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epa Research

A Critical Analysis of Ireland's Circular Material Use Rate (CAIR)

Authors: Jack McCarthy, Colman McCarthy, Carlos Pablo Sigüenza, Gergo Suto, Colum Gibson, Claire Downey and Adam Boland

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Rialtas na hÉireann
Government of Ireland

Environmental Protection Agency

The EPA is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

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> Greenhouse gas emissions from industry and aviation through the EU Emissions Trading Scheme.

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2. Office of Environmental Enforcement
3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

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Identifying pressures

This research examines Ireland's progress towards a Circular Economy (CE). Ireland has consistently registered a poor score in terms of its Circular Material Use Rate (CMUR) – a key CE metric of the EU. Moreover, Ireland's policy ambitions are to surpass the EU average CMUR by 2030. The task for this research was to interrogate Ireland's CMUR score – the second lowest in the EU as at 2020 – to determine why it has been so poor, and to identify potential pathways for improving Ireland's circularity performance.

To this end, a number of research tasks were undertaken, including:

- Reviewing the methodologies underpinning the CMUR metric and the data it draws upon;
- comparing Ireland's data and data collection methods with those of Austria, Croatia and the Netherlands;
- developing proposals of action for Irish policy-makers to ameliorate the situation;
- engaging with sectoral stakeholders to refine those proposals.

Informing policy

This research has specific relevance to developing policy for advancing the CE in Ireland. The research specifically illustrates the following points:

- To utilise CE metrics for policy decision-making, it is important to understand the processes, methodologies and data underpinning those metrics.
- Any given metric is limited in its scope and should be used in conjunction with other metrics and/or points of information. For instance, the CMUR metric is mass based and therefore does not directly consider other environmental pressures such as greenhouse gas emissions.
- The data underpinning the CMUR metric are important resources that, when explored in depth, can help to identify areas for policy intervention. In the case of this research, examining data underpinning Austria's and Croatia's CMUR scores led to the identification of effective policy interventions in the areas of (1) construction and demolition and (2) bioenergy generation, respectively.

Developing solutions

This research involved analysing data relating to Ireland's CMUR score, interrogating the methodologies involved in data collection and considering alternative datasets. This is the first study to carry out a comparison of CMUR scores between EU countries in terms of data and data collection. This led to a number of key recommendations, which are detailed in the report. In summary, Irish policy-makers should:

- pursue targeted sectoral interventions to achieve a CE, with reference to available data and best practice examples from across the EU, and in consultation and collaboration with relevant stakeholders.
- engage with Eurostat and other relevant EU institutions to further the development and improvement of environmental indicators.

EPA RESEARCH PROGRAMME 2021–2030

A Critical Analysis of Ireland's Circular Material Use Rate (CAIR)

(2022-GCE-1162)

EPA Research Report

Prepared for the Environmental Protection Agency

by

The Rediscovery Centre, Clean Technology Centre and Circle Economy

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This report is based on research carried out during 2023 using data from the 2010–2020 time period. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

The aim of the Critical Analysis of Ireland's Circular Material Use Rate (CAIR) project was two-fold. Firstly, the project sought to identify factors driving Ireland's relatively low Circular Material Use Rate (CMUR) – a prominent circularity metric in the European Union (EU). Secondly, the project sought to identify actions to improve Ireland's CMUR score.

The CMUR is calculated using the following equation:

CMUR = quantity of material recycled nationally/ quantity of material consumed nationally

As can be seen, the CMUR metric is simply the total quantity (in tonnes) of material recycled as a share of the total quantity of material consumed in a given EU Member State. This research project was motivated by Ireland's relatively poor CMUR. From 2010 to 2020, Ireland registered the lowest average CMUR score in the EU, at 1.8%. At a glance, Ireland's poor performance is due to both relatively high consumption rates – 21.7 tonnes per capita in 2020 (the seventh highest in the EU) – and relatively low recycling levels – 0.26 tonnes per capita in 2020 (the lowest in the EU).

This study sought to interrogate Ireland's performance using data from a range of sources, including existing documentation and research literature, public datasets, interviews with relevant stakeholders and a final workshop with participation from key sectoral stakeholders. These data sources supported the following key research activities:

- an interrogation of how the CMUR metric functions and the data on which it draws;
- the selection of three Member States for close comparison with Ireland;
- the mapping and comparison of data collection processes in Ireland and selected Member States;
- the development of statistical profiles for Ireland and selected Member States in relation to major CMUR data points;
- the development and refinement of proposals for improving Ireland's CMUR score.

The following four general findings and recommendations (described in more detail in Chapter 5) were produced:

1. The CMUR is a useful starting point for developing new circular economy policy options. Further analysis of the content and quality of Ireland's consumption and waste data should be undertaken to this end.
2. The CMUR relates only to consumption and recycling in terms of tonnage. Policy decision-making should use the CMUR in conjunction with other metrics to account for additional important factors, such as greenhouse gas emissions.
3. There are inconsistencies in how certain concepts (e.g. backfilling) are defined by different EU Member States, which has implications for data comparability. There is a need to ensure data consistency for the long-term credibility and utility of circularity metrics.
4. The main uncertainties around data quality for Ireland relate to the collection of primary data. These processes should be monitored and improved where possible.

Targeted findings, recommendations for policymakers and the potential impact on Ireland's CMUR are presented in Table ES.1.

Table ES.1. Targeted findings and recommendations

Finding		Recommended action	Potential CMUR impact
Methodological adjustments			
1	Certain features of the CMUR metric have a disproportionately negative impact on Ireland's CMUR score.	Query the discrepancy between Ireland's domestic material consumption and raw material consumption figures.	+1.96%
		Query the categorisation of spent grains imported as animal feed as a waste destined for recycling.	+0.44%
2	Increasing total quantities recycled would have a greater impact on Ireland's CMUR than reducing total quantities of materials consumed.	Increasing recycling and reducing consumption should nonetheless be pursued hand in hand.	NA
Sectoral interventions			
3	Ireland's consumption levels per capita are high, while recycling levels per capita are low. Comparatively speaking, Ireland underperforms in recycling construction and demolition waste; recycling animal urine, manure and faeces; and recycling other mineral wastes.	Develop policy interventions for the construction and demolition sector focused on waste prevention and separation of materials for recycling and reuse.	+0.77%
		Develop financial incentives to establish a biomethane infrastructure and support feedstock delivery.	+0.76%
		Explore possibilities for using wastes arising from metal manufacturing processes, in particular tailings from alumina, lead ore and zinc ore production and processing.	+1.62%
Overall			
Total possible benefits to Ireland's CMUR			+5.55%
Ireland's 2020 CMUR + potential impact of proposed actions			7.2%

NA, not applicable.

1 Introduction

The concept of a Circular Economy (CE), in which materials and products are maintained in economic circulation for as long as possible and the generation of waste is minimised, has gained significant purchase in policy frameworks at a range of geographical scales (Alberich *et al*., 2023). This includes recent policy initiatives in the European Union, such as the new Circular Economy Action Plan (CEAP; European Commission, 2020a), and in Irish national policy, such as the Whole of Government Circular Economy Strategy (Department of the Environment, Climate and Communications, 2021). As part of implementing such policies, EU agencies have sought to measure progress towards a CE (Mayer *et al*., 2019). To this end, Eurostat – the statistical office of the European Commission – has developed a CE Monitoring Framework, which monitors progress in five thematic areas of the economy:

1. production and consumption;
2. waste management;
3. secondary raw materials;
4. competitiveness and innovation;
5. global sustainability and resilience.

Eleven statistical indicators have been developed to monitor these thematic areas. The full list can be reviewed on the Eurostat website (see Eurostat, 2020). The research presented in this report focuses on one of these statistical indicators – Circular Material Use Rate (CMUR). The CMUR indicator has been specifically designed to quantify the rate at which secondary raw materials (waste) are recovered for economic use (Eurostat, 2018a). More specifically, and as represented in the equation below, the CMUR is essentially the total weight of waste material that is recycled in a given economy as a share of the total weight of material that is consumed in that given economy. The CMUR calculation method was first published in 2018 and applied retrospectively by Eurostat to EU datasets (Eurostat, 2018a). The CMUR is reported for the EU as a whole and for individual EU Member States based on the following equation (Eurostat, 2023b):

CMUR = quantity of material recycled nationally/ quantity of material consumed nationally

Ireland’s CMUR is very low in comparison with other EU countries, hovering at approximately 2% over a 10-year period (2010–2020) (Figure 1.1). Up-to-date figures show that Ireland’s 2020 CMUR stood at 1.65% (Eurostat, 2023a). Moreover, one of Ireland’s current policy aims is to achieve a CMUR above the EU average by 2030 (Department of the Environment, Climate and Communications, 2021).

With this context in mind, the central questions of this research are “Why is Ireland’s CMUR score so low?” and “What can be done to improve it?”

In order to address these questions, this research involved:

- reviewing the CMUR metric’s design and existing research on circularity metrics;
- selecting three EU Member States to compare with Ireland (Austria, Croatia and the Netherlands were selected);
- mapping the relevant data collection processes in each country;
- developing and critically comparing statistical profiles for each country related to key CMUR data categories;
- identifying recommendations for policymakers in order to improve Ireland’s CMUR.

In achieving each of these objectives, this research produced four broad findings and recommendations, which are presented in detail in Table 5.1 in Chapter 5 of this report. These relate to:

1. using the CMUR as a tool for analysis and policymaking;
2. the limitations of the CMUR as a metric;
3. the importance of consistent definitions for data categorisation;
4. monitoring and improving primary data.

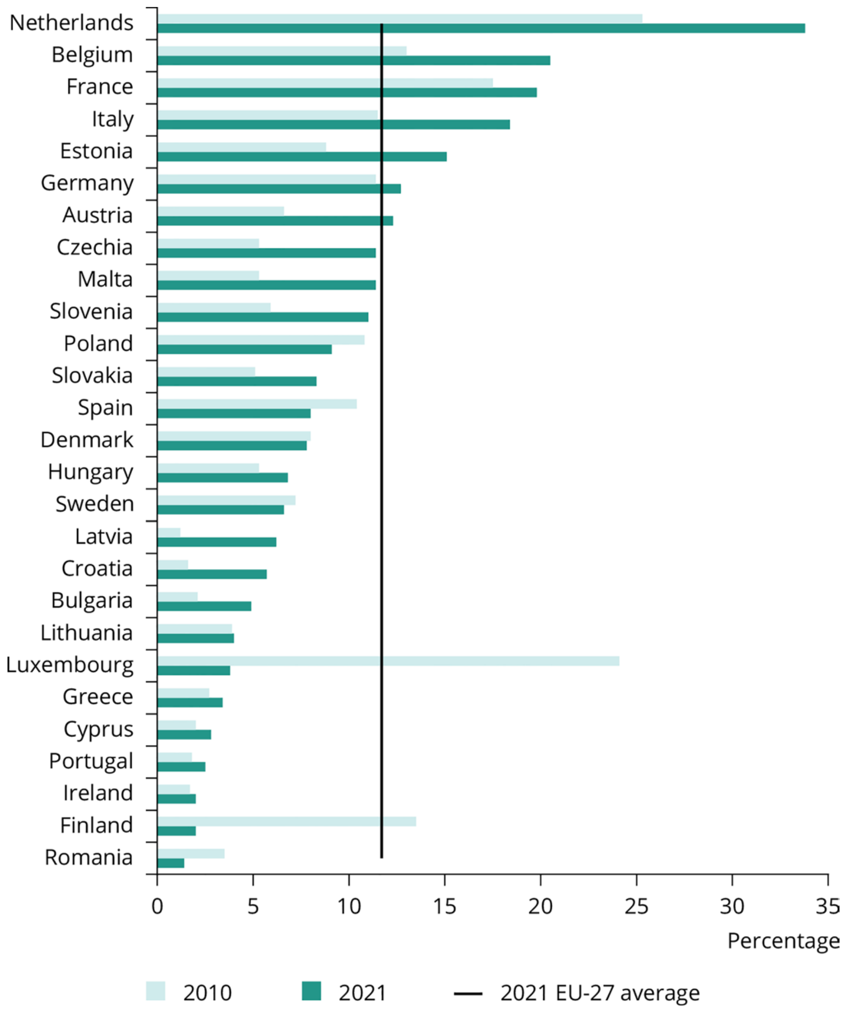

Figure 1.1. CMURs in the European Union. Source: reproduced from European Environment Agency (2023); licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

The project also developed a set of targeted recommendations (see Table 5.2) for improving Ireland's CMUR performance in specific areas. These are:

- to engage with Eurostat on methodological challenges around measuring the consumption and trade of waste for recycling;
- to improve recycling rates in Ireland, with particular focus on:
  - recycling construction and demolition waste (CDW), including soil and stone;
  - developing a national biomethane industry that uses indigenous feedstocks from farm residues;
  - exploring possibilities for recycling related to the other mineral wastes category.

Overall, this report illustrates that the CMUR metric can be a useful tool for identifying opportunities in secondary material use; however, it must be used with an awareness of its limitations.

2 Policy Context and Past Research

2.1 The Circular Economy in Ireland

It is important to contextualise Ireland's progress towards a CE in terms of recent developments. A 2022 report by the Organisation for Economic Co-operation and Development (OECD) is helpful in this regard (see Figure 2.1 for a visualisation of the statistics that follow). This report states that, in terms of gross domestic product (GDP), the services sector (59.7%) and the manufacturing industry (39.3%) account for the vast majority of Ireland's economy. Some 56% of enterprises in these sectors are small or medium-sized enterprises, which account for 56% of manufacturing employment and 74% of services employment. However, large companies dominate export-oriented industries, such as computer and pharmaceutical manufacturing. The remaining 1% of GDP is accounted for by Ireland's primary agricultural production sector, or 8% when agri-food processing is included (with food and beverage manufacturing accounting for 7%) (Department of Agriculture, Food and the Marine, 2020). Although small in GDP terms, 69% of Ireland's total terrestrial area is used for agricultural production (Central Statistics Office, 2022). The agri-food sector also accounts for (Department of Agriculture, Food and the Marine, 2020):

- 7% of total employment;
- 33% of greenhouse gas (GHG) emissions;
- 9.5% of merchandise exports.

Moreover, as at 2020, agriculture accounted for approximately 33% of total material consumption in Ireland (Eurostat, 2023g). The other very large contributor to material consumption is non-metallic minerals (approximately 50% of material consumption in 2020), which is primarily related to construction (Eurostat, 2023g). The remaining 17% of material consumption was accounted for by fossil energy materials/carriers (11%) and metal ores (6%).

2.2 Circular Economy Policy in Ireland

The OECD report further notes that Ireland adopted CE measures earlier than other Member States in relation to some challenges (Organisation for Economic Co-operation and Development, 2022). These measures include the plastic bag levy, which reduced plastic bag waste by 97.5% between 2001 and 2018, and the landfill levy, which contributed to reducing landfilling from 80% of waste treatment in 2002 to 10% by 2018. The latter was also supported by improved infrastructure for other waste treatment options and incentives for households and businesses to separate waste at source (Curran and O'Sullivan, 2021). A number of additional initiatives have been led by local government bodies, including the development of the Repair My Stuff website (www.repairmystuff.ie) and the Circular Bioeconomy Cluster

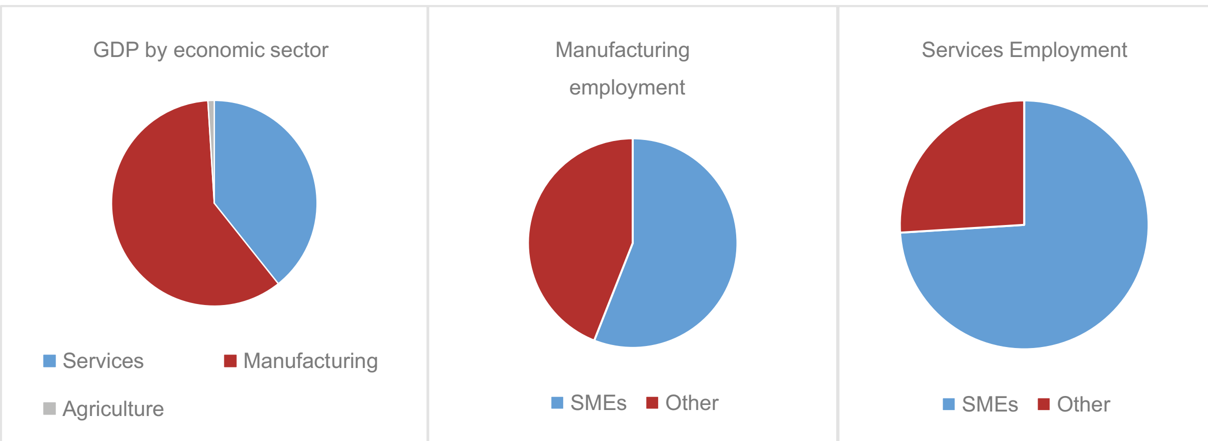

Figure 2.1. General information on Ireland's economy. SMEs, small and medium-sized enterprises.

South West. Resources have also been allocated to raising awareness about the CE, through the National Waste Prevention Programme, and to CE research and innovation, through the Green Enterprise Fund, the Circular Economy Innovation Grant Scheme and Circuléire's Innovation Fund (Organisation for Economic Co-operation and Development, 2022). Finally, a suite of waste and material management policies with the CE at their centre have been introduced since 2020 (European Topic Centre, 2022). In spite of these initiatives, Ireland still performs well below the EU average in terms of key metrics such as the CMUR. Before providing details of the research design used to investigate the causes of the low CMUR in Ireland, it is worth reviewing the emergence of the CMUR metric at the EU level.

2.3 Circular Economy Policy and the Emergence of the Circular Material Use Rate Metric

The concept of a CE has been gaining prominence in EU policy discourse since 2011 (Ellen MacArthur Foundation, 2022), and the European Commission adopted the first CEAP in 2015 (European Commission, 2015). This CEAP included 54 actions that spanned the broad areas of production, consumption, waste management and markets for secondary raw materials. It also included sectoral actions, for instance in relation to plastics, critical raw materials, and construction and demolition (European Commission, 2015, Annex I). The concept of a CE was subsequently afforded a central position in the European Green Deal of 2019 (European Commission, 2019), and a second CEAP was adopted in 2020 (European Commission, 2020a). The second CEAP reasserted the EU's commitment to "a growth model that gives back to the planet more than it takes" by "reducing its consumption footprint to within planetary boundaries" (European Commission, 2020a, p. 2). Underpinning this commitment is the logic that, by increasing the recovery of secondary materials that would otherwise be wasted, the EU can effectively reduce its demand for newly mined or extracted raw materials, and in turn reduce the environmental and social impacts of new extraction and waste management processes (European Commission, 2020a). Research by Mayer *et al*. (2019) corroborates this logic, as does a study by the OECD in 2010, which found that, for four countries that were the subject of its research, material management accounted for between 55% and 65% of national GHG emissions (Organisation for Economic Co-operation and Development, 2010).

The CMUR has gained prominence in European policy. For instance, the second CEAP sets the target of doubling the EU's CMUR by 2030, thereby positioning the CMUR as a key metric for measuring circularity and providing the EU with an incentive to focus on the specific data points that would improve the EU's CMUR (Christis *et al*., 2023). The CMUR has also gained prominence in Irish policy. In particular, the Whole of Government Circular Economy Strategy 2022–2023 established the goal of increasing Ireland's CMUR to above the EU average by 2030, which, all else remaining equal, would involve a more than a six-fold increase in Ireland's CMUR compared with the 2020 rate (Department of the Environment, Climate and Communications, 2021). If the EU achieves its target of doubling the CMUR of the EU as a whole, Ireland's goal will become even more ambitious.

The central position afforded to the CMUR in EU and Irish policy makes the research presented in this document particularly important. In particular, if Irish policymakers are to implement measures to improve the national CMUR it is important that these actions are targeted and evidence based to ensure that they result in real gains in Ireland's circularity and other areas of environmental sustainability, such as carbon emissions, biodiversity and water quality. The analysis of Ireland's CMUR that follows provides an in-depth understanding of how the CMUR metric functions in Ireland and how it can support this objective.

2.4 Circularity Metrics

A number of studies have explored factors that affect the progression of the CE at the national level. In a European context, Mazur-Wierzbicka (2021) identified correlations between positive progression towards a CE and:

- well-developed national CE policies;
- priority afforded to CE in political discourse;
- heavy industrialisation;
- high population density.

