Proposals for a Circular Economy Indicators Framework in Scotland

Prepared for **Zero Waste Scotland**
by Oakdene Hollins & CE Hub
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Glossary

ADEME	French environment ministry
BEIS	Department for Business, Energy & Industrial Strategy, UK
CAGR	compound annual growth rate
CE	circular economy
CMUr	circular material re-use rate
CSR	corporate social responsibility
DE	domestic extraction
Defra	Department for Environment, Food & Rural Affairs, UK
DMC	domestic material consumption
DMI	direct material input
ECI	Environmental Cost Indicator
EEE	electrical and electronic equipment
ELV	end of life vehicle
EoL	end of life
EoU	end of use
EU	European Union
FMCG	fast-moving consumer goods
GDP	gross domestic product
GHG	greenhouse gas (emissions)
GPP	green public purchasing
GVA	gross value added
GWP	global warming potential (quantified as tonnes CO_2 equivalent)
IRP	International Resources Panel
MFA	material flow account
PaaS	product as a Service
RMC	raw material consumption
RME	raw material equivalent
RMI	raw material input
RRRDR	remanufacturing, refurbishment, repair and direct re-use
SDG	United Nations sustainable development goal(s)
SIC	standard industry classification
SME	small and medium-sized enterprise
SWOT	strengths-weaknesses-opportunities-threats analysis
TCO	total cost of ownership
TMI	total material input
TMR	total material requirement
UDE	unused domestic extraction
UNEP	United Nations Environment Programme
VRPs	value retention processes
WEEE	waste electrical and electronic equipment
WTO	World Trade Organisation

(Comment xx:) Within the report, sections coloured and numbered like this are generally associated with summary or discussion sections. They highlight observations that could influence choice of indicators later in the report. They might also point out interesting approaches that, although not in the scope of this study, could be worth exploring in future policy development.

(Rationale xx:) Sections coloured and numbered like this generally appear within the description of indicator rationale sections and draw attention to cautions in the definition of indicators, variants or potential future developments.

Units

Conventional units and prefixes used throughout.

kt, Mt	Thousands, millions of metric tonnes mass (1 tonne = 2205 lb)
g, kg	Grammes, kilogrammes mass (1 kg = 2.205 lb)

Definitions – related to end-of-life treatment

Prevention
Measures taken before a substance, material or product has become waste, that reduce the quantity of waste, including through the re-use of products or the extension of the life span of products. (1)

Recovery
Any operation where the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. (1)

Recycling
Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.(1)

Direct re-use
Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived. (1)

Re-use type
Any activity on the spectrum of re-use ranging from direct re-use, repurposing (including cannibalisation for parts), repair, refurbishment and remanufacturing. (1)

Waste
Any substance or object which the holder discards or intends or is required to discard. (1)

Definitions – related to metrics

Global Warming Potential (GWP) – the capacity of an emission to affect climate, quantitatively expressed as tonnes of carbon dioxide equivalent ($CO2_e$) emitted. 'Equivalences accounts for the fact that the GWP of different emissions varies from that of CO_2 but has been scaled to be expressed as if it were CO_2.

Indicator - A key measure that will have the most impact in advancing the outcomes of strategy and policy. They clearly articulate and provide insight into what an entity (organisation, country, municipality) needs to measure and achieve to reach its long-term objectives.

Metric - A measure which also tracks and provides data on processes within the economy but is not as important as an indicator in measuring, monitoring, and performing against to make progress on the strategic plan.

1 Executive Summary

This report presents the findings of a study into proposals for a set of indicators of Scotland's performance in the circular economy (CE).

The circular economy is typically defined as one where products and materials are kept in circulation for as long as possible, by building upon established recycling initiatives and encouraging other life extension activities such as re-use and repair. Building a circular economy would lower demand for virgin materials and thus reduce the accompanying environmental impacts, improve the security of resource supply chains, and improve the wellbeing of citizens.

Scotland's circular economy is in development, but a range of relevant information has been reviewed to catalogue policy objectives, which explicitly or implicitly point to potential indicators that could be used for the measurement of success in those objectives. In parallel, we have reviewed 19 CE strategies and indicator frameworks in detail to learn from their approaches, rationale and common indicators. Findings have been augmented by the integration and benchmarking with the OECD's Inventory of Circular Economy indicators (2).

Criteria of practicality, data availability and connectedness (causality) to CE outcomes have been applied to narrow a long list of over 470 possible candidates from the different sources reviewed, to below 20. There appears to be a common core of 'headline' indicators related to resource consumption, as measured by flows of materials, carbon footprint and other outcomes. These indicators are largely already assembled for tracking our current 'recycling' economy and will continue to be relevant. However, the circular economy goes beyond recycling to include re-use and repair activities; direct national accounting methods for re-use do not currently exist, but the effect of circularity outcomes can be tracked to some extent by additional indicators.

The most developed metrics are seen in nations that acknowledge the timeline and data access limitations in the process of implementing circularity, such as the Netherlands. These nations recognise that we are at an early stage of the transition to a circular economy, and that it will be some time before the actions taken now manifest as measurable impacts. Therefore, the Dutch framework proposes 'transition' indicators which follow the enabling investments, behaviours, activities and processes that are required to happen to stimulate circular business. We have taken these learnings and applied them to the Scottish context, with potential additional indicators included in the set. Once circularity is well established, these transitional indicators may no longer be relevant (criteria for determining these trigger points will need to be established) and may be superseded by more relevant indicators as yet unknown, some ideas of these could be simply mentioned as roadmap indicators.

As noted, it is possible that the hard (outcome and measurement based) indicators will not provide sufficient insight to permit targeted action in CE 'hotspots' i.e., those areas of high environmental or other impact for which actions can be conceived and motivated by Government. Further, direct indicators of re-use, sharing, repair and remanufacture are sparse but are needed for further insight into these activities. Therefore, a third type of 'prospective' indicators is proposed, which will require data collection systems and estimation methods to be developed (for example, introducing better differentiation of re-use activities into SIC codes). We acknowledge that this latter proposal in particular would need time to develop, along with a political will and collaboration with other parts of the UK. If data is available, each of the hard indicators proposed have been crafted in a way that they can be applied at different scales; such as the industry level, or at the level of an individual business.

These proposed indicators, classified as 'hard', 'transition' and 'prospective', are summarised in the table and in a graphical format below.

Proposed Scottish indicator set

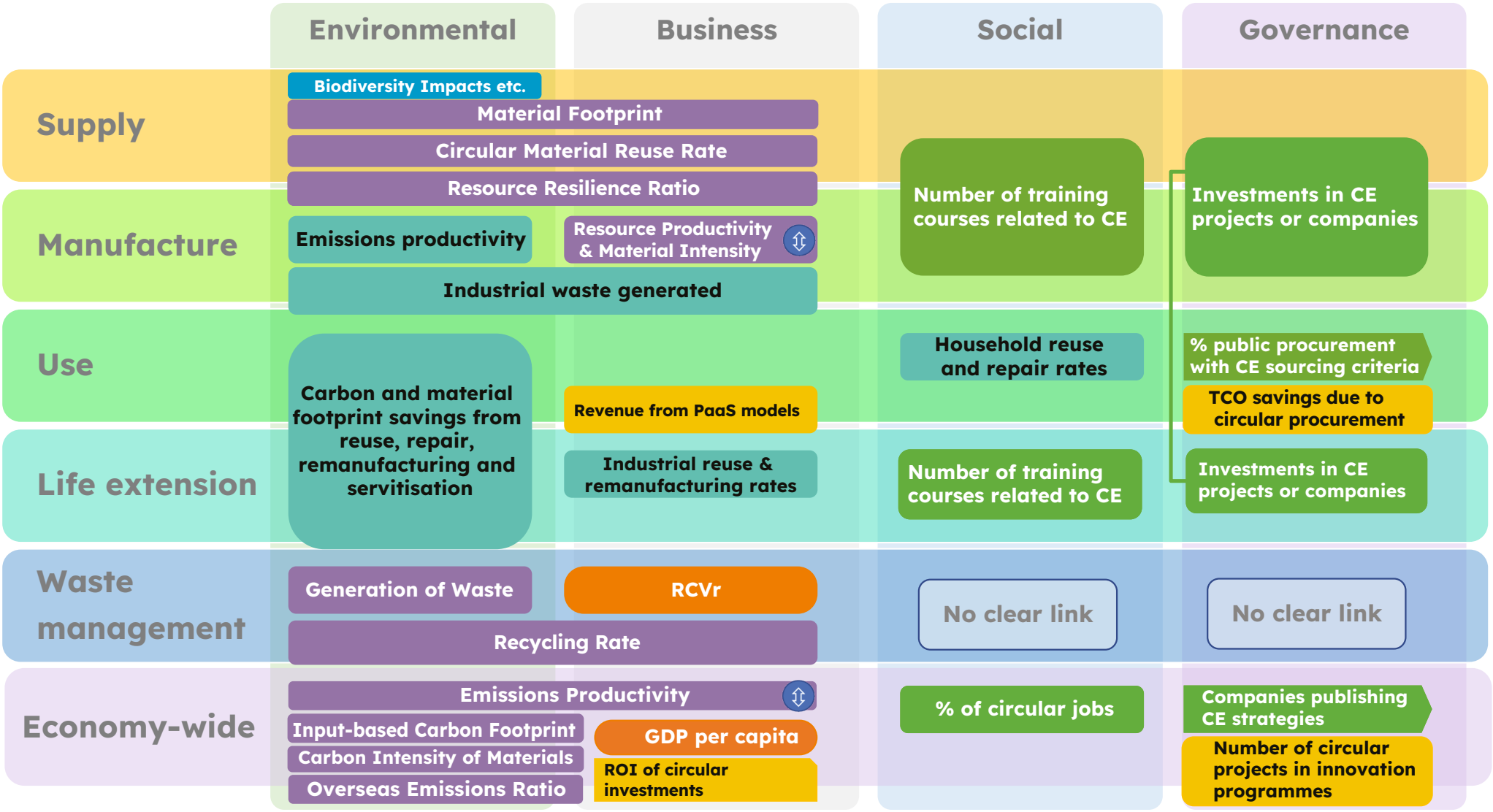
HARD INDICATORS			
Indicator	**Data sources**	**Needed metrics**	**Supporting Indicators**
Material Footprint/Raw Materials Input	Scotland MFA	DE, RME IMP	RMI by sector and material
Input-based Carbon Footprint	Scottish Government GHG Statistics, Scotland MFAs, Scope 3 emissions from imports (TBD)	RMI, GHG emissions	Intrinsic Carbon by industry/sector
Circular Material Use Rate - CMUr	Scotland MFA	RMI, RCVr, IMPs, EXPs	CMUr by sector and material
Resource Productivity and Material Intensity	Scotland MFA, Scotland's Input-Output tables	GDP, RMI	RMI and GDP by sector and material
Emissions Productivity	Scottish Government GHG Statistics, Scotland's Input-Output tables	Territorial GHG emissions, extraterritorial GHG emissions, GDP	GHG emissions per GVA of different sectors
Carbon Intensity of Materials	Scotland's Input-Output Tables, Scotland's MFA, Scottish Government GHG Statistics	RMI, Territorial GHG emissions, Extraterritorial GHG emissions	Carbon intensities of specific materials or different sectors.
Generation of Waste	Scotland MFAs	N/A	Municipal waste generation per capita, waste generation by type of material
Recycling Rate	Scottish Environment Protection Agency	Total recycling	Recycling rate excluding mineral waste, recycling rate of e-waste, recycling of biowaste, recovery rate of construction and demolition waste
Resource Resilience Ratio	Scotland MFA	RME, RMI	Resilience by type of material, resilience by industry
Overseas Emissions Ratio	Scottish Government GHG Statistics, Scope 3 emissions from imports (TBD)	Scope 3 emissions GHG Emissions, Resource Resilience Ratio. Carbon Intensity of Materials	Overseas emissions ratios at the sectoral level.

TRANSITION INDICATORS			
Indicator	**Objective**	**Needed definitions/ data sources**	**Roadmap indicators**
Number of companies publishing CE strategies or sustainability reports considering circular business practices	Increase corporate engagement in the CE	Accepted reporting standards	Companies with PaaS models (adoption rates).
Investments in circular economy projects or companies	Capital injection in the CE enabling processes and technologies	Definition of what is considered a circular project or company	Return on Investment (ROI) of circular investments, investments made without public funding support.
% of Public procurement with sustainable or CE sourcing criteria	Show government leadership and direction in sourcing	Sustainable procurement standards	TCO savings due to circular procurement practices.
% of circular jobs	Track employment effects of new circular practices and businesses in the economy	Definition of what is considered a circular project or company	% of circular jobs by sector, labour productivity (GDP per FTE worker) by sector.
Number of training courses related to Circular activities at tertiary level.	Track the level at which CE is being taught in universities	Definition of what training courses are considered to be related to circular activities.	Measure how embedded circular economy is at all levels of education, share/number of circular projects in innovation projects e.g. @InnovateUK
PROSPECTIVE INDICATORS			
Indicator	**Objective**	**Needed definitions/ data source**	**Roadmap indicators**
Industrial re-use and repair rates	For assessing the penetration of circular models in industry. It could also include product as a service models.		
Household re-use and repair rates	Initially this indicator would probably have to exclude vehicle maintenance and repair, as it could heavily skew the numbers.		
Industrial waste (efficiency of industry measure)	For determining how efficient are industry processes in transforming materials e.g. re-using processing scraps on site and reducing inputs into processes.		
Carbon and Material Footprint savings from re-use and repair	To determine the impact of more re-use and repair activities in terms of GHG emissions and Material Footprints.		
Biodiversity impact domestically (and abroad)	This indicator is declared within the Scottish Environmental Strategy; methods to determine the contribution of CE amongst other initiatives will be needed.		
Other environmental impacts	As yet unspecified, other impacts will attract more scrutiny as carbon reduction strategies are implemented and take effect.		

Definitions:

RMI = Raw Material Input
RCV_R = Recycled waste in domestic operations
EXP_S = Exported secondary material
TCO = total cost of ownership
RME = Raw Material Equivalents
IMP_S = Imported secondary material
DE = Domestic Extraction

Proposed Scottish indicator sector mapped to life-cycle phase (horizontal bands) and indicator type (vertical slices)



2 Scope and background

2.1 Scotland and the circular economy

This report presents the findings of a study into proposals for a set of indicators of Scotland's performance in the circular economy (CE). The circular economy is typically defined as one where products and materials are kept in circulation for as long as possible. It is based on three principles described by the Ellen Macarthur Foundation[1]:

- Eliminate waste and pollution.
- Circulate products and materials (at their highest value).
- Regenerate nature.

This is in contrast to our traditional economy which is characterised by such terms as a 'linear' or 'make-use-dispose' economy.

The Ellen Macarthur Foundation illustrates the circular economy in its butterfly diagram as shown below. It shows the product and material flows in the form of 'loops', both for the bio-based cycles and the non-bio-based cycles. Loops represent core approaches to circular economy, taking products and materials at their end of use back to an appropriate point further upstream in the economy. The 'outer' loop represents recycling, an approach applied to materials. The 'inner' loops represent largely product-based tactics such as remanufacturing, re-use, repair, and sharing.

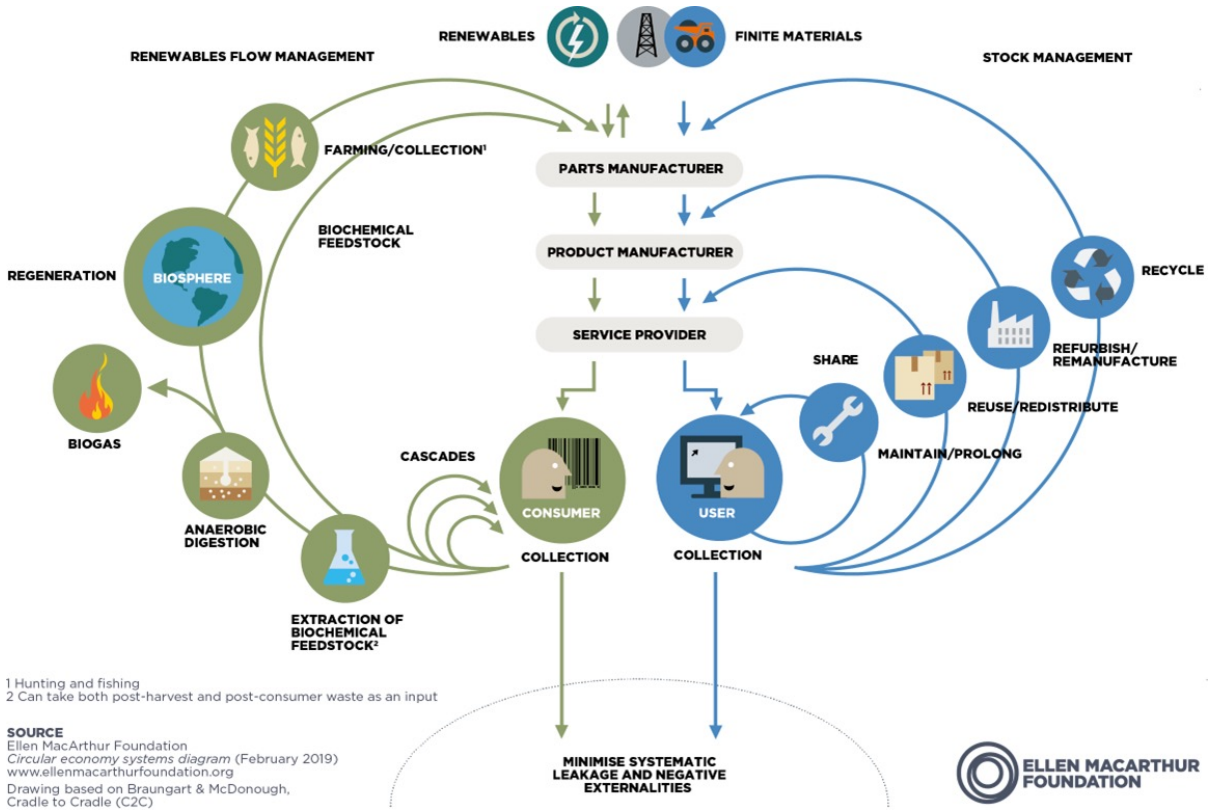


Figure 1: The Ellen Macarthur Foundation Circular Economy 'butterfly diagram'

[1] https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

2.2 Uses and properties of indicators

In the context of this work, we presume that indicators have three fundamental purposes. Figure 2 summarises these objectives and the properties or features of the indicator set, which make them fit for purpose.

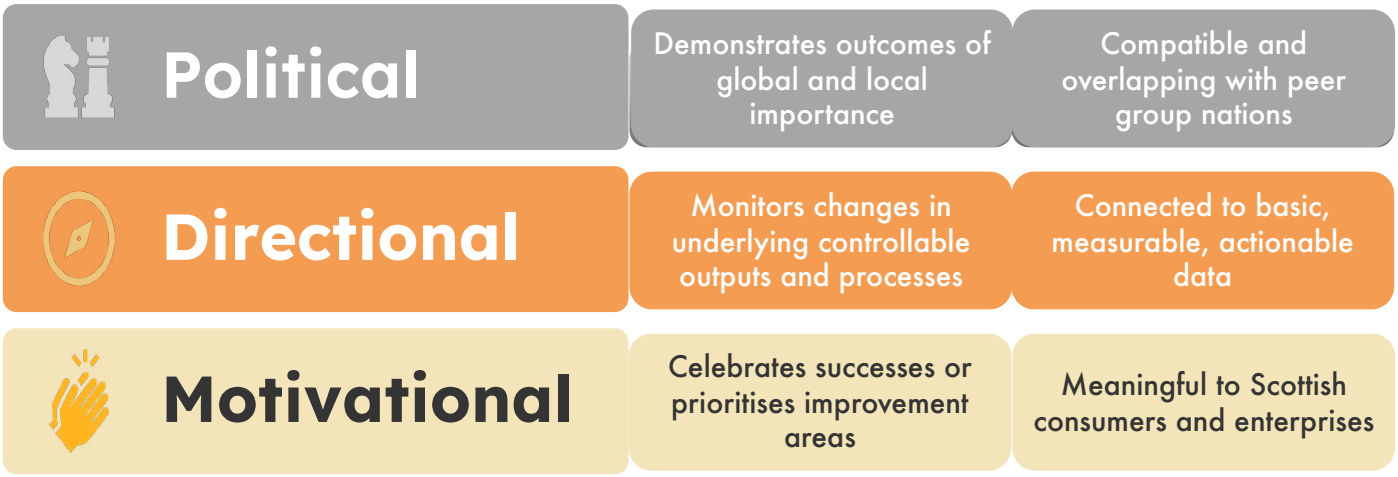


Figure 2: Uses of indicators and required properties

Some principles in respect of indicators were proposed in Zero Waste Scotland's Thoughts on Indicators (3) report, and may be summarised as:

- Any system is only as good as the data it is based on and improvement of data collection is an ongoing activity.
- Metrics must be relatively simple, independent, consistent, comparable and directly connected to relevant outcomes.
- A tiered approach may be needed to correctly track progress and inform policy.

Tier 1 indicators should indicate the progress of the entire economy, while Tier 2 indicators could focus on specific themes (or actors, geographies, industries), which might not be applicable to all circular economy actions. Proposed developments in this direction included measures of innovation and social equality (fairness).

2.3 Factors affecting choice and implementation of indicators

Selection of specific indicators should reflect national strategic priorities. These might be majorly driven by greenhouse gas (GHG) emissions, material security, or in securing a well-employed and prosperous population. In truth, all these goals are important, and circularity is an important tactic wholly or partially in each objective. The differing emphasis of the objectives is apparent across nations and is discussed within this report. Indicators should address not only the headline effects but measure the effectiveness of the actions within any action plan. In a complex economy, the headline effects are the sum of effects arising from multiple actions by sectors and along value chains. To reveal the contributory effects of these is likely to require further sub-metrics.

There is often a substantial time lag between actions taken and the effects being revealed in headline indicators. In contrast, the internal action indicators are often 'leading' they can alert well in advance that system changes are taking place. As a result, actions can be modified faster and can be better targeted for best impact.

Current indicator sets often reflect what it is convenient to measure with today's legacy reporting systems. Future indicator sets are likely to include metrics which are either not yet formally reported, or for which formal methods and data collection mechanisms do not currently exist.

2.4 Related indicator frameworks

Scotland's Environment Strategy Initial Monitoring Framework is a key component of the economic, social and environmental governance of the country. The framework is directed to environmental outcomes, but overlaps with themes relevant to the circular economy, such as impact on GHG emissions, waste & resources management, and preservation of natural capital. A potential circular economy indicator set is expected to be compatible with the objectives of the Environment Strategy and may use indicators in common, or variants attuned to the specific demands of the circular economy.

The rationale for the Environment Strategy is described on the Government's website and provides a possible model for this work (4).

Figure 3: Overview of indicators in the Environment Strategy Initial
Source: Environment Strategy for Scotland : Ininital Monitoring Framework (4)

2.5 Study aims

In pursuit of proposing a circular economy indicator set for Scotland, this study has reviewed numerous national strategies and policies to help address three key questions:

1. In what ways could Scotland learn from, and align with, approaches and best practices elsewhere?
2. In what ways are the current approaches insufficient or unsuitable for Scotland's political and socio-economic conditions?
3. In what ways could the Scottish Government be pioneers of innovative and ambitious approaches for circular economy monitoring, and how might we future proof the monitoring framework?

Insights arising from this review have fed into the indicator rationales, which have been guided by the following principles of practicality and comparability:

- A concern for what is achievable in establishing indicators in the immediate, near, and long term.
- A consideration of Scotland wishing to stay aligned to existing national frameworks, especially the EU's.
- A recognition that there needs to be a strong causal connection between circular economy actions, related indicators, and policy objectives.

Of these, the last point has presented the most difficulty. In some cases, policy objectives are ascribed to the circular economy which do not have obvious links to typical 'circular' actions. Some of these objectives would equally be true in a linear economy. Where appropriate, instances are discussed in the report.

3 Method and approach

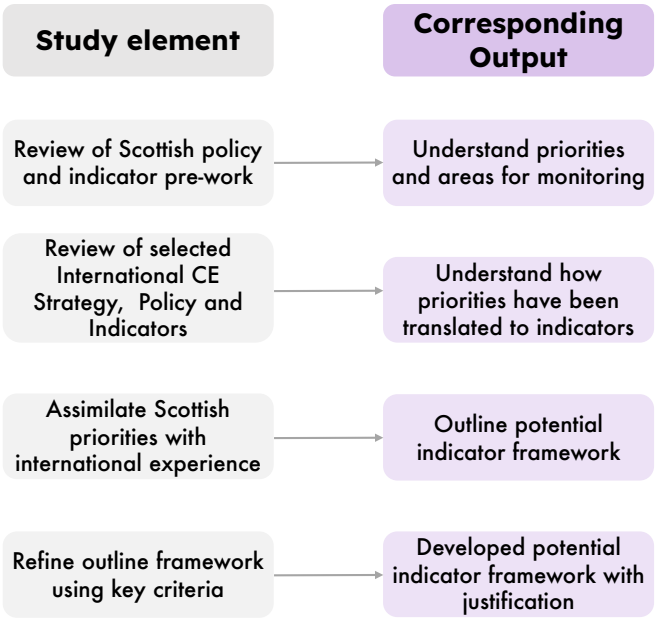


Figure 4: Summary of the key elements of the study

As shown in Figure 4, this study has comprised four component tasks. The first two tasks, covered in sections 4 and 5, consist of a review of Scottish circular economy related policies and of selected foreign nations from across the world and one city, Amsterdam. These countries were selected as representatives of different continents, and for being relatively developed countries. EU nations are well-represented and include nations which have common interests to Scotland, such as the preservation of natural capital.

The reviews considered the following elements of each nation's indicator choices:

- The objectives and priorities that adoption of the circular economy was designed to address.
- The framework or categorisation for chosen indicators.
- Description and justification of chosen indicators, with targets.
- The status of the indicators, that is, whether in development or implemented.
- Reviews of the current state and possible evolutions of the framework; these are valuable but were rarely found.

Not all of the countries examined have published a circular economy strategy or policy. Often, they refer instead to existing suites of legislation, strategy or policy which cover elements of what might become circular economy policy.

The international review included an assimilation of work carried out by the OECD to analyse national indicators from 28 nations, regions and cities. The OECD's report reveals the prevalence of different types of indicators, but not the connections to the strategies and policies behind them. However, it has value in showing the emphasis of current indicators and, because it is wide ranging, includes indicators which although rarely used, might be of interest to Scotland.

These tasks were the foundation for the subsequent deliverables.

The two subsequent tasks took the learning from the review phase to propose an indicator set for Scotland. In this report, the two tasks are presented as a unified activity. Section 6 describes in detail the stages of:

- Setting principles for the indicator set.
- Integrating reviewed national indicators with similar work by the OECD.
- Describing a skeleton for mapping CE objectives to ensure indicator coverage.
- From first principles, outlining how existing materials-based indicators can be extended to track progress in the circular economy.
- Rationalising the choice of Indicators for Scotland.
- Identifying how sometimes unmeasured processes and activities typical of circular economy might be tracked using 'Transitional' indicators, and indicators for which calculation methods may need to be developed in future.

The study concludes with a return to the indicator skeleton to judge the overlap between Scottish policy objectives and proposed indicators.

4 Review of Scottish economic landscape and policy

4.1 Purpose of reviewing Scottish economic landscape and policy

The possible choices for circular economy indicators for Scotland has already undergone some investigation by Zero Waste Scotland, including a review undertaken their behalf by Ricardo (7) and an analysis of material flow accounting (MFA) metrics. These analyses generated a long list of candidate indicators that broadly encompass most types of indicator discussed in other jurisdictions. This paper aimed to examine their relevance to Scotland's situation as well as their fitness to indicating circular economy performance.

In this work we have reviewed documents relevant to Scottish policy with regards to the circular economy. The purpose of this was to capture related indicators already in place or proposed; and to extrapolate what other indicators are inferred, for example, from targets set against economic, social and environmental objectives.

The following documents are highly relevant to this scoping exercise:

- The consultation document for the proposed Scottish Circular Economy Bill, Delivering Scotland's Circular Economy – A Consultation on Proposals for a Circular Economy Bill. (5)
- An early circular economy strategy piece, Making Things Last. (6)
- A report for Zero Waste Scotland by Ricardo Consulting, Measuring Scotland's progress towards a circular economy to help combat the climate emergency – Results from a preliminary scoping study reviewing key indicators. (7)
- Zero Waste Scotland's own work on

potential CE indicators, Zero Waste Scotland – thoughts on indicators. (3)
- Scottish Government's Indicators web-page.[2]
- The consultation document, Delivering Scotland's circular economy – A Route Map to 2025 and Beyond. (8)

These documents are relevant for materials, sector and financial context, but are less useful for determining targets:

- Eunomia's 'Delivering Scotland's first Material Flow Accounts'.[3]
- The Ellen MacArthur Report on CE opportunities for Scotland. (10)

N.B. Within this report, the term re-use (or re-use type) is taken to mean any or all of the spectrum of activities relating to products which include direct re-use (i.e., without modification in the original use), repurposing (use for a new purpose, including cannibalisation for parts), repair, refurbishment and remanufacturing. Materials quoted from other sources may use the term re-use in a more limited sense, typically direct re-use.

4.2 Scottish CE Bill consultation

The recent consultation document, Delivering Scotland's Circular Economy – A Consultation on Proposals for a Circular Economy Bill (5), proposed the introduction of a range of measures including taking enabling powers to set statutory targets in relation to a circular economy. The development of a 'monitoring framework' would allow for more holistic tracking of Scotland's consumption levels and wider measures of circularity, whilst ensuring the wider social, economic and environmental impacts are taken into account. A monitoring framework would also allow the Scottish Government to inform policy choices and prioritise action on areas of consumption, and to design specific targets to achieve these goals. In parts, the consultation frames areas of policy and action from which we have also tried to infer, however approximately, possible indicators.

The policy options for the Circular Economy Bill are explored in the consultation under themes of Strategic Interventions; Reduce and Re-use; Recycle; and Littering and Improving Enforcement. The stated ambition for a circular economy is one which:

- Cuts waste, carbon emissions and pressures on the natural environment.
- Opens up new market opportunities, improves productivity, increases self-sufficiency and resilience by reducing reliance on international supply chains and global shocks.
- Strengthens communities by providing local employment opportunities and lower cost options to access the goods we need.

The consultation explores a number of possible interventions summarised in Table 1 and annotated with proposed or implied indicators. It embeds the existing waste-oriented actions and it addresses a number of 'use phase' behaviours, such as bans on destruction of unsold durable goods, duty of care, and waste reduction incentivisation.

[2] https://nationalperformance.gov.scot/measuring-progress/national-indicator-performance
[3] Not reviewed since this study concerns the general approach to indicators rather than the details of a particular class of indicator, material flow analysis (MFA). The importance of MFA is recognised.

Table 1: CE Bill consultation themes and potential indicators

THEME	DESCRIPTION	POTENTIAL INDICATORS
Reduce-Re-use-Recycle Statutory targets	Responses to the previous consultation on proposals for Circular Economy Bill legislation in 2019 noted that there should be greater ambition in the field of consumption reduction targets. At a European level, in 2021, the European Parliament called on the European Commission to consider EU targets for 2030 to significantly reduce the EU material and consumption footprints and urged the European Commission to introduce a suite of indicators to measure resource consumption. Scotland's 2019 Food Waste Reduction Action Plan (FWRAP) made clear what measures Scottish Government believe are required to achieve its ambitious food waste reduction target of 33% by 2025.	A monitoring framework would sit alongside the Environment Strategy Monitoring Framework (4) Further potential targeted waste stream reductions
Ban the destruction of unsold durable goods	The destruction of unsold goods represents both wasteful practice and unsustainable behaviour. The EU Sustainable Product Policy Framework within the Circular Economy Action Plan identifies a range of potential legislative measures relating to the impact and design of sustainable products. This included measures to ban the destruction of unsold durable goods, which was consulted on in March 2021.	n/a
Environmental charging for single-use items	n/a	Weight of single-use items disposed
Mandatory reporting of waste and surplus	n/a	Contributes to waste reduction/RE
Recycle	Recycling rates increasing via DRS and EPR across various product streams	Recycling rate / % of net inputs attributable to recycling
Waste to landfill	n/a	Reduce to 5% of all waste generated by 2025
The Duty of Care for households	There is evidence to suggest that rates of non-participation by householders in separating recyclable waste properly is high. SEPA data shows that just under a fifth of materials put out for recycling by householders is non-recyclable.	Recyclate feedstock input quality increase / level of household compliance rises
Incentivising waste reduction and recycling (households)	Evidence suggests householders should be incentivised to minimise residual waste to support recycling rate improvements. In other countries this has been achieved in multiple ways, for example through restricting effective weekly residual waste capacity (via smaller bins and/or less frequent collections), enforced volume limits (as in Wales), or other measures.	Decrease in residual waste per household.
Business recycling collection zoning	Zoning has been utilised by a number of business districts, towns, cities and regions across the world, including Los Angeles, New York, Waregem (Belgium), Barcelona and London, as a method of improving their local environment. Analysis by WRAP has suggested that businesses could save up to 40% by collaborating on service procurement alongside container and collection optimisation.	Improved quality of collected materials + reduced cost to business

4.3 Making Things Last

The 2016 strategy, Making Things Last (6), was the first to set out priorities for moving towards a more circular economy in Scotland – where products and materials are kept in high-value use for as long as possible. It built on Scotland's progress in the zero waste and resource efficiency agendas. The belief being that a more circular economy will benefit the environment, the economy and communities.

The strategy advocated embedding resource efficiency practices and waste reduction to maximise life and value from natural resources used to supply goods and services; it alludes to the use of alternative business models other than ownership. Although these approaches do not have associated targets, they are possible subjects of indicators.

The strategy does address particularly impactful sectors, supporting capabilities that are required and general waste reduction approaches, but does not set any indicators or targets for these.

The priority areas are: food and drink, and the broader bio-economy; remanufacture; construction and the built environment; and energy infrastructure.

4.4 Delivering Scotland's Circular Economy

The consultation document, Delivering Scotland's Circular Economy: Route Map to 2025 and beyond (8), builds upon and further develops actions and priorities from the 2016 Making Things Last strategy. The Route Map's proposed packages and associated existing targets are summarised in Table 2, however it should be noted that these may be subject to change.

The Route Map is also subject to a further consultation, due to be published in 2023.

Table 2: Summary of Route Map packages and associated targets and action (underway and proposed)

PROPOSED ROUTE MAP PACKAGES	ASSOCIATED AND POTENTIAL TARGETS AND ACTIONS WHERE AVAILABLE
Package 1: Promote responsible consumption, reduction and re-use	Introduce ban on certain single-use plastic items; reduce use of single-use food containers; increase repair cafés to 100 by 2025; establish a Circular Economy investment fund; statutory consumption reduction targets; national re-use target; promote uptake of 'product longevity' business models; charges and bans on environmentally damaging products
Package 2: Reduce food waste	Waste per capita reduced by 33% by 2025 based on 2013 baseline; Food Waste Reduction Action Plan; fund community food redistribution networks; mandatory reporting of food surplus and waste; food waste reduction action plans; behaviour change strategy; business support measures.
Package 3: Improve recycling from households	Recycling rate raised to 60% for household waste by 2020; Recycling Improvement Fund; Deposit Return System; co-design for high performing services; monitoring and reporting framework for local authorities; statutory guidance for household services; statutory local performance targets; waste and recycling service charging.
Package 4: Improve recycling from commercial businesses	Recycling rate for all waste raised to 70% by 2025; digital waste tracking; composition study; compliance review; codesign service improvements; zoning.
Package 5: Embed circular construction practices	Uptake of Net Zero Public Sector Buildings Standard; NPF4; best practice standards; incentivise build refurbishment; measure use of secondary materials and assets; recycling bonds and devolved taxes to increase re-use and recycling; soil symbiosis
Package 6: Minimise the impact of disposal	Waste to disposal reduced to 5% by 2025; ban municipal biodegradable waste to landfill; residual waste plan; restrict incineration of fossil materials; fiscal measures to incentivise low carbon disposal
Package 7: Cross-cutting measures	Household composition analysis; Using existing Sustainable Procurement Toolkit; Climate Emergency Skills Action Plan; develop CE Strategy, monitoring and indicator framework and public procurement opportunities to reduce the environmental impact of public spending; support (measure) uptake of green skills, training, and development opportunities.

Notes: (Under way)(Proposed)

Public procurement is also identified as a component of a circular economy. Scottish Government identified public procurement as a priority area to increase sustainability, with the Procurement Reform (Scotland) Act 2014[4] and additional Sustainable Procurement Tools[5], and it is also features within the Route Map proposals as a key cross cutting measure.

We believe that procurement is probably the single biggest non-legislative step that the public sector could take to create a circular market pull and normalise circular behaviours; it deserves priority targeting, standardised circular-ready Green Public Procurement and committed measurement. This could be especially valuable in driving Package 1: Promote responsible Consumption, Package 2: Reduce food waste and Package 5: Construction.

4.5 Ricardo's analysis of potential indicators

In 2020, Zero Waste Scotland commissioned Ricardo to undertake a comprehensive review of potential indicators, Measuring Scotland's progress towards a circular economy to help combat the climate emergency (7), referring to numerous sources, some of which were also reviewed in this work. In the next section, international circular economy indicators have been reviewed, assembled and integrated with similar work carried out by the OECD (2). The resulting list is similar to Ricardo's but has been characterised and analysed in greater depth for the current purpose.

4.6 Zero Waste Scotland's work on CE indicators

Zero Waste Scotland thoughts on indicators* (2021), (3) is a useful reality check on the findings of the current work. It identified common international sources and described the potentially complex nature of the indicator set. It also set some context for framework development and the immediate and long-term needs of the audiences.

The study considered in detail the advantages and disadvantages of different metrics related to the materials flow into and out of Scotland. These concerned the practicality of different datasets which support the calculations as well as the political background in which certain key data might not be collected in future. This analysis will be useful later in this report when considering the practicality of particular indicators in the future.

The study outlines success criteria for indicators which monitor progress in consumption reduction with the expectation that they:

1. Show level of material consumption relative to other years and population as well as other regions or countries.
2. Show changes in raw material extraction, both domestic and imported.
3. Show changes in material inputs to goods used, both domestic and imported (i.e. builds on #1 but includes any re-use, recycling, remanufacture).
4. Show impact of lower carbon energy use in the production of goods.
5. Show emissions associated with the consumption phase of material goods.
6. Show level of waste, and the level of re-use, recycling, energy production and disposal.
7. Show any connection between material use and the economy.
8. Have the potential to show sector-level or material level progress in reducing raw material use or material consumption.
9. Have the potential to link with other indicators that show economic or social benefits gained.
10. Have the potential to link with other indicators that show wider environmental impacts such as biodiversity, land-use, water-use or air quality.

However, the study recognised that material indicators did not capture the full effect of the circular economy, or the process by which it would be achieved. Accordingly, it suggested the following classes of indicator in addition:

[4] https://www.legislation.gov.uk/asp/2014/12/section/9
[5] https://sustainableprocurementtools.scot/

- Environmental footprints (capturing the wider environmental impacts of products and materials).
- Economic and social indicators (capturing the impact of structural changes due to the circular economy transition).
- Policy, process and behaviour indicators (capturing the implementation of specific policy measures and initiatives).

4.7 Scottish Government's Indicators

Scotland already publishes a small number of indicators related to the circular economy.

The Government's web page, Climate Change Plan: monitoring reports 2022 – Chapter 5: Waste and the Circular Economy (9), reports against a number of policy outcomes as summarised in Table 3.

