Circular economy guidance for construction clients:

How to practically apply circular economy principles at the project brief stage

APRIL 2019

Partner:

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“At the Crown Estate our purpose is to create brilliant places through conscious commercialism. We recognise that our ability to deliver on our purpose is impacted by our planet’s finite resources and growing population, and the pressure this puts on our climate, as well as natural and built environments. This is why we are partnering with UKGBC on the circular economy programme, supporting clients who are looking to lead the way and specify circular economy principles. We believe through business leadership we can make positive strides towards creating a more circular built environment.”

Judith Everett
Chief Operating Officer, The Crown Estate
UKGBC Programme Partner for Circular Economy

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Foreword

The circular economy is a powerful and challenging idea to guide how humans might manage their material impact on the environment so that instead of steadily degrading, it continually regenerates. That is how the natural world works. Nothing is thrown away for there is no such place as 'away'. Any 'waste' from natural processes becomes food or fuel for other processes in the cycle of life.

We must move on from the take, make and dispose economic model that has underpinned development and GDP growth since the Industrial Revolution. Within this model, the construction, maintenance, modification and replacement of buildings and infrastructure is a huge consumer of material and a significant producer of waste.

In 2014, 120Mt of waste was generated from construction, demolition and excavation – equivalent to 59% of total UK waste and 30% of construction firms' pre-tax profit. In 2015, the UK economy used 576 Mt of materials, and as far back as 1998 construction accounted for roughly half of our national material consumption. While most construction waste is now diverted from landfill, little is being recycled or reused, and the quantity of reused materials in construction has actually decreased since 1998. At the same time, the rates of extraction of materials in our fast-developing world are already way beyond planetary capacity.

The circular economy, one that operates through 'designing out waste and pollution, keeping products and materials in use, and regenerating natural systems'[1] – is fast rising up the business and political agenda. Research suggests that by increasing resource productivity, a circular economy could add €0.6 trillion to the EU economy by 2030.

However, few construction clients are yet specifying zero waste in their procurement tenders or project briefs. Despite recent growth rates, offsite manufacturing - which can result in significant waste reductions on site - still represents a very small proportion of the market. That is partly because it is a challenge to convert the circular economy from a neat theory into replicable practice.

This guide, developed by UKGBC and its members, alongside a large number of interested stakeholders and experts, seeks to provide much-needed practical guidance for construction clients who are seeking to increase resource efficiency and reduce waste in their projects through the adoption of circular economy principles. It is intended to provide technical guidance on the types of clauses that clients might include in their project briefs at RIBA stages 1 and 2.

As well as serving as a source book for solutions, I hope that this guide will also inspire innovation to produce new solutions to release the power of an idea whose time has come.

Sunand Prasad
Founder Penoyre & Prasad and Trustee of UKGBC

1 Definition by the Ellen McArthur Foundation.

1 Introduction

1.1 PURPOSE

This guidance is designed to enable construction clients to include more ambitious circular design and construction principles in project briefs for non-domestic built assets.

This is achieved by addressing the common commercial obstacles that clients may encounter, and providing practical support and evidence to assist them in setting clear circular objectives for their construction projects.

The guidance also aims to ensure that the construction supply chain can effectively deliver circular economy goals and that budget, project management, and timescale risks are all minimised and mitigated.

1.2 TARGET AUDIENCE

This guidance is directed at construction clients who are writing project briefs which are looking to pursue circular economy principles in their developments.

The guidance will also be helpful for those in the supply chain looking to support construction clients on their journey towards specifying and practically applying circular economy principles. It will require buy in from all players in a supply chain to enable the successful application of circular economy principles.

1.3 SCOPE

This guidance focuses on RIBA stages 1 & 2 – 'Preparation and Brief' and 'Concept Design' – as shown in Figure 1, the output of which is the initial project brief. However, for circular principles to be successful, it will require a whole building lifecycle approach.

It also requires the client's strategic brief to have a clear vision for applying circular economy principles. The business case and subsequent vision will vary between clients and projects, whether achieving the lowest environmental impact or maximizing adaptability into the future. This is best considered using scenario planning during the development of the strategic brief in RIBA stage 0.

To maximise its effectiveness, this guide has been drafted using the following principles:

- Aimed primarily at construction clients and their project teams, it should not require a consultant to interpret the information
- Focuses on built assets, not at an organisational level. There are many toolkits that address the latter, such as [Business in the Community's (BitC) Circular Office Guide]
- Aimed at non-domestic buildings, although it is hoped that principles can be transferrable to domestic and infrastructure scenarios
- Primarily addresses RIBA stages 1 & 2 – Project Brief and Concept Design, not due diligence and acquisition stage or beyond the project brief
- Begins to collate evidence around the business case for circular construction and the commercial value associated with applying circular principles to built environment projects
- Provides suggested content for project briefs, the expected challenges and how they might be countered with currently available evidence
- Provides guidance for who clients should engage with, including the "when" and "how"
- Consists of a set of high-level circular principles, presented to aid circular thinking and improve sustainability performance. There are basic circular principles that should be applied to all projects; however, some additional solutions will be site-specific – therefore it is not feasible to present these principles in a hierarchical way
- Will be iteratively developed, being updated as new evidence becomes available (dependent on funding).

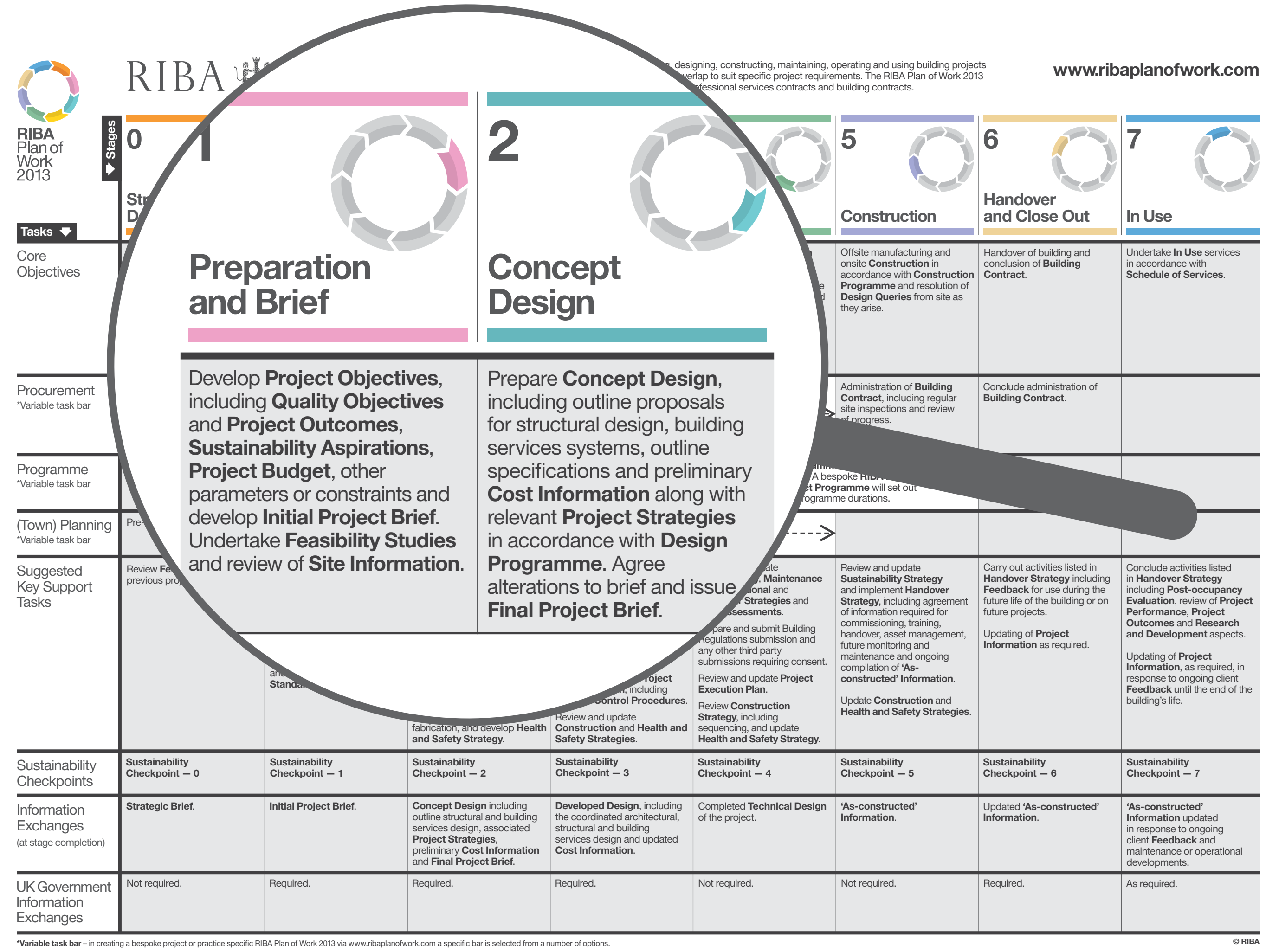

Figure 1. *The RIBA Plan of Work 2013.*[1]

2 Circularity

2.1 CIRCULAR ECONOMY AND THE BUILT ENVIRONMENT

Current and future trends point toward the need for a fundamental shift in the way resources are consumed to avoid ecological collapse, significant disruption to production lines and other business risks. There are also considerable economic opportunities created by a shift to a circular economy.

In contrast to a linear 'take-make-dispose' economy, a circular economy builds overall system health by gradually decoupling economic activity from the consumption of finite resources. This should be underpinned by a transition towards renewable energy sources, and is based on three principles:

1. Design out waste and pollution
2. Keep products and materials in use
3. Regenerate natural systems

The circular model distinguishes between technical and biological cycles, where biologically based materials and building components are generally designed to feedback into and regenerate living systems; while technical cycles recover and restore products, components and materials through strategies like reuse, repair, remanufacture or (as a last resort) recycling.

For further background information on the circular economy see Appendix 1: How circular economy links to other sustainability topics.

Of the 92.8 billion tonnes of minerals, fossil fuels, metals and biomass that enter the global economy, only 9% is circular, i.e. re-used annually.[2] *Circle Economy (2019)*

Annual global extraction of primary materials set to triple by 2050[3]
UN Environment Programme, 2016

Global waste on pace to triple by 2100[4]
The World Bank, 2013

60% of total UK waste is generated from construction, demolition and excavation[5]
Defra and Government Statistical Service (2019)

2.2 THE BUSINESS CASE FOR A CIRCULAR ECONOMY

For the economic opportunities to be realised, circular economy must be seen as a business strategy, not just a sustainability consideration. The Ellen MacArthur Foundation defines four building blocks for achieving a circular economy:

1. circular business models
2. circular design
3. reverse logistics
4. enablers and favourable conditions (i.e. public policy)

Up to now, much of the wider industry discussion around the built environment has focused on the second and fourth building blocks. Without addressing circular business models and new engineering processing it will be impossible for the built environment to fully move towards a circular economy. Therefore, it is critical that commercial leaders from all tiers of the supply chain work towards new business models.

To make the business case, the key point to realise is; how can most value be derived from the material and products that are no longer needed in a built asset, considering there is nowhere to throw resources 'away' to. Circular economy offers the opportunity to de-risk project pipelines, generate reliable lower-risk cash flow and create stronger, longer lasting relationships with clients. It is therefore key for commercial directors in the supply chain to engage with the discussion around circular economy principles in an open and collaborative way.

Once an open and collaborative approach has been agreed, these new approaches need rigorous testing on scalable, commercial pilot projects. The success of such projects will provide the evidence base to inspire decision makers and that will, in turn, support policy development.

For more information about how the demand and supply side can address business model change, see Appendix 2.

