Development of a circular material use rate for England and Northern Ireland

Final Report for the Office for Environmental Protection

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Report For

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Glossary

C&I	Commercial & Industrial Waste
CDE	Construction, Demolition & Excavation
CMUR	Circular Material Use Rate
DAERA	Department of Agriculture, Environment and Rural Affairs
DE	Domestic Extraction
DMC	Domestic Material Consumption
EA	Environment Agency
EPR	Extended Producer Responsibility
EU	European Union
EXPp	Export of Goods
EXPw	Exported Waste Bound for Recovery
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVA	Gross Value Added
HMRC	HM Revenue & Customs
IMPp	Import of Goods
IMPw	Imported Waste Bound for Recovery
MF	Material Flow
MFA	Material Flow Account
MRIO	Multi-regional environmental input-output
NGL	Natural Gas Liquids
NIAO	Northern Ireland Audit Office
NIR	Near-infrared
OEP	Office for Environmental Protection
ONS	Office for National Statistics
PAYT	Pay-as-you-throw
RCV_R	Waste Recycled in Domestic Recovery Plants
SITC	Standard International Trade Classification
TFS	Transfrontier Shipment Waste
U	Circular Use of Materials
WEEE	Waste Electrical and Electronic Equipment

1.0 Introduction

Eunomia Research and Consulting ('Eunomia') was commissioned by the Office for Environmental Protection (OEP) to provide a baseline for the circular economy in England and Northern Ireland. This project will support the OEP's understanding of circularity within each nation and will support the development of recommendations to improve government policy to increase circularity.

Outputs from this project will help the OEP fulfil its obligations under section 28 of the Environment Act 2021, to assess Government's progress towards, and prospects of meeting, the Environmental Improvement Plan and Environment Act targets in England and the Environmental Improvement Plan in Northern Ireland.

The main objectives of the project are to:

- Produce Circular Material Use Rate (CMUR) calculations for England and Northern Ireland;
- Produce Sankey diagrams of material flows (MF) for England and Northern Ireland; and
- Propose recommendations for opportunities to strengthen Government action to improve the CMUR of each nation.

The circular material use rate (CMUR) measures the share of material recovered and fed back into the economy in overall material use. A higher CMUR means that more materials are recovered and used as secondary materials in production, hence reducing the use of primary raw materials which have larger environmental impacts.

The CMUR methodology was developed in 2018 by Eurostat – the statistical office of the European Commission – to monitor the circularity of economies at macro economical level. Eurostat publishes the CMUR for all the Member States (MS) of the European Union (EU), annually.[1] The CMUR calculations presented in this report are the first time that the CMUR has been calculated for England and Northern Ireland.

The report is set out as follows:

- **Section 2.0** provides an overview of the CMUR calculation for England and Northern Ireland, including the CMUR equation, method, Sankey diagrams and limitations.
- **Section 3.0** presents an interpretation and analysis of the CMUR for England and Northern Ireland, including an overview of the drivers of CMUR in these countries and a comparison with other economies. This section also sets out a set of recommendations for England and Northern Ireland to improve the CMUR.
- **Section 4.0** concludes the report by focusing on the areas for improvement and priority areas for future research, including using the CMUR for policy assessment and filling evidence gaps and extending research on circularity in England and Northern Ireland.
- **Appendix A.1.0** details the methodology employed to calculate the CMUR for England and Northern Ireland.
- **Appendix A.2.0** presents a detailed breakdown of the CMUR calculations for England and Northern Ireland.
- **Appendix A.3.0** lists the data sources used to calculate the CMUR.

[1] Eurostat (2018) Circular material use rate: Calculation method. Available at link.

2.0 Calculating Circular Material Use Rates

2.1 CMUR equation

The European Union's methodology for estimating CMUR was followed when producing CMUR calculations for England and Northern Ireland.[2] According to the EU methodology, the CMUR is the ratio of the circular use of materials (U) to the overall use of materials (M). Table 2-1 outlines the equation used to calculate the CMUR.

Table 2-1: CMUR equation

Simple	Expanded
CMUR = U / M	CMUR = circular use of materials / overall use of materials
M = DMC + U	M = domestic material consumption + circular use of materials
U = RCV_R - IMPw + EXPw	U = waste recycled in domestic recovery plants - imported waste bound for recovery + exported waste bound for recovery
DMC = DE + IMPp - EXPp	DMC = domestic extraction + imports of goods - exports of goods

2.2 Method overview

Calculation of the CMUR (as outlined in section 2.1), relies on data inputs for domestic extraction, imports of goods, exports of goods, waste recycled in domestic recovery plants, imports of waste bound for recovery and the exports of waste bound for recovery, for England and Northern Ireland.

Material flows were grouped into the following key categories, which allowed for further investigation of the CMUR by individual material category:

- Metal ores, including ferrous and non-ferrous metals;
- Non-metallic minerals, including construction aggregates, limestones, and clays;
- Fossil energy materials/carriers, comprising of coal, natural gas and crude oil; and

[2] Eurostat (2018) Circular material use rate: Calculation method. Available at link.

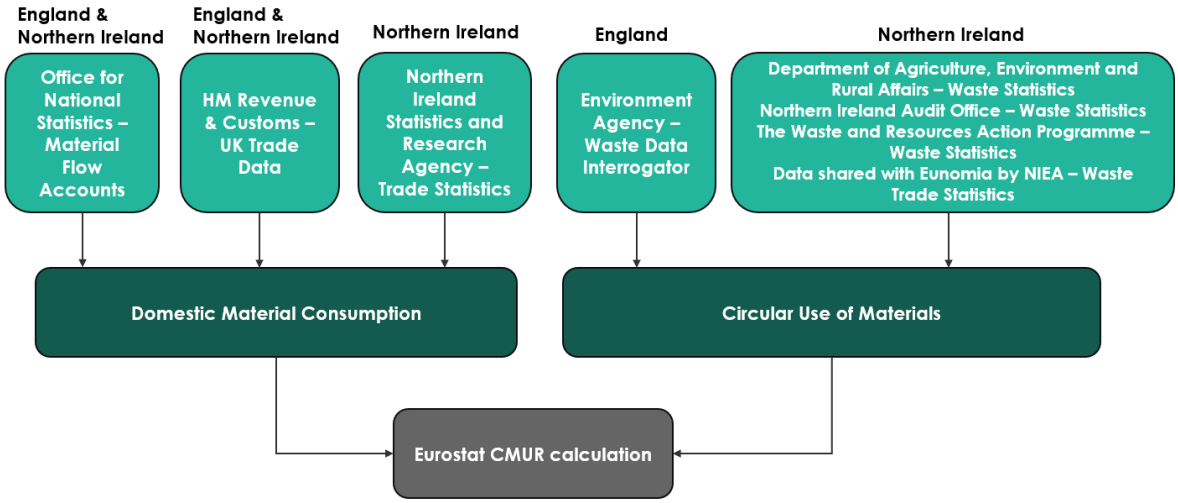
- Biomass, comprising of agriculture harvest, timber, animal grazing, and fishing.

The CMUR was calculated for the year 2022 based on latest available data.

2.2.1 Data sources

Key data sources used to gather the data inputs required for calculation of the CMUR for England and Northern Ireland include the Environment Agency (EA), HM Revenue & Customs (HMRC), the Department of Agriculture, Environment and Rural Affairs (DAERA), Office for National Statistics (ONS), the Northern Ireland Audit Office (NIAO) and the Northern Ireland Environment Agency (NIEA). Figure 2-1 presents the data flows for calculating the CMUR in England and Northern Ireland with reference to the relevant datasets. Links to the full list of data sources are provided in Footnotes and Appendix A.3.0.

Figure 2-1: Data flows for calculating England and Northern Ireland's CMUR



2.2.2 Data manipulation

The following data manipulations were performed on the data, to produce inputs for the calculation of the CMUR for England and Northern Ireland – the full methodology is outlined in Appendix A.1.0.

Domestic Extraction (England and Northern Ireland)

The data provided in the ONS's Material Flow Accounts is at the UK level. Therefore, collected data on UK domestic extraction, by material category (biomass, metal ores, non-metallic minerals, fossil energy materials/carriers), needed to be scaled to England and Northern Ireland. Data from a Materials Flow Account for Scotland was used to understand Scotland's contribution to UK domestic extraction. The remainder of domestic extraction was disaggregated to England, Northern Ireland and Wales based on the scaling factors outlined in Appendix A.1.0.

Imports and Exports of Goods (England and Northern Ireland)

The data for imports and exports of goods from outside the UK into England and Northern Ireland was obtained from HM Revenue & Customs UK Trade Info custom table build tool. The database used was the 'Regional Trade Data'. In this case the raw data was filtered to extract database entries for the volume of imports into and exports out of England, and separately for Northern Ireland, in 2022. The data was filtered by Standard International Trade

Classification (SITC) commodity code.[3] Further, data for trade which was 'unallocated' to a UK region was extracted.

The entries for England and Northern Ireland were mapped to five MF material categories – biomass, metal ores, non-metallic minerals, fossil energy materials/ carriers, and other products – by their SITC commodity code, using correspondence tables between the different classification systems provided in Eurostat Classifications (RAMON Archives).[4] Then the total tonnes of imported and exported goods were calculated for each MF material category, from the data extract. Total tonnages for MF category 'other' were proportionally re-distributed to the remaining four MF categories.

Additional data was collected for Northern Ireland to account for trade in goods between Northern Ireland and Great Britain. The data for England does not account for intra-UK trade.

