Using LCA to facilitate the development of a circular economy for refrigerated display cabinets in the UK

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Refrigerated Display Cabinets - RDCs

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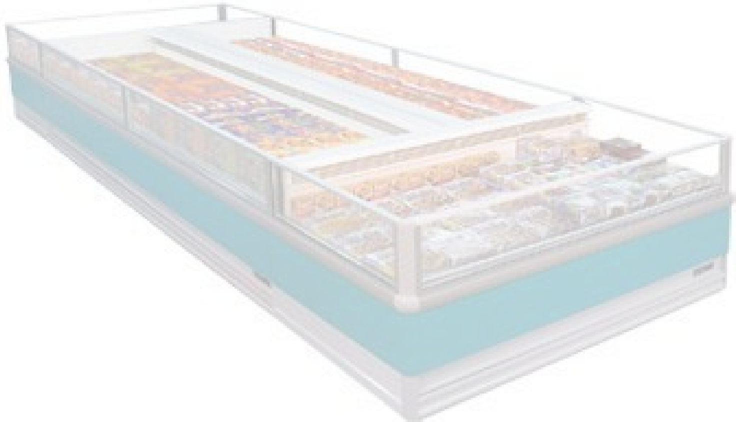
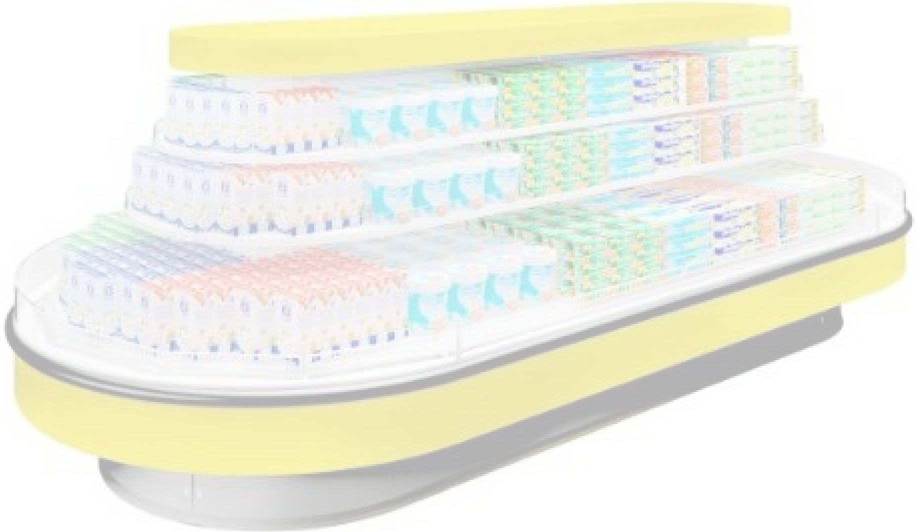
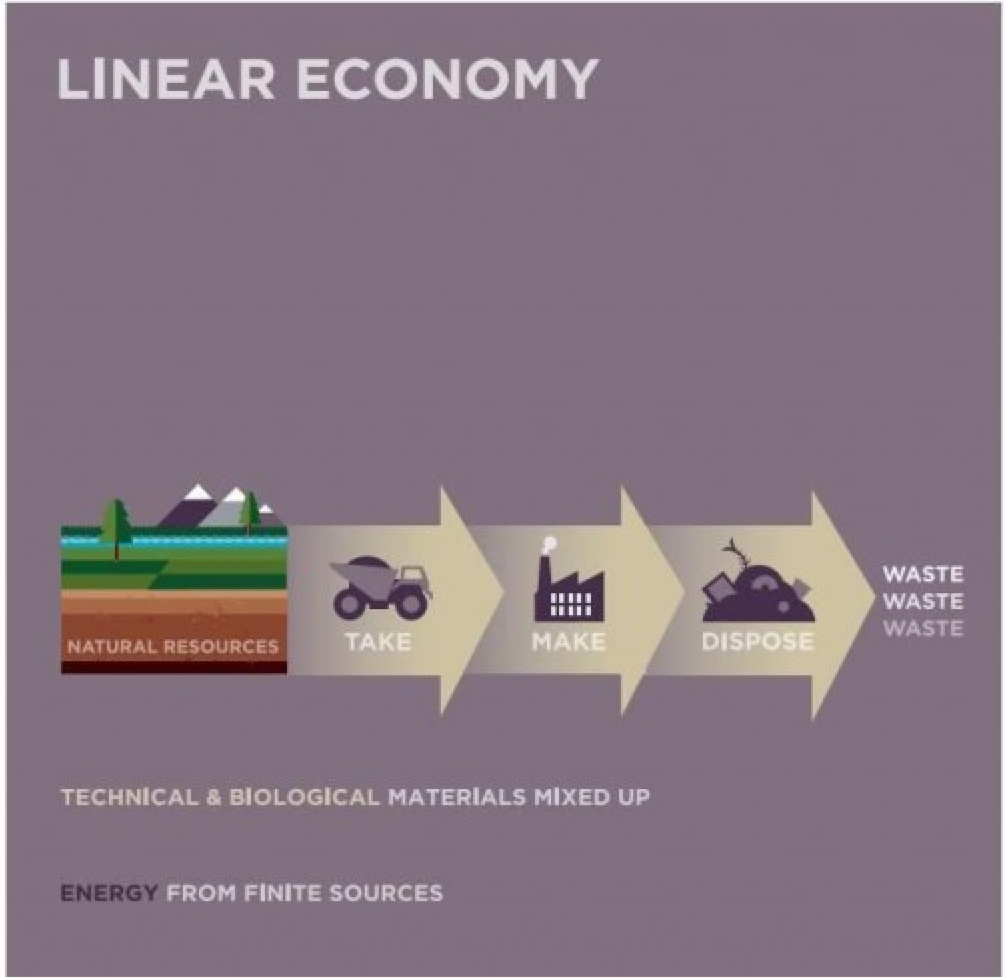
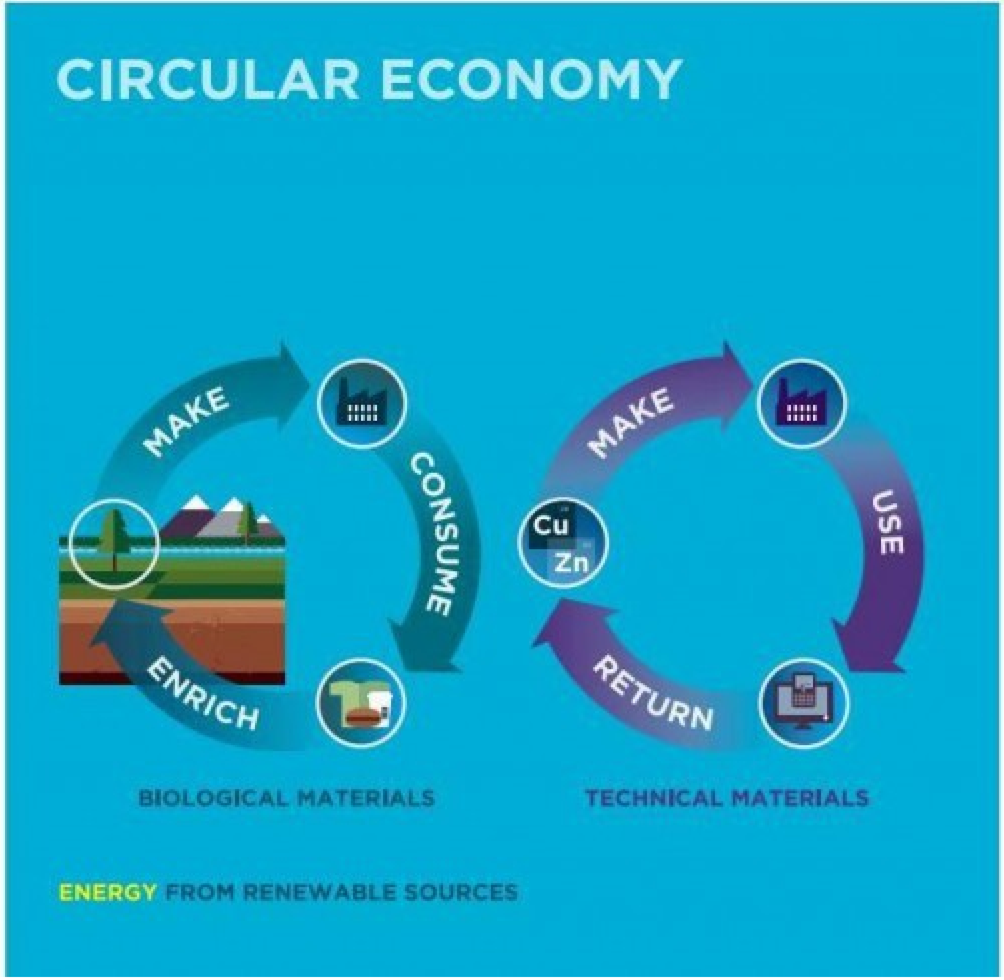




