Measuring Scotland's progress towards a circular economy to help combat the climate emergency.

Results from a preliminary scoping study reviewing key indicators.

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Zero Waste Scotland:

Zero Waste Scotland exists to lead Scotland to use products and resources responsibly, focusing on where we can have the greatest impact on climate change.
Using evidence and insight, our goal is to inform policy, and motivate individuals and businesses to embrace the environmental, economic, and social benefits of a circular economy.
We are a not-for-profit environmental organisation, funded by the Scottish Government and European Regional Development Fund.

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1 Foreword from Zero Waste Scotland

About four fifths of Scotland's carbon footprint is caused by the production, consumption and, too often, waste of goods, services and materials. This is the single greatest cause of the climate crisis. Adopting a circular economy nationwide will significantly reduce that waste and the emissions it generates.

In 2016, the Scottish Government published a clear, bold vision for a circular economy in Scotland, entitled *Making Things Last*[1]. The landmark strategy sets out the environmental benefits of a circular economy through reducing our unsustainable consumption of scarce resources. It also highlights the economic and community benefits in improved productivity and resilience and the creation of more, lower cost options to access the goods we need, including greater opportunities for social enterprise.

If Scotland is to make the transition to circular swiftly and successfully, it is vital that we can measure the impact of the changes needed to ensure our actions bring the right results. Zero Waste Scotland commissioned this study to assess the value of existing metrics and identify the most effective ways to drive and track progress on reducing our carbon emissions.

The study found that no single metric could be used to measure Scotland's progress on adopting a circular economy, and none of the metrics currently available would be adequate. This is because they focus largely on the impact of materials at their end-of-life. For a true measure of the carbon impact of our consumption habits we need to measure the emissions created across the whole supply chain, from extraction of raw materials through transportation, manufacturing, use and reuse, to disposal at end-of-life.

The study also identified further barriers to using existing metrics, such as those monitoring our material consumption and carbon footprint. Problems raised in this report included a lack of data currently available, the cost of data collection, and difficulties in understanding or using available metrics.

While the study concluded that no single metric could be used to monitor Scotland's progress on adopting a circular economy, authors identified that a range of metrics could be developed and used collectively. We recognise that two datasets in particular will be key to this as we move forward with our work to drive progress on switching to a circular economy and combating the climate crisis.

The first is a new Scottish material flows account. This will give us a better understanding of material consumption in Scotland: what do we extract, what do we import, and how do we use it? Zero Waste Scotland has already conducted an initial study on this, entitled the *Scottish Material Flow Account,* which we will publish later in 2020. That publication will be a first step towards developing a more robust framework for material flow accounting in Scotland.

The second key dataset is Scotland's Carbon Footprint[2]. This existing Scottish Government dataset shows in carbon terms the impact we have globally, not just the carbon emissions associated with production and consumption within our borders. While the government currently publishes annual updates from this dataset, more frequent updates are needed if it is to be used to inform decision-making.

Zero Waste Scotland will continue working to improve material consumption and carbon footprint indicators and seek to increase our understanding of the links between indicators. There may be potential to combine our developing *Scottish Material Flow Account* and Scotland's Carbon Footprint into a single metric to identify and measure the best ways to reduce Scotland's carbon footprint.

This work is crucial to developing the truly circular economy needed to reduce the waste and resultant carbon emissions behind the climate crisis. Success here is likely to have a significant impact in ensuring that Scotland meets the Scottish Government's aim of ending our contribution to climate change by 2045.

[1] https://www.gov.scot/publications/making-things-last-circular-economy-strategy-scotland/
[2] https://www2.gov.scot/Topics/Statistics/Browse/Environment/TrendCarbonFootprint

2 Objectives of the study

Our world is changing rapidly and we are fortunate to live in an age where more and more data is being created and compiled that we can access. Capturing this data, understanding what data and information is beneficial and being able to analyse it effectively will allow us to assess performance, provide an evidence base for decision-making and ultimately drive the circular economy forward. To do this the following needs to be considered:

Metrics – what's the current situation, what data is currently used and how effective is it? What metrics are used elsewhere and how effective are they? Do these metrics act as enablers of behavioural change and support better policy development?

Policy – what form of metrics could demonstrate performance and support existing and future policy? What could this cost and what would be the impact on organisations collecting, reporting and analysing data?

Horizon-gazing – what will happen in the future from a societal, economic and environmental perspective? What needs to be considered to drive the circular economy? What new data sources and systems will emerge - such as the Internet of Things (IoT), Quick Response (QR) codes, blockchain and artificial intelligence - for assessing secondary material suitability?

Applicability – how will this work 'on the ground'? How would data be captured and reported? Which sectors might this be applicable to? How readily available and replicable is the data?

To help answer some of these questions this piece of work aims to achieve the following three key objectives:

1. Supporting Zero Waste Scotland in the development of a broader, more robust monitoring and evaluation framework to support the developing evidence base for the shift to a circular economy.

