# Net Zero: investigating the role of site-based regulation in developing a circular economy

Chief Scientist's Group research report

September 2025

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If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environment-agency.gov.uk.

Dr Robert Bradburne
**Chief Scientist**

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# Disclaimer

The insights obtained from industry are the findings from selected meetings with representatives from organisations. The views raised by representatives are subject to the limitations of this review as described in this report. The views expressed do not necessarily reflect the official position of the organisation, the authors of this report, or the Environment Agency.

# Acknowledgements

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# Executive summary

AECOM Limited ("AECOM") was commissioned by the Environment Agency (EA) to review how circular economy (CE) principles have been adopted within the following selected industry sectors (herein referred to as the "industries"):

- Steel
- Cement
- Construction
- Textiles
- Vehicles
- Food and drink
- Glass
- Paper
- Chemicals
- Plastics

This review seeks to understand which CE practices the industries are adopting, the metrics they use to measure the impact of these practices, and the barriers and drivers they face in adopting CE practices. It consolidates these findings into key industry insights related to the Environmental Permitting Regulations (EPR) and its influence on CE, subject to practical limitations and constraints.

The research firstly involved a review of the regulatory landscape with regards to CE in the industries, with a particular focus on the EPR where applicable. Following this, research was conducted to identify organisations or projects within the industries which are demonstrating CE practices, to build a set of CE case studies for the Industries. Once the case study organisations had been identified, these organisations were engaged by means of virtual meetings to gain an understanding of how, if at all, regulations have influenced their CE practices, and to obtain any metrics these organisations use to measure their CE performance. Where possible, quantities of GHG reduction due to CE practices were obtained for the case studies.

Twenty-four case studies were developed (eleven in Phase 1 and thirteen in Phase 2). The case studies identified various barriers and enablers to CE, some of which are specific to each industry, but many of which are applicable across the industries. Several organisations indicated that the EPR had a neutral impact on their CE practices. For certain CE practices, organisations have not observed quantifiable GHG reductions, but these CE practices are rather driven by cost reduction and resource availability. Furthermore, it was noted that GHG benefits of CE practices may not be observed at facility level, but rather across the value chain, highlighting the potential need to consider systems of facilities rather than facilities in isolation.

Other barriers that emerged from the case studies include the perceived timescales associated with obtaining environmental permits and permit variations, issues around quantity and quality of available feedstock[1], and a perceived lack of commercial and financial incentives for circularity. Some organisations suggested that other regulations such as the UK/EU Emissions Trading Scheme (ETS) and Extended Producer Responsibility for Packaging included aspects which present potential financial barriers to circularity.

The findings of the review were analysed and consolidated into overarching insights related to the EPR and its influence on CE. These industry insights were grouped into three categories: regulation, enforcement approach, and monitoring and reporting. The insights are based on analysis of industry engagement and therefore represent the perspective of the Industries rather than that of the regulator. They include insights around permitting requirements for small-scale trials, enforcement mechanisms for alternative material reviews, and benchmarks and CE metrics for the Industries in accordance with the metrics identified in the case studies.

There are practical limitations in terms of implementing these insights, particularly with regards to timescale constraints and the fundamental facility-level basis of the EPR. Not all the insights are in the gift of the EA to effect. Some of the insights involve cross-Government working and engagement with third party actors and environmental management systems.

[1] In the context of CE, the term “feedstock” refers to non-virgin materials used as inputs to circular processes.

# Introduction

AECOM Limited (“AECOM”) was commissioned by the Environment Agency (EA) to conduct a review of evidence of how circular economy (CE) principles have been adopted within selected industry sectors. This review was conducted over two phases, each phase focusing on a particular set of industry sectors. This report presents the findings across both phases of this review. The following industry sectors (herein referred to as the “industries”) were selected for this review:

| Phase 1 | | Phase 2 | |
|---|---|---|---|
| | Steel | | Food and drink |
| | Cement | | Glass |
| | Construction | | Paper |
| | Textiles | | Chemicals |
| | Vehicles | | Plastics |

The objective of this research was to understand how circularity is being adopted in the industries, what metrics industries use to measure circularity, and what barriers and enablers Industries face in adopting CE practices.

The findings from this review were consolidated into main insights. These insights represent the overarching circularity themes observed throughout this review. Focus was given to how these insights relate to the Environmental Permitting Regulations (EPR).

This research report presents the findings of this review and is structured as follows:

- Overview of approach taken;
- Summary of main regulations and policies;
- Presentation of case study findings; and
- Discussion of insights.

# Approach

## Methodology

The approach to this review comprised the following steps.

***Evidence Gathering***

The initial outputs of Phase 1 and 2 of the Department of Energy Security and Net Zero (DESNZ) report 'Unlocking Resource Efficiency' (DESNZ, 2023 and 2024) were reviewed and relevant regulations and guidance for permitting within the industries were identified. A review was undertaken of both published and grey literature to identify a 'long list' of potential case studies of organisations within the industries adopting CE practices. This long list of case studies was screened and shortlisted in discussion with the EA Project Steering Group (PSG) and EA sector leads in terms of which to include or exclude based on the scope of this review as discussed below.

***Synthesis and Reporting***

After a shortlist of case studies had been agreed with the PSG and sector leads, AECOM contacted these organisations to request engagement. Organisations which accepted engagement comprised the final set of case studies. AECOM conducted virtual meetings with these case study organisations to obtain additional context and information for the case studies. This industry engagement focused on understanding the extent to which the existing permitting landscape has been conducive to the adoption of CE within the industries. This engagement also involved understanding which metrics the organisations use to quantify the results of their CE practices, including associated greenhouse gas (GHG) reductions where applicable.

Based on the case study findings, insights from across the industries were consolidated, including overarching themes around enablers and barriers to adoption of CE practices in the industries. Particular focus was given to how these circularity insights relate to the EA regulations on permitting.

## Scope

For all the industries, the research focused on activities that either are within the scope of the Environmental Permitting Regulations or activities for which there is the potential (given appropriate policies being implemented by others) for expanding the scope of EPR. Therefore, the study focused on installation-based activities for the industries and their value chains. Furthermore, the study focused on material efficiency rather than energy efficiency, as agreed with the PSG. GHG benefits arising from these material efficiency-based benefits were considered. This research focused on case studies in the UK, but where engagement from UK organisations was not forthcoming, international organisations were engaged.

The key scope considerations for the specific sectors are summarised below.

***Steel***

The steel research focused on installation activities within the value chain. The comparison of blast furnace versus electric arc furnace (EAF) as a circularity option is out of scope.

***Cement***

The cement sector research focused on installation activities within the value chain. The use of run-of-station pulverised fly ash (PFA) and ground granulated blast furnace slag (GGBFS) as alternative cementitious materials is out of scope.

***Construction***

The construction sector research focused on raw materials in the construction process, and reuse and recycling of materials. Plasterboard was considered as this is a key construction material regulated by the EA via the EPR. Waste segregation was considered as this is important for circularity in the construction sector.

***Textiles***

The textile sector research focused on manufacturing-based activities and processes. The research considered recycling and treatment of materials, production of sustainable bio-fibres as alternatives to cotton, and separation of mixed fibres into primary fibres as required for re-processing and remanufacture.

***Vehicles***

The vehicle sector research focused on end-of-life and input materials for vehicle manufacturing and the material circularity aspects of batteries.

***Food and drink***

The food and drink sector research focused on manufacturing-based activities and processes, rather than agriculture.

***Glass***

Glass manufacture is a Part A2 and Part B permitted industry and is therefore regulated by local authorities, not the EA. Subject to this limitation, this review focused on circularity insights from glass manufacturing-based activities and processes.

***Paper***

The paper sector research focused on paper manufacturing-based activities and process, particularly production of recycled fibre paper and tissue paper.

***Chemicals***

The chemicals sector research focused on chemicals manufacturing-based activities and process. The chemicals scope included the use of bio-based feedstocks in consumer care and life sciences products.

***Plastics***

The plastics sector research focused on plastic manufacturing-based activities and processes. The plastics scope included chemical recycling (also known as advanced recycling) of plastics into new plastic products.

# Regulatory Landscape

## The need for Environmental Regulation

The reasons for, and the benefits of, environmental regulation are set out in Regulating for People, the Environment and Growth (Environment Agency 2013). A clear regulatory framework with agreed standards and targets has helped to drive major environmental and public health improvements over the last few decades. Regulation continues to play an important part in reducing emissions to air, discharges to water, the quantities of waste produced by businesses, and the number of pollution incidents.

Regulation protects individuals from public health risks. It safeguards employees from harm at work, enabling a healthy and productive workforce. It can uphold vital standards in building safety, protecting residents and providing clarity so that developers can invest with confidence. It ensures that products are priced and traded fairly, protecting consumers from detriment and maintaining their confidence in markets (HM Treasury 2025).

Some facilities could harm the environment or human health unless they are regulated. This is why an environmental permitting regime is required to provide for ongoing compliance monitoring by regulators of activities which could harm the environment (Core Guidance for Environmental Permitting,2020).

The following sections present an overview of the most relevant environmental regulations and how they relate to CE within the context of this review.

# National Legislation

## Waste Framework Directive

The Waste Framework Directive (WFD) (EU, 2008) establishes the wider regulatory context for waste management across Europe. In addition to defining waste, it introduces the concept of the waste hierarchy and with the Landfill Directive, established landfill diversion targets for Member States. The waste hierarchy is illustrated in Figure 1. The WFD also defines requirements for End-of-Waste (EoW), which refers to when a waste material can be declassified as a waste following its recycling and repurposing.

The requirements of the WFD are transposed into applicable national law through the Waste (England and Wales) Regulations 2011 (H.M. Government, 2011) as amended and The Waste (Miscellaneous Amendments) (EU Exit) Regulations 2019 (H.M. Government, 2019).

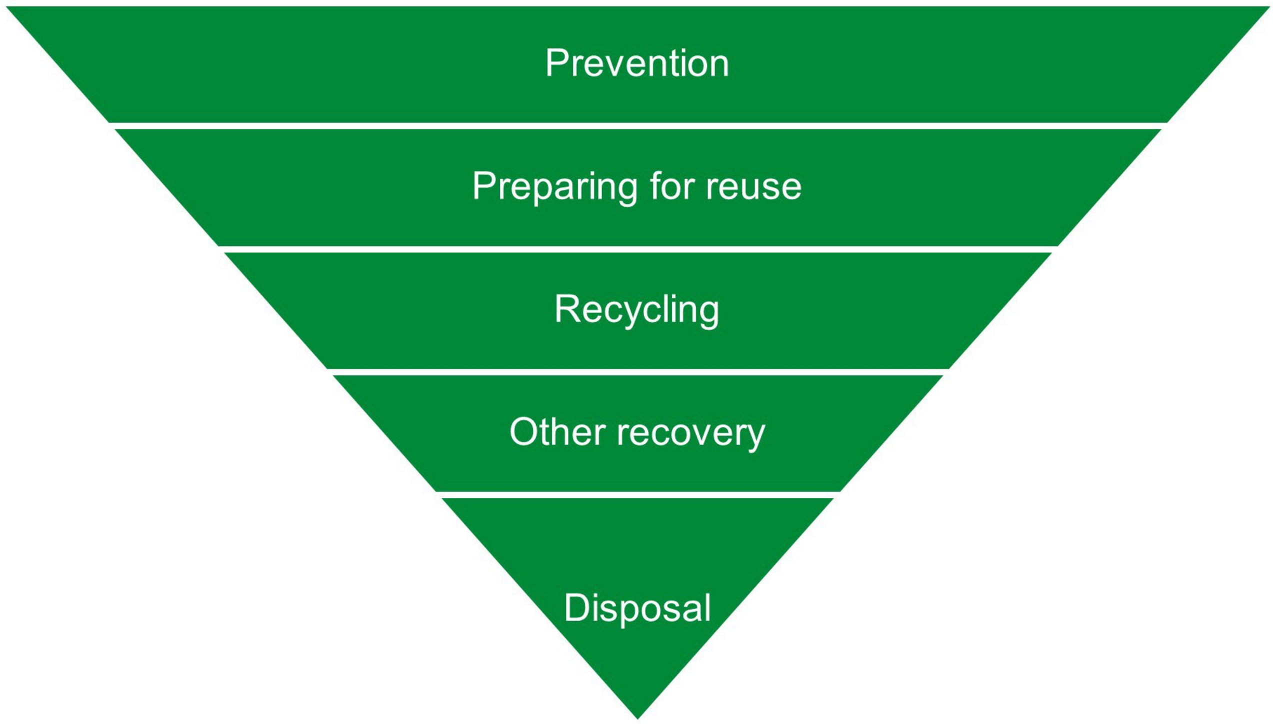


**Figure 1: The Waste Hierarchy, adapted from DEFRA's Guidance on Applying the Waste Hierarchy (DEFRA, 2011)**

## The Waste (England and Wales) Regulations 2011, as amended

These regulations (H.M. Government, 2019) transpose the requirements of the Waste Framework Directive (WFD) (EU, 2008) in England and Wales and require the Secretary of State (SoS) to establish waste prevention and waste management plans that apply to the waste hierarchy (as defined in the WFD).

Applied to the management of waste, the waste hierarchy prioritises waste prevention, followed by preparing for reuse, recycling, recovery and finally disposal. The Regulations require businesses to apply the waste hierarchy when managing waste.

By prioritising the prevention of waste, the waste hierarchy is aligned with CE principles in that it promotes elimination of waste and circulating materials at their highest values.

## Environmental Permitting (England and Wales) Regulations 2016, as amended

The Environmental Permitting Regulations (EPR) (H.M. Government, 2016) were the main focus of this study and require installations undertaking certain listed activities to hold and comply with an Environmental Permit during operation. The EPR aim to reduce the impact of installations on the environment by regulating emissions to air, water and land during the operation of the installation, as well as energy efficiency, resource efficiency and waste.

The EPR require installations to demonstrate that their environmental performance is in accordance with Best Available Techniques (BAT). BAT Reference Documents (BREF), developed by the European Commission, provide descriptions of applied techniques for particular sectors and installations, and contain BAT Conclusions (BATc). BATc describe best available techniques for installations and associated emission levels.

In addition to the environmental aspects already regulated by the EPR, there is potential to expand the coverage of EPR to further support and enable CE practices in permitted activities.