Table 3: Waste and the circular economy indicators

POLICY	INDICATOR
Reduction in waste sent to landfill	Total amount of landfilled waste (tonnes)
	Total amount of biodegradable landfilled waste (tonnes)
Reduction in emissions from closed landfill sites	Number of closed landfill sites with exploratory landfill gas capture/ flaring
A reduction in food waste	Household and non-household food waste reduced (tonnes)
Reduce waste and establish a more circular economy, where goods and materials are kept in use for longer	Total waste generated (tonnes)
Cross-sectoral social and economic indicators	FTE employment in Low Carbon Renewable Energy Economy
	The proportion of workers doing green tasks in Scotland
	The proportion of workers spending more than 20% of their time doing green tasks
	Proportion of overall hours spend doing green tasks

In addition and related to the Environment Strategy, another web page reports the indicators of Table 4.

Table 4: Resources-related indicators under the Environment Strategy

INDICATOR	DESCRIPTION
Total waste generated Target 15% reduction, 2011 to 2025	The annual amount of waste, in millions of tonnes, generated in Scotland from all sources: household, commercial, industrial and construction and demolition.
Material Footprint	The total quantity of raw materials worldwide used to produce the goods and services consumed in Scotland. It identifies the volume and types of materials being extracted in Scotland, imported into Scotland and exported from Scotland.
Carbon footprint of waste	The annual worldwide GHG emissions associated with Scotland's waste expressed in millions of tonnes of carbon dioxide equivalent (MtCO2e).

4.8 Ellen MacArthur foundation report into CE opportunities for Scotland

The report, Scotland and the Circular Economy (10) by the Ellen MacArthur Foundation has no official role in Scottish policy. However, it applies to the Scottish context learnings gathered from a global perspective. It proposed six core focus areas:

- Circular product design and innovation.
- Product re-use, repair and remanufacturing.
- Innovative business models.
- Renewable energy and materials substitution.
- Effective supply chain and cross-sectoral collaboration.
- Energy recovery.

The international review section later in this report identifies that a large proportion of these are not represented in indicator sets. Whilst they may not merit the status of indicators, they do form candidates for the expanded suite of lower-level metrics which monitor practice and behaviour changes associated with the circular economy.

4.9 Socio-economic context

The Ellen MacArthur Foundation (EMF) report into CE opportunities for Scotland (10) identified sectors which could benefit from, or which could have a large contribution to, the adoption of circular practices. It assessed that eight subsectors relevant to Scotland could realise £0.8bn to £1.5bn in cost savings. The identified sectors were (noting EMF named only 7 of them):

- Computer, electronic and optical products.
- Electrical equipment.
- Machinery and equipment not elsewhere classified.
- Motor vehicles, trailers and semi-trailers.
- Other transport equipment.
- Furniture.
- Other manufacturing.

A second evaluation considered the potential of fast-moving consumer goods (FMCG). Across 10 product categories, there were an estimated further £1.5bn is savings to be made, plus further associated reductions in impacts up the supply chain.

Both of the above savings were largely attributable to material reduction, substitution and efficiency of deployment. Comparable benefits could be available from the systems that support products in use: the re-use and life-extension activities of repair and remanufacturing.

The value retention process work mentioned above and for the EU has identified that re-use activities should net around 1.5 times as many jobs per unit of GDP as 'linear' manufacturing activities. Again, tracking and consolidating real-world jobs and economic impacts will require better segmentation of SIC codes to be fit for purpose.

4.10 Learning

Scotland has done much preparatory work to lay out the potential of the circular economy and where efforts might be placed to realise this potential. Previous work by Zero Waste Scotland on indicators has provided a valuable platform for the current study. The recent Route Map for Delivering Scotland's circular economy (8) consultation document identifies public procurement as a significant enabler of the circular economy; public procurement also features strongly in the Welsh Government's policies in this area. Given the scale of procurement, it is probably the single biggest non-legislative step that the public sector could take to create a circular market pull and normalise circular behaviours. Accordingly, it deserves assertive targeting and supporting purchasing protocols. This could be especially valuable in driving Package 1: Promote responsible Consumption, Package 2: Reduce food waste and Package 5: Construction.

Scotland, though, does not have a developed bespoke indicator set at present. There are legacy indicators associated with waste management and recycling, and those previously submitted to Eurostat for the EU indicator set. These have been augmented with indicators related to 'green' jobs and with the conversion of waste disposal to the carbon burden associated with the

unprofitable manufacture of those wastes (lost opportunity). For the current study, we have used the policy objectives expressed in the Circular Economy Bill consultation and related policies to map where indicators could be assigned to measure progress towards the policy objectives.

5 Learning from international experience

5.1 Background to and purpose of this study element

Scotland shares with other nations the challenge of defining systems which can help assess the progress in the transition to a circular economy. The ultimate purposes of the circular economy are various and include the imperatives of reduction of material supply risks, contributing to lowering environmental impact (including emissions) and to reduced resource depletion. These are the outcomes which are locally and globally important. However, they are the aggregate of many small actions in all sectors of the economy. Therefore, further insight is needed to reveal the impacts of more immediate underlying policies, actions and initiatives.

Each country has approached this challenge in its own way. Some elements are common because they align well with global initiatives such as sustainable development goals; some are regionally aligned because of a common mission such as in the EU; and others reflect local imperatives, issues of public importance and what data has historically been collected.

The purpose of this element of the study is to review how the policies or strategies of a number of other nations have been translated into indicators. A significant number of countries are still developing their strategies, but often refer to existing policies related to raw materials, waste, recycling, GHG emissions and other environmental effects which are components of a future CE policy. In such cases, any existing indicators have been included in the review.

5.2 Wales

Policy objective and guiding principles

Wales has been ambitious in its waste and recycling policy. A vision of the future is embodied in the Well-being of Future Generations Act, which lays out areas for targeting and monitoring. Although the circular economy is not mentioned, its indicator set includes expected waste and resource management measurements as well as a repair measurement. The key policy document is, however, the Beyond Recycling policy.

Indicator framework

The indicators link to the national indicators under the Well-being of Future Generations Act. Not all of them have protocols defined which translate from collected data to the indicator. Those which have been implemented are reported in the 2021 document, Beyond Recycling – Indicators (11), as shown in Table 5.

Indicators

Table 5: Indicators laid out in Beyond Recycling – Indicators

HEADLINE INDICATORS		
Level	**Indicator**	**Supporting Policy**
1.1	Household waste per capita	The production of the everyday products – including cars, clothes and food – accounts for 45% of global carbon emissions. In addition, our level of consumption uses far more than our fair share of the earth's resources.
1.2	Municipal waste sent to landfill	By 2025 we will send zero waste to landfill.
1.3	Municipal waste that is recycled	We want to make Wales a zero waste nation by 2050. This means effectively a 100% recycling, composting or preparation for re-use rate from all sectors.
1.4	Net zero carbon public sector	The Public Sector in Wales will collectively achieve net zero greenhouse gas emissions by 2030, decarbonising buildings, transport and supply chains

ACTIVITY DATA		
Level	**Indicator**	**Supporting Policy**
2.1	Food waste reduction	We will eradicate avoidable food waste. We will work with businesses across the whole supply chain, from farm to fork, to minimise waste and maximise resource efficiency and support Fareshare Cymru in their redistribution of surplus food.
2.2	Carbon saving per capita from recycling - the Carbon Index	The majority of Local Authorities in Wales have adopted the 'Collections Blueprint'. In Wales this has increased investment in reprocessing and reduced carbon emissions for every local authority.
2.3	2.3.1 We will work to prioritise the use of sustainable and low carbon materials in construction funded through WG Housing Capital Investment Programmes 2.3.2 We will work to use more low carbon materials in the refurbishment of the social housing stock 2.3.3 We will work to use more low carbon materials in the construction of new schools	We will apply the prioritisation of the use of sustainable and low carbon materials first to public sector construction including, the Innovative Housing Programme, the refurbishment of the social housing stock in Wales, and the construction of new schools. We will also explore the introduction of embedded carbon footprint technical standards.
2.4	Eco schools – percentage of primary and secondary schools that sign up	
2.5	Items repaired by repair cafes	
2.6	Procurement – percentage of public sector spend that is spent in Wales	Moving to a circular economy is key to the delivery of key environmental outcomes. But crucially it can also improve economic and social outcomes. Economically, through taking a circular approach which shortens supply chains, it can improve efficiency, create employment and increase competitiveness.
2.7	Plastic sent outside Wales – percentage of collected plastic waste that is not processed in Wales	We will take responsibility for our waste, not exporting it to be a problem elsewhere. We want to keep recycled resources in Wales for use in our material production and economy.

2.8	Modernising the waste fleet with ultra-low emissions vehicles (ULEV's) 2.8.1. Percentage of RRV (single-pass resource recovery vehicles) 2.8.2. Percentage of RCV (conventional refuse collection vehicles) 2.8.3. Percentage of light commercial vehicles	We will reduce environmental pollution through changing the collection vehicles used. This will also reduce air pollution, improving the environment and public health, whilst leading to a decrease in dependency on fossil fuels.

POLICY IMPLEMENTATIONS		
Level	**Indicator**	**Supporting Policy**
3.1	Welsh Government Collections Blueprint	Signing up to the collections blueprint means continuity in recycling and waste collections across Wales, leading to an increased quality of collected materials.
3.2	Sustainable businesses - increase the number of businesses adopting sustainable policies	We will also expand our innovation support on resource efficiency and increase the number of businesses signed up to the Business Wales' Green Growth pledge

Source. Beyond Recycling - Indicators (11)

Status

Four indicators have been identified as necessary, but do not yet have data collection and processing protocols associated with them:

- Consumption carbon data – these are territorial emissions so do not include impacts related to imports.
- Waste carbon footprint – with the ambition to develop an indicator similar to the Scottish Waste Carbon Metric.
- Material Footprint / One Planet Living – using a methodology developed at the Stockholm Institute (University of York) to assess what the sustainable materials consumption per person should be to stay within the limits of the planet.
- Circular economy jobs – with the ambition that the whole economy is circular not just a proportion of labour.

Commentary

The Welsh indicator set includes hard material outcomes, i.e. in waste management and recycling, but also proposes indicators of process and behaviour change (what has been termed 'transitional' indicators elsewhere). As a general indicator of a shift in business perspective, Wales proposes to count the number of companies signing up to the Business Wales Green Growth pledge; a parallel commitment is envisaged for aspects of public service, such as schools. Significantly, Wales has included the proportion of public spending spent in Wales in the belief that this represents localisation of supply and – consequently – closed loops of goods and services; we have not located research that supports this assumption, but it is notable that they have not specified a more explicit 'circular purchasing' policy.

5.3 EU Circular Economy indicators

Policy objective and guiding principles

The Circular Economy Action Plan (12) targets a cleaner and more competitive Europe and is a component of the European Green Deal. It builds on CE actions initiated since 2015. The objectives of the Circular Economy Action Plan are to reduce pressure on natural resources whilst creating sustainable growth and jobs; it is seen as an economic opportunity not simply as a cost burden, as a necessary contributor to achieving the EU's 2050 climate neutrality target and to halting biodiversity loss.

An important part of the plan is that it should move towards a regenerative economy where past damage to the environment is rectified.

Indicator framework

The indicator framework considers 4 key areas related to:

1. Production and consumption – material input, its procurement and waste generated.
2. Waste management – tracking recycling of key material streams, food and bio-materials.
3. Secondary materials – tracking the displacement of primary raw materials by recyclates recovered in Waste Management.
4. Competitiveness and innovation – tracking gross value added, jobs and investment.

The objectives of halting biodiversity loss and contribution to climate neutrality are not represented. Further, the Commission places sustainable products and related business models as the underpinning themes of its initiatives to deliver on the four areas outlined above. However, indicators related to progress on transitioning to these models are not apparent in the published set.

Indicators

Table 6: EU Indicators for Circular Economy

THEME	INDICATOR
Production and Consumption	EU self-sufficiency for raw materials -aluminium (%)
	Green public procurement (method not defined)
	Waste generation – municipal waste per capita (kg p.c.)
	Waste generation –all waste (excluding mineral) per GDP (kg/k€)
	Food waste (million tonnes)
Waste Management[6]	Recycling rates – municipal waste (%)
	Recycling rates – all waste excluding mineral waste (%)
	Recycling rates for specific streams: Packaging (%), plastic packaging (%), wooden packaging (%), e-waste (%), biowaste (kg per capita)
	Recovery rate of construction and demolition waste (%)
Secondary Materials	Contribution of recyclates to demand – End-of-life recycling input rates (%)
	Contribution of recyclates to demand – Circular material re-use rate (%)
	Trade in recyclables – Imports from non-EU countries
	Trade in recyclables – Exports to non-EU countries
Competitiveness and Innovation in CE Sectors	Gross investment in tangible goods (% of GDP)
	Persons employed (% of total employment)
	Value added at factor cost (% of GDP)
	Number of patents related to recycling and secondary raw materials

Source: EU Circular Economy Indicators Framework

Commentary
The EU indicator set has been implemented and mandated for use across member states. As such, it is probably the most widely used and transparent system in the world; and is connected to robust, uniformly defined national data sources.

Input-output measures are strongly represented in the EU indicator set. As noted in the framework section, there are few indicators related directly to the uptake of business processes or behaviour changes expected in a transition to a circular economy. Individual nations in the EU have created additional indicator sets, some of which do contain these process indicators, sometimes as primary indicators, sometimes as secondary indicators.

5.4 France

Policy objective and guiding principles
As for all EU member states, France subscribes to the EU indicator set by default. However, a second set of indicators has been developed which acknowledges certain input-output headlines but also digs deeper into underlying action areas, mainly on the consumer behaviour side.

According to ADEME, the French Environment Agency, the Circular Economy is:
"...an economic system based around the principle of exchange; it aims at every stage of the product life cycle (goods and services), to increase the efficiency of resource usage and lower environmental impact. At the same time the wellbeing of individual citizens should improve." (13)

This ambition embraces material and physical impacts, along with social benefits that are measured by the number of jobs in the circular economy.

Indicator framework
The French indicator framework is based around three areas, broadly representing input, use and end-of-life phases of materials and products. Each area contains one or more pillars which address its objectives, for each of which there is an indicator.

Figure 5: Areas and pillars of the French indicator set
Source: 10 Key Indicators of the Circular Economy (13)

Indicators

Table 7: French Circular Economy indicators

PILLAR	INDICATOR	RATIONALE (DIRECTLY QUOTED)
EXTRACTION/ OPERATION AND SUSTAINABLE SUPPLY CHAINS	Domestic Material Consumption per capita	The demand for goods and services from economic players requires the extraction of raw materials from the environment, as well as the export and import of both raw materials and manufactured goods. These material flows constitute Domestic Material Consumption (DMC). This readout provides an account of the effective quantities of goods consumed in a given country. This indicator is among the targets set by the UN's sustainable development goals for 2030.
	Resource Productivity	Resource Productivity is the ratio that weighs gross domestic product (GDP) against domestic material consumption (DMC). This indicator allows to measure the transition towards an economic system that is more frugal in its use of resources. This indicator is among the targets set by the UN's sustainable development goals for 2030.
ECO-DESIGN (products and processes)	Ecolabel Holders	Two ecolabels are currently awarded in France: the French ecolabel (NF Environment) and the European ecolabel (EU Ecolabel), recognised throughout the 28 EU Member States. These ecolabels are awarded based on voluntary measures and approaches. Products carrying an ecolabel have less environmental impact at each stage of their life cycle (manufacturing, use, transport and disposal) than non-certified products. A manufacturer may be awarded ecolabels for one or several products across different product categories.
INDUSTRIAL AND TERRITORIAL ECOLOGY	Number of industrial and territorial ecology projects	Industrial and Territorial Ecology (ITE), sometimes referred to as industrial symbiosis, is a form of inter-company organisation that focuses on resource exchange or pooling. The term refers to voluntary collective approaches implemented within a given region with a view to lessening the burden on resources (water, energy, waste) or improving productivity. ITE may involve the sharing of infrastructures or equipment (district heating, production tools or spaces, etc.), services (collective waste management, inter-company transport programmes, etc.) or materials (waste from one business becomes a resource for another). The approach was first introduced in France in the late 1990s.
FUNCTIONAL ECONOMY	Car-sharing	Promoted in 2015 within article 52 of the French law on Energy Transition for Green Growth, car-sharing aims to reduce the environmental impact of households' road journeys. Irrespective of the distance travelled, the idea is for individuals making the same journey to share vehicles, thereby reducing rates of solo driving.
RESPONSIBLE CONSUMPTION	Food Waste	France's "National Pact to Combat Food Waste" (pacte national de lutte contre le gaspillage alimentaire), published in May 2013, provides the following definition: any food item destined for human consumption which is lost, discarded or spoiled at any stage of the food cycle constitutes food waste. Food waste is a hallmark of the linear economy, causing direct and indirect wastage of resources (raw materials, water, energy). This indicator is among the targets set by the UN's sustainable development goals for 2030.
RESPONSIBLE CONSUMPTION	Household spending on product repair and maintenance	The extension of product life cycles is a key factor in lessening the environmental impact of consumerism by optimizing product use. Favouring repair over renewal means extending product lifespans, thereby limiting the need for replacement, which represents a further drain on resources. Monitoring the amount each inhabitant spends on product repair and maintenance enables us to analyse the development of household practices in this regard.

RECYCLING (material and organic matter)	Quantities of waste sent to landfill	According to the hierarchy of waste processing methods set out in European Commission Directive 2008/98/EC, the use of landfill sites is the least desirable method of waste disposal, along with incineration without energy recovery. Landfilling constitutes a waste of resources that might otherwise have been recycled, and impedes the development of a circular economy.
RECYCLING (materials and organic matter)	Use of recycled raw materials in production processes	Recycled raw materials, also known as secondary raw materials, are waste products that, having been sorted and processed, remain of sufficient quality to be reintroduced into the production process. They can be substituted for raw materials, thereby economising on resources. The "cyclical material use rate" shows the proportion of waste that has been recovered weighed against the material demands of the economy as a whole.
7 pillars + 1 adjacent pillar	Employment in the Circular Economy	This indicator aims to quantify the number of full-time or equivalent (FTE) jobs held in economic activities that form part of the circular economy. This indicator allows us to measure the transition towards an economic system that is more frugal in its use of resources. Employment in the circular economy is estimated across two levels: The 1st level examines the core activities of the circular economy via the 7 pillars defined by Ademe. The 2nd level is an "8th pillar", and includes what are known as "adjacent" activities – those whose primary objective is not the circularity of production processes or the reduction of resources used, but which will nonetheless contribute to these goals in a more or less permanent fashion.

Source: 10 Key Indicators of the Circular Economy (13)

Status
The indicator set has been implemented and is reported on a dashboard within the '10 Key Indicators' report (13).

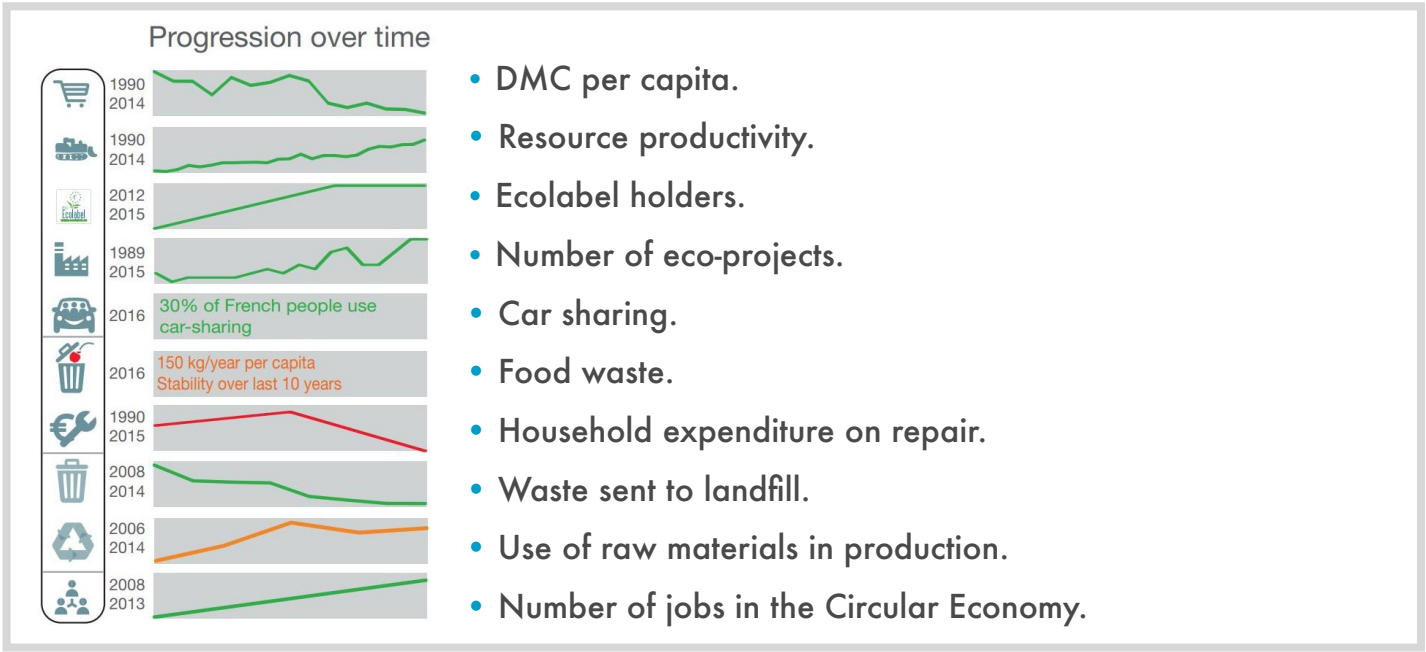


Figure 6: French indicator dashboard
Source: 10 Key Indicators for Monitoring the Circular Economy (13)

Per capita DMC is one of the recorded outcomes, which to some extent may address how France is moving towards 'one planet living' (the same concept as previously described in the section 5.2 Wales). The dashboard also reports the number of jobs in the circular economy, although how a circular job is defined is not explained.

Commentary

Car sharing and household expenditure on repair appear as two 'use phase' indicators, which is unusual within the indicator sets reviewed. A rise in repair expenditure is assumed to correlate to an increased tendency to repair rather than discard. However, increased repair and maintenance could be reflective of other effects, such as reduced product lifetimes, which would be counter to circularity principles. In addition, a large component of household repair is attributable to automotive maintenance. Maintenance costs are likely to be lower for electric vehicles because there are fewer wearing parts, resulting in a natural decline in total household bills.

Per capita domestic material consumption is one of the recorded outcomes, which to some extent may address how France is moving towards the ambition of "one planet living". However, at this first occurrence of the term DMC, we should note that this is only a partial view of the true impact of national demand for materials since it neglects the substantial burden of materials (or their equivalents within imported goods). These imports are yielding economic benefits through their transformation and ignoring them could be hiding 'offshoring', that is, shifting domestic material-consuming industries to imported goods produced in from the same industries operating abroad. This issue is revisited later in the report (section 7).

The dashboard also records the number of jobs in the circular economy, although how a circular job is defined is not explained.

5.5 Germany

Policy objective and guiding principles

Germany does not have an overall circular economy masterplan. Instead, there are a number of component policies in place, including the German Closed Substance Cycle and Waste Management Act (Kreislaufwirtschaftsgesetz, KrWG), in force since 2012 (14). This policy advocates closed-cycle management and a transformation to a sustainable and resource-efficient management of material flows. It is, though, almost entirely dedicated to the strengthening of the existing waste management and recycling protocols, including associated infrastructure. The KrWG is supplemented by a large number of regulations such as the Packaging Act (VerpackG) (15), the End-of-Life Vehicles Ordinance (AltfahrzeugV) (16), the Battery Act (BatterieG) (17) and the Electrical and Electronic Equipment Act (ElektroG) (18).

Overarching objectives of the Waste Prevention policy are to **decouple economic growth from resource use and associated waste generation**, and to reduce the **environmental impacts** associated with the use of resources and the generation of waste.

Indicator framework

Germany subscribes to the EU CE indicator set by default, but other indicators are implied because of related resources strategies.

The National Programme on Sustainable Consumption does not formulate quantified and binding targets, only a number of qualitative nudging approaches.

The German Resource Efficiency Programme 2016-2019 (ProgRess) (19) comprised 116 different proposals for resource efficiency actions. From these, indicators were selected that could track progress against targets.

Indicators

Table 8: Economic indicators and targets for resource use

Economic indicators and targets		
Approach	**Indicator**	**Target**
Continuous improvement in the resource efficiency of domestic production	Raw material productivity ((GDP/DMIabiotic materials) (indicator under the German Sustainable Development Strategy)	Doubling of raw material productivity from 1994 to 2020
Continuous improvement in resource efficiency, including biotic resources and making adequate allowance for imports	Total raw material productivity (GDP + imports)/RMI (including biotic materials)	Trend from 2000 to 2010 to be sustained to 2030

Table 9: ProgRess indicators and targets related to theme Recycling and Recovery

Approach	Indicator	Target
Increase in the recycling of municipal solid waste	Percentage of waste recycled	Permanent increase in the recycling rate of municipal solid waste to over 65% from 2020
Increase in the recycling of plastic waste (from which harmful substances have been removed)	Recycling rate for plastic waste	Significant increase in recycling rate by 2020
Increase in the rise of recycled construction materials - recycled aggregates as concrete aggregate	% of recycled aggregate used as concrete aggregates relative to total volume of minerals recycled construction materials	Significant increase by 2030
Increase in the high quality use of recycled construction materials - seperation of gypsum from constuction and demolition waste and establishment of recycling	% of recycled material in manufacture of gypsum board (plasterboard)	Significant increase by 2031
Improvement of end-of-life vehicles (ELVs) recycling - seperation of automotive electronic components (primarily circuit boards and rare earth magnets) from ELVs before shredding	Mass of seperated autimotive electronics per end-of-life vehicle	Largest possible proportion of automotive electronics removed from each end-of-life vehicle by 2020
Increase in collection and recycling of waste electrical and electronic equipment (WEEE)	Ration of total weight of collected WEEE to average weight of electrical and electronic equipment placed on the market in the three preceding years	Permanent increase in the collection rate: collection rather must be at least 65 percent from 2019
Increase in collection of recycling/recovery of organic waste	Quantity of orgnaicc waste collected	50% increase in the quantity of seperately collected organic waste and high-quality recycling/recovery of such waste - primarily cascading use - by 2020 relative to 2010
Increase in the recovery of economically usable phosphorous from secondary sources	Recovery rate of phosphorous (for example in readily plant-available sludge form) from wastewater/sewage sludge	Significant increase no later than ten years after entry into force of the new Sewage Sludge Ordinance

Table 10: ProgRess Recycling and Recovery indicators in development

Recycling and recovery indicators (in development)	
Approach	**Indicator**
Reduction in the primary material requirement (including for imported products) by the use of secondary raw materials (from which harmful substances have been removed)	Direct effects of recovery (DERec) as a percentage of direct material input (DMI)
Reduction in the primary material requirement (including for imports of raw materials used abroad) by the use of secondary raw materials (from which harmful substances have been removed)	TDirect and indirect effects of recovery (DIERec) as a percentage of raw material input (RMI)

Source of Table 8, Table 9 and Table 10: ProgRess report German Resource Efficiency Programme II (19) original data from Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUB)

Status
The 2016 ProgRess report contains performance data for key resource use indicators. The German Ministry for the Environment also publishes a report on raw materials consumption and use. For example, The Use of Natural Resources – Report for Germany 2018 (20).

Germany acknowledges that a framework is required and this will be a feature of the next iteration of the National Sustainable Consumption Policy and ProgRess. A policy framework which reduces waste by extending service life and increasing re-use and remanufacturing of products is recognised as necessary.

Commentary
The Eco-Innovation Observatory (EIO) in its 2020 review (21) asserts that the strengths of Germany are in its technology and innovation. To date, this has been applied to finding technical solutions to waste management, recycling and clean-up techniques. EIO notes that domestic recycling performance is now plateauing. It suggests that non-technical or at least non-material solutions will be the new frontier.

The 2016-2019 German Resource Efficiency Programme (ProgRess) report (19) also recognises that substantial innovation has taken place. EIO in (21) moderates this view, assessing the programme's reliance on voluntary instruments as a strategic weak point. The topics of digitalisation and the circular economy were highlighted as areas to be strengthened in the next iteration.

5.6 Denmark

Policy objective and guiding principles
In 2018, the Danish Government published a Strategy for Circular Economy (22). (Parts of the strategy built on a 2017 Utilities Strategy which largely tackled improving waste collection, sorting and recycling, and reducing incineration). The strategy aimed to "ease the pressure on natural resources and improve the environment to the benefit of future generations". It also proposes that new business models and technologies to enable a circular economy are a competitive opportunity for Denmark.

The strategy is divided in 6 action areas, which are built from 15 initiatives.

1. Strengthen enterprises as a driving force for circular transition.
2. Support circular economy through data and digitalisation.
3. Promote circular economy through design.
4. Change consumption patterns through circular economy.
5. Create a proper functioning market for waste and recycled raw materials.
6. Get more value out of buildings and biomass.

In 2021, The Ministry of Environment published an updated Action Plan for Circular Economy (23) linked to the Waste Strategy, but updated to incorporate indicators and metrics implied by the Strategy for Circular Economy, including "processes along the chain".

Of relevance to Scotland is the emphasis on three impactful areas, namely biomass, construction and plastics. These translated into five action areas:

1. Less waste and better use of natural resources.
2. More and better recycling.
3. Better use of biomass.
4. A sustainable built environment.
5. Plastics in a circular economy.

Indicator framework

Denmark updated its indicator framework as part of the Action Plan.

Indicators

Although Denmark's strategy is clear in the areas and actions that it would like to change. The two indicators which are explicitly stated in the original Strategy are shown in Table 11. Table 12 shows the developed indicator set associated with the 2021 Action Plan.

Table 11: Danish CE indicators named explicitly in the original strategy

Indicator	Rationale
Resource Productivity Target: raise by 40% between 2014 and 2030	The strategy seeks to raise ratio of economic activity to net use of materials. This is expressed as Danish Kroner (DKK) per kg of resources employed. Currently, the material mass is measured as domestic material consumption (DMC) and economic activity as gross domestic product (GDP). Figures are generated by the Danish Statistics agency and published periodically. Note that, to stay aligned to UN definitions, it is planned to switch from DMC to using raw materials consumption (RMC).
Share of recycling as a percentage of all waste treatment Target: raise from 58% in 2014 to 80% in 2030	The strategy focuses on recycling because Denmark has traditionally had a high reliance of incineration (over 30% of waste arising in 2014). Landfill is a small fraction of waste treatment, but also includes incineration without energy recovery. Therefore increasing recycling reduces incineration. The net effect is to keep materials in circulation longer, thus reducing demand for new materials and to reduce GHG emissions. Note: Waste excludes mineral spoils and tailings.

Table 12: The developed indicator set from the 2021 Action Plan

Targets and indicators	2014.000	2015.000	2016.000	2017.000	2018.000	2019.000	EU-target
Total waste sector CO2e emission (mil. tonnes)	2,8	2,8	2,8	2,9	2,9	2,9	-
Less waste and better use of natural resources							
Municipal waste per capita (kg)	810.000	812.000	820.000	816.000	799.000	842.000	-
Material Footprint (RMC per capita) (tonnes)	21,4	22,3	22,7	23,5	23,1	-	-
Resource productivity (BNP/RMC) (DKK per kg)	15,67	155,3	15,36	15,17	15,70	-	-
Number of products and services with Nordic Swan Ecolabel	>7.500	>9.000	>11.000	>12.500	>16.500	>18.000	-
Turnover of products and services with Nordic Swan Ecolabel (bil. DKK)	7,3	8,0	8,3	8,3	8,7	-	-
Circular material use rate (recycling and material recovery compared to DMC)	9,1 %	8,4 %	8,1 %	8,0 %	8,2 %	7,8%	-
Climate footprint of public procurement (mil. tons CO2e)	-	-	-	-	-	12,0	-
All public procurement must be eco-labeled by 2030							
-							
More and better recycling							
Recycling of municipal waste	-	-	-	-	42%	44%	>55 % in 2025 >60 % in 2030 >65 % in 2035
Landfilling of municipal waste	1%	1%	1%	1%	1%	1%	<10 % in 2035
Recycling of packaging waste	-	-	-	62%	63%	-	>65 % in 2025 >70 % in 2030
Recycling of glass packaging waste				91%	79%	-	>70 % in 2025 >75 % in 2030
Recycling of paper and cardboard packaging waste	-	-	-	80%	97%	-	>75 % in 2025 >85 % in 2030
Recycling of iron and metal packaging waste	-	-	-	64%	70%	-	>70 % in 2025 >80 % in 2030
Recycling of aluminium packaging waste	-	-	-	64%	70%	-	>50 % in 2025 >60 % in 2030
Recycling of wood packaging waste	-	-	-	55%	42%	-	>25 % in 2025 >30 % in 2030

"Recycling or preparation for reuse of end-of-life vehicles "	87%	86%	91%	89%	92%	90%	>85 %
Recycling, preparation for reuse or material recovery of end-of-life vehicles	87%	86%	98%	97%	99%	98%	>95 %
Separate collection of electronic waste (WEEE)	31%	42%	59%	46%	48%	56%	>65 %
Separate collection of battery waste	46%	46%	45%	53%	49%	56%	>45%
Significantly reduce the amount of marine waste							
-							
More value from renewable materials							
Share of biomass of domestic material consumption (DMC)	33%	29%	29%	30%	29%	-	-
Amount of recycled biowaste (kg per capita)	146	193	198	199	203	213	-
Recycling of phosphorus from sewage and sewage sludge	74%	71%	73%	73%	76%	-	-
Reduce the amount of food waste in all parts of the food value chain							
Amount of food waste from primary production (1000 tonnes)	-	-	-	-	59	-	-
Amount of food waste from food industry (1000 tonnes)	-	-	-	-	529	-	-
Amount of food waste from retail and wholesale (1000 tonnes)	-	-	-	-		99	-
Amount of food waste from the service sector (1000 tonnes)	-	-	-	-	71		-
Amount of food waste from households (1000 tonnes)	-	-	-	456	-	-	-
Reduce the environmental impact from construction and demolition							
Amount of minerals extracted on land and from the ocean incl. recovered materials (1000 m3)	28.210	27.808	28.886	30.560	31.051	29.684	-
Proportion of constructions certified with the Nordic Swan Ecolabel, DGNB, LEED or BREEAM	-	-	-	7%	16%	23%	-
Recycling of construction and demolition waste	-	-	-	-	36%	36%	-
Material recovery of construction and demolition waste	88%	88%	87%	85%	88%	87%	>70%
Reduce consumption and improve reuse and recycling of plastics							
Amount of marketed plastic packaging (1000 tonnes)	187	197	215	201	248	-	-
Amount of certain types of single-use products (tonnes)	-	-	-	-	6.272	-	-
Recycling of plastic packaging waste	-	-	-	19%	14%	-	>50 % in 2025 >55 % in 2030
Share of recycled plastic in new plastic bottles	-	-	-	-	-	28%	>25 % in 2025 >30 % in 2030
Separate collection of plastic bottles	-	-	-	-	-	94%	>70 % in 2025 >90 % in 2029

Source: The Danish Environmental Protection Agency, Ecolabelling Denmark, Eurostat, Statistics Denmark, Danish Brewers' Association, Dansk Retursystem, Byggefakta

Status

The indicators have been implemented; they largely build on data already routinely submitted to Eurostat.

Commentary

Within the action plan, under the intent to ensure less waste and better use of resources, the Government aspires, amongst other objectives, to: strengthen inclusion of eco-design principles; mandate use of eco-labels; and mandate total cost of ownership in public purchasing. Of these, in the indicator set, ecodesign principles are tracked by the uptake of Nordic Swan Ecolabel, although this largely targets consumer products; and public purchasing is measured by total carbon footprint, but there is no reporting of uptake of total cost of ownership.

5.7 The Netherlands

Policy objective and guiding principles

Since 2016 the Government of the Netherlands has been working towards the goal of creating a completely circular Dutch economy by 2050, with an interim goal of halving the consumption of primary raw materials by 2050 (24). A 2016 policy paper, A Circular Economy in the Netherlands by 2050 (25), described how these targets would be addressed, highlighting the following principles:

1. Ensuring that raw materials in existing supply chains are utilised in a high-quality manner. This increase in efficiency can lead to a decrease in the demand for raw materials in existing supply chains.
2. Substituting sustainably produced, renewable, and generally available raw materials for virgin resources that rely on fossil-based, critical and non-sustainably produced raw materials. Preserving the Netherlands' natural capital and enabling a more future-proof economy less dependent on the import of fossil fuels.
3. Developing new production methods, product designs and organisational structures that support more circular products and consumption patterns.

The 2016 policy paper has been followed by further policies and papers including the Raw Materials Agreement (26) in 2017, Transition agendas: focussing in on five sectors in 2018 (27), Implementation programme: actions and projects 2019-2023 in 2019 (28) and an update to A Circular Economy in the Netherlands programme in 2021 (29).

Indicator framework

The Dutch Government's approach to achieving the key strategic goals and targets of their circular economy transition plan revolves around five interventions that are within the scope of their influence. These interventions are:

- Fostering legislation and regulations.
- Intelligent market incentives.
- Financing.
- Knowledge and innovation.
- International cooperation.

The strategy highlights the Dutch Government's capacity to act as both a market regulator, director and network planner to support cooperation across value chains. Collaboration forms a sixth component to the strategy, leveraging the opportunities to support and accelerate the impacts of the above interventions (30).

Five supply chains and sectors are prioritised and have received their own 'transition agendas' to accelerate their transition. The five are: biomass & food, plastics, manufacturing, construction and consumer goods. As set out in the original 2016 strategy paper, the goal is that by 2050 each of these sectors will:

- Only use sustainably produced, renewable or generally available raw materials.
- Generate as little residual waste as possible.
- Ensure through measures such as smart return collection systems that end-of-life products undergo high quality recycling to be used to make new products. (31)

Indicators

Following the publication of A Circular Economy in the Netherlands by 2050, a report exploring the requirements for monitoring the transition was published jointly by PBL Netherlands Environmental Assessment Agency, Statistics Netherlands (CBS) and the National Institute for Public Health and the Environment (RIVM). Titled Circular Economy: what we want to know and can measure (32), it provides a robust analysis of what measurements are in place for the linear economy, and what sorts of measurements are needed for the circular economy. More specifically, the report considers what indicators are necessary for the transition between economic models, what they term 'effect monitoring'.

Of note is the report's exploration of 'transition dynamics monitoring' and the indicators required to do this. The Dutch Government believes that, only by systematically monitoring these dynamics and their related effects, can the circular transition be effectively steered over time.

In the suggested indicator framework a distinction is made between the indicators required for the 'formative phase' and 'growth phase' of the transition (see Figure 7 below).

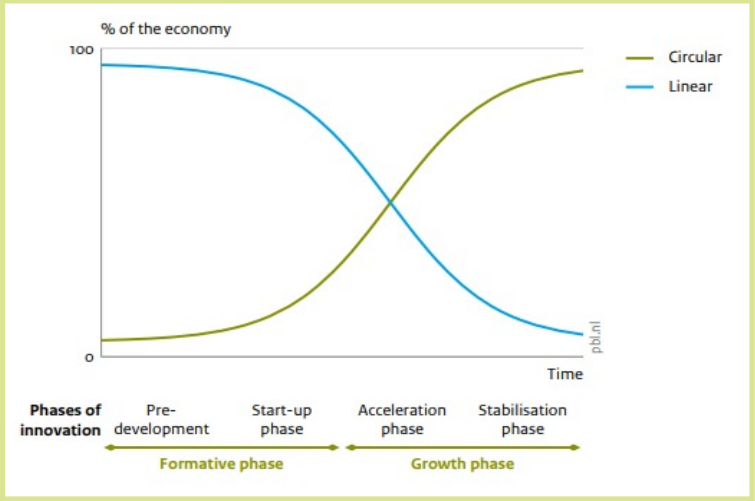


Figure 7: Depiction of the transition process against the degree of circularity

Source: Circular Economy: what we want to know and can measure (32)

In the start-up phase, it is suggested that clear definitions of the means, activities and legal instruments are required in order to effectively monitor the transition dynamics and effects. Later on, during the acceleration phase, the focus shifts to indicators for the innovation system itself.

