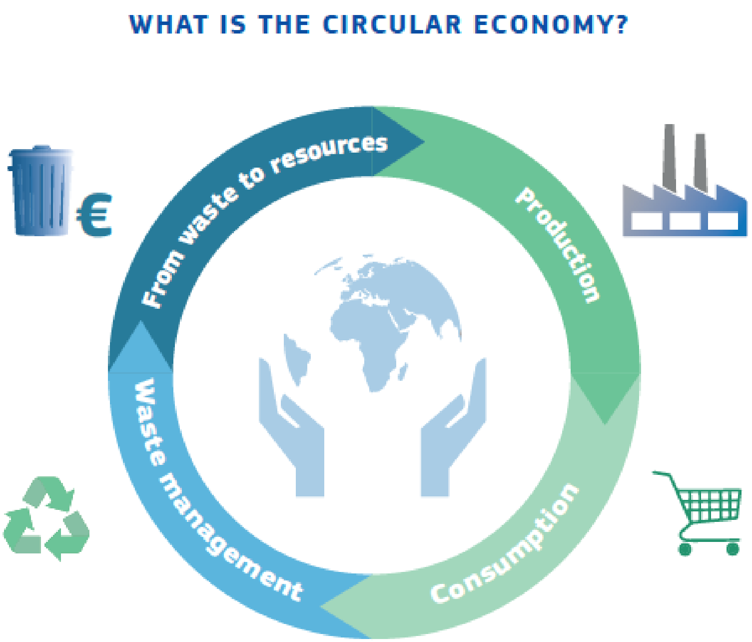
Sustainability and the Circular Economy

Dr. Paola Sassi
Oxford Brookes University



European Commission publication “CIRCULAR ECONOMY. Closing the loop. An ambitious EU circular economy package.”

- Historic perspective
- Current context and the CE
- Opportunities and principles for CE and closed material loops
- Benefits of CE

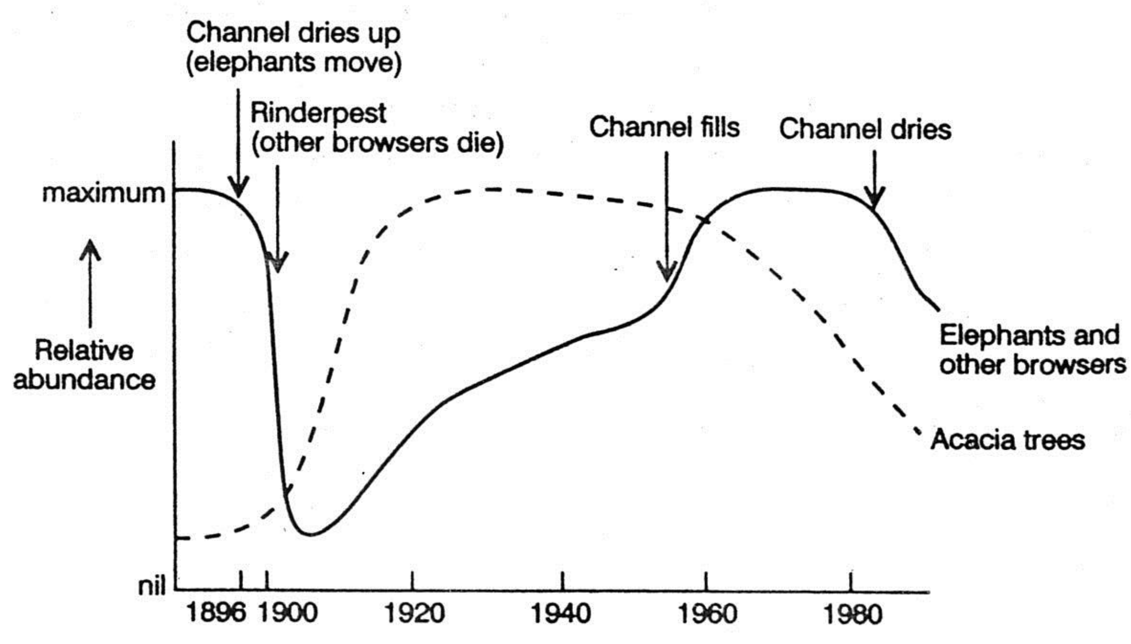
Historic perspective

Circular systems based on nature

Natural cycles are closed and balanced systems with solar energy as the only input, where all resources are recycled and waste from one organism becomes food for another (Frosch, R. A. and Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientific American.* 261 (3), September. pp. 94-102.)

Ecosystems are:

- complex with absence of complete knowledge
- dynamic
- subject to time-lags and feedback loops
- non-linear
- defined by limits



Leakey, R. (1996). *The sixth extinction.* London: Phoenix Press

Antecedents of Circular Economy

1970s

- Club of Rome – *Limits to Growth* – highlighted the limited resources on the planet (Meadows, D. *et al.* (1972). *The limits to growth: a report for the Club of Rome's project on the predicament of mankind.* London: Earth Island)
- Stahel and Reday - *The Potential for Substitution Manpower for Energy* – proposed approaches for energy efficient product-life extension.

1980s

- Stahel - *Product-Life Factor* – Introduces key principles that will form the basis for CE
- Industrial Ecology – the application of principles of natural ecology to industry (e.g. Frosch, R.A. and Gallopoulos, N.E. (1992), "Towards an Industrial Ecology," in Bradshaw, et al. (eds.) The Treatment and Handling of Wastes, Chapman and Hall, London, pp.269-292, page 290.)

1990s

- Rocky Mountain Institute (https://rmi.org/ -founded in 1980s) and Hawken, P., Lovins, A.B., Hunter Lovins, L., (1999). *Natural capitalism. The next industrial revolution*. London: Earthscan Publications.
- *The Hannover Principles: Design for Sustainability* (1992) William McDonough and Dr. Michael Braungart
- Janine Benyus (1997) *Biomimicry: Innovation Inspired by Nature.* New York: Morrow.

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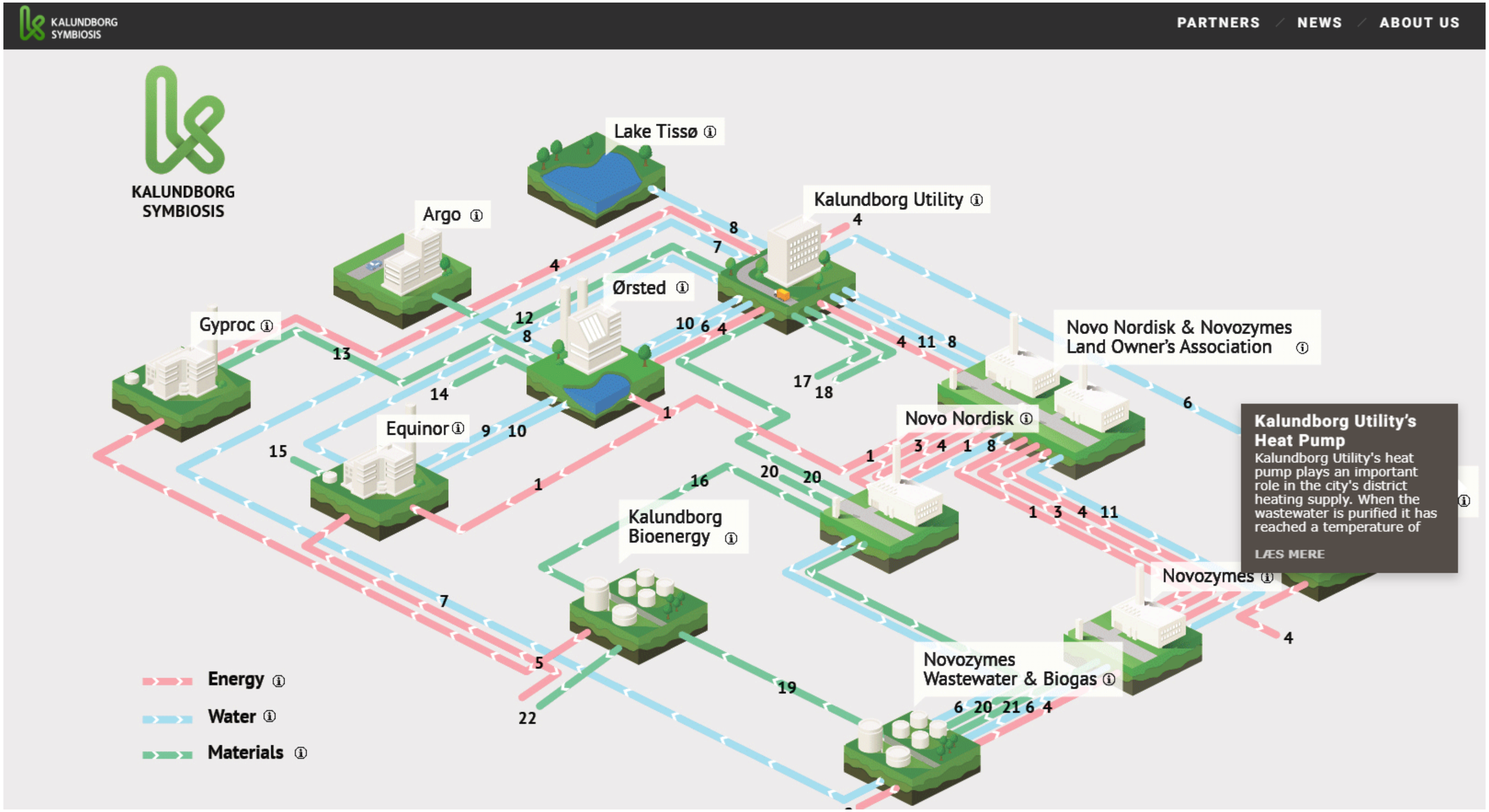
- McDonough, W. and Braungart, M. (2002). *Cradle to Cradle: Remaking the way we make things.* New Your: North Point Press.

