies have usually been the precursor to setting up policies on CE. As demonstrated in the previous sections, this trend is evident in each state/territory in Australia and in New Zealand.

6.4.1 Australian Capital Territory

The Australian Capital Territory Waste Management Strategy 2011–25 (ACT Government, 2011) focuses on 29 strategies covering waste from a range of different waste streams. It builds on the success of the previous strategy developed in 1996, reducing the volume of waste sent to landfill by nearly 60% from 1995–96 levels and to below 30% in 2003–04. The amount of waste generated in the Territory grew on average by 5% a year in the 15 years leading to 2011. Population growth, consumption patterns, consumer preferences for single-use plastic bags and single-use plastic containers as well as the shelf life of electronic items have all contributed to increased waste generation.

The Australian Capital Territory's population has increased over time, projected to reach around 450,000 people by 2022, representing an increase of 40,000 since mid-2017 (ACT Government, 2019). By 2058, an estimated 700,000 people will live in the ACT. However, an ageing population is expected to lead to a decrease in household sizes, and in turn to changes in the profile of waste.

Focusing on reducing the waste generated, government approaches include awareness-raising and education, supporting community gardens and composting, banning single-use plastic shopping bags, reducing packaging waste, promoting reuse through businesses and charities, promoting reuse through waste collection services and encouraging onsite reuse for C&D waste.

The government's resource recovery strategies include boosting commercial waste recycling, recovering optimal waste and developing markets for organic and residual waste and resources, considering e-waste, promoting education and active recycling, leading by example through government procurement, providing recycling bins and facilities in public places and at events, developing markets for recyclable materials, strengthening regional connections, and providing disincentives to sending waste to landfill such as via pricing and regulation.

The ACT Government's clean environment strategies are focused on education and awareness-raising such as around litter dumping and management, supported by appropriate laws; maintaining safe, environmentally responsible landfill facilities; managing hazardous waste; increasing soil reuse and rehabilitation; reviewing waste operations in terms of planning and building considerations; and developing resource recovery estates (ACT Government, 2011a).

Single-use plastic bags have already been banned (in 2011), methane capture to generate electricity has been piloted, and an increase in the reuse of reclaimed goods and bulky waste collections has been achieved. Community programmes for behaviour change have also been set up to ensure that the community increases its engagement in recycling and composting. The ACT has a well-developed waste management sector that generates significant employment opportunities, as well as economic activities across the collection, transportation, sorting and processing of waste to bring it back into the supply chain.

The ACT Government signing APCO's agreement 2011–16 (ACT Government, 2011b), which supports smart, sustainable and reduced levels of packaging waste, has been a step in the right direction. A new packaging covenant based on recent experiences is also currently being developed in the ACT.

6.4.2 New South Wales

In combination with its circular economy policy, the New South Wales Government has developed the WARR Strategy, or Waste Avoidance and Resource Recovery Strategy. The EPA in New South Wales has been leading the development of a 20-year waste management strategy that supports the use of a waste hierarchy for New South Wales (State of New South Wales and EPA, 2019). The strategy is focused on reducing waste and driving sustainable recycling markets. It also includes identifying and improving the state-wide and regional waste infrastructure network. The waste hierarchy proposes that actions towards mitigating the harm caused by waste are to be ordered from most to least favourable as follows: avoiding and reducing waste, reusing waste, recycling waste, recovering energy, treating waste and finally disposing of waste. For 2021–22, the targets set are to lower the amount of waste generated per person in NSW, to increase recycling rates to 70% for municipal waste, 70% for C&I waste and 80% for C&D waste.

6.4.3 Northern Territory

The Northern Territory has taken a fresh approach to environmental legislative and regulatory systems through a new Environmental Protection Act 2019 (NT). The government also previously introduced the Waste Management and Pollution Control Act 1998, which will guide innovative thinking and action into the new millennium. This approach has been encapsulated in a roadmap to support discussions on updated legislation, the waste hierarchy, data management, emerging new waste stream management and a new regulations framework. This roadmap includes roles for social enterprise and community procurement, a new market strategy and development for product recovery and reuse, resource recovery options and emergency waste challenges (Behrens, 2018).

To reduce the generation of waste, increase rates of resource recovery and minimising the environmental impacts of waste, collaboration across various industries, government at both the state and local levels, and community groups is required. Remote communities in the Northern Territory are often isolated, especially during the wet season, so it is particularly important to ensure that these communities have ownership of waste management as an essential service. To this end, the Northern Territory EPA has been engaging with communities, industries, councils at various levels and government agencies to improve waste management outcomes. It has also implemented specific projects to improve rates of resource recovery, manage high-risk landfills and plan for future and emergency waste. Also in train are improvements in waste data collection and effective monitoring and evaluation. In addition, enhancing the regulatory framework, undertaking periodic reviews and reporting on progress all form key actions of the government's waste management plan (Northern Territory EPA, 2015). Each of these actions is being undertaken in line with the principles of the waste management hierarchy.

6.4.4 Queensland

Central to Queensland's strategy on waste management is a waste disposal levy, which the government believes will attract industry and encourage innovation, create new jobs, and move Queensland towards a CE, while having no direct adverse impact on households in Queensland and delivering long-term value to the environment (Queensland Government, 2018). A waste disposal levy was introduced in Queensland in December 2011, at AUD35 per tonne (not including household waste); however, in 2012 this levy was repealed. This was clearly a wrong move because not only did Queensland's waste grow in tonnage as a result, but the state also received an increased importation of waste from other states, totalling around 900,000 tonnes in 2016–17 (Queensland Government, 2018). Types of waste exempt from the levy are waste resulting from natural disasters, litter and illegal dumping such as that collected on Clean Up Australia Day, and waste received by charities as part of donations left in and around charity donation bins.