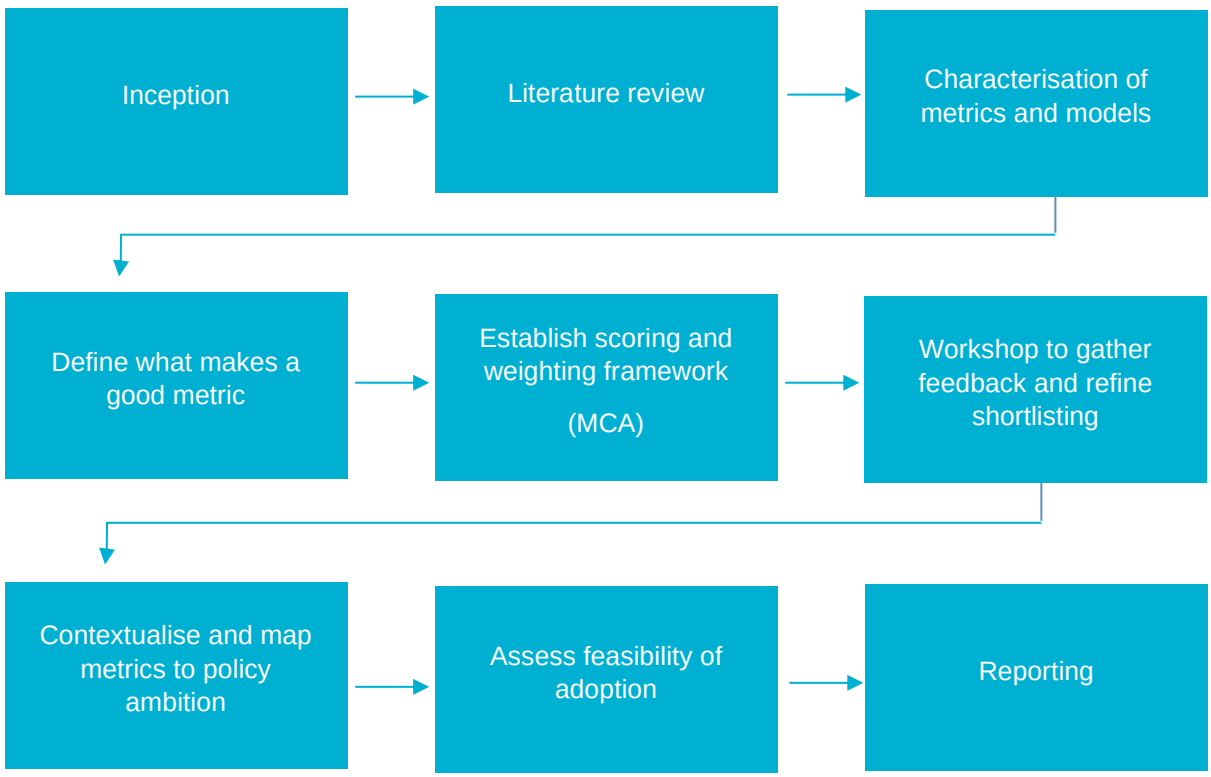
2. Undertaking the development of an evidence base which:
   - Reviews a wide range of currently utilised metrics and models;
   - Assesses the strengths and weakness of these metrics and models;
   - Demonstrates understanding of the data availability and requirements of the metrics; and,
   - Sets out the applicability of these metrics and models to Scotland and the specific policy framework and ambitions in Scotland.

3. Identifying a suitable suite of metrics that could be adopted in Scotland to support the transition to a circular economy.

3 Research methodology

The research methodology for this project was designed in line with a nine-step process set out in **Error! Reference source not found.**. This process takes the project from a literature review of a wide range of indicator/metric studies and reports, through a classification process for use within a multi-criteria analysis. The purpose of this study is to capture a wide and varied set of metrics, review them and provide a ranked set of metrics that could help support the monitoring and evaluation of a circular economy in Scotland.

Figure 1: Outline of the research methodology



3.1 Literature review of current available metrics and models

The literature review collated a whole range of relevant, selected national and international best practice information, studies and reports on the use of indicators and metrics which could be applicable to measuring the circular economy. This process involved the use of a proforma to capture key information about the indicator frameworks, what types of individual metrics they use and how they combine them to measure the circular economy. The proforma was also used to capture the strengths and weaknesses of each approach. This information supported the initial classification of indicators into their application level, be that at national, regional, city or business scale. This initial review took account of more than 25 separate studies (as referenced in appendix 1) and covered the UK, Europe and Asian economies. The review identified the best practice approaches already utilised for monitoring environmental, economic and social factors.

Criteria	Notes
Model/metric name	
Indicator description	
Link source	
Rationale	
Country of origin	
Date	
Metrics measured (e.g. resource productivity, proportion of waste sent to landfill)	
Number of metrics measured	
Application level (e.g. city, regional, national)	
Target material/product stream	
Strength	
Weakness	
Performance	
Connection to Scottish policy	

Figure 2: Proforma for data capture during literature review

3.1.1 Shortlist by geographic level and defining by tier and key typology

Once a full list of indicator tools had been compiled using the proforma in **Error! Reference source not found.** the individual metrics within them were further reviewed to extract those metrics that were most suitable for monitoring national performance of the circular economy. This included further assessment of each metric to classify them based on:

- **Tier 1 or Tier 2 metric**
  - **Tier 1** metrics are those that can be used at the top level to monitor the overall performance of the circular economy. For example economic indicators, such as material productivity, or carbon emissions emitted via the economy. In this regard, changes in these top-level indicators would suggest progress towards a circular economy, but not provide detail on causality.
  - **Tier 2** metrics are those that give a better indication of an individual process within the market and track data which could have which could have a more direct positive impact on resource efficiency, environmental performance, innovation or other aspects associated with a shift to the circular economy.
- **Typology of metrics and what they measure**
  - **Material flows** – metrics for monitoring and measurement of material flows through the economy. The quantity (tonnage) or efficiency of their use are common metrics in this group.

- **Environmental** – metrics that build on activity data to quantify potential environmental emissions from economic activities demonstrating the environmental benefits associated with shifting to a more circular economy.
- **Economic** – metrics that monitor economic activity linked directly to circular activities or used alongside material or environmental data to provide a metric measuring the economic efficiency of material use or environmental emissions.
- **Social** – metrics that include the value of broader societal impacts and changes alongside the circular economy. These could include indicators such as natural capital or 'one planet living' metrics. These aim to include the social value which the environment provides to help improve this alongside reducing inefficient use of materials.
- **Innovation** – metrics related directly to the level of innovation and investment within circular business models, patents or research and development which will advance progress towards the circular economy.

Over 30 individual metrics were reviewed and classified in this way providing a range of potential options for Zero Waste Scotland. Importantly, it is likely that no single metric will work in isolation, but instead a wider dashboard of metrics will be required. Using a range of metrics to monitor both top-level indicators and more detailed Tier 2 metrics should help Zero Waste Scotland understand more closely what the key drivers of performance are. This will also be important to evaluate which policy levers are working to progress the transition to the circular economy.

