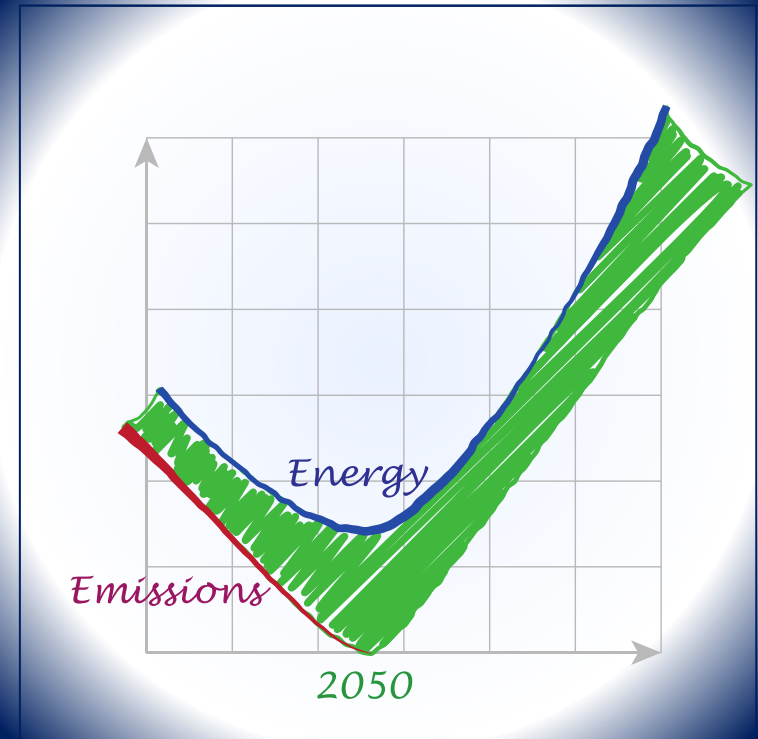


UK FIRES: Absolute Zero, Materials and Manufacturing

UK Manufacturing Forum
Tuesday 8th March 2022

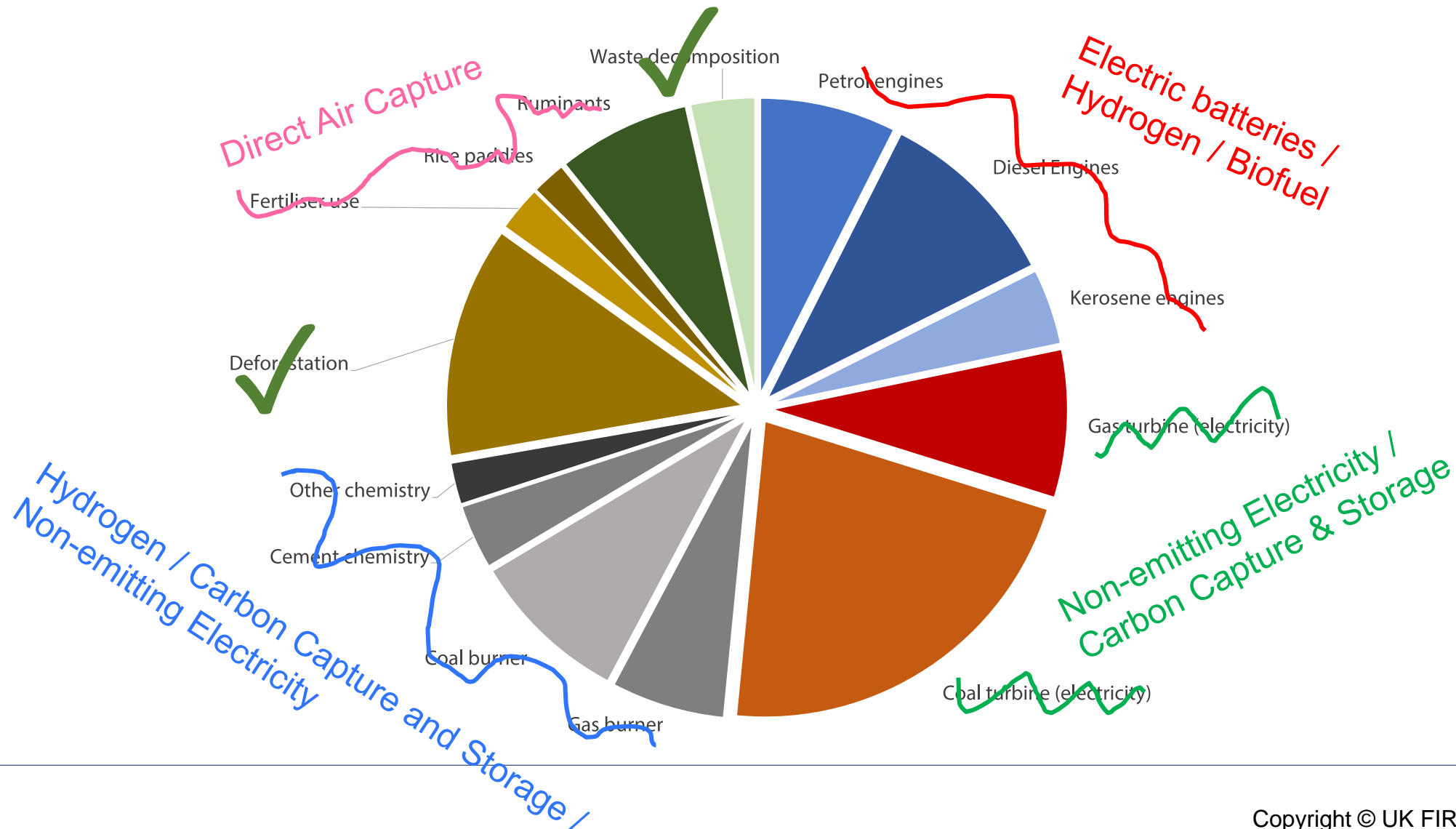
Dr Christopher Cleaver
Professor Julian Allwood
Dr. José Azevedo
Dr. Philippa Horton

Absolute Zero



Incumbent thinking on how to reach zero emissions

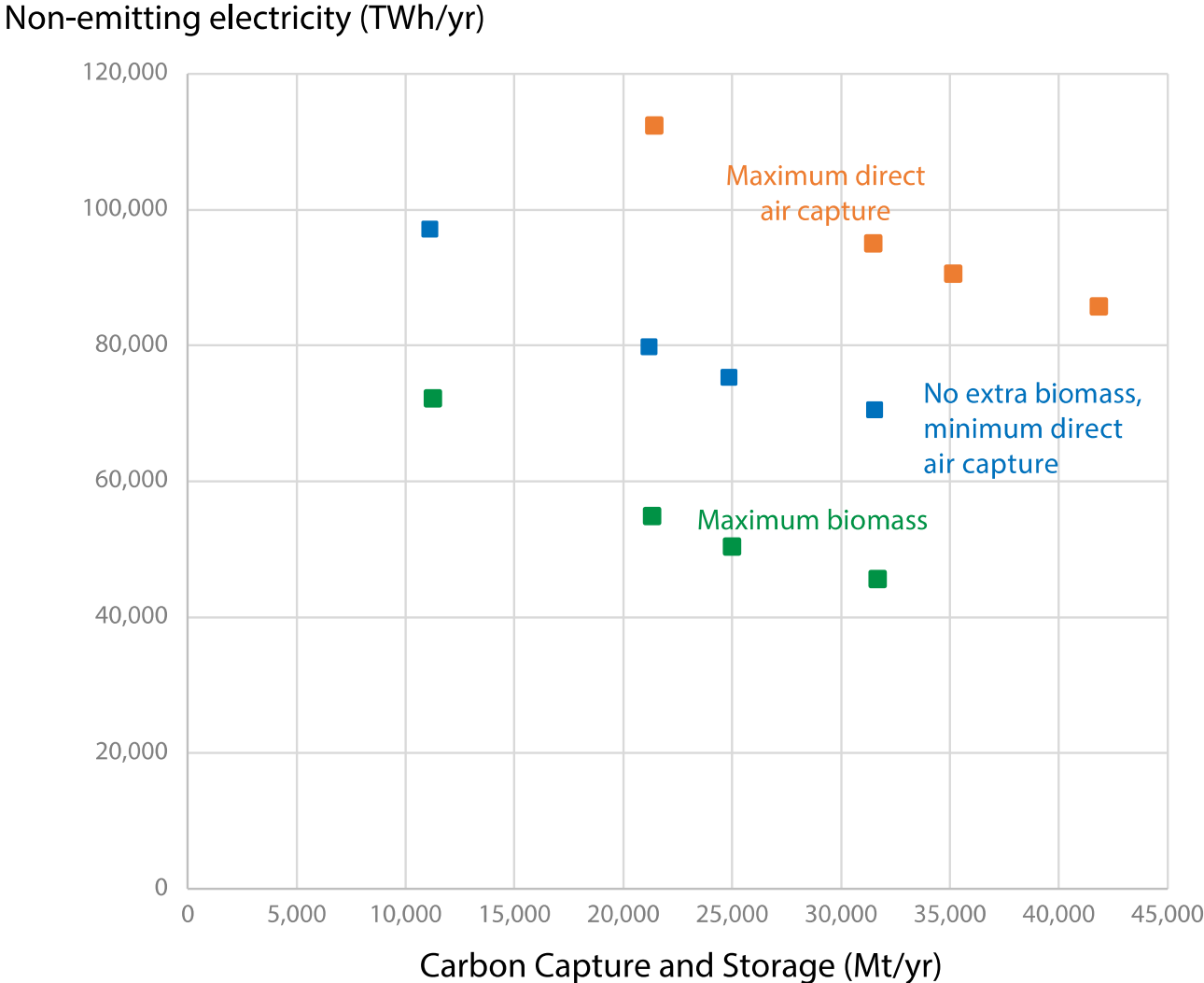
Global drivers of global warming: what we have to stop doing