A levy rate for disposal was reintroduced in 2019. This covers general waste, C&D, C&I and MSW and commences at AUD70 per tonne, with an increase of AUD5 per year over the subsequent four years so that by the end of 2022, the cost will be AUD90 per tonne. The cost of the levy for regulated waste will start at AUD150 for Category 1 and AUD100 for Category 2 (Queensland Government, 2018).

Category 1 waste refers to the list of items in the Environment Protection Register, Queensland (Queensland Government Department of Environment and Science, 2019). It refers to chemicals arising out of teaching activities and other chemicals; fly-ash; mercury and mercury compounds; lead and lead compounds; waste from heat treatments; and waste from the manufacture, formulation or use of organic solvents, resins, latex, plasticisers, glues and other

adhesives. Category 2 includes regulated waste such as asbestos, mineral oils, liquid food processing waste, tyres, vegetable oils, and waste from the manufacture, formulation or use of photographic chemicals or processing materials.

The commencement of this levy is seen as critical in enabling effective waste management behaviour in Queensland; and in supporting local governments, businesses and industry to reduce the volume of waste generated, in combination with awareness-raising programmes. The government is also considering supporting a transition to a circular economy by reducing the incentive to dispose to landfill and supporting a bio-futures industry by ensuring that feedstock is in the pipeline in the form of waste materials.

The need to think strategically about increasing recovery rates is critical in the face of diminished landfill capacity and reduced export markets for recycled materials. The Queensland Government is seeking to introduce a range of measures that will curb waste generation, increase resource recovery, and prevent littering and hazardous exposure to waste. These include a ban on single-use plastic bags (from 1 July 2018), a container refund scheme to improve the recycling of beverage containers (from 1 November 2018), regulatory reform of regulated waste and other appropriate activity frameworks, and the development of strategic partnerships to improve the management of organic waste.

In addition, the government has introduced the Litter and Illegal Dumping Plan for Queensland, the Plastic Pollution Reduction Plan and the waste disposal levy that commenced on 1 July 2019. Investment measures include the AUD100 million three-year Resource Recovery Industry Development Program, the AUD5 million waste to BioFutures Fund. Action plans support these measures through the Queensland Resource Recovery Industries 10-Year Roadmap and Action Plan and the Queensland Biofutures 10-Year Roadmap and Action Plan (Queensland Government, 2019a).

The vision is for Queensland to transition to a zero-waste society by achieving net zero emissions by 2050. The targets for 2050 are a 25% reduction in household waste, 90% waste recovery and a 75% recycling rate across all waste types. By 2030, the interim target is 30% below 2005 levels (Queensland Government, 2019a). These initiatives support a clear transition to a CE. The roadmaps support the growth of markets through industry development and engagement and catalyse innovation through bans on specific waste streams. Waste that cannot be recycled may be converted to fuel or energy.

The waste hierarchy will be used where possible commencing with a focus on waste avoidance as per the hierarchy. Waste avoidance reduces the amount of waste generated through the delivery of targeted education and information-sharing so as to reduce the MSW and waste from businesses. For MSW, using the year 2018 as a baseline with 0.54 tonnes per capita, the targets are a 10% reduction by 2020, a 15% reduction by 2030, a 20% reduction by 2040 and a 25% reduction by 2050. As per the waste hierarchy, the next step is to reduce the amount of waste sent to landfill. About 55% of all waste was sent to landfill in 2017–18. With the waste disposal levy introduced in 2019 clearly signalling the need to divert valuable material away from landfill, a number of alternative pathways are also now being explored by the government (Queensland Government, 2019a, 2019b).

Increased recycling rates are supported by market development and the delivery of infrastructure to meet market demands. To achieve this, the Queensland Government will work closely with industry and local government to ensure that waste recycling and reuse opportunities are maximised. The current baseline of a 31% recycling for MSW will be increased to 50% in 2025, 60% in 2030, 65% in 2040 and 70% in 2050. The C&I baseline recycling rate of 46.5% will be increased to 55% in 2025, 60% in 2030, 65% in 2040 and >65% in 2050. C&D waste will move

from the current baseline rate of 50.9% (in 2018) to 75% for 2025, 80% for 2030 and >80% for 2040 and beyond. Thus, the overall targets from the current 45% in 2018 will be 60% in 2025, 65% in 2030, 70% in 2040 and 75% in 2050 (Queensland Government, 2019a).

Clearly the state has a long way to go towards achieving its vision of zero waste.

6.4.5 South Australia

As a result of the South Australian Government's policies on CE, environmental gains are anticipated. It is expected that GHG emissions will be lowered by 27% overall, of which 21% will result from actioning efficient and renewable energy gains and 6% from actioning material efficiency gains. This will potentially reduce GHG emissions by at least 60% on the 1990 levels by the year 2050 (Lifecycles et al., 2017).

The state's 2015–20 waste strategy, South Australia's Waste Strategy, has targeted material and resource efficiency in addition to diverting waste from landfill for recycling, supported by a new Climate Change Strategy for South Australia aimed at achieving net zero emissions by 2050. The key objectives of the waste strategy are a resource-efficient economy, clear policy frameworks supporting a stable and efficient market, and an enabling culture that, through collaboration across different sectors, builds an innovative platform for implementation (Government of South Australia, Office of Green Industries, 2015).

6.4.6 Tasmania

While key streams from MSW, C&I and C&D waste have been identified in Tasmania, the lack of a landfill levy in the state (in contrast to Victoria, New South Wales and South Australia) is seen as the main inhibitor of innovation and market creativity in relation to low-cost, simple recovery processes for C&D waste in regional and local government landfill facilities. In 2016–17 the recycling rate in Tasmania was 49% compared to the national average of 58%, and if energy recovery from waste is included, the total resource recovery rate for Tasmania in the same period was 53%, against a national rate of 62% (Blue Environment and Randell Environmental Consulting, 2018, p. 26). C&D waste in particular has a much lower recovery rate in Tasmania (Tasmanian Government, 2020).