There are currently no BREF or BATc specifically for CE in the industries although many of the key attributes such as energy and waste minimisations are fundamental to defining BAT. Furthermore, the construction and vehicle manufacturing sectors are not currently regulated activities under the EPR and no BAT documentation exists for these sectors. Although the glass sector is not regulated by the EA, glass manufacture is a Part A2 and Part B activity regulated by local authorities, and BAT documentation exists for this sector.

Existing EU BATc continue to have effect in the UK through the EU Withdrawal Act 2018, but future UK BAT will be established by technical working groups for the relevant industrial sectors. At the time of writing, a review of UK BATc is currently underway by the technical working groups. In discussion with the PSG, it is understood that circularity aspects have not yet been successfully incorporated into this review of BATc.

## End-of-Life Vehicles Regulations

The End-of-Life Vehicles (ELV) Regulation 2003 (as amended) (H.M. Government, 2003) and the End-of-Life Vehicles (Producer responsibility) Regulations 2005 (H.M. Government, 2005) are underpinning legislation which aim to reduce the amount of waste generated when vehicles are scrapped. This is done through various measures to encourage the recovery, reuse and recycling of metals, plastics and rubber. The producer – the manufacturer or importer – placing the vehicle or component on the UK market is responsible for compliance.

The ELV regulations promote circularity in the vehicles sector by setting out requirements for take-back schemes, as well as recycling and recovery targets of 95% and 85% respectively for ELVs.

Regarding circularity of vehicle batteries, the Waste Batteries and Accumulators Regulations 2009 (H.M. Government, 2009) make it compulsory to take back and recycle batteries and prevent batteries from being incinerated or disposed of in landfill sites.

## The Waste (Circular Economy) (Amendment) Regulations 2020

These regulations (H.M Government, 2020) amend various legislation to implement a Circular Economy Package (CEP) in alignment with England's waste and resources strategy (H.M Government, 2018). The CEP is a revised legislative framework mainly about increasing resource efficiency, with the aim that fewer resources are sent to landfill and prioritising reuse and recycling. This is in alignment with the waste hierarchy and therefore promotes circularity. The CEP is an enabler not only for environmental regulation but also for implementation of more circular practices from a regulatory and planning perspective, i.e. better integration.

## REACH Regulation

Under the European Union (Withdrawal) Act 2018, the EU REACH Regulation was brought into UK law on 1 January 2021 and is known as UK REACH.  UK REACH regulates chemicals placed on the market in the UK.

REACH, and related legislation, were replicated in the UK with the changes needed to make it operable in a domestic context. The key principles of the EU REACH Regulation were retained in UK REACH.  The UK REACH and the EU REACH regulations operate independently from each other.

## Plastic Packaging Tax

The Plastic Packaging Tax (H.M. Government, 2022) is in force in the UK and aims to provide a clear economic incentive to use recycled plastic in packaging. This aims to stimulate an uptake in recycling and collection of plastic waste.

## 'Simpler Recycling' Regulations

The 'Simpler Recycling' Regulations (H.M. Government, 2024) intend to make recycling easier in the UK and to ensure core recycling collections are taking place throughout the country. The end goal of these regulations is to have glass, metal, plastic, paper and card (i.e. mixed recycling) and food waste collected separately from general waste from businesses in 2025, and both businesses and households from 2026.

## Extended Producer Responsibility for Packaging

The Extended Producer Responsibility for Packaging regulations (H.M. Government, 2022) impose fees for UK organisations on produced and imported plastic packaging.

# Case Study Findings

This section summarises the key findings emerging from the case study research. The detailed case studies with the full set of metrics, drivers and barriers are provided in Appendix A. The numbering of the case studies corresponds to the numbering in Appendix A. The numbering of drivers, barriers and metrics corresponds to case study numbering. For example, the drivers and barriers numbered “1”, relate to the case study numbered “1”.

The case study findings presented in this review are representative of the engagement with industry conducted within the scope of this research. These findings reflect the perspectives of the sample of industry representatives and do not necessarily reflect the views of the EA. These outputs are not an exhaustive list of all CE practices taking place within the industries. Furthermore, the metrics presented in this review have been self-reported by the case study organisations and have not been validated by AECOM.

## General

This study resulted in a number of findings which are common across the industries. Several organisations indicated that the EPR have not had a direct positive or negative influence on their CE practices. Although this indicates that the EPR is not a barrier for these organisations to adopt CE practices, it also highlights a potential missed opportunity for the EPR to promote CE best practice in the industries.

In addition, for certain CE practices in the industries, some organisations have not observed quantifiable GHG reductions. In these cases, CE practices are not necessarily driven by GHG reduction, but rather by cost reduction and resource availability.

It was further noted that GHG benefits of CE practices may not be realised at the level of a specific permitted facility, but rather in the wider value chain. It was therefore raised that there is a need for increased cooperation and collaboration across the value chain to better realise CE opportunities and the associated benefits. The benefits of CE, particularly the potential for GHG reduction, are not necessarily observed at one facility, but rather, across a system of facilities and activities across the value chain and across sectors. Since the EPR are based on a facility level, considering circularity on a systems level may present a challenge for how EPR could enable CE best practice.

Other key barriers that emerged from the case studies include the perceived timescales associated with obtaining environmental permits and permit variations, issues around quantity and quality of available feedstock, and a perceived lack of commercial and financial incentives for circularity. There was a perception that other regulations such as the UK/EU Emissions Trading Scheme (ETS) and Extended Producer Responsibility for Packaging could be better positioned to be drivers for circularity rather than presenting potential financial barriers to it.

# Steel

## CE Practices

The CE practices identified in the case studies for the steel sector are summarised in Table 1.

**Table 1: CE practices in steel sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 1 | Supply chain collaboration | Using waste steel from own customers to produce recycled steel, then selling recycled product to same customers |
| 2 | Recycled content | Using construction and demolition (C&D) waste as substitute flux material in EAF, then using slag from EAF to produce zero-carbon clinker for cement production |

## Drivers and Barriers

The key drivers and barriers for CE in the steel sector case studies are summarised in Table 2.

**Table 2: Drivers and barriers in steel sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 1 | Increases value and reduces costs | GHG benefits cannot be seen on a facility level and need to consider the wider value chain |
| 2 | Carbon pricing is a driver for the economic viability of the process | Contamination inherent to steel scrap requires addition of lime to maintain product quality. It is more economically viable to add virgin lime rather than clean the scrap |

The case studies identified CE synergies between the steel sector and the construction and cement sectors. These synergies have demonstrated GHG reductions and cost reductions, but the GHG reductions are not necessarily observed at a facility level and are rather observed in the value chain. This means that adopting these CE synergies can reduce Scope 3 (value chain) GHG emissions in the steel industry but can show increases in Scope 1 (direct) and Scope 2 (purchased energy) emissions due to processing requirements. Furthermore, it was noted that waste regulations may penalise mismanagement of waste in the steel sector but do not necessarily incentivise doing anything positive with it. This potentially presents an opportunity for the environmental regulations to help drive CE synergies by shifting from reactive to more proactive approaches.

## Metrics

The key metrics used to measure the results of the CE practices in the steel sector case studies are summarised in Table 3.

**Table 3: Metrics in steel sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 1 | % recycled content in product<br><br>$kgCO_2e$ reduction per tonne of steel (compared to European average EAF) | 98%<br><br>Reduction of 356 $kgCO_2e$/tonne steel |
| 2 | % recycled clinker in product<br><br>% reduction in $tCO_2e$ (compared to sectoral average) | 20-80%<br><br>40-150% |

# Cement

## CE Practices

The CE practices identified in the case studies in the cement sector are summarised in Table 4.

**Table 4: CE practices in cement sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 3 | Recycled content | Using reclaimed clay as cementitious material to substitute clinker |
| 4 | Waste recovery | Maximising reuse of bypass dust in the production loop and recovering the remainder for off-site uses |
| 5 | Material substitution | Produce cement using alternative low-emission waste materials |
| 6 | Recycled content | Use of historic waste PFA from landfill as a raw material substitute in cement production |

## Drivers and Barriers

The key drivers and barriers for CE in the cement sector case studies are summarised in Table 5.

**Table 5: Drivers and barriers in cement sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 3 | GHG reduction | Permitted waste code lists limit alternative raw materials due to time-consuming permit variation process |
| 4 | Reuse and recovery of waste | Permit variation process is time-consuming even for small-scale trials |
| 5 | British Standard (BS) 8500 recycled content requirements | Current demolition practices and definition of End of Waste limit feedstock of usable waste materials |

| # | Drivers | Barriers |
|---|---|---|
| 6 | Reuse and recovery of waste | Permitted waste code lists limit other potential alternative raw materials due to time constraints |

The case studies indicate that the cement manufacturing process has the technical ability to use a wide range of waste streams as resources, demonstrating that the cement sector can have a key role to play in the CE. However, it was noted that the existing lists of permitted waste codes may limit which wastes can be used as raw materials in production due to time constraints. These waste codes play an important role in environmental protection, health and safety. Permit variation is required for materials not on the permitted waste codes list, and this can be a lengthy process, even for small scale trials.

## Metrics

The key metrics used to measure the results of the CE practices in the cement sector case studies are summarised in Table 6.

**Table 6: Metrics in cement sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 3 | % of recycled content in product<br><br>% reduction in $tCO_2e$ | up to 40% reclaimed clay in cement<br><br>up to 30% relative to CEM I |
| 4 | % BPD recovered within production loop<br><br>% reduction in $tCO_2e$ | 15-20%<br><br>No significant difference to $CO_2$ footprint of clinker |
| 5 | % recycled aggregate in product<br><br>% reduction in $tCO_2e$ (compared to Ordinary Portland Cement) | Up to 100% recycled aggregates only for non-structural; Limited to 20% for structural (BS8500)<br><br>Up to 60% |
| 6 | % alternative raw material usage at facility<br><br>% reduction in $tCO_2e$ | 5.44% (in 2022)<br><br>Not quantified |

# Construction

## CE Practices

The CE practices identified in the case studies in the construction sector are summarised in Table 7.

**Table 7: CE practices in the construction sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 7 | Recycling | Recycle plasterboard offcuts from construction into new plasterboard |
| 8 | Recycling | Recycle post-consumer plasterboard waste from construction and demolition sites into new plasterboard |

## Drivers and Barriers

The key drivers and barriers for CE in the construction sector case studies are summarised in Table 8.

**Table 8: Drivers and barriers in the construction sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 7 | Gypsum cannot typically be sent to ordinary landfill and therefore a recycling route is needed as an outlet for that waste | Easier, cheaper, and generally less $CO_2$-intensive on a facility-level to process virgin gypsum than to recycle plasterboard |
| 8 | Gypsum cannot typically be sent to ordinary landfill and therefore a recycling stream is needed as an outlet for that waste | Contamination of post-consumer plasterboard<br><br>Cost of storing and testing post-consumer plasterboard |

The case studies have raised the need for a shift from traditional demolition practices to good quality dismantling and deconstruction, to provide good quality raw materials for recycling into new construction materials. Definition of Waste was mentioned as a potential barrier in the cement sector, in that this can restrict the availability of good quality construction and demolition waste available as feedstock from the construction sector, since often this material is classified as waste with intent to dispose. This raised the issue of requiring better collaboration with the value chain and construction sector to better coordinate opportunities to recover construction waste, and better deconstruction practices recovering more valuable resources that are not classified as waste as there is no intent to dispose.

## Metrics

The key metrics used to measure the results of the CE practices in the construction sector case studies are summarised in Table 9.

**Table 9: Metrics in construction sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 7 | % recycled content in product<br><br>% reduction in $tCO_2e$ | Up to 15% recycled gypsum and 100% recycled paper<br><br>Plasterboard recycling does not necessarily reduce $CO_2$ emissions compared to virgin production |
| 8 | % recycled content in product<br><br>% reduction in $tCO_2e$ | 8.5-12%<br><br>Not necessarily a reduction in $CO_2$ on a facility level, but benefits may lie in the wider value chain |

# Textiles

## CE Practices

The CE practices identified in the case studies in the textiles sector are summarised in Table 10.

**Table 10: CE practices in the textiles sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 9 | Process efficiencies | Fabric dying process with resource efficiency, green chemistry, and smart water use |
| 10 | Recycling | Fabric manufacturing which recovers fabric waste within the production loop and from own customers, and recycles it into new fabric |

## Drivers and Barriers

The key drivers and barriers for CE in the textiles sector case studies are summarised in Table 11.

**Table 11: Drivers and barriers in textile sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 9 | Resource efficiency driven by cost | Lack of guidance for circularity in textile sector |
| 10 | Recovering value in waste | Logistics are a challenge for waste take-back schemes |

Resource efficiency is a notable focus in the textile industry; however the emphasis is particularly on energy efficiency, water efficiency, material efficiency, and reduction in chemical use rather than CE specifically. This resource efficiency is driven primarily by cost, in particular reducing energy cost and recovering the value in the large volume of waste materials generated in the manufacturing processes. Although resource efficiency alone is not an appropriate case study for this review, this engagement has still revealed useful insight into the drivers and barriers related to CE in the textile industries. Reduction in chemicals not only improves process output emissions and downstream use emissions but also improves recyclability via a reduction in legacy restricted chemical presence. The case studies indicate that there is a lack of guidance for what CE means for the textile sector, and what textile facilities should be doing in terms of CE.

## Metrics

The key metrics used to measure the results of the CE practices in the textiles sector case studies are summarised in Table 12.

**Table 12: Metrics in textiles sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 9 | Chemical consumption reduction<br><br>% reduction in $tCO_2e$ | 100,000 tonnes annually<br><br>4,000 $tCO_2e$ annually (due to natural gas saving, not due to CE) |
| 10 | % recycled content in product<br><br>% reduction in $tCO_2e$ | 25%<br><br>28% |

# Vehicles

## CE Practices

The CE practices identified in the case study in the vehicles sector are summarised in Table 13.

**Table 13: CE practices in vehicles sector case study**

| # | CE Theme | CE Practice |
|---|---|---|
| 11 | Material substitution | Use of ‘green’ (recycled and bio-sourced) material in vehicles |

## Drivers and Barriers

The key drivers and barriers for CE in the vehicles sector case study are summarised in Table 14.

