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# Circular Economy in the Built Environment

Katherine Adams, Reusefully Ltd

Focus on Framing, 15th May 2024

# About Reusefully

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- Reusefully is a partnership created to provide **expert circular economy advice and support within the built environment.**
- We enable the **practical implementation of circular economy thinking** throughout the construction supply chain and provide evidence-based support and advice for related policy development. We collaborate and work with others who genuinely share this objective and value our commitment to delivering effective & impactful project outcomes.
- We address **material and resource efficiency, embodied carbon and net zero, design for deconstruction, waste prevention and waste management, end markets, reuse and recycled content**. Collectively, Reusefully brings together over 45 years of experience, working across multiple parts of the value chain, from small practical projects to large scale R&D, for a wide variety of clients. **www.reusefully.co.uk**

# Some Stats (based on Defra figures)

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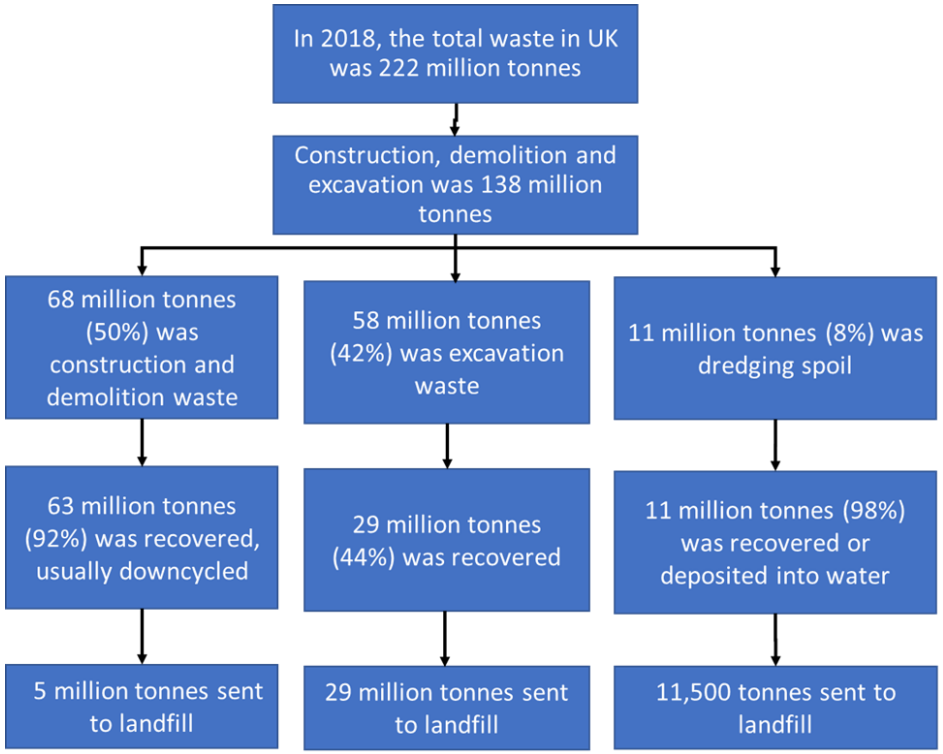
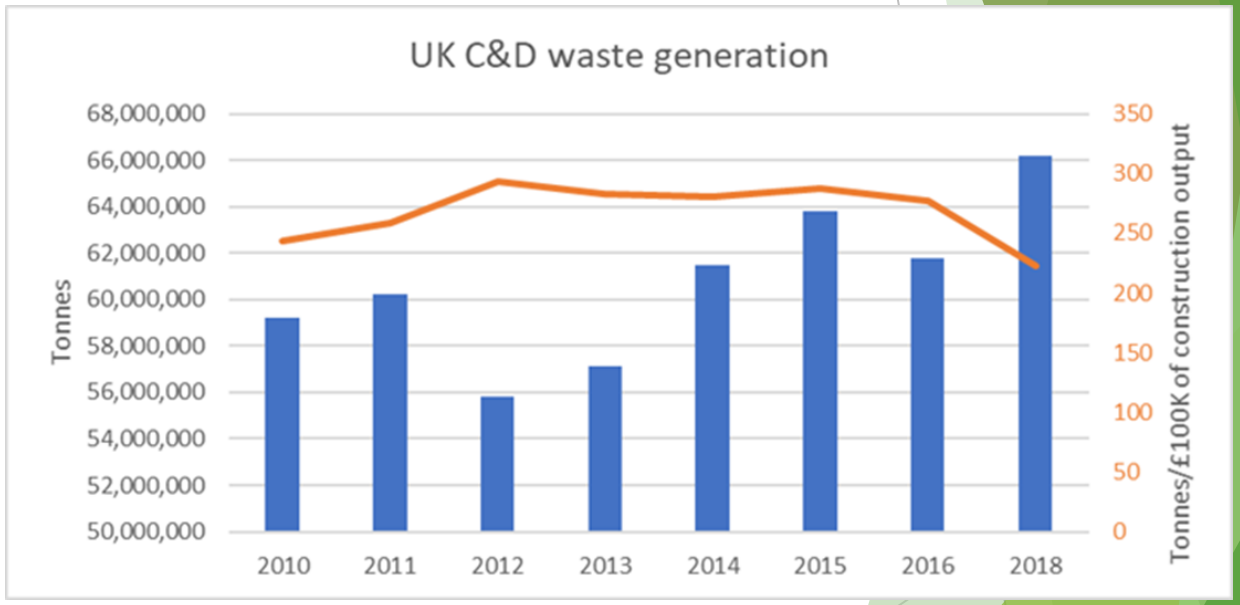
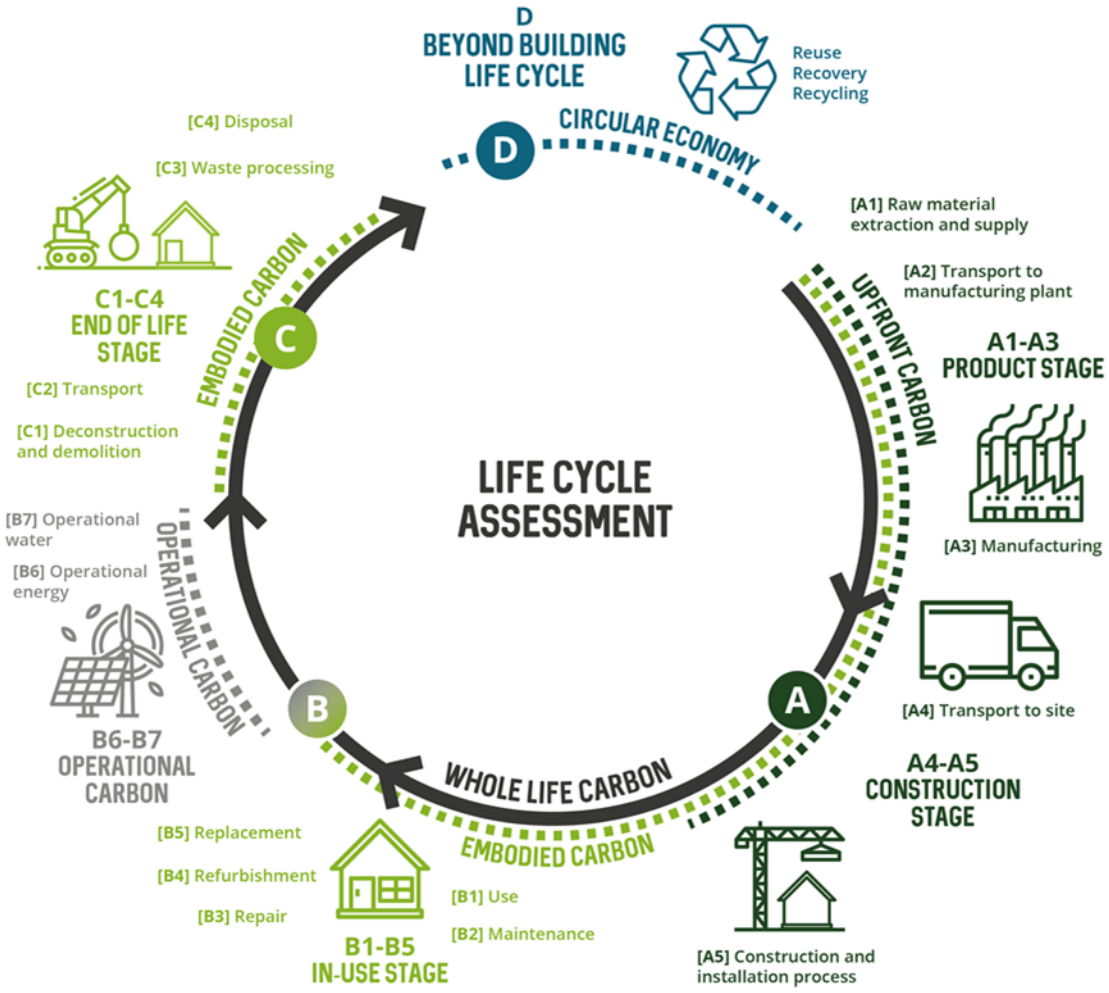