The absence of a landfill levy fails to capture the true value of the environmental and social costs associated with end of life. The funds obtained from landfill levies provides an opportunity to build strategy and a dedicated programme on waste such as Sustainability Victoria in Victoria, Green Industries in South Australia or the Waste Authority in Western Australia. With the absence of a state-imposed levy in Tasmania, several local councils have introduced landfill levies starting from AUD5 per tonne, increased by some councils to AUD7.50 per tonne – far lower than other states in the country. A levy is a potential funding source for a range of programmes for reducing, reusing and recycling waste. In addition, a container refund scheme (CRS) is set to commence in 2022 to support recyclable material supply chains and reduce the volume of litter in the state.

Councils are seen as key to developing best practice guidelines and support for councils has been prioritised. Best practice kerbside bin systems and organics collection for composting need to be identified and further developed. The recovery of specific materials for recycling such as glass, organics, e-waste and other specific classes like hazardous waste needs to be considered and separation at the source of the waste is urgently needed.

6.4.7 Victoria

Victoria has been sending 1.27 million tonnes of paper, plastic and cardboard each year to China and Malaysia, about 30% of which has the potential to be recycled (Victorian Government, 2020b). Four goals aligning with SDG 8 and SDG 12 drive Victoria's recently announced Circular Economy policy: Goal 1 – Design to last, repair and recycle; Goal 2 – Use products and create more value; Goal 3 – Recycle more resources; and Goal 4 – Reduce harm from waste and pollution (Victorian Government, 2020b). From a waste management perspective, Goal 3 and Goal 4 are most relevant.

The various initiatives already in place are increasing the recovery of organic waste by supporting expanded collection at the household level, banning e-waste from landfills from 1 July 2019, banning lightweight plastic shopping bags and developing a plastic pollution prevention plan (State of Victoria, 2019). Targets have been set and progress will be measured during the interim period to 2040. For Goal 3, the government plans to divert 80% of waste from landfill by 2030, with an interim target of 72% by 2025. Halving the volume of organics sent to landfill between 2020 and 2030, with an interim target of 20% reduction by 2025, as well as making available to all Victorians organic waste recycling services or composting by 2030 is a key action (Victorian Government, 2020b). Goal 4 involves reducing harm from waste and pollution, which will require that waste be managed more safely. In line with the National Waste Policy Action Plan, plastic, paper, cardboard, glass and tyres will be banned for export from July 2020; total waste generation in Australia is to be reduced by 10% per person by 2030; unnecessary and problematic plastics are to be phased out by 2025; the amount of organic waste sent to landfill for disposal is to be halved by 2030; the resource recovery rate is to be increased by an average of 80% from all waste streams and the use of recycled content by government and industry is to be supported, while also enabling better consumer, investment and policy decisions.

6.4.8 Western Australia

The target for avoiding waste in Western Australia is a 10% reduction in waste generation per capita by 2025 and a 20% reduction in waste generation per capita by 2030. Recovery will enable increased material recovery to 70% by 2025, to be further increased to 75% by 2030 (Government of West Australia, 2018). From 2020, the plan is to recover energy only from residual waste. For government and industry, targets have been set for both the C&I and C&D sectors.

For C&I, increased material recovery to 70% by 2020, 75% by 2025 and 80% by 2030 are the current targets set. For the C&D sector, increased material recovery to 75% by 2020, 77% by 2025 and 80% by 2030 are envisioned. Materials specifically identified for C&D are concrete, asphalt, rubble, bricks, sand and clean fill. Metals are steel, nonferrous metals, packaging and containers. Plastics for packaging and containers are also targeted. Protecting waste streams will ensure that, by 2030, no more than 15% of the waste generated in the Perth and Peel regions is being sent to landfill and that all waste is being managed/disposed to better facilities (Waste Authority, 2018a).

Further strategies supported by the Western Australian Government include separation at source, using local government support, supporting procurement practices, planning for the future in terms of both the levy itself and holistic programmes for waste reduction and elimination (Waste Authority, 2018b).

To support this process, targets have been set as indicated above. The Western Australian Government has been working with the Waste Authority, the Department of Water and Environmental Regulation (DWER) and other state government agencies (Waste Authority, 2018b). The Waste Authority is responsible for the Waste Authority Business Plan, Waste Data Strategy, Waste Authority Position and Guidance Statements, as well as Waste Authority programmes and initiatives. The DWER is responsible for Local Government Waste Plans, Waste Levy Administration, Compliance and Enforcement and the state's Waste Infrastructure Plan. Other government agencies are responsible for sustainable procurement policy and guidance, piloting the use of recycled C&D waste as road base and reducing the amount of single-use plastics produced by agencies. The resulting action plan will be reported on annually. Western Australia's business plan on waste reduction is perhaps the most advanced in Australia. Establishing relevant and accurate baseline data is part of this process, which will enable progress to be monitored.

6.4.9 New Zealand

In New Zealand, a levy of NZD10 on each tonne of waste sent to landfill is collected from landfill operators and paid to territorial authorities each year. Each territory's share is the levy collected less the levy refunded multiplied by the district's population (levy collected - levy refunded x district population), where the district population is calculated based on the most recent census (Ministry for the Environment, NZ, 2020c).

Waste minimisation projects have been funded by the waste disposal levy. Also in the mix are considerations for increasing the waste disposal levy through a suite of programmes. The National Waste Data Framework, launched in January 2018 by the local government waste management manifesto, includes CDSs and plastic products and materials. The Rebooting Recycling (wasteMINZ, 2018) report also supports and prioritises a range of measures for handling plastic. A code of practice, including a packaging and design checklist, has been developed by Packaging New Zealand to support the reduced use of plastics (Ministry for the Environment, NZ, 2019c). A soft plastic recycling scheme has also been introduced to ensure that plastics go back into the supply chain, and a compostable standard has been set up to certify compostable items, including common labelling to assist both industry and consumers. A guide has been prepared to provide information to consumers on biodegradable, degradable or compostable plastics and the complexities involved in their use.