Implementation of Industrial Ecology UK: Pimlico District Heating

Single focus on energy:
Pimlico District Heating Undertaking using waste heat from Battersea Power station and connected to 3,256 homes, 50 business premises and three schools. Decommissioned in 1983.

Implementation of Industrial Ecology: Kalundborg, Denmark



Kalundborg Symbiosis is the worlds' first industrial symbiosis and has evolved over the past 50 years. The cooperation between the companies in the symbiosis provides mutual benefits, economical as well as environmental. The main principle is that a residue from one company becomes a resource in another.

http://www.symbiosis.dk http://www.symbiosis.dk/en/

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Today (2010s) the Circular Economy

Legislation

- 2015 EU Action Plan for the Circular Economy
- 2019 EU Report on Implementation of the Circular Economy Action Plan

Institutes

- Ellen MacArthur Foundation (created 2010 - www.ellenmacarthurfoundation.org)
- Cradle to Cradle Products Innovation Institute (created 2010 - www.c2ccertified.org)
- World Economic Forum (https://www.weforum.org/agenda/archive/circular-economy)

Publications

- Ellen MacArthur Foundation
  - E.g. 2015 Growth Within: A Circular Economy Vision For A Competitive Europe
- European Commission (http://ec.europa.eu/environment/circular-economy/index_en.htm)
  - Report on the implementation of the Circular Economy Action Plan - press release - questions and answers
  - Staff working document with details on the 54 actions included in the action plan
  - Staff working document on Sustainable Products in a Circular Economy
  - Staff working document on the assessment of the voluntary pledges under Annex III of the Strategy on Plastics
  - Guidance and promotion of best practices in the mining waste management plans
  - Summary Report of the Public Consultation on the interface between chemicals, product and waste legislation
  - Report on improving access to finance for circular economy projects
  - Report on Horizon 2020 R&I projects supporting the transition to a Circular Economy
  - A circular economy for plastics – Insights from research and innovation to inform policy and funding decisions
  - Eurostat press release: Circular Economy in the EU
- Club of Rome and other research organisations and universities (e.g. http://circulareconomytoolkit.org/Toolkit.html)

Current context and the Circular Economy

Current context: the bigger picture

How do buildings relate to the bigger picture of sustainability?

What of the following do you think has the biggest carbon impact in the life of a UK citizen?

- *Consumerism*
- *Food*
- *Housing*
- *Travel*

(listed in alphabetical order)

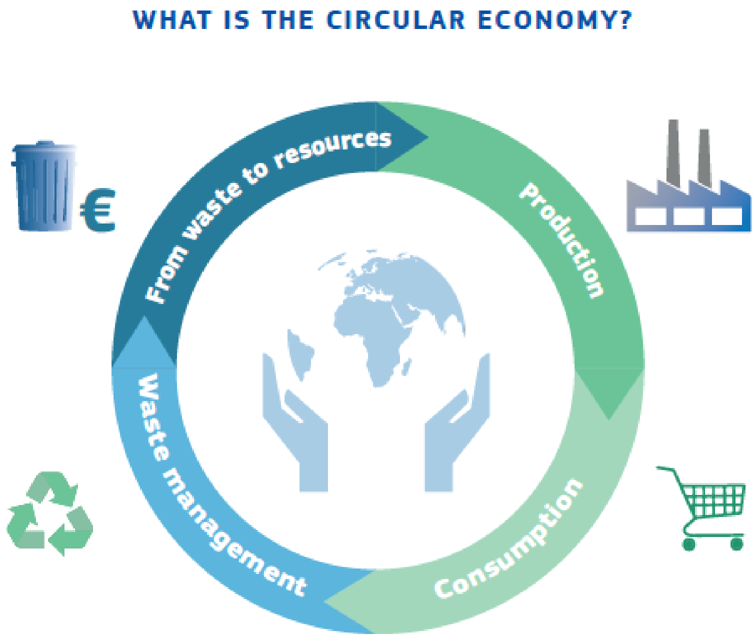
Individual lifestyles and global warming

Total CO_2	10.62 tons	%
Consumerism	3.05 tons	29%
Housing	2.86 tons	27%
Other	1.83 tons	17%
Travel	1.49 tons	14%
Food	1.39 tons	13%

CO_2 emissions/year of average British person 2006

(Carbon Trust report (2006) in Herbert and Brown (2006) Your carbon footprint revealed: Climate change report finds we each produce 11 tons of carbon a year - and breaks down how we do it. *The Independent Online.* 9 December 2006.)

CIRCULAR ECONOMY (CE) aims to **maximise the usefulness of resources and minimise the generation of waste** (including wasted resource and pollution e.g. carbon emissions)



European Commission publication "CIRCULAR ECONOMY. Closing the loop. An ambitious EU circular economy package."

The EU states that the Circular Economy benefits will include:

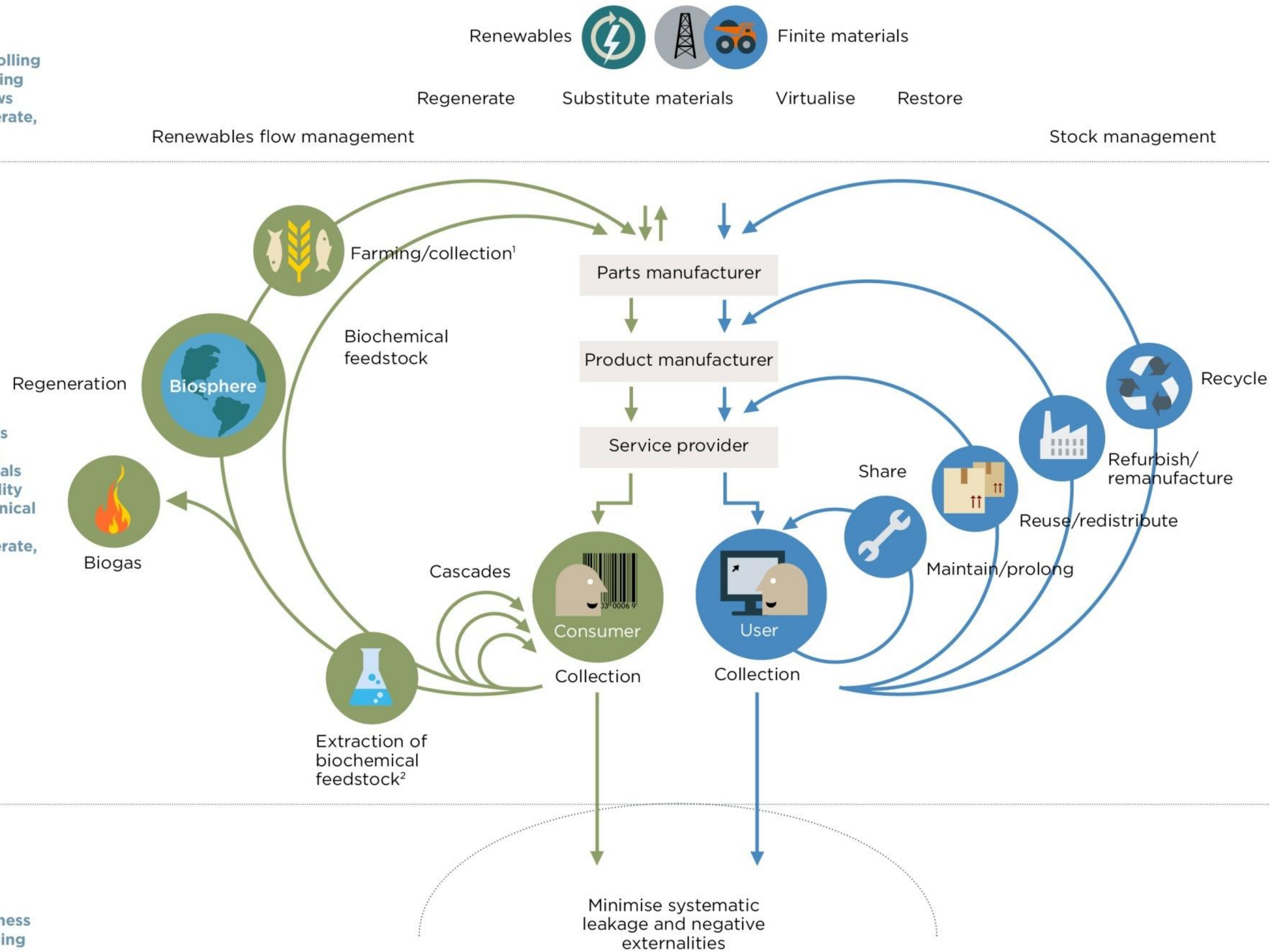
- Savings of €600 billion for EU businesses, equivalent to 8% of their annual turnover
- Creation of 580,000 jobs
- Reduction of EU carbon emissions by 450 million tonnes by 2030

OUTLINE OF A CIRCULAR ECONOMY

PRINCIPLE

1

Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
ReSOLVE levers: regenerate, virtualise, exchange



PRINCIPLE

2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
ReSOLVE levers: regenerate, share, optimise, loop

PRINCIPLE

3

Foster system effectiveness by revealing and designing out negative externalities
All ReSOLVE levers

1. Hunting and fishing
2. Can take both post-harvest and post-consumer waste as an input

Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

https://www.ellenmacarthurfoundation.org/circular-economy/infographic

Opportunities and principles for CE and closed material loops

Principles of CE in the built environment

1. **Reduce use of new materials**
   - **Maximise material efficiency**
   - **Longevity**
   - **New business models**

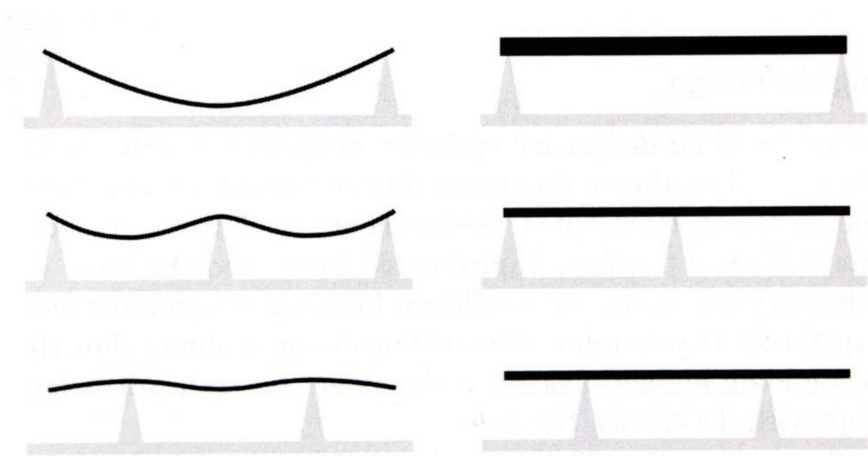
2. **Avoid waste generation**
   - **Reuse and closed loop industrial and natural recycling**
   - **Inter-industry reuse and recycling**

EC FRAMEWORK DIRECTIVE ON WASTE

1. waste prevention and minimisation
2. reuse of waste
3. recovery of waste (recycling and composting)
   (downcycling of waste)
4. energy recovery of waste (incineration)
5. landfilling of waste

Principle 1 – Reduce use of new materials

1. **Reduce use of new materials** by efficient design and maximising life of materials in use
   - **Efficiency** (material-efficient design e.g. structural efficiency, essential ornamentation, space efficiency)
   - **Longevity** (Maintain / repair / renovate / adapt / flexibility = maximise longevity)
   - **New business models** (leasing materials e.g. Interface, Desso and De Lage Landen carpets)



dematerialisation by structural design optimising

(Bisch, J. (2002). Natural metabolism. In: Kibert C.J., Sendzimir, J., Guy, B. (eds.) *Construction ecology. Nature as the basis for green building*. London and New York: Spon Press. pp.248-268)

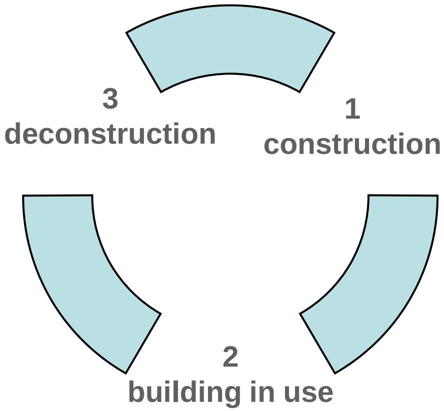
Principle 2: move from traditional linear building life

