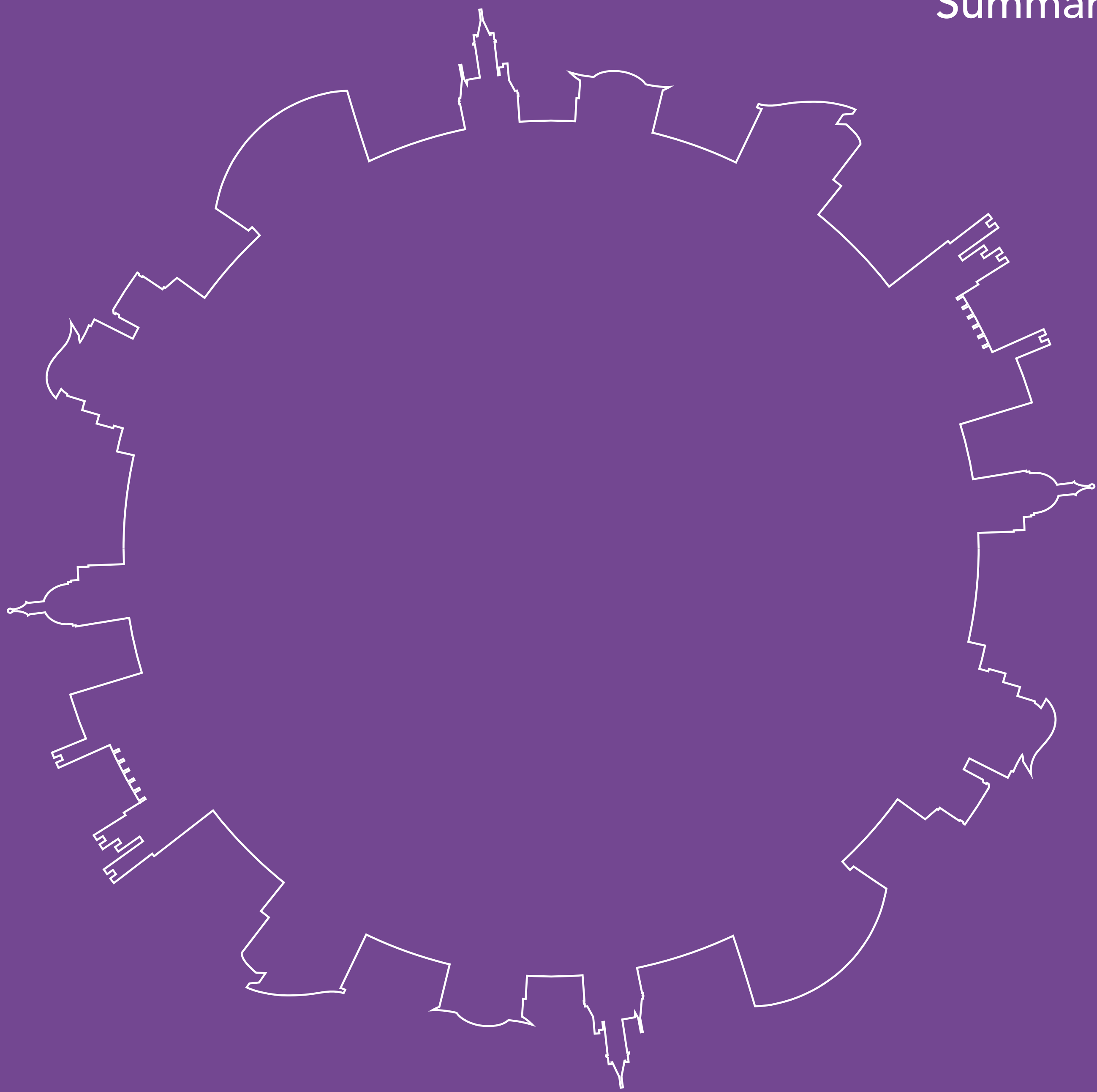
ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Closing the circle

Circular economy: Opportunity for the welsh built environment

Summary



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The full report is available here
http://www.cewales.org.uk/current-programme/circular-economy/

Foreword

When the Well-being of Future Generations Act was passed in 2015, the United Nations said that they hoped 'what Wales was doing today, the world would do tomorrow'[01]. The legislation is both internationally ground-breaking and game-changing, and the world's eyes are on us now to not only talk the talk of the Act but walk the walk. It is central for Welsh construction to play a role in the delivery of that walk.

After the UN's comment, the second, less quoted part of that speech is that 'actions more than words, is the hope for future generations', and that is where I see the challenge for the built environment; building today for the Wales we want tomorrow, and for future generations to come. It will be your actions, and the lead that you take throughout the construction sector, to embed the spirit of the Well-being of Future Generations Act, through the reduction in raw material consumption, waste production, of moving us towards a low-carbon, resilient society, of providing secure and well-paid jobs, and of building well-connected environments for everyone in Wales that improves our lives and enhances our well-being.

The Act defines sustainable development as 'improving the way we achieve our economic, social, environmental and cultural well-being'. I have been very clear that this is not just another piece of legislation – that this is the catalyst for culture change, throughout the public sector and for everything we do here in Wales.

We need to examine how the sector is performing and look to address activities that are not delivering across the seven well-being goals. The five ways of working offer a mechanism to begin to consider how changes can be made.

Using resources more efficiently in a loop, where they can be returned to use and their value retained will become an important economic consideration. Innovating in this manner to develop better ways of working that enable economic prosperity with positive impacts on the environmental and social well-being of Wales will be key to the successful delivery of the Act.

This sector has a key role to play in building environments that reflect the reality of the lives that people lead, and communities that enhance the lives and well-being of everyone here in Wales, today and for future generations.

Sophie Howe
Future Generations Commissioner for Wales

[01] Nikhil Seth, Director, Division for Sustainable Development, United Nations

Executive summary

The value creation opportunity from the circular economy has been clearly demonstrated. As the biggest consumer of raw materials (EEA, 2011), with eighty per cent of all materials produced used in the built environment, the scale of the opportunity for the sector and Wales is significant.

This report outlines a model demonstrating how circular economy principles may be applied to the built environment, the size of the economic opportunity, material priorities, challenges and recommendations to how the principles could be implemented across the sector to realise the benefit.

Our current linear "take-make-dispose" practices rely on large quantities of easily accessible materials, energy and landfill and it is reaching its physical limits. Notably in Wales the sector is the largest producer of controlled waste (EAW Survey, 2005).

The concept of a circular economy was inspired by the functioning of natural ecosystems where "nothing is lost and everything transformed". It is a development strategy that enables economic growth while optimising consumption and resources. The circular economy is one that is restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times. It aims to decouple economic development from resource consumption, whilst enabling key policy objectives such as generating economic growth, creating jobs, and reducing environmental impacts, including carbon emissions. Our model demonstrates how the principles of the circular economy can be applied to the sector to realise the potential benefits turning theory in practical application.