# Embodied carbon and circularity



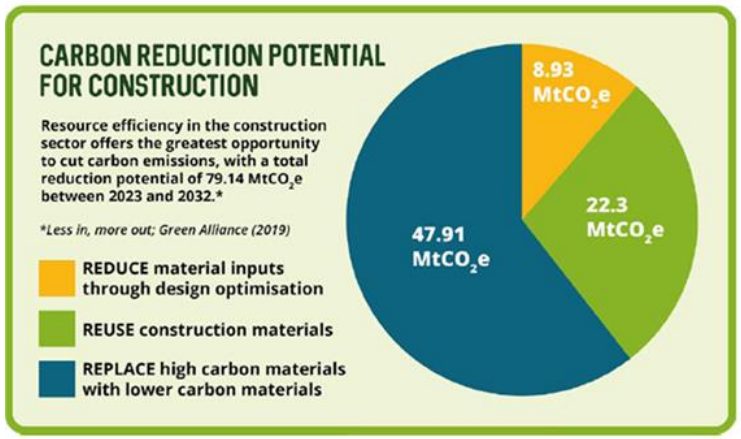
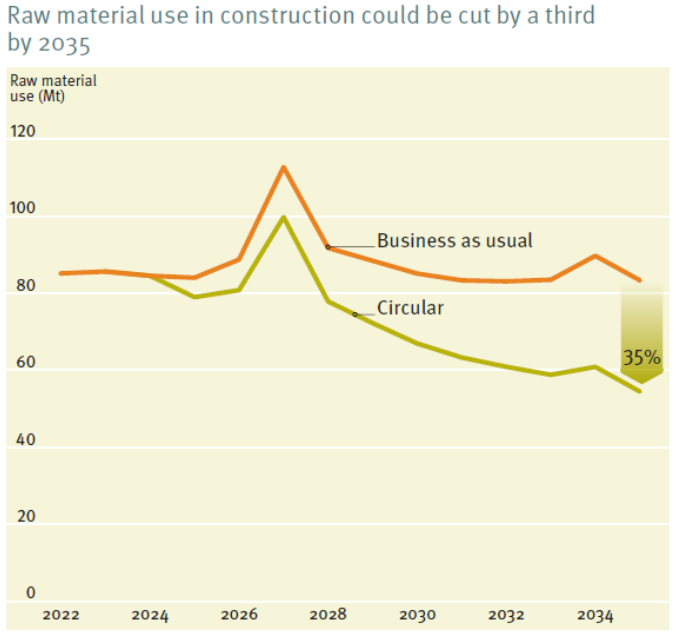




*Figure 5*
*Opportunities from increasing resource efficiency in construction*



# Circular economy to us

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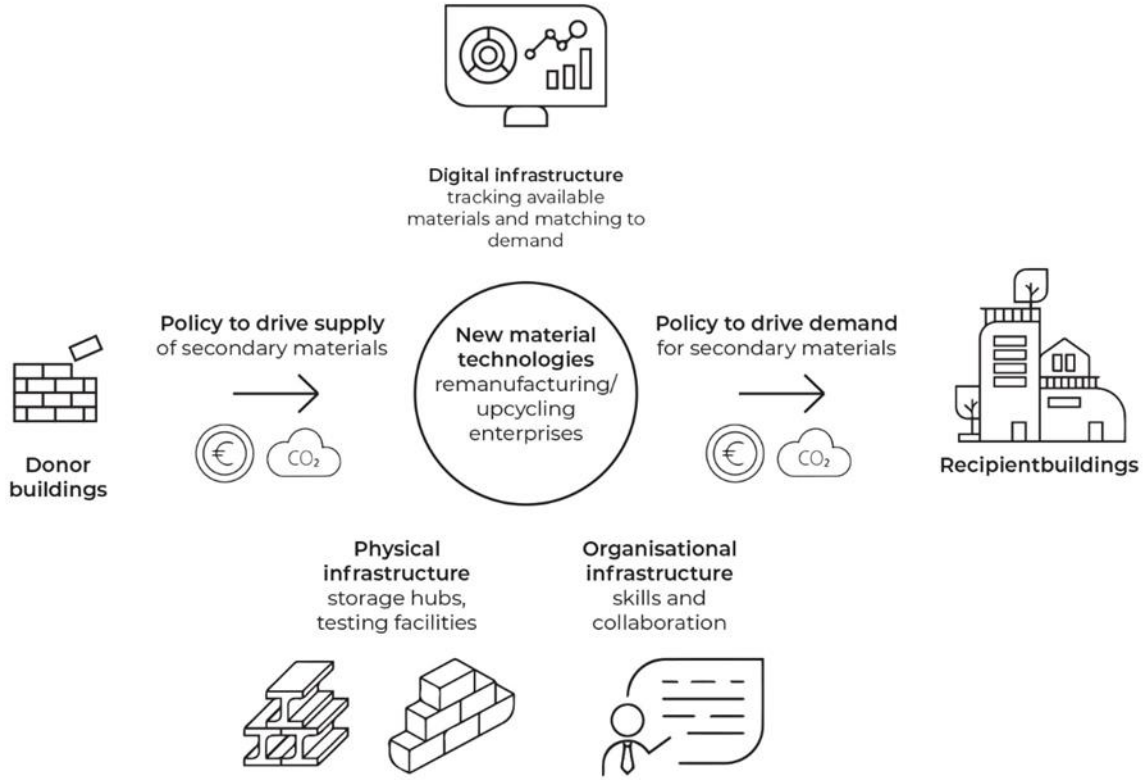
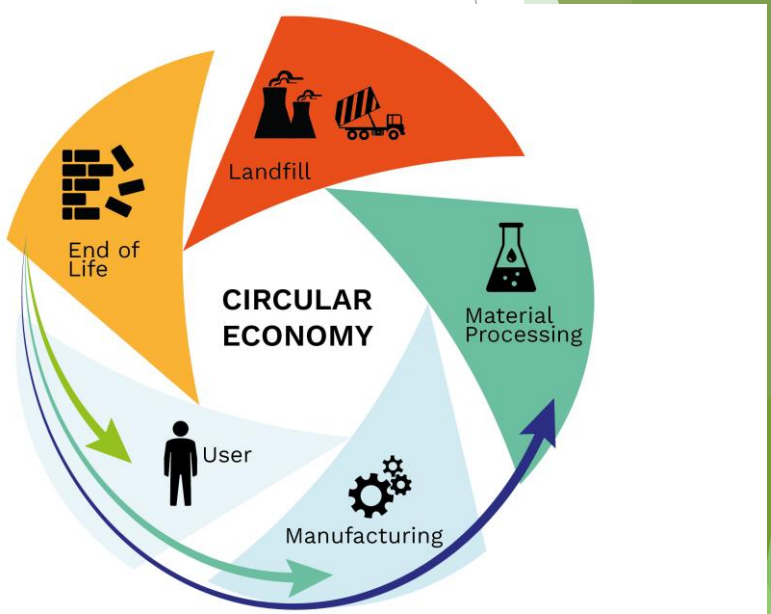
- Circular economy = doing more with less
- Requires deep change, driven by actions throughout systems
- Needs less talk more action




https://report.circuit-project.eu/chapter/increasing-the-reuse-recycling-building-materials

# Life cycle approach to Circular Economy

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**PREVIOUS BUILDINGS**

Donors of building products and materials

**CURRENT BUILDINGS**

Recipients – reducing carbon, cost and preserving heritage

**FUTURE BUILDINGS**

Designed for adaptability and future reuse = longer lived assets & future bank of resources

# Clients requirements/guidance

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| CIRCULAR ECONOMY | | Commercial | Retail | Logistics | Residential | Science & technology | Public spaces |
|---|---|---|---|---|---|---|---|
| GSD-21 | – Develop a Circular Economy Strategy. Prioritise reuse of existing structure/ materials, in line with our Circular Economy Protocol (see Development Policies Portal). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSD-22 | – Carry out a detailed pre-demolition Materials Mapping Audit. Use this audit to explore where materials can be reused on site or elsewhere. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSD-23 | – Set project-specific targets to maximise reuse, upcycling and recycling of unwanted resources.[4] Review at the end of every RIBA stage. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSD-24 | – Design and specify for disassembly and reuse, in line with BREEAM WST06. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSD-25 | – Design and specify one of the following:<br>> New materials for **disassembly and reuse** with a take-back scheme, to achieve our targets (by weight/volume).<br>> At least one construction package for **disassembly and reuse** with a take-back scheme or end-of-life scenario. | ≥30%<br>≥1 | ≥30%<br>≥1 | ≥30%<br>≥1 | ≥30%<br>≥1 | ≥30%<br>≥1 | ≥30%<br>≥1 |
| GSD-26 | – Develop materials passports for materials with potential for future reuse, in line with our Materials Passport Protocol (see Development Policies Portal). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSD-27 | – Source **reused materials or materials with recycled content**, instead of new materials, to achieve our targets (by value). | ≥50% | ≥50% | ≥50% | ≥50% | ≥50% | ≥50% |
| GSD-28 | – Source all construction materials from **ethical and sustainable sources**, in line with our Materials Schedule (see www.britishland.com/policies). Prioritise materials with Environmental Product Declarations and/or extracted or manufactured in the UK or EU. Report on compliance at the end of each RIBA stage. | 100% | 100% | 100% | 100% | 100% | 100% |
| GSD-29 | – **Divert all** unwanted resources[1] from landfill and incineration (tonnes). | 100% | 100% | 100% | 100% | 100% | 100% |
| GSD-30 | – Prioritise **reuse and high-value recycling** (upcycling and recycling) to achieve our targets (tonnes). | ≥90% | ≥90% | ≥90% | ≥90% | ≥90% | ≥90% |
| GSD-31 | – Recycle remaining materials via **downcycling** to achieve our targets. | ≤10% | ≤10% | ≤10% | ≤10% | ≤10% | ≤10% |
| GSD-32 | – Report unwanted resources[1] reused, upcycled, recycled and downcycled (tonnes). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# London Circular Economy Statement