3.2 Assessment of metrics

Following the literature review process and classification of the short-listed metrics, the project focused on identifying which of these metrics could be viable for Scotland. This included considering not only which performance metrics have functioned well internationally, but also which ones are well aligned with Scotland's goals, ambitions and data availability. This process was undertaken by means of a multi-criteria analysis focusing on nine key criteria. The nine criteria where chosen to represent what makes a good metric for Scotland. They are outlined in the following sections of the report.

3.2.1 Defining what makes a good metric

In collaboration with Zero Waste Scotland a set of criteria were outlined that established how to assess the question of 'What makes a good metric?'. Most of these criteria relate directly to the quality of data available to undertake analysis of each metric, and also to how monitoring each metric could influence behaviours of different stakeholders via its communication and use within a monitoring framework.

The core aim of setting the criteria framework was to create a level basis on which to appraise all metrics equally whilst also allowing the ability to differentiate between metrics that are attempting to monitor similar aspects but via different methodologies.

The nine key criteria used within the multi-criteria analysis were:

1. **Easy to measure/accurate data available**

   Is the data needed to monitor the metric readily available and robust?
   Does the data need regularly updating, or require complex programs or technical experience to calculate?

2. **Easy to implement at low cost**

   What is the extent of costs associated to implement the metric, its monitoring and reporting?

   Do Infrastructure or systems need to change, if so what is the scale of the costs?

3. **Easy to understand and communicate**
   Is the metric simple to understand as a concept and can it be communicated to all stakeholders easily?

4. **Does not create inappropriate incentives**
   High-level consideration to check that the metric does not cause negative impacts on other sectors, such as air or water pollution, or encourage biased prioritisation of materials.

5. **Equitable**
   High-level consideration to see if the metric negatively impacts one stakeholder group or sector.

6. **Offers consistency over time**
   A metric that can be measured long-term using a consistent methodology and data set.

7. **Compatible with other benchmarks**
   Is the metric compatible and comparable with other existing targets and goals in the resources sector, and more broadly in terms of carbon emission reduction targets.

8. **Good indicator of performance**
   Does this metric provide the best measure of performance, i.e. is the methodology the most robust relative to its peers? Is measuring per capita, per household or total the most beneficial format for the metric?

9. **Relevance to Scottish policy**
   Does the metric map well against Scotland's policy ambition? Will it act as a key monitoring tool and enabler?

3.2.2 Undertaking multi-criteria assessment

The multi-criterial analysis was developed based on a red, amber, green (RAG) assessment of each metric individually. The assessment provides the rationale for inclusion and identification of key strengths and weaknesses, as well as the scoring of each criterion. This process gives the robust basis on which to make an initial appraisal of the full set of 31 metrics. It offers a rapid assessment of which metrics work well for each primary typology (economic, environmental, material flow, etc.) and an overall scoring of each metric, which can be used to rank them for further interpretation.

Score	Rationale
1	Significant weaknesses in addressing criteria
2	Limited weaknesses in addressing the criteria
3	No weaknesses in addressing the criteria

Figure 3: Multi-criteria assessment scoring system

4 Summary outputs from the multi-criteria analysis

4.1 Tier 1 metrics

Tier 1 metrics are those that can be used at the top level to monitor the overall performance of the circular economy, be that as an economic indicator - such as material productivity - or carbon emissions emitted via the economy. In this regard, changes in these top-level indicators would suggest progress towards a circular economy, but not provide detail on causality. The Tier 1 metrics included within the analysis are set out in **Error! Reference source not found.** below, along with their scoring against the key criteria.

Metric	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9
Material productivity									
Material footprint									
Environmentally Adjusted Net Domestic Product (EDP)									
Carbon emissions per capita									
Carbon emissions per typical basket of goods and services									
Carbon emissions per £ of economic value									
One planet development									

Figure 4: Overview of scoring for Tier 1 Metrics

4.1.1 Findings from assessment of Tier 1 metrics

The need to create and implement indicators that are measurable using current data sets and easily communicable favours conventional metrics, such as material productivity and carbon emissions per capita. That is not to say these do not have their own difficulties, however. Disaggregation of data from national data sources (for example splitting out material flows from UK level data) is particularly complex and leads to the implementation of metrics that are still to a certain extent 'modelled' rather than based on live data sources. This difficulty of access to data also means that to be truly valuable the metrics at this level are not cheap to implement and not always straightforward to communicate to the public. Carbon emissions monitoring may well be useful in this regard because of its longer-standing use as a proxy indicator of the general environmental performance of an economy, particularly linked to climate change reporting.

More novel indicators are available such as the 'one planet' development indicator, material footprinting or carbon emissions per typical basket of goods. These, however, are similarly restricted in usefulness

due to the need for additional calculations, limited access to data and difficulties in making the output metrics credible and understandable for the full range of stakeholders.

4.2 Tier 2 metrics

Tier 2 metrics typically give a better indication of an individual process within the market and track data that could have more direct implications on changes in resource efficiency, environmental performance, innovation or other aspects associated with a shift to the circular economy. The Tier 2 metrics included within the analysis are set out in **Error! Reference source not found.** below along with their scoring against the key criteria.

Metric	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9
Raw material consumption									
Domestic material extraction									
Waste arisings									
Waste arisings per capita									
Recycling and recovery									
Circular material rate									
Energy efficiency									
Household spending on product repair and maintenance									
Socioeconomic resilience to ecological risks									
Circular employment opportunities									
Carbon emissions									
Land use indicators									
£ generated per land use area (industry / agricultural etc)									

Metric	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9
Carbon emissions generated per land use area (industry / agricultural etc)									
Natural resource stocks (natural capital)									
Patents delivered in circular economy products and services									
Private sector investment in circular economy									
Value generated by circular economy sector									
Water efficiency per £GDP									
Capture rates of key materials									
Circular public procurement									
Public R&D spending to support circular economy innovation									
Utilisation rate of industrial solid waste									
Major pollutants emissions									