Other authors (e.g. Marino and Pariso, 2020) have identified that wealthier countries that invest comparatively high portions of GDP in research and initiatives to advance towards a CE also tend to score better across a range of CE indicators. However, specific challenges exist in relation to measuring progress towards a CE. The following five points are worth noting:

1. A number of authors highlight the lack of research in this area (Elia *et al*., 2017; Mayer *et al*., 2019). While a range of studies exist analysing the application of CE principles to specific projects and contexts, far fewer studies have been carried out that assess the effectiveness of metrics and methods of measuring the CE. Mayer *et al*. (2019) is a landmark paper in this regard.
2. Efforts to measure the CE are hindered by a lack of universally accepted CE definitions (Kirchherr *et al*., 2023; Mazur-Wierzbicka, 2021). On this point, Mayer *et al*. (2019) assert that the concept of the CE is often applied in context-specific ways and depends on the interests of the stakeholders involved. For instance, in the EU, the CE is normally focused on business opportunities and resource efficiency, while in China the focus is more often on pollution reduction (Mayer *et al*., 2019).
3. A huge array of CE metrics have already been developed, underpinned by different definitions and focal points. In 2021, the OECD published an inventory of 474 CE-related indicators derived from studies carried out between 2018 and 2020 (Organisation for Economic Co-operation and Development, 2021). This inventory shows that existing CE indicators are diverse and have been developed in relation to many different proxies for measuring circularity and different areas of economic activity. These proxies are air quality; the built environment; energy; food; public administration; resource and materials; reuse, repair and sharing; waste; water; non-sector specific; and others (agriculture, culture, forestry, industry, land use, mobility, textiles and tourism were all featured). These indicators also vary in terms of the geographical scale at which they are applied, including at the national, regional, local and company levels.
4. There is a challenge in relation to generating standardised, high-quality data that can be used for the purpose of comparison between different geopolitical entities and geographical scales. Again, Mayer *et al*. (2019) explain that there remains uncertainty about the accuracy and comparability of material flow accounting data generated at the national scale, for which different statistical agencies may use different data sources and estimation methods.
5. Any given circularity metric is unlikely to provide adequate information on its own for the purpose of policy decision-making (Mayer *et al*., 2019). For instance, the CMUR is a mass-based metric (tonnes). For this reason, it places less importance on materials that may be low in mass but, for instance, high in environmental impact or of high socio-economic importance.

This study responds to a lack of research examining efforts to measure the CE at the national level. In addition, the results of this study are of relevance to points two, four and five of the aforementioned challenges. Specifically, discrepancies were found in the definitions used by Member States and in the data collection methods and the quality of data available, and biases were identified in the CMUR metric itself that need to be balanced with other considerations. The next chapter details the materials and methods used in undertaking data collection and analysis.

3 Materials and Methods

This study draws on a range of data sources, including quantitative datasets, documents and expert stakeholder feedback received during interviews and a workshop. It employs descriptive statistical analysis, qualitative content analysis and document analysis. An overview of the research process and data drawn upon is presented in Figure 3.1. This process is discussed in more detail in the following sections.

3.1 Review of the Circular Material Use Rate Metric

Based on the initial literature review, the first analytical task was to review and map out the CMUR metric in terms of how it functions. To this end, relevant documents and datasets were identified and compiled (see Tables 3.1 and 3.2).

Eurostat's 2018 document *Circular Material Use Rate: Calculation Method* (Eurostat, 2018a) provided an important starting point for the analysis, providing a basis for mapping out the equations used to calculate the CMUR, the datasets that the CMUR draws on and additional documentation that describes and governs the generation of those datasets. The review of this information, and the critique of the CMUR as a whole, focused on key decisions made by Eurostat in terms of the datasets utilised, how these were interpreted and/or corrected, and the relative impact of these decisions when comparing Ireland's CMUR with the EU average. The results of this process are discussed in detail in section 4.1.

3.2 Selecting Member States for Statistical Comparison

In order to gain additional insights, a statistical comparison between Ireland and three other EU Member States – the Netherlands, Austria and Croatia – was also undertaken. These Member States were chosen through three analytical steps that drew on data from the Economy-wide Material Flow Accounts (EW-MFA) and European Waste Classification for Statistics (EWC-Stat) datasets referred to in Table 3.2.

The analytical steps for selecting comparison countries were as follows:

1. First, points of underperformance (based on set criteria) in Ireland's CMUR stats in comparison with the European average were identified. These points included a high level of consumption (per capita), a low volume of waste treated, a low recycling rate and a high level of backfilling. Additional factors of importance considered were Ireland's relatively low population density and high resource productivity.
2. Other EU Member States were then evaluated using these criteria. A matrix for ranking Member

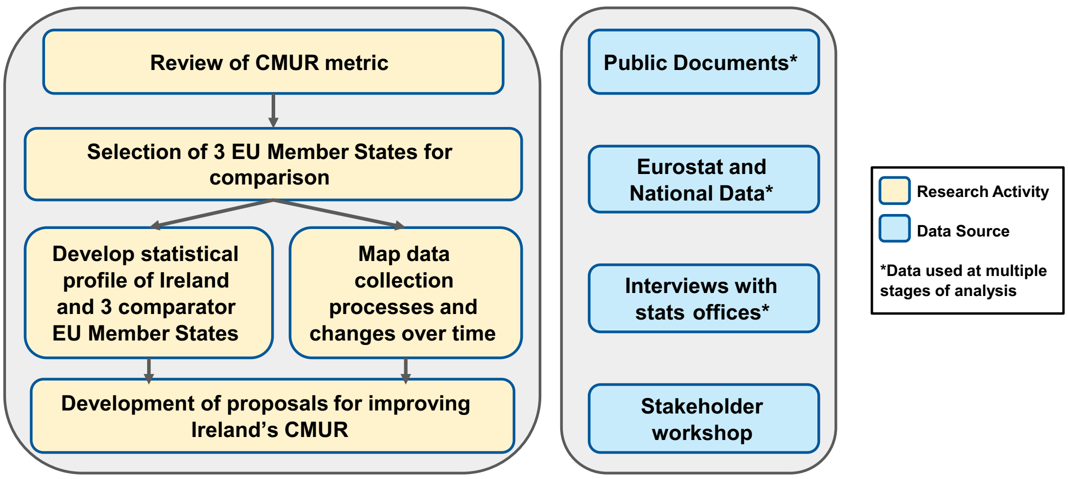

Figure 3.1. The research process in full.

Table 3.1. EU documentation reviewed

Author/organisation and year	Title
European Topic Centre (2022)	*Circular Economy Country Profile – Ireland*
Organisation of Economic Co-operation and Development (2017)	*Trade and Investment Statistical Note*
Eurostat (2018a)	*Circular Material Use Rate Calculation Method*
Eurostat (2018b)	*Economy-wide Material Flow Accounts Handbook*
Eurostat (2016)	*Economy-wide Material Flow Accounts – Manual 2016. Draft Version on Domestic Processed Output and Balancing Items*
Eurostat (2017b)	*Further Clarifying the Conceptual Treatment of Physical Imports and Exports in Economy-wide Material Flow Accounts (EW-MFA)*
Eurostat (2013)	*Manual on Waste Statistics: A Handbook for Data Collection on Waste Generation and Treatment*
Eurostat (2023d)	*European Business Statistics Compilers' Manual for International Trade in Goods Statistics – Detailed Data: 2023 Edition*
European Commission (2023)	Guidance for the compilation and reporting of data on municipal waste according to Commission implementing decisions 2019/1004/EC and 2019/1885/EC
European Commission (2020b)	Guidance for the compilation and reporting of data on packaging and packaging waste according to Decision 2005/270/EC
Eurostat (2017a)	*European Statistics Code of Practice*
Eurostat (n.d.a)	Guidance on the interpretation of the term backfilling
European Union (2002)	Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 of November 2002 on waste statistics
European Union (2011)	Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts
European Union (2019)	Regulation (EU) 2019/2152 of the European Parliament and of the Council of 27 November 2019 on European business statistics, repealing 10 legal acts in the field of business statistics

Table 3.2. Datasets used during analysis

Source	Title
Eurostat (2023g)	Material flow accounts
Eurostat (2023h)	Material flow accounts – domestic processes output (env_ac_mfadpo)
Eurostat (2023b)	Circular material use rate (env_ac_cur)
Eurostat (2023c)	Circular material use rate by material type (env_ac_curm)
Eurostat (2023k)	Material flows for circular economy – Sankey diagram data
Eurostat (2023n)	Treatment of waste by waste category, hazardousness and waste management operations (known as European Waste Classification for Statistics)
Eurostat (2024a)	EU trade since 1988 by HS2-4-6 and CN8 (former content) (ds045409) (known as International Trade in Goods Statistics)
Eurostat (2023e)	Generation of waste by waste category, hazardousness and NACE Rev. 2 activity (env_wasgen)
Eurostat (2023f)	Management of waste excluding major mineral waste, by waste management operations and waste flow (env_wasflow)
Central Statistics Office (2020)	*Single Integrated Metadata Structure (SIMS) Report for Environmental Accounts, Material Flow Accounts*
Central Statistics Office (2023a)	PRODCOM survey
Central Statistics Office (2023b)	*Road Freight Transport Survey*
National Transfrontier Shipment Office (2018a)	Public list register amber list waste (2018)
National Transfrontier Shipment Office (2018b)	Public list register green list waste (2018)

States based on their relative rank in relation to the key criteria was developed (the matrix is presented in Appendix 2).

3. The final countries that were selected for comparison were chosen because they represent an intersection of multiple different factors and were thus deemed to hold the greatest potential to generate insights into Ireland's CMUR.

Below, we provide a short rationale for the choice of countries.

The Netherlands was selected as best in class (with a CMUR of approximately 30% in 2020). The Netherlands' economy is largely service based and has a high volume of imports and exports, and the country has a relatively high population density (500/km^2). Similarly to Ireland, in 2020 biomass accounted for 35% of total material consumption. In contrast to Ireland's backfilling rate of 52% of all waste treated, the Netherlands consistently reports 0% waste treatment through backfilling. Therefore, comparing Ireland with the Netherlands had the added benefit of examining backfilling (or lack thereof) as a waste treatment method.

Austria significantly improved its CMUR over a 10-year period (68% increase between 2010 and 2020), mainly through increasing recycling volumes (by 86% between 2010 and 2018). Austria's material consumption per capita is similar to that of Ireland's – 19.3 tonnes per annum. In addition, iron consistently accounts for between 58% and 90% of Austria's overall metal ore consumption. In Ireland, lead/zinc and alumina/bauxite combined accounted for between 72% and 89% of the country's metal ore consumption from 2010 to 2020. It was thought at the time of Austria's selection that material extraction and waste management in the mining industry could represent a major point of comparison. In the end, this was not the case.

Croatia was selected because of similarities in population statistics with Ireland and the significant improvement in its CMUR from a low starting point (1.6% in 2010 to 5.6% in 2020). Croatia increased the volume of material recycled per annum by 400% between 2010 and 2018. Croatia's 2020 population is similar to Ireland's – 4.1 million and 4.9 million, respectively. More importantly, as at 2020 Croatia and Ireland's population densities were almost identical – 73/km^2 versus 72/km^2, respectively (Eurostat, 2023l).

3.3 Interrogating National Data Collection Systems and Changes

As part of the comparison between Member States, the data collection and categorisation processes were reviewed in each case. This involved:

- reviewing metadata and supporting documentation relating to the EW-MFA and EWC-Stat data submitted by each Member State;
- reviewing the data quality documentation produced by Eurostat;
- conducting semi-structured interviews with statistical officers responsible for compiling data in each Member State and asking follow-up questions;
- mapping and visually representing the data collection process of each Member State.

The aim of these tasks was to develop an understanding of the specific methods, processes and infrastructure for data collection of each Member State, and identify any factors that could help explain differences in the data, particularly with regard to Ireland's CMUR. These findings are presented in section 4.2.

3.4 Statistical Profiling of Ireland and Comparator Member States

Following the selection of Member States for comparison, statistical profiles were produced for each country using EW-MFA and EWC-Stat datasets and the International Trade in Goods Statistics (ITGS) dataset, from which data on international trade in waste can be derived (Eurostat, 2018a). The analytical steps taken in relation to each dataset are specified in Table 3.3 and presented in Figure 3.2. This approach allowed for more granular analysis of the specific areas and material streams in which each country was over- or underperforming.

3.5 Developing Recommendations for Policymakers

The final analytical task during this research was to identify policy recommendations for improving Ireland's

Table 3.3. Tasks involved in developing statistical profiles for each comparator Member State

Task	Description of task
Material consumption: EW-MFA dataset	
Task 1	A time series of histograms was produced for each country, breaking down consumption by the major material categories in the EW-MFA dataset – biomass, metal ores, non-metallic minerals and fossil fuels – for the years 2010–2020.
Task 2	A second time series was produced tracking material consumption subcategories in their lowest granularity for each of the four countries. Identifying the major consumption categories provided a basis for further scrutiny of data collection methods.
Recovery recycling: EWC-Stat dataset	
Task 1	A time series was produced for each Member State breaking down waste by treatment type: recovery – backfilling; recovery – recycling; recovery – energy; disposal – landfill; disposal – incineration; disposal – other.
Task 2	A detailed analysis was conducted on data for the year 2020 for each of the Member States. This involved (1) quantifying total waste treated for each subcategorised material type and (2) quantifying total waste recycled for each subcategorised material type. Comparing these two data points enabled identification of major waste categories in which Ireland was underperforming in terms of portion of recycling.
Trade in waste: ITGS and National Transfrontier Shipment (NTFS) statistics datasets	
Task 1	A time series was developed for each country using the ITGS dataset, dividing trade quantities into imports of waste for recycling, exports of waste for recycling, and trade balance regarding waste for recycling.
Task 2	Ireland's NTFS data for 2018 were converted into the EWC-Stat nomenclature for purposes of comparison. 2018 was selected as a test year as the year for which complete data were available at the time of analysis.

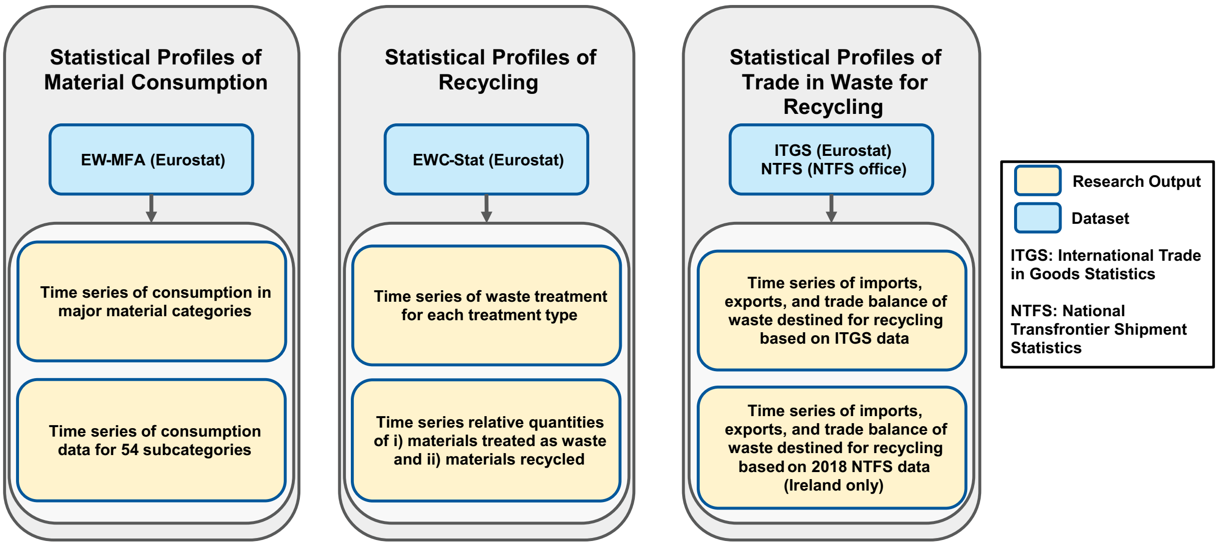

Figure 3.2. Visualisation of steps involved in developing statistical profiles for each comparator Member State.

CMUR. There were three main tasks involved in this analysis:

1. A qualitative investigation of areas where comparator Member States are outperforming Ireland was conducted. These areas were identified through statistical analysis, reviews of policy documents (Tables 3.1 and 3.4) and conversations with statistical officers from relevant national agencies.
2. A workshop was held with 18 stakeholders with expertise in specific industries/thematic areas in the Irish context. During this workshop, stakeholders were divided into groups based on their professional roles and presented with preliminary policy proposals. Each group was guided by a facilitator to refine a proposal that was developed from prior analysis (see Table 3.5), identify barriers to implementation and identify key steps to overcome these barriers and implement a workable solution. Stakeholders were included from the following three thematic areas:

(a) construction and demolition;

(b) biomethane;

(c) recycling infrastructure.

Table 3.4. National documentation reviewed

Source	Title
Netherlands Government: Rijkswaterstaat (2007)	Decree of 22 November 2007 containing rules with respect to the quality of soil (Soil Quality Decree)
Netherlands Government: Rijkswaterstaat (2024)	*National Waste Management Plan 3* (LAP3)
WIP Renewable Energies (2016)	*National Framework Conditions to Support the Establishment of "Bioenergy Villages" in Croatia, Macedonia, Romania, Serbia and Slovenia*
Croatian Ministry of the Economy (2014)	*Report on Progress in the Promotion and Use of Renewable Energy Pursuant to Article 22 of Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009*
Government of Croatia (2021)	Waste Management Act 2021
Federal Ministry for Agriculture, Forestry, Environment and Water Management (2024a)	*Entire Legal Regulation for Annual Waste Balances (Waste Balance Ordinance)*
Federal Ministry for Agriculture, Forestry, Environment and Water Management (2024b)	*Entire Legal Regulation for Recycled Building Materials Regulations*
Deloitte (2015a)	*Construction and Demolition Waste Management in Austria: V2 – September 2015*
Deloitte (2015b)	*Screening Template for Construction and Demolition Waste Management in Croatia*
Austrian Standards International (2014)	*Dismantling of Buildings as a Standard Method for Demolition*
Austrian Government: Bernhardt *et al.* (2016)	*Aushubmaterialien: Materialien zur Abfallwirtscahft*
Government of Ireland (2021)	*National Policy Statement on the Bioeconomy*
Environmental Protection Agency (2021)	*Best Practice Guidelines for the Preparation of Resource and Waste Management Plans for Construction and Demolition Projects*
Environmental Protection Agency (2023b)	Draft national by-product criteria: greenfield soil and stone
Environmental Protection Agency (2023c)	National end-of-waste criteria – recycled aggregates

Table 3.5. Proposals presented to stakeholders at the workshop

Proposal	Description of proposal
Proposal 1	Ireland should introduce stronger requirements for the separation of materials for reuse and recycling for construction and demolition projects
Proposal 2	Ireland should significantly expand/incentivise biomethane production and use by introducing a gas grid feed-in tariff[a]
Proposal 3	Ireland should expand the collection and processing capacity of recycling infrastructure to enable 15 million tonnes of waste to be recycled annually

[a]Participants were accidentally presented with wording that stated "electricity grid feed-in tariff"; this was amended to "gas grid feed-in tariff" during the workshop.

3. The project team met with Eurostat officers to explore the challenges they have identified in relation to CMUR and the relevance of our findings for the rest of the EU.

The results from this workshop were compiled and underwent a process of manual content analysis to identify the primary assertions, various dimensions of those assertions and the rationales underpinning those assertions. The insights generated were used to reflect upon and refine the recommendations presented in this report.

3.6 Modelling the Impacts on Ireland's Circular Material Use Rate

The findings and recommendations presented in Table 5.2 of this report include estimations of the impact of recommended actions on Ireland's CMUR. These estimations were calculated using the CMUR calculation equation presented in the next chapter (see Table 4.1). In each case, data relating to Ireland's 2020 CMUR score were substituted in line with hypothetical scenarios. These scenarios and the data substitutions are included in Chapter 4. One deliverable from this research project is an Excel-based tool for calculating the CMUR of EU countries. This tool has been delivered to the EPA. A table produced using this tool to model the impacts of the recommended actions arising from this research is included in Appendix 4.

4 Results

In this chapter, the results of the analyses are presented and the implications for Ireland's CMUR score are specified, numerically where possible. The results are divided into three main sections:

1. a review of the CMUR metric and the impact of certain methodological features on Ireland's score;
2. a comparison of the data collection processes and data used for some of the main statistical categories – consumption and recycling – in Ireland and the three selected comparator Member States;
3. case studies focusing on the specific material flows through which comparator Member States have improved their CMUR scores; these formed the basis for policy recommendations, which were refined following an expert stakeholder workshop.

4.1 The Circular Material Use Rate Metric

CMUR is calculated using the equation in Table 4.1, where:

- U = the quantity of material recycled nationally;
- M = the quantity of material consumed in an economy.

Importantly, a country's total recycling level is directly proportional to its CMUR score, while a country's total consumption is inversely proportional to its CMUR score. Table 4.1 unpacks the data categories used in this calculation into their component parts.

Figure 4.1 presents the reporting flows for Ireland with reference to the relevant datasets. All Member States are required by EU law to compile and report these data to Eurostat periodically (Eurostat, 2018a). This diagram shows that there are three datasets that feed into the calculation:

1. EW-MFA – domestic material consumption (DMC) is a metric derived from EW-MFA data and explained further in section 4.1.1 (Eurostat, 2023g);
2. national waste statistics data – the recovery recycling (RCV_R) treatment category of these data is relevant to the CMUR (Eurostat, 2023n);
3. ITGS (Eurostat, 2024a).

