

CIBSE HVAC – Embodied Carbon

- CIBSE TM65
- CIBSE TM65.1
- CIBSE TM65.2 - Sneak Peek



Yara Machnouk

Intermediate Environmental Engineer

Yara.machnouk@elementaconsulting.com



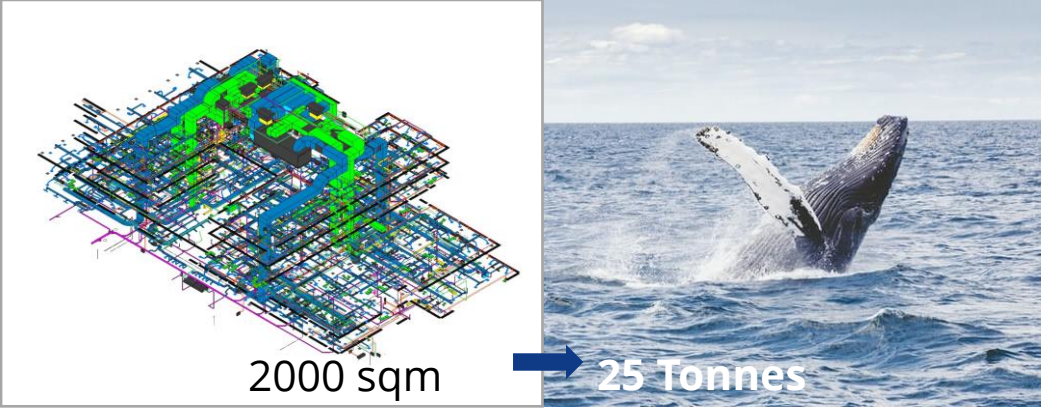
Agenda

- Context
- CIBSE TM65
 - Methodology
 - Calculation methods
- CIBSE TM65.1
 - Aim & scope
 - Product-level results
 - System-level results
- CIBSE TM65.2
 - Aim & scope
 - Product-level results