Our research has demonstrated a potential economic opportunity of an additional £1 billion per annum by 2035[2]. This is an increase of 12.5 per cent in the turnover of the Welsh built environment sector[3] and generating 7,300 jobs (gross). This figure is consistent with a growing body of research that identifies the economic opportunity and the importance of the sector in delivering. The built environment sector has a high environmental impact, retained financial value and potential for reuse[4].

The EU Exit provides an opportunity to move away from EU classifications of waste and develop national strategy to decouple waste generation from economic growth and accelerate a transition to a circular economy.

Focus is needed to develop the right conditions to enable Wales to make the most of the opportunity presented. Key to making the transition between linear and circular economies will be the ability of the sector to collaborate and innovate within its supply chain and across other industry sectors, working to design out waste at all construction stages, redefine waste as a resource and integrate circular economy principles into practice.

[2] Amec Foster Wheeler
[3] In 2015, 91,900 people employed in 46,220 enterprises with a turnover of £8 billion, Welsh Government
[4] LWARB, London: The Circular Economy Capital

1. Background

The Welsh Government has established sustainable development as its central organizing principle, the Well-being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016 provide a new sustainable development framework for Wales.

The development of policy therefore should contribute to the sustainable management of natural resources[5] (SMNR) (as provided by Part 1 of the Environment Act) which in turn contributes to the delivery of the seven well-being goals[6].

SMNR requires that any use (direct or indirect) of and actions on natural resources is undertaken in such a way that does not reduce the ability of ecosystems to continue to deliver the multiple services (supporting, regulating, provisional and cultural) they provide in the short, medium and long term.

Resource efficiency defined by the EU as 'using the Earth's limited resources in a sustainable manner while minimising impacts on the environment'[7] is therefore a key element of SMNR to reduce:

- the amount of natural resources used in the first instance;
- the impact of waste treatment processes on the health and functioning of ecosystems; and
- the impact of end-disposal on the health and functioning of ecosystems.

Construction is the biggest consumer of raw materials (EEA, 2011), with eighty per cent of all materials produced used in the built environment. Moving towards an economic model that delivers an efficient, resilient, innovative approach is in the best interests of the sector.

Established in 2002, Constructing Excellence in Wales (CEW) is the single organisation charged with driving change within construction. CEW is working to help the Welsh Government and the industry to make the changes necessary to move the industry towards a more circular approach making construction more efficient and effective, ensuring that the industry is able to deliver the best value built environment for Wales.

2. Aim

The aim of this report is to apply circular economy principles to the built environment sector moving theoretical concepts to demonstrable best practice.

As part of this approach, CEW has modelled what is required to achieve a "circular built environment" further highlighting the economic opportunity and the strategy necessary for the built environment in Wales to move away from a linear economy. In this new approach resources are not simply extracted, used and disposed of, but are put back in the loop so they can stay in use and retain value for longer. This work has been developed in accordance with the SMNR approach developed by Welsh Government.

In applying the circular economy to the sector and in accordance with the welsh context it is key that any methodology demonstrate:

- a "whole life approach";
- circular economy principles;
- value opportunities; and
- the inter-relationships between the built environment, other sectors and the natural environment

[5] Environment (Wales) Act 2016, s 3
[6] Well-being of Future Generations (Wales) Act 2015, s 4
[7] http://ec.europa.eu/environment/resource_efficiency/

3. The circular economy

The concept of a circular economy was inspired by the functioning of natural ecosystems where "nothing is lost, everything is transformed", the concept of circular economy has emerged in a context where it becomes increasingly more important for all economic actors to improve the management and efficiency of resources and to secure their long-term supply, by moving away from a linear supply chain, i.e. from a 'take-make-dispose' economic model[8].

3.1 Definition of circular economy[9]

Circular economy represents a development strategy that enables economic growth while optimising consumption of resources, deeply transforms production chains and consumption patterns, and redesigns industrial systems at the system level.

The circular economy aims to keep the value added in products for as long as possible and to cut residual waste close to zero. It could therefore be considered as a regenerative system, which retains the resources within the economy in contrast to the currently prevailing 'linear' model of extraction, manufacturing, consumption and disposal.

Moving to a circular economy requires changes in all parts of the value-chain, from consumer demand, through product design, new business models and new ways of turning waste into a resource. It implies a fully systemic change, affecting all stakeholders in the value chain.

Innovation, in all its forms – technological, organisational, and social – is one of the main drivers of the circular economy. A circular economy closes 'resource loops' in all economic activities in a sense that there is no 'end' within a circular economy, but a 'reconnection to the top of the chain and to various activity nodes in between'.

The circular economy is restorative, with materials designed to circulate at high quality with their economic value preserved or enhanced[10]. It is important to note that a circular economy goes beyond the pursuit of waste prevention and waste reduction to encourage technological, organisational and social innovation across and within value chains[11].

[8] EU Commission, Scoping study to identify economic actions, priority sectors, material flows and value chains, 2014, Annex I, p 11
[9] Ibid, Annex II, p 12
[10] Aldersgate Group, Resilience in the Round: Seizing the Growth Opportunities of a Circular Economy, 2012
[11] EU Commission, Scoping study to identify economic actions, priority sectors, material flows and value chains, 2014, p 3

4. Circular Economy model for the built environment

There are a number of challenges in applying the principles of circular economy (CE) to the built environment and translating this into a creating a CE model. A simple model representing the circular economy is presented at Figure 2.

Figure 2: Simplified illustration of the use of resources in circular economy[12]

Circular economy models in general have looked at production processes for a single product. Within the built environment, a project will comprise of numerous materials/products which make up the whole. Therefore, consideration needs to be given to examining the whole project as one and understanding how the numerous elements interact and co-exist with each other over time.

As such, the 'product' is the asset and various construction materials are the 'components'. When an asset is no longer required, it may be dismantled and its components (e.g. bricks, blocks, concrete) can be seen as a source of raw materials for re-use.

The ultimate aim is to preserve the value of these components through either direct re-use in another project or by 'up-cycling', retaining or even increasing their initial value. On construction and demolition sites this requires careful segregation of construction material components to avoid contamination, and identifying markets (e.g. contactors or component manufacturers) to re-use or up-cycle the components.

However, the construction is only one phase within a project as there are a number of inter-connected stages, these include concept, design, occupation and deconstruction/demolition. These phases are linear in process but circular due to the inter-relationships between decisions and actions at one stage impacting further along the process.

Assets are also used for a number of different purposes from commercial, public to private use. The use will impact upon its application for circular economy.

There are also a number of different disciplines and industrial sectors involved in the built environment, from extraction companies, to architects, designers, builders, manufacturers and reclamation/demolition companies.

In addition, the construction sector's role in a circular economy should include:

- Reuse of materials, components (reuse) or by-products, secondary materials and recycled products;
- To ensure that any primary use of components or products can subsequently enter the CE to be reused, recycled, remanufactured.

All of these factors make a single built environment model very complex, however the opportunities are vast and significant.

[12] European Commission COM(2014) 398

4.1 Why is a Circular Economy Model for the Built Environment required?

The following are some reasons as to why a CE model for the built environment is required:

- Resource and energy use;
- Rising commodity prices;
- Resource constraints (especially wood & timber);
- Stricter landfill requirements;
- Higher energy efficiency targets/standards for buildings; and
- Competing uses/priorities for materials.

