Identification of Circular Economy Opportunities in the Scottish Construction Sector

Prepared by: Dan Whittaker, Eunomia, and Mervyn Jones, SGR

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Contents

Zero Waste Scotland commissioned this report for information purposes, and the content reflects the data and feedback collected, and the interpretation of the authors. It does not necessarily reflect the views of Zero Waste Scotland or Scottish Government.

1 Executive Summary

Introduction

The project's objective was to identify potential Circular Economy (CE) opportunities that could deliver high economic and/or environmental benefits, taking into account the specific conditions of the Scottish construction sector. Increasing circularity of Scottish construction requires a number of factors to be considered:

- Identification of materials and products with the highest CE potential.
- Identification of key opportunities by sub-sector, e.g. housing, commercial, education.
- Matching ambition to resources and timescales, i.e. what is achievable, on what timescales, and which actors might be needed.
- Identifying and addressing barriers to opportunities, and
- Engagement with construction stakeholders at the right time in the process.

This project gathered and analysed publically available information on these factors, to focus on key opportunities and, importantly, the interventions required to take them forward. Three tasks were undertaken:

i Developing a list of planned Scottish construction, refurbishment and demolition projects to 2020.
ii A desk-based review of high impact CE opportunities in light of the planned construction pipeline.
iii Identifying and undertaking a more detailed analysis of a shortlist of opportunities.

Scotland's Construction Project Pipeline

Construction Industry Training Board (CITB)[1] has estimated that construction spend in Scotland will be in excess of £13billion p.a. over the period 2017-2020. The review explored this expenditure, drawing on a number of public sector and private sector information sources, including the Scottish Government's Infrastructure Investment Plan Pipeline, Glenigan web portal (Scotland's construction project leads based on planning permission), as well as supplementary information on public sector framework expenditure, local authority planning permissions and local development plans.

This review identified 1000+ projects across housing (social & private), commercial, light industrial, education, health, transport, utilities, ports, energy and regeneration activity. The output of the review included a series of searchable spreadsheets, which allows projects to be searched by type, location, expenditure and date.

Identifying high impact CE opportunities

A number of different approaches were taken to identify and prioritise key intervention opportunities from different perspectives. This was informed through desk review of interventions and practices in the UK and overseas and matched them against the specific conditions in Scotland. This included assessments of:

- Opportunities by material, assessing the barriers and interventions associated with each material.
- Significance of the subsector type (e.g. commercial, health, residential) in Scotland, potential for impact, and ease of Zero Waste Scotland influence.
- Opportunities by subsector type (e.g. commercial, health, residential) lifecycle stage.

This took into account the hierarchy of actions to use assets and resources more efficiently including:

- Design and materials choices
- Sourcing, e.g. increase recycled content
- Lower in-use impacts, e.g. increase utilisation, reduce carbon & energy impacts, asset management
- Disposal options e.g. take-back, reuse, waste separation, demolition materials reuse and recycling

[1] http://www.citb.co.uk/documents/research/csn%202017-2021/csn-scotland-2017.pdf

Identifying a shortlist

A qualitative review of the combined outputs from the three assessments informed identification of a shortlist of priority opportunities. The analysis identified the following priority opportunities:

- **Opportunity 1:** Modular design, (including design for deconstruction and material passports)
- **Opportunity 2:** Circular timber in construction
- **Opportunity 3:** Circular aggregates (including concrete, brick, soils and stones)
- **Opportunity 4:** Structural steel and aluminium reuse
- **Opportunity 5:** Closed loop and lean design and construction for plasterboard
- **Opportunity 6:** Making retrofit and refurbishment (including repair and maintenance) more circular
- **Opportunity 7:** Large infrastructure and regeneration projects – circular scoping studies, material banks/ reuse hubs
- **Opportunity 8:** Improving building utilisation and usage

For each of these opportunities a series of key interventions by stakeholder group were identified. A qualitative assessment of the evidence base status (i.e. is it an intervention that has been applied elsewhere), ease of implementation, and potential impact was undertaken to establish a series of quick win recommendations. While quick wins are highlighted, any strategic intervention in areas that are new or only proven elsewhere would require further (economic) assessment before being taken forward.

2 Introduction

This report summarises the findings of Zero Waste Scotland Project Identification of Circular Economy (CE) Opportunities in the Scottish Construction Sector (RAP002-001) undertaken by Eunomia and Sustainable Global Resources Ltd (SGR). The project's objective was to identify promising CE opportunities that are likely to deliver high economic and/or environmental benefits and take account of the specific conditions of the Scottish construction sector. It comprised two task:

- A comprehensive list of known construction, refurbishment and demolition projects planned to 2020 was identified, to enable the identification of specific CE opportunities in the next years.
- A desk-based review of high impact CE opportunities was undertaken, narrowing down options for the Scottish construction sector. This drew on ideas and practices in the UK and overseas and match them against the specific conditions in Scotland.

This report presents a series of opportunities and potential key interventions to aid direction for the programme. While quick wins are highlighted, any strategic intervention in areas that are new or only proven elsewhere might require further (economic) assessment before being taken forward.

3 Method

3.1 Task 1: Project Horizon Scan

The purpose of this task was to develop a comprehensive list of Scottish construction, demolition and refurbishment (2017-2020). A number of key sources were used:

- Construction Industry Training Board (CITB) produced the Construction Skills Network Scotland Industry Insights Forecasts (2016–2020) This included useful predicted construction output data by sector (e.g. public housing, transport)
- The Scottish Government's Infrastructure Investment Unit (IIU) produces an Infrastructure Investment Plan Pipeline[2], which is an excel spreadsheet of projects with a capital value of £20 million or more where Scottish Government has a lead role in procurement or funding. This included Regeneration, Energy, Health, Education, Justice, and Transport.
- Transport Scotland's investment priorities[3] for Road, Rail and Sea transport infrastructure.
- Local Authority Planning Portal planning Permission listings, where aggregated lists were available (Edinburgh and Glasgow).
- Local Development Plans – for planned commercial and residential developments/ land allocations.
- Glenigan web portal - a provider of UK construction project leads, market analysis and company intelligence. This is an extensive list of projects in the planning process, included Residential, Commercial and Industrial projects.
- ABI Barbour Index - a provider of UK construction project leads, market analysis and company intelligence.
- Scotland Excel Demolition Framework predicted spend areas.

The information was drawn together into a series of searchable spreadsheets and documents[4]:

- **Scottish Project Pipeline (2017-2020) 16032017.**
  - Worksheet 1 contains analysis of the CITB data.
  - Worksheet 2 contains a searchable list of pipeline projects.

[2] http://www.gov.scot/Topics/Government/Finance/18232/IIP

[3] https://www.transport.gov.scot/projects

[4] Note: There is some duplication of projects within some spreadsheets due to the multiple sources used; and associated project categorisation e.g. mixed use developments may be in both residential and commercial listings.

    - Worksheet 3 contains a summary of potential total construction value by project type based on worksheet 2. This estimates spend (2017-2020) for those projects with construction values, and start and end dates. It assumes an even spend across each year of the projects construction programme, and a formula calculates the 2017-2020 spend.
    - Worksheets 4, 5, 6 contain various estimates of housing related spend by local authority area. This shows which local authorities are likely to see the highest levels of housing new build and repair/ maintenance. Note: There is a separate housing project pipeline spreadsheet (see below).
    - Worksheet 7 contains details from the larger Scottish local authorities on the areas allocated to employment land. This shows which local authorities are likely to see the highest levels of commercial and industrial type developments. Note: There is a separate commercial/ industrial project pipeline spreadsheet (see below).
    - Worksheet 8 contains details from Scotland Excel's Demolition Framework team, on those local authorities that are likely to procure demolition contracts via the framework, and overall estimated value of spend by local authority based on historic activity
    - Worksheet 9 contains historic demolition data for Scotland and identifies those local authorities that are likely to see high levels of demolition, based on the magnitude of their existing building stock.
- **Glenigan Scotland Housing Projects (2017)**
    - Worksheet 1 contains a list of social residential projects extracted from Glenigan's database of planned Scottish construction projects.
    - Worksheet 2 contains a list of private residential projects extracted from Glenigan's database of planned Scottish construction projects.
- **Glenigan Commercial-Industrial Data (2017)**
    - Worksheet 1 contains a list of commercial and industrial projects extracted from Glenigan's database of planned Scottish construction projects.
- **Glasgow Planning Application Extant List** – a pdf list of current (March 2017) projects with planning permissions.
- **Glasgow - Sites available for Industrial/ Business Development March 2016**, last updated March 2016.
- **City of Edinburgh Planning Permission Summer 2016** – an excel sheet of projects last updated summer 2016.
- **ABI Barbour Index** - a Word document with 25 commercial developments provided as a sample of their service offering.

3.2 Task 2: Assessing CE Potential

The purpose of this task was to identify functional CE intervention ideas applicable to the construction programme, and subsectors where intervention would promise the biggest benefits. A number of different approaches were taken to identify and prioritise these intervention ideas from different perspectives. This included reviewing:

1. Opportunities by material, assessing the barriers and interventions associated with each material.

2. Significance of the subsector type (e.g. commercial, health, residential) in Scotland, potential for impact, and ease of Zero Waste Scotland influence.

3. Opportunities by subsector type (e.g. commercial, health, residential) lifecycle stage.

The spreadsheet Materials-Build-Matrix 10-03-2017 contains a number of worksheets matrices summarising each of these assessments.

3.2.1 Assessment 1. Opportunities by material

Priority material types were first identified by analysing two key sources of information:

- Ellen MacArthur Foundation Material Circularity Indicator were used to identify priority material types. These indicators reflect the circularity potential and actual current status of different material types (worksheet 1).
- RAP002-002 Construction Waste Arising Study - This project focused on where construction waste is being generated in Scotland with a particular focus on where waste destined for landfill is generated. This included identification of typical waste material arisings related to specific construction project types.

This focused on the potential to reuse or recycling of materials for its original purpose, over recycling for lower grade uses. The following materials were identified as being priorities for more detailed evaluation:

- Aggregates
- Insulation
- Structural metals
- Fit-out metals
- Concrete/ cement
- Composites/Structural Insulated Panels (SIPs)
- Plasterboard
- Timber (including pallets)
- Glass
- Plastic

Worksheet 2 contains an assessment of each priority material as follows:

- CE opportunities and where they sat on the Hierarchy of CE loops based on EMF Systems diagram i.e. prioritising opportunities by value retention as follows:
  - Reuse in its existing form, with servicing/ maintenance (including sharing)
  - Reuse via refurbishment - to optimise or extend existing lifetime
  - Remanufacture – applied to an end-of life part or product
  - Closed loop recycling i.e. processing back into its original product or equivalent technical grade[5]
  - Recycling for other further uses
- Barriers to implementation
- Potential interventions by different stakeholders/ built environment lifecycle steps
- Procurement opportunities
- Design opportunities
- Build opportunities
- Fit-out opportunities
- Refurbishment opportunities
- In-use opportunities
- Demolish/ Deconstruct opportunities

3.2.2 Assessment 2. Significance of the subsector type to Scotland and Zero Waste Scotland

Worksheet 3 contains a review of each Scottish construction subsector (residential, commercial, light industrial, schools, health, infrastructure, regeneration) identifying:

- Significance of planned construction between 2017-2020, based on the construction project pipeline.
- Whether stakeholders and supply chain are easy for Zero Waste Scotland to access and influence.

[5] Note: Closed loop recycling is not possible in such narrow terms for certain products and materials with global supply chains or highly technical manufacturing. E.g. steel – could not be guaranteed to be recycled into another girder or truss, but yit could be guaranteed to be of sufficient quality (and therefore value) to be that product.

- Likely presence of Small and Medium Sized Enterprises (SMEs) within the supply chain, as these are the key group for the European Regional Development Fund (ERDF) funded programme.
- Significance of priority material use within the subsector i.e. which materials are likely to associated with typical building types.

3.2.3 Assessment 3. CE opportunities by subsector type (e.g. commercial, health, residential) lifecycle stage

Worksheet 4 contains a high level review of the potential impact of CE principles by the lifecycle stages (Procurement, Design, Build, Fit-out, Refurbishment, In-use, Demolish/ Deconstruct) on each Scottish construction subsector.

So for example in terms of Commercial properties, key themes and considerations identified were:

- Procurement: Ensuring materials and RE requirements (e.g. Design for Deconstruction, Design for Recyclability, Materials passport) are incorporated into existing public sector frameworks; along with establishing feasibility of Resource Efficient Business Models (REBMs) and shared space models.
- Design: Embedding flexibility, standardisation, and design for shared use.
- Building: Improving onsite waste prevention.
- In Use: Maximising the benefits of Building Information Modelling (BIM). Increasing the creation of flexible spaces. Incorporating greater repair & maintenance during in-use phase.
- Refurbishment: Use of pre-refurbishment audits and site waste management plans to increase reuse and recycling. Embedding Design for Deconstruction, Design for Recyclability and Materials passport into the design and refurbishment phases.
- Deconstruction: Use of pre-demolition audits and deconstruction practices to increase reuse.