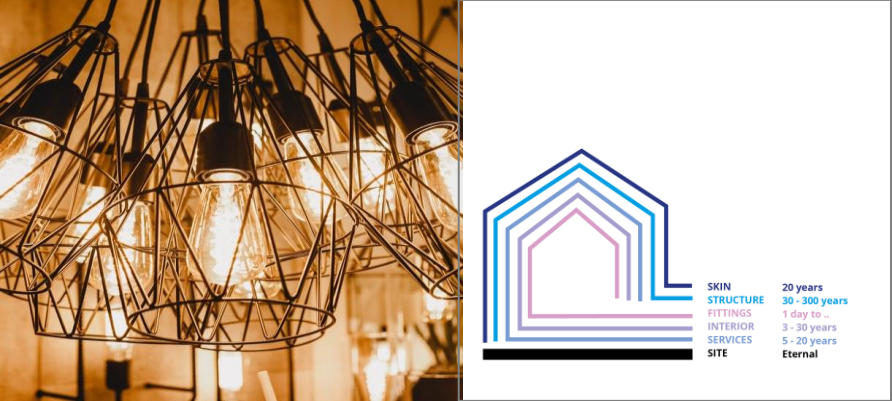


Embodied carbon and building services

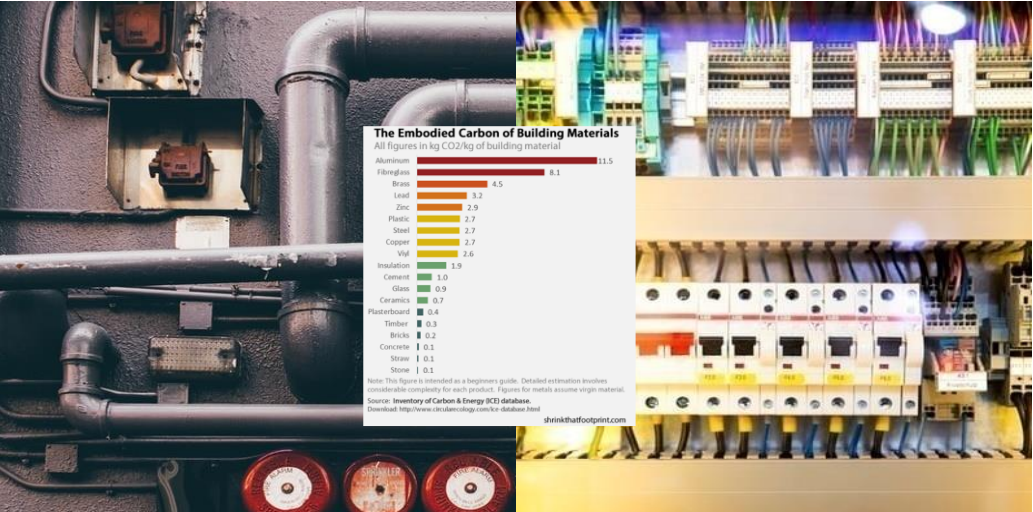
Big quantities



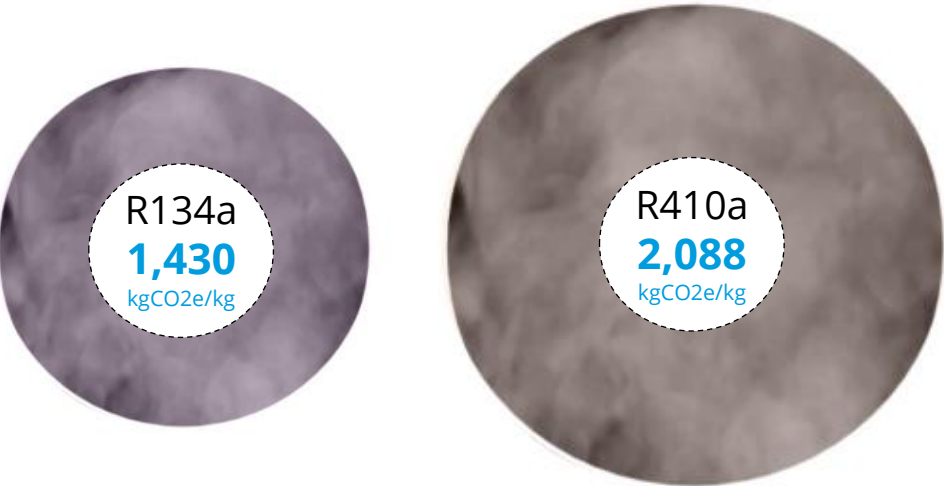
High replacement rates



High impact materials



Refrigerant impact



TM65 (2021)



CIBSE TM65



Whole life carbon

Embodied carbon

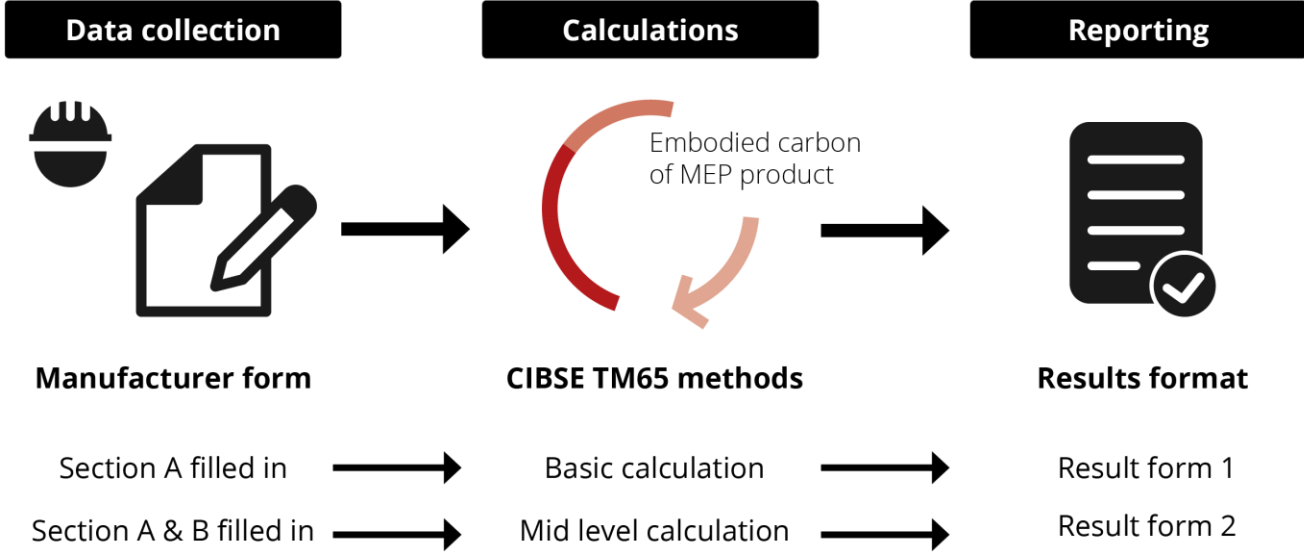
A	Product	A1	Material extraction	<input checked="" type="checkbox"/>
		A2	Transport to factory	<input checked="" type="checkbox"/>
		A3	Manufacturing	<input checked="" type="checkbox"/>
	Construc-	A4	Transport to site	<input checked="" type="checkbox"/>
		A5	Construction	<input checked="" type="checkbox"/>
B	In use	B1	Use	<input checked="" type="checkbox"/>
		B2	Maintenance	<input checked="" type="checkbox"/>
		B3	Repair	<input checked="" type="checkbox"/>
		B4	Replacement	<input type="checkbox"/>
		B5	Refurbishment of the building	<input type="checkbox"/>
	Operation	B6	Operational energy use	<input type="checkbox"/>
		B7	Operational water use	<input type="checkbox"/>
C	End of life	C1	Deconstruction	<input checked="" type="checkbox"/>
		C2	Transport	<input checked="" type="checkbox"/>
		C3	Waste processing	<input checked="" type="checkbox"/>
		C4	Disposal	<input checked="" type="checkbox"/>
D	Beyond the life cycle	D	Reuse, Recovery, Recycling	<input checked="" type="checkbox"/>

