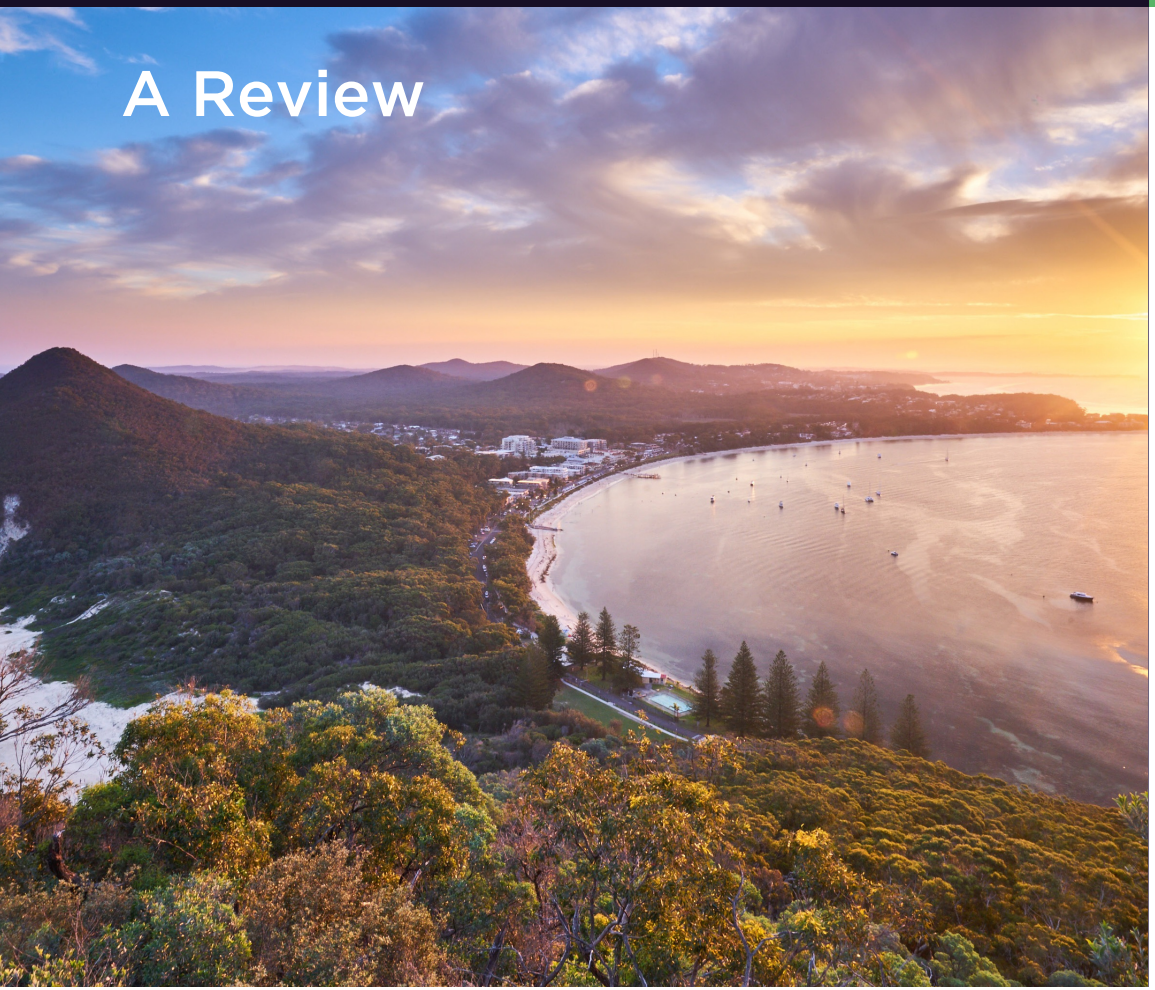
Circular Australia

UTS

# Circular Economy Metrics

## A Review



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# Acknowledgement

The Institute for Sustainable Futures (ISF) is a transdisciplinary research and policy institute at the University of Technology Sydney with over 100 research staff and students. Since 1997, ISF has been working collaboratively with governments, businesses, organisations and communities to create change towards sustainable futures. Our work in Australia and around the world aims to protect and enhance the environment, human wellbeing and social equity. We do this by developing transformative ideas into strategies that deliver impact and have a strong record of achievement in advancing circular economy and resource stewardship initiatives.

For further information visit: www.isf.uts.edu.au

Circular Australia is an independent, national body working to influence more and more Australians, governments and businesses to implement circular strategies. Our expertise, programs and partnerships drive change, measure impact and accelerate the circular economy transition. Our mission is to lead and inspire others to implement circular strategies to fast track the circular economy in Australia through: national influence; evidence and trust; collaboration and capacity; assisting to deliver new circular economy markets, infrastructure and services; and advocating to establish policies and programs that promote circular economy practices and attract investment.

For more information visit www.circularaustralia.com.au

## Research team

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## Acknowledgement of Country

We acknowledge the traditional custodians of Country and pay our respects to Elders past, present and emerging. We recognise that our built environment and activities are on Aboriginal land and commit ourselves to thoughtful, inclusive and respectful ongoing management of these places.