**Table 14: Drivers and barriers in vehicles sector case study**

| # | Drivers | Barriers |
|---|---|---|
| 11 | ELV regulations | EU regulation on battery recycled content may cause feedstock issues (especially for precious metals)<br><br>The manufacturer has no control on where ELV material ends up in other industries |

It was found that the main driver for circularity in the vehicles sector is the ELV regulations. In the EU, the Regulation concerning batteries and waste batteries (EU) 2023/1542 (EU, 2023) will require targets on recycled content in batteries. If the UK aligns to these regulations, it may be a challenge to access this recycled material. This is a feedstock issue as currently car lifetimes mean that not enough vehicle batteries would be available for recycling. Furthermore, it was noted that although the ELV regulations emphasise producer responsibility in design and manufacture for recycling and recovery, the producer has no control where ELV material ends up in other industries, limiting their influence on circularity.

## Metrics

The key metrics used to measure the results of the CE practices in the vehicles sector case study are summarised in Table 15.

**Table 15: Metrics in vehicles sector case study**

| # | Metrics | Metric Results |
|---|---|---|
| 11 | % recycled content in product | By 2025 Stellantis Group vehicles will contain 25% of green materials |
| | % reduction in $tCO_2e$ | Not quantified due to lack of consistent measure for this |

# Food and drink

## CE Practices

The CE practices identified in the case studies in the food and drink sector are summarised in Table 16.

**Table 16: CE practices in food and drink sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 12 | Waste Recovery | Upcycling of surplus bread into beer |
| 13 | Waste Recovery | Co-product[2] production from sugar manufacture |
| 14 | Process efficiencies and recycling | Produce ready-cooked meals and have a closed-loop recycling system for plastic meal trays |

## Drivers and Barriers

The key drivers and barriers for CE in the food and drink sector case studies are summarised in Table 17.

**Table 17: Drivers and barriers in food and drink sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 12 | Driven by the organisation's aim to solve environmental problems | Feedstock challenges including obtaining appropriate volumes, proving it as genuinely surplus, and obtaining documentation for food safety requirements<br><br>Processing challenges including food chemistry performance |

[2] The term "co-product" is used here rather than "byproduct" since the co-product is produced and sold as a product as part of this organisation's business model.

| # | Drivers | Barriers |
| --- | --- | --- |
| 13 | Improved efficiency and reduced costs across the supply chain<br><br>GHG reductions | Developing co-products and bringing them to the market can be difficult in terms of commercial/financial feasibility |
| 14 | Customer drive to reduce waste<br><br>GHG reductions | Liable to pay Extended Producer Responsibility for Packaging fees even though their packaging is closed-loop |

GHG reductions were identified a key driver for CE in the food and drink case studies. Plastic Packaging Tax was noted as a driver for circular packaging for food and drink, whereby adopting circular packaging results in significant tax savings. However, Extended Producer Responsibility for Packaging fees for circular packaging were noted as a challenge, due to difficulties around obtaining exemptions for this. Food safety requirements may limit feedstock availability for circular processes. One case study organisation mentioned that they experienced permitting delays for their combined heat and power (CHP) plant. Links were observed between the food and drink sector and the plastics sector (for plastic packaging).

## Metrics

The key metrics used to measure the results of the CE practices in the food and drink sector case studies are summarised in Table 18.

**Table 18: Metrics in food and drink sector case studies**

| # | Metrics | Metric Results |
| --- | --- | --- |
| 12 | Malt replaced by surplus bread<br><br>$tCO_2e$ reduced by substituting malt with surplus bread | 25%<br><br>5.3 $tCO_2e$ per annum |
| 13 | Waste to landfill / disposal | Less than 200 g waste for every tonne of sugar produced (i.e. virtually zero waste) |
| 14 | Plastic meal trays recycled content<br><br>$CO_2e$ reduction from closed-loop plastic meal tray recycling | 80%<br><br>c. 1.68kg $CO_2e$ saved per kg of trays |

# Glass

## CE Practices

The CE practices identified in the case studies in the glass sector are summarised in Table 19.

**Table 19: CE practices in glass sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 15 | Recycling | Manufacture low-carbon architectural glass produced with renewable energy and high recycled content |
| 16 | Recycling | Remanufacture waste flat glass from customers into new flat glass |
| 17 | Recycling and lightweighting | Produce foamed glass aggregate from recycled glass |

## Drivers and Barriers

The key drivers and barriers for CE in the glass sector case studies are summarised in Table 20.

**Table 20: Drivers and barriers in glass sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 15 | Energy and resource efficiency, and associated cost savings<br><br>GHG reductions | Feedstock quantity and quality challenges<br><br>Lack of sufficient financial incentives to upcycle waste glass rather than landfill |
| 16 | Energy and resource efficiency, and associated cost savings<br><br>GHG reductions | Feedstock quantity and quality challenges<br><br>Lack of sufficient financial incentives to upcycle waste glass rather than landfill |
| 17 | Lightweighting reduces transportation costs<br><br>GHG reductions | Supply chain security |

As a Part A2 and Part B regulated activity, glass manufacture is regulated by local authorities, not the EA. This was apparent in the relative lack of barriers noted in the case studies. Glass manufacture is typically energy intensive. Therefore, a key CE driver for the glass sector is energy and resource efficiency, and the associated cost savings. GHG reduction was also noted as a key driver for CE. The main barriers arising from the case studies were challenges around feedstock quantity and quality, as well as a general lack of incentive to upcycle glass waste rather than downcycle it or send it to landfill. Although included as one of the case studies, downcycling of waste glass into aggregate is a less circular process than recycling of waste glass into new glass products.

## Metrics

The key metrics used to measure the results of the CE practices in the glass sector case studies are summarised in Table 21.

**Table 21: Metrics in glass sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 15 | Low-carbon glass embodied carbon reduction | 52% |
| 16 | $CO_2e$ reduction (using one tonne of cullet[3] rather than one tonne of raw materials)<br><br>Virgin raw materials saved (using one tonne of cullet), including sand, soda ash and limestone | 0.7 $tCO_2e$<br><br>1.2 tonnes |
| 17 | Recycled glass content in foamed glass aggregate<br><br>Weight reduction (compared to traditional aggregates) | 99%<br><br>85% |

[3] The term "cullet" refers to crushed glass used as a feedstock for glass recycling.

# Paper

## CE Practices

The CE practices identified in the case studies in the paper sector are summarised in Table 22.

**Table 22: CE practices in paper sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 18 | Recycling | Produce recycled paper and recover energy from non-hazardous production wastes for use in the process |
| 19 | Process efficiencies | Waste tissue paper from production is reused in the production process, and cardboard cores for reels are reused |
| 20 | Recycling | Initiatives to collect used paper hand towels and recycle them into new paper hand towels; recovery of process rejects |

## Drivers and Barriers

The key drivers and barriers for CE in the paper sector case studies are summarised in Table 23.

**Table 23: Drivers and barriers in paper sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 18 | Organisational environmental policies and goals | Inconsistent waste collection<br><br>Time requirements for permit variations |
| 19 | Operational efficiency and cost effectiveness<br><br>GHG reductions | Limited infrastructure for waste processing |
| 20 | UK/EU Emissions Trading Scheme (ETS) and GHG reductions | Inconsistent waste collection<br><br>Time requirements for permit variations |

The paper sector case studies identified GHG reductions and carbon pricing as key drivers for CE. The Plastic Packaging Tax was also noted as a driver for use of recycled paper packaging instead of plastic packaging. Key barriers include limited infrastructure for waste processing and inconsistent waste collection. One example mentioned that it can be inefficient and costly to ship material between borders of different countries, even though the material is transported for circularity applications. Time requirements for permit variations were noted as a challenge. Due to the nature of paper fibre, paper can only be recycled a limited number of times, meaning that a proportion of virgin feedstock is still required. Furthermore, the reuse of waste tissue paper from the production process ("broke") back into the production process is the industry norm and not necessarily a CE initiative.

## Metrics

The key metrics used to measure the results of the CE practices in the paper sector case studies are summarised in Table 24.

**Table 24: Metrics in paper sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 18 | Amount of paper processed at production site (2024)<br><br>Waste recovery rate at production site | 460,000 tonnes<br><br>88.5% |
| 19 | Cardboard core recycled content<br><br>Poly wrap recycled content | 100%<br><br>Minimum 30%, can provide up to 50% |
| 20 | Waste reduction from paper towel recycling initiative<br><br>$tCO_2e$ reductions from paper towel recycling initiative | Up to 20%<br><br>Up to 40% |

# Chemicals

## CE Practices

The CE practices identified in the case studies in the chemicals sector are summarised in Table 25.

**Table 25: CE practices in chemicals sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 21 | Bio-based feedstocks | Use readily biodegradable[4] ingredients in production of consumer care and life sciences products. |

## Drivers and Barriers

The key drivers and barriers for CE in the chemicals sector case studies are summarised in Table 21.

**Table 26: Drivers and barriers in chemicals sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 21 | GHG reduction<br><br>Increased expectations from manufacturers, consumers and regulatory authorities on biodegradability information | Material recovery for consumer care and life science applications is typically challenging (e.g. material recovery from wastewater is difficult for the producer to control)<br><br>Sourcing of raw materials can be challenging, in terms of scaling up novel feedstocks from research and development (R&D) level in an economically viable way. |

The case study engagement found that GHG reduction is a driver for circularity in chemicals production. Material recovery for consumer care and life sciences chemicals is typically challenging, for example materials end up in wastewater and recovery of these

[4] Products are considered “readily biodegradable” when they have the natural ability to biodegrade to their natural state, when subjected to sunlight, water and microbial activity, to at least 60% biodegradability in 28 days.

materials is difficult for the producer to control. Therefore, the CE focus for such chemicals tends to be on the feedstock side, hence the focus on readily biodegradable ingredients and using organic raw materials from bio-based sources. It was noted that there is a lack of infrastructure to process novel feedstocks required for circular processes, as the technology associated with these novel feedstocks is still emerging. Regulations limit the use of waste materials in consumer applications, typically for health and safety reasons, which means novel feedstocks can require extensive R&D and testing before they can be adopted commercially. There was also apparent overlap between the chemicals sector and the plastics sector, particularly in terms of chemical recycling of plastics.

## Metrics

The key metrics used to measure the results of the CE practices in the chemicals sector case studies are summarised in Table 27.

**Table 27: Metrics in chemicals sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 21 | Organic raw materials from bio-based sources (2023) | 59.4% |

# Plastics

## CE Practices

The CE practices identified in the case studies in the plastics sector are summarised in Table 28.

**Table 28: CE practices in plastics sector case studies**

| # | CE Theme | CE Practice |
|---|---|---|
| 22 | Chemical / advanced recycling | Use supercritical water to recycle waste plastics back into fossil-equivalent feedstocks to make new plastics |
| 23 | Chemical / advanced recycling | Advanced recycling of PVC to make new PVC |
| 24 | Circular product design | Produce a portfolio of circular plastic products, including chemical and mechanical recycling and bio-based renewable products |

## Drivers and Barriers

The key drivers and barriers for CE in the plastics sector case studies are summarised in Table 29.

**Table 29: Drivers and barriers in plastics sector case studies**

| # | Drivers | Barriers |
|---|---|---|
| 22 | Recovering difficult-to-recycle waste<br><br>Packaging and Packaging Waste Regulations (PPWR)<br><br>Single Use Plastics Directive (SUPD)<br><br>End of Life Vehicles (ELV) Regulations<br><br>UK Plastic Packaging Tax | Inconsistent waste collection<br><br>Delivery timelines for environmental permits are a financial challenge for startup circular businesses<br><br>ETS charges are a financial challenge for startup circular businesses |

| # | Drivers | Barriers |
|---|---|---|
| 23 | Recovering PVC waste which is otherwise difficult to recycle<br><br>Removal of harmful legacy compounds in PVC | Lack of incentive to divert PVC from landfill/incineration<br><br>The technology and infrastructure needs significant investment to be commercially viable |
| 24 | Packaging legislation driving purchasing choices<br><br>GHG reduction | Lack of infrastructure for sorting of plastic wastes can constrain feedstock availability<br><br>Permitting for new assets is time consuming |

According to the case studies, GHG reduction is generally a driver for CE in plastic manufacture. However, carbon pricing can become a financial barrier for circular plastic producers under the UK/EU ETS, especially for startup businesses. It was noted that there is a lack of infrastructure for waste management (including sufficient investment in waste collection, transport and sorting infrastructure) and lack of financial incentive to divert waste from landfill or incineration. This results in constraints on feedstock quantity and quality. The case studies noted that the environmental permitting process can be time consuming, which is especially challenging for startup circular businesses. There was apparent overlap between the plastics sector and the chemicals sector, particularly in terms of chemical recycling of plastics. Links were also observed between the plastics sector and the food and drink sector (in terms of packaging) and vehicles sector (in terms of plastic parts for automobiles).

## Metrics

The key metrics used to measure the results of the CE practices in the plastics sector case studies are summarised in Table 30.

**Table 30: Metrics in plastics sector case studies**

| # | Metrics | Metric Results |
|---|---|---|
| 22 | Site production capacity<br><br>$tCO_2e$ savings per tonne of product vs fossil equivalent | Currently 20,000 tonnes per year<br><br>0.5 $tCO_2e$ |
| 23 | Planned processing capacity of first industrial PVC waste recycling plant | 40,000 tonnes of PVC waste processed per year |

| # | Metrics | Metric Results |
|---|---|---|
| | GHG reduction | c. 40% (based on previous technology; number in process of being updated for latest technology) |
| 24 | Certified circular polymers: kg $CO_2$e reduction per kg of polymer resin (based on diversion from incineration with energy recovery)<br><br>Bio-based renewable products: kg $CO_2$e reduction per kg of polymer resin (in comparison to traditional feedstock alternatives) | Reduction of approx. 2 kg $CO_2$e per kg of certified renewable polymer resin<br><br>Reduction of approx. 4 kg $CO_2$e per kg of bio-based renewable polymer resin |

# Industry Insights

Throughout the meetings with the selected organisations, overarching insights emerged around how the EPR process relates to CE in the industries. These insights include how the EPR operates, and its effect on the operations of these organisations and the potential to influence CE practices. The key findings across the case studies have been analysed and consolidated industry insights into the following three areas:

- Regulation
- Enforcement Approach
- Monitoring and Reporting

These industry insights are based on the findings of this review, in combination with analysis to draw out key themes. However, the insights acknowledge and are subject to the practical constraints as described in the ‘Limitations’ section below, as well as the context of the regulatory landscape and the need for environmental regulation as set out earlier in the document. These insights do not represent the position of the EA.