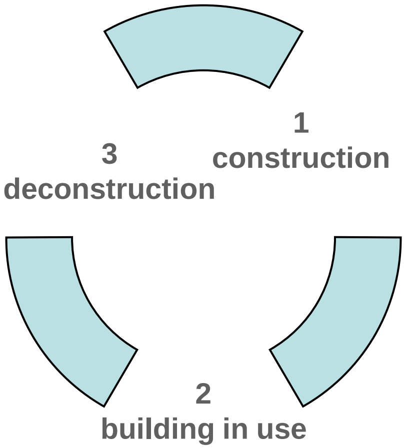
1
construction

2
building in use

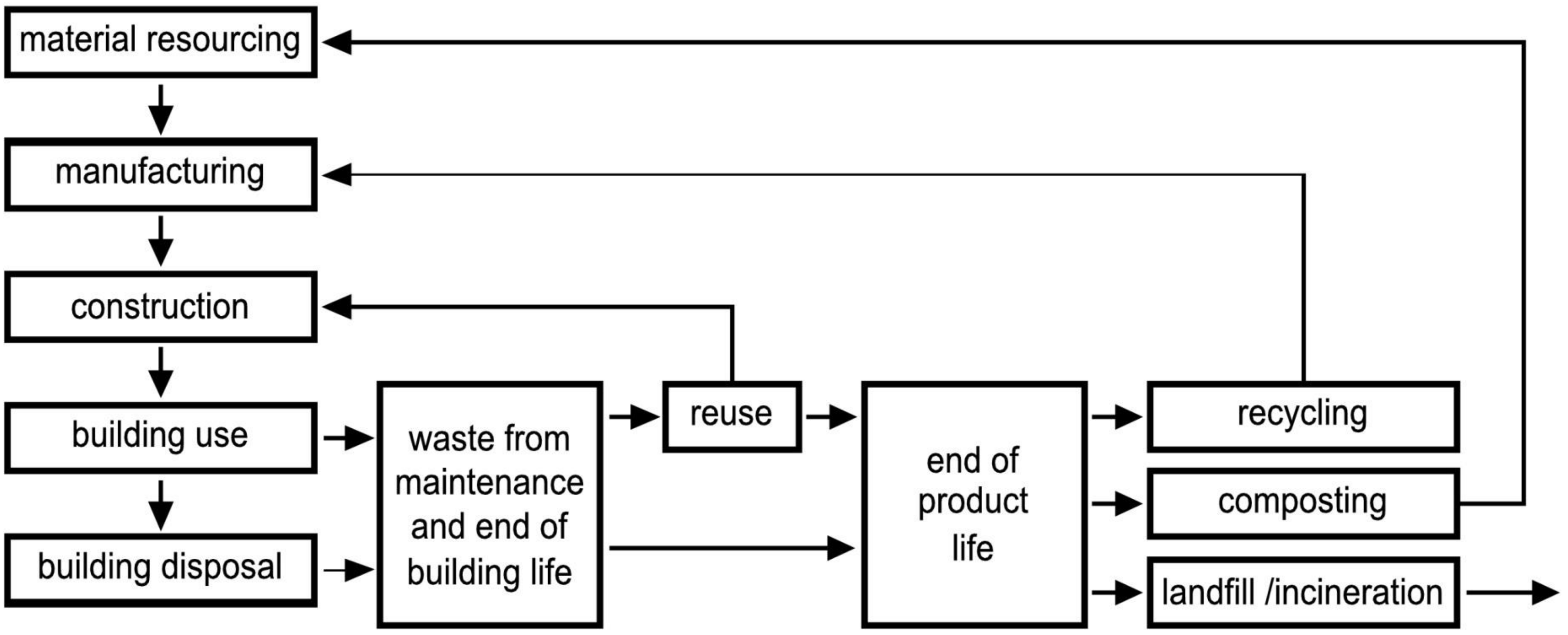
3
demolition

............to a closed loop system





Principle 2: move to a closed loop system



Reuse and closed loop industrial and natural recycling (Dismantle and reuse/ recycle /biodegrade = closed loop material cycles)

Inter-industry reuse and recycling (e.g. industrial waste heat)

Case studies / examples

Working with existing resources

- Reusing whole buildings
- Reusing structures as a whole
- Dismantling buildings to allow maximum reuse
- Dismantling to allow maximum recycling
- Use reclaimed building components
- Use recycled building materials
- Use building products made of recycled materials

Working to enable the use of resources in future

- Design to enable future dismantling, reuse and closed loop recycling
- Design for longevity, flexibility and adaptability

Whole building reuse

Stables converted into a house in Edinburgh – Richard Murphy Architects

Dismantling buildings to allow maximum reuse and recycling

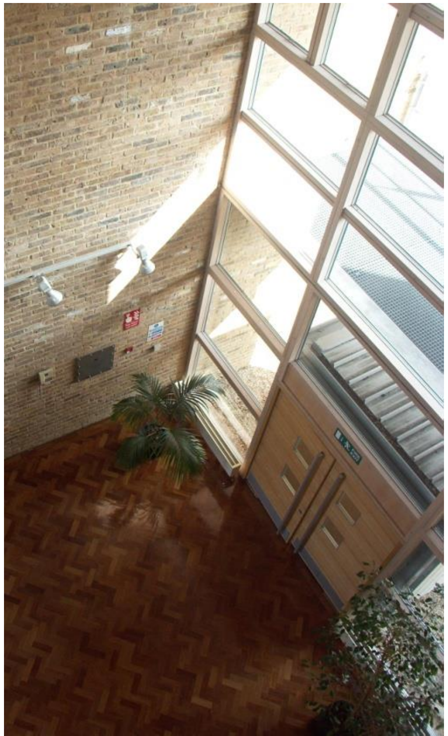
The existing building was dismantled and **96% of the materials by volume were reused or recycled**

- fixtures, fittings, and furniture were given to charities
- roof sheeting, slate cladding and cast iron drainpipes were reclaimed
- metals and timber were recycled
- masonry was downcycled

The new building used:

- reclaimed timber floors
- reclaimed bricks
- aggregate in the structural concrete

BRE Building 16, Watford, UK – Feilden Clegg Bradley Architects



Use reclaimed building components

BedZED, Sutton – Bill Dunster Arch + Bioregional
54,000 m of reclaimed timber studwork
98 tonnes of reclaimed structural steel
700m² of reclaimed floor boards
reclaimed ply shuttering

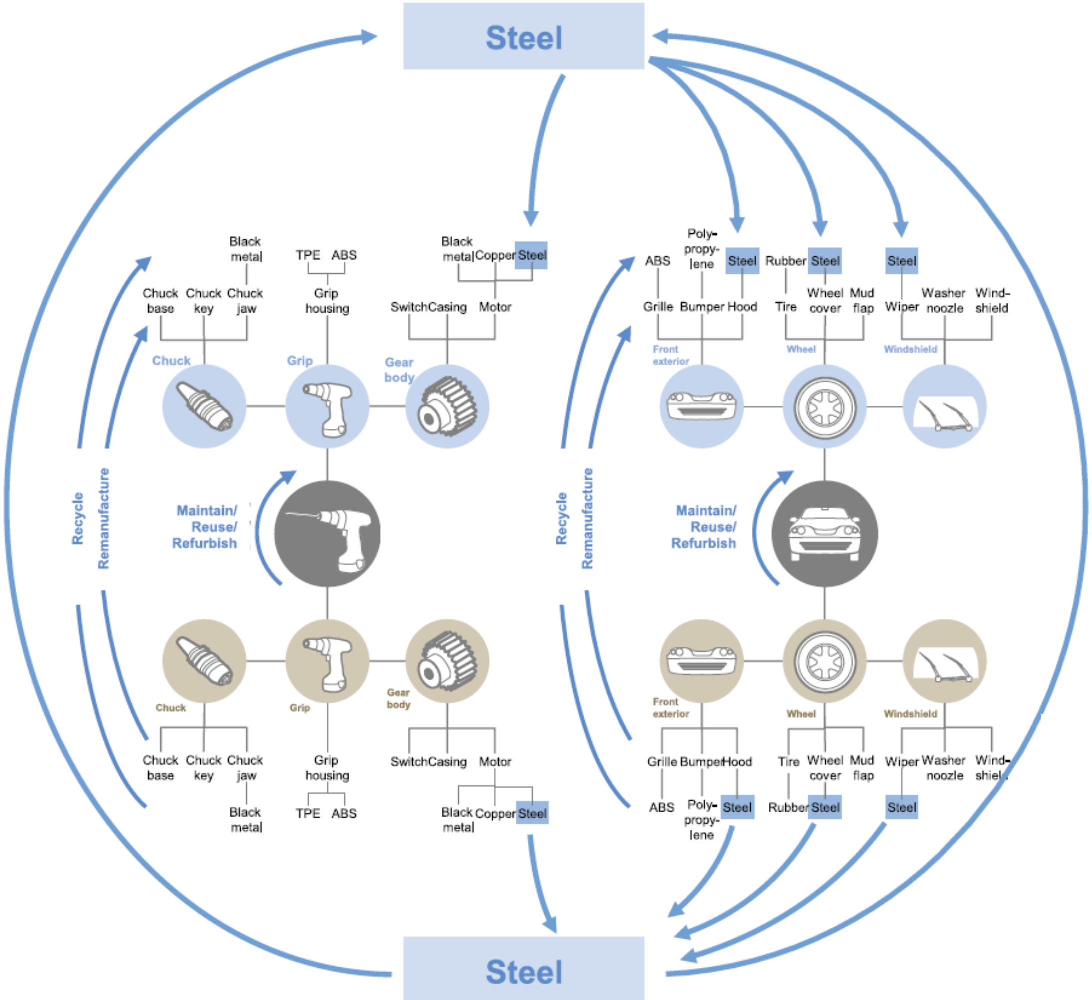
Cloud House designed to make use of reclaimed of glazed units, Regin Schwaen , Professor North Dakota State University

