The Green Construction Board

Construction Leadership Council

# The Routemap for Zero Avoidable Waste in Construction

## Introduction

Waste costs the construction industry an estimated £11 billion per annum and emits 3.5 million tonnes of CO2e, yet waste can be reduced, materials used more efficiently, and buildings and structures at end of life repurposed, refurbished or dismantled to enable products and materials to be a resource for new activities.

This Routemap aims to catalyse actions by all parts of the supply chain to reduce and ultimately eliminate all avoidable waste. It adopts the interpretation of Zero Avoidable Waste in construction published by the Green Construction Board (GCB) in 2020 and adopts the principles of the waste hierarchy and life cycle assessment.

The Routemap is an interactive infographic identifying aims, actions, context and guidance. Click on an Aims button and a new page appears. Hover over Context and an explanation appears. Click Guidance and a new page links to published guidance.

It has been prepared by the GCB's Resources and Waste Task Group with the principal authors being Katherine Adams, Rob Pearce and Jane Thornback. The project received financial support from BEIS, and was in collaboration with Defra.

Click for Context

Targets and Guiding Principles

Click for Acknowledgements

| Theme | Aim | 2020s | 2030s | 2040s |
|---|---|---|---|---|
| Pre Construction Clients & Design Teams | Design for end of life | ● | ● | ● |
| | Design out waste | ● | ● | ● |
| | Encourage refurbishment over demolition | ● | ● | |
| | Procure with Zero Waste in mind | ● | ● | |
| Materials | Ensure materials are readily recoverable | ● | ● | ● |
| | Exploit off site manufacture | ● | ● | ● |
| Construction | Reduce volume of soil to landfill | ● | ● | ● |
| | More reuse and recycling of new build waste | ● | ● | |
| | Reduce waste from temporary works | ● | ● | |
| | Better waste services for SMEs | ● | ● | |
| In Use & End of Life | Waste from refurbishment is reduced | ● | ● | ● |
| | Less down cycling of waste from demolition | ● | ● | |
| | Accurate asset info available in digital form | ● | ● | |
| Landfill | Joint plan to reduce waste to landfill by 2040 | ● | ● | ● |
| Better Measurement – Better Management | Analyse and report waste to landfill | ● | ● | ● |
| | Report on waste at project and company level | ● | ● | |
| | Strategic understanding of material flows | ● | ● | ● |

08705 | Version 1.0 | June 2021

# Context

The government's Resources and Waste Strategy (2018)[1] has the stated ambition 'to eliminate avoidable waste of all kinds by 2050' in England. This includes waste from all sectors of society including the construction sector (both buildings and infrastructure).

Constructing our built environment uses the largest flow of materials, and produces the largest waste stream by tonnage. In 2016 this amounted to 60 million tonnes of construction and demolition waste and 51 million tonnes of excavation waste. For waste from new build construction, this represents a 'true' cost of £11 billion per year and a carbon cost of potentially 3.3 million tonnes/$CO_2$e per year.

The purpose of this Routemap is to identify the actions to be taken right across the construction sector and by government to reduce this waste stream to zero. The Green Construction Board interprets Zero Avoidable Waste (ZAW) to mean:

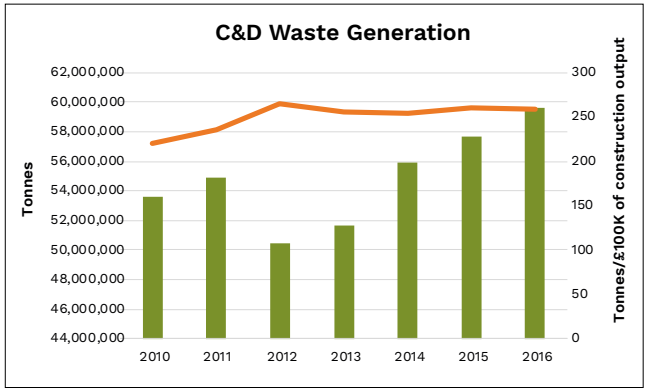
> ***Zero Avoidable Waste in construction means preventing waste being generated at every stage of a project's lifecycle, from the manufacture of materials and products, the design, specification, procurement and assembly of buildings and infrastructure through to deconstruction. At the end of life, products, components and materials should be recovered at the highest possible level of the waste hierarchy, i.e. reused before being recycled, whilst ensuring minimal environment impact. Green Construction Board, 2020***

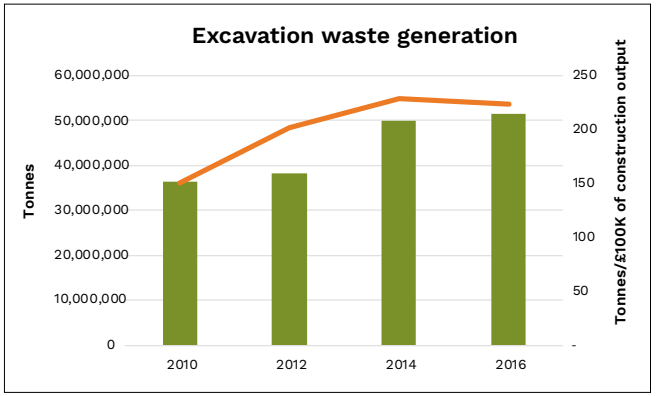
When considering Zero Avoidable Waste in construction we need to consider two clear focal points:

- **New Build** – ensure new buildings and structures use resources efficiently, are designed for durability and longevity and safety, and are designed for deconstruction and disassembly at end of life.
- **Existing Buildings** – most of the buildings and structures we will use in the future already exist today, so at end of their current use can they be repurposed for new uses, and if not can they be demolished in a way to ensure the maximum amount of product and material is reused, recycled or recovered.

We emphasise that to meet a target of Zero Avoidable Waste we need robust measurement systems to enable consistent and regular monitoring which feeds into the development of a National Materials Strategy. Only then will we begin to realise a true circular economy.

There is much to do in progressing ZAW in the construction sector. The graphs show that for C&D waste, there has been little, if any reduction in the amount of C&D waste arising in absolute and relative terms (based on construction output). This is also the same for excavation waste (soils). This suggests that waste reduction may not currently be seen as a priority for the sector, and that action is required if the environmental targets for carbon reduction are to be addressed.




1 Defra (2018) Resources and Waste Strategy, HM Government London.
Available at https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england

Back to Route Map

# Targets and Guiding Principles

The overall target is for "zero avoidable waste (ZAW) in the construction sector by 2050". The working interpretation of what is meant by ZAW was produced in February 2020[1]. There are a number of other targets included with the Routemap:

- By 2030 costs are reduced by 10% through designing out waste and material optimisation.
- By 2040 eliminate all but hazardous C&D waste entering landfill.
- By 2040 reduce soil to landfill by 75% based on a 2020 level and by 2050 this should be zero unless required for landfill operation purposes.

The setting of targets is also recommended for waste reduction in the Design out Waste and Procure with Zero Waste in Mind themes. As the Routemap is taken forward it is likely that other targets will be set to drive ZAW in the construction sector.

There are a number of over-arching principles which apply to the Routemap and to achieve ZAW in the sector. These are also presented in the Working Interpretation Report. These include:

- The primary objective is to prevent materials, products or components from becoming waste in line with the waste hierarchy.
- If waste cannot be prevented then the secondary objective is for waste to be kept at its highest level by following the waste hierarchy.
- The Routemap is intended to progress the implementation of a circular economy, with materials flowing round the economy.
- Choices should be based on life cycle assessment, considering the impact on energy, carbon, water, toxicity, air quality, biodiversity etc.
- The design life of a project should inform the choice of the materials, components, and elements. For example, projects with a long service life will be delivered using long life materials, and vice versa.
- Providing for adaptability in buildings and infrastructure is a fundamental principle in achieving ZAW.
- The feasibility for reuse and/or adaptation of existing structures and buildings should be a primary consideration to minimise waste production.

1 https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2016/05/ZAW-Report-Final-Draft-25-February-2020.pdf

Back to Route Map

# Acknowledgements

The Routemap has been co-authored by:

| | |
|---|---|
| Katherine Adams | Independent Consultant – Reusefully Ltd |
| Robert Pearce | Haskoll Architects and GCB Board Member, Resources and Waste (Chair) |
| Jane Thornback | GCB Co-Secretariat and CPA Sustainability Advisor, GCB Resources and Waste Co-Chair |
| Hayley Kilby | Graphic Design |

The Green Construction Board is very grateful for the time and expertise provided by members of the GCB Resources and Waste Task Group as well as of the government officials involved in the project. Those that have contributed to the Routemap include:

| Name | Affiliations |
|---|---|
| Jane Anderson | Open University and UK Expert on European CEN 350 & EN15804 standards<br>Co-Author of the BRE Green Guide to Specification |
| Howard Button | National Federation of Demolition Contractors (NFDC) |
| Maya De Souza | Defra |
| Hattie Emerson | Mace |
| Olu Fasan | BEIS |
| Peter Kelly | ISG and Chair of CIWM Construction and Demolition Waste Group |
| Nitesh Magdani | RIBA Sustainable Futures Group and Net Positive Solutions Ltd |
| Prof. Mohammed Osmani | Loughborough University and Chair BS 8895 Committee on designing for resource efficiency |
| Sam Ralph | Defra |
| Mike Sansom | Steel Construction Institute |
| Andrew Stott | University of Wolverhampton, EnTRESS |
| Guy Thompson | Mineral Products Association – Concrete Centre |
| Danielle Densley Tingley | University of Sheffield |
| Maxine Townsend | Skanska |
| Debbie Ward | University of Wolverhampton, EnTRESS |
| Karen Wood | BEIS |
| Graham Winter | Waste Strategy Team, Environment Agency |

Back to Route Map

# Design for End of Life

Aim: **The consideration of the end of life stage is required for all major projects at the design and planning stage**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Training for Design for Deconstruction is embedded within relevant University courses and Professional CPD.<br>• Large metropolitan planning authorities require major projects to submit an end of life plan in planning applications. | • By the early 2030s national planning framework policy requires end of life plans for major projects.<br>• By the early 2030s Building Regulations require major projects to be designed for deconstruction and disassembly. | • Structures made from reusable components, easily deconstructed without compromising safety become the norm. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

There is no mandatory requirement to design for the end of life buildings. As such there is little incentive for clients and design teams to consider how their buildings will be managed at end of life and how the design and choice of materials may affect this. Current drivers are obtaining credits within BREEAM or undertaking a circular economy statement for referable developments as part of the London Plan requirements. Without any Regulation it is unlikely that designing for deconstruction will become commonplace. Design for deconstruction principles together with technical guidance (which also encompass flexibility and adaptability) have been available for over 20 years, there are few buildings in the UK where these principles have been applied in practice. With a focus on delivering Net Zero via a Future Homes Standard in planning and Building Regulations, and reform of the planning system there is no mention of resource efficiency, waste reduction and designing for end of life.

## Act now

**Government**

- Government begins the policy development and consultation process to introduce this requirement by 2030s.

**Industry**

- Clients require end of life plans for their buildings as part of the design process.
- Design teams utilise technical guidance to assist the design for deconstruction and reuse potential for different components and elements which they commonly use.
- If flexibility and adaptability is being considered by design teams, extend this thinking to cover end of life.
- Contractors ensure that during construction, components and elements are constructed in a way that they can be disassembled at end of life.
- Design teams share their learnings and best practice on designing for deconstruction within their practices and externally through their networks.
- Design teams write up case studies on how design for deconstruction has been considered within the design process and what changed as a result.
- Other professional bodies and University Courses develop training for respective disciplines.

# Design for End of Life

Aim: **The consideration of the end of life stage is required for all major projects at the design and planning stage**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Training for Design for Deconstruction is embedded within relevant University courses and Professional CPD.<br>• Large metropolitan planning authorities require major projects to submit an end of life plan in planning applications. | • By the early 2030s national planning framework policy requires end of life plans for major projects.<br>• By the early 2030s Building Regulations require major projects to be designed for deconstruction and disassembly. | • Structures made from reusable components, easily deconstructed without compromising safety become the norm. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- Short courses via the professional institutes based on existing guidance and standards to be delivered as part of CPD.
- Working with the Joint Board of Moderators, relevant University courses, such as architecture and engineering courses to include designing for deconstruction principles and their practical application.
- BRE and the Greater London Authority to share how projects have considered design for deconstruction and functional adaptability as part of BREEAM requirements and the Circular Economy Statements.
- As clients rarely demand that their buildings be designed for deconstruction at end of life, requirements through planning would show intent (this could follow the approach for the circular economy statement within the London Plan). Longer term requirements could be built into national planning policies and a new Part of Buildings Regulations to design buildings for disassembly and deconstruction.
- As approximately a quarter of construction output is public sector, Government can take a lead in requiring design for deconstruction within their procurement processes. This could be requiring an end of life plan.
- Research: research is required on the costs and other impacts for designing for deconstruction for different component, element and building types. This could also include the possibility of buildings becoming stranded assets if they are not designed for adaptability, longevity and end of life.