Table 13 lists the generic transition dynamics indicators for all priority themes within the 2050 strategy. A list of all action indicators suggested in the report can also be seen in Table 14.

Table 13: Indicators required in the transition start-up phase

Suggested indicators for transition dynamics monitoring for circularity initiatives in all priority themes (generic indicators)			
	Capacity (able to)	Permission (allowed to)	Motivation (want to)
	All the indicators below are measured in three sub-classes R0–R2: Smarter product use and manufacture R3–R7: Extend lifespan of product and its parts R8–R9: Useful application of materials		
Means (input)	For increasing circular knowledge and expertise, e.g.: - Number of circular economy researchers (in FTE) - Investment in research (in euros) - Circular courses	For developing circular regulations and change 'linear' regulations, e.g.: - Number of circular policy advisers (in FTE) - Number of circular advisers in branch organisations (in FTE)	For developing circular visions and transition agendas, e.g.: - Number of people actively
Activities (throughput)	Related to knowledge and expertise, e.g.: - Number of circular innovation projects - Share of circular projects in total number of innovation projects - Number of network meetings for circular projects	Related to developing circular and changing 'linear' regulations, e.g.: - Policy process for new circular laws and regulations - Negotiations for circular standards	Related to increasing motivation for the circular economy, e.g.: - Number of vision-forming meetings - Number of awareness campaigns - Description of awareness campaigns - Development of new laws and regulations that discourage linear practices (e.g. resource tax, public circular procurement, resource passport)
Achievements (output)	Knowledge- and expertise-related activities, e.g.: - Number of publications - Number of patents (technology, product design) - Number of new revenue models - Number of new circular products - Share of circular products in total number of products - Number of circular start-ups	New and changed regulations that permit circular initiatives, e.g.: - Number of legal and regulatory barriers to the circular economy removed - Description of new standards and regulations	Results of activities that increase motivation for circular economy, e.g.: - Number and description of vision documents - Number of circular economy media reports - Consumer perception of circular economy - Market volume of public circular procurement - Number and description of new laws and regulations that discourage linear practices (e.g. resource tax, public circular procurement, resource passport)
Core achievements (core output)	Circularity strategies & Substitution		

Source: Circular Economy: what we want to know and can measure (32)

Table 14: Classification and listing of Dutch action indicators

Group	Indicators (relationship with action number)	Indicator type
Biomass and food	- Number of sustainability certificates issued - Amount of biomass consumed - Amount of reused phosphate exported as fertilizer	Achievement Core achievement Core achievement
Plastics	- Packaging waste recycling objective - Amount of plastic in litter - Number of brand owners who participate in activities to close loops	Core achievement Core achievement Achievement
Manufacturing industry	- Number of successful coalitions with serious business cases - Number of studies conducted for circular economy top sector policy	Activity Activity
Construction sector	- % recycled concrete granulate - Amount of secondary material used compared with construction volume - % new buildings for which an MPG (Milieu Prestatie Gebouwen; environmental performance of buildings) score has been calculated (including the score)	Core achievement Core achievement Achievement
Consumer goods	Annual amount of household waste, per resident - Number of companies that take part in IRBC agreements - Recycling objectives achieved for packaging waste	Core achievement Achievement Core achievement
Stimulative legislation	- Number of regulatory obstacles removed	Achievement
Smart market incentives	- Amount of biomass that meets requirements of sustainability frameworks - Extent of socially responsible procurement by national government	Core achievement Achievement
Financing	- Number of actions carried out in the Nederland Circulair! (The Netherlands Circular!) programme	Achievement
Knowledge and innovation	- Number of projects submitted/requested, e.g. for KIEM (Knowledge and Innovation Mapping) - Number of companies that use the resources tool - Number of top sectors for which the circular economy is a clear criterion/focal area	Achievement Achievement Activity
International cooperation	- Number of Platform Holland Circular Hotspot network events	Activity
Cooperation between government and chain partners	- Number of companies involved in transition agendas	Activity

Source: Circular Economy: what we want to know and can measure (32)

Status

The latest update to the Dutch Circular Economy Implementation Programme (2021-2023) (33) notes progress on the Implementation Programmes five transitional agendas, ten 'crosscutting themes' and regional objectives. It reports achievements against objectives.

Commentary

The Dutch approach to indicators is one of the most sophisticated seen amongst those reviewed in this study. The segregation of 'transitional' and 'accelerating' indicator sets is unique.

The Implementation Programme reports: the creation of a province-by-province map of circular economy action plans which will allow policymakers to highlight opportunities for 'transition flows' across regional and national borders and support via collaboration and legislation; the launch of the CIRCO programme to support and encourage designers and companies to adopt more circular design strategies for their products and services; a 'Denim Deal' in which the signatory brand owners and retailers commit to collaborating an a value chain to create 3 million pairs of denim jeans with 20% post-consumer cotton fibres over a 3 year period.

Although these initiatives are beyond the scope of the indicators work in this study, they are reported here as approaches of potential interest which Scotland may wish to explore later.

5.8 Amsterdam

Policy objectives and guiding principles

As laid out in Amsterdam's Circular 2020-2025 Strategy (34), a circular economy is seen as an economy where "we live in social prosperity and respect the ecological

boundaries of the Earth". This manifests as a goal to halve Amsterdam's use of primary raw materials by 2030 and to become 100% circular by 2050. It contributes to a fairer, more resilient society, a healthier world and a more efficient economy.

The whole strategy is covered in four complementary reports:

- Circular Strategy: why and how Amsterdam will be circular (35).
- Innovation & Implementation Programme: the projects which will shape the Circular Economy (28).
- The Waste & Raw Materials Implementation Programme 2020-2025: a component of the Implementation Programme (36).
- The Monitor: how the extent of Circular Economy will be measured (37).

Within the Circular Strategy, guiding principles for the circular economy are outlined:

1. **An end to waste:** preservation of products and materials in closed cycles.
2. **More with less:** reducing pressure on natural resources and improving fairness of access.
3. **Climate neutrality:** contributing to hitting Paris 2015 climate accord targets (1.5°C limits).
4. **Preserving value:** use of a value hierarchy to prioritise solutions at different life-cycle stages.[7]
5. **'Frontrunner opportunities':** leveraging CE learning for economic benefit, being first to market with new models or selling enabling capability and know-how.

Indicator framework

The indicator suite is intended to provide a snapshot of the city's environmental and social impacts, updated periodically. The Monitoring Framework builds on the previous strategy report. Presentationally, the indicator suite is known as the Monitor and is built on the 'Amsterdam City Doughnut' concept created by Doughnut Economy Action Lab for the city. The doughnut essentially provides a graphical indication of which of the UN's Sustainable Development Goals (UN SDGs) are addressed by a particular action under the strategy.

The Monitor focuses on five value chains: Food & Organic Waste Streams, Consumer Goods, Built Environment, Manufacturing Industry and Plastics. In its first release, the monitor covered only three of these value chains in detail: food & organic waste, consumer goods, & built environment. These value chains were selected based on their economic significance to the city, their impact on ecology and climate, and the opportunity and capability of Amsterdam to exert influence on circularity objectives.

The actions considered for the three initial sectors are described in Table 15.

[7] For example, (refuse, rethink, reduce) are top-ranked and relate to changing use and design; (re-use, repair, refurbish, remanufacture) relate to prolonging product lifecycles; (repurpose, recycle, recover) cover product end-of life.

Table 15: City of Amsterdam's priority value chains with rationale for choice

Target value chain	Rationale
Food & organic waste	The target of action is all food waste, in homes and food service. Production (and overproduction) of food has a large ecological impact through energy required, habitat destruction and chemical releases. Actions: • Create circular food production in (and for) urban areas. {stream 1} • Encourage healthy, sustainable and plant-based food consumption by all inhabitants. {stream 1} • Minimise food waste by retail, hotels & restaurants, and households. {stream 2} • Scale up the separate collection of organic waste from households and businesses for high-quality processing. {stream 3} • Scale up high-quality processing of biomass and food waste streams. {stream 3} • Accelerate the closure of local nutrient cycles from biomass and (waste) water streams. {stream 3} Related strategy: Amsterdam Food Strategy.
Consumer goods	This value chain mainly concerns electronics, textiles and furniture. These are chosen because of resource depletion effects, especially critical raw materials; pollution poor working conditions during extraction, before goods arrive in Amsterdam; and high GHG burdens of these goods. Actions: • Reduce consumption and avoid overconsumption. {Goods 1 &2} • Stimulate high-quality recycling of complex consumer goods. {Goods 3} • Aim for shared and long-term use of products. {Goods 2} • Increase the number of local craft centres for repair and restoration of products. {Goods 2} • Use and design standardised and modular products that are suitable for re-use, repair, and recycling. {Goods 1 &2} Related strategies: Circular Textiles policy adopted by the City in 2019 and the Amsterdam Leader in Sustainable Textiles initiative (2019).
Built environment	This value chain concerns largely publicly commissioned or permitted buildings. The large volume of materials which are inefficiently used and subsequently wasted is a concern for greenhouse emissions and resource consumption. However, it is an area where the City can have a major influence. Actions: • Stimulate circular area development with an urban design, an integrated approach and climate-proof construction, with special attention paid to closing cycles. {Built environment} • Use circular criteria in land allocation and tendering of all construction and infrastructural projects and in the public space. {Built environment 2} • Develop buildings with adaptable functions and systems. {Built environment 2 & 3} • Scaling up circular disassembly and separate collection for the purposes of high-quality applications. {Built environment 2 & 3} • Use renewable and secondary building materials. {Built environment 2 & 3} • Stimulate circular renovation in private and social housing. {Built environment 3}

Source: The Monitor (37).
Notes: {bracketed figures} relate to corresponding ambition in 2020-2025 strategy (34).

Indicators

The following figure shows the classification of indicators according to the stage of a product or material's use, from raw material through to end-of-life or recycling; the tables (from the same source) show the indicators assigned to each of these stages, with the social foundation being a cross-cutting theme.

Figure 8: Graphical mapping of the 5 elements of The Monitor
Source: The Monitor (37)

Table 16: Indicators from Monitor Parts 1-4

Monitor section	Indicator	Availability
Input	Total weight of materials in each value chain Total CO_2 impact of each value chain Total ECI impact of each value chain	Yes Yes Yes
Throughput	To be determined	
Waste collection by public authorities	Total weight of materials in each value chain Total CO_2 impact of each value chain Total ECI impact of each value chain	Yes No No
Waste processing in regional industry	Total weight of materials in each value chain Total CO_2 impact of each value chain Total ECI impact of each value chain	Yes No No

Source: The Monitor (37)

Table 17: Indicators from Monitor Part 5

Indicator	Year	Definition
Work & Income		
Average standardised income	2017	Average disposable income corrected for differences in household size and composition.
Long-term unemployment	2018	The percentage of the working-age population unemployed for a year or more.
Employment opportunities	2017	Number of jobs divided by working-age population.
Labour participation	2018	The proportion of the employed working-age population in the population (working-age and non-working-age population).
Number of circular jobs	2018	The proportion of circular jobs compared to the total number of jobs.
Environment and climate Social domain		
Satisfaction about the green space	2017	Score given for green areas.
Income inequality	2017	Gini coefficient#.
Wealth inequality	2017	Gini coefficient#.
Perceived health	2016	Percentage of the population that indicates it is in (very) good health (population aged 19 years and over).
Overweight	2016	Percentage of the population with a BMI of 25 and higher.
Mental health	2016	Percentage of the population with a moderate to high risk of anxiety disorder or depression (population aged 19 years and older).
Loneliness	2016	Percentage of the population that indicates it is moderately to severely lonely (population aged 19 years and over).
Volunteer work	2016	Percentage of the population that has been active as a volunteer in the last four weeks.
Living Environment		
Election turnout	2017	Percentage of persons entitled to vote who voted in the parliamentary elections.
Participation in lifelong learning	2018	Percentage of the employed working-age population that enrolled in a study programme or course in the last twelve months.
Satisfaction with home	2017	Degree of satisfaction with the home (total score), as a score of 1 to 10 (1 = very unsatisfied, 10 = very satisfied).
Quality of homes	2017	Assessment of the state of repair of the home, as a score of 1 to 10 (1 = very poor, 10 = very good).
Perception of housing costs	2017	Percentage of the population that assesses rent/mortgage as a heavy burden.
Distance to main road	2017	Distance to main road.
Commuting time	2017	Average commuting time of all residents in an area per year.
Victimhood of crime	2017	Percentage of the population that has been the victim of a crime in the last twelve months.
Perceived nuisance	2017	Combined score for various forms of nuisance (1 = little nuisance, 10 = a lot of nuisance)
Feelings of unsafety	2017	Percentage of the population that indicates that it ever feels unsafe.

Source: The Monitor (37)
Note: The The Gini coefficient# is a standard measure of inequality in national incomes or wealth.

Status
Implemented but does appear to have been reported recently.

Commentary
The Amsterdam suite of circularity documents reads as a very well-considered and exemplified instance of taking strategy through to indicators. The city has identified where it can best apply its power to act and to influence, especially in using its purchasing power to pull markets and demonstrate leadership. The social foundation indicators are the most detailed and comprehensive seen throughout this review. However, it is not apparent how the effects of adoption of circular economy can be causally linked to the social indicators. That may not be important if the aim is simply to see improvement in the social foundation over time, by whatever means.

5.9 Finland
Policy objectives and guiding principles
The SITRA document Leading the cycle – Finnish road map to a circular economy 2016-

2025 (38) describes the Finnish approach to transitioning to a circular economy.
It frames the circular economy as a growth opportunity for which it recognises the need to nurture a platform that is:

- Favourable for the domestic market and companies.
- Supportive of the export of innovative technologies.
- An enabler of comprehensive solutions and co-operation along value chains.

The document identifies the need to develop a road map for pilots to test concepts and practices. It outlines five interlinked focus areas as shown in Table 18.

Table 18: Policy action areas from the Finnish Government

Five interlinked focus areas	Policy actions	Owner	Key projects	Pilots
Sustainable food systems	Create a market for organic recycled nutrients, minimise food waste by eliminating barriers and creating incentives; support biogas systems and other renewable energy solutions to replace fossil fuels in agriculture.	Ministry of Agriculture and Forestry	A regional sustainable food system	Waste food, Nutrient recycling, Diets
Forest based loops	Making the main target of the national forest strategy the overall value of Finnish forest-based products and services rather than maximising the amount of wood; encourage the use of wood-based and other products made from renewables in public procurements; support for investment aimed at demonstrating bio products and bio services on a commercial basis; create incentives to develop Finnish wooden construction and the design of wooden furniture and interior design sector.	Finnish innovation fund – Sitra	An international demonstration platform for new bio products	Industrial symbiosis New innovations Eco system services Digitalisation Nutrient recycling
Technical loops	Promoting the use of secondary raw materials, including waste act interpretation and streamlining the environmental permit procedure. The goal must be to utilise secondary raw materials, such as industrial side streams as effectively as possible by actively seeking uses for side streams instead of allowing them to become waste; Use of the side streams produced during the project, such as surplus spoil, should be planned and described in the environmental impact assessment and environmental permit processes, including ecodesign requirements in product design and construction and in the material development phase.	Federation of Finnish Technology Industries	Circular economy demonstration plant; Artic industries ecosystem and Kemi-Tornio circular economy innovation platform.	Industrial and construction material flows, Construction and property use, Increasing knowledge, B2B consumer interface.
Transport and logistics	Develop incentives and policy instruments to accelerate a radical change towards a more service-based transport system. Develop tax and other steering to support the termination of fossil fuel use in private cars by 2040 and promote the implementation of biofuels produced in a sustainable manner.	Smart and clean foundation	Promoting and prioritising Mobility as a Service (MaaS) in the Helsinki capital region.	Energy, Regional trials, Logistics, Alternative forms of transport
	purchasing new solutions and products that support the circular economy. An education and research policy that enables the circular economy; dismantling regulatory barriers and creating incentives. Changing the focus of taxation, guidance and synergies with initiatives in other parts of administration. A digital and service-centred circular economy; circular economy indicators.	Ministry of the environment, Ministry of economic affairs and employment, Koli Forum	Economy Forum 2017 and Finland as a circular economy host country.	and export, increasing knowledge, regional trials

Source: Leading the cycle – Finnish road map to a circular economy 2016-2025 (38)

Indicator framework

The Finnish Roadmap is not connected to an underlying strategic legislative or policy platform. Despite having identified action areas, few identifiably quantifiable objectives have been set, the exception to this being the target of achieving 70-90% replacement of fuel by bio-fuel in the Helsinki public bus fleet by 2019. It is possible to speculate on possible indicators (such as use of secondary materials) but they are either already covered by EU indicators, or not concrete enough in their statement to give any confidence that they have been adopted.

Indicators

None located beyond the EU framework.

Commentary

Although the document does not describe indicators, it does highlight specific objectives within identified focus areas. The common interest with Scotland is the forestry-based loops theme where the emphasis is on maximising value rather than maximising harvesting. There are links to public purchasing, which it envisages taking a leadership role in buying sustainably managed wood and other bio-products.

The Finnish Roadmap is a set of pilots with a defined timeline (Figure 9). These milestones could be interpreted as 'start-up' indicators related to process and activity. If this is the case, the pilots should yield information about the productivity of approaches, leading to a more concretely targeted plan beyond 2025.

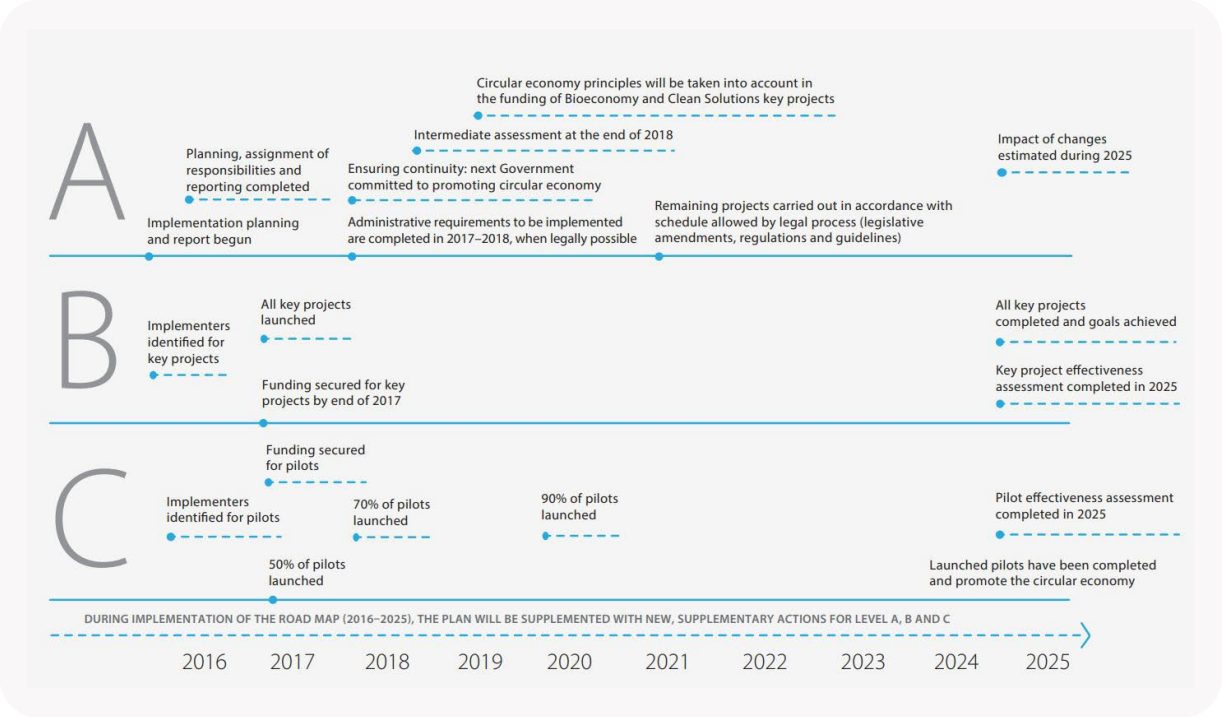


Figure 9: Division of road map actions (Finland)

Source: Leading the cycle – Finnish road map to a circular economy 2016-2025 (38)

5.10 Ireland

Policy objective and guiding principles

In support of the Government of Ireland's Programme for Government (39) and the Climate Act 2021 (25) the strategy supports the transition to a circular economy so helping to meet the country's target of halving emissions by 2030 and reaching net-zero by 2050.

As articulated by Minister of State Ossian Smith in the foreword of the Government of Ireland's Whole of Government Circular Economy Strategy 2022 – 2023 (40), the core purpose of the strategy is to address "two of the major obstacles holding back the development of the circular economy in Ireland":

1. The absence of a cohesive national policy framework for the circular economy in Ireland and a poor understanding of how the circular economy relates to sectoral policies and how these can support circularity.
2. A poor understanding amongst policy makers, industry actors and the public of the circular economy and the alternatives to the existing linear modes of production and consumption.

To achieve this, the strategy identifies the following five key objectives;

1. To provide a national policy framework for Ireland's transition to a circular economy which leverages the public sector leadership role.
2. To support and implement measures that significantly reduce Ireland's circularity gap compared to with other EU Member States.
3. To raise awareness amongst households, business and individuals about the circular economy and how it can improve their lives.
4. To promote increased investment in the Circular Economy in Ireland for growth and employment.
5. To tackle barriers to circular economy adoption.

The strategy document follows an earlier Waste Action Plan for a Circular Economy, which set out the Government of Ireland's overall policy for the transition to a circular economy. The first edition of the strategy acknowledges that it is not yet an action plan but rather a catalogue of the existing targets and actions that have already been set. Future revisions will bring in sector analyses and build action plans. Within the most recent strategy document, no mention is made of indicators, apart from the first goal of improving Ireland's circular material use rate in absolute terms and in comparison to other EU states. Instead the document outlines the new political entities and structures created to drive Ireland's circular economy transition.

Indicator framework

The indicative work programme set out to achieve these goals can be seen below in Table 19. Under the strategy, sectors of construction, transport, agrifood, consumer goods and procurement have been highlighted as important for the circular transition and requiring specific sectoral roadmaps. Within the existing strategy a number of potential actions for each of these sectors have been highlighted and these too can be seen below in Table 20. Finally, a full list of existing support measures for the circular economy in Ireland as identified in the strategy can be seen in Table 21.

Table 19: Indicative work programme set out for the Circular Economy Working Group (40)

Awareness	Mapping/ Policy Coherance	Policy Development
Circular Economy Platform – scoping exercise (Q1 2022) Circular Economy Branding – scoping exercise (Q1 2022) Other Circular Economy Awareness measures	Material Flow Analysis – scoping exercise (H1 2022) Circular Economy Funding Map Circular Economy Activity Map Circular Economy Policy Coherence Map	Consideration of OECD Report Recommendations (Q1 2022) Sectoral Roadmaps Consideration of additional policy measures, e.g. additional economic instruments Agreement of additional targets and actions for inclusion on next iteration of Strategy

Table 20: Preliminary outline of actions for inclusion in Sectoral Circular Economy Roadmaps

Sector	Potential Actions
Construction	• Increased use of offsite design and manufacture • Modular building design • Refurbishment and retrofitting of existing stock • Tackling dereliction and bringing stock back into occupancy • Increase use of Construction & Demolition Waste as a secondary construction material
Transport	• Increased use of telecommuting, as well as of local and regional hubs • Prioritising resource-efficient personal mobility, e.g. walking and cycling • Expanding public transport capacity and promoting shared mobility schemes • Efficient end-of-life vehicle waste management schemes
Agrifood	• Reduction of fossil fuel and external chemical inputs • Divert agricultural and food waste into the Bioeconomy • Interventions to reduce food supply chain losses • Reduce food waste at retail, commercial and household level • Identify opportunities for 'low and no' levels of food packaging, consistent with food safety and hygiene requirements
Consumer Goods	• Repair: • Promote design for improved repairability, durability and increased energy efficiency • Address product liability for repaired and re-used goods • Support education in repair and refurbishment skills • Explore economic incentives for repair • Increase level of remanufacturing for consumer goods • Extend use of EPRs • Promote leasing and sharing based business models • Incentivise take-back and refurbishment models for large household goods • Address product liability for repaired and re-used goods
Procurement	• Mainstreaming Green Criteria. • Identify international opportunities for cooperation on green public procurement. • Review National Policy Framework.

Source: Whole of Government Circular Economy Strategy 2022 – 2023: Living More, Using Less (40)

Table 21: Whole Government Circular Economy Strategy – Current measures supporting the circular economy in Ireland (40)

Theme	Initiative	Detail
Economy and finance	Plastic Bag Levy	Anti-litter measure aimed at reducing the use of disposable bags.
	Landfill levy	Incentivising the reduction of materials sent to landfill.
	CIRCULÉIRE Innovation Fund	Systems-level innovation in the manufacturing sector.
	EPA's Green Enterprise Innovation for a Circular Economy	Demonstrating innovative consumer and business solutions for the circular economy in Ireland.
	EPA Research 2030: A Framework for EPA Research 2021-2030	Address medium to long-term policy needs through desk studies, capacity development projects and with funding research fellowships to support capacity building.
	Circular Economy Innovation Grant Scheme (CEIGS)	Support circular economy projects with a view to advancing the circular economy in Ireland and raising awareness on the need for a transition from a linear to a circular economy.
Green Public Procurement (GPP)	Interreg Europe project GPP4Growth	Exchange experience and practices among nine member countries and improve capacity to implement resource efficiency policies promoting eco-innovation and green growth through GPP.
	EPA's Green Procurement Guidance for the Public Sector	Guidance and a toolkit for public procurers to include sustainable and green criteria in key sectors for the circular economy such as construction, transport, energy, food and catering, textiles, cleaning products, paper and ITC equipment. Training course delivered. Further training for suppliers in development. (2021)
	Rediscovery Centre	Courses and events on the use of GPP in the building sector.
	Irish Green Building Council	Working Group on Training Clauses in GPP in construction (2021).
	Local Authority Climate Action Region Offices	Training local authorities in green public procurement.
Capacity building	National Waste Prevention Programme (NWPP)	The EPA-led NWPP seeks to prevent waste and drive the circular economy, focusing on national-level strategic programmes with high visibility, impact and influence. Includes 'Green Government', supporting government departments in adopting sustainable behaviours.
	EPA Tool for Resource Efficiency	Support for companies to analyse their level of resource efficiency.
	EPA's Construction and Demolition Web Resources and Publications	EPA webpage presenting guidance in waste prevention in the construction and demolition sector.
	Local Authority Prevention Network (LAPN)	Co-operation between the EPA and local authorities to build local authority expertise and capacity in waste prevention and circular economy at the local level.
	Rediscovery Centre's Circular Economy Academy	Mentoring support programme to assist social enterprises and community organisations in increasing sustainability in their activities and embracing the circular economy.
	Modos	Circular economy training programme for micro, small and medium size enterprises by the Dublin City Council's Economic Development Office and Regional Waste Management Planning Offices.
Awareness raising	NWPP Food Charter	A public commitment that organisations can make to fundamentally change their approach to food waste.
	NWPP Stop Food Waste programme	Provide information about food waste prevention and composting to households, communities and businesses, among others.
	MyWaste.ie	Provide information and engage stakeholders on waste prevention, re-use and upcycling.
	Rediscovery Centre	Raise awareness through specific activities including education programmes and workshops.

Stakeholder engagement	Rediscovery Centre	Support research and education for the circular economy
	CIRCULÉIRE	Public-private partnership supporting manufacturers and their value chains to increase circularity in their businesses.
	Local authority prevention network (LAPN)	Improve local authorities' capacity to promote waste prevention.
	Smart Farming programme	Partnership between the EPA and the Irish Farmers Association providing tailored advice to farmers on solutions for low cost or no cost interventions to increase resource efficiency.
	Community Resources Network Ireland (CRNI)	Network for community-based re-use, repair and recycling organisations.

Source: Whole of Government Circular Economy Strategy 2022 – 2023: Living More, Using Less (40)

Status
The strategy highlighted a number of key sectors and indicative further actions to be undertaken after the formation of a Circular Economy Working Group (see Table 19). Based on the proposed outline, an update to the strategy including new sectoral strategies is be expected in late 2023 or 2024.

Commentary
The Irish strategy is short on concrete indicators and targets, but it is very strong in outlining the key changes in behaviours, opportunities and types of activities it would like to see change and grow. It's treatment of re-use type activities is particularly strong and segments well the 'informal' re-use and repair types, from the distinctly industrialised remanufacturing types.

The document reviewed covers the period 2022-2023, so a further iteration is likely shortly.

5.11 Sweden

Policy objectives and guiding principles
The Swedish Government adopted a national strategy for a circular economy on the 9th July 2020. Sweden's ambition is to use circular economy to achieve the environmental and climate objectives, as well as delivering many societal targets within its 'Agenda 2030'. The new strategy focuses on efficient use of materials, increasing their lifespan and value, and reducing both the extraction of new raw materials and disposals of landfill waste.

Subsequently, the Government published its Action plan for the transformation of Sweden (41) which outlined the four thematic focus areas and described action areas within each. Like Finland, a number of these action areas resonate with the Scottish situation, notably actions directed towards the bio-economy and sustainable management of forestries.
In addition, and complementary to the circular economy strategy, the Swedish government intends to develop an electrification strategy, a water strategy and a national bio-economy strategy.

Indicator framework
The action plan does not itself declare specific indicators. The four thematic areas are presented in Figure 10, taken from the Action Plan.

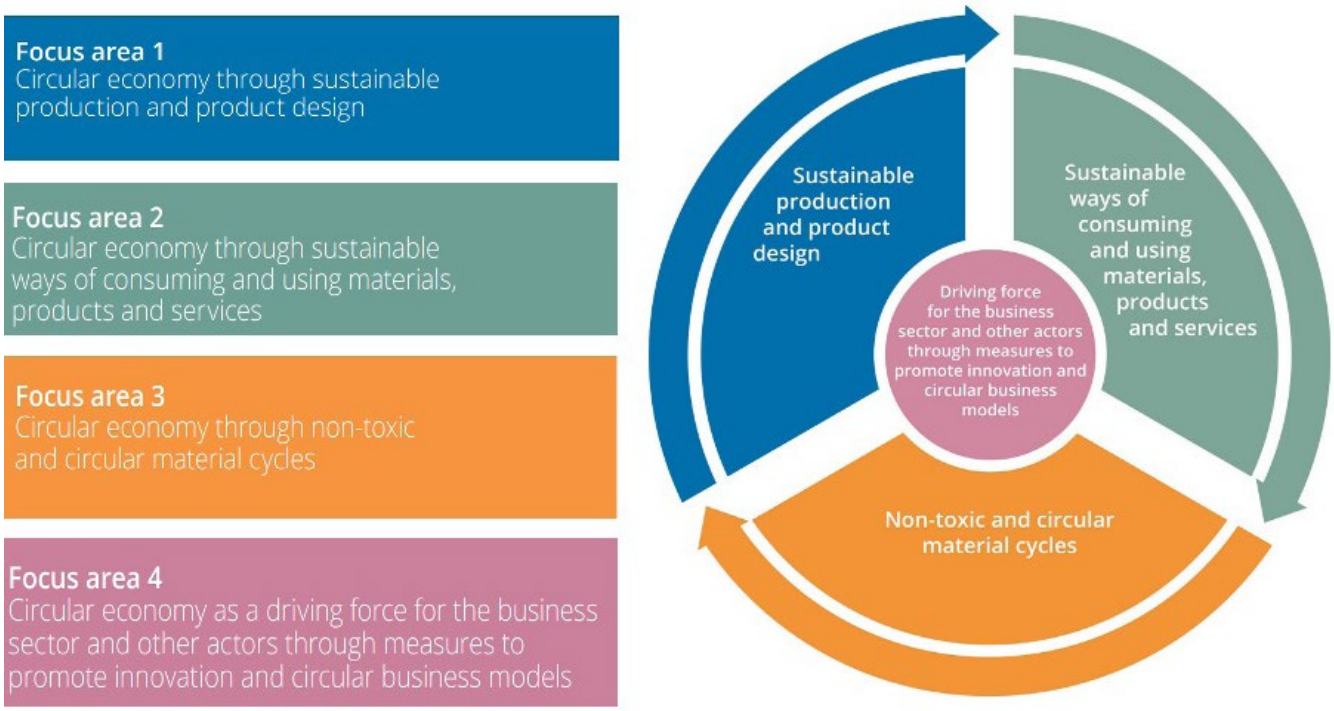


Figure 10: Four thematic areas of the Swedish Circular Economy Action Plan
Source: Action plan for the transformation of Sweden (41)

A number of prior policies and strategies have been published which detail related targets, including:

- The Revised National Forestry Accounting Plan for Sweden (42).
- Responsible Consumption and Production (statement aligned to UN SDG 12) (43).
- Strategy for Sustainable Consumption (44).

Indicators

The European Environment Agency reviews Sweden's circular economy efforts in its Circular Economy country profile (45). Going beyond EU indicators, it reports Sweden to be using the indicator (GDP/RMC)[8] which is close to the SDG indicator 12.2. Publication of the first assessment of this was due in late 2022. Besides Eurostat's indicator set, Sweden has indicators from the Delegation for Circular Economy[9]

These targets, which are in line with EU targets, are about reduction of greenhouse gases, packaging, food waste and municipal waste. One target, for example, is that the share of packaging which is reusable should increase by 20 % from 2022 to 2026 and by 30 % from 2022 to 2030.

Table 22: Swedish indicators (including beyond EU indicators)

EU Theme	Swedish indicator	Example target
Competition and innovation	Value added in the CE at factor cost (actual cost)	
	Value added at factor cost in the circular sector – percentage of gross domestic product (GDP)	
	Gross investment in tangible goods in the circular sector.	
	Gross investments in tangible goods in the circular sector – percentage of GDP)	
	Number of people employed in the private circular sector	
	People employed in the circular sector – percentage of total employment	

[8] Gross Domestic Product/Raw Material Consumption
[9] https://delegationcirkularekonomi.se

Production and consumption	Generation of municipal waste per person	Targets for single use plastics (cups, bags)
	Generation of waste excluding major mineral wastes per unit of GDP	
	Waste per person	
	Generation of waste, excluding major mineral wastes, per unit domestic material consumption	
	Total tax deduction for repair of domestic white goods	
	Food waste per person	Undefined method
	Resource productivity – raw material consumption (GDP/ RMC)	
Secondary raw materials	Circular material use (CMUr) rate in industrial production	Target set for plastics as 30% in packaging
Recycling	Recycling rate of municipal waste	Increase to 55% min by 2025, to 60% min by 2030, and to 65% min by 2035
	Recycling rate of all waste excluding major mineral waste	
	Recycling rate of packaging	Increase by 20% between 2022 & 2026 Increase by 30% between 2022 &2030
	Recycling rate of construction and demolition waste	Must be 70% by 2025
	Recycling rate of food waste from homes and hospitality	75% to be directed to biogas generation by 2023

Source: European Topic Centre on Circular economy and resource use (45)
Note: Indicators beyond EU standard set in red

Status
SCB, The Statistics Authority, has commenced publication of data as tables and diagrams[10] (in Swedish).

Commentary
Like Finland, the Swedish action plan very clearly describes action areas and desirable outcomes, but these are not framed as objective indicators and targets. It should also be noted that some action points are not uniquely defined by the circular economy, for example reduction of toxic substances, since this is already the target of action at national, EU and international level.

Of interest in implementation, "..in 2020, the Swedish National Public Procurement Agency produced a guide on how procurement can be used as a strategic tool for a circular adjustment throughout the procurement process. Examples of areas with new circular criteria are furniture, waste mitigation measures in the construction sector and plastic packaging from the healthcare, food and construction sectors." (45)

The mentioned Forestry Accounting Plan could be of interest to the Scottish Government as it details quantitative methods for assessing the "natural capital, abstraction and regeneration, management scenarios, and assessment of carbon capacity & absorption potential".

5.12 Spain

Policy objective and guiding principles
The Spanish circular economy policy is laid out in the document Circular Spain 2030 – Spanish Circular Economy Strategy (46).

[10] https://scb.se/hitta-statistik/statistik-efter-amne/miljo/miljoekonomi-och-hallbar-utveckling/cirkular-ekonomi/#_Tabellerochdiagram

Spain describes explicitly its unique position in which it doesn't have the abundancy of natural resources of comparable economies, such as Germany, France, Sweden, and the United Kingdom. Some of the international context for the plan is given by the UN's Sustainable Development Goals, European Action Plan for the Circular Economy, European Green Pact, and new Circular Economy Action Plan for a Cleaner and More Competitive Europe, and European Framework for Research and Innovation.

The policy states the following general principles:

- Protection and improvement of the environment.
- Preventive action.
- Decarbonisation of the economy.
- Whoever pollutes must pay.
- Health protection.
- Rationalisation and efficiency.
- Cooperation and coordination amongst public administrators.
- Public participation.
- Sustainable development.
- Solidarity amongst people and territories.
- Integration of the environmental aspects in decision making.
- Improvement of economic competitiveness.
- Quality employment generation.

Indicator framework

The action plans of this policy will be focused in five specific categories: Production, Consumption, Waste Management, Secondary Raw Materials, and Water Reuse and Depuration; and three cross-category action lines: Sensibilisation and Participation, Research, Innovation and Competitiveness, and Employment and Training.