Ellen MacArthur Foundation Circular Economy Introductory Kit





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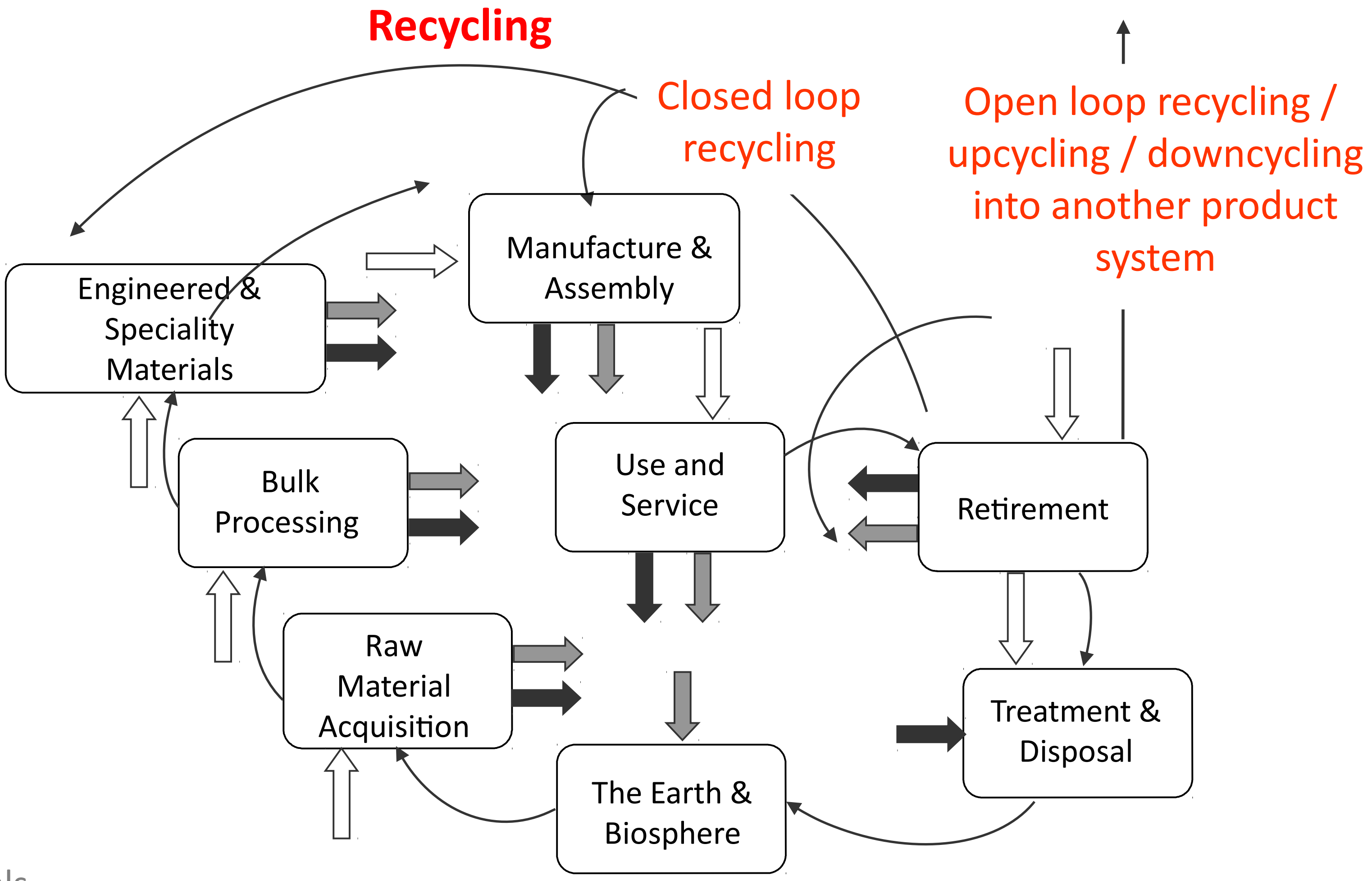
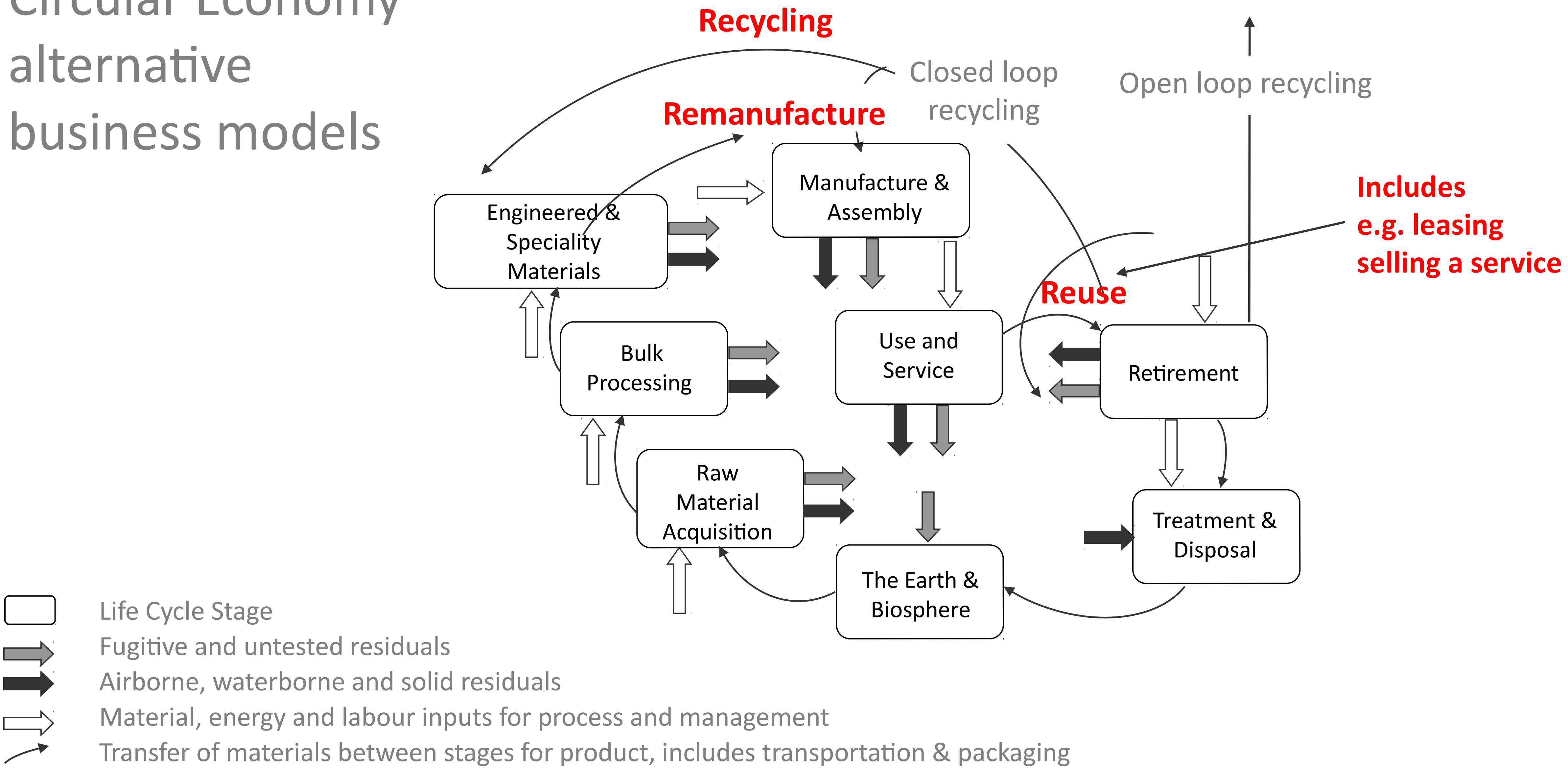
Circular Economy