3.3 Task 3: Identifying a shortlist

Worksheet 5 includes a qualitative review of the combined outputs from the three assessments led to the identification of a shortlist of key opportunities, based on the:

- Significance of the subsectors and associated material type use to Scotland.
- Key CE principles associated with priority building subsectors and associated materials.
- The potential impact in terms of scale and quick wins associated with the opportunity.

The shortlist opportunities include:

- **Opportunity 1:** Modular design, (including design for deconstruction and material passports)
- **Opportunity 2:** Circular timber in construction
- **Opportunity 3**: Circular aggregates (including concrete, brick, soils and stones)
- **Opportunity 4:** Structural steel and aluminium reuse
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For each of these a series of key interventions with relevant stakeholders (Clients, Planners, Designers, Contractors, and Deconstruction sector) across the buildings lifecycle were identified.

Whilst plastic, glass and insulation materials were identified initially as priority materials, during the more detailed assessment they did not progress to the shortlist, as other opportunities presented greater potential. This doesn't however mean that there aren't opportunities with these streams that are worth further research.

4 Opportunity Shortlist

The following report sections provide an assessment of each opportunity and highlight potential key interventions that would support their implementation and uptake in Scotland.

For each opportunity the following information has been identified:

- **CE principles** - that can be applied, and where they sit on a CE hierarchy.
- **Relevance to Scotland** - based on current Government policies and strategies, construction subsectors, planned project pipeline, building types and priority construction materials.
- **Potential Impact** – identifying existing evidence base of the impact of applying these principles
- **Feasibility** - including existing barriers, market demand, practicalities, and any regulatory aspects.
- **Scalability and spread** - identifying where there are opportunities for learnings to be applied across other subsectors or materials.
- **Key interventions** - required to embed these principles into Scotland's construction sector. This also includes whether:
    - Zero Waste Scotland alone can make the intervention
    - The maturity of the intervention, with 3 levels depending on the strength of the evidence:
        - **New** - A circular intervention that has been identified as a conceptual (e.g. Ellen MacArthur Foundation type) winner but yet to be systematically tested anywhere.
        - **Proven** - A circular intervention that has proven examples from other countries, but yet to be tested and systematically applied in Scotland.
        - **Well tested** - A circular intervention that has been tested in Scotland and needs scaling up and applying systematically to realise the benefits.
    - A qualitative ranking of each intervention's likely impact compared to the other interventions within an individual opportunity – High, Medium or Low. Note: Not ranked across interventions. At this stage, this is purely based on the team's views based on the information collated. To fully understand the impacts, more in-depth analysis (such as marginal abatement cost curves) would be required.
    - A qualitative ranking of each intervention's ease of implementation compared to the other interventions – Easy, Moderate or Hard. This is a measure of complexity and potential cost and upfront investment.
    - Whether an intervention represents a Quick Win.

4.1 Opportunity 1 – Modular Design (inc Design for Deconstruction and Material Passports)

Opportunity 1 – Modular Design, (inc Design for Deconstruction and Material Passports)

CE aspects it promotes:

Resource efficiency and lean construction (CE Hierarchy – Medium)

- Modularity can provide a range of resource efficient construction benefits associated with offsite manufacture. Construction programmes can be simplified, made more efficient due to construction in factory environment, which has associated environmental benefits.

1st life extension (CE Hierarchy – High)

- Modularity facilitates flexibility and adaptability in building use. In theory, making in life building changes, easier and less material intense and wasteful.

Preparation for reuse (CE Hierarchy – Medium)

- Design for deconstruction facilitates reuse and recovery via repair and maintenance and retrofit activities.
- Material Passports are also critical to understand original material specification, standards, and in life maintenance to facilitate reuse.

Relevance to Scotland

- An important part of making buildings more circular is substituting materials that are difficult to reuse and recycle, or that make it difficult to reuse or recycle other materials, with non-toxic, renewable alternatives. Modular designs support this principle, and its increased application would contribute to reducing the ecological footprint of buildings in Scotland.
- Housebuilding will be an area of significant focus during 2017-2020, with modularity having the potential to be an important theme in this construction activity. Also, modularity is not just limited to house designs and therefore good practices can influence construction across a range of building types.
- Modular buildings are already being built in Scotland, it is therefore a proven approach where learning and experience of good practice can be understood and disseminated. As an existing but small market, it presents an opportunity for development and growth. It is unclear how well design for deconstruction and material passports are embedded in this process, again presenting opportunities for development.
- Modular construction techniques can reduce total construction costs 30–60 percent according to the Ellen MacArthur Foundation[6].
- Public sector can drive this opportunity into public sector procured development.
- SMEs are well represented in the house building market, therefore it is assumed that some modular house builders will be SMEs. Further research would be required to investigate the extent of SME presence in the market.

[6] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

Planned Scotland construction spend:

- Public sector expenditure forecasted within both the CITB data and the Construction Pipeline Horizon Scan (2017-2020) has identified significant areas of spend that could potentially benefit from improved modularity, flexibility and design for deconstruction. This includes:
  - Social Housing, sheltered and student accommodation. For example, Scottish Government has committed to at least 50,000 affordable homes by March 2021, backed by over £3 billion of investment.
  - Schools and Hospitals. The Construction Pipeline Horizon Scan estimated £800million+ of planned construction spend on schools and £700million on health.

Priority Material Streams:

- This opportunity is relevant to timber, and to a lesser extent structural metal, fit out metals, concrete/ cement, plasterboard.

Potential Impact

- Greater reuse and remanufacturing will optimise product lifetimes, leading to embodied carbon reduction through product lifetime extension.
- Modular Design, (including Design for Deconstruction and Material Passports) will be critical for efficiency of future retrofit repair and maintenance.
  - Modular construction can lead to:
  - Reductions in site waste by up to 70%
  - Faster on site construction time – speed increased by up to 50%
  - Lower capital costs – reduction by up to 10%
- Supporting Scotland's modular building manufacturing sector, would contribute to local economic development, potentially protecting and creating jobs

Feasibility

Barriers:

There are a number of potential barriers to implementing modular building on a large scale. However if these can be overcome they represent significant benefits for both builders and users of the built environment. These include:

- Standardisation - Currently the vast majority of buildings, certainly outside the residential sector, are bespoke. This is a major obstacle for modular offsite manufacturing where standardisation is key.
- Variety - If a high degree of standardisation occurs, our built environment will become uniform and unable to meet the bespoke needs of its occupiers. The answer to this is modular buildings that can be constructed in a large number of configurations from standard components to suit different uses, similar to the automotive industry.
- Quality - Quality of production has been raised as a barrier to offsite manufacturing. In a modular building, especially one with inbuilt internal infrastructure an error in design can have significant knock on effects. With a traditional construction project, the design can be modified as the project progresses to overcome unforeseen problems and changing requirements, something that is difficult with prefabricated buildings. To avoid this requires design it right first time by collaborating with all stakeholders at the very start of the process and using tools such as digital modelling i.e. BIM.

Demand:

- Modularity has the greatest potential where the public sector will have lifetime ownership of properties. This allows the long term benefits of flexibility, in use repair/ retrofit and material value from deconstruction to be realised by the stakeholders initially investing in the properties.

Practicality:

The USA are world leaders in modular design and building (see Reference 5 below for example). Modular buildings are occurring on a small scale in Scotland. For example:

- Tigh Grian - Gaelic for House of Sun – is a building firm which constructed 48 new "pod" homes in Alva, Clackmannanshire for Link Housing Association. The firm is also working with a housing association, the NHS and a hospice to manufacture "highly innovative" sheltered accommodation that can change and adapt as residents age and their health declines.
- In 2015 - Architects Anderson Bell Christie and Adston Construction Group introduced its innovative new housing development in Eyemouth, Berwickshire to the Scottish Federation of Housing Associations (SFHA). The development was the first major application of pre-assembled modular SIPs (structural insulated panel) construction for social housing in Scotland. All 32 homes were pre-assembled in the factory and transported to site with 2 pre-built modules per house. Lewisham Council, built Ladywell Place, a redeployable residential development to meet a shortfall in temporary accommodation. A number of other prefabricated and modular house builders in Scotland, have been identified - Wee House, Scothaus, R.HOUSE, Scotframe, MorrisLesslie. Also Scottish Procurement Alliance has an offsite new homes framework; contractors include Caledonian Modular, CCG Scotland Ltd, Cruden, Keepmoat, and Stewart Milne Group. Some of these are potentially SMEs, and could act as stakeholders in working groups, piloting, trials and support.
- China National Building Material Company is building six offsite factories around the UK. One is proposed in Scotland.
- Material Passports is an emerging area, TurnToo and BAMB2020 (Buildings As Material Banks 2020) have been developing buildings, where components of the modular-designed building are registered in a raw materials passport (see Reference 2 below). BAMB2020 pilot construction projects include - Reversible Experience Modules - EPEA, Green Design Centre Building - SGDF, Refurbishment Lab - VUB, Event & Greenhouse Facility - BE, New Office Architecture - D&S.
- Design for Deconstruction/ Disassembly is also an emerging area e.g. Brummer Town Hall in the Netherlands where 90% of all the materials can be disassembled and be reused. Mountain Equipment Co-op (MEC) store in Ottawa is another example where these principles were embedded into the design.

Regulatory issues/ opportunities:

- No regulatory barriers identified

Scalability/ Spread

- Modularity, design for deconstruction and material passports are all relevant to other sectors such as Private Housing, Commercial, Education and Health. Principles also relevant to planned refurbishment and retrofit activity (see Opportunity 6), and therefore has the potential to impact wider spend areas.
- Critical to supporting future refurbishment and retrofit when deconstruction occurs.

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Capture and disseminate existing good practice on modular buildings to public sector and house building sector.	Zero Waste Scotland	Well tested	Easy	Low	✓
De-risk and understand economics - Develop and provide an evidence base on the benefits of procuring modular construction and operating/managing modular buildings. This will be new to those procuring and they will need to understand the economics and environmental benefits.	Zero Waste Scotland	Proven	Moderate	Medium	x
Provide tools to support procurement activity. Link to Sustainable Public Procurement and CE in public sector procurement (e.g. Procurement Reform Act). Look to embed requirements also into existing frameworks, including the provision of direct Zero Waste Scotland support.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Consider supporting module production facilities - encouraging the finance sector to increase funding as these facilities can yield good returns (co-related to fiscal incentives). Low-cost loans could also start addressing the access to capital barrier and accelerate the development of appropriate circular infrastructure in Scotland. This might include loans at market rates that have been designed to meet the complex financing needs, e.g. the UK Green Investment Bank model.	Beyond Zero Waste Scotland scope	Proven	Hard	High	x
Consider generation of fiscal incentives to buildings that are designed for deconstruction, reuse and recycling. One emerging concept is sustainability performance bonds, a market mechanism that seeks to pre-emptively improve performance.	Beyond Zero Waste Scotland scope	New	Hard	High	x

Designers/Contractors

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Help designers and contractors understand benefits of and evidence base for suitability of available technologies, suppliers, etc.	Zero Waste Scotland	Well tested	Moderate	Medium	x
Promote concepts and approaches: • Building Shell (e.g. 50-75 years lifespan): generous floor to ceiling heights allow flexibility; Spacious cores and risers enable flexibility to adapt to changing expectations; Use bolted rather than welded connections; Design for Deconstruction systems e.g. ClickBrick envelope system • Services (e.g. 15-20 years lifespan): ensure services are accessible and demountable for ease of repair or replacement; Look at modular systems that will allow simple upgrade to services without the whole system becoming obsolete; Consider leasing arrangements rather that outright purchase, as this passes responsibility onto the manufacturer for upgrades and changes • Interiors (e.g. 5-10 years lifespan): Look for modular designs that enable partitions to be dismantled and relocated into different configurations, allowing a space to be easily modified to create new spaces. Floor finishes laid employing a semi-tack adhesives. Flooring laid employing edge restraint and tacked through joints.	Zero Waste Scotland	Proven/ Well Tested	Easy	Medium	✓

Product Suppliers

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Support the development of in-country manufacturing base, through business support to those developing innovative modular buildings. The market appears to include a number of small Scottish business involved in modular solutions. Provide design reviews, and support them in developing improved modular, deconstructable solutions (see Reference 3 below), with material passport systems (see Reference 2 below). Helping assess costs and benefits of systems, support trials of new technique's and materials etc.	Zero Waste Scotland	Well tested	Hard	Medium	x

Support the development of in-country manufacturing base, through focused financial mechanisms e.g. business grants, Residual Value Guarantee (RVGs) and loans on setting up/ expanding manufacturing facilities in Scotland, rather than importing modular building elements from outside Scotland.	Beyond Zero Waste Scotland scope	New	Hard	High	x

Further examples & case studies

1. Circular building design – Bullit Centre, Seattle, USA
2. Cordis project – Buildings as Materials Banks
3. Design for deconstruction - SEEDA guidance and US EPA guidance
4. Modular steel frame design guidance
5. Modular office design – United States of America
6. BRE Design for Deconstruction Case Studies

4.2 Opportunity 2 – Circular Timber in Construction

Opportunity 2 – Circular Timber in Construction

CE aspects it promotes:

Timber construction

Preparation for reuse **(CE Hierarchy – Medium)**

- Design for deconstruction to allow reuse and recovery, via repair and maintenance and retrofit activities. Development of high quality reusable materials, which can be dismantled and returned to their original manufacturers at the end of the building's 1st life.
- Design for Durability and longevity to extend 1st life as well as reuse. With timber, for example, material selection for reuse is a priority, both the quality and sizing is important. Note that this may counter lean design and material light-weighting opportunities as more initial material may be required to facilitate reuse. Components may need to be made larger not thinner, showing that CE principles are not necessary the same as in a linear waste hierarchy principles, where less not more material would have been considered an achievement.
- Material Passports are also critical in order to understand original timber material specification, standards, and in life maintenance.