Global warming potential (GWP) in kgCO₂e

Module included in an embodied carbon assessment at product level



CIBSE TM65 - process summary



	'Basic' calculation				'Mid level' calculation				EPD			
Easy	●	●	●	○	●	●	○	○	●	○	○	○
Manufacturer involvement	●	○	○	○	●	●	●	○	●	●	●	●
Detailed	●	●	○	○	●	●	●	○	●	●	●	●



CIBSE TM65 – Manufacturer form

Data collection



Manufacturer form

Section A

Capacity of equipment/size
Product service life (year)
Product weight (kg)

Material composition breakdown (95%)

Refrigerant used + charge (kg)
Components replaced over service life

Essential information
to carry any CIBSE
TM65 calculations

Section B

Final assembly factory location
Final assembly factory energy use (kWh)
Factories from supply chain location

Supplementary information
needed for Mid Level
calculations

Section C

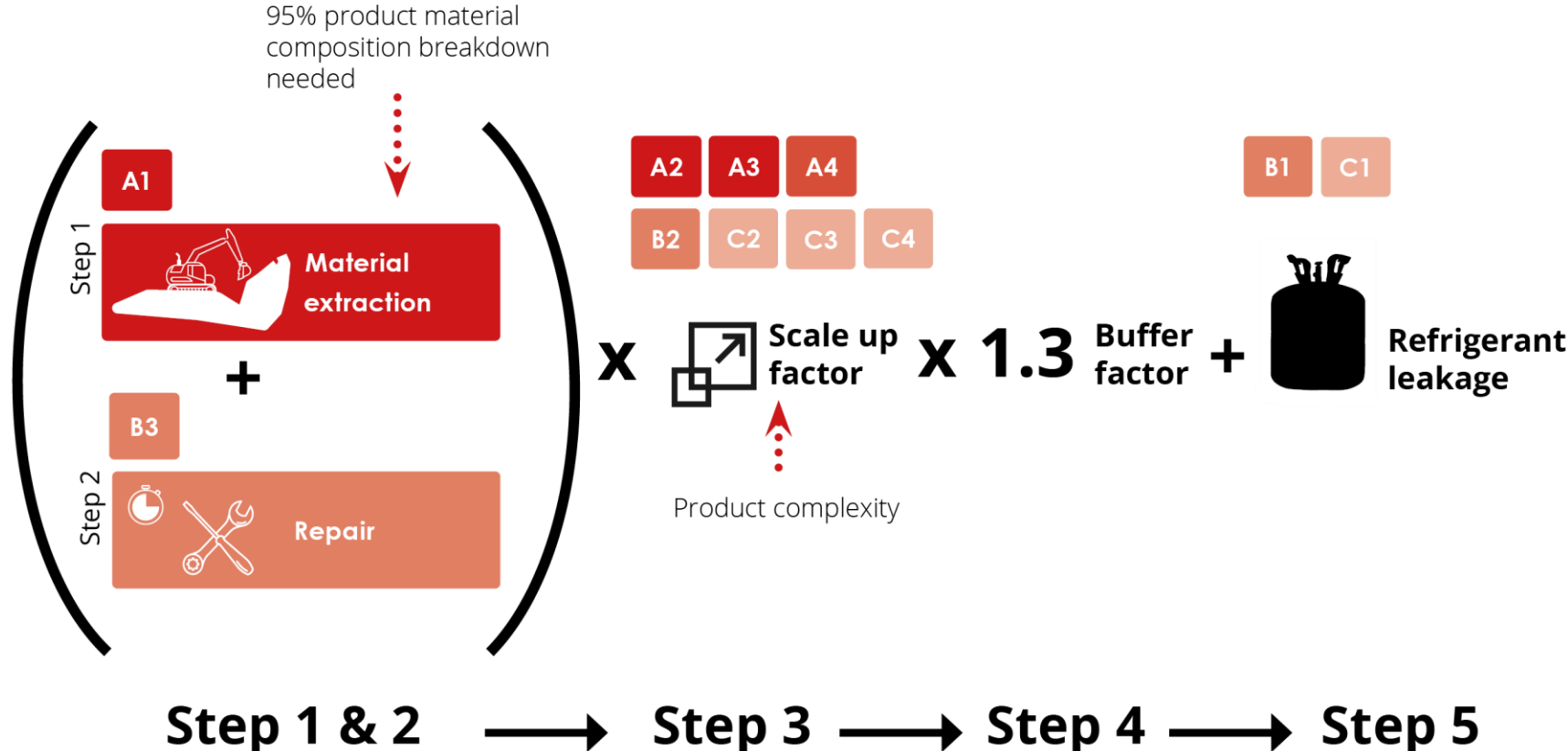
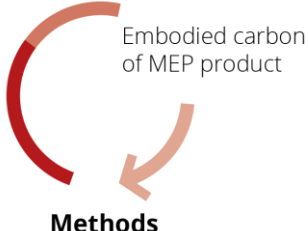
Operational efficiency of product
Annual waste output at final assembly
factory (kg)
Annual water consumption at final as-
sembly factory (m3)
Renewable energy onsite factory (kWh)
% product reused, recovered or recycled
Maintenance recommendations
Warranty (years)
Ownership mode