Domestic Recovery (England)

Data on 'Wastes Received' was obtained from the Environment Agency's 2022 Waste Data Interrogator. The entries included in the extracted data were mapped to MF material categories – biomass, metal ores, non-metallic minerals, fossil energy materials/ carriers – by their waste code, using the correspondence factors from EWC-Stat waste categories to material categories given in the EU's circular material use rate calculation methodology.[5]

The total tonnes of waste recycled in domestic recovery plants was then calculated for each MF material category, from this data extract.

Domestic Recovery (Northern Ireland)

Data on wastes received by recovery facilities in Northern Ireland, from within Northern Ireland, was extracted from a waste summary returns annual data snapshot for 2022, obtained by request from NIEA. The entries included in the extracted data were mapped to MF material categories by their waste code, using the same methodology as that used for England.

The total tonnes of waste recycled in domestic recovery plants was then calculated for each MF material category, from this data extract.

Imports of Waste Destined for Recovery (England)

The data on 'Wastes Received', obtained from the Environment Agency's 2022 Waste Data Interrogator, was used as the source for data on imports of waste destined for recovery. In this case the raw data was filtered to extract database entries for waste that originated outside of England, but otherwise with the same characteristics as specified for domestic recovery above.

As for domestic recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste imports destined for recycling were calculated for each MF material category, from the data extract.

Imports of Waste Destined for Recovery (Northern Ireland)

Data shared with Eunomia by NIEA, compiled from waste summary returns from certain authorised site-based waste authorisations in Northern Ireland, was used to estimate imports of waste from outside the UK into Northern Ireland, destined for recovery. The total imports of

[3] United Nations (2008) Standard International Trade Classification, Revision 4. Available at link.
[4] Eurostat Classifications – Correspondence Tables. Available at link.
[5] Eurostat (2018) Circular material use rate: Calculation method. Available at link.

waste from outside the UK into Northern Ireland, destined for recovery, was assumed to be distributed across MF material categories based on the same proportions of MF material categories in imports of waste destined for recovery for England.

This data does not include imports of waste destined for recovery into Northern Ireland from the rest of the UK. It was, therefore, supplemented with data on wastes received by recovery facilities in Northern Ireland, from other UK nations, extracted from a waste summary returns annual data snapshot for 2022, obtained by request from the NIEA. The entries included in the extracted data were mapped to MF material categories by their waste code, using the same methodology as described above.

Exports of Waste Destined for Recovery (England)

The source for data on exports of waste destined for recovery was the data on 'Wastes Removed', obtained from the Environment Agency's 2022 Waste Data Interrogator. In this case the raw data was filtered to extract database entries for waste with a destination outside of England, but otherwise with the same characteristics as specified for domestic recovery above. As for domestic recovery and imports of waste destined for recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste exports destined for recycling were calculated for each MF material category, from the data extract.

Exports of Waste Destined for Recovery (Northern Ireland)

Data on wastes removed from facilities in Northern Ireland to the Republic of Ireland, other UK nations or other countries outside of the UK, destined for recovery, was extracted from a waste summary returns annual data snapshot for 2022, obtained by request from the NIEA. The entries included in the extracted data were mapped to MF material categories by their waste code, using the same methodology as described above.

The total tonnes of waste exports destined for recovery was then calculated for each MF material category, from this data extract.

2.3 Limitations

There are two main limitations of the CMUR calculation for England:

1. Data on domestic extraction of materials is not available for England. Therefore, the data used in the England CMUR calculation is a scaled version of UK-level domestic extraction. The UK-level data has been scaled based on Gross Value Added (GVA) and, for fossil energy materials/carriers, taking into account known differences in domestic extraction across the UK nations (see Appendix 1.0). However, for other material categories, there could be discrepancies between each UK nation's share in UK GVA and their share in UK domestic extraction.

2. Data on imports and exports of products was obtained from HMRC and it does not account for intra-UK import/export, i.e. imports to England from Wales, Scotland or Northern Ireland/ exports from England to Wales, Scotland or Northern Ireland. Whereas, data on imports and exports of waste destined for recovery was obtained from the Environment Agency's Waste Data Interrogator and does account for intra-UK trade.

There are three main limitations of the CMUR calculation for Northern Ireland:

1. Data on domestic extraction of materials is not available for Northern Ireland. Therefore, the data used in the Northern Ireland CMUR calculation is a scaled version of UK-level domestic extraction. The UK-level data has been scaled based on GVA

and, for fossil energy materials/carriers, taking into account known differences in domestic extraction across the UK nations (see Appendix A.1.0). However, for other material categories, there could be discrepancies between each UK nation's share in UK GVA and their share in UK domestic extraction.

2. Data on imports and exports of products was obtained from HMRC and it does not account for intra-UK import/export, i.e. imports to Northern Ireland from Wales, Scotland or England/ exports from Northern Ireland to Wales, Scotland or England. Whereas, data on imports and exports of waste destined for recovery was extracted from data obtained by request from NIEA and does account for intra-UK trade.

2.4 CMUR calculations

2.4.1 England

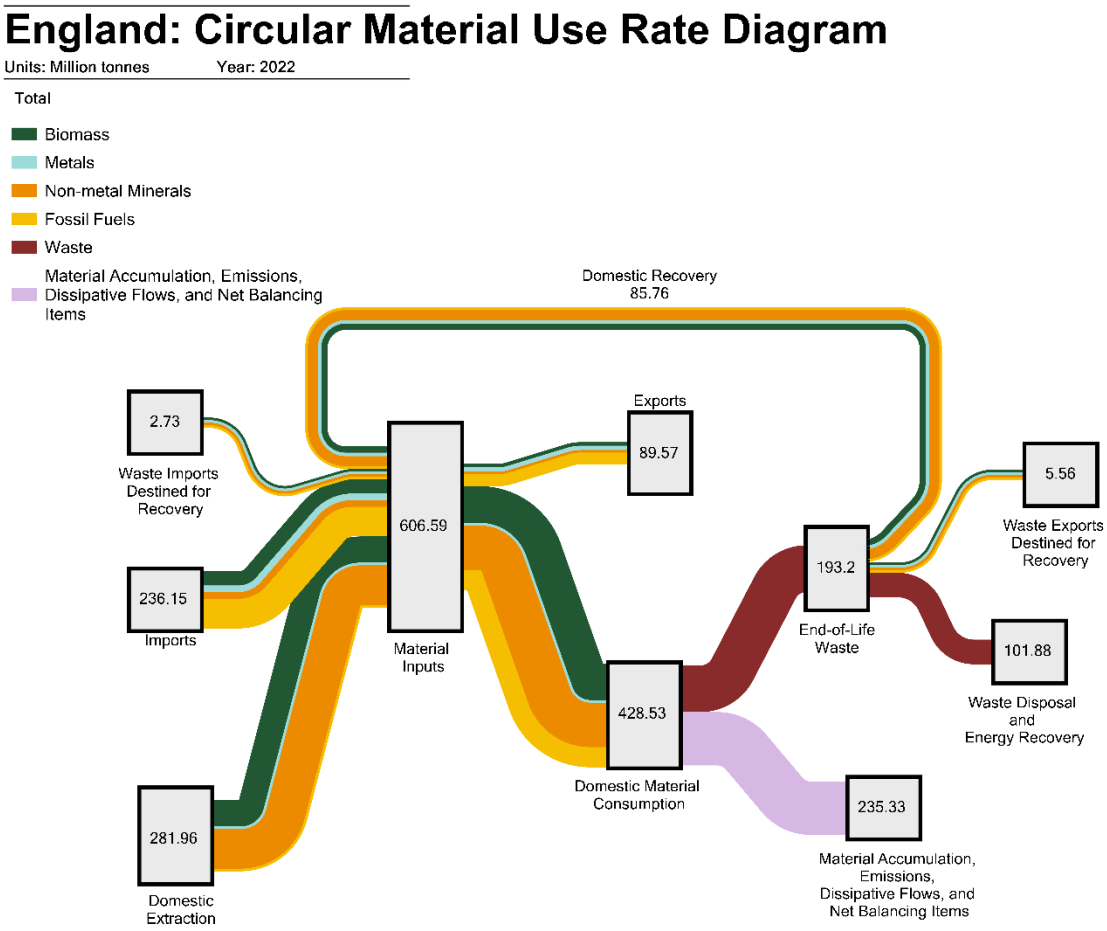
England's CMUR, circular use of materials, is 17%. Material flow data gathered to calculate the CMUR are visualised in a Sankey diagram (Figure) to reflect the size of material and waste flows.

In England, 429 million tonnes of materials were domestically consumed in 2022. DMC, is driven by non-metallic minerals (184 million tonnes), biomass (152 million tonnes) and fossil energy materials/carriers (83 million tonnes), with significantly lower consumption of metal ores (9.5 million tonnes). In the same year, 89 million tonnes of materials were recovered. U is primarily driven by non-metallic minerals (42 million tonnes), followed by biomass (26 million tonnes), metal ores (17 million tonnes) and fossil energy materials/carriers (3.6 million tonnes).

The CMUR was highest for metal ores (65%), followed by non-metallic minerals (18%), biomass (15%) and fossil energy materials/carriers (4%).

A full breakdown of the findings is outlined in Appendix A.2.1.