The denominator (M) and the numerator (U) are examined in the following sections, with reference to the relevant datasets.

4.1.1 Calculating the denominator M

The denominator M = mass of material consumed in an economy. This includes new material and secondary material that has been recovered (i.e. U in Table 4.1). For CMUR calculation purposes, new material consumed is represented by DMC, a metric that draws on EW-MFA data (Eurostat, 2023g). DMC is defined as the total material used within an economy that is either transformed into wastes and emissions or gets accumulated in societal stocks (e.g. buildings) (Eurostat, 2018b). There are two broad categories within this dataset that are used to calculate DMC:

1. **domestic extraction**, i.e. solid, liquid and gaseous materials (excluding air and water extracted from the natural environment to be used as inputs in the economy);
2. **physical commodities imported and exported** as mass units, including materials at all stages of processing.

Table 4.1. CMUR equation

Simple	Expanded
CMUR = U / M	CMUR = (material recovered through recycling + physical exports for recycling – physical imports for recycling) ÷ (domestic extraction + physical imports – physical exports + U)

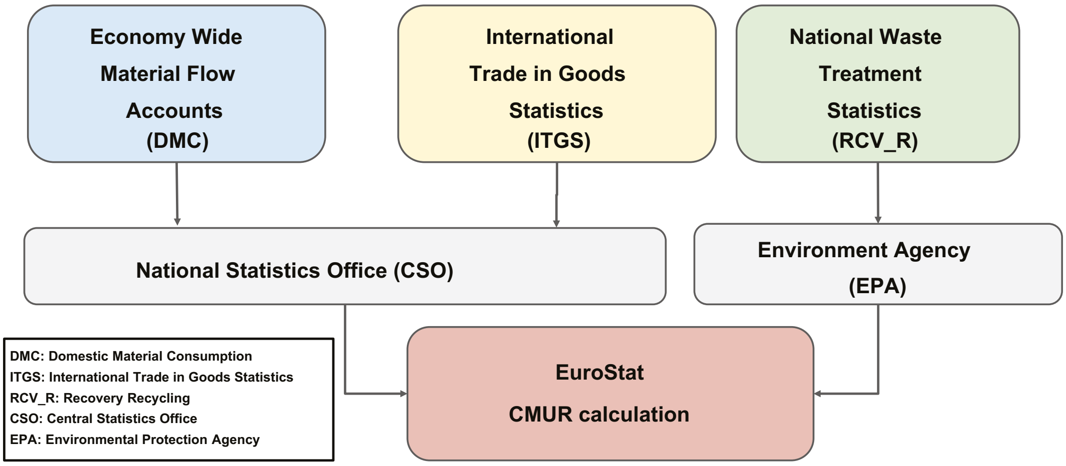

Figure 4.1. Data flows for calculating Ireland's CMUR.

DMC is calculated using the following equation:

DMC = domestic extraction + physical imports – physical exports

All EU Member States must report these data every year (European Union, 2011). Eurostat provides a data capture form to national statistical agencies.[1] Reported data related to each of the 58 different material categories are returned for domestic extraction, physical imports and physical exports (see Appendix 3).[2] These data may be generated through a number of different approaches, including:

- surveys, to fill specific data needs;
- administrative sources, meaning that data are collected by institutions or companies and self-reported to relevant statistical agencies;
- estimation methods, where data do not exist.

The data are aggregated into four overarching categories: biomass, metal ores, non-metallic minerals and fossil fuels (see Figure 4.2). Reported data are checked for completeness by Eurostat, queried if necessary and validated (Eurostat, 2023i). While the overall quality of data is considered high and comparable between Member States, the quality and scope of data provided by different Member States, as well as data collection processes, can vary (Eurostat, 2023i). Consequently, a more in-depth look at the differences between Ireland and other Member States was carried out. Further details on this are provided in section 4.2.

Returning to our CMUR equation presented in Table 4.1, DMC + U is equal to the denominator.

4.1.2 *Calculating the numerator U*

In the CMUR equation, U = mass of recycled waste material. U is calculated using the following equation:

U = waste recovered through recycling (RCV_R) – imports of waste for recycling (IMPw) + exports of waste for recycling (EXPw)

The calculation of U draws heavily on waste treatment data (Eurostat, 2023n). EU Member States are legally mandated to report waste treatment data to Eurostat every 2 years (European Union, 2002). Countries report on a number of categories, including waste treatment activity, waste material category and mass (tonnes), using the EWC-Stat nomenclature. RCV_R is one of six aggregated treatment activities reported (Eurostat, 2022b). The full list includes:

- disposal – landfill (DSP_L);
- disposal – incineration (DSP_I);

1 The data capture form submitted by national statistical agencies is available at https://ec.europa.eu/eurostat/documents/1798247/6191533/Economy-wide+material+flow+accounts+%28EW-MFA%29+questionnaire (accessed 18 June 2024). Annexes explaining calculation and conversion of categories and data are available at https://ec.europa.eu/eurostat/documents/1798247/6191533/Annexes+of+EW-MFA+questionnaire (accessed 18 June 2024).

2 See also the annexes to Regulation (EU) 691/2011 (European Union, 2011) and data found at https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_MFA/default/table?lang=en Eurostat (Eurostat, 2023g).

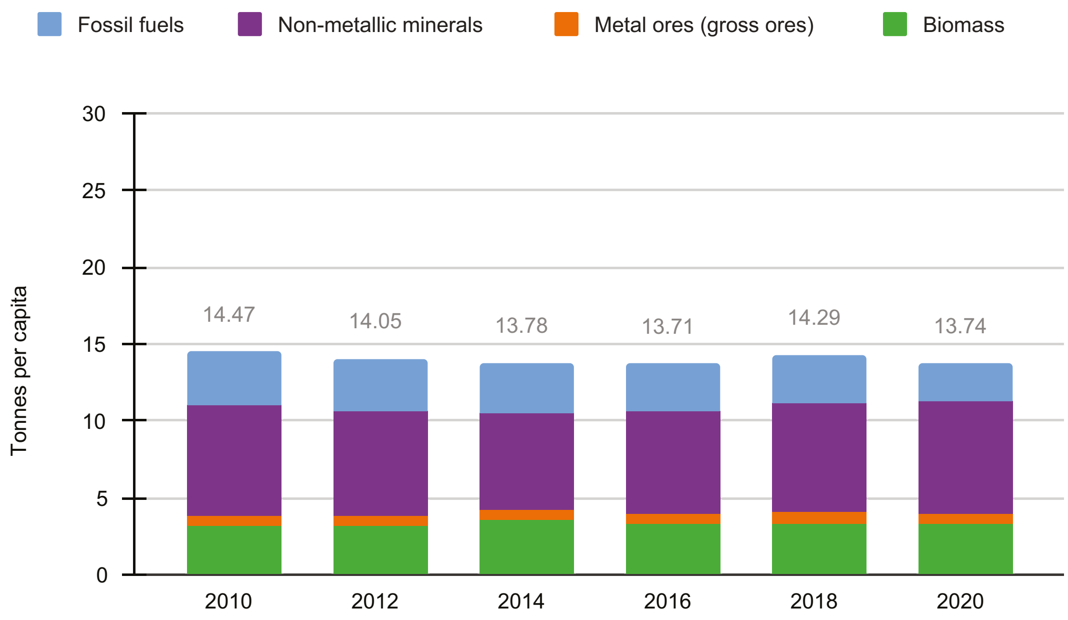

Figure 4.2. DMC for the EU-27.

- disposal – other (DSP_OTH);
- recovery – energy recovery (RCV_E);
- recovery – recycling (RCV_R);
- recovery – backfilling (RCV_B).

Only waste that is recovered through recycling (RCV_R) is included in U for the purposes of calculating the CMUR. Recovery activities such as backfilling (RCV_B) and energy recovery through incineration (RCV_E) are explicitly excluded for CMUR calculation purposes. Similarly, material that does not enter the official waste management system (non-waste reuse, repair or remanufacturing activities) is not accounted for in the CMUR (Eurostat, 2018a). In order to arrive at a final number for total recycling in a country, RCV_R is corrected for trade. This correction involves subtracting waste imported for recycling (IMPw) from and adding waste exported for recycling (EXPw) to a country's overall figure (see again Table 4.1). This correction is designed to avoid double counting (Eurostat, 2018a).

Imports and exports of waste for recycling are quantified by Eurostat using trade data from the ITGS dataset. These data are reported by EU Member States on a monthly basis (European Union, 2019). Data are submitted using an eight-digit code known as a combined nomenclature (CN) code. These data cover categories including mass, monetary value and import/export status (Eurostat, 2024a). CN codes are highly granular and, at present, more than 40,000 codes are in use for different materials and products (European Commission, 2022). Table 4.2 shows the CN code and corresponding description for one material.

For the purposes of CMUR calculations, Eurostat documentation states that materials corresponding with approximately 148 CN codes, when traded, are assumed to be destined for recycling (RCV_R) (Eurostat, 2022a). Associated quantities are thus subtracted or added to a country's overall recycling quantities depending on whether they are imported or exported (Eurostat, 2018a).

4.1.3 Converting waste data to the EW-MFA nomenclature

Most EU countries collect waste data in the form of the List of Waste (LoW) nomenclature, which includes

Table 4.2. Example of a CN code and material description

CN code	Description
05059000	Skins and other parts of birds, with their feathers or down, feathers and parts of feathers, whether or not with trimmed edges, not further worked than cleaned, disinfected or treated for preservation; powder and waste of feathers or parts of feathers (excl. feathers used for stuffing and down)

843 categories (European Union, 2001). Three steps, as outlined below, are therefore required to convert these data to the EW-MFA nomenclature so that they can be used to generate a CMUR score for each of the major material classes (Eurostat, 2018a):

1. LoW data are converted to EWC-Stat nomenclature by the Member State authority, prior to transmission to Eurostat (Eurostat, 2013). EWC-Stat data are more aggregated than LoW data, with 51 material categories (European Union, 2002). Table 4.3 provides an example of how the categories are converted for illustrative purposes (Eurostat, n.d.b).

2. Eurostat converts data from EWC-Stat to the EW-MFA nomenclature as follows: material flow 1 (MF1) – biomass; MF2 – metal ores; MF3 – non-metallic minerals; and MF4 – fossil energy carriers. As presented in Figure 4.3, some categories can be fully attributed to a specific material flow; for example, W013 (used oils) are wholly assigned to MF4 (fossil energy carriers). Other waste categories are divided between two or more of the MF categories, e.g. health care and biological wastes.

3. The data used to correct recycling statistics for trade undergo a similar conversion. Essentially, each of the 148 categories identified as destined for recycling is designated a particular MF classification (Eurostat, 2018a). Figure 4.4 provides an indication of how this is undertaken.

4.1.4 *Limitations of the CMUR methodology*

There are a number of limitations to the CMUR methodology. Some of these have disproportionate negative impacts on Ireland's CMUR score.

4.1.4.1 General methodological choices

A number of methodological choices were made when designing the CMUR metric. Each of these features is important to consider when interpreting the figures produced by the metric as a whole. The following points should be noted:

- DMC and RCV_R are measured in terms of mass (Eurostat, 2018a). This means that mass of material recovered or consumed is measured, but other factors are not accounted for, such as

Table 4.3. LoW to EWC-Stat conversion example

LoW code	EWC-Stat 4 code	EWC-Stat 4 label	LoW label
07 01 03	01.11	Halogenated spent solvents	Organic halogenated solvents, washing liquids and mother liquors
07 02 03	01.11	Halogenated spent solvents	Organic halogenated solvents, washing liquids and mother liquors
14 06 01	01.11	Halogenated spent solvents	Chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons

Code	EWC-Stat label	MF1 biomass	MF2 Metal ores	MF3 Non-metallic minerals	MF4 Fossil energy carriers
Total	Total Waste	0%	0%	0%	0%
W011	Spent solvents	0%	0%	0%	100%
W012	Acid, alkaline or saline wastes	0%	0%	100%	0%
W013	Used oils	0%	0%	0%	100%
W02A	Chemical wastes (W014+W02+W031)	7%	16%	18%	59%
W032	Industrial effluent sludges	42%	8%	43%	6%
W033	Sludges and liquid wastes from waste treatment	21%	16%	47%	16%
W05	Health care and biological wastes	62%	1%	3%	35%
W061	Metal wastes, ferrous	0%	100%	0%	0%
W062	Metal wastes, non-ferrous	0%	100%	0%	0%
W063	Metal wastes, mixed ferrous and non-ferrous	0%	100%	0%	0%
W071	Glass wastes	0%	0%	100%	0%
W072	Paper and cardboard wastes	100%	0%	0%	0%

Figure 4.3. EWC-Stat to EW-MFA conversion table. Source: Eurostat (2018a).

Product	Description of CN-code (label)	Material	factor_oper
05059000	Skins and other parts of birds, with their feathers or down, feathers and parts of feathers, whether or not with trimmed edges, not further worked than cleaned, disinfected or treated for preservation; powder and waste of feathers or parts of feathers (excl. feathers used for stuffing and down)	MF1	1
05119110	Fish waste	MF1	1
05119910	Sinews or tendons of animal origin, parings and similar waste of raw hides or skins	MF1	1
09019010	Coffee husks and skins	MF1	1
15220091	Oil foots and dregs; soapstocks (excl. those containing oil with characteristics of olive oil)	MF1	1
15220099	Residues from treatment of fatty substances or animal and vegetable waxes (excl. those containing oil with characteristics of olive oil, oil foots and dregs and soapstocks)	MF1	1

Figure 4.4. Example of conversion from CN to EW-MFA nomenclature. Source: Eurostat (2021).

GHG emissions, embodied carbon, impacts on biodiversity or socio-economic factors.

- Reused material that does not enter the official waste management system is not directly accounted for by the metric. An appropriate dataset does not yet exist for this category (Eurostat, 2018a).
- Member States are credited for *collection* of waste for recycling, rather than material *actually* recycled. This decision was made in order to avoid double counting. One effect of this is that importing waste for recycling reduces a country's CMUR, while exporting waste for recycling improves a country's CMUR (Eurostat, 2018a).
- There are several limitations associated with the conversion of waste data to the EW-MFA nomenclature (Eurostat, 2018a):

  (a) The water content of waste is ignored for conversion purposes, resulting in potential overcounting of waste with a high water content.

  (b) The entire mass reported and converted are assumed to be recycled and returned to economic circulation. The portion of materials recycled that actually re-enter economic circulation is not well understood (Mayer *et al.*, 2019).

  (c) The conversion ratios presented in Figure 4.3 are based on an audit of German waste statistics and do not necessarily correspond with different compositions of waste categories in other EU Member States.

  (d) Waste statistics for metals are reported in terms of mass of pure metal, which does not correspond directly with metal ores.

A detailed analysis of these four limitations was outside the scope of this research, or not possible with the available data and resources. That being said, a number of assertions can be made based on the information provided above. Firstly, CMUR scores should be read in conjunction with other environmental indicators in order to identify and navigate trade-offs. Secondly, it should be acknowledged that many activities that can contribute to a CE are not directly measured by the CMUR metric (e.g. reuse, repair, prevention of waste). Thirdly, the impact of the point at which data are recorded (e.g. collection vs treatment of waste) should be considered in further research. This point is touched upon in section 4.1.4.3. Finally, additional research is needed to fully understand the impact of nomenclature conversions on the overall data used as part of the CMUR calculation.

4.1.4.2 RMC versus DMC

Another major limitation, and the most significant for Ireland's CMUR, relates to the use of the DMC metric. Section 4.1.1 described how DMC is corrected for physical imports and exports. However, DMC measures only the mass of imports/exports, not the materials *required* to produce those imports/exports. In other words, DMC measures material consumption, but not the total material footprint of that consumption (Eurostat, 2018b).

Raw material consumption (RMC) is an alternative metric to DMC. Unlike DMC, RMC does account for materials required in production by converting traded products into the mass of material required to produce them (Eurostat, 2018b). RMC is therefore a more accurate representation of the material footprint of consumption. DMC is nonetheless favoured for the following reasons (Moll, 2014):

- Unlike DMC, RMC data are not governed by a regulation, but are collected voluntarily – just five

EU countries work on RMC estimates and there are no official statistics.

- Unlike DMC, there are no standard estimation methods for RMC and accuracy is low, meaning that data quality cannot be assessed. In fact, since the analysis for this report was conducted, the RMC figures for the EU have been revised, resulting in an increase in Ireland's estimated RMC (see Eurostat, 2024b).

RMC data disaggregated by material subcategory are less accurate than DMC data, or are completely unavailable. The choice of DMC makes more sense when the correlation with RMC at the EU scale is considered. Figure 4.5 shows that RMC and DMC are closely correlated when aggregated at the EU level. Both indicate just under 14 tonnes of consumption per capita in 2020.

In order to investigate the impact of this methodological choice on Ireland's CMUR, we compared DMC and RMC at the country level for the year 2020. The results are presented in Figure 4.6, which shows that, for the majority of EU countries, RMC and DMC per capita are relatively similar. However, a small number of countries have a dramatically different RMC to DMC ratio. The largest difference among EU countries is in the case of

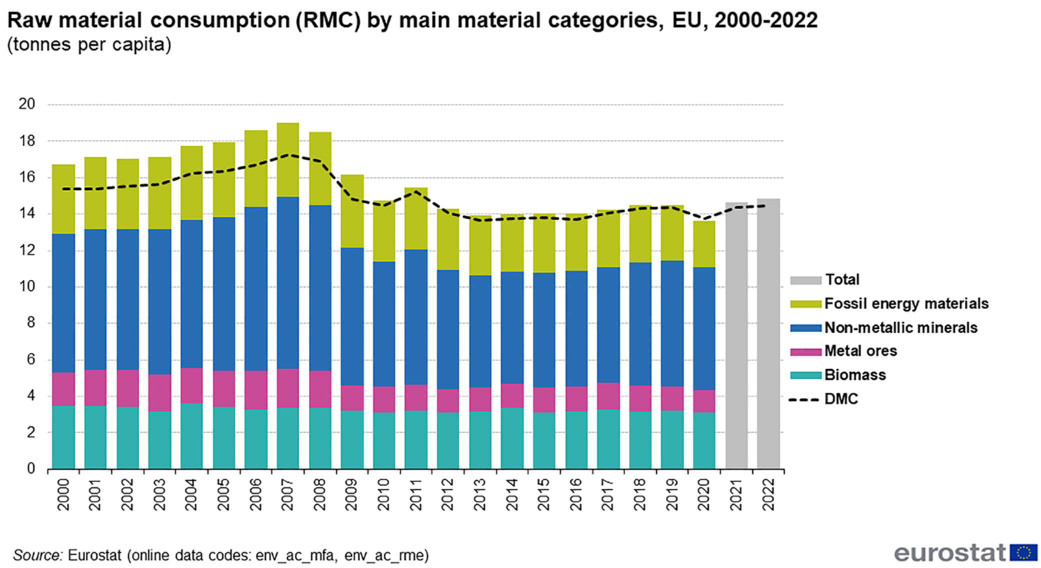

Figure 4.5. RMC and DMC in the EU, 2000–2022. Source: Eurostat (2023j).

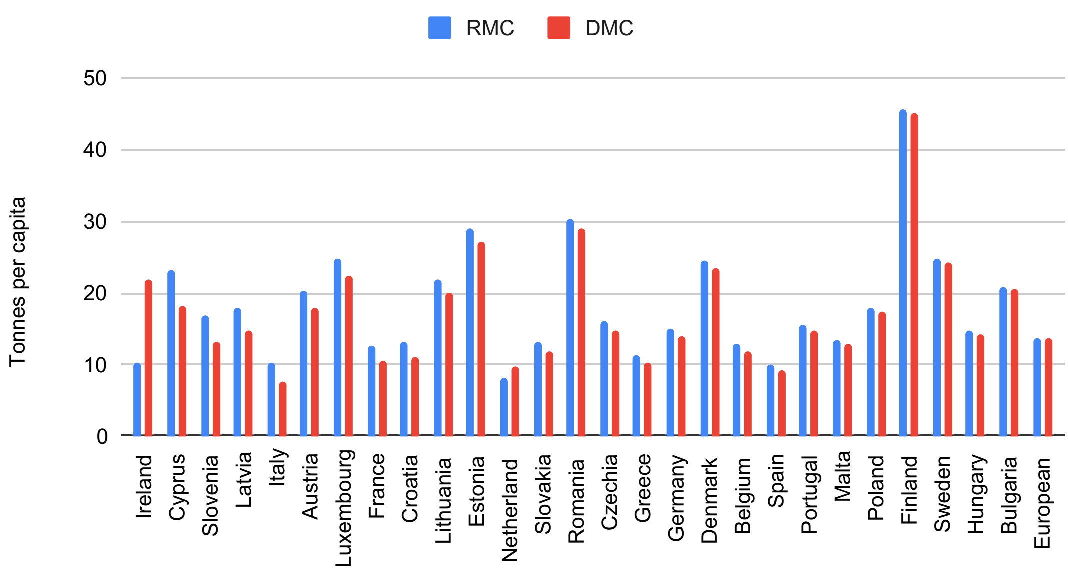

Figure 4.6. RMC versus DMC in EU Member States, 2020. Data source: Eurostat (2023g, 2024b).