The price of construction materials increased 4.9% from May 2017 to May 2018[6]
BEIS (2018)

Over the next 10 years the circular economy market will boost economic growth by up to 4%[7]
ING (2015)

Adopting a circular economy represents a €1.8 trillion opportunity for the EU by 2030[8]
McKinsey Center for Business and Environment (2015)

2.3 POLICY LANDSCAPE

There is a growing body of government policy relating to a circular economy, at both national and local levels, although there are inconsistencies in ambitions between government departments.

In 2016, the UK Government Chief Scientific Adviser issued a report called 'From waste to resource productivity', which sets the tone for a renewed approach to waste and recommends a review of innovative circular economy practice throughout the economy.[9] This was followed by the UK Government's 2017 'Industrial Strategy' which set out a national framework for bringing government and industry together to create a stronger, more resilient industry for the future and included a commitment towards moving to a more circular economy.[10] Out of this Strategy came the Construction Sector Deal which recognises that more efficient processes will help minimise the 60% of UK waste that comes from construction, demolition and excavation.[11]

In early 2018, the UK Government committed to doubling resource productivity over the 25 Year Environment Plan's lifetime and to making the UK a world leader in resource efficiency[12]. A new national Resources & Waste Strategy setting out how these targets would be achieved is expected in 2019.

The EU's Circular Economy Package (CEP) was ratified into law in July 2018 and member states are now working towards putting it into national legislation[13]. Despite Brexit, the UK Government has ratified the new proposals and will work towards the targets set within it.

"We are pleased to be progressing the Draft London Plans ambition for major developments to produce Circular Economy statements. This London based proposed policy, combined with the UKGBC guidance will help drive more practical solutions in the built environment."[14]
Doug Simpson, Principal Policy and Programme Officer, Waste and Green Economy Team, Greater London Authority

There is progress across the UK at a regional and local level, with the following policies developing and testing requirements for circular economy statements:

- Wales Future Generations Act
- Circular Economy Strategy Scotland
- Circular Peterborough
- Circular Glasgow
- Circular London
- Draft London Plan

There is clearly a new role for Government to put in place a clear regulatory and legislative framework to help drive the outcomes that leading industry players want to see. The following opportunities for government were identified by UKGBC members after meeting with officials from Defra and BEIS in December 2018[15]:

- Accelerate better resources and waste data
- Implement taxes that prevent resources going to landfill or incineration and instead generate fiscal incentives to encourage reuse
- Implement regulation to encourage greater reuse and opportunities for circular principles such as assimilating the EU Circular Economy Package and ideally going further than those intentions
- Government should show leadership and drive circular principles through their own public procurement processes

The Netherlands has set itself a target of having a 50% circular economy by 2030 and to be fully circular by 2050.[16] But most governments have yet to realise the potential of the circular economy, and the interrelated benefits, to reduce biological impacts whilst diversifying and improving economic opportunities.

3 Design principles

3.1 WHO TO ENGAGE IN THE PROCESS AND WHEN

For circular economy principles to successfully work in the built environment, business models need to evolve across the entire value chain to generate an alternative approach to developments.

Investors, planners and prospective tenants could play a critical role by asking construction clients for details of the proposed longer-term strategy for the building and the risks associated with potential early demolition, change of use or building obsolescence due to varying externalities such as changes in local land values. Investors should therefore ask about designing for disassembly and recoverability when looking at the lifetime of projects they are evaluating and consider long-term cost optimisation and financial risk.

In addition, early input and buy-in is needed from all players with financial gains shared across the value chain to incentivise these changes. Specifically, this applies to contractors and manufacturers of key materials and building elements along with designers. If known, the end user and/or the building/estate management provider should also be engaged. This is especially important to determine the lifecycle implications of the design approach, for example:

- How the building will be maintained
- What budgets are available
- Is there an operational cost benefit from a circular approach

Where possible, partnerships should be sought with integrated teams that have sustainability as a primary mission. Initial outcomes and objectives for the development should be revisited periodically through focused workshops and reviewed regularly at key stages.

Case Study: At Park 2020, Delta Developments engaged directly with material manufacturers and had an open book arrangement with the main contractor to alleviate concerns of the contractor.[17] They agreed profit margins with their contractor to enable this.

Case Study: At ABN Amro Pavillion, Circl, BAM was engaged early on to work with the architect to redesign an initial concept. Key suppliers were brought in to this process – i.e. facade and timber frame suppliers, as well as an urban miner (to identify reused elements to incorporate into the design). This was, in effect, an extended pre-construction phase occurring while the contract between BAM and ABN Amro was still being finalised.

Example timeline

This guidance focuses on RIBA stages 1 & 2 – 'Preparation and Brief' and 'Concept Design'. However, for circular principles to be successful, a whole building life cycle approach is required. Figure 2 below suggests methods to incorporate circular economy principles into a development process using the RIBA stages as an indicator of when actions should be undertaken. Please note there is no 'recipe for success' and that during early adoption of circular economy principles a degree of flexibility and reflection is essential. Ideally there will be an overarching and clear objective set from the outset to develop a new circular way of working in collaboration with the whole value chain.

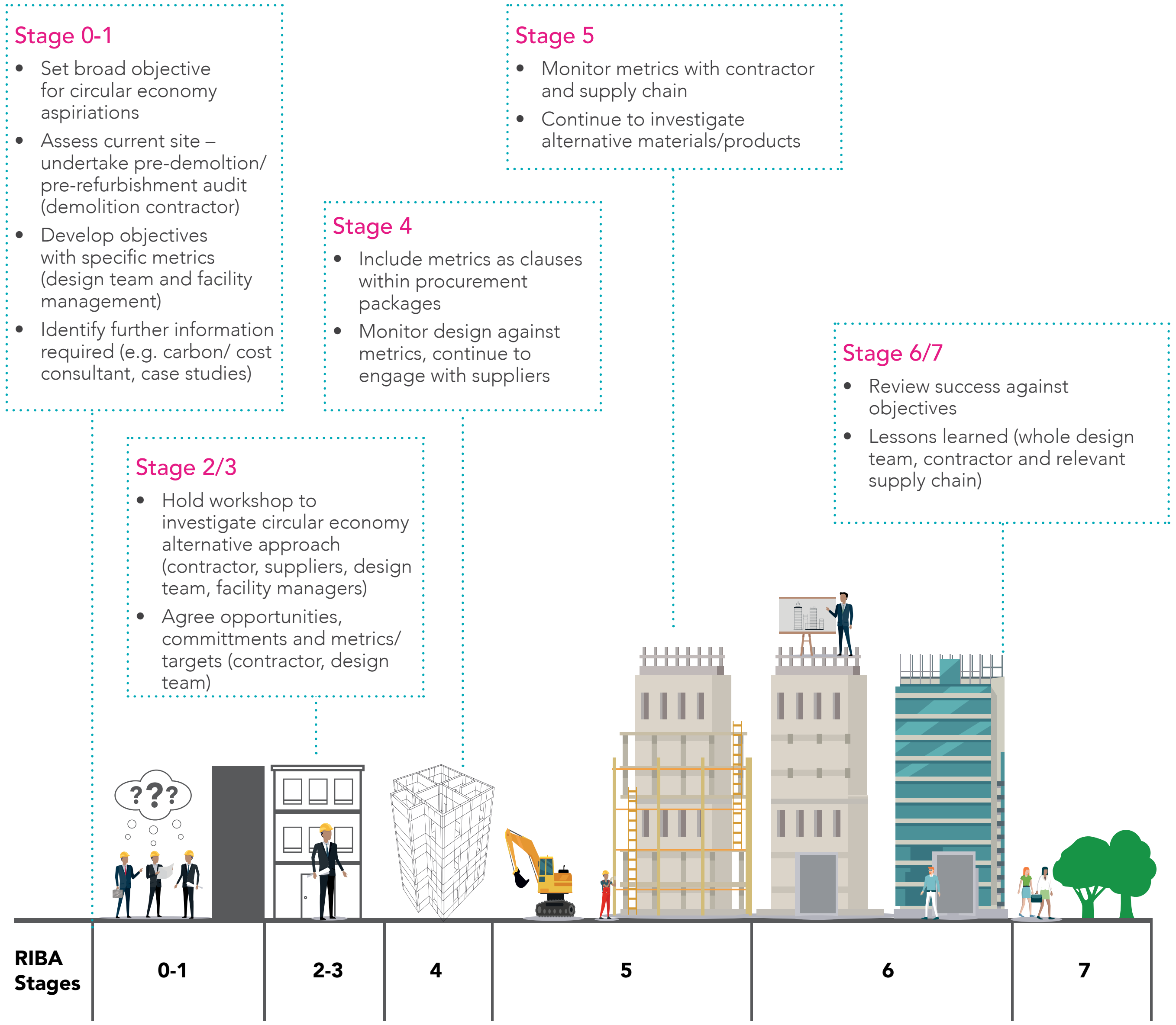

Figure 2. *Methods to incorporate circular economy principles into a development process using the RIBA stages*

3.2 OVERARCHING STRATEGY

This section sets out the strategic approach a construction client could take depending on a number of scenarios, for example, whether the client is refurbishing an existing asset or developing a new building. Each development will require an approach that is suitable to the geographical context and vision of the organisation, but usually the commercial gain associated with the asset will be the strongest driver of the strategy.

A warning about building lifetimes

Many built assets are designed for an arbitrary 60 year life and clearly some buildings last longer and others much less. Therefore, it is important to consider realistic alternative lifetimes for the building, and where possible, involve the end user in decisions and use analysis which informs the overall design philosophy for the building and the design approach for each element of the building. Designing for longevity is important for all eventualities. However, building should also be designed for deconstruction, flexibility and adaptability to situations where a buildings or elements life are shorter than the predicted 60 years. These changes in a building's actual life can result from varying external factors such as shifting planning policy, increases in land value, changes in market demand or technological advances (floor to ceiling heights mean many buildings cannot accommodate raised access flooring for data cables). Resultant regulatory noncompliance or loss of commercial or market value, or practical functionality can result in the building having a shorter life than hoped. On the other hand, some institutions, such as universities may be in a position to design for a lifespan of 100 or more years.

Determine realistic lifetimes for the elements of a building

This should be based on the 'building in layers' principles, as shown in Figure 3 below, and should consider the desire to adapt the structure and fabric – for example, whether the facade would need to be replaced to adapt the building to a new use. The likely lifetime of the interior fitout would be determined by the leasing arrangements and market trends. The lease may require the premises to be returned to the landlord in a certain condition and incoming tenants may wish to refit the premises.

