scottish science advisory council

# SSAC Report - Towards a Circular Economy: Scotland's Bioresource Flows

# Towards a Circular Economy: Scotland's Bioresource Flows

# Contents:

# Executive Summary

Scotland has a large natural economy, and much to gain from better management of by-products and wastes (alternatively referred to as 'bioarisings') from the bioresources sector. This report concentrates on the challenges to, and recommendations for, increasing the contribution of bioresources to the development of a circular economy in Scotland. It focuses especially on how to quantify and track bioarisings in Scotland, and how to improve connectivity between producers and manufacturers.

Twin global pressures of the high commodity prices and the NetZero imperative puts the concept of economic circularity high on the political agenda in Scotland[1]. Economic circularity features prominently in the Programme for Government 2022, with the Scottish Government set to introduce a Circular Economy Bill in 2023. It is also relevant to the National Strategy for Economic Transformation (2022), and the proposed structured payment for sustainable practice in the Agriculture Bill to be launched in 2024/25. Many reports on circularity and the Scottish bioeconomy have been produced by, and commissioned through, Zero Waste Scotland (ZWS) (Government-funded not-for-profit environmental organisation) and other government-funded bodies (including the Biorefining Potential for Scotland (2017) report[2]). None have assessed the underlying data quality.

This report comprises of an independent assessment by the Scottish Science Advisory Council (SSAC) of the scientific quality of underlying evidence on bioarisings, a synthesis of stakeholder views, and a set of recommendations. It is targeted to provide insights to the Circular Economy Unit of the Scottish Government's Environment and Forestry Directorate as the Circular Economy Bill makes its way through Parliament during 2023 and 2024.

An in-depth review of the underpinning evidence used by all reports on bioresources in Scotland revealed that none of the datasets meet all the benchmarks of good quality, and primary data for bioarisings is scarce (Annex E).

In addition to reviewing the evidence, written and verbal stakeholder views were gathered by the SSAC in a roundtable discussion format. Overall, three areas of concern emerged:

I. Connectivity across the produce-use-reuse / recycle circular supply chain.
II. Infrastructure / planning models for a circular supply loop.
III. Implementation and methodology of digital waste data tracking.

Taking all evidence into account, one key finding, and four main recommendations emerged. These are highlighted below, followed by a more detailed consideration. Full evidence is provided in the annexes.

[1] Ellen MacArthur Foundation working with Zero Waste Scotland and Scottish Enterprise (2010). *Scotland and the Circular Economy A preliminary examination of the opportunities for a circular economy in Scotland*. Available online
[2] Zero Waste Scotland (2017). *Biorefining Potential for Scotland*. Available online

# Main Findings and Recommendations

## Finding: data quality

No data sets used by any report on bioresources in Scotland meet all the benchmarks of good quality (detailed later in this report), and primary data on bioarisings is scarce. Introduction of mandatory digital waste tracking in Scotland and the wider UK (in line with UK Government plans) is critical to improve the availability and quality of data on bioresources.

## Recommendation 1: Circular Economy target definition.

Targets must be SMART (specific, measurable, attainable, relevant, time-bound), policy aligned, cross-sectoral and incentivising. Given the necessary breadth and complexity of targets, the Scottish Government should convene a working group to define standards for data collection, and bioresources management practices which should then be regulated and monitored. Without standards, targets are unmeasurable and meaningless. Efforts to establish standards for the bioresources sector must be considered alongside other elements of economic circularity.

## Recommendation 2: Connecting supply chain commerce.

Lack of quality data on bioarisings and a shallow understanding of the complexity of their input into supply chains is stifling innovative commercial demand in circularity. The Scottish Government should facilitate a significant uplift in specific Circular Economy (CE) enlightenment and match-making partnerships by creating a digital CE marketplace, via existing networks and organisations. For small and medium enterprises (SMEs), access to good data on bioarisings must go hand-in-hand with an enlightened view of the time-varying and geographic spread of bioarising availability, and the competitive nature of their reuse.

## Recommendation 3: Civil planning and circularity.

Scotland's geographic diversity makes for a complex bioresource ecosystem. EU Waste Framework articles or equivalent UK frameworks should be used to inform a statutory interface between regional, inter-regional and national planning processes, accompanied by a public information campaign. National coordination alone, however, is not sufficient: innovation often arises at the local level. Progress would be accelerated if Scottish Government were to facilitate better international connectivity between sub-national entities (e.g., Vlaco, Flanders. https://vlaco.be/en).