## Disclaimer

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# Foreword

**We know how vital the circular economy is to grow jobs, industry and investment in a resource and carbon-constrained future.**

Measuring the circular economy (CE) in the Australian context is essential to enabling a safe and speedy transition to the new zero carbon zero waste future.

Circular Australia is proud to have partnered with the Institute for Sustainable Futures (ISF), University of Technology Sydney, on this excellent project to develop a suite of wide-ranging Australian circular economy metrics to assist governments, organisations and businesses set targets and measure progress towards a circular economy.

These metrics help make it possible to measure job creation, develop new business cases for circular solutions, and monitor the gaps that need to be closed as we progress to a circular economy. Metrics are essential as they allow organisations and governments to set circular economy ambitions and measure progress, and inspire action to design out waste and GHG emissions.

The development of CE metrics will continue to evolve as Australian governments and businesses seek to unlock the substantive economic opportunities associated with designing out waste, changing their supply chains to keep materials in the economy, and regenerating natural systems. An Australian circular economy can unlock $1.9 trillion economic benefits over the next 20 years by keeping resources in the economy longer to generate new jobs and catalyse new industries.

Circular Australia's intention is for these metrics to be discussed and assessed by the Australian circular economy community of practice, companies, governments, their agencies and departments, not for profits and research organisations. We intend to accelerate the discussion on Australian CE metrics to help move towards consensus and action.

We would like to thank the NSW Office of Chief Scientist and Engineer (NSW OCSE) for supporting this work over the past year.

**Terri Butler**

**Chair of the Board, Circular Australia**

# Introduction

> **Effective metrics are essential for a circular economy to measure progress**

As governments, businesses and communities seek to drive a circular economy, there is significant interest in finding ways to measure progress towards a circular economy. There are many established and relatively new metrics that could be used to measure the transition to a circular economy. These metrics have applications at different scales and can reflect different goals and perspectives, with various strengths and weaknesses which warrant exploration.

The Institute for Sustainable Futures at UTS were commissioned by Circular Australia (formerly NSW Circular) to research international best practice in circular economy metrics and to assess potential metrics that could be used by the NSW State Government. The intention was to consider a broad range of metrics encompassing all aspects of the circular economy, including those that relate to: resource use, recycling, energy consumption, carbon emissions, water consumption and jobs. Aligned to the definition of a circular economy, the reviewed metrics relate to a variety of circular economy actions, such as redesign, reducing consumption, use and reuse, repair, remanufacture, recycling, recovery, waste, and disposal. The scope also included metrics that could be used at different scales, ranging from local government areas and precincts to state and national metrics.

### METHODOLOGY

The research team undertook a number of steps to scope, identify, assess and short-list metrics for this study. The major steps are explained below.

1. We established a framework of three circular economy principles from the Ellen MacArthur Foundation to help scope and consider a broad range of metrics:
   a. Eliminate waste & pollution
   b. Keep products and materials in use
   c. Regenerate natural systems

2. The team searched for metrics in academic papers and in grey literature with reference to the three principles stated above, and then mapped them against:
   a. five key themes – 1) material use, 2) energy and greenhouse gas emissions, 3) jobs and investment, 4) water, 5) natural and regenerative environment.
   b. seven circular economy actions: 1) Redesign, 2) Reducing consumption, 3) Use & reuse, 4) Repair, 5) Remanufacture, 6) Recycling, 7) Recovery.

# Introduction cont.

3. The initial literature search found 110 circular economy metrics, of which we shortlisted 47 potentially relevant metrics after addressing overlapping concepts. The team then undertook a preliminary appraisal of these metrics and further shortlisted 31 metrics (the "long list") which were assessed for application to NSW. Metrics were excluded if they were less circular economy focused or constituted repetition in terms of the whole suite of metrics to consider.

4. In order to assess the suitability of metrics in the long list, the team prepared a high level overview for each metric, documenting key information, such as: current examples of its use, the method of calculation, the scale at which the metric is most applicable, availability of data for NSW, and the nature of the metric as 'modelled or measured', and 'absolute or relative'.

5. The team then conducted a simple traffic light assessment considering the context of NSW, with regard to the ease of data collection, the circular economy focus of the metric, and its alignment with NSW policy.

### THIS DOCUMENT

In this document we present a snapshot of 31 different metrics. Each snapshot provides a description and details various attributes of the metric. The snapshots also provide a high-level multi-criteria assessment to consider their potential use in NSW. The assessment was based on three criteria, which are: ease of data collection; circular economy focus; and whether they aligned with NSW policy.