## Act now

**Government**

- Government begins the policy development and consultation process to introduce this requirement by 2030s.

**Industry**

- Clients require end of life plans for their buildings as part of the design process.
- Design teams utilise technical guidance to assist the design for deconstruction and reuse potential for different components and elements which they commonly use.
- If flexibility and adaptability is being considered by design teams, extend this thinking to cover end of life.
- Contractors ensure that during construction, components and elements are constructed in a way that they can be disassembled at end of life.
- Design teams share their learnings and best practice on designing for deconstruction within their practices and externally through their networks.
- Design teams write up case studies on how design for deconstruction has been considered within the design process and what changed as a result.
- Other professional bodies and University Courses develop training for respective disciplines.

Back to Route Map

# Guidance

There is various guidance, tools and case studies available. Relevant projects are also listed.

- Greater London Authority Circular Economy Statement and Guidance
- Regenerate Tool for Circular Economy Design and Construction
- SEDA Design for Deconstruction Guidance (2005)
- ISO 20887:2020 Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance (2020)
- UK Government; Planning for the Future (2020)
- European Commission Circular Economy Principles for Building Design (2020)
- David Cheshire, Building Revolutions – Applying the Circular Economy to the Built Environment Book (2019)
- Building as Material Banks H2020 project, Reversible Design guidance
- Adaptable Futures – case studies and tools
- CIOB & ARUP; Designing for the Deconstruction Process
- Climate KIC Reusable Buildings, Final Report
- Alliance for Sustainable Building Products (ASBP) The Re-Fab project
- BRE
  - Design for Deconstruction
  - Design for Deconstruction Case Study
  - BREEAM New Construction 2018 – Credit for designing for disassembly and adaptability
  - CEEQUAL
- RICS Ska Rating
- H2020 CIRCuIT project

Back to Route Map

Back to previous page

# Design out waste

Aim: **The use of materials is optimised in the design of the buildings and structures and waste is designed out throughout the design and construction process**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Waste reduction targets are commonplace in most construction projects.<br>• Professional institutions develop training and CPD.<br>• BS8895 is widely adopted throughout the design process for major projects. | • By 2030 costs are reduced by 10% through designing out waste and material optimisation. | • The amount of waste generated from new build construction is minimal. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

Whilst there has been much guidance on waste prevention, such as WRAP's Designing Out Waste toolkits and the BS8895 Standard on designing for material efficiency in buildings, the construction industry continues to produce high levels of waste from new build activities. Approximately 13 million tonnes of waste is produced annually from new build construction activities, with a true cost of £11 billion (material, labour, rework, VAT and waste management costs). Much of this is preventable. Reasons for this waste are varied: design decisions, over-ordering, poor workmanship, packaging, the construction process and poor handling and storage of materials. Preventing this waste results in the use of less resources, a reduction in environmental impact and a significant cost saving. There is no mandatory requirement to reduce waste arisings and the cost of waste is included in project contract costs, so there is often little incentive to reduce it at project level. This is reflected in national levels of construction waste which appear to vary more with economic activity than with a coherent drive for waste reduction. It is unlikely that any Regulation to require waste reduction could be viably framed and enforced – this is an action that industry will need to take responsibility for delivering a step change. Some projects, maybe driven by the waste reduction credits that can be achieved in environmental certification schemes, but these are limited in their application.

## Act now

- Clients, design teams and contractors set project waste reduction targets during design and construction.
- Design teams share their learnings and best practice on designing out waste within their practices and externally through their networks.
- Design teams write up case studies on how designing out waste has been considered within the design process and what changed as a result.
- Design teams implement waste reduction practices in their design work.
- Design teams undertake material optimisation through design choices and material selection working with manufacturers.
- Professional Institutions and universities and colleges include designing out waste in training, CPD and academic courses.
- If participating in environmental certification schemes, such as BREEAM, LEED etc pursue the credits that relate to waste reduction and material efficiency.
- At project level, contractors and quantity surveyors, reduce the wastage allowances that are set for materials and do not over order.
- Contractors incentivise subcontractors to reduce waste.
- Contractors and subcontractors manage materials on site carefully to avoid damage.
- Manufacturers and contractors collaborate to implement reusable packaging schemes.

Back to Route Map

# Design out waste

Aim: **The use of materials is optimised in the design of the buildings and structures and waste is designed out throughout the design and construction process**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Waste reduction targets are commonplace in most construction projects.<br>• Professional institutions develop training and CPD.<br>• BS8895 is widely adopted throughout the design process for major projects. | • By 2030 costs are reduced by 10% through designing out waste and material optimisation. | • The amount of waste generated from new build construction is minimal. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- The use of waste reduction targets on construction projects by clients and contractors would drive the design and construction process to reduce waste.
- Measuring the amount of materials that are used and the material intensities (the relative amount of material use as kg/m$^2$ of floor area) as part of the design phase of a project would allow benchmarks to be generated. This is a requirement in the London Plan for circular economy statements.
- One of the aims when using BIM, needs to be reducing waste for example by avoiding clashes and rework.
- The use of modular and offsite construction decreases waste during work on site – waste generated during the factory-based stage needs to be better assessed.
- Research: research is needed for how components and structures can be made “leaner” thereby using less material. For example, it has been estimated that structural design can use somewhere between 20–50% more material than necessary which may be due to risk mitigation, rationalisation or inappropriate standards. Research by the University of Cambridge has shown that that some offices are being designed using far higher for loading than the design code requirements, which can lead to significant material inefficiencies.
- Research: better data is needed for the wastage rates of materials and the causes of these.

## Act now

- Clients, design teams and contractors set project waste reduction targets during design and construction.
- Design teams share their learnings and best practice on designing out waste within their practices and externally through their networks.
- Design teams write up case studies on how designing out waste has been considered within the design process and what changed as a result.
- Design teams implement waste reduction practices in their design work.
- Design teams undertake material optimisation through design choices and material selection working with manufacturers.
- Professional Institutions and universities and colleges include designing out waste in training, CPD and academic courses.
- If participating in environmental certification schemes, such as BREEAM, LEED etc pursue the credits that relate to waste reduction and material efficiency.
- At project level, contractors and quantity surveyors, reduce the wastage allowances that are set for materials and do not over order.
- Contractors incentivise subcontractors to reduce waste.
- Contractors and subcontractors manage materials on site carefully to avoid damage.
- Manufacturers and contractors collaborate to implement reusable packaging schemes.

Back to Route Map

# Guidance

There is some guidance specifically for reduction of waste during design and construction which is listed below. Organisations such as WRAP developed Designing out Waste guidance and tools but these have not been updated following the change in scope of WRAP.

- BS8895 Standard on designing for material efficiency in buildings
- WRAP Designing out Waste Guidance
- BRE
  - Material resource efficiency in construction: Supporting a circular economy (FB 85) – (2017)
  - BREEAM New Construction 2018 – Credit for Construction Waste Management (Wst0)
  - CEEQUAL
- Zero Waste Scotland
  - Reducing Construction Waste
  - Best Practice Guide to managing waste on construction sites
- Concrete Centre guidance on material efficiency (2018)
- Steel Construction Institute guidance tool for optimisation of beams and columns
- CIBSE TM56: Resource Efficiency of Building Services (2014)
- RICS Ska Rating

There are also a few case studies available:

- Crossrail Designing out Waste
- Olympics 2012
  - NoWaste Lean Construction Training Programme
  - Waste Implementation Guidance for Project Teams and Waste Minimisation Action Reports
  - Designing out Waste in the Olympic Park
- Thameslink Case Studies

Back to Route Map

Back to previous page

# Encourage Refurbishment over Demolition

Aim: **Waste from demolition is reduced due to the widescale refurbishment of buildings and infrastructure**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government to review tax implications of refurbishment versus building new and avoid any unintended consequences.<br>• Government to assess if changes to the planning system such as permitted development process may create more waste though for example, being easier to demolish certain types of properties.<br>• Developers, owners and design teams make the assessment of refurbishment a priority when considering existing assets. | • Requirements in most planning applications to explain why existing buildings and structures cannot be retained.<br>• Provision of planning incentives for buildings that are retained. | |

## Act now

**Industry**

- Developers and asset owners promote refurbishment and reuse in their sustainability policies.
- Developers, asset owners and design teams consider reuse in the very first stages of project appraisal.
- Design teams advise on refurbishment and adaptive reuse options for existing assets.

Context

What else would advance the delivery of this ambition?

Click for Guidance

Back to Route Map

## Context

Demolition waste accounts for around 30-40 million tonnes of waste produced every year. This waste can be reduced by refurbishing buildings and infrastructure and extending their lifetimes, with associated benefits for whole life carbon. The decision on refurbishment versus demolition is complicated and will vary by sector; for example, some legacy structures may be not fit for purpose and impossible to upgrade. By contrast, there are many successful conversions and refurbishments of disused warehouses, forming new residential and commercial facilities.

There is growing attention to refurbish, rather than demolish and build new, largely being driven by the savings in embodied carbon, particularly when retaining the structure. There are other benefits, such as a lower level or risk involved, the programme can be faster and if its social housing, less disruption to the tenants. Other drivers include the changes in our building usage e.g. less retail units, which can be adapted for alterative use.

There is no Government policy or fiscal incentive to refurbish. Indeed there is currently a financial disincentive, as 20% VAT is applied on refurbishment as opposed to 0-5% on new build. Revision to planning policy, such as the permitted development process, could lead to more demolition waste.

# Encourage Refurbishment over Demolition

Aim: **Waste from demolition is reduced due to the widescale refurbishment of buildings and infrastructure**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government to review tax implications of refurbishment versus building new and avoid any unintended consequences.<br>• Government to assess if changes to the planning system such as permitted development process may create more waste though for example, being easier to demolish certain types of properties.<br>• Developers, owners and design teams make the assessment of refurbishment a priority when considering existing assets. | • Requirements in most planning applications to explain why existing buildings and structures cannot be retained.<br>• Provision of planning incentives for buildings that are retained. | |

## Act now

**Industry**

- Developers and asset owners promote refurbishment and reuse in their sustainability policies.
- Developers, asset owners and design teams consider reuse in the very first stages of project appraisal.
- Design teams advise on refurbishment and adaptive reuse options for existing assets.

Context

What else would advance the delivery of this ambition?

Click for Guidance

Back to Route Map

## What else would advance the delivery of this ambition?

- More guidance on the links between the refurbishment of buildings, the reduction of waste, and the reduction of environmental impact by professional institutions.
- Research: assess the impacts of refurbishment in wider society including the effects of waste generation and recovery.
- More case studies on refurbishment by developers and building owners showing the financial and environmental savings.
- Better information is required on what products and components have been used in a building.

# Guidance

Sources of data are listed, as well as some of the organisations and projects that are active in this area.

- Architects Journal, Retrofit First campaign
- UCL, Demolition or refurbishment of social housing? (2017)
- Greater London Authority Circular Economy Statement and Guidance
- David Cheshire, Building Revolutions – Applying the Circular Economy to the Built Environment Book (2019)
- Regenerate Tool for Circular Economy Design and Construction
- Adaptable Futures – case studies and tools
- Climate KIC Reusable Buildings, Final Report (2019)
- UK Green Building Council DEEP DIVE: The choice between demolition or reuse: developer insights
- H2020 CIRCuIT project
- Construction Leadership Council Greening Our Existing Homes National retrofit strategy A consultative document (2020)

Back to Route Map

Back to previous page

# Procure with Zero Waste in mind

Aim: **Construction procurement includes resource efficiency/ delivery of ZAW in evaluation prior to appointment of teams/contractors**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Included in procuring for value approaches with effective monitoring.<br>• Government to address resource efficiency in the Construction Playbook.<br>• Major private clients and developers adopt resource efficiency within their procurement processes. | • Consideration of waste is factored in and business-as-usual in public procurement decisions.<br>• Wide ranging private clients and developers adopt resource efficiency within their procurement processes. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Act now

**Clients**

- Set targets for waste reduction and recovery of waste in procurement contracts.
- Use established KPIs for waste arisings (e.g. tonnes of waste/100m$^2$ of floor area).
- When the procurement route allows, early involvement of the contractor, with the design team can assist in designing out waste and the reuse and recycling of waste materials.
- If requiring BREEAM or other schemes, make sure that the relevant waste credits are part of the assessment.