## Recommendation 4: Digital waste tracking.

To implement a digital waste tracking service the Scottish Government should grant statutory powers on regulation and enforcement for the Circular Economy. The statutory body(ies) for Circular Economy, should work with public and private sector partners to consider how to use digital waste data to realise Circular Economy opportunities for bioresources. Supporting

legislation associated with the UK Government's mandatory digital waste tracking may contribute to this[3].

# Synthesis of Evidence

A review was conducted of 67 reports, either specifically on, or referring to, circular bioresources, produced by government, industry, and other organisations (listed in Annex E). This review informed the selection of 34 stakeholders from a range of sectors (Annex C), all with an interest in a circular biosector, who were invited to complete a questionnaire and attend a roundtable discussion on the 20th of October 2022 (Annex B). A total of 12 organisations responded to the questionnaire, and several additional comments were made which did not specifically address the questions, but which were nonetheless informative. For example, there were 17 participants in the roundtable discussion (excluding SSAC subgroup members and observers). Responses and discussion points have been integrated by topic in Annex D. All responses in their original wording, anonymised and numbered, are recorded in Annex D.

The many reports (footnotes and Annex E) relating to circularity in the bioresources sector in Scotland are largely based on the same source data, predominantly held by SEPA. Data from SEPA are updated annually; however, in general, data sources are sparse, of low quality, and inadequate when it comes to improving circularity in the biosector. In the stakeholder questionnaire, it was suggested that a key requirement for circular bioresources was for accurate and reliable digital tracking. Accordingly, **three priority areas** were proposed, and stakeholders were invited to comment. Synthesising stakeholders' views and integrating with independent analysis by the SSAC, there is broad agreement on three priority areas for action on a circular bioresource sector in Scotland.

The first area which hampers innovation is that of poor connectivity between producers and users of bioarisings. Some examples of good practice exist, but many potential SME innovators simply do not know the quantity, quality (value) or location of bioarisings that could support their businesses, nor what competing uses may exist for a particular bioresource. Furthermore, the seasonality and perishability of some bioarisings and difficulties in providing adequate storage from pests underline how critical it is to identify users and transport them quickly. Case studies are an important and under-utilised tool for demonstrating the possibilities and processes of a circular biosector, and particularly of how digital waste tracking might work in practice. Highly publicised case studies can also be used to tackle the perennial issue of the language and terminology surrounding reuse of bioresources. One key element to capturing all bioresources that can be moved from a linear to a circular economy is to move away from the language of 'waste': a word which holds both legal and emotive meaning. Language is a vital part of changing social attitudes, another important lever for growing the circular economy. There is widespread public awareness of the issue of food waste; however, recording and recovery of food bioarisings

[3] https://www.gov.uk/government/publications/digital-waste-tracking-service

is particularly difficult, both practically and socially, and an estimated 600,000 tonnes of food and drink waste were being thrown away by households in 2014, according to ZWS[4].

The second priority area concerns planning and regulation. There is a tension between supporting emerging technologies to grow, adapting regulation to avoid unintended consequences, and simultaneous avoidance of regulatory "lock-in" to suboptimal technologies when there may be alternatives that better meet the aims of the circular economy. Regulation is universally applicable, but interpretation and implementation and innovation are often local/regional. For instance, municipal bio-recycling is uneven across Scotland, as well as a cause of public confusion; for example, there is no common understanding of the terms “compostable” and “biodegradable”). Examples of good practice and positive cooperation between public and private sectors need to be better shared between municipalities, both within Scotland and internationally. Greater coordination between local, inter-regional and national planning and regulation processes is needed, facilitated by examples of good practice which generally emerge at the local/regional level.

The third priority area is the need for accurate and reliable bioresource digital tracking. How far away we currently are from that is revealed by our independent analysis of bioresource data, presented now in greater detail.

# Digital Challenge to Circular Bioresources in Scotland

Of the 67 reports reviewed, two were especially relevant to our focus on bioresources in Scotland, both published by ZWS: Biorefining Potential for Scotland (2017), hereafter BPS2017; and The Scottish Material Flow Accounts (2021)[5], hereafter MFA2021.