**Criteria used for traffic light assessment of metrics**

| Criteria & Performance | Grey | Yellow | Green |
|---|---|---|---|
| **Ease of data collection** | Data not available and future availability is not known, or significant amount of research is required to develop the methodology for data collection. | Only some of the data is available, or data is not available but the method for obtaining data is known, or source data is available, but some work is required to arrive at metric. | Data is readily available and published. |
| **Circular economy focus** | Metric is relevant to a CE but primarily supports a linear economy (e.g. waste to energy). | Metric provides baseline information that supports the circular economy, but also supports a linear economy (e.g. waste generation data). | Metric directly supports circular economy strategies – reduce, redesign, repair, reuse, remanufacture, share, recycle, recover etc. |
| **Alignment with NSW policy** | Relevant CE metric but not directly supported by NSW policy. | Implied alignment stated in NSW policies and National Waste Policy CE objectives. | Aligns directly with stated NSW policies and National Waste Policy CE objectives. |

CHAPTER ONE

# Material flow metrics

Each of the following sections divides metrics into 'established' or 'new and emerging'. Most of the established metrics for material flow, such as waste generation and recycling, are already widely used. New and emerging metrics, such as product longevity and the sharing economy, address some of the key themes for a circular economy.

### Metrics assessment for NSW: established metrics (materials)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Waste generation | 🟢 | 🟡 | 🟢 |
| Waste per material consumption | 🟡 | 🟢 | 🟡 |
| Material recycled into new products | 🟢 | 🟢 | 🟢 |
| Material recycling rate | 🟢 | 🟢 | 🟢 |
| Material recycling collection rate | 🟡 | 🟢 | 🟡 |
| Local material recycling rate | 🟡 | 🟡 | 🟢 |
| Share of waste recovered for energy | 🟢 | ⚫ | 🟢 |
| Food production and waste | 🟡 | 🟢 | 🟢 |
| Repair economy – value of service and sales | 🟡 | 🟢 | 🟢 |

### Metrics assessment for NSW: new & emerging metrics (materials)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Green public procurement | 🟡 | 🟢 | 🟢 |
| Longevity indicator for EE products | 🟡 | 🟢 | 🟢 |
| Products sold for reuse | 🟡 | 🟢 | 🟢 |
| UNIDO EIP toolbox | 🟡 | 🟢 | 🟡 |
| Industrial Symbiosis indicator | ⚫ | 🟢 | 🟡 |
| Eco-efficiency indicator | ⚫ | 🟢 | 🟡 |
| Sharing economy goods utilisation | ⚫ | 🟢 | 🟢 |
| Vehicle sharing – private vehicle km travelled | ⚫ | 🟢 | 🟡 |
| Circularity Index and Circularity Gap | ⚫ | 🟢 | 🟢 |

# Waste generation - tonnes

Waste generation measures the quantity of material that needs to be recovered at end of life to ensure a circular economy. Total waste generation should trend down in the transition to a circular economy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| **Description** | Amount of solid waste generated |
| **Calculation** | Total amount of material going to recycling and energy from waste plus waste disposed to landfill (tonnes) |
| **Scale** | State & potentially Local Government Area (LGA) |
| **Already reported for NSW?** | Yes - National Waste Report 2020, WARR Progress Report 2017-18 |
| **Modelled or measured? Absolute or relative?** | Measured (see methodology report)<br>Absolute |
| **Data source/s** | • National Waste Report Excel database (public) (NSW)<br>• NSW EPA waste and recycling surveys + data from licensed facilities |
| **Example(s) of use** | • National Waste Report<br>• NSW EPA WARR progress reports |

# Waste per material consumption

Domestic Material Consumption (DMC) measures the amount of materials directly used in the economy. Waste generation and DMC, both in absolute terms and as per unit intensities, are important indicators as "building blocks" for CE.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| **Description** | The ratio is relevant as an index of relative intensity of raw material and waste "pressures" of an economy. The ratio is expressed in % as both terms are measured in the same unit, namely tonnes. |
| **Calculation** | All waste generated, excluding major mineral wastes, divided by DMC |
| **Scale** | National |
| **Already reported for NSW?** | No |
| **Modelled or measured? Absolute or relative?** | Measured<br>Relative |
| **Data source/s** | • National Waste Report Excel database (public) (NSW)<br>• IRP Global Material Flows database |
| **Example(s) of use** | EU CE Monitoring Framework |

# Material recycled into new products

Material recycling keeps materials within the economy for a longer period of time. The total quantity of material recycled into new products is used to track diversion from landfill and growth in the recycling industry.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Amount of solid waste diverted from landfill and recovered through material recycling or organics recycling processes (excludes stockpiles and energy recovery) |
| Calculation | Total amount of material recycled (tonnes) |
| Scale | National, State and potentially LGA |
| Already reported for NSW? | Yes - National Waste Report 2020, WARR Progress Report 2017-18 |
| Modelled or measured? Absolute or relative? | Measured<br>Absolute |
| Data source/s | • National Waste Report Excel database (public) (NSW)<br>• NSW EPA waste and recycling surveys + data from licensed facilities |
| Example(s) of use | • National Waste Report<br>• NSW EPA WARR progress reports |