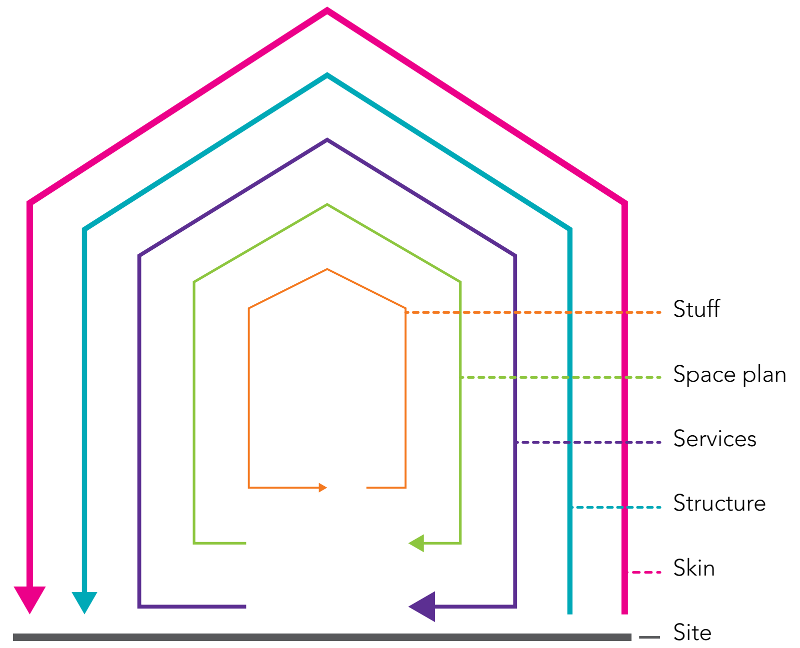

Figure 3. *Building in Layers*[18]

Selection hierarchy

When selecting and designing components, the following hierarchy should be applied:

Table 1. *A hierarchy of actions to apply when selecting and designing components.*

Design out	• Design out the need for the component or material (e.g. passive design negating the need for cooling or ventilation; inherent finishes avoiding the need for paint, etc.)
Reclaimed, remanufactured components	• Use reclaimed materials over new • Use remanufactured components over new
Product selection	• Use products with labels such as Cradle to Cradle (C2C) and Natureplus • Select products that can be remanufactured or reused at end of first life • Use materials with recycled content • Select products that are designed for disassembly • Select materials that can be reused at end of first life • Select materials that can be recycled or composted at end of life • Consider leasing short-lived components

Procurement strategy

Applying these principles requires complete transparency and visibility throughout the supply chain. This requires early engagement with the contractor and partnering within the supply chain.

Case study – Clarion's circular economy strategy

For Clarion the successful implementation of the circular economy strategy requires a systems-thinking approach which considers the social, financial, natural, built environment and human frameworks in which businesses operate. Clarion's circular economy strategy is built around three principles:

1. Building in layers – the concept of designing adaptable and flexible buildings by considering the intended lifespan of each independent building layer, optimising building longevity and maximising material reclamation at end-of-life
2. Social value – a critical element for client and local stakeholder-led initiatives which intends to reduce waste, strengthen community networks, create a sense of ownership for residents and promote a sharing economy
3. The waste hierarchy – a set of philosophies for managing waste, ordered by environmental preference. It supports activities which eliminates and reduces waste prior to considering conventional waste management opportunities such as recycling.

Based on an initial assessment of the 2,800-home Merton Regeneration Project, currently underway in South West London, the scale of benefits that may be realised through comprehensive implementation of Clarion's circular economy strategy are significant.

For the demolition and construction phase alone benefits could include:

- £5,000,000 cost savings in waste disposal and materials purchase
- 16,500 fewer HGV movements
- 7,760 tonnes CO_2 e saving, equivalent to the annual operation of approximately 2000 homes
- 122,000 tonnes of virgin material use avoided.

However, for Clarion the real value of the circular economy approach is achieved not during the construction period but the decades of operation, maintenance and adaptation that follow. Clarion recognises that for those benefits to be realised, circular economy principles need to be embedded in every aspect of its regeneration activity from day one – with circular economy as DNA.

Lifetime strategy and tactics

Table 2. *Sets out examples of the lifetimes of different elements and 'layers' of the building and the different strategies and tactics that can be applied.*

		Short life components		Long life components	
	Lifespan	0-5 years	5-10 years	20-30 years	30-300 years
	Example components	Internal finishes, furniture	Internal partitions, ceilings, floors, local services	Building services	Sub-structure, structure, floors, fabric
	Overall strategy	Match material to lifespan, design for disassembly and return to manufacturer	Design for reconfiguration, use modular systems	Design for maintenance, replaceability, remanufacture	Long life, loose fit Adaptable to different uses Temporary buildings designed to be relocatable
Principles and examples of application	Designing in layers	Ensure finishes allow access to services	Non-structural partitions	Services to be accessible and replaceable	Avoid interdependency of structural frame and facade
	Lean design	Inherent finishes	Exposed soffits Modular tea points	Design out systems	Lightweight structures
	Design out waste and use of reclaimed materials/ components	Remanufactured furniture; remanufactured paint	Reclaimed glass partitions	Modular systems, offsite manufacture to reduce site waste Challenge supply chain to provide remanufactured equipment	Offsite manufacture Standardised components Select grids that optimise material efficiency
	Partnership models and return to manufacturer	Lease components or arrange for return to manufacturer	Design interiors that can be reconfigured or disassembled	Leasing service arrangements for items such as lifts and lighting	Select elements that can be reused or returned to manufacturer
	Materials selection	Use biological materials that can be composted at end of life or certified products (e.g. C2C / Natureplus)	Use partitions made from bio -composites Use certified products (e.g. C2C / Natureplus)	Use plant and equipment that can be remanufactured Fabric ductwork	Structural elements with recycled content Certified facade systems
	Design for disassembly	Use furniture and fittings designed for disassembly	Dry-lay floor tiles Relocatable partitions	Equipment and distribution systems that are modular	Structure and facade that is designed with reversible mechanical fixings

4 Specifying circular economy principles in the project brief

This section provides details to assist those construction clients wishing to specify circular principles in the project brief. It considers a range of circular economy aspects and their benefits and gives suggestions of what to ask for in the brief. It also features consideration of potential commercial challenges and suggested responses. Each section is accompanied by examples of how the principles discussed have been applied on real projects.

This structure has been illustrated below

Circular principles addressed in guidance

A. Reuse (including refurbish and repurpose)
   i. Reuse the existing asset
   ii. Recover materials and products on site or from another site
   iii. Share materials or products for onward reuse

B. Design buildings for optimisation
   i. Design for longevity
   ii. Design for flexibility
   iii. Design for adaptability
   iv. Design for assembly, disassembly and recoverability

C. Standardisation or modularisation

D. Servitisation and leasing

E. Design and construct responsibly
   i. Use low impact new materials
   ii. Use recycled content or secondary material
   iii. Design out waste
   iv. Reduce construction impacts

Support from guidance

- Aim
- Benefits
- How to ask for it in the project brief
- Actions and strategies
- Perceived challenges and solutions
- Examples of projects that took this approach
- Reference and useful information

A Reuse (including refurbish and repurpose):

i Reuse the existing asset

Aim

Reusing an entire asset, or reusing a significant proportion of the existing asset, to accommodate similar or different needs and/or uses (e.g. from industrial use to mixed use) whilst exceeding current regulations and standards through restoration or significant changes.

Benefits

- Reduce embodied carbon impact
- Minimise demolition waste and new resource depletion
- Reduce disruption to local neighbourhood from construction works, e.g. noise and dust, leading to better community relationships
- Reduce construction traffic impacts
- Cost and programme savings, depending on the scope of refurbishment
- Phased refurbishment could allow parts of the asset to remain in operation
- Potential to lead to an easier planning route
- Heritage of iconic features
- Achieve BREEAM credits

How to ask for it in the project brief

- Ensure a presumption in favour of retaining most, if not all, of the asset (structure, facade, building services, fixtures and fittings) based on whole life cost modelling
- Aim for a percentage reduction in embodied carbon against the total for a notional reference building, deemed to be typical of that building class, see the RICS Embodied Carbon database. Otherwise, where possible, set a whole life carbon target for an assumed design life based on comparison with benchmark data, see the RICS professional statement Whole life carbon assessment for the built environment.

Actions and strategies

- Build in sufficient time and budget to undertake the initial surveys and feasibility studies, these might include:
  - Asbestos refurbishment/demolition survey
  - Condition survey and feasibility studies to understand existing asset in terms of:
    - Remaining lifespan of the existing asset and components
    - Upgrades required to comply with current legislation
    - Interventions required to ensure the asset is fit for purpose in the long term
    - Floor to ceiling heights, terrace space, floor plates with good natural daylight
  - Existing user surveys (occupants, facilities management) to understand users' perceptions of what works/doesn't work from the existing asset.
- Design team appraisal of the asset's latent or potential qualities; discourage conservatism and support radical thinking on interventions that could unlock an asset's value.
- Gather as much information as possible about the existing asset and work that has been undertaken over its lifespan; carry out a new measured survey if no 'as-built' information is available
- Appoint a team with experience, willingness and vision to embrace reuse of existing the asset.

Perceived challenges	Solutions
Compliance with current building regulations and legislation.	Appoint technical specialists to undertake a feasibility study
Limited or unknown information on the technical performance of the current asset, e.g. loading capacity of the structural frame, energy performance of the facade.	Consultant technical specialists alongside the architect at the outset to identify required surveys so that sufficient time and budget can be allocated, these may include: • Structural engineer • Building services engineer • Acoustician • Fire engineer • Inclusive design consultant • Sustainability & energy consultant • Cost consultant
The asset is approaching obsolescence	Explore options to extend end of life as part of the feasibility study. If extending is not feasible, consider replacement scenarios, the impact on maintenance programme and whole life costing.
The appearance is outdated / clients prefer new / not an appropriate look for the new use of building / looks physically degraded.	Consider the following options to adjust the asset's aesthetic: • Overclad • Strip back • Juxtapose with contemporary elements • Adapt or conceal offensive elements • Repair or replace elements that are not fit for purpose • Make a virtue of heritage features
Architects have a different aesthetic in mind.	Make 'willingness to embrace reuse aesthetic' and demonstrable 'good judgement' criteria in the selection of architects; include in the brief from the start of the project.
Heritage restricts opportunities for reuse.	Consult with Historic England/Wales/Scotland/Ireland to discuss how to repurpose the asset in an effective manner. These organisations are known to be interested in working towards a circular economy.
Planning constraints.	Design team should carry out an appraisal of the asset's latent or potential qualities; discourage conservatism and support radical thinking on interventions that could unlock an asset's value.
Whole life carbon and wider impacts.	Use the BREEAM Refurbishment scheme to help drive the design process
Adds time and cost to project,	Appoint a team with experience, willingness and vision to embrace reuse of the existing asset.

Examples of projects that took this approach

- The Bartlett School of Architecture was refurbished to provide 3000m^2 of additional floor area.
- Derwent London's Angel Building in Islington London was overclad and fully let within 13 months.
- The Senator building in London is being refurbished by Legal & General to high sustainability standards.
- Argent's Kings Cross Development includes over 20 reused and refurbished buildings.
- LWARBs office was fitted out in just four weeks, using circular principles. The result is a smart, medium spec, modern working environment delivered for the same price as a traditional cat B, low spec fit out.
- UKGBC office refit reused or repurposed 98% of original fixtures and fittings.
- The University of Cambridge's David Attenborough building had poor energy and comfort performance, but also a significant volume of embodied carbon locked into the compact 16,000m^2 of valuable real estate. The University challenged the design team to retain the building and it is estimated that over 82% of the building's embodied carbon has been saved through the refurbishment works.

For more information see Appendix 5: Further reading

A Reuse (including refurbish and repurpose):

ii Recover materials and products on site or from another site for reuse

Aim

Incorporating reuse elements and materials that have been recovered from the existing site, or from another site, into the new development.

Benefits

- Save on the cost of procuring new materials
- Contribute towards reuse and recycling targets
- Deliver carbon savings

How to ask for it in the project brief

- Where an existing asset is on site, carry out a resource optimisation audit/pre-demolition audit to understand the pool of resources available for reuse, reuse with modification, repurpose, refurb or recycling. See diagram in Appendix 2 for how this process could work.
- Where the asset cannot be reused, a percentage of materials (by value and quantity) should be recovered and reused on site or reused elements should be incorporated from offsite locations.
- All elements from the deconstruction phase that cannot be reused on site should be sent to organisations for onward reuse.

Actions and strategies

- The pre-development audit should be undertaken by an independent party, ideally in compliance with relevant codes of practice.
- To drive innovation and circular principles products should be specified using performance criteria, rather than by brand or specification. For example, tensile and yield for steel and lux levels for lighting.
- Throughout this process ensure carbon impacts aren't compromised.