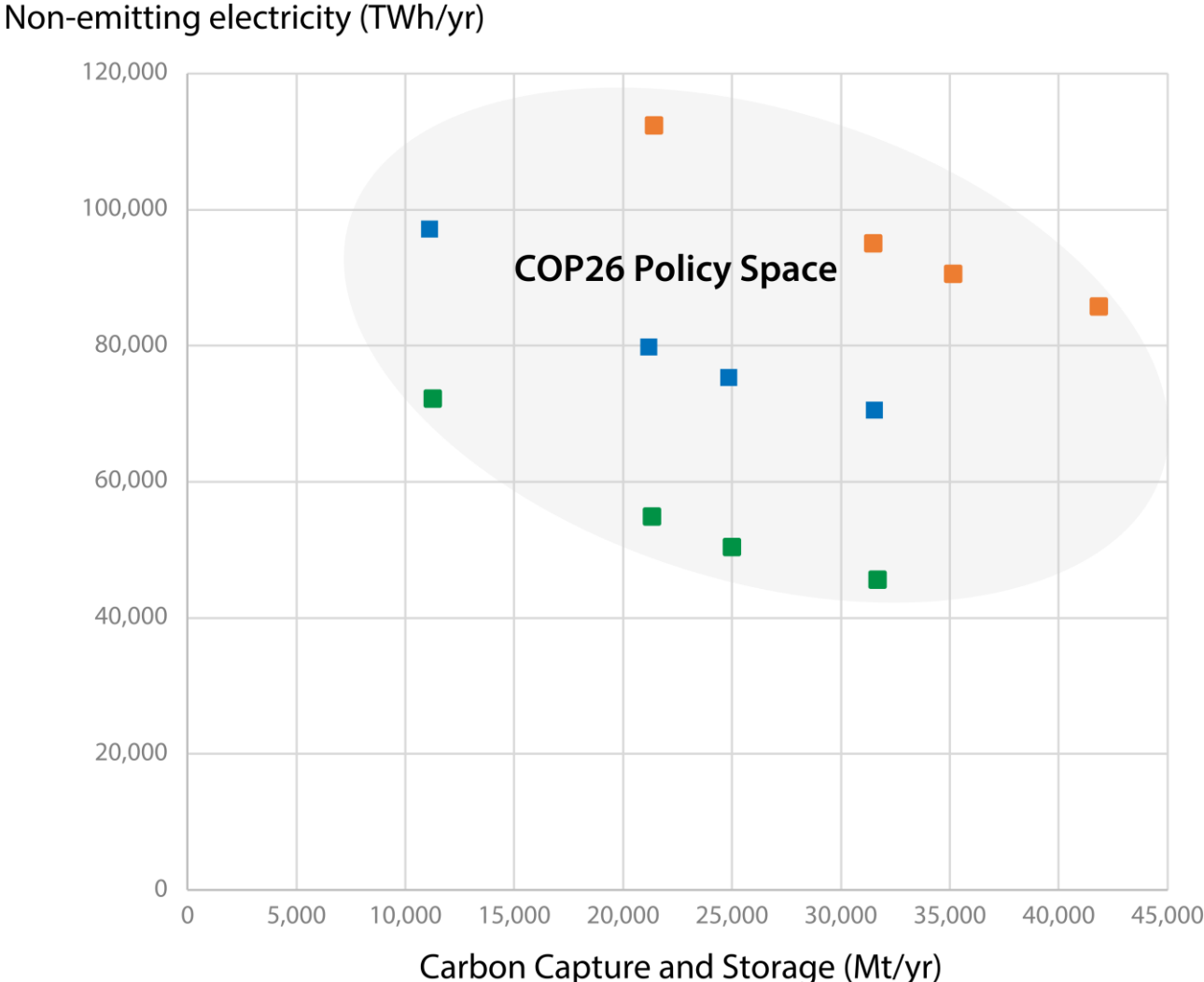
Analysis of techno-optimistic resource needs

Sector	2020 GHGs (MtCO2/yr)	Physical units	Option 1	Option 2
Road vehicles	6,100	2,700 G litres petrol/diesel	140-320 litres biofuel per tonne biomass	6 litres petrol equivalent to 20kWh electric power
Train	200	40 G litres diesel	As above	As above
Shipping	900	370 G litres diesel	As above	19kWh per litre synthetic fuel
Aviation	2,900	470 G litres kerosene	As above	As above
Electricity (emitting)	10,000	17,000 TWh	10,000 Mt CCS	17,000 TWh non-emitting generation
Electricity (non-emitting)		9,900 TWh		
Space heating	6,700	8,800 TWh gas boiler output	6,700 Mt CCS	1kWh heat pump = 3.1kWh gas boiler
Blast furnace Steel	3,700	1,400 Mt Steel	3,700 Mt CCS	3.5MWh/tonne steel via green hydrogen
Cement	3,100	4,100 Mt Cement	3,100 Mt CCS	
Other industry	6,700		6,700 Mt CCS	Same total electricity as steel
Deforestation	1,100	Assumed to stop		
Fertiliser/rice/soil/crop	5,300	Un-changed	Direct Air Capture	
Ruminants	3,000	Un-changed	Direct Air Capture	
Waste	1,600	Assumed to stop		
Direct Air Capture		Applicable to all emissions	4MWh/t capture and store plus 1 t CCS per t DAC	

Incumbent thinking on how to reach zero emissions (global)