Figure 2-2: Sankey diagram for England



2.4.2 Northern Ireland

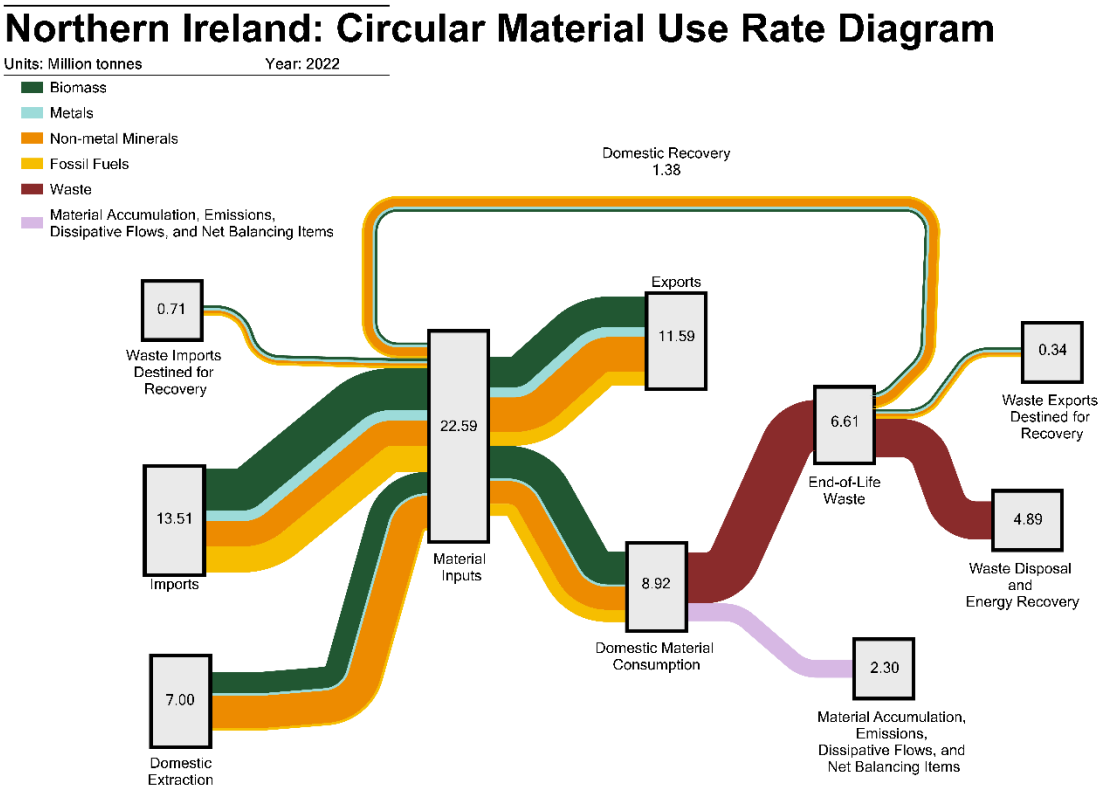
Northern Ireland's CMUR is 10%. Material flow data gathered to calculate the CMUR are visualised in a Sankey diagram (Figure) to reflect the size of material and waste flows.

In Northern Ireland, 8.9 million tonnes of materials were consumed throughout 2022. DMC is driven by biomass (4.3 million tonnes), non-metallic minerals (3 million tonnes) and fossil energy materials/carriers (1.6 million tonnes), with significantly lower consumption of metal ores (73,000 tonnes). In the same year, 1.4 million tonnes of materials were recovered domestically. U is primarily driven by non-metallic minerals (952,000 tonnes), followed by biomass (-58,000 tonnes), metal ores (136,000 tonnes) and fossil energy materials/carriers (-20,000 tonnes).

The CMUR was highest for metal ores (65%), followed by non-metallic minerals (24%), biomass (-1%) and fossil energy materials/carriers (-1%).

A full breakdown of the findings is outlined in Appendix A.2.2.

Figure 2-3: Sankey diagram for Northern Ireland



3.0 Interpretation & Analysis

This Section provides an interpretation and analysis of the CMURs for England and Northern Ireland presented in Section 2.4. In Section 3.1, the drivers of the calculated CMURs for England and Northern Ireland are explored. In Section 3.2, the calculated CMURs for England and Northern Ireland are compared with European counterparts. A comparison of the CMUR for Northern Ireland is also made with an alternative circularity indicator.

3.1 Drivers of CMUR in England and Northern Ireland

The overall CMUR is 17% in England and 10% in Northern Ireland. In both countries, the most circular materials are metal ores and non-metallic minerals, while biomass and fossil energy materials/carriers are the least circular.

Fossil energy materials/carriers

Fossil energy materials/carriers is the category with the lowest CMUR rate in England (4%) and Northern Ireland (-1%). The low CMUR is primarily driven by limited recovery, both domestic and international, combined with relatively high DMC. Further, the CMUR for fossil energy materials/carriers for Northern Ireland is negative because imports of waste destined for recovery are larger than the total amount of material recovered domestically and exported as waste destined for recovery.

Fossil energy materials/carriers, in particular fuels used for energy purposes (e.g. gasoline, diesel and natural gas) are inherently non-circular. Once burned, the fuels are emitted into

the atmosphere as greenhouse gases (GHGs), posing challenges for recovery.[6] While predominantly used for energy purposes, in Europe approximately 5% of fossil energy materials/carriers are used as a feedstock to produce plastic polymer resins.[7] Given that plastics can be recycled and fossil fuels cannot (with the exception of a small amount of waste oils), the majority of recovery operations within the fossil energy materials/carriers category relate to plastic recovery.

In England, of the 83 million tonnes of fossil energy materials/carriers consumed in 2022, 3.6 million tonnes were estimated to have been recovered in that year. The majority (~97%) of recovery operations took place domestically in England. While consumption in Northern Ireland was significantly lower (1.6 million tonnes), we have estimated that 0.02 million tonnes of fossil energy materials/carriers were recovered domestically, 0.05 million tonnes of fossil energy materials/carriers were imported for recovery and 0.01 million tonnes of fossil energy materials/carriers were exported for recovery.

The relatively high DMC of fossil energy materials/carriers in both countries is primarily driven by high imports. Domestic extraction is low in England (10 million tonnes out of a total DMC of 83 million tonnes) and zero in Northern Ireland. While DMC of fossil energy materials/carriers is not as high as DMC for biomass or non-metallic minerals, the disparity between DMC and U in both countries results in a low CMUR.

Biomass

Similarly, the low CMUR for biomass in England (15%) and Northern Ireland (-1%) is primarily driven by low recovery levels and high consumption. In particular, the CMUR for biomass for Northern Ireland is negative because imports of waste destined for recovery are larger than the total amount of material recovered domestically and exported as waste destined for recovery.

In England and Northern Ireland, the majority (approximately 65-90%) of biomass imports and exports are food crops or food items (including animal products).[8] Considering that biomass recovery predominantly relates to wood, cotton, and other non-food-based materials, recoverable biomass materials constitute a relatively small proportion of DMC and thus limit the potential for high recovery levels.

In 2022, England consumed 152 million tonnes of biomass, mostly domestically extracted (108 million tonnes) but also imported (59 million tonnes). Exports of biomass from England were low (15 million tonnes). The majority of England's recovery operations for biomass took place domestically (26 million tonnes).

Northern Ireland consumed 4.3 million tonnes of biomass in 2022, of which 2.8 million tonnes were extracted domestically. Northern Ireland imported a significant volume of biomass (5.4 million tonnes) while also exporting a lot (4 million tonnes). Animal feed is one of the top five biomass products imported into Northern Ireland and thus has a significant impact on the environment through land use for animal feed production and consequent GHG emissions from livestock production.

In Northern Ireland, agriculture and food processing dominate the economy. While there is a contribution from in-house animal feed production to the tonnes of biomass per year extracted, the imports of animal feed are higher than the amount produced in Northern Ireland. Considering that the majority of farmland in Northern Ireland is used for the purpose of farming cattle and sheep, the country produces significantly more food than is needed to

[6] Circle Economy (2022) The Circularity Gap Report Northern Ireland. Available at link.
[7] British Plastics Federation (2024) Oil Consumption. Available at link.
[8] Figure estimated from modelling the CMUR in England and Northern Ireland.

feed its population. Hence, 80% of food – namely meat and dairy – ends up being exported.[9] In 2022, 278,000 tonnes of biomass were recovered domestically, 359,000 tonnes were imported for recovery and 23,000 tonnes were exported for recovery. Most of the recovered biomass waste is generated by households.

Non-metallic minerals

England's CMUR for non-metallic minerals is 18% - similar to the overall CMUR for England. The CMUR is primarily driven by a high DMC and a relatively high level of recovery. In 2022, 184 million tonnes of non-metallic minerals were consumed in England, of which 164 million tonnes were extracted domestically. Non-metallic minerals also have a high domestic recovery rate in England.

Northern Ireland's CMUR for non-metallic minerals is 24%. The rate is driven primarily by high levels of consumption and relatively low levels of recovery.

Metal ores

Metal ores is the category with the highest CMUR rate in England (65%) and Northern Ireland (65%). In both countries, the driver of the high CMUR is limited domestic metal ore extraction combined with significant domestic recovery and exports of metal waste destined for recovery.

Domestic extraction of metal ores in England and Northern Ireland is low (2,000 and 100 tonnes, respectively). In the UK, metal mining activities have been limited historically and have decreased over time. This has led to a greater reliance on imports of raw metals or metal-containing products, rather than mining metal ores domestically.[10]

Metals have high recycling potential since they can be recycled almost indefinitely.[11] There is an added economic incentive as recycling metals is often more cost-effective than mining and processing new ores.[12]

In England, domestic recovery of metal waste (14 million tonnes) and exports of metal waste destined for recovery (3.9 million tonnes) are relatively high. In particular, exports of waste metal destined for recovery outside of the UK are significant (see Table 3-1).