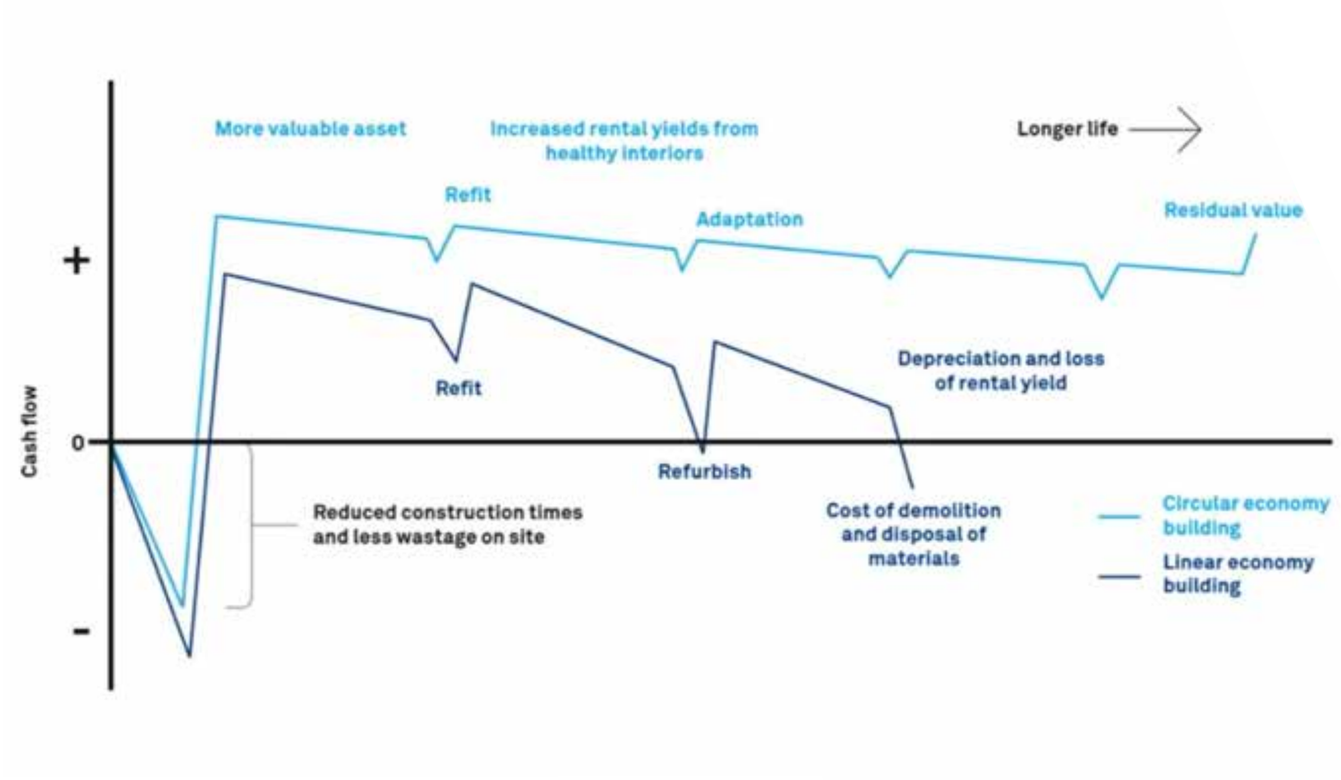
In developing a model it is important that it considers and delivers a SMNR approach working to achieve the goals of WFG and Environment Act. If the theory can be put into practice and a transition made the model offers a substantial mechanism for maximising the prosperity and resilience of Wales.

4.1.1 Identified benefits of circular economy approach

A circular approach has been demonstrated to offer multiple benefits, these include warding against increasing material prices, conserving embodied carbon and adding value to end of life.

David Cheshire, AECOM within Building Revolutions has prepared an illustrative comparison of circular economy buildings and conventional building. The graph is based on ideas from Coert Zachariassee and research from Loughborough University.

Figure 3: Benefits of circular economy buildings



Reproduced with permission from: Building Revolutions, David Cheshire, RIBA

AECOM

In adopting a more adaptable approach to building design, where disassembly and reuse are considered it is possible to achieve a positive residual value. The graph above compares a traditional approach to building, highlighting where circular economy building can reduce construction and refurbishment time and associated costs, maintaining the value of the asset whilst protecting the rental yield.

We recognize that in order to realise the benefits the sector will need to embrace a different approach to its delivery. It will be necessary to move towards a more collaborative approach to working across the supply chain in an earlier and more integrated manner than is currently commonplace.

4.2 Circular Economy Model & Construction Phases

We have an uncertain future, we take a finite number of resources, make something out of them and ultimately at the end of their life throw them away. The wasteful approach we have applied to natural resources in construction is not compatible with the well-being of future generations. In a circular economy resources are kept in use and their value retained.

The model demonstrates how the circular economy applies to the built environment. The model has been developed to reflect:

1. The key phases in a construction project and how they connect to one another. e.g. design links to:

a. Construction;
b.How the property will be used;
c. Demolition/Deconstruction; and
d. In reverse to the concept which can impact on what sort of design is required

2. Each phase is represented by its own circular hierarchy reflecting the key components within a circular economy approach, for example, for construction this shows:

a. Electing to use reused, recycled materials;
b. Using materials that can be disassembled (so linking to demolition/deconstruction);
c. Using non-hazardous materials, which enable disassembly and therefore further reuse or recycling;
d. Using materials (where primary materials) that can be reused, recycled or remanufactured

