



Construction Resources

For a Circular Economy

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EUROPE & SCOTLAND
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Investing in a Smart, Sustainable and Inclusive Future

A circular economy is about retaining the value of all products and materials for as long as possible. Ideally it is a closed loop system, reducing non-renewable raw material input, and minimising any 'leakage' of materials out of the system.

It is an approach that needs to be designed and planned for, so we can move from our current linear economy approach to a circular economy. We can apply this circular economy approach to how we plan for, design, construct, maintain and replace all of our buildings and infrastructure.

General circular economy construction resources

Who is this relevant for?	<ul style="list-style-type: none"> • All construction project stakeholders, organisations and workforces • New Build, refurbishment and facility management • All project types: Residential, commercial, Industrial, infrastructure • Planning, all build phases and end of life: RIBA 0 to 7
Drivers and calls to action	<ul style="list-style-type: none"> • Making Things Last: a circular economy strategy for Scotland, 2016 • RIBA Sustainable Outcomes Guide
Delivery mechanisms	<ul style="list-style-type: none"> • Extended Producer Responsibility (EPR)
Good practice guidance	<ul style="list-style-type: none"> • Towards a Circular Economy, NetRegs • Practical how-to guide: Build Circular Economy Thinking into Your Projects, UKGBC
Implementation Tools	<ul style="list-style-type: none"> • Top Tips for Embedding Circular Economy Principles in The Construction Industry, 2017
Training resources	<ul style="list-style-type: none"> • Circular Economy & the Construction Sector - City of Glasgow College • Circular Economy in the Built Environment – Sign up to UKGBC's Course Mail series for on-demand weekly emails • Circular Economy for a Sustainable Built Environment, Delft University of Technology. Free 6 module online course
Case studies	<ul style="list-style-type: none"> • Circular Economy UKGBC Sustainability 360 survey findings, 2017 • Circularity in The Built Environment: Case Studies, Ellen MacArthur 2016
Publications, presentations and media articles	<ul style="list-style-type: none"> • Building Revolutions by David Cheshire • Cradle to Cradle. Remaking the Way, We Make Things by Michael Braungart and William McDonough • Supporting the construction industry to achieve zero waste, recorded PowerPoint by Clive Bowman • A circular economy approach to designing for a changing climate, recorded PowerPoint by Clive Bowman • The circular economy concept explained - Brendon Rowen, Cradle to Cradle Marketplace Limited for Government Europa Quarterly, October 2018 • Can the circular economy in construction really work?, Raconteur 2019 • Can the circular economy make construction more sustainable?, PCBtoday 2020 • Closing the circle Circular economy: Opportunity for the welsh built environment, CE Wales • Sustainable Construction Guidelines for Public Authorities - A Circular Economy perspective, ACR 2019

Resources specific to circular economy construction principles

10 construction circular economy principles

The concept of a circular economy approach to construction can be explained through 10 principles which we believe can be applied to all aspects of building design and placemaking activities to deliver a wide range of benefits. The principles are as follows and supporting resources are detailed per principle.

- [Collaboration](#)
- [Whole life value](#)
- [Health and wellbeing](#)
- [Long Life / Loose Fit](#)
- [Low carbon](#)
- [Smart construction](#)
- [Material recoverability](#)
- [Design Out Waste](#)
- [Circular products and services](#)
- [Material management](#)

The list of resources in this document are a collection of suggested useful resources from across a wide range of sources collated by the Zero Waste Scotland Construction Industry Support Programme.

If you would like to suggest any other useful resources that could be included in this document please contact circularconstruction@zerowastescotland.org.uk.

The [Zero Waste Scotland Construction Industry Support Programme](#) provides 1-2-1 advice and support to SMEs in the construction sector in Scotland to help embed circular economy principles into live projects. For more information please access the following Zero Waste Scotland Support a Circular Construction Industry flyers:

- [Construction support service summary](#)
- [Support for circular design](#)
- [Support for sustainable procurement](#)
- [Support for construction site material and waste management](#)
- [Support for digital technology solutions](#)



1. Collaboration

The principle explained

To successfully embed circular economy principles throughout the construction industry and ensure our built environment is fit for future, we need to collaborate and align objectives right across policy levels, supply chains and stakeholders for the whole life of projects. We need to pool our expertise and experience and share our resources to ensure opportunities are not missed to deliver best practice.