Table 3-1: Exports from England of metal waste destined for recovery

Destination Region	Metal ores (000 tonnes)
Wales	408
Northern Ireland	2
Scotland	10

[9] Circle Economy (2022) The Circularity Gap Report Northern Ireland. Available at link.
[10] UK EITI (2024) Mining & Quarrying in the UK. Available at link.
[11] EuRIC (n.d.) Metal Recycling Factsheet. Available at link.
[12] Metals Mining Review (2024) Advancing sustainability through metal recycling. Available at link.

Outside UK	3,494
Total	**3,913**

The UK produces more scrap metal than is required for domestic recycling markets.[13] Further, there is strong international demand for scrap metal, particularly from countries with robust metal recycling industries, such as China and Turkey. These countries often have lower labour and processing costs, making it desirable to export metal waste for recycling.[14]

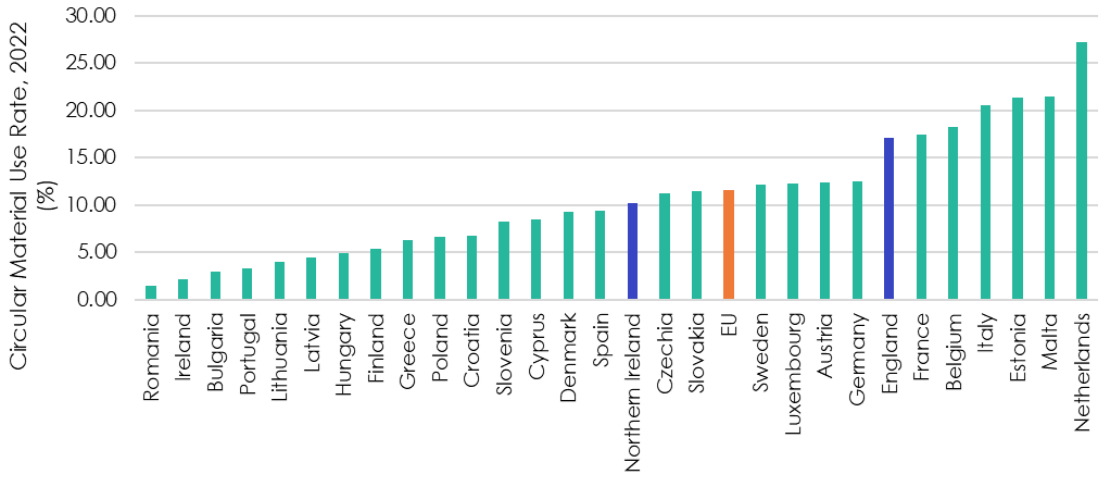
The low domestic extraction of metals leads to a low DMC value for metals in England (9.5 million tonnes), while the high level of domestic recovery of metals (14 million tonnes) combined with a high level of export (3.9 million tonnes) and very little import (0.7 million tonnes) of metal waste destined for recovery lead to an overall high level of circular material use (U) for metals (17.5 million tonnes). Together, the high level of U and a relatively low level of DMC lead to a high level of CMUR for metals.

3.2 Comparison of circularity indicators for England and Northern Ireland with other economies

This Section compares the calculated CMURs for England and Northern Ireland with European counterparts. A comparison of the CMUR for Northern Ireland is also made with the Circularity Gap report for Northern Ireland.[15]

Comparison with EU Member States

Figure 3-1: Circular material use rates for EU Member States, England and Northern Ireland, 2022[16,17]



[13] British Metals Recycling Association (2023) Metals Recycling in the UK. Available at link.
[14] BCG (2024) Shortfalls in Scrap Will Challenge the Steel Industry. Available at link.
[15] Circle Economy (2022) The Circularity Gap Report: Northern Ireland. Available at link.
[16] Eurostat (2024) Circular material use rate. Available at link.
[17] Eunomia's calculations.

Among the EU-27, England's CMUR of 17.13% in 2022 ranks it below France, Belgium, Italy, Estonia, Malta and Netherlands, but above the EU-27 average of 11.54% (Figure 3-1). Northern Ireland's CMUR of 10.18% in 2022 ranks it mid-pack amongst EU Member States, below the EU-27 average CMUR.

The Netherlands was the highest performing country among EU-27 in 2022, with a CMUR of 27.19% (Figure 3-1). DMC was 176.7 million tonnes in 2022 (41% fossil energy materials/ carriers, 18.9% non-metallic minerals, 4.6% metal ores, 35.4% biomass).[18] The European Environment Agency categorises factors that explain differences between national CMUR rates and the EU average as economic (structure), infrastructure and policy effects.[19] Characteristics of the Netherlands that help to explain why it has a higher CMUR than other EU member states include: [20]

- The country is a European front runner in terms of its recycling rate. The Netherlands recycles 80% of its waste (although this does often involve low-grade recycling, e.g. the use of recycled construction and demolition waste as recycled aggregates in infrastructure projects).[21]
- A high population density drives efficient use of raw materials for the provision of infrastructure (e.g. roads, railroads, pipe systems, recycling and waste management). This contributes to lower domestic consumption of raw materials. The Netherlands' domestic consumption of raw materials is below the EU average (at 22%).
- The Netherlands has a service-oriented economy.
- The country's waste policy has been proactive and ambitious for decades, with recent developments focusing on a circular economy model aimed at minimising waste and maximising resource efficiency.

Malta and Estonia have the joint second highest CMURs among the EU-27. Malta's CMUR of 21.5% in 2022 lies well above the EU average.[22] In particular, Malta has excelled in its management of Construction and Demolition (C&D) waste, achieving a 100% recovery rate. This success is attributed to the increased recycling of C&D waste, along with the reuse of non-metallic mineral C&D waste for purposes such as backfilling in quarries and recovery. This is an area that could be targeted for improvement in England and Northern Ireland, since England's CMUR rate for non-metallic minerals is calculated at 18%, while for Northern Ireland it is 24%.

Estonia also had a CMUR of 21.5% in 2022.[23] This is despite Estonia's struggles around resource productivity, which remains low even though it has been on the rise since 2013 (by 32%). Specific challenges faced by Estonia include: a high share of low-value material production, with low economic incentives for recycling; a dispersed and low-density population, which reduces the efficiency of material use, e.g. in infrastructure; and a lack of domestic processing capacity, which increases reliance on external facilities for recycling and material recovery.[24]

In Estonia, implementation of waste reform is expected to drive further improvements across various circularity metrics. The waste reform includes measures aimed at reducing waste and promoting recycling.[25] Municipalities will be set targets to improve sorted waste collection, and packaging waste collection will be shifted to the point of generation. To prioritise

[18] European Environment Agency (2024) Circular economy country profile 2024 – The Netherlands. Available at link.
[19] European Environment Agency (2022) Circular Economy policy innovation and good practice in Member States . Available at link.
[20] European Environment Agency (2024) Circular economy country profile 2024 – The Netherlands. Available at link.
[21] Circle Economy (2022) The Circularity Gap Report: Built Environment, the Netherlands. Available at link.
[22] European Environment Agency (2024) Circular economy country profile 2024 – Malta. Available at link.
[23] European Environment Agency (2024) Circular economy country profile 2024 – Estonia. Available at link.
[24] European Environment Agency (2022) Circular Economy policy innovation and good practice in Member States . Available at link.
[25] European Environment Agency (2024) Circular economy country profile 2024 – Estonia. Available at link.

recycling, landfill fees are being increased, an incineration fee introduced, and waste incineration incorporated into the EU emissions trading system. The reform also emphasises digitalising waste data for better management, and fosters innovation and competition in waste-related sectors to enhance service quality and affordability.

Italy had a CMUR of 20.6% in 2022.[26] This places Italy above the EU average, with the performance largely attributed to waste management practices. Italy has a long-established framework of environmental laws governing waste management. For decades it has implemented separate waste collection, supported by the growth and evolution of numerous recycling companies. Italy's recycling rate for municipal waste was 2 percentage points higher than the EU average and the recycling rate for all waste was 14 percentage points higher than the EU average, in 2021.

Comparison by material category

Table 3-2: Circular material use rates, 2022

	England, 2022[27]	Northern Ireland, 2022[28]	EU-27, 2022[29]
Total	**17%**	**10%**	**12%**
Biomass	15%	-1%	9%
Metal ores	65%	65%	23%
Non-metallic minerals	18%	24%	13%
Fossil energy materials/carriers	4%	-1%	3%

England and Northern Ireland have high CMUR for metal ores; 65%, versus the EU-27 average of 23% (Table 3-2). Reasons for these high CMURs for metal ores are discussed in Section 3.1.

Both England and Northern Ireland perform just above the EU-27 average in terms of their CMUR for non-metallic minerals. While England's CMURs for biomass and fossil energy materials/ carriers are above the EU-27 average, for Northern Ireland they are below the EU-27 average.

Comparison with the Circularity Gap report for Northern Ireland

Previous research focussed on quantifying circularity in Northern Ireland has calculated that Northern Ireland is 7.9% circular, leaving an estimated circularity gap of 92%.[30] According to this metric, Northern Ireland's performance on circularity is just the below the global average.

[26] European Environment Agency (2024) Circular economy country profile 2024 – Estonia. Available at link.
[27] Eunomia calculations
[28] Eunomia calculations
[29] Eurostat (2024) Circular material use rate.
[30] Circle Economy (2022) The Circularity Gap Report: Northern Ireland. Available at link.