Life Cycle Stage
Fugitive and untested residuals
Airborne, waterborne and solid residuals
Material, energy and labour inputs for process and management
Transfer of materials between stages for product, includes transportation & packaging

Environmental Protection Agency (EPA)
http://www.epa.gov/ORD/NRMRL/lcaccess/lca101.htm

Circular Economy alternative business models



Environmental Protection Agency (EPA)
http://www.epa.gov/ORD/NRMRL/lcaccess/lca101.htm

Using LCA to facilitate the development of a circular economy for refrigerated display cabinets in the UK

1. encourage remanufacturing and reuse of RDCs

In UK

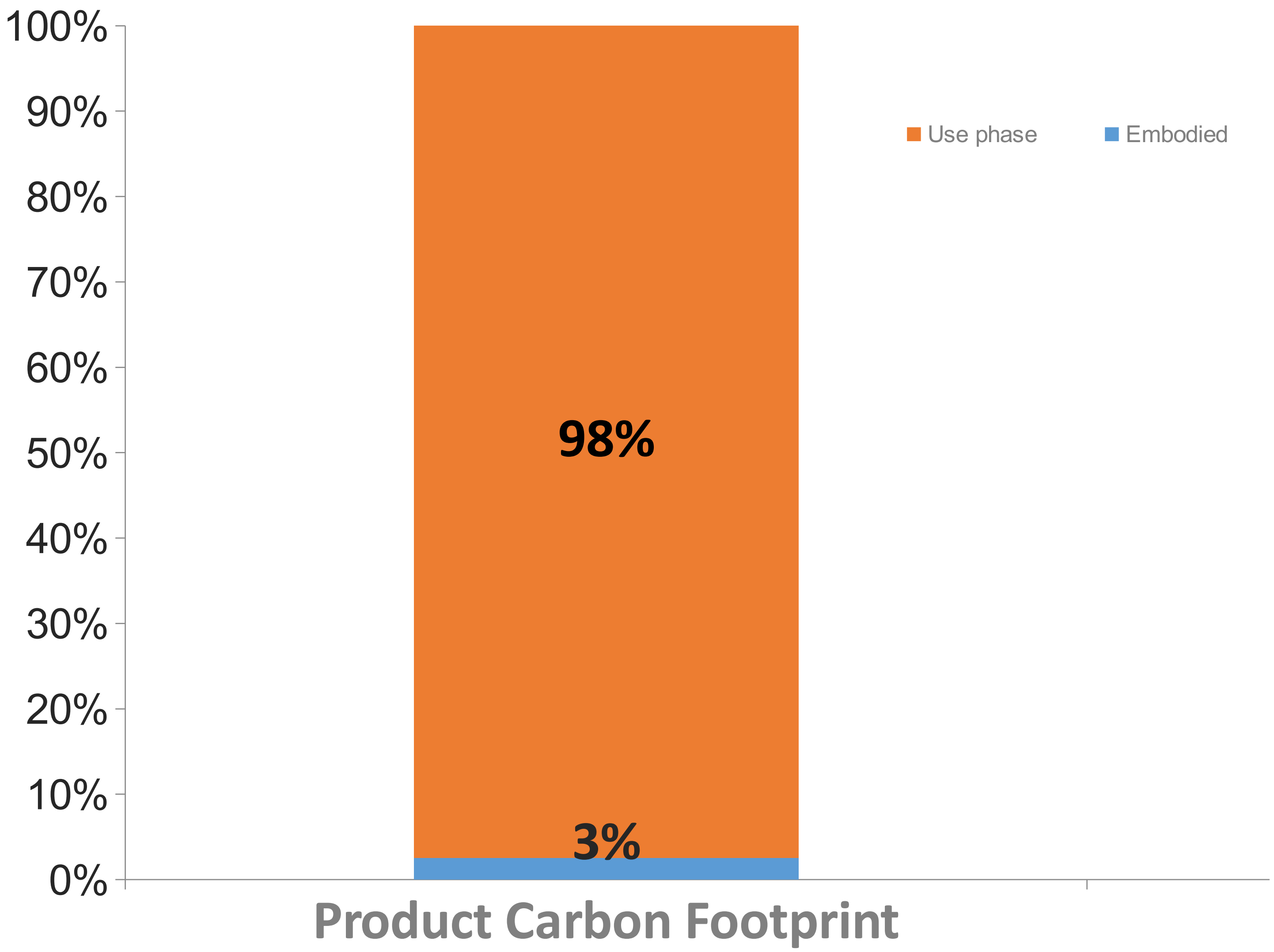
9,200+ supermarkets and food outlets

800,000 RDCs

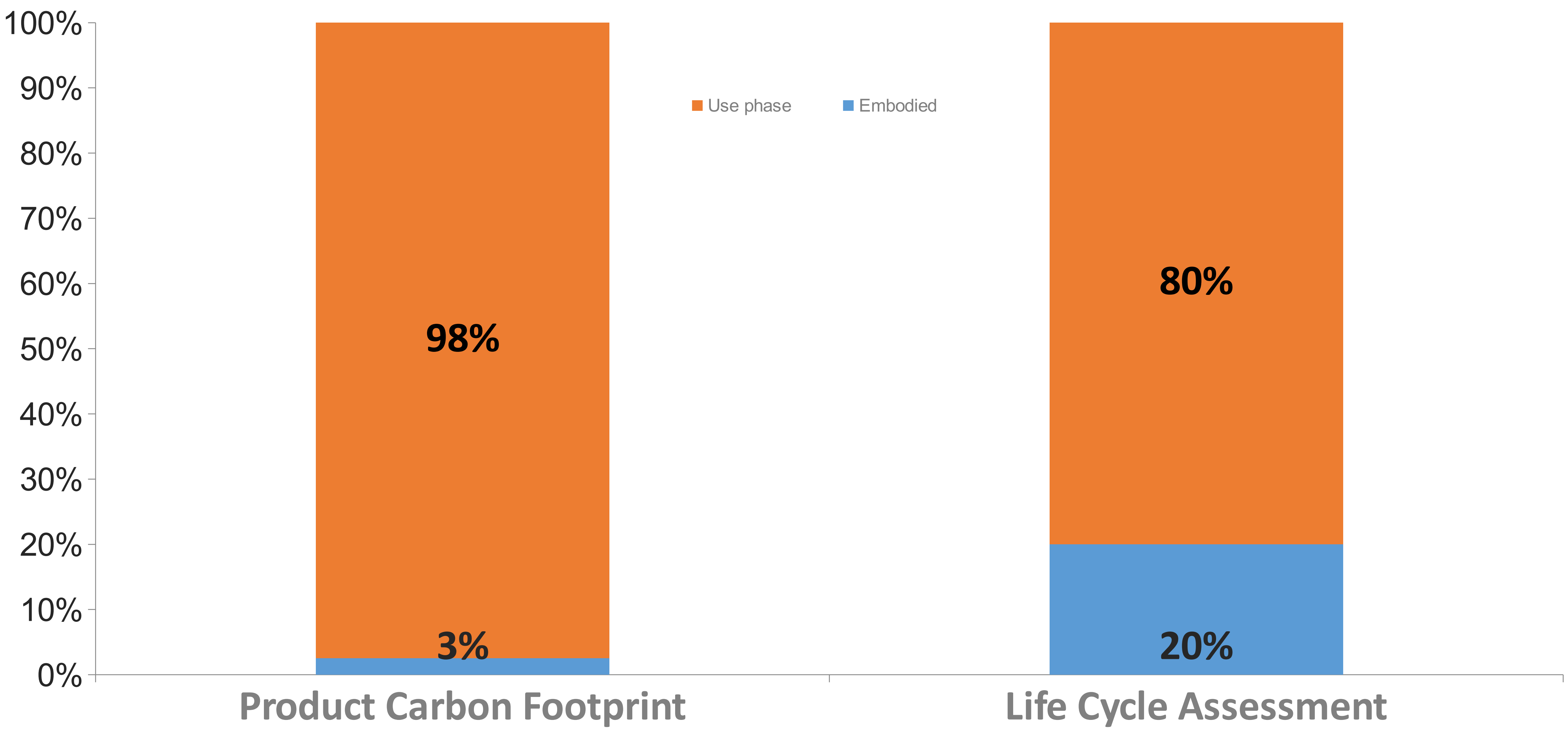
per year - supermarket refrigeration
uses 3.8 million kWh electricity and
produces 1.5 M tCO_{2e}

until now emphasis of environmental impact -
energy consumption and reduction

‘typical’ RDC - life cycle impact



‘typical’ RDC - life cycle impact



The BOND GROUP

supply all UK leading supermarkets and food retailers

UK lead - remanufacture of RDCs

BRITISH REFRIGERATION ASSOCIATION

FETA 30 SINCE 1984 Federation of Environmental Trade Associations

safecontractor APPROVED

SSIP SAFETY SCHEMES IN PROCUREMENT

CARBON TRUST

defra

remanufactured RDCs are as good as / better than new RDCs

includes component upgrade –
reduce operational energy:
replace fluorescent lights with LEDs ent
refrigeration systems s,
evaporators, c.)

remanufactured RDCs are as good as / better than new RDCs

reuse / remanufacture
of cabinets and parts and
- reduces materials use
- reduces energy inputs
- reduces environmental impact