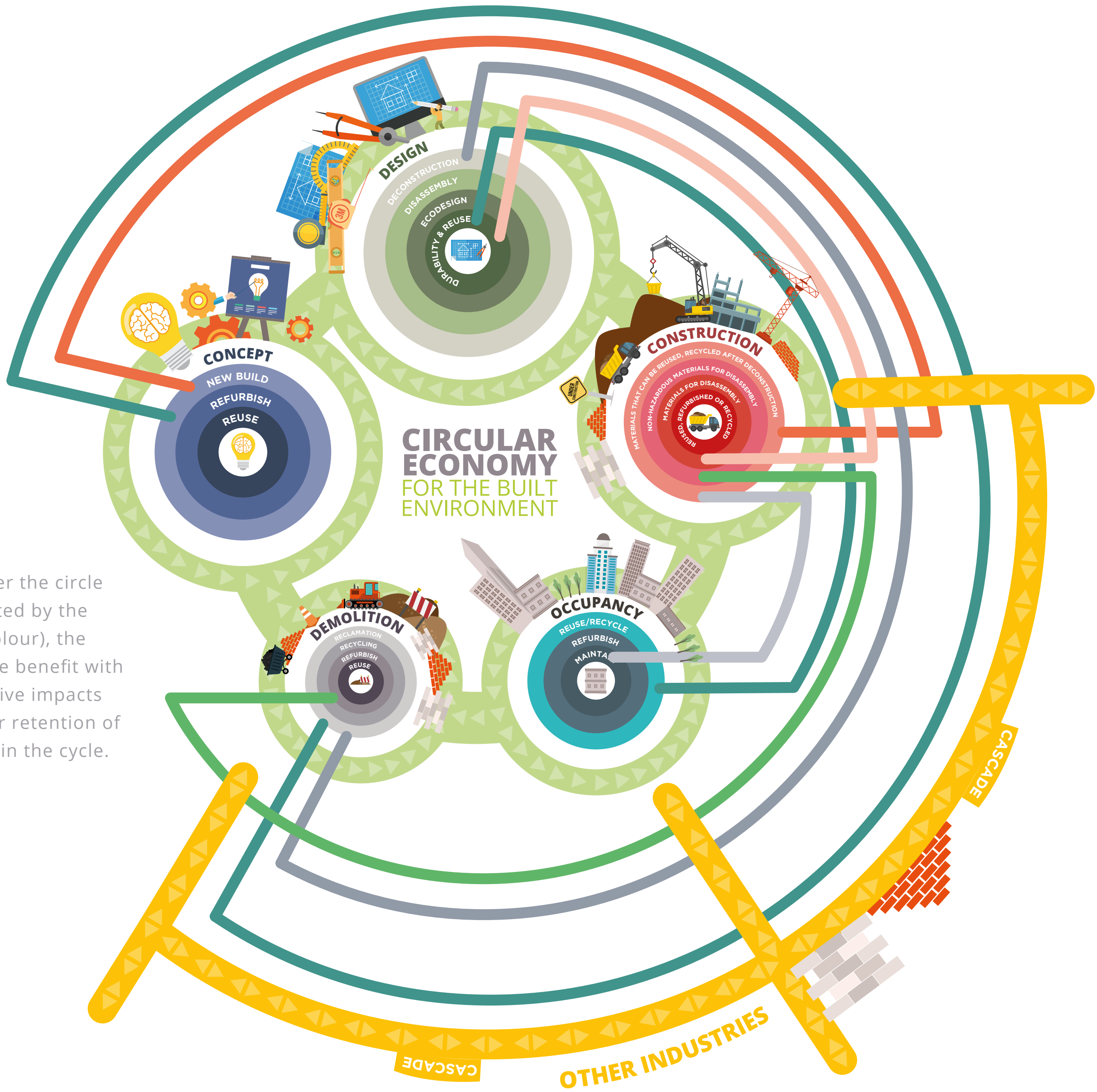
3. External connection to cascading, identifying opportunities for inter-linkages between other sectors/ resources/materials from other sectors, where:

a. Construction projects can use cascaded materials (e.g. aggregates); or
b. Can send materials into the cycle to be reused (e.g. wood, metal).

This ensures that products and materials are retained within the lifecycle of a building for as long as possible and that products and components are designed in such a way to ensure that they can be disassembled for reuse, recycling or remanufactured (if technical materials) or reclaimed (e.g. through extraction, anaerobic digestion) if biological material.

To achieve circularity no phase can work in isolation. The sustainable management of natural resources will require industry to capitalise upon opportunities offered by other sectors.

Circular economy model for built evironment by phase



The smaller the circle (represented by the darkest colour), the greater the benefit with less negative impacts and longer retention of value within the cycle.

4.3 Circular Economy Model by Project

This model guides the decision making process for a project example. A project can be any type and in any stage in the construction lifecycle for example housing, a school, hospital or road and at any stage of the lifecycle, for example during construction, demolition or design. Opportunities closest to the project provide the highest value least impact option where materials are retained for the same purpose within the same state.

The model helps to demonstrate how materials can be retained in circulatory and the resource recovery process. It reflects:

1. A value chain by focusing firstly on on-site reuse, refurbishment or recycling opportunities;

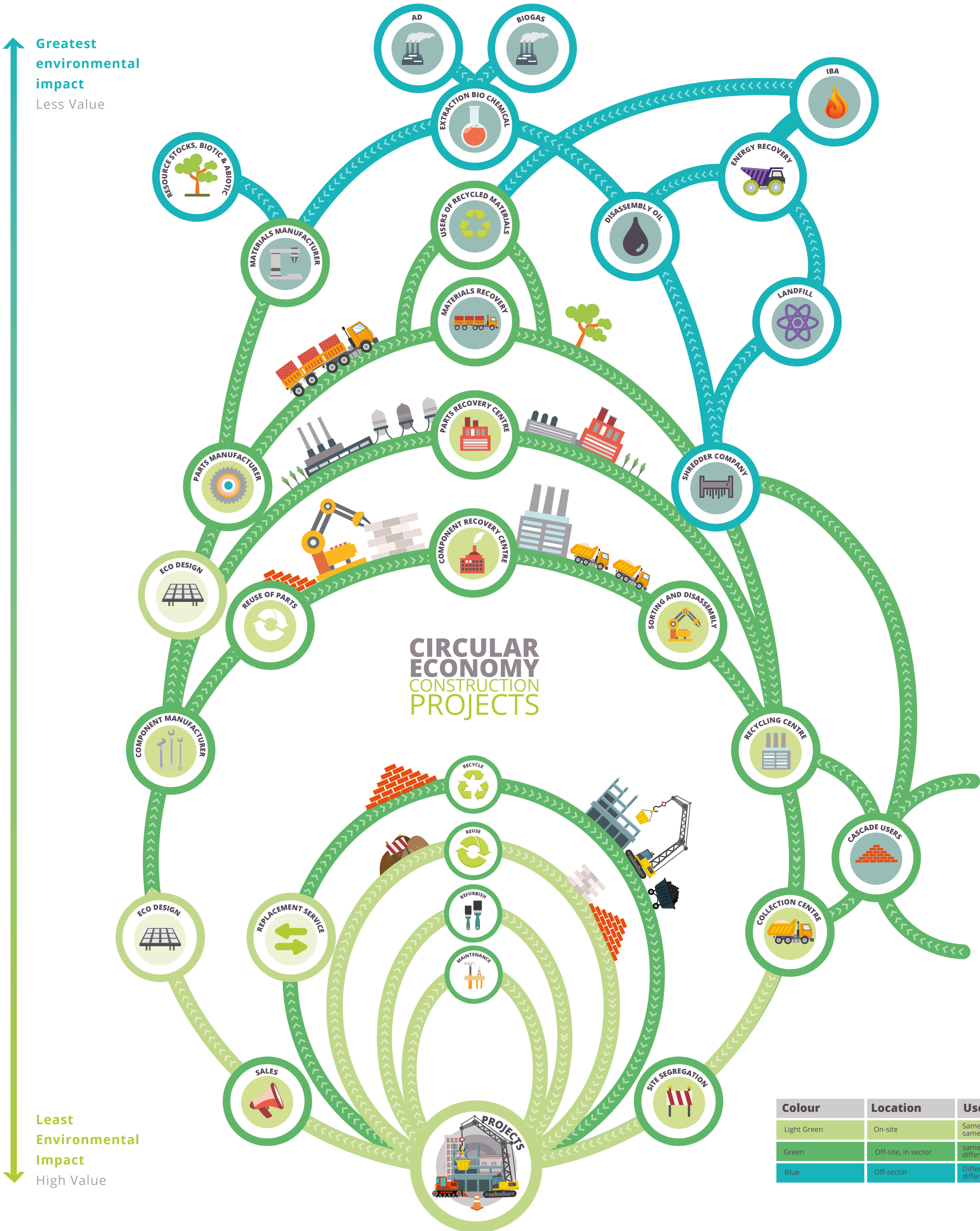
2. Closed Loop - Connection to external collections and the ability of products, components or parts to be able to be entered back into the cycle through reuse, refurbishment or recycling and this returning back into the construction cycle by the user;