Key drivers of Northern Ireland's Circularity Gap, identified in Circle Economy (2022), include:

- Low population density, which means that more material consumption is required per person for the delivery of amenities, such as road and utilities infrastructure.
- Growth of the construction sector in response to growing demand for housing from a rising population, which translates to growth in resource use by the construction sector.
- Large area of farmland, which is dominated by livestock farming.

These findings are consistent with the CMUR calculated for Northern Ireland in this report. Northern Ireland's CMUR of 10% is below England's CMUR (17%) and below the EU-27 average of 11.54%.

3.3 Increasing the circular material use rate

The CMUR can be increased by reducing DMC – domestic material consumption – or increasing U – the circular use of materials. Two important avenues for reducing domestic material consumption in England and Northern Ireland are reductions in consumption of fossil energy materials/carriers and biomass. In England and Northern Ireland, an important avenue for enhancing the circular economy is through strategies like reuse and remanufacturing. However, the measure U focusses on increasing the circular use of materials by increased recycling of waste in domestic recovery plants.

3.3.1 Reducing domestic material consumption

The following are key measures aimed at reducing DMC:

Switching from fossil fuels to renewable energy. England and Northern Ireland are heavily reliant on imported fossil fuels for energy – increasing domestic generation of renewable energy would reduce this dependency. Moreover, switching to renewables creates opportunity for both countries to improve their CMUR through reducing DMC. A 20% reduction in DMC for fossil energy materials/carriers increases overall CMUR for England from 17.1% to 17.7% and for Northern Ireland from 10.2% to 10.5% - while not an insignificant impact, benefits are greater when combined with an increase in recovery. Currently, over half of Great Britain's electricity supply is powered by renewable sources such as wind, solar and hydropower and capacity is expected to increase in future years.[31] However, the electrification of industries such as transport (one of the UK's most energy intensive industries) is crucial to ensure that benefits of renewable energy are maximised.[32]

Introducing agricultural policies to reduce demand for animal feed, focusing on demand for meat and dairy. Biomass is currently the largest and second-largest contributor to DMC for Northern Ireland and England, respectively. As discussed in section 3.1, in Northern Ireland, agriculture and food processing dominate the economy, however, Northern Ireland does not produce enough biomass for animal feed domestically, therefore the imports of biomass as animal feed are higher than the in-house production. Given that Great Britain is the largest market for Northern Ireland's meat exports, policy decisions should be a coordinated effort between governments in England and Northern Ireland. UK-wide policies could focus on reducing the demand for meat and dairy exports from Northern Ireland and thereby reducing animal feed imports and production. Policy makers could be unwilling to implement such measures due to the wider economic implications on Northern Ireland. Moreover, reductions in Northern Ireland's supply of meat and dairy products could be

[31] National Grid (2024) Energy explained – how much of the UK's energy is renewable? Available at link.
[32] Office for National Statistics (2022) Business energy spending: experimental measures from the Office for National Statistics' business surveys. Available at link.

substituted with increases in supply else in the world, resulting in zero global net benefit in terms of land use and GHG emissions.

Introducing agricultural policies to reduce demand for animal feed, focusing on feed efficiency. Another solution to reduce demand for animal feed involves improving feed efficiency and thereby reducing the overall quantity of feed required to produce the same quantity of meat and dairy products. Concerns around animal welfare often arise when considering such efficiency gains, for example, significant increases in the use of housed animal systems. Moreover, impacts are limited as many farmers already implement such efficiencies. The most effective policy option involves substituting soy, a high-protein animal feed which is expensive and land-intensive to produce, with alternatives that utilise organic wastes. For example, yeast protein – produced using precision fermentation. While a reduction in land use and improved recovery of organic wastes provide benefits for circularity, the overall consumption of materials remains unchanged.

Implementing policies on food waste reduction. The UK wastes approximately 10.7 million tonnes of food each year, originating from households (60%), farms (15%), manufacturing (13%), hospitality and food service (10%) and retail (2%).[33] Hence, reducing DMC for biomass hinges on resolving the issue of food waste. A 20% reduction in DMC for biomass increases overall CMUR for England from 17.1% to 18.2% and for Northern Ireland from 10.2% to 11.1%. England and Northern Ireland have made voluntary commitments aiming to reduce food waste by 50% by 2030. Numerous strategies to achieve this aim have been proposed, for example: information campaigns to raise consumer awareness of food waste; better recording of food waste data, particularly from farms and large businesses; improving date labelling; and selling more fruit and vegetables uncut and free of packaging to prolong shelf life.[34]

Implementing policies on the circularity of furniture. Improving the circularity of furniture, particularly through reuse, would reduce demand for virgin materials such as wood, metals, glass and plastics, while using less energy in the manufacturing process. In the UK, it is estimated that approximately 17% of domestic furniture is reused.[35] Barriers to a circular furniture sector are wide ranging but include poor product design and use of low-quality materials, limited collection and reverse logistics infrastructure; high cost of repair and refurbishment; weak demand for second-hand furniture; and weak over-arching policy design.[36] Improving the circularity of furniture would reduce DMC for all material categories, particularly biomass, which is a key driver of CMUR in England and Northern Ireland.

Imposing ban or charges on single-use items. Banning or disincentivising the use of single-use items and thereby incentivising reuse would reduce demand for virgin material production. This strategy can be used to reduce consumption of all material categories; however, benefits would be greatest for fossil energy materials/carriers. The University of Cambridge has reported that 97% of the University's waste comes from single-use items, of which nearly half is from plastics.[37] While waste composition varies across sectors, a university's waste is likely similar to waste in the service sector, which accounts for 83% of the UK's employment, indicating the potential to reduce consumption by focusing on single-use items more broadly.[38] The reduction can be achieved through legislation (e.g. bans or charges on single-use items across sectors, not limited to plastics) and through actively encouraging the use of reusable and refillable packaging (e.g. adding measures on reuse to packaging Extended Producer Responsibility legislation).

[33] UK Parliament (2024) Food waste in the UK. Available at link.
[34] UK Parliament (2024) Food waste in the UK. Available at link.
[35] WRAP (2011) Benefits of Reuse Case Study: Domestic Furniture. Available at link.
[36] European Environment Bureau (2017) Circular economy opportunities in the furniture sector. Available at link.
[37] University of Cambridge (2021) Which single-use disposables do we use the most and how can we reduce them? Available at link.
[38] UK Parliament (2025) Service Industries: Economic indicators. Available at link.

3.3.2 Increasing material recovery

The following are key measures aimed at improving recycling in domestic recovery plants, including plastic recovery facilities, paper and cardboard recycling facilities, glass recycling facilities, metal recycling facilities, CDE waste recycling facilities, wood recycling facilities, WEEE recycling centres, textile recycling facilities, composting sites and hazardous waste recycling facilities:

Introducing a pay-as-you-throw tax. Behavioural incentives can be implemented in England and Northern Ireland to increase domestic recovery of waste in poorly recycled waste streams; in particular, household waste. The main objective of a "pay-as-you-throw" (PAYT) tax, is to incentivise households to reduce their waste generation and increase their recycling efforts. PAYT instruments charge residents based on the weight, volume and/or collection frequency of the waste they dispose of (usually excluding recyclables). For example, legislation in the Republic of Ireland mandates incentivised charging for household waste collection.[39] A well-designed PAYT charging system should encourage reduced waste generation and better sorting of waste streams, leading to improved domestic recycling rates.

Increasing the Aggregates Levy. Increasing the rate of the Aggregates Levy in the UK could incentivise higher recycling of CDE waste by making the use of virgin aggregates more expensive. The levy, which is applied to the extraction and use of primary aggregates, raises the cost of materials like sand, gravel, and crushed stone.[40] By increasing the rate of the Aggregates Levy, the financial incentive to recycle and reuse CDE waste, such as crushed concrete and reclaimed asphalt, becomes stronger, reducing reliance on virgin materials.

Imposing taxes on virgin material extraction. Taxes similar to the UK Aggregates Levy could be imposed on the extraction of other virgin minerals and metals, such as coal, gypsum, tungsten and gold, to reflect the environmental costs of mining and resource depletion. Internationally, for example, mining taxes and/or mining royalties or mineral land taxes are imposed on mining operations in all Canadian provinces and territories.[41] These taxes make virgin mining more expensive, incentivising industries to invest in recycling as an economical alternative.

Increasing the landfill tax rate for inert materials. Increasing the landfill tax rate for inert materials, such as construction, demolition, and excavation (CDE) waste, in England and Northern Ireland would create stronger financial incentives for recycling and reuse of these materials. Inert materials make up a significant proportion of waste sent to landfill in England and Northern Ireland. Raising the landfill tax rate could drive investment in alternative treatment methods, such as aggregate recovery and the production of secondary construction materials, which are critical for supporting a circular economy. For example, Belgium has successfully reduced the landfilling of CDE waste, driven in part by high landfill tax rates.[42]

Integrating circular principles into public procurement practices. By adopting circular procurement, public authorities can promote reuse and recycling of materials and stimulate the development of circular business models. England and Northern Ireland can learn from initiatives such as the Green Deal Circular Procurement implemented by Circular Flanders in

[39] Department of Communications, Climate Action and Environment (n.d.) New Incentives to Reduce Waste and Encouraging Recycling. Available at link.
[40] HM Revenue & Customs (2023) Guidance: Check when Aggregates Levy applies. Available at link.
[41] Government of Canada (2023) How mining is taxed in Canada and internationally. Available at link.
[42] Deloitte (2015) Screening template for Construction and Demolition Waste management in Belgium. Available at link.