Bioresources are one part of the Circular Economy, and their relative contribution can be broadly categorised under “biomass” in MFA2021, discussed in more detail later in this report (figure 1). Here we return to the source data to disaggregate and then review the bioresources sector, identifying that improvement is needed in both the quality of data (figure 2) and the quantity of data that details the availability and variability in time and space, of bioarising. A visual “Sankey Diagram '' comparator of the different potential resources as material flows has been created (figure E1, Annex E) using all available data on bioarisings in Scotland, predominantly from BPS2017 (detailed Annex E). Despite being the best available, many of the data were out-of-date at time of publication in 2017, with an updated version yet to be published. Nevertheless it illustrates the material flow complexity and additionally the dominance of agricultural bioarisings in Scotland. We provide a summary graphic of our findings on the overall data quality in figure 2.

[4] https://www.zerowastescotland.org.uk/content/how-much-food-waste-there-scotland
[5] Zero Waste Scotland (2021). *Scottish Material Flow Accounts: Technical Report*. Available online

## Bioresource data quality

BPS2017 represents the first attempt to identify and quantify individual bioarisings from biowaste, by-products, agricultural residues, and sewage sludge produced by households and sectors of industry in Scotland. As far as we are aware, the report is the most detailed of its kind available for any country worldwide. However, there are several shortcomings affecting the quality of data, and therefore the accuracy of estimates made in BPS2017 (and the numerous other reports based on the same data).

Data were assessed against standard benchmarks of good quality, specifically:

- **Data are primary (measured), not secondary (estimated)**: primary data on bioarisings measured at source, and ideally tracked from source to fate, are more accurate and less prone to error than estimates made using a combination of alternative data on, for example, products or more aggregated waste, and the application of factors for the average proportions of bioarisings per unit.
- **Data are collected and published on a regular basis (at least annually)**: data that are collected as near to continuously as possible and regularly published provide the most accurate and up-to-date figures on bioarising availability. A high frequency of data recording is important for the bioresources sector, which needs to be agile and respond quickly to changes in feedstock availability. Data from one-off reports can quickly become outdated, become less accurate with time, and add to uncertainty.
- **Data are Scotland-specific and ideally collected at local authority level**: knowledge of where bioarisings are pooled geographically, in addition to their quantities, are crucial to infrastructure planning and for linking producers with bioresources sector. This is a primary motivation for the collaboration between ZWS and IBiolC to create a bioresource mapping tool [more detail below].
- **Data are publicly accessible**: Close cooperation between industry, government and academia is important for the success of a circular bioeconomy. Data that are made open and accessible — while considering any strictly necessary commercial confidentialities — underlie this and are key both to the processes that structure a circular bioeconomy (e.g., infrastructure planning, market assessments, technological development). Publicly accessible data also fosters trust among stakeholders, including the wider public, particularly with regards to infrastructure planning, which can be contentious.

None of the datasets used in BPS2017 met all the benchmarks, and primary data for bioarisings is scarce, as summarised in figure 2.

The datasets which best met good quality criteria were those for household waste produced by the Scottish Environment Protection Agency (SEPA). These include primary data for individual waste streams (e.g., paper and cardboard, mixed food waste), which are published annually, are publicly accessible, and are available for each local authority (LA). It should be noted that further

disaggregation of these streams is needed, particularly of 'Animal and mixed food waste' and 'Paper and cardboard wastes'.

For bioarisings from sectors other than households, data either do not presently exist (e.g., bread waste, coffee grounds, wood fibre from forestry), or are estimated using a combination of data (e.g., hectarage of a crop, average weight of livestock carcasses, and coefficients for the average proportions of bioarisings from a unit of product).

Estimates are useful for filling gaps in the data; yet they are error-prone compared with regularly reported primary data. It is therefore important that the method of estimation and all sources for data and coefficients used in calculations be stated clearly and be readily accessible (which is currently not current practice).

Annex E gives a detailed assessment of data sources used for each bioarising in BPS2017. For many bioarisings the report referred to publicly accessible datasets and reports. However, for some bioarisings, sources (often one-off reports) are no longer available, or figures were based on unpublished 'expert' information, or the source was not given.