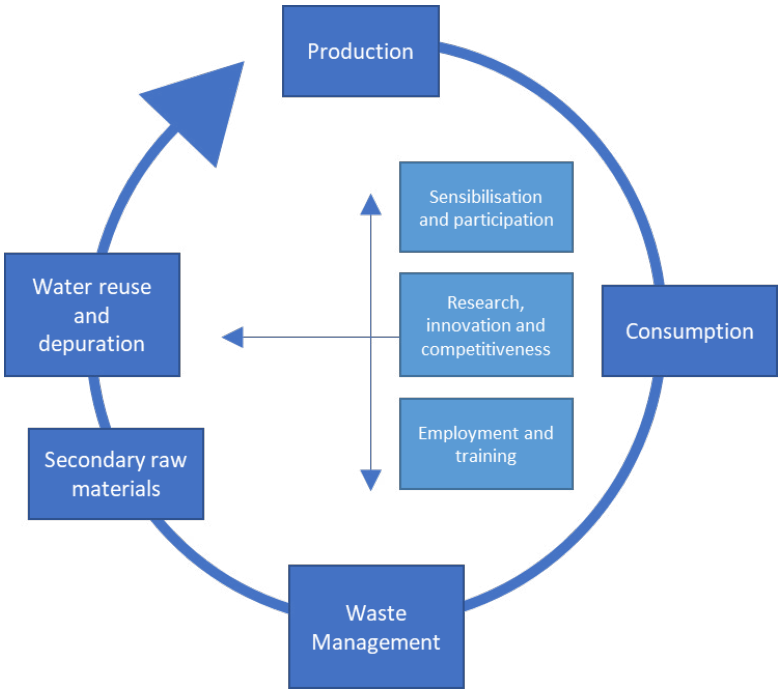


Figure 11: Action areas of the Spanish Circular Economy policy
Source: Circular Spain 2030 – Spanish Circular Economy Strategy (46)

Although all sectors are considered within the plan, six are considered a priority:

- Construction
- Textiles and confection
- Tourism
- Consumer goods
- Industry
- Agro-food, fisheries and forestry

Indicators

Table 23: Spanish circular economy indicators

Number	Indicator	Unit	Data source	Frequency	Starting year	End year	Most recent value for Spain
Production and consumption							
00	National material consumption	Mt	INE	Annual	2008	2018	422,974.60
01	Self-sufficiency in the production of critical raw materials in the EU	% (mass)	European Commission DG GROW		2015	2016	
02	Green public procurement	No. €	European Commission				
03	Waste generation						
03.1	Municipal waste generation per person	kg/hab	Eurostat	Annual	2004	2018	475.00
03.2	Waste generation (not considering waste proceeding from mineral waste) in respect to GDP	kg/€	Eurostat	Every two years	2004	2016	62*
03.3	Waste generation (not considering waste proceeding from minerals) respect to domestic material consumption	% (mass)	Eurostat	Every two years	2004	2016	17.20
04	Food waste	t	Eurostat				
Waste Management							
05	Preparation of reutilisation	%	SIG	Annual		2017	
06	Recycling rates						
06.1	Municipal waste recycling rate	% (t)	Eurostat	Annual	2004	2018	35.00
06.2	Recycling rate excluding minerals	% (t)	Eurostat	Every two years	2010	2016	46.00
07	Valorisation/Recycling per waste flow						
07.1	Container recycling rate	% (t)	Eurostat	Annual	2000	2017	68.50
07.2	Plastic container recycling rate	% (t)	Eurostat	Annual	2000	2017	47.90
07.3	Wooden container recycling rate	% (t)	Eurostat	Annual	2000	2017	67.50
07.4	Electric and electronic waste recycling rate	% (mass)	Eurostat	Annual	2008	2017	41.00
07.5	Organic waste recycling rate	kg/hab	Eurostat	Annual	2000	2017	84**
07.6	Construction and demolition recycling rate		Eurostat	Every two years	2010	2016	79.00
Secondary Raw Materials							
08	Contribution of recycled materials to raw material demand						
08.1	Waste recycling rate of products at the end of life	%	European Commission DG GROW		2016	2016	
08.2	Circular material rate	%	Eurostat	Annual		2017	7.4**
09	Recycled raw materials trade						
09.1	Import from third countries		Eurostat	Annual	2004	2016	668,219.00
09.2	Export to third countries		Eurostat	Annual	2004	2016	1,317,559.00
09.3	Intra-communitary imports		Eurostat	Annual	2004	2016	5,435,184.00
09.4	Intra-communitary exports		Eurostat	Annual	2004	2016	796,630.00
Competitiveness and Innovation							
10	Private investment, employment, gross value add relative to circular economy sectors						

10.1	Gross investment in tangible goods	%	Eurostat	Annual	2008	2017	0.10
10.2	No. of jobs	%	Eurostat	Annual	2008	2017	2.04
10.3	Added value to factor cost	%	Eurostat	Annual	2008	2017	1.05
11	Patents related to recycling and secondary raw materials as representative of innovation	No.	European Commission Joint Research Centre	Annual	2008	2015	19.82
Climate Change							
12	National Greenhouse Effect Gas Inventory						
12.1	Contribution of GHG in the waste sector	CO_2e (kt)	MITERD	Annual	1990	2018	13,471.00

* provisional data **Eurostat estimation

Source: Spanish Circular Economy Strategy (46)

A number of targets have also been set:

- Reducing by 30% the national consumption of materials relative to GDP, taking 2010 as base value.
- Reducing waste generation by 15%, taking 2010 as base value.
- Reducing food waste across the food chain: 50% per capita in home and retail and 20% in production and supply chains from 2020, contributing to the SDG.
- Increase the re-use and preparation for re-use targeting a mass equivalent to 10% of municipal waste.
- Reducing GHG emissions to under 10 million tonnes CO_2e per annum.
- Improve water usage by 10%.

Status

Largely implemented because of overlap with the EU data set.

Commentary

The indicator set replicates the EU indicator set almost entirely. However, it is supplemented with detailed targets for headline indicators, including a target for reducing water consumption, which is not unexpected for such a water-stressed region. Like the Netherlands, the national plan is well connected to robust regional plans that address local priorities according to geography or demographics.

A leading role in the introduction of the Spanish policy is dedicated to the ecological footprint, to highlight the importance of resource efficiency for the country. This is because, even though Spain was the fifth largest EU economy in 2018 [according to Spain Circular 2030, (46)], it differs significantly from larger EU economies in its natural resources and productive land. Specifically, Spain's ecological footprint per capita, although low compared to others, exceeds its per capita biocapacity, hence the need of making the most of all available resource.

5.13 Portugal

Policy objectives and guiding principles

Portugal's circular economy approach is laid out in the document Leading the transition – Action plan for circular economy in Portugal: 2017-2020 published in 2017 (47). This document frames circular economy as the means to decouple raw material demands from economic activity (value creation), addressing material price volatility and reducing GHG emissions. In addition, it is seen as a method of closing Portugal's productivity gap to its peer-group nations. The action plan relies heavily on the core principles (waste prevention, product longevity, regeneration), and building blocks (design and dematerialisation, new business models, reverse cycles and supportive economic framework) described by the Ellen MacArthur Foundation.

The ambition set out for Portugal 2050 consists of the following elements:

- **A carbon-neutral economy that is efficient and productive in its use of resources:** neutral GHG emissions and effective use of materials (a significant fall in the extraction and importing of materials, a significant fall in final waste generated, better management and value extraction from the resources in circulation).

- **Knowledge as an enabler:** focusing on research and innovation creates solutions – in products, services, business models, consumption/use, behaviour – with lower emissions and resource intensity, integrated into business models that spur job creation, efficient and effective use of mobilised resources, and their lasting economic value.

- **Inclusive and resilient economic prosperity:** economic development that impacts all sectors of society, is resilient against price and risk volatility and gradually decoupled from negative environmental and social impacts.

- **A flourishing, responsible, dynamic and inclusive society:** an informed, participative and more collaborative society – a society guided by being caring, rather than wanting and possessing and which conserves and cares for its natural capital.

Indicator framework

Three levels of actions are considered and are paraphrased from the 'Leading the transition' document:

- **Macro** (or whole economy): high-level cross-sectoral actions producing systemic effects. These actions require a coordinated, harmonised approach, such as driving recycling targets and associated infrastructure. Indicators for these are, in essence, the EU Circular Economy indicator set.

- **Meso** (or sectoral): actions or initiatives defined and accepted by all players in the value chain of sectors to raise productivity and the efficient use of the country's resources; a sector is taken to mean the entire supply chain, for example, construction runs from the point of raw material extraction to build, use, demolition and recycling. The focus of each sector will be different and will demand bespoke actions in design, resource efficiency, use, re-use and recovery.

- **Micro** (or regional/local): actions or initiatives defined and adopted by all regional and/or local government, economic and social actors which incorporate a local economic aspect and which address social challenges.

Indicators

The indicator set for Portugal effectively sets goals at the macro (whole economy) level. This is because the Government believes that specific circular economy tactics are a sector (meso-level) decision, supported by tailored local (micro) initiatives; its primary mechanism for driving the exploration of CE approaches is through sector voluntary agreements on achieving sub-targets of the whole economy indicators.

Table 24: Portugal's macro-level indicator/target set

Strategic instrument	Goal	Indicator	Unit	Base information		2020 TARGET	2030 TARGET
				Year	*Figure*		
National Reform Plan	*Territorial enhancement*	Increase urban waste prepared for recycling	%	2016	38%	50%	65%[1]
		Cut biodegradable urban waste going to landfill	%	2016	41%	35%	10%[2]
		Cut primary energy use in all sectors	Mtoe	2015	21.7	22.5	3)
Green Growth Commitment	*Promote the efficient use of resources*	Raise resource productivity in the national economy (LCC - GOAL 4 / PNGR)	€/t	2013	1.14	1.17	1.72
		Increase the incorporation of waste into the economy (LCC - GOAL 5 / PNGR)	%	2012	56%	68%	86%
		Focus on urban rehabilitation (LCC - GOAL 6)	%	2013	10.3%	17%	23%
	Contribute to sustainability	Raise energy efficiency (cut energy intensity) (LCC - GOAL 7 / PNAEE)	toe/€m GDP	2013	129	122	101
		Raise water efficiency (LCC - GOAL 8 / PENSAAR2020)	%	2012	35%	25%	20%
		Cut CO_2 emissions (LCC - GOAL 10 / PNAC 2020-2030)	Mt CO_2 eq.	2005	87.8	68-72	52.7-61.5
		Boost the share of renewable energy (LCC - GOAL 11 / PNAER)	%	2013	25.7	31%	40%

Notes: 1) and 2) targets currently under negotiation in the context of the European Commission's legislative waste package: 1) for urban waste recycling in 2030; 2) maximum urban waste in landfills. In the case of 3), the target for 2030 is now set by the "Raising Energy Efficiency" target;

Source: Leading the transition – Action plan for circular economy in Portugal: 2017-2020 (47)

The Plan is short of specific targets at sector level because the Government believes that they should be determined at the time that dedicated action plans are formulated and implemented. However, the Plan does provide examples of how it sees the Plan being put into action for products and sectors. These 'protocols' highlight CE tactics expected to be employed, and the types of **complementary indicators** that could be used to judge how the system is adapting.

The following tables summarise the indicators suggested for the identified approaches. In the language of this report, complementary indicators can be read as 'metrics' or secondary indicators.

Table 25: Portugal's complementary indicator set aligned to circular economy tactical approaches

Tactic	Complementary indicators
Design, Repair, Re-use (EPR) (product-consumption)	• Ratio of shops offering repair services to total number of shops; • Repair cafés and/or local actions realised; • No. of users of the services made available; • Ratio of products repaired to new products sold (including re-used vs. new school books) • Saving per student on the price of a basket of school books for each school year; • No. of partnerships with municipalities/distribution; • No. of awareness-raising actions and their respective impact.
Incentivising a circular market (product-consumption)	• Impact of the tax benefit awarded; • GVA generated; • Number of companies or products with tax benefits; • Amount invested in circular economy projects.
Educating for a circular economy (consumption-knowledge)	None developed.
Eat without waste: sustainable production for sustainable consumption (consumption–waste, by-products, secondary raw materials)	None developed.

Source: Leading the transition – Action plan for circular economy in Portugal: 2017-2020 (47)
GVA: Gross Value Added

Status
The plan was adopted by the Council of Ministers in 2017 after public consultation. Governance is carried out by an inter-ministerial Commission to ensure integration with related policies, and an Action Plan stakeholder group of public and private interests more concerned with processes for goal setting, implementation and monitoring at 'meso' and 'micro' levels.

Commentary
Although Portugal's 'macro' level indicator set is not unusual, its lower level 'meso' and 'micro' level indicators are of interest. These indicators are associated with the implementation of actions at the sector level where process change is anticipated. This is akin to the Netherland's concept of transitional indicators.

While outside the scope of this study, the example action plans are reported in a template which might have value for Scotland if considering similar approaches, such as sector-level agreements. Sector-level agreements are a fundamental tactic for Portugal and Finland's strategies, although the former has clearly considered achieving consensus among stakeholders before taking action in more detail. This approach may go some way to addressing the criticism of voluntary approaches levelled by some critics of national policy.

5.14 Canada

Policy objective and guiding principles [11]
Canada does not have an overarching circular economy strategy at this time. However, some component initiatives have been formulated and enacted though others remain in development.

In place:
1. A Healthy Environment and a Healthy Economy
Encourages adopting resource-efficient approaches that underpin a circular economy in order to build the path to a resilient future.

2. Greening Government Strategy
Seeks to establish Canada as a global leader in government operations that are low-carbon, resilient and green. Includes transition to a circular economy through procuring goods and services with a reduced environmental impact, life-cycle assessment, and clean technologies.

3. Mining Wastes as Resources
Seeks to re-imagine the idea of mine tailings and waste within the "circular economy" paradigm. Focus on testing current technologies, developing new ideas and supporting collaborative solutions. Complemented by Canadian Minerals and Metals Plan (CMMP)

4. Canada-wide Strategy on Zero Plastic Waste
Outlines areas where changes are needed across the plastic lifecycle, from design to collection, clean-up, and value recovery, and underscores the economic and business opportunities resulting from long-lasting and durable plastics.

5. A Forest Bioeconomy Framework for Canada
Details an approach to stimulating new economic activity by converting sustainably managed renewable forest-based resources into products and services using novel and repurposed processes.

In development is:
6. A National Strategy to Encourage Remanufacturing and Other Value-Retention Processes in Canada
Supports the transition to a circular economy via re-use processes, and contributes to the Canada-wide Strategy and Action Plans on Zero Plastic Waste.

Indicator framework
In advance of an overarching CE strategy, Environment and Climate Change Canada (ECCC) commissioned a study in 2020, Measuring the Circular Economy in Canada (48). This document offers a definition of the circular economy which targets a reduction in raw material extraction and releases of

[11] https://www.canada.ca/en/services/environment/conservation/sustainability/circular-economy/circular-economy-initiatives.html

wastes into the environment. The document employs four tactics, broadly summarised as:

- Design for pollution prevention (lightweighting, resource efficiency, use secondary materials).
- Life extension (refurbishment and re-use).
- Sharing economy and servitisation.
- Waste management and energy recovery (recycling and waste-to-energy).

The report assessed the availability and specificity of data needed to offer insight into these themes and provided a number of recommendations where enhancements would be beneficial (largely to government agencies and Statistics Canada). These imply a number of measurement areas and indicators. The selected recommendations include:

- **Recommendation #2:** ...extend physical flow accounts to cover biomass and mineral flows using basic data available from [agencies].
- **Recommendation #4:** ...improved waste output statistics, with priority given to [material breakdown of municipal solid waste and industrial scrap metals], dissipative nutrient losses, unused extraction of bio-mass in agriculture, and fishing & forestry.
- **Recommendation #5:** ...improved product design and production, data on: water use, irrigation methods & manure management, environmental management practices, and pollution prevention methods.
- **Recommendation #6:** ...expand physical flow accounts to include household goods and services.
- **Recommendation #7:** ...extend Statistics Canada's Repair & Maintenance Services Industry Survey to include [more detail of] the second-hand economy (including remanufacturing, refurbishment, re-use).
- **Recommendation #8:** [to better understand servitisation, assess]...the extent of vehicle sharing through the various services in Canada.

Commentary

Measuring the Circular Economy in Canada (48) is an advisory report which has not manifested in an official national strategy or a singular measurement. However, its recommendations follow a line of logic similar to other nations: The priorities are to improve data regarding waste collection and recycling; to consider measures to prevent waste and minimise resource use; to efficiently use natural capital; and to adopt indicators of process and behavioural change within the re-use spectrum.

Notably, many of the recommendations anticipate additional data collection needs as well as the development of methods to process collected data into indicators.

5.15 United States of America

Policy objective and guiding principles

The USA does not have a bespoke circular economy strategy. An Environmental Protection Agency (EPA) report (49) of September 2022 reviews the suite of relevant policies and developments. It frames intended circular economy policy in the following way:

"Because recycling alone will not achieve a circular economy and reduce GHG emissions, EPA is developing other strategies in the Circular Economy Strategy Series to identify the actions needed to reduce impacts associated with material use, consumption, and disposal."

These include a food waste and organics strategy and a plastics strategy for which it intends to release drafts to the public in 2022. EPA has also started consultation on a critical minerals and electronics strategy, which will include actions to support the recovery of critical minerals through recycling. However, the only component already in place is the recycling strategy which lays out these objectives:

- Improve markets for recycled commodities.
- Increase collection and improve materials management infrastructure.
- Reduce contamination in the recycled materials stream.
- Enhance policies and programs to support circularity.
- Standardise measurement and increase data collection.

Indicator framework
No framework in place.

Indicators (pre-existing, not CE-tailored)
No indicators are in place, but the US is considering using the following existing indicators, to be developed further:

Table 26: Pre-existing indicators and targets monitored by the United States Government

Category	Indicators and targets
Resource Input	Commercial municipal solid waste generation
	Commercial construction and demolition debris generation
	Commercial RCRA hazardous waste generation
Social Impact	Jobs supported
Economic Impact	Jobs supported
	Value added to economy
Environmental Impact	Acidification potential
	Freshwater ecotoxicity potential
	Eutrophication potential
	GHG emissions
	Human health respiratory effects
	Human health toxicity
	Human Health cancer
	Human Health non-cancer
	Ozone depletion
	Smog formation potential
	Hazardous Air Pollutants
	Pesticides
Targets: Resource Circulation	Reduce U.S. food loss and waste by 50% by 2030
	Increase national recycling rate to 50% by 2030
Targets: Environmental Impact	Reduce climate impacts of materials use in U.S.

Source : G20 Resource Efficiency Dialogue

5.16 Chile

Policy objectives and guiding principles
Chile's circular economy plan and ambitions are contained in the Roadmap for a Circular Chile 2040 (50). The document is closely aligned to the Ellen MacArthur Foundation model and goes into a brief explanation of the technical and biological cycles. The Chilean situation is then put into context against local and global trends. The plan that is laid out in the document follows the vision:

"By 2040, a regenerative circular economy drives Chile to a sustainable, fair and participatory development that puts people at the centre; this, through the care of nature and its living beings, the responsible and efficient management of our natural resources, and a society that uses, consumes, and produces in a sustainable and conscious way, promoting the creation of green jobs and opportunities for people and organisations through the country."

This vision, the document says, requires a future where:
- The circular economy has been embedded in the culture of the country, generating sustainable production and consumption patterns in all levels of society.
- Circular practices have driven the regeneration of nature, positively and sustainably impacting the lives of people and

the environment.
- The innovation potential of the circular economy has been fully tapped into, igniting the creativity of people for the design and implementation of more efficient and sustainable production systems.
- The circular economy has reached all regions of the country, promoting sustainable local development compatible with the visions and vocations of each place.
- The circular economy has become a generous source of opportunities, enabling a fair transition.
- The profound changes brought about by the transition have been the result of the collaborative and participatory work of a diverse set of actors.

Indicator framework

The outcomes of a circular economy set the context for the indicators, and are laid out as long-term goals set for 2030 and 2040 as shown in Table 27. Effectively these form headline indicators.

Table 27: Chilean indicators matched to long-term goals

Goal	2030	2040
1st Goal: Generation of green jobs	100,000 new jobs	180,000 new jobs
2nd Goal: Generation of municipal solid waste per inhabitant	10% decrease	25% decrease
3rd Goal: Total waste generation per GDP	15% decrease	30% decrease
4th Goal: Material productivity	30% increase	60% increase
5th Goal: General recycling rate	40% increase	75% increase
6th Goal: Municipal solid waste recycling rate	30% increase	65% increase
7th Goal: Reclamation of sites affected by illegal disposal	50% recovery	90% recovery

Source: Roadmap for a Circular Chile 2040

To achieve these goals, there are 27 individual initiatives clustered around 4 pillars: circular innovation (yellow), circular culture (green), circular regulation (blue), and circular territories (red) as shown in Table 28.

Table 28: Chilean mapping of initiative contributions to goals

¿WHICH INITIATIVES CONTRIBUTE DIRECTLY TO WHICH GOALS?

INITIATIVES / GOALS	1ST GOAL: GENERATION OF GREEN JOBS	2ND GOAL: GENERATION OF MUNICIPAL SOLID WASTE PER CAPITA	3RD GOAL: TOTAL GENERATION OF WASTE PER PIB	4TH GOAL: MATERIAL PRODUCTIVITY	5TH GOAL GENERAL RECYCLING RATE	6TH GOAL: RECYCLING RATE OF MUNICIPAL SOLID WASTE	7TH GOAL: RECOVER OF SITES AFFECTED BY ILLEGAL DUMPING
1 - Zero Waste Firms							
2 -Promotion of Circular Models							
3 - R&D for a Circular Economy							
4 - Strategic Collaboration for High Impact...							
5 - Scale-up of High Potential Circular Solutions							
6 -Information Systems for Modelling the Local...							
7 - Technical Standards for the Circular Economy							
8 - Circular Public Procurement							
9 - Dissemination of Circular Habits...							
10 -Circular Economy in the School Community							
11 - Skills for a Circular Economy							
12 - Ecolabelling System for Chile							
13 - Transparency and Traceability for the...							
14 - Monitoring Progress towards a Circular...							
15 - Expand the Range of Products Subject to EPR							
16 -Update the Regulatory Framework for Waste...							
17 -Incentives and Information for Separation...							
18 - Solidarity Fee for Municipal Solid Waste...							
19 - Product Standards in the Circular Economy ...							
20 - Strengthening the Inspection of Inadequate...							
21 - Driving the Circular Economy at the Int...							
22 - Circular Economy for the Reactivation of...							
23 - Provision of Meeting and Participation...							
24 - Recognition and Inclusion of Waste Pickers							
25 - Regenerative Production Systems							
26 - Local Infrastructure and Equipment for the...							
27 - Incorporation of a Circularity Focus in the...							

Source: Roadmap for a circular Chile by 2040 (50)

Although there are no specific indicators for each initiative, they do have clear actions for the short (before 2022 year end), mid (before 2026 year end), and long term (before 2031 year end), with leading institutions and key actors defined.

Commentary

The Chilean circularity strategy is a well constructed plan; it clearly defines the material flow outcomes of circularity related to conventional measurements of inputs, wastes and recyclates, plus the net outcome of higher material productivity which characterises the circular economy. The second aspect of the plan describes component initiatives and goals which cut across the achievement of the headlines.

Whilst they contribute to the headlines, the initiatives themselves could well be the subject of their own indicators since they comprise what will – later in this report – be described as Transition indicators. The presentation of this 'matrix' of initiatives and outcomes is different from the format proposed for

Scotland, but is not incompatible; it just organises according to different aspects and could equally be adopted if useful for communication or decision-making.

5.17 Costa Rica

Policy objective and guiding principles

The Costa Rican Integral Waste Management policy is owned and managed by the country's health ministry; this means that its framing revolves around human health and wellbeing rather than sustainability objectives. The objective of the document 'National Plan for Integral Waste Management 2016-2021' is to "strengthen the coordination and strategic actions between institutions and people for Integrated Waste Management", with the purpose of improving life quality and the environment (73). The guiding principles are:

- Shared Responsibility
- Extended Producer Responsibility
- Internalisation of Costs
- Prevention at the Source
- Precaution
- Access to Information
- Duty to Inform
- Citizen Participation

And the orientating focuses:

- Social Cohesion
- Human Rights
- Diversity
- Equality and Gender Equity

Indicator framework

The framework to set the initiatives and indicators has 6 spaces at the top of the hierarchy, and then divided in policies, strategies, activities and indicators. For each indicator there is an accountable entity and sometimes co-accountables, as shown in the framework sample of The plan sets out 108 indicators around the six spaces. However, as it is a very nascent plan, a lot of them are around setting the bases, which is reflected in the space of Education, Training and Social Communication having the most indicators (73).

Indicators

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Table 29: Sample of policy framework in Costa Rica

SPACE 1: ⟶	**LEGAL**				
Policy	**Revision, updating and application of the regulatory framework for Integral Waste Management and international treaties**				
Strategy	**Activities**	**Goal**	**Indicator**	**Accountable**	**Co-Accountable**
Preparation and adjustment of regulations to promote integrated waste management in order to guarantee the protection of the environment and the health of the population	Design and implementation of legal instruments for those wastes that do not have a specific regulation, radioactive, organic, and construction, among others	Three legal instruments for regulating types of waste that require specific regulations by 2021	Number of legal instruments for regulating types of waste that require specific regulations implemented	Ministry of Health	MINAE: Ministry of Environment and Energy MAG: Ministry of Agriculture and Livestock

Source: Translated from Integrated Waste Management Plan 2016-2021 Costa Rica (73).

Table 30: Costa Rican indicator set (abridged)

Space	Indicator examples
Legal (9 indicators)	Number of legal instruments for regulating waste types, inventory of instruments Evaluation on the implementation of regulation Number of mechanisms for technical advisory Number of trained institutions in regulation Number of municipalities with incentive and grant programmes
Education, training and social communication (29)	% of teachers trained and implementing the national education programme Number of education institutions implementing the national education programme Communication strategy implemented Evaluation surveys created National reducing, reusing, disposal strategy implemented Communication programmes implemented Curriculum designed and implemented for different audiences Certification protocols for training plans
Economic (22)	Number of entities with defined budgets to be executed Number of projects for international cooperation presented Database of projects created Incentives system (taxes, tariffs, grants) created Number of incentives granted Number of companies per sector separating waste Number of industries separating waste Number of houses per borough separating waste Creation and evaluation of a fund for waste management Number of financial instruments for financing projects created Number of financing applications (% approved)
Institutional and organisational strengthening (17)	Creation of platforms and mechanisms for cross institutional collaboration Progress in the implementation of regulation for waste management Number of government employees trained Number of municipal plans created and evaluated % of budget assigned to waste management Implementation of Information Systems to support integral waste management Number of partnerships created for developing integral waste management
Human habitat (15)	National risk management plan created Number of municipal plans that include management of dangerous waste Number of valorisation activities carried out Number of implemented projects for mitigating effects of climate change Number of implemented projects for energy sustainability Database of centres for recovering valuable waste Number of projects for generating energy Diagnosis of technologies for treatment and disposition of waste
Tech R&D (16)	Number of strategic partnerships Number of activities and events on waste management technologies Number of protocols for evaluating technologies Number of companies using more efficient production systems Number of research pieces

Source: Translated and summarised from Integrated Waste Management Plan 2016-2021 Costa Rica (73).

Commentary

Costa Rica is a good example of how environmental (and other) policy is implemented in developing countries; while information on the circular economy is now widely available, implementation in Latin America is still overall nascent. Along with more sophisticated economies progressing in their policies, this creates regulatory pressure for implementing a comprehensive sustainability strategy without having established institutions and capabilities for doing so. The result, in this case, is a strategy with a large indicator set composed almost exclusively of what we have defined as transition indicators, which enable the activities and processes needed for creating a circular economy, but are not closely related to measured outcomes.

5.18 China

Policy objective and guiding principles

China's CE policies are grounded in the Circular Economy Promotion Law (51) and seek to align environment and development with economic, environmental (carbon, water and air pollution) and social indicators. This is in contrast to the EU's focus on waste hierarchy and product policies (e.g. Ecodesign for Sustainable Products Regulation).

There are specific targets for select materials, waste streams and sectors, aligned with sectors strategic to the Chinese economy:

- Current key sectors highlighted in the policy:
  - Agriculture
  - Construction
  - Metals and mineral production

- Forward-looking and in support of the national industrial strategy (2021-2025):
  - New generation of information technology.
  - Bioindustry: Biomedicine and biomanufacturing.
  - New and advanced materials
  - Digital creativity.
  - Advanced manufacturing (aero space, marine, agriculture, food, textile, medical, smart manufacturing technologies).
  - Low-carbon technologies (renewable energy, energy efficiency, resource conservation, circular economy, zero emission vehicles).

Indicator framework

In its CE ambitions, China places much emphasis on supply chains, on scale and on place (72). Accordingly, China's CE indicators cover macro (in society and at provincial levels), meso (in industrial parks) and micro (in enterprises) cycles plus the waste industry (on treatment and resource recovery).

China's Circular Economy index system was established by the National Development and Reform Commission. The indicators are based on their MFA method and includes 3 interconnected categories:

- **Comprehensive indicators:** measure the overall productivity of main resources, such as fossil fuels, metals, minerals, and biological resources. They also measure the recycling rate of the main waste streams from agriculture, industries, urban construction, and urban food etc.
- **Specialised indicators:** measure specific streams of resource productivity, waste recycling rates, and the value added by recycling industries.
- **Supplemental indicators:** focus on the end-of-pipe treatment of waste, such as industrial, solid, and wastewater municipal waste, and the emission of main pollutants.

Comprehensive indicators align with the concept of Headline Indicators, whereas Specialised more aligns to Directional Indicators.

Indicators

CE Targets are set in the Chinese practice of 5-year plans. The current, 14th Five Year Plan (71) considers the period 2021 to 2025 with the following quantified aims:

- Increasing resource productivity by 20 percent compared to 2020 levels.
- Reducing energy consumption and water consumption per unit of GDP by 13.5 percent and 16 percent respectively, compared to 2020 levels.
- Reaching a **utilisation rate** of 86 percent for crop stalks, 60 percent for construction and demolition waste, and 60 percent for solid waste from commodity sectors (e.g. coal gangue, fly ash, tailings from mining operations, smelting slag, industrial by-product gypsum).
- **Utilisation rate of select waste materials:** 60 million tons of waste paper and 320 million tons of scrap steel.
- **Production of select recycled materials:** Producing 20 million tons of recycled non-ferrous metals.
- Increasing the **output value of the resource recycling industry** to RMB 5 trillion (US$773 billion).

Supplementing the above aims are additional targets for priority projects and action areas:

- Targeting approximately 60 cities for the development of re-use and recycling infrastructure.
- Establishing 50 industrial hubs for increasing utilisation of solid waste from commodity sectors and for promoting industrial symbiosis activities
- Establishing 50 demonstration cities for promoting the reduction, re-use and recycling of construction and demolition waste.
- Establishing approximately 10 remanufacturing clusters and targeting the output value of the remanufacturing sector to reach RMB 200 billion (US$28 billion).
- By 2025, achieve phasing out of secondary packaging for delivery parcels, and targeting for the scale of circular (reusable, recyclable) packaging to reach 10 million units.

Certain indicators are not currently quantified:

- Building a resource recycling industry system and improving resource utilisation efficiency.
- Building a recycling system for waste materials and fostering a recycling-orientated society.
- Deepening the development of the agricultural circular economy and establishing circular agricultural production.
- Increasing the environmental regulatory supervision.

Commentary

The Chinese approach is sophisticated in its slicing of the economy and society into thematic areas in which change will be targeted. Although the current framework is light on assessment of inner loop circular economy activities, the 29 themes at least form a platform for the development of measurable tactics to achieve their aims. As such, it adopts one of the most holistic approaches to the CE amongst all of the national strategies reviewed, going beyond the circular economy as a technical problem to a way of life which applies at local regional and national level.

5.19 Japan

Policy objective and guiding principles

Japan was an early adopter of circular economy thinking, publishing its first vision document in 1999. The vision was built on the concepts of "reduce, re-use, recycle" and looked for both economic and environmental outcomes. In May 2020, it published its updated CE strategy, Circular Economy Vision 2020 (52) in which it acknowledged that, although good progress had been made on recycling, it had fallen short on promoting reduction of demand and re-use.

It still considers the benefits of a circular economy to be reduced stress on natural resources and in de-risking its material supplies. However, in the 2022 strategy, because it is so dependent on imports, Japan recognises that it needs an increased external focus on incoming and outgoing materials and products if it is to progress. Its bases abroad need to adopt the same practices as at home, and it recognises the role of accelerating practices:

- Reconceptualising 'products': Dematerialisation and servitisation to break the link between materials demand and service supply.
- Efficiency through data: Using digital technologies to maximise manufacturing efficiency.
- Embedding Circular Economy: Using public interest in seeing headline issues (such as plastic waste) being tackled to cement the benefits of the circular economy and drive further investment in change.

Indicator framework

Japan's indicator framework is rooted in the 2003 Fundamental Plan for Establishing a Sound Material-Cycle Society. It has targets for resource productivity, recycling rates, and the final waste disposal amount and was last updated in 2018[12]. (Note that in much public strategy in this area, reference is made to the EU Circular Economy Strategy, and statistics comparable to the EU indicators are available.) The plan considers 7 strategic pillars, namely:

[12] https://www.env.go.jp/recycle/recycle/circul/keikaku/pam4_E.pdf

1. Integrated Measures towards a Sustainable Society.
2. Regional Circulating and Ecological Sphere.
3. Resource Circulation throughout the entire Lifecycle.
4. Proper Waste Management and Restoration of Environment.
5. Disaster Waste Management Systems.
6. International Resource Circulation.
7. Sustaining Fundamentals for 3Rs and Waste Management.

Within pillar 3 (Resource Circulation), the focus is on promoting businesses related to reducing and reusing, and resource efficient design; it also lays out six priority areas: plastics; biomass, especially concerning food waste and loss; metals; construction materials; solar panels.

The CE strategy overlaps with the Material Cycle plan (embodied as The 4th Fundamental Plan for Establishing a Sound Material-Cycle Society 2018 (53), particularly in the area of resource efficiency of recovery and re-use. Novel aspects of the CE strategy are the promotion and uptake of new business models although it is not clear whether this is targeted or monitored.

Indicators

The Plan has a 151 indicator set including material flow analysis to monitor progress. Of these, 4 are classified as Headline Indicators since they are the main targets of policy.

Table 31: Japanese headline indicator targets for 2025

Primary indicator	Commentary
Resource Productivity Target: 490,000 JPY / ton (approximately double from FY2000)	GDP / Direct Material Input of natural resources shows how effectively materials are used by generating more wealth while using fewer resources directly.
Cyclical use rate (resource base) Target: 18% (approximately 80% increase from FY2000) Hit 15.4% in 2016.	Amount of cyclical use / (amount of cyclical use + input of natural resources). In effect, this is the displacement of virgin resources by recyclates. The related indicator, recycling rate, defined as material recycled / amount collected as waste, is also applied for particular packaging materials such as glass, steel, aluminium and PET, and for a range of household goods including electronics.
Cyclical use rate (waste base) Target: 47% (approximately 30% increase from FY2000) Hit 39.3% in 2017	Amount of (cyclical use / generation of waste). In effect, the recycling rate.
Final disposal amount Target: 13 million tonnes (a 77% decrease from FY2000)	The amount of waste put in landfills.

Source: The 4th Fundamental Plan (53)

A set of 'secondary' indicators (which brings the total to 151, including the above), probes particular material or sector components of the primary indicators, emerging markets in the circular economy, land area under eco-management, uptake of reskilling courses, governance actions by the legislature and many more.

Status

The indicator set has been in place since 2003.

The Circular Economy Vision reports on progress against the plan; the progress against some indicators is noted in the table above (52). The Vision also describes the effectiveness of sector-based voluntary initiatives aligned to the Plan; most of these are material reduction and recycling-related, but there are examples of industrial and business product re-use models in action. Of particular note is the imaging equipment sector initiative to re-use parts and deploy remanufacturing in photocopiers, citing parts re-use rates of 79% and energy reduction in manufacture of the photocopier of 80%

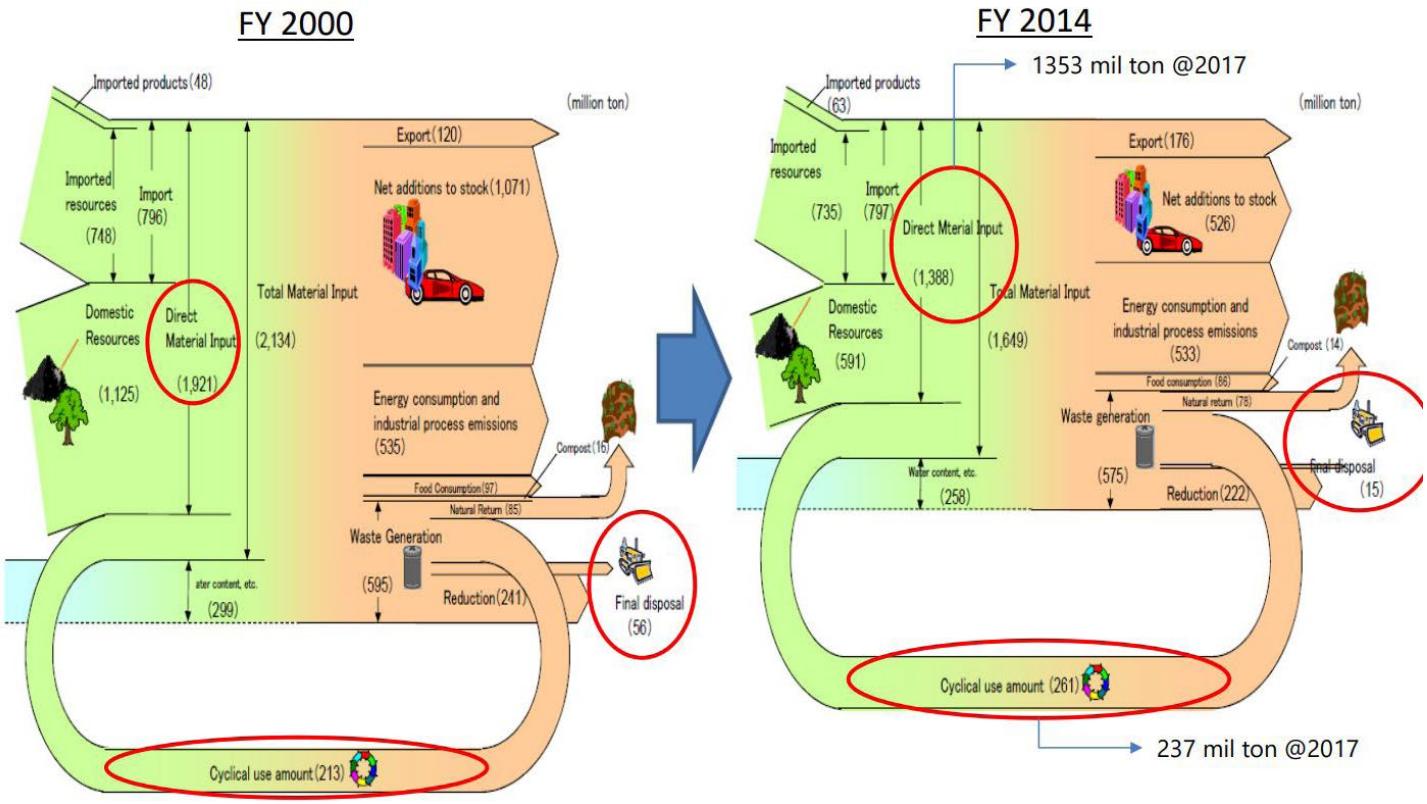


Figure 12: Changes in Material Flow as a result of Japanese CE action
Source: Institute for Global Environmnetal Strategies (54) from (53)

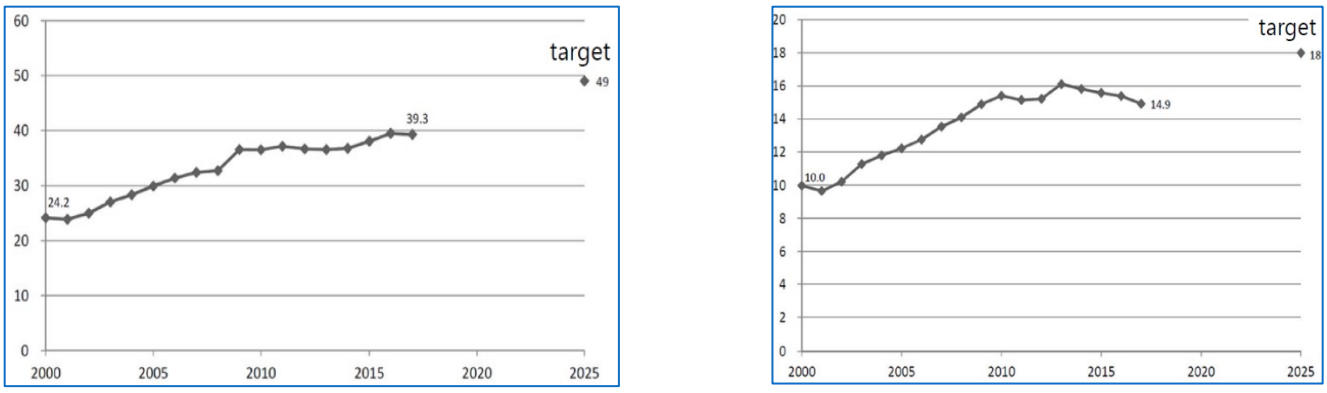


Figure 13: Progress in Resource Productivity (GDP/DMI) and Cyclical Use Rate (input basis)
Source: Institute for Global Environmnetal Strategies (54)

Note: Resource Productivity vertical axis is [10,000 ¥]; Cyclical Use Rate vertical axis is %.

Commentary

The indicator set is almost exclusively input material, waste and recycling oriented. However, the secondary indicator set (a large fraction of the total 151 indicators) is much more diverse in its approach covering a range of themes around governance, skills, business adoption of ecodesign, activity measures on infrastructure creation, and market growth in re-use activities. These are comprehensively listed in The 4th Fundamental Plan (53) and are reproduced in full in Annex B.

The Plan also acknowledges the difficulties of harmonisation of indicators amongst nations, especially when many are constrained in their sourcing and disposal options. Further it recognises lack of data sources in many areas, such as re-use, and the fact that many key future streams do not fall within reporting structures of local or federal government. It is, though, optimistic on the future ability to calculate the impacts and lost opportunities associated with not just wastes, but also between alternative candidate 'circular' approaches.