Ireland, which had a DMC of 21.86 tonnes per capita, but an RMC of just 10.19 tonnes per capita. The next closest discrepancy is in the case of Cyprus, with a DMC and an RMC of 18.2 and 23 tonnes per capita, respectively. While the methodological decision to use DMC instead of RMC can be defended for the reasons listed above, this decision disproportionately negatively affects Ireland's CMUR. In fact, if RMC were utilised instead of DMC, Ireland's CMUR for 2020 would more than double, from 1.65% to 3.61% (+1.96%) (Appendix 4).

A full analysis of the reasons for the divergence between Ireland's DMC and RMC is beyond the scope of this study. However, Lutter *et al*. (2016) provide an indication in their assertion that the DMC indicator allows countries to "reduce their national material consumption and improve material productivity by dislocating material-intensive industries to other countries and substituting domestic material extraction by imports". This may apply to the case of Ireland, and three major industries in particular may have an impact, each of which has a high ratio of inputs to outputs by mass (see Table 4.4). A full analysis of the discrepancy between DMC and RMC is beyond the scope of this research. It is possible to complicate matters further, however, by noting that Eurostat's RMC methodology takes a particular approach, which would need to be compared with alternatives (see Lutter *et al*., 2016).

4.1.4.3 Trade in waste statistics

Another methodological feature that directly impacts Ireland's CMUR relates to trade in waste destined for recycling. As discussed in section 4.1.2, imports of waste destined for recycling are subtracted from a given country's RCV_R number, while exports of waste destined for recycling are added. This feature rewards countries such as Ireland that export more waste for recycling than they import. As shown in Figure 4.7, Ireland is a net exporter of waste for recycling, exporting approximately twice as much waste for recycling as it imports, resulting in a net trade balance of roughly half a million tonnes per annum. **Using the calculation tool developed as part of this research, it was determined that this methodological feature benefited Ireland's CMUR to the tune of approximately 0.9% in 2020** (Appendix 4).

In order to scrutinise data relating to Ireland's trade in waste, the research team undertook three tasks:

1. ITGS data were compiled for Ireland for the year 2018. At the time of analysis this was the most recent year for which a full verified dataset existed

Table 4.4. Ratios of material inputs to outputs by material/product

Product	Input material	Input to output ratio	Source
Beef	Grass and feed	4.8–10:1	McGee (2014)
Alumina	Bauxite	2.6:1	Georgitzikis *et al.* (2021)
Cement	Limestone, clay, fuel	2.5:1	British Geological Survey (2005)

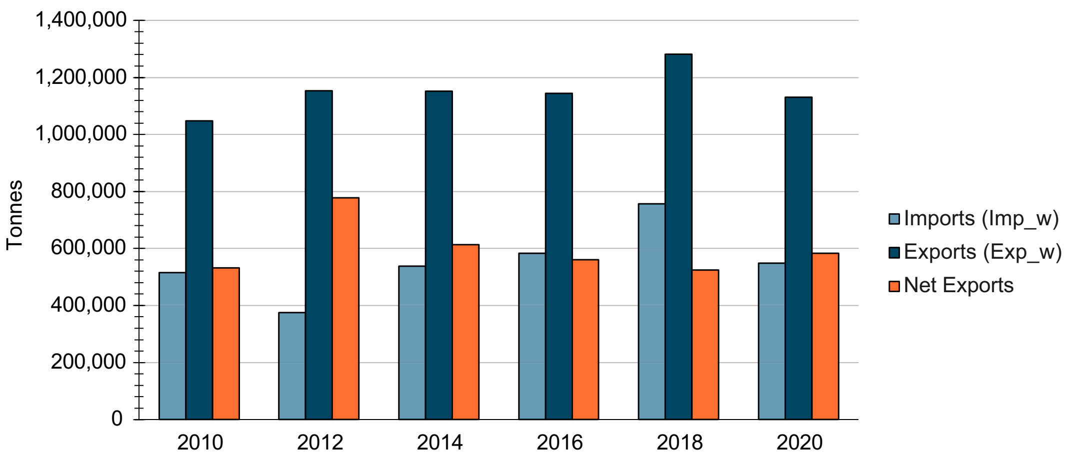

Figure 4.7. Trade in waste for recycling Ireland, 2010–2020. Data source: Eurostat (2024a).

for waste statistics. Trade in waste data were then extracted based on the 148 CN codes identified by Eurostat (see Eurostat, 2022a). These data were converted into the EW-MFA nomenclature, which allowed for further subdivision into import, export and major material categories. The outputs of this process are presented in Figure 4.8.

2. Transfrontier shipment (TFS) data were identified as an equivalent dataset that could be used to scrutinise the data on trade in waste from the ITGS dataset. TFS data are compiled by Ireland's National TFS office[3] as part of Ireland's obligations under the Waste Shipment Regulations, which govern the movement of waste across national borders, both between EU Member States and between Member States and non-EU countries (European Union, 2006). These regulations also require that comprehensive records of all shipments of waste are maintained. Data are compiled from notifications submitted by transporters of waste to national offices. In Ireland's case, this work is undertaken by the National Transfrontier Shipment Office. The notifications submitted include a description of the waste, LoW classification, mass and intended recovery operation.
3. The research team converted TFS data from the LoW nomenclature to EWC-Stat and then to EW-MFA. For some data points several LoW codes were included. In these instances, judgement calls had to be made based on other descriptions of the materials in question. Data were also filtered to remove any data points relating to shipments destined for disposal (D1–D15), energy recovery (R1), exchange (R12) or storage prior to recovery (R13).[4] Again, some shipment of waste notifications included a combination of R-codes. For this reason, all data not exclusively attributed to a D-code, R1, R12 or R13 were included. The resulting comparison of TFS data and ITGS data is presented in Figure 4.9.

There is a clear discrepancy between these two datasets. Ireland's total trade in waste for recycling balance according to the TFS dataset is more than double that according to the ITGS data. There are differences across all major material categories.

Members of the research team discussed these discrepancies with technical officers from Eurostat, who explained that the identification of waste shipments by Eurostat based on 148 CN codes is a shortcut through which they arrive at an approximate

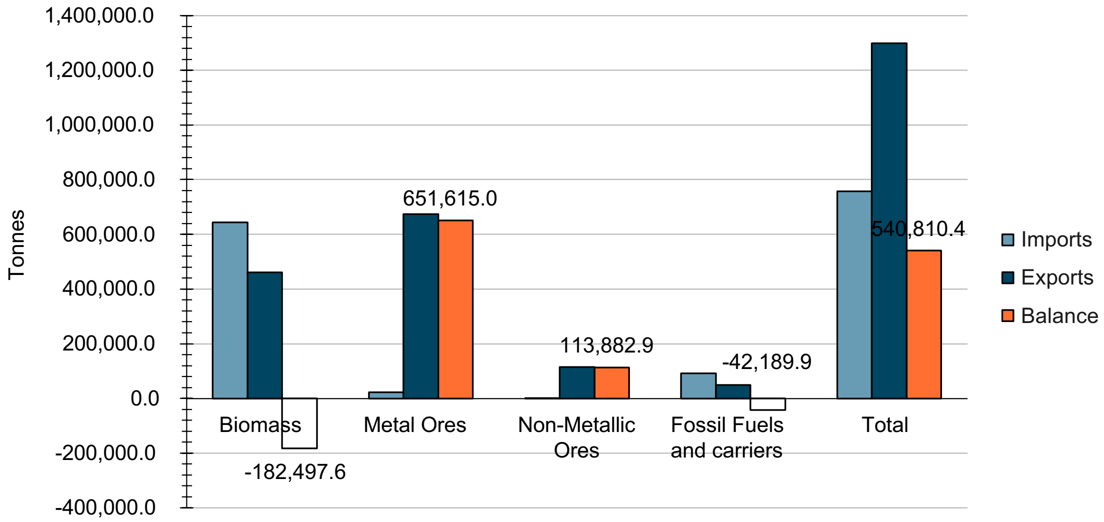

Figure 4.8. Trade in waste for recycling in Ireland by EW-MFA type, 2018. Data source: Eurostat (2024a).

3 https://www.dublincity.ie/residential/environment/national-tfs-office

4 For full list of D and R codes, see Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives, 2008 (European Union, 2008).

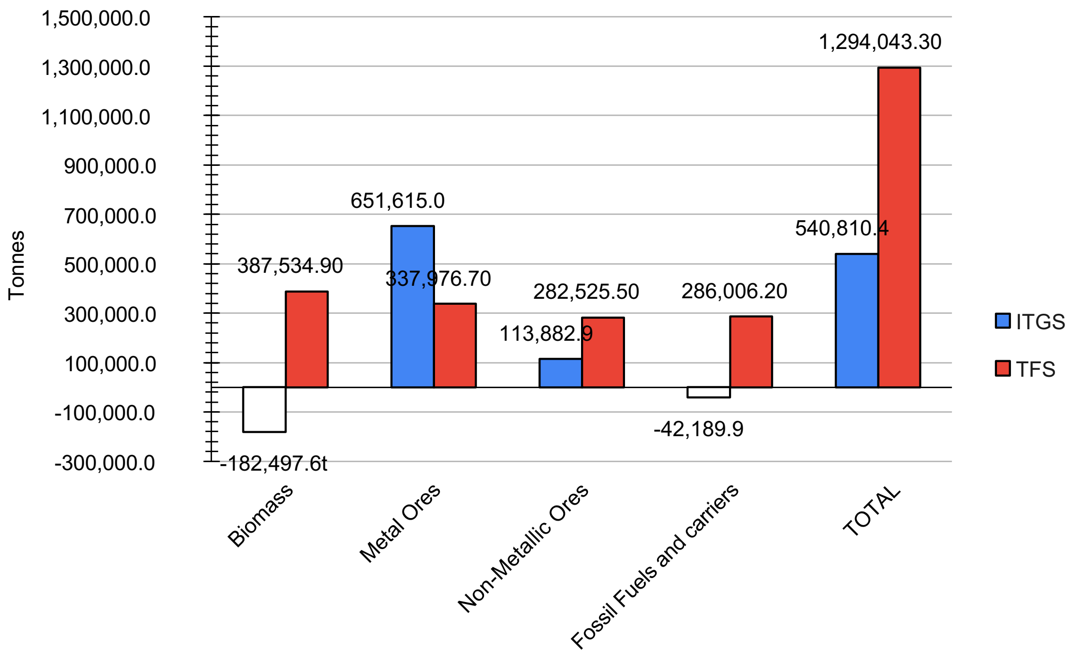

Figure 4.9. ITGS versus TFS data. Data sources: National Transfrontier Shipment Office (2018a,b); Eurostat (2024a).

number for trade in waste with the limited resources at their disposal. Therefore, for CMUR calculation purposes it is assumed that when the materials on this list cross a national boundary they are destined for recycling.

Further focused analysis was undertaken by the research team in relation to Ireland's single largest category of waste traded for recycling: brewing or distilling dregs and waste (CN code 23033000). In 2018, 590,000 tonnes of this material were imported, while just 56,000 tonnes were exported (net trade deficit of 534,000 tonnes). The vast majority of this material is imported from North America (World Integrated Trade Solution, n.d.). Through direct consultation, Central Statistics Office (CSO) staff indicated that this material is largely imported by companies involved in the manufacture of animal feeds for agriculture.[5] In addition, Eurostat statisticians stated that Ireland imports 60% of all brewing or distilling dregs and waste imported into the EU. It is important to note in relation to the CMUR metric that, given the far smaller quantity of biomass material recorded as imported for recycling through the TFS data, it is questionable whether any of the brewing or distilling dregs and waste enters the official waste management system. Therefore, it is possible that this material should be excluded from the trade in waste data. **Using the calculation tool developed as part of this research, it was determined that, if this category were not counted as waste, Ireland's CMUR for 2018 would increase from 1.6% to 2.04% (+0.44%)** (Appendix 4).

A full analysis of the effect of using TFS data instead of ITGS data on CMUR scores across the EU was not possible within the scope of this project. However, such an analysis would be useful to determine if this issue applies to additional categories in the ITGS dataset. Nonetheless, the principle holds that a methodological shortcoming is present in relation to this one material (CN-23033000).

4.2 Comparison between Countries across Major Circular Material Use Rate Statistical Categories

Although the CMUR metric has limitations, important insight can be gained by comparing associated data and data collection methods from the EU Member

5 Data on this point are commercially sensitive. See also https://www.teagasc.ie/media/website/animals/beef/concentrate-feeds.pdf and http://www.southernmilling.ie/distillers-dark-grains/ for information on the import and use of distillers spent grains.

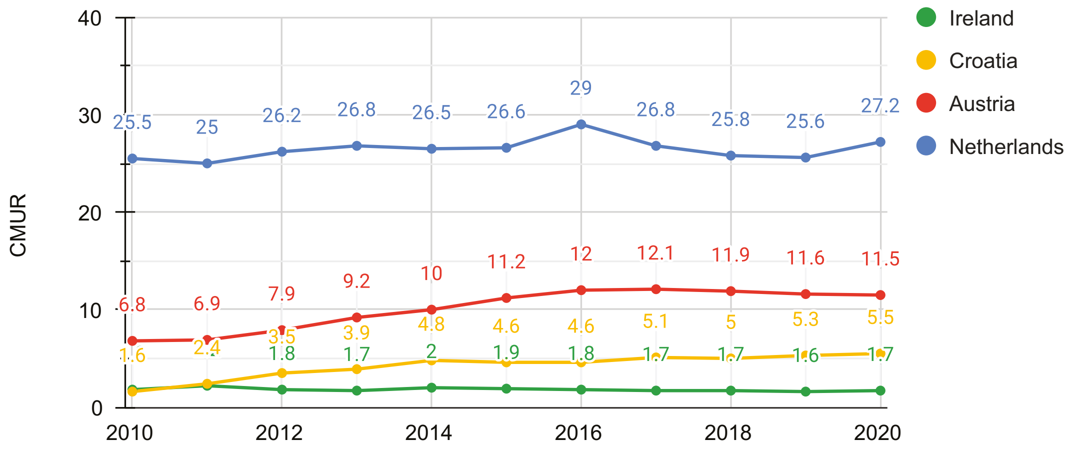

Figure 4.10. CMUR of selected countries. Data source: Eurostat (2023a).

States selected for comparison. Figure 4.10, which presents the CMUR of the four countries over a 10-year period, shows some of the trends referred to earlier. Specifically, Ireland's CMUR, displayed in green, has hovered at a relatively low rate of between 1.6% and 2.0% over the period. Croatia, displayed in yellow, begins from a low base similar to Ireland but increases to 5.5% by 2020. Austria's CMUR improves steadily from 2010 to 2017, before a slight regression. The Netherlands' CMUR remains consistently high throughout, rising to 29% at its peak in 2016, and never falls below its 2011 low of 25%. The sections that follow unpack these figures in terms of (1) DMC and (2) waste treatment.

At this point, it is worth recalling that Ireland's goal is to increase the national CMUR to above the EU average. All else remaining equal, this would require an almost eight-fold increase in recycling, an eight-fold decrease in consumption or some mixture of the two (Appendix 4).

4.2.1 DMC statistical profiles

It is useful to begin by breaking down Ireland's DMC into its major material categories (see Figure 4.11). A few key points are worth noting. Firstly, Ireland's DMC per capita has been relatively high in the context of the EU, ranging between 18.6 and 23.5 tonnes over a 10-year period. The EU average has ranged between 13.7 and 15.2 tonnes during this same period. Moreover, looking at Figures 4.11–4.14, Ireland's DMC is consistently the highest. Only Austria comes close, with a DMC ranging between 18.6 and 19.6 tonnes in this same period. As discussed already, a higher DMC negatively affects a country's CMUR score.

Four points are worth noting in relation to Ireland's profile:

1. As discussed in section 4.1.4.2, part of the reason for Ireland's high DMC is the way in which trade in materials is recorded. Specifically, DMC is concerned only with the weight of materials traded, not the entire material footprint of a given material. The alternative consumption metric – RMC – records a consumption value for Ireland that is consistently 50% lower than its DMC. Ireland is an outlier in terms of the discrepancy between DMC and RMC.

2. Biomass is consistently one of the two largest categories of consumption in Ireland, and yet there is very little fluctuation in the quantities consumed. This may indicate a relative inflexibility in the associated industries, i.e. agriculture and forestry (Geoghegan and O'Donoghue, 2018), and potential difficulty in improving Ireland's CMUR through reduced consumption of this material type. Referring to section 4.1.4.2, Ireland's biomass consumption may be inflated by the high material input to output material ratios involved in beef produced for export in particular.

3. The non-metallic minerals consumption category saw the largest fluctuations, ranging in Ireland's case from approximately 7 tonnes per capita in 2014 to 11 tonnes per capita in 2018. Non-metallic mineral consumption correlates with periods of economic growth and contraction in Ireland

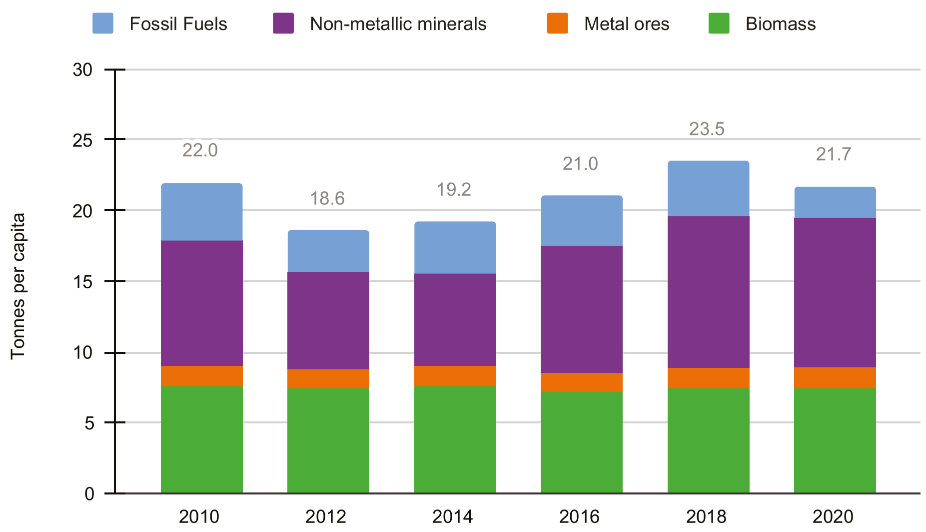

Figure 4.11. Ireland's DMC. Data source: Eurostat (2023g).

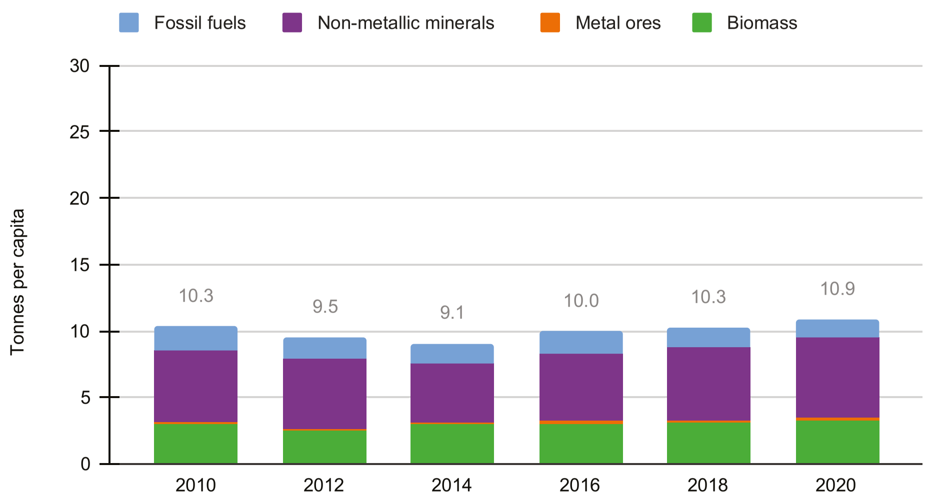

Figure 4.12. Croatia's DMC. Data source: Eurostat (2023g).