## Other analyses of bioresource data

In addition to BPS2017, there are several other resources and reports which attempt to quantify material flows in Scotland. Three deserve particular attention: The Scottish Bioresource Mapping Tool[6], which quantifies bioarisings specifically, MFA2021 which, as already noted does not, and The Circularity Gap Report Scotland[7] which similarly does not.

The Scottish Bioresource Mapping Tool is a collaboration between the Industrial Biotechnology Innovation Centre (IBiolC) and ZWS and was initially based on the same data as BPS2017 and there is a working assumption that both will be continually updated. The mapping tool is intended for the use of companies and investors to provide information on what bioresources are available and where, to support decisions such as where to site operations based on proximity of feedstock. This is particularly important because of the perishability of many bioarisings, difficulties of storage free-from pests, and the subsequent need for rapid transport to the user. Because some data are business-sensitive, the mapping tool is not publicly available (enquiries of the data can be made through IBiolC).

ZWS's Scottish Material Flow Accounts (MFA2021) attempts to quantify the flow of all materials — biomass, metals, non-metal minerals, fossil fuels and waste — into, through and out of the Scottish Economy as imports, domestic extraction, domestic material consumption and exports. Flows of materials (in millions of tonnes) are visualised as a Sankey diagram where the width of flows are proportional to their mass (figure 1).

[6] https://www.ibioic.com/scottish-bioresource-mapping-tool
[7] Circle Economy (2023). *The Circularity Gap Report Scotland*. https://www.circularity-gap.world/scotland

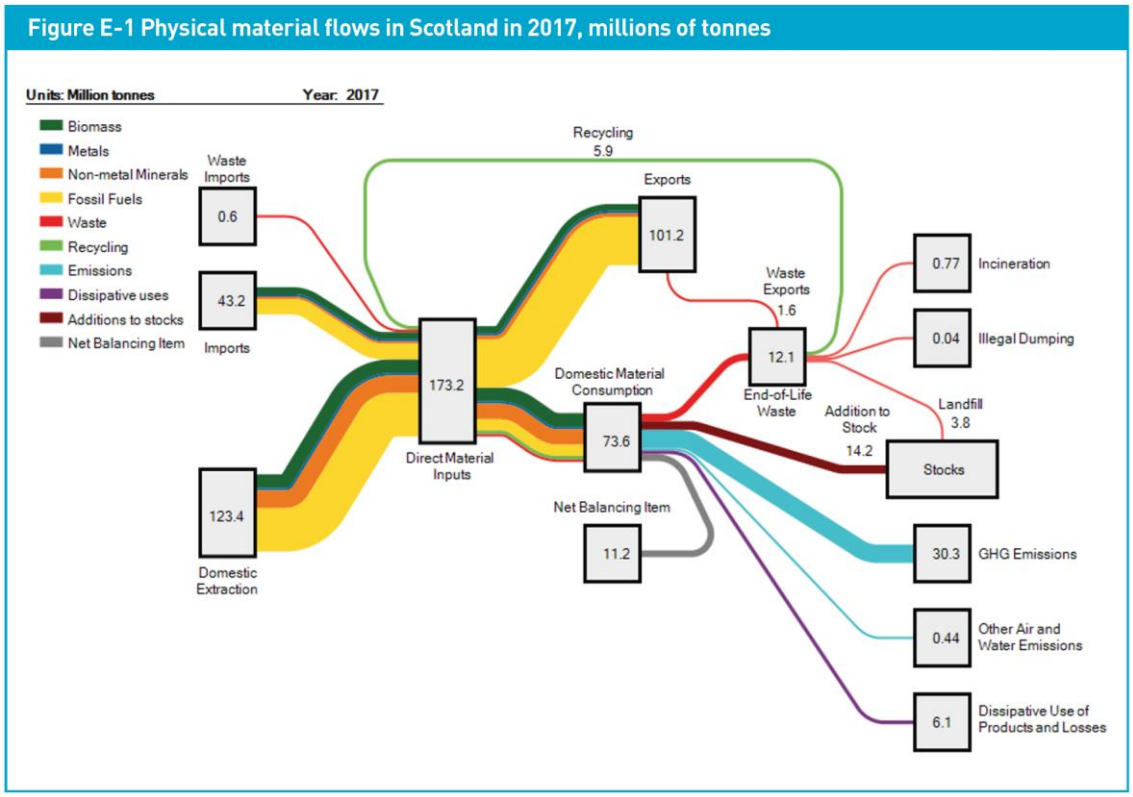


*Figure 1: Sankey diagram of Scotland's material flows, taken from Zero Waste Scotland's Scottish Material Flow Accounts technical report (2021).*