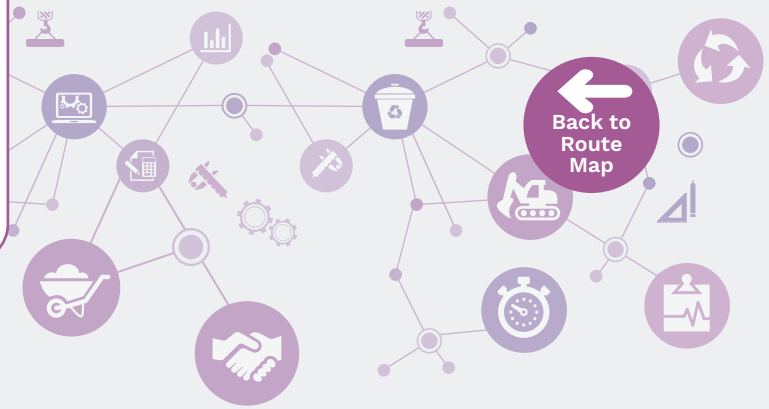
## Context

This is a key stage in the construction process and one which can have a significant influence on the waste stream of a project. Currently, lowest cost dominates the procurement process and decisions very rarely factor in the waste stream and end of life (EoL) implications. There is often little consideration of how different procurement routes or indeed different implementation teams may affect this. If it is not taken into account at this key stage, then any improvement is unlikely to happen.

In the public sector there are routes to embed waste within public procurement. The Construction Innovation Hub (CIH) is developing a 'procure for value' framework, which will be tested in various Government departments prior to roll out. In the Government's Construction Playbook, there is a recommendation that contracting authorities should adopt the use of whole life carbon assessments to understand and minimise the GHG emissions footprint of projects and programmes throughout their lifecycle, but there is currently no direct mention of waste – and it is recommended that consideration of waste is made explicit.

In the private sector, some leading developers are setting targets for waste, which includes the role of the procurement process, but such consideration is not commonplace.

Construction clients – both public and private – can, by setting project standards through BREEAM or LEED, influence construction waste. By including consideration of waste streams in procurement decisions (and the carbon and cost impacts) clients can put focus on this topic and play a key part in driving waste reduction.



# Procure with Zero Waste in mind

Aim: **Construction procurement includes resource efficiency/ delivery of ZAW in evaluation prior to appointment of teams/contractors**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Included in procuring for value approaches with effective monitoring.<br>• Government to address resource efficiency in the Construction Playbook.<br>• Major private clients and developers adopt resource efficiency within their procurement processes. | • Consideration of waste is factored in and business-as-usual in public procurement decisions.<br>• Wide ranging private clients and developers adopt resource efficiency within their procurement processes. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Act now

**Clients**

- Set targets for waste reduction and recovery of waste in procurement contracts.
- Use established KPIs for waste arisings (e.g. tonnes of waste/100m$^2$ of floor area).
- When the procurement route allows, early involvement of the contractor, with the design team can assist in designing out waste and the reuse and recycling of waste materials.
- If requiring BREEAM or other schemes, make sure that the relevant waste credits are part of the assessment.

## What else would advance the delivery of this ambition?

- A set of standardised questions, procurement clauses and specifications for Zero Avoidable Waste would assist in the uptake and provide robustness and consistency of the procurement process. To be developed by CIPS and relevant professional bodies.
- A library of case studies by professional bodies would be useful to present the procurement ‘ask’ in terms of ZAW, whether this was achieved and include lessons learnt.
- Research: there is little understanding of how different procurement routes and relationships with different parts of the supply chain affect waste generation and recovery. A research study could provide some evidence.

Back to Route Map

# Guidance

There is little current guidance specifically for construction waste and procurement- organisations such as WRAP developed procurement toolkits to encourage those procuring construction projects to set targets for zero waste to landfill and recycled content but have not been updated following the change in scope of WRAP. Examples of initiatives, guidance and relevant organisations are listed.

- Zero Waste Scotland Procuring Resource Efficient Construction Projects (2017)
- Construction Innovation Hub – Procuring for Value Toolkit (2021)
- HM Government – Construction Playbook (2021)
- Construction Leadership Council (CLC) Procuring for Value (2018)
- Northern Ireland Government Construction Clients Sustainability Action Plan (2012 – 2015)
- NI Public Procurement (Northern Ireland) Procurement Guidance Notes
- London 2012 Learning Legacy Procurement
- WRAP Cmyru Public Health Wales Sustainable Procurement Case Study (2016)
- Infrastructure and Ports Authority - Common Minimum Standards for the Procurement of Built Environment in the Public Sector (2017)
- UK Government Greening Government Commitments (2018)
- BRE BREEAM and CEEQUAL
- European Commission Green Public Procurement
- Construction Products Association (CPA) Procurement Guidance Tool
- Key Performance Indicators – available from BRE's SmartSite
- Chartered Institute of Procurement and Supply (CIPS)

Back to Route Map

Back to previous page

# Ensure materials are readily recoverable

Aim: **Ensure materials are recoverable at their highest value at end of life**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Materials and products have established recovery routes at end of life.<br>• Manufacturers continue to develop Resource Efficiency Action Plans and/or enter into voluntary agreements with Government.<br>• Continued R&D on recovery options for composite materials, working with Composites UK.<br>• Identify and communicate end of life options for new advanced materials. | • Advanced and new materials pose no problem for the waste stream.<br>• Manufacturers and/or third parties offer recycling schemes, including for composite and other difficult to recover waste streams.<br>• No composites or advanced/new materials are sent to incineration (energy from waste) at end of life.<br>• New generation of materials, products and components are available with enhanced recovery routes at end of life. | • All materials and products in construction can be dealt with at end of life to retain their highest value. |

## Act now

- Manufacturers provide information to design teams and contractors on end of life options for their products.
- Designers and contractors use Environmental Product Declarations (EPD) to determine recycled content and end of life routes to ensure no unintended life cycle impacts.
- Design teams avoid specifying materials and products that have no known recovery route.
- Design teams, manufacturers and contractors collaborate and share knowledge on new or improved recovery routes for advanced and new materials.

Context | What else would advance the delivery of this ambition? | Click for Guidance

Back to Route Map

## Context

Within construction product manufacturing processes it is common practice to reduce waste and recycle material and the uptake of recycled material is actively pursued provided it is of appropriate and consistent quality, is in sufficient quantity and is at a competitive price. Efforts to increase recycled content do need to be assessed through a life cycle assessment, as there is no point increasing recycled content at the cost of much greater carbon emissions.

Many UK-based manufacturers through their trade associations and working in collaboration with their supply chains have produced Resource Efficiency Action Plans (REAPs) with commitments to improve the waste performance of their products. In addition, many product and material sectors and manufacturers also have advanced sustainability strategies, which include waste and resource efficiency themes with targets and metrics.

Consideration must be given to how materials and products can be recovered to their highest waste value at the end of their life. Depending on the product they may be suitable for reuse or remanufacture or as a material, used as recycled feedstock for the same or different construction product or in a different sector.

Increasingly consideration is being given to what testing is required if a construction product is to be reused. The Steel Construction Institute for instance has developed a Protocol for the reuse of structural steel beams.

However, certain materials may present challenges for recovery at end of life. For example, advanced materials are being increasingly used in construction due to their inherent properties such as added strength and thermal performance but as yet there is little research on how these materials affect recovery routes at end of life. This includes nanomaterials, such as graphene, which may be used in concrete, glass and as coatings, as well as insulation and specialist steels. Other examples include Phase change materials which are used to store and release energy and may vary in their composition and how they are applied to the product. Or concrete with added macro fibres, aerogel and vacuum insulated panels. The increasing use of sensors embedded in products may well hinder easy recovery of materials at end of life.

The range of composite materials and products that will arise as waste is growing (e.g., wind turbines); research is being undertaken on the ability to recover them at end of life, which has significant technical challenges.

There is always the potential for new material, products, and components to be developed which offer improved environmental/sustainability/waste performance over existing solutions. Industry can shape requirements for improved future materials working with specialist material or component manufacturers.

# Ensure materials are readily recoverable

Aim: **Ensure materials are recoverable at their highest value at end of life**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Materials and products have established recovery routes at end of life.<br>• Manufacturers continue to develop Resource Efficiency Action Plans and/or enter into voluntary agreements with Government.<br>• Continued R&D on recovery options for composite materials, working with Composites UK.<br>• Identify and communicate end of life options for new advanced materials. | • Advanced and new materials pose no problem for the waste stream.<br>• Manufacturers and/or third parties offer recycling schemes, including for composite and other difficult to recover waste streams.<br>• No composites or advanced/new materials are sent to incineration (energy from waste) at end of life.<br>• New generation of materials, products and components are available with enhanced recovery routes at end of life. | • All materials and products in construction can be dealt with at end of life to retain their highest value. |

## Act now

- Manufacturers provide information to design teams and contractors on end of life options for their products.
- Designers and contractors use Environmental Product Declarations (EPD) to determine recycled content and end of life routes to ensure no unintended life cycle impacts.
- Design teams avoid specifying materials and products that have no known recovery route.
- Design teams, manufacturers and contractors collaborate and share knowledge on new or improved recovery routes for advanced and new materials.

Context | What else would advance the delivery of this ambition? | Click for Guidance

Back to Route Map

## What else would advance the delivery of this ambition?

- Research: research funded by Government is required to understand how the use of advanced materials may affect end of life options. As advanced materials are used in many sectors, projects could be cross-cutting.
- Research to remove any technological constraints to the reuse and recyclability of materials.
- Greater knowledge amongst manufacturers of how their products are managed at end of life and the options and resource implications. This may include detailed life cycle assessments.
- Longer term, it may be that Regulations are needed to regulate how some advanced materials are used, if they have a high waste impact.
- Composites UK to continue to work with other relevant organisations on recoverability and end of life issues.

# Guidance

A few of the organisations working in this area are listed, together with relevant guidance and other documentation.

- Construction Products Association and its members
- Veolia closes the loop with Knauf Insulation
- Protocol for Reusing Structural Steel
- Resource Efficiency Action Plans:
  - Zero Avoidable Waste in Flooring: Towards a Circular Economy (2021)
  - Bricks, Blocks and Concrete
  - Mineral Wool Ceiling Tiles
  - Decorative Paint
- Mineral Products Association Resource Reports
- TRADA Waste Reports
- Composites UK
  - Resource Efficiency Action Plan (2013)
  - Vision and Roadmap for Sustainable Composites (2019)
  - FRP Circular Economy Study (2018)
  - Composites Recycling – Where are we now? (2016)
  - What can I do with my waste?
  - Composites Strategy
- Composites Leadership Forum The 2016 UK Composites Strategy (2016)
- BRE Dealing with Difficult Demolition Wastes: A Guide (2013)
- Nanowerk
- Henry Royce Centre – UK National Institute for Advanced Materials Research and Innovation

Back to Route Map

Back to previous page

# Exploit off site manufacture

Aim: **The contribution of off-site/ modular construction towards ZAW is maximised**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Studies to look at total waste production, both in the factory and on site, material usage and end of life considerations.<br>• The efficiency benefits of using offsite/modular systems are promoted to clients and specifiers. | • Continued improvement of systems though waste reduction, and enhanced disassembly and material optimisation. | • All modular construction positively contributes to ZAW in its design, construction, operation and end of life. |

Context

What else would advance the delivery of this ambition?

Click for Guidance

## Context

For the purposes of this routemap, modular construction refers to the group of processes and techniques that combine reduced on-site construction programmes with efficient, good quality factory-based manufacture of transportable finished building sections. Modular offsite construction is a key part of the modernisation agenda due to its benefits of greater productivity and efficiency. The resultant industrialisation of the construction process reduces the amount of waste onsite, with some studies showing a reduction of up to 70%.

To maximise its contribution to ZAW, a better understanding is needed on how these systems can be recovered at end of life, and the number of materials that are used. It is important to avoid methods or materials in modular systems which may be difficult to deconstruct at end of life, resulting in a reduction in the amount of materials recovered.

## Act now

**Industry**

- Modular and offsite providers ensure that disassembly is designed into their processes and procedures.
- Modular and offsite providers and contractors measure and report on the type and amount of waste generated from this method, including waste that is generated in the factory and onsite.
- Modular and offsite providers engage with demolition contractors, through the National Federation of Demolition Contractors (NFDC) MMC working group and the Institute of Demolition Engineers to understand demolition processes and recovery routes at end of life.
- Modular and offsite providers and design teams undertake whole life carbon studies and life cycle assessment of offsite systems.
- Modular and offsite providers produce case studies, demonstrating how systems maybe suitable for reuse, through for example reconfiguration or relocation. This should include any economic, environmental, and social benefits.

Back to Route Map

# Exploit off site manufacture

Aim: **The contribution of off-site/ modular construction towards ZAW is maximised**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Studies to look at total waste production, both in the factory and on site, material usage and end of life considerations.<br>• The efficiency benefits of using offsite/modular systems are promoted to clients and specifiers. | • Continued improvement of systems though waste reduction, and enhanced disassembly and material optimisation. | • All modular construction positively contributes to ZAW in its design, construction, operation and end of life. |

Context

What else would advance the delivery of this ambition?