Who is this relevant for?

- All construction project stakeholders, organisations and workforces
- All construction activity and project types
- All build phases: **RIBA 1 to 7**

Drivers and calls to action

- [A circular economy design approach](#) – Clive Bowman for RIAS Journal issue 40 page 42.

Drivers and delivery mechanisms

- Vertical and horizontal policy alignment
- Supply chain workshops
- Stakeholder engagement
- Digital communication tools e.g. BIM, Virtual Reality (VR).

Implementation Tools

- [Building Information Management \(BIM\)](#)
- [Cloud based Project management software](#)

Case studies

- [VR improves collaboration and saves money for Anglian Water](#)
- [How a collaborative approach between Network Rail and Costain encouraged a sustainability 'blueprint'](#), Thames Link Programme

Publications and presentations

- [Construction industry needs a collaborative 'evolutionary jump' towards a circular economy](#), Edie 2016
- [Collaborative Placemaking](#), John Thompson & Partners

Research

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2. Whole Life value

The principle explained

Upfront construction costs are only one type of cost to consider when building. The key to sustainability and carbon reduction is taking a wider, long-term view. The lifetime positive and negative impacts of a building on society and the environment from its construction, use, maintenance and repairs, decommissioning and disposal need to be recognised and accounted for.

Who is this relevant for?

- Construction project stakeholders and decision makers
- New Build, refurbishment, but particularly asset and facility management
- All project types: residential, commercial, industrial, infrastructure
- Planning, early design phases and in use: **RIBA 0 to 3 & 7**

Industry standards / Regulations

[Sustainable procurement duty](#), Scottish Government 2014

Drivers and calls to action

- An ecosystem / whole-systems approach that considers [Natural Capital](#)
- [Procuring for Value](#), Construction Leadership Council, 2018

Delivery mechanisms

- [Sustainable procurement](#)
- [Placemaking – a place-based approach to planning policy](#), The British Academy, 2017

Good practice guidance

- [Driving social value in new development: options for local authorities](#), UK Green Building Council (2019)
- [Building Value - A pathway to Circular Construction Finance](#) - January 2019

Implementation Tools

- [Whole Life Cost tool](#) - calculate your building and infrastructure lifetime costs using Zero Waste Scotland's whole life costing tool.
- [Whole Life Appraisal Tool for the Built Environment](#), Scottish Futures Trust

Training resources

- [Whole Life Costing Tool training modules](#), ZWS

Case studies

- [Procuring for Value](#), Construction Leadership Council

Publications and presentations

- [Zero waste Scotland NPF4 consultation response, April 2020](#)
- [Whole-life value in construction is a lot like buying a new car](#), Construction News, 2019

Research

- [Researching whole life value methodologies for construction](#)



3. Health and wellbeing

The principle explained

Designing and maintaining all of our infrastructure, both indoor and outdoor spaces to maximise quality of life, comfort, productivity, mental and physical wellbeing, through consideration of air quality, ventilation, active and low carbon travel opportunities, flexible and adaptable working and living spaces, quality indoor and outdoor greenspace, public spaces and neighbourhoods, and access to healthy food, social connectivity. A healthier population uses resources more efficiently.

Who is this relevant for?