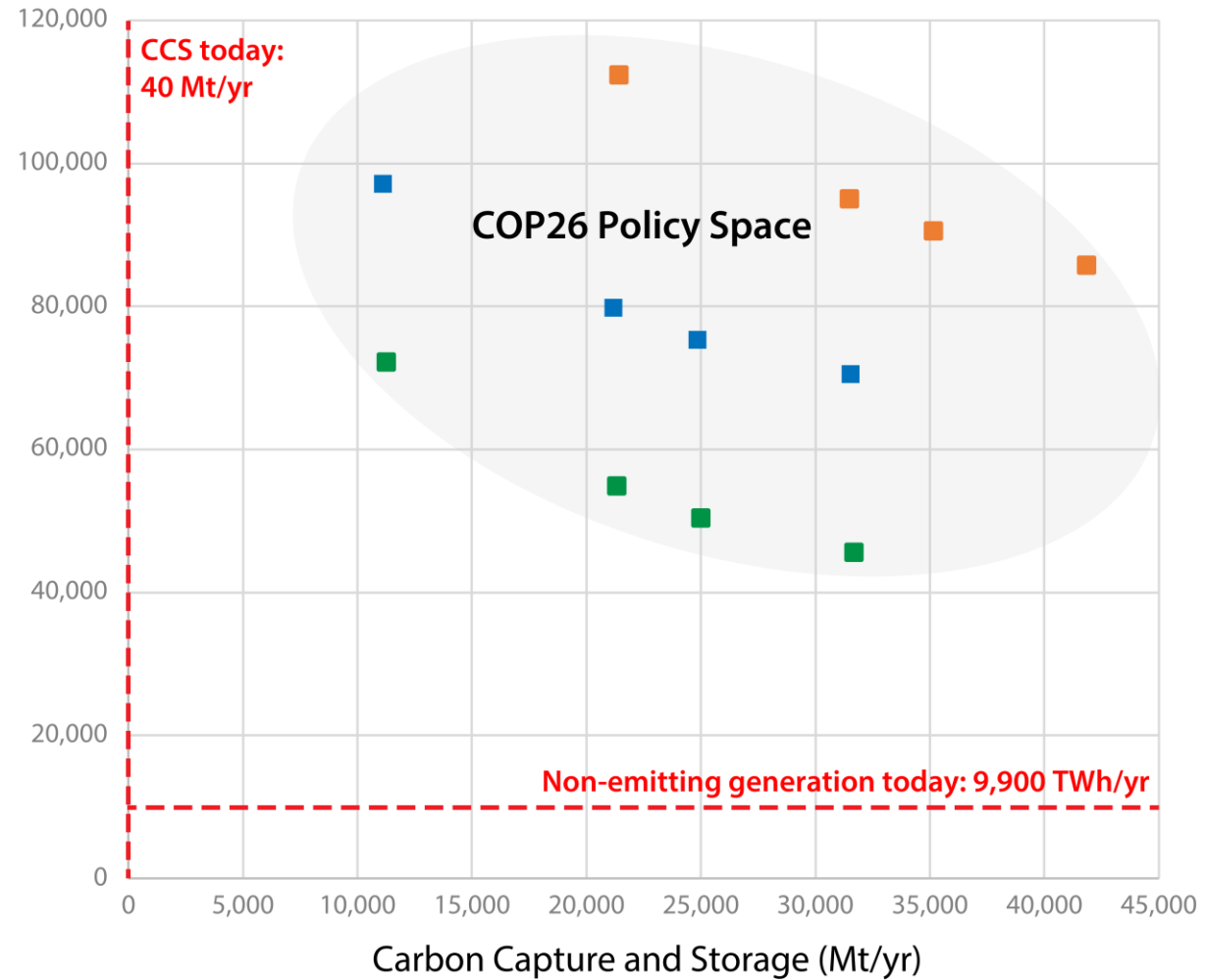


Incumbent thinking on how to reach zero emissions



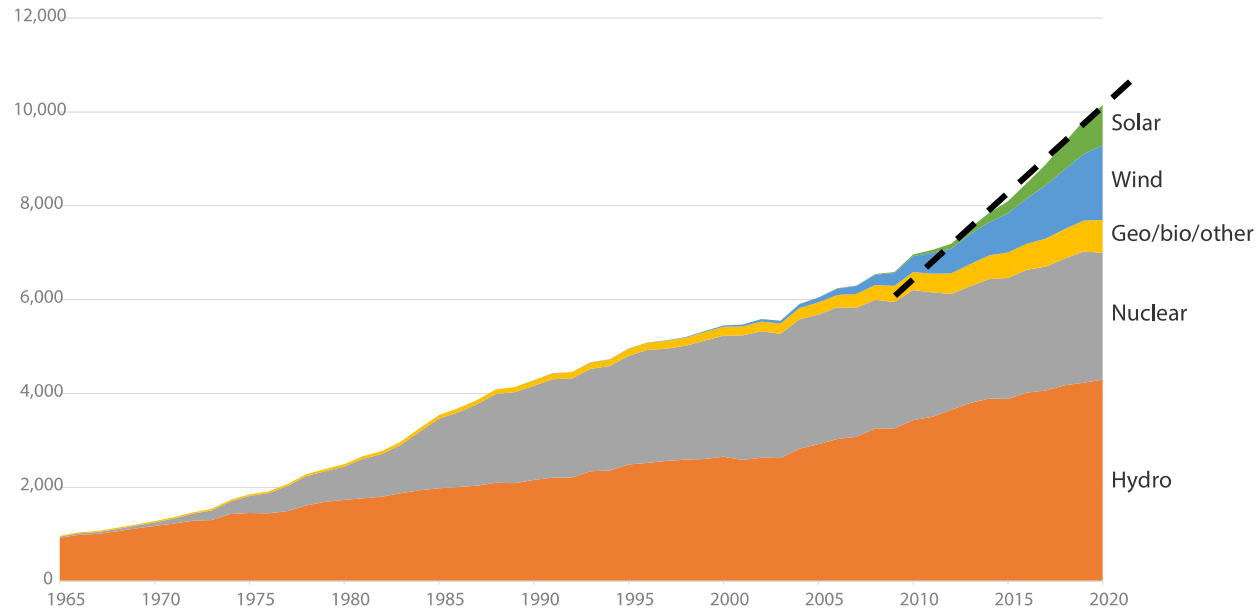
Progress to date

Non-emitting electricity (TWh/yr)



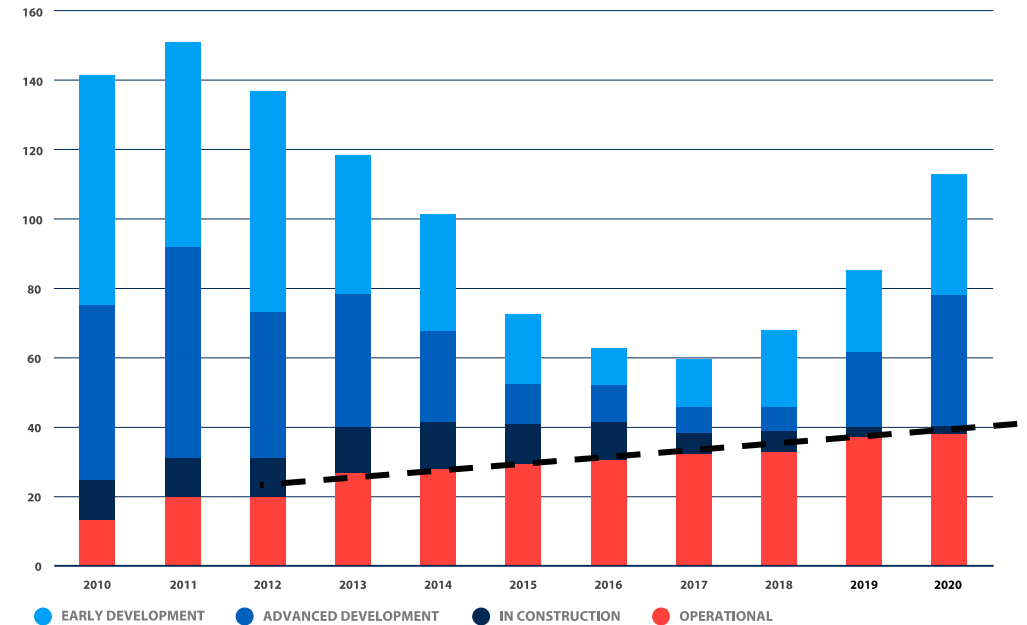
Deployment rates

Worldwide non-emitting electricity generation (TWh / year)



Growth: ~350TWh/yr/yr

CO2 capture and storage annual capacity (Mt / year)

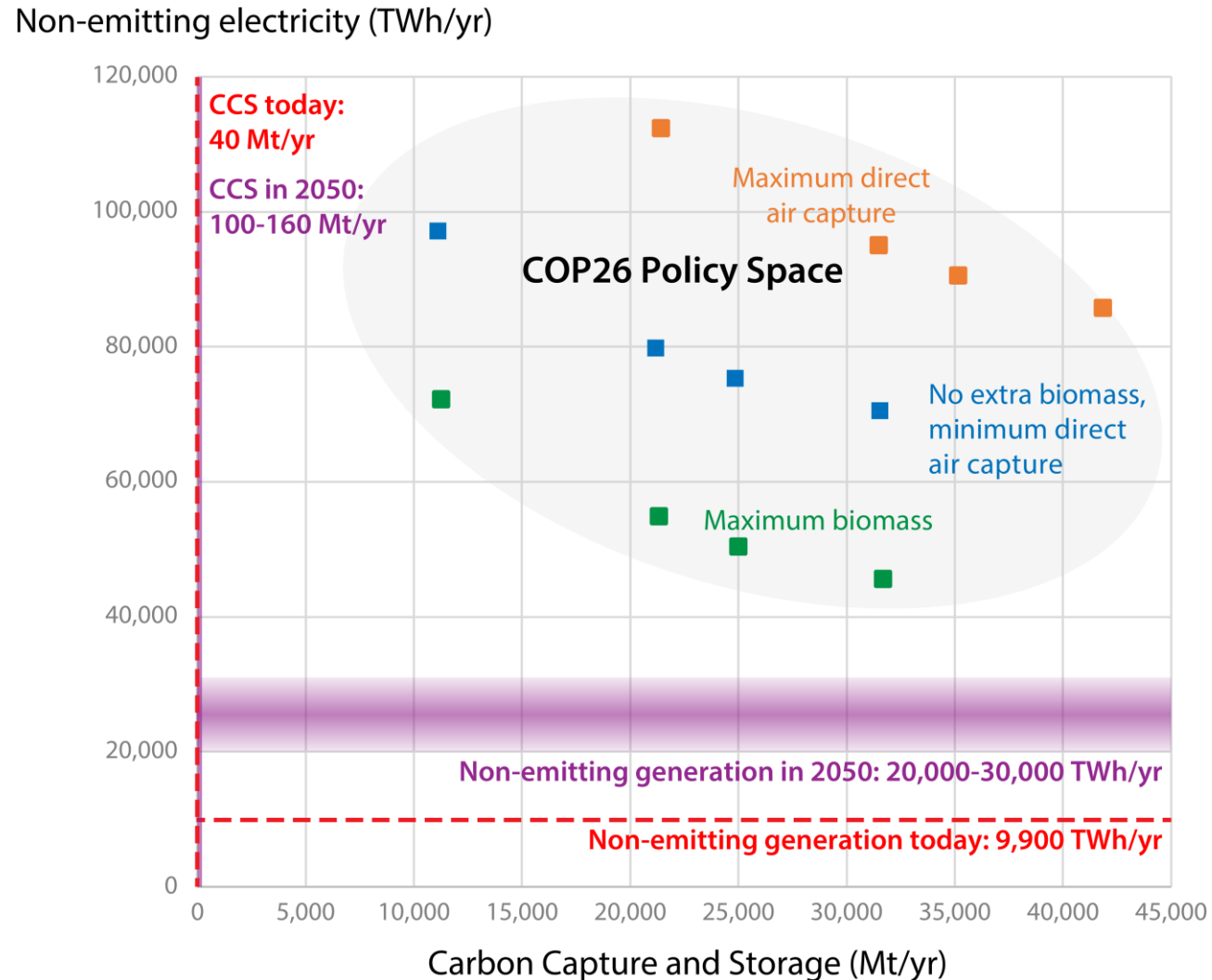


Most plans to date have not become reality

75% of CCS today increases fossil fuel extraction

Growth: ~2MtCO₂/yr/yr

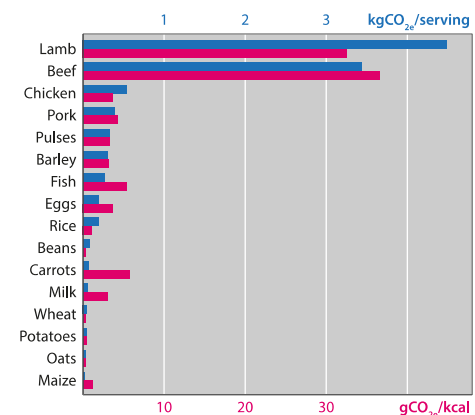
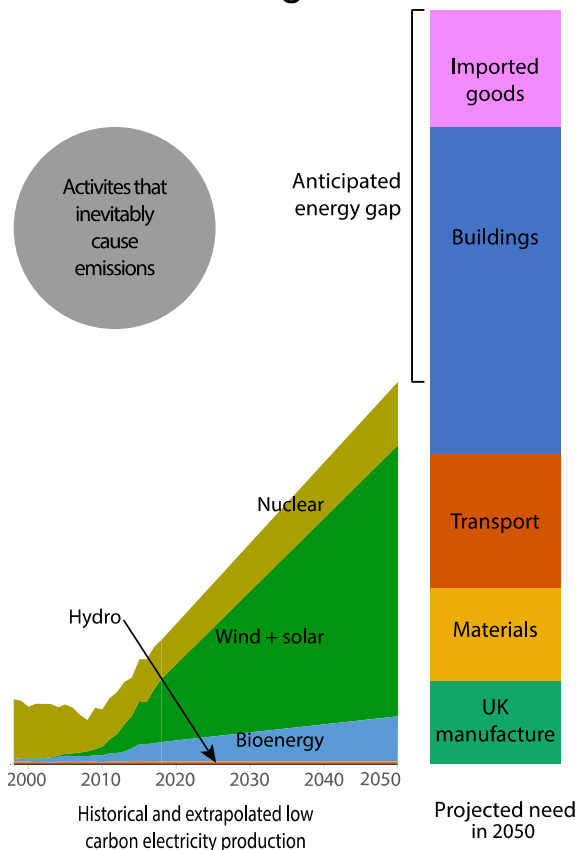
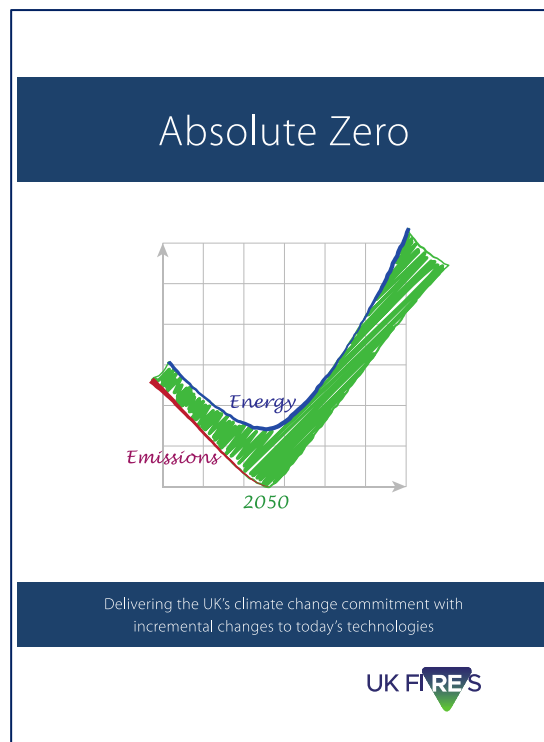
Incumbent thinking on how to reach zero emissions