remanufactured RDCs are as good as / better than new RDCs

reuse / remanufacture
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 reduces materials use
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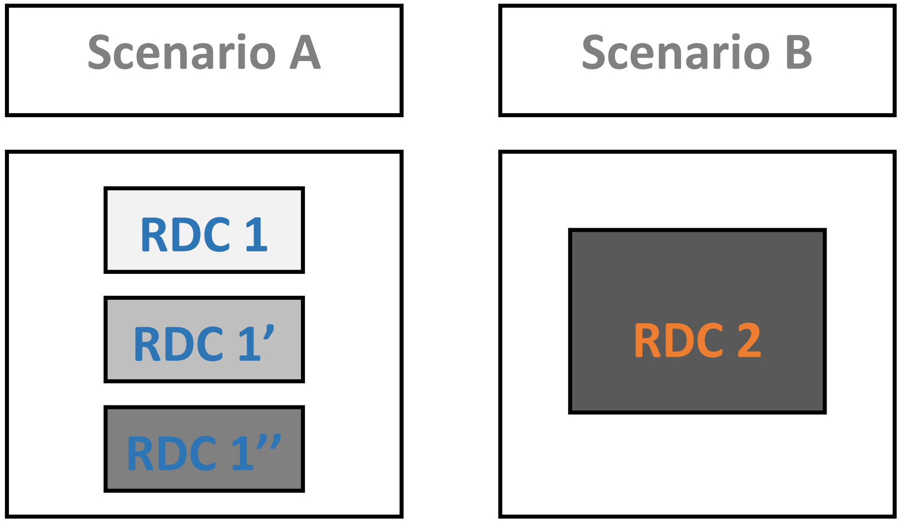
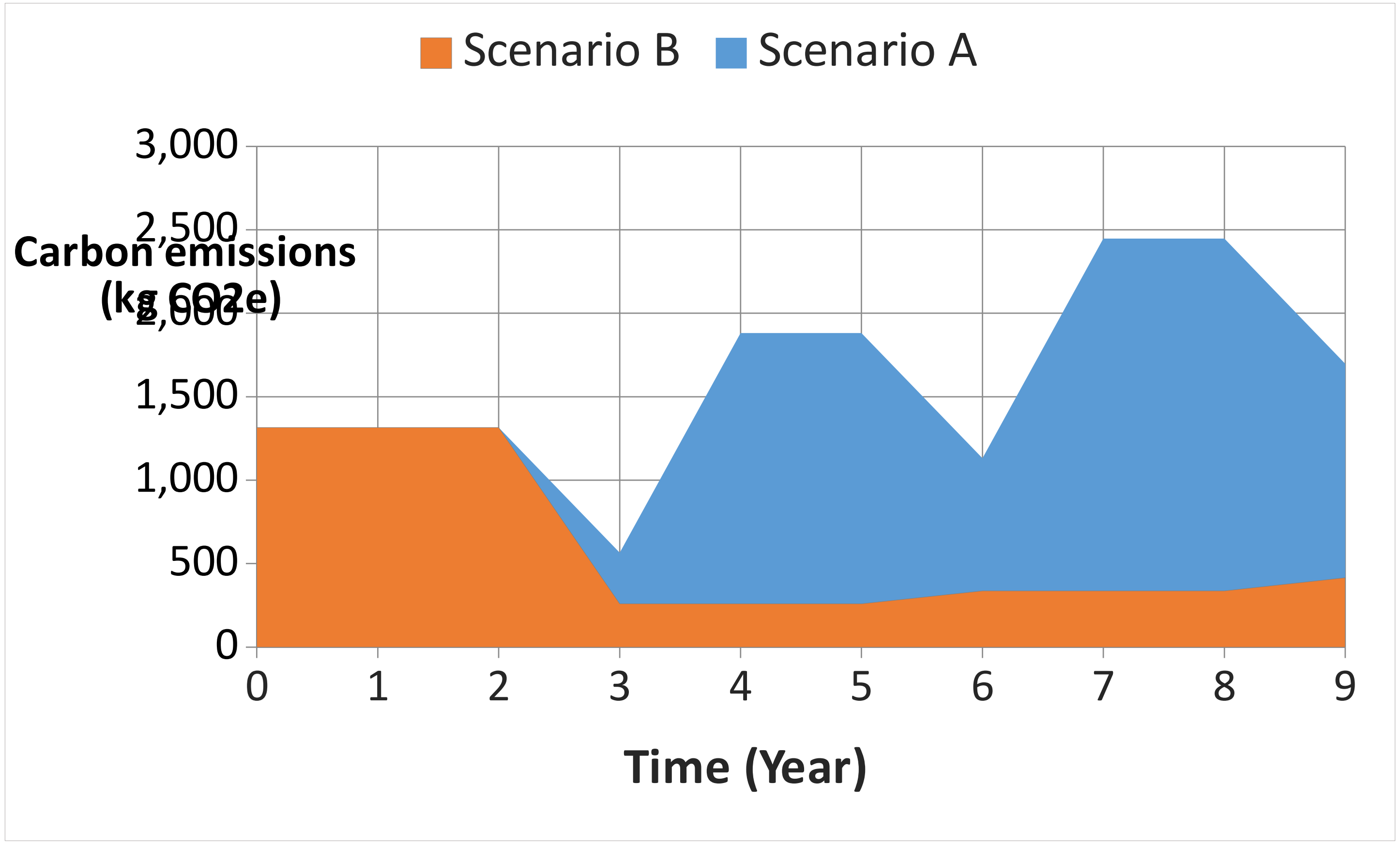
only 12.5% RDCs are remanufactured

Carbon Calculator – shows iterative refurbishment of RDCs reduces carbon output and costs





A report by the All-Party Parliamentary Sustainable Resource Group

All-Party Parliamentary sustainableresource Group

REMANUFACTURING

TOWARDS A RESOURCE EFFICIENT ECONOMY

Remanufacturing presents a huge financial and environmental opportunity for the UK. Estimates suggest that the value of remanufacturing in the UK is £2.4 billion[1], with the potential to increase to £5.6 billion[2] alongside the creation of thousands of skilled jobs. Further, the remanufacturing of products results in reduced greenhouse gas emissions, material use and water consumption when compared to the manufacture of new products. Remanufacturing can be considered one element of the wider 'circular economy', where products and components are designed, made and reused. However due to the opportunity that remanufacturing presents to the UK's economy it will be the sole focus of this paper.

There is no universally accepted definition of remanufacturing and there are widespread market and regulatory barriers which impede its uptake. This briefing paper identifies the opportunities and challenges relating to remanufacturing and makes recommendations to Government as to how it can overcome these.

Using LCA to facilitate the development of a circular economy for refrigerated display cabinets in the UK

1. encourage reuse of RDCs and
   use of remanufactured RDCs

2. assess materials suitability / potential substitution in Circular Economy

materials

average RDC – 450kgs

800,000 RDCs in UK

360,000 tonnes materials in use in sector

some materials recycled -
- could this be increased?
- alternative end-of-life treatment?

materials in a typical RDC	
metals	steel (stainless, carbon, galvanised), aluminium alloy, brass, copper
polymers – thermoplastics and thermoset plastics	rigid polyurethane foam (PUR), polystyrene (PS) & phenolic foams, polycarbonate (PC), polypropylene (PP), polyethylene (PE)
glass	plate, fibre
MDF (medium density fibreboard)	wood and other natural fibres, urea formaldehyde resin
electronics	including precious metals

materials **widely reused / recycled**	
metals	steel (stainless, carbon, galvanised), aluminium alloy, brass, copper
polymers – thermoplastics and thermoset plastics	rigid polyurethane foam (PUR), polystyrene (PS) & phenolic foams, polycarbonate (PC), polypropylene (PP), polyethylene (PE)
glass	plate, fibre
MDF (medium density fibreboard)	wood and other natural fibres, urea formaldehyde resin
electronics	including precious metals

materials **could be reused / recycled**	
metals	steel (stainless, carbon, galvanised), aluminium alloy, brass, copper
polymers – thermoplastics and thermoset plastics	rigid polyurethane foam (PUR), polystyrene (PS) & phenolic foams, polycarbonate (PC), polypropylene (PP), polyethylene (PE)
glass	plate, fibre
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materials **could be substituted?**	
metals	steel (stainless, carbon, galvanised), aluminium alloy, brass, copper
polymers – thermoplastics and thermoset plastics	**rigid polyurethane foam (PUR),** polystyrene (PS) & phenolic foams, polycarbonate (PC), polypropylene (PP), polyethylene (PE)
glass	plate, fibre
MDF (medium density fibreboard)	wood and other natural fibres, urea formaldehyde resin
electronics	including precious metals

2. assess materials suitability / potential substitution in a Circular Economy

use LCA – compare range of different materials, manufacturing, installation processes, end-of-life scenarios and operational energy inputs