Many of the insights are applicable across more than one of the selected industries. Where applicable, the key sectors of relevance are indicated.

## Regulation

The industry insights around regulation and CE are presented in Table 31. Detail on each insight is provided below the table.

**Table 31: Regulation insights**

| # | Insights |
|---|---|
| 1 | Process of amending permitted waste codes for proven waste materials |
| 2 | Permit process for small-scale trials |
| 3 | Consolidation of permits at variation |
| 4 | Sector-specific guidance on definition of CE |
| 5 | End of Waste and Waste Classification guidance, and cross-sector utilisation of surplus materials and waste |
| 6 | Permitting applications and system level considerations |
| 7 | Regulations on vehicles and feedstock issues if introducing EU-equivalent regulations in the UK |
| 8 | Manufacturer responsibility in the industries |
| 9 | Product circularity certification scheme |

**1: Process of amending permitted waste codes for proven waste materials**

The case studies indicated that the permit variation process can be complex and time-consuming regarding having the permitted waste code list updated after the waste has been proven as suitable during a trial. This can be a barrier to the substitution of virgin raw materials. CE in the industries could potentially benefit if this were addressed via a minor technical variation supported by a report on the trial outputs. Existing guidance for carrying out research or trials with waste could be amended accordingly. Permitting implications would have to be considered alongside planning and investment, as these may affect the complexity of any proposed changes and may also influence timeframes.

**2: Permit process for small-scale trials**

It was noted in the case studies that the permit process for small-scale trials can be as rigorous as that of full-scale installations, requiring time and resources which may deter organisations from doing trials related to circularity. CE in the industries could benefit if the permit process for small-scale trials had reduced or streamlined permit application requirements compared to full-scale installations. However, streamlining the process is constrained by the quality of the permit applications and practicalities in the time required to process permit applications. The EA's Modernising Waste Regulatory Panel (MWRP) provides an alternative route to trial materials in shorter timescales, but this was not mentioned in the case studies, indicating that it may not be well known externally and may require more visibility.

**3: Consolidation of permits at variation**

In modern standard environmental permits, the requirement for future reviews of alternative materials tends to be emphasised more than for permits issued under earlier regimes. Such changes are not always picked up in permit variations. CE in the industries could benefit if the consolidation of these changes to new modern permits could be actioned automatically rather than an optional request. This could consistently incorporate alternative material reviews into permits for existing permitted installations. Consolidation of permits may allow for appeals against previously agreed permit conditions.

**4: Sector-specific guidance on definition of CE**

It was noted that there can be a perceived lack of guidance as to how CE is defined for the respective sector and what CE best practice is for the sector. Industries perceived that CE could benefit from further sector-specific guidance (for example, BAT guidance) which defines circularity in the context of each Industry and helps point the industries towards what they should be doing to pursue best practice. This may be a challenge, as attempts to amend BATc with CE considerations have been met with resistance in the past – evidence had not been collected to support what sector-specific best practice linked to CE. Sector specific guidance could be supported by high-level generic guidance, potentially building on work done by the National Interdisciplinary Circular Economy Research (NICER) programme. This guidance would have to be aligned with the waste hierarchy.

**5: End of Waste, Waste Classification guidance, and cross-sector utilisation of surplus materials and waste**

Based on the research, it was evident that there is a perceived lack of guidance and clarity about the EoW regulations and a lack of coordination across sectors, for example between the construction sector and cement sector, regarding how materials are classified in terms of the waste regulations. Construction companies may classify material as waste without being aware of the opportunities available to collaborate with other industries which can utilise this material as a resource stream.

CE in the industries could benefit if EoW and Waste Classification guidance had clearer timelines around obtaining EoW decisions, and more transparent communication throughout the processes. It would also be beneficial to CE in the industries if guidance provided better education around adoption of site waste management plans and material management plans and promoted good quality dismantling and deconstruction. This could contribute to promoting the positive use of surplus material, which would otherwise be classified as waste.

### 6: Permitting applications and system level considerations

The permitting process is on a facility basis. It was found in the research that circularity benefits, and the associated GHG reductions, may sometimes be observed across a system of facilities but are not necessarily observed at a facility in isolation. CE in the industries could potentially benefit if the permit application process allowed for facilities to also consider the circularity benefits of other facilities in the upstream and downstream system (e.g. as a consideration to demonstrate BAT). It is acknowledged that this may add complexity to the permitting process.

### 7: Regulations on vehicles and feedstock issues if introducing EU-equivalent regulations in the UK

If the UK seeks to adopt an equivalent regulation to the EU regulations on vehicle batteries, it could be beneficial to CE in the industries if the recycled content requirements could be amended to better reflect the practical availability of these recycled materials, especially for precious metals. This could help prevent feedstock issues. Analysis would be required to understand the potential implications of different levels of recycled content requirements.

### 8: Manufacturer responsibility in the industries

It was noted in the case study research that the EU regulations are putting increasing emphasis on manufacturer responsibility in ELV regulations. If the UK follow this example and increase the emphasis on manufacturer responsibility in the UK ELV regulations, it could promote better control of circularity within the vehicle sector. There is potential opportunity for producer responsibility or product stewardship to be similarly emphasised in other industries to promote circularity.

However, Extended Producer Responsibility for Packaging was noted as a barrier for circular packaging in the case studies. If producer responsibility schemes were designed to better distinguish between linear and circular processes, this could benefit CE in the industries.

### 9: Product circularity certification scheme

Organisations responsible for product certifications could benefit if they were supported to embed CE principles into the design of products. If the EA were to engage with the organisations responsible for such schemes, and organisations responsible for standard setting more generally, this could assist in understanding how the EA or an appropriate alternative body could appropriately support in this regard.

# Enforcement Approach

The industry insights relating to the enforcement approach are provided in Table 32.

**Table 32: Enforcement approach**

| # | Insights |
|---|---|
| 10 | Enforcement mechanisms for alternative material reviews |
| 11 | Circularity benefits at the permit application stage |

### 10: Enforcement mechanisms for alternative material reviews

Environmental permits require operators to review and record every four years whether there are suitable alternative raw materials that could be used to reduce environmental impacts and improve material efficiency. Whilst operators are required to review and record raw materials and alternatives, and take further appropriate measures, there is currently no requirement to submit the review, nor is the operator ‘incentivised’ from a compliance point of view to implement changes. Currently it relies on the review and follow-up actions being picked up by EA compliance inspections, which is usually not the focus of such visits. If reviews had to be submitted to the EA every four years instead of relying on the inspections picking it up, then where improvements are identified the regulator could request these to be implemented. This could help drive circularity improvements in the industries.

### 11: Circularity benefits at the permit application stage

It could be beneficial to CE in the industries if circularity benefits could be evaluated at the permit application stage, for example by means of BAT assessment. When considering whether circularity is in accordance with BAT, it would have to be kept in mind that not all circularity initiatives are necessarily driven by GHG reduction.

## Monitoring and Reporting

The industry insights relating to monitoring and reporting are provided in Table 33.

**Table 33: Monitoring and reporting**

| # | Insights |
|---|---|
| 12 | Accounting for emission reduction when reporting information as per permit requirements |
| 13 | Standardised GHG benchmarks and factors for consistent reporting of GHG reduction for each sector |
| 14 | Approach to reporting GHG emissions across the lifecycle |
| 15 | Tool for GHG reporting requirements and environmental permitting requirements |
| 16 | Sector-specific circularity metrics in reporting |
| 17 | Monitoring and reporting on key value chain activities relevant to circularity |

### 12: Accounting for emission reduction when reporting information as per permit requirements

Permit requirements include reporting a range of information, including GHG emissions. As well as reporting GHG emissions, GHG reductions could potentially also be reported, or automatically determined based on a prescribed benchmark (see Insight 13 below). Furthermore, metrics for performance against the waste hierarchy could potentially be included in a similar fashion, if and where feasible.

### 13: Standardised GHG benchmarks and factors for consistent reporting of GHG reduction for each sector

The case studies noted challenges in determining GHG reductions associated with CE due to a perceived lack of consistent or agreed industry benchmarks against which to measure this GHG reduction. Standardised GHG benchmarks and conversion factors could potentially be prescribed in environmental permitting for each of the industries, for example the EU ETS benchmarks. This could enable consistent reporting of GHG reductions for each sector. These standards could start as voluntary and then adopted by regulators, if and where feasible.

### 14: Approach to reporting GHG emissions across the lifecycle

If a consistent approach is followed for reporting GHG emissions across lifecycle stages, this could potentially prevent different allocations of emissions across lifecycle stages and promote consistent approaches across sectors. This could also limit the risk of double counting.

### 15: Tool for GHG reporting requirements and environmental permitting requirements

A common tool could potentially be used for both GHG reporting requirements and environmental permitting requirements, rather than using separate tools. This could potentially help improve consistency and efficiency between different reporting requirements (e.g. for the installation permit and for a GHG permit).

### 16: Sector-specific circularity metrics in reporting

The steel sector, for example, currently requires reporting on 'scrap metal melted'. There is a need for sector-specific circularity metrics for each of the industries, acknowledging that the same metric cannot necessarily be used across each Industry due to the nuances of each sector. This case study research (see Appendix A) has identified various metrics which could potentially be used as appropriate to monitor and report on circularity performance in each of the industries.

### 17: Monitoring and reporting on key value chain activities relevant to circularity

A key finding of the case study research is that circularity benefits may not be observed at a single facility alone but may be observed across a system of facilities or a sector. Where applicable, it could benefit CE in the industries if permitted facilities could also report on key metrics from other relevant facilities in their system or value chain which demonstrate their circularity benefits.

# Limitations

The insights emerging from this review are based on analysis of case study findings. These insights reflect the barriers to CE in the industries and how these may relate to the EPR process. However, any ideas raised are subject to practical limitations of the EPR and other practical considerations.

These insights are from a relatively small number of industry representatives as per the scope and context of this review, and do not necessarily provide the full picture of CE in the industries.

It is acknowledged that practicalities around time required for permit processing are a limiting factor for the timescales of the environmental permitting process, and that the quality of the permit application from the applicant is a major factor on how long a permit application can take. The insights identified around timescales are therefore constrained in terms of the extent to which timescales can realistically be shortened.

Not all of the insights fall wholly within the remit of the EA. Many of the insights are around cross-Government collaboration. Some are around third-party collaborations, for instance any certification schemes and Environmental Management Systems (ISO 14001).

The EPR's current scope to focus on facility level means that the EPR has limited ability to influence the wider value chain beyond permitted installations. Systems-level considerations would therefore be limited by facilities covered by EPR, and the practical extent to which interactions between permitted facilities could be assessed.

# Conclusion

Various CE practices are being adopted across the industries. Many CE practices involve systems of facilities rather than a single facility and can even be cross-sectoral due to the synergies between industries. This may make it challenging for the EPR to embed CE given its current basis on a facility level. To date, many CE examples focus on resource efficiency rather than wider CE aspects, as there is a perceived lack of regulatory and economic infrastructure, metrics and integration, to prove a certain specified level of circularity.

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# List of Organisations Engaged

The following organisations were engaged in the case study research.

| Phase 1 | | | Phase 2 | | |
|---|---|---|---|---|---|
| **Sector** | **#** | **Organisation** | **Sector** | **#** | **Organisation** |
| Steel | 1 | CELSA Steel UK | Food and drink | 12 | Toast Brewing |
| | 2 | Cement2Zero / Cambridge Electric Cement | | 13 | British Sugar |
| | | | | 14 | apetito |
| Cement | 3 | Mineral Products Association Ltd | Glass | 15 | NSG Group |
| | 4 | CEMEX | | 16 | Saint-Gobain |
| | 5 | Holcim | | 17 | Thomas Armstrong |
| | 6 | Breedon / Hope Cement Works | | | |
| Construction | 7 | British Gyspum | Paper | 18 | Saica |
| | 8 | Knauf | | 19 | Sofidel |
| | | | | 20 | Essity |
| Textiles | 9 | Pincroft | Chemicals | 21 | Croda |
| | 10 | Camira | | | |
| Vehicles | 11 | Vauxhall / Stellantis | Plastics | 22 | Mura Technology |
| | | | | 23 | INEOS Inovyn |
| | | | | 24 | SABIC |

# List of abbreviations

| Abbreviation | Definition |
|---|---|
| ACT | Autosort for Circular Textiles |
| ARM | Alternative Raw Material |
| BAT | Best Available Technique |
| BATc | BAT Conclusion |
| BPD | Bypass Dust |
| BREF | BAT Reference |
| C&D | Construction and Demolition |
| CE | Circular Economy |
| CEM I | Portland Cement |
| CEP | Circular Economy Package |
| $CO_2$ | Carbon Dioxide |
| DESNZ | Department of Energy Security and Net Zero |
| EA | Environment Agency |
| EAF | Electric Arc Furnace |
| ELV | End-of-Life Vehicles |
| EoW | End-of-Waste |
| EPR | Environmental Permitting Regulations |
| ETS | Emissions Trading Scheme |

| Abbreviation | Definition |
|---|---|
| FGD | Flue-gas Desulphurisation |
| GGBFS | Ground Granulated Blast Furnace Slag |
| GHG | Greenhouse Gas |
| GVA | Gross Value Added |
| GPDA | Gypsum Products Development Association |
| ISO | International Organisation for Standardisation |
| $kgCO_2e$ | Kilogrammes of Carbon Dioxide equivalent |
| LCA | Life Cycle Analysis |
| LCV | Light Commercial Vehicle |
| PFA | Pulverised Fly Ash |
| PPC | Pollution Prevention and Control |
| PPT | Plastic Packaging Tax |
| PPWR | Packaging and Packaging Waste Regulations |
| PSG | Project Steering Group |
| PUR | Polyurethane |
| REACH | Registration, Evaluation, Authorisation and Restriction of Chemicals |
| SBTi | Science Based Targets initiative |
| SUPD | Single Use Plastic Directive |
| $tCO_2e$ | Tonnes of Carbon Dioxide equivalent |

| Abbreviation | Definition |
| --- | --- |
| WFD | Waste Framework Directive |
| WRAP | Waste and Resources Action Programme |

# Glossary

| Term | Definition |
|---|---|
| Broke | Partly or fully manufactured paper or board that is discarded from paper or board making, converting, and finishing processes |
| Co-product | A product produced alongside the main product in a manufacturing process, which is a sold as a product as part of the manufacturer's business model. |
| Cullet | Crushed glass used as a feedstock for glass recycling. |
| Facility | An individual site carrying out a particular activity. |
| Feedstock | In the context of CE, the term "feedstock" refers to non-virgin materials used as inputs to circular processes. |
| Installation | A facility where listed activities (under the EPR) are carried out. |
| Readily biodegradable | Products are considered "readily biodegradable" when they have the natural ability to biodegrade to their natural state, when subjected to sunlight, water and microbial activity, to at least 60% biodegradability in 28 days. |
| Scope 1 Emissions | GHG emissions from sources owned or controlled from the reporting entity, e.g. combusting fuel on-site. These are direct emissions. |
| Scope 2 Emissions | GHG emissions from purchased energy, e.g. grid electricity. These are indirect emissions as the actual emissions occur off-site (e.g. at the power station) but the reporting entity has a degree of control over these emissions by controlling their energy consumption. |
| Scope 3 Emissions | GHG emissions that occur in a reporting entity's value chain. These are indirect emissions. |
| System | A group of facilities considered together. |
| Value chain | Activities upstream (e.g. supply chain) and downstream (e.g. end users) from a particular facility or activity. |

# Appendix A: Detailed Case Studies

This appendix contains the detailed case studies compiled as part of this research. The information, ideas and metrics provided in each case study are as provided by the respective organisations during virtual meetings. The case studies do not present an exhaustive list of CE initiatives, drivers and barriers for the industries, but rather reflect the outcomes of this particular Industry engagement.