The Vision report acknowledges the limitations of the materials-based recycling approaches stating that recycling rates have stagnated and add little value to the economy. (Note that the progress graphics above do not even acknowledge the 'hidden' re-use-type flows.)

It uses this as evidence that a deeper involvement in circularity will be needed in its next round of planning, hence the three action areas in the first section of this Japanese review.

5.20 South Korea

Policy objective and guiding principles

The Republic of Korea is a resource-poor nation heavily reliant on imports of raw materials; its main production industries of steel, semiconductors, automobiles and ship building are highly dependent on imported resources including fuels (55).

The Government of Korea wants to transition towards a 'resource circulating' society that "ensures maximum efficiency in all stages of the resource life cycle, from production and distribution to consumption and disposal, decreasing the country's reliance on imports of raw materials and reducing the pressure on the nation's landfills" (55).

The Framework Act on Resource Circulation (FARC) (56) came into effect in January 2018 to formalise the shift from waste to resource management. Key measures include an intent to streamline regulations, foster recycling industries, manage resource recycling performances, and introduce waste disposal fees for public sector and private sector bodies that dispose of recyclable wastes via incineration or landfill (see Figure 14).

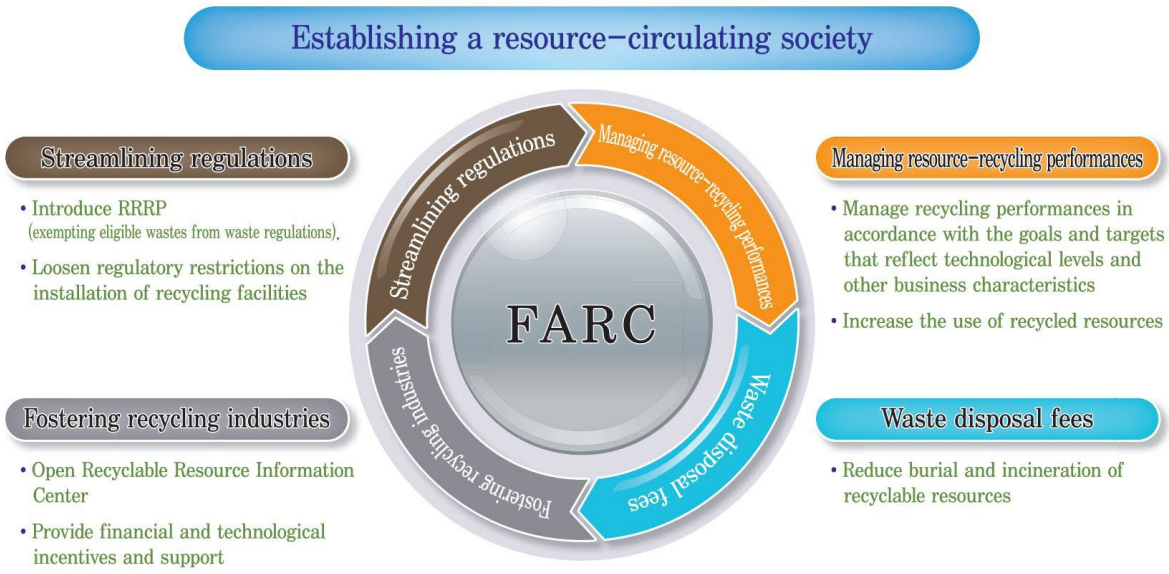


Figure 14: Summary of measures included in the 2018 Framework Act on Resource Circulation.
Source: Korea Environmental Policy Bulletin Vol. XIV Issue 2, 2016

Indicator framework

The FARC legislation restructured Korea's waste management legislation and integrated previously separate local and national waste management plans. Figure 15, taken from Evaluation and development of Korea's national plan for resource circulation towards a circular economy (56), depicts how the FARC legislation integrated the separate approaches towards national-level waste management and local-level waste treatment. All previous waste management legislation is now unified under FARC.

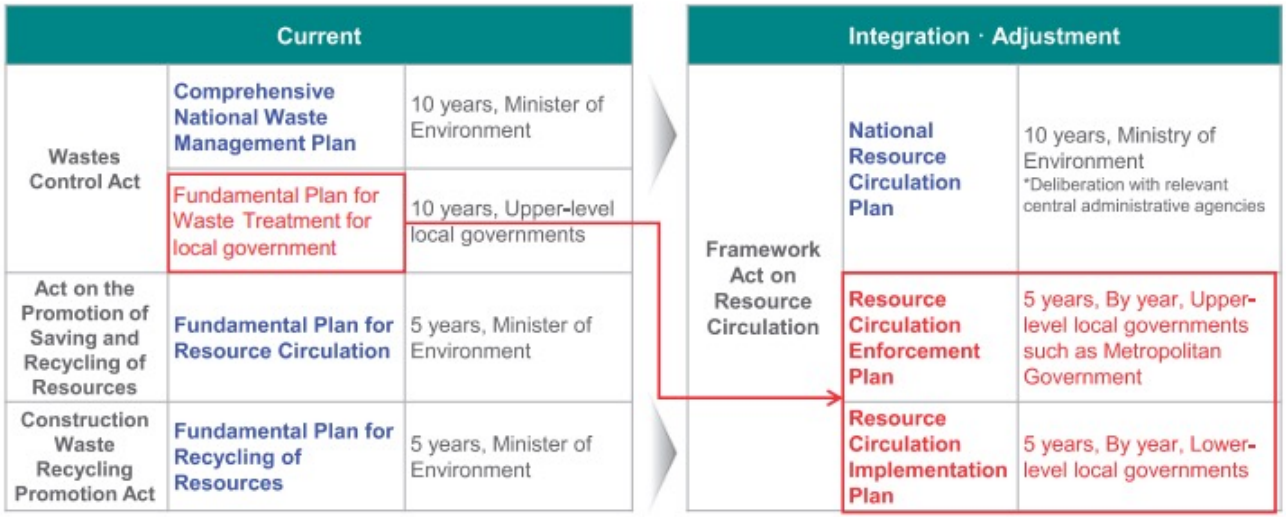


Figure 15: Depiction of the impact of the Framework Act on Resource Circulation on waste management legislation.

Source: Yi (56)

Korea's approach can be broken down into the three key objectives of establishing a basis for resource circulation, promoting resource circulation, and supporting recycling industries (55). Targets have been set for key indicators as described below.

Indicators

Within Article 14 of the FARC legislation it is set out that national medium-long term goals for resource circulation will be set using the indicators of Table 32.

Table 32: South Korean material recirculation indicators

Indicator	Description
Terminal treatment ratio	The ratio between the quantity of terminally treated wastes and total generated wastes.
Circular utilisation ratio	The the ratio between the quantity of circularly utilised wastes and total generated wastes.
Energy recovery ratio	The ratio between the quantity of wastes converted to energy and the generated wastes suitable for energy recovery.

Source: Framework Act on Resource Circulation (FARC) (56)

Status

The indicator set has been implemented.

Commentary

The approach offers little insight beyond recycling and waste management.

5.21 Other country initiatives

A number of nations and regions in the EU have widened the scope of policy and targeting to include re-use. The re-use action group, RE-USE produced an information leaflet which described a handful of European schemes directed at re-use of products after they had been consigned as waste: (57)

Table 33: Abstracts of European re-use targets compiled by RRE-USE (57)

Country	Scope	Intent	Indicator
Spain	Waste: WEEE, textiles, furniture	Make all the actors of the preparing for re-use value chain (Producer Responsibility organisations, Local Authorities and preparing for re-use operators) cooperate and improve the re-use rates of several types of products. The objective was also to create green jobs, notably because of the pre-eminence of the social economy in that sector. Producers must achieve: (a) for large equipment (50+ cm), a minimum preparation for re-use target of 3%; (b) for small IT and telecommunication equipment, a minimum preparation for re-use target of 4%. There is also a target to prepare for re-use 2% of waste deriving mainly from textiles, WEEE, furniture and other waste streams.	Kg per capita of of waste prepared for re-use within that product category [prepared/collected]
France	Waste & non-waste: Textiles, WEEE, sports and outdoor equipment, tool, tools	The aim Is to ensure circularity, proper waste management, waste prevention, extend the useful life of products, and provide social inclusion through employment. By 2030, the weight of re-used and prepared for re-use products (including textiles, furniture and Electric and Electronic Equipment) must equal at least 5% of the weight of municipal waste. This is transposed into specific re-use targets for each category of product covered.	% of weight of municipal waste
Flanders	Non-waste: All goods passing through a re-use centre	Make re-use centres from the social economy actively participate in waste prevention and management, increase the professionalisation of the re-use sector, create jobs for people at risk of socio-economic exclusion, improve re-use rates, achieve waste prevention objectives and, finally, make everyday goods accessible to low income households. Re-use target of 7kg per capita and year by 2022	kg per capita, per year
Wallonia	Non-waste: All goods passing through a re-use centre	The aim is to promote longer product lifespans, make re-use more attractive, and reduce pressure on natural resources. Re-use target of 8kg per capita and year by 2025 (non-binding).	Kg per capita, per year
Wallonia	Waste: WEEE (6 categories)	The goal is to prevent waste whilst making producers responsible for that task. 2% of WEEE to be prepared for re-use from January 2020, covering six categories of WEEE.	% of waste prepared for re-use within that product category [prepared/collected]

These activities fall into the category of preparation for re-use. This usually occurs once products have been collected by public authorities or have been deposited at nominated facilities. They should fall within the waste accounting system so tracking their flows should be straightforward.

Schemes typically deal with consumer goods such as household electrical products and tools. A wider range of re-use activities occurs in business-to-business transactions of machinery and industrial equipment, an activity which does not pass through public waste handling and is unlikely to be recorded in the same way or to the same extent. Again this highlights the issue that national accounting systems are not sub-classified in sufficient detail to account for and spot trends in the activity. This is likely to be more important if businesses adjust their business models to bring consumer-oriented repair, refurbishment and re-use into their offerings (as Dyson has begun to do, for example) and if this flow is selected as an indicator of re-use activity outside of preparation for re-use.

5.22 The OECD inventory of circular economy indicators

The OECD Inventory of Circular Economy Indicators (2) collates 474 circular-economy-related indicators. Indicators have been gleaned from 27[13] CE studies, eight of which were at the national, eight regional and 11 at the local level. Geographically, the majority are from Europe, with a smaller number of representative examples from other regions.

Input, process and output indicators were collated; but this work does not relate them to the originating strategies or policies. It provides a high- level view of the totality of metrics, with the intention that it:
"...[helps to] identify measurement gaps and can be a source of inspiration for governments wishing to develop or use indicators to improve circular economy related policies."

In the context of this study, the report has been used as the OECD intended: as a sense check for the findings in this report about how common different types of indicators are; more specifically to observe nuances in particular indicators, such as choice of scope for material flow indicators; and to locate indicators that might be of use in the Scottish context, even if they appear infrequently in the inventory.

The indicator inventory has been queried in detail in later sections of this report.

A useful feature of the inventory is the classification that OECD has applied to indicators. It defined five themes. Taking directly from the inventory:

- **Environment** (39% of all indicators): Collects indicators with a direct impact on the ecosystem, such as emissions, output material process and production and consumption.
- **Governance** (34%): Focuses on indicators related to education, capacity building and regulation, among others.
- **Economic and business** (14%): Includes those indicators expressed in monetary units such as the value-added of the circular economy and the public investment in circular economy projects, as well as those indicators specifically focusing on activities performed by and within companies.
- **Infrastructure and technology** (8%): Covers all the indicators that aim to measure the existence of tools, technologies and spaces that boost the circular economy.
- **Jobs** (5%): Gathers indicators associated with employment and human resources.

Apart from jobs being the only indicator that could be classed as 'social'; the categorisation can be mapped to the environmental, social and governance (ESG) reporting framework increasingly used by business. Adopting or including this ESG classification for a proposed indicator framework may make it easier for entities to map indicators and themes to their current reporting standards for consistency.

5.23 Findings

While this review has not been a fully comprehensive exercise, it has been sufficient to reveal key learning points that can be taken into the indicator development for Scotland.

- The most transparent, widely adopted set of indicators is that of the European Union; information is collected from member states via Eurostat into immediately available indicators. Exit from the European Union will not have materially affected the UK's ability to aggregate this data for its own use in the short term, but policy on data collection may change.

Comment 1: In pursuit of harmonisation with the EU, there should be few if any barriers to Scotland replicating this system wholly or partly in the very near term.

- China's approach is more holistic in its treatment of the circular economy than the majority of nations. It sees a circular economy not as a technical solution to certain

[13] The report states 29 studies, but the inventory tables show just 27. The balance could be attributable to information submitted by organisations in a separate OECD survey.

problems; but as a shift in behaviors and practices at the local, regional and national level. This is reflected in the variety of themes covered within the 29 implementation plans.

- A Western economic approach is more likely to focus on establishing the correct environmental conditions (policies, standards, definitions, measurement techniques, investment vehicles, fiscal incentives & penalties, and state-sponsored infrastructure.) in order to provide predictable conditions for change by businesses and investors, as well as signalling expected behaviors to consumers and purchasers. Such a coherent approach is not generally found within the CE strategies reviewed but is certainly needed if shifts to re-use activities are to be motivated and measured.

- The EU indicator set is one agreed by all member states. As individual member states have created their own bespoke, additional indicators, it could be inferred that they do not consider the EU set as sufficient. The EU set deals largely with the net inputs and outputs (I/O) from the material economy (sometimes normalised to GDP or per capita). National sets tend to bring in process or activity indicators reflective of the adoption of CE principles.

Comment 2: The EU indicator set is a foundation for monitoring the circular economy. Further indicators are needed to monitor and take action on key actions and flows within the economy.

- Indicator sets from all non-EU countries reflect their own local priorities coloured by their state of development in materials recovery and reprocessing infrastructure. There is no standard approach to indicator set definition. The individualistic nature of choice of indicators can be seen visually: Annex C maps all the major indicators and secondary indicators located in this study, for each country against a categorisation of type (the first page of Annex C relates to EU countries, and the second page to the rest of the world). Some aggregation of metrics has been necessary to improve communication.

The lower third of the rows relate to indicators of governance (public oversight), natural environmental impacts, social impacts and process changes within the economy. This area is notably sparse.

- Indicator sets generally focus on the material inputs and outputs to economic activity. Recycling is a circular economy tactic, but is only as prominent as it is because it crosses a reporting boundary i.e. waste is regulated and measured. There is a problem with assessing internal flows within the economy because they do not cross such boundaries. Sometimes these flows can be inferred from monetary flows, but these are not well or uniformly demarcated in national accounts. For example, repair or maintenance services appear as a SIC code or subcode in the UK National Audit Office classifications in machinery, motor vehicles and computers, but not across all sectors in a uniform manner. This issue extends also to the recognition of other aspects of the circular economy for example differentiating business models which deliver products, product services or product performance in contrast to the 'linear' sales model. Bringing these two threads together, in a circular economy, manufacturers may be undertaking manufacturing, repair, remanufacture, pay-per use and other means of service provision in parallel; these would be impossible to track under current systems.

Comment 3: Given that other 'circular' activities might need to be tracked in future, Scotland should consider advocating for or preparing to establish its own SIC codes to monitor 're-' activities: re-use, repair, remanufacturing, servitisation'. RRE-USE's review illustrates that re-use targets are feasible albeit still on the outside of the waste boundary.

- There are good examples of countries which have taken a view of indicators well beyond the core data set established by the EU. In Europe the French set identifies a number of indicators associated with change of either businesses or consumers. The Dutch have gone further to define 'transitional' indicators for the early stages of the adoption

of circular thinking; and 'accelerating' indicators for once it is established but still growing.

- The need for indicators beyond input-output measures is exemplified by the German situation. As reported in the German review, independent analysis suggests recycling performance has stalled, but there are no other indicators reflective of approaches beyond recycling which could assist in advancing circular practice.

- Chile is a non-European country which has a forward-thinking view of the circular economy. Its policy framework is at an early stage and lacks concrete indicators; a periodic review of Chile's CE progress is recommended.

Comment 4: An indicator set which measures the adoption of or success of CE practices within the economy will be necessary for effective monitoring and control of interventions.

- On the whole, national indicator sets concentrate on the macro-economic indicators, the input-output material flows and GWP impacts. The regions and local governments have a greater interest in how the circular economy might impact their local environment such as quality of life, access to repair facilities and equity of access to goods and services; and to the natural environment, preservation or regeneration of spaces, ensuring 'sustainable' use of forestry assets and the like.

- The OECD analysis, while not claiming to be a framework, might be of some help as it categorises indicators as environmental, social, governance, infrastructure and business. This has the merit of being reflective of the rise of 'ESG' as a common currency amongst business. ESG, though, is reported separately to business reports, but is an integral part of the circular economy.

- Many strategies highlight the economic opportunities associated with the circular economy, so it is surprising that the indicators are dominated by the 'circular' material aspect. There is no consideration of value flows or value preservations in an analogous way, though the Scottish policy does acknowledge this potential. Here 'value' could be interpreted as monetary or, say, the GHG emissions embodied in material flows. Consideration of these different perspectives might lead to alternative priorities in materials or products to target for maximum benefit.

Zero Waste Scotland's Thoughts on Indicators(3) and the Scottish Government's Environment Strategy(4) were used to gather some insights on the direction that the framework should take. Including:

- Consumption reduction is a key objective to pursue and its measurement should be a priority. For it correctly being an account of circularity, it should be looked at in a wider set of measurements.

- There are some indicators within the consumption reduction space (both direct and proxies) that are mature in various economies; these can provide an easy benchmarking opportunity, such as: material flow accounts, levels of waste, levels of recycling, material extraction, or energy use.

- There is a recognition that in the early stages, these high-level indicators may not show progress appropriately; the focus is more on developing underpinning skills and enabling change. This is in line with what has been found in other economies, with the more nascent programmes focusing on progress indicators and the more mature ones in high-level steering and results.

- The Environment Strategy Indicator Framework(4) describes desired environmental outcomes and indicators for them. There is some overlap with mainstream CE indicators, such as generation of waste and GHG emissions. There are also other high-level human wellbeing measures that are not accounted in any of the frameworks reviewed, such as access to green space, or visits to the outdoors.

There is no direct causal linkage between implementation of circular practices and these outcomes so they remain the target of the Environment Strategy alone.

6 Outline of an indicator framework

6.1 Objectives of this task

The purpose of this section is to describe the outline of a meaningful, practical and engaging set of metrics which could illustrate Scotland's performance, direction and progress in moving towards a circular economy. This proposal is built on the review of indicators used by other nations and regions but adapted to account for Scottish interests and ambitions, as stated or inferred from the review. The subsequent section describes the indicators and their rationale in detail.

6.2 Success criteria in choosing potential indicators

We considered the following guidelines in compiling potential indicators:

- The total number of headline indicators should be limited in number to ensure that clear messages on outcome, output or activity are apparent and easily communicable.
- Scotland wishes to stay aligned to EU thinking on the circular economy; this implies compatibility with key elements of the EU indicator set. Full compatibility will not be possible to achieve thoroughly in a reduced set of indicators.
- The indicator set should preferably extend beyond material and GWP impacts to embrace the wider Environmental, Social and Governance agenda and economic impacts. (This element is explained further below.)
- The indicators need to have a clear meaning and connection to root causes and outcomes. Often, though, indicators measure only one of several contributory factors to an outcome. In these cases, the rationale for choosing them as proxies needs to be clear.
- To illustrate leadership, the indicator set should show ambition to some degree, even if some data sets and methodologies for certain indicators are still in development.

Previous work by Zero Waste Scotland on indicators, and the indicators seen in numerous national monitoring frameworks, strongly indicates the practicality of a headline set of indicators related to outcomes. These are frequently supported by 'Tier 2' or 'secondary' indicators that expand particular aspects of the headlines e.g. by material or sector, or track activities or behaviours indicative of the uptake of 'circular' practices by companies, individuals or institutions. The most sophisticated approaches as reviewed in this document acknowledge that the CE is in an early stage of development and that the most appropriate indicators may evolve over time; these approaches further partition Tier 2 indicators as a 'Transition' set. Replicating this segregation is part of the Scottish indicator proposal as described in later sections.

6.3 Recognising the circular economy

Before considering indicators in detail, it is worth reflecting on the fundamentals of a circular economy. The purpose of this reflection is twofold: to recognise how existing indicators are already recording parts of the circular economy, and to hone in on those aspects not currently being measured. The fundamental nature of these considerations means that they ought to provide context for any indicator set, including those reviewed in the previous section, and that is indeed what has been found: certain related headline indicators are a recurring feature of national sets. This provides some reassurance that a common understanding and common basis exist.

In a highly simplified form, Figure 16 illustrates the progression from a linear economy – the make-use-dispose model – through to a circular economy.

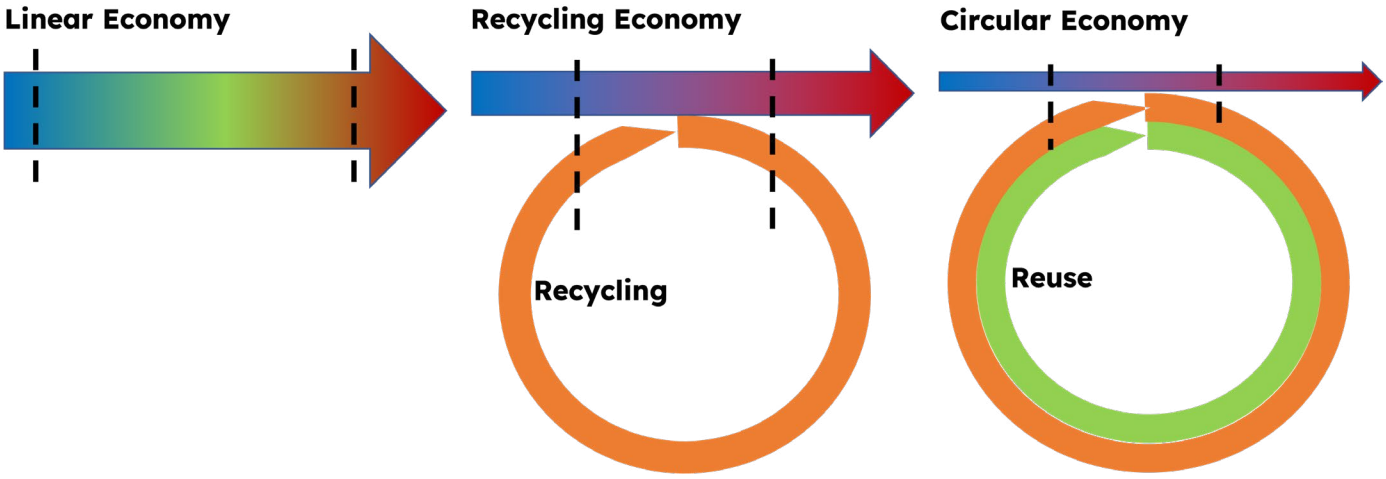


Figure 16: Progression from a linear to a circular economy

In this desired state, there is a large proportion of product and material recirculation which, assuming it is broadly comparable with GDP, results in a much-reduced demand for virgin raw materials (resources) and consequent reduction in carbon footprint. The conventional wisdom is that we are in a transition via a 'recycling economy', where the focus is on end-of-life recovery and reprocessing to secondary materials to displace virgin inputs. Indeed, this is reflected in the existing materials-based indicator sets – broadly represented by the dashed lines in Figure 16 above– which are the points where input and output measurements are collected by governments:

- (Raw) material inputs.
- Waste generated.
- Waste disposed to landfill.
- Waste diverted to recycling.
- Use of recyclates as secondary materials to displace virgin inputs.

Note, for the simplified purposes of this discussion, we imply no particular variant of raw material measurement (e.g. DMC, RMC, RMI).

Beyond recycling to circularity

The circular economy embraces a further class of activity, the re-use spectrum (which in this discussion contains different specific activities such as refurbishment, remanufacture, repair, direct re-use, etc.). Undoubtedly, a certain amount of re-use is already taking place, for example, by consumer-to-consumer exchanges, but this is informal and not quantified. As noted, some repair activity is recorded, but a further class of industrial remanufacturing is not. Other studies[14] have estimated this to be at around 2% of manufacturing output, but only by periodic study; it appears to have substantial opportunity to grow.

A key objective of the circular economy is to decouple the desired economic outputs (i.e., growth, prosperity, equality) from resource consumption (especially material resources). As portrayed in Figure 16, if these inner loop activities grow, they will contribute to increased circularity and net reduction in virgin material requirements. (They may grow at the expense of recycling, for example, but as long as net virgin material input is reducing, the circular economy is succeeding in its decoupling objective.)

Also apparent from Figure 16: Progression from a linear to a circular economy is that the 'conventional' input-output indicators continue

[14] Oakdene Hollins (2009) Remanufacturing in the UK.; Parker, D. et al (2015) Remanufactuirng market study.; Oakdene Hollins & Dillon Consulting (2021) Socio-Economic and Environmental Study of the Canadian Remanufacturing Sector and Other Value-Retention Processes in the Context of a Circular Economy.

to be wholly relevant in the measurement of the circular economy. The challenge is, therefore, how to augment these to account for the re-use cycle. In terms of measuring the overall progress towards circularity, a solution is strongly indicated in the previous paragraph: a reduction in virgin inputs whilst maintaining adequate standards of living. If virgin inputs are reducing whilst maintaining economic activity, we can infer that re-use and recycling activities are growing. This ratio between material consumption and GDP is known as 'resource productivity' and has been adopted by numerous nations (including the EU) as its headline measure of 'circular success'. However, this indicator alone does not account for reductions in the total environmental impact.

GHG reduction

Another declared objective of the CE is to assist in reducing GHG emissions. Decarbonisation of the energy supply chain has been a primary target of supply-side interventions (i.e., switching energy generation to renewable sources or away from fossil fuels); this tackles domestic emissions (Scope 1 and 2), the target of Net Zero in the UK Climate Change Act 2008 (58). In contrast, the circular economy is more oriented towards demand-side (consumption) interventions – the less materials required, the less energy is needed to process those materials into final products; this addresses Scope 3 emissions, the GHG emissions embedded by the upstream processes of supplier nations which largely supply those materials. National reviews show that GHG indicators are commonly used but there is mixed practice as to whether they include the Scope 3 emissions arising from the import/export balance.

A further justification for measuring GHG emissions mapped to territorial plus import-based activities is that a rise in circular activities will require an increase in energy used to carry out domestic recycling and re-use-type operations. Offset against this is a larger reduction in the energy needed to extract and process materials into products from other countries. Overall, there is typically a net reduction in total energy consumption but an increase in territorial emissions; so accounts based on territorial activities would, therefore, fail to show the net global benefits of the circular economy being contributed by Scotland.

Some cautions are advised in applying this indicator. Although the global long-term objective is Net Zero, in the journey to this objective, GHG emissions should be normalised against GDP or Material Footprint to allow benchmarking with other nations and correctly inform reduction strategies. In addition, preferably, the separate effects of energy supply decarbonisation should be separated out to discern the effectiveness of 'circular' benefits of the economy. In this respect, it may be more fitting to track the energy use of the economy rather than GHG emissions, since the energy use will persist despite decarbonisation, but should track downwards with increasing circularity.

Measuring re-use in depth

As was noted in the findings of the previous review sections, there are no direct indicators of activity within the re-use spectrum apart from a few repair SIC codes. However, with re-use presumed currently to be at a low level, it is likely to be more important to measure activities related to the gestation and growth of re-use and alternative business models prior to seeing major economy-wide impacts. Such an approach is observed selectively amongst the 'leading' nations reviewed in this study. For example, spending on repair, uptake of shared services such as cars and commitment of businesses to 'circular' models. This aspect forms an important part of the sections which follow.

6.4 Mapping Scottish circular economy intentions and aspirations

The purpose of this section is to introduce a 'scaffold', a mechanism used during the analysis process to identify and map both the objectives and intentions of Scottish circular economy strategy and policy, and the proposed indicators.

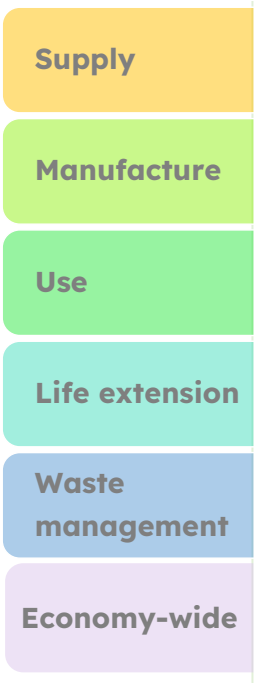
Most of the frameworks examined in this study clustered their indicators in some

fashion. Common categorisations are material inputs, use and waste management; with variations including secondary material flows, innovation and social impacts. These are useful, but often do not provide insight into the underlying drivers of change for the indicators and overall policy goals.

For the purposes of this work, we have created a scaffold diagram to attempt to address this issue. Please note that this is only a suggestion for the mapping of indicators; the indicators are not intrinsically linked to or dependent on this format and have been presented elsewhere as a more conventional table. This format has benefits apart from those stated thus far. One benefit of this scaffolding approach is that it can be used, even before indicators are selected, to map policy objectives to intervention points. An overlay of indicators should then reveal whether there is a match between policy goals and measurement. Further, gaps in the scaffold can indicate where there may be opportunity for future policy interventions, noting that there is not necessarily a significant or appropriate policy for all elements of the matrix.

The subsection below describes the structure of the scaffold in detail.

6.4.1 The scaffold characterisation



The scaffold is a matrix categorisation according to two key aspects of the economy. These are the lifecycle stage of products and materials, and the 'stakeholder' to whom (or which) a particular indicator is relevant. The rationale for this choice is as follows.

With respect to life-cycle stages, many of the national strategies frame their actions and indicators in a variety of these terms (the proposed Scottish scaffold contains the most differentiation of stages). For example, the EU framework maps 'Secondary materials', 'Production & consumption' and 'Waste management'; the French align their 10 key indicators to 'Inputs', 'Consumer demand' and 'Waste management' with 'Social' as an adjunct, and the Dutch similarly. In numerous cases, the lifecycle is presented as a circle. This is an obvious metaphor for circularity, but presents limitations if further 'dimensions' are considered. The Scottish scaffold is presented as a linear axis simply to assist presentation and communication.

- This scaffold separates Supply and Manufacture which are often treated as one. Manufacturing is separated because it involves actions related to product conceptualisation, design for circularity, modularity and efficiency of materials use i.e., it maps well to conventional resource efficiency advocated by the four UK administrations. These indicators are poorly represented in international frameworks, though a limited few consider eco-design compliance. Supply is treated on its own as it can involve different high-impact activities such as extraction, transport and trade.

- Supply relates to supply of virgin materials or imported products and displacement of virgin materials by recyclates. It also includes consideration of sustainable supplies of bio-based materials from food and agriculture, and by-products.

- 'Use' and 'Life extension' are closely related but are worth treating separately. In this skeleton, 'Use' embraces both the means of delivery of products; such as servitisation, pay per use, lease-based models, etc.; but also repair and re-use which – under the United Nations Environment Programme definition (59) – are techniques which enable a product to reach its intended extent of first life. These aspects are rarely reported by indicators in international frameworks.

- In this same scheme, 'Life extension' invokes techniques such as remanufacturing, refurbishment and cannibalisation[15], applied industrially to yield '2nd life' products, those having potential for a whole new life.

[15] Cannibalisation is the act of taking apart a complex assembly to retrieve viable components to purposefully re-use some or all of them, but not in the original assembly. Other processes in re-use include repurposing, the use of a whole product in a different application to its original one.

These aspects are at best covered by repair-oriented or preparation for re-use indicators in some nations.

- 'Waste management' relates to end-of-life or end-of-use operations, collection, sorting, assessment for re-use after products and materials (including bio-materials) are consigned to waste. Most international frameworks measure performance in this area.

- 'Economy-wide' relates to effects which are cumulative across all life-cycle stages. Prime examples are GHG emissions, jobs and GDP; in some cases, however, it may be relevant to consider these effects at a material or sector level if it is useful to track future policy or action.

With respect to stakeholders, these are aligned to four types as below:

Environmental | Business | Social | Governance

These have been selected for two reasons:

- They align to the categories used by the OECD in its analysis of indicators, with one exception: They also include an 'Infrastructure' category; for our purposes, and because this is usually a public investment, it has been rolled into Governance.

- Perhaps more importantly and practically, they align to the rising ESG agenda being adopted by businesses; in addition, it also aligns with the new EU business reporting guidelines under the Corporate Sustainability Reporting Directive. When taken in conjunction with the traditional financial reporting (under Business), the set has clear parallels. The advantage of this is that a common mapping of interests and indicators could assist with communication, engagement and outcome tracking, particularly if – for example – businesses can recognise how their efforts align to the national mission.

In this categorisation:

- 'Environmental' refers to all material and environmental impacts associated with the 'circular' aspect of the circular economy. That is, the impacts related to resource extraction, biodiversity, land use, water and carbon impacts as well as the gross handling of materials themselves as inputs, wastes and secondary material flows.

Note that there are diverse environmental impacts related to material extraction and processing; LCA analysis commonly reports multiple indicators. Typically, though, the focus is on carbon because that is the pressing concern, but also because the causality between circular activities and the impacts are poorly developed, except for carbon because it relates to energy use. Generally, most environmental impacts (land, biodiversity etc.) are associated in some way with virgin material extraction and processing. Therefore, reducing virgin material impacts should result in environmental benefits directly even if not well quantified.

- 'Business' relates to financial (and financial/material ratios) associated with the economy aspect of the circular economy. Of specific interest may be those elements related to 'circular' business models, servitisation (also known as "products-as-a-service"), remanufacturing, repair and re-use.

- 'Social' refers to general impacts on society and personal well-being; it includes jobs which is seen in virtually all indicator sets, often as the only social indicator, but could also include upskilling for 'circular' business. Note that some frameworks present a wide diversity of social indicators including for example loneliness, access to green spaces and 'well-being'. However, for some of them, it is not clear how the adoption of circular practices in particular will affect those indicators; political choices in directing resources to those who might benefit more, or corporate employment practices which 'level up', reskill or improve employee work-life balances may have greater effect. As a result, we have been selective in the recommendations here; those indicators may, of course, still be monitored as indicators of societal benefits from wider policies and actions but almost certainly require methods to be developed if benefits are to be ascribe to circular economy practices.

- 'Governance' relates to indicators of actions taken by government in particular (but perhaps cascaded to businesses and other employers), dealing with investment, innovation, training and education and infrastructure as well as improving the fiscal and legislative framework related to promotion of the circular economy over linear options.

6.4.2 Aligning national and corporate indicators

At this point, we would like to reiterate an advantage of the proposed indicator set which further adds to the list of success criteria put forward in Section 6.2. The purpose of the scaffold is, in part, to present an indicator 'landscape' which resonates at both the corporate and national level. Going beyond this, we propose that the indicators should have a direct correspondence in their meaning and application at national and corporate levels. For example, considerations of Material Footprint and Carbon Footprint for organisations necessarily take a holistic view of their subject i.e. they consider both domestic and import/export effects. In this sense, they are somewhat in advance of typical national accounting practice: In this proposal for indicators, these views are harmonised such that national indicators (for the hard indicators) also take a holistic view (for example by use of raw materials input) and so directly correspond to organisational metrics.

With such an approach, measuring change on the same basis, the opportunity for mismatch between drivers of change should be reduced. The basic mass, value and carbon (and other impacts as they become necessary) are identical and may be summated at the organisational level to generate national aggregates, with appropriate data collection mechanisms in place.

Accordingly, it could then be possible to reconcile bottom-up metrics with top-down.

6.4.3 Mapping proposed circular economy objectives onto the scaffold

Two key Scottish documents are the Circular Economy Bill Consultation (5) and the Climate Change Plan (9). From these, key circular economy policy objectives have been inferred. These have been mapped onto the scaffold in Figure 17.

Ideally, there should be correspondence between indicators and these objectives. Later in this report, Figure 25 and Figure 26 show how the indicator set fits the scaffold.

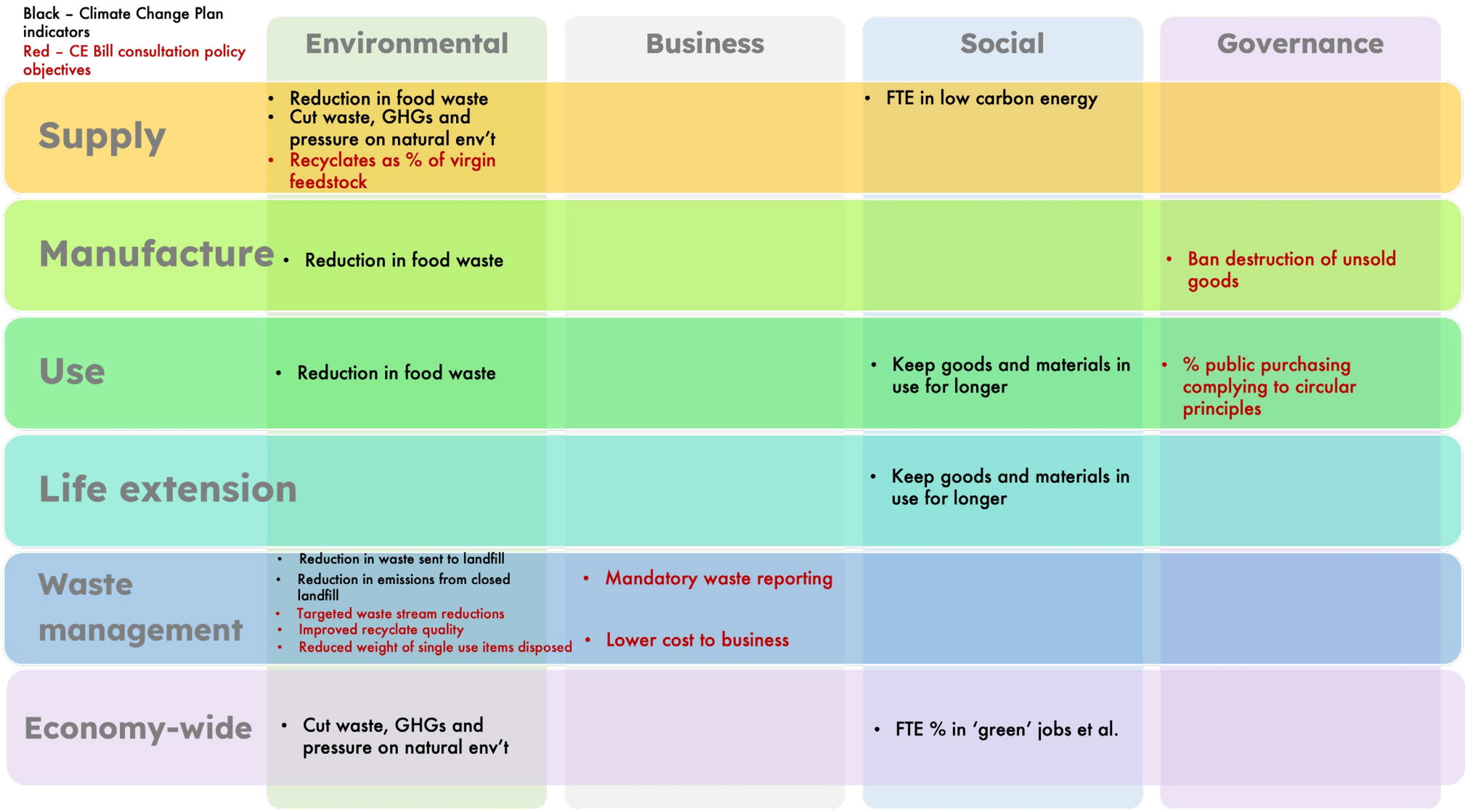


Figure 17: Mapping of Scottish policy objectives and currently targeted activities

6.5 Assembling an indicator set for Scotland

6.5.1 Gathering potential indicators from the international review

Initially, from the OECD's indicator inventory (2), the categories and subcategories were used to map a structure of common themes. The OECD set has a large diversity of indicators providing a thorough set of examples from which to determine the potential of each subcategory for producing a relevant indicator. As the OECD list is an amalgamation of indicators used in different frameworks and not a set on its own, many indicators are replicated, hinting at the importance or prevalence of some. After reviewing the list, an example of those staple indicators per subcategory was selected to screen. Additionally, the EU indicators were mapped on this subcategory structure to detect any potential gaps or redundancies.