Click for Guidance

## What else would advance the delivery of this ambition?

- Research: a study supported by Government & Industry to understand the environmental impacts of modular construction through the construction lifecycle and how it contributes to ZAW especially at end of life. This could build upon on the Homes England research study which is monitoring the construction of around 1,500 homes with different types of modern methods of construction over several years.
- Development of industry guidance and Standards to include the effects on resource use through design and designing for reuse and recoverability at end of life by the professional institutions and trade bodies.
- Investigation of how Design for Manufacture and Assembly (DfMA) principles and related platforms can also include Design for Disassembly principles (which also encompass adaptability and flexibility), by bodies such as the Construction Innovation Hub, Build Offsite, and the Manufacturing Technology Centre.
- Transfer of knowledge of where there are already established business models of reuse, for example, the portable buildings sector. This could extend to understanding the opportunities of using reusable temporary solutions for meanwhile spaces and urgent building needs such as changes in housing requirements or in office density.

## Act now

**Industry**

- Modular and offsite providers ensure that disassembly is designed into their processes and procedures.
- Modular and offsite providers and contractors measure and report on the type and amount of waste generated from this method, including waste that is generated in the factory and onsite.
- Modular and offsite providers engage with demolition contractors, through the National Federation of Demolition Contractors (NFDC) MMC working group and the Institute of Demolition Engineers to understand demolition processes and recovery routes at end of life.
- Modular and offsite providers and design teams undertake whole life carbon studies and life cycle assessment of offsite systems.
- Modular and offsite providers produce case studies, demonstrating how systems maybe suitable for reuse, through for example reconfiguration or relocation. This should include any economic, environmental, and social benefits.

Back to Route Map

# Guidance

Some guidance and case studies are available for offsite construction and reducing waste, though most of these are over 5-10 years old. Key organisations are also listed.

- Construction Innovation Hub (CIH)
- Manufacturing Technology Centre
- Build Offsite
  - Offsite Construction – Sustainability Characteristics (2013)
- NHBC Foundation:
  - Modern Methods of Construction – who is doing what? (2018)
  - Modern Methods of Construction – views from the industry (2016)
- BRE – Dealing with Difficult Demolition Wastes: A Guide (2013)
- BSI – The role of Standards in Offsite Construction (2019)
- Offsite Hub – Has a number of WRAP case studies on reduction of waste
- RICS – Modern Methods of Construction A forward-thinking solution to the housing crisis? (2018)
- WRAP – Current Practices and Future Potential in Modern Methods of Construction (2007)
- Zero Waste Scotland Case studies:
  - New South Glasgow Hospital
  - Resource Efficient House Case Study (2014)
- London Olympics Learning Legacy Case Study – McDonald's: embedding sustainability into the design, construction and disassembly of their Olympic Park restaurant (2012)

Back to Route Map

Back to previous page

# Reduce volume of soil to landfill

Aim: **Reduction of soils to landfill to zero except for when needed for landfill operation purposes**

### 2020s

- Design Teams and contractors always seek to eliminate soils going to landfill.
- Analysis is made of the apportionment of soils to landfill between the building and infrastructure sectors.
- The institutions of respective sectors develop action plans and training to minimise or eliminate soils.
- Government to review the definition of waste for soils and other legislation to aid its reuse.
- Government to review Landfill Tax bands for different types of soils.
- Defra with local authorities to trial local intermediate storage sites for soils.

### 2030s

- Specific soils legislation is drafted with the aim of protecting it as a resource.
- A levy to be introduced by HMRC which is tiered based on the reuse options and benefits.

### 2040s

- By 2040 actions and improved practices result in soils going to landfill being reduced to 75% of 2020 level, zero by 2050.

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

Over 40% of the industry's waste is soil from excavation activities - in England in 2016 this amounted to 51.8 million tonnes. Of this large waste stream 26Mt (53%) was sent to landfill. Whilst it may be seen as a "safe" or even "natural" waste, and a small proportion may justifiably be used in the operation of landfill sites, the movement of so much material represents at the very least a significant economic and carbon cost. The Landfill Tax alone, excluding the cost of transport, handling and management of this waste stream was nearly £81 million in 2016. To achieve the desired reduction in landfill it is important that the transportation of millions of tonnes of soils to landfill is no longer seen as just an inevitable consequence of construction.

## Act now

With such a large waste stream there are many opportunities for reduction. With the obvious exception of a small number of types of site (e.g constrained sites in inner city areas) much can be done in design and construction to reduce the volume of material removed off site to landfill.

**Government**

- There is a clear need to understand how the generation of soils is apportioned between the two principal sectors generating this waste - Building and Infrastructure. This will enable each sector to develop its own action plan.

**Local authorities**

- Within design codes consider the location of buildings and how they relate to land use and the generation of excavation materials such as soils.

**Industry**

- Respective sectors can begin, ahead of accurate analysis, to form tailored action plans for improvements in both Infrastructure and Building.
- Design teams on projects of all sizes can consider appropriate site levels to optimise cut-and-fill, thereby eliminating the requirement to move soils to other sites, or landfill.
- Clients and design teams develop site layouts and landscape schemes that can retain excavated material on site.
- Civil engineers and contractors design and build foundations and drainage to minimise removal of excavated material from site.
- Contractors use CL:AIRE's The Definition of Waste: Development Industry Code of Practice (DoWCoP), which provides a management process for soils ceasing to become a waste.
- Clients and design teams allocate land within the development site for the storage of soils during the construction phase. This is important as soils are not classified as a waste until it leaves site.

# Reduce volume of soil to landfill

Aim: **Reduction of soils to landfill to zero except for when needed for landfill operation purposes**

### 2020s

- Design Teams and contractors always seek to eliminate soils going to landfill.
- Analysis is made of the apportionment of soils to landfill between the building and infrastructure sectors.
- The institutions of respective sectors develop action plans and training to minimise or eliminate soils.
- Government to review the definition of waste for soils and other legislation to aid its reuse.
- Government to review Landfill Tax bands for different types of soils.
- Defra with local authorities to trial local intermediate storage sites for soils.

### 2030s

- Specific soils legislation is drafted with the aim of protecting it as a resource.
- A levy to be introduced by HMRC which is tiered based on the reuse options and benefits.

### 2040s

- By 2040 actions and improved practices result in soils going to landfill being reduced to 75% of 2020 level, zero by 2050.

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- CL:AIRE's DoWCoP, is a process to enable soils to be reused and not to be classified as waste. It has been successful to date with it being used for 120 million $m^3$ of soil in 10 years (equivalent to approximately 180 million tonnes); in 2021 this was 25 million $m^3$ (approximately 37.5 million tonnes). However, there are recommendations to improve the existing system including how it is used for smaller amounts of soils waste arsing allowing for a 'lite touch'. The Environment Agency and CL:AIRE are key stakeholders for this.
- BRE could add more credits for soil reuse in the environmental certification schemes: BREEAM and CEEQUAL.
- The development of a system of regional, long term storage facilities by local authorities with Government assistance would allow for the storage of materials that may be suitable for reuse on other projects in the future. An example of this is the Grondbank soil management system which is being used in Flanders, Belgium.
- Landfill operators need to ascertain how much material is actually needed for engineering and cover purposes on non-hazardous waste landfill sites.
- It is often cheaper to send soils to landfill than it is to move it from site to site. It could be that there is a new landfill tax bracket for non-hazardous soils.
- Research: more research in the UK on the potential of reusing soils in various applications such as rammed earth walls.

## Act now

With such a large waste stream there are many opportunities for reduction. With the obvious exception of a small number of types of site (e.g constrained sites in inner city areas) much can be done in design and construction to reduce the volume of material removed off site to landfill.

**Government**

- There is a clear need to understand how the generation of soils is apportioned between the two principal sectors generating this waste - Building and Infrastructure. This will enable each sector to develop its own action plan.

**Local authorities**

- Within design codes consider the location of buildings and how they relate to land use and the generation of excavation materials such as soils.

**Industry**

- Respective sectors can begin, ahead of accurate analysis, to form tailored action plans for improvements in both Infrastructure and Building.
- Design teams on projects of all sizes can consider appropriate site levels to optimise cut-and-fill, thereby eliminating the requirement to move soils to other sites, or landfill.
- Clients and design teams develop site layouts and landscape schemes that can retain excavated material on site.
- Civil engineers and contractors design and build foundations and drainage to minimise removal of excavated material from site.
- Contractors use CL:AIRE's The Definition of Waste: Development Industry Code of Practice (DoWCoP), which provides a management process for soils ceasing to become a waste.
- Clients and design teams allocate land within the development site for the storage of soils during the construction phase. This is important as soils are not classified as a waste until it leaves site.

# Guidance

There is some guidance on how soils should be managed and when it is a waste; this includes:

- Association of Geotechnical and Geoenvironmental Specialists Waste Classification for Soils – A Practitioners' Guide (2019)
- Capita Symonds Construction, demolition and excavation waste arisings, use and disposal for England 2008; CON900-001: Final Report, WRAP (2010)
- Society of the Environment Soil sand Stones Task Group - Soils and Stones Report: Sustaining Our Future by Influencing Change in the UK and Beyond (2021)
- CECA Waste Classification & Permitting In Construction Guidance for the construction industry on the Waste Permitting Regime (2019)
- CL:AIRE
  - Definition of Waste: Code of Practice
  - The Definition of Waste: Development Industry Code of Practice (2011)
- Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009)
- IEMA (2021) IEMA GUIDE: A New Perspective on Land and Soil in Environmental Impact Assessment – to be published shortly.

There are also some case studies:

- CrossRail
  - The restoration of Wallasea Island (2017)
  - Excavated Materials Story (2017)
  - The transport and beneficial reuse of Crossrail excavated material (2015)
- HS2 Excavated materials strategy (2017)
- National Grid London Power Tunnels – Soil reclamation and reuse
- London Olympics Waste Recovery Licenses (2011)

Back to Route Map

Back to previous page

# More reuse and recycling of new build construction waste

Aim: **The reuse of surplus products and materials from new build construction, and recycling of waste into the same products or products equivalent in value is standard practice**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Targets are within contractual documentation for the reuse and recycling of key products and waste materials.<br>• Improved training of the construction work force for the separation of materials on site.<br>• Resource Management Plan for most projects in place including commitments for reuse and recycling.<br>• Extended Producer Requirements by Government are in place for suitable materials by the mid 2020s.<br>• New venture businesses that reuse and recycle construction waste are stimulated through start-up support schemes. | • Updating of Extended Producer Responsibility Requirements.<br>• A mature supply chain of businesses reusing products and recycling waste streams. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

There is an opportunity to reuse more products and materials that are generated as waste as part of the new build construction process. These may be surplus materials and offcuts. It is preferable for the construction sector to retain these products and materials so they do not become waste. If reuse is not suitable, then they should be recycled. Whilst there are high recycling rates for wasted construction materials, some are downcycled and although this can avoid landfill, it significantly reduces their value. Recycling of these materials is a commercial activity primarily driven by the value of materials and the markets for them. It is important that there is adequate segregation either onsite or at a waste transfer station, to ensure a consistent quality of feedstock. There is a lack of reporting of what happens to waste once it reaches a waste facility – be it recycling at constant value, or downcycling. Without legislation being in place, the key drivers for reuse and recycling waste will remain cost reduction and/or alignment with corporate social responsibility goals.

It is noted that in the manufacturing processes for the many components and materials used in construction, use of recycled content has been actively pursued and it is common practice to reduce waste and recycle. However, waste from this manufacturing process is currently recorded and classified in the manufacturing statistics – it is not a measure of recycling in the construction industry.

There have been many initiatives that have encouraged contractors to manage their waste appropriately and recover as much as possible, including the Site Waste Management Plans (SWMPs) as a voluntary code of practice in July 2004. These were made mandatory in 2008 but were repealed as part of the Red Tape Challenge in 2013. However, these continue to be used as good practice by many leading contractors and are more commonly known as Resource Management Plans and are a requirement of BREEAM. Legislating these would enable them to more widely adopted.

## Act now

**Contractors**

- Prioritize reuse over recycling for suitable products and materials.
- Find out what is happening to your waste, once it enters a waste transfer station; for example, where is it being sent and how it is being recycled.
- Put requirements for reuse of products and recycling of key materials into your subcontractor and waste contracts.
- Identify which materials are being downcycled (losing their value) and establish the reasons why; is there anything you could do differently to enable them to be upcycled?
- Make use of opportunities to reuse and recycle materials such as third-party specialists, manufacturers take back schemes and social enterprises.
- Share best practice for waste materials, in the form of case studies where they have been reused or recycled back into the same product or into a new one.