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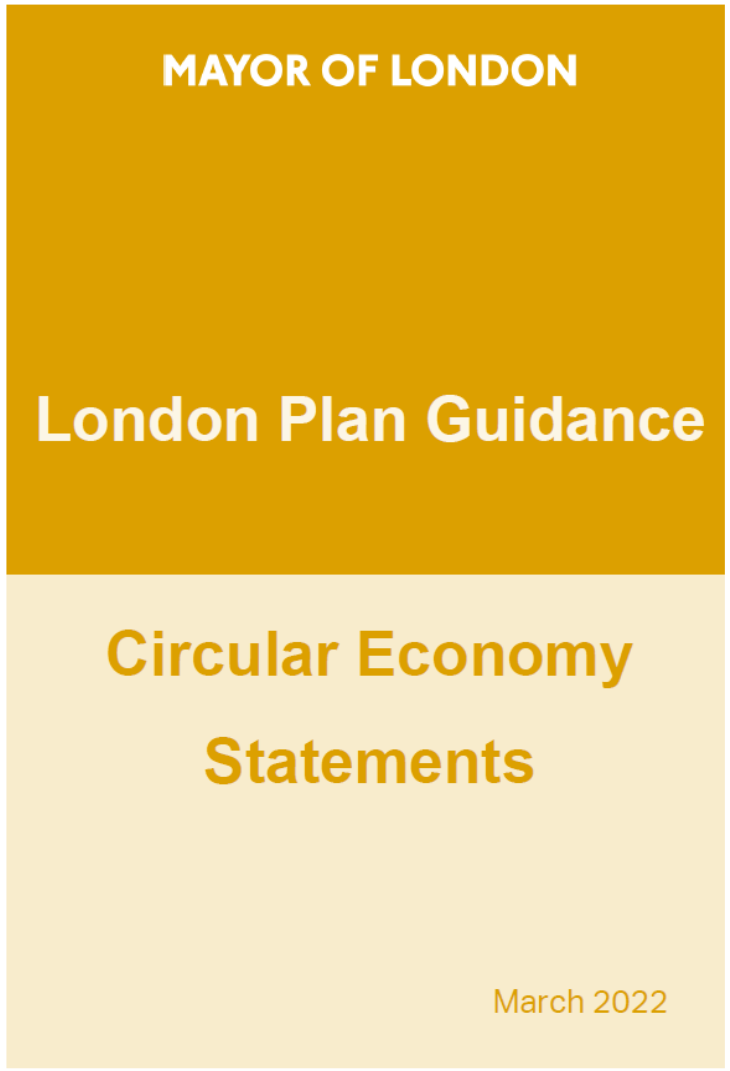


- Existing buildings
  - Pre-redevelopment audits
  - Pre-demolition audits
- New buildings
  - Recycled content 20% by value
  - Recycled content for each product
  - End of life scenarios
  - End of life plan
  - Wastage rates
  - 95% diversion from landfill for CD&E waste
  - Design aspects

https://www.london.gov.uk/programmes-strategies/planning/implementing-london-plan/london-plan-guidance/circular-economy-statement-guidance

# Camden

Camden Planning Guidance | **Energy efficiency and adaptation**

## 9. Reuse and optimising resource efficiency

**KEY MESSAGES**

- We will expect creative and innovative solutions to repurposing existing buildings, and avoiding demolition where feasible;
- All development should seek to optimise resource efficiency and use circular economy principles.

**Supporting information**

- Condition and feasibility study, and options appraisal. See paragraphs 9.4 – 9.7. (applies to: major redevelopment applications, any development proposing substantial demolition)
- Whole Life Carbon assessment and pre-demolition audit. See paragraphs 9.6 – 9.7. (All applications where the option is substantial demolition)
- Resource efficiency plan. See paragraph 9.10. (All major applications, and new buildings)

| **Condition and feasibility studies (to understand the reuse potential of the existing building/s)** | |
|---|---|
| Existing building uses | • How well does the building function? Identify operational positives/negatives.<br>• Existing user surveys (if occupied) to understand what works / or doesn't work<br>• If the building is not occupied have other options for reuse been explored? |
| Servicing | • Summary of MEP (Mechanical, Electrical, Plumbing) servicing, thermal performance and efficiency for each building component.<br>• Identify remaining lifespan of plant and discuss pros/cons of plant upgrade. |
| Technical: review, with evidence and photos, of existing building, based on intrusive survey. | • Upgrades required to comply with current legislation<br>• A material inventory audit, including an estimate of embodied carbon<br>• Scaled section drawings showing slab depths, floor to ceiling dimensions etc.<br>• Loading capacity of structural frame, materials strength, pile testing<br>• Energy performance of the façade<br>• SBEM (Simplified Building Energy Model) energy modelling<br>• Details of Air Tightness, thermal bridge modelling and condensation analysis in exploration of limits to fabric upgrade in existing building<br>• Future projections for carbon content of electric load should incorporate latest BEIS carbon factors |
| Site capacity | • What is the best use of the site? And can optimal site capacity be achieved? |

### Reusing existing buildings

9.1 "Retaining the resource value embedded in structures is one of the most significant actions you can take to reduce waste and material consumption. Include a stage in your asset management process to review the need for a brand new building/asset." (Green Construction Board, Top Tips for Embedding Circular Economy Principles in the Construction Industry)

9.2 Local Plan policy CC1 states we will e) require all proposals that involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building; and f) expect all developments to optimise resource efficiency.

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**Substantial refurbishment and extension**
This option is similar to the above, but takes into consideration the need to optimise site capacity and alter the existing structure to meet future needs. This may involve significant changes to the façade (façade replacement) but should seek to retain as much of the existing building as possible reducing the need to use new materials and reduce the loss of embodied carbon in the existing structure. If this option includes partial reclaim and recycle the development proposal should include a pre-demolition audit, as specified below.

**Reclaim and recycle**
Where it is demonstrated to the Councils satisfaction, that the above options are not feasible the development proposal should include a pre-demolition audit identifying all materials within the building and documenting how they will be managed. The preference should be for re-use on site, then re-use off site, remanufacture or recycling. (Providing time in the project plan for selective deconstruction techniques and materials storage to maximise reuse). . New London Plan policy SI7 expects 95% of construction and demolition waste to be diverted from landfill

https://www.camden.gov.uk/documents/20142/4823269/Energy+efficiency+CPG+Jan+2021.pdf/96c4fe9d-d3a4-4067-1030-29689a859887?t=1611732902542

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# Existing buildings

# Decision making process

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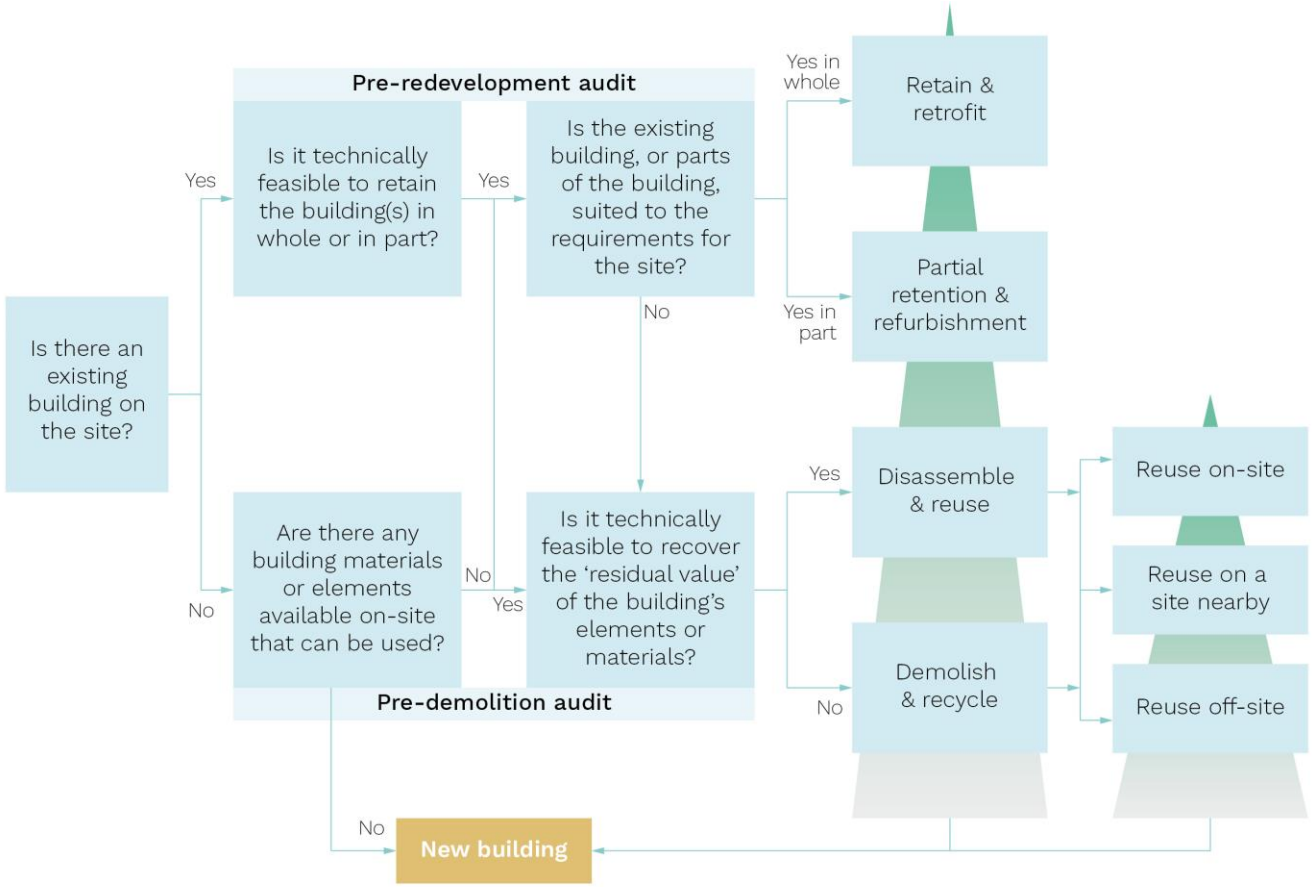