# Material recycling rate – recycled/ generated

The material recycling rate is an important measure of circularity as it measures progress in diverting materials from landfill to a second use. High recycling rates are essential in a circular economy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Percentage of solid waste diverted from landfill and recovered through material recycling or organics recycling processes (excludes stockpiles and energy recovery) |
| Calculation | Total amount of material recycled (tonnes) divided by total amount of waste generated, (%) |
| Scale | National, State and potentially LGA |
| Already reported for NSW? | Yes - National Waste Report 2020, WARR Progress Report 2017-18 |
| Modelled or measured? Absolute or relative? | Measured<br>Absolute |
| Data source/s | • National Waste Report Excel database (public)<br>• NSW EPA waste and recycling surveys + data from licensed facilities |
| Example(s) of use | • National Waste Report,<br>• NSW EPA WARR progress reports |

# Material recycling collection rate – collected/generated

The collection rate measures the quantity of waste material that is source separated and collected for recycling. The difference between the collection rate and the recycling rate represents material lost in the recovery process.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Percentage of solid collected for recycling through kerbside, commercial & industrial (C&I) collections, container deposit schemes (CDS) etc. |
| Calculation | Total amount of material collected for recycling (tonnes) divided by total amount of waste generated, (%) |
| Scale | National, material type |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Modelled<br>Relative |
| Data source/s | National Waste Report |
| Example(s) of use | • National Waste Report,<br>• Australian packaging consumption and recycling data |

# Local material recycling rate – recycled in AU/ generated

Increased recycling generates investment and jobs. The local material recycling rate measures progress in growing the Australian recycling industry rather than exporting material to be recycled overseas.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Percentage of solid waste diverted from landfill and recovered through material recycling or organics recycling processes within Australia |
| Calculation | Total amount of material recycled within Australia (tonnes) divided by total amount of waste generated, (%) |
| Scale | National, State, material type |
| Already reported for NSW? | No, although waste exports by material type are reported for each state and territory (e.g., Blue Environment 2020) |
| Modelled or measured? Absolute or relative? | Measured<br>Relative |
| Data source/s | • National Waste Report<br>• Blue Environment (2020), Exports of Australian waste derived products, 2019-20 |
| Example(s) of use | • National Waste Report<br>• Australian packaging consumption and recycling data |

# Share of waste recovered for energy

Recovery of waste for energy is a less circular option compared to material recycling but is becoming an increasingly important way of diverting waste from landfill while providing cleaner energy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Percentage of solid waste diverted from landfill and recovered through thermal processes. Excludes incineration without energy recovery. |
| Calculation | Total material diverted through thermal processes (tonnes) divided by total amount of waste diverted from landfill, (%) |
| Scale | National, State |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured<br>Relative |
| Data source/s | National Waste Report Excel database (public) (NSW) |
| Example(s) of use | National Waste Report |

# Green public procurement

Measuring green public procurement (GPP) can reduce government expenditure and waste from purchased goods & services, increase resource efficiency, and stimulate markets for sustainable products and services, owing to the high share of government procurement in the economy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | This metric is used to measure the share of green procurement by governments. To be effective, GPP requires the inclusion of clear and verifiable sustainability criteria for products and services in the public procurement process. |
| Calculation | Items addressing one or more criteria as a ratio of total procurement (%, volume and value) – minimum thresholds & base criteria to be established |
| Scale | State (Department level) and LGA (Councils) |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured<br>Relative |
| Data source/s | • NSW Waste and Sustainable Materials Strategy (2041)<br>• Local Government NSW Sustainable Procurement Guide<br>• Sustainable Procurement Guide for Commonwealth (2020) |
| Example(s) of use | EU CE Monitoring Framework |

# Longevity indicator for Electrical and Electronic products – years

Lifetime extension is particularly important for e-waste. This metric can keep track of whether product lifetimes for electrical and electronic goods (EE) are rising or falling overall.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Product lifetimes for a basket of EE goods |
| Calculation | Average years of life per product type added together. Using six categories identified in studies: 1) Fridges, 2) LCD TVs, 3) Laptops, 4) Major appliances (washing machine, oven), 5) Small appliances (microwave, kettle), 6) Smartphones. (Could use budget/entry level or mid-range products as basis for benchmark) |
| Scale | National |
| Already reported for NSW? | No, but has been studied for Australia in 2018. |
| Modelled or measured?<br>Absolute or relative? | Measured<br>Absolute |
| Data source/s | Choice surveyed in 2018. |
| Example(s) of use | WRAP UK ICT metrics look at average age of ICT by type<br>Studies: WRAP; Cox et al, 2013; Brazil - Echegaray, 2016; Germany - Hennies and Stamminger, 2016 |

# Products sold for reuse – number of items

Reuse is an important way to extend product lifetimes and reduce waste. Recording the number of items that are sold in the second-hand economy is a useful indication of the practice.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | The number of items sold second hand in Australia by charity shops and major online platforms |
| Calculation | Charitable Recycling Australia (CRA) currently collects data on the entire charitable reuse sector in Australia in tonnage, # products, # transactions. For a fuller picture could include online marketplaces and other second hand shopfronts and community facilities. |
| Scale | National and potentially State |
| Already reported for NSW? | State reporting from CRA, partial Sydney metro data from The Bower, Gumtree reports on similar statistics. |
| Modelled or measured?<br>Absolute or relative? | Measured<br>Absolute |
| Data source/s | Charitable Recycling Australia, Gumtree, The Bower |
| Example(s) of use | • CRA report<br>• Gumtree Second-hand economy report<br>• The Bower annual report |