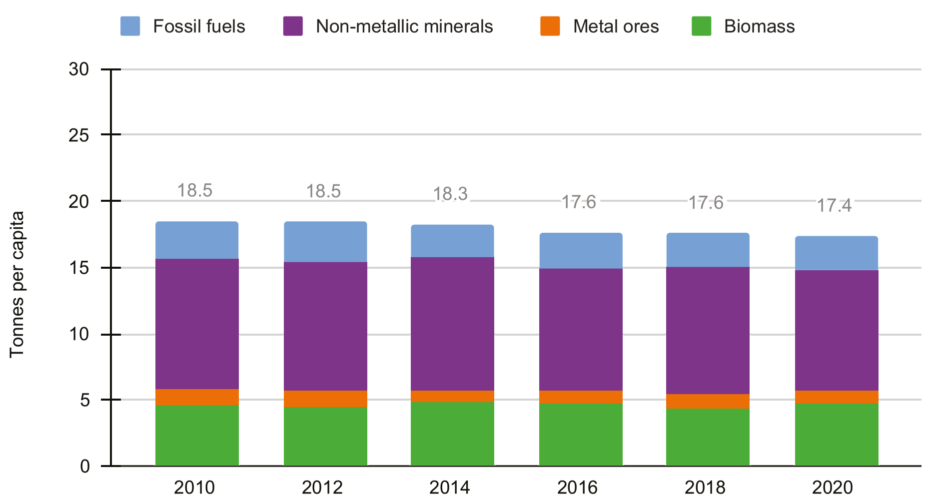

Figure 4.13. Austria's DMC. Data source: Eurostat (2023g).

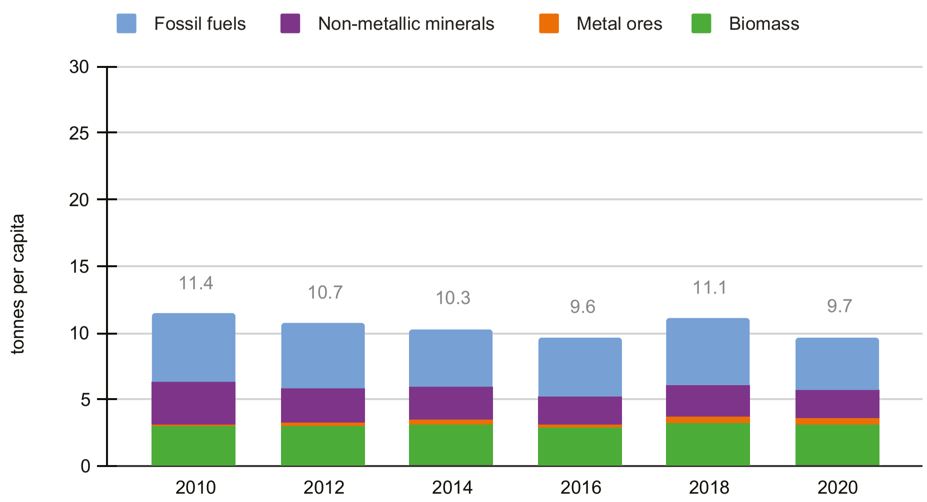

Figure 4.14. The Netherlands' DMC. Data source: Eurostat (2023g).

(see Coulter and Arqueros-Fernández, 2020), and is mainly accounted for by the construction sector. These fluctuations also indicate a level of uncertainty in the consumption of this material. Similarly to Ireland's biomass consumption, Ireland's consumption of non-metallic minerals may be inflated by the high material input to ouput ratios associated with cement produced for export (see again section 4.1.4.2).

4. In Ireland, fossil fuels and metal ores account for the lowest consumption by mass. However, it has been established that the production and consumption of these materials is carbon intensive (Intergovernmental Panel on Climate Change, 2023; Yokoi *et al*., 2022). **This further highlights the need to incorporate additional considerations (e.g. carbon released through consumption of materials) when utilising the CMUR metric to inform policy decision-making.**

Looking further at Croatia, Austria and the Netherlands, two additional points are worth noting:

1. The DMC of Austria, Croatia and the Netherlands remained largely consistent over the 10-year period. This means that Austria and Croatia's CMUR improvements were primarily achieved through the recycling side of the CMUR equation.
2. In Croatia and Austria, non-metallic minerals also consistently represented the largest share of consumption.

4.2.2 DMC data collection

The CMUR data from each Member State were also scrutinised through a review and comparison of the methods and processes used to collect relevant data and report them to Eurostat. For material flow datasets, EU Member States are required to follow the processes described in the EW-MFA handbook or to justify divergence (Eurostat, 2018b).

This research examined the data quality of DMC subcategories that met two main criteria:

1. They represent at least 5% of total consumption on average between 2010 and 2020, and therefore have a substantial impact on Ireland's overall CMUR.
2. They are estimated, because of the lack of a direct data source, and are therefore more likely to have data quality issues (Eurostat, 2023i).

Figure 4.15 shows a breakdown of Ireland's DMC by material subcategory, while Table 4.5 presents the material subcategories that are estimated in each Member State, and whether these follow the Eurostat guidelines. Custom approaches to estimating quantities are used either because no methods are offered by the handbook, or because another method is considered to be more suitable for a specific country or context. For example, CSO staff commented that Ireland uses a custom approach to calculate biomass consumption using a highly developed agricultural research infrastructure.

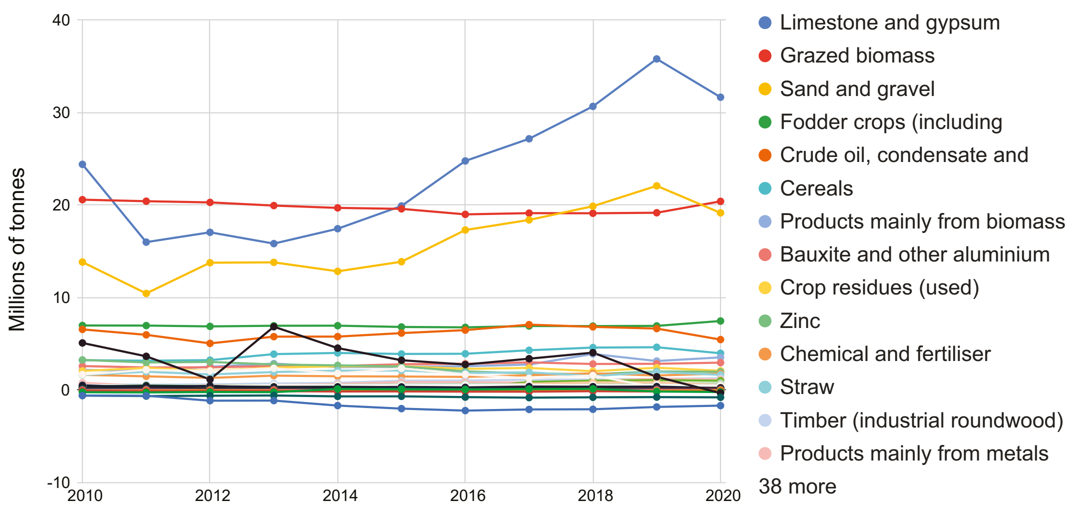

Figure 4.15. Ireland's DMC by material. Data source: Eurostat (2023g).

Table 4.5. Estimated data categories

Estimation method	Netherlands	Austria	Croatia	Ireland
Follows Eurostat guidelines	Fodder crops Grazed biomass Clay and kaolin	Fodder crops Grazed biomass Wood fuel Crushed rock Other crop residues (timber) Natural gas Hunting	Fodder crops Grazed biomass Straw Other crop residues	Sand and gravel Straw Crushed rock Other crop residues
Custom approach	Sand and gravel	Sand and gravel Fruit (grapes)	None identified	Fodder crops Grazed biomass Lead, zinc Peat

Source: Eurostat (2023i).

Data quality challenges do exist in many of the major material categories that account for large portions of consumption in these countries. Having spoken with the officials responsible, the broad challenge faced in each country is compiling a comprehensive dataset when the availability of data varies from year to year. Other challenges noted below include reliance on self-reporting by companies (e.g. through the PRODCOM survey) and measuring resource production in a spatially expansive industry, such as agriculture.

In Ireland's case, four of the estimated categories – fodder crops; grazed biomass; sand and gravel; and crushed rock – account for 71% of total DMC. Fodder crops and grazed biomass are estimated in all comparator countries, while crushed rock, and sand and gravel are estimated in two of the four. Additional information was sought in relation to how each of these categories is estimated and to help identify where data quality issues might arise. Ireland's material flow account metadata (Central Statistics Office, 2020) and CSO statisticians were consulted on these points specifically. While no major data quality issues were found, areas of uncertainty were identified. **Therefore, it is recommended that the quality of raw data pertaining to consumption should be closely monitored and improved where possible.** The following information was compiled.

4.2.2.1 General

In Ireland, CSO statisticians undertake in-depth analyses in order to investigate any unexpected changes in time series pertaining to any of the DMC subcategories. Therefore, the final data that are presented have been adjusted, interpreted and validated in relation to economic, policy and other variations. DMC statistics appear to be revised for all countries retrospectively, for instance if there is a change in methodology, which brings an added degree of comparability between different years (Eurostat, 2023i).

4.2.2.2 Fodder crops and grazed biomass

Data for land under fodder crop cultivation are supplied by the CSO's agriculture division. These data are then multiplied using national yield coefficients to arrive at dry weight estimates. To estimate grazed biomass, the CSO uses a variation of Eurostat's supply-side approach (Eurostat, 2018b). Data for land area used for silage, hay, pasture and rough grazing are supplied by the CSO's agriculture division. These are also multiplied by national yield coefficients to arrive at grazed biomass estimates. Eurostat recommends that a demand-side calculation – i.e. number of grazing animals – is used to verify these figures. The CSO officers explained that a demand-side calculation is not undertaken because more data are available for supply-side estimations. Therefore, those figures are more accurate. It was also emphasised that, given the historical importance of grass-based agriculture, there is a high level of indigenous expertise. Much of this expertise is embedded within Teagasc, Ireland's agricultural development agency (see Teagasc, 2024). The only caveat is that the yield coefficients are not adjusted annually, and so some quality issues may arise in that respect. Austrian, Croatian and Dutch statistical officers each stated that they use the Eurostat method.

4.2.2.3 Crushed rock and sand and gravel

Crushed rock figures are aggregated with limestone and gypsum in Eurostat data. Crushed rock, and sand and gravel figures are both calculated by the CSO using PRODCOM data. PRODCOM is an annual survey in EU Member States whereby national statistical institutions collect data from enterprises (Eurostat, 2023m). PRODCOM accounts only for goods that are sold, and so there is a risk of underestimation using this method alone. For this reason, the CSO supplements PRODCOM data with Road Freight Transport Survey data, which is a weekly survey carried out on a sample of registered goods vehicles over 2 tonnes in weight. As part of the survey, vehicle owners are required to submit the kinds of goods and weights that they are transporting (Central Statistics Office, 2023b). In relation to this category, CSO statisticians highlighted that the variable level of information technology infrastructure and expertise in quarrying and adjacent enterprises could affect data quality. This may result in lower quality data on which the CSO relies. Eurostat recommends estimating crushed rock, and sand and gravel based on concrete and cement production data, which can be generated through PRODCOM. CSO officers reported that while PRODCOM is used as a data source, these categories are reported directly. Therefore, the CSO does not use the concrete/cement estimation approach in the Eurostat guideline (see Eurostat, 2018b).

In relation to the comparator countries, Austria estimates sand and gravel in line with the Eurostat handbook. Croatia does not classify sand and gravel or crushed rock as estimated; however, these are also estimated based on PRODCOM survey data, so there is a form of estimation based on proxy data. The Netherlands used a data source for sand and gravel until 2018. At that point they switched over to the “recommended approach” (Statistics Netherlands, 2023). This is assumed to be the Eurostat handbook method.

4.2.3 Recovery recycling

After DMC, the other major area for statistical comparison between the four comparator Member States is waste collected for recycling. Figures 4.16 and 4.17 illustrate that:

- Ireland is third out of the four Member States in terms of total quantities of waste treated per capita.
- Ireland is fourth out of the four Member States in terms of waste treated through recycling per capita.

From a purely statistical point of view, Ireland’s low rate of waste treatment per capita means that there is less opportunity to recycle compared with Austria and the Netherlands, at least. **This is important because increasing quantities of recycling would positively affect Ireland’s CMUR.** In addition, although Ireland treats more waste per capita than Croatia, it still recycles less waste than Croatia. Comparatively speaking, then, Ireland underperforms in the waste-to-recycling ratio.

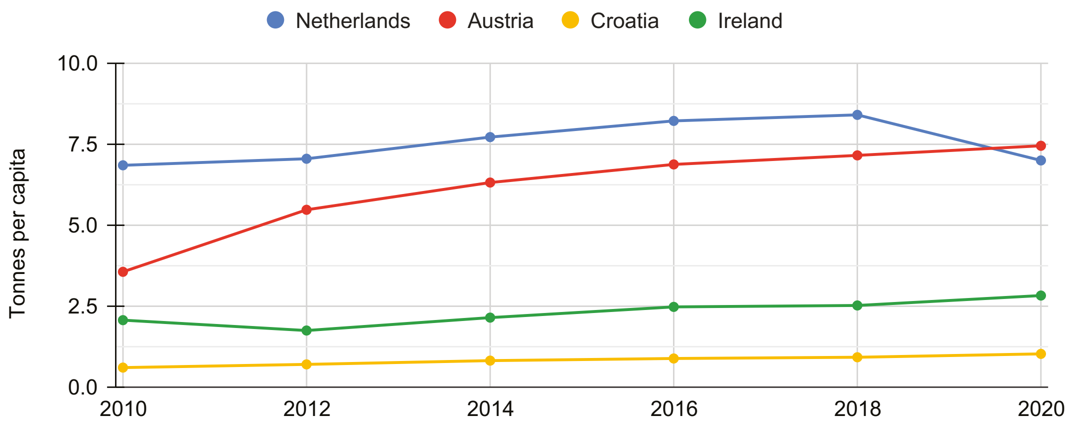

Figure 4.16. Waste treated nationally. Data source: Eurostat (2023j).

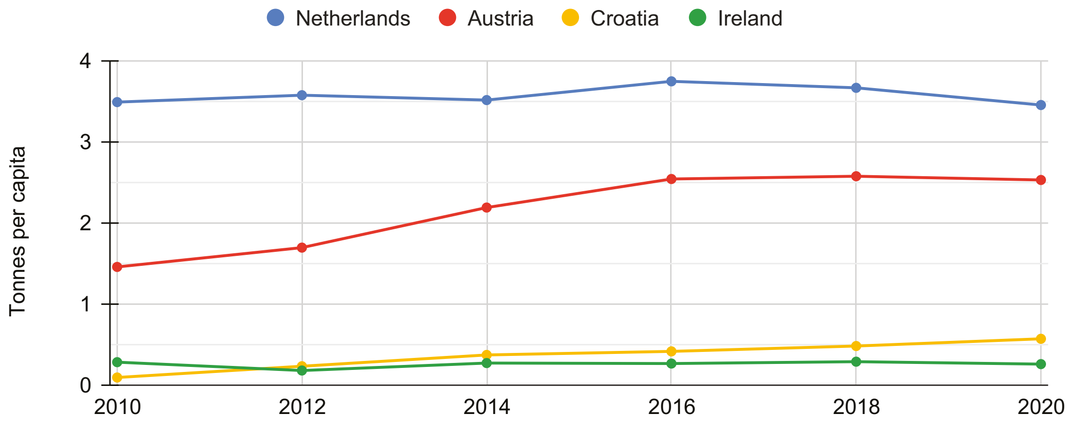

Figure 4.17. Waste recycled nationally. Data source: Eurostat (2023j).

4.2.4 Waste treatment data collection

Before exploring the details of the recycling statistics, it is useful to consider the data collection systems used for this category in each of the four countries. Waste treatment data quality is considered by Eurostat to be "fairly high" and comparable among Member States (European Commission, 2020c). In order to explore comparability further and probe any quality issues, a mapping exercise of the waste data collection infrastructure in each of the four comparator countries was undertaken (Figures 4.18–4.21). In spite of the differences described below, no major data quality issues were identified. The following sections describe the main points arising from this exercise.

Ireland's process for collecting data on waste essentially relies on waste processors as the primary source of data. The following data collection processes are in place:

- Larger scale waste facilities report waste treatment data directly to the Environmental Protection Agency (EPA).
- Large-scale industries, such as the alumina processing industry, treat waste on-site and report quantities directly to the EPA.
- Smaller scale waste collectors and waste facilities that serve most domestic households and small and medium-sized enterprises report to the National Waste Collection Permit Office. Data from collectors and facilities are cross-referenced to validate each other.
- A sample survey of approximately 5000 non-licensed businesses is carried out by the CSO in order to estimate the relative quantities of waste produced by each economic (NACE) sector.

The project team consulted with statistical officers from the EPA to enquire about any data quality issues. The EPA officers stated that the main data quality questions for them relate to the data initially received from waste treatment facilities. Thus, while no specific data quality issues were identified, areas of uncertainty are present. **Therefore, and similarly to consumption data, it is recommended that the quality of raw data pertaining to waste collection and treatment is closely monitored and improved where possible.**

Austria and Croatia's approaches are based on the same principle as that followed in Ireland. In Austria, enterprises with waste treatment permits submit annual waste balances via an online system to the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). The BMK runs a number of supplementary processes to estimate potentially underreported quantities of waste from construction and demolition activities, and several other processes for which no public documentation was available (Bernhardt *et al*., 2016). It was not possible to interrogate these processes further as part of this project.

The current reporting structure in Croatia largely resembles that of Austria. Enterprises permitted to treat waste are required to report relevant quantities and categories via the online Environmental Pollution Register. Data reported through the register are examined and validated by 21 local government offices (county offices and the City of Zagreb Office) (Eurostat, 2022b). The Institute for Environment and Nature performs additional data validation before

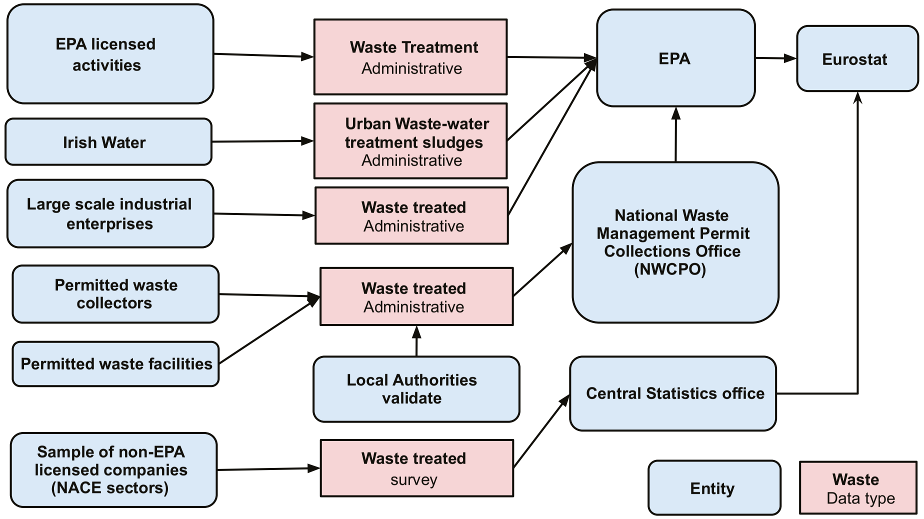

Figure 4.18. Waste reporting in Ireland.

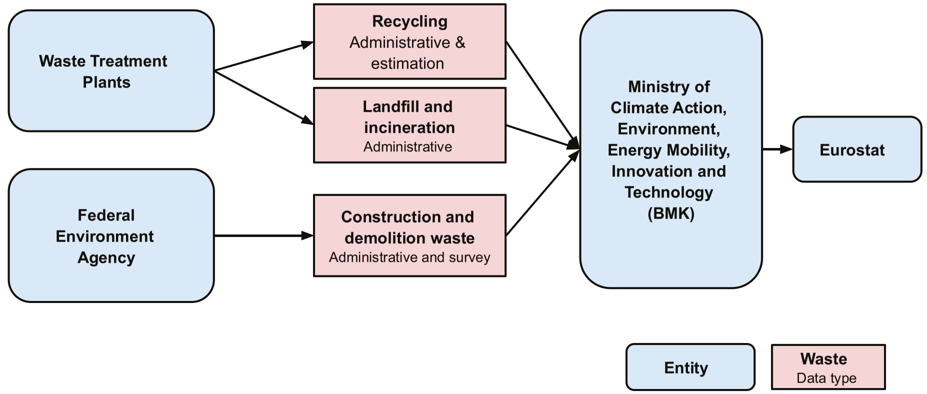

Figure 4.19. Waste reporting in Austria.

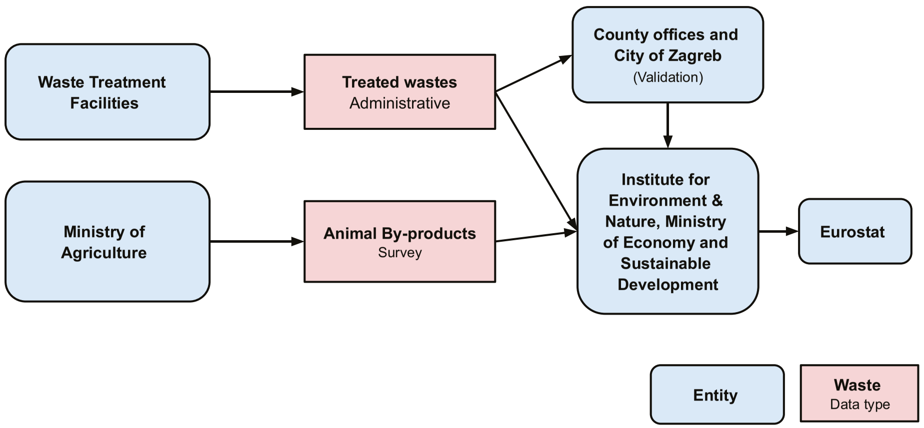

Figure 4.20. Waste reporting in Croatia.