Such coarse material flow accounts do not disaggregate flows of bioarisings from total biomass. Some, but not all, bioarisings will be encompassed within flows of biomass in the MFA — said to include commercial crops, fodder crops, grazed biomass, crop residues (but only those used as animal feed), timber (excluding wood extracted for fuel or other uses because the data does not exist), livestock, and fish (including both wild and farmed) — and may then emerge as part of waste and recycling. However, 'End-of-life Waste' in the MFA includes biogenic and non-biogenic waste from all sectors, making it impossible to determine what tonnage is attributable to bioarisings specifically. Furthermore, the MFA does not consider any bioresource which is not used in the economy, e.g., crop residues other than those used for animal feed, whey disposed of to sea, bread waste, etc.

Information about sources of data for biomass and waste in MFA2021 are not as detailed as BPS2017, although a summary of the main data sources used is provided together with a Red-Amber-Green (RAG) assessment of data quality (Scottish Material Flow Accounts: Technical Report 2021). From this and via communication with ZWS we understand that SEPA's data on waste from all sources (WFAS) are used to quantify waste flows in the MFA. According to SEPA, WFAS refers to total waste from households, construction and demolition, and commerce and industry. These datasets are more aggregated than those used for the BPS2017 (see Annex E), and do not include information on which sectors produced the waste, or where in Scotland the waste was produced. SEPA's WFAS does, however, provide information about quantities of individual

waste types and their management/fates (i.e., how much of each were landfilled, incinerated, or recycled). These are produced annually and are available via SEPA's Waste Discover Data Tool[8].

It is highly unlikely that all bioarisings which are potentially available to the bioresources sector are included in the SEPA WFAS dataset. Not all bioarisings are collected as waste; some will not be captured at all if disposed of to sea (e.g., whey from dairy) or via wastewater (where it forms homogenised waste). Most agricultural residues remain on the farm, are classed as food 'loss', rather than 'waste', and will not become part of the waste streams recorded by SEPA; consequently, agricultural residues are not necessarily targeted by plans to tackle 'food waste'. Furthermore, some bioarisings may be captured by SEPA's WFAS, but they are 'hidden'; for example, fish processing by-products may be included in 'Animal and mixed food waste' from commerce and industry, but their inclusion in these aggregate streams cannot be verified because the datasets do not include information on which industries produced the waste. Even if bioarisings could be traced to source, most food manufacturers do not know the composition of their waste and there is no requirement for them to disaggregate and record details of it. Some of these same issues have been identified in BPS2017 which accordingly used alternative sources of data and coefficients to try to estimate some of these missing or hidden streams.

One final resource worth highlighting, published in December 2022, is The Circularity Gap Report Scotland, produced by the Circle Economy in partnership with ZWS. The Circle Economy is an organisation that produces annual reports on the global flow of material resources and links these to greenhouse gas emissions. In doing so, it attempts to quantify the reductions in material consumption that are required to meet climate change targets (the 'circularity gap'). Using a similar methodology, it also produces reports tailored to specific countries, including Scotland.

There is little information about data sources for material flows given in The Circularity Gap Report Scotland. A single sentence states that, "To ensure our data is in line with the reality of Scotland, we worked with ZWS using data from the Scottish Government, the UK Government and Eurostat." SEPA's WFAS dataset from 2018 (assessed above) is cited among the references of the report. Further information is provided in a 'Methodology document', which indicates that the Circle Economy used ZWS's MFA model as the base of its analysis: "At the time of this analysis, a Scottish Material Flow Account for the year 2018 was already developed and was therefore used as the starting point for the application of the extended MFA approach as outlined in the following section. For the methodological details behind the Scottish MFA refer to the ZWS website." The Circularity Gap Report Scotland report, though just published, is subject to the same data issues outlined for both BPS2017 and MFA2021 and summarised in figure 2.