Figure 5: Overview of scoring for Tier 2 metrics

4.2.1 *Findings from assessment of Tier 2 metrics*

At the second tier of metrics it is important to highlight that there is a much broader range of typologies of metrics which must be considered. This results from the need to not only capture a top-level performance metric, as per Tier 1, but to also look in more detail at parts of the economy that are working well in supporting the shift to the circular economy. In addition to this, there are also a range of contributing factors that need to be supported as part of the transition to a circular economy, for example innovation and investment in circular business models. Without metrics set up to monitor these more refined activities, it is difficult to measure progress and understand to what extent any policy levers put in place will encourage progress. This is a critical element of having the right set of metrics not only to monitor overall performance, but also to appropriately monitor and evaluate the performance of interventions designed to encourage the transition. This is especially important given the relative immaturity of the circular economy and its need to accelerate more rapidly and proliferate throughout the economy. This point of accelerated uptake is a very important phase to monitor and may require metrics which hold less weight when considering the evaluation of a more mature circular economy's performance. In this regard over time as circular economy principles become embedded, the metrics which hold most weight with policymakers may change from those that monitor key inputs and enablers of the circular economy, to those that monitor output performance more holistically.

Particular issues arising from the use of targeted 'circular economy targets':

- **Defining circular economy activity** - attempting to define investment in circular economy sectors or business models is increasingly a difficult activity to undertake. This is true for two reasons. Firstly, we have limited 'buckets' or Standard Industrial Classification (SIC) codes within which to classify business activities. Defining these as circular, when circular activities take place within all of them, is a very arbitrary approach which can lead to skewed measurement. Secondly, by its very nature, defining a circular sector goes against the concept of a circular economy as circular activities perforate all economic activity and resource consumption.
- **Measuring both input and output data** - following on from the difficulty of defining circular activity there is also an issue of being able to disaggregate and measure output data relating to specific investment in circular activities. Although challenging, it may be possible to measure the investment in circular sectors. However, measuring the output and added value achieved as a result of those investments, as opposed to broader activity in the sector, is even more difficult.
- **Current metrics may need refocusing or adjusting to suit the needs of the circular economy as defined by policy in Scotland** - Metrics such as those focused on recycling and recovery have clear ties to the circular economy, but are currently focused on the first tier of the supply chain in collection and disposal. The re-definition of recycling rates in the circular economy package will change this, focusing the point of reporting further down the supply chain closer to the point at which materials are returned to the system as secondary materials.
- **Inclusion of the bioeconomy** - The bioeconomy is not explicitly mentioned in any of the metrics. This is not to say the metrics available cannot be used to monitor progress towards the bioeconomy. It may just be that there needs to be work undertaken on the definition of materials and processes included. For example, a recycling and recovery metric would include food waste collected and sent to anaerobic digestion, but would other organic materials collected and sent for biorefining also be included? As discussed within the 'biorefining potential report for Scotland'[3] , there are potentially a huge amount of materials which could be diverted via biorefining processes and this would demonstrate progress towards the bioeconomy. It will be important, however, to be clear on what is being defined as permissible to include with regards to both materials and processes.

[3] https://www.zerowastescotland.org.uk/sites/default/files/Biorefining%20Potential%20for%20Scotland%20Final%20report.pdf

4.3 Overarching observations

A detailed review of the metrics and indicators is available within the multi-criteria assessment sheet that accompanies this report. However, some overarching observations have been provided below.

The need for a Scotland-specific materials database

In order for many of the material extraction, consumption and productivity metrics to be used in a truly meaningful way for Scotland there is a need to create a disaggregated set of Scotland-specific material accounts. This is paramount in understanding the inputs to the economy from both a domestic extraction perspective, and also those that are brought in and out of the country via trade. Understanding these material accounts at a national level is important as it is the base data for understanding key circular economy principles such as:

- Raw material extraction
- Domestic material consumption
- Material productivity
- Material foot-printing
- Activity data for emissions inventories
- Material scarcity, trade dependencies and exposure to international risks

Understanding the material accounts at a national scale is also important in helping to support the development of key sectors for delivering resource efficiency productivity gains. Having a better, more granular national database could be seen as a big step in the right direction in enabling better monitoring and measurement of the transition to the circular economy.

Measuring the effectiveness of the resource recovery sector

Within the metrics reviewed there is also a tranche that sit well with monitoring the effectiveness of the resource recovery sector and how it is acting as an enabler of the circular economy. Traditionally, some of these recycling and recovery targets have been used as proxy environmental metrics. Instead, they could be used as practical measures of how well the sector is performing its duty in collecting wastes and translating them back into valuable materials for the circular economy. This more practical monitoring of these metrics would better take account of where process losses may be apparent in the system so that targeted investments can be made to address these and stimulate a more efficient system of delivery. This transition to practical system monitoring should coincide with the circular economy package and the introduction of targets at the point of secondary material production. This shift would then allow a much more transparent view of the true secondary material recovery rate and of where material is being lost.

Environmental metrics should be reported in tandem with material and economic data flows

As highlighted above, there is a need for true environmental metrics to be monitored, so as not to chase weight or economic value to the detriment of the environment. Although carbon emissions reporting provides a good top-level proxy for this value, metrics such as material foot-printing and industrial pollutant emissions (if enabled by better data) could become very important as a means to keep the drive for greater material productivity and economic output framed by environmental performance.

Circular economy metrics as a measure of the general acceleration of the transition

In the short and medium term understanding the activity that is classified as circular economy in nature will also be important to keep track of. Although metrics on employment, private sector investment, R&D investment or patents delivered by circular activities are not ideal they will still provide a good understanding in the trends and growth of the circular economy. These types of metrics will also be key in identifying the impact of policy measures put in place to stimulate the circular economy and monitoring the value generated via government investment in schemes developed.

Procurement as a key enabler

A final point to consider is the key enabling power of procurement in developing the circular economy, not only in relation to providing fiscal stimulus shaped by circular principles, but also its ability to specify the data requirements. It can be a key tool to measure the number of clauses based on circular principles and also allows better collation of data to enable new monitoring and measuring procedures. One example of where this has been integrated before is by schemes such as the green investment bank. For this, Ricardo developed a tool to support environmental appraisals to sit alongside financial appraisals of infrastructure and infrastructure retrofitting schemes to ensure resource efficiency was central to investments made.