# Circular Economy – Maximising Value

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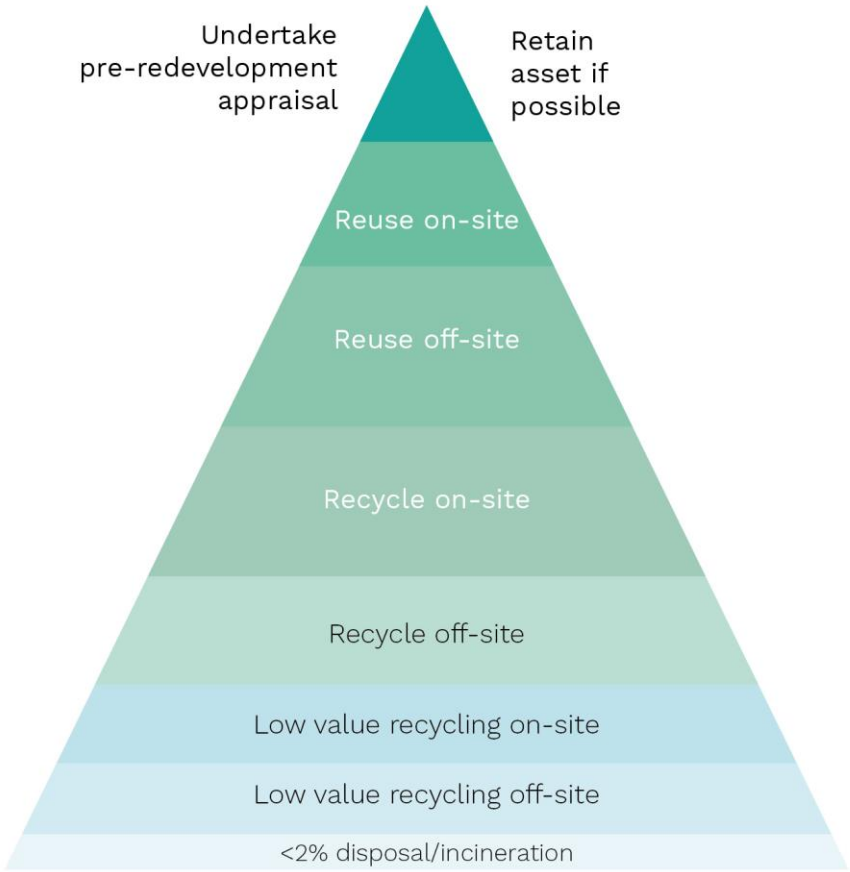


- Recommendations for reuse/higher value materials
- Relevant and helpful case studies
- Local organisations
- Advice on practicalities
- Potential carbon savings

# Material audits – Information Gathering

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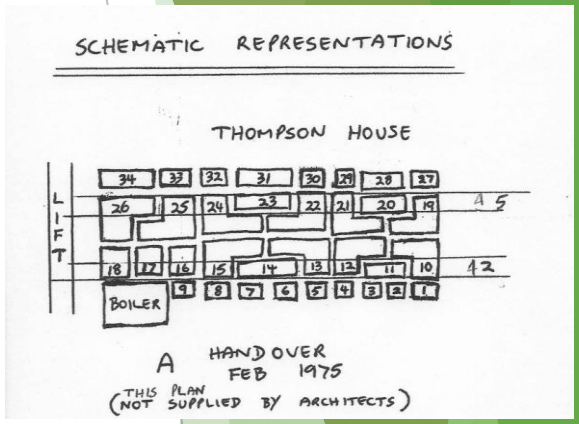
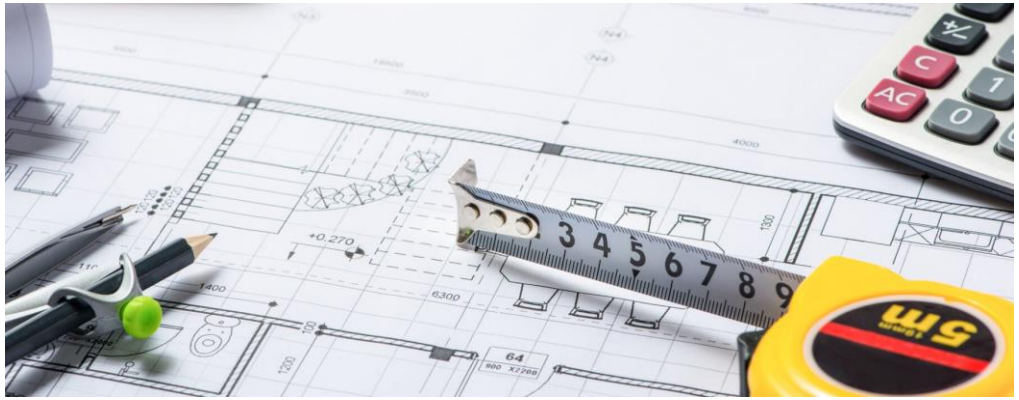
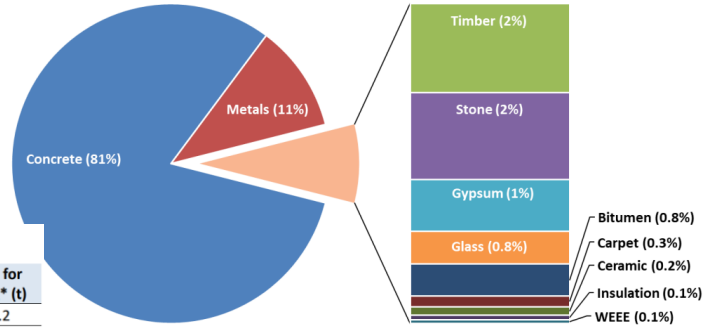
- Public data – Google Streetview, EPCs, Ordnance Survey, planning archives
- Pre-existing surveys (eg asbestos, condition)
- Drawings – original and/or updated
- Sketches
- Site visit – measurements, notes, photos
- 3D imaging/scanning
- Information from building personnel



# Material audits – Analysis & Reporting

- Identify materials and components present, describe condition & location, photos
- Quantities (tonnes, $m^3$, $m^2$, other) of key components/materials
- Targets for % reuse, recycling, energy from waste/other, landfill
- Bulk volume / Number of skips
- Embodied carbon (avoided thru reuse)
- **Detailed guidance: Methods/procedures, Legal requirements, Companies, Initiatives**




## Overall quantities

*Table 2. Estimated concrete arisings and potential recovery amounts*

| Source/Component | Tonnes | Volume ($m^3$) | Suitable for reuse (t) | Suitable for recycling* (t) |
|---|---|---|---|---|
| In-situ concrete floors | 15033.5 | 6264.0 | 0.0 | 14883.2 |
| In-situ concrete walls | 8884.8 | 3702.0 | 0.0 | 8796.0 |
| Floors - Omnia deck planks | 2815.3 | 1173.0 | 0.0 | 2815.3 |
| RC beams | 2772.9 | 1155.4 | 0.0 | 2745.2 |
| Other RC columns | 1492.3 | 621.8 | 0.0 | 1477.4 |
| Façade columns | 801.0 | 333.8 | 160.2 t | 632.8 |
| Bases for plant equipment | 178.0 | 74.1 | 0.0 | 178.0 |
| Concrete paving slabs | 52.3 | 21.8 | 49.7 t | 2.6 |
| Foundations | 44.9 | 18.7 | 0.0 | 44.5 |
| Blockwork masonry walls | 22.4 | 16.0 | 0.0 | 22.1 |
| LWC blocks (Omnia floor system) | 14.9 | 10.5 | 0.0 | 14.9 |
| Cement mortar | 2.1 | 1.1 | 0.0 | 2.1 |
| **Total** | **32114.3 t** | **13392.2 $m^3$** | **209.9 t** | **31613.9 t** |

## Reuse opportunities

| Item | Materials | Tonnes potentially suitable for reuse |
|---|---|---|
| Raised access floor panels | Chipboard, Steel | 900.9 |
| Granite cladding panels | Stone | 467.1 |
| Large pebbles (rooftop) | Stone | 198.2 |
| Façade columns | Concrete, Steel (rebar) | 176.3 |
| Perforated metal ceiling panels (incl. insulation) | Steel, Insulation | 122.3 |
| Carpet tiles | Carpet, Plastic | 85.5 |
| Stone paving | Stone | 81.5 |
| Concrete paving slabs | Concrete | 49.7 |
| Glass office partitions | Glass, Aluminium | 29.3 |
| Hanging strip lights in offices | WEEE | 23.3 |
| Ceramic floor tiles | Ceramic | 22.9 |
| Timber doors (plus glass vision panels) | Timber, Glass, Metals | 21.5 |
| Steel stairs | Steel | 19.3 |
| Handrails | Steel, Aluminium | 15.0 |
| Reconstituted stone tiles | Stone | 13.9 |
| Black reconstituted stone cladding panels | Stone | 11.3 |
| Ceramic wall tiles | Ceramic | 11.0 |
| Supporting structures for rooftop plant | Steel | 7.6 |
| WC pans | Ceramic | 4.8 |
| Rectangular light panels | WEEE | 4.0 |
| Ceramic sinks | Ceramic | 3.6 |
| Glass blocks - basement main lift area | Glass | 3.4 |
| Urinals | Ceramic | 3.2 |
| Laminated MDF kitchen cabinets, shelving and worktops | MDF (laminated) | 3.1 |
| Recessed downlights | WEEE | 2.1 |
| Hand dryers | WEEE | 1.9 |
| Timber handrails | Timber | 1.7 |
| Bulkhead lights | WEEE | 1.4 |
| Misc rooftop metal items | Metals | 1.0 |
| **Total** | | **2286.6 t** |