The Prime Minister's Statement to the Parliament over 10 years ago in 2007 suggested the need for some form of waste levy to help fund waste minimisation. This led to calls for a national waste levy enshrined in legislation and administered through the councils and territories. The legislation also supported the product stewardship scheme reporting to the Ministry for the Environment via the councils and operators of recycling and disposal facilities. A new waste advisory board was also set up to advise the Minister for the Environment on the provisions and functions of the new waste legislation (Ministry for Environment NZ, 2019c). A Waste Minimisation (Solids) Bill amendment was proposed on 20 September 2007 (New Zealand, 2007).

These developments by the government have led to a clear direction for future work on waste minimisation, which will ensure that New Zealand is able to meet its targets for reduced environmental pollution. The associated public policy objective is to lower the social costs and risks of waste, reduce the damage to the environment from waste generation and disposal, and increase the economic benefits through more efficient use of materials. Increased funding and improved reporting and governance form the basis for the policy objectives. A levy of NZD10 for every tonne of solid waste disposal into landfill provides NZD31 million annually. The cost

of the levy is expected to be sufficiently small not to unduly disadvantage households while supporting local waste minimisation objectives and projects (Ministry for the Environment, NZ, 2019a, 2019c). However, there has been no policing of the levy and there is no level playing field, rendering this approach ineffective (Blumhardt, 2018).

Preventing the contamination of recyclables in New Zealand relies on education, service configuration and monitoring, and enforcement by councils (Wilson et al., 2018). There are no standardised approaches to procurement and contracts, and as there are often no transparent ways to check material grades, it is difficult to put this into practice.

New Zealand's waste strategy involves a two-pronged attack: reducing the effects of harmful waste and improving the efficiency of resource use (New Zealand Government, 2018). Since the Waste Strategy was released in 2002, access to kerbside recycling in New Zealand has improved and the government's approach to moving towards zero waste has been supported by business, government and communities. The number of operational waste disposal facilities has increased over time. The best practice guidelines proposed have resulted in larger, better designed and managed facilities that reduce environmental pollution and capture gas where possible. The regulatory framework for efficient resource use has improved and increasing the levy rates has encouraged more recycling. A suite of legislative and regulatory frameworks including the Waste Minimisation Act 2008, the Local Government Act 2002, the Hazardous Substances and New Organisms Act 1996, the Climate Change Response Act 2002 and the Resource Management Act have assisted New Zealand to maintain its trajectory of resource recovery and minimisation. Reducing the harmful effects of waste and improving the efficiency of resource use has assisted the New Zealand Government in maintaining a flexible approach to waste that can be adapted to various situations. It is in the government's second goal of improving efficiency that the principles of circularity are seen, through eliminating waste and ensuring that products are reusable, durable and repairable.

All levels of government, both central and local and including regional councils and territorial authorities, are engaged in waste management. The waste industry and businesses and communities are also required to help minimise waste and support waste management actions, whether product stewardship or behaviour change programmes.