5 Contextualising metrics from a Scottish perspective

Scotland is internationally renowned for its progress in shifting towards a circular economy. This progress is founded on well embedded policy, such as the Scottish Government's landmark Making Things Last strategy, in combination with practical support packages for small and medium-sized enterprises via programmes such as Zero Waste Scotland's Resource Efficiency Scotland programme. This puts Scotland in a very good position to be ambitious in its upcoming circular economy bill and to put in place a robust framework of metrics to continue monitoring progress, demonstrating the value of implementing circular economy initiatives.

As identified in Figure 6, the circular economy is very cross-cutting and touches all parts of the economy and material consumption. Consequently, it would be a very difficult transition if only a narrow set of metrics were to be used to monitor progress. Based on the findings from the multi-criteria analysis it is advised that the monitoring of the circular economy needs instead a dashboard of metrics. This should enable top-level measuring and monitoring of environmental and economic performance in combination with more specific targets to monitor specific target areas, or the performance of measures designed to support the transition to a circular economy. These second-tier metrics can then be better aligned with the key target areas as set out within the Making Things Last strategy.

Figure 6: Extract from Making Things Last: A Circular Economy Strategy for Scotland identifying the key enablers of the circular economy in Scotland

Given the key goals of the circular economy, Scotland should consider the use and monitoring of two top-level metrics focused on economic and environmental performance. Based on the outcome of the multi-criteria analysis it is advised that these should relate to the material productivity and environmental performance utilising a carbon emissions per capita, or per £GDP approach. Using these two metrics with the denominator as an economic data set (either GDP or GVA) means that not only is there a focus on the material efficiency and environmental performance, but the progression towards them is also undertaken in a way that is not to the detriment of economic performance.

These top-level metrics should then be supported by additional metrics to help target specific interventions that support the ambition as set out by material productivity or environmental performance.

6 Future measurement of the circular economy

The Ellen Macarthur Foundation[4] describes recycling as taking place in cascades. It explains cascading as 'the use of (a part of) a product for a different application. When a product is no longer in a position to fulfil its initial function, it is given a new function in which it can be used again. While materials are used in cascades, the quality of the material decreases, and energy is consumed.'

This means that most materials, such as fossil fuels, plastics and metals are finite and cannot be indefinitely reused – for example, newsprint can only be recycled a certain number of times before the fibres become too short. In the value chain, this degradation must be recognised; whilst using secondary materials reduces extraction and consumption of raw materials, value retention must incorporate the option of alternative uses for recyclable materials as entropy takes its toll – at which point paper fibres which are too short for newsprint can be used to produce cardboard and other packaging.

The aim of a circular economy should be to match the quality and capability of each material stream. Where possible, materials should be reused for functions which are equal (functional reuse) or of higher value (upcycling) than their initial function. However, where this is not possible, alternative uses will extend the circularity of the material. This will ensure that, whilst the value of the material (in practical and financial terms) will fall over time, a degree of value is retained or enhanced for as long as possible.

However, there will always be a loss of 'value', which means the need for new 'input' remains necessary. In other words, a 100 per cent closed loop circular economy is not possible.

To be able to fully capture the complexity of the flow of material throughout this revised vision of the value chain, a far more sophisticated analysis of the journey of each material stream will be required. This will involve assessing the inter-relationships across producers and consumers, as materials will move through a range of processes and through varying stages, dependent on the manner and frequency in which they are reused, recycled and reprocessed. As a result, there is a much greater ambition to look at capturing data which allows a more comprehensively granular picture of the stocks and flows of materials as they circulate within and through the supply chain.

6.1 In the medium term (2-5 years)

To assess the feasibility of tracking the impacts of circular economy policies and measures, the study team consulted with Ricardo Energy & Environment (REE) colleagues who compile the carbon emissions inventory for Scotland, as part of the National Atmospheric Emissions Inventory work programme. The REE inventory team has many years of experience of working with surveys and datasets that help to monitor the performance of the Scottish economy. Through discussions, a number of opportunities were highlighted where either existing datasets could directly inform impacts of the developing circular economy, or where further data gathering and reporting could be implemented to improve the sensitivity of the inventory (or other standalone metrics) to inform policy impacts.

[4] Ellen Macarthur Foundation

Two approaches were discussed, to explore development of monitoring metrics:

- To use the existing emissions inventory and review its sensitivity to circular economy policies and then identify existing or new data that could improve its ability to reflect circular economy actions (data scoping);
- To develop a new proxy circular economy inventory dataset that could host new and emerging data sets and could be used for circular economy policy assessment.

6.1.1 Inventory sensitivity to circular activities

The Scottish carbon emissions inventory estimates are compiled for each source of emissions using the best available data and method that enables consistent, accurate and transparent emission estimates across the time-series, i.e. from 1990 to the latest year (as 1990 is the base year for UK mitigation targets under the United Nations Framework Convention on Climate Change (UNFCCC). The scope of reporting and method options is consistent with guidance from the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC) , combining bottom-up data methods (where complete data on activity and emissions in Scotland are available), and some top-down estimates derived from UK emissions totals (where the Scotland-specific data are limited or incomplete).

Compiling the carbon emission inventories for Scotland and other UK countries is done using the same methodology to calculate emission estimates , where possible, as that used for the UK inventory. However, for many emission sources, the data available for constituent UK country emissions is less detailed than for the UK as a whole and, for some sources, country-level data is not available at all. This presents challenges to derive accurate and policy-sensitive inventory estimates for Scotland and increases uncertainty in the underlying evidence base for policy development and target tracking at the sub-UK level.

At present there is no energy balance for Scotland. At the UK level there is resolution of which fuel is used in which sector. However, at the Scotland level there are a few sectors where data is good, but circular economy policies will act across the business supply chain and the data for fuel or raw material use is not good across different economic sub-sectors. Therefore, it is not possible to see changes in consumption of fuels and other raw materials, for a given economic sector. The inventory estimates have to be modelled using best available proxy data. For example, assuming a consistent ‘energy use per employee’ for a sector.