## Skip requirements

*Table 10. Bulk volume and number of skips required*

| Material | Calculated volume | Waste volume | Skips number (8 yard) |
|---|---|---|---|
| Concrete | 13392.2 | 16,070.6 | 2628 |
| Timber | 1240.4 | 1,984.6 | 325 |
| Metals | 565.9 | 1,697.8 | 278 |
| Gypsum | 672.9 | 874.8 | 144 |
| Insulation | 725.7 | 870.8 | 143 |
| Stone | 363.2 | 435.8 | 72 |
| Bitumen | 165.3 | 198.3 | 33 |
| Carpet | 133.7 | 160.4 | 27 |
| Glass | 130.2 | 156.2 | 26 |
| Ceramic | 34.4 | 41.3 | 7 |
| WEEE | 32.7 | 39.2 | 7 |
| **Total** | **17,456.4 $m^3$** | **22,529.9 $m^3$** | **3696** |

## Carbon implications

*Table 12. Estimated embodied ('embedded') carbon of materials present, and the potential embodied carbon avoided if reuse opportunities are exploited*

| Material | Tonnes | $tCO_2$ embedded | $tCO_2$ avoided (reuse only) |
|---|---|---|---|
| Aggregate | 208.7 | 1.6 | 1.5 |
| Aluminium | 10.9 | 71.9 | 20.9 |
| Asphalt | 300.0 | 15.0 | 0.0 |
| Softwood | 49.8 | 14.9 | 6.0 |
| Stainless steel | 0.4 | 1.8 | 0.0 |
| Steel | 3496.4 | 5419.4 | 91.3 |
| Stone | 640.3 | 448.2 | 401.6 |
| Vinyl flooring | 10.3 | 32.9 | 0.0 |
| WEEE | 35.0 | - | - |
| **Total** | **39,532.3 t** | **12,699.1 $tCO_2$** | **2114.0 $tCO_2$** |

# Resource tracking & implementation

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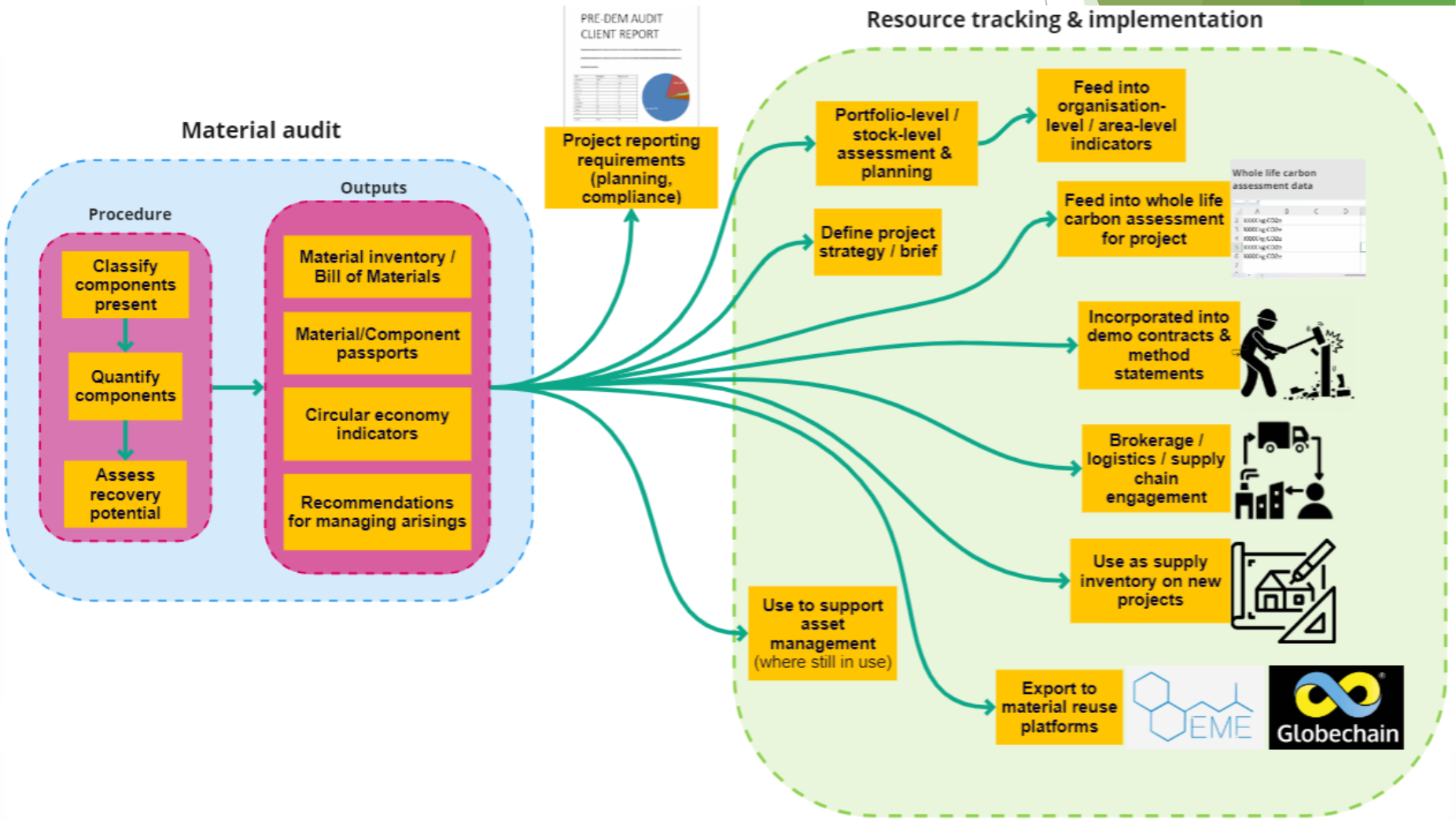
**Material audit:** Snapshot in time

**Resource tracking:**

- Continually update understanding of components & materials present
- Successive material audits, either of full building or target parts)
- Detailed logistical / practical planning & implementation
- Log decisions/actions
- Actual recovery rates vs targets/forecasts
- Lessons learned

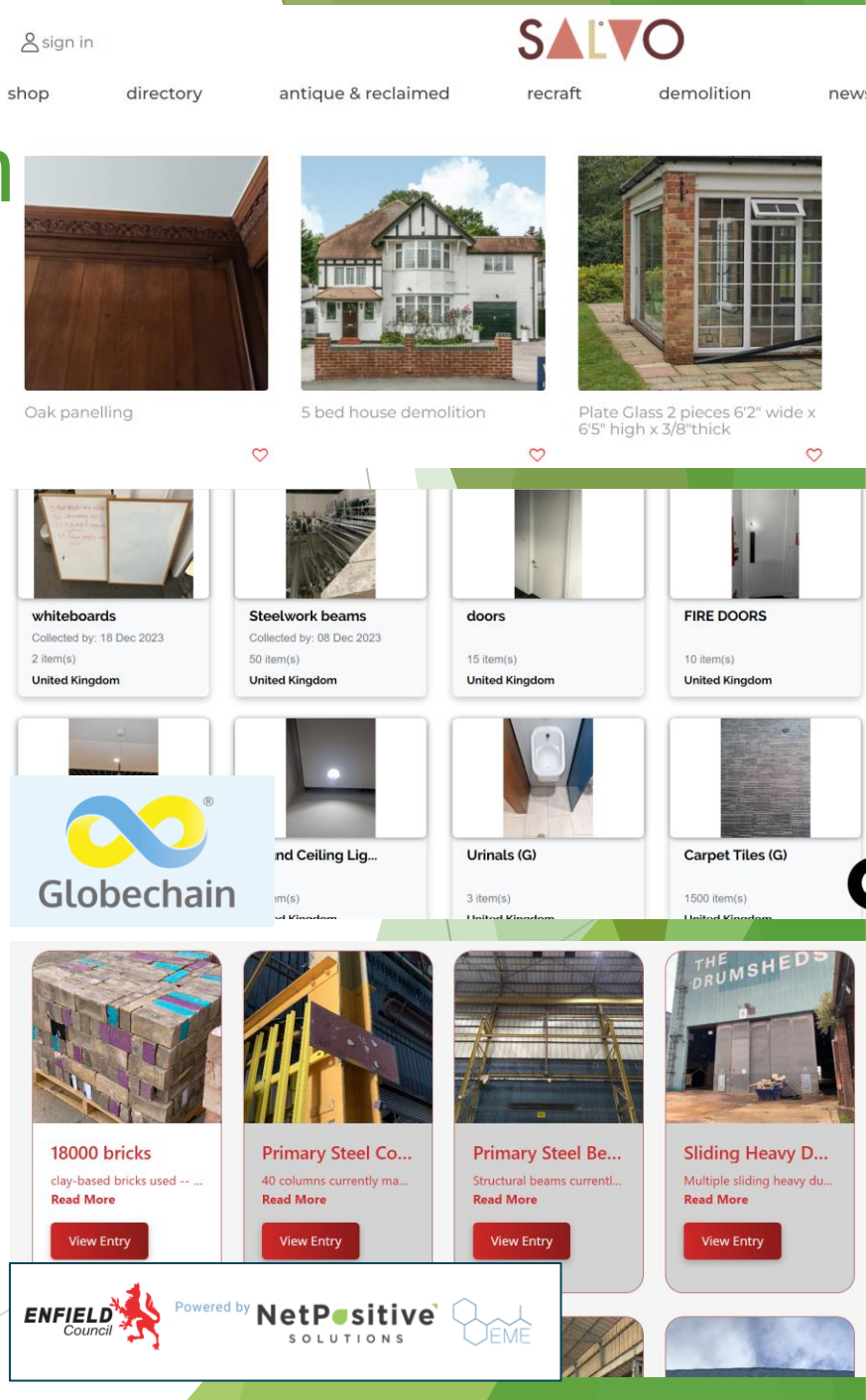


# Resource tracking & implementation

## Online reuse marketplaces

- Like eBay for building materials
- **Salvo** – been around a long time, mostly (but not all) lower-volume higher-value salvage items
- **Globechain** – requires subscription, charity-focused, seems mostly commercial items
- **Excess Materials Exchange (EME)** – UK-wide, dedicated marketplaces for certain clients eg Enfield, Westminster
- **Enviromate**
- **Material Reuse Portal** – aggregator of other platforms for London