3. Open Loop - Extraction of biomass components back into the system

The start of the chain focusses on on-site activities such as reuse, refurbishment and recycling. These opportunities all help to contribute to the extended use of materials and are the preferred activities as they result in higher resource value. Segregation of materials on site helps to encourage material reuse and higher quality recycling opportunities.

Environmental impact is minimised and value highest when materials are used for their original purpose. As materials are repurposed by altering their physical state or original use the amount of input increases therefore increasing cost which may impact on their value.

Circular economy model for built environment (on decision basis) by project



Colour	Location	Use
Light Green	On-site	Same purpose, same state
Green	Off-site, in sector	same state, different purpose
Blue	Off-sector	Different state, different purpose

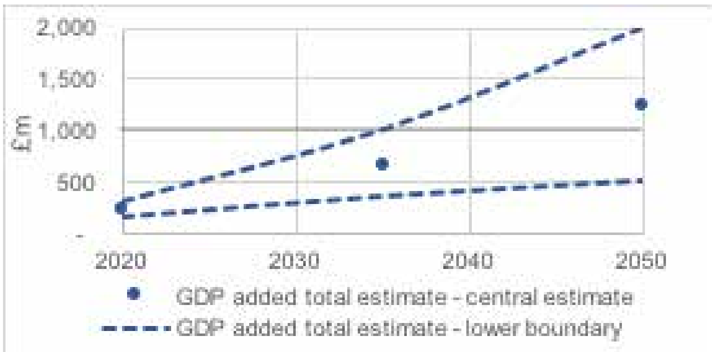
5. What does the circular economy mean for the built environment in Wales: value of economic opportunity

Amec Foster Wheeler wre commissoned to analyse the value of the economic opportunity from the circualr economy for the built environment. The following is a summary extract taken from the full report. The complete research is detailed in full with the main report.

The structure of the Welsh economy and its political environment support an ambitious transition scenario for implementing the circular economy (CE) in Wales. Many focus areas identified in government strategies for the development of the Welsh economy are also key areas for transition to the CE. Traditional manufacturing and associated skills remain an important factor in the Welsh economy and in its transformation to circularity. The institutional environment and especially the political support for this transition, both in general and specifically for the built environment sector, are particularly strong in Wales.

A literature and data review has been conducted to determine the availability of appropriate data for the assessment of the circular economy benefits in the built environment in Wales, covering the housing stock, the developers and constructors, the users and the materials of the built environment in Wales. Current CE practices are reviewed using Constructing Excellence in Wales (CEW) case studies of projects which optimise construction and minimise waste arising from the built environment. One case study identified cost savings attributed to consideration of the waste hierarchy and effective waste management of over 2% of the project budget. Furthermore, two sources have been identified which quantify the wider benefits of implementing CE in the built environment. Both are recent reports from the Ellen MacArthur Foundation ("Growth Within" and "Delivering the Circular Economy – A Toolkit for Policymakers").

Estimates of the benefits of implementing CE in the built environment from the Ellen MacArthur Foundation studies as well as from a CEW case study, are extrapolated to totals for Wales, using Wales-specific data identified in the data review. This yields an aggregate estimate of £2.5bn added annually to GDP added by 2035 from implementing CE in the built environment in Wales, which is likely to be an overestimate, as well as four separate estimates of savings arising from specific circular economy activities (each between £50m and £210m by 2035), which are exclusive of wider economic effects and reflect only selected parts of the circular economy. Combining these estimates with each other and with the qualitative evidence presented in this report, an indicative range of the expected overall net benefit in terms of an increase in annual GDP is estimated (see figure below). The most optimistic estimate indicates net benefits of £1bn in 2035. A central estimate reflecting the midpoint of the upper and lower estimates indicates around £700m will be achieved in 2035 and around £1.2bn in 2050. In conclusion, we estimate that adopting circular economy practices in the construction and built environment sectors in Wales could lead to a benefit in the region of £1 billion annually from 2035.



6 Material Security in the built environment: Critical and Essential Materials for Construction

The Ecodesign Centre Wales were commissoned to analyse the material security within the built environment. The following is a summary extract taken from the full report. The complete research is detailed in full with the main report.

Amongst the guiding principles of the circular economy is maintaining and enhancing the resilience of ecosystems by using materials in a way and at a rate that controls finite stocks and balances renewable resource flows[13]. Two key principles in achieving this are: not overusing valuable finite resources; and not overusing renewable resources at a rate that jeopardises their ability to renew. Whilst these principles should be borne in mind for all materials in a building project, there are two classes of materials where their application is particularly important: the so-called 'critical resources' and essential resources for the industry.

It is not straightforward to precisely calculate the supply risk for a material. However, the EU has identified thirty-five materials of importance to EU industry and Table 1 shows the supply risk values calculated for the 'EU 35' materials during The Mapping Critical Resources for Wales project in 2014[14]. It is important to note that supply risks can change rapidly and these values are only given for illustration.

Table 1: Supply risk values for materials relevant to Welsh industry calculated for 2014

Material	Supply risk value	Material	Supply risk value	Material	Supply risk value	Material	Supply risk value	Material	Supply risk value
Antimony	7.5	Cobalt	6.6	Indium	6.8	Niobium	6.5	Silicon metal	6.2
Arsenic	6.4	Coking coal	5.8	Lead	5.4	Phosphate rock	5.9	Silver	5.4
Barytes	6	Copper	4.3	Lithium	5.6	Platinum group metals	6.4	Strontium	7
Beryllium	6.5	Fluorspar	6.1	Magnesite	6.3	Rare earths (heavy)	9.5	Tantalum	5.9
Borates	5.3	Gallium	6.3	Magnesium	6.3	Rare earths (light)	8.4	Tellurium	5.3
Carbon/ graphite	6.5	Germanium	6.8	Manganese	5.2	Rhenium	5.7	Tin	5.7
Chromium	5.5	Gold	5	Mercury	7	Selenium	5.8	Tungsten	7.6

[13] Ellen MacArthur Foundation (2015). Towards a Circular Economy: Business rationale for an accelerated transition.
[14] Ecodesign Centre (2014). Mapping Critical Resources for Wales. A report for Welsh Government.