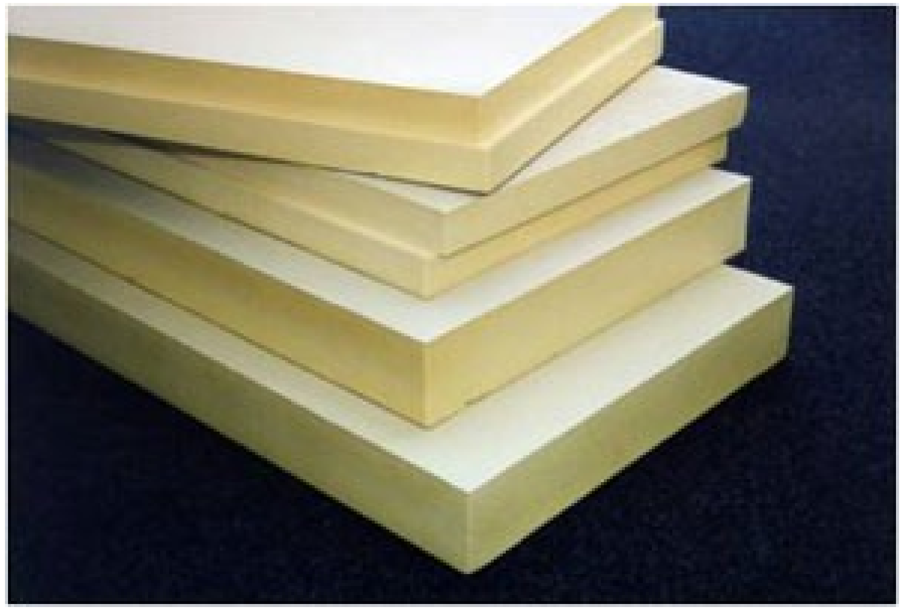
more comprehensive accurate than carbon 'footprint'

PUR (rigid polyurethane foam) insulation





PUR sheets - construction industry and refrigeration units



for Circular Economy - can PUR be substituted?

established synthetic materials

mineral wool

glass fibre

high-tech synthetic materials

VIP (vacuum insulated panels)