- All construction project clients, designers and specifiers
- New Build, refurbishment and facility management
- All project types: Residential, commercial, Industrial, infrastructure
- Planning, design phases and in use: **RIBA 0 to 4 & 7**

Industry standards, policies and regulations

- [Building standards technical handbook 2019: domestic buildings](#)
- [Building standards technical handbook 2019: non-domestic buildings](#)

Drivers and calls to action

- [The Real Cost of Poor Housing](#), Simon Nicol, BRE, 2013
- [The cost of poor housing to the NHS - Briefing Paper](#), BRE 2015
- [Health, Wellbeing & Productivity in Offices The next chapter for green building](#), WorldGBC

Delivery mechanisms

- [WELL certification](#)
- [BREEAM 2018](#)

Good practice guidance

- [Good Homes Alliance overheating tool and guidance](#)
- [WELL Building Standard v2 Preconditions](#), 2019.
- [CIBSE TM40: Health and wellbeing in building services webinar](#)
- [Applying BREEAM and The WELL Building Standard](#). WELL Building (2019)

Implementation Tools

- [Design and detailing for toxic chemical reduction in buildings](#) – Sandy Halliday, SEDA

Training resources

- [Sustainable Construction and Development](#) – free online course from the University of Bath

Case studies

- [Acharacle Primary School](#) by Gaia Architects
- [Inverness new-build](#)
- [The Piggery](#) by Sam Foster Architects

Publications and presentations

- [Occupant Comfort and the circular economy](#) - Clive Bowman for ADS, April 2020
- [Circular Economy Materials for Low Carbon, Healthy Buildings](#) – Clive Bowman for ADS, November 2019
- [Office buildings are key to workers' health, wellbeing and productivity](#), The Guardian, 2014
- [Ventilation and Indoor Air Quality in New Homes](#), Aecom Ltd, 2019

Research

- [The impact of classroom design on pupils' learning](#), University of Salford



4. Long Life / Loose Fit

The principle explained

A building's ability to evolve and adapt through time to reflect changes in fashion, use, need and changing impacts such as climate change, population, digital technology and demographics. The 'sheering layers' principle recognises layers that have different life spans and designing with this principle in mind can help a building adapt and last longer, with a minimum of 'wasted' resources.

Who is this relevant for?

- All construction project stakeholders, designers and decision makers
- New Build, refurbishment and facility management
- All project types: Residential, commercial, Industrial, infrastructure
- Planning, design stages and in use: **RIBA 0 to 4 & 7**

Industry standards, policies & regulations

- [National Planning Framework 4](#) (in consultation)

Drivers and calls to action

- [The time is right for long life, loose fit](#), New London Architecture
- [RetroFirst: Can policy change encourage more retrofitting?](#), AJ

Delivery mechanisms

- Climate change adaptation: integrated 'green' and 'blue' infrastructure
- Policies and mechanisms that enable 'climate ready' investment delivering long-term, lasting social, environmental and economic benefits

Good practice guidance

- [Sustainable renovation guide](#) – Chris Morgan, SEDA and The Pebble Trust.
- [Designing buildings for adaptability, durability, and positive impact](#), Ellen Macarthur Foundation
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Training resources

- [How Buildings Learn - Stewart Brand - 6 of 6 - "Shearing Layers"](#)

Case studies

- [Design for future climate: adapting buildings competition, CIRIA 2019](#) - A selection of factsheets that provide insight into the approaches taken to consider climate change effects in the design of real-life construction and building refurbishment projects.
- [Amsterdam Temporary Courthouse](#), Archi-Europe Group.
- [Brummen Town Hall, Netherlands](#), Construction Manager Magazine.

Publications and presentations

- [The case for ... never demolishing another building](#) – The Guardian, January 2020
- [Operating and Maintaining buildings for maximum regenerative performance](#) Ellen Macarthur Foundation



5. Low carbon / sequestration

The principle explained

Design all infrastructure to facilitate both a low operation and low embodied carbon, low resource use society. We need to create landscapes and built assets which sequester (draw down) carbon dioxide by using and producing more products based on materials that we have grown rather than mined or extracted.

Who is this relevant for?