Tracking material flows between economic sectors and across borders within the UK is a challenge. Using the waste management sector as an example, data is available for:

- ‘the point of production’ data for waste arisings;
- ‘at the point of treatment’ data at various points in the waste management chain (for example local authority waste transfer stations, MBT plant, composters etc – where we could get some data); and
- ‘at the point of disposal’ data (incinerators, landfills) , but the data resolution by that point is much poorer.

We only have interstitial information from waste composition surveys, for example. These are ‘good enough’ for estimating point source carbon emissions, but they are not good enough for understanding or tracking the impacts of circular economy policies and changes in behaviour. At present it is not possible to track waste arisings and disposal specific to Scotland due to data gaps in exports and imports from the rest of the UK overseas.

Given the existing data limitations, the development of an inventory that is sensitive to circular economy policies should be acknowledged as a medium-term objective or aspiration. Work should focus on the development of the data reporting systems to look more closely at circular economy policy implementation. A good approach would be to prioritise action in specific sectors of relevance to Scotland and learn lessons from a targeted number of datasets. For example, organic collection and

treatment data, resource utilisation reports from Pollution Prevention and Control (PPC) permitting. Ultimately this will provide a richer seam of data for the inventory to use and make reporting of data for the Scottish Government more accurate, which will improve the overall accuracy and cost-effectiveness of future circular economy mitigation action.

Where comprehensive Scotland-specific data is *not* available, a "top-down" or modelled approach to estimating emissions is used. In these cases, regional parameters such as population, employment or industrial production statistics are used to estimate the Scotland (and other devolved administrations) share of the UK total emissions. The use of such proxy data introduces a greater level of uncertainty in the Scotland inventory compared to a 'bottom-up' approach. It also signals the source estimates within the inventory that are likely to be the least sensitive to local policy actions.

Given the current suite of data and methods available for inventory compilation, the sensitivity of the Scottish inventory to policy actions is variable according to source, policy, data and methods available. As a result some policy actions will be well reflected in the Scotland carbon emissions inventory while others will not.

This means there is an opportunity to conduct a sensitivity analysis of the Scottish carbon emissions inventory for policies related to the circular economy. A sensitivity analysis is a quick and cost-effective way of mining data and identifying where there are data gaps. The results can then determine whether there are cost-effective ways of augmenting current surveys, using different data sets from existing data gathering systems, or whether we need to develop entirely new surveys. A good example is the information currently extracted from the PPC site returns data. At present the data collected only relates to emissions to support the carbon emissions inventory. However, there are many more data sets which PPC sites need to report (such as resource utilisation reports) which would be much more useful from a circular economy perspective.

The key opportunity would be to use additional 'bottom-up' data to provide more policy-sensitive emission estimates. For example, the recent organics arisings and processing study[5] done by Zero Waste Scotland could provide valuable data allowing the organic collections and treatment policies to be better-reflected within the emissions inventory.

Similar analysis has been initiated for the Welsh Government, with a preliminary desk study to review priorities and potential for improvements to inventory sensitivity, including circular economy impacts.

Case study: Policy sensitivity analysis of the Welsh Government Greenhouse Gases (GHG) Inventory (including circular economy)

- The main aim of the project was to deliver a policy sensitivity assessment of the current Welsh Greenhouse Gas inventory in order to identify methodological, or data collection improvements that could help to better reflect carbon emissions in Wales and improve the sensitivity of decarbonisation policies in Wales.
- This was achieved through reviewing how key current and future policies are or would be reflected in the current GHG inventory for Wales, assessing the potential for improvements to the GHG inventory and considering how such improvements may be incorporated.

Lessons learned

What can Welsh Government learn from the experience of other countries that have implemented Measurement, Reporting and Verification (MRV) systems?

- The activity of tracking progress of a specific policy, mitigation action, or towards a target is often referred to as Measurement, Reporting and Verification (MRV).
- Evidence from a review of international best practice indicates that even a well-resourced inventory improvement programme may not enable the impacts of all policies to be accounted for and tracked within the Wales inventory. However, improvements can be achieved across most policy areas. Such improvements largely focus upon obtaining more

[5] Biorefining Potential for Scotland: Mapping bioresource arisings across Scotland

detailed activity data, hence data availability often defines the degree to which an inventory can successfully track specific mitigation actions. The availability, quality and completeness of data is perhaps the greatest driving force in determining the accuracy and granularity of the inventory. Improving the policy sensitivity of an inventory is therefore heavily reliant upon being able to access suitable data which allows the use of detailed bottom-up compilation methods which reflect the country circumstances and key policies. However, a detailed, bottom-up inventory method does not always mean that a policy will be well reflected. For example, where a policy only impacts on a sub-set of an emission source, it may be difficult to track. For example, there is a policy in Wales aimed at reducing energy use in intensive dairy and poultry farms; this policy is not well reflected in the inventory, as the inventory sectors are not granular or detailed enough to be sensitive to this. In order to track the impact of policies and measures effectively, data needs to align with a scope, format or boundary already reported in the national inventory, in accordance with the prevailing UNFCCC/IPCC international inventory reporting guidance (by IPCC sector).