aerogel

natural

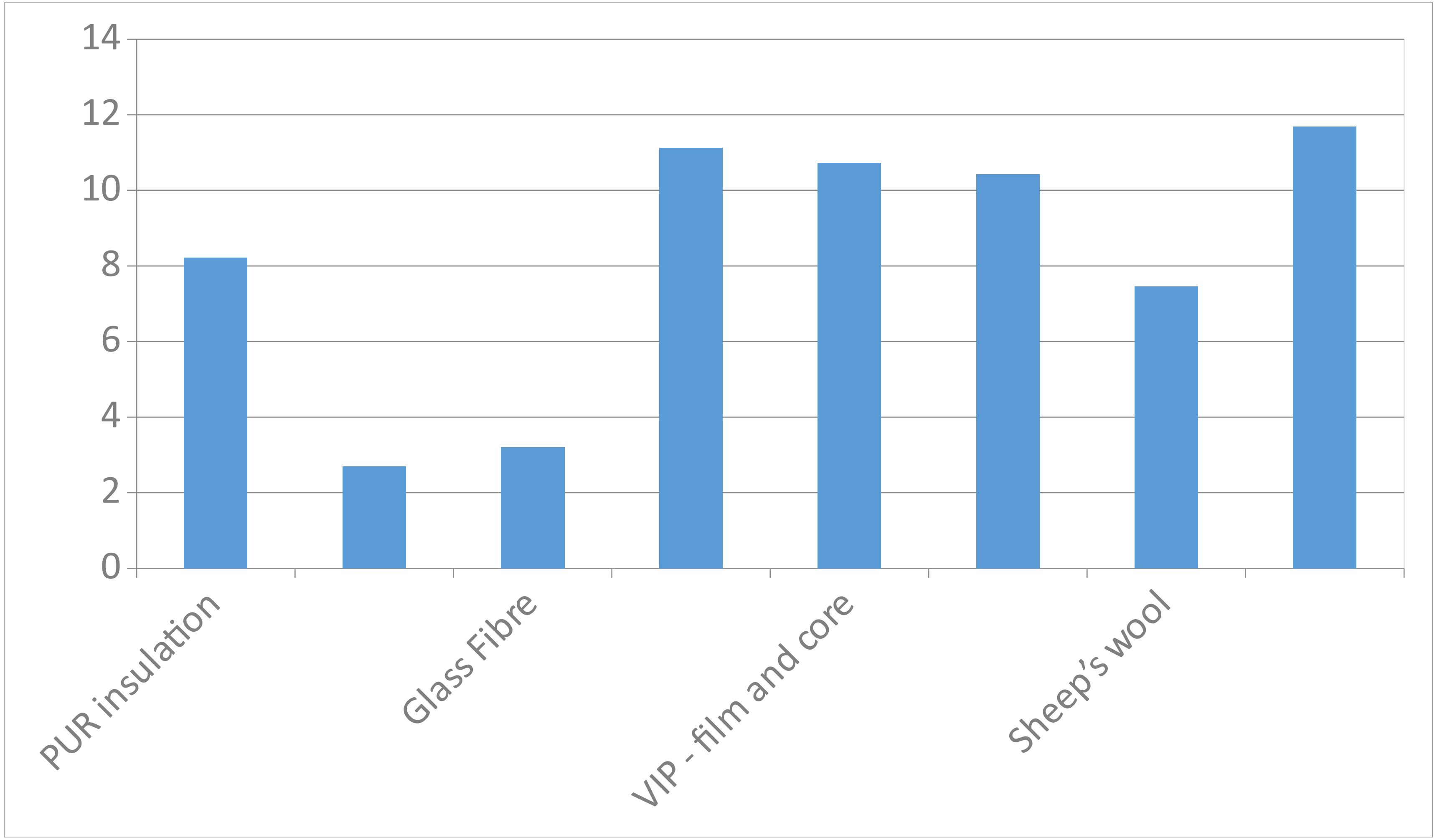
cork

sheep's wool

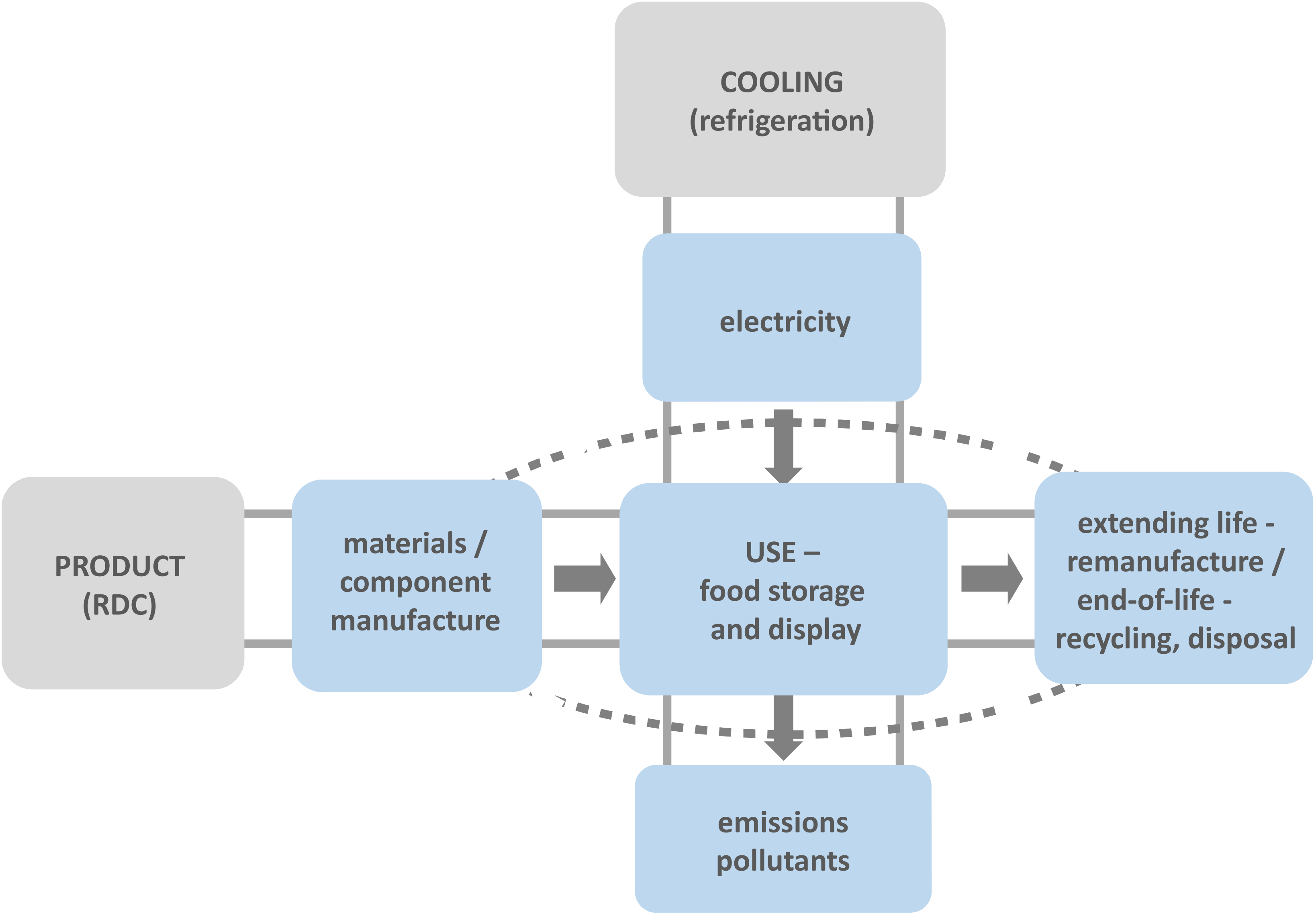
cotton

insulation panel - 1.8m (w) x 1.86m (h) x 40mm (d)

Product only - impact in mPoints



whole life cycle: integrating energy & product chains



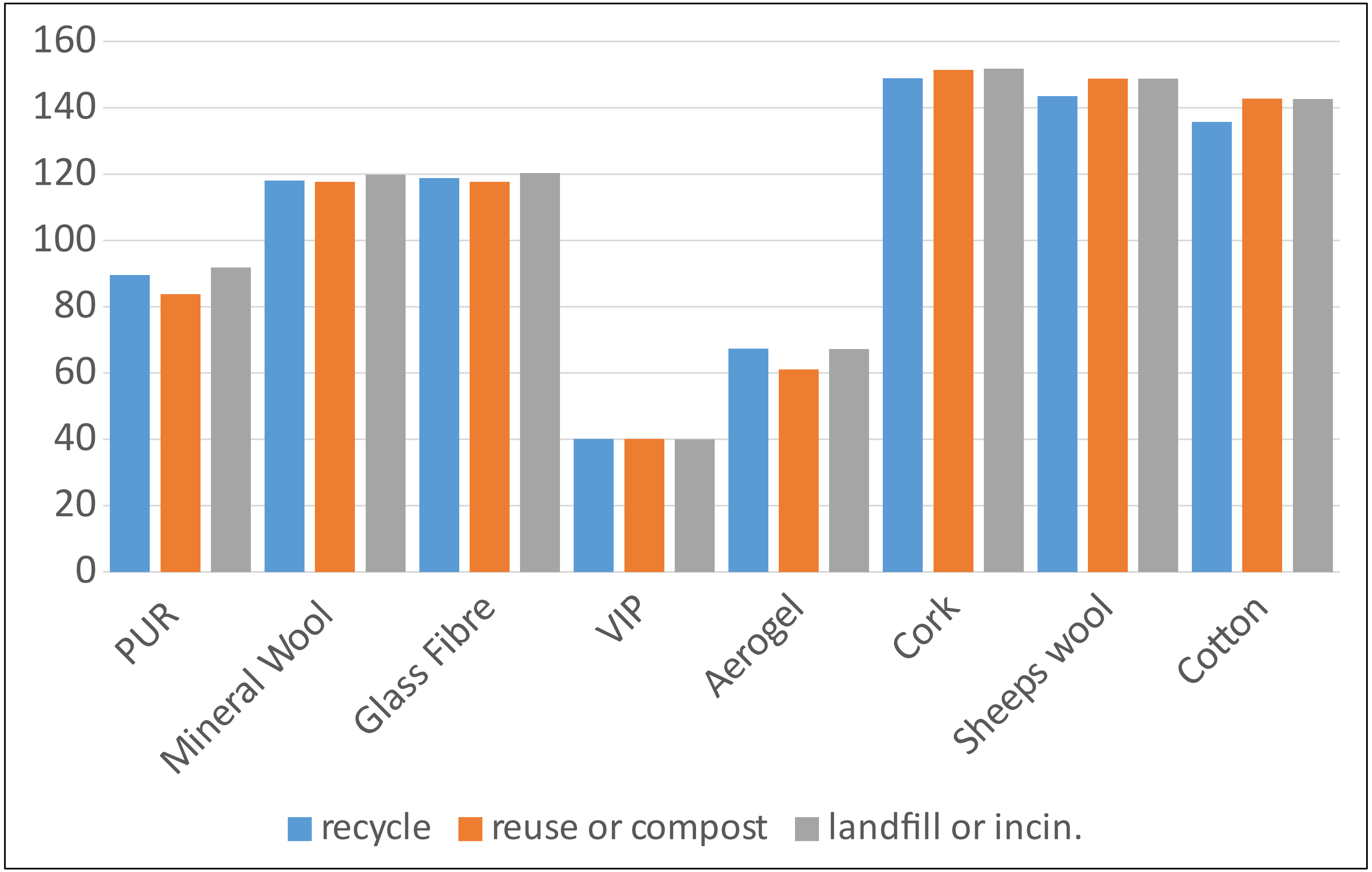
developing a Circular Economy - end-of-life scenarios

materials group	materials	end-of-life scenario			
		reuse	recycle	compost	landfill / incin.
established synthetic materials	PUR	chipped with resin - board	chemical / pyrolysis		✓
	mineral wool	✓	✓		✓
	glass fibre	✓	✓		✓
high-tech synthetic materials	VIP	filler / incinerate film	filler / incinerate film		✓
	aerogel	✓	✓		✓
natural	cork	✓	✓	✓	✓
	sheep's wool	✓	✓	✓	✓
	cotton	✓	✓	✓	✓