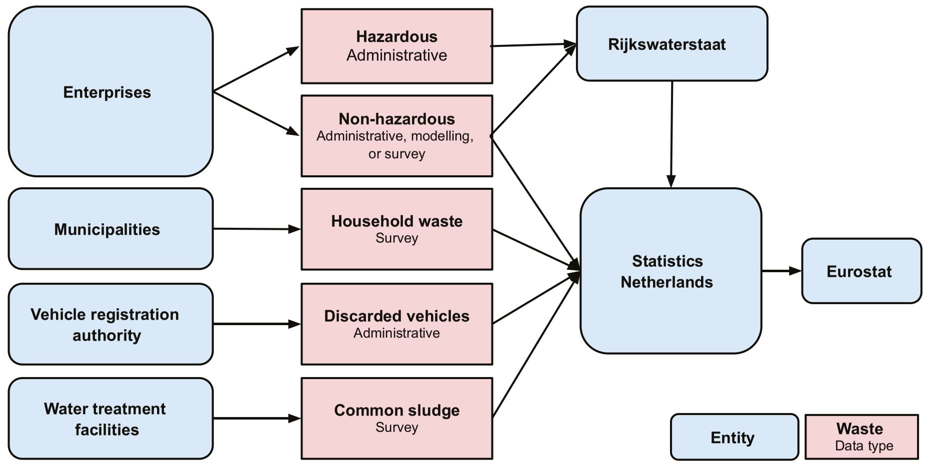

Figure 4.21. Waste reporting in the Netherlands.

compiling the final datasets and transmitting these to Eurostat.

The Netherlands uses a different approach from Ireland, Croatia and Austria. The key difference is that Statistics Netherlands relies less on collecting data on waste *treated* directly from waste treatment facilities and more on collecting and quantifying data from enterprises and municipalities on waste *generated*. (Eurostat, 2022b). In fact, data from waste treatment facilities account for just 8% of data pertaining to waste treated in 2020. The remaining 92% of waste treated is derived using the following formula:

$$\textit{Waste treatment} = \textit{waste generated} + \textit{waste imported} - \textit{waste exported}$$

When the total figure has been calculated it is then divided into treatment types by applying the ratios available in the Dutch Registry of Waste Treatment, which is based on industry reports, transport notifications and assumptions, and is updated every 3–5 years (Eurostat, 2022b). In addition to collecting data from administrative sources relating to hazardous waste, non-hazardous waste and vehicles (Figure 4.21), Statistics Netherlands collects primary data, mainly through surveys (Eurostat, 2022b).

4.2.4.1 Changes to waste reporting processes

Through consultation with statistical officers from the four comparator counties, certain changes to waste reporting processes were identified. These should be taken into account when reading waste statistics time series:

- From 2015 onwards, Ireland transitioned to an electronic system managed by the National Waste Collection Permit Office. From this point, all waste facilities and collectors issued with permits were required to submit data online. It is difficult to know whether the steady increases in the amount of waste treated from 2015 onwards are related to the new and continually improving system now in place.
- In Austria, a new, more comprehensive electronic data management (EDM) system was introduced in 2010, and refined in 2012 and 2014. Statistical officers from the BMK explained that 2010 and 2012 should be considered trial years for this new EDM and, therefore, the data from 2014 onwards is not comparable. Indeed, the data stabilises after this point, and from 2016 onwards in particular. They also asserted that the new EDM system contributed to the overall increase in waste treatment recorded (Federal Ministry for Agriculture, Forestry, Environment and Water Management, 2024a). The BMK officers also stated that the Ordinance for the Recycling of Building Materials was a key catalyst in increasing waste recycling from construction and demolition activities (Federal Ministry for Agriculture, Forestry, Environment and Water Management, 2024b). Indeed, continual increases are recorded in recycled materials overall from 2010 onwards, while an upward trend of recycling construction and demolition materials is recorded from 2012 onwards. Further analysis would be required to verify a causal link between changes to regulations and the increase in recycling construction and demolition materials.
- In 2012, responsibility for waste data reporting in Croatia moved from the Croatian Bureau of Statistics to the Institute for Environment and Nature (part of the Ministry of Economy and Sustainable Development).[6] This change was accompanied by a revised methodology and a new digital reporting system named the Environmental Pollution Register. Waste treatment statistics pre-2012 are therefore not comparable with statistics after this point.

Changes in institutional arrangements and methodologies for waste data collection have occurred in each of the four comparator countries. **These changes should be considered when reading CMUR time series and when comparing CMURs among different EU Member States, and in continued efforts to ensure data quality and comparability at the EU level.**

4.2.5 Statistical waste treatment profiles

Figures 4.22–4.25 provide profiles of the main waste treatment routes for the four comparator countries between the years 2010 and 2020. It is important to

6 Interview with data stakeholders of Croatia (11 May 2023).

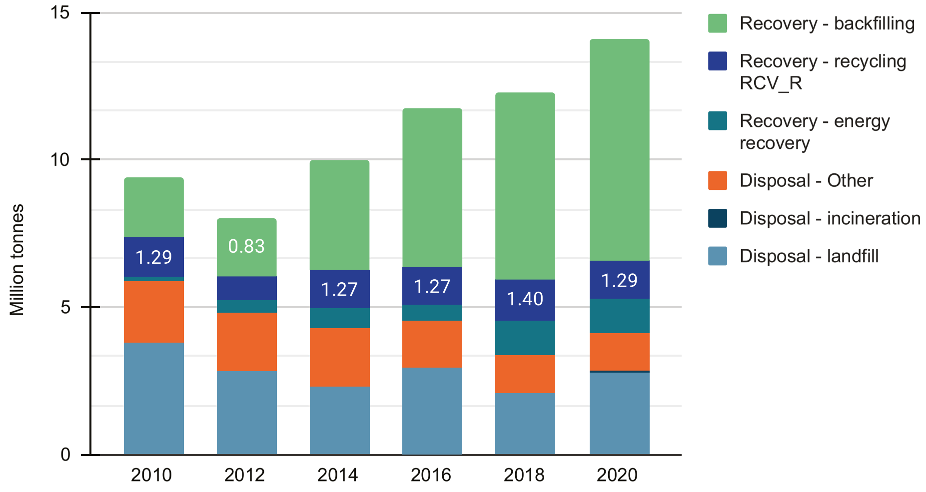

Figure 4.22. Waste treatment in Ireland. Data source: Eurostat (2023j).

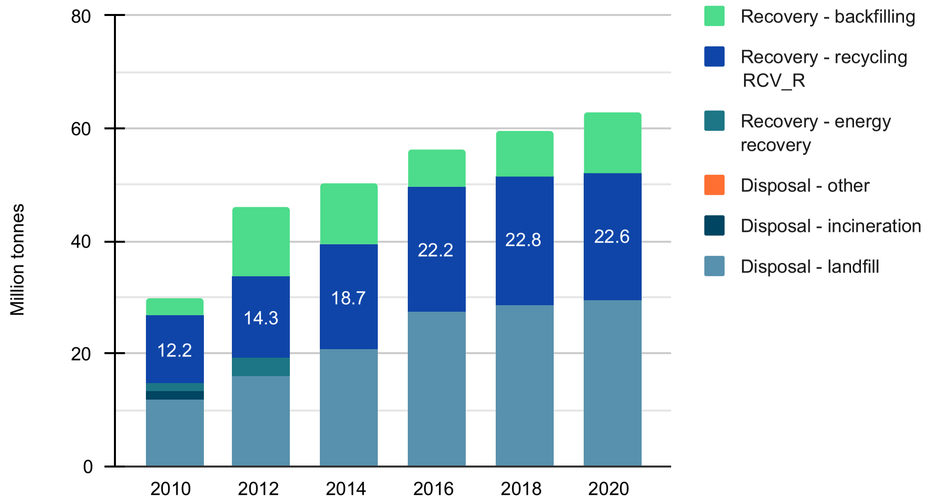

Figure 4.23. Waste treatment in Austria. Data source: Eurostat (2023j).

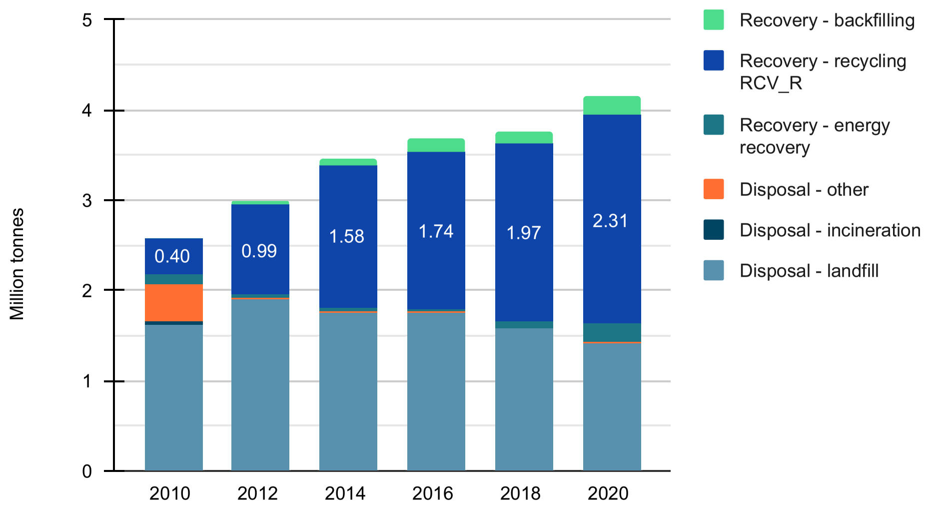

Figure 4.24. Waste treatment in Croatia. Data source: Eurostat (2023j).

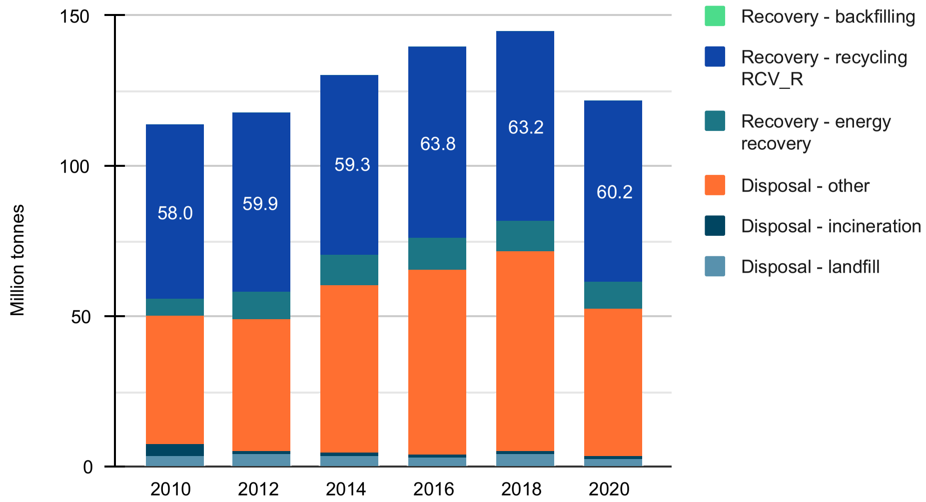

Figure 4.25. Waste treatment in the Netherlands. Data source: Eurostat (2023j).

note that each of these figures are to different scales. A number of points are noteworthy:

- Ireland's recycling quantities remained relatively unchanged in absolute terms between 2010 and 2020 (1.29 Mt in 2010; 1.29 Mt in 2020), while overall waste treatment increased by approximately one-third. The majority of the additional waste appears to have been treated through backfilling (2 Mt in 2010; 7.5 Mt in 2020). Backfilling does not count as recycling for the purposes of CMUR calculations. Construction and demolition activity accounts for the majority of this material and the majority of the overall increase in waste treated (Environmental Protection Agency, 2023a).
- In Austria, total waste treatment more than doubled from 29.8 Mt to 66.4 Mt. The additional waste volume was treated through a number of avenues. Landfilling saw the largest increase, from 11.8 Mt to 29.6 Mt. Recycling increased from 12.2 Mt to 22.6 Mt, although recycling as a proportion of total waste treatment decreased from 41% to 34%. Backfilling fluctuated between 2.8 Mt and 12.5 Mt over the 10-year period, but increased consistently in reporting years from 2016. The 10 Mt of additional material recycled was the main driver increasing Austria's CMUR.
- In Croatia, total waste treatment increased between 2010 and 2020 from 2.5 Mt to 4.1 Mt. Crucially, total waste recycled increased by 250% between 2012 and 2020. Croatian statistics officers with whom we spoke asserted that the increase in recycling was achieved through additional technology and infrastructure that supports separate collection of waste, sorting and composting of relevant materials. In 2012, responsibility for data collection was transferred to the Croatian Institute for Environment and Nature, and changes to the national infrastructure were introduced. In section 4.3.2, we discuss the development of the biogas sector, which has also played an important role and holds particular lessons for Ireland. These are the main factors that contributed to increasing the CMUR in Croatia's case.
- In the Netherlands, overall waste treatment consistently increased between 2010 and 2018. Waste treatment decreased in 2020, possibly as a result of the COVID-19 pandemic. During this same period, recycling levels remained relatively stable (± 5%), representing between 43% (2018) and 51% (2010) of total waste treatment.
- Of particular interest, considering the level of backfilling in Ireland, is the fact that the Netherlands reports 0% backfilling. Through reviewing available documentation and discussions with statistical officers, it was identified that a different definition of backfilling is used by the Netherlands, which is not consistent with the Waste Framework Directive. The directive defines backfilling as "any recovery operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials, be suitable for the aforementioned purposes, and be limited to the amount strictly necessary to achieve those purposes" (European Union, 2008). In the Netherlands, backfilling is defined as "the deposition of waste in mines" (Eurostat, 2022b). In addition, permits can be issued to use waste instead of primary materials in infrastructure projects (Rijkswaterstaat, 2024), and such use appears to be recorded as recycling (see Schut *et al*., 2015). More detail can be found in documents from the Ministry of Infrastructure and Water Management (Rijkswaterstaat, 2007, 2024). In Austria and Ireland, such use is considered to be backfilling (direct correspondence with the EPA) (Bernhardt *et al*., 2016). It was not possible to determine Croatia's interpretation of backfilling during this project. However, approximately 200,000 tonnes of material were backfilled in 2020, indicating that Croatia's definition is unlikely to align with that of the Netherlands (Eurostat, 2023n). **The key point is that more robust and consistent definitions are needed in relation to waste treatment processes across the entire EU to allow accurate comparison of CMUR scores among Member States and lend credibility to the metric.**

4.3 Case Studies and Pathways of Action

The analysis presented so far has provided an overview of the data collection systems, materials consumption levels and waste treatment volumes in the countries selected for comparison. The current section builds on this analysis by identifying and focusing on specific material flows that present opportunities for Ireland to improve its CMUR. The next three sections present and describe recommendations in relation to CDW, biomethane and other mineral waste.

4.3.1 Focus on materials 1: construction and demolition waste

The first focal point is CDW. CDW is not a specific EWC-Stat category but includes a number of waste categories. Soils[7] and mineral waste from construction and demolition[8] accounted for 88% of this waste stream in the EU in 2020 (Eurostat, 2023e). Therefore, these two categories receive the most focus in the current section. By weight, CDW is the largest waste stream in Ireland and in the EU (Eurostat, 2023n). In 2020, CDW represented 82% of Ireland's total waste (Environmental Protection Agency, 2023a). CDW increased consistently in Ireland from 3.14 Mt in 2012 to 9 Mt in 2021 (Regional Waste Management and Planning Offices, 2020). Moreover, Ireland's national strategy – Project 2040 – sets the goals of delivering 6000 affordable homes per annum between 2021 and 2030 and implementing a suite of major infrastructural improvements (Department of Public Expenditure and Reform, 2021). CDW is therefore projected to continue increasing (Environmental Protection Agency, 2021).

Figures 4.26 and 4.27 were developed to facilitate more detailed comparison of Ireland's performance in waste treatment and waste recycling for the year 2020. These figures present the relative share of each material category in terms of total waste treated and total waste recycled, respectively. Table 4.6 pulls these data apart further, with particular focus on waste soils and mineral waste from construction and demolition.

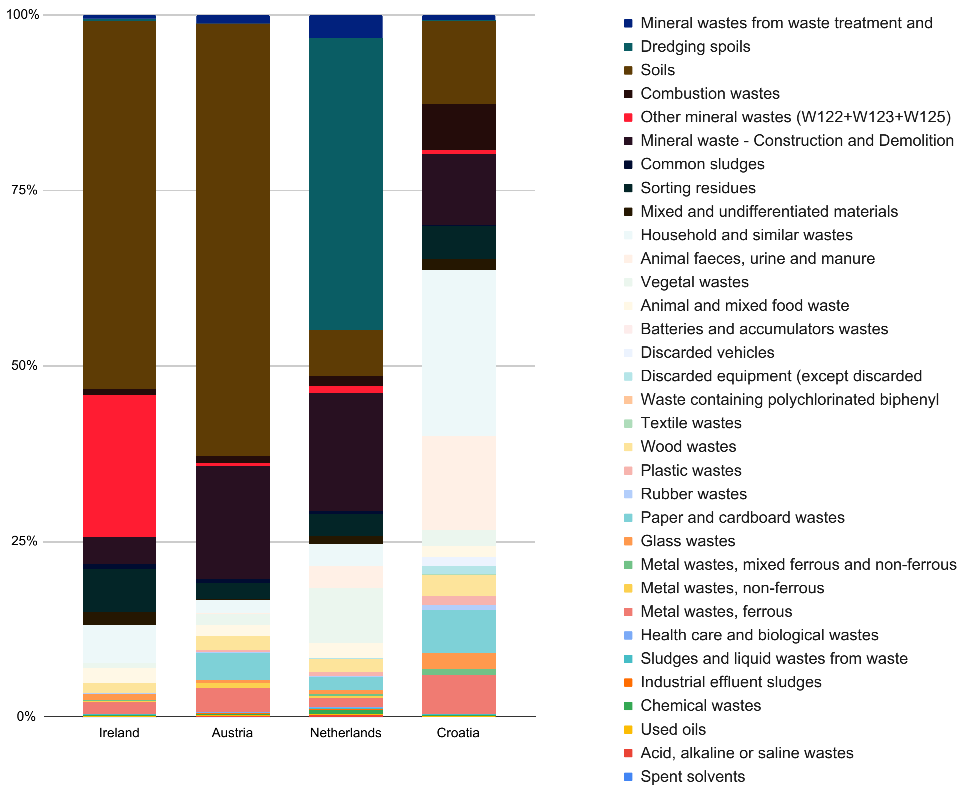

Figure 4.26. All waste treatment by material, 2020. Data source: Eurostat (2023j).

7 Soil and stone that originate mainly from construction activities, the excavation of contaminated sites and soil remediation. They are hazardous when containing organic pollutants, heavy metals or oil (Eurostat, 2013).

8 Concrete, bricks and gypsum waste; insulation materials; mixed construction wastes containing glass, plastics and wood; and waste hydrocarbonated road-surfacing material. They originate from construction and demolition activities. They are hazardous when containing organic pollutants (Eurostat, 2013).

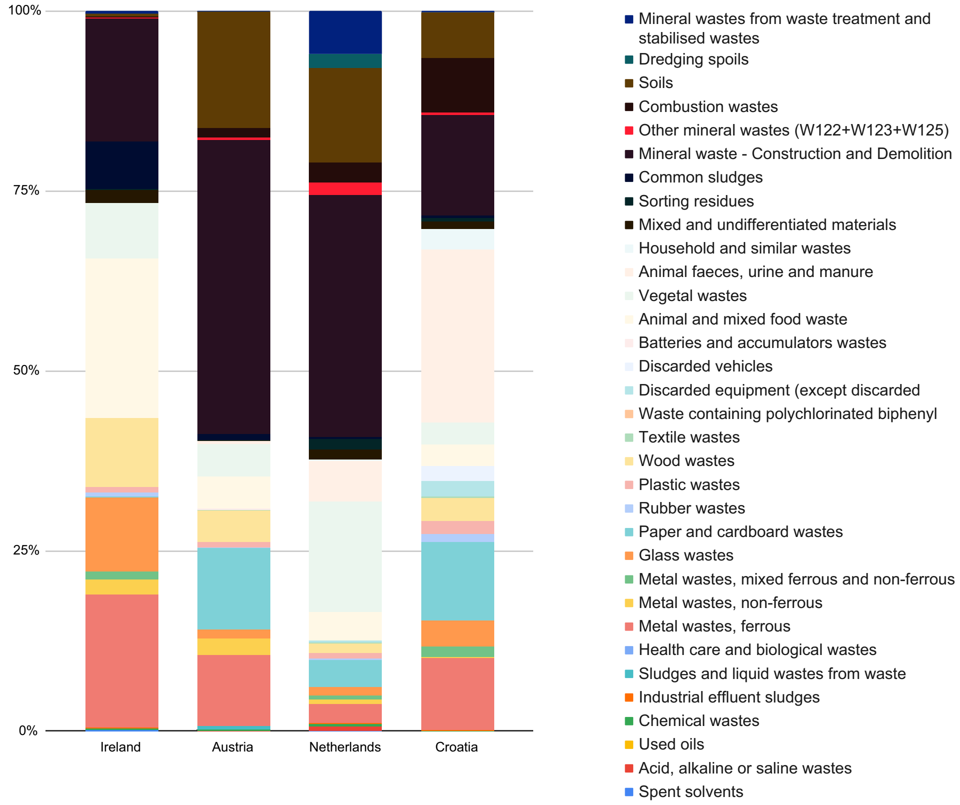

Figure 4.27. All recycling by material, 2020. Data source: Eurostat (2023j).