These platforms require a **critical mass** of users to function effectively



# Case study – 1 Triton Square (London)

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**Year:** 2021

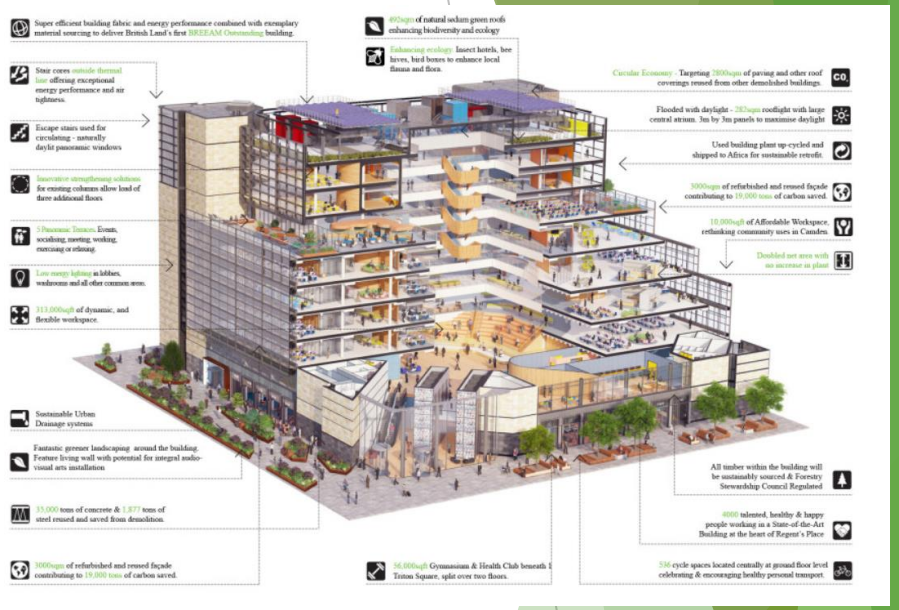
**Sector:** Office

**Scale:** 47,170m² / 507,735ft² (GIA/IPMS 2)

**Type:** Deep retrofit

**Project Team:** British Land (Client), ARUP (architecture, façade, and engineering), M3 Consulting (Project manager), Lendlease (Main-Contractor), AECOM (Cost Consulting, Employers Agent), Gartner (Façade Contractor)

- Updating a 1998 structure that was no longer fit for purpose.
- Retaining the original structure saved significant embodied carbon and led to further exploration of circularity.
- An estimated 25,000 tonnes of $CO_2$ was saved.
- Increase in operational efficiency.
- 88% of the substructure, 3300m$^2$ limestone, 35,000 tonnes of concrete, and 1877 tonnes of steel were retained, amounting to 45% of the total carbon saving.
- 3000m$^2$ of the panelised façade was reused.
- 2800m$^2$ of paving and other roof coverings were reused from other demolished buildings.
- The new extension was designed for disassembly.
- They estimate to have saved between £5-7 million by reusing materials.
- The building achieved BREEAM outstanding.



https://ukgbc.org/wp-content/uploads/2022/08/Whole-Life-Carbon-Circular-Economy-Report.pdf

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# New buildings

# Design and specification of new buildings and spaces

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- **Select reused & recycled components and materials**
- **Lightweighting (avoid overengineering)**
- **Enabling circularity at future stages in building lifecycle**
  - Design for disassembly
  - Design for adaptability
  - Information: ensure relevant actors later in the building lifecycle know how to use, adapt, and disassemble the building – in building information, include drawings of key systems, descriptions of technical sequences/procedures, and scenarios
  - **But:** We need to minimise virgin resource use and waste **now**

# Design for efficiency/adaptability/flexibility

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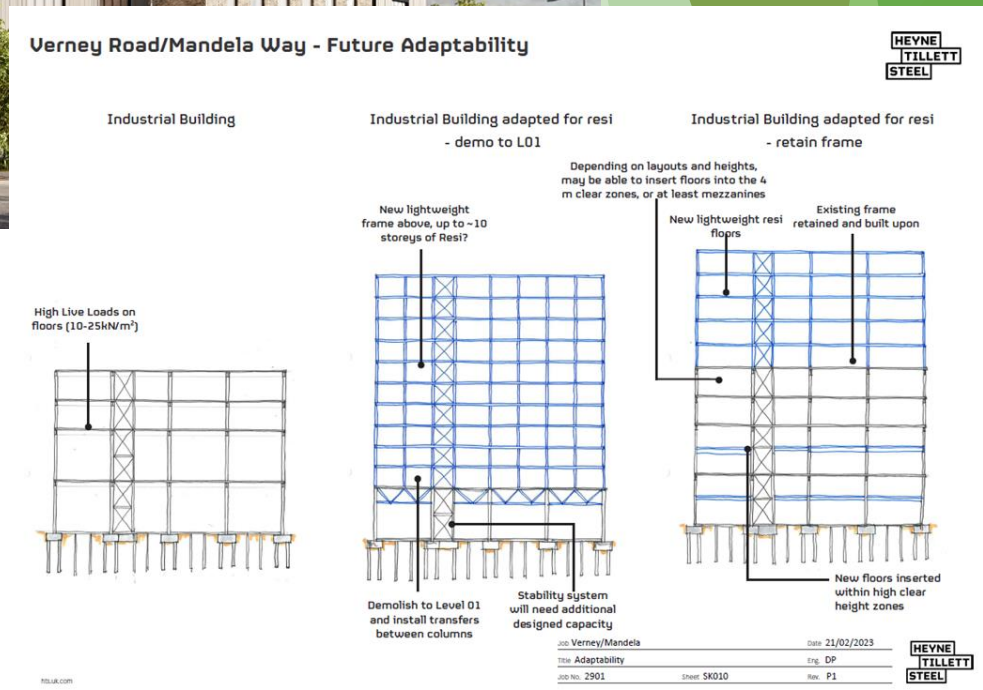
- 10mx10m to provide maximum material efficiency in terms of steel sizing and structural tonnage.
- Review of floor loads and material requirements (reduction in upper levels)
- Use of SUDs reducing the sizes of underground storage tanks
- Designing to standard material dimensions to reduce off-cuts and waste on site
- Removing redundant materials from design
- ‘Exposed thermal mass' design strategy to reduce finishes
- Elevations to be structured to utilise translucent materials to give natural light into space and avoid complex lighting systems
- Allows for sub division and to create openings and interconnecting floors



# Enabling future circularity

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## Disassembly principles

- Easy access to components and services
- Durability
- Exposed connections
- Independence
- Avoidance of unnecessary finishes
- Supporting reuse (circular economy) business models
  - Reuse(d), refurbish, remanufacture, recycle(d)
- Simplicity
- Standardisation
- Safety of disassembly

Green Transformable
Building Lab - Heerlen

*From ISO 20887 Design for Disassembly and Adaptability*

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# Product and material level

# Circular business models

- Supplier takeback and remanufacture/recycling, e.g.
  - Carpet tiles (eg Interface)
  - Ceiling tiles (eg SAS)
  - Flat glass (closed loop recycling)
- Leasing e.g.
  - Façade (TU Delft Netherlands)
  - Lighting
  - Lifts
- Third party remanufacture, e.g.
  - Raised Access Flooring
  - Heating and cooling systems
  - Lighting



# Case study – Circular business models

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## RMF Raised Modular Flooring

- Take-back of raised access flooring
- Work closely with strip out and demolition contractors and pay for flooring
- Test – check, clean, deflection tests
- Rewarranty
- Sell reused RAF back to CAT B fit-out market (10% cheaper than new panels)
- Hold an EPD for reused RAF panels
- If not reusable, will recycle

# Steel reuse

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- Production of a tonne of steel generates on average 1.85 tonnes of $CO_2$.
- Recycled content can be nearly 100% for rebar; structural steel varies (around 20% in UK)
- Technically established and cost effective (post 1970s steel) for steel **reuse** but encased steel is difficult
- Not enough scrap to meet the demand of new steel
- Limited reprocessing of scrap in the UK due to type of furnaces; 8.7 million tonnes are exported
- Galvanised steel difficult to rework for reuse

ASBP DISRUPT project: https://asbp.org.uk/disrupt

# Reuse is not new: Bus station Schiphol – Nord, Amsterdam, The Netherlands

**1)** Hangar at the airport for the British Royal Air Force that could be built up quickly, 1942

**2)** The hangar was sold and moved to Zestienhoven airport, Netherlands, 1958

**3)** Transformed into Rotterdam detention centre, 2003

**4)** Transformed into the bus station, 2015

https://www.steelconstruct.com/wp-content/uploads/FS08-Bus-station-Schiphol-Nord.pdf