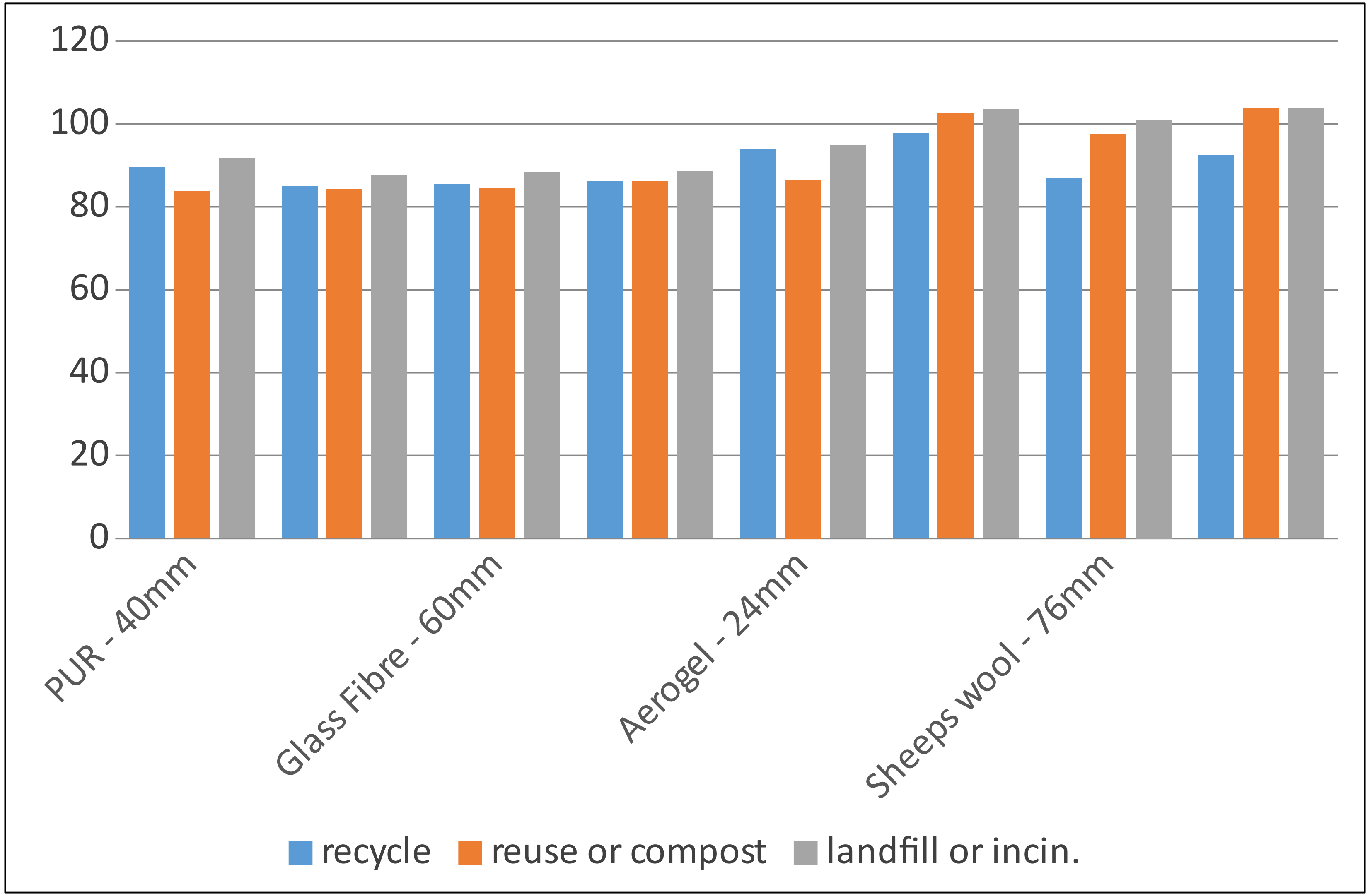
materials properties & performance	PUR	mineral wool	Fibreglass	VIP	Aerogel	Cork 160kg/m³	Sheep's wool	Cotton
Thermal conductivity ($W\ m^{-1}\ K^{-1}$)	**0.022**	**0.033**	**0.033**	**0.008**	**0.014**	**0.042**	**0.042**	**0.038**
Thickness (mm)	40	40	40	40	40	40	40	40
U value ($W\ m^{-2}\ K^{-1}$) heat loss	0.47	0.66	0.7	0.2	0.32	0.8	0.8	0.7
Heat through insulation (W)	97	136	136	39	61	164	164	152
Energy use ($kW.h\ yr^{-1}$)	**567**	**794**	**794**	**227**	**380**	**959**	**959**	**888**
CO_2 from use (kg CO_{2e} yr^{-1})	252	354	354	101	169	427	427	395
Volume of insulation (m^3)	0.411	0.411	0.4	0.4	0.411	0.411	0.411	0.4
Density of insulation ($kg\ m^{-3}$)	42	45	45	composite	109	160	14	19
Mass of insulation (kg)	17	18.5	19	33 (80% core, 20% film)	45	66	6	8

Life Cycle Impact over 5 years

40mm insulation / different thermal performance



Life Cycle Impact over 5 years –
same thermal performance / different thickness insulation



Conclusion and future work

RDCs - PUR cannot be easily recycled or reused
substitute other materials – develop a Circular Economy?

40mm panels -

thermal performance - on average impact of operational energy is 14 times higher than impact of insulation

has a significant impact on Life Cycle of all materials

must be included in Life Cycle Assessment

natural / organic materials – can be recycled / composted

suggests - more suitable for Circular Economy but

thermal performance is relatively poor - overall environmental load is high

established synthetic materials - thermal performance is relatively poor - overall environmental load is higher than PUR

hi-tech synthetic materials – excellent thermal insulation properties, filler/core can be reused but film can't – is this suitable for Circular Economy?

Conclusion and future work

Structure and form:

PUR is structural – can’t necessarily substitute materials
e.g. VIPs / Aerogel - present shape – can only be used for flat panels (e.g. back)
Will other materials fill voids as well as PUR?
do panels need to be redesigned for substitute insulation materials?

VIPs are relatively fragile – wastage could be higher –
increase environmental load & cost

Could PUR be blown into film for easy disassembly?
Could steel panels be coated with release agent?
Could this be viable if commercial recycling facilities are developed?
Will benefits be short term as oil prices / PUR rise?

Conclusion and future work

Panels – same thermal performance / different thickness

Natural materials compare favourably with synthetic materials but panels are thicker

Need to investigate

technical feasibility (structure, assembly and disassembly)
impact of additional steel and
all economic factors

Finally…

Developing a Circular Economy is very complex

LCA is invaluable tool in development of CE –

1. clearly illustrates benefits remanufacture
2. LCA results have raised rather than answered questions
   clearly highlighted areas for further investigation

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New Designs for a Circular Economy

http://vimeo.com/80559448