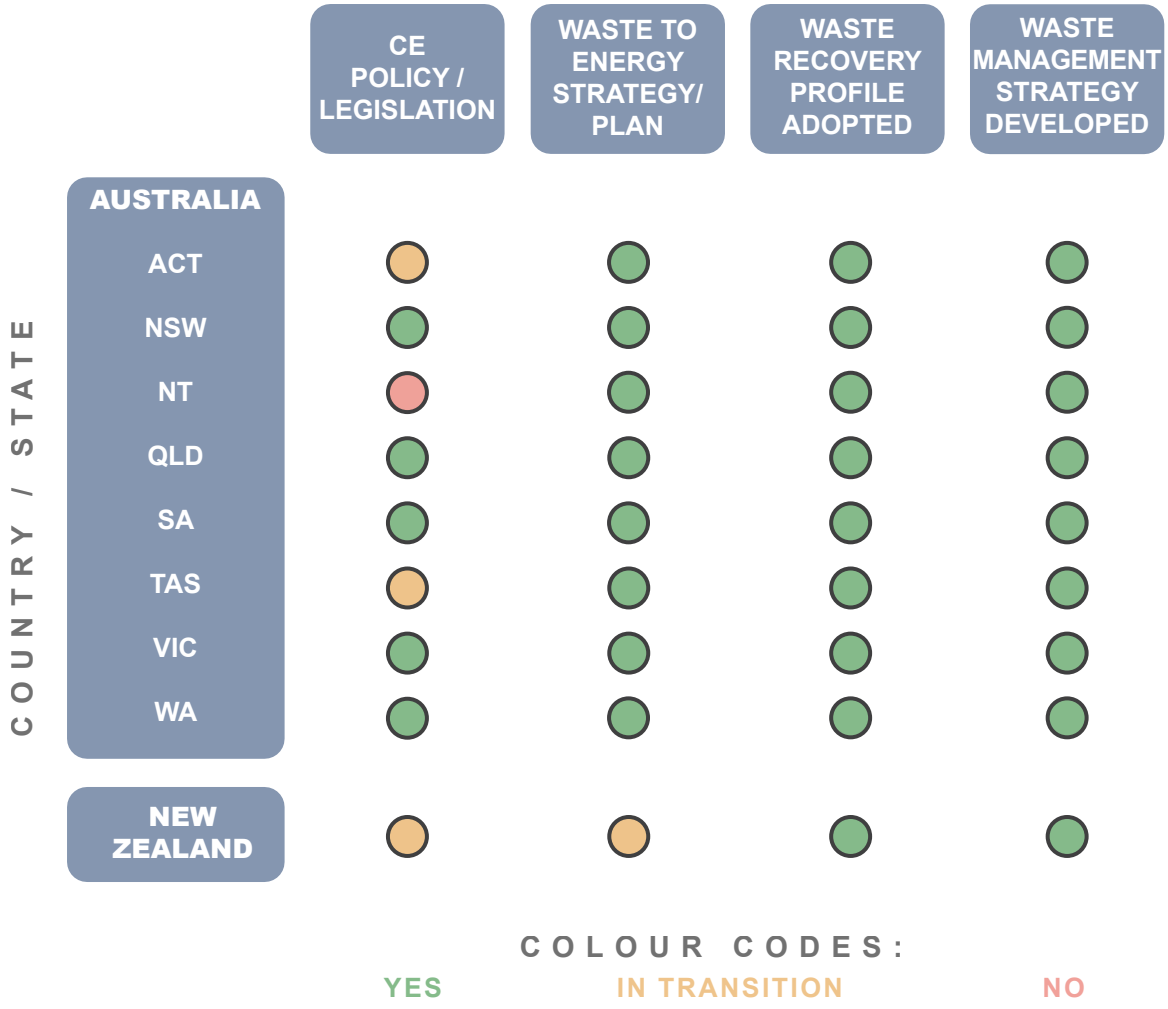
7. Analysis

In early 2018, China imposed strict contamination standards on the import of mixed recyclables into the country, including paper and plastics. Some other countries, including Indonesia and India, have already begun to push back regarding the types of waste that are being imported into the country, particularly around the contamination of waste. The loss of an export market for waste has been a driver of CE policies in Australia and New Zealand.

Table 1 provides a summary of the policies/approaches taken across Australia and New Zealand in relation to the main criteria considered in section 6. These include CE policy, waste to energy options, waste recovery profiles, and the development and implementation of waste management strategies.

Table 1: Waste in Oceania

Source: Author
Graphics: Ninni Westerholm



7.1 CE policies

Zero waste/carbon neutrality is seen to be the underpinning of CE in Australia and New Zealand. Both countries are facing rising populations, resulting in government policies and programmes aimed at reducing the amount of waste while also supporting the design and resource recovery of materials into the future. This is of particular importance in places with the highest population growth, such as Victoria, which is expected to have a larger population than other Australian states.

A definition of CE has been provided by the governments of New South Wales, South Australia and Victoria. They have also explicitly announced CE policies and prepared discussions/ papers outlining policies and programmes/roadmaps to achieve a transition to CE. New South Wales's CE policy is based on seven principles, whereas Victoria has announced four goals and associated targets. South Australia has already begun to implement its CE policy.

Jobs have been a major driver of CE policies in South Australia. Jobs in construction are ranked second in terms of numbers and economic activity as a result of these policies. In the state, CE has the potential to enable broader GHG emissions reductions in transport, manufacturing and agriculture by ensuring that circularity practices are put in place. Thus, it has been shown that CE can support economic activity, create jobs and new business opportunities, and generate savings for all. In the Victorian context, a study concluded that a 5% materials efficiency improvement could increase the size of the state's economy by AUD6.4 billion or close to 2% GDP (Centre for International Economics, 2017, p. 2). Likewise, in Tasmania, the move from a linear to a circular economy is seen to support the creation of jobs, and a reduction in both the use of virgin materials and the need to divert waste to landfill.

Creating a shared performance-based economy has spurred the transition to a CE in South Australia. However, appropriate infrastructure needs to be put in place to support a CE. In South Australia, the underpinning CE policy supports hiring or leasing products to ensure that they are kept running longer, especially through maintenance, repair and design for durability. The sharing of household products and tools is also being used to support this approach. This is aligned to other business models that are based on a performance-based economy, where manufacturers are focused on performance outputs by retaining ownership of their product. This leads to products that are made to last rather than designed according to planned obsolescence. In line with such models, computers, printers, carpets and lighting services, among other products/services, are increasingly being leased. Incentivised returns support the return of 'used' products that may be refurbished and resold. An approach to asset management is being adopted that minimises purchases by maximising product lifetimes through reuse, repair and redeployment (Lifecycles et al., 2017).

South Australia has already tested some business models for CE with success, such as Precycle (Australia) (Government of South Australia and Precycle, 2019) in the building and construction industry. Precycle is perhaps the most advanced business model in Australia with respect to reducing building and construction waste. It sorts recyclable materials at their source, predominantly on construction sites before sending them to be recycled. This not only assists in recovering materials, but also minimises hazards, increasing overall safety and hygiene.

7.2 Energy from waste

Energy from waste is the least preferred option as it releases the embodied energy and does not support the reuse of resources. Queensland and Victoria are the only states in Australia that have funds allocated to support a bio-futures industry. Queensland has identified eight principles to support energy from waste technologies, ensuring that considered decisions are made. The Australian Capital Territory also recognises the importance of using bio-organic sources rather than fossil fuel–based sources.

New Zealand does not have any explicit waste to energy policies or programmes but energy from waste is considered to be one of the suite of issues regarding waste management and recovery options prioritised by the New Zealand Government.

7.3 The status of waste across Australia and New Zealand

A number of states in Australia are aspiring towards a zero-waste outcome. Clearly, Australia has a long way to go, but most states are implementing increasingly stringent measures leading up to 2030. C&D waste is a large proportion of the waste stream in Australia and New Zealand. The reduction of waste going into landfill is a driver of CE. Tasmania has the lowest landfill diversion rate in the country, at 37%, against the Australian average of 58% (Cocks and Bassi, 2017).

The Australian Capital Territory has adopted a stringent approach to increased recycling for the period 2015–25, with a proposal that 90% of all waste is being diverted from landfill by 2025. Likewise, New South Wales aims to improve its recycling rates to 80% for C&D waste in the near future. The Northern Territory not only supports increased recycling, but also seeks to align the move to a CE by supporting the creation of local jobs. Considering the impact that the waste industry has had on jobs growth, with an increase of nearly 15% in building and construction, a strong case may be made for the transition to a CE as it also lowers the environmental impact. As a result of transition to CE an increase in jobs is also predicted for Victoria, based on trends in South Australia's CE evolution.