Table 2 provides examples of common construction materials that may be affected by reliance on high supply risk (or critical to some businesses) materials, and measures that companies may consider to mitigate them. The list illustrates how supply risks may be 'hidden' in the construction industry's long, complex supply chains. Materials are listed in alphabetical order.

Table 2: Examples of construction materials affected by high supply risk

Construction material	Associated supply risk material	Type of supply risk	Rationale for risk	Potential mitigating strategies
Aggregates	Aggregates	Regulation/ standards	UK planning regimes leading to limited availability and associated price rises. [15]	• Use industry by-products (PFA, steel slag, IBA) as total/partial substitutes where possible • Use crushed recycled glass and demolition rubble in backfill applications
Aluminium	Fluorspar; magnesium	Geopolitical	Fluorspar is used as a source of cryolite for the aluminium electrolysis process. Magnesium is used in 5000 series alloys. Both materials are produced predominantly in China.	• Use recycled aluminium wherever possible • Design buildings to enable recovery of aluminium at end-of-life • Where possible, substitute 5000 series alloys with 3000 series alloys or ultra high-strength steel.[16]
Architectural glass	Indium; tin	Available reserves; geopolitical; regulation	Indium-tin-oxide (ITO) layers are used on glass as low-emissivity coatings. Indium is a by-product of zinc production and is dependent on zinc markets. It is also widely used in high-technology markets, leading to competition for materials. The primary ore of tin is identified as a potential 'conflict material'	• Where possible, replace ITO layers with fluorine-doped tin oxide • Practice responsible sourcing of materials
Cutting tools	Tungsten; cobalt	Geopolitical; regulation	Tungsten is used in cemented carbides for cutting tools. It is predominantly extracted in China but has also been identified as a potential 'conflict material' in other extraction locations. Cobalt is a binder phase for cemented carbides and is identified as a potential 'conflict mineral'	• Consider lease/access business models for cutting tools • Refurbish exhausted cutting blades with carbide metal powders, rather than replacing blades/ buying new tools • Practice responsible sourcing of materials
Fibre-optic services	Germanium	Available reserves	Germanium is used as a dopant in fibre-optics for telecommunication and internet applications. It s a by-product of the zinc mining process.	• Design buildings to enable disassembly of telecommunications systems at end-of-life • Negotiate lease/access business models with suppliers
Flame retardants	Antimony	Regulations/ standards; geopolitical	Antimony is used as a flame retardant material in cable coatings, wall coverings and building panels. It is on the REACH SVHC list and is largely produced in China	• Explore the appropriateness of alternative flame retardants (e.g. hydrated aluminium oxide).

[15] BRE (2013). Critical Materials and Materials Security in the Construction Industry and Its Supply Chains. Available from: https:/www.brebookshop.com
[16] CRM_InnoNet (2013). Critical Raw Materials Substitution Profiles, September 2013.

LED lighting systems	Gallium; indium;	Available reserves; geopolitical	Gallium and indium compounds may be used in LEDs. Both are by-products of other metal extraction processes. Extraction of gallium is primarily in China, Kazakhstan and Ukraine.	• Keep up-to-date on innovation in the sector (organic LEDs, zinc oxide-based LEDS) • Replacement of LEDs with fluorescent or incandescent light bulbs introduces other material security and environmental issues. Instead, negotiate lease/access business models with suppliers to ensure appropriate material stewardship at end-of-life[17]
Solar panels	Gallium; germanium; indium	Available reserves; geopolitical	Gallium, germanium and indium may all be used in solar panel applications. All are by-products and mined in a small number of locations.	• Keep informed about developments in the field; alternative low-cost abundant materials are in early stage commercialisation • Consider lease/access models to allow good material stewardship • Consider how solar panels are integrated into building projects to ensure recovery is possible at panel end-of-life
Steel	Fluorspar; natural graphite; niobium; rare earth elements; tungsten	Available reserves; geopolitical; regulation	Fluorspar and graphite are used in the steel production process; niobium, rare earth metals and tungstens may all be used in construction steel alloys. The materials are variously potential 'conflict minerals', by-products and extracted in limited locations	• Practice responsible sourcing • Source steel that is produced without the use of fluorspar (substitutes include aluminium smelting dross and calcium chloride)[18] • Design buildings for simple recovery of steel where possible • Only use steel alloyed with high risk materials where it is unavoidable • Use recycled steel wherever possible
Timber	Timber	Essential material factors	Increasing global demand and increasing import prices affect the markets for timber[19]	• Practice responsible sourcing to ensure renewable supplies of timber in the long-term • Use reclaimed timber where possible • Reuse timber within different phases of a project

[17] The National Union of Students has negotiated a 'Pay-per-lux' access-based lighting system with Phillips that sees Phillips retaining responsibility for the LED after a fifteen-year lifespan. The business model incentivises Phillips to provide high-efficiency lighting. See http://theenergyst.com/philips-delivers-cradle-cradle-lighting/

[18] CRM_InnoNet (2013). Critical Raw Materials Substitution Profiles, September 2013.

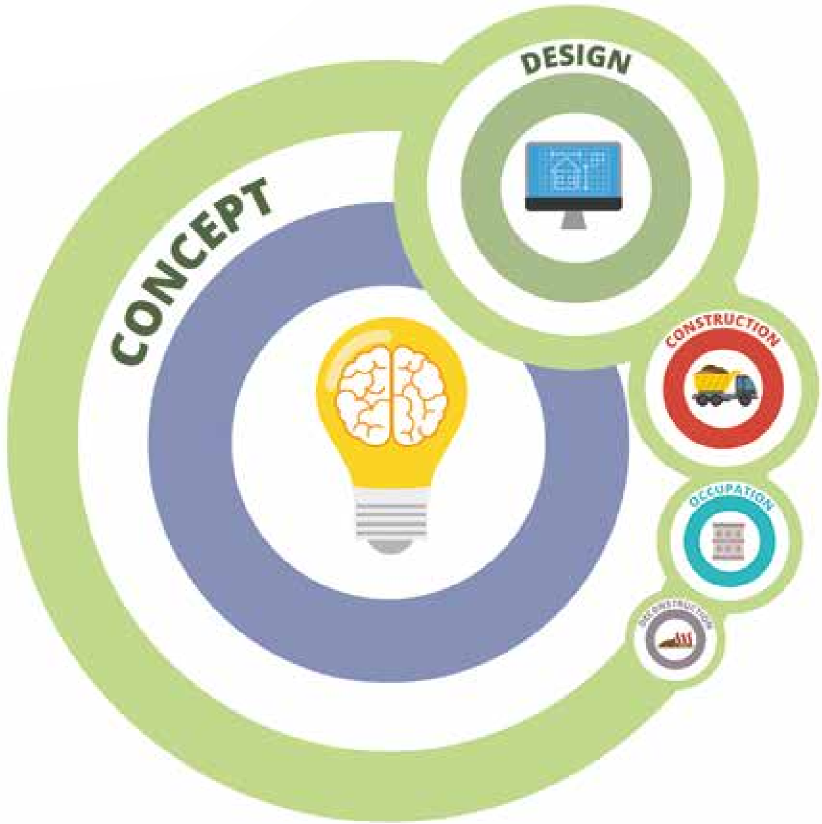
[19] BRE (2013). Critical Materials and Materials Security in the Construction Industry and Its Supply Chains. Available from: https:/www.brebookshop.com

7. Challenges/opportunities

To deliver the opportunities afforded by the circular economy there will be a need to address the identified challenges/barriers to implementation.