Use building products made of recycled waste

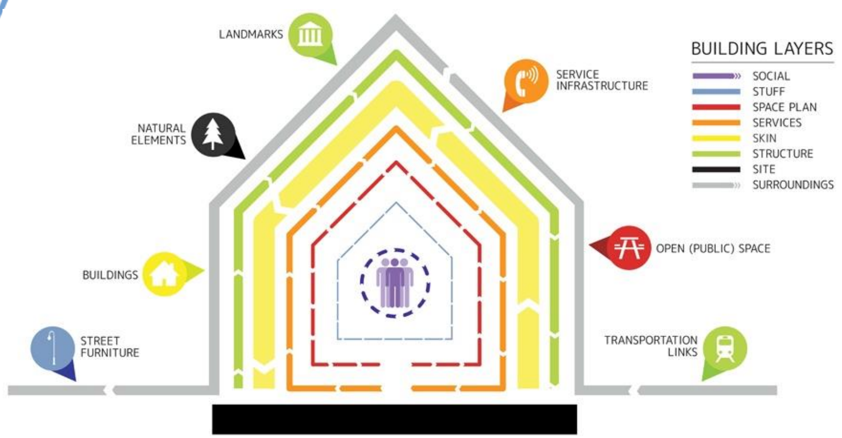

Straw Bale Theatre

The house of waste built from recycled materials at the University of Brighton. Photograph: Jamie Smith
Duncan Baker-Brown https://bbm-architects.co.uk/portfolio/waste-house/.

Design for deconstruction, reuse, recycling



World Economic Forum (2014) Towards the Circular Economy: Accelerating the scale-up across global supply chains



http://adaptablefutures.com/our-work/toolkit/

Design to enable future dismantling, reuse and closed loop recycling

Principles of design to enable		
DECONSTRUCTION	REUSE	RECYCLING /DISINTEGRATION /BIODEGRADABILITY
Provide information for deconstruction unless common knowledge	Provide information required for reinstallation	Provide identification of constituent materials
Use installation systems and fixing methods that are reversible	Design to minimise reprocessing requirements	Durability for the purpose of transport
Ensure ease of access to / handling of elements	Consider performance compliance (warranties etc.)	Avoid hazards
Avoid hazards (toxins, structural, handling)	Ensure durability possibly oversize elements	Ensure material purity/ Avoid additives, toxic treatments and other impurities
Minimise time required to dismantle elements	Ensure aesthetic desirability	Reduce reprocessing requirements
Use robust materials/elements that will withstand multiple handling	Ensure design flexibility	Ensure speed of biodegradability/ disintegration /recycling is within an acceptable limit
Design to include suitable tolerances		

Deconstruction is key

Design for deconstruction: material connections are key

Don’t use composite building element

Do use pure materials

Don’t use applied finishes

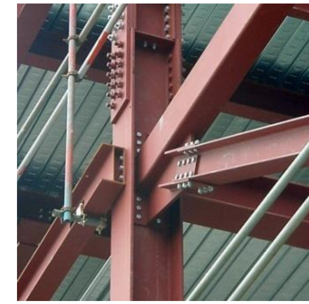
Do use removable finishes

Don’t use adhesives and welding

Do use mechanical fixings

Existing technologies in relation to deconstruction

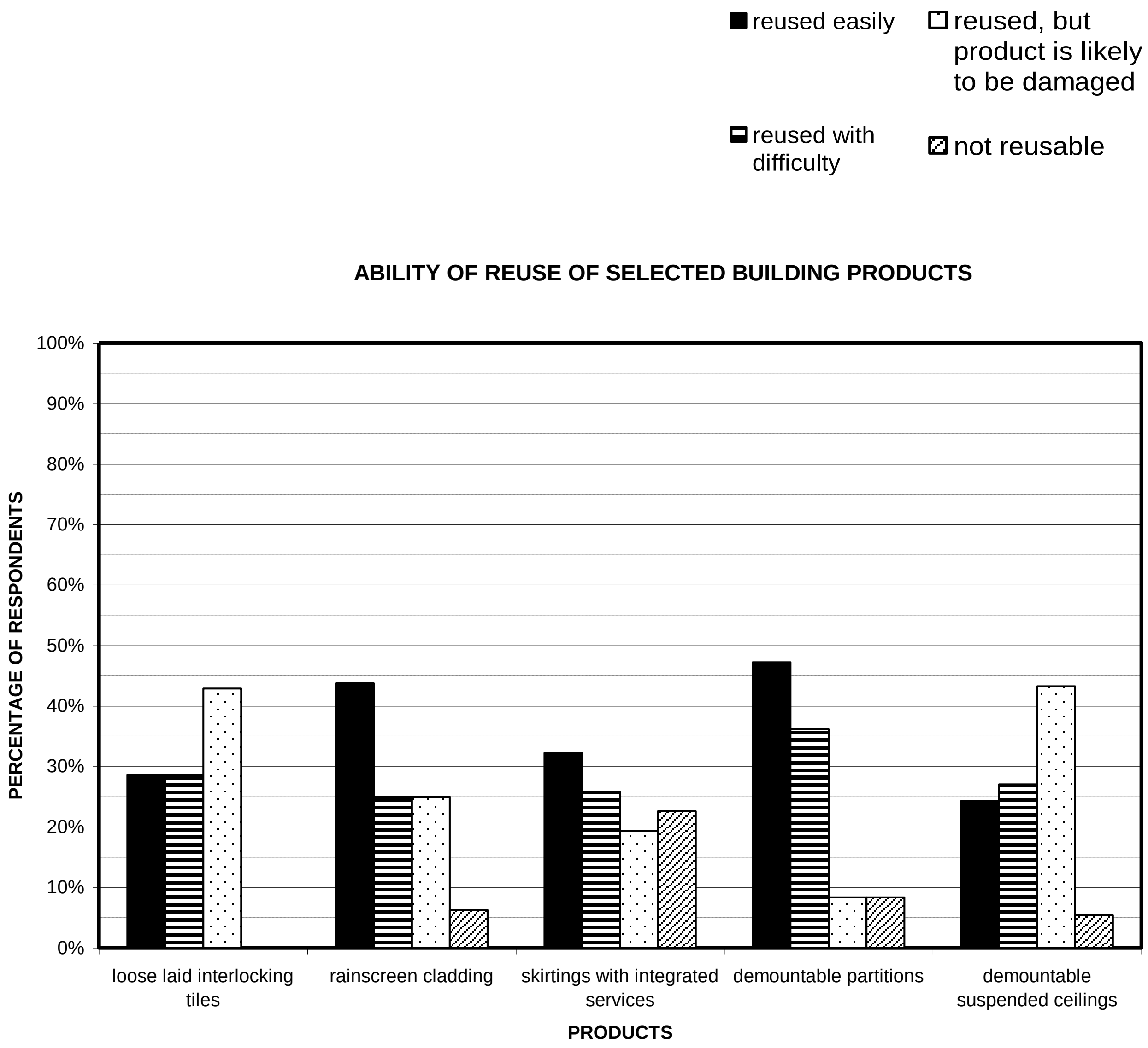
Group 1
Designed for or easily deconstructed