Absolute Zero for the UK

If we say global warming is serious, we should plan to reach zero emissions (by 2050) assuming:

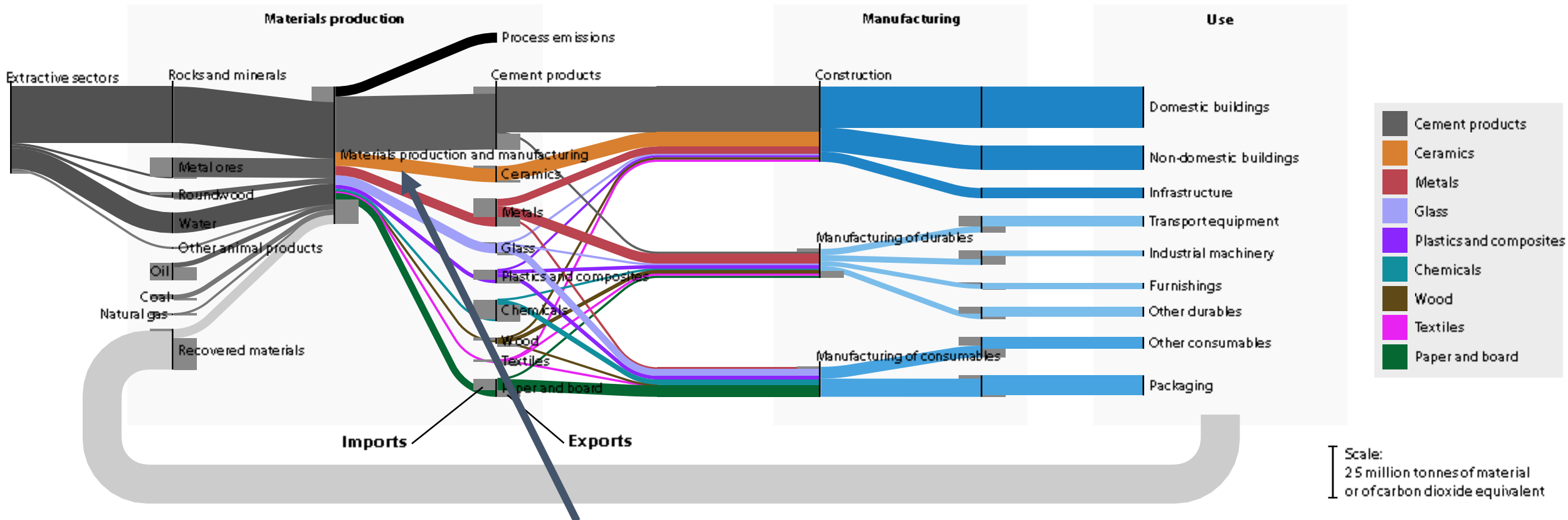
- That all energy is non-emitting electricity – and we won't have as much as we'd like
- That we do not expand total human use of biomass
- That there are no negative emissions technologies: Net Zero = Absolute Zero



Business growth in AZ materials and manufacturing

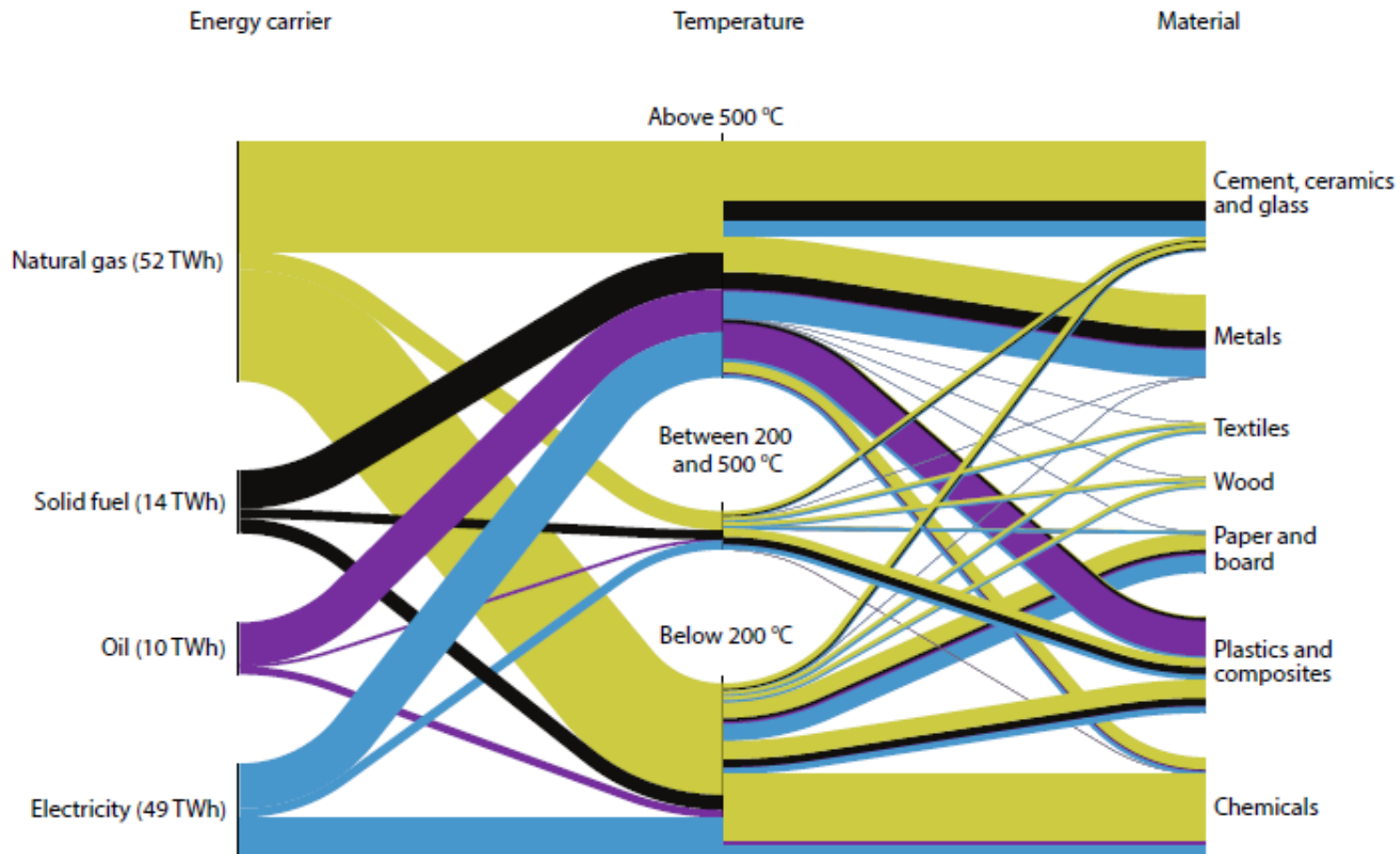
<https://ukfires.org/materials-manufacturing/>





1. Process heating accounts for about 50% of industrial emissions. Let's **electrify** this and use non-emitting electricity

Electrification of process heat



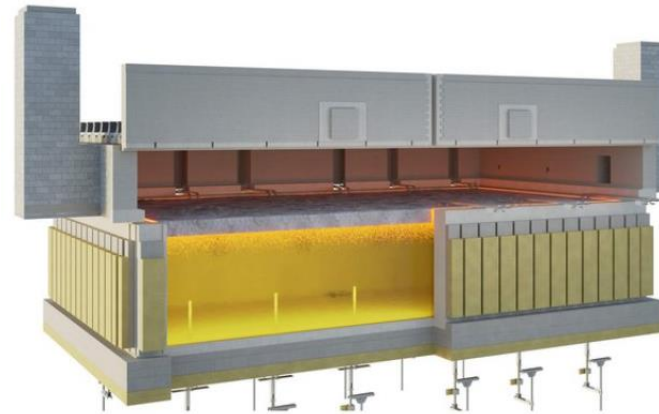
**Solid fuel is 85% coal and 15% coke and does not include waste or bioenergy.*