Within figure 4 the circles have been scaled using data gathered as part of research into the circular economy in Wales. The size of the circle represents the size of the economic opportunity by the construction phase. The data indicates that the concept/design stage offers the greatest opportunity, the potential at design stage is ten times that of construction, with the opportunity at the occupation stage approximately half that of the construction phase. This provides a clear indication of where the biggest opportunities lie and how actions may be prioritised.

Figure 4 Wales circular economy, scale of economy benefit for built environment



7.1 Challenges

The transition to a circular economy will require a change in process, this will bring significant challenges within all phases of construction. Key challenges to transitioning include:

Transforming mindsets

A lack of client awareness/demand and/or associated negative perception is a big risk to the successful implementation of circular economy principles within the sector. A change in economic model may be perceived as risky, with associated costs and benefits that are realized in the future. This will require a strong business case for change to be demonstrated.

Legislative barriers

The unintended consequences of the existing waste regulatory framework, for example definitions act as a barrier hindering trade and transportation of resources/products for reuse/remanufacturing. These may be addressed with the exit from the EU, however, this brings its own uncertainty and legislative challenge.

Infrastructure constraints

There needs to be investment made to ensure there is the infrastructure in place to enable products to be recycled/recovered. This needs to include physical infrastructure to ensure good quality reused and recycled materials as well as generating markets for recyclates, secondary materials and by-products. Uncertainty over recyclates markets will not encourage their use.

In addition, work will need to be undertaken to ensure products are capable of being reused, remanufactured, recovered, and recycled. It is common place for buildings to be constructed with design lives beyond 2050 using materials and products that are not able to be reused or recovered and whose only end of life option is landfill.

Supply chain

Currently there is limited information, knowledge and economic incentive for key elements in the supply and maintenance chain e.g. chemical composition and strength. This makes it difficult to repair, refurbish and/or recycle materials, reducing the value and recovery opportunities. In addition, a lack of supply chain integration means that often decisions are made in isolation with little consideration for the wider impact.

Products

Products/components are currently on the market that are unable to be disassembled/repaired/replaced. A lack of quality assurance, traceability and the absence of certification means that even products/components that are capable of being recovered are often not identified and segregated making it very difficult. There exists a widespread planned obsolescence in products, limiting reuse, repair, refurbishment and recovery opportunities.

7.2 Opportunities

The following identified opportunities would support and accelerate a transition towards a circular economy and its development. These include:

7.2.1 Government policy

The Welsh Government has chosen sustainable development as its central organizing principle, this has established a framework providing a clear direction. The 2016-2021 programme for Government 'Taking Wales Forward' outlines as part of it's business support the need to promote and invest in a green economy for growth.

Building upon this, the introduction of the Well-being of Future Generations Act and the Environment Act put in place the legislation needed to plan and manage Wales' resources in a more sustainable, joined up way. The recent Natural Resource Policy Consultation highlights opportunities to accelerate green growth by increasing resource efficiency, renewable energy and supporting innovation towards a more circular economy.

As a devolved power planning and tax raising provide opportunities to encourage the conditions necessary for a circular economy. Planning and building regulations could actively encourage development to maximise resource use, supporting the use of recycled/secondary materials and by products. Newly acquired tax raising powers could be used to increase the levy applied to virgin aggregates to favour recycled alternatives. A coordinated UK approach could look to lower VAT applied to products containing recycled content to incentivise their use.

The UK's exit from the EU and Wales' role within this may offer opportunities to address legislative challenges associated with the classification of waste and introduce more proactive resource based legislation.

7.2.2 Role of the public sector

The public sector spends nearly half of its budget on construction. This makes procurement to consider circular economy principles a significant opportunity. The education of the public sector client is key to bringing about change within our economic approach. Procurement can be used to influence the construction outcome through placing circular economy requirements on the supply chain.

Within Wales the public sector estate is large, it is believed the annual cost of maintaining unused public sector buildings is in excess of £12million. The circular economy offers a viable method of transforming these buildings into functional use. Models include the use of innovative products and business models including reusable steel, pay per lux, leasing components and eco-design.

7.2.3 Resource availability

Current research indicates that resource costs are likely to increase due to volatile markets and demand pressures. Within Wales there is a large volume of secondary materials and by-products, generated in large part from steel and power generation activities. The utilization of these materials would provide volume aggregate materials bringing a positive environmental impact, reducing the carbon footprint and addressing material legacies.

7.2.4 Realisation of multiple benefits

The application of the circular economy to buildings generates a multitude of benefits, that may not be realised elsewhere. Advantages include: reduced use of natural resources, mitigation against material prices, land savings, resource efficiency, reduced greenhouse gas emissions and energy consumption during the construction, use and demolition of buildings. Making an important contribution towards delivering in accordance with the Well-being of Future Generations Act.

7.2.5 Economics

Adopting circular economy practices makes economic sense. Achieving Growth Within[20] identifies a total economic benefit of up to €135 billion by 2030 in reduced utility, repair and maintenance cost, in addition to a €105 billion investment opportunity between now and 2025.

Arup[21] have identified that designing steel for reuse could generate high potential value for building owners, estimating savings of 6-7% for a warehouse, 9-43% for an office, and 2-10% for a whole building, with up to an additional 25% savings on materials. Working with Arup and Kier at the design and construction of the Ice Arena Wales, CEW have prepared a report identifying and grading the steel frame for future use, reuse, and recycling. Through the use of the building information model a colour coded animation was prepared, colour coding the various steel values and virtually deconstructing the building, all prior to its physical completion. The model is available at https://youtu.be/GQESvkJ8oBU

7.2.6 Changing the way we use our built environment

We need to change the way we think about how we use our built environment. We currently under occupy our buildings, typically 35-40% of offices in Europe are occupied[22] , the same report identified that within UK homes 49% are under occupied. The advent of the driverless car could change the way we use roads, enabling vehicle spacing distances to be reduced. The UK Government has allowed trials of driverless cars on public roads since 2014.

[20]Ellen MacArthur Foundation, Achieving Growth Within: A €320 billion circular economy investment opportunity available to Europe up to 2025, 2017
[21]Arup, Circular Economy in the Built Environment, 1996
[22] Ellen MacArthur Foundation, Growth Within, 2015

8. Recommendations/actions

This report outlines a model for how the circular economy may be applied to the built environment, the size of the economic opportunity and how the principles could be implemented across the sector to realise the benefit.

The recommendations included are consistent with and intended to build upon the framework established by the Well-being of Future Generations Act, Environment Act, and Wales' Waste Strategy Towards Zero Waste. It is important to note that Wales is the only nation to establish waste prevention targets. These elements form the foundations of a positive policy basis in which Wales can transition towards a circular economy.