Pallets

Reverse Logistics **(CE Hierarchy – Medium)**

- Takeback schemes to maximise reuse pushes this material up the waste hierarchy, and also supports repair for reuse. Using delivery/return logistics and pallet repatriation schemes to recover materials and return to construction product manufacturers.

MDF

***Recycling* (CE Hierarchy –Low)**

- Medium Density Fibreboard (MDF) has been historically difficult to recycle, often sent to landfill or energy from waste. New technology is being developed that can recover the wood fibres.

Relevance to Scotland

- Timber is a priority material stream identified in Making Things Last - A CE Strategy for Scotland. Working to avoid depletion of timber through enhanced recycling of demolition materials was identified as a priority activity.
- With well over 70% of Scotland's new housing based upon timber construction methods, timber will have an important role to play going forward. Housebuilding will be an area of significant focus during 2017-2020. The country already has an industry well versed in the application of Modern Methods of Construction (MMC) to housebuilding with wood. Yet innovations and support will be required to optimise building design and construction to reduce end of 1st life impacts though application of principles of design for deconstruction and reuse/ remanufacture and material passports; linking closely with Opportunity 1.
- The Scottish Government's economic strategy and carbon emission reduction targets for 2020 are a good driver for increased innovation in timber construction. Particularly in the areas of design for deconstruction, reuse and recyclability. Innovation in timber construction presents a good opportunity for support by Zero Waste Scotland CE in Scotland funding and the Construction Scotland Innovation Centre, helping to conceive and deliver new and advanced building components, systems and processes. This could make good use of home-grown timber in the domestic house design and construction markets. Scotland would consequently be well placed to become the UK centre for CE innovation in timber house design and construction.
- Architectural firms are typically well represented by SMEs, and therefore design related opportunity represents a potential area for Zero Waste Scotland to influence.
- Pallets and MDF have always been problematic waste streams to move up the waste hierarchy.
- The public sector is in a good position to drive this opportunity into its procured development. Particularly due to level of central spend, and the lifetime public sector ownership of properties, allowing the long term benefits of flexibility, deconstruction and reuse to be realised by those initially investing in the properties.
- The opportunity is equally applicable to private sector developments but more difficult to influence. Supporting public sector housing should have trickle-down effect on the private sector as well.

Planned Scotland construction spend:

- All housing, but social and affordable housing are a key area of focus as they present the greatest opportunity for public sector intervention. Primarily new build, but also relevant to refurbishment of existing timber frame properties. Scottish Government has committed to at least 50,000 affordable homes by March 2021, backed by over £3 billion of investment.

Priority Material Streams:

- Timber framed construction
- Timber pallets – can be addressed through take-back and waste specification clauses
- MDF

Potential Impact

- Timber is a significant material stream in residential construction.
- WRAP research estimated that designing out waste principles save between 8-9% on timber materials[7].
- Higher quality (and increased value) reuse could be achieved through closed loop approach. WRAP estimated that 79% environmental impact saving could be achieved when reclaiming and reusing timber (WRAP, 2008)
- Supporting local timber frame manufacturing sector, would contribute to local economic development, potentially protecting and creating jobs.

Feasibility

Barriers:

Timber Construction

There are a number of barriers to deconstruction and reuse/ remanufacture of timber construction materials, including:

- Deconstruction of wood building can be difficult. Use of the new generation of products can make deconstruction more difficult (due to adhesives/ bonding material). In addition, MDF/ Oriented Strand Board (OSB) has historically been difficult to recycle.
- During demolition, wood waste is often mixed with other materials and contaminated by other substances.
- Low cost and abundant availability of new building materials.
- Lack of regulations demanding waste management plans for timber framed building types.

Pallet reuse barriers

- Low value product
- Practicality and economics of logistics of return and repair

MDF recycling barriers

- Technology is still in its infancy, only one plant in the UK

Demand:

[7] WRAP Waste Minimisation through Offsite Timber Frame Construction 2007

- As noted above, forecast spend on housing will be significant between 2017-2020, with a well-established timber frame sector in Scotland. Timber frames are often promoted on the basis of its environment performance, so manufacturers may be open to further environmental innovations to strengthen their brands.
- Pallets and MDF are problematic waste stream for the construction sector, and therefore cost effective alternatives to current disposal routes would be considered if available and logistically feasible.

Practicality:

- The fact that 70% of Scottish new housing construction is timber and that Towns of Vaxjo[8] in Sweden and Hackney in the UK have clearly chosen wood as a construction material demonstrate its practicality. The concentration and diversity of timber buildings in Hackney demonstrates it wide applicability, beyond housing. For example, it includes the world's largest cross laminated timber building, currently under construction – Dalston Lane. The possibilities for advanced design in timber have been pushed further and higher with large-scale timber housing projects built or proposed in many major cities around the world. From London to Melbourne, Bergen to Chicago, the energy currently being applied to innovation in the use of timber in housing design is internationally recognised. Supporting design for improved circularity in Scotland based on its existing experience and learning from its own good practices and those from other countries presents a promising step for the industry.
- Scott ELM run a pallet repatriation scheme, demonstrating that it can be achieved, although the economics and logistics provide challenges.
- MDF Recovery Ltd, Macclesfield has developed a novel, proprietary process to recover wood fibre from waste MDF.

Regulatory issues/ opportunities:

- No regulatory barriers identified

Scalability/ Spread

- Timber construction has the potential to grow in construction sectors other than housing, but likely to only have limited impact outside of the housebuilding sector in the short term.
- Wooden pallets and MDF are problematic waste streams beyond construction

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

[8] https://www.innobyg.dk/media/64785/pierre%20landel%20sp%20-%20modern%20timber%20construction%20in%20sweden.pdf

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
De-risk and understand economics - Develop and provide evidence base on the benefits of procuring timber construction with design for deconstruction and reuse in mind. As noted above may include procuring larger timber components to enable reuse/ remanufacture. This will be new to those procuring and they will need to understand the economics and environmental benefits.	Zero Waste Scotland	Proven	Moderate	Medium	x
Public sector demand pull will help developing new markets, primarily targeting new social housing developments, but also retrofit and refurbishment. Provide tools to support procurement activity e.g. targets and KPIs associated with design for deconstruction and reuse. Promote application of 4Rs procurement guidance into public sector procurement. Look to embed requirements also into existing frameworks including the provision of direct Zero Waste Scotland support.. Embed the principle that reusable/ recyclable product should always be the first option in Green Public Procurement (GPP).	Zero Waste Scotland	Well tested	Easy	High	✓
Work to embed GPP Core criteria for demolition/refurbishment audits into public sector office contracts. Mandatory audits of the buildings, prior to demolition, can help assess what is recyclable and recoverable in the building and in which amount. Recording of these audits and penalties in case of non-compliance appear necessary for an effective implementation. Consider extending beyond offices.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Work with pilot projects to involving suppliers at a very early stage in the design phase to deliver a very high degree of circularity of the building.	Zero Waste Scotland	Proven	Easy	Medium	✓
Provide/ promote a supply demand co-ordination tool for structural timber reuse. i.e. availability of reclaimed sections particularly of the desired size, volume and in the right place at the right time.	Zero Waste Scotland	New	Moderate	Medium	x
CE voluntary agreement equivalent of the Halving Waste to Landfill commitment to provide focus and collaborative approach within sector.	Zero Waste Scotland	Well tested	Moderate	High	✓

Consider generation of fiscal incentives to buildings that are designed for deconstruction, reuse and recycling.	Beyond Zero Waste Scotland scope	New	Hard	High	x
For pallets – When exploring proposals for Packaging Extended Producer Responsibility (EPR) in Scotland, asssess options and measurement methods for higher reuse / recycling rates for timber pallets.	Beyond Zero Waste Scotland scope	New	Hard	High	x

Designers/Contractors

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Develop and provide a technical evidence base featuring key considerations when designing timber construction with deconstruction and reuse in mind. Good practices, design decision tools etc. Promote concepts and approaches such as: • Jointing, the use of bolts or metal plate connectors are ideal for deconstruction with minimal damage. Screws, nails, staples and adhesives in joints should be avoided as they make deconstruction difficult and limit future reuse. Ends of the timber elements are often damaged due to nailing. Avoid adhesives, such as when fastening floor sheathing to joists. • Consider panelised construction, particularly at roofs, to permit final deconstruction on the ground. • Robust moisture management techniques- recovery rates can be significantly reduced if damp has penetrated the building envelope. • Keep services (plumbing, electrical, Heating, Ventilation and Air Conditioning (HEVAC)) separate from structure. • Clear span floors built from engineered wood products like 'I' beams allow adaptability of layouts and innovative panel based roof structures allow future expansion into loft space, allowing simple future adaption by occupiers • Label materials. Labels should include information that will simplify reuse. For instance, the label may include the date, material grade, material strength,	Zero Waste Scotland	Proven/ well tested	Easy	Medium	✓

and any special handling instructions. Safeguard original drawings. Provide a specific, labelled, on-site storage place for as built drawings.					
Designing out waste, design for resource efficiency – focused on opportunities such as: • Dimensions of exterior walls to optimises the utilisation of e.g. Oriented strand board (OSB) • Locations of framed openings e.g. doors and windows to optimise the use of materials e.g. number of studs used in wall panels, as well as the cutting patterns of OSB panels. • Quantify the exact number of nails, plates, connections, ties, etc. required for each building. Producing an exact bill of materials for erection. • Number of different parts for e.g. the panels to limited errors during the manufacturing /erection process. • Use of a limited number of standard details as developed by Timber Research And Development Association (TRADA). The use of the TRADA details also allows other timber frame workers not only to properly erect the structure, but to modify or repair buildings years after their completion. • Cutting patterns for chipboard for floor cassettes and for OSB racking panels to reduce the amount of waste and improve utilisation. • Optimisation of joists and beam lengths to maximise reuse potential.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Encourage greater adaptive reuse. This is a strategy for existing buildings. Timber frame buildings are often well suited for making major changes to layout and which can result in extending the life of a building instead of its demolition. Adaptive reuse is when there are specific components of the building that are removed, redesigned and/or adapted in order to change the functionality of an existing building. Wood framed buildings are particularly well suited to this type of renovation given the ease with which wood framing can be adapted and moved. Timber frame can be utilised here to retain existing facades via use of drop-in prefabricated “rooms” to maintain existing street lines or, use of prefabricated ’retro-fit’ packages, or bringing existing roof space into habitable use via panel based replacement roofing solutions.	Zero Waste Scotland	New	Moderate	High	✓

Product suppliers

Note: Contractor interventions also relevant to product suppliers

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Funding (and dissemination of funding available) to timber housing industry to support development of new technologies & processes to facilitate deconstruction, reuse and remanufacture. Build on work being undertaken by Construction Scotland Innovation Centre.	Zero Waste Scotland	Proven	Easy	Moderate	✓
MDF Recovery Ltd, Macclesfield has developed a novel, proprietary process to recover wood fibre from waste MDF. Until now, landfill or burning were the only options for disposing of MDF. This solution generates a new raw material source for the wood/natural fibre industry that reduces demand on standing forests. The recovered fibre is of the same high quality as virgin wood fibre and provides a feedstock to the manufacturers of MDF board, insulation products and formable packing materials.	Zero Waste Scotland	Proven	Moderate	Low	x
Assess business case for pallet repatriation scheme in Scotland. Likely to need to focus on Scotland/ Northern England suppliers to be logistically and economically feasible.	Zero Waste Scotland	New/ proven	Moderate	Low	x

Demolition Sector

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Work with demolition contractors on the issues associated with dismantling timber frame buildings to maximise potential for reuse. Demolition contractors likely to be SMEs. Develop good practice guidance on the findings, to help improve the deconstruction process by taking more care in dismantling of components (remove fixings), undertaking recertification, insurance negotiation, fabrication (frames including reused sections) etc. Will also link to development of good practice design for deconstruction.	Zero Waste Scotland	Proven	Moderate	Low	x

Could potentially require development or trialling of suitable machines/ equipment/ techniques for deconstructing existing buildings.					
Similarly work with specifiers, manufacturers and demolition contractors to understand material passport, quality testing and liability type issues associated with reuse and develop approaches to overcome them. Help improve and streamline the process of re-grading structural timber. May require structural testing, demonstration projects of deconstruction.	Zero Waste Scotland	New	Moderate	Medium	x

Further examples & case studies

1. Raploch Timber Frame housing - Deeside TF
2. Timber recycling –window frames – CMS, Cumbernauld
3. Design for structural timber reuse – Brummen Town Hall, Netherlands

4.3 Opportunity 3 – Circular Aggregates (inc Concrete, Brick, Soils and Stones)

Opportunity 3 – Circular Aggregates (inc Concrete, Brick, Stones and Soil)

CE aspects it promotes:

Extending life beyond 1st life, though reuse and recycling (CE Hierarchy – Medium/ Low)

- Recycling and reuse of a high volume resource that is critical to Scotland's construction industry.
- The focus is on keeping aggregate (and associated recyclable inert resources – concrete, brick, stones, and aggregates from soil washing) resource circulating in use longer, extracting maximum value of resources when in use, and recovering and regenerating products and materials at the end of the life.