Group 2
can be deconstructed if specified appropriately

Group 3
not deconstructable

Common elements that can be reused and why some are not reused



Example 1 - Design for dismantling and repositioning

http://www.arvesund.com/en/vistet_36_en/

Vistet Fritid Prototype deconstructable House

Architect Thomas Sandell and Professor Anders Landström

Example 2 - Design for flexibility and adaptability

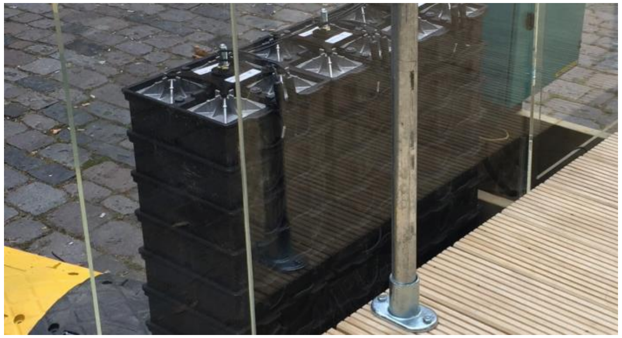
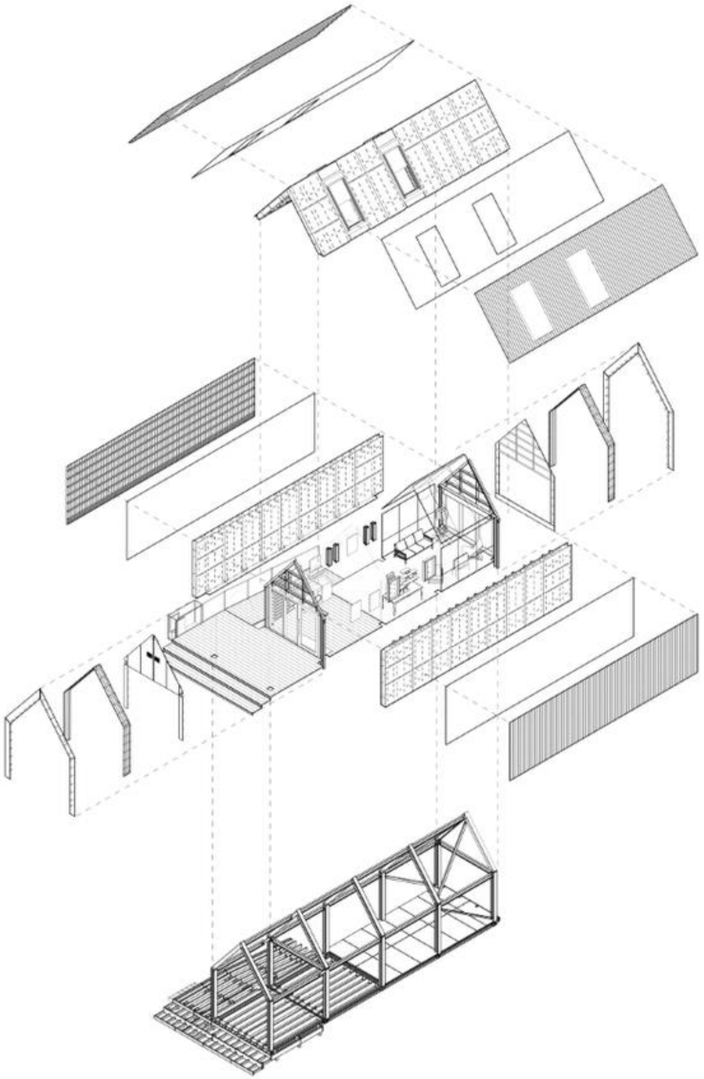
Kings Cross Community Centre, London - Architype

3 - Delivering CE solutions: Design for maximum reuse and recycling

Glencoe National Trust Visitor Centre
Gaia Architects

4 - Delivering CE solutions: Service industry and take-back schemes



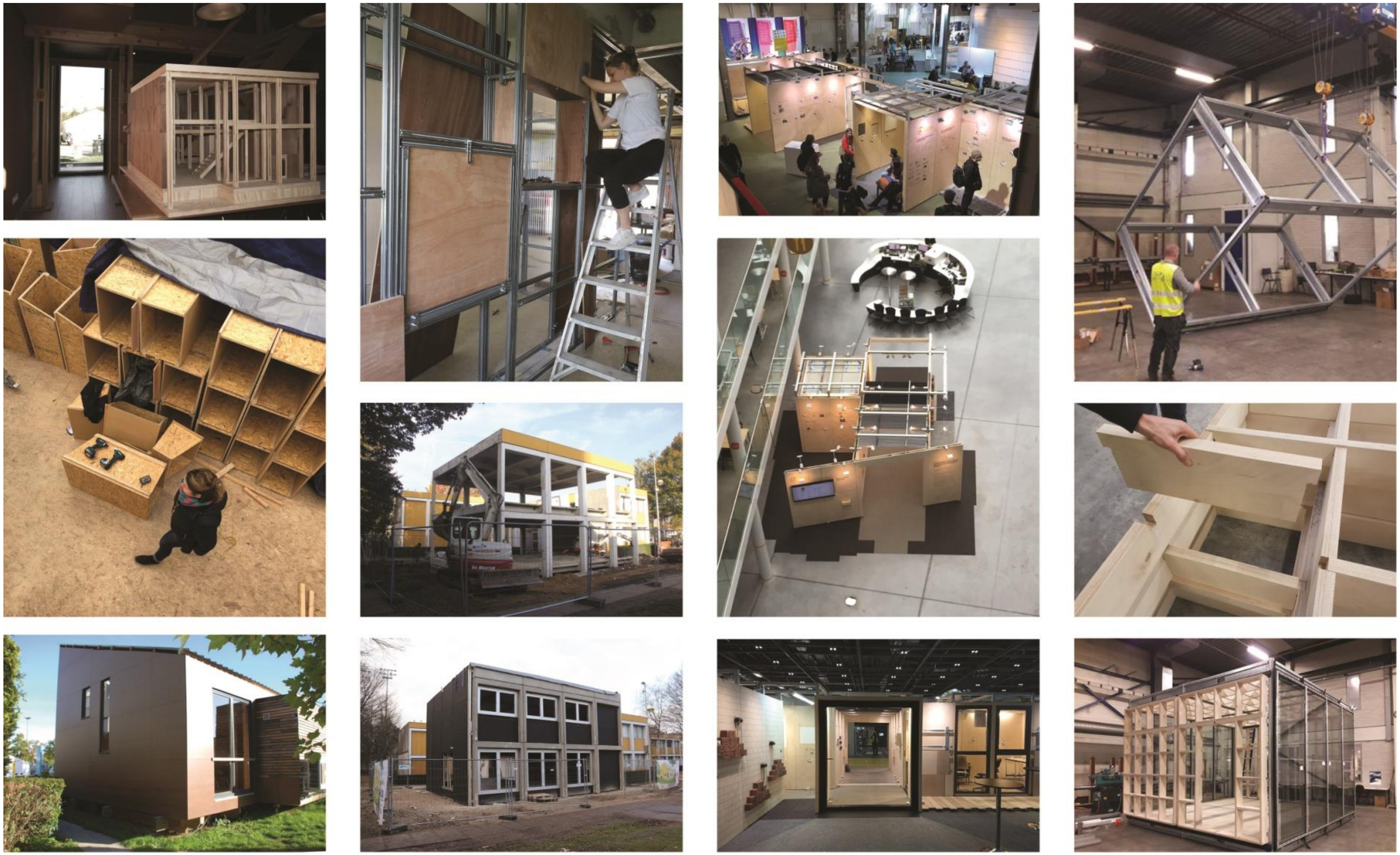



An exploration by Arup, Frener & Reifer, BAM and the Built Environment Trust of circular economy principles in the industry incorporating salt-water battery
https://www.arup.com/perspectives/the-circular-building

5 - Delivering CE solutions: C2C certified products

NASA Sustainability Base, Moffett Field, California, William McDonough + Partners
https://mcdonoughpartners.com/projects/nasa-sustainability-base/#big-image

6 - Delivering CE solutions



BAMB
BUILDINGS AS MATERIAL BANKS

TESTING BAMB RESULTS THROUGH PROTOTYPING AND PILOT PROJECTS

D14 – 4 pilots built & feedback report 28.02.2019

BAMB Building As Material Banks – EU project completed 2019 (www.bamb2020.eu)

Delivering CE solutions - BAMB






BAMB Building As Material Banks – EU project completed 2019 (www.bamb2020.eu)