Opportunities to supply electric process heating equipment

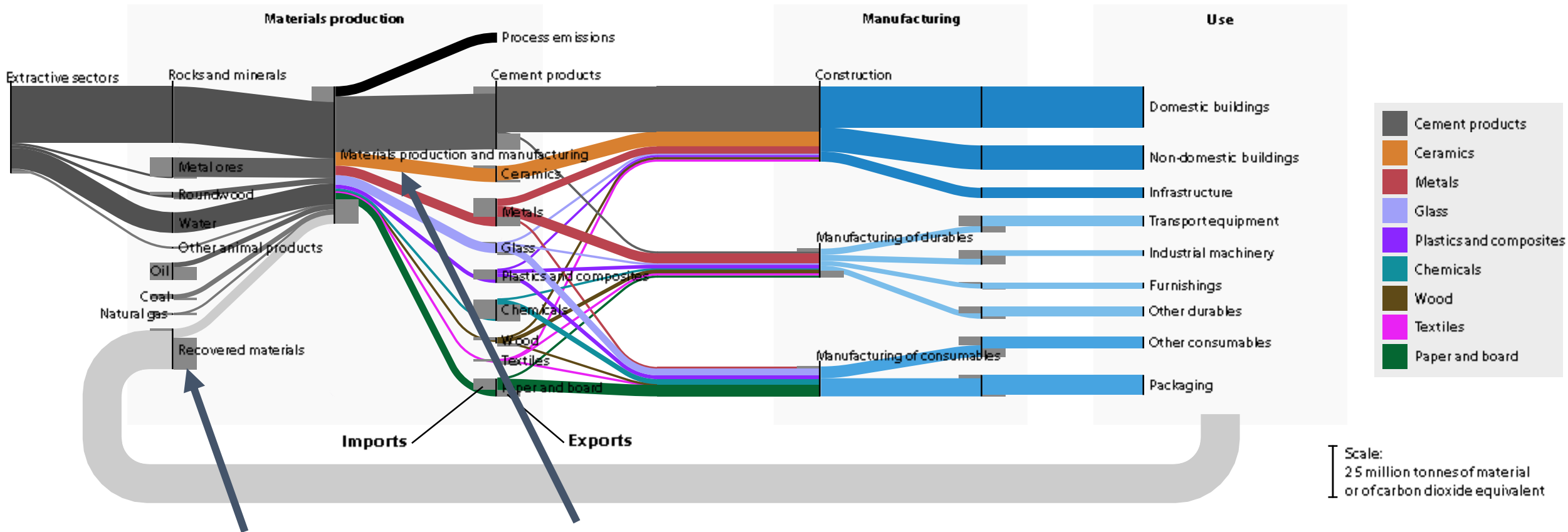
- £3.9 bn **industrial heat pumps**
- 4.2 GW capacity
- £4.4 bn **electrode boilers**
- 4.7 GW capacity
- £14 bn **specialised high temperature heat**
- £8 bn metals
- £3 bn glass and ceramics
- £3 bn plastics and chemicals



Industrial heat pump at Hutten slaughterhouse



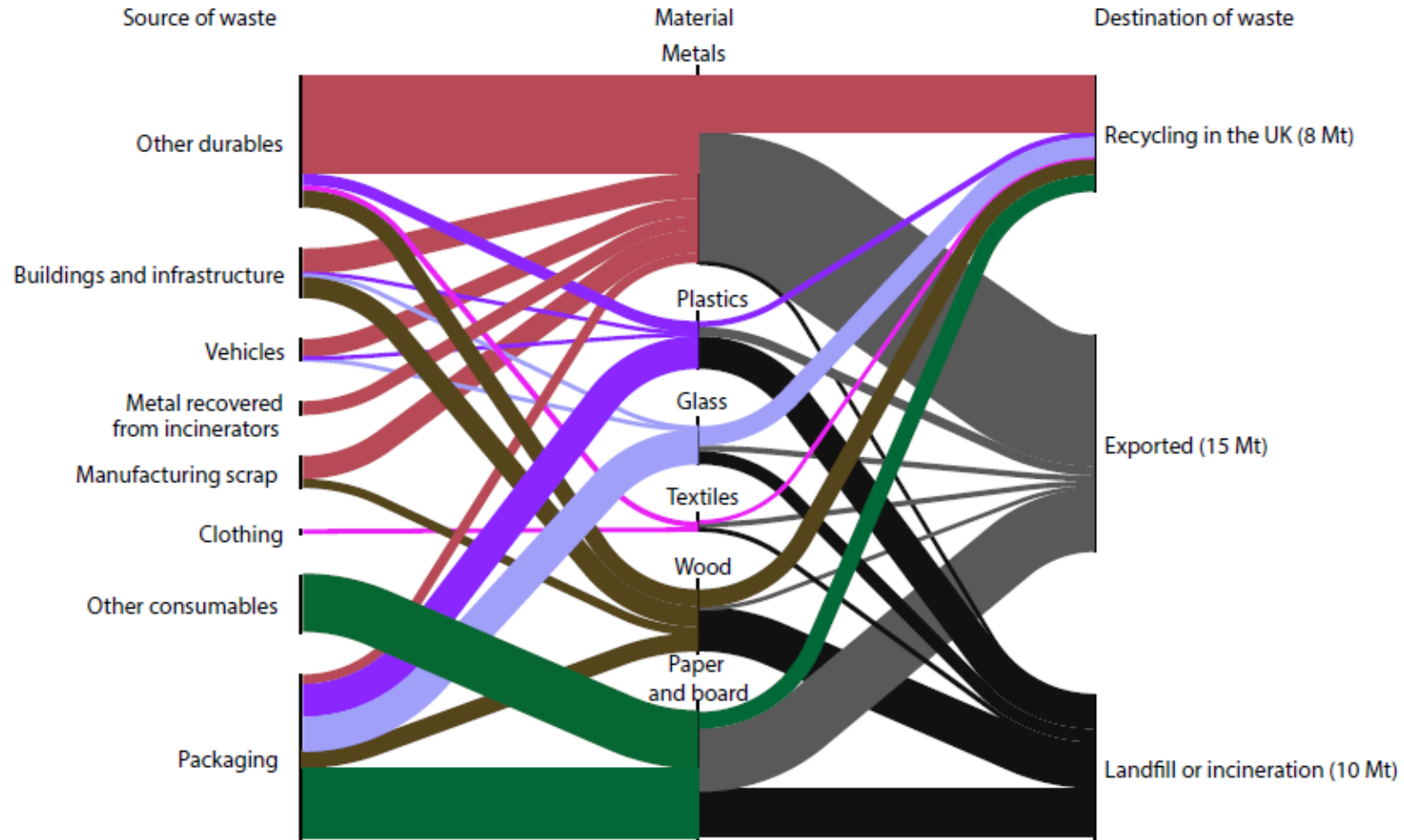
All-electric furnace, Horn Glass GmbH



2. Only 25% of waste collected is recycled in the UK. Let's do more **high quality recycling**

1. Process heating accounts for about 50% of industrial emissions. Let's **electrify** this and use non-emitting electricity

High quality recycling



Opportunities in high quality recycling

- **Better material sorting & feedstock preparation**

£0.6bn annual value-add by avoiding downcycling

£0.7bn annual value of Critical Raw Materials recoverable

£2.0bn equipment for sorting and disassembly

- **Bulk material production** from recovered materials

£8.1bn annual production:

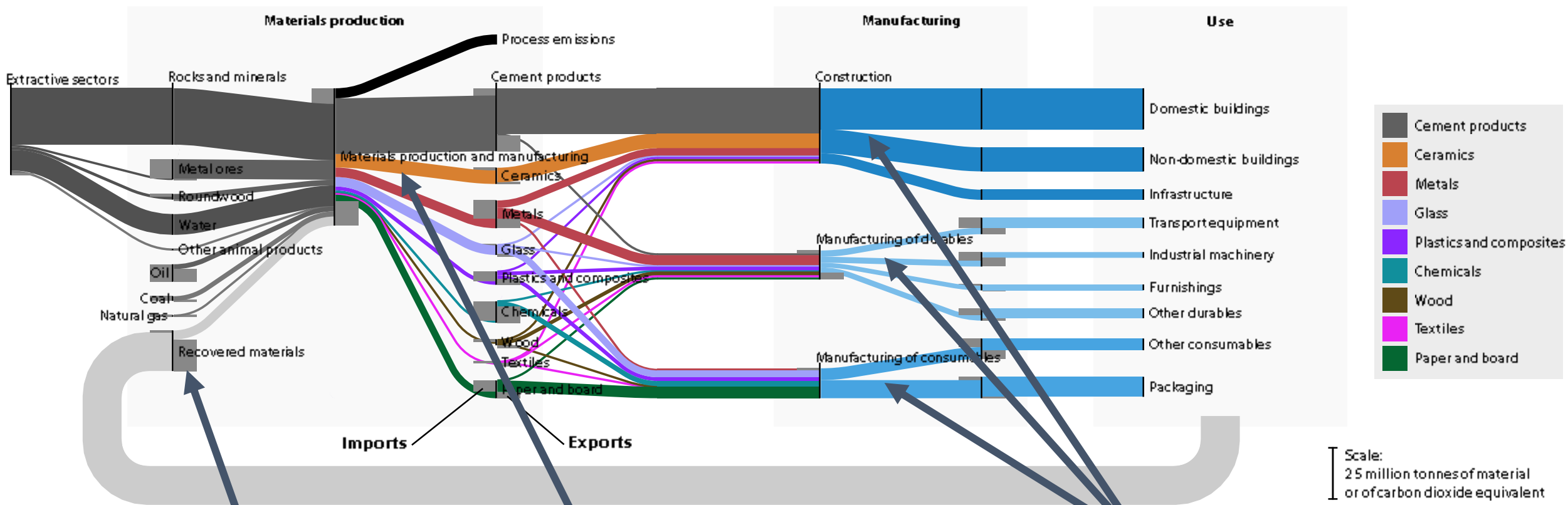
- £4.6bn paper and board
- £2.7bn metal
- £1.7bn plastics



- Increased use of **secondary material in products**

Annual savings in packaging alone:

- £120m plastics
- £70m steel
- £90m paper and board
- £60m glass

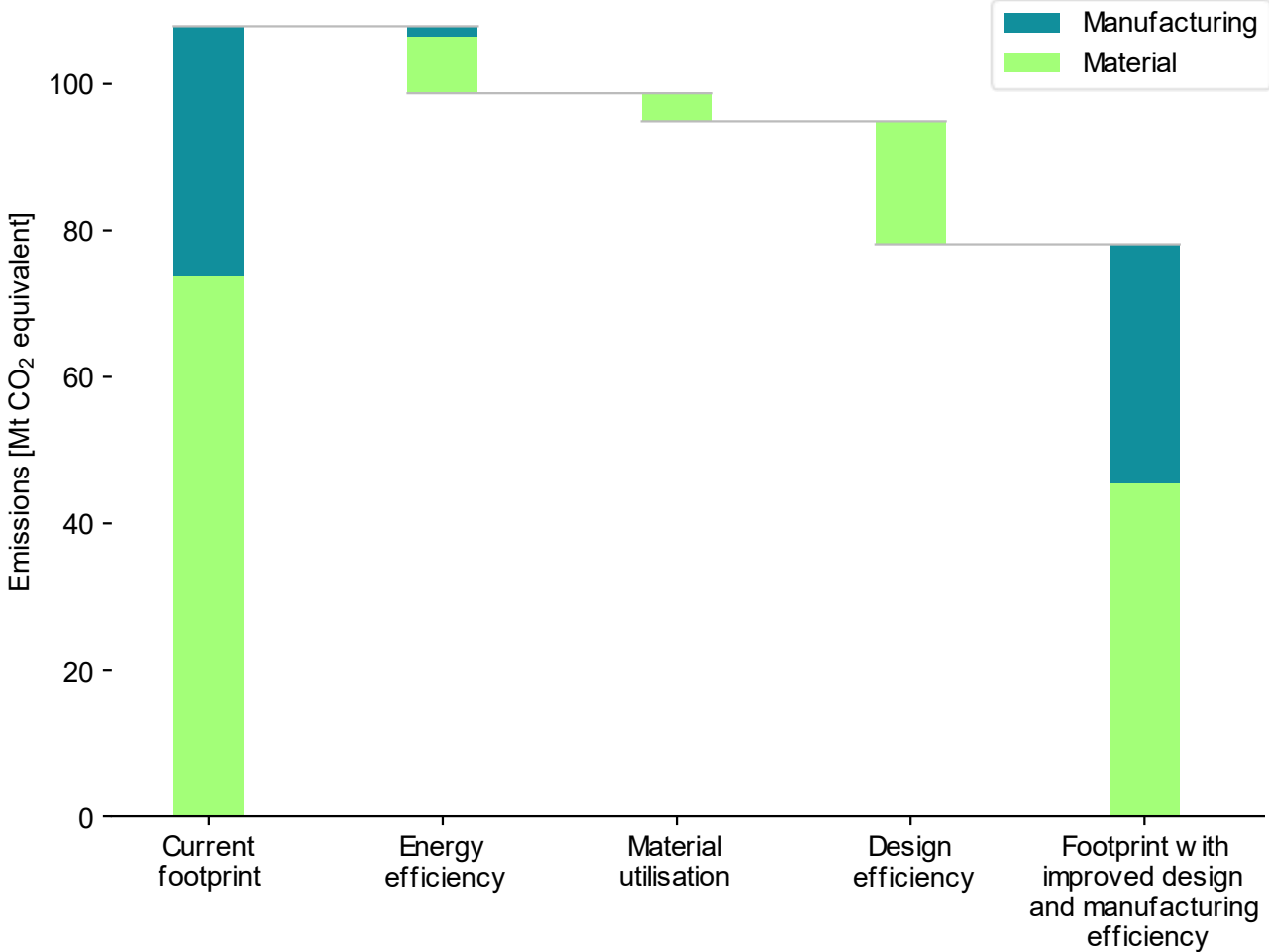


2. Only 25% of recovered materials in the UK is recycled in the UK. Let's do more **high quality recycling**

1. Process heating accounts for about 50% of industrial emissions. Let's **electrify** this and use non-emitting electricity

3. Manufacturing sectors use 40% more material than needed. Let's improve **resource efficiency**

Making goods more efficiently



Opportunities for cost saving, enabling technology

➤ **Cost savings** for companies

£3.3bn annual total:

- £0.8bn energy efficiency
- £0.5bn material utilisation
- £2.0bn reduce material by design

➤ Supply of **design services**

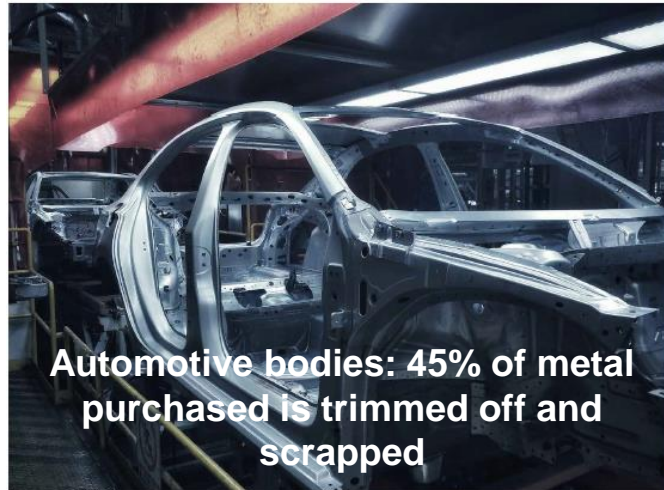
£0.8 bn annual total:

- £0.4bn construction
- £0.3bn manufacturing

➤ Supply of **equipment**

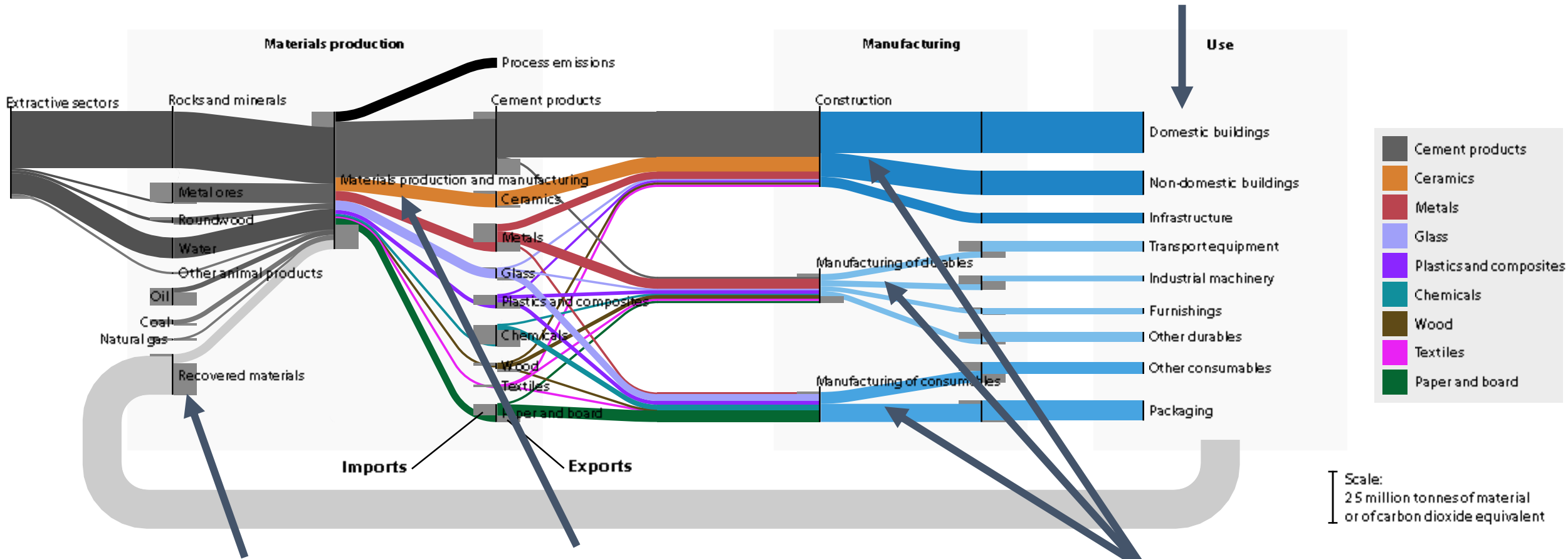
£0.5bn high efficiency motors

£0.9bn high efficiency heating



PANDA design: aiding early stage construction design

4. Fewer goods can be used to deliver the same service. Let's improve **service efficiency**

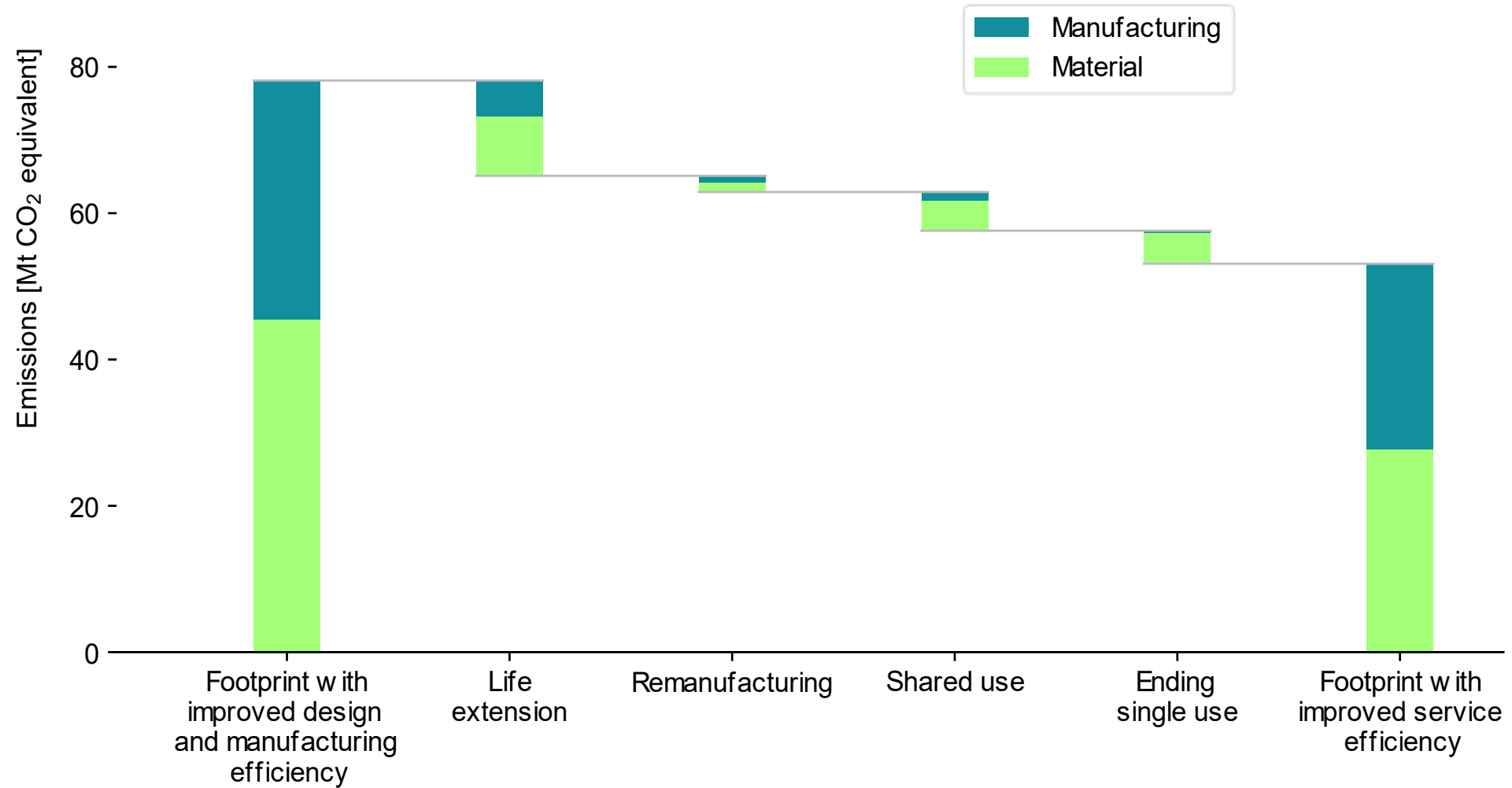


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More service, for longer



Opportunities for business model innovation, new products

➤ **Business model** innovation

£36bn total annual market for supply of equipment through recondition and service contracts

- £11bn Industrial equipment (average life extends to 62 years)
- £8bn Appliances (19 years)
- £17bn Transport equipment (37years)

➤ **High productivity repair**

£11bn total annual market for repair services

- Increase productivity from current £23/hour to manufacturing average £35/hour



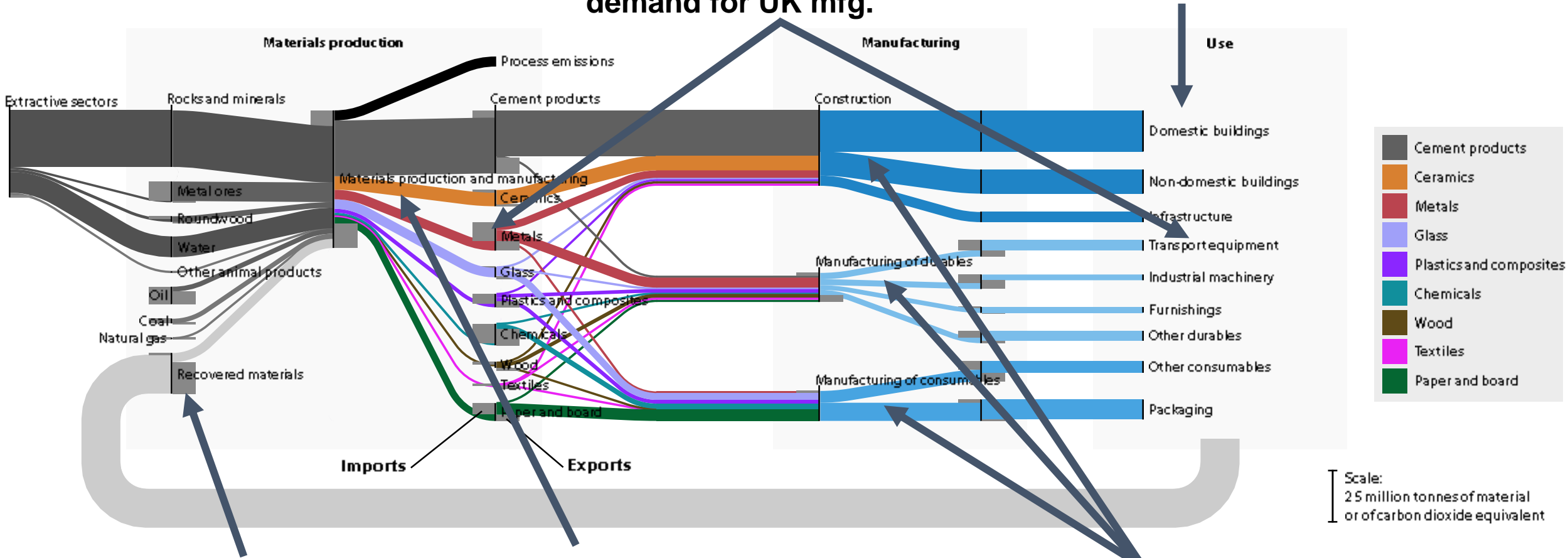
➤ **Ending single use:** new products

£1.2bn total annual market for durable alternatives:

- £0.6bn packaging
- £0.6bn household consumables

5. We need new equipment for decarbonisation and fewer imports. There will be **new demand for UK mfg.**

4. Fewer goods can be used to deliver the same service. Let's improve **service efficiency**

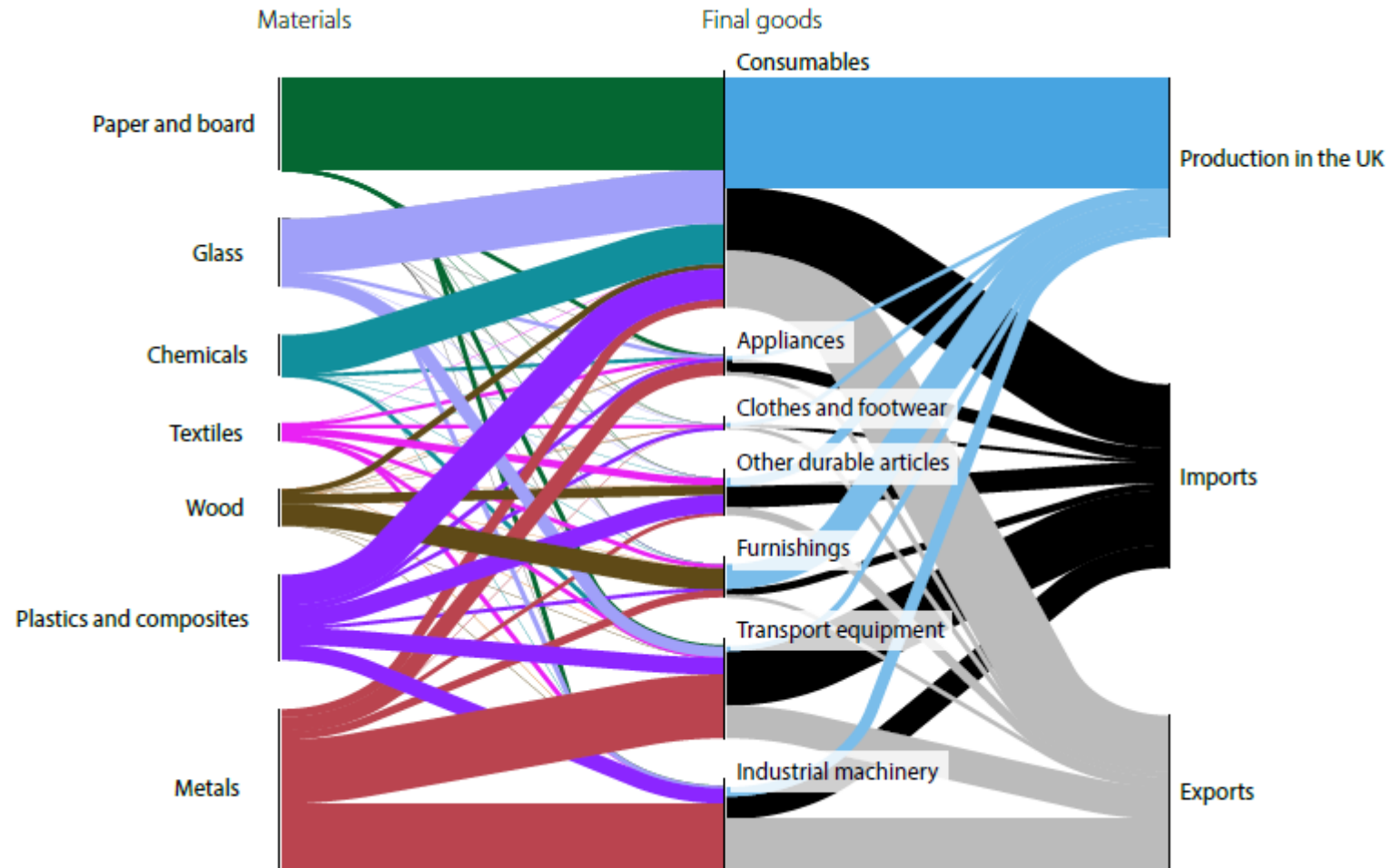


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New demand for UK manufacturing