Perceived challenges	Solutions
Regulations don't allow for reuse.	In many cases they do, the Construction Product Regulation is intended to meet seven declared tenets. The seventh tenet is "the sustainable use of natural resources" and so sustainability is intended to be fundamental in construction. See Appendix 3: Opportunities for reuse for an outline of how this can be overcome in relation to steel.
It is overly complicated to design in reuse elements.	Ensure that architects/engineers and contractors are all bought in to the concept and therefore take a flexible approach to non-standard solutions. Having a specific representative who is responsible for ensuring reuse is applied will help challenge the traditional approach.
Organisations are unwilling to take on the liability for passing elements on for reuse.	Sampling and testing should be possible and when it is not, specify reused materials so their performance risk is shared. See section 4. Aiii Reuse.
No space for storage.	A demolition contractor should be engaged early in the process to enable products to be reused. This will enable value to be extracted and shared between the client and the demolition contractor.
Heritage considerations.	Consult with Historic England, Scotland, Wales, Ireland who are engaged and interested in circular approaches.
The system may be fragile and require specific skill sets to deconstruct.	Liaise with onsite contractors to ensure this is carried out correctly. Contractors could, when tendering, agree to waiver any additional fees for taking out items more carefully if the item has a high resale value.
Contamination.	Look at opportunities for refurbishment or further opportunities for reuse in an alternative setting.
Lack of data about material elements.	Look to design team for suggestions or down cycle if structural integrity is unclear.

Examples of projects that took this approach

- As the population grows people are increasingly moving from rural to urban locations leading to an increase in empty homes. Resource Rows will become Denmark's first residential area built out of materials from abandoned homes making a 70% carbon saving.
- As part of a lighting upgrade at Cheshire Police Headquarters, BAM explored an opportunity with Whitecroft Lighting to reuse many of the existing light fittings and create a more efficient and easier to maintain system.
- Instead of new steel, the NTS warehouse building reused steel and made significant cost and carbon savings.
- SEGRO relocated a warehouse building to Cambridge Avenue making a 25% cost saving compared to a new build and a 6% lower whole life carbon footprint compared with a new build.
- The reuse of existing piles on a project at 6 Bevis Marks, London has allowed a 16 story structure to replace an old eight story building, doubling the lettable space. In addition, cost, programme and CO_2 savings have also been achieved. A steel framed structure with precast slabs was demolished and replaced with a 16 story steel structure incorporating a composite deck. This lighter form of construction allowed the reuse of the existing foundations and achieved the net lettable areas the client wanted.
- Hackney City Farm School was due to close as it had unisex bathrooms (not legal anymore in schools) and it had no funds to build separate ones. Crossrail donated bathroom ceramics and construction materials via Globechain. These were used to create male and female bathrooms in the school, which enabled it to continue to operate. 1000 kilos were diverted from landfill and reused.
- Skanska sought to reuse the piling from 5 Broadgate, in order to make significant cost and carbon savings.
- BRE have several pre-demolition audit case studies.
- Virgin Management acheived significant cost savings by utilising existing materials, including: glazing, doors, partition layouts and flooring. A cost saving greater than £10,000 was made by procuring furniture in this environmentally friendly way.

For more information see Appendix 5: Further reading.

A Reuse (including refurbish and repurpose):

iii Share materials or products for onward reuse

Aim

Where materials and products cannot be reused on site they will be sent for onward reuse via a broker or back to the material supplier for refurbishing, repurposing or recycling as a last resort.

Benefits

- Reduce landfill costs.
- Contribute towards reduced waste and diversion from landfill target.
- Provide carbon savings.
- Increase social value of development.

How to ask for it in the project brief

- Where an existing asset is on site, carry out a resource optimisation audit/pre-demolition audit to determine the pool of resources available for reuse, reuse with modification, repurpose, refurb or recycle.
- All elements from the deconstruction phase that cannot be reused on site should be sent to organisations for onward reuse.

Actions and strategies

- A demolition contractor should be engaged early in the process to enable products to be reused (this will enable value to be extracted and shared between client and the demolition contractor). This can include ensuring high quality segregation of materials, such as demolition aggregate, to enable higher grade reuse.

Perceived challenges	Solutions
Lack of commitment to take on organisational liability for passing elements on for reuse.	Establish liability contracts prior to goods being available for transfer.
Difficulties finding someone to take the products and materials on.	If selling goods on for reuse they must be accurately described. Efforts to maintain traceability and provenance will be key for confidence later.
Potential for products and services to be destroyed during deconstruction phase.	Ensure cost benefits are shared between all parties.
Adds time and cost to project.	Appoint a team and supply chain with the experience, willingness and vision to embrace opportunities for onward reuse of existing materials and products.

Examples of projects that took this approach

- Verde SW1 achieved significant cost and embodied carbon savings through glass recycling.
- The Conduit was a complex project as it consisted of seven floors from a converted hotel, some tenanted some empty. Globechain worked with the client and ISG to scope out what items could be reused i.e. fire doors, glass paneling, carpet, marble. 100% of these items were rescued and the client obtained a high sustainability score.
- The ambition of the Super Circular Estate, in the Netherlands, is to reuse the materials of two vacant high-rise apartments for the construction of around 130 new homes and the development of new public space.

Brokers or product suppliers taking products for onward reuse, refurbishment, repurposing or recycling:

- Globechain provides a broker service for unwanted resources that can be reused by other projects.
- Cl:aire service for reuse of land.
- Rype office refresh existing furniture and provide full office refits which produce aesthetically pleasing, healthy, socially responsible, environmentally sustainable solutions at half of the cost of traditional alternatives.
- Premier Workplace Services deliver sustainable reuse solutions for large scale building clearances that are fully aligned to waste prevention and reuse.
- WarpIT helps distribute, reuse and recycle surplus redundant resources such as furniture, equipment, fixtures and fittings.
- Desso, Interface, Shaw Contract and Tarkett are all flooring suppliers that operate a take back scheme for recycling.
- Hason work with demolition contractors and the supply chain to ensure higher quality secondary aggregate is produced, which enables high grade re-use (e.g. in concrete).
- Saint-Gobain offer a take back scheme for recycling plasterboard and glass cullet.
- The National Community Wood Recycling project is a nationwide network of wood recycling social enterprises.

B Design buildings for optimisation:
i Design for longevity

Aim

To create a built asset with well defined long term needs, while being durable, resilient or able to cope with societal and environmental change. It will require little modification/no replacement of parts, due to its 'loose fit', generous proportions and readiness for alternative technologies.

Benefits

- Long term operational cost and whole life carbon savings, due to the reduced need of repairing and replacing damaged elements from operational wear and tear, as well as avoidable weathering and changes to climatic conditions over time.
- Contributes towards sustainability benchmarking schemes.

How to ask for it in the project brief

- Ensure the long term durability of building elements and services and effective recoverability during maintenance, refurbishment and disassembly.
- Ensure that the built asset allows for changing climatic conditions. For example, to protect materials from degradation due to environmental conditions, adopt passive design strategies to provide resilience, size systems to cope with future climate scenarios
- Design a robust frame to enable changes in building use, for example design loads.

Actions and strategies

- Maximise the durability and service life of building elements and services in relation to their replacement cycle.
- Plan for an appropriate and simple maintenance strategy from the design stage, including using condition-based monitoring for equipment
- Select materials from manufacturers offering take-back schemes and leasing

Perceived challenges	Solutions
Longevity could increase the capital expenditure, as it may require further consultancy cost during the design phase to evaluate different options, higher material quantity to ensure future adaptability, and a more limited selection of durable and resilient products.	Depending on the client's motivation and commercial model, the cost model could be amended to ensure opportunities to make long term cost savings which would benefit the tenant are included. Engaging the managing agent to inform tenants of these benefits and conveying these during marketing could increase desirability of the building.
Forecasting what future fashions and trends may be is difficult.	Look at population trends and speak with the local authority to understand future projections.
Requires a change in culture away from traditional design to adopt adaptability and flexibility approaches.	Appoint a team and supply chain with the experience, willingness and vision to embrace opportunities for new approaches to assets.

Examples of projects that took this approach

- Fetter Lane, New Street Square, London increased basement areas to ensure structural longevity and also to provide additional development and building services space.
- Ash Court, Girton College, Cambridge used a concrete frame and masonry construction to meet high thermal performance standards, achieving excellent airtightness, longevity and passive cooling, as well as providing resilience to climate change impacts and the challenges of student occupation.

B Design buildings for optimisation:
ii Design for flexibility

Aim

To balance the needs of the present with how those needs will change in the future and to enable change through frequent reconfiguring including reconfiguration of non-structural parts – configurations are likely to be pre-agreed with planning and building control and not involve 'wet trades' or any waste.

Benefits

- Long term operational cost and whole life carbon savings, due to the reduced need to refurbish.
- Marketing opportunity with future tenants by highlighting flexibility of space.

How to ask for it in the project brief

- Ensure the built asset allows for flexibility to cope with a diversity of scenarios, e.g. flexible space planning.
- Develop a 'meanwhile' strategy for more efficient use of the built asset in operation to ensure full utilisation of the space.

Actions and strategies

Perceived challenges	Solutions
Flexibility could increase the capital expenditure, as it may require additional consultancy cost during the design phase to evaluate different options and higher material quantity to ensure flexibility.	Engage designers early in the process.
Forecasting future requirements might be a challenge if it is a speculatively developed asset.	Provide opportunities to enable separating / subdivision of spaces, location of cores to facilitate multiple layouts, design of servicing for ease of upgrading/reorienting M&E.

Examples of projects that took this approach

- Sky Central has been designed to promote flexibility, openness and ease of access. The project delivered the client's aspirations for a super-fast, super-flexible building through the use of prefabrication and simple yet robust detailing and design.
- ThoughtWorks found an agile and multi-functional space which accommodated their flexible staff movements as teams are rotated on a project-by-project basis.
- DIRTT provides several case studies of projects that have designed with flexibility and adaptability in mind.

B Design buildings for optimisation:
iii Design for adaptability

Aim

To meet the needs of the present, but with consideration of how those needs might change in the future, and to enable change in the form of periodic remodelling. This should include alterations or replacement of non-structural parts, whilst modifications are likely to involve planning, building control and 'wet trades'.

Benefits

- More likely to be granted planning permission due to consideration of future adaptability of the built asset.
- Provides a potential marketing opportunity for future tenants as it enables the space to adapt to their anticipated needs.
- Retains the asset value.
- Long term cost and carbon savings.

How to ask for it in the project brief

- Ensure that the built asset allows for adaptability to cope with a diversity of future scenarios. For example, flexible space planning, location of cores, and generous floor to ceiling heights.
- Develop a 'meanwhile' strategy for more efficient use of the built asset in operation to ensure full utilisation of the space.

Perceived challenges	Solutions
Adaptability could increase the capital expenditure, as it may require further consultancy cost during the design phase to evaluate different options and higher material quantity to ensure flexibility.	Engage designers early in the process and employ a team that is open to new ideas and approaches.
It may be difficult to define future flexibility in speculative developments.	This can be designed into the core to allow for future layout flexibility and fitting out.
It may be difficult to change the culture away from traditional design towards adopting flexibility.	Engage designers early in the process and employ a team that is open to new ideas and approaches.