- All construction project stakeholders and decision makers,
- All build types and all project types
- All planning & build phases through to end of life: **RIBA 0 to 7**

Industry standards, policies & regulations

- [Scottish Government Net Zero Carbon 2045 target](#)
- Whole life carbon assessment

Drivers and calls to action

- [The Living Building Challenge 3.1- Imperative 11 Embodied Carbon Footprint](#)

Delivery mechanisms

- Whole Life Embodied Carbon Assessment
- Accreditation schemes e.g. [BREEAM](#), [CEEQUAL](#), [Home Quality Mark ONE](#) and [Passivhaus](#)

Good practice guidance

- [Whole Life Carbon Assessment for Built Environment](#), RICS (2017)
- [Embodied and whole life carbon assessment for architects](#), RIBA
- [Five key Components of Net-Zero Carbon Buildings](#), LETI (2019)
- [Net Zero Carbon Buildings: A Framework Definition](#), UKGBC
- [Targeting Zero: embodied and whole life carbon explained](#), RIBA
- [Embodied carbon - Developing a client brief](#), UKGBC 2017
- [Delivering Low Carbon Infrastructure](#), UKGBC 2017

Implementation Tools

- [One Click LCA](#)
- [RICS Building Carbon Database](#)
- [The Carbon Smart Materials Palette](#)

Training resources

- [A range of free online Construction CPD and Courses at the BRE Academy on BREEAM](#)

Case studies

- [Passivhaus standard with the MAKAR off-site n-Sip panel system](#)

Publications and presentations

- [Whole Life-Cycle Carbon Assessments guidance – London Plan Pre-consultation draft.](#)
- [Embodied carbon in construction setting the scene for Scotland](#), edited by Clive Bowman, ZWS for RIAS April 2020.
- [Options for incorporating embodied and sequestered carbon into the building standards framework](#) - Report prepared by AECOM for the Committee on Climate Change, 2019.

Research reports and documents

- [UK Green Building Council](#)
- [Embodied Carbon Scoping Study for Zero Waste Scotland](#) - JH Sustainability Ltd, March 2020.



6. Smart construction

The principle explained	Making use of digital technology, modularisation and modern methods of construction to increase resource efficiency, improve quality and monitor performance.
Who is this relevant for?	<ul style="list-style-type: none"> • All construction project stakeholders, organisations and workforces • All build and asset management activities • All project types: Residential, commercial, Industrial, infrastructure • All planning, design, build use and end of life phases: RIBA 0 to 7
Industry standards, policies & regulations	<ul style="list-style-type: none"> •
Drivers and calls to action	<ul style="list-style-type: none"> • Use of technology, database platforms and quality accreditation schemes to support a material reuse marketplace
Delivery mechanisms	<ul style="list-style-type: none"> • BIM and digital twins, • materials and buildings passports, • augmented and virtual reality • offsite construction & modular building • Building performance monitoring and data analysis
Good practice guidance	<ul style="list-style-type: none"> • Smart Construction - A Guide for Housing Clients, Construction Leadership Council.
Implementation Tools	<ul style="list-style-type: none"> • Building Information Modelling (BIM)
Training resources	<ul style="list-style-type: none"> • Online BIM resources at the Construction Scotland Innovation Centre (CS-IC) • Offsite Systems Fundamentals: Modern Methods of Construction, SCSS
Case studies	<ul style="list-style-type: none"> • Improved Building Information Modelling set to achieve material savings of 15% for Carbon Dynamic. • PORTAL offers a new approach to building to meet the challenges of the Circular Economy. • DfMA Case study • Richmond House, London – using thermal imaging to refurbish and reduce operational energy use
Publications and presentations	<ul style="list-style-type: none"> • New Housing & Future Construction Skills Adapting and Modernising for Growth, Professor Sean Smith, Chair of the Short Life Working Group, New Housing & Future Construction Skills, May 2019. • Working Together, Transforming Construction, Manufacturing Technology Centre. • WEF - The Future of Construction, Shaping the Future of Construction - A Breakthrough in Mindset and Technology (2016).
Research reports and documents	<ul style="list-style-type: none"> • Increasing offsite housing construction in Scotland: An evidence base to support new policy and systems, in January 2020 for Scottish Government, SE, and the CSIC. • Research paper explores how blockchain technology can benefit the built environment industry



7. Material recoverability

The principle explained

Design from the outset for deconstructability is needed for 100% material recoverability. This requires pre-planning for end of life by designers, clients, facility managers and demolition contractors and an established infrastructure network with regulation, quality control and consumer market that allows 'waste' and secondary resources to retain value and be reused.