Benefits and conclusion

Impact of design for closed loop on waste to landfill: Cardiff closed loop flats



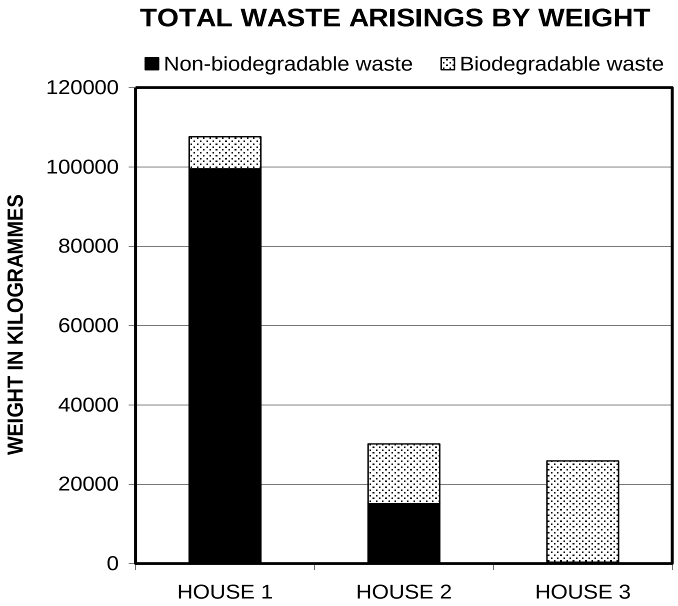






Quantifying the benefits of CE design to whole building

Roof: concrete tile covering House 1			Overall compliance with closed loop material cycle criteria		x
Constituent part compliance			Key: compliant = ✓ non-compliant = x Disposal options: RI = Industrial recycling RN = Natural recycling L = Landfill or incineration		
Constituent part description			Quantity		RI/RN/L
Roof slates			1320 kg		L
Deconstruction process	✓	notes			
Ability to access	✓	accessible with scaffolding			
Accessibility of fixings	✓	good			
Types of connections	✓	good			
Durability of fixings	✓	good			
Information	✓	standard construction			
Recycling process					
Concrete	**Recycling through industrial processes**	x	**Recycling through natural processes**	x	
	Infinite recycling	x	Rate and efficiency		
	Processing efficiency	x	Hazards and quality		
	Hazards	✓			



Case study
Timber framed Cardiff Ecoflats designed for deconstruction and closed loop material cycles would result in 85% reduction in materials by weight that would go to landfill

Economic adaptability to addressing climate change?

Case study – 1960s office building in London, ca 2000sqm, upgraded in 1997 adding an additional 6th floor

Elements included in the study

- Curtain walling
- Stone cladding elements
- Roofing system

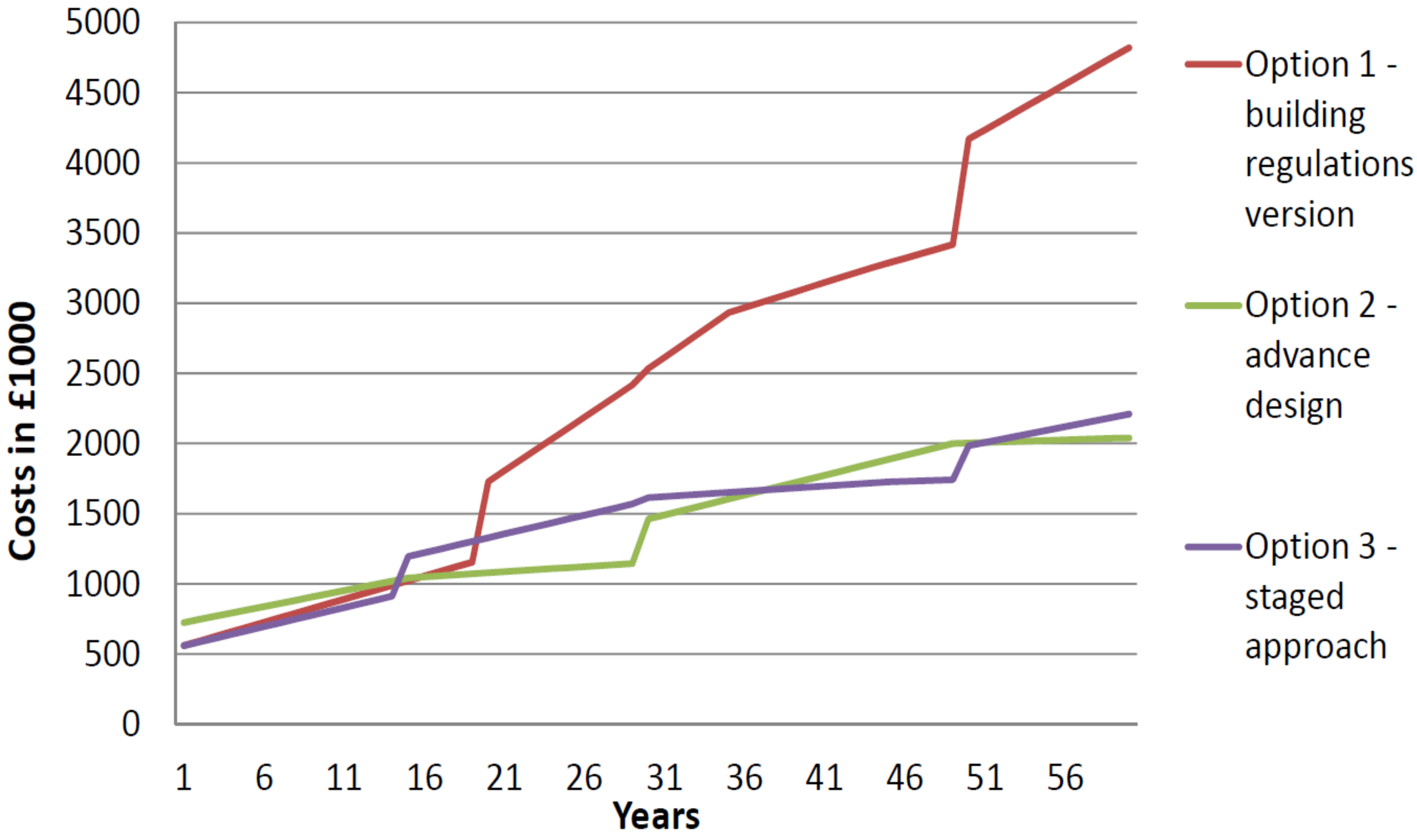
Measurements to include over 60 years

- Embodied energy of external envelop
- Operating energy for heating
- Waste associated with external envelop
- Cost of building operation, maintenance and waste