**Government**

- Consult and request proposals from industry for new ways of dealing with the construction waste stream from both existing manufacturers and suppliers, and also from potential new entrants.
- Review the fiscal and logistical incentives that could be offered to enable both new start-ups in this sector, and existing operators to increase reuse and recycling operations.
- Work with the industry to determine barriers for reuse and recycling and how these might be overcome from a Regulation perspective.

Back to Route Map

# More reuse and recycling of new build construction waste

Aim: **The reuse of surplus products and materials from new build construction, and recycling of waste into the same products or products equivalent in value is standard practice**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Targets are within contractual documentation for the reuse and recycling of key products and waste materials.<br>• Improved training of the construction work force for the separation of materials on site.<br>• Resource Management Plan for most projects in place including commitments for reuse and recycling.<br>• Extended Producer Requirements by Government are in place for suitable materials by the mid 2020s.<br>• New venture businesses that reuse and recycle construction waste are stimulated through start-up support schemes. | • Updating of Extended Producer Responsibility Requirements.<br>• A mature supply chain of businesses reusing products and recycling waste streams. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- Contractors are driven by client requirements - clients need to be clear on their ambition for waste and their preferences for reuse and recycling.
- More onus needs to be placed on reuse where it is suitable, this could be via clients setting requirements for reuse or contractors within their CSR commitments.
- Viable commercial models need to exist for moving up the waste hierarchy and to reuse and recycle products. Some of these exist for certain materials e.g. closed loop recycling of plasterboard but Government should work with manufacturers and third party suppliers to develop new approaches where these do not currently exist. Regulation, in the form of Extended Producer Responsibility maybe required for certain materials, such as those which have may have a shorter lifespan, e.g flooring or a high value as a feedstock, e.g glass.
- Research: It may be that in some cases, some types of recycling and recovery could cause more of an environmental impact than others (for example if waste is having to be transported a long way to be recycled as aggregates). Robust evidence is needed to aid decision making and the formation of guidan0ce.
- Closer collaboration with the waste industry to understand the UK waste infrastructure capacity and how this ties into higher value levels of recovery now and in the longer term.

## Act now

**Contractors**

- Prioritize reuse over recycling for suitable products and materials.
- Find out what is happening to your waste, once it enters a waste transfer station; for example, where is it being sent and how it is being recycled.
- Put requirements for reuse of products and recycling of key materials into your subcontractor and waste contracts.
- Identify which materials are being downcycled (losing their value) and establish the reasons why; is there anything you could do differently to enable them to be upcycled?
- Make use of opportunities to reuse and recycle materials such as third-party specialists, manufacturers take back schemes and social enterprises.
- Share best practice for waste materials, in the form of case studies where they have been reused or recycled back into the same product or into a new one.

**Government**

- Consult and request proposals from industry for new ways of dealing with the construction waste stream from both existing manufacturers and suppliers, and also from potential new entrants.
- Review the fiscal and logistical incentives that could be offered to enable both new start-ups in this sector, and existing operators to increase reuse and recycling operations.
- Work with the industry to determine barriers for reuse and recycling and how these might be overcome from a Regulation perspective.

# Guidance

Much guidance and case studies have been produced on construction and demolition waste management including from WRAP, but these have not been updated following the change in scope of WRAP. There was also much guidance produced for undertaking Site Waste Management Plans. Some of the key ones are listed. More information on Reuse is within the Better waste services for smaller companies section.

**Best Practice Guidance**

- EU Construction & Demolition Waste Management Protocol (2018)
- BRE
  - Material resource efficiency in construction: Supporting a circular economy (FB 85) ¬ (2017)
  - BREEAM Construction Waste Management Credit
  - CEEQUAL
- Environment Agency and WRAP Quality Protocol Aggregates from Inert Waste (2013)
- CIWM Construction and Demolition Waste Forum What is Waste Guide (2019)
- Civil Engineering Contractors Association (CECA) Waste Classification & Permitting In Construction Guidance for the construction industry on the Waste Permitting Regime (2018)
- CIRIA's Environmental good practice on site guide (C741) (2015)
- Zero Waste Scotland Maximising reuse of materials on-site
- Zero Waste Scotland Best practice guide to improving waste management on construction sites
- Supply Chain Sustainability School
  - Waste information including map of material exchange schemes
- NetRegs Environmental guidance for businesses in Northern Ireland & Scotland
- Crossrail Recycled Content in Construction materials (2017)

**Site Waste Management Plans**

- Defra The Site Waste Management Plans Consultation (2013)
- Defra Public Consultations. Proposed repeal of construction Site Waste Management Plan Regulations (2008) Summary of responses and Government response (2013)
- NetRegs Site Waste Management Plans
- BRE SmartSite tool
- Zero Waste Scotland SWMP Lite
- NHBC Foundation Site waste management: guidance and templates for effective site waste management plans (NF8) (2008)

Back to Route Map

Back to previous page

# Reduce waste from temporary works

Aim: **There is no waste landfilled from temporary work on-site such as fencing panels, hoarding, shuttering, crane bases, protection etc; reuse is the norm**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The reuse of temporary works items across construction projects is common practice, suppliers providing reuse services and contractors requiring these.<br>• Manufacturers of temporary systems to design for reuse through modularization and standardisation, for example, steel support structures. | • The reuse of temporary works items via leasing and buy/take back models is the norm.<br>• Products which are used for temporary works are designed to be reused and repaired. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

Items used as temporary works on construction sites are often considered to be disposable, are not given the same attention as the permanent works and so readily enter the construction waste stream. It is often seen as quicker and cheaper to dispose of items rather than to reuse them. Whilst there are a few products used in temporary works such as hoarding and temporary protection which are now becoming available for reuse or can be taken back for recycling, there is opportunity to do more.

## Act now

**Contractors**

- Measure and report on the amount of waste generated from temporary works and how much is reused, recycled, recovered, or sent to landfill. Develop a list of items where there is the most potential for reuse.
- Engage with suppliers to understand if you can lease temporary work items such as hoarding, which can be returned for reuse.
- Provide space to store reusable temporary work items and a management system to track their delivery to site, uses and subsequent return.
- Use schemes such as material exchanges, local websites etc., if items cannot be reused on your other sites or cannot be returned to suppliers.
- Establish the types of equipment, plant and tools that should be prioritised for repair rather than disposal and engage with specialist suppliers for support.
- Write up case studies, demonstrating the environmental and economic benefits of reusing temporary work items.

Back to Route Map

# Reduce waste from temporary works

Aim: **There is no waste landfilled from temporary work on-site such as fencing panels, hoarding, shuttering, crane bases, protection etc; reuse is the norm**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The reuse of temporary works items across construction projects is common practice, suppliers providing reuse services and contractors requiring these.<br>• Manufacturers of temporary systems to design for reuse through modularization and standardisation, for example, steel support structures. | • The reuse of temporary works items via leasing and buy/take back models is the norm.<br>• Products which are used for temporary works are designed to be reused and repaired. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- More case studies of best practice from contractors and suppliers to show how temporary works items can be reused and made available through relevant training and professional bodies.
- Development of guidance to aid the reuse of temporary work items, to include aspects such as designing for reuse, procurement routes and reuse/repair options through existing bodies.
- Research: short studies to understand the feasibility of different reuse options for temporary work items including the economic, social and environmental impacts.
- The role of product tagging in enabling reuse is worthy of investigation by suppliers. There are a few examples of where tagging has been used on temporary work items driven largely by the need to ensure that it has been approved for use and checked as required, especially for plant and lifting equipment.
- Fiscal incentives, such as reduced VAT, could offer a way to promote products that can be leased (for reuse) and repaired or remanufactured.

## Act now

**Contractors**

- Measure and report on the amount of waste generated from temporary works and how much is reused, recycled, recovered, or sent to landfill. Develop a list of items where there is the most potential for reuse.
- Engage with suppliers to understand if you can lease temporary work items such as hoarding, which can be returned for reuse.
- Provide space to store reusable temporary work items and a management system to track their delivery to site, uses and subsequent return.
- Use schemes such as material exchanges, local websites etc., if items cannot be reused on your other sites or cannot be returned to suppliers.
- Establish the types of equipment, plant and tools that should be prioritised for repair rather than disposal and engage with specialist suppliers for support.
- Write up case studies, demonstrating the environmental and economic benefits of reusing temporary work items.

Back to Route Map

# Guidance

There is no guidance currently available specifically on temporary works and reduction of waste; however, the following organisations do provide information that may be useful and relevant:

- Temporary Works Forum
- Considerate Construction Scheme case studies:
  - Hoarding made from recycled U-PVC
  - Hoarding reused at a local school
  - Hoarding reused from one contractor to another
  - Reuse of a shuttering system
  - Repurposing of scaffolding
  - Closed loop recycling or temporary protection
- Supply Chain Sustainability School – Map of material exchange schemes
- Construction Plant-hire Association
- CITB – Temporary Works Co-ordinator Training Course
- Institution of Civil Engineers Temporary Works: Principles of design and construction Book
- Institution of Structural Engineers – Temporary Works Toolkit

Back to Route Map

Back to previous page

# Better waste services for smaller companies

Aim: **Improved waste management services for smaller companies in the construction sector are available to lever ZAW in this sector**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Establish the size and nature of the SME construction waste stream.<br>• Innovative trials and mechanisms to help SMEs to better manage their waste are developed and improvements rolled out.<br>• A number of local initiatives are available for SMEs to reuse and recycle waste. | • Widely available services across England by 2030. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

There is very little information on the overall contribution to construction waste and waste to landfill from the SME construction sector, and it is important that studies are undertaken, and engagement improved to better understand the needs of this sector.

Construction SMEs currently almost entirely rely on waste management companies to segregate and recover their waste; it is not clear how to learn lessons with this waste stream and plan improvements. Whilst some SME builders may use systems where surplus materials can be sold/exchanged locally there is little visibility where this is happening successfully. There are only limited local opportunities for managing this waste differently such as 'round robin' schemes or storing items for reuse e.g. Community Wood Recycling.

There is no central programme offering support and advice to SMEs to either reduce their construction waste arising or being able to recover more of it apart from a few regionally funded projects, such as EnTRESS. Government has provided support in the past through programme's such as Envirowise in the 2000s; this type of funded programme no longer exists.

## Act now

**Building merchants**

- Set up easy to use and cost effective sale and return services for builders to use.

**SME contractors**

- Utilise schemes such as Community Wood Recycling and online material exchanges for products that may be able to be reused.
- Share both excess materials and recovered materials and products on local platforms and networks for reuse.
- Use your sale or return service for surplus materials provided by local builder's merchants.
- Use local authority recycling routes for waste materials in the local area.
- Use suitable containers/ bags for smaller amounts of waste, to segregate materials that can be sent directly for recycling e.g. timber, plasterboard and metals.

**Government & Industry**

- There is a need to establish the amount and composition of SME construction waste, and what is going to landfill. This will inform the next stage of action planning with the sector.

Back to Route Map

# Better waste services for smaller companies

Aim: **Improved waste management services for smaller companies in the construction sector are available to lever ZAW in this sector**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Establish the size and nature of the SME construction waste stream.<br>• Innovative trials and mechanisms to help SMEs to better manage their waste are developed and improvements rolled out.<br>• A number of local initiatives are available for SMEs to reuse and recycle waste. | • Widely available services across England by 2030. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- Research: we do not know what proportion of the overall construction waste is generated by smaller builders compared to say, the top 100 contractors. A study, promoted by Government & Industry could establish this and determine where to focus our efforts in avoiding this waste.
- Whilst better guidance to SMEs will be useful, consideration is needed of the most effective way of communicating to the sector. One to one support does show changes in behaviour and is likely to be worth the cost of support. Easy, accessible solutions are required such as online training, working with trade and business associations.
- Local authorities can investigate opportunities to help SMEs manage their waste better, through for example, Household Waste Recycling Centres, storage yards for reuse of materials and sharing systems.
- Mechanisms that could assist SMEs in managing their waste include support from builders' merchants in the form of information provision, takeback of materials, widespread sale or return schemes, round robin (milk round collections), utilising social enterprises and online applications. Government should provide solutions to any potential regulatory barriers, such as the need for environmental permits.
- Trade bodies that represent construction SMEs can engage with the waste industry to understand if there are opportunities to offer different services such as bin types and collection.

## Act now

**Building merchants**

- Set up easy to use and cost effective sale and return services for builders to use.

**SME contractors**

- Utilise schemes such as Community Wood Recycling and online material exchanges for products that may be able to be reused.
- Share both excess materials and recovered materials and products on local platforms and networks for reuse.
- Use your sale or return service for surplus materials provided by local builder's merchants.
- Use local authority recycling routes for waste materials in the local area.
- Use suitable containers/ bags for smaller amounts of waste, to segregate materials that can be sent directly for recycling e.g. timber, plasterboard and metals.

**Government & Industry**

- There is a need to establish the amount and composition of SME construction waste, and what is going to landfill. This will inform the next stage of action planning with the sector.