Who is this relevant for?

- All construction project stakeholders, organisations and workforces
- New Build, refurbishment and facility management
- All project types: Residential, commercial, Industrial, infrastructure
- Planning, all build phases and end of life: **RIBA 0 to 7**

Industry standards, policies & regulations

- [EU Construction and Demolition Waste Management Protocol, 2018.](#)
- [ICE Demolition Protocol, 2008](#)

Drivers and calls to action

- Material supply chain resilience

Delivery mechanisms

- Pre-demolition audits
- Building standards
- Material passports
- Extended Producer Responsibility (EPR)

Good practice guidance

- [Guidelines for the waste audits before demolition and renovation works of buildings](#) (May 2018).
- [Design for Deconstruction](#) - SEDA Design Guides for Scotland.
- [DfD: Design for Disassembly in the built environment - a guide to closed-loop design and building](#), City of Seattle

Implementation Tools

- [Material passports.](#)
- [EU GPP criteria for Office Building Design, Construction and Management.](#)
- [EU GPP criteria for Road Design, Construction and Maintenance.](#)

Training resources

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Case studies

- [Buildings as Material Banks \(BAMB\)](#)

Publications and presentations

- [Building Glass in a Circular Economy](#), UKGBC October 2018
- [The Oil and Gas Deconstruction for Construction Workshop Slides](#), CSIC, November 2018.

Research reports and documents

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8. Design out waste

The principle explained

We need to plan, design, maintain and decommission all out built assets in line with the waste hierarchy – avoid - reduce - reuse – recycle - energy recovery - and lastly waste disposal to minimise the unnecessary use of primary materials and promote efficient use of secondary materials.

Who is this relevant for?

- All construction project stakeholders, organisations and workforces
- New Build, refurbishment and facility management
- All project types: Residential, commercial, Industrial, infrastructure
- all planning, design and build phases and end of life: **RIBA 0 to 7**

Industry standards, policies & regulations

- [The Waste Hierarchy](#)

Drivers and calls to action

- [RIBA Sustainable Outcomes Guide](#), Royal Institute of British Architects 2019.

Delivery mechanisms

- alternative design and construction methods
- waste-efficient procurement- project waste reduction targets
- digital tools to increase resource efficiencies
- design recognising 'layers' and material lifespans

Good practice guidance

- [Designing Out Construction Waste](#) - A guide for project design teams
- [Procuring Resource Efficient Construction Projects](#) - Model procurement wording for public and private sector clients and contractors on construction projects.
- [Guidance to minimise plasterboard waste](#) – FIS.
- [Sustainable Construction: Clients](#) – Constructing Excellence

Implementation Tools

- [Waste tracking spreadsheet template – Zero waste Scotland](#)
- [Net Waste Tool](#)

Training resources

- [Net Waste Tool training modules.](#)

Case studies

- [Resource Efficient House a demonstration construction project](#)
- [London Bridge Station](#), Thames Link Programme
- [The circular economy and the promise of glass in concrete](#), Ellen McArthur Foundation.

Publications and presentations

- [Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage.](#)
- [Lean in construction – Implementation support](#) – CIRIA 2016.

Research reports and documents

- [Resource efficiency and climate change - Material Efficiency Strategies for a Low-Carbon Future, Summary for Policymakers](#), UN.