The Ellen MacArthur Foundation identified key enablers to assist in the delivery of a circular approach, namely:

- Collaboration
- Rethinking incentives
- Providing suitable environmental rules
- Leading by example & driving up scale fast
- Access to financing
- Early adoption

Many of these enablers link to the Rethinking Principles identified by the Egan and Latham reports. Constructing Excellence in Wales have been working to demonstrate, these actively compliment the ways of working identified with the Well-being of Future Generations Act. For Wales, the key drivers of delivering a circular approach include:

- Collaboration
- Innovation
- Thinking for the long term
- Taking a preventative approach

From the research undertaken in the development of this report, CEW has identified the following as being key to achieving circularity within the built environment, these are:

- Design out waste at all stages e.g. design, construction/manufacture, end of life
- Products designed to be reused/remanufactured/reassembled/biological basis
- Waste redefined as resource
- Working across the supply chain/across the sector

It has been noted[23] that making small, incremental changes towards resource efficiency could drive up capital costs and/or design fees, this is difficult to defend against lowest-cost tendering and value engineering. Developing a whole circular economy narrative, with collaboration across the entire supply chain and the ability to design for the whole life, including the end of life is necessary to fully realize an economic return.

- To truly evolve into a circular industry there will be a need to bring together the process start and end, aligning design and demolition to remove the current disconnect. Design practices will need to consider what and how materials are used, are extracted and reused within the built environment, with demolition removing materials to protect the reuse value.

8.1 Industry focus

The actions of industry will be key to the success and speed of implementation towards circularity. CEW has identified some early industry lead instances of best practice from these Welsh examples the following actions are considered key elements to delivering and necessary for best practice to become mainstream practice.

a. Materials selection

Materials will need to be selected with consideration given to their end of life, there are numerous commonly used building materials that have no alternative recovery option other than landfill.

b. Standardised components

There is a need to look towards manufacturing principles, such as component standardisation to deliver efficiencies including enhanced time in use, extended life, facility to repair/refurbish

c. Design for circularity, principles include:

- Design for flexibility/adaptability to extend life
- Design for deconstruction – requirement to consider end of life in current design – especially important for assets with design lives beyond 2050 (zero waste to landfill target)
- Design for disassembly/deconstruction and reuse of asset/elements

d. Product design

Design for longevity – eliminate current practice to design planned obsolescence within asset and products

- Design for separation/on site management/demolition
- Design for reuse/site management/demolition
- Buildings as materials banks

[23] David Cheshire (2016) Building Revolutions: Applying the Circular Economy to the Built Environment, RIBA

e. Building core competencies to facilitate:
Product reuse, Recycling, Cascading - Requires advanced skills sets/information sets/working methods

8.2 Policy focus

Industry will require policy support to deliver effective action, the following are considered key areas for government policy development:

a. Market development: Quality supply and demand
There is much to be done to support the development of markets for the large quantities of by-products, secondary materials and waste, such as IBA, PFA and steel slags. Many of these legacy materials need assistance to develop markets and routes to market for the type and volumes of these high quality by-products/secondary materials and recyclates.

b. Sector support
The construction sector is fragmented, this is true across the industry and government. This does not provide a solid basis for end of life material extraction. There is a need for a cohesive construction strategy to be developed to provide clear direction and remove barriers to scalability and applicability.

c. Development of Infrastructure
The sector consumes and generates large volumes of materials. There will be a need to develop cost efficient, better quality collection and treatment systems and effective segmentation of end of life. Without this investment the leakage of materials out of the system will continue, undermining development towards circular economy.

d. Role of the public sector client
The public sector client is responsible of between 45 – 55% of annual construction spend, therefore the role of the sector as a construction client is significant. The development of consistent approaches to the design, build and deconstruction of public funded construction with consideration of circular economy principles would provide clear direction creating stable investment and development platform for green growth.

e. Alignment of capital and revenue funding
Current public funding differentiates between monies available for capital and revenue elements. This often results in decisions made at design and build stages funded by capital budgets negatively impacting on future decision making and longer term revenue funds. The Well-being of Future Generations Act provides a useful basis to resolve these issues and develop coherent strategies for decision making. With an alignment of capex and opex budgets in a more totex approach circular thinking can be embedded and opportunities realised, such as products as services.

Following the UK Sustainable Development Strategy developed approach table 3 outlines key actions across a range of options, primarily aimed at the development of policy to support a transition to a circular economy.

Table 3: Policy Actions to support a transition to a circular economy

	Concept	Design	Construction	Occupancy	Deconstruction
Enforce	Planning policy/ requirements Waste Regulation - development of resource framework	Prevention targets Policy/requirements	Targets Building standards/ requirements	Targets	Buiding standards favouring deconstruction
BIM Policy					
Encourage	Tax advantages	Skills R&D Support Tax advantages for CE materials Voluntary schemes	Tax advantages for CE materials Skills	Tax advantages reuse/remanufacture Skills R&D Support	Tax advantages for CE materials Skills
Enable		Sector guidance Standard designs/ details	Sector guidance Labelling	Labelling	Labelling
Exemplify	Government funded demonstrators				
	Public sector procurement to favour CE/ requirements in favour of CE	Public sector procurement to favour CE/ requirements in favour of CE			
Engage	Awareness raising/information				

9. Conclusions

The circular economy presents a significant opportunity, delivering multiple benefits across multiple platforms/portfolios/agendas.

Wales, through its sustainable development commitment has put in place a framework which establishes many areas identified as key for a transition to a circular economy, such as low carbon energy and environment, advanced engineering and materials, ICT and the digital economy. It is considered that the institutional environment, together with the political support for a transition to the circular economy in general and for the built environment is strong in Wales. This supports the potential for an ambitious transition scenario, and with focus the right conditions can be developed to enable Wales to make the most of the opportunity presented.

As demonstrated within our models working across the supply chain throughout projects and between sectors will be key to the success of a transition between linear and circular economies.

Our research has demonstrated a potential economic opportunity of an additional £1 billion per annum by 2035. This is an increase of 12.5 per cent in the turnover of the welsh built environment sector and generate 7,300 jobs (gross). It is important to acknowledge that these economic gains can only be achieved working across the supply chain. Making small incremental changes towards resource efficiency could drive up capital costs and/or design fees, this becomes difficult to defend against lowest-cost tendering and value engineering.

We need to redefine waste as a resource, if we continue to define material surplus as waste we will struggle to close resource loop and retain value. EU exit brings the potential for legislative change to address issues with the classification of waste in EU definitions, develop a more Wales specific approach.

Key to the application of the approach will be design, influencing at the earliest possible opportunity. It is at the design stage that decisions are made that impact 80% of the waste generated on a project. Adopting circular design will require the sector to embrace new ways of working, collaborating at earliest possible stages across the supply chain, thinking for the long term and embracing innovation in product and process.

CEW are working across its programmes to demonstrate how the theories described can become best practice examples delivering transformational change across Wales. The built environment sector is seen as key to the delivery of a circular economy. The Ellen MacArthur Foundation has identified the built environment sector as key to the delivery of a circular environment.

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