Examples of projects that took this approach

- London 2012 venues are an example of adaptability, where they were designed for a single use but allowed for the building to be adaptable for future alternative uses.
- The Granary Square, London development brief required capacity to adapt to future social and economic behaviour.
- As part of the EU funded BAMB project, Green Transformable Building Lab (GTBL) has been developed around a reversible multifunctional steel frame which was filled by independent, exchangeable, standardised and reversible floor, facade and roof components. To date, a single module has been built with the newly developed components: universal steel profile, standardised reversible wooden cassette, glass heated facade. The GTBL is intended to be up scaled in the future.
- Another BAMB pilot project, BRIC (Build Reversible in Conception) is a sustainable, scalable and reversible construction developed by the interdisciplinary Brussels training centre (EFP), during three consecutive academic years, starting in Autumn 2017. BRIC is being assembled and disassembled on a yearly basis, with each transformation accompanied by a change in function: from an office in 2018 to a shop in 2019 and eventually an acoustic laboratory in 2020. The first building tested the capacity of a wooden construction to integrate reclaimed materials, applying reversible solutions that minimise the waste during transformations.

B Design buildings for optimisation:
iv Design for assembly, disassembly and recoverability

Aim

Products and services are designed to be assembled, deconstructed and reused or recycled on a part-by-part basis.

Benefits

- Future proof the asset and make it flexible for future tenants' needs, increasing length of occupancy.
- The tenant can remain in place while the works happen, causing less disruption and eliminating void periods.
- Demonstrate to planners that future alternative use has been considered, which could enable quicker planning permission. For example, where office buildings are no longer required, but perhaps more housing or care homes are needed for an ageing population, this can be managed without demolishing parts of buildings.

How to ask for it in the project brief

- Ensure that the asset has been designed to allow for easy assembly and reconfiguration for alternative future uses for example, design of interior systems for disassembly.
- The material and product manufacturer should outline the future life of the product and how it can be reused or repurposed.
- Ensure that the materials have the option to be taken apart through mechanical and reversable fixings to allow for future reuse. Avoid permanent fixing of products, such as by glue and cement mortar, to enable end of life deconstruction and salvage of building elements. Ensure fixings are easy to access to enable disassembly.
- Ensure layer independence: the design of building systems and components in layers so that the removal, adjustment or replacement of some elements is feasible, especially when different components have different life spans and maintenance needs.
- Ensure unnecessary toxic treatments and finishes are avoided. Some finishes can contaminate the substrate in a way that they are no longer reusable or recyclable. This should be avoided unless finishes serve a specific purpose.
- Ensure all materials with a planned short life span have an agreement with the manufacturer to take back or that they are procured through a service agreement.

Actions and strategies

- Engage with the design team to address the end of life strategy for the material. The future of disassembled materials could be planned through a contractual agreement.
- Make information available via a material passport and apply Building Information Modelling (BIM) to understand future life.
- Put in place a risk and reward contract with the demolition contractor.
- Use BIM to create a materials library or knowledge bank of what materials and products have been used in the asset.
- A materials inventory should be created for the entire building that includes a detailed breakdown of all the building elements that sets out the constituents of each product and material, the structural loadings, and the ability for each material to be reused/recycled, etc.

Perceived challenges	Solutions
The cost is prohibitively more expensive than traditional construction techniques.	As this requirement is increasingly being asked for by clients, the number of suppliers will increase and costs will decrease. In the long term the additional costs will be recouped.
The need to change the culture away from traditional design to adopt design for disassembly.	Engage designers early in the process and employ a team that is open to new ideas and approaches.
Difficult to know that the project will be carefully dis-assembled at the end of life.	Build this information into BIM, which will make the disassembly and retrieving of materials more likely.

Examples of projects that took this approach

- Circle House is Denmark's first circular housing project, and it aims to achieve 90% of the project's materials to be reused without loss of value due to being designed for disassembly.
- Place Ladywell in Lewishman, London is an innovative temporary housing and community space that opened in 2016. The buildings exceed space standards by 10% and can be deconstructed and relocated.
- The Arup Circular Building uses Lindapter clamps which provides a bolt system to clip the wall and roof together.
- Venlo City Hall was designed to address a number of circular principles including designing for disassembly, a material bank and material health. The client asked material suppliers for guaranteed take-back systems at the end of the building's life and that materials keep their residual value. The client made an agreement of 18% residual value for the furniture which was a total saving of €300,000.
- District Court of Amsterdam was designed with a short lifespan and so that it could be easily de-mounted and re-mounted at another site, retaining much of the residual value from materials and products.
- Derwent London's 25 Saville Row incorporated design for disassembly at the end of life. The project targeted and achieved a Gold SKA rating. High use of natural recyclable and re-usable materials were included in the new material specifications.

C. Standardisation or modularisation

Aim

Designing and constructing buildings that apply standardised elements or modular designs for materials and products that enable a reduction in construction waste and easier reuse in next life.

Benefits

- Enable easier future recovery, incorporation in new designs, and reuse.
- Results in less waste in manufacture and construction – standardised elements mean raw materials can be ordered 'to size' and in bulk with minimal excess.
- Enable less material being used, especially with structural elements for high-rise construction and precision in factory manufacturing.
- Higher and more consistent quality, more reliable performance through repeat production.
- Easier quantifying of repeat standardised elements and better representation in BIM models; future re-use is simplified through Radio Frequency Identification (RFID) tagging.

How to ask for it in the project brief

- Elements should use standardised design formats to enable future reuse.
- Work towards <5% 'special' components across standardised and/or modular designs.
- Require disassembly as a feature of modular construction.

Perceived challenges	Solutions
Perception of reduced architectural interest.	Frame the architectural challenge positively as an architectural challenge to achieve interesting, adaptable, user-friendly buildings from modular designs. Danish architects 3XN/GXN, known for their bespoke architecture, did a study that highlighted that around 70-80% of the 'bespoke' buildings they designed could have been standardised while still appearing as bespoke.
Matching standardisation with a variety of end uses.	Organise collaboration with design consultants and manufacturers to address the challenges, including demountability.

Examples of projects that took this approach

- Laing O'Rourke Explore Industrial Park highlights how steel use in pre-cast columns on two major London residential schemes was reduced by almost 40%. This was through precision in steel placement, a result of factory-produced laser-profiled steel templates. Use of 'reduced partial material factors' in complying with Eurocodes was key.
- Legal & General Modular Homes have invested in Europe's largest modular homes factory, which produces a range of typologies and the capacity to produce up to 3,000 homes per year, employing several hundred local people.
- Danish architects, 3XNGXN have set up Circle House, a demonstration project and Denmark's first circular housing project.
- The WWF-UK Living Planet Centre design pays particular attention to the standardisation of elements and maximised environmental performance in its efficient two storey in-situ reinforced concrete frame. The repetitive nature of the roof structure facilitated the offsite manufacture of a 'kit of parts', thereby reducing the onsite assembly time and material wastage.
- The Sky Central project saw 600m^2 of roofing panels erected per day, complete with waterproof membrane and pre-installed insulation.

D. Servitisation and leasing

Aim

Establish and promote a payment structure through which customers have unlimited access to resources but only pay for what is actually used, or for the result linked to their use. This represents a transition from selling products to selling services.

Benefits

- Requires less time and budget in maintenance and management of services – guaranteed service is delivered by a specialist organisation.
- Enable greater opportunities for future reuse and recycling of parts.
- Reduce initial investment required for the renovation and construction of high-performance building envelopes. This could, in turn, increase the rate and depth of technical improvement on both new buildings and building energy renovations and technical retrofits.
- Accelerate market uptake of new building technologies through Facade Leasing; optimised reuse and recycling of components and materials within the construction industry as technologies are retained by their manufacturers.
- Deliver reallocation of risk from building owner to the equipment / component supplier.
- Deliver realignment of business drivers as the supplier is best placed and incentivised to deliver an efficient and lean system. Leasing incentivises the supply chain to:
  - Optimise proactive maintenance.
  - Maximise equipment economic life.
  - Avoid unplanned downtime and minimise fines for non-compliance with the performance specification.
  - Monitor and record service life data to assist in maintenance and to recover maximum value at end of life, realizing the value of reuse, remanufacture and recycling parts and/or whole systems.
  - Minimise waste through supplier incentives to feed material back into the (re)manufacturing process. This leads to materials/products being designed for (re)manufacturing and upgrades and improvements of components and systems.

How to ask for it in the project brief

- Explore opportunities for leasing services within the asset – e.g. for ventilation, heating, cooling, lighting, lifts, and facades.

Actions and strategies

- Engage with manufacturers early to identify opportunities for leasing services within the asset.

Perceived challenges	Solutions
Industry is not set up to allow for this due to the emphasis on capital expenditure, with operational budgets separate from development budgets.	Establish budgets to enable capital and operational budgets to be reviewed concurrently.
Too much risk as the supplier may go out of business during the contract.	With a market created for suppliers, they are less likely to go out of business. Create a legal agreement and contract clauses that protect the client from this scenario.
Risk of early engagement and 'lock-in' to specific manufacturers.	Ensure transparent accounting and pricing, supported by appropriate legal frameworks.
Leasing model is relatively immature which poses additional risk.	See case studies below and follow up with construction clients who have implemented servitisation/leasing for feedback.

Examples of projects that took this approach

- Contracts with Delft University for a leased facade meant the client hired energy performance and user comfort services.
- ABN AMRO have set up a partnership with Mitsubishi to lease the lift service to outlast standard lifts. When a lift eventually needs to be replaced, Mitsubishi recycles or reuses the materials, meaning more than 95% of the lift's parts are repurposed.
- At the Kings Cross NUS site, an agreement was set up with Philips Lighting to offer light as a service, which provided predicted costs over 15 years and carbon savings. This was also established at Schiphol Airport

E Design and construct responsibly:
i Use low impact new materials

Aim

Any new materials specified in the development are low impact materials with little or no adverse effect on either the environment or on human health throughout its lifecycle.

Benefits

- Contributes towards sustainability benchmarking schemes.
- Enables carbon reductions.
- Lead to improved health and wellbeing for building users through material ingredient transparency and optimisation – benefiting a range of building types and users, including commercial office space, health care, education or residential.

How to ask for it in the project brief

- Ensure where new materials are being specified they should have little or no adverse effect on either the environment or on human health throughout its lifecycle.
- Chemicals on the Cradle to Cradle Red list will be eliminated.

Actions and strategies

- While some materials will be healthy, they may not be considered the lowest carbon option as they may have been imported or manufactured via a carbon intensive process. Clear, defined targets should be set early in any project, so all parties are aware of whether health and wellbeing is the strategic aim, or whether alternative options are to be considered, if resources or carbon savings are the preferred targets.
- Ensure that material specification is clear, particularly with regards to the use of low-impact materials. Both designers and contractors should include the necessary performance data when researching materials, including, for example, the specification of Environmental Product Declarations (EPDs). This should not preclude the opportunity to use innovative materials where an EPD is not available. Product specific Type III EPDs are preferable, as they are third party verified and use data from a life-cycle assessment (LCA). They are also defined by product category ruling (PCR) meaning that all Type III EPDs for a product are comparable.
- Specify biological and compostable materials where this is viable.
- Obtain an inventory of all ingredients used within each product. The level of reporting provided by a manufacturer could perhaps be to 100ppm (preferably) or 1000ppm but requesting any level of transparency from the manufacturer would be helpful. Some example labels for material transparency include:
  - Health Product Declaration (HPD)
  - Declare Label
  - Cradle to Cradle Material Health Certification
- The above addresses product inventories, but this information won't necessarily lead to a healthier building. In addition to transparency, consideration could be given to optimisation strategies, such as the elimination of REACH SVHC chemicals, and the avoidance of LT-1s / BM1s.
- Establish a system or plan to monitor what is being delivered to site and ensure that it aligns with the specification. This could be computerised or a simple delivery check protocol.
- Set measurable targets for the project, i.e. specification and installation of at least 10 low-impact materials. This could be a scalable target dependent upon the scope and scale of the project.
- Avoid toxic materials.
- Request a Life Cycle Assessment (LCA) on the building's design with the aim to improve the overall environmental impact (look at 2-4 design for superstructure, substructure and core services, as required by BREEAM).