[8] https://informatics.sepa.org.uk/WasteAllSources/

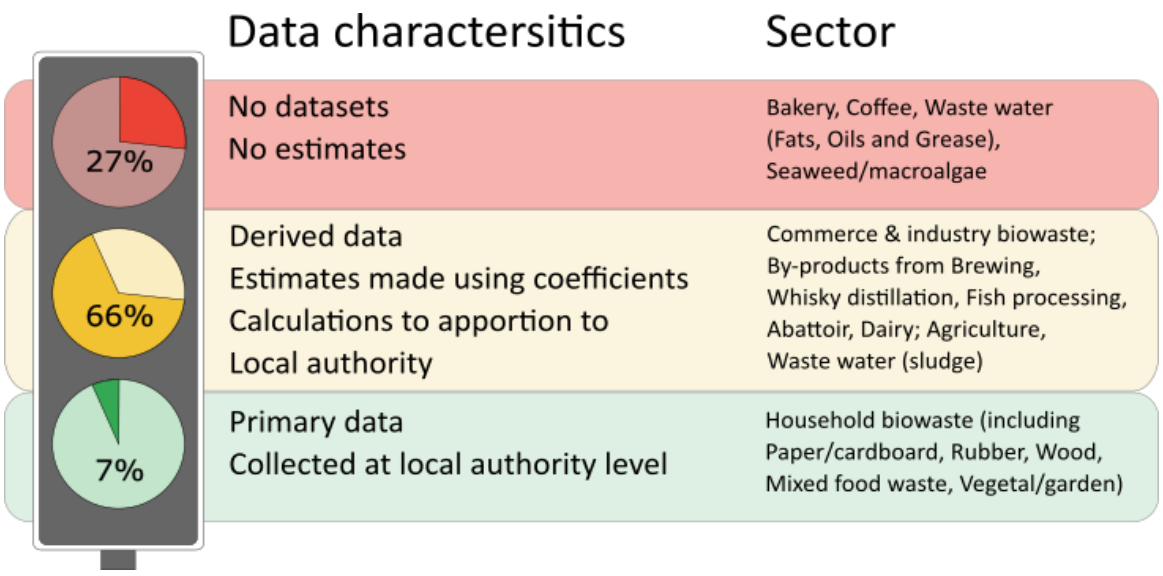


*Figure 2: Infographic giving the characteristics of data classified as red/amber/green and which sectors have data belonging in each category. Pie chart percentages are based on counts of sector and so are in no way representative of volume or value of bioarising for which we lack good data.*

The aim of the report was to work with ZWS, to independently assess work on circularity within the Scottish biosector, and to identify challenges to different supply flows of bioarisings that currently hamper environmental and economic gain. The key message is one regarding the quality, quantity, and availability of digitised information (data). Complex, interconnected, and circular material flows require a robust universal system of digital data recording with free and open sharing, here we have identified necessary practical steps to move Scotland forward in our aspirations of a more circular bioeconomy.

# Glossary of Terms

Definitions of terms used in reviewed reports are usually poor or lacking. Lack of a consistent terminology can lead to confusion; hence we include here a glossary of terms.

**Biowaste**: This term is falling out of use and is uncommon in the CE documents reviewed. It does not promote a positive attitude toward reuse. Bioarisings and bioresources are more targeted and useful terms.

**Bioarisings**: Waste or by-products from managed biogenic systems which can be used as inputs to alternative supply chains.

**Bioresources:** Resources of biogenic (produced by living organisms) origin which are not fossil-based.

**By-products:** A material that is not deliberately produced in a production process and is not a waste.

**Derived data**: Data that are not primary, but by necessity have been estimated using a combination of primary data and factors/coefficients.

**Digital Waste Tracking:** a system that records individual material flows through digital transactions from manufacturer, through waste/by-product management processes and infrastructure, to its destination of reuse, recycle, recovery or disposal.

**Factors/coefficients:** Known proportions of a material (e.g., animal carcass or vegetable) that become a by-product or waste (a bioarising in the present terminology).

**Primary data:** Data that have been recorded, not derived.

**Waste:** Any substance or object which has no current commercial value, and which is usually discarded. We retain the word waste when referring to Digital Waste Tracking.

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