Table 4.6. Treatment and recycling of CDW in four countries

CDW category	Ireland	Austria	Netherlands	Croatia
Waste soils				
Treated (Mt)	7.3	40.95	7.98	0.49
Recycled (%)	1	9	99	29
Mineral wastes from construction and demolition				
Treated (Mt)	0.55	10.7	20.26	0.42
Recycled (%)	39	86	99	76

Data source: Eurostat (2023j).

In relation to these two categories, the following points are relevant:

- Waste soils account for a large percentage of total waste treatment in Ireland (52%) and Austria (61%), but a smaller percentage in the Netherlands (6.5%) and Croatia (11.9%).
- Waste soils recycling levels are much higher in Austria (9%), the Netherlands (99%) and Croatia (29%) than in Ireland (1%).
- Ireland's recycling rate of mineral waste from construction and demolition (39%) is much lower than in Austria (86%), the Netherlands (99%) and Croatia (76%).
- These low rates of recycling negatively affect Ireland's CMUR.

In order to glean insights on improving Ireland's CDW recycling rates, more detail about CDW recycling in the comparator Member States was explored. The Netherlands has the highest recycling rate in this area. However, as discussed in the previous section, much of this recycling can be accounted for by a different definition of backfilling. For this reason, Austria, which manages backfilling data in a similar fashion to Ireland, was assessed in relation to recycling of CDW. Croatia was excluded because detailed information about the processes surrounding soil recycling were not publicly available.

Figures 4.28 and 4.29 provide additional insight here. These figures show that treatment of soils and mineral waste from construction and demolition in Austria increased over a 10-year period (2010–2020) by 28 Mt and 4.8 Mt, respectively. In addition, 12% of the additional soils waste was recycled in 2020, while 78% of the additional mineral waste from construction and demolition was recycled. Statistically speaking, the overall increase in recycling contributed to improvements in Austria's CMUR over this same period, increasing from 6.8% in 2010 to 11.5% in 2020. **Moreover, if Ireland were to achieve the same recycling rates as Austria for soil (9%) and mineral waste from construction and demolition (86%), Ireland's CMUR for 2020 would increase from 1.65% to 2.42% (+0.77%)** (see Appendix 4 for calculation). The improvements in Austria can be linked with certain developments. As mentioned in section 4.2.4, Austria introduced some regulatory changes during the 2010s in terms of how waste was reported and related to the recycling of waste from construction and demolition projects. Each of these is discussed below:

- **Austria's Waste Balance Ordinance** was phased in between 2009 and 2014, gradually lowering the threshold that triggered the requirement for waste treating entities to report through an EDM system (Federal Ministry for Agriculture, Forestry, Environment and Water Management, 2024a). By 2013, any waste processing entity treating more than 20 types of waste, 10,000 tonnes of non-hazardous waste and 2000 tonnes of hazardous waste was required to submit electronic returns. Statistical officers from Austria said this development represented a "tightening up" of waste reporting and phasing out of paper record-keeping.

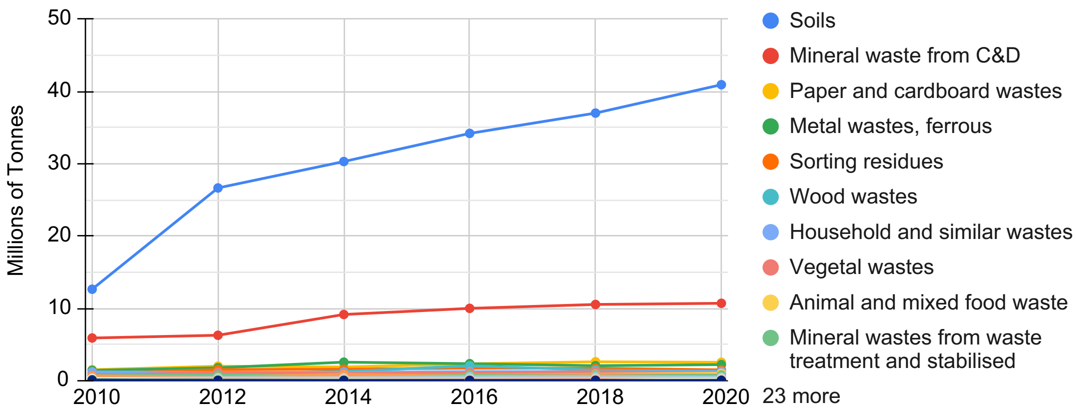

Figure 4.28. Austria's waste treatment totals by material. C&D, construction and demolition. Data source: Eurostat (2023j).

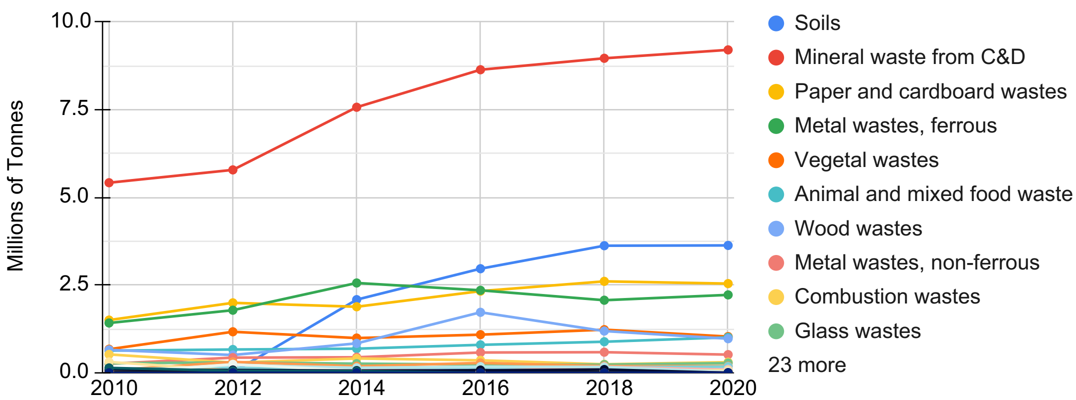

Figure 4.29. Austria's recycling totals by material. C&D, construction and demolition. Data source: Eurostat (2023j).

- **The Recycling Building Materials Ordinance** was introduced in 2016 with the aim of increasing recycling of waste material from construction and demolition projects (Federal Ministry for Agriculture, Forestry, Environment and Water Management, 2024b). This legislation introduced material management requirements for construction and demolition projects with waste projected to exceed 750 tonnes.

As shown in Figure 4.30, Austria's Recycling Building Materials Ordinance introduced new requirements to document, separate and make available specific materials that were deemed to be valuable for recycling and reuse. The current project sought to assess the possibility of introducing something akin to Austria's Recycling Building Materials Ordinance. A first step involved reviewing the regulatory landscape in Ireland. Construction and demolition operators in Ireland are already subject to certain legislative provisions. These include:

- **The Waste Management Act.** This sets down requirements for the management of waste for any party in possession of waste. This basically requires holders to manage waste in such a way that it does not cause environmental pollution, and to transfer it only to an appropriate party for further management (i.e. a collector or facility with a permit) (Government of Ireland, 1996).
- **The Waste Framework Directive.** This was transposed into Irish law through Statutory Instrument 323 (Government of Ireland, 2020) in order to comply with amendments in 2018 to the EU Waste Framework Directive. These amendments set targets for the reduction of waste through prevention and effective management (Environmental Protection Agency, 2021). Much of the language in these regulations emphasises encouragement to prevent waste and promote reuse and recycling. Binding targets or requirements are not in place.
- **A resource and waste management plan.** The EPA recommends that this be developed for all projects as part of the planning application process. The precise requirements are flexible to the scale of the project, but the plan should detail processes for waste prevention, reuse, recycling, green public procurement, off-site construction, materials optimisation, flexibility and deconstruction. The EPA also recommends tiered requirements commensurate with the scale of a project (Environmental Protection Agency, 2021).
- **Article 27 of the Waste Framework Directive.** This "allows for the notification of a material as a by-product rather than a waste where certain criteria can be demonstrated" (Environmental Protection Agency, 2021, p. 4). By-product criteria for greenfield soil and stone have now been

Figure 4.30. Austria's Recycling Building Materials Ordinance.

published for Ireland (Environmental Protection Agency, 2023b).
- **Article 28 of the Waste Framework Directive.** This provides a framework for the development of end-of-waste criteria whereby materials can be deemed to be no longer waste (Environmental Protection Agency, 2021). End-of-waste criteria for recycled aggregates were published in late 2023 (Environmental Protection Agency, 2023c). The impact of these criteria on waste treatment and consumption in Ireland has yet to be seen.

A second step involved conducting a workshop with nine construction and demolition industry stakeholders, representing contractors, material manufacturers and government agencies. As described in section 3.5, these stakeholders were presented with the Austrian context and asked to develop a workable proposal for an Irish context. Overall the group agreed that Ireland should:

> Introduce stronger requirements to separate materials for reuse during construction and demolition projects. However, requirements should be considered at design, construction and pre-demolition phase, alongside tracking and traceability of materials and project scale considerations.

Significant complexity was also highlighted by the workshop group. The following points were raised:

- In-depth engagement with industry and policy stakeholders is needed to develop functioning legislation. The implementation of any changes will take time for the sector to adapt to.
- Policy measures are needed to create a level playing field. At present it is more expensive and time-intensive to “be circular”, which adds to costs in a competitive market.
- There are technical barriers to the use of recycled materials in aggregate. Stringent quality controls are required for the manufacture of concrete.
- A market for recycled construction and demolition materials needs to be developed. This includes building confidence in the quality of recycled materials; developing policy supports so that recycled materials are an attractive option from an economic perspective; and the introduction of certain technologies, such as mobile crushing equipment, so that materials may be reused on-site for non-structural functions, such as paths and floor substrate.
- A system is needed to track materials digitally.
- Regulatory requirements should be commensurate with project scale so as not to undermine the economic viability of smaller construction and demolition projects.
- Infrastructure, in terms of facilities and storage, will be needed to facilitate further separation of materials for reuse and recycling. The backfilling waste treatment option currently acts as a pressure release valve for the treatment of unseparated CDW.
- Confidence and understanding must be built in relation to regulations. For instance, demolition contractors are wary of Article 27 by-product criteria because they are not well understood. Presumably Article 28 end-of-waste criteria will need similar considerations.
- Skilled personnel will be needed in order to undertake, for instance, design-phase planning for waste prevention, reuse and recycling, and for pre-demolition audits.

4.3.2 Focus on materials 2: agricultural residues and biomethane

Looking once more to Figures 4.26 and 4.27, an additional important point should be noted in relation to Croatia: in 2020, 24% of Croatia’s total recycling was accounted for by animal faeces, urine and manure.[9] The trend over time is presented in Figure 4.31, which shows the increase in Croatia’s recycling of this material over a 10-year period, amounting to approximately 0.14 tonnes per capita in 2020, or 0.55 Mt in total.

Eurostat documentation notes that this development relates to the establishment of new waste collection and biogas infrastructure (Noel *et al.*, 2021). Table 4.7 shows the increase in Croatia’s biogas production in gigawatt hours from 8.76 in 2009 to 316.5 in 2018. Croatia achieved this outcome primarily through the introduction of feed-in tariffs to support

9 These wastes are slurry and manure, including spoiled straw. They originate from agriculture. Animal faeces, urine and manure are non-hazardous (Eurostat, 2013).

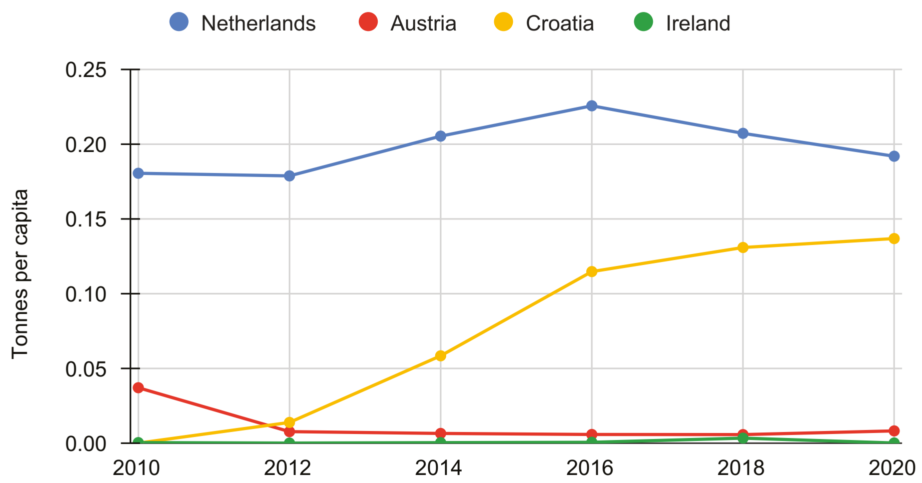

Figure 4.31. Animal faeces, urine and manure recycled. Data source: Eurostat (2023j).

Table 4.7. Biogas production for energy in Croatia

Year	Quantity of animal manure (tonnes)	Anaerobic digestion plants	GWh
2009	0	1	8.76
2018	536,000	38	316.5

Data source: Petravic-Tominac *et al.* (2020).

the operation of biogas power plants. There were two rounds of feed-in tariff supports: one in 2007 and another in 2012 (Croatian Ministry of the Economy, 2014).

For Ireland, this example highlights an important missed opportunity. In fact, this area was highlighted as a valuable opportunity for Ireland as far back as 1999 (Department of Public Enterprise, 1999). Although research has been funded in the intervening years, little action has been taken to operationalise the sector in a meaningful way. As at 2023, there were two functioning biomethane plants in Ireland (European Biogas Association, 2023). Moreover, Eurostat estimates that Ireland produces roughly 10 Mt of slurry from animal agriculture every year, of which almost none is treated as waste (Eurostat, 2023h,n). Similarly to CDW, the relevant policy in Ireland was reviewed and, based on this, a policy proposal was workshopped with sectoral experts on this topic.

The policy context in Ireland for biomethane is as follows. Ireland's Climate Action Plan includes the goal of producing 5.7 terawatt hours of energy annually from biomethane by 2030 through the construction of 150–200 40 GWh anaerobic digestion (AD) plants (Department of the Environment, Climate and Communications, 2022). In terms of volume of material that would be required, assuming a 60:40 mix between other biomass and slurry, and using the coefficients for tonnage of material to energy potential from a feasibility study carried in out in South Kerry (XD Sustainable Energy Consulting Ltd, 2022), approximately 0.89 Mt of slurry and 1.33 Mt of grass silage would be required annually. This mix of required materials poses the potential risk of creating increased demand for silage, thereby diverting the material from agricultural use, or driving demand for imports or productive land. **From a CMUR perspective, an additional 0.89 Mt of waste recycled would increase Ireland's 2020 CMUR from 1.61% to 2.37% (+0.76%)** (Appendix 4).

The expert workshop group developed a proposal that the national objective should be to:

> Expand bio-refining to displace fossil fuels and improve circularity.

Overall, developing a biomethane network was seen as an important opportunity for Irish farmers, as well as a means to produce renewable energy in areas of the country that currently may be limited in decarbonising options (e.g. the north-west). However, there were significant reservations in relation to national policy currently in development. The following main points were made:

- Several useful products can be derived from AD, including biomethane as an energy source, digestate as a fertiliser source, and biogenic CO_2 for the beverage industry. Therefore, as well as increasing Ireland's CMUR score, the products derived from this process can reduce primary consumption through the replacement of virgin materials in terms of natural gas, synthetic fertilisers and industrial CO_2 from other sources.
- Those present had been tracking the progress of the National Biomethane Strategy, which was published in May 2024.[10] There was a critique of the most recent proposal. Specifically, it was warned that a binding target of 5.7 TW by 2030 should not be pursued through punitive measures, such as fines. Rather, financial supports and incentives should be introduced to develop the indigenous industry as a whole, including feedstocks, by-products and infrastructure. Otherwise, the target is likely to be met through importing feedstocks, thereby missing an opportunity to valorise biowaste and diversify the national bioeconomy.
- The *Manual for National Biomethane Strategies* (Emprin *et al*., 2022) was referred to as an excellent resource that should guide the development of the National Biomethane Strategy.
- Irish investors are already investing heavily in AD plants elsewhere in Europe, which indicates confidence in the sector as a whole but a lack of confidence in the sector in Ireland.
- Gas infrastructure would need to be expanded so that injection points would be accessible for more areas in order to support a regional approach to production and collection of feedstocks, as well as energy generation.
- At the same time, biomethane is a portable energy source that could be transported for use by heavy industry in the north-west, particularly for combined heat and power units.
- Farmers would need to be brought on board, and current agricultural policy (e.g. the Common Agricultural Policy) would need to be considered.

4.3.3 Focus on materials 3: other mineral wastes

Returning once more to Figures 4.26 and 4.27, other mineral wastes[11] accounted for about 20% of total waste treated in Ireland in 2020, or 2.8 Mt in mass. Pathways for improving recycling or reducing consumption of materials that generate this waste were not explored in depth as part of this research. A recommendation in this regard is that these material flows should be explored further in terms of reducing consumption and increasing recycling. The following points are relevant:

- Ireland recycled less than 1% in 2020, while Austria, the Netherlands and Croatia recycled other mineral waste at rates of 28%, 77% and 37%, respectively.
- The weighted average of recycling of other mineral wastes in the three comparator countries is 67%. If Ireland achieved this rate, it would increase its 2020 CMUR from 1.65% to 3.27% (+1.62%) (Appendix 4).
- Of the 2.8 Mt treated in 2020, it is likely that 1.6 Mt was waste from alumina processing (Environmental Protection Agency, 2020).

10 https://www.gov.ie/en/publication/d115e-national-biomethane-strategy/ (accessed 18 June 2024).

11 Other mineral wastes is defined as "waste gravel, crushed rocks, waste sand and clays, muds and tailings from extractive industries; blasting materials, grinding bodies, sludges, particulates and dust from the manufacture of glass, ceramic goods and cement; casting cores and moulds from the casting of ferrous and non-ferrous pieces; linings and refractories from thermal processes; and asbestos materials from all branches (asbestos processing, cement, brake pads, etc.). They are hazardous when containing asbestos, oil or heavy metals." (Eurostat, 2013).

5 Recommendations and Conclusion

Table 5.1 presents the general findings and recommendations from this project. Table 5.2 presents targeted findings and recommendations that could boost Ireland's CMUR by specific, although estimated, quantities.

Focusing for a moment on Table 5.2, it is possible to assert that methodological flaws and features of the CMUR metric negatively impact Ireland's score in quantifiable ways. Although there are reasons for the choice, the use of DMC rather than RMC as an indicator for consumption, and the categorisation of imported brewers' spent grains as waste destined for recycling, reduces Ireland's overall CMUR score by 2.4%. Irish government agencies should engage with Eurostat on this matter.

At the same time, policy interventions targeted to specific sectors should be further explored in relation to actual reductions in consumption and increases in recycling. It is clear by an order of magnitude that increased recycling would benefit Ireland's CMUR more than reductions in consumption. Nonetheless, consumption and recycling data are interwoven, and improvements to both should be pursued through complementary approaches (i.e. through reusing, reducing and recycling waste to replace virgin raw materials). On this basis, it is recommended that further work be undertaken to reduce material consumption through interventions in the construction and demolition sector and biomethane sector, and interventions that target other sizable waste streams, such as other mineral wastes. **The estimates produced as part of this research indicate that these interventions could increase Ireland's 2020 CMUR by up to 3.15%.**

While the actions and recommendations presented in this report do not add up to achieving a CMUR of 12% by 2030, clear directions of travel are indicated. Specifically, the development of targeted sectoral interventions, in consultation and collaboration with key stakeholders, represents a useful and practical approach for improving Ireland's circularity. In addition, in relation to the limitations of the metric, Irish policymakers should continue to engage constructively with Eurostat officers and other relevant EU institutions so that credible, useful indicators can be developed and improved.