Back to Route Map

# Guidance

There is some guidance available for SMEs with regard to construction waste; though a lot of it is quite old. Relevant organisations have also been listed.

- Envirowise
  - Reducing your construction waste: Guidance for small and medium sized contractors
  - Managing packaging waste on your construction sites
- NetRegs – Environmental guidance for businesses in Northern Ireland & Scotland
- Zero Waste Scotland Construction Waste Resources
- Environmental Services Association Right Waste Right Place Campaign
- Civil Engineering Contractors Association (CECA) Waste Classification & Permitting In Construction Guidance for the construction industry on the Waste Permitting Regime (2018)
- Supply Chain Sustainability School
  - Waste information including map of material exchange schemes
- EnTRESS project – support to SMES on low carbon and resource efficiency in the Black Country, Stoke and Staffordshire
- Finishes and Interiors Sector (FIS) Sustainability Hub
- Defra; Duty of Care: Code of Practice (2018)
- CIRIA's Environmental good practice on site guide (C741) (2015)
- Constructing Excellence
- Local Recycling Advisory Committee (LARAC)

Back to Route Map

Back to previous page

# Waste from Refurbishment is reduced

Aim: **The waste stream from refurbishment is substantially reduced**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The reuse of products and materials from commercial refurbishment is the preferred recovery route.<br>• Pre-refurbishment audits become best practice on all major refurbishment projects.<br>• The waste implications from retrofit policies are understood and do not add to landfill.<br>• Pilot projects to trial the leasing of many of the components of short/medium lease tenancies – aligning leasing of fit out with lease of space. | • Pre-refurbishment audits become best practice on most refurbishment projects.<br>• Leasing models dominate the procurement model for suitable interior products. | • Fit out products commonly stay in place when the tenant changes. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Act now

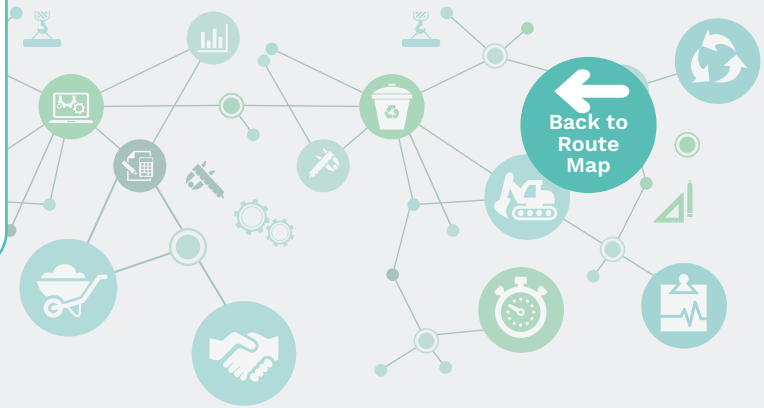
**Building owners**

- Make sure a pre-refurbishment audit is undertaken as early as possible.
- Set targets for the reuse of products in refurbishment contracts.
- Utilise one of the growing organisations that can help with finding reuse routes.
- For commercial tenanted buildings optimise the scope of Cat A vs Cat B fit out to minimise waste when tenancies change.
- Check your tenant contracts, from a waste perspective – having to 'make good' to items which the next tenant may remove will create waste that could be avoided.
- Certain items may be able to be leased in, such as lighting, carpet tiles and returned to the manufacturer or third party for reuse/remanufacture.

## Context

There is no data about waste generated from refurbishment activities in all sectors of the market and how it is managed. This needs to be addressed to properly inform waste reduction and recovery actions. In the commercial office and retail sectors, units are refitted every 5-7 years respectively on average, with some products regularly replaced. Waste can also occur from requiring tenanted office space to be 'made good' at the end of a contract. The replacement of Cat A and Cat B fixtures and fittings due to tenants demands is understood to occur regularly. Due to short life cycles of some of these interior fit outs, some products will be suitable for reuse e.g. carpet tiles, ceiling tiles, raised access flooring etc or for remanufacture in the case of lighting and some HVAC equipment. Older buildings may have products that are suitable for architectural salvage e.g. cast iron fireplaces, doors and wood panelling.

In the housing sector, domestic retrofit polices for carbon reduction may lead to the replacement of heating and hot water installations and upgrading of doors and windows across the building stock. The waste stream may be substantial and there will be a need to optimise the way in which redundant components and materials are dealt with.



# Waste from Refurbishment is reduced

Aim: **The waste stream from refurbishment is substantially reduced**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The reuse of products and materials from commercial refurbishment is the preferred recovery route.<br>• Pre-refurbishment audits become best practice on all major refurbishment projects.<br>• The waste implications from retrofit policies are understood and do not add to landfill.<br>• Pilot projects to trial the leasing of many of the components of short/medium lease tenancies – aligning leasing of fit out with lease of space. | • Pre-refurbishment audits become best practice on most refurbishment projects.<br>• Leasing models dominate the procurement model for suitable interior products. | • Fit out products commonly stay in place when the tenant changes. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

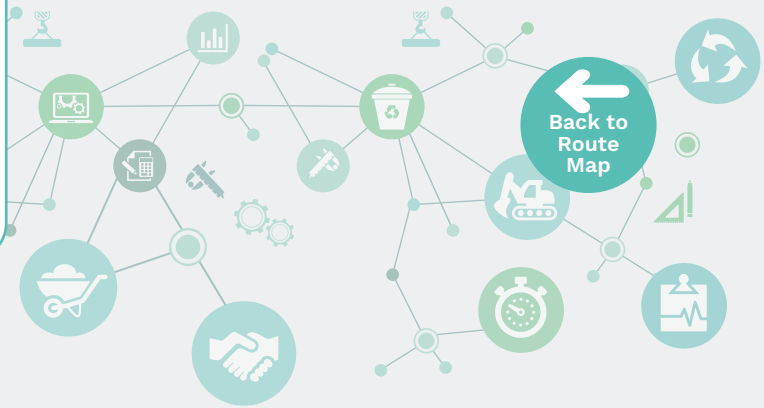
## What else would advance the delivery of this ambition?

- Research: Whilst there are some benchmarks for how much refurbishment waste is created relative to the floor area of a project, it is not known how much is created by refurbishment activities overall and what happens to this waste; therefore, a study is needed.
- Development of good practice guidelines for different building types with the relevant professional and trade associations.
- Case studies by RICS and BRE of successful reduction and reuse of refurbishment waste from applying the Ska Assessment and BREEAM.
- More technologies such as Virtual Reality to be utilised, so building interiors are not finished until they are leased to the tenants; this would reduce waste by not having to remove products which do not suit the needs of the incoming tenant.
- Awareness raising of managing agents on the waste impact when changing the interior layout and associated components for new tenants.
- Government incentives or Regulation maybe needed to encourage more reuse.

## Act now

**Building owners**

- Make sure a pre-refurbishment audit is undertaken as early as possible.
- Set targets for the reuse of products in refurbishment contracts.
- Utilise one of the growing organisations that can help with finding reuse routes.
- For commercial tenanted buildings optimise the scope of Cat A vs Cat B fit out to minimise waste when tenancies change.
- Check your tenant contracts, from a waste perspective – having to 'make good' to items which the next tenant may remove will create waste that could be avoided.
- Certain items may be able to be leased in, such as lighting, carpet tiles and returned to the manufacturer or third party for reuse/remanufacture.



# Guidance

There is limited guidance and case studies in this area. Information on reuse has also been included.

**Best Practice Guidance**

- Better Building Partnerships
  - Responsible Property Management Toolkit
  - Strip out waste guide (2015)
- RICS Ska Rating
- BRE BREEAM Refurbishment and Fit Out Standard
- Finishes and Interiors Sector (FIS) Client Guide to Office Fit out and Refurbishment (2018)
- CIRIA, Fit-out environmental good practice on site guide (C757) (2016)
- British Council for Offices (BCO) Fit Out Guide (2011)
- UK Green Building Council (UKGBC) – Implementation Packs for leasing and reuse (2020)
- Crown Estate
  - Fit Out Guide for Offices
  - Fit Out Guide for Leisure and Retail
- Grosvenor Sustainable Refurbishment: a Toolkit for Going Green (2013)
- BRE Code of Practice for a Pre-redevelopment audit (2017)

**Reuse information**

- Salvo, Architectural Salvage
- Bioregional and WRAP (2008) Reclaimed Building Guidance
- Supply Chain Sustainability School
  - Waste information including map of material exchange schemes
- Zero Waste Scotland Maximising reuse of materials on-site

Back to Route Map

Back to previous page

# Less down cycling of waste from Demolition

Aim: **Materials arisings from demolition are reused or sent for open/closed loop recycling**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Pre-demolition audits are undertaken on all major projects, preferably through requirements in Building Regulations.<br>• Reuse of products is required to be considered for all major projects as part of the demolition permitting system.<br>• More materials arising from demolition can be sent for open or closed loop recycling.<br>• End of waste criteria and quality protocols are reviewed for existing materials and developed for other materials to enable more recycling. | • Pre-demolition audits are undertaken on most projects, preferably through requirements in Building Regulations.<br>• Reuse of products is required to be considered for most projects as part of the permitting system. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

The members of the National Federation of Demolition Contractors (NFDC) generated nearly 25 million tonnes of waste in 2018 (this is from 145 companies across the UK). Of this around 96% is recovered. However, the amount that is salvaged for reuse has decreased significantly (an estimated 750,000 tonnes in 2011) due to a variety of reasons including matching supply with demand, health and safety implications, risk implications, the cost of dismantling and storage.

Many products are of relatively low value, so at end of life it can be too costly to make them available for reuse, compared to a new product. However, some products, such as steel, slate tiles, solid wood, are suitable for reuse or repurposing. For recycling, much of the demolition waste is downcycled (it loses its value); concrete and brick waste is regularly crushed on site and used as fill. Timber may either be sent for energy as biomass or chipped for particle board. Plasterboard may be sent for recycling or spread on land. Some waste will be sent off mixed from the demolition site and sorted at the waste transfer station for recovery.

Takeback schemes that exist for a growing number of materials, often do not take back materials arising from demolition. Some materials such as asbestos and certain treated timbers are are hazardous and can be difficult to recycle. Pre-demolition audits are becoming more common through requirements from BREEAM and the London Plan Circular Economy Statement; guidelines also exist for the structural reuse of products such as steel.

It appears that more recent buildings are beginning to present challenges to the efficient demolition / deconstruction process due to increased use of bonded and composite materials compared to older building stock. More information is needed from the demolition industry to enable improved “end of life” planning by design teams.

## Act now

**Building owners**

- Make sure a pre-demolition audit is undertaken as early as possible so the recommendation can feed into the design process and/or markets can be found for reuse.
- Set targets for the reuse of products in demolition contracts.
- Set targets for open and close loop recycling of materials within demolition contracts.
- Have early involvement of the demolition contractor.

**Demolition contractors**

- Discuss and plan with the client and/or contractor the reuse and recycling routes for products and materials.
- Advise the client and/or contractor on the value of materials at end of life.
- Make use of the growing number of reuse organisations and architectural salvage companies.

**Government**

- Work with the industry to determine barriers for reuse and recycling and how these might be overcome from a Regulation perspective.
- Fund a study to understand the levels and related trends of reuse for different types of construction products.

Back to Route Map

# Less down cycling of waste from Demolition

Aim: **Materials arisings from demolition are reused or sent for open/closed loop recycling**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Pre-demolition audits are undertaken on all major projects, preferably through requirements in Building Regulations.<br>• Reuse of products is required to be considered for all major projects as part of the demolition permitting system.<br>• More materials arising from demolition can be sent for open or closed loop recycling.<br>• End of waste criteria and quality protocols are reviewed for existing materials and developed for other materials to enable more recycling. | • Pre-demolition audits are undertaken on most projects, preferably through requirements in Building Regulations.<br>• Reuse of products is required to be considered for most projects as part of the permitting system. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- Research: work with the National Federation of Demolition Contractors (NFDC) to have a better understanding of the recovery routes for different materials and the cost and other implications of changing these. For example, there is a need for recycled aggregates of which most come from demolition waste. There is also a need to use materials for fill applications.
- Research: a study to establish any real or perceived issues of risk related to the reuse of materials arising from demolition and how these can be overcome.
- Clients to collaborate with architectural salvage companies and Salvo on how more products could be salvaged for reuse.
- NFDC, Salvo and other reuse organisations to develop case studies on how products have been reused from projects.
- Provision of more technical guidance by relevant trade associations to enable the reuse of structural products.
- Government incentives or Regulation maybe needed to encourage more reuse and higher quality recycling.

## Act now

**Building owners**

- Make sure a pre-demolition audit is undertaken as early as possible so the recommendation can feed into the design process and/or markets can be found for reuse.
- Set targets for the reuse of products in demolition contracts.
- Set targets for open and close loop recycling of materials within demolition contracts.
- Have early involvement of the demolition contractor.