The narrative and metrics presented in these case studies have been self-reported by organisations and have not been validated by AECOM.

# Steel

## CELSA Steel UK

| | |
|---|---|
| **Case Study No.** | 1 |
| **Sector** | Steel |
| **Location** | UK |
| **CE Theme** | Supply chain collaboration |
| **Type of CE Measure** | Using waste steel from own customers to produce recycled steel, then selling recycled product to same customers |
| **Website** | https://www.celsauk.com/ |

**Background**

- CELSA Steel UK are one of the largest producers of EAF recycled steel in the UK
- CELSA Circular Steel Programme is a strategic initiative that is exploring the variety of circular economy (CE) principal applications across the CELSA Group
- The first scalable application is the resource efficiency of UK construction materials
- On a basic level, it involves transforming construction and demolition (C&D) ‘waste’ (scrap steel) back into a valuable resource for utilization within the UK economy, entirely based on supply chain collaboration
- Scrap steel recovered from CELSA’s construction sector customers is recycled into steel reinforcement products. CELSA then supplies the recycled steel, though the Group’s fabricators, back to these same customers, thus creating a closed-loop system and a platform for collaborative circularity
- An example of where this has been done is the Plaza Cinema in Port Talbot
- Even at this early stage of development, CELSA is seeing a reduction in built environment whole-life carbon (from Scope 3 waste and procured material), increase in gross value added (GVA), reduced costs, full lifecycle traceability and transparency, alongside newly explored supply chain collaboration based on trust and shared value

| Metrics | Results |
|---|---|
| % recycled content | 98% |

| | |
|---|---|
| % reduction in $tCO_2e$ | reduction of 356 kg $CO_2$/ tonne of steel (compared to European average EAF) |
| Plaza Cinema case study | 14 t reinforcement steel purchased<br><br>Carbon saving (compared to European average EAF) based on 14 t steel = 4.984 $tCO_2$ (It is anticipated that the carbon saving is higher if considering the wider value chain)<br><br>UK GVA based on 14 t steel = £12,273 |

**Key Focus Areas for Consideration**

**Drivers:**

- Increases value across the system

**Barriers:**

- EPR have not really influenced circularity, there is a need for regulations to be more ambitious in terms of encouraging circularity
- The focus on measuring carbon reduction in silos (i.e. Scope 1 and 2 emissions, company specific, etc.) does not give a representative sense of the whole-system benefits. There may be potential opportunity for Royal Institution of Chartered Surveyors (RICS) whole-life carbon guidelines (RICS, 2023) and PAS 2080 (BSI, 2023) guidelines to address this
- The assumed value of C&D 'waste' can be a barrier. When contractors have established relationships with sub-contractors or merchants there is a risk of undervaluing the existing/legacy material assets
- Material traceability is low, so having better visibility of where the material comes from will enable whole life carbon analysis
- Need for a cultural shift and educating the supply chain

## Cement2Zero / Cambridge Electric Cement

| | |
|---|---|
| **Case Study No.** | 2 |
| **Sector** | Steel |
| **Location** | UK |
| **CE Theme** | Recycled content |
| **Type of CE Measure** | Using C&D waste as substitute flux material in EAF, then using slag from EAF to produce zero-carbon clinker for cement production |
| **Website** | [https://cambridgeelectriccement.com/](https://cambridgeelectriccement.com/) |

**Background**

- The Cement2Zero project uses a process developed by Cambridge University to produce low carbon cement based on circularity synergies with the steel sector
- The process has been demonstrated on pilot scale, and CELSA Steel UK is collaborating on the project to work towards demonstrating it on an industrial scale
- This project uses end-of-life cement from the demolition of buildings as a substitute flux material in the electric arc furnace (EAF) steelmaking process
- The slag from the EAF is then used to make zero-carbon cement clinker called Cambridge Electric Cement (CEC)
- This uses existing cement manufacturing technology and focuses on reconfiguring the supply chain

| Metrics | Results |
|---|---|
| % recycled clinker in product | 20-80% |
| % reduction in $tCO_2e$ compared to sectoral average | 40-150% (corresponding to proportion of recycled clinker in product) |

**Key Focus Areas for Consideration**

**Drivers:**

- CEC technology produces Portland clinker, so falls within current regulations

- Carbon pricing has helped with economic viability of the process

**Barriers:**

- Waste regulations do not incentivise doing anything positive with waste material
- Need to reconfigure the supply chain
- The contamination inherent to steel scrap used in commercial operations would introduce silica and alumina to the slag, requiring the addition of more lime to the flux to reach the required product composition. It sometimes does not make economic or practical sense to fully clean contamination when lime can just be added. This reduces the proportion of recycled demolition waste used in the process
- Current carbon accounting practices for GHG reporting are not representative of the system-level benefit in $CO_2$ reduction. If CELSA uses the lime replacement material, they benefit in $CO_2$ reduction, but if they produce the clinker, their Scope 1 emissions will increase (although emissions across the wider value chain decrease)

# Cement

## Mineral Products Association Ltd

| | |
|---|---|
| **Case Study No.** | 3 |
| **Sector** | Cement |
| **Location** | UK |
| **CE Theme** | Recycled content |
| **Type of CE Measure** | Using reclaimed clay as cementitious material to substitute clinker |
| **Website** | https://www.mineralproducts.org/ |

**Background**

- Mineral Products Association (MPA) is a trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries
- MPA are currently undertaking a project to develop industrial symbiosis using UK waste clay and other clay resources as a cementitious material to replace clinker in cement production
- This includes clay which is unused in quarries, and brick dust from brick manufacturers. Some calcined clay is needed to make up for secondary cementitious materials
- This is an important ongoing project for the cement industry

| Metrics | Results |
|---|---|
| % of recycled content in product | Up to 40% reclaimed clay in cement |
| % reduction in $tCO_2e$ relative to Portland cement | Up to 30% relative to CEM I |

**Key Focus Areas for Consideration**

**Drivers:**

- The main driver for this kind of project is to reduce $CO_2$, in accordance with the MPA net zero roadmap

- The more $CO_2$ that can be reduced in the process, the less carbon capture required
- There are many waste streams that can be used in the cement sector as input materials

**Barriers:**

- EPR have not had a direct influence on this specific project
- However, in the past, MPA have encountered issues in the need for permitting for projects focusing on circularity and $CO_2$ reduction
- For a fuel switch project, even though these trials were only running for a few hours at a time and the trial fuels had no negative environmental implications, the MPA required a variation to the permit. This was time-consuming and delayed the trials
- If materials are different to those covered by permitted waste codes included on the existing permit, a permit variation is required, even for a small-scale trial. As this is time consuming, it can deter MPA members from doing trials in the first place
- There is a need to get interest from MPA members to use new waste streams in the cement sector, despite regulatory delays

## CEMEX

| | |
|---|---|
| **Case Study No.** | 4 |
| **Sector** | Cement |
| **Location** | UK |
| **CE Theme** | Waste recovery |
| **Type of CE Measure** | Maximising reuse of bypass dust in the production loop and recovering the remainder for off-site uses |
| **Website** | [https://www.cemex.co.uk/](https://www.cemex.co.uk/) |
| **Background** | |
| • CEMEX is a major cement producer in the UK that aims to maximise the reuse of bypass dust (BPD) in the production loop and when this is not possible, recover it for other uses, such as soil stabilisation, and fertiliser enhancer<br>• In the past, CEMEX used BPD in concrete blocks, but stopped this due to increased permitting requirements | |
| **Metrics** | **Results** |
| Rugby Plant | Approximately 3-5 kt BPD to building products (15-20% of BPD production rate) |
| | Approximately 25 kt BPD to land treatment |
| % reduction in $tCO_2e$ relative to primary production | Using BPD in concrete blocks resulted in $CO_2$ reductions, but this is no longer done |
| | BPD alone has a similar $CO_2$ footprint to clinker. However, recovering BPD results in less raw clinker required, thereby reducing $CO_2$ across the product lifecycle. The percentage lifecycle $CO_2$ reduction depends on the percentage BPD recovered |

**Key Focus Areas for Consideration**

**Drivers:**

- The Rugby Plant has a Part A1 permit and can use BPD on site. When the BPD is sent off-site, the other sites or organisations need to get the respective permit

**Barriers:**

- The permitting involved in using BPD as a fertiliser is time consuming and causes limitations in the volumes used
- Using BPD in concrete blocks had approval from all the regulators involved for the Part B permit and the EA. However, waste regulators now require a much stricter level of permitting to use BPD in concrete blocks, which would require the same level of permitting as the Rugby plant itself
- CEMEX have stopped using BPD in concrete blocks because the permitting is now too onerous. This is a missed opportunity for circularity, especially since BPD is handled in the exact same way as cement

## Holcim

| | |
|---|---|
| **Case Study No.** | 5 |
| **Sector** | Cement |
| **Location** | UK |
| **CE Theme** | Material substitution |
| **Type of CE Measure** | Produce cement using alternative low-emission waste materials |
| **Website** | [https://www.holcim.com/](https://www.holcim.com/) |
| **Background** | |
| • Holcim is a leading producer of sustainable building materials, they produce the 'ECOPlanet green cement' range using alternative low-emission materials, including calcined clay, pozzolanic products, silica, and limestone<br>• Focuses on carbon footprint reduction, as well as circular economy<br>• Holcim has a part of their business which invests in startups, where there is a lot of opportunity for circularity in waste management | |
| **Metrics** | **Results** |
| % of recycled aggregate | Up to 100% recycled aggregates only for non-structural<br><br>Limited to 20% for structural (BS8500) |
| % reduction in $tCO_2e$ relative to Ordinary Portland Cement | Can reduce carbon footprint by up to 60% |
| **Key Focus Areas for Consideration** | |
| **Drivers:**<br><br>• In terms of circularity, the main driving standard for Holcim cement is British Standard (BS)8500 which includes recycled content requirements (BSI, 2023). Holcim do not currently work towards BS8001 for this product range | |

- European standards around Environmental Product Declarations (EPDs) drive a focus on accurate carbon data collection, as Holcim needs to prove that their products are low carbon

**Barriers:**

- BS 8500 places caps on recycled content, which can limit circularity
- Using construction and demolition (C&D) waste does not necessarily reduce $CO_2$ although it improves circularity. Research and collaboration are needed on a systems level to demonstrate the wider potential benefits
- There is a need for good quality dismantling and deconstruction to get good quality C&D ‘waste’. This requires alignment in waste management in the wider value chain
- Current demolition practices and definition of End of Waste (EoW) are an issue for feedstock of usable waste materials

## Breedon / Hope Cement Works

| | |
|---|---|
| **Case Study No.** | 6 |
| **Sector** | Cement |
| **Location** | UK |
| **CE Theme** | Recycled content |
| **Type of CE Measure** | Use of historic waste PFA from landfill as a raw material substitute in cement production |
| **Website** | https://www.breedongroup.com/products-and-services/gb/our-products/cement |

**Background**

- Hope Cement Works (HCW) is part of the Breedon Group and is the UK's largest cement works by capacity
- Uses a range of waste materials within the cement manufacturing process, either as fuels for the combustion process, or as alternative raw materials
- Uses conditioned pulverised fly ash (PFA) from landfill as an alternative raw material (ARM) to make cement. This is not fresh (run of station) PFA but is waste material which was sent to landfill
- Other waste materials used include chipped tyres, polyurethane (PUR) foam, and solid waste fuel. HCW also uses sodium bicarbonate / carbonate waste (low volumes) and synthetic gypsum from waste sources
- The ash content from waste fuels used in the combustion process is incorporated into the final product and therefore can be considered a closed-loop process

| **Metrics** | **Results** |
|---|---|
| KPI: Alternative Raw Material (ARM) Usage | Approximately 80 kt ARM<br><br>2022: 5.44% ARM usage (HCW) |
| % reduction in $tCO_2e$ | $CO_2$ reduction is not tracked with regards to alternative raw materials. Anticipated that it will make minimal difference on a facility level and is more about the wider circularity benefits |

**Key Focus Areas for Consideration**

**Drivers:**

- The cement sector is good at using waste streams as resources
- Carbon pricing is the clearest regulatory ‘incentive’, primarily from an alternative fuel aspect but also for alternative raw materials