# Carbon impact

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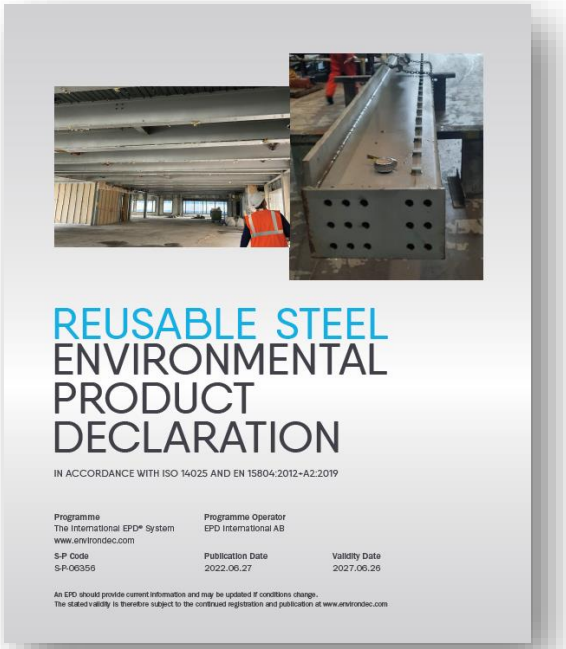
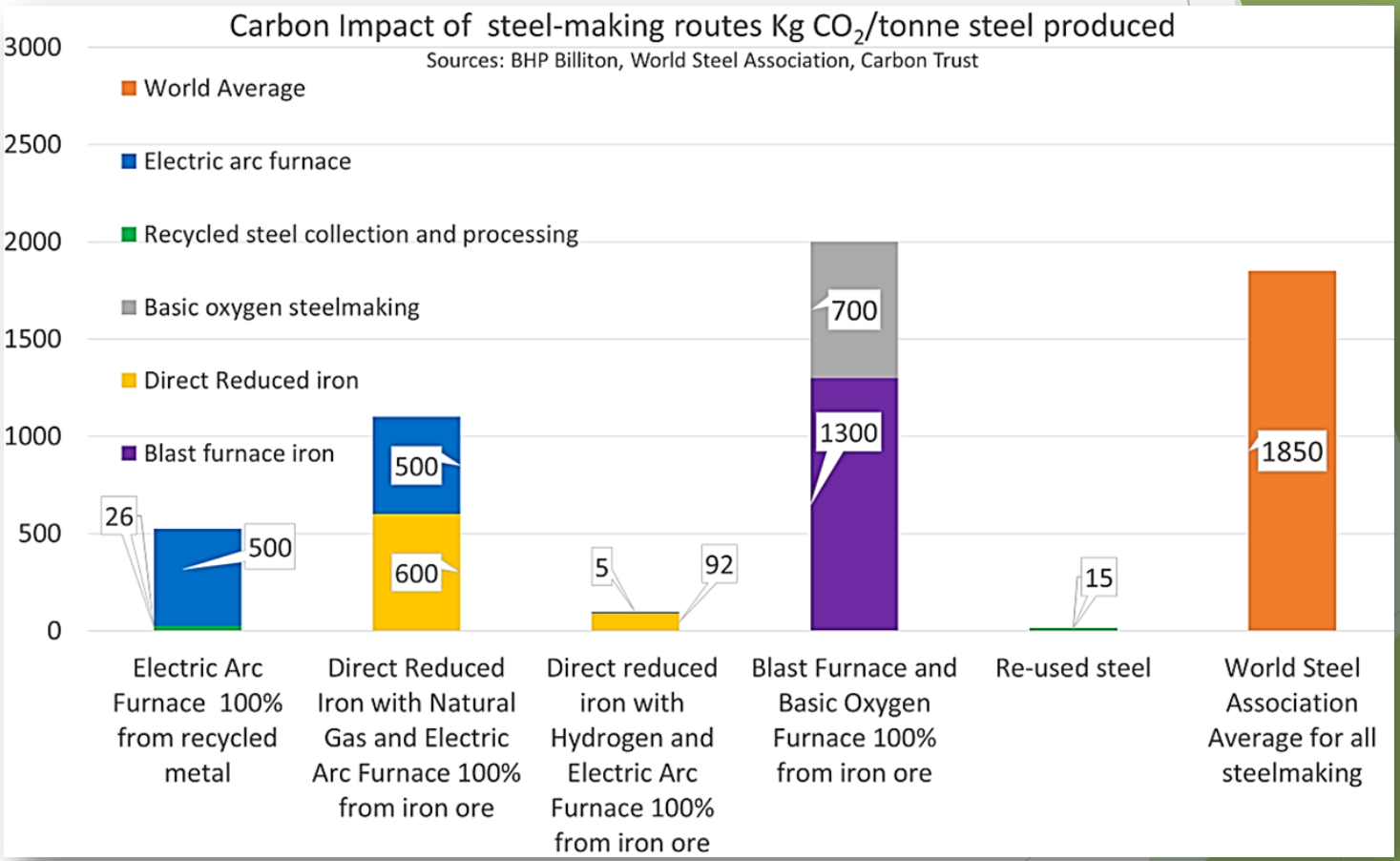
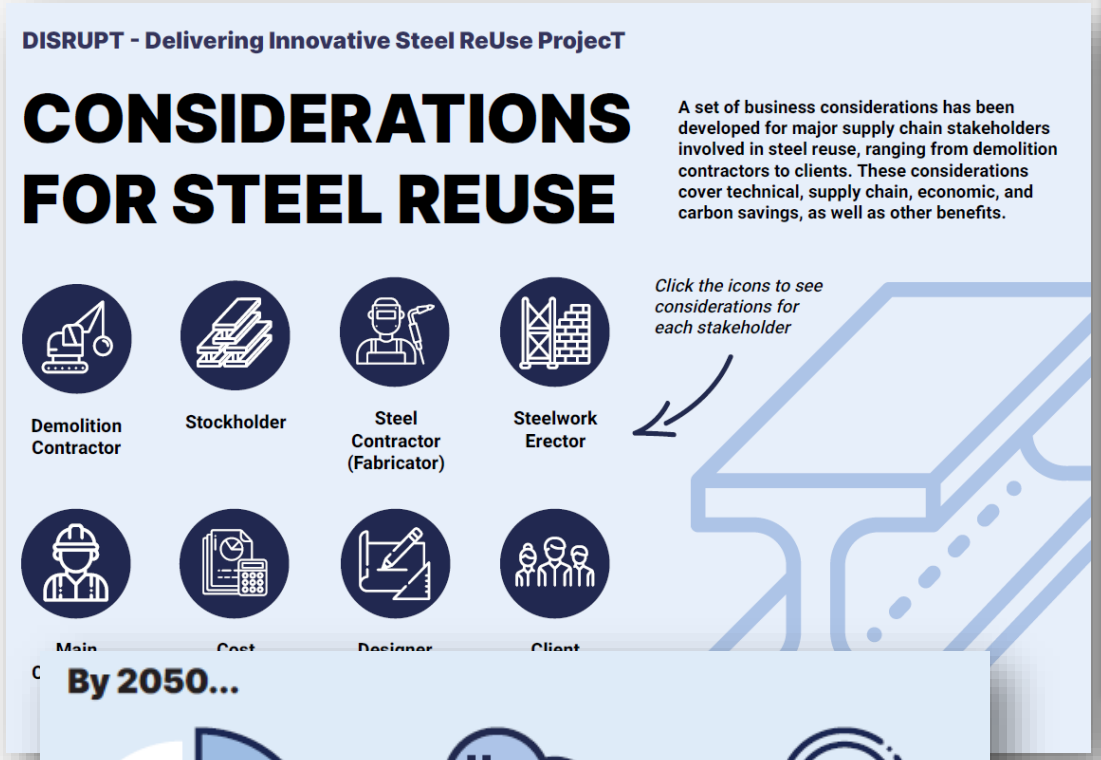
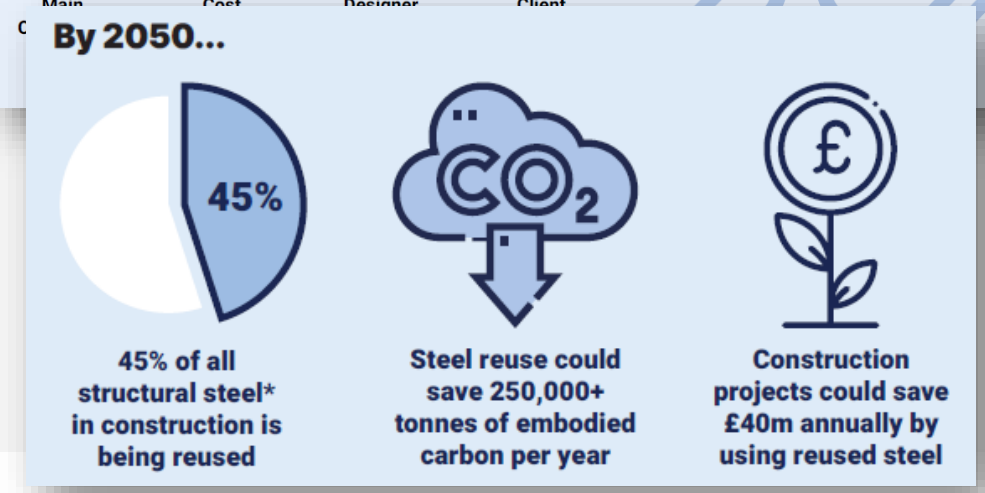
EPD by EMR, 2022



# DISRUPT Toolkit




55 Great Suffolk Street

Southwark, London



Brent Cross Town Primary Substation

Brent Cross, London



Elephant & Castle Town centre redevelopment

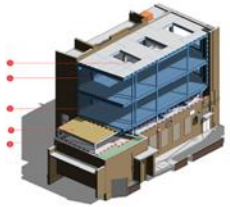
Southwark, London

Holbein Gardens (DISRUPT)

Sloane Square, London

Meridian Water

Enfield, London



Sloane Square House

Sloane Square, London

| Result | Size | Amount of steel reused | Carbon savings | Implications on project budget | Implications on timelines |
|---|---|---|---|---|---|
| 9 successful<br>2 unsuccessful | 154 - 70,000 sq m | 353 tonnes | 660 tonnes | 5 cost savings<br>2 cost neutral<br>2 slightly more expensive | No |