Relevance to Scotland

- Aggregates are a priority material stream identified in Making Things Last - A CE Strategy for Scotland. Working to avoid depletion of primary aggregates through enhanced recovery, recycling and reuse of demolition and excavation materials is a priority activity. Note however, it has a relatively low cost and embodied carbon relative to its material tonnage.
- Aggregate related waste management industry (Construction Materials Recovery Facilities (MRFs)), and demolition contractors should be well represented by SMEs.

- Infrastructure and Regeneration activity is significant in Scotland. Large tonnages of aggregates, concrete, brick and stone will both be being generated and consumed. Economics of logistics; storage and permitting all act as barriers; however, these are most likely to be overcome on large scale projects, which are closely co-located.

Planned Scotland construction spend:

Aggregate use cuts across all construction types. It is particularly prevalent in:

- Infrastructure – £1.3 billion+ of construction expenditure was identified in the Construction Pipeline Horizon Scan across transport and energy projects alone. Aggregates will make up a significant proportion of the material used in these projects. When looking at CITB's estimates of total committed Scottish Infrastructure between 2017-2020 the forecasted infrastructure spend data is almost double that identified within the Construction Pipeline Horizon Scan, so this is potentially a large stream of material.
- Building - Aggregates will also contribute a significant proportion of the building materials used on the estimated £7 billion+ expenditure on buildings identified in the Construction Pipeline Horizon Scan**.**

Priority Material Streams:

- Aggregates, concrete, bricks, stone and soil.

Potential Impact

- Higher quality (and increased value) recycling through closed loop approaches, will deliver material savings and embodied carbon impact savings. In 2013 Scotland construction aggregate demand was some 29 million tonnes of which in the region of 20% is met with recycled aggregates.[9] Due to high consumption volumes, aggregates along with concrete, brick and block are a significant waste stream. Small % improvements in diversion from landfill will have significant waste tonnage and embodied carbon impacts. It has been estimated that recycled and secondary aggregates have the potential to meet 25% of Scotland's needs for construction aggregates within the built environment[10]. To give an indicative feel for scale, an improvement of 5% would be equivalent to ~1.5 million tonnes. Whilst the volumes of low value aggregate material (clean spoil & soils) allocated to planned landfill and brownfield site restoration is not understood at this stage, it is anticipated that the proposed opportunities would only affects a share of the aggregate waste flow, and be particular focused on the higher value material. A more thorough investigation would be required to understand any potential impacts of CE opportunities on existing planned lower value use demand.

Feasibility

[9] Recycled Aggregates from Inert Waste, SEPA

[10] http://www.gov.scot/Topics/Environment/SustainableDevelopment/funding/Aggregatesprojects2002-07/7510

Barriers:

There are a number of barriers to be overcome:

- Significant primary production, in a well-established sector. Increased recycled and secondary aggregates will affect the primary aggregate market.
- Low value of material per tonne.
- Carbon Footprint – transporting materials for recycling and then on to new sites can result in a higher footprint than virgin materials and also impact on the economics. In the past, a WRAP broad rule of thumb was that virgin aggregates could typically be cost effectively sourced within a 12 mile radius of a site, whilst recycled aggregates had to be within a 10 mile radius to be economically feasible[11].
- Contamination – ensuring there is no cross contamination from other streams is important, where the economics of processing are marginal.
- Time constraints associated with sourcing, and timings of supply and demand and associated storage requirements.

Demand:

- There is an established demand for recycled aggregates. The construction industry also understands the environmental issues and benefits, opportunity and approaches, which presents an easier opportunity for promoting greater use of recycled material. Further growth limited by those barriers highlighted above, particularly the economics of logistics.

Practicality:

- There are a range of well-established approaches, techniques and uses for recycled and secondary aggregates. WRAP (via its Aggregain programme) developed a body of evidence on recycled and secondary aggregate applications.
- Plant and equipment used for crushing and grading, and soil washing plant to produce, clays, sand and gravels, are all available on the market. Issues of supply and demand, together with economics are the main limitations to future growth of the secondary materials market.
- WRAP already developed a Quality Protocol to establish end of waste criteria for use of secondary materials in the construction sector.
- Due to the low value, economics are important. As noted above, issues such as contamination leading to increased treatment can make the economics unfeasible. The Institute of Civil Engineers (ICE) developed the Demolition Protocol which sets out a range of approaches and tests to streamline this process. Although no longer readily available this resource demonstrates the practicalities of preparation for reuse/ recycling demolition material.

Regulatory issues/ opportunities:

- A lot of previous work undertaken by WRAP to remove regulatory barriers - e.g. the Quality Protocol, and end of waste criteria have been established.

Scalability/ Spread

[11] Pers comms – Mervyn Jones

- Any interventions focused on Infrastructure and Regeneration would also support circularity of aggregates across all construction sectors and building types as it is an integral material.

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Demand Pull - Public Sector Procurement – e.g. Transport Scotland – Set a target for Recycled Aggregate Use. Make a requirement to include a certain percentage of recycled aggregates in projects.	Zero Waste Scotland	Well tested	Moderate	High	✓
Work to embed GPP Core criteria for demolition/refurbishment audits into public sector office contracts. Mandatory audits of the buildings, prior to demolition, can help assess what is recyclable and recoverable in the building and in which amount. Recording of these audits and penalties in case of non-compliance appear necessary for an effective implementation. Consider extending beyond offices.	Zero Waste Scotland	Well tested	Easy	Medium	✓
CE voluntary agreement equivalent of the Halving Waste to Landfill commitment to provide focus and collaborative approach within sector	Zero Waste Scotland	Well tested	Moderate	High	✓
Assess availability of material coming from major regeneration schemes, dredging activity for Ports, Housing, at a national level to support linkages between large developments. Support this further by facilitating collaboration across major regeneration/ infrastructure.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Assess if it is a key material for Reuse Hubs in big regeneration areas – Opportunity 7.	Zero Waste Scotland	Proven	Easy	Medium	✓
Consider reduction of economic incentive for inert waste disposal to landfill. Investigate scope for tightening exemptions, and what activities qualify as aggregate 'recovery'.	Beyond Zero Waste Scotland scope	New	Hard	Medium	x

Designers/ Contractors

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Revitalise tools such as Aggregain, Waste Specifier tool and promote Resource Efficient Scotland's (RES) Recycled Aggregate Directory. Assess how this fits with the Material Marketplace being reviewed by Scottish Enterprise (SE) and Zero Waste Scotland.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Designing out waste, design for resource efficiency for example: • Reusing existing foundations, floor slabs, pavements, structures and drainage • Designing site layout to use existing topography and features • Balancing cut/fill quantities • Manufacturing soils on site using PAS 100 compost • Recycled aggregates in lower strength concretes • Treating of soils with cementitious agents and use of hydraulically bound materials (HBM) • Using geosystems to enable use of material on site • In-situ remediation or encapsulation of contaminated land • Crushing/screening arisings for use as recycled aggregates • Cold recycling of pavements • Use of prefabricated manholes; retaining walls, bridges and other structures; piles; tunnel segment.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Allocate areas for storage – especially large regeneration schemes/ transport/ civils.	Zero Waste Scotland	Proven	Hard	Medium	x
Aggregate supply could provide a focus for SE/Zero Waste Scotland Material Marketplace, RES Construction Materials Marketplace.	Zero Waste Scotland	Proven	Easy	Medium	x

Product suppliers

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Aggregate demand could provide a focus for SE/Zero Waste Scotland Material Marketplace, RES Construction Materials Marketplace.	Zero Waste Scotland	Proven	Easy	Medium	✓
Consider capital funding for mobile recycled aggregate plant, soil washing kit.	Beyond Zero Waste Scotland scope	Proven	Moderate	High	✓

4.4 Opportunity 4 – Structural Steel and Aluminium Reuse

Opportunity 4 – Structural Steel and Aluminium Reuse

CE aspects it promotes:

Preparation for reuse (CE Hierarchy – High)

- A move up the waste hierarchy from recycling to reuse of structural metals (primarily steel; and aluminium), rather than recycling - e.g. reuse of steel is currently at about 5%, recycling 90%+[12]
- Better understanding of design for deconstruction by clients, designers and product manufacturers.
- Standardisation of components and connections by the steel/ aluminium construction sector.
- Stimulating a stronger market for reusable steel/ aluminium construction products.
- At the building systems level, modular construction offer the greatest opportunities for reuse. Modules or pods can be deconstructed from the building and refurbished and reused on the same or an alternative building. This links with Opportunity 1 – Modular design.

[12] Survey of NFDC members 2013

Relevance to Scotland

- Structural steel and aluminium are significant construction resources used as part of the frames and envelopes of Scotland's buildings and infrastructure. Both have significant use in commercial, school, health and industrial buildings, both existing stock and new build, as well as having extensive use in transport and oil and gas infrastructure projects.
- Both have high embodied carbon, inherently durable for reuse and lesson learnt from metals will apply to the circularity of other materials.
- Demolition contractors, along with designers (those that specify steel frames) and steel fabricators making the steel frames are likely to be well represented by SMEs.
- Public sector buildings and Private/Public regeneration programmes, will be specifying steel and aluminium structural frames and envelopes for new build, and these projects will be where demolition of (in particular) steel framed buildings might be occurring. The ideal situation being to link the deconstruction and new build activity.
- Public sector new build represents an opportunity to drive design for deconstruction and standardisation of structural metal specifications.
- Public sector demolition represents an opportunity to address issues of programming to allow deconstruction, logistics; storage; quality assurance i.e. allowing suitable time within the programme for effective deconstruction.
- Regeneration areas present the best opportunity for economies of scale and local reuse.
- Whilst these opportunities are equally important to the private sector activity, public sector presents easier intervention points, and should have trickle down effects into private sector developments.

Planned Scotland construction spend:

Structural metal use cuts across all construction types. It is particularly prevalent in:

- Infrastructure – It is an important material in a wide range of transport projects – rail, road (e.g. Bridges). £1.3 billion+ expenditure was identified in the Construction Project Horizon Scan (2017-2020) across transport and energy projects alone. Whilst aggregates will make up a significant proportion of the estimated 7 million tonnes of materials, steel/aluminium will have a small contribution to this tonnage but a large impact in terms of value and embodied carbon.
- Building - In particular commercial, schools, health, regeneration areas. Construction Pipeline Horizon Scan (2017-2020) estimated £800million+ of planned construction spend on schools, £700million on health and £1.7billion+ on regeneration, which will include a significant proportion of commercial development. Even if structural metals only represent a small percentage of that overall spend, it still is a significant value and tonnage of material and embodied carbon.

Priority Material Streams:

- Structural Steel and Aluminium

Potential Impact

- Research carried out by the Steel Construction Institute (SCI)[13] has estimated that there is around 100 million tonnes of steel in buildings and infrastructure in the UK. This 'stock' of steel is an important and valuable material that will be reclaimed and either reused or recycled in the future.
- Higher quality (and increased value, reuse should offer capital cost savings) reuse through closed loop approach. In terms of environmental impacts reused steel has 4% of the embodied impact of new steel (BRE 2002)[14], as it avoids energy intensive recycling.
- Whilst Aluminium use is lower than steel, similar benefits could potentially be achieved.
- Developing the reuse sector would also add social value; creating jobs, skills, as well as keeping material flows local to Scotland.

Feasibility

Barriers:

There are a number of barriers to reuse that will need to be overcome:

Technical barriers:

- Lack of standardisation of components
- Quality assurance and warranting the performance of reused components
- Lack of detailed knowledge of the product's properties and in-use history
- Robustness of products in the deconstruction process
- Practicalities of economic deconstruction including composite components

Logistical barriers:

- Assured availability of supply
- Demolition programmes are too short to enable contractors to deconstruct buildings
- Sufficient storage space for recovered products

Cost:

- Lack of commercial drivers for reuse
- Cost of storage, cataloguing, refurbished products, etc.
- Cost of testing to verify and guarantee properties
- Client expectation that 'second-hand' products should be cheaper than new ones
- Additional cost of deconstruction over (faster) demolition

Liability:

[13] Ley, J.: An environmental and material flow analysis of the UK steel construction sector, DEng thesis submitted to the University of Wales, 2003

[14] http://asbp.org.uk/wp-content/uploads/2016/08/Gary-Newman-Resource-9th-Marchfinal.pdf

- How to manage and apportion risk and liability associated with deconstruction and reuse.