**Barriers:**

- To use a waste material that is not in the permitted list of waste codes requires a permit variation, which can be a lengthy process
- There should be a streamlined way to update permitted list of waste codes based on new data and evidence for wastes which have been successfully demonstrated
- Fuel ash acts as a raw material for the final product and must meet specifications, limiting the range of alternative fuels that can be used

# Construction

## British Gypsum (BG)

| | |
|---|---|
| **Case Study No.** | 7 |
| **Sector** | Construction |
| **Location** | UK |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Recycle plasterboard offcuts from construction into new plasterboard |
| **Website** | [https://www.british-gypsum.com/](https://www.british-gypsum.com/) |

**Background**

- Part of the Saint-Gobain Group, manufacturer of plasterboard and plaster
- Made efforts to reduce environmental impact using recycled materials and sustainable manufacturing practices
- British Gypsum uses recycled gypsum waste from their own facility, as well as from external sources
- Their plasterboard recycling scheme involves collection and processing of waste plasterboards to then be used in the manufacture of Gyproc plasterboards – reducing virgin raw materials demand
- The waste plasterboard collected is ‘clean’ offcuts from construction, rather than demolition waste
- Saint-Gobain’s global targets by 2030 (relative to a 2017 baseline):
    - 30% increase in virgin materials avoided
    - 33% reduction in Scope 1 and 2 emissions
    - 16% reduction in Scope 3 emissions

| Metrics | Results |
|---|---|
| % of recycled content in plasterboard | Up to 15% recycled gypsum and 100% recycled paper<br><br>A proportion of the gypsum (5-6% on average) is from own facility waste, with the remainder from external sources |

| | |
|---|---|
| % reduction in $tCO_2e$ relative to primary production | Plasterboard recycling does not necessarily reduce $CO_2$ emissions compared to virgin production |
| % of waste reused | All materials not fit for sale are reused |
| % of waste sent to landfill | No plasterboard is sent to landfill |

**Key Focus Areas for Consideration**

**Drivers:**

- Gypsum is ideal for the circular economy as it can be recycled many times
- Ashdown Agreement (2007) between Waste & Resources Action Programme (WRAP) and Gypsum Product Development Association (GPDA) set annual targets to reduce waste and increase recycling
- Quality protocol for recycling gypsum from waste plasterboard necessary to ensure standards are met

**Barriers:**

- The limit of up to 15% recycled gypsum is due to approval up to this limit from a technical point of view. Not all sites have approval yet to bring external scrap to site, so the average figure can be lower. Also, the split between own site waste used and external waste used can vary widely from week to week depending on, for example, trials
- Post-consumer plasterboard can be of varying levels of quality and can be contaminated with paints, nails and ceramics
- May require more water and energy than processing virgin raw material
- Collecting of post-consumer plasterboard can be a challenge
- Need approval to use recycled material in production – this can be approached either as a waste licence or a permit variation. It has been easier to get a permit variation for raw material rather than a waste licence (there may be a time lag associated with getting approval)
- It is easier for BG to use gypsum powder than to process plasterboard waste themselves. However, this is from a technical/practical standpoint and regulations have not influenced this
- Recycling plasterboard does not necessarily result in lower $CO_2$ emissions than producing from virgin materials. There may therefore be a trade-off between producing low-carbon plasterboard or producing plasterboard with greater circularity

## Knauf

| | |
|---|---|
| **Case Study No.** | 8 |
| **Sector** | Construction |
| **Location** | UK |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Recycle post-consumer plasterboard waste from construction and demolition sites into new plasterboard |
| **Website** | https://www.knauf.co.uk/ |

**Background**

- Knauf are one of the leading UK manufacturers of gypsum-based plasterboard.
- They have a partnership with a Countrystyle recycling plant next to their Sittingbourne factory
- All Knauf's production waste goes to the nearby Countrystyle recycling plant for recycling. No manufacturing waste is sent to landfill
- The Countrystyle plant reclaims and re-processes post-consumer plasterboard waste from construction and demolition sites
- Knauf uses the gypsum from the Countrystyle plant in their own manufacturing

| **Metrics** | **Results** |
|---|---|
| % of recycled content in product | 8.5% - 12% |
| % reduction in $tCO_2e$ relative to primary production | Not necessarily a reduction in $CO_2$ on a facility level, but benefits may lie in the wider value chain |

**Key Focus Areas for Consideration**

**Drivers:**

- Gypsum is ideal for the circular economy as it can be recycled many times
- Knauf's Sittingbourne facility is permitted under Part A Pollution Prevention and control (PPC)

**Barriers:**

- The total virgin gypsum content of Knauf plasterboards has increased over the past three years as Flue Gas Desulphurisation (FGD) gypsum has become more scarce, due to the world moving away from coal-fired power stations
- Post-consumer plasterboard can be of varying levels of quality and can be contaminated with paints, nails and ceramics, and therefore may require more water and energy than processing virgin gypsum
- Collecting of good quality (minimal contamination) post-consumer plasterboard can be a challenge
- If recycling processes for waste plasterboard could be improved to remove more contamination this would reduce natural resource use and could lower production costs
- Knauf's plasterboard recycling started off with cost saving as a main driver, but now that the testing regime has ramped up, this is no longer the case
- The main barriers are technical and practical, including the need to store and test feedstock, which adds to the cost
- Knauf's circularity is not driven by carbon considerations, but rather because gypsum waste cannot be landfilled – it needs an outlet to be recycled, otherwise the whole system would break down. This demonstrates how regulations have indirectly influenced Knauf's circularity practices

# Textiles

## Pincroft

| | |
|---|---|
| **Case Study No.** | 9 |
| **Sector** | Textiles |
| **Location** | UK |
| **CE Theme** | Process efficiencies |
| **Type of CE Measure** | Fabric dying process with resource efficiency, green chemistry, and smart water use |
| **Website** | [https://pincroft.co.uk/](https://pincroft.co.uk/) |

**Background**

- Pincroft is a commission dyer, printer and textile finisher based in Lancashire, UK
- Pincroft's fabric dyehouse has one of the industry's largest heat recovery systems, recovering waste heat from wastewater and atmospheric releases to heat clean process water
- In the fabric dyehouse, water for all wet processes has been reduced to well below industry benchmarks, by using best available equipment, greener chemistry, and smart water use
- Chemical recovery systems in the dyehouse as well as chemical substitution and process optimisation result in a significant reduction in chemical consumption
- Pincroft's purchasing policy minimises waste and where possible all remaining packaging is reused or recycled. These ideals are passed onto Pincroft's supply chain. As a result of these measures, significant amounts of waste have been diverted from landfill

| Metrics | Results |
|---|---|
| Natural gas saving | 750,000 $m^3$ annually |
| $CO_2$ reduction due to natural gas saving | 4,000 $tCO_2e$ annually |
| Effluent reduction | 50,000 $m^3$ annually |

| | |
|---|---|
| Chemical consumption reduction | 100,000 tonnes annually |
| **Key Focus Areas for Consideration** | |

**Drivers:**

- Greater demand for circular products from end customers, driven by European legislation which places requirements on percentage of recycled content
- Circularity and resource efficiency is driven primarily by cost, especially energy prices. Also driven by broader environmental issues such as keeping microfibres out of the environment

**Barriers:**

- There is no reference to circularity in permitting
- Circularity does not feature on available guidance for the textile sector (e.g. BAT). Rather, the focus is on resource and energy efficiency and those associated emissions
- There is a lack of guidance for textile manufacturing facilities in terms of what circularity means for them and what they should be doing
- Technology to separate mixed fibres is still in its infancy and is expensive, limiting commercial opportunities. Once fibres are separated and recovered, they need to be spun and woven before they can be used. This is easier for vertically integrated businesses, but “middleman” companies in the value chain (such as Pincroft) cannot do this on their own
- It can be a challenge for recycled fibres to have the same longevity as virgin products

## Camira

| | |
|---|---|
| **Case Study No.** | 10 |
| **Sector** | Textiles |
| **Location** | UK |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Fabric manufacturing which recovers fabric waste within the production loop and from own customers, and recycles it into new fabric |
| **Website** | https://www.camirafabrics.com/en-uk |

**Background**

- Camira are a fabric manufacturer based in the UK
- Use wool recycling machinery to re-purpose their own waste yarn and fabric, pulling it back to raw fibre which is then woven into new fabric
- Provide recycling and take-back services to the wider textile and furniture industries, particularly for Camira's own customers, indicating a closed-loop system
- Partnered with UK government funded project ACT (Autosort for Circular Textiles) which will allow automatic identification of raw material types to speed up the initial sorting of textiles for increased recycling and reduced waste to landfill
- Also use bio-based fibres made from harvested fibre plants such as nettles, hemp, flax and jute
- Camira were involved in a four-year research and development project to make sustainable fabric from nettles
- The project involved growing crops from high-fibre nettle clones, understanding techniques to extract the fibre, and understanding optimum fibre blends for technical performance
- A unique selling point of these bio-based fabrics is that they meet higher-level UK flammability standards without the need to add chemicals
- Camira's current recycled wool product, Revolution, consists of 25% recycled content with a $CO_2$ reduction of 28% compared to virgin wool. A new product ReSKU 2.0, launched in 2024 has a recycled wool content of 64%

| Metrics | Results |
| --- | --- |
| Percentage recycled content in wool | 25% |
| $CO_2$ reduction compared to virgin production | 28% |

**Key Focus Areas for Consideration**

**Drivers:**

- The key driver for circularity at Camira is recovering value in waste. A large volume of waste is generated as part of the process, and this waste has a large value
- Another key driver for circularity is customer driven, as Camira's customers also generate large amounts of waste and need to do something with it
- Life cycle assessment (LCA) conducted on Camira's recycled wool product compared to virgin manufacture demonstrates $CO_2$ reduction

**Barriers:**

- There is a large demand for take-back services from Camira's customers, but Camira are limited by the amount of waste they can take back as they need to maintain a commercial outlet and cannot simply act as a waste merchant
- Waste permits are needed which adds complexity to the process
- Logistics can be a challenge for take-back schemes, especially for international customers
- The LCA process to quantify carbon benefits of circularity is not straightforward

# Vehicles

## Vauxhall / Stellantis

| | |
|---|---|
| **Case Study No.** | 11 |
| **Sector** | Vehicles |
| **Location** | UK |
| **CE Theme** | Material substitution |
| **Type of CE Measure** | Use of ‘green’ (recycled and bio-sourced) material in vehicles |
| **Website** | [https://www.vauxhall.co.uk/](https://www.vauxhall.co.uk/) |

**Background**

- Vauxhall Motors Limited is a British car company in the UK and owned by Stellantis (Netherlands). Stellantis has manufacturing plants in Luton and Ellesmere Port, producing Vauxhall vans / Light Commercial Vehicles (LCVs)
- Their ‘Design for Sustainability’ is a key element in their recycling strategy. Product responsibility is integrated into the development, production, usage and recovery processes
- Design teams must follow "Recyclability/Recoverability" guidelines, created to support engineers and suppliers to assess the ease of recyclability for parts and components
- Vauxhall uses recycled materials in manufacture
- As an industry requirement, Vauxhall has a legal obligation through End-of-Life Vehicles (ELV) legislation, to decrease the amount of waste created during vehicle production and at end-of-life
- Vauxhall takes back their vehicles for free and recycles them through partners Autogreen and CarTakeBack
- Stellantis has committed to the following targets:
    - Carbon net zero by 2038
    - Any vehicle launched from 2030 will be 40% ‘green’ material (recycled and bio-sourced material)

| Metrics | Results |
|---|---|
| % recyclability of products by mass | 85% (as per ELV) |

| | |
|---|---|
| % recoverability of products by mass | 95% (as per ELV) |
| % of recycled content in product | By 2025 Stallentis Group vehicles will contain 25% of green materials |
| % reduction in $tCO_2e$ relative to primary production | Not quantified |

**Key Focus Areas for Consideration**

**Drivers:**

- Legal obligations of Vehicle End-of Life Requirements
- Maintaining value and reducing dependency on virgin materials

**Barriers:**

- EU legislation (Regulation concerning batteries and waste batteries (EU) 2023/1542) sets the percentage of recycled content required in batteries from 2031, requiring a step change for precious metals
- If the UK aligns with these regulations, it will be a challenge to get access to this recycled material. This is a feedstock issue as currently car lifetimes mean not enough vehicle batteries would be available for recycling
- It is not practical trying to make a battery last as long possible whilst the recycled content requirements ramp up. The legislation is important for circularity in principle but may not be practical
- When old vehicles come to their end of life, remaining materials are sent to be used as resources in other industries, and it is up to these industries how they handle these resources
- If the vehicle industry knew these materials were coming back into their own industry they could have more control over its circularity
- EU regulation is starting to put more responsibility on the manufacturer to address this. Legislation could help, but there are many stakeholders in the value chain and leakage of materials presents a challenge

# Food and drink

## Toast Brewing

| | |
|---|---|
| **Case Study No.** | 12 |
| **Sector** | Food and drink |
| **Location** | United Kingdom |
| **CE Theme** | Waste Recovery |
| **Type of CE Measure** | Upcycling of surplus bread into beer |
| **Website** | https://www.toastbrewing.com/ |

**Background**

- Use surplus bread from bakeries and sandwich makers to produce beer, reducing waste.
- Excess bread replaces about a quarter of the malted barley in their beers.
- Spent grain is used for animal feed. Spent hops for composting.
- 100% of profits go to charities, with at least 1% of revenue dedicated to impact giving and investing.
- Their business model focuses on industry change.
- They open-source their home-brewing recipe.
- Collaborate with competitors to create circular beer and understand customer acceptance.
- Exploring an ingredients business to remove supply chain barriers for others.

| Metrics | Results |
|---|---|
| Malt replaced by surplus bread | 25% |
| $tCO_2e$ reduced by substituting malt with surplus bread | Surplus bread malt is approximately 60% less CO2 intense than barley malt (0.487 $kgCO_2e$/kg malt vs 0.19 $kgCO_2e$/kg malt). Applied to 25% of malt substituted: 15% GHG reduction overall (avoids 5.3 $tCO_2e$ p/a) |
| Bread waste diverted from landfill (to date) | 3.3 million slices |

| | |
|---|---|
| Avoided land use (to date) | 71 acres |
| Avoided water consumption (to date) | 420,000 litres |

**Key Focus Areas for Consideration**

**Drivers:**

- Toast Brewing aims to solve environmental problems.
- Creates a revenue stream for bakeries to sell waste bread.