9. Circular products and services

The principle explained	Utilisation of assets, use of renewable, recycled, pre-used or surplus built assets, products and materials. Use of local, renewable, natural materials that can be returned to the earth at end of life and alternative business models to facilitate circularity such as greater servicisation.
Who is this relevant for?	<ul style="list-style-type: none"> • All construction project stakeholders and decision makers • New Build, refurbishment and facility management • All project types: Residential, commercial, Industrial, infrastructure • Planning, all build phases and end of life: RIBA 0 to 7
Industry standards, policies & regulations	<ul style="list-style-type: none"> • Vacant & Derelict Land Register
Drivers & calls to action	<ul style="list-style-type: none"> • Why do we need a circular performance assessment? Clive Bowman for RIAS Practice Notes, January 2020. •
Delivery mechanisms	<ul style="list-style-type: none"> • Circular procurement • Maximise building and infrastructure utilisation - adapt, refurbish and reuse existing buildings & materials • Asset and stock data and maintenance coordination • Adoption of repair/reuse/lease approaches across supply chains through alternative business models
Good practice guidance	<ul style="list-style-type: none"> • Reuse and Products as a Service Implementation Packs – UKGBC, 2020 • Circular Business Models for The Built Environment, Arup
Implementation Tools	<ul style="list-style-type: none"> • Material Considerations: A Library of Sustainable Building Materials - A web and a physical resource based at The Lighthouse, Glasgow,
Training resources	<ul style="list-style-type: none"> •
Case studies	<ul style="list-style-type: none"> • Bute Recycling Centre – Collective Architecture • Cleveland Steel Warehouse, ASBP • Park 2020, Amsterdam
Publications and presentations	<ul style="list-style-type: none"> • Circular Economy Implementation Packs for Reuse and Products as a Service – UKGBC has published implementation packs on reuse and Products as a Service to assist built environment projects adopt circular economy principles. • The Circular Economy, Brendon Rowen, Cradle to Cradle Marketplace Limited for Government Europa Quarterly 29
Research reports and documents	<ul style="list-style-type: none"> • Identification of Circular Economy Opportunities in the Scottish Construction Sector by Dan Whittaker, Eunomia, and Mervyn Jones, SGR, April 2017.



10. Material Management

The principle explained	Best Practice management of construction materials from specification and ordering through to packaging and delivery, handling, storage, use and reallocation of surpluses will help minimise wastage and retain values.
Who is this relevant for?	<ul style="list-style-type: none">• All construction project designers, specifiers, manufactures, suppliers and installers• New Build, refurbishment and facility management• All project types: Residential, commercial, Industrial, infrastructure• all design and build phases and end of life: RIBA 2 to 7
Industry standards, policies & regulations	<ul style="list-style-type: none">• The Waste (Scotland) Regulations 2012 - targets/landfill bans
Drivers and calls to action	<ul style="list-style-type: none">• Scottish Landfill Tax (SLfT)
Delivery mechanisms	<ul style="list-style-type: none">• Coordination of activities and trades through use of digital communication tools• Accurate quantity and timely ordering, and careful handling and storage of materials• Waste management cost forecasting and forward planning to maximise surplus material values• Handling and storage of materials to retain value• Set standards for best practice management of deliveries, packaging and storage
Good practice guidance	<ul style="list-style-type: none">• Maximising re-use of materials on-site guide.• Best practice guide to improving waste management on construction sites – Zero Waste Scotland.• A Practical Handbook for Supervisors (Circular Construction) -• Managing packaging waste on your construction site
Implementation Tools	<ul style="list-style-type: none">• Site Waste Management Planning - Track and quantify construction waste on construction sites with Zero Waste Scotland's free tool.• Construction Material Exchange Post a listing for construction materials you don't need but don't want to pay for disposal.• mywasteportal.com
Training resources	<ul style="list-style-type: none">• Site Waste Management Plan Tool training modules.
Case studies	<ul style="list-style-type: none">• Balfour Beatty Video - What happens to construction waste?• SCSS Video - Reducing construction waste in Scotland – Carey
Publications and presentations	<ul style="list-style-type: none">• With the right tools, we can mine cities - identifying the material resources in 13,000 buildings in central Melbourne, Australia.• SEPA Video - How to Manage Waste on a Construction Site
Research reports and documents	<ul style="list-style-type: none">• Saving money and raw materials by reducing waste in construction: case studies

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