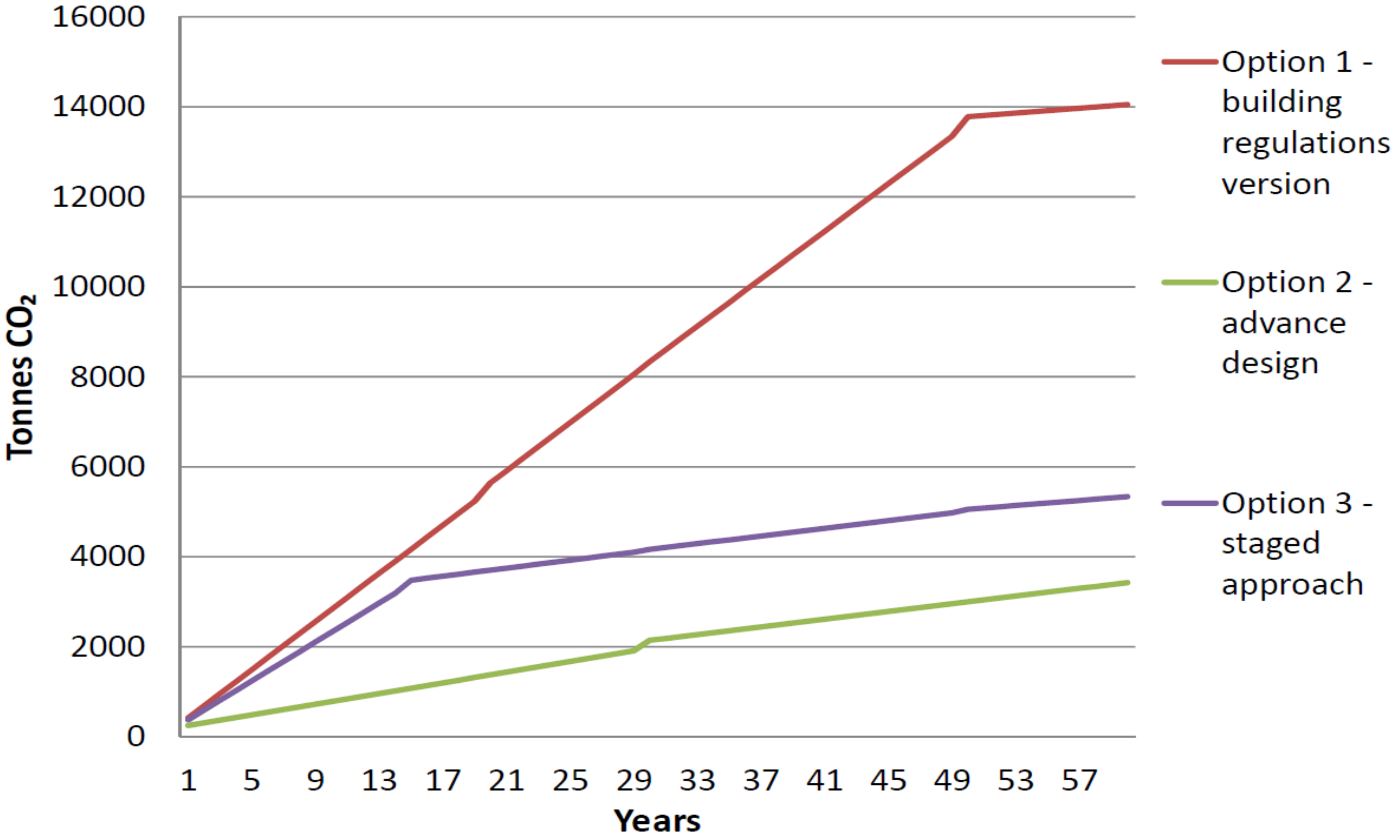
Staging of building upgrades over 60 years

	Year 0	Year 15/ 20	Year 30	Year 50
Option 1 **Minimum capital cost with minimum building regulations compliance**	Double glazed curtain walling 10ach 90mm roof insulation 50 mm insulated stone cladding	Commercial refurbishment: Double glazed facade upgraded with improved airtightness 4ach	Roof recovered with additional insulation	Performance retrofit: Triple glazed facade stone cladding insulation airtightness 2ach
Option 2 **State of the art environmental design** **Capital cost not limited**	Triple glazed curtain walling with 2ach 250mm roof insulation 150mm insulated stone cladding		Replacement curtain walling with PV integrated system Replacement roofing	
Option 3 **Staged approach** **Minimising capital cost**	Double glazed curtain walling mechanically fixed - airtightness 4ach 90mm roof insulation 150 mm insulated stone cladding	Performance retrofit: Triple glazed facade with integrated PVs airtightness 2ach	Roof recovered with additional insulation	Performance retrofit: Triple glazed facade with integrated advanced PVs

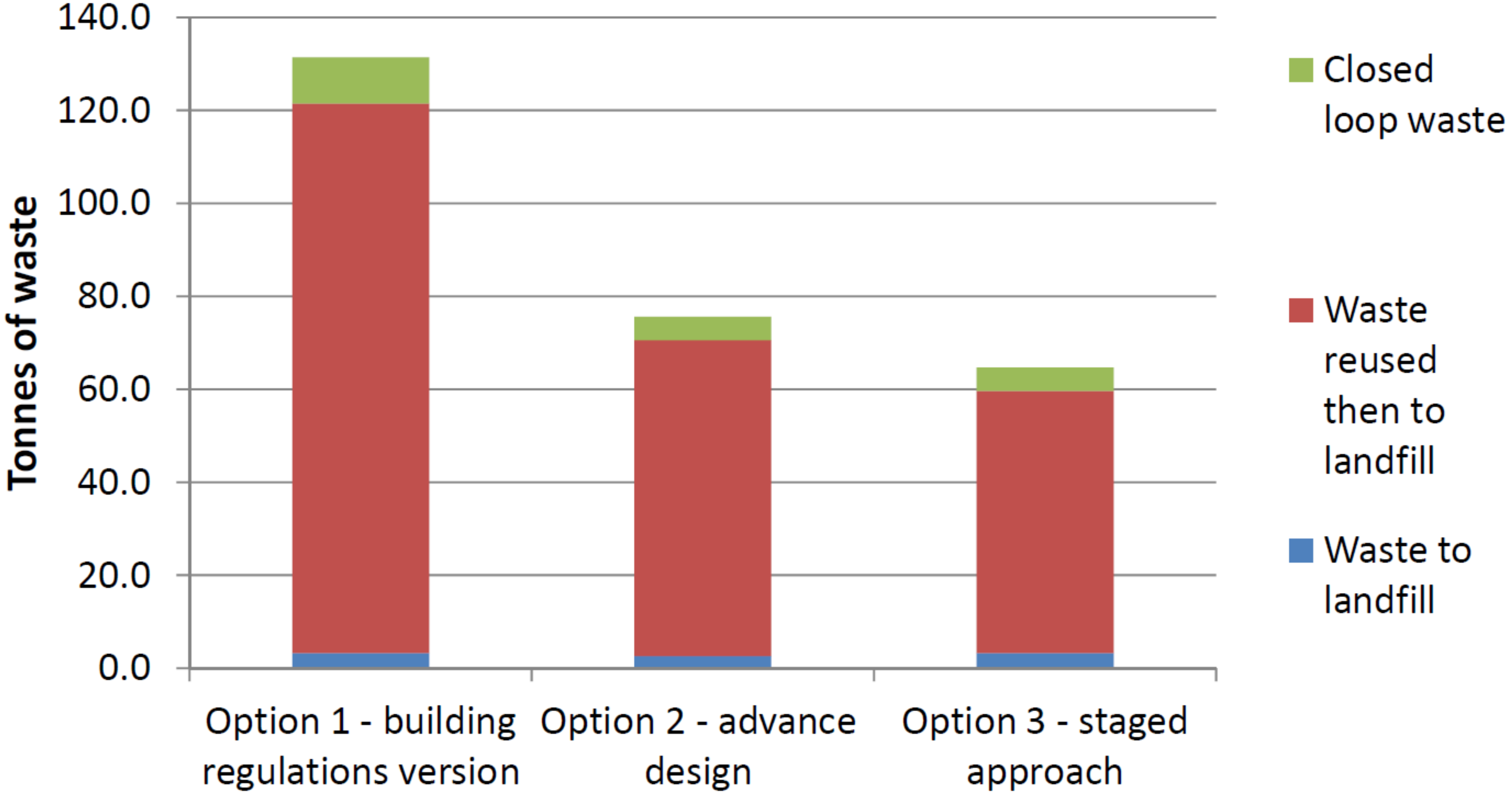
RESULTS - Total cost associated with building envelop and operational energy over 60 years



RESULTS - Total CO2 emissions associated with building envelop and operational energy over 60 years



RESULTS - Total waste associated with building envelop over 60 years



Socio-economic benefits

New industries associated with

- Service industry for materials
- Storage of materials
- Dismantling by hand or robotic developments
- Maintenance businesses
- Repair industry
- Consultation on waste-free material-efficient design

Conclusion

Worth noting:

- CE and closed loop recycling is more than just recycling

Challenges:

- Principles of circular economy, DfD, reuse, and closed loop cycle materials in the building industry are well established but not extensively applied (possibly not so well understood)
- Technically feasible but there is room for improvement
- Still lack of awareness and knowledge
- Cost is a barrier
- Benefits appear to long term

Room for optimism:

- Environmental and social benefits will become more significant
- Costs benefits will begin to materialise as material, energy and waste costs rise

Thank you for listening

psassi@brookes.ac.uk