Demand:

- It is a high value product with significant demand for new structural metal. Demand for structural metal reuse is low, limited by the barriers highlighted above. For example, steel reuse currently sits at ~5% with 90% recycling, so offers great potential in terms of increasing reuse.
- Most UK scrap steel is currently exported, with a large proportion of new structural metal imported. Reuse would retain economic activity within Scotland, and also increase resilience to international market price spikes.

Practicality:

- High levels of structural metal reuse is technically viable. Steel and aluminium construction products are highly and intrinsically demountable. This potential is illustrated by the large number of temporary works systems that use steel components, e.g. scaffolding, formwork, sheet piles, etc. Provided that attention is paid to eventual deconstruction at the design stage, there is no technical reason why nearly all of the steel building stock should not be regarded as a reusable resource. Already some industries such as the agricultural sector (where aesthetics are generally of less concern than other sectors) commonly reuse steel structures and cladding components.
- Many steel construction products and components are highly re-usable including:
  - Piles (sheet and bearing piles) or other steel products for piling uses[15].
  - Structural members including hollow sections
  - Light gauge product such as purlins and rails
- There is already high levels of capture at end of life, just that at present this principally goes to recycling (90 %+).
- Approaches, techniques and tools to increase the level of steel reuse have been developed by Innovate UK via two projects. The Alliance for Sustainable Building Products (ASBP) have been undertaking work on Circular Economy Business Models (CEBM) for reuse of structural steel within construction[16, 17], and the SCI have been leading a supply chain integration project supporting the supply chain for steel reuse.

Regulatory issues/ opportunities:

- Legal intervention such as reduce taxation on reused products, and legal requirements for demolition audits would promote greater reuse.

Scalability/ Spread

- As noted above, limited reuse of structural metals currently occurs, presenting a large opportunity.
- Activities pursued with the public sector will have trickle down effects to the rest of the sector. Private sector commercial development is a large area of spend, with metal frame and envelope material an integral part of that construction type. Learning will be transferable.
- Learning could also be transferred to fit out metals construction processes.

[15] http://johnlawrie.com/tubulars/piling-pipe

[16] http://asbp.org.uk/resource-report/barriers-structural-steel-reuse

[17] http://asbp.org.uk/asbp-news/asbp-launches-reusable-buildings-network

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Work to embed GPP Core criteria for demolition/refurbishment audits into public sector office construction contracts.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Require Material Passports for key materials in public sector contracts.	Zero Waste Scotland	Proven	Moderate	Medium	x
Focus on construction programmes for public sector demolition projects to allow deconstruction. Scottish Excel Demolition Framework provides a good set of target projects. More broadly, work with public procurement on requirements for design for deconstruction of structural metal framed buildings, or those with metal envelopes.	Zero Waste Scotland	Well tested	Moderate	Medium	x
Establish a central database of public sector new steel structures to facilitating future refurbishment, reuse and recycling scenarios. Procurement requires as built BIM files provided on request. Require uploaded to database to facilitate future opportunities.	Zero Waste Scotland	Proven	Moderate	Low	x
CE equivalent of the Halving Waste to Landfill commitment to provide focus and collaborative approach within sector.	Zero Waste Scotland	Well tested	Moderate	High	✓
Consider generation of fiscal incentives to buildings that are designed for deconstruction, reuse and recycling.	Beyond Zero Waste Scotland scope	New	Hard	High	x
Fiscal/ Taxation incentives – Linked with the above, most used structural metal is exported, and new metal imported. Viability of reuse today unlikely to yield a viable business model without legislative drivers as at present economic case is marginal other than for niche markets and scenarios.	Beyond Zero Waste Scotland scope	New	Hard	High	x

Contractor / Product Supplier

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Review projects that are going to be using steel frames (2017-2020) (focus on schools, hospitals, commercials, industrial new build), to target for design support.	Zero Waste Scotland	Proven	Moderate	Medium	x
Provide/ promote a supply demand co-ordination tool for steel reuse i.e. Availability of reclaimed sections particularly of the desired size, volume and in the right place at the right time. Review: • How structural metal reuse fit in with plans for a Materials Marketplace. • The Innovate UK funded feasibility study and its supply demand co-ordination tool for steel reuse, which may act as a starting point. • How the steel research could be expanded to include Aluminium, is Aluminium as viable an option.	Zero Waste Scotland	Proven	Easy	Medium	✓

Work with designers (those that specify steel frames) and steel fabricators making the steel frames - a number of SMEs are likely to be in the sector. Fabricators - Grampian Steel, Rippin Ltd, Robinsons Scotland Ltd are potentials for engagement on:
• Practical tools and steel based technologies to be able to design steel and composite structures for deconstruction, repair and reuse. (e.g. other options to welding). Good practice includes:
  • Use bolted connections. Explore using clamped friction connections.
  • Avoid conventional composite floor systems using welded studs and cast-in-place concrete. New systems using bolted or clamped fasteners and precast elements need to be developed.
  • Use precast decks.
  • Use common shapes and avoid short filler pieces.
  • Use regular spacing.
  • Mark steel grades and shape designations on members.
  • Seek alternatives to spray-on fire-proofing. Although spray-on fireproofing no longer contains asbestos, it is difficult to remove from steel framing. If left on
	Zero Waste Scotland	Proven/ New	Easy	Medium	✓

salvaged members, it adds shipping weight and volume, can be damaged during transport, and is an impediment to refabrication.[18,19,20,21] • Development of business case, and cost models for standardisation to facilitate reuse. • Use of Materials passport -Traceability and properties for optimising recycling and reuse.					
Review how best to links materials from oil and gas decommissioning, with designers/ fabricators. Material Marketplace approaches may have a role in this.	Zero Waste Scotland	Proven	Hard	Low	x

Demolition Sector

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Work with demolition contractors on the issues associated with dismantling metal frame and envelope buildings to maximise potential for reuse. Demolition contractors likely to be SMEs. Develop good practice guidance on the findings, to help improve the deconstruction process by taking more care in dismantling of components (remove fixings), undertaking shot blasting and recertification, insurance negotiation, fabrication (frames including reused sections) etc. Will also link to development of good practice design for deconstruction.[22,23] Could potentially require development or trialling of suitable machines/ equipment/ techniques for deconstructing existing buildings.	Zero Waste Scotland	Proven/ New	Moderate	High	✓
Similarly work with specifiers, manufacturers and demolition contractors to understand material passport, quality testing and liability type issues associated with reuse and develop approaches to overcome them. Help improve and streamline the process of re-	Zero Waste Scotland	Proven/ New	Moderate	High	✓

[18] http://www.lifecyclebuilding.org/docs/Designing%20Structural%20Systems%20for%20Deconstruction.pdf
[19] http://www.reuse-steel.org/files/Information%20papers/Deconstruction%20IP%2010-5.pdf
[20] http://www.4darchitects.nl/download/TG39_2003_3.pdf
[21] https://www.steel-sci.com/assets/downloads/LSF/ED014%20Download.pdf
[22] http://asbp.org.uk/wp-content/uploads/2016/08/Gary-Newman-Resource-9th-Marchfinal.pdf
[23] https://www.steel-sci.com/assets/downloads/structural-steel-reuse/161130-bcsa-cullen%20002.pdf

grading structural steel components. May require structural testing, demonstration projects of deconstruction, along with engagement with financial sector on insuring products such as reused structural steel					
Engage with SCI[24] which has been undertaking work in this area for Steel so as not to duplicate effort.	Zero Waste Scotland	Well tested	Easy	Medium	✓

Further examples & case studies

1. Modular steel frame design guidance

4.5 Opportunity 5 – Closed loop and lean design and construction for plasterboard

Opportunity 5 – Closed loop and lean design and construction for plasterboard

CE aspects it promotes:

***Closed loop recycling* (CE Hierarchy – Medium/ Low)**

- Primarily focused on improved recycling, but this is the most effective way of extracting maximum value of waste plasterboard, recovering and regenerating products and materials at the end of the life. Gypsum products can be counted amongst the very few construction materials where "closed-loop" recycling is possible, i.e. where the waste gypsum is used to make the same product again repeatable, with the paper fraction also potentially recyclable several times. Whilst there are other lower value markets for waste plasterboard, reprocessing it back into plasterboard retains it at its highest value. The challenge for Scotland is that manufacturers are distant from some areas e.g. the Highlands, where the economics of logistics are likely to act as a barrier. If the economics of return to manufacturers cannot be improved, the alternative markets need to be developed.

***Preparation for reuse at end of 1st life* (CE Hierarchy – High)**

- Design for deconstruction, deconstruction at end of 1st life and reuse of plasterboard are higher up the hierarchy than closed loop recycling. It is theoretically technically possible but at present will only be occurring infrequently, due to boards being cut to bespoke size, and being contaminated with paint/wallpaper. Presents a better opportunity for ceiling tiles.

[24] http://www.steel-sci.com/assets/downloads/structural-steel-reuse/SCI-conclusions.pdf

Resource efficiency (CE Hierarchy – High)

- Material optimisation opportunities, through improved design to minimise offcuts and reuse offcuts generated.

Relevance to Scotland

- Whilst closed loop recycling of plasterboard has great potential, the current situation is some way from this outcome. Plasterboard waste is a regular component of construction and demolition waste, and will be generated during the construction, refurbishment and demolition phases across Scotland's building types, but particularly housing and commercial sectors during internal fit out. It has been estimated that typically ~10-15% wastage of plasterboard occurs when installed (either at the new build or refurbishment stages) with wastage up to 30% in poor practice circumstances[25].
- Housing, Commercial new build and repair, refurbishment and maintenance are key users of plasterboard and represent significant planned spend (2017-2020). CITB data estimates in excess of £4 billion of construction spend in these areas in Scotland.
- Particularly applicable because:
  - Public sector contracts can drive material optimisation, create demand pull through recycled content requirements. Public sector also have lifetime ownership of properties, allowing the long term benefits of deconstruction and reuse to be realised by the stakeholders initially investing in the properties.
  - Regeneration projects may present opportunities to investigate deconstruction and reuse opportunities, due to economies of scale. This highlights plasterboard as key material stream for the Material Hub/ Reuse Centre type opportunities- Opportunity 7.

Planned Scotland construction spend:

- All housing, education, health and commercial properties, but those supported by public sector investment reflect the best opportunity.

Priority Material Streams:

- Gypsum containing products – primarily wall board products (and potentially ceiling tiles).

Potential Impact

- Plasterboard waste is not created in as significant volumes as other streams such as inert, metal, timber, but it is still a noteworthy waste stream, in terms of quantities, its ban from landfill, and there being limited alternative markets. The Market Transformation Programme predicted that UK could be generating over 500,000 tonnes of plasterboard waste each year by 2020[26]. Smartwaste data from RAP002-002 Construction Waste Arising Study was showing that once soil and inert waste was removed plasterboard accounted for 5-10% of the remaining stream.
- Higher quality (and increased value) recycling through closed loop approach. Increasing recycled content in plasterboard would have embodied carbon impacts. Gypsum to Gypsum G2G[27] project identified 9% life cycle carbon savings associated with different levels of recycled gypsum reincorporated in the manufacturing process (0%, to 18.5%, respectively).

[25] https://www.nibusinessinfo.co.uk/content/recycling-plasterboard-and-gypsum-construction-projects
[26] https://www.bre.co.uk/filelibrary/pdf/rpts/waste/Roadmap_final.pdf
[27] http://gypsumtogypsum.org/

- Improved Scotland's recycling infrastructure would also potentially protect and create job's associated with increased recycling capacity.

Feasibility

Barriers:

There are number of potential barriers to increased circularity:

Logistics and economics of take back schemes and recycling

- Take back schemes are in operation but logistics of returning plasterboard to manufacturers may be challenging, certainly in Highlands. British Gypsum has a manufacturing site in Cumbria, but do have regional skip hubs and all material goes via Bywaters recycling plant. Siniat has sites in Yorkshire and County Durham, Knauf has sites in Kent and Lincolnshire.
- Other recycling infrastructure is present in Scotland, but the coverage and final destination of recyclate is unclear. Hamilton Waste & Recycling Ltd established a plasterboard recycling facility in Scotland. Agricore have a facility in the North East of England that operates in Scotland. The plant opened in March 2010. There is a small market for ground gypsum as soil nutrition in the UK but is a lower value end use than back into plasterboard manufacture.

Demolition/ refurbishment

- In terms of demolition - Plasterboard can be part of a composite board, or mixed with other waste materials and contaminated by other substances causing difficulties for recyclers. Overcoming this is one of the biggest challenges for greater levels of recycling.
- Reuse has best potential on large regeneration sites where economies of scale may come into play. This is likely to be reuse of virgin board (e.g. due over ordering) rather than deconstructed material. It could then be made available for small maintenance/ refurbishment projects.