C&D forms a significant percentage of the total volume of waste in Australia and New Zealand. In Queensland, for instance, C&D comprises close to 51%, while Western Australia has a similar profile. In Queensland, concrete, asphalt, ferrous scrap metal, and bricks and tiles represent, in order from highest to lowest volume, the C&D waste generated. Although other states do not have such detailed figures, the data on Queensland and Western Australia demonstrates the potential for waste recovery in the building and construction industry. In Victoria, emission reductions of up to 40% by 2050 have been anticipated by the statutory authority Sustainability Victoria, resulting from the emissions 'saved' due to the extraction of virgin materials.

Improved food waste management has also been identified as important in supporting a bio-futures industry.

7.4 Waste and circularity

If the strategic underpinnings are set appropriately, waste management can quickly support a clear and strong CE strategy. This is primarily in terms of the expected economic opportunities arising from the creation of jobs and businesses that support the waste sector.

In the 2017–18 period in the Northern Territory, 744 jobs were secured in the waste management and secondary resources industry, equating to AUD46.1 million in salaries and wages, with an average annual wage of AUD61,932. The jobs related to this industry are truck and forklift drivers, recycling and rubbish collectors, earth-moving plant operators, factory process workers, and general and production managers. Directly and indirectly, the waste management and secondary resources industry is estimated to provide of 1165 FTE jobs in the Northern Territory over the period 2017–18 (Behrens, 2018).

The FTE salaries in the waste industry in the Northern Territory are approximately AUD8000 higher per annum than Australian national averages. The waste management and secondary resources industry is estimated to contribute to AUD97 million to the Northern Territory's GSP during 2017–18 (Behrens, 2018), or 40 cents in every AUD100 to the territory's economy. A total of 53 private sector businesses are also supported by this industry.

This industry has had a collective turnover of AUD152 million, with AUD54 million injected into the economy in Northern Territory over the 2017–18 period. The investments in the form of land, building, bins and other collection services using physical assets are valued at AUD36.6 million. The value of managed assets associated with waste collection is AUD16.1 million, with 120 collection vehicles used. The combined Commonwealth and territory taxes accrued as a result of waste totalled AUD3.5 million. Over the past 11 years, the waste management and secondary resources industry has increased employment in the Northern Territory by nearly 14.5%.

In South Australia, CE policies have the potential to create 25,700 FTE jobs by 2030 (Green Industries South Australia, 2017, 2019) and deliver significant reductions in GHG emissions. Of these 25,700 jobs, 21,000 jobs will be the result of actioning material efficiency gains such as repair, sales and second-hand goods markets and 4700 jobs by actioning efficient and renewable energy gains such as leasing and sharing. The potential growth in jobs in professional scientific and technical services is high, followed by jobs in construction, personal and other services, and waste management services (Lifecycles et al., 2017). In Victoria, 3900 jobs are expected to be created as a result of the new CE policy launched in 2020.

The growth in population and the increase in the volume of waste are not quite aligned in Australia and New Zealand. Often, the population increases have been more modest compared to the volume per capita of waste generated. This has been the case in the Australian Capital Territory, Queensland and Western Australia as well as in New Zealand. South Australia has had great success with recycling rates, at 80%, but the state is still keen to improve these rates to close to 100%.

The EPA has legislative power in the states. Transparency around waste streams is required and therefore how local councils are managing waste needs ongoing monitoring. Targets need to be set so that it is easier to develop ongoing roadmaps; it is also important to check progress against targets. In Queensland, waste levy policing has been supported by the EPA; but in New Zealand it was found that, despite regulatory measures being put in place for the landfill levy, the impact has not reached the intended targets.

7.5 Incentives

Landfill levies are seen as a means of curbing materials use at the source. Levies have been introduced in Australian states and New Zealand in recent years, with varying degrees of success. All states in Australia have recently supported CE platforms. It appears that clear policies on CE (even if linked to waste), as introduced in South Australia and New South Wales in recognition of the broader importance of CE, are a step in the right direction. Thus, government policy and support for CE is an important consideration. Landfill levies that are policed are also important to move away from the practice of ‘out of sight, out of mind’. CDSs or CRSs encourage ‘good’ behaviour even if the refund amounts are not the driver of the recovery practices to be entrenched.

7.6 Product stewardship/design and material use

Acknowledging the importance of improving resource recovery and seeking the right opportunities to support expansion into the existing and untapped markets are considered pivotal in the process of product stewardship. Enabling industry to optimise waste by moving away from traditional manufacturing approaches and expanding markets is essential to ensuring the support of industry players in the process. Such approaches also facilitate innovation for expansion into new markets and the creation of new business ventures. Community engagement around reducing waste and supporting the recovery of efficient resources is also important.

Product stewardship has been the foundation of the CE policy in New South Wales. Clever design supports long-term use, reuse, remanufacture and resource recovery, which in turn prevents materials ending up in landfill. Valuing resource productivity is critical to this process. Queensland sees product design as an important step to ensuring that products last longer in the system. Such designs can ensure that products can be repaired, recycled, and upcycled or disassembled at the end of useful life. The use of efficient and integrated post-consumer recovery and reprocessing of products and materials is also considered part of the design and recovery process.

Effective product stewardship approaches ensure that environmental harm is reduced. An industry-led scheme provides an opportunity to regulate in a way that prevents free riders from taking advantage of a voluntary scheme. Only when all players are participating in a scheme can they all enjoy the benefits of the scheme. Such approaches cannot force an unwilling industry to engage in waste issues.