Perceived challenges	Solutions
There is a potential cost uplift associated with some materials. Therefore, projects may not set budgets to allow for this, with emphasis on capital expenditure. There are also potential programme implications due to lead times needing consideration.	Liaise with material manufacturers early in the programme to understand availability and opportunities for low impact materials that don't add to cost and programme. See case studies for examples.
Risk and liability associated with materials. There are often various specification requirements that materials must meet, such as fire rating requirements.	Liaise with material manufacturers early in the programme to understand any risk and liability issues.
Impact on aesthetics and function, as the specification of certain natural and healthy materials may not fit with the look and feel of a space.	There are many examples of low impact materials that deliver against aesthetics and function.
Reduced product choices could skew the market in favour of larger manufacturers. Often manufacturers incur significant costs to obtain Environmental Product Declarations or material transparency labelling, meaning smaller manufacturers are sometimes unable to implement them.	Liaise with material manufacturers early in the programme and understand availability. The industry is changing with small improvements in these areas, particularly where requirements are being asked for on a project.
Through the provision of a material inventory, manufacturers could be at risk of exposing proprietary information and data to the wider industry. This often discourages some manufacturers from providing this level of detail, limiting availability of product-level information.	Liaise with material manufacturers early in the programme and understand availability of data.
Some product suppliers show further progress than others regarding sustainability and material reporting. There may be some products for which there are no alternatives.	There are various groups that share latest product innovations that are low impact. See examples of projects.
The budget set up may be limited, for example with emphasis on capital expenditure. Performance may not be equivalent to traditional materials; therefore it will increase maintenance costs.	Set budgets to enable concurrent capital expenditure and operational expenditure review.

Examples of projects that took this approach

- The University of East Anglia Enterprise Centre been constructed using a number of healthy and low impact materials within the budget and programme timescales. Another version of the case study can be found here.
- The London Waste and Recycling Board fitted out their new office space using healthy and low impact materials at no extra cost.
- The Biological House in Denmark example of a house built with biological materials which are all available commercially and thoroughly tested and approved.
- ASBP's Natural Fibre Insulation Group provides a list of renewable materials for natural insulation as well as a number of case studies and product suppliers.

E Design and construct responsibly:
ii Use recycled content or secondary material

Aim

To recognise and encourage the use of recycled content and secondary aggregates, thereby reducing the demand for virgin material and optimising material efficiency in construction.

Benefits

- Avoid the use of virgin materials and enable the use of waste byproducts.
- Reduce embodied carbon.
- Contribute towards sustainability benchmarking schemes.

How to ask for it in the project brief

If suitable recycled material is available in the local area, then a high proportion of recycled content and secondary material should be specified. As a minimum:

- Engineered fill (up to 100% recycled content).
- Concrete (up to 10% recycled aggregate content, and/or 10% cement replacement with Ground Granulated Blast-furnace Slag (GGBS). The latter figure can be increased to above 40% for all mixes providing longer curing time can be accommodated in the construction process).
- Blockwork and concrete paving (at least 50% recycled content).
- Insulation (at least 50% recycled content).
- Plasterboard (at least 95% recycled content).
- Carpet tiles (at least 50% recycled content).
- Asphalt roads (Highways England currently permit up to 50% recycled content in base and binder courses. While surface course mixes are permitted to add 10% recycled content). See Specification for Highway Works.

Actions and strategies

Carry out research to determine the best approach to recycled content and secondary materials based on the location of the site.

Perceived challenges	Solutions
Curing time is longer for higher percentage content.	Ensure good construction planning and engagement with suppliers.
Risks and liability associated with high levels of recycled aggregate content, particularly in structural concrete.	Effective collaboration between demolition contractors and supply chain can ensure higher quality.
Recycled aggregate can incur cost increases.	Identify appropriate local sources of recycled aggregate early.
Aesthetic issues as concrete with high cement replacement is whiter than normal concrete.	Early engagement with architects and client to accept this.
Limited availability of suitable recycled or reuseable material.	Identify appropriate and local sources of recycled aggregate early in the process.
Meeting the required standards can be difficult.	Early collaboration between designers and engineers.

Examples of projects that took this approach

- The Enterprise Centre used Regen concrete which had a high recycled content and provided a 62% embodied carbon saving.
- ORTUS a learning and events centre developed for the mental health organisation Maudsley Charity at the Maudsley Hospital in Denmark Hill, used concrete with a recycled content and significantly reduced embodied carbon.
- Huckletree office space was designed to be flexible, and use low impact materials and recycled content. This was achieved on a low budget and tenanted within 2 months.
- Built in 1997, BRE's Environmental Building incorporated 100% recycled aggregates and GGBS in all in situ concrete, alongside 80,000 reclaimed bricks and reclaimed flooring.

E Design and construct responsibly:
iii Design out waste

Aim

To design out waste over the whole life cycle of the building, so there is minimal waste during the design, construction, deconstruction and next life of the built asset.

Whilst designing out waste is key, it should be noted that when designing for future adaptability and flexibility, it could require over specifying the structure to support additional loadings in the future.

Benefits

- Reduce waste arising from the project and associated landfill costs.
- Reduce embodied carbon resulting in cost and carbon savings.
- Enable BREEAM and other certification credits to be achieved.
- Reduce the number of finishes, which may result in greater flexibility in use.
- A disassembly and recycling guide for the asset could result in an additional potential source of future revenue for the client.
- Deliver reputational benefits, especially associated with academic / university buildings.
- Achieve faster construction times and reduced snagging / quality assurance issues, particularly if this is achieved through offsite construction.

How to ask for it in the project brief

- Optimise opportunities to design out waste, and to maximise reuse during demolition, remediation, construction and future life of the building components.

Actions and strategies

Refer to key questions that should be asked, as set out within the WRAP Designing out Waste: a design team guide for buildings. These include:

- Design for reuse and recovery.
- Design for deconstruction and flexibility.
- Design for off-site construction.
- Design for materials optimisation.
- Design for waste efficient procurement.

Perceived challenges	Solutions
Requires very early involvement from the correct design team members, which will add cost.	Speak to experts within the value chain and get them involved as early as possible in the design process.
Material reuse / salvaging may impact lead in times and aesthetic.	Get your manufacturer to review the design to enable efficiency of product and reduce waste.
Requires additional time in the programme to build in design reviews. Potential additional cost to have an expert in place to review designs.	This could be off-set by material cost savings. See London 2012 project example below.
Requires good communication between the design team and those delivering the building on site.	Ensure the main contractor is onboard with the designing out waste principles.
Requires an informed design team.	Choose an architect and contractors who are willing to work with the opportunities to design out waste.
May be difficult to encourage team members / designers / contractors etc to incorporate a strategy which will see its main benefits in the future.	Engage a design team that is bought into the concept.
Architect will want finishes which may necessitate waste e.g. visual lines in the ceiling which require tiles to be cut.	Get the manufacturer to review or undertake the design of the finish to enable efficiency of product and reduce waste.

Examples of projects that took this approach

- London 2012 – Resource efficient Use of Mixed Waste demonstrates the process that was put in place using Design Reviews to ensure waste is designed out. A number of iterations of designs were made to ensure material optimisation. See here for more information on design optimisation of venues.
- The Velodrome generated savings of approximately 1,000 tonnes of steel worth £4m and saved 3,000 tonnes of embodied CO_2 through revisiting the design.
- WWF Living Planet Centre reduced embodied carbon emissions by 42% through redesign and reducing materials.
- On the Heysham to M6 bypass in Lancashire, Tarmac and Costain were able to offer an alternative road design and by working closely throughout the project they cut aggregate demand by 200,000 tonnes (23%), concrete by 9,000 m^3 (26%) and generated zero mineral waste.
- Brighouse and Sowerby Bridge leisure centres made a 0.5% reduction in total project costs and a saving of £56,175 through designing out waste.

E Design and construct responsibly:
iv Reduce construction impacts

Aim

Ensure construction sites reduce on-site waste, including packaging.

Benefits

- Deliver cost savings on logistics and waste management.
- Ensure safer working environment for those on site.
- Contribute toward reuse and recycling targets.
- Contribute towards sustainability benchmark schemes.
- Reduce costs and time through avoidable waste.

How to ask for it in the project brief

- Ensure all products delivered to site use packaging that is taken back by the supplier for reuse or recycling.
- Ensure onsite waste management is set up to enable reuse, with recycling as a final option.

Actions and strategies

See Appendix 5 for how to engage with designers, sub contractors, waste management and material suppliers

Perceived challenges	Solutions
Space for segregation, particularly in city contexts.	Specify materials with manufacturers that provide a take back service during disassembly.
Time constraints in removing items from site.	Materials can be placed with a broker and taken from site.
No proper network of sites for reuse.	There now exists a number of brokers who enable reuse. See Section 4 Eiii.
Finding a logistics contractor that has capacity and resource for the project.	Incentivise contractors to allocate resource to the project.
Changing the traditional mind-set of waste management on construction sites.	Set targets on waste reuse as opposed to recycling.
Perception that it is cheaper to dispose of packaging that return it.	Specify materials with manufacturers that provide a take back service during disassembly.
Waste management companies have material recycling facilities and therefore don't often encourage separation of packaging for reuse.	Make the requirement for reuse clear in the contract.
Reverse logistics can be difficult to manage.	Employ organisations who have experience in this area.
Stored packaging may be seen as a fire risk.	Specify in the contract that packaging should not pose a fire risk and should be taken back upon delivery.
Waste management contractors and logistics contractors will not engage with the topic.	They are willing, particularly if they are brought in at an early enough stage to put a resource strategy in place.

Examples of projects that took this approach

- The Considerate Constructors Scheme have a number of case studies exploring package reduction on site.
- ISG have been trialling the use of a returnable plastic crates, developed in collaboration with metal ceiling tile manufacturer, SAS, to transport a variety of tiles on a project in London. This switch removed the need for 4,200 wooden crates with plastic sheet wrapping.

5 Next steps for UKGBC and its members

Following a clear mandate from our members that UKGBC should be driving the practical application of circular economy principles in new and existing built assets, it is hoped that this guidance will provide the encouragement and guidance that is needed.

Transitioning to a circular economy represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits. At a built environment level, this requires a fundamental shift away from the current procurement and business models that are in place. It considers the optimal solutions for each development as part of a whole society system. This requires policy changes, organisational partnerships and business models that aren't typically in place and need to be evolved.

We appreciate systemic change can't happen overnight, but gradually over time we can collectively shift design and construction approaches to enable more advances in circular economy buildings. This change will be facilitated through construction clients learning from the examples in this report, testing new ways of applying these reliable approaches, and sharing the knowledge that they develop.

We will engage and work with construction clients to ensure circular principles are integrated into their project briefs, and that the buildings that result are sustainable to build, good to occupy, commercially successful, efficient to maintain, simple to deconstruct and have long lives beyond their initial use.

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Appendices

Appendix 1: How circular economy links to other sustainability topics

Net zero carbon

Circular principles will be important to achieving a net zero carbon economy by helping to minimise the energy associated with extraction, processing and management of materials. However, during the transition to a net zero economy conflicts will occur, and it is worth highlighting the complexities of how the application of circular principles can impact on actual carbon savings. For example, specifying resource efficient measures such as recycled content or reuse of materials, to avoid the use of virgin materials could require additional transportation of materials. This of course generates carbon and will affect the Scope 3 carbon emissions associated with the development as well as affecting construction site impacts such as local air quality.

UKGBC is taking forward an Advancing Net Zero programme with an aim of transitioning the built environment to net zero carbon. This work includes examining the role of embodied and whole life carbon in creating net zero carbon buildings and developing guidance on Scope 3 emissions reporting for commercial clients. The two programmes are inherently aligned and highlight opportunities for carbon savings and resource efficiency. A life cycle assessment will help calculate the wider impact and solutions will always depend on the geographical location.