This initial exercise produced a list of 33 subcategories with their typical indicators including the comparable EU indicators.

Some of the reviewed national indicator sets contain over 100 indicators, but these are largely differentiated aspects of the 'major' indicators to reveal detail within sectors, materials or aspects of society. The proposals in this report do not drive down to this level of detail because they concentrate on higher-level effects. However, the sub-indicators do exemplify how – as needs arise – a tiered approach to indicators can be taken. For example, as the CE evolves, focus might shift to impact and action hotspots which require such bespoke indicators. This echoes the evolutionary approach described in the Zero Waste Scotland Thoughts on Indicators report(3).

6.5.2 Applying the screening criteria of Section 6.2 to hone the list

The following step was a simplification of screening criteria for the subcategories, starting from the Scottish Government's Environment Strategy (4) and taking two of the seven criteria for selecting indicators.

Table 34: Rationale for screening criteria used at the outline stage of framework development

Criterion	Definition	Used / not used in analysis	Why/why not?
Relevance	There must be a clear relationship between the indicator and strategy outcome.	Used	With the current understanding of the Scottish strategy and position, and the different frameworks from other economies, there is enough information to broadly assess the relevance of a high-level indicator. Relevance also denotes the connection to a root cause.
Validity	The indicator must measure what it is supposed to measure.	Not used	At this point, as analyses are mostly theoretical, all indicators comply
Distinctiveness	The indicator must not measure something already captured under other indicators.	Not used	This should be assessed with more detail in a following phase, where selected indicators' data sources are thoroughly compared with other indicators that may already exist.
Practicality	The indicator must provide value for money and it must be feasible and affordable to obtain data.	Used	Indicators are assessed as useful for providing visibility or for steering policy. Affordability is difficult to assess at this point.
Clarity	The indicator must be straightforward to interpret by the intended audience. It must clearly communicate the measure that it is trying to assess.	Not used	As indicators are still in a conceptual high-level phase and not their final definition, clarity cannot yet be assessed thoroughly for initial screening. In the discussion of each indicator it might be brought up.

Credibility	The indicator must be based upon impartial, reliable data that is precise enough to show change over time.	Not used	At this level it is assumed all proposed indicators are assumed credible, as data sources are not determined.
Public interest	Indicators must be engaging and relevant for members of the public.	Not used	This should be assessed with more detail in a following phase where a communication or dissemination plan for the indicators is designed and audiences evaluated.

In addition to relevance and practicality, two other criteria were used:

- **Ambition:** The indicator either implies ambition or its target setting can provide an opportunity for Scotland to significantly influence the adoption of circular activities, so differentiating from peer group nations or, as mentioned before, to illustrate leadership.
- **Scalability:** Having a preference for indicators that were consistent and comparable at both the national level and, below that, at the organisational level. More preferably, underlying 'elemental' metrics related to mass, value, and embodied carbon should be should be carried through from the products and materials input level. In practice, as will be discussed in the relevant sections, this means adopting a broader scope of inputs to the national Material Flow Accounts and Carbon Footprint Accounts than is currently employed in most nations.

The process produced the following list of potential headline indicators that at this stage fulfil all or most of the criteria (practical, relevant, ambitious).

1. Circular Material Use Rate (In current indicators, Section 6.3, Use of Secondary Materials to displace Virgin Materials).
2. Resource Productivity.
3. GHG Emissions per Unit of GDP.
4. Generation of Waste (In current indicators, Section 6.3, Waste Generated).
5. Waste diverted to recycling (In current indicators, Section 6.3, Waste Diverted to Recycling).
6. Raw Materials Input (In current indicators, Section 6.3, Material Inputs).
7. Resource Resilience.
8. Input-based Carbon Footprint.
9. Intrinsic Carbon Intensity.
10. Number of companies publishing CE. strategies or sustainability reports considering circular business practices.
11. Investment in circular economy projects or companies.
12. Percentage of Public procurement with circular economy sourcing criteria.
13. Percentage of Circular jobs Share of circular products in total number of products.
14. Number of training courses on the circular Economy.

The choice of raw material indicator is important, but is the subject of much debate because of the implied scope of responsibility for material and GHG impacts of a nation that the choice implies. Tracking material flows is methodologically complex and is a distinct addition to the national accounts process; this will be discussed further later.

These indicators provide a broad overview of the different aspects of the circular economy as we have defined it. The following sections further scrutinise the utility of these indicators, the scope of their application, the availability and meaning of relevant data and the specific recommendations for their application and interpretation. For this refining process, further considerations need to be taken into account, as outlined in the following section.

6.5.3 Further considerations for the indicator group

The introduction to this report identified the uses of indicators. This is reflected in the OECD's categorisation of indicators as shown in Figure 18.

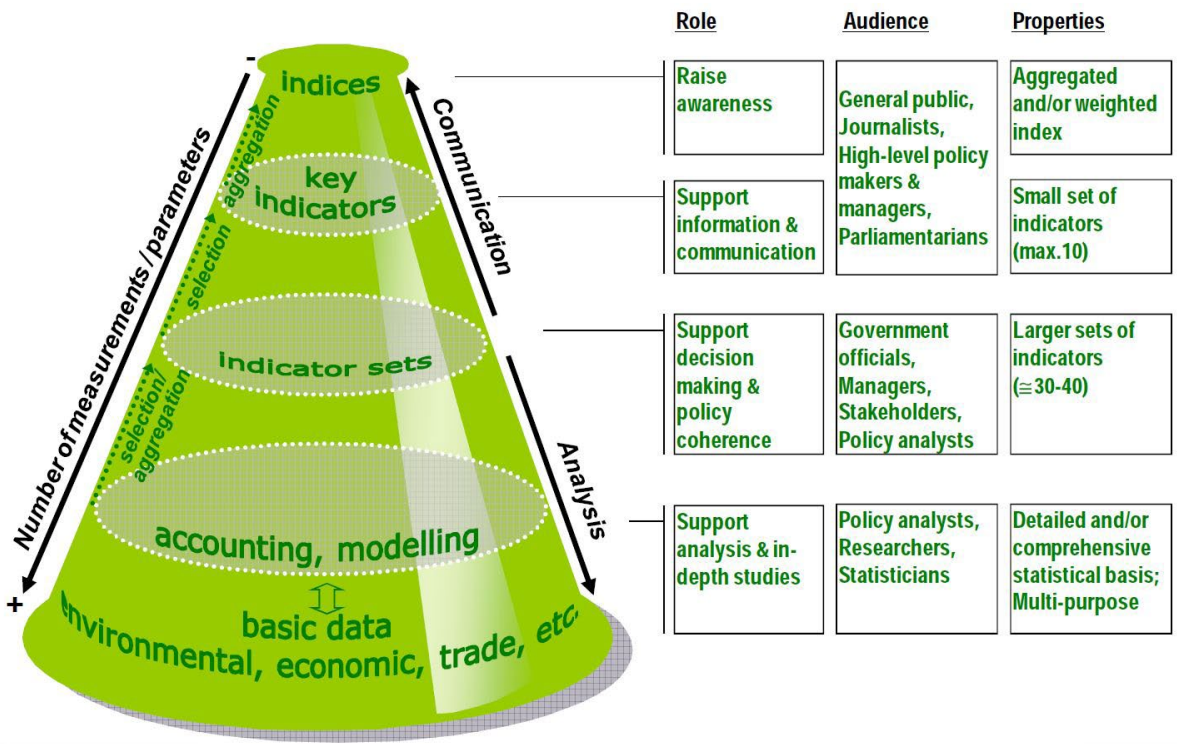


Figure 18: Information Pyramid for indicators
Source: OECD

In Section 6.2 it was proposed that a subsidiary set of 'Transition Indicators' could usefully assist in monitoring and directing the initial shift to a circular economy. Previous work by Zero Waste Scotland on indicators, and the practices seen in numerous national indicator sets, strongly indicates the practicality of a headline set of indicators related to outcomes (3). These are frequently supported by 'Tier 2' or 'secondary' indicators that expand particular aspects of the headlines e.g. by material or sector, or track activities or behaviours indicative of the uptake of 'circular' practices by companies, individuals or institutions. The most sophisticated approaches acknowledge that the circular economy is in an early stage of development and that the most appropriate indicators may evolve over time; these approaches further partition Tier 2 indicators as a 'Transition' set. Replicating this segregation is part of the Scottish indicator proposal as described in later sections.

Transition Indicators

A graphic presenting a simplified view of the transition from linear through recycling to a circular economy was presented in Figure 18; the circular economy element is presented here in Figure 19, expanding on the 'inner loop' processes of the re-use spectrum; in general, these processes are not well tracked in traditional national accounts, and lack data needed to derive hard indicators.

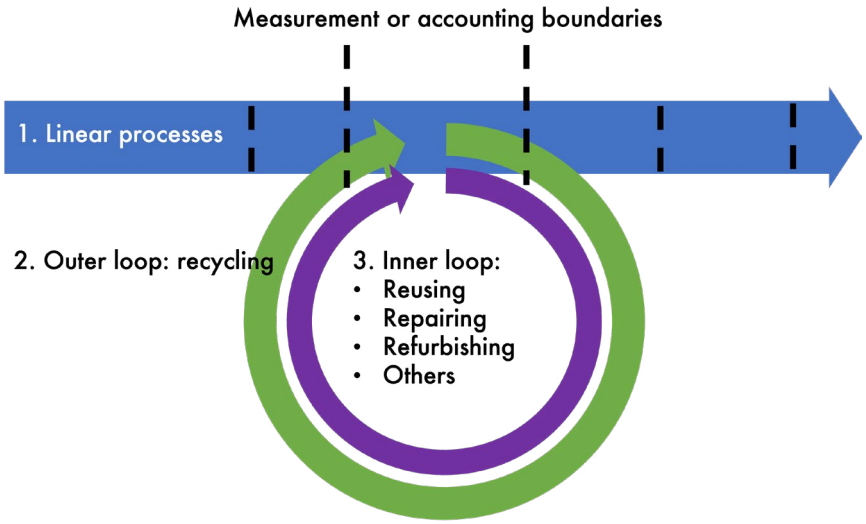


Figure 19: Simplification of the butterfly diagram

This concept of transitional indicators was described in Section 6.2, where the idea that other indicators would be needed to track the rise in the adoption of circular practices, including enabling processes, systems, policies, regulations and resources. As these might evolve over time, such indicators have been called transition (or sometimes 'progress') indicators. Following the review of national indicator sets, and taking consideration of practicality and causality, the following are suggested as candidates for transition indicators:

- Number of companies publishing circular economy strategies or sustainability reports considering circular business practices.
- Investment in circular economy projects or companies.
- Percentage of public procurement with circular economy sourcing criteria.
- Percentage of circular jobs.
- Number of Training Courses related to Circular Activities at the Tertiary level.

These are all aspects of the circular economy that are starting from a low base and would be expected to grow strongly in the early phases of adoption; they might, however, not grow as strongly, or would likely plateau, once circularity is embedded. At this point, their use might be limited or discontinued, perhaps replaced by topical indicators. In this respect, it is prudent to plan for the uptake (as projected by the Dutch in the relationship seen in Figure 7). One way of doing this is by setting targets for different timeframes and even proposing new indicators to take over the initial ones when they are more suitable. An example of this is shown in illustrated in Table 35. Note that the targets are not being recommended and this is just to illustrate a methodology for using transition indicators.

Table 35: Recommended information for the application of a transition indicator

Space:	**Governance**			
Objective:	Boost circular economy practices adoption in the private sector			
Indicator	Data source	1st year goal	5th year goal	Next phase indicators
Number of companies publishing circular economy strategies or sustainability reports considering circular business practices	Companies house report filings. Third parties commissioned with collecting the information.	10% (example)	70% (example)	Once the level of this indicator surpasses 50% (example), a different or additional measure needs to be implemented. For example, revenue from circular products or services.

Other transition indicators can be useful for tracking progress in the inner loops of the circular economy but might need new data collection systems, proxies, or the adaptation of traditional national accounting processes. However, the latter could require the adaptation of SIC codes, which in the UK is managed by the Office for National Statistics, and was last updated in 2003. Therefore, circular processes such as Re-use, Repair, Remanufacturing and Sharing lack the necessary measurements or even proxies suitable for harder indicators.

An important aspect is the international relevance and possibility of benchmarking of the different indicators. As with any national policy, it is important to check the progress when compared to that of peer nations or territories, especially in a field with constant new developments, such as the circular economy.

Finally, the intention of the indicator set is to provide an economy-wide view; but for providing greater detail to inform policymaking, more granular information is needed. In the cases where this granular information is relevant, options for further tiers of the indicator families will be outlined with their possible applications.

7 Indicator rationale

This section describes in detail the indicators presented in section 6.5.2 and the rationale for their selection. Most follow a common format, commencing with the summary box as shown here.

Name of Indicator – Units of Indicator

Questions about the Circular Economy that the indicator addresses.

There follows a discussion of the choice, international relevance and possible expansions or sub-categorisations of the indicator, for example to track key material, product or sector activities. As has been noted earlier, there are fundamental choices available for some indicators, particularly around the materials flow accounting of inputs to the economy. In reality, however, each of these bases reveals a different truth about the materials underpinning Scotland's standard of living. It may be necessary to track more than one such input basis to obtain a balanced picture, which permits a fair international comparison.

Rationale xx: Boxes like this provide commentary providing cautions or limitations on use of the particular indicator, or on variants that could be employed.

Boxes like this provide brief summaries of pros and cons of indicator types presented in section 6.5.2

7.1 Hard indicators

Hard indicators relate to the direct measurement ment of the physical flows of materials, products or their consequential impacts (such as GHG emissions). Generally, they offer comparability to other nations and are relatively easy to communicate.

7.1.1 Material Footprint

Material Footprint defined as RMI – [tonnes]

Is material use growing?
What material flows are relevant to stated policy goals?

The Material Footprint can be defined as a direct measure of resource use resulting from a country's activities. A corresponding indicator should provide information on the total amount of resource consumption being caused by a country's economic activity. The Material Footprint is selected from the wider set of material flow indicators that can be calculated with an economy-wide Material Flow Account (MFA). Material flow analysis embraces various schools of thought on how to measure these flows, and how they can be aggregated or segmented to reveal different aspects of the economy. There is no clear choice of which indicator from an MFA should be used to represent a nation's Material Footprint. In this section we attempt to delineate the considerations this decision requires, as well as our rationale for our working definition of Scotland's Material Footprint.

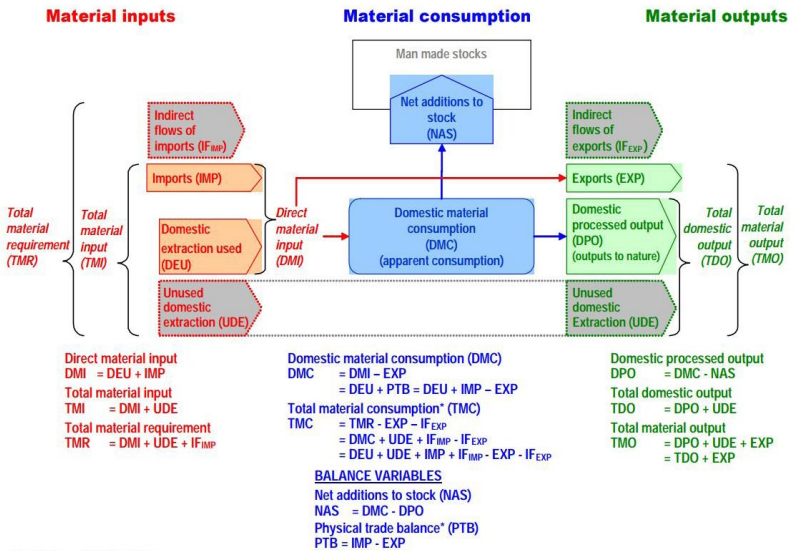


Figure 20: Material Flow Accounts Definitions
Source: OECD, based on Eurostat (2001)

Defining a country's Material Footprint as its Domestic Material Consumption (DMC) used to be a common practice for governments and MFA practitioners. DMC is calculated by taking the materials being extracted from the environment within a nation's borders (its domestic extraction [DE]), adding the materials that are being directly imported (IMP) and then subtracting the materials that are being directly exported (EXP).

However, this definition of Material Footprint has fallen out of favor over time and has been replaced with the indicator of Raw Material Consumption (RMC). RMC, like DMC, is a consumption-based measure following the same functional form of domestic extraction, plus imports, minus exports. The key difference is in how those exports and imports are defined. RMC incorporates what is called the raw material equivalent of imports and exports into its calculations. These are the amount of materials consumed upstream in the supply chain to create the goods that are imported or exported. This is an important consideration as a nation's DMC account can shrink if a country is offshoring the production of its goods but is maintaining the same level of consumption. This has been a common occurrence over the last few decades due to globalisation and the highly developed countries moving towards increasingly financialised, service-based economies. There is a degree of uncertainty with the estimation of the materials 'embedded' in a nation's imports and exports; however, given the importance of accounting for these overseas impacts, estimation methods have become highly refined and widely agreed upon.

RMC accounts for the upstream material extraction associated with traded goods; however, by defining Material Footprint as RMC or DMC, exported materials are not accounted for. Defining Material Footprint in these ways tacitly asserts that a nation should only account for the environmental impacts of the materials that it is consuming. In effect, these indicators are capturing the concept of consumer responsibility but ignoring the concept of producer responsibility.

If we were to add the exported materials back into DMC and RMC, we would have the indicators of Domestic Material Inputs (DMI) and Raw Material Inputs (RMI), respectively. While DMI suffers from the same offshoring bias as DMC, RMI does not and is the most expansive of the commonly used material flow indicators. Utilising the input indicators as a working definition of the Material Footprint could be presenting an issue of 'double counting' of the materials two nations may be responsible for, as one nation's exports are another's imports. However, this is not an issue for the purpose of this monitoring framework or any associated policy targets that could be associated with this indicator. While it may be simpler to limit the scope of a nation's material account to either the materials it is consuming or the materials it is using in production; in truth, both the exporter

and the importer nations are partially dependent on the traded materials, as both are benefiting from the transaction. Exported materials directly contribute to a nation's GDP and are thus indirectly contributing to that nation's standard of living. Broadly speaking, while the materials included in RMC are contributing to the physical dimensions of a nation's wealth, the materials being exported are contributing to the financial dimensions of the nation's wealth. It could also be argued that because a nation's government has more direct control over the production processes of the products being exported than it does over the products being imported, that is where they may wish to focus their policy efforts. Making an indicator more reactive to changes in domestic production processes is extremely important for the purposes of a monitoring framework. And for Scotland specifically, exports represent an extremely large proportion of its material flows, with exports and RME exports being larger than their DMC and RMC counterparts.

There are other material flow indicators that are more expansive but less commonly used; such as the nation's Total Material Requirement (TMR) or Total Material Consumption (TMC). These aren't commonly calculated as they require the estimation of the unused materials resulting from the extraction of other materials.

These material flows are not often estimated and, if attempted, would come with a high degree of uncertainty and this uncertainty is only compounded for their associated environmental impacts. They are not currently included within Scotland's Material Flow Account.[16]

Because of its scope, reactivity to policy and conformity with other economic and environmental indicators (which we will expand on later) it is recommended that Scotland define its Material Footprint as its RMI for the purposes of this monitoring framework. That being said, it should be noted that while under this definition the material impacts occurring upstream in Scotland's supply chains are accounted for, the impacts its exports are causing downstream in Scotland's supply chains are not. Such impacts could be considered part of Scotland's footprint because these wealth-generating exports are causing material consumption and environmental impacts that would not have occurred if the supply of Scotland's exports was reduced. Excluding these materials also somewhat limits this indicator's relationship to Scotland's economic activity because, if there is a shortage in some of these materials and their substitutes, demand for production inputs from Scotland would likely decrease[17]. In that sense, some of the materials Scotland is dependent on are not encapsulated here.

While, to our knowledge, there is currently no established material flow indicator that incorporates this concept, it would be straightforward to calculate under the standard Leontief Input-Output framework and subject to no more uncertainty than the well-established raw material equivalent indicators.

[16] Scotland's Material Flow Accounts

[17] An exception to this would be if stockpiling of of these materials occurs in anticipation of the export of production inputs from Scotland returning to previous levels.

Summary of RMI Indicator

Calculation	Includes	Excludes
Raw Material Inputs = Domestic Extraction + Direct Imports + Indirect Imports	• Materials directly contributing to Scotland's physical wealth. • Materials indirectly contributing to Scotland's physical wealth (footprint of offshored production). • Materials directly contributing to Scotland's financial wealth. • Materials indirectly contributing to Scotland's financial wealth.	• Material consumption occurring indirectly due to growth in Scotland's financial wealth (because of Scotland's exports). • Unused materials extracted in Scotland's territory. • Unused materials extracted to create Scotland's Imports. • Unused materials extracted because of Scotland's Exports.

Treatment of fossil fuels

The extraction and sale of fossil fuels is an activity of great economic significance to Scotland. There are differing opinions on whether fossil fuel extraction is included or excluded from the Material Footprint measure as a large fraction of it is exported. If excluded, it would be honest to subtract the economic benefits of fossil fuels from the national GDP (as a metric required for derivation of a number of ratios in this proposal). If included, benefits can then also be included in national GDP. This matter requires (further/continuing?) serious consideration.

Fossil fuels are clearly problematic because of the uncomfortable fit with the drive to Net Zero. The Government's goal is a rapid decarbonisation of the energy supply chain, which means reducing domestic use of this resource. And of course, fossil fuels are largely derived from oil, which is the major feedstock for organic chemicals, and especially for plastics.

Pros	Cons
• Commonly used material flow indicator. • Reactive to government policies. • Includes all materials supporting a nation's economic activity and standard of living. • Includes extraterritorial material inputs. • Data more robust than 'Total' material flow indicators.	• Uncommon definition of Material Footprint may hinder communication. • Excludes material consumption being caused by exported materials. • Excludes unused materials extracted both within Scotland and abroad. • Data has more uncertainty than the 'Direct' and 'Domestic' material flow indicators.

7.1.2 Input-Based Carbon Footprint

Greenhouse gas emissions resulting from RMI– [tonnes CO_2e]

Are the emissions caused by material use growing?
Which emissions are relevant to stated policy goals?

The Material Footprint of a nation is broadly interpreted as a proxy indicator for the environmental impacts caused by economic activity. While there are many environmental impacts directly resulting from economic activity (e.g. water footprint, biodiversity, air quality, etc.), equally pertinent are the impacts that will be caused indirectly due to the generation of greenhouse gas emissions.

As some materials have different emissions intensities than others, a Material Footprint expressed in tonnages will not capture a country's move towards the consumption of better materials. While the emissions intensity of materials should be tracked as an independent indicator (discussed later in the document), an aggregate carbon impact indicator will account for the interaction between these two indicators to provide a clearer picture of an economy's contribution to global warming. Like the Material Footprint, this concept is used as an input to some of the other indicators discussed in this section.

While this may be the most comprehensive accounting of impacts achievable in the short-term, the environmental impacts directly resulting from economic activity are still missing from this proposed example monitoring framework.

If robust impact coefficients are developed within the Leontief input-output framework,

aggregated impact indicators should be included for each environmental impact related to government's stated policy goals (e.g. water footprint of materials, biodiversity impact of materials, etc.).

Different definitions of the Material Footprint will naturally have different carbon impacts associated with them. For the purpose of this discussion, a taxonomy on the different carbon footprint indicators and their associated scope of materials included is provided below.

Proposed taxonomy on the GHG impacts of different material flow indicators:

- Territorial emissions – Domestic Extraction.
- Consumption-based Carbon Footprint – Raw Material Consumption.
- Input-based Carbon Footprint – Raw Material Inputs.
- Impact-based Carbon Footprint – RMI+, Total Material Requirement, etc.

As we have recommended that, at a minimum, RMI be used for the Material Footprint for the purposes of this monitoring framework we have had to develop a new name for the associated carbon indicator. We will refer to this as the 'Input-based Carbon Footprint' for now as we have been unable to find any established nomenclature for this concept. As we had the same issue of no established terminology for the more expansive material flow indicators, we will refer to the carbon impact of these as the 'Impact-based Carbon Footprint'.

By including the exported materials in our calculation of the carbon footprint, its calculation is as simple to take the nation's territorial emissions and adding the emissions associated with its imports and their supply chains.

This is an exact parallel to the way a business or industry would calculate their Scope 3 carbon footprint, by adding the direct emissions and supply chain emissions needed to deliver their product (exports) and pay their employees (citizens).

The Scottish government regularly publishes a consumption-based carbon footprint account (which defines the Material Footprint as RMC). Because of the abstruse nature of the MFA concepts involved in calculating these indicators, the government may have difficulty communicating the nuance between emissions accounts.

Pros	Cons
• Strong synergy with stated policy goals. • Comparable with other carbon impact indicators. • Data on carbon impacts is robust.	• Communication may be difficult depending on how Material Footprint is defined. • Does not capture most environmental impacts occurring in the short-medium term

7.1.3 Circular Material Use Rate

Circular Material Use Rate (CMUr) – [Circular Material Used / Total Material Used, (%)]

How much of current material needs are being addressed through recyclates?
How much is extraction of raw materials being avoided?

The circular economy proposes that materials are kept in use for as long as possible. This should mean that less materials are needed to recharge the economy and offer a degree of resilience to supply disruption. As the circular economy is composed of different 'loops', there is no single measurement for its efficiency or impact. However, recycling as a process is already embedded in most economies and is accurately accounted for; it is already recognised in the material flow accounts.

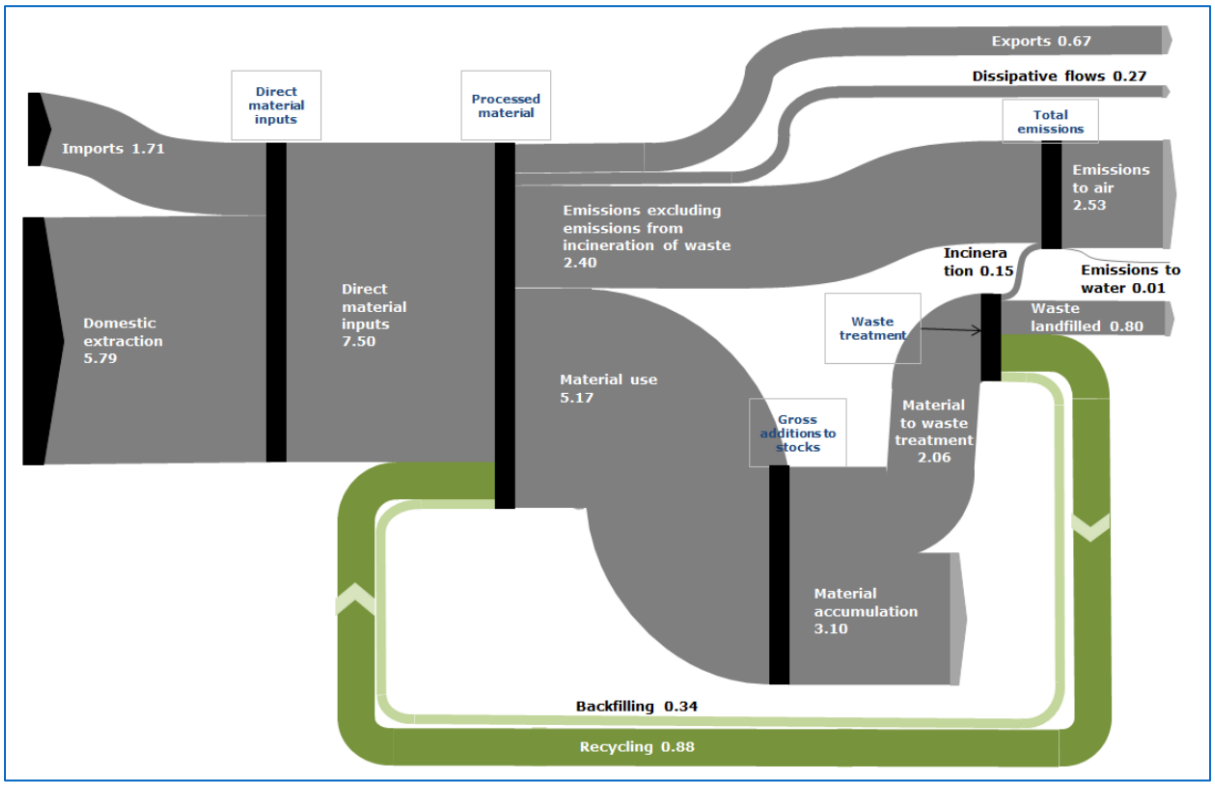


Figure 21: Material Flow Accounts – illustration of the recycling loop

Source: Eurostat (60)

Recycling is not as resource or energy efficient as other circular economy processes, such as, repair or consumption prevention. However, these processes are currently not accounted for in a comprehensive way to produce a recognised process indicator, as was described in Section 6.3. The effect of this is that the CMUr likely underestimates the 'true' circularity in material terms. Therefore, the current form of CMUr could be seen as a stepping stone for the eventual inclusion of re-use and repair activities, although these would require new data collection processes.

With these data limitations in mind, the current calculation of the indicator requires the 'Circular Materials' in the numerator, which can be defined as the recycled waste coming from domestic treatment plants, adjusted for the imports and exports of recycled waste as needed for the defined Material Footprint. For the denominator, we add the total Material Footprint, expressed here as Raw Material Input - RMI, to the circular material being consumed to ascertain the total amount of materials being consumed (virgin materials plus secondary materials).

$$CMUr = \frac{U}{RMI + U} = \frac{(RCV_R + IMP_S - EXP_S)}{RMI + (RCV_R + IMP_S - EXP_S)}$$

Where:
U = Circular Material
RMI = Raw Material Input
RCV_R = Recycled waste in domestic operations
IMP_S = Imported secondary material
EXP_S = Exported secondary material

Rationale 1: Note that certain nations have deprioritised indication of some material flows. For example, the Dutch realise that large flows of relatively low value sand, gravel, spoil, and construction waste can skew both the recycling indicators and the Circular Material Re-use Rate, and thus have chosen to exclude them. Additionally, Scotland may want it's sub-indicators to target specific critical materials, possibly taken from the UK CRM list.

International relevance

Circular Material Use Rates are implemented in the EU. Although the indicator has the limitations described, it does provide an intuitive view of material circularity and there is ample data for benchmarking.

Breakdown and tiers

This indicator can be broken down by types of material to indicate progress. It can also inform policy on needed infrastructure or regulation for the treatment of some materials.

Pros	Cons
• Waste data and Raw Material Input indicator are already available in Scotland's Materials Flow Account. • Comparable to EU countries. • Is simple to communicate.	• Circular material data comes from recycling, which can be skewed by biasing materials (minerals & soils) and hidden flows. • The name 'circular material' can be deceptive, as this currently only accounts for recycling and not all of the value retention processes of the circular economy. A more inclusive assessment of re-use flows (as further circularity flows) would present a 'truer' picture of total recirculation compared to virgin inputs. • As this is a relative measure, it does not give information about the total material use of the economy or the value of particular flows.

7.1.4 Resource Productivity and Material Intensity

Resource Productivity and Material Intensity– [GDP / Raw Material Input (£/tonne)] and [Raw Material Input / GDP, (tonne/£)]

How efficient is the country in extracting value from each unit of material input?
Does the trend show a decoupling of economic activity from material usage?

As defined in the OECD's Measuring Material Flows and Resource Productivity (61), efficiency indicators are ratios which track the linkage between economic output and material flows. The choice of specific indicators when composing the ratio reflect considerations of importance, international comparison and the practicality of their derivation. The reason for including this indicator in a circular economy framework is simple: circular activities aim to reduce the demand for virgin materials (both domestically and upstream) while maintaining or improving people's standard of living (here measured by GDP). For example, assuming everything else stays equal, if recovery or recycling rates increase and those secondary raw materials are sold back into the economy and reduce the need for virgin materials, resource productivity will increase. The same can happen with other circular activities depending on pricing, business models, rebound effects and other commercial considerations.

It is true that the indicators have limitations and need additional information to be interpreted. For example, if the price of a commodity extracted domestically increases sharply in international markets, it may produce a rise in resource productivity that holds no link to circular practices or improvements in people's standard of living. However, as part of an economy-wide indicator set, it can provide necessary insights about how a country uses and transforms resources.

International relevance

Currently, both EU and OECD frameworks track material productivity in terms of DMC. The issue for correctly interpreting the indicator is that DMC does not consider the material effects of exports, while GDP does, as described in subsection 7.1.1. This means efficiency in handling and manufacturing of exports is not incentivised and decreases the need of generating high value added exports. This is additional to the effects of IF_{IMP} already discussed in the definition of a Material Footprint metric, shown in Figure 20. As recommended by the United Nations and the European Commission, some countries, such as Denmark, plan on moving to using raw material equivalents. Due to recommendations of the United Nations and the European Commission (62) (63), expressing material productivity in terms of RMI can show ambition and leadership in the short to mid-term for Scotland.

Breakdown and tiers

As part of using these indicators to inform specific industry actions, it can be useful to start measuring resource productivity for different sectors or industries. Doing this would require the use of industry or sectoral GDP, as well as determining the correct measure of Material Footprint for companies whose operations map to an RMI approach (including products sold).

Perhaps, due to the great importance of fossil fuels in Scotland's exports, there could be value in looking at material productivity information excluding fossil fuels. (See RMI subsection 7.1.1 for commentary of fossil fuels.)

Pros	Cons
• There is already expertise and processes in place to measure. • The international community will seek to move to RMI instead of DMC as a base. • There is an opportunity for showing leadership and ambition	• Accounting for unused extraction will continue to be an obstacle in the short to mid term. • There is nothing said about the ways materials are used. • Water use is not considered in current material flows. • The transition to a greener economy will need intensive extraction in the coming years, going against the desired trend. • Not clear for all audiences due to its nuances.

7.1.5 Emissions Productivity

Emissions Productivity– [tonnes CO_2e / £] and as inverse [£ / tonne CO_2e]

Is economic growth decoupled from GHG emissions?
What is the impact of the Net Zero transition in this decoupling?

One of the most scrutinised effects of the circular economy is its impact on carbon and GHG emissions. Although this is not the only end goal of circular practices, the urgency of tackling global warming has brought GHG emissions to the fore when discussing the implementation of the circular economy. There are mature systems for monitoring and governance around national emissions related to primary energy inputs, making it an indicator which should have a good platform for implementation and tracking.

Rationale 2: Note that the embodied emissions associated with traded materials and goods are less well quantified (the Scope 3 emissions) due to the complexity of aggregating emissions along supply chains. This is a complicating factor of implementing GHG accounting systems based on a Raw Material Equivalent.

The goal of Net Zero implies that, globally, absolute emissions will drive to zero, but this may not be true for every nation in the short term. For developing nations, emissions may well rise as standards of living improve. Developed nations appear to have shown some level of decoupling between economic growth and GHG emissions. However, the reality of the situation is far more complex; as this apparent decoupling may be from the offshoring of production as the most developed economies have become increasingly servitised and dependent on trade. To counter this offshoring bias, emissions accounting should look past territorial emissions and include upstream Scope 3 emissions. It is important, however, to track emissions per unit of GDP, to understand how costly in terms of GHG it is for the economy to create wealth for its people. Because we are making this trade off, the amount of GDP created could be seen as an effective valuation of the environmental damages caused by these emissions. Beyond tracking decoupling trends, comparing this effective valuation with natural capital assessments and climate change's projected impacts on the economy can help identify where present economic activity may be a long-term drag on the economy.

Particularly, the transition to a Net Zero economy will require such a large amount of materials for the manufacturing, transportation and installation of renewable energy infrastructure that it will likely have a severe impact on consumption-based emissions. These types of effects need to be accounted for in any strategy and target setting for this indicator to be insightful.

International relevance
The inputs to this indicator are commonly published but the indicator itself is often with different definitions of Material Footprints and, therefore, scopes of GHG emissions being accounted for. While the calculation of the carbon footprint of differently defined Material Footprints is a relatively straightforward process, carbon impact calculations based on RMI are rarely published. Care should be taken when comparing indicators that may be using DMC or RMC, as their defined Material Footprints.

Additionally, to correctly align ambitions and steer actions, comparisons should be made with countries with similar production activities and resource availability.

Breakdown and tiers
This indicator should be divided by industries, relating their contribution to GDP and to emissions to detect opportunities for further business or regulatory action. Additionally, as Scotland's energy mix is highly based on renewables, industry ambition needs to start steering towards operational reduction strategies and Scope 3 emissions.

Pros	Cons
• Most information already available • Data available from most countries • Can condense a lot of information	• Not straightforward and requires of context to interpret. • Can amplify different effects so it can be challenging to set targets. • Any comparison to other countries should be carefully interpreted. • Adding Scope 3 emissions to source emissions can come with a high degree of uncertainty.

7.1.6 Carbon Intensity of Materials

Input-based Carbon Footprint (ICF) – [GHG Emissions/ Raw Material Input ($MtCO_2e$ / tonnes)]

Are the materials being used in the economy emission intensive?

The emission intensity of materials indicates whether or not a nation is consuming more sustainable alternatives, independent of whether or not its overall GHG impact is going down. The important thing to highlight here is that, as RMI takes into account the Raw Material Equivalents of exports and imports, the associated GHG measure will account for upstream emissions of imports as well as Scotland's territorial emissions. Therefore:

Input - based Carbon Footprint = Territorial Emissions + Scope 3 emissions from imports ÷ Raw Material Input (RMI)

International Relevance
In the international context there are many different emission intensity measures related to different economic or industrial activities.

However, in the frameworks reviewed, there was no indicator that had this type of measure applied to a Material Footprint. This was likely due to their concentration on the domestic consumption and territorial emissions. The Input-based Carbon Footprint is a more comprehensive overall assessment of the inputs and impacts of a nation and draws a direct parallel to the way the carbon footprint of a business is calculated.

Breakdown and Tiers
As carbon foot-printing becomes a mainstream business practice, this indicator can be easily calculated for individual firms.

Pros	Cons
• It can provide data on how impactful the materials used in the economy are. • Provides a view based on near-complete inputs and impacts.	• Scope 3 emissions for upstream supply chains may be difficult to account for accurately. Simplifications will likely be needed.

7.1.7 Generation of Waste

Generation of Waste – [tonnes]

Are the initiatives within all the recycling and re-use loops working?
Does waste diminish as the economy becomes more efficient?

Although this is a basic measure, it is necessary to keep track of this in relation to the previously described indicators. For example, the Circular Material Use rate (CMUr), measures how much secondary material is used compared to all material needs; the ideal is that CMUr should rise as materials are recovered and used. However, as it is a relative measure, it is conceivable that total material consumption rises at the same time as CMUr, so creating an absolute increase both in general waste and landfilled waste.

Rationale 3: Note that the accounting of waste data from commercial and industrial (C&I) sources is more problematic than household waste. However, knowledge of waste from C&I sources would be most useful in diagnosing the resource efficiency of industries in transforming inputs to outputs. This might be particularly relevant to sectors such as construction, bio-based sectors, or those employing significant volumes of critical materials.

In the case of resource productivity, the indicator can also rise due to more valuable materials being extracted and/or processed instead of greater value extraction within the inner loops, where materials are retained. In such a case, the total amount of waste could stay constant while material productivity rises. These examples illustrate that an economy-wide indicator dashboard needs to have aggregated indicators like total waste as a control check. Additionally, eliminating waste and pollution is one of the underlying principles of the circular economy, hence any attempt at measuring circularity should include accounting for waste. This is an area where the Scottish Government has agency.

International relevance
Waste generation is part of the EU consumption and production indicators, so it is compatible with that framework. Normalising the waste tonnages to per-capita terms will help with international comparisons but detach the indicators from the total impact on the environment.