Belgium, which aimed to promote and facilitate the adoption of circular procurement through collaboration and knowledge sharing among a network of organisations.[43]

Expanding Extended Producer Responsibility schemes. Extended Producer Responsibility (EPR) increases recycling by shifting the financial and operational responsibility for waste management from local governments to producers, incentivising them to design products and packaging with end-of-life management in mind, and driving innovation and investment in recycling infrastructure. The UK already has several EPR schemes in place, focused on products that generate significant waste. Current schemes cover packaging waste, waste electrical and electronic equipment (WEEE), and batteries.[44] Extension of EPR schemes to other materials, such as textiles and tyres, could help to drive improvements in the recycling rates of poorly recycled products in England and Northern Ireland.

Integrating advanced sorting technologies. Integration of advanced sorting technologies into sorting facilities can help to achieve higher recycling rates by enhancing the separation of recyclable materials and reducing contamination. These technologies, including AI-driven optical sorting systems, near-infrared (NIR) technology and advanced robotic systems, allow for the precise identification and sorting of materials that are difficult to sort manually, increasing the overall recovery rate.[45]

Proliferating circular business models. Retailer take-back schemes, whereby a retailer offers services to collect used or unwanted products from customers so they can be reused, recycled, or properly disposed of, for example, help extend the lifecycle of products and materials and encourage closed-loop systems. For example, IKEA offers a take-back scheme for used furniture, ensuring that it is either reused or recycled.[46] Similarly, brands like Patagonia and H&M offer take-back schemes for used clothing, encouraging customers to return items for reuse or recycling.[47,48]

Standardising recycling collections. Implementing consistent recycling collections across local authorities can help to improve material recovery rates and reduce contamination of recycling streams in England and Northern Ireland. Steps towards implementing consistent recycling collection systems are already being taken in England, through the Simpler Recycling policy.[49] Northern Ireland could also work towards implementing consistent recycling collections across its local authorities.

Improving recycling collections for plastics, particularly flexible packaging, a packaging structure which flexes easily and can be made of both single and multiple layers of materials, such as plastic film and aluminium foil. In the UK, approximately 800,000 tonnes of flexible plastic packaging are placed on the market each year, however, only 12% of local authorities collect plastic films and flexibles for recycling at the kerbside.[50,51] Policies are being implemented in England to introduce kerbside plastic film collection from businesses and relevant non-domestic premises, and households, by March 2027. While similar policies are being proposed in Northern Ireland, strong commitments and robust implementation plans are needed to increase investment in recycling infrastructure for flexible plastics.[52] However, improving plastic recycling alone is not enough. Reducing the use of plastics at the source—

[43] Circular Flanders (n.d.) Green Deal Circular Procurement (2017-2019. Available at link.
[44] PWC (n.d.) Update on Extended Producer Responsibility Changes in the UK. Available at link.
[45] Recycling Inside (2024) Innovations in Advanced Sorting Technologies for Recyclable Materials. Available at link.
[46] IKEA (n.d.) IKEA Buyback & Resell Service. Available at link.
[47] Patagonia (n.d.) Worn Wear Patagonia. Available at link.
[48] H&M (n.d.) Our work Let's close the loop. Available at link.
[49] Defra (2024) Simpler Recycling in England: policy update. Available at link.
[50] Suez (2021) Leading household brands join forces to tackle flexible plastic packaging recycling in the UK. Available at link.
[51] Recoup (2023) Plastic Packaging Use and Recycling Collection Rates Drop for the First Time. Available at link.
[52] Suez (2021) Leading household brands join forces to tackle flexible plastic packaging recycling in the UK. Available at link.

through, for example, packaging redesign, increased use of reusable alternatives, and promoting material substitution—should also be a priority.

Improving recycling collections for textiles. In the UK, approximately 1 million tonnes of textiles are thrown away each year. It is estimated that over half of the discarded textiles are recyclable, however, in practice only a quarter are reused or recycled.[53] Globally, approximately 70% of textiles are made from synthetic fibres and approximately 30% are made from plant or animal fibres.[54] Therefore, improving collection and recycling of textiles helps to increase the recovery of biomass and fossil energy materials/carriers, the two material categories with the lowest recovery rates in England and Northern Ireland.

4.0 Conclusions

This section outlines key limitations and areas for improvement in the calculations of the CMURs for England and Northern Ireland presented in this report. Priority areas for future research are also identified.

4.1 Areas for improvement

The CMUR calculations for both England and Northern Ireland presented in this report face important limitations, primarily due to data gaps and reliance on scaling methods. For England and Northern Ireland, domestic extraction data is unavailable, leading to reliance on scaled UK-level data, which may not accurately reflect regional variations. Additionally, for England, HMRC data on imports and exports of products does not account for intra-UK trade, whereas waste trade data from the Environment Agency and the Northern Ireland Environment Agency does account for intra-UK trade.

These issues highlight the need for improved and region-specific data to enhance the accuracy of CMUR calculations. Priorities for data collection include:

- Amount of domestic extraction in England
- Amount of domestic extraction in Northern Ireland
- Imports and exports of products in England and Northern Ireland accounting for intra-UK trade

4.2 Future research

4.2.1 Using the CMUR for policy assessment

CMUR calculations could serve as a valuable tool for ex-ante policy assessment.

Prior to policy implementation, CMUR calculations can be used to help predict the potential impact of different policy options on circularity, aiding in the selection of the most effective measures. By modelling how various interventions affect the CMUR, policymakers can identify strategies with the greatest potential to increase circularity.

This type of analysis would require estimation of the impact of given policy options on inputs to the CMUR calculations, e.g. the rate of recycling in domestic recovery facilities or the volume of material extracted domestically, for specific material categories. The calculated

[53] WRWA (n.d.) Mixed textiles & clothing. Available at link.
[54] Textile Exchange (2023) Materials Market Report. Available at link.

impacts on the CMUR would then allow for comparison across policy options, indicating which areas of focus could achieve the largest impact on circularity.

4.2.2 Filling evidence gaps and extending research on circularity in England and Northern Ireland

The following are potential areas for further research to advance understanding of circularity in England and Northern Ireland and to support the transition to more circular economies:

Environmentally Extended Input-Output Tables. A sector-specific approach to analysing the circularity of an economy can be supported by the use of environmentally extended input-output tables. Traditional input-output tables show how industries interact with each other by detailing the goods and services industries purchase from other industries to produce their output, and the goods and services sold to other industries. Environmentally extended input-output tables additionally link environmental impacts, including resource use, to economic activities.[55,56] Therefore, environmentally extended input-output tables can be used to trace the environmental impacts of specific industries and to assess interventions aimed at improving circularity.[57]

EXIOBASE is a multi-regional environmental input-output (MRIO) database used extensively in the European Union to analyse the environmental impacts of economic activities, including in the context of circular economy strategies.[58] EXIOBASE can be applied to study sector-specific material flows, e.g. a study on the Danish plastic industry employed EXIOBASE to trace material flows and indicate opportunities for applying circular economy strategies.[59]

Official environmentally extended input-output tables are available for Scotland.[60] However, England and Northern Ireland do not have separate environmentally extended input-output tables. The development of national environmentally extended input-output tables for England and Northern Ireland would enhance the ability to assess sector-specific resource use and environmental impacts at a regional level.

Material Flows Accounts for England and Northern Ireland. Material Flow Accounts (MFA) have been produced for Scotland, providing a detailed understanding of material flows into and out of the Scottish economy.[61] Scotland's MFA help to improve understanding of material consumption in Scotland and identify areas for change that can move Scotland towards a more circular economy. England and Northern Ireland should develop their own MFA to gain insights into material flows through their economies. Key outputs of the MFA are indicators for Domestic Extraction and Domestic Material Consumption, which are critical components of the calculation of the CMUR. Therefore, the process of developing MFA for England and Northern Ireland would require the collection of data that would also help to address limitations in the calculation of the CMUR for England and Northern Ireland.

Carbon Flow Analysis. Material Flow Accounts developed for England and Northern Ireland could be further enhanced by applying carbon factors to the material flows. Carbon factors represent the amount of greenhouse gas emissions (GHGs) associated with the extraction,

[55] Kitzes, J. (2013) An Introduction to Environmentally-Extended Input-Output Analysis. Resources, 2(4), 489-503.
[56] Eurostat (2021) Producing environmental accounts with environmentally extended input output analysis. Statistical Working Papers. Available at link.
[57] Aguilar-Hernandez, G.A., Sigüenza-Sanchez, C.P., Donati, F. et al. (2018) Assessing circularity interventions: a review of EEIOA-based studies. Economic Structures, 7(14). Available at link.
[58] EXIOBASE (n.d.) About EXIOBASE. Available at link.
[59] Vingwe, E., Towa, E., & Remmen, A. (2020) Danish Plastic Mass Flows Analysis. Sustainability, 12(22), 9639. Available at link.
[60] Scottish Government (2024) Supply, Use and Input-Output Tables. Available at link.
[61] Zero Waste Scotland (2023) Material Flow Accounts (MFA). Available at link.

production, use, and disposal of materials. Integrating these factors into MFAs enables more comprehensive assessment of the GHG impacts associated with material flows across the whole lifecycle.

Single-Use Products Indicators. While there have been some measures implemented in the UK to tackle the environmental impact of single-use plastics and other disposable items, such as the plastic bag charge[62] and bans or restrictions on single-use plastic products such as plastic stirrers, cutlery, straws and cotton buds,[63] there is no overarching, comprehensive national legislation that targets single-use products across sectors. The lack of a dedicated focus on single-use products in UK legislation, especially in comparison with the EU's Single-Use Plastics Directive,[64] highlights a potential gap in addressing the environmental impacts of these items. In the absence of specific legislation, indicators related to single-use items can track their contribution to waste generation, resource use, and pollution, e.g.:

- Quantities of single-use plastic and other disposable products in the municipal waste stream.
- Recycling rates for single-use items.
- The volume of plastic waste per capita or per unit of Gross Domestic Product (GDP).