**Demolition contractors**

- Discuss and plan with the client and/or contractor the reuse and recycling routes for products and materials.
- Advise the client and/or contractor on the value of materials at end of life.
- Make use of the growing number of reuse organisations and architectural salvage companies.

**Government**

- Work with the industry to determine barriers for reuse and recycling and how these might be overcome from a Regulation perspective.
- Fund a study to understand the levels and related trends of reuse for different types of construction products.

Back to Route Map

# Guidance

Much guidance has been produced on construction and demolition waste management including WRAP guidance and case studies – but these have not been updated following the change in scope of WRAP. There was also much guidance produced for undertaking Site Waste Management Plans. Some of the key ones are listed, as is information for reuse.

**Best Practice Guidance**

- NFDC Demolition Refurbishment Information Datasheets
- Bioregional Reuse and Recycling on the London 2012 Olympic Park (2012)
- EU Construction & Demolition Waste Management Protocol (2018)
- BRE Material resource efficiency in construction: Supporting a circular economy (FB 85) – (2017)
- Environment Agency and WRAP Quality Protocol Aggregates from Inert Waste (2013)
- CIWM Construction and Demolition Waste Forum What is Waste Guide (2019)

**Pre refurbishment and demolition audits**

- European Commission Guidelines for the waste audits before demolition and renovation works of buildings (2018)
- BRE Code of Practice for a Pre-redevelopment audit (2017)
- VTT Pre-demolition audit – overall guidance (2019) document

**Reuse information**

- Steel Construction Institute (SCI) Protocol for reusing structural steel (2019)
- Salvo, Architectural Salvage
- Bioregional and WRAP (2008) Reclaimed Building Guidance

**Supply Chain Sustainability School**

- Waste information including map of material exchange schemes
- Zero Waste Scotland Maximising reuse of materials on-site

**Site Waste Management Plans**

- Defra The Site Waste Management Plans Consultation (2013)
- Defra Public Consultations. Proposed repeal of construction Site Waste Management Plan Regulations (2008) Summary of responses and Government response (2013)
- NetRegs Site Waste Management Plans
- BRE SmartSite tool
- Zero Waste Scotland SWMP Lite

Back to Route Map

Back to previous page

# Accurate asset information available in digital form

Aim: **Widespread availability of digital information on construction assets, giving easy access to material and component data facilitating reuse and recycling to deliver ultimately a circular economy**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Hackitt Review Golden Thread / digital twin of buildings implemented.<br>• Location and method of data storage reviewed on a national basis, working practice in place by 2025.<br>• Consultation with multiple property owners and agreement on asset record format in place by 2025.<br>• Data security protocols and working practices for holding BIM models are discussed and agreed by 2030.<br>• Benefits to specifiers, insurers and owners communicated widely. | • From 2030, access to data about buildings and infrastructure is accessible with secure protocols. | |

Context

What else would advance the delivery of this ambition?

Click for Guidance

## Act now

**Industry**

- Designers and contractors obtain information on end of life options from Environmental Product Declarations (EPD).
- Design teams and contractors review the compatibility of BIM software to store relevant product information.
- Contractors include end of life data in the handover information and in the O&M manual.
- Facility managers and asset owners can make sure BIM models are kept up to date.

## Context

Digitalisation of construction is a central part of the modernisation agenda for the construction sector, encompassing digitalisation of products, structures, and systems. Although the primary focus of the digitalisation programme is to increase productivity and efficiency, the resultant information on materials and products is essential when considering reuse at end of life.

This is because to manage a circular flow of materials requires accurate information about the products and materials initially used in the construction of a building or structure, then what repair, maintenance or replacement/ refurbishment has occurred during its lifespan. Such a data record is then available at end of life and will assist with the reuse, recycling or recovery of the products and materials as potential future resources. This is a complex area as legacy information has not always been collected, and the format for the information may not be in a standardised form.

Emerging schemes and working practices are demonstrating that the demands of insurers, etc when considering component reuse can be assisted through the use of comprehensive record information. This is a busy space, with numerous initiatives in development, including from a circularity perspective, the move towards material passports, which whilst in their infancy are gaining more attention.

# Accurate asset information available in digital form

Aim: **Widespread availability of digital information on construction assets, giving easy access to material and component data facilitating reuse and recycling to deliver ultimately a circular economy**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Hackitt Review Golden Thread / digital twin of buildings implemented.<br>• Location and method of data storage reviewed on a national basis, working practice in place by 2025.<br>• Consultation with multiple property owners and agreement on asset record format in place by 2025.<br>• Data security protocols and working practices for holding BIM models are discussed and agreed by 2030.<br>• Benefits to specifiers, insurers and owners communicated widely. | • From 2030, access to data about buildings and infrastructure is accessible with secure protocols. | |

Context

What else would advance the delivery of this ambition?

Click for Guidance

## Act now

**Industry**

- Designers and contractors obtain information on end of life options from Environmental Product Declarations (EPD).
- Design teams and contractors review the compatibility of BIM software to store relevant product information.
- Contractors include end of life data in the handover information and in the O&M manual.
- Facility managers and asset owners can make sure BIM models are kept up to date.

## What else would advance the delivery of this ambition?

- The digitalisation of construction data – products, buildings and between assets (smart cities) is a major research work programme. This is driven by many factors, and ZAW/resource efficiency should benefit from this digitalization work. Liaison with the Construction Innovation Hub is needed to ensure that appropriate information is collected and maintained.

Back to Route Map

# Guidance

Sources of data are listed, as well as some of the organisations and projects that are active in this area.

- Centre for Digital Built Britain
- Construction Innovation Hub (CIH)
- Construction Products Association and BRE Lexicon
- Construction Products Association
- Market Integrity Group
- Code for Construction Product Information (CCPI)
- UK Government Hackitt Review (2018)
- Draft Building Safety Bill
- CIOB and i3PT Golden Thread Report (2020)
- Construction Leadership Council Digital Network
- Buildings as Material Banks – Material Passports
- Structural Steel Reuse Protocol

Back to Route Map

Back to previous page

# Joint plan to reduce waste to landfill by 2040

Aim: **Eliminate all but hazardous C&D waste entering landfill by 2040**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government and Industry produce an Action Plan to first reduce, and then potentially eliminate, C&D wastes entering landfill based on the evidence study.<br>• Annual reporting is continued to track progress and for joint Government and Industry action to identify improvements required.<br>• Analysis is made of the apportionment of C&D waste to landfill between the building and infrastructure sectors. | • Action Plan updated periodically to identify actions required to continue reduction of C&D waste to landfill.<br>• Consideration is given to Regulatory and/or Fiscal measures that may be required to reduce this stream.<br>• During the second half of the decade, if required, Regulatory and/or Fiscal measures are introduced. | • Government and industry has developed their approach so that only hazardous C&D waste items which cannot be eliminated at source or recovered are landfilled. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Act now

**Government**

- Industry and Government should work together to produce an action plan and targets for the reduction of waste to landfill.

**Industry**

- Industry working group is established to identify priority actions to begin the process of waste reduction to landfill, and their work is disseminated across the supply chain.
- Case studies are produced of the current best practice, recognising that a few clients and supply chains have begun making progress.
- There is a clear need to understand how the generation of C&D waste is apportioned between the two principal sectors generating this waste – Building and Infrastructure. This will enable each sector to develop its own action plan.

## Context

Following on from the data study to understand the composition of waste from the construction sector sent to landfill, the sources and the reasons why (Analyse and report waste to landfill), an action plan is to be produced to reduce it and finally eliminate it. This is likely to include some of the other actions in this Routemap.

This builds on industry commitment with some contractors and clients already having targets for zero waste to landfill. Demolition contractors regularly achieve around 96% diversion of waste from landfill. To meet the aim of ZAW and in accordance with the interpretation of ZAW, only the most hazardous items of C&D waste should be being landfilled by the 2040s. Some material sent to landfill may be needed by landfill operators for operation purposes and materials may also be required to fill void spaces (as part of planning requirements).

Back to Route Map

# Joint plan to reduce waste to landfill by 2040

Aim: **Eliminate all but hazardous C&D waste entering landfill by 2040**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government and Industry produce an Action Plan to first reduce, and then potentially eliminate, C&D wastes entering landfill based on the evidence study.<br>• Annual reporting is continued to track progress and for joint Government and Industry action to identify improvements required.<br>• Analysis is made of the apportionment of C&D waste to landfill between the building and infrastructure sectors. | • Action Plan updated periodically to identify actions required to continue reduction of C&D waste to landfill.<br>• Consideration is given to Regulatory and/or Fiscal measures that may be required to reduce this stream.<br>• During the second half of the decade, if required, Regulatory and/or Fiscal measures are introduced. | • Government and industry has developed their approach so that only hazardous C&D waste items which cannot be eliminated at source or recovered are landfilled. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Act now

**Government**

- Industry and Government should work together to produce an action plan and targets for the reduction of waste to landfill.

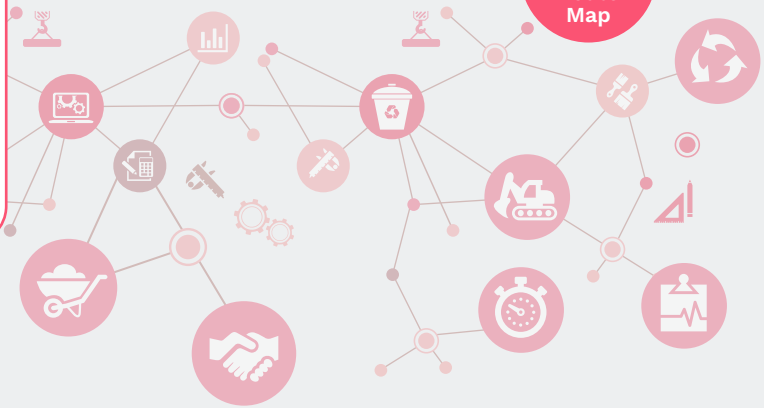
**Industry**

- Industry working group is established to identify priority actions to begin the process of waste reduction to landfill, and their work is disseminated across the supply chain.
- Case studies are produced of the current best practice, recognising that a few clients and supply chains have begun making progress.
- There is a clear need to understand how the generation of C&D waste is apportioned between the two principal sectors generating this waste – Building and Infrastructure. This will enable each sector to develop its own action plan.

## What else would advance the delivery of this ambition?

- An appreciation of the materials that are needed by landfill operators (possibly through the Environmental Services Association) and with the Environment Agency and waste planning authorities and how these may alter in the future. This could also include requirements for void spaces such as quarries to be filled.
- The interpretation of ZAW has highlighted the need to avoid unintended consequences and to ensure that a positive overall environmental impact is always achieved e.g. if the waste has to be transported a long way to be recovered this may produce an overall adverse environmental impact. This should be considered in any action plan, and thresholds may need to be developed by the waste management industry to avoid a negative environmental outcome.
- This is likely to include medium to long term actions (depending on the study's findings on C&D waste to landfill) such as new bands and/or increases in Landfill Tax; more R&D on materials that are difficult to recover and development of upgraded recycling/recovery infrastructure.

Back to Route Map



# Guidance

Relevant organisations and examples are listed.

- Defra
- Environment Agency
- HMRC
- Construction Leadership Council
- WRAP had a programme of encouraging companies to commit to halving their waste to landfill; this no longer exists

Back to Route Map

Back to previous page

# Analyse and report waste to landfill

Aim: **Waste being landfilled from the construction sector is properly understood**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The constituent parts of construction and demolition waste to landfill are identified by Government and the reasons for them entering landfill understood.<br>• Industry responds to the findings by seeking ways of eliminating material in this waste stream.<br>• Use of a regularly updated national dashboard for waste to landfill with key materials displayed. | • Annual government monitoring and dashboard becomes part of a National Materials Strategy.<br>• Industry develops improved ways to drive further reductions in this waste stream. | • Annual government monitoring and dashboard.<br>• By 2040 eliminate all but hazardous waste entering landfill. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

In 2019, around 3.8 million tonnes of construction and demolition (C&D) waste was landfilled representing 8% of total C&D waste. The cost of this waste stream in carbon and fiscal terms is significant – the cost is estimated at £271 million just in landfill tax in 2019 and nearly 155,000 tonnes of $CO_2e$ from landfilling. To meet the aim of ZAW and in accordance with the interpretation of ZAW, only the most hazardous items of C&D waste should be being landfilled, where there is no alternative treatment, by the 2040s. Progress to this outcome will rely on developing a detailed understanding of the composition of this waste stream to landfill. Whilst we know some of the wastes going to landfill, we do not understand all of them including their source, what percentage is avoidable, and the reasons why it is going to landfill, rather than being recycled – or even arising in the first place. This waste stream can only be eliminated based on knowledge of the materials and components that are finding their way to landfill and developing new approaches to avoid this happening. Early action is needed to provide data on the materials and components in this waste stream, and Government has a key role in taking this first step. This will then pave the way for focussed work across the industry to begin the work to reduce the volume of material going to landfill.