- The investment to support the development and implementation of MRV systems in developed and developing countries has been substantial – in the tens of millions of pounds. There are good practice examples from this work that can inspire and guide the Welsh Government as they enhance their current MRV system.
- The current Welsh Government indicator framework incorporated into the Climate Change Strategy for Wales: Emissions Reduction Plan provides a comprehensive approach for tracking carbon emissions reduction in Wales and is an example of international best practice. To maintain and implement an updated form of this framework, with the Welsh GHG inventory as a key component, would provide a holistic GHG Emissions Reduction Tracking MRV System for Wales for 1) developing and evaluating GHG mitigation policies and measures, and 2) tracking progress to national or sectoral decarbonisation targets. Such a system would build upon the existing indicators to provide additional granularity and insight into individual policies and actions. Indicators enable the progress of individual policies to be tracked in more detail; for example, tracking implementation (i.e. *has a policy been initiated or not*?) and effectiveness (i.e. *to what extent is it achieving its original aims?*). Such information can be used to establish a detailed feedback mechanism between evidence compilers and policy makers, allowing policies to be adapted, or even terminated, if not effective. This would be in line with international best practice for adopting a comprehensive MRV system for this purpose and would build upon the current GHG inventory and indicator system. We strongly recommend that the Welsh Government considers adopting such a holistic MRV based approach going forward.
- For the circular economy example, a number of key limitations in the data were identified. Policies that would lead to reducing the volume of waste created in Wales would be relatively well captured over time as waste volumes reduce; however, periodic research (at least) to ensure the tracking of activity data to a high level of resolution for Wales would be needed.

6.1.2 Inventory data scoping

At present the inventory uses Scottish and UK data from a large and diverse set of sources. The data that are utilised specifically for the carbon emissions inventory are those that match the precise inventory method, whilst other data that are directly relevant to material, water, energy and waste flows (and hence useful to aid assessment of the Scottish circular economy) are not required for the carbon emissions inventory so this is disregarded. For example, where industrial operators report on carbon emissions under Industrial Emissions Directive permits or through corporate or sector reporting mechanisms, the submissions to regulators do include information on material flows/fate, use of water and chemicals, disposal of effluent/waste to watercourses, landfill and incineration. However, the reporting of all parameters is not mandatory and so a piecemeal approach is inevitable, with no data from some operators. This is certainly the case for the resource utilisation reports that are used when operators report as part of the PPC licensing requirements. In addition, the reporting by public sector bodies (such as NHS trusts, schools and universities) on energy use and emissions is part of wider performance reporting that may include waste, recycling rates and other annual performance metrics. A review of current data sources may help to identify if existing surveys and systems could be extended to provide

cost-effective routes to gathering new data to underpin circular economy policy development and tracking.

6.1.3 Using a proxy inventory or metric alongside the carbon emissions inventory

This would be a development dataset, using similar high standards of data collection as in the carbon emissions inventory, but would sit alongside the carbon emissions inventory as a separate reporting system or metric. Whilst reflecting circular economy policies in the carbon emissions inventory is ultimately desirable, it may not be feasible in the short term. Therefore, to progress data gathering and reporting in parallel to the inventory should not be discounted. Indeed, in some cases the scope and methods that define the inventory methods may not be the most appropriate; the scope of inventory reporting (such as national boundaries, production-based emissions, non-reporting of biocarbon emissions) may not align with the data needed to fully appraise the impact of circular economy policies, which are in essence not intended to be constrained by geographical boundaries. For example, where integrated solutions across sectors or actors may involve transfer of materials within the UK or overseas.

6.1.4 Discussion

- This process would provide an interim solution to a single measurement tool suitable for the forthcoming Circular Economy Bill in Scotland.
- As data improves new data could be added and data collection processes established.
- This 'proxy' metric/inventory could be used as a policy assessment tool.
- The 'proxy' metric could be added to over time when new data sets arise and eventually could form a new standalone circular economy data metric just as the carbon emissions inventory has developed for emissions.

6.2 In the longer term (5-10 years)

To be able to fully capture the complexity of the flow of material throughout this revised vision of the value chain, a far more sophisticated analysis of the journey of each material stream will be required. This will involve assessing the inter-relationships across producers and consumers, as the materials will move through a range of processes and through varying stages, dependent on the manner and frequency in which they are reused, recycled and reprocessed. As a result, there is therefore a much greater need to look at capturing data which allows a more comprehensively granular picture of the stocks and flows of materials as they circulate within and through the supply chain.

Incorporating a 'stock and flows' approach, emphasising the circularity of a system where a waste product from one process can become an element of the stock for a subsequent process, will provide:

- a better understanding of where and how materials accumulate at a more granular level as they are transferred between businesses and sectors; and,
- a far more comprehensive understanding of the material efficiencies and material productivity gains that can be made by implementing more circular business models and strategies.

In addition to the more sophisticated methodology for the monitoring of resource flows, this approach will also represent a fundamental shift from the current linear measurement of economic performance. This will assist in understanding the potential implications of disruptive technologies and circular approaches, facilitating the analysis of how the shift to a circular approach could fundamentally change industry structures and the methodology of value flows between them.

Office of National Statistics work in the area

An example of this approach is the activity currently being undertaken by the Office of National Statistics (ONS), which is working with the Department for Business, Energy & Industrial Strategy (BEIS) and the Department for Environment Food & Rural Affairs (Defra) on the possibility of developing a materials flow data base. Their ambition is to shape this into a 'live dynamic materials flow tracking data system'.

The cornerstone of their approach is to avoid being limited by the information and data which is already available, and instead to explore what an ideal system would need to look like to enable the analysis of the much more granular information required.

An important advantage is that ONS has the legal power to approach industry at all points of the supply chain to request detailed product information, including point of sale data. The ability to source data so extensively and comprehensively could be a gamechanger not only in understanding the source and levels of stocks and flows of materials, but also through an understanding of the geographical flows from source through to the point of consumption.

This initiative is understandably proving to be of great interest to both the resource sector (Defra and BEIS) and also government economists, as a potential methodology to adapt the way the overall UK economy is monitored and measured.

There is also seen to be a corresponding potential for this approach to also have a substantial impact on the detail that can be included within material flow accounting (through the enablement of disaggregation by materials at a much more granular level, as well as facilitating disaggregation by devolved authority or even region).

The ten-year development plan set out by the ONS for their materials data base includes:

- A year-long study which ONS is currently finalising, which will result in a report assessing the potential and value of such a system.
- Those findings will be utilised to secure funding for a two-year research phase to collate the data and methodology required for development of the database.
- Subsequently, a further three-year incubation stage will be undertaken with the aim of developing a feasible working model, which will be capable of exploring test flows for specific material flow systems (such as plastics).
- The remaining five-year period of the project will focus on scaling up and expanding this methodology to enable it to cover the full suite of materials, products and sectors.