Demand:

- Plasterboard is a high use construction material to Scotland, and is a problematic waste stream, as it is banned from landfill, so opportunities to reduce waste and cost effective alternative treatments are desirable.

Practicality:

- Good practice for plasterboard material optimisation/ designing out waste are well documented. WRAP[28] for example undertook an extensive programme of work.
- European Commission LIFE Programme and Eurogypsum - G2G project report identifies best practices for deconstruction, recycling and reincorporation in the manufacturing process of recycled gypsum to create the 'perfect' loop. It also sets out a roadmap for future implementation of a sustainable value chain, which it says will require intense collaboration between demolishers, constructors, recyclers, and manufacturers.
- Manufacturers are achieving between 18-30% recycled content in new products, so incorporation of recycled content into new product is achievable and commonplace.

[27] http://www.wrap.org.uk/category/materials-and-products/plasterboard

Regulatory issues/ opportunities:

- Considerable work undertaken by WRAP and the manufacturing industry to develop end of waste criteria and quality protocol to facilitate preparation for recycling and remanufacture.

Scalability/ Spread

- Targeting plasterboard in public sector procurement and projects will have a trickle-down effect on private sector.
- Improved recycling infrastructure benefits all building types both private and public producing plasterboard waste.

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Work to embed GPP Core criteria for demolition/refurbishment audits into public sector office contracts. Mandatory audits of the buildings, prior to demolition, can help assess what is recyclable and recoverable in the building and in which amount. Recording of these audits and penalties in case of non-compliance appear necessary for an effective implementation. Consider extending beyond offices.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Demand pull – set targets for plasterboard recycled content and design for deconstruction in public sector procurement. The US Environmental Protection Agency's buildings One and Two Potomac Yard in Arlington, VA, were built using 27% recycled content – including slag concrete aggregate, fly ash, and gypsum wallboard.	Zero Waste Scotland	Well tested	Moderate	High	✓
Undertake a market and value chain assessment for plasterboard waste and what actions are required to address barriers identified. Beyond recycling back into plasterboard, other potential uses include Unfired Clay Blocks, Cement Manufacture, Road Bases/ Sub bases and stabilised sub grades, Slope stabilisation, Mould material for ceramic and metal casting, Mushroom compost, Soil Conditioner, and Granular Absorbent. (Note: recycled gypsum quality criteria already well developed). The assessment would need to evaluate the logistics economics of feeding waste	Zero Waste Scotland	Proven	Easy	Medium	✓

plasterboard to the English manufacturers, whether government fiscal intervention is required, or whether alternative local markets are more economically feasible.					
As part of market assessment review existing infrastructure, to ensure recycling plant or warehouses are strategically located, with adequate storage for gypsum waste and recycled gypsum storage. Test potential for mobile recycling plant.	Zero Waste Scotland	Proven	Easy	Medium	✓
Assess potential for cities to act as plasterboard urban mines (for recycling)	Zero Waste Scotland	New	Hard	High	x
CE voluntary agreement equivalent of the Halving Waste to Landfill commitment to provide focus and collaborative approach within sector	Zero Waste Scotland	Well tested	Moderate	High	✓
Assess whether extended producer responsibility, or incentivised product return principles could practically be applied to plasterboard.	Zero Waste Scotland	Proven	Hard	Medium	x

Designers

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Reduce dependency on gypsum products and focus on designing out waste due to high on-site wastage levels of >15%.	Zero Waste Scotland	Proven	Hard	High	x
Encourage standard sizing where possible and matching floor-ceiling heights to reduce on-site waste.	Zero Waste Scotland	Well tested	Easy	Medium	✓

Contractors

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Develop/ revitalise good practice and promote designing out waste (material optimisation, use of BIM for material optimisation, e.g. the new REVIT ® module specifically for plasterboard); design for deconstruction and recyclability. Focus on:	Zero Waste Scotland	Well tested	Easy	Medium	✓

• Trimming losses – A survey of a housebuilder showed that 70% of plasterboard yield losses are due to either board height or width trimming and hence represents a significant area of opportunity. • Lack of drylining contractor accountability for waste arisings • Over-ordering - The general philosophy adopted for housing is that it is better to have four sheets per development too many than to be one sheet short • Stairwells - In typical house builds the stairs are fitted prior to drylining, resulting in the need to cut the board to fit the angle of the stairs • Weather damage.					
Assess potential for design for disassembly and reuse of plasterboard sheets. What are the barriers, what circumstance presents an opportunity? Maximising reuse potential has to be linked to floor to ceiling heights matching board lengths, types of fixings and coatings/ finishes. E.g. Graham & Brown developed a peelable wallpaper. This is particularly applicable to short lease office space where the tenant has to take the building back to its original layout as part of its lease exit requirements.	Zero Waste Scotland	New/ proven	Moderate	Low	x
Promote application of deconstruction good practices: • Perform an on-site segregation of recyclable (e.g. plasterboard, blocks) gypsum waste • Implement an effective pre-deconstruction audit for gypsum-based systems • Train workers concerning gypsum products dismantling, as well as sorting and storing of gypsum waste • Plan coordination and review meetings about C&D waste • Perform gypsum waste traceability, from source to final destination • Draft and implement a precise site waste management plan (SWMP) • Plan number and size of containers needed to minimise number of roundtrips (from building site to transfer station/recycling)	Zero Waste Scotland	Well tested	Easy	Medium	✓
Promote the use of good practice technology, e.g. WHISCERS™ type technology for plasterboard refurbishment fitout (particularly in Social Housing). WHISKERS™ is used during the survey to laser scan the dimensions of a room. Software then converts the room measurements into the required board sizes, and the resulting digital data is downloaded to a factory-based, off-site cutting machine. The cut	Zero Waste Scotland	Well tested	Easy	Low	✓

boards then match the walls perfectly, optimises the process to minimise wastage and allows for quick installation.					
Support the development of closed loop recycling and preparation for reuse/ recycling for gypsum products through: • Deconstruction pilot projects. Test Deconstruction techniques, applied systematically to demolition and refurbishment projects. To identify best practice required to recover plasterboard from different construction systems/ approaches and contamination. Promotion of European handbook of best practice in deconstruction of gypsum systems. • Ensure processing is carried out according to existing standards PAS109.	Zero Waste Scotland	Proven	Easy	Medium	✓

Product suppliers

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Establish links between design and manufacturers for large scale projects to optimise product sizing.	Zero Waste Scotland	New/ Proven	Hard	Medium	x
Establish suitable supply contracts between recyclers and manufacturers.	Zero Waste Scotland	Proven	Moderate	Medium	x
Work with manufacturers on design for deconstruction opportunities e.g. fixings, peelable wallpapers.	Zero Waste Scotland	New/ Proven	Moderate	Low	x
Work with plasterboard manufacturers to agree realistic targets for recycled content in public sector procurement.	Zero Waste Scotland	Well tested	Easy	High	✓

Further case studies and examples

1. Gypsum plasterboard deconstruction to recycling Economic study in Europe
2. End-of-life of gypsum plasterboard: European case studies analysis

4.6 Opportunity 6 – Making Retrofit and Refurbishment more circular

Opportunity 6 – Making Retrofit and Refurbishment (inc Repair and Maintenance) more circular

CE aspects it promotes:

Preparation for recycling and reuse **(CE Hierarchy – Medium/Low)**

- Pre refurbishment strip out audits to understand potential for recycling and reuse – whilst ~90% of construction & demolition waste is recycled, it is low quality and low value (WRAP, EMF).
- Design for deconstruction/ flexibility (particularly retail/ office) to allow future reuse and recovery via repair and maintenance and retrofit activities. Combined with using Material Passports to understand original material specification, standards, and in life maintenance.

Resource efficiency **(CE Hierarchy – Medium/Low)**

- Material optimisation opportunities when undertaking refurbishment/ retrofit, through improved design, simplifying and standardising materials and component, dimensional coordination (where possible) and good on site construction practices.
- Reuse of existing building components either onsite or offsite as currently <1% reuse from demolition and refurbishment (EMF, 2015).

Performance/Service System **(CE Hierarchy – High)**

- On public sector commercial properties (where public sector also occupier – offices, schools, health) look to service based models for heating and lighting performance outputs where the manufacturer retains ownership, has greater control over the production of a product, and therefore has more interest in producing a product that lasts.

Relevance to Scotland

- 80% of building stock is already in existence.
- Retrofitting existing buildings can profitably reduce energy consumption by 20–40 percent. Passive and zero-net-energy houses are already making money in several market segments but remain a minority of new buildings according to EMF Growth Within Report (2015).
- Combined Non Housing and Housing Repair and Maintenance is one of the top forecast spend areas (2017-2020) by CITB at £3.8 billion. This also ranks high in terms of material consumption and waste generation.
- Scotland has ambitious retrofit programmes and frameworks (e.g. £300 million Non Domestic Energy Efficiency (NDEE) framework, and Energy Efficiency Standard for Social Housing (EESSH)) that have the potential to drive CE good practice in retrofit and refurbishment.
- Minor works (including retrofit and refurbishment activity) are expected to be well represented by SME designers and contractors.
- Across all retrofit and refurbishment, commercial retail/ office and public buildings generate the greatest tonnage per 100m^2, based on BRE Refurbishment data[29]. As noted above, commercial repair and maintenance is a large area of proposed spend, as is housing.

[29] Refurbishment Waste Benchmark Report, Construction Resources and Waste Platform (CRWP), 2009

- The public sector is also in a good position to drive this opportunity into public sector procured development. This is particularly due to centralisation of public sector spend, and that the public sector will have lifetime ownership of properties, allowing the long term benefits of product service systems and design for deconstruction to be realised by the stakeholders initially investing in the properties. Completed in 2013, Turntoo led the work of retrofitting the Brummen Town Hall in the Netherlands, where the architects worked together with the material suppliers to establish performance contracts where the suppliers retained ownership of the materials. The renovated town hall is designed for disassembly and has an attached materials passport to fully track the building's material assets.
- Equally applicable to private sector developments but more difficult to influence.
- Regeneration projects may present opportunities to investigate deconstruction and reuse opportunities, due to potential economies of scale associated with high levels of local projects.

Planned Scotland construction spend:

- Public sector offices, education and health facilities. The average design life of office refurbishment, for example, is ~7 years so presents some short term impacts. Trickle down influence will occur, impacting private sector commercial properties as well.
- All housing, but social and affordable housing are a key area of focus, as presents greatest opportunity for public sector intervention.

Note: There are various levels of refurbishment (and project value) from 1) Do bare minimum (very minor redecoration) 2) Refresh (minor redecorations, new floor/ ceiling finishes and making good after Information and Communication Technology installations) 3) Refurbish (significant strip out but leaving the external envelop in place), and 4) Remodel (significant strip out occurs typically back to the frame). More significant impact will be in refurbish and remodel. Resource efficiency and circularity issues will be a low priority, for Do Bare Minimum and Refresh, with cost and quick delivery being paramount.

WRAP research in 2010/11[30] showed that a significant proportion of the refurbishment market with respect to financial value was in Do Bare Minimum, Refresh and Refurbish. Therefore based on low project value being correlated with a lack of resource efficiency implementation, it was concluded that a significant part of the sector does not typically address resource efficiency issues, and presents opportunity to influence.

Priority Material Streams:

- Insulation
- Plasterboard
- M&E
- Fit out metals
- Timber

Potential Impact

- Increased use of pre-refurbishment strip out audits would help upcycling and reuse, from lower quality and value uses.

[30] The WRAP Characterising the Market for Refurbishment Works in the Built Environment Report 2010/11

- Targeting public sector retrofit frameworks in particular would lead to potential quick win carbon reduction through material optimisation, and medium to long term impacts through design for deconstruction. Some 2010 WRAP estimates based on conversations with Architects were that ~30% of buildings at end-of-life today that could have been economically re-used if they had been subject to Design for Deconstruction. WRAP research estimated that designing for less waste on site (e.g. to cut wastage rates on the top 10 materials from baseline to good practice) could lead to ~10% carbon savings[31]
- Increased Gross Value Added (GVA) and encourage innovation through more REBMs, such as Product Service Systems e.g. Pay per lux

Feasibility

Barriers:

There are a number of barriers:

- General - The size of refurbishment projects can lead to a lack of planning/ legal requirements being placed upon them and associated BREEAM, LEED or SKA ratings leading to limited environmental requirements. Government and public sector refurbishment projects (being larger) are more likely to require minimum BREEAM/SKA requirements, but again there are financial thresholds set for these requirements to be applied.
- General - Resource efficiency is often seen as the contractors' responsibility, by which point many opportunities to prevent and reduce waste had passed, suggesting there is still a role for interventions to improve the link between designers and contractors.
- Pre refurbishment/ retrofit audits – where projects are typically small in value and have a short programme there is limited time for planning and delivery. Potential perceptions of cost/low savings opportunity from undertaking an audit, and additional cost of deconstruction over (faster) demolition act as disincentives. Undertaking surveys however should be more commonplace in refurbishment than demolition to understand existing building fabric.
- Building component reuse may require testing and quality checks. Supply and demand of reusable components is challenging. Also perception of residents/ occupiers of reused elements can limit the appetite for reuse.
- Material Optimisation - always challenging in existing buildings as building dimensions, location of openings, are already set. Also fit-out subcontractors may not be responsible for disposal of their own waste, responsibility sitting with the principal contractor.
- Product Service Systems - the lack of consumer and business acceptance regarding the CEBM; and lack of policy drivers to make change.
- Design for deconstruction – demonstrating the benefits to clients (upfront costs likely to be higher than traditional approaches. Design for durability can conflict with Design for deconstruction product design). Standardisation helps design for deconstruction, but potentially difficult when retrofit/ refurbishment may not facilitate standardisation

Demand:

- At present the demand for these types of opportunity is low and are only being requested by clients in good practice situations. They all however, have significant potential due to low take up at present.