New demand for UK manufacturing

➤ Supply of **decarbonisation equipment**

- £3bn heat pump devices
- £5bn offshore wind supply chain
- £41bn battery electric vehicles



➤ **Greenshoring**

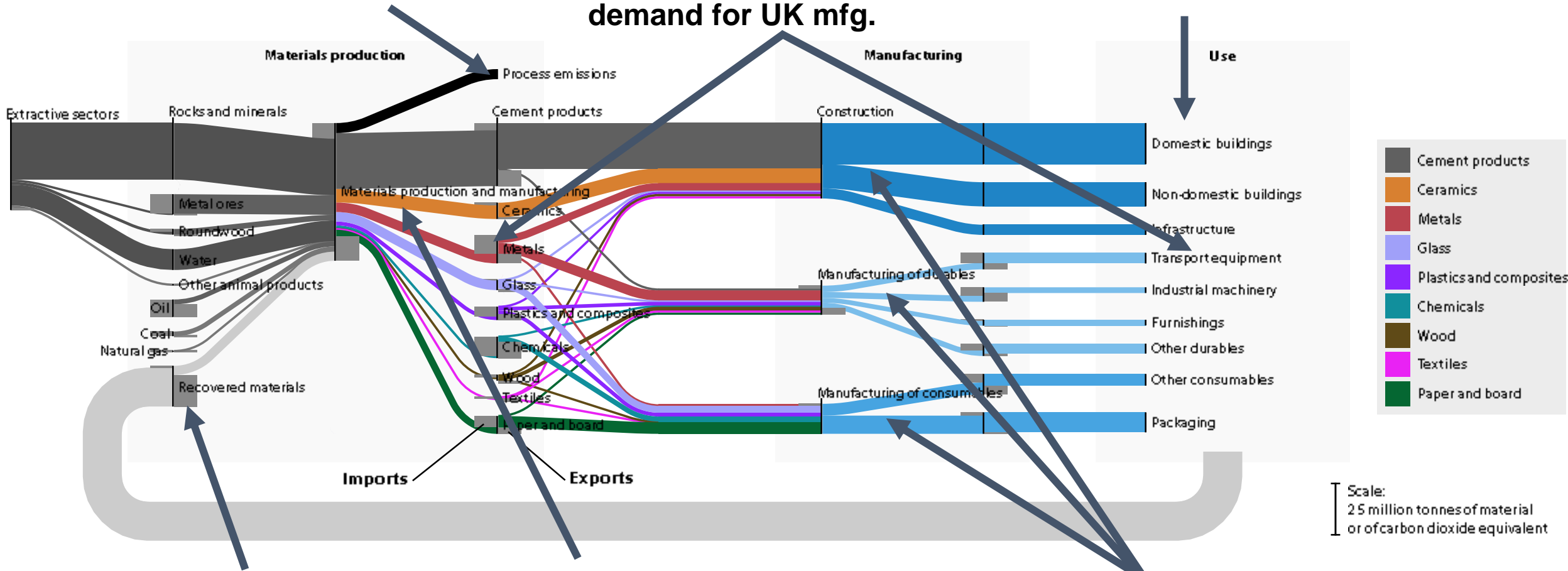
- £7bn bulk materials
- £49bn manufactured goods



6. We have to **eliminate process emissions** from making materials and using goods

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4. Fewer goods can be used to deliver the same service. Let's improve **service efficiency**

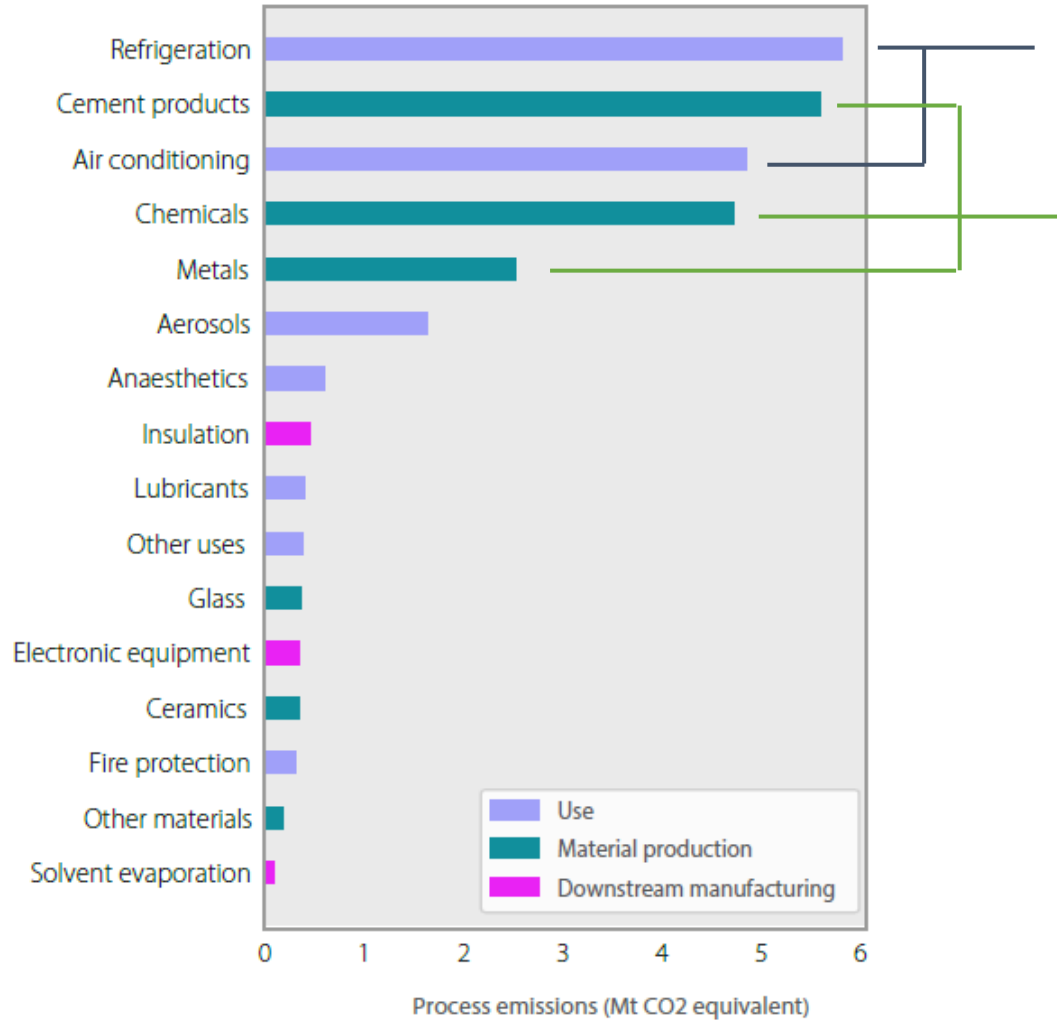


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Eliminate process emissions



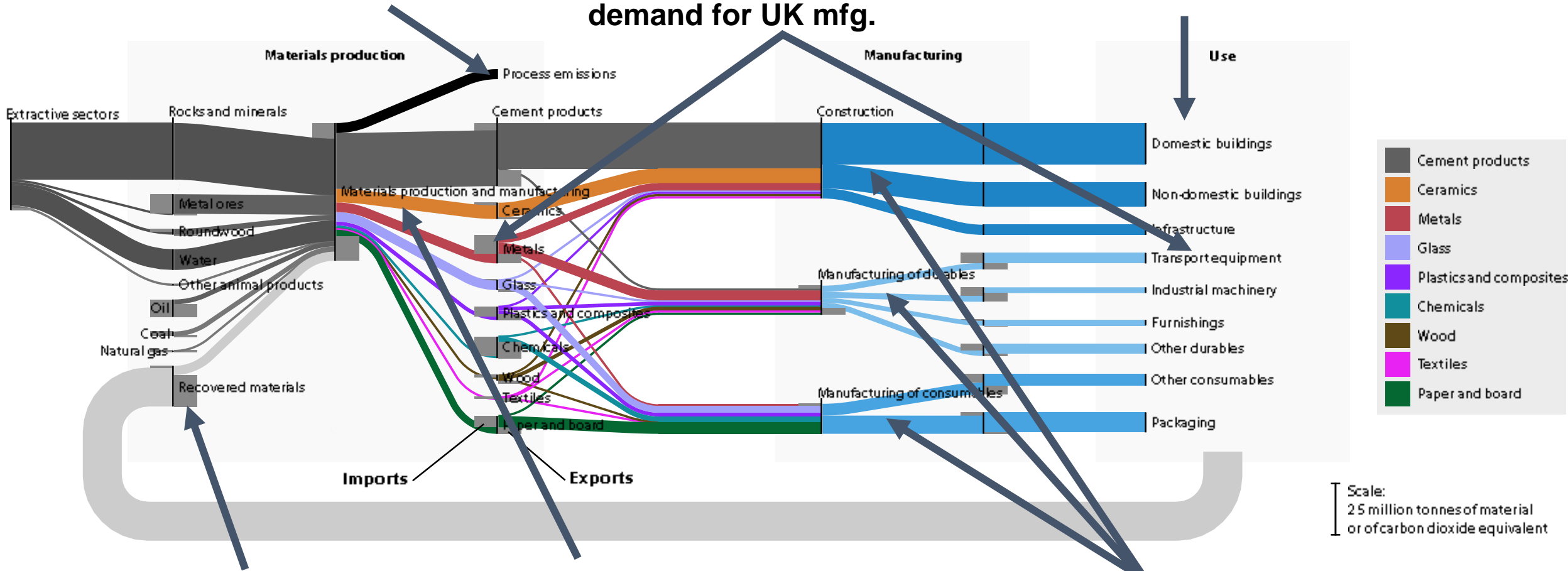
➤ £40m annual market for alternative refrigerants

➤ High quality recycling?

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