**STUDY ON MEASURING THE APPLICATION OF CIRCULAR APPROACHES IN THE CONSTRUCTION INDUSTRY ECOSYSTEM**

**June 2022 – May 2023**

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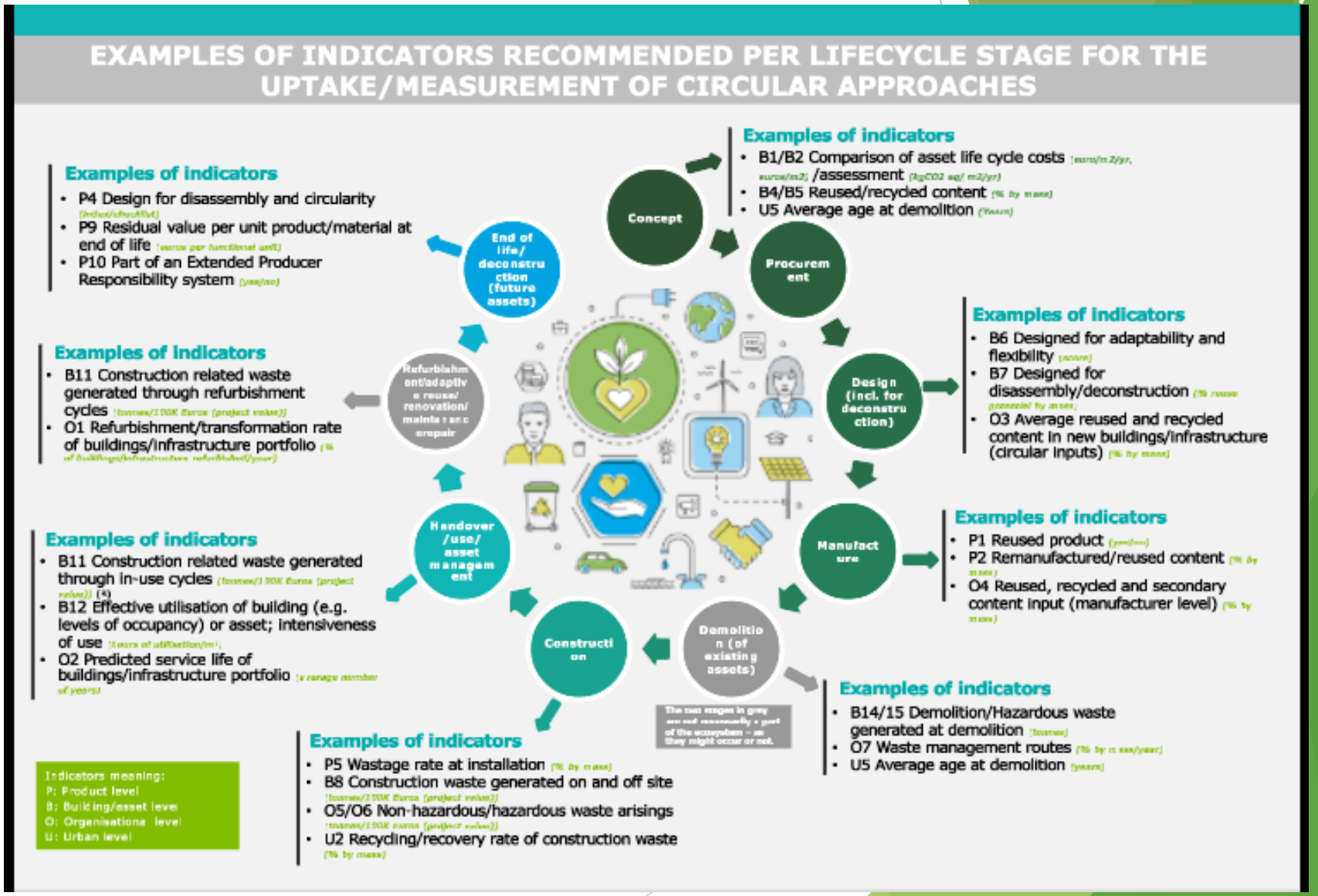
Recommendations for:
21 Core indicators
19 Supplementary indicators

4 levels – product/material; building/infrastructure; organisational; urban

Learning from 7 case studies e.g. GLA Circular Economy Statement, Level (s) sustainability standard etc



# Routemap

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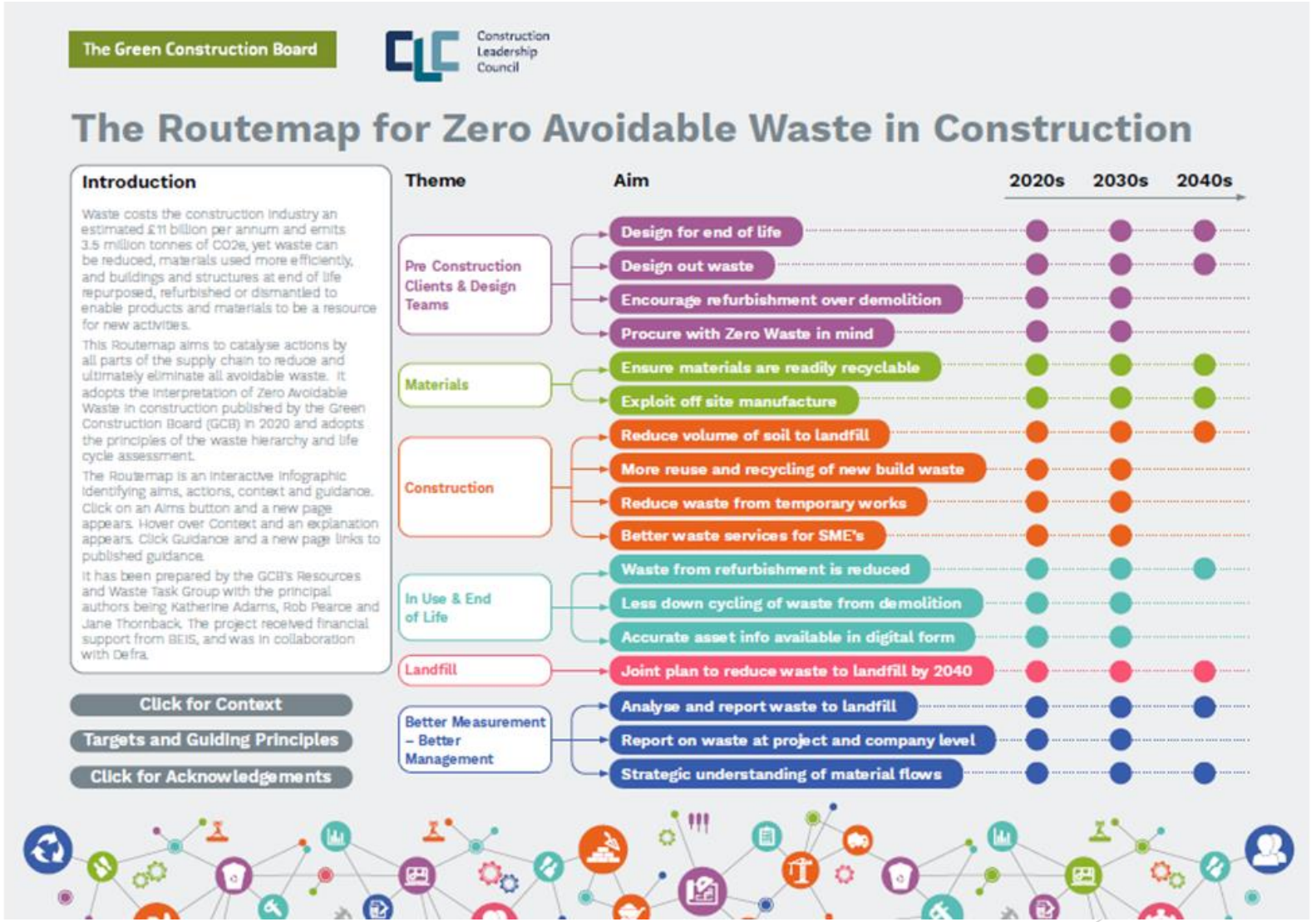

# EU Taxonomy

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- Various criteria e.g. construction of new buildings
  - Use of pre-demolition audits
  - 90% target for reuse and recycling of construction and demolition waste (excluding backfilling)
  - Life-cycle Global Warming Potential (GWP) of the building resulting from the construction has been calculated for each stage in the life cycle and is disclosed to investors and clients on demand
  - Construction designs and techniques support circularity via the incorporation of concepts for design for adaptability and deconstruction - via Level(s) framework
  - The use of primary raw material in the construction of the building is minimised through the use of secondary raw materials with requirements e.g metals – maximum of 30% of the total material come from primary raw material
  - Electronic tools to describe the characteristics of the building as built, including the materials and components used, for the purpose of future maintenance, recovery, and reuse

https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity/350/view

# EU Revised Construction Product Regulations

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- Every construction product sold within the EU will need to disclose its Global Warming Potential (GWP)
- By 2030 manufacturers will be expected to report the full range of environmental impact data contained within EN 15804-based Environmental Product Declarations (EPDs)
- Commission the authority to establish mandatory minimum environmental sustainability requirements for the public procurement of construction products
- Design and manufacture a product and their packaging in such a way that their overall environmental sustainability reaches the state of the art level;
- Give preference to recyclable materials and materials gained from recycling;
- Respect the minimum recycled content obligations and other limit values regarding aspects of environmental sustainability;
- Make available, in product databases, instructions for use and repair of the products;
- Design products in such a way that re-use, remanufacturing and recycling are facilitated.

# Thanks for listening!

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