# Repair economy – value of service and sales

Fostering a repair economy is a key pillar of the circular economy. Available industry statistics can be used to monitor growth in the sector. There is also potential to seek data on the number of repaired items.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Repair and maintenance industry sales and service income. Could also seek data on number of transactions. |
| Calculation | ABS data on industry income |
| Scale | National and state |
| Already reported for NSW? | No, but breakdown of ABS statistics would yield data |
| Modelled or measured? Absolute or relative? | Measured/surveyed<br>Absolute |
| Data source/s | ANZSIC codes for repair industries: automotive (941), machinery and equipment (942) and other repair and maintenance (949). Sub-category: Domestic appliance repair and maintenance (9421). There is also informal repair data for number of items repaired from The Bower. |
| Example(s) of use | Household spending on repair flagged by Zero Waste Scotland |

# Sharing economy goods utilisation – sharing number transactions / inventory

Sharing and reuse are important CE strategies. Sharing businesses can keep goods circulating in the economy and reduce virgin resource consumption, particularly where sharing intensifies the use of goods.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | The number of transactions conducted by sharing businesses divided by their inventory of shared goods. Could include car-sharing, but not ridesharing. |
| Calculation | Survey goods-sharing businesses to document the number of sharing transactions and their inventory. |
| Scale | Sector level, could be done at state level depending on scale of survey. Partnering with ABS to do a survey could broaden the scale. |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured/surveyed<br>Relative |
| Data source/s | Data would need to be collected through a survey of sharing businesses. |
| Example(s) of use | We have not found examples of this, so it would be a new and leading example. |

# Vehicle sharing – private vehicle km travelled (VKT)

Passenger or private vehicle kilometres travelled (VKT) is widely used as an all-in-one indicator by transport planners, but has not specifically been used for vehicle sharing in Australia. It has potential to very clearly measure the CE impact of ride-hailing and ride-pooling services.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | This metric can help measure the use intensity of vehicle sharing through ride-hailing and ride-pooling platforms, by determining kilometres travelled per passenger. |
| Calculation | The total kilometres travelled on ride-hailing and ride-pooling trips, divided by the total number of passengers. This data would need to be collected from platform providers. |
| Scale | Data collection from platforms can be state and national. |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured/surveyed<br>Relative |
| Data source/s | Would need to be collected from platform providers e.g. Ola, Uber/Uberpool, Shebah, Didi. |
| Example(s) of use | VKT is calculated by federal authorities. E.g.:<br>• Bitre for the Australian Infrastructure Statistics Yearbook<br>• Stanley, 2014, but not specifically for vehicle sharing. |

# Food production and waste

Food waste constitutes a high proportion of all food produced & consumed. Measuring wastes along the food supply chain will provide insights to meet Australia's goal of halving food waste by 2030.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | Waste generated in the production, distribution and consumption of food (in mass unit) |
| Calculation | Estimated generation of waste across the food value chain, by waste category, hazardousness and type of activity |
| Scale | National and State |
| Already reported for NSW? | Data mostly reported for wastes from households |
| Modelled or measured? Absolute or relative? | Modelled<br>Absolute |
| Data source/s | • 'Love Food Hate Waste' tracking survey (2017), NSW EPA<br>• FOODmap: An analysis of the Australian food supply chain (2012)<br>• National Food Waste Strategy (2017) |
| Example(s) of use | EU CE Monitoring Framework |

# Industrial symbiosis assessment using UNIDO framework

UNIDO has developed eight assessment tools to plan, implement & monitor industrial symbiosis (IS) activities. These tools are useful for eco-industrial park (EIP) and circular precinct managers, firms, policy makers & researchers.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | The UNIDO assessment framework is useful to plan and evaluate industrial symbiosis progress in existing and new industrial parks and precincts such as Australia's first UNIDO Eco-Industrial Parks. |
| Calculation | Three tools are shortlisted for this assessment:<br>i) Industrial symbiosis identification: to identify IS opportunities and infrastructure planning.<br>ii) RECP monitoring: a standardized method to calculate and monitor the economic, environmental & social savings from Resource Efficient and Cleaner Production (RECP) activities, in EIPs and circular precincts.<br>iii) Industrial synergies monitoring tool: to monitor & report resource savings, improvements, and impacts of industrial synergies. |
| Scale | Eco-industrial park, precinct |
| Already reported for NSW? | No |
| Modelled or measured?<br>Absolute or relative? | Measured & modelled<br>Absolute & relative |
| Data source/s | UNIDO (2021) |