Breakdown and tiers
As with the EU framework, municipal waste generation per capita can be useful for understanding household consumption, and waste generation by each material category can provide insights regarding specific actions that can be taken to reduce such wastes.

A useful measure of efficiency for the industrial and manufacturing sectors would be the waste generation of different activities. This data has been gathered yearly by the Scottish Environment Protection Agency but has not been published since 2018 due to a cyber-attack. Unfortunately, this data's sectoral accounts are aggregated much higher than Scotland's economic Input-Output accounts, rendering it useless for policy tracking and comparisons to value-added. Until disaggregated data is available, industrial waste will be proposed as a prospective indicator.

Pros	Cons
• Simple and easy to communicate. • Easy to compare internationally. • Scottish government has agency over this area. • Already in use. • Separates out end-of-life impacts.	• Does not account for domestic stock accumulation. • It has to be read together with other indicators to gather relevant information.

7.1.8 Recycling Rate

Recycling rate – [tonnes of waste recycled / tonnes of waste received, %]

Is there need for more recycling infrastructure? Is it consistent with the other trends?

Recycling activity is a well established and recognised element of circularity, although it is not the most 'value-adding' tactic as a circular action[18]. However, recycling is a mature industrial activity, with a reasonably transparent audit trail from the point of collection to reprocessing into secondary materials, meaning data availability is less of a concern than with other aspects of the circular economy.

Rationale 4: The comment made in Circular Material Re-use Rate regarding selecting sub-indicators of value or criticality relevance is applicable here. Recycling achievements should not be unduly biased by 'churn' of high volume, low value, low impact materials.

As described in Section 6.3, once the circular economy is well established, Recycling Rate may well fall as a fraction of overall circularity. A challenge for the transition to this state is to avoid promoting recycling as a default option at the expense of higher value options.

Furthermore, although recycling is not a high value recovery tactic when compared to practices such as reusing or refurbishing, it is necessary to recognise that as technologies change, there is a limit to the number of times a product or component can be re-used. It is therefore still necessary to maximise recycling in the absence of more valuable alternatives.

[18] The study Socio-Economic and Environmental Study of the Canadian Remanufacturing Sector and Other Value-Retention Processes in the Context of a Circular Economy describes economic and employment input-output factors which describe the superior employment opportunities et al. of re-use.

This indicator is therefore necessary to inform policy on trends in recycling capabilities, infrastructure and processes.

International relevance

Recycling rate is a mainstream waste management indicator, it is part of the EU's framework and is listed in many different frameworks referenced by the OECD (Figure 22). Definitions are standard as recycling is a mature activity, therefore benchmarking is very accessible.

Breakdown and Tiers

As different types of waste demand different processes and infrastructure for collecting, separating and processing, it is useful to separate recycling rates per type or source of material. Tracking the capacity of such infrastructure, at the same time as recycling rates of different materials or industries can help inform on where investments or incentives on infrastructure should be made in a timely manner. This is an example from the EU:

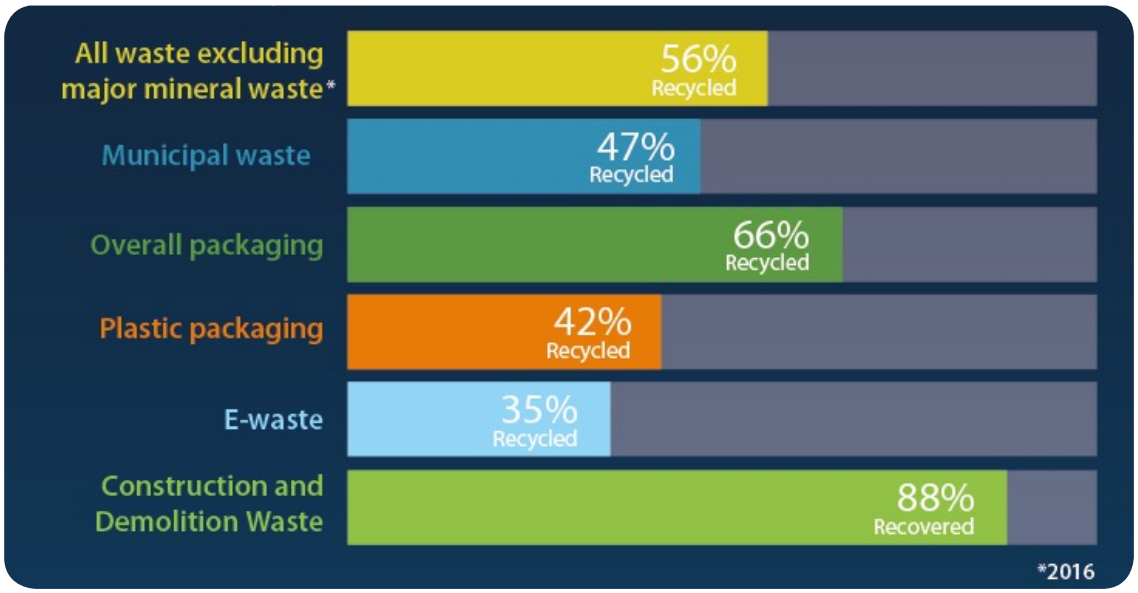


Figure 22: Recycling rates of different waste streams – EU, 2018

Source: Indicators – Circular Economy – Eurostat (64)

Pros	Cons
• Simple and easy to communicate. • Is directly related to circular activity.	• Does not account for other loops like reusing, refurbishing or repairing. • The increase of the activities in the other loops may drive it down eventually. • It only conveys ambition through target setting.

7.1.9 Resource Resilience Ratio

Resource Resilience – [Raw Material Equivalent of imports (RME) / Raw Material Input (RMI), %]

Is there a high dependency on imported materials or goods?
Are the products being targeted for recirculating the ones with high Raw Materials Equivalents?

The Resource Resilience indicator is meant to capture one of the co-benefits of the circular economy, which is the resistance to international shortages of key materials. If the indicator is trending lower over time, it means the economy is becoming less dependent on imports to maintain the country's standard of living. While increasing domestic material cycling will lower this indicator, the rebound effects of more cycling will not influence it because both the numerator and denominator would grow in equal measure.

This indicator, although useful when used in a larger set, does not account for what is physically possible to produce in a territory (i.e. the biocapacity of the economy). It is probable that, even with high levels of

circularity and resilience, some imports will still be needed. Therefore, it may be useful to complement or augment this measure with some account of biocapacity or ecologic footprint of the land.

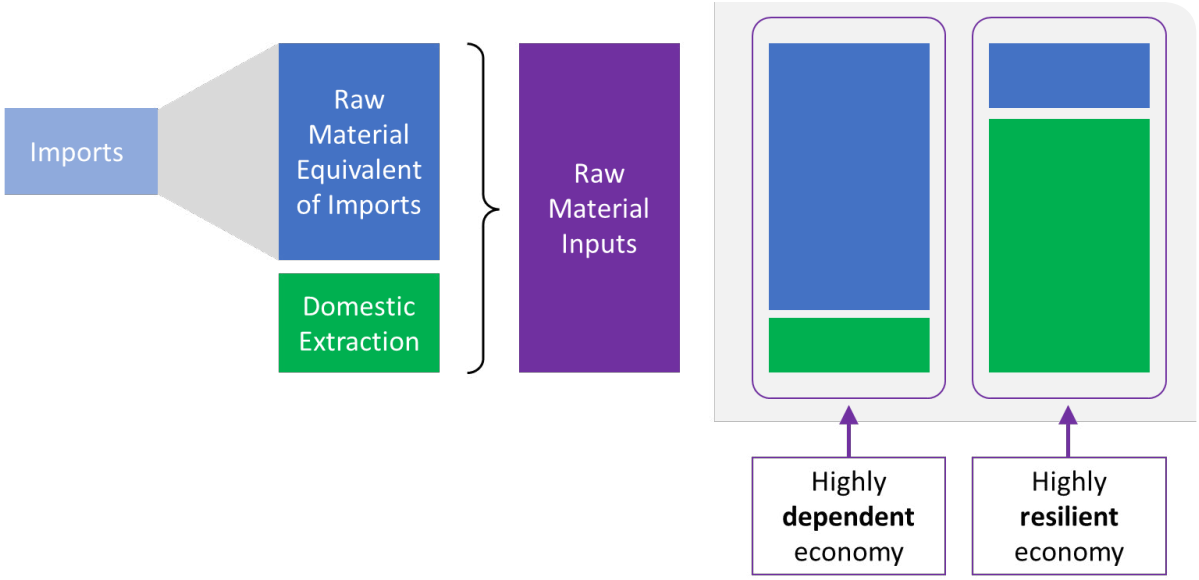


Figure 23: Shifting from a dependent to a resilient economy

International Relevance

The EU Indicator set contains the 'Self-Sufficiency' indicator which fulfills broadly the same role as the proposed Resource Resilience indicator. However, there are a few significant differences between this indicator and the EU's indicator (65):

- Firstly, the European indicator is only looking at what the EU defines as 'Critical Raw Materials', not the economy-wide totals.
- Secondly, the EU calculates its ratio using direct material flows, so the material inputs needed for imports are not included.
- Thirdly, exports are subtracted out from both the numerator and the denominator, drawing parallels with the way Balance of Payments accounts are calculated. While they do not use this language, they keep the physical trade balance in the numerator and something akin to Domestic Material Consumption in the denominator (depicted below). The Physical Trade Balance in the numerator can be interpreted as a measure of resource resilience as well, except this would be acting under the implicit assumption that imports and exports have equivalent value, and thus exports will always be able to purchase an equivalent amount of imports.
- And lastly, while not explicitly stated in the supporting documentation, the purpose of the denominator appears to be to normalize the size of the trade balance against their 'total material consumption'. This normalisation was likely done for the sake of international comparability; however, our proposed resource resilience indicator cannot be compared with the EU's because it is both conceptually different and uses a different working definition of the Material Footprint.

Breakdown and Tiers

Two different approaches to scaling down this indicator could be:

1. By type of material, which could provide information on the materials most critical for economic activity or national security.
2. By industry, evidencing which industries are most vulnerable to international shock and could require more domestic supply (preferably from cycled materials) or diversified supply chains.

Pros	Cons
• Can be derived from current Material Flow Account figures. • It is linked to a simple message that can be easily communicated. • It is more ambitious than the current EU indicator.	• It can be misleading on its own, and requires a thoroughly calculated cap to understand its limitations. • It differs from what the EU is measuring, making comparisons difficult.

7.1.10 Overseas Emissions Ratio

Overseas Emissions Ratio – [Emissions from RME Imports/ Input-Based GHG Emissions]

What proportion of the Scottish emissions are occurring overseas?
How important are the import supply chains in emissions?

One of the points that has been raised in the discussions so far is the relevance of including upstream (Scope 3) emissions in any calculations with GHG emissions. This consideration of offshored impacts is an important concept for contextualizing Scotland's progress to Net Zero. Including this indicator can inform both public and private procurement focused policies, such as incentives for businesses or industries to source inputs from lower impact supply chains.

This indicator needs to be interpreted with caution; however, as movements in both directions can be interpreted as either positive or negative changes. For example, if Scotland is decarbonising faster than its supplier nations, the indicator will rise; which could be incorrectly interpreted as increased offshoring unless movements in the resource resilience ratio are considered. Before a value judgement on a movement in this indicator is made, movements in the resource resilience ratio and the emission intensities of the material groups in the numerator and denominator of this indicator need to be considered. As Scotland approaches Net Zero, this indicator will trend toward a value of 1.

International Relevance
As carbon foot-printing methods and GHG protocols become more mature, every country will be aiming to measure both their territorial and extraterritorial emissions. It is only natural that, as many companies are already doing, the communication of those numbers will include indicators of the proportion between them.

Breakdown and Tiers
The same indicator can be applied to companies which are already measuring their emissions. And, as this practice becomes more prevalent, more accurate measurements will become available that can inform us of the most emissions intensive trading partners and industries.

Pros	Cons
• Easy to communicate without value judgments. • Central to informing Net Zero policy. • Is easily calculated.	• Scope 3 emissions for upstream supply chains can be difficult to accurately estimate. • Nuance interpretation of the indicator are needed to please value judgements on movements.

7.2 Transition Indicators

Transition indicators are those which will be useful in the short to medium-term to monitor the uptake of the circular economy. These are indicative of underlying behaviours and practices, and of proxies for progress. As such they are generally not themselves indicators of the expected beneficial outcomes of the circular economy.

7.2.1 Number of Companies publishing CE Strategies

Number of companies publishing CE strategies or sustainability reports considering circular business practices – [number count]

How aware is the private sector of circularity and its importance?
How engaged is the private sector in circular practices and in which sectors?

The redesign of business models, or emergence of new business models, is recognised in most circular economy frameworks as one of the key enabling factors for implementing circularity. Each company; depending on its sector, operating

model, products, impact and capabilities is responsible for determining their own roadmap to implement circular business models. From Product-as-a-Service offerings to a complete restructuring of supply chains favouring value retention, there are many different ways for business to engage in circular economy practices; which raises an issue in terms of measuring and monitoring circular activity.

One of the main goals of a circular economy strategy, is to encourage the participation and engagement of the private sector in the adoption of circular principles and practices. While one day circular activities will be codified commercially, that information is not yet available. Therefore, as an alternative, companies should be asked to include in their ESG reporting (regardless of the standards being used) an explicit mention of their approach to the circular economy. This would not only raise awareness on the issue of material consumption, but it would also highlight its importance and provide valuable information regarding the state of circularity within the private sector.

Rationale 5: Wales has proposed an indicator which counts signatories to its Business Wales 'Green Growth' pledge a measure of the uptake of sustainable (if not circular) thinking. Scotland might consider what standard of adoption by companies of circular strategy is appropriate. This might appeal to an as yet unknown international protocol, or one developed locally.

International relevance
In the OECD Inventory of Circular Economy Indicators and other frameworks and policies, there are different governance indicators that act as a proxy for private sector engagement. However, most of them are very specific to a region's strategy and are not replicable. The recently adopted Corporate Sustainability Reporting Directive (CSRD) will cover a range of environmental and social issues including circularity (66); it will also embrace such topics such as resource use and circular economy performance. The CSRD will be mandatory for around 50,000 companies in the EU from 2024.

Breakdown and Tiers
As with any information in the private sector, it is useful to have a breakdown of the figures by relevant business categories, such as industry or sector and size in terms of revenue. This can help analyse, for example, what industries are further ahead in their circular transition, and determine if any assistance should be provided to smaller companies, or particular sectors for building a circular economy strategy.

Pros	Cons
• It can use existing sustainability reporting frameworks, such as GRI, the 'Integrated Reporting Framework', or the Global e-Sustainability Initiative. Additionally, it can be addressed in non-financial materiality assessments (67) • It is a way to both engage and motivate the private sector	• Loose connection to results. • No guarantee that companies are being ambitious in their transition. • Increased scrutiny for companies may hinder their innovation. • Although information may be available. The use of different reporting methods may pose a challenge for producing the indicator.

7.2.2 Investment in circular economy projects or companies

Investment in circular economy projects or companies – [M£ per annum]

What level of resources have been dedicated to the transition to a circular economy?

Rationale 6: A real challenge of implementing this indicator lies in the definition of what is a circular economy project or company and how to correctly account for investments in them. For example, if an established company develops a circular product or service, how can investments in the target product line or business unit be distinguished from investments in the rest of the company. This may require some refinement of corporate and national accounting practices to properly differentiate, allocate and report such investments.

An alternative proxy for identifying how the circular economy is being pursued is through tracking where money is being invested in it: building facilities, adopting new business models, redesigning products, new business ventures and beyond. As new companies with innovative circular models emerge, the expectation is that more investment will be

channelled into them. This is particularly relevant in the early stages of adopting circular practices because investment will precede outcomes (financial and environmental), so commitment to the process of change is a likely precursor to these outcomes.

Rationale 7: Some nations have separated the tracking of private and public investment. The caution here is that reporting public funding might then raise expectation of a particular target funding level. Such an expectation – without time limits – presents a political hazard especially when the nature and level of investment is uncertain.

Amalgamating public and private spending would permit a more flexible, tactical approach to public investment in the light of other indicators.

A possible half-way house might be to provisionally target a percentage of, say, innovation funding for circular economy related projects.

Another aspect to take into account is the source of the resources for each case. If both private and public money is tracked and accounted for, then part of the transition expected with this indicator is to see initially more public funds as the systems and incentives are put in place for a circular transition. This might be expected to later reduce to a lower level, surpassed gradually by private capital as the economic case improves. This kind of thinking is reflected in initiatives such as the one from the European Investment Bank in 2019, which aimed to provide €10 billion in CE investments, but until 2023. As a reference, the types of projects recognised as eligible by the EIB are:

- Circular Design and Production
- Circular Use and Life Extension
- Circular Value Recovery
- Circular Support

International relevance
The EU counts private investments in their pool of CE indicators, and the OECD inventory considers it along other similar ones. However, there does not seem to be any indicator in mainstream frameworks that considers investments segmented into private and public sources. This differentiation could be important to monitor the extent to which the circular economy has become profitable for private enterprise as opposed to being purely supported by taxpayers.

Breakdown and Tiers
Again, as this tracks the investments made in companies and projects, distinctions between sectors and types of receiving companies can be useful for spotting gaps and opportunities. In this case, however, making that distinction by the source of the investments may be equally as important to informing policy and strategies.

Pros	Cons
• Good for informing policy opportunities and the effectiveness of current ones. • It is more closely linked to the desired effects of a CE strategy.	• No guarantee that companies are being ambitious in their transition. • Definitions and tracking systems are crucial for making this a useful indicator.

7.2.3 Percentage of Public Procurement with Circular Purchasing Criteria

% Public procurement with circular economy sourcing criteria – ['circular' spend /total spend, %]

How is the public sector setting example?
How can public spend influence circularity in the country?

Public procurement is widely recognised as one of the most effective ways that governments can influence market behaviours without requiring regulation. In the case of Scotland, the public sector spends over £13 billion annually in goods, services and works. Furthermore, Scotland's public procurement legislation creates a coordinated environment, (Figure 24) in which all public spend is ruled by consistent strategy and priorities (Figure 24). For the period between 2021 and 2024, one of the priorities is the Climate Emergency (including carbon reduction and circular economy) so there is already an explicit commitment to mobilise public spending towards CE.

In practice, the implementation of sustainable or circular sourcing criteria can take many different shapes. It can be as simple as a

light ESG factor checklist that a supplier must abide by; or it can be a comprehensive review of the goods/services to be purchased to reduce their impact. Additionally, different categories of public spend may intend to address different priorities and impacts; it is common, for example, for construction works to be one of the most representative categories in spending, and it is one in which it can be challenging to achieve a significant impact.

The reality is that an indicator for monitoring progress will not convey information about the nuances of different categories, types of contracts and suppliers. However, it is a good way of sending a message to the market and motivating procurement teams towards outcomes beneficial to the development of a circular economy.

Rationale 8: A known barrier to Total Cost of Ownership (TCO, total of costs incurred in purchasing, maintenance and disposal) criteria is the separation of capital purchasing functions from asset maintenance functions. Competing drives to minimise cost can result in sub-optimal outcomes from a financial and environmental perspective. TCO therefore requires procurement professionals of separate categories, as Capital Expenditure (assets) and Operations (facility management, maintenance) to work together and build joint business cases.

Another barrier is the perceived risk of servitised or remanufactured products. To some extent this can be offset when guarantees are in place or when assets remain the property of the supplier, but for 2nd life purchases, Scotland may need to consider standards or labelling schemes to ensure provenance of products or processes supporting the products.

Figure 24: Strategic drivers for public procurement in Scotland
Source: Annual Procurement Report 2020-2021 (68)

International relevance:
Almost all OECD countries have strategies or policies to support green public procurement; in the OECD inventory of CE indicators, public procurement is a whole subcategory with 18 different indicator variants. However, the level of sophistication of those indicators is not consistent: there seems to be a need for tightly defining circular and green procurement.

Breakdown and Tiers
Interrogation of procurement information relating to supplier practices may assist the Government in understanding how the adoption of circular practices is distributed across different types of suppliers. It may, therefore, provide supplementary insights into the uptake of circular practice according to, for example, organisation type, size and sector.

Pros	Cons
• Easy to communicate and available data sources • Can steer market behaviour and send a clear message	• Definitions need to be made and possibly tailored to different spend categories • The indicator doesn't necessarily mean the purchases being made are greener or circular, only that the criteria is being followed

7.2.4 Percentage of Circular Jobs

Percentage of Circular jobs – [number of circular jobs / total number of jobs]

Are circular initiatives materially impacting the labour market?
Are investments translating into correctly categorised jobs?

The creation and long-term feasibility of green, or circular, jobs is an important measure to keep track of because, in the different frameworks reviewed, it is the only mainstream indicator of social wellbeing commonly employed. In the transition to a circular economy, it is expected that domestic circular jobs related to re-use-type activities (re-use, remanufacture, repair, share) will start displacing offshore manufacturing jobs in the transition to a circular economy. Circular jobs should focus on these activities as indicators life extension and product use intensity increase.

Considering a transition from a linear to circular, even a fully developed circular economy will contain a large proportion of 'linear jobs', particularly in the supply chains of inherently dissipative goods such as personal hygiene products, paints, or fertilisers. It is therefore difficult to set a target for this indicator or apply an appropriate normalisation for comparisons. Moreover, with 'circular' being the norm, in the future this indicator would not provide further insight into the circular economy (this is noted in the commentary of the Welsh Beyond Recycling strategy (11)). As a result, we propose that this indicator be considered a transitional one which has use in the early phases of adoption in order to track adoption of circular practices as an economic opportunity by businesses. As described in a recent paper by the University of Warwick (69), every major international sustainable transition strategy calls for the creation of 'green jobs'. However, there is no consensus on how these jobs are defined (see Table 36 for examples); it is likely that this must be tailored to the characteristics of the local economy. Furthermore, tracking the number or proportion of these types of jobs in the economy doesn't really account for the quality, salary level, or overall job satisfaction.

Table 36: University of Warwick definitions of 'green' occupational categories

Green Occupation Category	Definition
New and Emerging	New occupations, created by the needs of the green economy.
Enhanced Skills and Knowledge	Occupations which need to enhance their skills in order to respond to the new green economy.
Increased Demand	Occupations that will not change substantially but will have increased demand due to the green economy.

International relevance
Green jobs or a similar indicator can be found in almost all frameworks. However, it is important to validate the definition of each before comparison, especially if the term Circular Job (which is not as mainstream as 'green') is being used.

Rationale 9: Despite the lack of consensus on 'green' jobs definition, for the purposes of this framework, we consider 'circular jobs' to be those associated primarily with re-use-type and recycling activities; jobs in decarbonised energy supply industry are not included (they generally form part of the 'green jobs' metric.) The value that materialises from the underlying circular activity will no doubt steer supporting action towards those activity types that offer most benefit to society.

Breakdown and tiers

There are several ways in which this indicator could be enhanced. One of the most useful would be by sector or industry as a way of detecting the leaders and laggards in the transition. Another easy and important segmentation is by gender, which is an important measure for UN SDG Number 5[19] and ther demographic categories.

Pros	Cons
• Simple and easy to communicate. • Show social benefit of the circular economy.	• Definitions may make it difficult to compare to other economies. • Changes in definitions can also make tracking it in the long term difficult.

7.2.5 Number of Training Courses related to Circular Activities at the Tertiary Level

In the different frameworks reviewed, some of the most common indicators that would qualify as 'transition indicators' in this categorisation, are around the areas of financing, awareness raising, capacity building and education. Taking a closer look at each of those, some quick conclusions can be reached.

Financing has been addressed already in the indicator 'Investment in circular economy projects or companies', and is also linked to public procurement. Europe in general, and the UK in particular are at the forefront of awareness raising in the topic of circular economy, so no indicator is proposed for this yet. Capacity building is of prime importance as a transition indicator, but from the different examples seen in the review, indicators on this front are usually specific to different sectors or industries; 'Number of companies publishing CE strategies' can be a proxy in a reduced indicator set such as this.

Rationale 10: Tertiary education is the most immediate source of transformational leadership exposed to circular thinking as a standardised practice. The following cohorts will too need induction into this mode of thinking. Therefore, a development of this indicator could measure the exposure of primary and secondary level pupils to 'sustainability'. For example, many secondary schools have lessons on 'global citizenship' or 'personal, social, health and economic education'. These seem appropriate vehicles for transferring new thinking in this field.

That leaves education as one of the main transition enablers that has not yet been addressed. In that sense, it is then necessary to determine at which level of education can more impact be created in a transition period. Thinking in the mid-century timeframe for international sustainability goals, the targets of interest are the decision makers of the period who will drive transitional change within business and society. Such leaders will be leaving tertiary education in the short to medium term. Therefore, an indicator that tracks instruction in circular economy and circular practices at tertiary level is an appropriate complement for the transition indicators in this set.

International relevance

Seen mostly in the OECD inventory, and some countries like Ireland and Costa Rica, indicators around CE education or training are not as mainstream or explicit at a national level as it could be expected. It is then, an opportunity to easily communicate progress in this area and send a message to education institutions.

Breakdown and tiers

This indicator does not provide many significant options for further tiers. However, drilling down to the types of institutions providing the training, or the courses to which they are linked (e.g. business or environmental sciences) can provide some useful insights.

Pros	Cons
• Simple and easy to communicate. • Show social benefit of the circular economy. • Send a message to the education sector.	• Difficult to link to any short-term outcome. • Doesn't contemplate the quality of the education.

[19] UN SDG 5

8 Indicator dashboard

The selected indicators are intended to be the headline (Tier 1) indicators of the proposed set. When mapped against the scaffold proposed in Figure 25, this set of indicators shows a substantially complete view of the different aspects of CE, but also highlights some areas of opportunities.

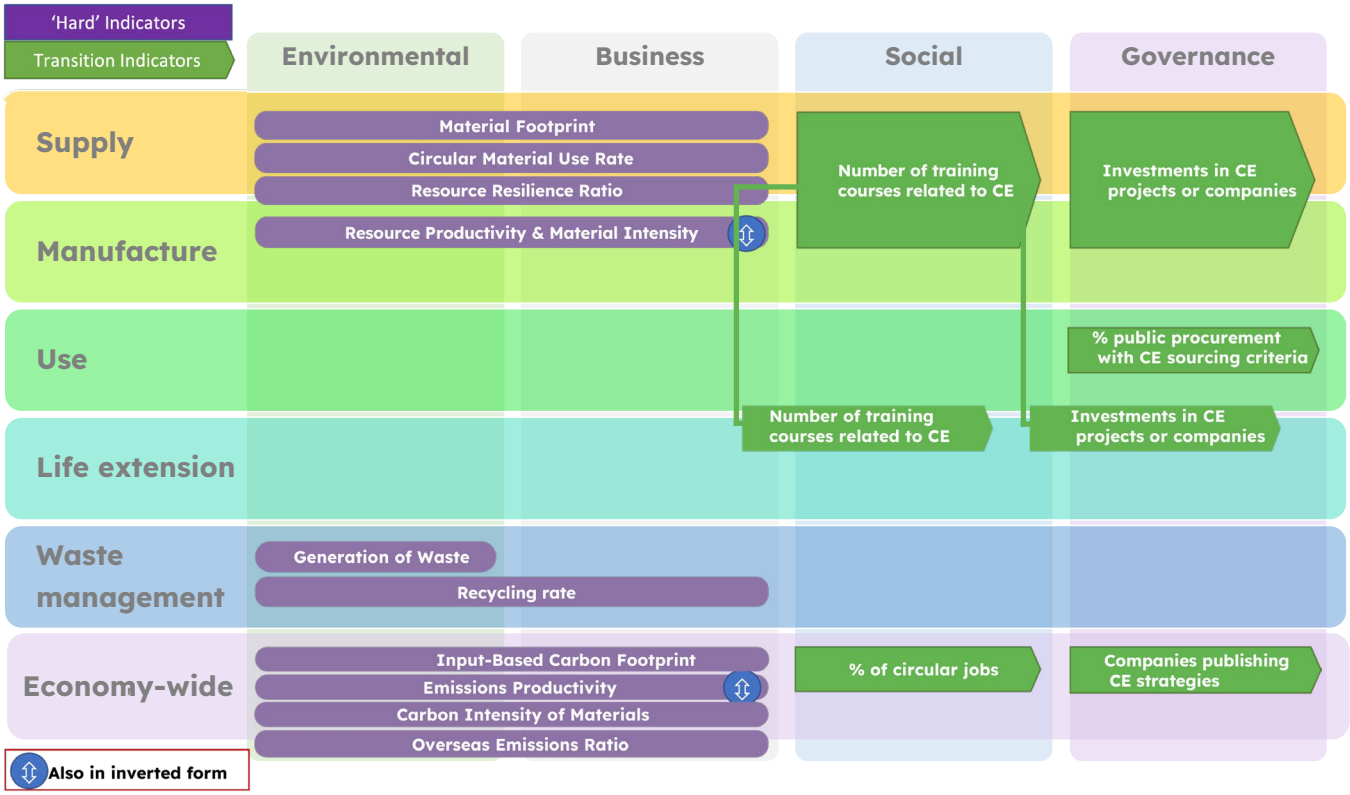


Figure 25: Map of proposed 'Hard' and 'Transitional' indicators for Scotland

Comparing with Figure 17 it is apparent that the proposed indicator set is strongly aligned with established policy objectives, particularly in the area of Environmental/Business related to the outcome measures, and under Governance. This reinforces the point that the indicator set builds on existing initiatives and indicators. It is also evident that the use and re-use phases are difficult to track as hard indicators; hopefully, this will be addressed in part with the prospective indicators.

These headline indicators compose the base Framework for measuring a circular economy. This framework should be continuously enhanced by indicators beyond the headline as follows:

- Transition indicators: Metrics and key ratios just below 'hard' level which are important in monitoring behaviour and practice shifts and guiding future action.
- Prospective indicators: Useful indicators but without a clear source of data for deriving them.
- Supporting (Tier 2) indicators: For drilling down into specific aspects. The ones mentioned in the discussion of each indicator are ideas based broadly on how useful they can be. The specific Tier 2 indicators that end up being selected should depend on the specific and explicit goals that will come from a Scottish CE strategy.
- Roadmap indicators: For the continuation of the objectives set in transition indicators; these may also require new data sources or processes and may vary in their timeframe.

The following table amalgamates both the dashboard indicators and the selected 'prospective' indicators alluded to in the discussions of indicator rationale and elsewhere. Some of these indicators may have an intuitive desired trend (e.g. CMUr going up), but the real importance lies in using them together to understand which are the root causes for certain behaviours and what opportunities they point to.

Table 37: Dashboard of 'Hard' , 'Transition' and 'Prospective' indicators for Scotland

Hard Indicators			
Indicator	**Data sources**	**Needed metrics**	**Supporting Indicators**
Material Footprint/Raw Materials Input	Scotland MFA	DE, RME IMP	RMI by sector and material
Input-based Carbon Footprint	Scottish Government GHG Statistics, Scotland MFAs, Scope 3 emissions from imports (TBD)	RMI, GHG emissions	Intrinsic Carbon by industry/sector
Circular Material Use Rate - CMUr	Scotland MFA	RMI, RCVr, IMPs, EXPs	CMUr by sector and material
Resource Productivity and Material Intensity	Scotland MFA, Scotland's Input-Output tables	GDP, RMI	RMI and GDP by sector and material
Emissions Productivity	Scottish Government GHG Statistics, Scotland's Input-Output tables	Territorial GHG emissions, extraterritorial GHG emissions, GDP	GHG emissions per GVA of different sectors
Carbon Intensity of Materials	Scotland's Input-Output Tables, Scotland's MFA, Scottish Government GHG Statistics	RMI, Territorial GHG emissions, Extraterritorial GHG emissions	Carbon intensities of specific materials or different sectors
Generation of Waste	Scotland MFAs	N/A	Municipal waste generation per capita, waste generation by type of material
Recycling Rate	Scottish Environment Protection Agency	Total recycling	Recycling rate excluding mineral waste, recycling rate of e-waste, recycling of biowaste, recovery rate of construction and demolition waste
Resource Resilience Ratio	Scotland MFA	RME, RMI	Resilience by type of material, resilience by industry

Overseas Emissions Ratio	Scottish Government GHG Statistics, Scope 3 emissions from imports (TBD)	Scope 3 emissions GHG Emissions, Resource Resilience Ratio. Carbon Intensity of Materials	Overseas emissions ratios at the sectoral level

Transition indicators			
Indicator	**Objective**	**Needed definitions/ data sources**	**Roadmap indicators**
Number of companies publishing CE strategies or sustainability reports considering circular business practices	Increase corporate engagement in the CE	Accepted reporting standards	Companies with PaaS models (adoption rates)
Investments in circular economy projects or companies	Capital injection in the CE enabling processes and technologies	Definition of what is considered a circular project or company	Return on Investment (ROI) of circular investments, investments made without public funding support
% of Public procurement with sustainable or CE sourcing criteria	Show government leadership and direction in sourcing	Sustainable procurement standards	TCO savings due to circular procurement practices
% of circular jobs	Track employment effects of new circular practices and businesses in the economy	Definition of what is considered a circular project or company	% of circular jobs by sector, labour productivity (GDP per FTE worker) by sector
Number of training courses related to Circular activities at tertiary level.	Track the level at which CE is being taught in universities	Definition of what training courses are considered to be related to circular activities.	Measure how embedded circular economy is at all levels of education, share/number of circular projects in innovation projects e.g. @InnovateUK

Prospective indicators	
Industrial re-use and repair rates	For assessing the penetration of circular models in industry. It could also include product as a service models.
Household re-use and repair rates	Initially this indicator would probably have to exclude vehicle maintenance and repair, as it could heavily skew the numbers.
Industrial waste (efficiency of industry measure)	For determining how efficient are industry processes in transforming materials e.g. re-using processing scraps on site and reducing inputs into processes.
Carbon and Material Footprint savings from re-use and repair	To determine the impact of more re-use and repair activities in terms of GHG emissions and Material Footprints.
Biodiversity impact domestically (and abroad)	This indicator is declared within the Scottish Environmental Strategy; methods to determine the contribution of CE amongst other initiatives will be needed.
Other environmental impacts	As yet unspecified, other impacts will attract more scrutiny as carbon reduction strategies are implemented and take effect.

Definitions:
RMI = Raw Material Input
RME = Raw Material Equivalents
RCV_R = Recycled waste in domestic operations
IMP_S = Imported secondary material
EXP_S = Exported secondary material
DE = Domestic Extraction

Rationale 11: There are diverse environmental impacts related to material extraction and processing; LCA analysis commonly reports multiple indicators. Typically, though, the focus is on carbon because that is the pressing concern, but also because the causality between circular activities and the impacts are poorly developed, except for carbon because it relates to energy use. As a rule of thumb, most critical impacts (land, biodiversity etc.) are associated with virgin material extraction and processing. Therefore, reducing virgin material use should result in environmental benefits directly even if not well quantified.

Finally, when all of these are laid out in the same framework as before, it is much more evident that they would provide a more holistic view of circular activity across different parts of the economy. It is important to recognise at this point that prospective and roadmap indicators cannot yet be implemented, so these gaps must be closed progressively as more data becomes available. In the same sense, any other opportunities or gaps should be addressed similarly, acknowledging that the circular economy is in an evolving state where any indicator set needs to be dynamic enough to accommodate new developments.

The entire set of immediate proposals (hard and transition) and long-term suggestions (prospective and roadmap) have been incorporated in the full mapping of Figure 25. Comparing this to the policy map in Figure 17, the coverage of indicators is virtually complete.

There are some gaps in the mapping, but there is no implication in the map that every cell must have a policy and indicator. For some cells, though, there is no obvious linkage between circular practice though this might change in future. For others, it could be argued that they are covered by another indicator. For example, under Social, the Courses at Tertiary Level is an indicator whose impacts may cut across not just Supply, but Manufacture and Life Extension since these are the points where such skills will be deployed.

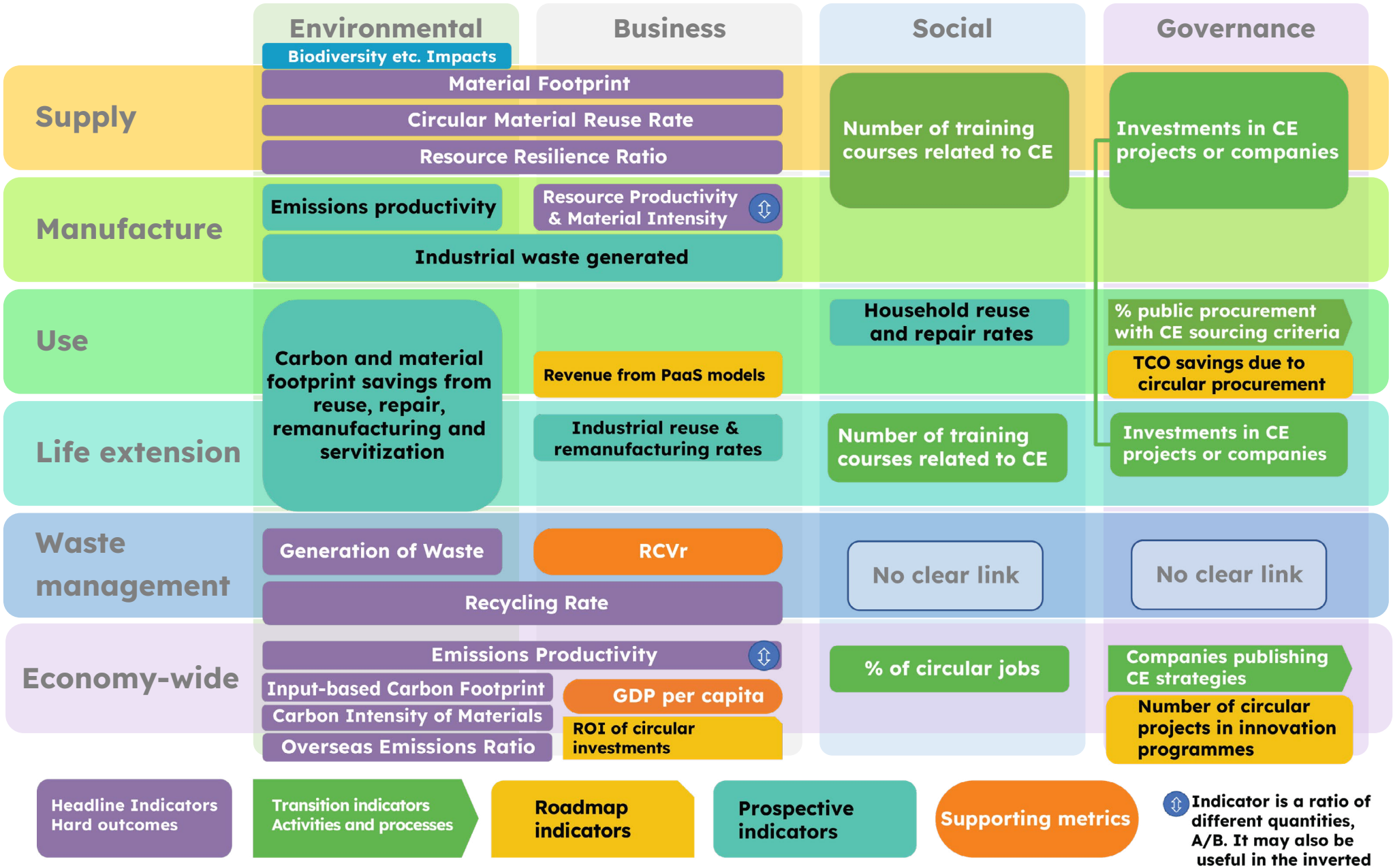


Figure 26: Complete map of short term and long-term suggestions for Scottish circular economy indicators

9 Data sourcing

Most of the indicators classified under Hard Indicators comprise either existing reported measurements or developments of those indicators which are already recognised and are being addressed. Other indicators, those in the Transition or Prospective categories, require data collection mechanisms to be defined, definitions of scope to be set, or conversion methodologies to be agreed (such as conversion of materials to carbon equivalents).