**Barriers:**

- As a small brewery, Toast has limited purchasing power and so is a challenge to establish direct supply links.
- Barriers begin from sourcing – getting appropriate volumes, proving genuinely surplus, documentation for food safety requirements.
- Processing – challenges of just in time delivery and preservation, performance of chemistry, operational challenges of adding separate ingredients manually.
- Setting up relationships with bakeries and aligning their segregation processes for brewing requires time and cost that companies do not want at waste stage.
- Risks de-incentivising waste production.
- Wider sector barrier: Some breweries do not know about circularity as a possibility, or it does not fit with their brand.

## British Sugar

| | |
|---|---|
| **Case Study No.** | 13 |
| **Sector** | Food & drink |
| **Location** | United Kingdom |
| **CE Theme** | Waste Recovery |
| **Type of CE Measure** | Co-product production |
| **Website** | [https://www.britishsugar.co.uk](https://www.britishsugar.co.uk) |

**Background**

- UK's sole processor of sugar beet sugar crop, in partnership with 2,300 growers
- Operate an advanced manufacturing model that avoids waste by turning process outputs into a wide range of co-products, including:
    - Aggregate (recovered from beet crop)
    - Topsoil (recovered from beet crop)
    - Animal feed
    - Electricity (from combined, heat and power [CHP])
    - Soil conditioning (LimeX)
    - Renewable energy (anaerobic digestion plant at Bury St Edmunds site)
    - Bioethanol
    - Horticulture (ingredients for pharmaceuticals)
    - $CO_2$ for food and drinks industry
- Focus on increased productivity has environmental benefits, including lower waste and GHG emissions.
- Improving yield is an important metric.
- Exploring biotechnology and gene editing for disease prevention, supporting increased yields, greater efficiency and reduced waste.

| **Metrics** | **Results** |
|---|---|
| Percentage Reduction (measuring efficiency) | 26% reduction in water use<br>12% reduction in energy use<br>21% reduction in GHG emissions<br><br>(based on 2018 baseline) |
| Waste to landfill / disposal | Less than 200 g waste for every tonne of sugar produced (i.e. virtually zero waste) |

**Key Focus Areas for Consideration**

**Drivers:**

- Improved efficiency and reduced costs across the supply chain.
- GHG reduction commitments: SBTi approved decarbonisation targets of near term and net zero (2030 and 2050)

**Barriers:**

- Developing co-products and bringing them to the market can be difficult in terms of commercial/financial feasibility and requires engagement across the value chain. Broader support from the government is not present.
- There is a lack of incentive on the production and consumer side to support and produce circular co-products.
- There is a general lack of visibility of British Sugar's circularity efforts to the end customer (consumer).
- UK Innovation Fund is a good source of funding for circularity in the sector but is not exploited as much as it could be.
- Co-products need to be viable for the future and appropriate infrastructure needs to be in place to utilise these co-products (e.g. sustainable fuels).
- CHP permitting process was too slow and resulted in compliance issues, specifically associated with recent CHP project at Cantley (had to operate as a non-conforming organisation).

## apetito

| | |
|---|---|
| **Case Study No.** | 14 |
| **Sector** | Food & drink |
| **Location** | United Kingdom |
| **CE Theme** | Process efficiencies and recycling |
| **Type of CE Measure** | Ready-cooked meals with closed loop tray recycling |
| **Website** | [https://www.apetito.co.uk/](https://www.apetito.co.uk/) |

**Background**

- Produce ready-cooked meals for health and social care sector with end customers including hospitals, care homes, school, nurseries, local authorities and direct to customers' homes through Wiltshire Farm Foods.
- Business-to-business (B2B) and a business-to-consumer (B2C) brand (Wiltshire Farm Foods).
- Cook-freeze solution means meals have a longer shelf-life than pre-prepared chilled meals and are packed in flexible portion sizes to reduce wastage.
- B2B business orders are delivered in plastic crates, and apetito drivers collect empty crates to reuse.
- In 2024, apetito won the King's Awards for Enterprise in Sustainable Development, in part due to their closed-loop recycling initiative.
- Closed loop recycling system (predominantly for B2C due to type of packaging and delivery) involves plastic meal trays collected from customers and taken to a processing facility where they are recycled for new meal trays, which are sent back to the production facility to be used for the next round of meals.
    - 35 million trays recycled so far
    - 100% recyclable
    - Independent peer reviewed LCA conducted to ensure most sustainable packaging format for apetito
    - Returns rates of around 50%

| **Metrics** | **Results** |
|---|---|
| Plastic meal trays recycled content | 80% |

| | |
|---|---|
| $CO_2e$ reduction from closed-loop plastic meal tray recycling | Circ. 1.68kg $CO_2e$ saved per kg of trays. This carbon saving compares not recycling the tray with recycling through a closed-loop system. |
| **Key Focus Areas for Consideration** | |
| **Drivers:**<br>• apetito's GHG reduction commitments (net zero by 2040).<br>• Values driven and enables competitive advantage.<br>• Saving significant costs of Plastic Packaging Tax.<br>• Observed notable drive from end customers to reduce their waste.<br>**Barriers:**<br>• apetitio are liable to pay Extended Producer Responsibility for Packaging (pEPR) fees for packaging even though their packaging is closed-loop. Exemptions for pEPR are challenging to obtain. It would be beneficial to have a standard pEPR exemption for closed-loop systems which achieve better results than household recycling.<br>• Although a closed-loop system is in place for plastic trays, it is a challenge to implement a closed-loop system for aluminium trays due to technical constraints and a lack of processing facilities in the UK. | |

# Glass

## NSG Group

| | |
|---|---|
| **Case Study No.** | 15 |
| **Sector** | Glass |
| **Location** | United Kingdom |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Re-use and recycling of glass |
| **Website** | https://www.nsg.com |

**Background**

- Leading glass/glazing manufacturer, includes Pilkington, which has UK facilities for architectural and automotive glass production.
- Reuse trimmed glass from raw float glass plates in the melting process, replacing virgin raw materials.
- Cullet and rejected parts from further processing are recycled within NSG or by external partners.
- The Pilkington *renew:glass* initiative aims to increase responsible recycling to help reduce landfill waste.
- Low-carbon glass product, Pilkington **Mirai™**, uses alternative fuel, high recycled glass content, and renewable electricity.
- Sphera data collection software tracks material usage, water and energy consumption, and waste at the site level.

| Metrics | Results |
|---|---|
| GHG emissions reduced | Remelting 1 tonne of cullet avoids 0.4-0.6 $tCO_2e$ |
| Pilkington **Mirai™** glass embodied carbon reduction (compared to 4 mm standard glass product) | 52% |

**Key Focus Areas for Consideration**

**Drivers:**

- Glass production is energy intensive. Re-melting of glass cullet significantly helps to reduce energy consumption and related $CO_2$ emissions.
- Circularity is part of the NSG Group's mission.

**Barriers:**

- The waste stream from grinding of automotive glass edges and glass drilling cannot be prevented.
- Post-consumer cullet is in its infancy in the flat glass sector due to a fragmented infrastructure and complexity of removal/collection of glass. Segregation of the end-of-life product (car/building/PV panel) currently does not lead to sufficient quality and quantity of cullet.
- Working with novel sources of cullet, such as scrap windscreens, requires high tech plants.
- An environmental permit for waste treatment is required to process scrap windscreens, which results in costs.
- Architectural glass has much higher quality constraints than container glass.
- There are currently limited mandatory recycling targets for glass as it is seen as a low value waste stream, especially waste glass from demolition. It would be beneficial if there were more waste targets or higher tariffs/fees if glass is sent to landfill, and education around this.
- NSG Group is global and circularity challenges are country-specific. Alternative fuels and lower carbon solutions are currently more expensive to manufacture with limited legislative factors to drive this until at least 2030 for new buildings.

## Saint-Gobain

| | |
|---|---|
| **Case Study No.** | 16 |
| **Sector** | Glass |
| **Location** | United Kingdom |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Flat glass recovery and recycling |
| **Website** | https://www.saint-gobain-glass.com/ |

**Background**

- Saint-Gobain is a producer of architectural flat glass with a production facility in Eggborough, North Yorkshire.
- Saint-Gobain's 'Glass Forever' approach to circularity involves working with customers to actively divert waste glass from landfill and remanufacture it into new flat glass.
- The process involves collecting glass cullet at customer sites in bags which are then transported back to the Eggborough site for treatment and remanufacture into new flat glass.
- The process is largely focused on pre-consumer waste glass (waste at product manufacture) but is expanding into post-consumer waste glass (waste flat glass from the construction and demolition sector).
- Saint-Gobain monitor their glass production process very closely, gathering metrics which drive process efficiency, such as energy and material consumption.

| **Metrics** | **Results** |
|---|---|
| Energy reduction (from melting cullet rather than raw materials) | 30% |
| $CO_2e$ reduction (using one tonne of cullet rather than one tonne of raw materials) | 0.7 $tCO_2e$ |
| Virgin raw materials saved (using one tonne of cullet), including sand, soda ash and limestone | 1.2 tonnes |

**Key Focus Areas for Consideration**

**Drivers:**

- Strategic driver for circularity from a group level as part of the group’s route to net zero GHG emissions.
- Less requirements for raw materials and energy (and therefore cost savings).
- Increased competitiveness by meeting the market demand for recycled products.

**Barriers:**

- Glass falls under a low bracket of landfill tax, meaning there is insufficient incentive to seek alternatives to landfilling waste glass.
- There is no penalty for downcycling glass as opposed to remanufacturing into new high-quality glass.
- Post-consumer glass is generally where the main wastage is, but there are significant challenges in recycling this into new high-quality flat glass. Post-consumer glass requires a complex handling process, is inefficient to transport, and is susceptible to contamination. This poses increased costs with little incentive to pursue.
- There is a need to develop infrastructure for post-consumer glass remanufacture, and engage with and upskill construction and demolition stakeholders.

## Thomas Armstrong

| | |
|---|---|
| **Case Study No.** | 17 |
| **Sector** | Glass |
| **Location** | United Kingdom |
| **CE Theme** | Recycling and lightweighting |
| **Type of CE Measure** | Recycling of container glass into foamed glass aggregate |
| **Website** | https://www.thomasarmstrong.co.uk/ |

**Background**

- Thomas Armstrong Group is a UK-based manufacturer of building materials and products.
- Foamed Glass UK Ltd, part of the Thomas Armstrong Group, produce foamed glass aggregate from recycled container glass. This supports recycling and reduces landfill waste.
- The foamed glass aggregate:
    - Offers good thermal insulation for building foundations and roofs, reducing energy costs.
    - Is lightweight and high strength and has applications in roads and railways (less soil stabilisation requirements than traditional aggregate).
    - Offers drainage and filtration for stormwater management and landscaping.
    - Is high durability, fire resistance, and inert.
- Used in-house as aggregate for concrete blocks as a replacement for ash.
- First foamed glass manufacturer in UK.
- Use locally sourced raw material from bottle banks.
- Low weight aggregate can be transported further in bigger loads.
- All sweepings go back into process, what cannot be used in foamed glass goes into concrete block plants.
- No effluent and no waste (except for contaminants).
- The foaming agent is silicon carbide in dry powder form and is completely inorganic and inert. No harmful chemicals are used at any stage of the process.

| Metrics | Results |
|---|---|
| Recycled glass content in foamed glass aggregate | 99% (remainder is foaming agent) |

| | |
|---|---|
| Weight reduction (compared to traditional aggregates) | 85% |
| Glass bottles recycled every year | >10 million |

| Key Focus Areas for Consideration |
|---|
| **Drivers:**<br>• Lightweighting reduces transportation costs.<br>• Popular choice material for sustainable construction.<br>• GHG reductions.<br>• All that is required is a Part B PPC permit, not an environmental permit for waste treatment. The cullet taken in is deemed a ‘product’ and not a waste – it has End of Waste status as per regulations for glass cullet to the European Regulation EU/1179/2012.<br>• Only producer in the UK.<br>**Barriers:**<br>• Security of supply may be a risk in future as they obtain their glass from one supplier – however, currently this is not a barrier. |

# Paper

## Saica

| | |
|---|---|
| **Case Study No.** | 18 |
| **Sector** | Paper |
| **Location** | UK |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Recycled fibre paper |
| **Website** | [https://www.saica.com/en/saica-paper/](https://www.saica.com/en/saica-paper/) |

**Background**

- Producer of recycled fibre (RCF) paper and produce 100% recycled paper for corrugated cardboard.
- Circularity is integrated into Saica's production model:
    - Saica Natur recovers waste paper;
    - Saica Paper recycles this waste into 100% recycled paper reels;
    - Saica Pack converts this into new products;
    - This avoids paper being sent to landfill.
- Non-hazardous waste from the paper manufacturing process (including plastics) is used as fuel to generate the thermal energy necessary for production process.
- Operate a paper factory in Partington, near Manchester.

| Metrics | Results |
|---|---|
| Recycled content (corrugated cardboard containers and packaging developed by Saica Pack) | 100% |
| Amount of paper processed (Partington site) (2024) | 460,000 tonnes |
| Waste recovery rate (Partington site) (2024) | 88.5% |

**Key Focus Areas for Consideration**

**Drivers:**

- Saica’s business model and ethos is based on recycled paper.
- High-level policy for Saica has environmental goals.

**Barriers:**

- Inconsistency across the UK in terms of the way paper waste is collected. Council waste collections differ by area and often the waste is not consistently segregated, causing feedstock contamination and quality issues.
- Permits limit the amount of paper that can be produced, and exceeding a 10% variation of this limit requires a full permit application. Organisations would benefit from having better thresholds for permit variation or using existing permits for variation purposes.
- Permit variations take time. For waste recovery, the time taken to vary the permit to add biomass as a permitted fuel for Saica’s Energy recovery boiler (following a trial) was not efficient.