Appendices

Appendix 1: Longlist of metrics

Appendix 2: List of studies reviewed

Appendix 1 – Longlist of metrics

Metric	Typology 1	Typology 2	Tier 1 or Tier 2?
Raw material consumption	Material flows	Environmental	Tier 2
Domestic material extraction	Material flows	Environmental	Tier 2
Material productivity	Material flows	Economic	Tier 1
Material footprint	Material flows	Environmental	Tier 1
Waste arisings	Material flows	Environmental	Tier 2
Waste arisings per capita	Material flows	Environmental	Tier 2
Recycling and recovery	Material flows	Economic	Tier 2
Circular material rate	Material flows	Environmental	Tier 2
Energy efficiency	Material flows	Environmental	Tier 2
Household spending on product repair and maintenance	Economic	Social	Tier 2
Environmentally adjusted net domestic product (EDP)	Economic	Environmental	Tier 1
Socioeconomic resilience to ecological risks	Environmental	Social	Tier 2
Circular employment opportunities	Economic	Social	Tier 2
Carbon emissions	Environmental	Social	Tier 2
Carbon emissions per capita	Environmental	Economic	Tier 1
Carbon emissions per typical basket of goods and services	Environmental	Economic	Tier 1
Carbon emissions per £ of economic value	Environmental	Economic	Tier 1
Land use indicators	Environmental	Economic	Tier 2
£ generated per land use area (industry / agricultural,etc)	Economic	Environmental	Tier 2
Carbon emissions generated per land use area (industry / agricultural etc)	Environmental	Economic	Tier 2
Natural resource stocks (natural capital)	Environmental	Social	Tier 2
Patents delivered in circular economy products and services	Economic	Innovation	Tier 2

Private sector investment in circular economy	Economic	Innovation	Tier 2
Value generated by circular economy sector	Environmental	Economic	Tier 2
Water efficiency per £GDP	Environmental	Economic	Tier 2
Capture rates of key materials	Material flows	Environmental	Tier 2
Circular public procurement	Economic	Social	Tier 2
Public R&D spending to support circular economy innovation	Economic	Innovation	Tier 2
Utilisation rate of industrial solid waste	Material Flows	Environmental	Tier 2
Major pollutants emissions	Material Flows	Environmental	Tier 2
One planet development	Environmental	Social	Tier 1

Appendix 2 – List of studies reviewed

Green Horizon Scoreboard - https://green-horizons.eu/content/about-website

Raw material consumption - https://circulareconomy.europa.eu/platform/sites/default/files/summa_-_indicators_for_a_circular_economy.pdf

Material System Analysis (MSA) - https://circulareconomy.europa.eu/platform/sites/default/files/summa_-_indicators_for_a_circular_economy.pdf

Circular material use rate - https://ec.europa.eu/eurostat/documents/3859598/9407565/KS-FT-18-009-EN-N.pdf/b8efd42b-b1b8-41ea-aaa0-45e127ad2e3f

Material Circularity Indicator - https://circulareconomy.europa.eu/platform/sites/default/files/summa_-_indicators_for_a_circular_economy.pdf
https://www.ellenmacarthurfoundation.org/resources/apply/circularity-indicators

Green growth indicators - https://wedocs.unep.org/bitstream/handle/20.500.11822/9434/-Green_Growth_Indicators-2014OECD_GreenGrowthIndicators_2014.pdf.pdf?sequence=3&isAllowed=y

Indicators for a resource efficient and green Asia and the Pacific - https://wedocs.unep.org/bitstream/handle/20.500.11822/9589/-Indicators_for_a_resource_efficient_and_green_Asia_and_the_Pacific-2015Indicator-for-a-RE.pdf?sequence=3&isAllowed=y

A monitoring framework for the circular economy - http://ec.europa.eu/environment/circular-economy/pdf/monitoring-framework.pdf

The circularity gap report (circle economy) - https://docs.wixstatic.com/ugd/ad6e59_ba1e4d16c64f44fa94fbd8708eae8e34.pdf

Sustainable development indicators - http://www.indicators.be/en/g/VNR17/

Circular economy toolkit - http://circulareconomytoolkit.org/Toolkit.html

EASAC indicators for a circular economy - https://www.easac.eu/fileadmin/PDF_s/reports_statements/Circular_Economy/EASAC_Indicators_web_complete.pdf

Fundamental plan for establishing a sound material cycle society - https://www.env.go.jp/en/recycle/smcs/3rd-f_plan.pdf
https://www.env.go.jp/en/recycle/smcs/2nd-f_plan-result2.pdf

Fusions - https://www.eu-fusions.org/phocadownload/Publications/D3.5%20recommendations%20and%20guidelines%20food%20waste%20policy%20FINAL.pdf

Global material flows and resource productivity: assessment report for UNEP international resource panel - http://wedocs.unep.org/bitstream/handle/20.500.11822/21557/global_material_flows_full_report_english.pdf?sequence=1&isAllowed=y

Circular economy: measuring innovation in the product chain - https://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

Circular economy promotion law - http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170112_834922.html

10 key indicators for monitoring circular economy - http://temis.documentation.developpement-durable.gouv.fr/docs/Temis/0086/Temis-0086452/22978_2017_ENG.pdf

Understanding employment in the circular economy in the Netherlands - https://www.circle-economy.com/wp-content/uploads/2017/03/goldschmeding-jobs-report-20170322-lite.pdf

Germany resource efficiency programme - https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/german_resource_efficiency_programme_ii_bf.pdf

Green growth knowledge platform (2016), measuring inclusive green growth at the country level - http://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Measuring_Inclusive_Green_Growth_at_the_Country_Level.pdf

Circular economy in Europe: developing the knowledge base - https://www.eea.europa.eu/publications/circular-economy-in-europe#tab-data-visualisations

ReSOLVE: Growth within: A circular economy vision for a competitive Europe - https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

Indicators for a circular economy - https://circulareconomy.europa.eu/platform/sites/default/files/summa_-_indicators_for_a_circular_economy.pdf

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