# Industrial Symbiosis Indicator (ISI)

The ISI indicator is useful to encourage the expansion of symbiotic relationships between co-located firms.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | The metric considers waste flows within an EIP or precinct, to measure the evolution & performance of symbiotic relationships. |
| Calculation | A list of 5 criteria with 3 evaluation metrics each are considered. Values can range from 0 to infinity (the higher the better). The 5 criteria are i) Legislation ii) Class of waste iii) Use of waste iv) Destination of waste v) Problems/risks. |
| Scale | Eco-industrial park, precinct |
| Already reported for NSW? | No |
| Modelled or measured?<br>Absolute or relative? | Modelled, empirical validation is needed.<br>Absolute |
| Data source/s | Felicio et al. (2016); Mantese and Amaral (2016) |

# Eco-efficiency indicator

The eco-efficiency indicator measures financial outcomes alongside environmental metrics, for industrial symbiosis exchanges. The results can be used to evaluate efficiency of symbiotic transactions, and to further encourage symbiosis.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | This is a composite metric which measures 4 indicators: one economic indicator & three environmental indicators. The novelty is the measurement of financial outcomes. |
| Calculation | 4 metrics: Net Economic Benefit; Raw Material Consumption; Energy Consumption; CO2 Emissions. |
| Scale | Eco-industrial park, precinct |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Modelled, empirical validation is needed. Absolute |
| Data source/s | Mantese and Amaral (2016); Park and Behera (2014) |

# Circularity Index and Circularity Gap

The circularity gap is the inverse of the circularity index or metric. The Circularity index refers to economy wide modelling to determine the percentage of an economy that is driven by circular resource use, however, it primarily focuses on recycling. It is used by the Circularity Gap Reporting Initiative (CGRi).

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Material Flows |
|---|---|
| Description | The circularity index is an economy wide material flow analysis (MFA) which considers the flow of materials from extraction and import, through to processing and consumption, then accumulation as stocks, and finally recycling and waste products and emissions. |
| Calculation | Economy wide material flow analysis (EW-MFA), which uses an input output database to model stocks and flows of materials through an economy |
| Scale | National, based on high level material flows |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Modelled<br>Relative |
| Data source/s | The International Resource Panel (IRP)'s Global Material Flow database |
| Example(s) of use | Circularity Gap Quebec |

CHAPTER TWO

# Energy & greenhouse gas emission metrics

2

A much smaller group of metrics relate to energy consumption and greenhouse emissions. Established metrics such as the proportion of energy from renewable sources are commonly used by government and industry. The carbon dividend from recycling seeks to link material flows and emissions within a more integrated circular economy context.

## Metrics assessment for NSW: established metrics (energy and emissions)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Energy from renewable sources | ● | ● | ● |
| Electricity consumption per capita | ● | ● | ● |
| Greenhouse gas emissions per capita | ● | ● | ● |

## Metrics assessment for NSW: new & emerging metrics (energy & emissions)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Carbon dividend of recycling materials | ● | ● | ● |

# Energy from renewable sources

This is an established metric useful to assess shifts in energy generation from fossil fuels to renewable energy sources. It is important to track capacity addition, generation and consumption from different energy sources.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Energy and greenhouse gas emissions |
|---|---|
| Description | Electricity generation from renewable sources, in NSW. |
| Calculation | Renewable energy as a ratio of total electricity generation (%) |
| Scale | National and State |
| Already reported for NSW? | Yes |
| Modelled or measured?<br>Absolute or relative? | Measured<br>Relative |
| Data source/s | • Australian energy update (2020)<br>• NSW Renewable Energy Action Plan<br>• 5 Renewable Energy Zones (REZ) planned in NSW |
| Example(s) of use | NSW State of Environment Report |

# Electricity consumption per capita

This is an established metric useful to assess trends in electricity consumption. The metric complements metrics for capacity addition and generation of energy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Energy and greenhouse gas emissions |
|---|---|
| Description | Electricity consumption per capita, in NSW |
| Calculation | Electricity demand per total population |
| Scale | National and State |
| Already reported for NSW? | Yes |
| Modelled or measured?<br>Absolute or relative? | Measured<br>Absolute |
| Data source/s | • Australian energy update (2020)<br>• NSW Renewable Energy Action Plan<br>• 5 Renewable Energy Zones (REZ) planned in NSW |
| Example(s) of use | NSW State of Environment Report |

# Greenhouse gas emissions (GHG) per capita

GHG emissions are important indicators of global warming. Emissions generally rise with income levels, thus, per capita calculations are useful to account for population growth.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Energy and greenhouse gas emissions |
|---|---|
| Description | Greenhouse gas emissions per capita, in NSW. |
| Calculation | Carbon dioxide equivalent (CO2e, tonnes) per total population |
| Scale | National and State |
| Already reported for NSW? | Yes |
| Modelled or measured? Absolute or relative? | Measured<br>Absolute |
| Data source/s | Adapt NSW, DPE |
| Example(s) of use | NSW State of Environment Report |