Table 38: Indicator data sourcing commentary for indicators

Hard Indicators	
Indicator	**Commentary on data sourcing and processing**
Material Footprint source data Carbon Footprint source data Circular Material Use Rate – CMUr Resource Productivity – GDP / RMI Emissions Productivity – GHG / GDP Carbon Intensity of Materials Generation of Waste Recycling Rate Resource Resilience Ratio Overseas Emissions Ratio	These indicators share some data sources which are already available: • Current Material Footprint data: Scotland Material Flow Accounts • GHG Emissions for scope 1 and 2: Scottish Greenhouse Gas Statistics • GDP: Scottish Government Economy Statistics • Recycling rates: Scottish Environment Protection Agency For scope 3 emissions there will be the new requirements both for more data collection and for accurate GHG emission factors for different materials and products, and according to their country of origin. Further segmentations by product or sector are probably needed.
Transition Indicators	
Indicator	**Commentary on data sourcing and processing**
Number of companies publishing CE strategies or sustainability reports considering circular business practices	A very direct approach to this may be the easiest way given the relative crudity of the measure. For example, periodically, assess the presence and quality of declared CE strategies by, say, the top 500 companies in the FTSE. These should be segmented by company size. Quality assessment should reward those strategies which undertake more long-term and fundamental changes to business models as opposed to simple waste reduction and recycling. Future developments of this analysis may need a more sophisticated assessment of the organisation's position in the supply chain, its ability to influence user behaviour in particular, and the durability of its products (virtual, long-lived or consumed). There needs to be a continuous assessment of how different reporting standards account for Circular Economy to determine if data can be easily found. The CSRD standard coming to the EU in 2024 will have explicit requirements for circular practices, so if its adoption permeates the UK it may be a good source.
Investments in circular economy projects or companies	For this, no distinction has been made between public and private contributions. Again, correct definition of the scope of what constitutes a CE project should be defined and should be compatible with similar considerations made for defining a circular job. Note that the correlation between investment and the strategy uptake as reported above may reveal whether actions are matching the words. There should be caution though that the dynamics of investment beyond the transition phase may make this indicator less favourable in the longer term.

% Public procurement with sustainable or CE sourcing criteria	Public procurement data sourcing depends on the collation of data from multiple public authorities including agencies, institutions and regional governments. The challenge is to fairly assign procurement spend to genuine CE actions. This will require development of criteria for what is in and out of scope. Note that efforts in 'Green' and 'Sustainable' public purchasing are already under way, so a good platform for this should already exist.
% of circular jobs	This has been estimated for Scotland before using a combination of its Input-Output tables and the Business Register and Employment Survey. If a new definition of what constitutes a circular job is developed, Scotland's Material Flow Account may be needed as well.
Number of training courses related to Circular activities at tertiary level.	Requires cooperation of Education Scotland and higher educational establishments to define minimum curriculum standards, count number of courses or modules in place and even the number of recipients of instruction. Segment by topic/target sector, for example.
Prospective indicators	
Indicator	**Commentary on data sourcing and processing**
Industrial re-use and repair rates	The objective is to assess, in particular, the shift towards adoption of circular business models, remanufacturing, repair and other re-use activities. This would be most easily done in financial terms through segmentation of SIC codes. Conversion to materials impact would require substantial factor development by sector and even by product class.
Household re-use and repair rates	This information, in financial form, is already collated and published as an interactive categorised spend map by ONS. One of the categories is related to automotive maintenance, which constitutes a large fraction of household spend (see Figure 27); this element is highly likely to reduce with the shift to electric vehicles due to expected lower maintenance costs. Therefore, this indicator should probably exclude vehicle maintenance and repair, as it could heavily skew the numbers.
Industrial waste (efficiency of industry measure)	Improvements to the waste reporting system are required to enable this. It may be prudent to exclude 'inert' and low value streams, as described in the hard indicators, but ensure that critical material streams are identified and segmented as appropriate.
Carbon and Material Footprint savings from re-use and repair	As a precursor, this requires information from the repair rates indicator above, then combination with the product/material related factors for carbon conversion. Further method development will be needed to generate specific factors for remanufacturing and for repair based on average scope of parts replacement or material inputs.

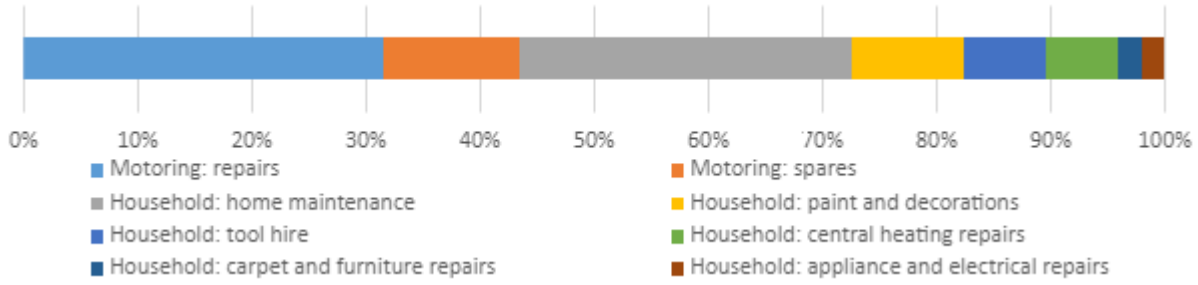


Figure 27: Breakdown of household spending on maintenance and repair
Source: Office of National Statistics[20]

[20] https://www.ons.gov.uk/

10 Next steps

10.1 Strategy and goal setting

The indicators presented in this report were derived from an international review but tailored to the Scottish reality based on the information that was found and inferred from the material described in Sections 4 and 5. However, for any indicator set to be truly useful, it is necessary that the strategy in which it is framed in is clear and has explicit goals. Having these goals clearly set out can correctly guide and inform any future indicator set.

The role that this set of indicators can allow thought provoking and ambition setting policy choices to be informed, and action to be prioritised on areas that will deliver a circular economy in Scotland.

10.2 Target Setting

For any set of indicators, a baselining exercise is needed to determine what is an appropriate benchmark for the value of those indicators at that time. Additionally, intermediate targets for different timeframes need to be determined and informed by a circular economy strategy.

10.3 Data sources and resources

The previous section was clear that the data sourcing and processing steps for a number of indicators, mainly those in the Transition and Prospective sets, have not been defined in detail. Further research is needed to identify potential data sources and estimate the costs of collection. This may involve exploration of whether similar data has been collected in other contexts, (e.g. those not related to circular economy) to capitalise on that learning.

A key target for engagement will be the business community. Many of the circularity actions require individual and concerted action from them. In compiling the proposals for the indicators, we created a scaffold aligned to modern business reporting. A key benefit of this is its use in communicating the parallels between the national targets and the underlying contributions to those targets and indicators by businesses and other reporting organisations. Even if this scaffold is not adopted, consideration is needed on how communication to and data flow from businesses could be improved in this field for carbon, materials (with key materials segmented) and other environmental priorities, as they achieve prominence.

The report has also identified that SIC codes are not uniformly adapted for reporting on the circular economy, since they are largely predicated on linear processes. The suggestion of increasing code segmentation to include alternative business models, at least, but preferably reporting activities related to all aspects of the re-use spectrum, should be investigated further.

10.4 Links and Causality

An important area for further research and exploration is to determine the causal relationships and other links between the CE and other social issues. As part of the broader sustainability agenda and due to conceptual connections, CE has been portrayed as being a solution (or part of the solution) to issues like inequality and biodiversity loss, amongst others. As circular practices gain traction (and market share) in different economies, there needs to be a critical review of those proposed links, to understand if they truly exist and of what magnitude they are.

10.5 Differentiating energy use from GHG emissions

Section 6.3 offered some discussion of the difference between territorial emissions and total emissions, the latter of which include impacts highly influenced by circular actions on product and material actions. The recommendation therefore centres on the indicators of total materials input and total GHG emissions. There was a further recommendation to explore separating the effects of energy supply decarbonisation (highly linked to territorial emissions) in order to discern the effectiveness of 'circular'

benefits of the economy. The commentary noted that it may be more fitting to track the energy use (terra joules) of the economy rather than GHG emissions, since the energy use will persist despite decarbonisation, but should track downwards with increasing circularity.

10.6 Awareness raising

Awareness raising is mentioned as an enabler of the circular economy (and any transition) in different frameworks. However, as mentioned in the discussion on education, Europe and the UK are considered to be in a good place regarding public awareness in this space. However, some work is likely required to test and adapt language and messaging so that the objectives, priorities and actions by individual stakeholders resonate with them.

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Annex A: National CE visions collated by Finland

Circular economy throughout the world: circular economy visions of different countries

Source: circular economy websites from each country

#	COUNTRY	VISION	FOCUS AND GOALS
1	DENMARK	*"BECOMING THE STATE OF GREEN"*	• Environmental focus, vision does not focus on the circular economy per se, but more broadly on resource wisdom • Top goal: Denmark has decided to be the first country in the world to transition into an economy that is entirely independent from fossil fuels by the year 2050
2	HOLLAND	*"A GLOBAL HOTSPOT FOR CIRCULAR ECONOMY IN 2016"*	• The vision is campaign-based and tied to Holland's EU Presidency in 2016 • The focus of the campaign and approach is particularly on success stories and events. In addition to this, a programme for promoting a circular economy has been launched in Holland, focusing on, for example, improving the technological requirements for circular economy, eliminating barriers and increasing knowledge and awareness • Waste and eco-planning are the focus of regulation
3	SCOTLAND	*"MAKING THINGS LAST"*	• Scotland is focusing its circular economy strategy on four different areas: 1) Food and drink; 2) Remanufacture; 3) Construction and the built environment; and 4) Energy infrastructure • Waste management is a key focus uniting all four areas: Scotland's goal is that 70% of all waste generated will be recycled by the year 2025
4	CANADA	*"A STRONGER, CLEANER ECONOMY THAT BUILDS A BETTER FUTURE FOR ALL CANADIANS"*	• The circular economy roadmap in Canada: "Smart Prosperity" (2016) • A holistic and broad focus: "smart welfare" means a healthy economy, a healthy environment and high quality of life, into which top goals and methods are incorporated; e.g. "In 2020, Canada will be seen all over the world as a model country, which combines environmentally-friendly economic management with economic success"
5	LUXEMBOURG	*"A KNOWLEDGE CAPITAL AND TESTING GROUND FOR THE CIRCULAR ECONOMY"*	• A circular economy roadmap commissioned by the Luxembourg Ministry of the Economy in 2014; the primary focus is economic competitiveness, employment and improving the state of the environment • In particular, the roadmap describes the potential of the circular economy quite comprehensively in different areas and from different viewpoints. However, the actual goals are primarily at the top level; the roadmap identifies the need for more detailed roadmaps and goals
6	SWEDEN	*"SWEDEN WILL BE A WORLD LEADER IN THE INNOVATIVE AND SUSTAINABLE INDUSTRIAL PRODUCTION OF GOODS AND SERVICES"* [1]	• Sweden does not currently have an actual roadmap or vision for a circular economy. It aims to realise its "Smart Industry" vision through four main areas: 1. Industry 4.0 (Exploiting the potential of digitalisation) 2. Sustainable production 3. Industrial skills boost (Ensuring industrial competences) 4.Test bed Sweden (Creating attractive innovations)
7	JAPAN	*NO ACTUAL VISION, BUT JAPAN IS CONSIDERED A RECYCLING PIONEER IN THE WORLD.*	• Japan currently does not have an actual circular economy roadmap or vision. Japan is a pioneer in recycling, as there is very little space and a lack of raw materials in the country • Japan has focused its efforts particularly on waste management regulation, and the country has enacted revolutionary waste legislation, which often takes the entire product lifecycle into consideration. For example, each person purchasing a vehicle in Japan is required to pay for its recycling
8	AUSTRALIA	*NO ACTUAL VISION, BUT STRATEGIC STEPS HAVE BEEN TAKEN TOWARD THE CIRCULAR ECONOMY IN THE STATE OF SOUTH AUSTRALIA.*	• The new Waste Strategy 2015–2020 focuses on the recycling of landfill waste as well as material and resource efficiency. • Newly formed state government organisation Green Industries SA, whose purpose is to monitor implementation of the waste strategy. • The new Climate Change Strategy, so that the state can achieve its zero net emissions target by the year 2050

Annex B: Annex B Japan's full indicator set from the 4th Fundamental Plan

Exhibit 2　Indicators and Numerical Targets for the Establishment of a Sound Material-cycle Society

Boldface: Primary indicators; Fine letters: Supplementary indicators; ※: New indicators added to the Fourth Fundamental Plan

Indicator		Numerical target	Target year	Remarks		
Overall picture of a sound material-cycle society	Inlet	Material flow indicator	**Resource productivity** [1]	**Approx. 490,000 yen/ton**	**FY2025**	
			Resource productivity excluding the input of non-metallic mineral resources [69]	Approx. 700,000 yen/ton	FY2025	
			Resource productivity in terms of primary resources converted [70]	—	—	
			※ Consumption of natural resources [71]	—	—	Comparison and verification with the corresponding SDG indicator
			Per-capita consumption of natural resources in terms of primary resources converted [54]	—	—	Comparison and verification with the corresponding SDG indicator
	Circulation	Material flow indicator	**Cyclical use rate at inlet** [2]	**Approx. 18%**	**FY2025**	
			Cyclical use rate at outlet [45]	**Approx. 47%**	**FY2025**	
			Cyclical use rate at outlet for municipal waste [72]	Approx. 28%	FY2025	Basic Waste Management Policy [53]
			※ Cyclical use rate at outlet for municipal waste for industrial waste [73]	Approx. 38%	FY2025	Basic Waste Management Policy
	Outlet	Material flow indicator	**Final disposal amount** [3]	**Approx.13 million tons**	**FY2025**	
			※ Generation of municipal waste	Approx. 38 million tons	FY2025	Basic Waste Management Policy
			※ Final disposal amount of municipal waste	Approx. 3.2 million tons	FY2025	Basic Waste Management Policy
			※ Generation of industrial waste	Approx. 390 million tons	FY2025	Basic Waste Management Policy
			Final disposal amount of industrial waste	Approx. 10 million tons	FY2025	Basic Waste Management Policy

Indicator		Numerical target	Target year	Remarks		
Integration of efforts toward creating a sound material-cycle society into those for a sustainable society	Integration of efforts toward environmental and economic considerations	Material flow indicator by objective	※ Resource productivity based on the consumption of natural resources in terms of primary resources converted [74]	—	—	Comparison and verification with the corresponding SDG indicator
			※ Resource productivity by industry (in terms of primary resources converted)	**—**	**—**	
		Effort indicator by objective	**Market size of business related to sound material-cycle society business**	**Almost double from FY2000**	**FY2025**	
			Number of business operators that have set goals towards improving resource productivity	—	—	
	Integration of efforts toward environmental and social considerations	Material flow indicator by objective	**※ Generation of household food loss**	**Decrease by half from FY2000**	**FY2030**	**Comparison and verification with the corresponding SDG indicator**
			※ Generation of commercial food loss	**To be set in the basic policy for the Food Recycling Act**		**Comparison and verification with the corresponding SDG indicator**
		Effort indicator by objective	※ Ratio of consumers who are aware of the issue of food loss and working on its reduction, as found in a consumer awareness survey	—	—	SDGs Implementation Guiding Principles
	Integration of efforts toward cyclical use and low-carbon	Material flow indicator by objective	Resource productivity of fossil resources [75]	—	—	
			Emission of greenhouse gas from the waste sector	**—**	**—**	
			Reduction of greenhouse gas emissions from other sectors through the utilization of waste as raw materials and fuel as well as sources for power generation [46]	**—**	**—**	
			※ Domestic shipment of biomass plastics	1.97 million tons	FY2030	Plan for Global Warming Countermeasures
			※ Amount of municipal plastic waste incinerated (dried basis)	2,458, 000 tons	FY2030	Plan for Global Warming Countermeasures

Indicator		Numerical target	Target year	Remarks		
			※ Cyclical use rate at outlet by type of waste, etc. (biomass [15])	—	—	
			※ Amount of RPF produced	1,003,000 tons	FY2030	Plan for Global Warming Countermeasures
		Effort indicator by objective	**※ Average power generation efficiency of garbage incineration facilities constructed or improved during the specified period [47]**	**21%**	**FY2022**	**Waste Treatment Facility Preparation Plan**
			Capacity of waste power generation, total waste power generation	—	—	
			※ Amount and rate of waste heat utilized	—	—	
	Integration of efforts toward cyclical use and harmony with nature	Material flow indicator by objective	**Ratio of domestically-produced biomass resources to total natural resources input [48]**	**—**	**—**	
			※ Amount of fuel wood utilized	8 million tons	FY2025	Basic Plan for Forest and Forestry
			※ Cyclical use rate at outlet by type of waste, etc. (biomass)	—	—	The same indicator as that which appeared earlier but this time for biomass
		Effort indicator by objective	※ Amount of natural stock (area of forests)	—	—	SDGs Implementation Guiding Principles
			※ Growing stock of forests	—	—	SDGs Implementation Guiding Principles
			※ Area of forests protected by law	—	—	SDGs Implementation Guiding Principles
			※ Area of forests for which specific forest management plans are formulated	**—**	**—**	**SDGs Implementation Guiding Principles**
			※ Self-sufficiency rate of wood supply	—	—	
			※ Certification regarding sustainable use of resources acquired [76]	—	—	
Formation of diverse regional circulating and ecological sphere		Material flow indicator by objective	※ Generation of municipal waste	Approx. 38 million tons	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier

Indicator	Numerical target	Target year	Remarks		
		Cyclical use rate at outlet for municipal waste	Approx. 28%	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier
		※ Final disposal amount of municipal waste	Approx. 3.2 million tons	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier
		※ Generation of industrial waste	Approx. 390 million tons	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier
		※ Cyclical use rate at outlet for municipal waste for industrial waste	Approx. 38%	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier
		Final disposal amount of industrial waste	Approx. 10 million tons	FY2025	Basic Waste Management Policy; the same indicator as that which appeared earlier
		Per-capita waste generation per day [49]	**Approx. 850 g/person/day**	**FY2025**	
		Per-capita household waste generation per day [50]	**Approx. 440 g/person/day**	**FY2025**	**Basic Waste Management Policy**
		Business waste generation [51]	**Approx. 1.1 million tons**	**FY2025**	
	Effort indicator by objective	※ **Number of local governments working on the formation of regional circulating and ecological sphere[52]**	**—**	**—**	
		Number of fundamental recycling plans drawn up by local governments	—	—	
		Ratio of local governments providing household waste collection for a fee	—	—	

Indicator	Numerical target	Target year	Remarks		
		※ Number of prefectures and municipalities with biomass utilization promotion plans in place	47 prefectures and 600 municipalities	FY2025	Basic Act for the Promotion of Biomass Utilization
		※ Number of municipalities selected as biomass industrial cities	—	—	
Thorough circulation of resources throughout the lifecycle of goods and services	Material flow indicator by objective	**Per-capita consumption of natural resources in terms of primary resources converted**	**—**	**—**	**The same indicator as that which appeared earlier; comparison and verification with the corresponding SDG indicator**
		Cyclical use rate at outlet	**Approx. 47%**	**FY2025**	**The same indicator as that which appeared earlier**
		※ Resource productivity by industry (in terms of primary resources converted)	—	—	The same indicator as that which appeared earlier
		※ Input of renewable resources	—	—	
		※ Cyclical use rate at inlet for each of the four types of resources [56]	—	—	
		※ Generation of waste, etc. by type	—	—	
		※ Cyclical use rate at outlet by type of waste, etc.	—	—	
		※ Cyclical use rate at outlet by material/product	—	—	
		Reuse rate of bottles	—	—	
		※ Final disposal amount by type of waste, etc.	—	—	
		※ Amount of material stock by material/product	—	—	

Indicator		Numerical target	Target year	Remarks		
			Recycling rate of specified home appliances	Air conditioner 80%; TV (CRT) 55%; TV (LCD/PDP) 74%; refrigerator/freezer 70%; washing machine/clothes dryer 82%	In or after FY2015	Home Appliance Recycling Act
			Rate of specified home appliances waste collected	56% in the total of all the specified items	FY2018	Basic policy for Home Appliance Recycling Act
			Recycling rate of the specified items generated from end-of-life vehicles	Automobile shredder residue 70%; airbag-related products 85%	In or after FY2015 for the automobile shredder residue target	Automobile Recycling Act
		Effort indicator by objective	※ Rate of materials added to stock [77]	—	—	
			Average use years of durable consumer goods	—	—	
			Rate of refills/replacements shipped	—	—	
			Market size of reuse	**—**	**—**	
			Market size of sharing (car sharing [55] etc.)	**—**	**—**	
			※ Number of registered members of major online platforms for C-to-C reuse	—	—	
			Implementation rate of green purchasing [58]	—	—	
			Number of Eco-Action 21 [78] certifications issued	—	—	
			Publication rate of environmental reports [65]	—	—	
			Development of guidelines for product assessment (design for environment) by industries	**—**	**—**	
	Plastics	Material flow indicator by objective	※ Generation of waste, etc. by type (plastic waste)	—	—	The same indicator as that which appeared earlier

Indicator		Numerical target	Target year	Remarks		
			※ Amount of plastic container and packaging waste sorted and collected	—	—	Container and Packaging Recycling Act
			※ Cyclical use rate at outlet by type of waste, etc. (plastic waste)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Domestic shipment of biomass plastics	1.97 million tons	FY2030	The same indicator as that which appeared earlier; Plan for Global Warming Countermeasures
			※ Amount of municipal plastic waste incinerated (dried basis)	2,458,000 tons	FY2030	The same indicator as that which appeared earlier; Plan for Global Warming Countermeasures
			※ Final disposal amount by type of waste, etc. (plastic waste)	**—**	**—**	**The same indicator as that which appeared earlier**
		Effort indicator by objective	Ratio of people carrying their own shopping bags instead of using shops' plastic bags	—	—	
			※ Number of local governments collecting containers and packaging, and ratio of consumers sorting and otherwise properly discharging their waste to the total population (plastics)	—	—	Container and Packaging Recycling Act
	Biomass (food, wood, etc.)	Material flow indicator by objective	**※ Generation of household food loss**	**Decrease by half from FY2000**	**FY2030**	**The same indicator as that which appeared earlier**
			※ Generation of commercial food loss	**To be set in the basic policy for the Food Recycling Act**		**The same indicator as that which appeared earlier**
			※ Targets for the control of food waste generation [79]	Targets set by public notice issued under the Food Recycling Act	FY2019	

Indicator		Numerical target	Target year	Remarks		
			※ Cyclical use rate at inlet for each of the four types of resources (biomass)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Cyclical use rate at outlet by type of waste, etc. (biomass)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Amount of fuel wood used	8 million tons	FY2025	The same indicator as that which appeared earlier; Basic Plan for Forest and Forestry
			※ Final disposal amount by type of waste, etc. (biomass)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Amount of paper container and packaging waste sorted and collected	—	—	Container and Packaging Recycling Act
		Effort indicator by objective	※ Number of local government members of the National Oishii Tabekiri Campaign Network Conference	—	—	
			※ Ratio of consumers who are aware of the issue of food loss and are working on its reduction, as found in a consumer awareness survey	—	—	SDGs Implementation Guiding Principles; the same indicator as that which appeared earlier
			Implementation rate of recycling of cyclical food resources	**Food processing 95%; food wholesale 70%; food retail 55%; food service 50%**	**FY2019**	**Food Recycling Act**
			※ Number of local governments collecting containers and packaging, and ratio of consumers sorting and otherwise properly discharging their waste to the total population (paper)	—	—	Container and Packaging Recycling Act

Indicator		Numerical target	Target year	Remarks		
	Metals	Material flow indicator by objective	**※ Cyclical use rate at inlet for each of the four types of resources (metals)**	**—**	**—**	**The same indicator as that which appeared earlier**
			Cyclical use rate of metal resources at inlet based on the TMR indicator, which includes hidden flows [80]	—	—	
			※ Cyclical use rate at outlet by type of waste, etc. (metals)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Final disposal amount by type of waste, etc. (metals)	**—**	**—**	**The same indicator as that which appeared earlier**
			※ Amount of waste compact rechargeable batteries collected and their recycling rate	—	—	
			Amount of small waste electrical and electronic equipment collected	140,000 tons/year	FY2018	Basic policy for the Small Home Appliance Recycling Act
			Amount of small waste home appliances collected and recycled by approved businesses	—	—	
		Effort indicator by objective	Number of local governments collecting small waste electrical and electronic equipment, and ratio of consumers sorting and otherwise properly discharging their waste to the total population	—	—	Basic Waste Management Policy
	Earth and rocks, construction materials	Material flow indicator by objective	**※ Cyclical use rate at inlet for each of the four types of resources (non-metallic minerals)**	**—**	**—**	**The same indicator as that which appeared earlier, but this time for non-metallic minerals**
			※ Amount of glass container and packaging waste sorted and collected	—	—	Container and Packaging Recycling Act
			※ Cyclical use rate at outlet by type of waste, etc. (non-metallic minerals)	**—**	**—**	**The same indicator as that which appeared earlier, but this time for non-metallic minerals**

Indicator		Numerical target	Target year	Remarks		
			Recycling rate of specified construction waste [81]	Set for each type of waste	FY2018	Construction Recycling Act
			※ Final disposal amount by type of waste, etc. (non-metallic minerals)	**—**	**—**	**The same indicator as that which appeared earlier, but this time for non-metallic minerals**
		Effort indicator by objective	※ Number of local governments collecting container and packaging waste, and ratio of consumers sorting and otherwise properly discharging their waste to the total population (glass)	—	—	Container and Packaging Recycling Act
			※ Establishment rate of life extension plans for individual facilities (individual facility plan)	**100%**	**FY2020**	**Priority Plan For Infrastructure Development**
			※ Ratio of long-life quality housing to new housing total	20%	FY2025	Basic Plans for Living (national plans)
	Products and materials introduced widely as a measure against global warming	Effort indicator by objective	※ Reuse rate and recycling rate of solar panels	—	—	
			※ Number of verification projects regarding the 3Rs for newly diffused products	—	—	
Continued promotion of proper waste treatment and environmental restoration	Continued promotion of proper waste treatment	Material flow indicator by objective	**Amount of illegal dumping**	**—**	**—**	
			※ Amount of waste treated improperly	**—**	**—**	
			※ Amount of asbestos waste (intermediate treatment, final disposal)	—	—	
			※ Amount of mercury waste (intermediate treatment, final disposal)	—	—	
		Effort indicator by objective	**Number of illegal dumping cases**	**—**	**—**	
			※ Number of improper waste treatment cases	**—**	**—**	

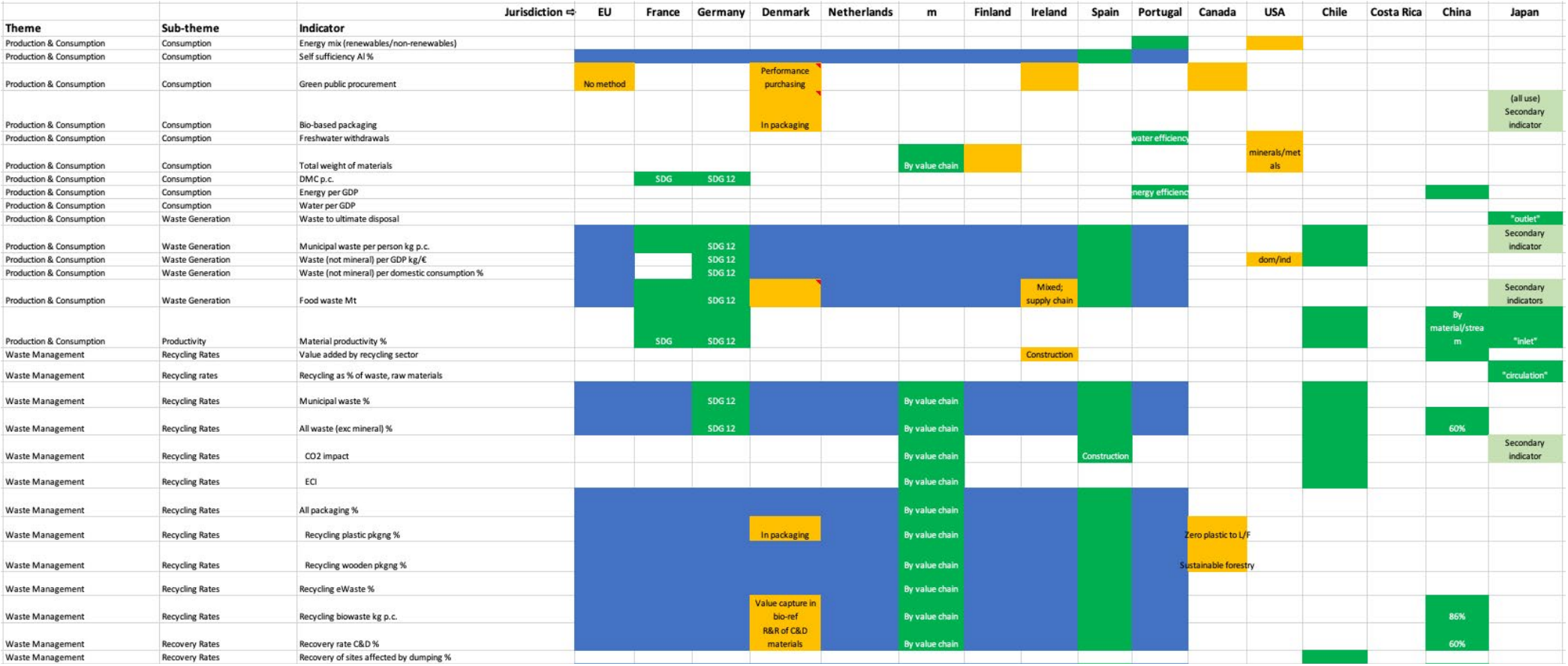
Indicator		Numerical target	Target year	Remarks		
			※ Number of asbestos waste treatment facilities (intermediate treatment, final disposal)	—	—	
			※ Number of mercury waste treatment facilities (intermediate treatment, final disposal	—	—	
			Number of industrial waste disposal businesses approved as high quality	—	—	
			Diffusion rate of electronic manifests [38]	**70%**	**FY2022**	
			※ Number of remaining sustainable years of municipal waste final disposal sites [57]	**Maintain the same level as in FY2017 (20 years)**	**FY2022**	**Waste Treatment Facility Preparation Plan**
			※ Number of remaining sustainable years of industrial waste final disposal sites	**Number of years required for the final disposal of 10 years' worth of waste volume**	**FY2020**	**Basic Waste Management Policy**
	Environmental restoration	Material flow indicator by objective	**Amount of illegal dumping**	**—**	**—**	The same indicator as that which appeared earlier
			※ Amount of waste treated improperly	**—**	**—**	The same indicator as that which appeared earlier
		Effort indicator by objective	**Number of illegal dumping cases**	**—**	**—**	The same indicator as that which appeared earlier
			※ Number of improper waste treatment cases	**—**	**—**	The same indicator as that which appeared earlier
			※ Number of municipalities with plans for abandoned houses, etc. in place to the total number of municipalities	Approx. 80%	FY2025	Basic Plans for Living (national plans))
Development of a well-planned framework for disaster waste management		Effort indicator by objective	**※ Ratio of local governments with a disaster waste management plan in place** [82]	**Prefectural governments: 100% Municipalities: 60%**	**FY2025**	**Fundamental Plan for National Resilience**

Indicator		Numerical target	Target year	Remarks		
			※ Ratio of facilities whose operations can be resumed in the event of a disaster [83]	50%	FY2025	Fundamental Plan for National Resilience
			※ Ratio of waste incineration facilities taking measures against deterioration [84]	85%	FY2025	Fundamental Plan for National Resilience
			※ Rate of progress in the construction of temporary disaster waste storage facilities [85]	70%	FY2025	Fundamental Plan for National Resilience
			※ Implementation rate of training regarding disaster waste [86]	Prefectural governments: 80% Municipalities: 60%	FY2025	Fundamental Plan for National Resilience
			※ Ratio of major cities discussing measures for the management of hazardous waste in the event of a disaster [87]	100%	FY2025	Fundamental Plan for National Resilience
Development of proper international framework for circulation of resources and overseas expansion of waste management and recycling industries	Development of proper international framework for circulation of resources	Material flow indicator by objective	Amount of circulative resources exported/imported [14]	—	—	
			※ Amount of secondhand goods exported/imported	—	—	
		Effort indicator by objective	※ Prices of circulative resources exported/imported	—	—	
			※ Number of nations with which a memorandum of understanding or other agreement on environmental cooperation (including that for resource circulation) is signed	—	—	
	Promotion of the overseas expansion of waste management and recycling industries	Effort indicator by objective	**※ Number of projects of overseas expansion of waste management and recycling industries**	**—**	**—**	
			Number of local governments collaborating with overseas cities regarding the creation of a sound material-cycle society	—	—	

Indicator		Numerical target	Target year	Remarks		
Development of infrastructure in the area of recycling	Development of information infrastructure in the area of recycling	Effort indicator by objective	**Diffusion rate of electronic manifests**	**70%**	**FY2022**	**The same indicator as that which appeared earlier**
	Technological development and utilization and application of the latest technologies in the area of recycling	Effort indicator by objective	**※ Ratio of research projects with the result of ex-post evaluation being S or A in the Environment Research and Technology Development Fund (ERTDF) program (sound material-cycle field)**	**—**	**—**	
			※ Number of supported research projects	—	—	
	Development of human resources as well as dissemination and enlightenment in the area of recycling	Effort indicator by objective	**Reduction of waste generation and awareness for cyclical use and green purchase**	**Approx. 90%**	**FY2025**	
			Implementation rate of specific 3R actions	**Increase by approx. 20% from the FY2012 poll**	**FY2025**	
			※ Ratio of consumers who are aware of the issue of food loss and are working on its reduction, as found in the Basic Survey on Consumer Life	—	—	SDGs Implementation Guiding Principles; the same kind of indicator as that which appeared earlier

Source: The 4th Fundamental Plan for Establishing a Sound Material-Cycle Society 2018 (53)

Annex C. Graphical summary of reviewed nation indicator coverager (simplified)



Theme	Sub-theme	Indicator	Jurisdiction ⇨ EU	France	Germany	Denmark	Netherlands	m	Finland	Ireland	Spain	Portugal	Canada	USA	Chile	Costa Rica	China	Japan
Production & Consumption	Consumption	Energy mix (renewables/non-renewables)																
Production & Consumption	Consumption	Self sufficiency AI %																
Production & Consumption	Consumption	Green public procurement	No method			Performance purchasing												
Production & Consumption	Consumption	Bio-based packaging				In packaging												(all use) Secondary indicator
Production & Consumption	Consumption	Freshwater withdrawals										water efficiency						
Production & Consumption	Consumption	Total weight of materials						By value chain						minerals/metals				
Production & Consumption	Consumption	DMC p.c.		SDG	SDG 12													
Production & Consumption	Consumption	Energy per GDP										nergy efficiency						
Production & Consumption	Consumption	Water per GDP																
Production & Consumption	Waste Generation	Waste to ultimate disposal																"outlet"
Production & Consumption	Waste Generation	Municipal waste per person kg p.c.			SDG 12													Secondary indicator
Production & Consumption	Waste Generation	Waste (not mineral) per GDP kg/€			SDG 12									dom/ind				
Production & Consumption	Waste Generation	Waste (not mineral) per domestic consumption %			SDG 12													
Production & Consumption	Waste Generation	Food waste Mt			SDG 12					Mixed; supply chain								Secondary indicators
Production & Consumption	Productivity	Material productivity %		SDG	SDG 12												By material/stream	"inlet"
Waste Management	Recycling Rates	Value added by recycling sector								Construction								
Waste Management	Recycling rates	Recycling as % of waste, raw materials																"circulation"
Waste Management	Recycling Rates	Municipal waste %			SDG 12			By value chain										
Waste Management	Recycling Rates	All waste (exc mineral) %			SDG 12			By value chain									60%	
Waste Management	Recycling Rates	CO2 impact						By value chain			Construction							Secondary indicator
Waste Management	Recycling Rates	ECI						By value chain										
Waste Management	Recycling Rates	All packaging %						By value chain										
Waste Management	Recycling Rates	Recycling plastic pkgng %				In packaging		By value chain					Zero plastic to L/F					
Waste Management	Recycling Rates	Recycling wooden pkgng %						By value chain					Sustainable forestry					
Waste Management	Recycling Rates	Recycling eWaste %						By value chain										
Waste Management	Recycling Rates	Recycling biowaste kg p.c.				Value capture in bio-ref		By value chain									86%	
Waste Management	Recovery Rates	Recovery rate C&D %				R&R of C&D materials		By value chain									60%	
Waste Management	Recovery Rates	Recovery of sites affected by dumping %																

Notes: Green fill: method in place; light green fill: secondary indicator; blue fill: EU indicators; amber fill: method not in place
BM: business model; IP: intellectual property; ECI: Environmental Cost Indicator; OSM: off-site manufacturing; RRR: re-use, recycling and recovery;

		Jurisdiction ⇨	EU	France	Germany	Denmark	Netherlands	m	Finland	Ireland	Spain	Portugal	Canada	USA	Chile	Costa Rica	China	Japan
Theme	**Sub-theme**	**Indicator**																
Secondary RM	Demand	As fraction of demand - r/c input AI %															Absolute target for steel/paper/non-ferrous	
Secondary RM	Demand	As fraction of demand - r/c input all (circ rate) %																
Secondary RM	Supply	Imports from non-EU t																
Secondary RM	Supply	Exports to non-EU t																
Secondary RM	Supply	Intra-EU trade t																
Competitiveness & Innovation	Private Investment	As fraction of GDP - Investment in tangible goods %	%	%	%	%	%	%	%	%	%	%						
Competitiveness & Innovation	Private Investment	As fraction of total employment - Persons employed %	%	%	%	%	%	%	%	%	%	%			Absolute			
Competitiveness & Innovation	Private Investment	As fraction of GDP - Value added at factor cost																
Competitiveness & Innovation	IP investment	Number of patents related to RRR																
Competitiveness & Innovation	BM Investment	Remanufacturing and new BMs				of machinery							VRP strategy					
Competitiveness & Innovation	BM Investment	Sharing/multipurposing				of buildings												Secondary indicator
Competitiveness & Innovation	BM Investment	OSM and 3D printing				of buildings												
Competitiveness & Innovation	BM Investment	Market size of 'circular' business (reuse etc)																Secondary indicator
Competitiveness & Innovation	Business	Ecodesign uptake		Via ecolabel						Packaging								
Competitiveness & Innovation	Business	Value added to economy																
Social foundation	Mixed indicator set	Multiple indicators						Multiple 'soft' survey								Secondary indicator		Secondary indicator
Social foundation	Jobs	Jobs as fraction of all jobs - number of 'circular' jobs %												Absolute jobs				
Social foundation	Wellbeing	Health and wellbeing						Multiple 'soft' survey						Mixed				
Auxilliary	Use intensity	Car-sharing																Secondary indicator
Auxilliary	Use intensity	Household spending on repair																
Environment	Ecology	Number of industrial and territorial ecology projects														Secondary indicator		
Environment	Ecology	Areas of forest under management plan											Sustainable mgt					Secondary indicator
Environment	Ecology	Land use										ban rehabilitati						
Environment	Ecology	Various impacts												Mixed				
Governance	Skills investment	Number of CE researchers / courses														Secondary indicator		
Governance	Innovation	Investment in research											For new processes			Secondary indicator		
Governance	Innovation	No. of innovation projects and related														Secondary indicator		
Governance	Infrastructure	Number of LAs with recycling networks														Secondary indicator		Secondary indicator
Governance	Obligations & commitments	Mixed measures re EPR, liability, lifetime support																

ZERO WASTE SCOTLAND

OAKDENE HOLLINS

CE-HUB
UKRI National Interdisciplinary Circular Economy Research