Practicality:

[31] Cutting embodied carbon in construction projects, WRAP 2011

- Pre refurbishment survey – already an approach adopted by the sector, but at present without a focus on resource efficiency. GPP procurement requirements available to embed in procurement (note: GPP requirements only relates to office developments, but are equally applicable to other building types)
- Material Optimisation – well understood area, with a body of WRAP research, case studies and good practices. Applying good practice via procurement to existing public sector framework is an approach Zero Waste Scotland and WRAP have taken in the past.
- Design for deconstruction – There is potentially more of a driver for design for deconstruction/ flexibility in refurbishment than on new construction projects; especially in leased commercial properties, where the tenant is responsible for fit out and has to take the appearance back to 'as was' before the lease.
- Product Service Systems, although relatively new, are now on the market, for example Pay per lux.

Regulatory issues/ opportunities:

- GPP Core criteria for demolition/refurbishment audits into public sector office contracts has been developed to help drive this opportunity.

Scalability/ Spread

- They all however have significant potential due to relatively low take up at present.

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Awareness raising and economic cost and benefits of performance service systems	Zero Waste Scotland	Proven	Moderate	Medium	x
Embed into public procurements: • Performance/ service systems into public sector non domestic retrofit e.g. Pay as you use type service models for lighting/ heating. Pay-per-lux' intelligent lighting system is a common example of this approach, to fit the requirements of the space, at a manageable price. Philips retain control over the items they produce, enabling better maintenance, reconditioning and recovery (see Reference 3 below). • Recycled content targets and specifications. • Design for deconstruction, and material optimisation requirements.	Zero Waste Scotland	Well tested	Easy	High	✓

• GPP Core criteria for demolition/refurbishment audits into public sector office contracts. Consider widening this requirement to other public sector buildings Opportunities include: • £300 million Non Domestic Energy Efficiency (NDEE) framework (2016-2020) to the Scottish public sector. This will include M&E and building fabric improvements. Particularly in terms of external and internal insulation and M&E. Contractors include Alternative Heat Ltd, Ameresco Ltd, Blackbourne Ltd, British Gas Trading Ltd, Cofely Ltd, Cynergin Projects Ltd, Everwarm Ltd, FES Ltd, Matrix Control Solutions Ltd, Robertson Group Ltd, SSE Contracting Group Ltd, Vital Energi Solutions Ltd. • Similarly the Energy Efficiency Standard for Social Housing (EESSH) aims to improve the energy efficiency of social housing in Scotland. Embedding recycled content, design for deconstruction, material optimisation requirements into programme of this nature would also appear relevant. • Some large public sector e.g. Defence Infrastructure Organisation (DIO) frameworks require use of standardised approved materials in refurbishment. This warrants research to determine whether standardisation of materials could be investigated to encourage wider specification of recycled content in refurbishment.					

Contractors

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Wins - ✓/x
Support to those on the Non Domestic Energy Efficiency (NDEE) framework and equivalents on developing Product Service System offers.	Zero Waste Scotland	Proven	Easy	Medium	✓
Development of a set of requirements/ guidelines to support small refurbishment projects (particularly housing and commercial) which are delivered over short timescales (often 4-8 weeks), with the intention of finding the balance between improving resource efficiency (material optimisation and waste prevention), whilst not being too onerous in its application. This could include standard business practices /procedures which can be adopted at a refurbishment contractor	Zero Waste Scotland	Proven	Easy	Medium	✓

corporate level to support refurbishment projects which demand a fast turnaround i.e. actions that can be rolled out on all projects within a company, to avoid the reactive nature of the project planning stage.					
In 2012/13 Morgan Lovell were looking into the use of CGI (computer generated imagery) alongside BIM as a tool to replace CAT A fit-outs on speculative developments. Virtual reality being used to market and sell refurbished space without the need to apply finishes that the client will replace on occupation. It is worth reviewing this good practice and what its potential impact is.	Zero Waste Scotland	Proven	Easy	Low	x

Product suppliers

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Wins – ✓/x
Promote/ support growth of WHISCERS™ type technology for plasterboard fitout[32] (particularly in Social Housing). This uses laser scanning to measure the dimensions of a room and combines this technology with cutting the insulation board off-site and very quick installation.	Zero Waste Scotland	Well tested	Easy	Medium	✓
Review key product types associated with leased commercial properties where the tenant is responsible for fit out and has to take the appearance back to 'as was' before the lease. Focus on supporting design for deconstruction and material passports with this product/ manufacturer group.	Zero Waste Scotland	Proven	Moderate	Medium	x

Further examples & case studies

1. Flexible refurbishment – long life loose fit examples including Dunfermline Fire Station
2. Refurbishment - Liander Head Office, Netherlands Thomas Rau architects
3. FM Pay per lux lighting - Philipps case study, Turntoo & Schiphol Airport, Netherlands
4. FM Carpet tiles service maintenance model – ProRail, Utrecht, Netherlands
5. ICE Demolition Protocol 2008

[32] http://www.nef.org.uk/service/search/result/whiscers

4.7 Opportunity 7 – Large Infrastructure and Regeneration projects - circular scoping studies

Opportunity 7- Large Infrastructure and Regeneration projects – circular scoping studies, material banks/ reuse hubs

CE aspects it promotes:

Large regeneration schemes have the potential for a critical mass of construction, demolition and refurbishment in a localised area to allow CE synergies. Two key (linked) opportunities are:

Circular Scoping Studies **(CE Hierarchy – High)**

- Regeneration areas present a particular opportunity to establish the feasibility of applying CE principles across the overall development. As an example recently London has started to commission specific feasibility studies on large redevelopment areas e.g. Old Oak and Park Royal Redevelopment and London Borough of Sutton. The purpose is to make specific clear recommendations as to how these principles could be embedded into planning, design, construction, procurement, operation and end-of use stages (see references 1-3 below).

Building Material Reuse Centres (BMRC). **(CE Hierarchy – High/medium)**

- As part of a circular scoping study, the potential for BMRCs should be assessed. These are defined as a retail focused business with relevant wider construction material services attached. They generate core revenue by selling building products to both general public and trade customers at reduced prices. These are predominately sourced from the building industry's waste stream through a competitively priced site clearance and collection service. The main sources of material will include construction site excess products (as new), retail end of line products (new) and demolition site reclaimed products (second use). A BMRC would therefore provide an opportunity to consolidate reusable demolition materials for retention in a local area. It would increase the potential for repair/ refurbishment of materials, and it would also provide an opportunity to move construction site excess products up the waste hierarchy, as it is assumed that the majority of this is recycled presently rather than reused. It may also have added value in areas with a particular building heritage linked to the area, supporting architectural salvage and reuse.

Relevance to Scotland

Scotland has a number of large nationally important regeneration schemes that offer the potential for CE construction related interventions, due to the scale of demolition, construction and refurbishment occurring. This is potentially beneficial to:

- The localised regeneration area creating potential for reuse and recycling of materials within the regeneration project.
- Other local projects outside the regeneration area due to the volume of material being generated. For example providing recycled aggregates from demolition to infrastructure projects.

The Construction Pipeline Horizon Scan (2017-2020) identified an estimated £1.7billion+ spend on Regeneration schemes, so presents a significant value of projects to influence.

Particularly applicable to:

Some of the most significant schemes in Scotland include:

- Irvine and Ardeer Peninsula
- National Planning Framework - Ravenscraig (Motherwell)
- National Planning Framework - Dundee Waterfront
- City Deal: Glasgow Airport Investment Area
- Clyde Waterfront and Renfrew Riverside
- Glasgow City Centre Districts Regeneration Framework
- Candleriggs Quarter, Glasgow
- Edinburgh St James
- Edinburgh and the South East of Scotland City Region Deal

Priority Material Streams:

Presents an opportunity to target all priority materials:

- Aggregates, Insulation, Structural metals, Fit-out metals, Concrete/ cement, Composites/SIPs, Plasterboard, Timber (inc packaging)

Potential Impact

- Reduction of waste to landfill
- Reduced wastage from over-ordering displacing virgin materials
- Increasing materials circularity through wider opportunity to reuse and recycle across phases.
- Reduction in carbon equivalent – deconstruction can reduce carbon emissions by 85% compared with traditional demolition[33]
- Reduced transport requirement.

Feasibility

Barriers

There are a number of barriers:

- Getting agreement from stakeholders to participate may require a number of dialogues and engagement.
- Regeneration schemes may already be well underway and opportunity to influence going forward is diminished.
- Schemes may be early in the planning/ on hold and are not in a position to undertake such an exercise.

[33] **See for example** www.wired.co.uk/news/archive/2013-01/15/japan-eco-demolition; www.taisei.co.jp/english/csr/hinsitu/jirei_hinsitu.html

Demand:

- With CE scoping studies being a developing area, there may be a lack of demand due to lack of awareness of the benefits of such an approach.

Practicality:

- As noted above, these type of study are being used in other areas of the UK and Europe to understand CE related opportunities (see Reference 4 below).

Regulatory issues/ opportunities:

- The feasibility studies, for example, offer a sound evidence base for the Regulation 19 stage of the local plan, developing on the policy themes within EU5: CE and resource efficiency, and complement the other environmental strategies being developed in parallel. The CE study act as a link between and inform the delivery of, these strategies and 'future-proof' the commercial regeneration and residential development.

Scalability/ Spread

- These type of innovative approach are only in their infancy so represent an opportunity to test develop and disseminate.
- Some commercial examples are available, e.g. ReciproCity Wirral, ReBuilding Center, Oregon, Restore, Seattle, Restore, Danes County).

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win - ✓/x
Identify and engage with suitable regeneration projects during planning to assess potential: • Glasgow have a number of regeneration projects underway that could present in aggregate a significant opportunity. • Similarly Dundee Waterfront is a large scheme, but has been underway for a number of years. • Whilst Edinburgh St James has only just begun, so may also present opportunities.	Partly within Zero Waste Scotland scope	Proven	Easy to Moderate (depends on the lever from government and the phase)	High	✓
Systematically review the CE concepts, to identify those that are most applicable to the individual developments with the overall regeneration scheme. There are a range of stakeholders, supply chains, cycles and loops within the built environment lifecycle which present the potential for influence. Some CE concepts will present good opportunities,	Zero Waste Scotland	Proven	Moderate	High	✓

whilst others will offer fewer practical opportunities, so it is important to understanding the overall scale of opportunity for each concept, its deliverability, potential impact, and identify key practicalities and potential interventions required to make them happen, e.g. requirements, objectives and targets, planning guidance (e.g.requiring developers that wish to demolish to demonstrate that refurbishment is not possible / desirable), specifications, procurement requirements, tools and processes etc. Developing a business case demonstrating those CE concepts that are realistic and feasible options.					

Further examples & case studies

1. Glasgow Circular City Roadmap
2. Amsterdam Circular City Roadmap
3. London Circular City Roadmap
4. Adaptable space design – 2 case studies (Italy, England)
5. Raploch mixed use regeneration project – Huntly crescent and Regeneration Guide case study
6. Construction Consolidation Centres
7. Online materials reuse platforms - Recipro

4.8 Opportunity 8 – Improving Building utilisation and usage

Opportunity 8 – Improving Building utilisation and usage

CE aspects it promotes:

Construction focusses heavily on where products come from and how they are treated at end of first life. Focussing on how buildings and products are used creates opportunities to increase circularity and contribute to the CE by enabling more resource efficient business models to be considered. Opportunities include:

Increasing utilisation rates and occupancy in buildings **(CE Hierarchy – High)**

- In the built environment, the average European office is used only 35–40 percent of the time, even during working hours. This includes offices on expensive inner-city land.
- Linking with other opportunities, flexible use of space can help optimise occupancy rates and increase rental revenues.

New models for products and services to support flexible use. **(CE Hierarchy – High/medium)**

- Lease and hire models as alternatives to ownership would help ensure that at end of first life the products are returned to the manufacturer or supplier for potential reuse, remanufacturing or value-optimised recycling.
- Pay per use models e.g. lighting enable quicker access to technological advances (e.g. LED lighting) as it is in the suppliers interests to reduce running costs. Accessing technological innovation and pay per use services linked to facilities management can help increase productivity and utilisation through reduction in downtime in servicing, refurbishment and repair. Philipps have pioneered the approach with various clients including National Union of Students Headquarters building in London and Schiphol Airport in the Netherlands.
- Product servicisation enables ownership to be retained by suppliers incentivising the ambition to optimise product lifetimes. There are also schemes which encourage desk space sharing across the public sector[34].