# Carbon dividend of recycling materials

An important benefit of recycling is that it reduces carbon emissions by avoiding landfill and the manufacture of new raw materials. This metric links progress towards material circularity with carbon reduction goals in the Net Zero Plan.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Energy and greenhouse gas emissions |
|---|---|
| Description | Carbon savings from recovery of solid waste through material recycling or organics recycling processes (excludes stockpiles and energy recovery) |
| Calculation | Quantity of each material recycled (tonnes) multiplied by carbon reduction factor, (CO2 reduced/waste recycled, CO2tonnes eq) |
| Scale | State and LGA |
| Already reported for NSW? | Partial. Data is available on quantity recycled but not converted into CO2eq. |
| Modelled or measured? Absolute or relative? | Modelled<br>Absolute |
| Data source/s | • Life Cycle Assessment (LCA) data in GISA (2019)<br>• Online calculators for NSW or Victoria<br>• DPE is proposing to develop a new measure of emissions from waste and materials management. For example DPE (2021) |
| Example(s) of use | • NSW Waste and Sustainable Materials Strategy 2041 (p. 15)<br>• APCO (2020), Australian Packaging Consumption & Recycling Data 2018-19, p. 89 |

CHAPTER THREE

# Water, natural environment & regeneration metrics

This group of metrics measure different aspects of the natural environment and progress towards a regenerative circular economy.

### Metrics assessment for NSW: established metrics (water and nature)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Water use per capita | ● | ● | ● |
| Water reuse and recycling per capita | ● | ● | ● |
| Litter volume | ● | ● | ● |
| Soil Organic Carbon (SOC) stocks | ● | ● | ● |
| Landcover change rates | ● | ● | ● |

### Metrics assessment for NSW: new & emerging metrics (water and nature)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Nutrient capture and reuse – phosphorus | ● | ● | ● |
| Ecological footprint per capita | ● | ● | ● |

# Water use per capita

The transition to a circular economy requires more efficient use of all natural resources including water. Water use relative to population measures water efficiency and effectiveness of educational initiatives.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| Description | Volume of water used by households, industry and agriculture per head of population |
| Calculation | Water use (self extracted, distributed, reuse) divided by the population, (ML/capita). See methodology for source data |
| Scale | National and State |
| Already reported for NSW? | No – needs to be calculated from ABS data (see below) |
| Modelled or measured? Absolute or relative? | Measured<br>Relative |
| Data source/s | • ABS Water Account for water use<br>• ABS population data |
| Example(s) of use | ABS Water Account |

# Water reuse and recycling per capita

The amount of water reused or recycled per capita measures progress towards water circularity and more sustainable water management practices.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| Description | Volume of water reused (the transformation of wastewater into another economic product that is distributed throughout the economy) |
| Calculation | Water reuse divided by the population, (ML/capita). See methodology for source data |
| Scale | National and State |
| Already reported for NSW? | No – needs to be calculated from ABS data (see below) |
| Modelled or measured? Absolute or relative? | Measured<br>Relative |
| Data source/s | • ABS Water Account for water use<br>• ABS population data |
| Example(s) of use | ABS Water Account |

# Litter volume – litres/1000m²

Litter represents leakage of materials into the natural environment. It also causes damage to wildlife. This metric is used to monitor changes over time and the effectiveness of anti-litter programs.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| **Description** | Volume of product disposed of as litter |
| **Calculation** | National litter survey conducted across 1000 sites nationally. NSW data is measured by count and volume across 151 sites. Number of items is converted to volume using a formula, (litres/1000m2) |
| **Scale** | National and State |
| **Already reported for NSW?** | Limited data reported for NSW |
| **Modelled or measured? Absolute or relative?** | Modelled<br>Absolute |
| **Data source/s** | National Litter Index - No longer publicly available but available to purchase |
| **Example(s) of use** | • NSW Waste and Sustainable Materials Strategy 2041 – % reduction in litter (not clear if this is by count or volume)<br>• NSW litter report 2012-17<br>• WARR Progress Report 2017-18 |

# Soil Organic Carbon (SOC) stocks

SOC is a crucial component of terrestrial ecosystems and key to controlling nutrient and water cycling. In agricultural systems, it is one of the main indicators of soil health, increasing resilience to conditions of erosion and drought.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| **Description** | Increasing SOC is associated with improved soil conditions due to high biological activity, nutrient availability, improved physical structure, water-holding capacity and aeration. |
| **Calculation** | Tonnes per hectare |
| **Scale** | National, State and Regional |
| **Already reported for NSW?** | Yes |
| **Modelled or measured? Absolute or relative?** | Modelled and measured<br>Absolute |
| **Data source/s** | • NSW State of Environment >> Soil conditions (2021)<br>• Australia State of Environment>> State and trends of soil carbon, Land (2016, 2011)<br>• CSIRO Soil and Landscape Grid of Australia<br>• University of Sydney (2020)<br>• NSW Department of Primary industries |
| **Example(s) of use** | NSW State of Environment >> Soil conditions (2021) |