Waste Minimisation and Reuse Indicators. Indicators relating to waste minimisation and reuse can complement CMUR calculations by providing broader insight into key elements of the circular economy that are not explicitly measured by the CMUR. Indicators may include:

- Waste generation per capita
- Waste generation per unit of GDP
- Proportion of products that are reused
- Rate of repair activities
- Market share of second-hand goods
- Average lifespan of products

Tracking these indicators can provide valuable insights into the progress of a circular economy.

Behavioural Feedback. The provision of information allowing consumers to track their circularity behaviours (e.g., reducing waste, recycling more, buying second-hand) can provide incentives to maintain and improve these actions. Further, providing feedback comparing an individual's progress to national averages or targets can motivate consumers to adopt more circular practices. Such feedback could be provided through, for example, a consumer-facing platform that provides an individual with information on their personal recycling rate, based on data collected from their household waste collection, and compares it to their local or national average recycling rate.

[62] Defra (2015) Carrier bags: why there's a charge. Available at link.
[63] Defra (2024) Guidance: Single-use plastics bans and restrictions. Available at link.
[64] European Union (2019) Single-use plastics – fighting the impact on the environment. Available at link.

Appendix

A.1.0 Detailed Methodology

This section outlines the detailed methodology, including departures from the Eurostat CMUR methodology and how UK-level data has been disaggregated for each nation.

Domestic Extraction (England and Northern Ireland)

The data provided in the ONS's Material Flow Accounts is at the UK level. Therefore, collected data on UK domestic extraction, by material category (biomass, metal ores, non-metallic minerals, fossil energy materials/carriers), needed to be scaled to England and Northern Ireland.

In previously published work, Eunomia has produced a Materials Flow Account for Scotland (the latest version was produced for 2018).[65] The first step taken in scaling UK domestic extraction was to remove Scottish domestic materials extraction from the UK domestic extraction figures. This was achieved by calculating Scotland's share of total UK domestic extraction in 2018 and removing the same share from UK domestic extraction in 2022.

Next, scaling factors were developed to account for England, Wales and Northern Ireland's share in the UK, excluding Scotland, domestic extraction totals for 2022 (see Table 4-1). For MFA material categories MF1 - Biomass, MF2- Metal ores and MF3 – Non-metallic minerals, scaling factors were based on each nation's proportional share of GVA in 2022, redistributing Scotland and extra-region GVA to England, Wales and Northern Ireland, proportionally. For MFA categories MF41 - Coal and other solid energy materials/carriers, MF421 - Crude oil, condensate and natural gas liquids (NGL) and MF422 - Natural gas, a similar procedure was followed, except known differences in the extraction of fossil energy materials/carriers across the UK nations were also taken into account. For category MF41, it was assumed that Northern Ireland has no coal extraction.[66] For categories MF421 and MF422, it was assumed that neither Wales nor Northern Ireland has any oil or gas extraction.[67][68]

Table 4-1: Scaling factor for scaling UK domestic extraction data

Country	GVA, 2022 (current basic prices, £ millions)	% of UK GVA	Scaling factors MF1, MF2 & MF3	Scaling factors MF41	Scaling factors MF421& MF422
England	1,940,267	86.39%	93.97%	96.30%	100.00%
Scotland	165,714	7.38%			
Wales	74,545	3.32%	3.61%	3.70%	0.00%
Northern Ireland	49,901	2.22%	2.42%	0.00%	0.00%
Extra-region	15,620	0.70%			
UK Total	**2,246,047**	**100%**	**100%**	**100%**	**100%**

[65] Zero Waste Scotland (2023) Scottish Material Flow Accounts. Available at link.
[66] British Geological Survey (2020) Directory of Mines and Quarries 2020. Available at link.
[67] BBC (2021) Climate change: Wales pledges to stop licensed oil and gas production. Available at link.
[68] BBC (2011) Quest for oil in Northern Ireland has its cost. Available at link.

These scaling factors (Table 4-1) were applied to the calculated UK, excluding Scotland, domestic extraction figures, for the respective MF categories, to estimate England-level domestic extraction in 2022.

Imports and Exports of Goods (England and Northern Ireland)

The source for data on imports and exports of goods was 'Regional Trade Data', obtained from HM Revenue & Customs UK Trade Info custom table build tool. In this case the raw data was filtered to extract database entries for the volume of imports into and exports out of England in 2022, by Standard International Trade Classification (SITC) commodity code. Further, data for trade which was 'unallocated' to a UK region was extracted.

The entries for England were mapped to five MF material categories – biomass, metal ores, non-metallic minerals, fossil energy materials/ carriers, and other products – by their SITC commodity code, using correspondence tables between the different classification systems provided in Eurostat Classifications (RAMON Archives).[69] Then the total tonnes of imported and exported goods were calculated for each MF material category, from the data extract. Total tonnages for MF category 'other' were proportionally re-distributed to the remaining four MF categories.

The 'unallocated' trade data was mapped to MF categories using the same methodology as for England. Further, total tonnages of 'unallocated' trade were proportionally distributed to each UK nation using scaling factors outlined in Table 4-2. Scaling factors were based on each nation's proportional share of GVA in 2022, redistributing extra-region GVA to England, Scotland, Wales and Northern Ireland, proportionally. Finally, England's proportion of 'unallocated' trade was added to England's trade totals for each MF category to estimate England-level imports and exports of goods.

Table 4-2: Scaling factor for scaling unallocated trade volume

Country	GVA, 2022 (current basic prices, £ millions)	% of UK GVA	Scaling factors for unallocated trade
England	1,940,267	86.39%	86.99%
Scotland	165,714	7.38%	7.43%
Wales	74,545	3.32%	3.34%
Northern Ireland	49,901	2.22%	2.24%
Extra-region	15,620	0.70%	
UK Total	**2,246,047**	**100%**	**100%**

Additionally, data for trade between Northern Ireland and Great Britain was obtained from the Northern Ireland Statistics and Research Agency. The data was reported in values; hence a scaling factor was used to convert the data to tonnages. Further, the data was disaggregated into material categories using proportions from trade with the rest of the world.

Domestic Recovery (England)

Data on 'Wastes Received' was obtained from the Environment Agency's 2022 Waste Data Interrogator. The raw data was filtered to extract database entries for waste that:

- Originated in England
- Was destined for recovery

[69] Eurostat Classifications – Correspondence Tables. Available at link.

- Was received at a site categorised as one of the following: MRS (Metal Recycling), Treatment, Processing, On/In Land, Use of Waste, Mobile Plant. This avoids double counting of database entries, e.g. of waste that was destined for recovery but first passed through a transfer site.
- Has been assigned a Recovery and Disposal code R2 - R11. Recovery and Disposal codes R2-R11 relate to the recovery operations specified for inclusion according to the EU methodology.[70]

The entries included in the extracted data were mapped to MF material categories – biomass, metal ores, non-metallic minerals, fossil energy materials/ carriers – by their waste code, using the correspondence factors from EWC-Stat waste categories to material categories given in the EU's circular material use rate calculation methodology.[71]

The total tonnes of waste recycled in domestic recovery plants was then calculated for each MF material category, from this data extract.

Domestic Recovery (Northern Ireland)

Data on wastes received by recovery facilities in Northern Ireland was extracted from a waste summary returns annual data snapshot for 2022, obtained by request from the Northern Ireland Environment Agency.

The raw data was filtered to extract database entries for waste that:

- Was received from within Northern Ireland
- Was received at a site categorised as one of the following: Waste soil / rock treatment for para 9 / 11 & other manufacture; Waste used for Construction, Maintenance or Improvement of Relevant Work; Waste Metal, Plastic, Glass, Ceramics, Rubber, Textiles, Wood, Paper or Cardboard finished goods manufacture; Benefit to agricultural land or Ecological Improvement of same or non-agricultural land; Repair, Refurbishment, and Storage of Waste Electrical and Electronic Equipment (WEEE); non-hazardous treatment & transfer composting; non-hazardous treatment & transfer wood; non-hazardous treatment & transfer plastic; inert treatment & transfer; treatment & transfer composting; hazardous treatment & transfer chemical waste; treatment & transfer oil; hazardous treatment & transfer ATF & scrap metal; hazardous treatment & transfer ATF, WEEE & scrap metal; hazardous treatment & transfer ATF; hazardous treatment & transfer scrap metal; non-hazardous treatment & transfer oils / fats; hazardous treatment & transfer; non-hazardous treatment & transfer scrap metal; hazardous treatment & transfer WEEE; non-hazardous treatment & transfer tyres; hazardous treatment & transfer municipal WTS & CA Site; hazardous treatment & transfer clinical/healthcare; treatment & transfer WEEE; treatment & transfer production of cement and lime; treatment & transfer recovery. This avoids double counting of database entries, e.g. of waste that was destined for recovery but first passed through a transfer site.
- Has been assigned a Recovery and Disposal code R2 - R11. Recovery and Disposal codes R2-R11 relate to the recovery operations specified for inclusion according to the EU methodology.[72]

The entries included in the extracted data were mapped to MF material categories – biomass, metal ores, non-metallic minerals, fossil energy materials/ carriers – by their waste code, using the correspondence factors from EWC-Stat waste categories to material categories given in the EU's circular material use rate calculation methodology. [73]

The total tonnes of waste recycled in domestic recovery plants was then calculated for each MF material category, from this data extract.