A mandatory approach, on the other hand, forces everyone involved in the market to be on a level playing field. Such a playing field can be led by government, who can enforce regulation/ legislation governing all aspects of the supply chain: product design requirements, mandatory consumer information, collection and recycling targets, mandatory financing mechanisms, waste collectors and end of supply chain manufacturers/businesses to be involved in the process as having equal stake. New Zealand has supported a mandatory scheme through mandatory regulation. The New Zealand Government's product stewardship scheme focuses on reducing waste volume, and supports industry through efficient design, material recovery and reduced waste management. There may be upfront costs to the industry; however, the benefits will far outweigh the costs and will support consumers to engage in waste management practices (Ministry for the Environment, NZ, 2019b). To date, however, some areas have been found to be lacking in implementation, particularly the diversion of waste to landfill.

8. Discussion

Oceania's CE practices are not on par with those of Europe. For instance, Austria's CE is quite mature and was found to be 9.7% higher than the average of 9.1% across Europe, as identified in the 2019 Global Circularity Gap report (Circle Economy, 2019). Austria's roadmap includes moving from fossil fuels to renewable resources, greater efforts around recycling, using old stock of building materials to maintain and refurbish current buildings/infrastructure or build new buildings/infrastructure, and using imports of secondary materials to improve the value of existing stock. If countries like Austria have 58% of municipal waste being recycled, then Australia's performance is not too bad. South Australia's recycling rate of 80% is very good (see section 6.3.5).

Despite waste being a catalyst for work in the CE space, market price signals for Australia and New Zealand are weak. Only metals (steel and aluminium) and fibre (paper and cardboard) have inherent and sufficient economic value to be processed and recycled. Other materials that do not fit in the waste streams incur greater costs for removal and reintegration or having to be subsidised by someone else. While some materials may have to be stockpiled, as has occurred in Australia and New Zealand as a result of China's National Sword policy, other materials are difficult to stockpile, such as fibre (cardboard) which needs to be stored indoors. Contamination occurs through materials not being accepted in recycling and recovery systems and where recycled materials of two different types are mixed. This also needs to be considered because if contamination occurs, more energy is required for separation into reusable waste streams.

Governments have a role to play in improving the inherent value of waste materials. Governments can foster the market conditions that enable the right signals to be sent to the community to ensure that waste diversion from landfill is achieved. The cost of state-based landfill levies are not uniform across Australia, with some states such as New South Wales and Victoria having higher levies than Queensland and Western Australia. As occurs in the EU, waste could be banned from landfill and converted into processing as waste going into the landfill is unsorted waste.

This presents an opportunity. Rather than converting waste straight to energy as power or heat, it makes more sense to upcycle the waste where possible, as the waste sector in Australia contributes to 2.7% of total GHG emissions (Ritchie, 2019). Population size also matters as households contribute a reasonable proportion of the material collected for recycling; for example, in New Zealand this equates to over a quarter of the total. Glass is dominant in material sources. The recovery of recyclable materials from households has always been an issue because the service operates at a net cost, and the difficulty in finding markets for these materials raises the cost. While China has stopped taking waste, Malaysia, Thailand and Indonesia have stepped in, although these countries are also finding it hard to deal with contaminated waste.

New Zealand has undertaken detailed studies, as shown in the preceding sections, to understand how best to respond to China's National Sword policy. Several responses have been suggested by government, including engagement with industry and the development of regulatory impact statements, as well as other proposals (Yuen, 2018). Some of these include supply chain interventions, such as a short-term gate fee at facilities, model contract development, reduction of contaminants, improving the quality of material recovery facilities, developing a database of domestic reprocessors, national data waste systems and procurement policies on the growth of onshore plastic processing, education around reducing contamination, stopping the collection of plastic grades 3–7, and regulation of the recyclability of packaging and of the recycled content of packaging. Markets for mixed plastics of grade 3–7, mixed paper and cardboard are not a viable option in New Zealand.

Based on the analysis presented in section 7, the model that seems to work best is the adoption of CE as a clear policy platform by government. Some governments have set their own CE definitions and those models that were advanced had created a clear pathway or roadmap for engagement. While waste has spurred CE policies, other considerations such as jobs, the digital economy and engaging with businesses locally are also critical. Energy from waste in Australia and New Zealand is not as advanced as it is in other countries such as Northern European countries or even Singapore in the Asia-Pacific region.

The development of regulatory frameworks, mainly through the environment planning authorities, is also important as it supports and reinforces CE policy. However, without such a framework in place, waste continues to be a key driver of CE. The reduction of waste at

the source and opportunities to recover materials and bring them back into the supply chain need to be considered in further detail. Given the size of the Australian and New Zealand populations and economies, identification of the sweet spot for getting the scales right also needs consideration. This is where product stewardship and the role of design is critical to ensure that material use becomes central to the discussions.

In sum, failures exist largely because of a widespread inability to position a circular economy as a strategic approach to dealing with resource optimisation. A systemic approach to CE must be recognised. A holistic approach supporting material tracking systems, education to embed CE as a corporate strategy, incentives for technological investment, and incentives to encourage design for disassembly is required. Without this, CE strategies will become elaborate recycling strategies that fail to address complex systemic problems with new understanding and innovative approaches.

9. Conclusion

The move to a CE in the Oceania region requires a collaborative effort between government, industry and the community. Governments need to set the agenda and provide clear leadership to enact policies and develop programmes to support such policies. Supporting businesses in their supply chain management requires effort at the local, national and regional levels to eliminate traditional jurisdictional limitations and barriers to trade and investment. Mainstreaming resource efficiency from a systemic perspective along with product stewardship such as environmental labelling, information sharing schemes and developing mutual recognition across geographical boundaries will avoid duplication and support cross-cutting sectoral collaboration. This will also allow for the sharing of existing resources (and not having to reinvent the wheel) and minimise unnecessary cost, time and other resources. Improving data collection and transparency of data across the board will support tracking and monitoring to ensure that the targets set can be achieved.

Communities can be engaged in raising their own awareness, leading to changes in behaviour to reduce contamination at the source and the sharing of examples of successful behaviours and practices at the local level. Encouraging communities to support the move to zero waste also relies on governments supporting and encouraging their own communities, not just in terms of enhancing knowledge but also in experimenting as appropriate to test various solutions.