Reuse, manufacturing and repurposing of products **(CE Hierarchy – High/medium)**

- Following the waste hierarchy principles these create the opportunities not just to optimise the embodied carbon within products but also to retain and create additional value from used products.
- Repair and maintenance helps to optimise product lifetimes, e.g. HEVAC, M&E and mobile assets like office furniture. Linking repair and maintenance services in provision utilises product servicisation and can help optimise product lifetimes.
- Remanufacturing has been identified as an important mechanism for delivering CE in a number of sectors in Scotland but there is scope to give this more explicit consideration in construction.

Relevance to Scotland

This is potentially beneficial to:

- The public sector in delivering on Procurement Reform Act 2014 and sustainable public procurement. Links to Green Public Procurement (GPP) criteria and Scottish Government reporting requirements.
- Public sector changing requirements for floor area and desk space, e.g. due to teleworking and/or staff reduction. LiquidSpace and Hoffice (a Swedish home-working concept for optimising teleworking) provide working examples. Commercially, models like AirBnB have demonstrated there are viable ways of increasing utilisation through shared use.
- Commercial utilisation of valuable city land in Scotland's central belt. Total value of commercial sales in Scotland for 2015 topped £3.5bn, an increase of 4% on the 2014 total according to the Scottish Property Federation.

Particularly applicable to:

- Large scale regeneration projects linked to master planning (e.g. Clyde Waterside) – see Opportunity 7 above for further details.

[34] https://civilservice.blog.gov.uk/2015/07/24/commuter-hubs-bridging-the-gap-between-home-and-work/

- Public sector bodies with existing building assets and increasingly flexible working. For example NHS Scotland has space utilisation KPIs as part of their Property and Asset Management Strategies (PAMS).
- Private sector commercial premises (offices).

Priority Material Streams:

Presents an opportunity to target products rather than materials. Key fit-out and asset management streams:

- Lighting services – pay per use
- Office furniture (chairs, desks and storage units)
- Fit-Out – pay per use e.g. carpets (including cleaning)
- M&E services
- HEVAC

Potential Impact

- Carbon reduction through product lifetime extension and lower in-use energy demand - EU: the European Energy Performance of Buildings Directive (EPBD) requires new buildings to be 'nearly zero-energy' by 2020. Potential savings are two-fold. First is reduction in embodied carbon through lifetime optimisation (this is independent of energy use). The second is in-use energy efficiency through optimised utilisation. A number of businesses using shared facilities will increase the overall energy consumption of the shared services but this will be less than the individual energy consumption of multiple ICT units that are sub-optimally utilised (e.g. reduction in stand-by consumption for one).
- Increased GVA through more REBMs
- Greater reuse and remanufacturing to optimise product lifetimes
- Higher quality (and increased value) recycling through closed loops service models
- Encouraging innovation through REBMs

Feasibility

Barriers:

There are a number of barriers:

- Lack of demand-pull from clients.
- Risk and financing of suppliers is a barrier identified in European pilots for pay-per-use. Clients have to be sufficiently large for suppliers to be interested in offering circular REBMs.
- Developers are not currently incentivised to optimise occupancy due to rateable value schemes. Rateable values affect the rental and commercial value of buildings. There is a market failure in that it is cheaper for some landlords to have unoccupied premises rather than partially occupied premises[35]. This may

[35] Mervyn Jones pers comms with developers

therefore act as a disincentive for landlords in starting to offering flexible use space which initially may be underutilised (there is no rebate scheme to cover the cost so it is easier to let the space remain vacant).

Demand:

- Inadequately defined legal frameworks.
- Unintended consequences of existing regulations.
- Customers need flexibility in budgets as pay-per-use shifts emphasis from capex to opex; risks also for customers in choosing smaller suppliers for contracts extending over several years.
- Ownership models for stock versus leasing and rental options are more traditional and easier to finance.

Practicality:

- Shared use is not a common approach in UK although there are a number of pilot examples. Schools for example are increasing utilisation through community use in the evening, but this is not universal within schools or widely used outside of education sector.
- Innovative models have been proven at pilot scale but not universally applicable or universally available.
- Maximising shared use requires extension of operating hours, e.g. sharing use between office space during working hours and community use in evenings and weekends.

Scalability/ Spread

- These type of innovative approach are only in their infancy so represent an opportunity to test develop and disseminate.
- European shared use models have been in existence for over 5 years with little penetration beyond pilot demonstration schemes (e.g. Norway, Netherlands, Germany etc). However they represent a quick win if implemented and can be worked into public sector change management programmes especially where staff reductions are being considered.

Intervention Opportunities

The following tables identify key potential interventions by stakeholder group.

Zero Waste Scotland and Government

Potential Intervention	Intervention Lead	Evidence Base Status	Ease of Implementation	Likely Impact	Quick Win – ✓/x
Encouraging and accelerating repurposing of existing floor space would make it possible to better utilise old buildings, e.g. change of use from office space to residential housing, in a cost-efficient way and reduce the need for demolition and renovation. This potentially requires a review of planning consents.	Zero Waste Scotland/ potentially beyond Zero	New	Hard	Medium	x

	Waste Scotland scope				
Encourage and adopt Design, Build, Fund & Operate (DBFO/DBFM) models to encourage Life Cycle Costing and Total Cost of Ownership considerations (see Reference 6 below).	Zero Waste Scotland	Proven	Moderate	Medium	x
Market engagement and early collaboration to assess the potential for construction sector to deliver more circular solutions and adopt more circular REBMs, (cf REBus project website).	Zero Waste Scotland	Proven	Easy	Medium	✓
Bringing together all stakeholders in the construction value chain - to work on systemic solutions to address the lack of skills and established norms that stand in the way of industrialising production. This could take numerous forms, e.g. an industry-wide partnership focused on knowledge sharing and collaboration, a project with specific short-term objectives, or a private public partnership.	Zero Waste Scotland	Proven	Hard	Medium	x
Setting up municipal access portals that provide information on public building availability and matches users with providers, e.g. this could start out with public buildings (see Reference 2 below). Approach proven in commercial sector but needs more testing for non-rental space	Zero Waste Scotland	Proven	Hard	Medium	x
Launching public procurement pilots. Such pilots could: • demonstrate the viability and benefits of existing circular materials and construction techniques; • stimulate the development of new materials and techniques (design competitions offer an alternative); and • develop the necessary guidance and procedures for procurement teams to be able to accommodate such new or unfamiliar elements (e.g. adjustments to the typical pre-construction dialogues).	Zero Waste Scotland/	Proven	Easy	Medium	✓
Consider review of National Non-Domestic Rates (Business rates) to incentivise greater utilisation.	Beyond Zero Waste	New	Hard	High	x

	Scotland scope				

Building landlords

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win – ✓/x
Consider review of contractual restrictions on tenants/owners to their sub-letting.	Beyond Zero Waste Scotland scope	New	Hard	Medium	x
Consider creating financial incentives or financial support to local, regional and national public-sector entities such as schools and other public infrastructure could help overcome hesitance towards renting out their properties when not in use (without distorting competition). This could also have demonstration effects for private owners, facility managers in industrial and commercial real estate, and landlords (see Reference 7 below).	Beyond Zero Waste Scotland scope	New	Hard	High	x

Suppliers

Potential Intervention	Intervention Lead	Evidence base status	Ease of Implementation	Likely Impact	Quick Win– ✓/x
Adopting and offering circular REBMs alongside (or in place of) standard ownership models for products.	Zero Waste Scotland	Proven	Moderate	High	✓
Developing more sustainable product servicisation propositions – not all servicisation models are inherently sustainable or circular.	Zero Waste Scotland	Proven	Moderate	Medium	x

Further examples & case studies

1. Shared space - Sundtkvartalet (Healthy Quarter) Business Centre, Oslo, Norway
2. Office space utilisation rate - Winchester City Council asset management system
3. NAO Office utilisation guidance – 6 case studies
4. FM Pay per lux lighting - Philipps case study, Turntoo & Schiphol Airport, Netherlands
5. FM Carpet tiles service maintenance model – ProRail, Utrecht, Netherlands
6. Service models - infrastructure projects – A12 highway DBMO case study
7. Shared space – Office for Public Management, 5 shared ownership case studies

Additional references

Knowledge resource portal for circular thinking in construction

5 Summary of interventions by stakeholder

As intervention types can be cross cutting across material, principles and subsectors, an alternative way of presenting the findings is by intervention type, as shown in the following tables.

5.1 Procurement

Intervention	Material/ Principle	Construction subsector
Evidence base for economic/ environmental cost and benefits of CE models	• Modularity	• Housing, education, health
	• Design for deconstruction	• Commercial, social housing, education, health
	• Product service systems	• Housing, education, health
	• Material optimisation in retrofit/ refurbishment	• Commercial, housing
Requiring design for deconstruction, reuse and repair	• Timber	• Housing
	• Structural metal	• Commercial, education, health
Setting Recycled Content targets	• Aggregates	• Infrastructure
	• Plasterboard	• Housing, commercial, education, health
Requiring Demolition/ Refurbishment Audits	• Aggregates	• All
	• Timber	• Housing – principally social housing
	• Plasterboard	• Commercial, social housing, education, health
	• Structural (and wider fit out) metal	• All

5.2 Designers & Contractors

Intervention	Material/ Principle	Construction subsector
Help designers and contractors understand available technologies, suppliers, benefits and evidence base for suitability	• Modularity	• Housing, education, health
Design for deconstruction, reuse and repair good practice guidance	• Timber	• Housing
	• Structural metal	• Commercial, education, health
Material optimisation/ standardisation, designing out waste, good practice guidance	• Timber	• Housing
	• Aggregates	• Infrastructure
	• Plasterboard	• Housing, commercial, education, health
	• Structural metals	• Commercial, education, health, infrastructure
	• Retrofit/ refurbishment	• Commercial
Supply and demand coordination of reusable materials e.g. central databases/ material marketplaces	• Timber	• Housing
	• Aggregates	• Infrastructure
	• Structural metals	• Commercial, education, health, infrastructure

5.3 Product Suppliers

Intervention	Material/ Principle	Construction subsector
Support in developing improved products, deconstructable solutions, with material passport systems. Helping assess costs and benefits of systems, support trials of new technique's and materials etc.	• Modularity	• Housing, education, health
	• Timber	• Housing
	• Structural metals	• Commercial, education, health, infrastructure
	• Refurbishment - key product types associated with leased commercial	• Commercial

Intervention	Material/ Principle	Construction subsector
	properties where the tenant is responsible for fit out and has to take the appearance back to 'as was' before the lease.	
Capital funding/ grants for new technologies	• Modularity	• Housing, education, health
	• Aggregates	• Infrastructure
Establish links between design and manufacturers for large scale projects to optimise product sizing.	• Plasterboard	• Housing, commercial, education, health
Establish suitable supply contracts between recyclers and manufacturers.	• Plasterboard	• Housing, commercial, education, health
Adopting and offering circular REBMs alongside (or in place of) standard ownership models for products.	• Extending & optimising product lifetime	• Public sector and commercial office space
	• Increasing utilisation rates	• Health
	• Closing product & material loops	• Education
Developing more sustainable product servicisation propositions – not all servicisation models are inherently sustainable or circular.	• Fit-out & maintenance (e.g. lighting, carpets)	• Commercial and public sector premises
	• Facilities management & space utilisation	• Health, education
	• Closing product & material loops	• Infrastructure

5.4 Deconstruction

Intervention	Material/ Principle	Construction Subsector
Good practice guidance to demolition contractors on deconstruction undertaking recertification, insurance negotiation, fabrication (frames including reused sections) etc to maximise potential for reuse.	• Timber	• Housing
	• Structural metals	• Commercial, education, health

Intervention	Material/ Principle	Construction Subsector
Development or trialling of suitable machines/ equipment/ techniques for deconstructing existing buildings	• Timber	• Housing
	• Structural metals	• Commercial, education, health
	• Plasterboard	• Housing, commercial, education, health
	• Note: also wider streams such as insulation, fitout metals may benefit	• Housing, commercial, education, health
Work with specifiers, manufacturers and demolition contractors to understand material passport, quality testing and liability type issues associated with reuse and develop approaches to overcome them. Help improve and streamline the process of re-grading. May require structural testing, demonstration projects of deconstruction.	• Timber	• Housing
	• Structural metals	• Commercial, education, health
Capital funding/ grants for new technologies	• Timber	• Housing
	• Structural metals	• Commercial, education, health
	• Plasterboard	• Housing, commercial, education, health
	• Note: also wider streams such as insulation, fitout metals may benefit	• Housing, commercial, education, health

01786 433930 zerowastescotland.org.uk @ZeroWasteScot