The RICS Whole Life Carbon Assessment for the Built Environment provides guidance around measuring carbon associated with the projected lifetime of a project.

Zero Waste Scotland carried out a study to understand the carbon associated with a circular economy and the potential for savings.

Life cycle assessment

Life cycle assessment (LCA) is a tool to measure how effective different design strategies are at improving wider environmental (or cost) performance. It is then used to prioritise which strategies will provide the best value. If a building can be adapted for a new purpose it is less likely to be demolished in the future. If a building lasts twice as long because it is adaptable, then it is effectively halving its embodied carbon impacts.

LCA can support these decisions but the functional unit and life expectancy must be appropriate, i.e. $kgCO_2e/m^2$GFA over 60 years is industry standard but not realistic. Some buildings may last 20 years, some 120 therefore impacts should be measured in terms of $kgCO_2e/m^2$/year.

Social value

Within a circular economy there are huge opportunities to increase the social value of a built asset. Circular economy can be achieved more successfully where people are put at the heart of the built asset development from the early stages. Opportunities include making better use of assets for community uses out of hours, promoting a sharing economy for materials and products and generating community led designs. Whilst this has social benefits it also enables a greater residual value of investment and future proofs the design. Tenants are more likely to stay in the asset if consideration was given to potential future needs and if it is adaptable to those needs.

Appendix 2: Making the business case for the demand and supply side

DEMAND SIDE

The basic commodity of the demand side of the built environment is space. Increasing resource productivity on the demand side can mean delivering more societal value by utilising space more effectively, see new models for shared living such as The Collective. https://www.thecollective.com/

There are four strategies that can be adopted to add value and reduce waste in buildings:

1. Flexible occupation: smart asset utilisation.
2. Resource productivity: highest impact resource inflows and outflows.
3. Market adaptation: change in the value of the built asset over time.
4. Minimising downtime: the true cost of demolition and refurbishment.

Flexible occupation

The average European office building is unused or unoccupied 35-40 percent of the time, during office hours.[19] By making smarter use of an asset or portfolio of assets, the demand for building new, purpose-built assets diminishes and adds to the revenue-raising capability of existing assets.

Resource productivity

Resource flow analysis provides an overview of how reliant a business is on resource flows, covering materials (and waste), energy and water. Adding a layer of cost and carbon analysis helps prioritise where to apply circular economy principles first. Once the highest cost, highest impact flows with the greatest lost value have been identified, procurement of those flows should be re-examined using circular business models to consider whether the flow can be designed out or replaced with a greater value alternative for the lowest cost and environmental impact.

Market adaptation

Adapting to market conditions is complex but addressing this is key to achieving a circular economy, with the aim of keeping materials at their highest value for as long as possible. This requires consideration of design, construction, planning, accounting and tax. The value of the building will differ from the land value, and the value of both will primarily be determined by location. The use of the building is significant along with potential future uses for a building along with changing tastes. Accounting rules determine how buildings appear on balance sheets, planning rules influence the value of the land and tax changes can also have a significant impact.

Minimising downtime

Through following circular economy principles, all buildings will be deconstructed, not demolished, however, the business case for designing for deconstruction is limited. This, in part, is because of the unrealistically long design lives that are designed for, as discussed in this guidance document. However, if considering the costs and lost value of refurbishment or deconstruction – the loss of revenue in the time taken to demolish and reconstruct a building is recouped through increased rents or area in the new building. If refurbishing assets was easier and quicker, buildings might be restored to market value without the time and cost of demolition and refurbishment. Designing for adaptability and flexibility ensures buildings can survive changing markets, making refurbishment cheaper and quicker, protecting the value of the materials within them.

SUPPLY-SIDE

Where there are increasing demands for circular principles within clients' briefs, the supply chain needs to be in a position to respond. The added value or cost reductions achievable from the above strategies will be maximised if the supply chain is agile, collaborative and has already explored what circular economy principles mean to their business models.

There are four strategies that the supply chain can adopt to create a more flexible, high-value built environment with less waste:

- **Value proposition**: Product-as-a-service.
- **Addressing risk and opportunity**: resource prices and climate change.
- **Digital transformation**: digital technology enabling change within the business.
- **Managing innovation**: creating change.

The value proposition

A circular economy approach aims to decouple business growth from resource consumption and moves away from the concept of selling products with no further ownership responsibility. Forward thinking businesses within the supply chain are moving towards supplying services that offer value to their customers, independent of the physical resource. And this is the first step towards realising circular and societal value for successful and future proofed businesses. For example, the Phillips / Signify pay-per-lux scheme is a good example of this and DIRTT have strong partnerships with installers for its de constructible partition system.

Addressing risk and opportunity

In an increasingly volatile political environment for international trade, material prices have started to increase rather than reduce. And combined with climate change risks comes increased taxes and increasing resource price volatility. Supply chain organisations need to understand these risks and take measures to mitigate for them; for example, implementing take-back schemes like Armstrong Ceilings; redesigning the product to maximise recyclability, like DSM-Niaga have done with carpet tiles, or upskilling to be able to work in multiple materials, as B&K Structures has done.

Digital transformation

The rapid development of digital technology, from artificial intelligence and machine learning to automation and internet of things, is changing the possible equation for utilising existing resources, building client relationships and managing and tracking resource flows. For example, integrating 7D Building Information Modelling (BIM) for the asset management phases and material passports for the suppliers visibility of what has happened to its product during use are changing what is possible at current investment levels and offers the opportunity for businesses to break free from the risk, volatility and rigidity of the linear system.

Managing innovation

Change needs to happen before projects begin. Given the size of the circular economy opportunity enabled by digital technology, securing investment to fund development projects that bring circular products and service offerings to market is possible. The supply chain needs to work closely with the client sector to create opportunities in commercial-scale projects.

Appendix 3: Opportunities for reuse

This information relates to Section 4 Aii

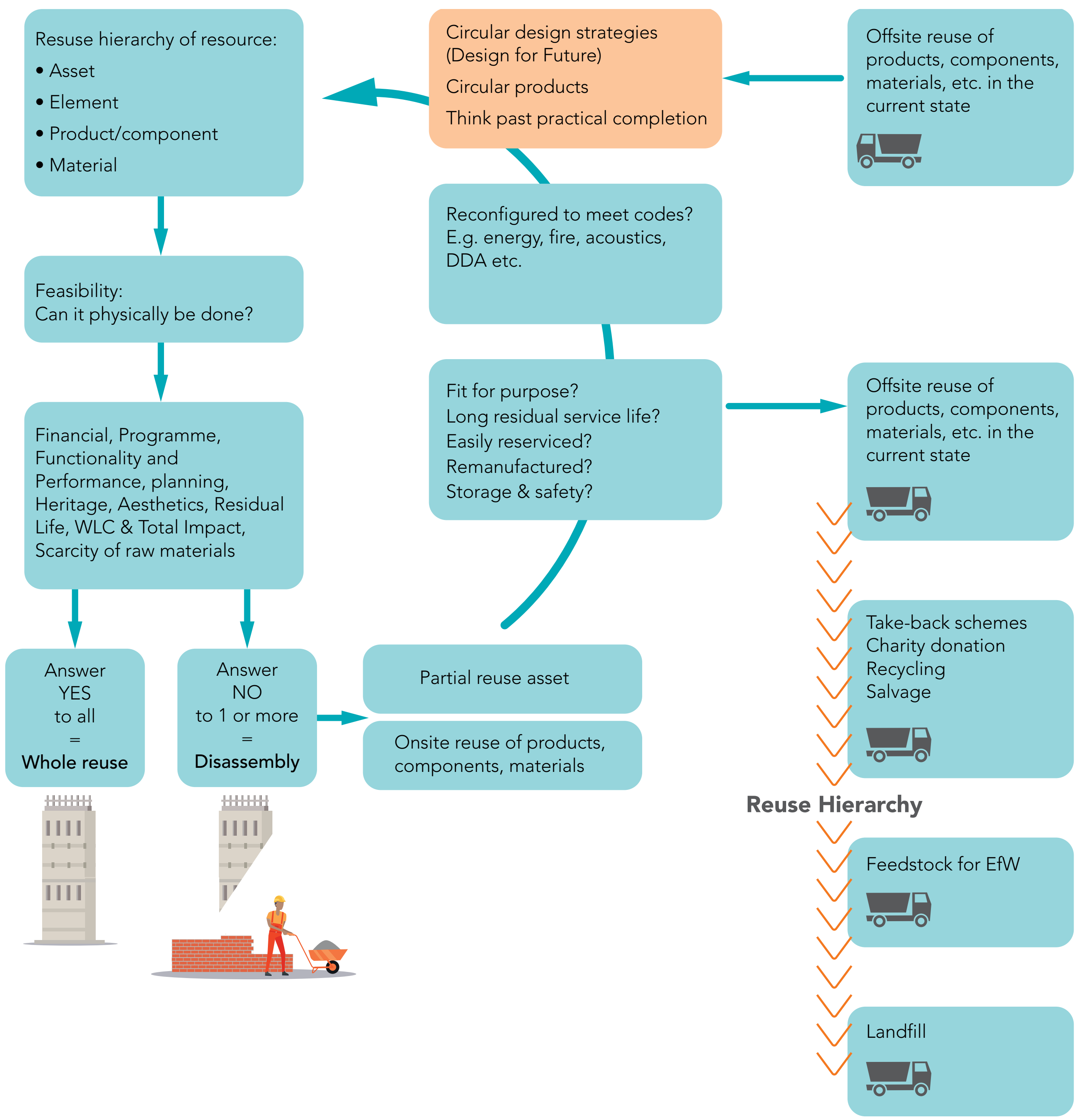

Figure 4. *A decision tree for the prioritisation of material reuse from construction*

Appendix 4: Reusing aggregate, concrete, asphalt and steel

Reusing products does present some technical challenges to a risk adverse construction industry. Ultimately, compliance with Building Control is necessary, who, in turn, reference the Construction Product Regulations and Eurocodes which are driven by a whole array of product standards.

Be aware of what you are asking for as it is not advisable to ask for a blanket statement of recycled content. The amount requested depends on your location and availability of local sources of recycled or secondary material. The life cycle approach to decisions should also be considered. I.e. recycled steel content could mean shipping in from abroad which impacts on carbon emissions, but locally sourced steel could, in some cases, mean sourcing virgin materials. Your best option in the case of least impact would be to reuse material.

Aggregate and concrete

Similarly, specifying the use of recycled aggregate may involve importing aggregates a significant distance and this combined with the processes involved in sorting aggregate of the correct quality may make it a more carbon intensive solution than using virgin aggregate, particularly if quality is a key concern, as it would be if the aggregate is going into concrete. Often if recycled aggregate is used in concrete then the cement content has to be increased, as cement is the most carbon intensive element in concrete this again will increase the embedded carbon.

There is often an opportunity when specifying concrete to replace some of the cement with alternative cementitious materials. These mainly comprise PFA (residue from coal burnt in power stations) and GGBS (ground granulated blastfurnace slag), a byproduct of iron manufacture. Both materials utilise what could otherwise be a waste and also have a significantly lower embodied carbon content than cement. GGBS can replace 50% or more of the cementitious materials depending on the use of the concrete. Although the use of GGBS makes the curing time slightly longer, this can have the benefit of reducing thermal cracking. The resultant concrete is actually stronger after 60 days, is more resistant to chemical attack (eg from sulphates) and also has a lighter colour which on occasions is more desirable architecturally.

Asphalt

In asphalt it is often possible to use RAP (recycled asphalt planings) as a significant proportion of the aggregate input. As well as avoiding the use of virgin aggregate this also utilises the bitumen on the reused stone. Use of such material is dependent on its availability, the type of processing plant and the performance requirements of the road surfacing.