[70] Eurostat (2018) Circular material use rate: Calculation method. Available at link.
[71] Eurostat (2018) Circular material use rate: Calculation method. Available at link.
[72] Eurostat (2018) Circular material use rate: Calculation method. Available at link.
[73] Eurostat (2018) Circular material use rate: Calculation method. Available at link.

Imports of Waste Destined for Recovery (England)

Similarly, the data on 'Wastes Received', obtained from the Environment Agency's 2022 Waste Data Interrogator, was used as the source for data on imports of waste destined for recovery. In this case the raw data was filtered to extract database entries for waste that originated outside of England, but otherwise with the same characteristics as specified for domestic recovery above.

As for domestic recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste imports destined for recycling were calculated for each MF material category, from the data extract.

Imports of Waste Destined for Recovery (Northern Ireland)

Data shared with Eunomia by NIEA, compiled from waste summary returns from certain authorised site-based waste authorisations in Northern Ireland, indicates the volume of waste received in 2023-24 from outside the UK into Northern Ireland, for all types of recovery, excluding R1. This volume was taken as the total imports of waste into Northern Ireland from outside the UK, destined for recovery. The total was assumed to be distributed across MF material categories based on the same proportions of MF material categories in imports of waste destined for recovery for England.

It should be noted that this data does not include the waste streams 17 05 04 (soil & stones from construction and demolition) or 20 02 02 (soil & stones from municipal gardens & parks). It also does not include imports of waste destined for recovery into Northern Ireland from the rest of the UK.

Therefore, this data was supplemented with data on wastes received by recovery facilities in Northern Ireland, from other UK nations, extracted from a waste summary returns annual data snapshot for 2022, obtained by request from the NIEA. In this case, the raw data was filtered to extract database entries for waste that was received from 'Other UK' nations, but otherwise with the same characteristics as specified for domestic recovery above. As for domestic recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste imports destined for recycling from other UK nations were calculated for each MF material category, from the data extract.

Total imports of waste into Northern Ireland, destined for recovery, were calculated as the sum of imports from outside the UK and imports from other UK nations, for each material category.

Exports of Waste Destined for Recovery (England)

The source for data on exports of waste destined for recovery was the data on 'Wastes Removed', obtained from the Environment Agency's 2022 Waste Data Interrogator. In this case the raw data was filtered to extract database entries for waste with a destination outside of England, but otherwise with the same characteristics as specified for domestic recovery above. As for domestic recovery and imports of waste destined for recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste exports destined for recycling were calculated for each MF material category, from the data extract.

Exports of Waste Destined for Recovery (Northern Ireland)

The source for data on exports of waste destined for recovery was the data on wastes removed, extracted from a waste summary returns annual data snapshot for 2022, obtained by request from the NIEA. In this case the raw data was filtered to extract database entries for waste with a destination outside of Northern Ireland, but otherwise with the same characteristics as specified for domestic recovery above. As for domestic recovery, the entries included in the extracted data were mapped to MF material categories by their waste code. Then the total tonnes of waste exports destined for recycling were calculated for each MF material category, from the data extract.

A.2.0 Detailed CMUR Calculations

A.2.1 England

Table 4-3: Domestic Material Consumption, 2022

Indicator	2022 (000 tonnes)
Domestic extraction	**281,955**
Biomass	108,122
Metal ores	2
Non-metallic minerals	163,906
Fossil energy materials/carriers	9,926
Imported products	**236,147**
Biomass	58,600
Metal ores	27,247
Non-metallic minerals	27,866
Fossil energy materials/carriers	122,434
Exported products	**89,570**
Biomass	15,170
Metal ores	17,774

Indicator	2022 (000 tonnes)
Non-metallic minerals	7,594
Fossil energy materials/carriers	49,032
Domestic material consumption, DMC	**428,532**
Biomass	151,551
Metal ores	9,475
Non-metallic minerals	184,178
Fossil energy materials/carriers	83,327

Table 4-4: Circular Use of Materials, 2022

Indicator	2022 (000 tonnes)
Domestic recovery	**85,756**
Biomass	26,072
Metal ores	14,219
Non-metallic minerals	41,918
Fossil energy materials/carriers	3,547
Imported waste for recovery	**2,728**

Indicator	2022 (000 tonnes)
Biomass	1,381
Metal ores	677
Non-metallic minerals	471
Fossil energy materials/carriers	199
Exported waste for recovery	**5,559**
Biomass	1,101
Metal ores	3,913
Non-metallic minerals	250
Fossil energy materials/carriers	295
Circular use of materials, U	**88,588**
Biomass	25,793
Metal ores	17,455
Non-metallic minerals	41,697
Fossil energy materials/carriers	3,643

Table 4-5: Circular Material Use Rate, 2022

	CMUR, 2022
Total	**17%**
Biomass	15%
Metal ores	65%
Non-metallic minerals	18%
Fossil energy materials/carriers	4%

A.2.2 Northern Ireland

Table 4-6: Domestic Material Consumption, 2022

Indicator	2022 (000 tonnes)
Domestic extraction	**6,996**
Biomass	2,781
Metal ores	0.1
Non-metallic minerals	4,215
Fossil energy materials/carriers	0
Imported products	**13,506**
Biomass	5,440

Indicator	2022 (000 tonnes)
Metal ores	1,387
Non-metallic minerals	3,300
Fossil energy materials/carriers	3,380
Exported products	**11,588**
Biomass	3,965
Metal ores	1,314
Non-metallic minerals	4,518
Fossil energy materials/carriers	1,790
Domestic material consumption, DMC	**8,915**
Biomass	4,255
Metal ores	73
Non-metallic minerals	2,997
Fossil energy materials/carriers	1,590

Table 4-7: Circular Use of Materials, 2022

Indicator	2022 (000 tonnes)
Domestic recovery	**1,380**
Biomass	278
Metal ores	5
Non-metallic minerals	1,074
Fossil energy materials/carriers	22
Imported waste for recovery	**711**
Biomass	359
Metal ores	176
Non-metallic minerals	122
Fossil energy materials/carriers	54
Exported waste for recovery	**342**
Biomass	23
Metal ores	307
Non-metallic minerals	0
Fossil energy materials/carriers	12

Indicator	2022 (000 tonnes)
Circular use of materials, U	**1,010**
Biomass	-58
Metal ores	136
Non-metallic minerals	952
Fossil energy materials/carriers	-20

Table 4-8: Circular Material Use Rate, 2022

	CMUR, 2022
Total	**10%**
Biomass	-1%
Metal ores	65%
Non-metallic minerals	24%
Fossil energy materials/carriers	-1%

A.3.0 List of Data Sources

A.3.1 England

Component of the CMUR calculation	Data source
Domestic extraction	Office for National Statistics (2024) Material Flow Accounts. https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsmaterialflowsaccountunitedkingdom
Imports of goods	HM Revenue & Customs UK Trade Info (2024) Build a Regional Trade Data Table. https://www.uktradeinfo.com/trade-data/rts-custom-table/
Exports of goods	HM Revenue & Customs UK Trade Info (2024) Build a Regional Trade Data Table. https://www.uktradeinfo.com/trade-data/rts-custom-table/
Waste recycled in domestic recovery plants	Environment Agency (2024) 2022 Waste Data Interrogator: Wastes Received. https://www.data.gov.uk/dataset/aa53a313-f719-4e93-a98f-1b2572bd7189/2022-waste-data-interrogator
Imports of waste bound for recovery	Environment Agency (2024) 2022 Waste Data Interrogator: Wastes Received. https://www.data.gov.uk/dataset/aa53a313-f719-4e93-a98f-1b2572bd7189/2022-waste-data-interrogator
Exports of waste bound for recovery	Environment Agency (2024) 2022 Waste Data Interrogator: Wastes Removed. https://www.data.gov.uk/dataset/aa53a313-f719-4e93-a98f-1b2572bd7189/2022-waste-data-interrogator

A.3.2 Northern Ireland

Component of the CMUR calculation	Data source
Domestic extraction	Office for National Statistics (2024) Material Flow Accounts. https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsmaterialflowsaccountunitedkingdom

Component of the CMUR calculation	Data source
Imports of goods	HM Revenue & Customs UK Trade Info (2024) Build a Regional Trade Data Table. https://www.uktradeinfo.com/trade-data/rts-custom-table/ Northern Ireland Statistics and Research Agency (2022) Northern Ireland Economic Trade Statistics 2022. https://datavis.nisra.gov.uk/economy-and-labour-market/northern-ireland-economic-trade-statistics-2022.html#32_Trade_Balance_by_Industry
Exports of goods	HM Revenue & Customs UK Trade Info (2024) Build a Regional Trade Data Table. https://www.uktradeinfo.com/trade-data/rts-custom-table/ Northern Ireland Statistics and Research Agency (2022) Northern Ireland Economic Trade Statistics 2022. https://datavis.nisra.gov.uk/economy-and-labour-market/northern-ireland-economic-trade-statistics-2022.html#32_Trade_Balance_by_Industry
Waste recycled in domestic recovery plants	NIEA (2022) Waste summary returns annual data snapshot for 2022, with exemptions.
Imports of waste bound for recovery	Data shared with Eunomia by NIEA, compiled from waste summary returns from certain authorised site-based waste authorisations in Northern Ireland. NIEA (2022) Waste summary returns annual data snapshot for 2022, with exemptions.
Exports of waste bound for recovery	NIEA (2022) Waste summary returns annual data snapshot for 2022, with exemptions.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