In a broader sense, the chief finding and main recommendation to policymakers from this research is to utilise the CMUR metric based on its strengths. Specifically, and as illustrated in this report, the CMUR

Table 5.1. General findings and recommendations

	Finding	Recommended action
1	The CMUR and associated data can be utilised as a valuable starting point for developing new policy options in relation to the recycling of large and valuable waste streams that can replace consumption of virgin raw materials.	Further comparative analysis of Ireland's consumption and waste data should be performed to identify opportunities and develop policies that will support more efficient use of secondary resources nationally.
2	The CMUR draws on consumption and recycling data measured in terms of mass. However, the CMUR does not account for other impacts of the materials in question, such as GHG emissions.	CMUR scores should be read with an awareness of how the metric functions and its limitations. For policy decision-making, the CMUR should be used in conjunction with other relevant metrics and/or contextual information (e.g. potential GHG emissions reductions).
3	Certain definitions (e.g. backfilling) are interpreted differently by different Member States, resulting in data that are not comparable.	Irish government agencies should underline the importance of consistent definitions for data reporting purposes, especially in the area of waste statistics.
4	The main points of data quality uncertainty relate to the primary data received by government agencies.	The quality of raw data collected pertaining to consumption and waste treatment statistics should be closely monitored and improved where possible.

Table 5.2. Targeted findings and recommendations

Finding	Recommended action	Potential CMUR impact
Methodological adjustments		
1 Certain methodological features of the CMUR metric have a disproportionately negative impact on Ireland's CMUR score. In particular, DMC as an indicator for national consumption quantities and the method for identifying waste destined for recycling that is traded across borders negatively affects Ireland's score.	Irish government agencies should query the discrepancy between Ireland's DMC and RMC figures. There is scope to recommend improvements to the DMC metric in terms of accounting for material footprint.	+1.96%
	Irish government agencies should query the categorisation of spent grains imported as animal feed as a waste destined for recycling.	+0.44%
2 By an order of magnitude, increasing total quantities recycled would have a greater impact on Ireland's CMUR than reducing total quantities of materials consumed.	Increasing recycling and reducing consumption should be pursued hand in hand.	NA
Possible CMUR improvements through methodological adjustments		+2.4%
Sectoral interventions		
3 Ireland's consumption levels per capita are high, waste generation is low and recycling levels are low.	Develop policy interventions for the construction and demolition sector focused on waste prevention and separation of materials for recycling and reuse.	+0.77%
Ireland underperforms in comparison with selected Member States in recycling of CDW; recycling animal urine, manure and faeces; and recycling other mineral wastes.	Develop financial incentives to establish a biomethane infrastructure and support feedstock delivery.	+0.76%
	Explore possibilities for using wastes arising from metal manufacturing processes, in particular tailings from alumina, lead ore and zinc ore production and processing.	+1.62%
Possible CMUR improvements from sectoral interventions		+3.15%
Overall		
Total possible benefits to Ireland's CMUR		+5.55%
Ireland's 2020 CMUR + potential impact of proposed actions		7.2%

NA, not applicable.

and associated data represent a valuable resource for identifying specific materials and economic sectors for which policy interventions can be developed to improve circularity. At the same time, it is important to acknowledge and be aware of the limitations of the CMUR metric. The metric provides one perspective, one information point, on the challenge of transitioning to a CE. Therefore, it should be employed for policy decision-making in conjunction with additional information and data, including an understanding of the contexts to which it applies and consideration of other factors, such as GHG emissions. At the same time, specific shortcomings of the metric cannot be overlooked. Factors that may affect comparability of CMUR score data among different countries are a challenge to the utility of the tool, but also to the credibility of the metric itself and any policy decisions that draw upon it. These limitations include inconsistency between definitions, for instance the definition of backfilling, as well as the challenge of ensuring robust and consistent primary data quality. Continued engagement and collaboration between EU- and national-level institutions, particularly in relation to the collection and categorisation of data, are needed to improve measurement of circularity in the EU and develop policies that support a more circular economy.

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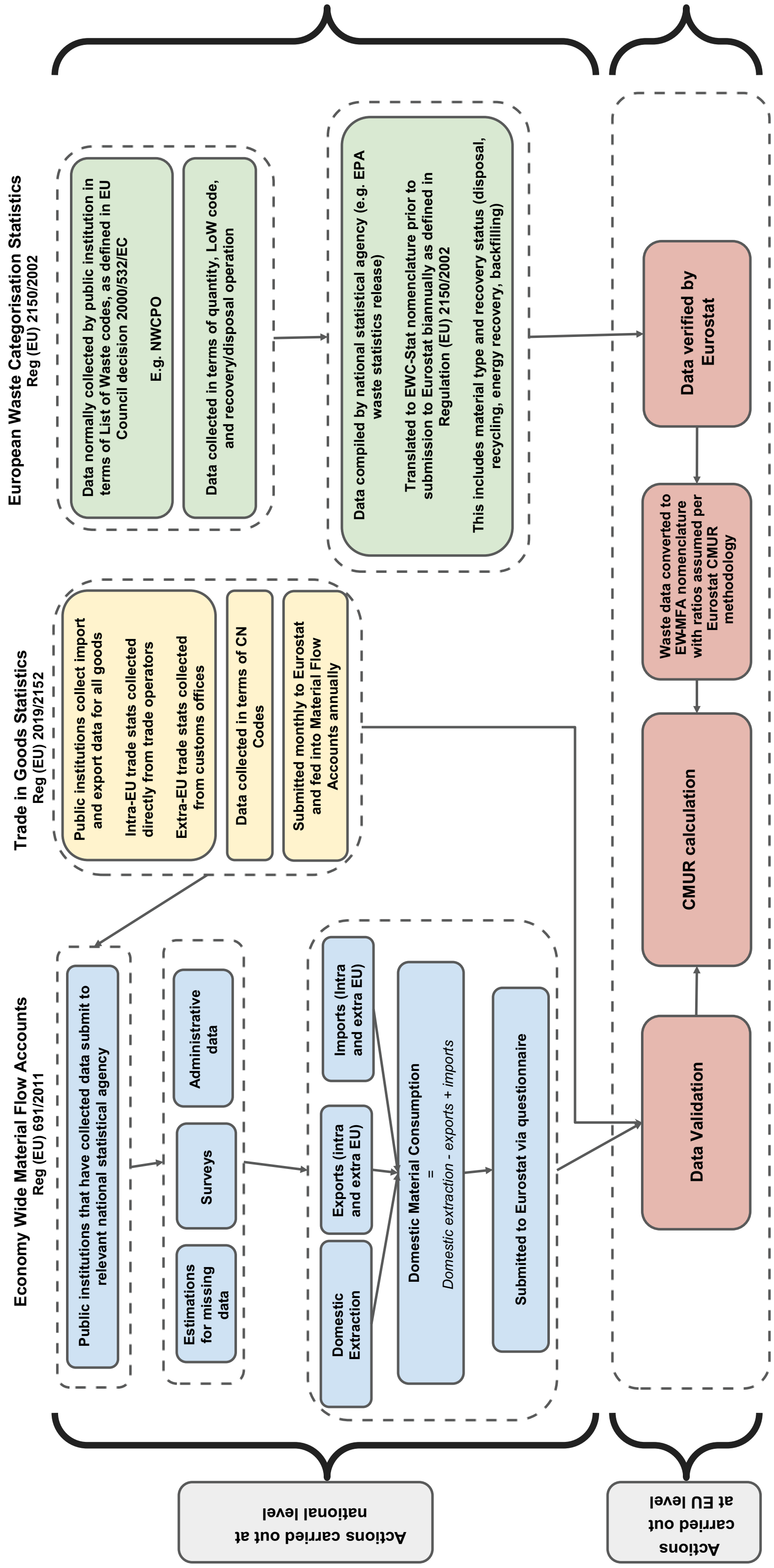
Abbreviations

AD	Anaerobic digestion
BMK	Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
CDW	Construction and demolition waste
CE	Circular Economy
CEAP	Circular Economy Action Plan
CMUR	Circular Material Use Rate
CN	Combined nomenclature
CSO	Central Statistics Office
DMC	Domestic material consumption
EDM	Electronic data management
EWC-Stat	European Waste Classification for Statistics
EW-MFA	Economy-wide Material Flow Accounts
GDP	Gross domestic product
ITGS	International Trade in Goods Statistics
LoW	List of Waste
MF	Material flow
OECD	Organisation for Economic Co-operation and Development
RMC	Raw material consumption
TFS	Transfrontier shipment

Appendix 1 Detailed Diagram of Data Collection Relevant to the Circular Material Use Rate



Appendix 2 Matrix Used to Select Comparator Countries

Performance metrics	
Quartile 4	4 points
Quartile 3	3 points
Quartile 2	2 points
Quartile 1	1 point

Country	CMUR in 2020	Change in CMUR: 2010–2020	DMC change: 2010–2020	Change in recycling (domestic by volume): 2010–2018	Resource productivity (€ GDP generated per tonne DMC): avg. 2010–2020
EU-27	10.2	24%	–5%	10%	2
Belgium	23.0	+77%	–3%	+57%	2.7
Bulgaria	2.6	+24%	+17%	+78%	0.4
Czechia	13.4	+153%	–6%	+133%	1.1
Denmark	7.7	–4%	+18%	+33%	2.1
Germany	13.4	+18%	–9%	+10%	2.5
Estonia	17.3	+97%	+18%	+145%	0.6
Ireland	2.1	+24%	+8%	+9%	2.4
Greece	5.4	+100%	–47%	–14%	1.3
Spain	11.2	+8%	–28%	–37%	2.6
France	22.2	+27%	–11%	+14%	2.9
Croatia	5.1	+219%	–4%	+389%	1.1
Italy	21.6	+88%	–33%	+26%	3.2
Cyprus	3.4	+70%	–28%	–2%	1.3
Latvia	4.2	+250%	+42%	+216%	1.0
Lithuania	4.4	+13%	+46%	+49%	0.8
Luxembourg	13.6	–44%	+20%	–30%	4.1
Hungary	8.7	+64%	+43%	+127%	1.0
Malta	7.9	+49%	+119%	+232%	2.0
Netherlands	30.9	+22%	–27%	7%	4.2
Austria	12.0	+82%	+6%	+87%	2.1
Poland	9.9	–8%	+4%	+1%	0.7
Portugal	2.2	+22%	–17%	+23%	1.1
Romania	1.3	–63%	+101%	–14%	0.4
Slovenia	12.3	+108%	–16%	+47%	1.5
Slovakia	6.4	+25%	–10%	–8%	1.2
Finland	6.2	–54%	–1%	–60%	1.2
Sweden	7.1	–1%	+24%	+9%	1.9
United Kingdom	16.4 (2019)	+14%	–1%	+16%	1.0

Country	Within 10%		1 point added to the overall score for each instance					
	Tonnes DMC per capita: avg. 2010–2020	Biomass % of DMC: avg. 2010–2020	Metal ores % of DMC : avg. 2010–2020	Non-metallic minerals % of DMC: avg. 2010–2020	Fossil fuels % of DMC: avg. 2010–2020	CMUR average: 2010–2020	Population (millions): 2020	Population density (people per km^2): 2020
EU-27	13.96	23.71%	4.95%	48.45%	22.84%	11.4	448	
Belgium	13.77	32.47%	6.66%	39.93%	22.87%	18.1	11.5	377
Bulgaria	18.98	14.33%	22.75%	35.40%	28.85%	2.7	7	63
Czechia	15.61	13.72%	2.61%	46.18%	37.31%	8.1	10.6	138
Denmark	23.24	31.54%	0.60%	48.40%	20.40%	7.8	5.8	138
Germany	15.16	18.41%	3.21%	45.30%	33.22%	11.9	83	235
Estonia	27.50	13.78%	0.21%	45.21%	41.29%	13.6	1.3	31
Ireland	21.77	37.12%	6.29%	39.39%	16.39%	1.8	4.9	72
Greece	13.17	21.95%	3.87%	31.80%	42.41%	2.7	10.7	82
Spain	9.39	30.62%	5.45%	43.85%	20.79%	9.2	46.9	94
France	11.57	30.48%	2.34%	49.52%	16.90%	18.7	67	106
Croatia	10.11	28.86%	1.41%	53.34%	15.14%	4.2	4.1	73
Italy	8.89	24.97%	2.88%	46.27%	26.55%	16.6	60.4	202
Cyprus	18.72	10.89%	9.47%	63.57%	14.38%	2.4	0.9	96
Latvia	12.57	22.17%	0.16%	68.61%	9.75%	4.1	1.9	30
Lithuania	15.84	38.41%	0.31%	51.11%	11.91%	4.0	2.8	45
Luxembourg	22.94	16.39%	7.01%	48.39%	25.14%	13.9	0.6	240
Hungary	12.33	27.98%	1.56%	50.85%	19.95%	6.4	9.77	107
Malta	11.40	12.80%	3.54%	49.25%	31.65%	6.0	0.5	595
Netherlands	10.02	30.01%	3.31%	24.21%	42.09%	27.7	17.3	507
Austria	19.31	23.80%	5.10%	56.25%	14.01%	9.7	8.9	108
Poland	17.35	22.46%	5.81%	48.46%	23.92%	10.6	38	124
Portugal	16.29	19.51%	6.68%	62.98%	9.71%	2.1	10.3	113
Romania	21.21	16.03%	1.31%	70.70%	11.79%	2.0	19.4	83
Slovenia	13.51	16.82%	2.13%	54.78%	27.06%	9.2	2	103.7
Slovakia	12.54	26.58%	5.16%	47.66%	19.44%	5.1	5.5	112
Finland	33.20	19.48%	14.24%	54.11%	11.50%	8.7	5.5	18
Sweden	23.70	25.85%	22.79%	42.04%	7.57%	7.0	10.2	25
United Kingdom	8.83	30.15%	2.06%	36.88%	29.43%	14.9	67	273.80

Appendix 3 Subcategories for Reporting EW-MFA

MF.1 Biomass	
MF.1.1 Crops (excluding fodder crops)	MF.1.1.1 Cereals
	MF.1.1.2 Roots, tubers
	MF.1.1.3 Sugar crops
	MF.1.1.4 Pulses
	MF.1.1.5 Nuts
	MF.1.1.6 Oil-bearing crops
	MF.1.1.7 Vegetables
	MF.1.1.8 Fruits
	MF.1.1.9 Fibres
	MF.1.1.A Other crops (excluding fodder crops)
MF.1.2 Crop residues (used), fodder crops and grazed biomass	MF.1.2.1 Crop residues (used)
	MF.1.2.1.1 Straw
	MF.1.2.1.2 Other crop residues (sugar and fodder beet leaves, etc.)
	MF.1.2.2 Fodder crops and grazed biomass
	MF.1.2.2.1 Fodder crops (including biomass harvest from grassland)
	MF.1.2.2.2 Grazed biomass[a]
MF.1.3 Wood	MF.1.3.1 Timber (industrial roundwood)
	MF.1.3.2 Wood fuel and other extraction
MF.1.4 Wild fish catch, aquatic plants and animals, hunting and gathering	MF.1.4.1 Wild fish catch
	MF.1.4.2 All other aquatic animals and plants
	MF.1.4.3 Hunting and gathering
MF.1.5 Live animals and animal products (excluding wild fish, aquatic plants and animals, hunted and gathered animals)	MF.1.5.1 Live animals (excluding wild fish, aquatic plants and animals, hunted and gathered animals)[b]
	MF.1.5.2 Meat and meat preparations[b]
	MF.1.5.3 Dairy products, birds eggs, and honey[b]
	MF.1.5.4 Other products from animals (animal fibres, skins, furs, leather etc.)[b]
MF.1.6 Products mainly from biomass[b]	
MF.2 Metal ores (gross ores)	
MF.2.1 Iron	
MF.2.2 Non-ferrous metal	MF.2.2.1 Copper
	MF.2.2.2 Nickel
	MF.2.2.3 Lead
	MF.2.2.4 Zinc
	MF.2.2.5 Tin
	MF.2.2.6 Gold, silver, platinum and other precious metals
	MF.2.2.7 Bauxite and other aluminium
	MF.2.2.8 Uranium and thorium
	MF.2.2.9 Other non-ferrous metals
MF.2.3 Products[b] mainly from metals	
MF.3 Non-metallic minerals	
MF.3.1 Marble, granite, sandstone, porphyry, basalt, other ornamental or building stone (excluding slate)	
MF.3.2 Chalk and dolomite	
MF.3.3 Slate	
MF.3.4 Chemical and fertiliser minerals	

Continued

MF.3.5 Salt	
MF.3.6 Limestone and gypsum	
MF.3.7 Clays and kaolin	
MF.3.8 Sand and gravel	
MF.3.9 Other non-metallic minerals	
MF.3.A Excavated earthen materials (including soil), only if used (optional reporting)	
MF.3.B Products mainly from non-metallic minerals[b]	
MF.4 Fossil energy materials/carriers	
MF.4.1 Coal and other solid energy materials/ carriers	MF.4.1.1 Lignite (brown coal)
	MF.4.1.2 Hard coal
	MF.4.1.3 Oil shale and tar sands
	MF.4.1.4 Peat
MF.4.2 Liquid and gaseous energy materials/carriers	MF.4.2.1 Crude oil, condensate and natural gas liquids
	MF.4.2.2 Natural gas
	MF.4.2.3 Fuels bunkered (imports: by resident units abroad; exports: by non-resident units domestically)[b]
	MF.4.2.3.1 Fuel for land transport
	MF.4.2.3.2 Fuel for water transport
	MF.4.2.3.3 Fuel for air transport
MF.4.3 Products mainly from fossil energy products[b]	
MF.5 Other products	
MF.6 Waste for final treatment and disposal	

Data from Eurostat (2018b, Annex A).

[a]Requested as part of domestic extraction only.

[b]Requested as part of import and export reporting only.

Appendix 4 Calculations for Modelling Circular Material Use Rate Scenarios

Table A4.1. Actual CMUR Ireland (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R	1,288,699	826,823	1,268,031	1,265,506	1,404,463	1,289,517
Trade balance for recycling	531,635	777,729	614,019	560,682	523,699	583,230
EW_MFA (DMC)	103,560,501	88,801,885	92,769,658	103,379,571	118,136,914	111,854,542
CMUR (actual)	1.73%	1.77%	1.99%	1.74%	1.61%	1.65%

Table A4.2. Target 12% via recycling (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R						14,669,662
Trade balance for recycling						583,230
EW_MFA (DMC)						111,854,542
CMUR (target)						12%

Table A4.3. Target 12% via consumption (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R						1,289,517
Trade balance for recycling						583,230
EW_MFA (DMC)						13,733,478
CMUR (target)						12%

Table A4.4. CMUR based on RMC instead of DMC (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R						1,289,517
Trade balance for recycling						583,230
EW_MFA (RMC)						50,577,714.72
CMUR (revised)						3.57%

Table A4.5. Excluding distilling dregs and/or waste (CN-23033000) from Ireland's trade in waste (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
ITGS trade balance					523,699	
ITGS trade balance excluding CN-23033000					1,057,793	
RCV_R					1,404,463	
EW_MFA (DMC)					118,136,914	
CMUR (revised)					2.04%	
CMUR difference					0.44%	

Table A4.6. Replicating Austria's construction and demolition recycling (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
Soil recycling rate (AT)						0.09
Mineral waste from construction and demolition (MWCD) recycling rate (AT)						0.86
Soil waste Ireland (tonnes)						7,300,000
Mineral waste Ireland (tonnes)						550,000
Soil waste recycled Ireland with AT recycling rates						657,000
MWCD recycling Ireland with AT recycling rates						473,000
RCV_R (actual)						1,289,517
Soil recycled currently						5632
MWCD recycled currently						220,230
RCV_R (revised for AT rates)						2,193,655
Trade balance for recycling						583,230
EW_MFA (DMC)						111,854,542
CMUR (revised)						2.42%
CMUR difference						0.77%

AT, Austria.

Table A4.7. Replicating Croatia's animal manure recycling (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R						1,289,517
RCV_R + 0.89 Mt of manure						2,179,517
Trade balance for recycling						583,230
EW_MFA (DMC)						111,854,542
CMUR (revised)						2.41%
CMUR difference						0.76%

Table A4.8. Replicating average recycling of other mineral wastes (tonnes)

Variable from dataset	2010	2012	2014	2016	2018	2020
RCV_R						1,289,517
Other mineral waste total for HRA, NL and AT						1,776,915
Other mineral waste recycling for HRA, NL and AT						1,195,986
Weighted % recycling of other mineral wastes in HRA, NL and AT						0.67
Other mineral wastes Ireland total						2,845,731
Other mineral wastes Ireland current recycling						2352
0.67 of Ireland other mineral wastes minus current recycling quantity						1,906,640
New RCV_R						3,193,805
Trade balance for recycling						583,230
EW_MFA (DMC)						111,854,542
CMUR (revised)						3.27%
CMUR difference						1.62%

AT, Austria; HRA, Croatia; NL, the Netherlands.

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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