## Act now

This is a strategic, over-arching action on national waste statistics which is for Government to undertake.

**Contractors**

There are smaller scale, tactical actions which contractors can take:

- Ask waste management contractors, what types of waste are being landfilled from your projects and why. This could be part of your procurement and waste audit processes. This may differ geographically, by types of project (e.g. new build vs demolition) and by waste contractor.
- Specify the use of PAS 402:2009 Waste resource management – Specification for performance reporting which acts as a framework to provide better reporting at waste facilities.
- Provide more detail on the types and amounts of wastes that are being landfilled in your annual reporting and the reasons for this.
- Develop company action plans to reduce key waste streams that are being landfilled.
- Liaise with landfill operators to understand what type of waste materials are being used for landfill engineering and cover purposes.

Back to Route Map

# Analyse and report waste to landfill

Aim: **Waste being landfilled from the construction sector is properly understood**

| 2020s | 2030s | 2040s |
|---|---|---|
| • The constituent parts of construction and demolition waste to landfill are identified by Government and the reasons for them entering landfill understood.<br>• Industry responds to the findings by seeking ways of eliminating material in this waste stream.<br>• Use of a regularly updated national dashboard for waste to landfill with key materials displayed. | • Annual government monitoring and dashboard becomes part of a National Materials Strategy.<br>• Industry develops improved ways to drive further reductions in this waste stream. | • Annual government monitoring and dashboard.<br>• By 2040 eliminate all but hazardous waste entering landfill. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- More detailed annual reporting of the C&D waste going to landfill to be included in the annual waste statistics publication provided by Government, and as a dashboard and eventually become part of a National Materials Strategy.
- An appreciation of the materials that are needed by landfill operators by the Environmental Services Association and Environment Agency and waste planning authorities and how these may alter in the future. This could also include requirements for void spaces such as quarries to be filled.

## Act now

This is a strategic, over-arching action on national waste statistics which is for Government to undertake.

**Contractors**

There are smaller scale, tactical actions which contractors can take:

- Ask waste management contractors, what types of waste are being landfilled from your projects and why. This could be part of your procurement and waste audit processes. This may differ geographically, by types of project (e.g. new build vs demolition) and by waste contractor.
- Specify the use of PAS 402:2009 Waste resource management – Specification for performance reporting which acts as a framework to provide better reporting at waste facilities.
- Provide more detail on the types and amounts of wastes that are being landfilled in your annual reporting and the reasons for this.
- Develop company action plans to reduce key waste streams that are being landfilled.
- Liaise with landfill operators to understand what type of waste materials are being used for landfill engineering and cover purposes.

Back to Route Map

# Guidance

There are a number of sources of waste statistics which include information on C&DW listed. Relevant organisations are also listed.

- Defra
  - UK Statistics on Waste
  - Digest of Waste and Resource Statistics (2018)
- Environment Agency
  - Waste Data Interrogator (2019)
- EuroStat
  - Waste database (which UK reports into) (2018)
- Green Construction Board with BEIS and Defra
  - Zero Avoidable Waste in Construction – What do we mean by it and how best to interpret it. A recommendation from the Green Construction Board. (2020)
- Mineral Product Association From waste to resource – a UK Mineral Products industry success story (2019)
- HMRC
- NFDC
- CECA
- CIWM C&D Waste Forum

Back to Route Map

Back to previous page

# Report on waste at project and company level

Aim: **The generation, true cost and recovery routes for all construction waste streams is known in detail**

| 2020s | 2030s | 2040s |
|---|---|---|
| • CLC to require standard and consistent reporting for major projects from 2022.<br>• Contractors to develop key performance indicators and benchmarks for all building and waste types by 2024.<br>• The true cost of waste is starting to be measured and reported on major projects. | • CLC to require standard and consistent reporting for medium sized projects from 2030.<br>• CLC works with industry to agree voluntary waste reduction targets.<br>• Refinement of key performance indicators and benchmarks.<br>• True cost of waste is commonly measured for most projects. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## Context

There is no mandatory requirement for contractors or clients to report their waste from construction, demolition and excavation making it difficult to assess what is good and best practice for waste generation and recovery. Moreover, the true cost of waste (the cost of the materials wasted, labour, management and disposal costs) is rarely measured and reported. Older and more recent studies have shown this can be up to 13 times as much as the disposal cost. If this figure was to be applied to approximately 13 million tonnes of waste that is generated from new build activities then the true cost of this is estimated at £11 billion per year. Whilst some companies do report their waste performance on a company basis, this varies in its consistency and granularity. Waste data on certain projects may be collected and reported via environmental certification schemes, but this is not collected centrally. Historically, projects were reporting waste as part of the Site Waste Management Plan Regulations, but government halted this in 2013. The only system that aggregates data on waste arisings and recovery routes and generates KPI's is BRE's SmartSite, which are available for a fee. These KPIs are used to set benchmarks in BREEAM. The National Federation of Demolition Contractors require their members to report on their waste and produce annual reports.

When the capability to properly measure and report waste has been established, CLC can work with industry to agree voluntary targets for reducing the amount of waste year-on-year.

## Act now

**Clients**

- Work with other clients to ensure consistency with waste reporting requirements.

**Contractors**

- Provide more detailed information by reporting on waste arisings and recovery for key waste streams and share through appropriate forums and bodies.
- Analyse project data to develop KPIs and benchmarks for waste generation and recovery by building/infrastructure type and waste type.
- Work out how much waste is costing you, including the materials you are wasting.
- Work with waste management companies to generate better data from waste facilities by requiring the PAS402: Waste resource management – Specification for performance reporting Standard.

**Software providers**

- Work with contractors to review data inputted on waste and develop key performance indicators.

Back to Route Map

# Report on waste at project and company level

Aim: **The generation, true cost and recovery routes for all construction waste streams is known in detail**

| 2020s | 2030s | 2040s |
|---|---|---|
| • CLC to require standard and consistent reporting for major projects from 2022.<br>• Contractors to develop key performance indicators and benchmarks for all building and waste types by 2024.<br>• The true cost of waste is starting to be measured and reported on major projects. | • CLC to require standard and consistent reporting for medium sized projects from 2030.<br>• CLC works with industry to agree voluntary waste reduction targets.<br>• Refinement of key performance indicators and benchmarks.<br>• True cost of waste is commonly measured for most projects. | |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- In the absence of any national mandatory requirement for measurement, guidelines are required, potentially in the form of a PAS to ensure the consistency of data collection and reporting.
- Clients can require the data collection and reporting of waste, following the development of guidelines within tender documentation. CLC can take a lead on this.
- Production of an agreed methodology by contractors to be able to measure the True Cost of Waste uniformly working with RICS and other professional bodies.
- Defra and Environment Agency review and improve the waste codes used in order to provide greater granularity.

## Act now

**Clients**

- Work with other clients to ensure consistency with waste reporting requirements.

**Contractors**

- Provide more detailed information by reporting on waste arisings and recovery for key waste streams and share through appropriate forums and bodies.
- Analyse project data to develop KPIs and benchmarks for waste generation and recovery by building/infrastructure type and waste type.
- Work out how much waste is costing you, including the materials you are wasting.
- Work with waste management companies to generate better data from waste facilities by requiring the PAS402: Waste resource management – Specification for performance reporting Standard.

**Software providers**

- Work with contractors to review data inputted on waste and develop key performance indicators.

Back to Route Map

# Guidance

Sources of data are listed, as well as some of the organisations and projects that are active in this area.

- BRE SmartSite System
- ENCORD, Construction Waste Measurement Guide (2013)
- Zero Waste Scotland, True Cost of Waste, Pilot Study
- BSI, PAS402: Waste resource management. Specification for performance reporting (2013)
- Defra; electronic waste tracking project
- CIWM Construction and Demolition Waste Forum
- National Federation of Demolition Contractors
- Environment Agency
- WRAP encouraged contractors to report in the past through a tool called Measure (no longer available)
- BREEAM
- CEEQUAL
- Ska Assessment
- Construction Leadership Council

**Sotware tools:**

- BRE SmartSite System
- Credit360
- QFlow

Back to Route Map

Back to previous page

# Strategic understanding of material flows

Aim: **Detailed understanding of construction material use and flows, at a local, regional and national level**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government has initiated a National Materials Strategy.<br>• Government funded research into understanding construction material use and flows.<br>• Clients and design teams to develop material intensity benchmarks and targets for common building and infrastructure types.<br>• Development of local material resource matching tools, supported by local and regional authorities. | • Annual monitoring of a National Materials Strategy.<br>• National Materials Strategy is linked to planning considerations for buildings and infrastructure.<br>• Material intensity targets required as part of planning applications. | • Annual monitoring of a National Materials Strategy. |

Context

What else would advance the delivery of this ambition?

Click for Guidance

## Context

There is very little data available for material resource use in the construction sector. There are some high-level national statistics for material use and modelling undertaken at a national level to aid in setting carbon reduction strategies; however, the last full mass balance study of material flows in the construction sector was undertaken in 2003.

There is little understanding of the amounts and types of materials that are used in construction, particularly at a regional and local level and how much is wasted and recovered (the flows); and how much is already in our buildings and infrastructure (the stocks). Without knowing this, it is difficult to assess how overall material usage could be reduced and how much material inputs can come from recycled and secondary sources and the existing building stock. It is also challenging to set targets and benchmarks for material usage for common types of building and infrastructure. Encouragingly, there are a few research projects which are developing models to measure and predict resource use and flows.

## Act now

**Government**

- Government through the UKRI support research into understanding construction material use and flows with industry collaboration.

**Industry**

- Clients work with design team and contractors to record the amount and types of materials on a project throughout the design, procurement and construction stages.
- Design teams use material quantities data from whole life carbon assessments to understand better material use at a project level.
- Clients, design teams and contractors share relevant data such as material quantities, design drawings, BIM models with the research community to enable them to develop resource use models.

**Research community**

- Research community share findings with key stakeholders in an accessible manner.

Back to Route Map

# Strategic understanding of material flows

Aim: **Detailed understanding of construction material use and flows, at a local, regional and national level**

| 2020s | 2030s | 2040s |
|---|---|---|
| • Government has initiated a National Materials Strategy.<br>• Government funded research into understanding construction material use and flows.<br>• Clients and design teams to develop material intensity benchmarks and targets for common building and infrastructure types.<br>• Development of local material resource matching tools, supported by local and regional authorities. | • Annual monitoring of a National Materials Strategy.<br>• National Materials Strategy is linked to planning considerations for buildings and infrastructure.<br>• Material intensity targets required as part of planning applications. | • Annual monitoring of a National Materials Strategy. |

Context | What else would advance the delivery of this ambition? | Click for Guidance

## What else would advance the delivery of this ambition?

- Research: more Government funded research is required to model the resource flows and stocks of all construction materials at a local, regional and national level. This is one of the key activities of the Circular Centre for Minerals UKRI funded Circular Economy Centre.
- Government to develop a National Materials Strategy and database, with the aim of optimising the use of construction materials and maximising the use of reused products and recycled materials, and associated reduction in environmental impact.
- Local authorities to gather data that will assist in understanding local flows of materials and material use within the existing stock, through for example, demolition and planning requirements.
- Clients and designers to measure material intensity for key materials as kg/m$^2$ of gross internal floor areas, to produce benchmarks and targets which can be set for different building and infrastructure types. These could eventually be set within planning applications.

## Act now

**Government**

- Government through the UKRI support research into understanding construction material use and flows with industry collaboration.

**Industry**

- Clients work with design team and contractors to record the amount and types of materials on a project throughout the design, procurement and construction stages.
- Design teams use material quantities data from whole life carbon assessments to understand better material use at a project level.
- Clients, design teams and contractors share relevant data such as material quantities, design drawings, BIM models with the research community to enable them to develop resource use models.

**Research community**

- Research community share findings with key stakeholders in an accessible manner.

Back to Route Map

# Guidance

Sources of data are listed, as well as some of the organisations and projects that are active in this area.

- Office for National Statistics
  - Environmental accounts
  - Material flow accounts
- BEIS
  - Building materials and components: monthly statistics Consultative Committee on Construction Industry Statistics (CCCIS)
  - PRODCOM data
- Eurostat – European Statistics
- UK Research and Innovation
  - Circular Economy Research Hub (CE-Hub)
  - Interdisciplinary Circular Economy Centre for Mineral-based Construction Materials
  - Circular Centre for Metals
- H2020 CIRCuIT project
- REBUILD project
- University of Sheffield
- CVORR Project
- Leeds University
- International Synergies

Back to Route Map

Back to previous page