Steel

For steel structures, the issue of CE marking came into force in 2012/14 for constituent products and then for structures. These are encapsulated within the EN1090 series of standards. EN1090- 1 has just been revised and EN1090-2 was recently revised. These regulations and standards don't make real allowance for re-use, however Building Control are much more sympathetic to the use of alternative products and focuses solely on fitness for purpose, the following overview provides commentary around the various clauses that support reuse and overcomes the challenge that reused steel cannot easily be specified:

Under the **Building Regulations 2010** the following clauses support reuse:

- Clause 1.7 – 'if the declared performance of a product is suitable for its intended use, the building control body should not prohibit or impede the use of the product'.
- Clause 1.14 – allows other international standards to be used to demonstrate fitness for purpose.
- Clause 1.15 – allows for independent certification to certify compliance with the requirements of a 'recognised document' ie harmonised standard.
- Clause 1.17 – allows for tests and calculations to prove 'fitness' of non-harmonised products

The **Eurocodes** also have room for manoeuvre, but less so than Building Control.

Eurocode 3-1 design of steel structures – This allows for products made to alternative standards to the modern standards to be used.
Eurocode 3-5- Piling section 3.1 (3)
P – This allows for re-used and second quality piles to be used if geometrically and materially acceptable and free from 'deleterious' damage/matters.

New EN1090-1/2 Standard
Since 2014 all steel structures placed on the market have to be CE marked. It is largely misunderstood in the market place that all constituent products also have to be CE marked, they do not. Any constituent product manufactured before 2012 does not need to be CE marked. Any constituent product not *placed on the market* or manufactured to a harmonised standard does not need to be CE marked. The latest revision of EN1090-1 is being voted through EU. The latest revision of EN1090-2 was brought into force in 2017 (EN1090-2 – 2017)

EN1090-1 Standard
This standard excludes the following, so any of these can be constructed without execution classes or CE marks being applied:

- Non-fabricated piles
- Temporary structures
- Offshore structures

In which case, the following applies:

Clause 3.2 Component specifications – document or documents provided by manufacturer and/or purchaser giving all necessary information and technical requirements for manufacturing the structural component.

This requires the purchaser to specify the material the supplier is to offer if it is not to a harmonised standard. This may mean changing the specification slightly.

Clause 5.1: 'documents supplied with constituent products may include test reports, inspection certs or declaration of compliance as given in EN1090-2 – 12.2.1' (see below)

EN1090-2-2017
This new revision came out in 2017 and it is being broadly interpreted as meaning that only CE marked steel can be used and that it must have a 3.1 certificate, which is incorrect.

Clause 5.1: 'if constituent products that are not covered by the standards are to be used, their properties shall be specified. The relevant properties to be specified shall be taken from the following list:-'

This clearly allows for materials that are not on the harmonised list to be used. API pipe is not covered and nor are other International standards and grades of steel. If the steel has been manufactured to the harmonised standard then it must be CE marked and 3.1 certified. If it was manufactured or "placed on the market" as something else, then it need not be 3.1 nor CE marked

Clause 5.2: *'inspection documents according to EN10204 shall be as listed in table 1'*

This is the clause that throws up the problem as table 1 states that if the grade is >S275 then you require a 3.1 cert + CEV values stated. However, this details the quality of inspection document required for EN10210 and EN10219 materials, it does not dictate material must be used.

Clause 5.2: also states *'the properties of the constituent products shall be documented in a way that enables them to be compared to the specified properties checked in accordance with 12.2'*

This clearly indicates that alternative documentation is acceptable and refers to 12.2 to specify what documentation is required

Clause 5.3.1: *Structural steel products shall conform to the requirements of the relevant standards unless otherwise specified.*

This means that alternatives can be used if specified. The specifier can be the purchaser as previously stated in EN1090-1

Clause 12.2.1 Constituent products table 1 *'note 1 – these documents include inspection certificates, test reports, declaration of compliance as relevant'*

So, this now is reflected in EN1090-1 and EN1090-2 and very clearly lists inspection documents that are not 3.1 certs.

Clause 12.2.1 Table 1 *'note 2 – This documentation check is intended to obviate the need for testing products generally.'*

This clearly implies that 'testing products' could be equivalent to a document check but is considered more onerous. This clause nor any other in EN1090 suggests testing is not allowed.

All the above refers to constituent products. For steel work there are further considerations regarding use of whole components or use of whole buildings.

If components or buildings are not to be amended, but reused as is, then as long as they were "placed on the EU market" prior to 2012 then they do not require to be CE marked. If they were placed on the market after 2012 then they would already be CE marked and the existing mark can be used unless the structure is modified. If there are to be modifications, then there should be a CE mark.

Appendix 5: Further reading

Organisations:

- BRE
- Dutch Green Building Council
- The Ellen MacArthur Foundation
- The Green Construction Board

Reports and publications:

- AECOM: Building Revolutions: Applying the Circular Economy to the Built Environment. David Cheshire
- Arup and the Ellen MacArthur Foundation: First steps towards a circular built environment
- Arup: The Circular Economy in the Built Environment
- Construction Resources & Waste Platform: Overview of Demolition Waste in the UK
- Climate-KIC: Digitalisation – unlocking the potential of the circular economy

A Reuse (including refurbish and repurpose) i Reuse the existing asset:

- Energy Efficiency and Historic Buildings (Historic England, 2018)
- Appraisal of Existing Structures (IStructE, 2010)
- Reuse of Foundations for Urban Sites – A Best Practice Guide
- Reuse of Substructure Mindmap, IStructE
- HIST Guide to Building Services for Historic Buildings
- TM56: Resource Efficiency of Building Services
- Bell et al. (2014) Making Decisions on the Demolition or Refurbishment of Social Housing:
- Crawford et al. (2014) Demolition or Refurbishment of Social Housing? A review of the evidence:
- Power (2010) Housing and sustainability: demolition or refurbishment?

A Reuse (including refurbish and repurpose) ii Recover materials and products on site or from another site:

- Characterising existing buildings as material banks (E-BAMB) to enable component reuse
- Reusing crushed concrete and bricks, instead of gravel, in pipe beddings or inverted roofs can create a new habitat for invertebrates

B iv Designing for – assembly, disassembly and recoverability:

- Closed loop material cycle construction: Defining and assessing closed loop material cycle construction as a component of a comprehensive approach to sustainable material design in the context of sustainable building
- "ISO 20887 Sustainability in buildings and civil engineering works – Design for disassembly and adaptability – Principles, requirements and guidance" provides potential options and considerations for owners, architects, engineers, and product designers and manufacturers, and also for other parties who are responsible for financing, regulating, constructing, transforming, deconstructing or demolishing construction works. It is applicable to all types of buildings, civil engineering works and their constituent parts and provides guidance on measuring performance.

E i Designing and constructing responsibly – Low impact new materials:

- Environmental Product Declaration
- C2C Red List
- Living Building Challenge (LBC) – Material Petal
- Health Product Declaration (HPD)

E iv Detailed strategy for reducing construction impacts:

Consultant designers

Designers should be required to nominate a designer waste champion and a deputy who will:

- From as early in the design stage as possible, comment on a waste and resource minimisation ideas register circulated by main contractor. Ensure waste prevention and minimisation ideas are developed and design solutions are technically and commercially viable as far as reasonably practicable and submitted to main contractor for review.
- Specify materials with increased levels of recycled content where there is no impact on cost or performance.
- Work with the project team to ensure that design actions to reduce construction waste and increased reused/recycled content are implemented within their area of responsibility.

Subcontractors

Before starting on site, each subcontractor organisation should nominate a waste champion and a waste administrator (can be the same person) and their deputies which is recorded and minuted at a meeting before the subcontractor starts on site.

- The subcontractor waste champion should inform the main contractor of the actions that the Subcontractor proposes to take to reduce waste, increase recovery/recycling through workshops and the use of the resources register, as well as the corresponding roles and responsibilities, and quantifying the resulting changes as far as practicable.
- Where the subcontractor has responsibility for the removal of waste, the subcontractor must comply with the specific requirements for waste management companies.
- The subcontractor must be responsible for organising the take back of packaging waste with their suppliers, including pallets, where they can be re-used as a material as opposed to disposing as waste.
- Contractors are required to explore reusable packaging solutions with key product manufacturers at the earliest opportunity. Solutions may include:
  - Flat pallets: wood pallets have the greatest potential for cutting costs and emissions and reusable plastic pallets are better for waste reduction.
  - Box pallets: High quality plastic folding box pallets (reduces the need for disposable packaging).
  - Bulk bags: can replace palletised disposable paper/ plastic stacks (for repeat deliveries).
  - Steel stillages: specialist steel A-frame stillages (for carrying plate glass) can replace single trip pallets of non-standard sizes and associated protective disposable packaging. This could be extended to be used for other products such as dense cladding, heavy panels and frames.
  - Cable drums: returnable drums can replace smaller disposable cardboard and plastic reels.
  - Plastic crates: Small folding creates used in the retail sector are good for smaller distribution.

Waste management companies

If a direct subcontractor of the main contractor, the waste management companies should be required to nominate an individual as the project waste manager and a deputy who should:

- Review the ideas and proposals for waste minimisation and offer advice on waste management actions.
- Submit actual waste data to the main contractor for construction, demolition and excavation waste streams separately, measured in m^3. Report on the different quantities of waste generated, and the split of each waste stream according to the waste management method (reuse, recycling, recovery through a waste transfer station, landfill and other) and, in the case of reuse, whether this has taken place on- or off-site.
- Submit monthly actual waste recycling rates of the waste facilities used.
- Aim to maximise the reuse of demolition and excavation waste.
- Identify ways to increase the recovery rate of materials by finding end-destinations with high recovery rates.
- Submit all data and evidence within the project reporting deadlines.
- Use a systematic process to record and check waste, recovery and recycling data which is available for inspection on request.

Material suppliers

Each subcontractor should ensure that material suppliers are required to:

- Work with the main contractor and the subcontractors to minimise wastage of the products that they supply (for example, through logistics, taking back surplus materials, packaging and waste or by providing pre-assembled / pre-cut products).
- Advise on the level of recycled content of key construction materials that are to be supplied by the subcontractor, and offer to supply materials with a higher level of recycled content where technically and commercially viable.
- Identify and inform the subcontractor how packaging waste on site will be reduced.

Construction and demolition waste should be consistently measured, for example:

- Percentage reduction in weight of packaging waste (through supplier take-back or reuse schemes).
- Level of segregation of all plastic film and timber packaging for high value recycling or reuse.

Supply chains should be engaged with waste minimisation initiatives and targets in tenders and contracts.

A strategy should be put in place to minimise the space taken by stored materials. This strategy could include the following measures:

- The storage area should be carefully planned so that frequently used items are easy to access. This will increase efficiency and minimise wastage due to damage.
- The prolonged storage of materials on site should be avoided. The implementation of 'just in time' deliveries should be encouraged.
- Any surplus materials or offcuts should be considered for other sites.

Contributors

This guidance document is an output from the UKGBC Circular Economy programme, which began in April 2018. The Crown Estate is a Programme Partner and year one Programme Sponsors were Clarion Housing Group, Cleveland Steel, ISG, HS2, Telford Homes, and TFT.

The guidance has been produced through a combination of desktop research, meetings, a task group, a working group, industry consultation events and individual feedback.

We are grateful to the task group and working group members from the UKGBC membership for developing the guidance and its supporting content. Further assistance was provided by Knowledge Contributors whose time and experience have been essential to the success of this project.

We are delighted to have a number of Programme Supporters, who are trade associations, professional institutions and non profit organisations, that are collaborating with us to accelerate the move towards a circular built environment.

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RICS
Supply Chain Sustainability School

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