## Sofidel

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|---|---|
| **Case Study No.** | 19 |
| **Sector** | Paper |
| **Location** | UK |
| **CE Theme** | Process Efficiencies |
| **Type of CE Measure** | Waste minimisation |
| **Website** | [https://www.sofidel.com/en/](https://www.sofidel.com/en/) |

**Background**

- Manages 16 companies producing and converting tissue paper across 13 countries in Europe and the US.
- Sofidel UK has four sites: two integrated plants in Leicester and Baglan, a paper mill in Lancaster, and a converting plant in Leicester.
- Waste tissue paper from the internal production process (i.e. "broke") is reused in production.
- Cardboard cores from tissue reels are returned to the parent company or sent to local recyclers.
- Chemicals in IBCs are returned to suppliers or third parties for reuse or recycling.
- Waste poly is recycled by a third party.
- Tissue waste which they are unable to process is sold to another paper company for processing.
- Fibre recovered from wastewater is reused in production.

| **Metrics** | **Results** |
|---|---|
| Cardboard core recycled content | 100% |
| Poly wrap recycled content | Minimum 30%, can provide up to 50% |

**Key Focus Areas for Consideration**

**Drivers:**

- Operational efficiency and cost effectiveness.
- Sofidel's climate goals in line with SBTi.

- Customer preference for high recycled content, or preference for paper packaging over plastic.
- Regulations such as Plastic Packaging Tax.

**Barriers:**

- Balancing sustainability with perceived hygiene requirements of tissue paper.
- Geographic barriers – the site in South Wales tends to have less available infrastructure to recycle waste materials than the Leicester sites which are more central.

## Essity

| | |
|---|---|
| **Case Study No.** | 20 |
| **Sector** | Paper |
| **Location** | UK & Europe |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Recycling of used tissue paper and recovery of rejects |
| **Website** | [https://www.essity.com/](https://www.essity.com/) |

**Background**

- Producer of tissue paper with sites in UK and Europe.
- Circularity initiatives at UK sites:
    - **Rejected Fibre:** Reused in the system for processing.
    - **Reusable Cores and Pallets:** Utilized to minimize waste.
    - **Paper Hand Towels:** Collected from public washrooms and recycled into new tissue products at the Stubbins site.
- Circularity initiatives at European sites:
    - **Tork PaperCircle:** Collects and recycles used paper hand towels from businesses into new tissue products.
    - **Wheat Straw Integration:** Uses leftover wheat straw as a fibre source, requiring less energy and water than wood fibre while maintaining quality.
    - **Sludge Rejects:** Used for energy recovery and sometimes repurposed for building materials.
    - **Plastic Rejects:** Used for energy recovery, with pilot projects recycling them into low-quality plastics or converting them into high-quality recycled plastic.

| Metrics | Results |
|---|---|
| Essity global: Production waste subject to material or energy recovery | 67% |
| Essity global: Share of packaging manufactured from renewable and/or recycled material | 78% |

| | |
|---|---|
| Tork PaperCircle: Waste reduction | Up to 20% |
| Tork PaperCircle: $tCO_2e$ reductions | Up to 40% |
| **Key Focus Areas for Consideration** | |
| **Drivers:**<br>• UK/EU ETS is a driver, especially in terms of energy efficiency.<br>• Market drive towards a green economy.<br>**Barriers:**<br>• Permit variations, for example when new technologies are implemented, are a time-consuming process.<br>• Recycling rules are inconsistent across different countries.<br>• It can be inefficient and costly to ship feedstock between borders of different countries.<br>• Limited national infrastructure to support the recycling of used paper towels.<br>• Feedstock quality issues in terms of contamination and mixing of waste | |

# Chemicals

## Croda

| Case Study No. | 21 |
|---|---|
| **Sector** | Chemicals & Plastics |
| **Location** | UK |
| **CE Theme** | Bio-based feedstocks |
| **Type of CE Measure** | Biodegradable ingredients |
| **Website** | [https://www.croda.com/en-gb](https://www.croda.com/en-gb) |

**Background**

- Croda is a UK-based speciality chemicals company producing consumer care and life sciences products.
- Transitioning away from fossil and petrochemical feedstocks, towards bio-based feedstocks.
- Design ingredients that are recyclable or biodegradable to support a circular economy.
- Have internal R&D facilities to test the biodegradability of ingredients.
- Currently focusing on 'readily biodegradable' ingredients as defined by OECD 301 as this is most used in the market, however Croda is engaged in projects to assess true environmental degradation of their materials.
- External collaborations around using food waste and feedstock.
- Other initiatives across the company include self-generation of renewable energy and use of biogas and waste-to-energy sources of fuel.

| Metrics | Results |
|---|---|
| Organic raw materials from bio-based sources (2023) | 59.4% |
| Process waste from Croda manufacturing sites diverted from landfill (2024) | >99% |
| Goal to conduct LCAs on key products (which will demonstrate $CO_2$ emissions/reductions) | Goal for 100 LCAs conducted by 2030 |

**Key Focus Areas for Consideration**

**Drivers:**

- Carbon is a key driver for circularity at Croda. There is a drive to low carbon footprint materials due to customer demand, and circularity contributes to Croda's organisational decarbonisation.
- Manufacturers, consumers and regulatory authorities increasingly expecting biodegradability information.

**Barriers:**

- Material recovery for consumer care and life science applications is typically challenging (e.g. material recovery from wastewater is difficult for Croda to control) – therefore circularity at Croda is driven from the feedstock side.
- Sourcing of raw materials can be challenging, in terms of scaling up novel feedstocks from R&D level in an economically viable way.
- Lack of infrastructure to manage waste/novel feedstocks, as new technology is required to process novel feedstocks.
- Regulations limit the use of waste materials in consumer applications and require tests before waste can be used as a feedstock.
- Achieving end-of-waste or demonstrating byproduct status can be a barrier to for materials with low economic value.

# Plastics

## Mura Technology

| | |
|---|---|
| **Case Study No.** | 22 |
| **Sector** | Chemicals & Plastics |
| **Location** | UK |
| **CE Theme** | Chemical / advanced recycling |
| **Type of CE Measure** | Production of circular hydrocarbons |
| **Website** | https://muratechnology.com/ |
| **Background** | |
| • Mura Technology's Hydro-PRT® uses supercritical steam to convert waste plastics into ISCC+ certified, REACH/UK REACH registered liquid hydrocarbon feedstocks – achieving End of Waste status.<br>• The process produces four outputs: three Circular Hydrocarbon Oils for new plastics and one Circular Residual Oil for asphalt.<br>• It targets hard-to-recycle plastics, preventing incineration or landfill.<br>• The first commercial plant is in Teesside, UK, with projects in the UK, Germany, US, and Asia. Two plants in Japan and South Korea are set to commission in Q1 2025. | |
| **Metrics** | **Results** |
| Yield rate | c. 95% across 4 liquid products and process (C2-4) gas |
| Wilton plant production capacity | 20 kta (Phase 1); Expansion to 70 kta in Ph2 new, larger reactor |
| $tCO_2e$ savings at Wilton plant | c. 40,000 $tCO_2e$ (based on 20,000 tpa production); c. 0.5 $tCO_2e$ saving per tonne of product vs fossil equivalent (Ozoemena and Coles 2023) |
| $tCO_2e$ reductions relative to Energy from Waste (EfW); resource conservation | c. 80% (1.86 $tCO_2e$ avoided vs 2.34 $tCO_2e$ from incineration) |

| | |
|---|---|
| | >5 barrels of oil saved per tonne of plastic processed (Ozoemena and Coles 2023) |
| $tCO_2e$ reductions of EfW + mechanical + chemical vs mechanical and EfW only | c. 42%. (Paper – Ozoemena et al 2025 submitted) |

**Key Focus Areas for Consideration**

**Drivers:**

- **Advanced recycling** offers a value chain for contact-sensitive packaging (food, personal care, medical) that mechanically-recycled plastics cannot.
- **Helps meet EU packaging regulations:** Packaging and Packaging Waste Regulations (PPWR), Single Use Plastics Directive (SUPD), End of Life Vehicles Regulations (ELVR), and UK Plastic Packaging Tax targets.
- **Reduces carbon footprints** compared to incineration and fossil products, conserving resources.

**Barriers:**

- **REACH:** need for novel testing as the original material is a 'waste', and not a fossil-based crude oil, leads to not being able to draw from existing dossiers, and this extra testing leads to excessive costs for the SMEs involved.
- **Waste Framework Directive** classification of chemical recycling as 'recycling' is unclear; UK EoW assessment is essential for EU market sales.
- **Recycled plastic bale quality** needs enhancement to deliver c90% PP/PE content bales for viable advanced recycling.
- **PPWR 'Mirror Clause 7'** requires non-EU suppliers to follow EU regulations; UK must align with WFD to avoid market barriers – if UK is not aligned to the requirements of environmental management/operations, recycled content calculations and sustainability assessments, the UK will not be able to sell recycled plastics into the EU market, and UK oils that go into the petrochemical industry in the EU would not otherwise be counted as a recycled credit in the plastics they produce.
- **PPWR, SUPD:** 10% minimum content for flexible, contact-sensitive packaging creates 0.5mt annual demand, but >1 mt EU capacity gap; UK investment needed.
- **Mass Balance** accounting for recycled content calculations unresolved in UK or EU; in development by HMT/HMRC and DG ENV (2025).
- **Delays to consistent collection** of low-value flexible packaging resolved for 2027; creates feedstock supply but needs investment in advanced infrastructure.
- **Delivery timeline for Environmental Permits:** future UK plants would benefit from fast-tracked permits.

- **Circularity needs agreed metrics:** consistent rules needed for comparability and stakeholder trust; requires academic leadership.
- **ETS charges/tax:** should drive recyclable plastic away from incineration to recycling; circular industries would benefit from being exempt.
- **Sustainable Aviation Fuel (SAF) Mandate:** The SAF mandate may create incentive to use soft plastics to produce SAF, but advanced recycling could be a more circular route for this waste.

## INEOS Inovyn

| | |
|---|---|
| **Case Study No.** | 23 |
| **Sector** | Chemicals & Plastics |
| **Location** | Belgium |
| **CE Theme** | Recycling |
| **Type of CE Measure** | Advanced recycling of PVC |
| **Website** | https://www.ineos.com/businesses/inovyn/ |

**Background**

- 'Project Circle' programme is pioneering advanced recycling technologies for end-of-life PVC products, with an ambition to have industrial advanced recycling units on stream by 2030 and bring circular product offers to market.
- Aim to increase circularity of PVC by processing PVC waste which cannot be recycled mechanically.
- The Project Circle team are exploring three possible advanced recycling technologies using dissolution (Vinyloop technology which achieves 100% PVC recycling), pyrolysis and gasification, which would also remove harmful legacy additives that have been used in the past, such as lead, cadmium and certain phthalates (REACH compliant).
- Collaborating with their supply chain by forming consortiums with customers, waste collectors and sorters (e.g. Vinylplus).
- Commissioned two new pilot plants at their R&D centre in Jemeppe-sur-Sambre site in Belgium in 2024. Aiming for first industrial PVC waste recycling unit, capable of processing up to 40,000 tonnes of PVC waste each year, to be operational by 2030.

| **Metrics** | **Results** |
|---|---|
| Planned processing capacity of first industrial PVC waste recycling plant | 40,000 tonnes of PVC waste processed per year |
| $CO_2$ reduction (Vinyloop*)<br><br>*based on previous technology, number to be updated | c. 40% |

**Key Focus Areas for Consideration**

**Drivers:**

- Recovering PVC waste which is difficult-to-recycle through mechanical recycling.

**Barriers:**

- To accelerate the circularity in the PVC value chain, developing advanced recycling technologies to tackle PVC waste that cannot be mechanically recycled, such as PVC containing legacy additives and composites is needed.
- Access to PVC waste currently sent to landfill, incineration due to a lack of market for this kind of PVC waste.
- Advances in sorting technology are crucial for increasing the recycling rates of PVC and requiring investment.
- Advanced recycling technologies development to further enhance the circularity of PVC and driving the transition towards a circular economy for PVC in Europe
- Need incentives in Europe (e.g. funding, taxes, bonuses, or penalties) to be economically viable.
- Technology needs large investment, but low probability (~8%) of getting funding from the EU Innovation Fund due to difficult award criteria.

## SABIC

| | |
|---|---|
| **Case Study No.** | 24 |
| **Sector** | Chemicals & Plastics |
| **Location** | Global |
| **CE Theme** | Material substitution |
| **Type of CE Measure** | Circular product design |
| **Website** | [https://www.sabic.com](https://www.sabic.com) |

**Background**

- SABIC is a global diversified chemicals company, headquartered in Riyadh, Saudi Arabia with manufacturing facilities in the Americas, Europe, Middle East and Asia Pacific
- SABIC's TRUCIRCLE™ portfolio and services are focused on closing the loop on plastic, and include:
    - Design for products that have better recyclability characteristics
    - Certified circular products, made through advanced recycling of difficult-to-recycle used plastic
    - Mechanically recycled products to improve recyclability and end-use properties
    - Certified bio-renewable products from second-generation bio-based feedstock
    - Closed loop initiatives to recycle plastic back into high quality applications and help prevent valuable used plastics from becoming waste.

| Metrics | Results |
|---|---|
| TRUCIRCLE™ certified circular polymers: kg $CO_2e$ reduction per kg of polymer resin (based on diversion from incineration with energy recovery) | Reduction of approx. 2 kg $CO_2e$ per kg of polymer resin |
| TRUCIRCLE™ bio-based renewable products: kg $CO_2e$ reduction per kg of polymer resin (in comparison to traditional feedstock alternatives) | Reduction of approx. 4 kg $CO_2e$ per kg of polymer resin |

**Key Focus Areas for Consideration**

**Drivers:**

- Customer and market drive to show value through plastic circularity.
- Carbon reduction/neutrality.
- Keeping carbon in the loop.
- Packaging legislation driving purchasing choices.

**Barriers:**

- In Europe, the sector would benefit from clarity on legislation, such as clear statements on what will be implemented when.
- Competitiveness needs to be enhanced to lower feedstock and energy costs.
- Limited infrastructure for sorting of plastic wastes in Europe can constrain feedstock availability.
- Lack of infrastructure (e.g. power) is a challenge for smaller companies to initiate or facilitate the required changes.
- Permitting for new assets in Europe is time consuming.
- The affordability of the solution and how the costs are mitigated for the public need to be managed.

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