# Landcover change rates

Monitoring of landcover change is used to measure environmental, social & economic impacts on natural resources and biodiversity.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| **Description** | This metric includes woody vegetation loss due to agriculture, forestry and infrastructure; changes in landcover due to fire and vegetation loss. |
| **Calculation** | Satellite imagery is used to detect vegetation change. Statewide Landcover and Tree Study (SLATS) method is used to calculate woody vegetation changes. Absolute and % rates are reported. |
| **Scale** | National, State, LGA |
| **Already reported for NSW?** | Yes |
| **Modelled or measured? Absolute or relative?** | Measured<br>Absolute & Relative |
| **Data source/s** | NSW DPE landcover change reporting (2020) |
| **Example(s) of use** | Woody vegetation change SLATS results (2019) |

# Nutrient capture and reuse – Tonnes of phosphorus

Nutrients are critical for food security and successful agriculture and they are a major source of water pollution. The capture of nutrients in wastewater and food waste for reuse is an important CE strategy.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| **Description** | Tonnes of phosphorus captured for reuse |
| **Calculation** | Phosphorus content of biosolids from all wastewater plants (in NSW or in any area) (measured). Plus food and green waste composted x phosphorus content (modelled) |
| **Scale** | City, State or National |
| **Already reported for NSW?** | Not yet aggregated |
| **Modelled or measured? Absolute or relative?** | Measured and some modelled<br>Absolute |
| **Data source/s** | Water utilities data (Sydney Water etc.)<br>Food waste and composting scheme data |
| **Example(s) of use** | Modelling has been undertaken to calculate phosphorous resources for the Sydney Basin (Metson et al., 2018)<br>Global figures for agricultural reuse from wastewater (Kok et al, 2018) |

# Ecological footprint – hectares per capita

Ecological footprint is an expression of the land required to support the resource consumption and waste produced by a population. It can be a useful combination metric for CE to reflect consumption, waste and environmental impacts together.

| Metrics Assessment | |
|---|---|
| Ease of data collection |  |
| Circular economy focus |  |
| Alignment with NSW policy |  |

| Metric Category | Water and nature |
|---|---|
| **Description** | A measure of the land required to support resource consumption and waste assimilation |
| **Calculation** | Modelling based on databases of land use and resource consumption divided by population |
| **Scale** | Individual, City, State or National |
| **Already reported for NSW?** | Has previously been included in State of Environment reporting for NSW, but not recently |
| **Modelled or measured? Absolute or relative?** | Modelled<br>Absolute |
| **Data source/s** | International databases such as the Footprint Network |
| **Example(s) of use** | SoE reporting 2006, 2009, Calculated for Australia (Simpson et al., 2013) (6 ha/capita) |

CHAPTER FOUR

# Jobs & investment metrics

The final two metrics consider the opportunity that a circular economy transition can enable for employment and investment in Australia, specifically examining recycling, repair and material reuse.

### Metrics assessment for NSW: new & emerging metrics (jobs & investment)

| Metrics | Ease of data collection | Circular economy focus | Alignment with policy |
|---|---|---|---|
| Planned new investment in recycling | ● | ● | ● |
| Employment in recycling, repair and material reuse | ● | ● | ● |

# Planned new investment in recycling capacity

Recycling targets and waste export bans are driving significant investments in new recycling capacity. Announcements of increased capacity are a leading indicator for local recycling rates.

| Metrics Assessment | |
|---|---|
| Ease of data collection | |
| Circular economy focus | |
| Alignment with NSW policy | |

| Metric Category | Jobs and investment |
|---|---|
| Description | Additional tonnes of recycling capacity arising from announced new investments (not yet operational) |
| Calculation | A database of announced new capacity for recycling (from the Recycling Modernisation Fund (RMF), other NSW Government grants and industry investments) used to estimate total additional tonnes by material type. This could be an annual or cumulative figure for announced capacity improvements. |
| Scale | National and State |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured<br>Absolute |
| Data source/s | NSW Government grant announcements, Recycling industry media announcements, Federal Government RMF database |

# Employment in recycling, repair and material reuse

A more circular economy will create jobs in businesses providing repair, reuse and recycling services. While employment in the suggested sectors would be the easiest to track initially, other activities could be added over time e.g. jobs in the sharing economy.

| Metrics Assessment | |
|---|---|
| Ease of data collection | |
| Circular economy focus | |
| Alignment with NSW policy | |

| Metric Category | Jobs and investment |
|---|---|
| Description | Number of people employed in selected industries related to the CE, e.g. waste treatment, repair & maintenance, rental & hiring services, charity shops |
| Calculation | Employment in selected CE activities Australia-wide could be estimated using a combination of existing data sources (see below) or using a new, specially designed survey for NSW |
| Scale | National. Could be used to estimate NSW employment based on share of population or GDP. |
| Already reported for NSW? | No |
| Modelled or measured? Absolute or relative? | Measured<br>Absolute |
| Data source/s | ABS, Employment data (rental and hiring services excl. real estate; waste collection, treatment & disposal; repair & maintenance)<br>Access Economics (2009), Employment in waste and recycling<br>Charitable Recycling Australia, 2021 Impact report |
| Example(s) of use | KPMG (2020), Potential economic payoff of a circular economy |

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