Based on this study, in particular some of the issues identified in sections 3–6, the following list of more detailed considerations for a building's lifecycle is provided as a starting point to a roadmap in the Oceania region for CE across different lifecycle phases of the built environment: capital cost, operational costs, environmental impacts, new businesses, and green jobs and skills. To develop realistic solutions, industry must work together to identify common goals and business opportunities to scale up pilot initiatives. Identifying opportunities for engagement, experimentation and innovation is part of the journey towards a CE.

Built environment projects that involve new or refurbished building and construction projects should consider an approach to capital cost that supports holistic thinking, where product stewardship opportunities and related concepts can be fully explored. Trial and experimentation can also be used to support circular product development. Where renovations are to take place, as opposed to a new build, flexible planning and use of materials should be adopted such that parts may be easily replaced or changed/reused elsewhere. There also needs to be transparency in the use of building materials so that, at end of life, materials may be reused or upcycled.

For buildings that are currently in operation, service considerations include the use of renewables and lifecycles. Where appropriate, collaboration to support service types of contracting where longer lifecycles are maintained/enhanced should be at the forefront of operational considerations. Where renovations are considered, flexible adaptation of building components should also be considered. Deconstruction should maintain or enhance the value of recovered building products.

From an environmental impact perspective, virgin materials should be avoided completely as they enhance embodied content and attendant GHG emissions to air, land and water. Use of renewables in the manufacturing phase and more efficient resource use leading to reductions in the overall environmental impact will be favoured. Design for disassembly and transparency in the use of materials that make up the various components of buildings are valuable steps in ensuring that materials and products can be reused after useful life of the building. Buildings that are no longer in use may be 'mined' for new construction or refurbishment.

As identified by the literature, new business opportunities may arise from circular economy practices, leading to growth in jobs. Government support can spur product development and innovative solutions, allowing local supply chains to take risks that they would otherwise avoid. Combined with the use of energy-efficient and renewable energy approaches, business can incorporate manufacturing and operational strategies combined with 'low hanging fruit' to support local economies where possible. New resource streams may be created, which will require track and trace support for product and material stewardship.

All of the above initiatives will result in an expansion of green jobs and skills. Thus, upskilling for a circular economy is urgently needed. New supply chains may lead to new business innovation models and the development of quality products from waste streams. With regulatory and CE-based policy support, construction can become more modular, enabled by digitalisation and the creation of new opportunities for servicing and circular maintenance in buildings. These are presented in Table 3.

Table 3: Considerations for different lifecycle phases of the built environment

Source: Author
Graphics: Ninni Westerholm

	CAPITAL COSTS
MANUFACTURE 	Trial and experimentation (R&D), cost benefits of the use of waste and by-products, circular product development
DESIGN 	Product stewardship, holistic thinking, lifecycle assessments
CONSTRUCTION 	Government policy and regulation on CE supported by resource use, economic benefits of circular building products
OPERATION AND USE 	Behaviour change programmes, lifecycle cost savings, increased value
RENOVATION 	Reusability and replaceability of building products and systems, flexible planning for long-term regulatory support where appropriate to use recycled/reused products
DECONSTRUCTION END OF LIFE 	Plan as appropriate, value of recovered building products, upcycling

OPERATIONAL COSTS

MANUFACTURE 	Service considerations, collaborations as appropriate, lifecycle considerations, use of renewables/resources where possible
DESIGN 	Design for multi-use, design for flexibility and adaptability, disassembly and for longer lifecycles
CONSTRUCTION 	Reduced waste, prefabrication where possible, use of local materials, reduced maintenance
OPERATION AND USE 	Better maintainability, longer shelf life, low operational costs
RENOVATION 	Disassembly/demountability and reusability of building products
DECONSTRUCTION END OF LIFE 	Regulatory support (potable water use, grey water use), value of recovered building products, upcycling

ENVIRONMENTAL IMPACTS

MANUFACTURE 	Reduced emissions and waste, use of renewable sources, reduction of resource use
DESIGN 	Understanding operational considerations and services, LCA design for multi-use and flexibility, design for disassembly
CONSTRUCTION 	Reduced emissions and waste, low or no use of virgin materials
OPERATION AND USE 	Reduced emissions and waste, longer life in current construction, service models
RENOVATION 	Reduced emissions and waste
DECONSTRUCTION END OF LIFE 	Reduced emissions and waste, also in second life

NEW BUSINESSES

MANUFACTURE 	Government support, digital marketplace, upcycling product development, supporting secondary use and reuse
DESIGN 	LCA design for multi-use and flexibility, design for disassembly, tracking products and materials to understand digital supply chain maps, product stewardship, operational considerations
CONSTRUCTION 	Circular construction, tracking products and materials to understand digital supply chain maps, product stewardship
OPERATION AND USE 	Use of renewables, material tracking, understanding supply chains, ownership to service model, zero waste, reduced emissions
RENOVATION 	Assessment (may be using digital platforms) for high value recovery of building products, material tracking, product stewardship
DECONSTRUCTION END OF LIFE 	High value recovery of building products and systems, new resource streams

GREEN JOBS AND SKILLS

MANUFACTURE

Developing quality products from waste streams, business innovation models, scouting new supply chains

DESIGN

Regulatory support, quality assurance, design for disassembly, entrepreneurship

CONSTRUCTION

Professional development, material tracking/product stewardship, skills/jobs in prefabrication and digitalisation

OPERATION AND USE

Material tracking, circular maintenance (new service rather than traditional ownership models), remodelling/construction of flexible spaces, behaviour change mentors

RENOVATION

No waste/low waste, no/low emissions, use of existing materials and products (high value recovery of existing products), upcycling

DECONSTRUCTION END OF LIFE

Skills in disassembly to retain value or upcycle, material tracking recovery to put back in supply chains

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