Optional information
for development of the
next CIBSE TM65



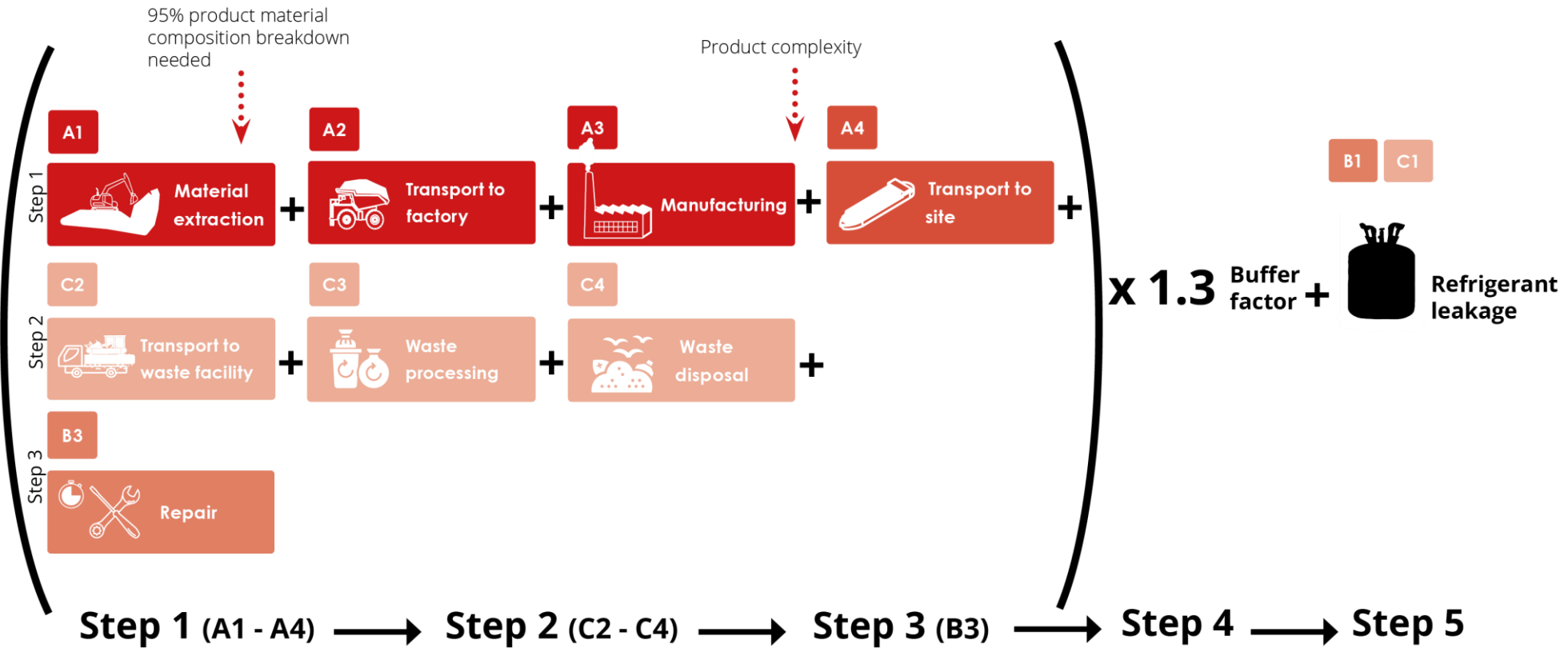
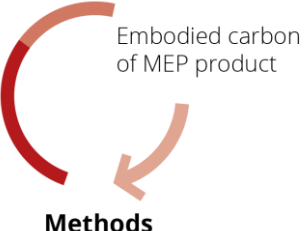
CIBSE TM65 – Basic calculation method

Calculations



CIBSE TM65 – Mid level calculation method

Calculations

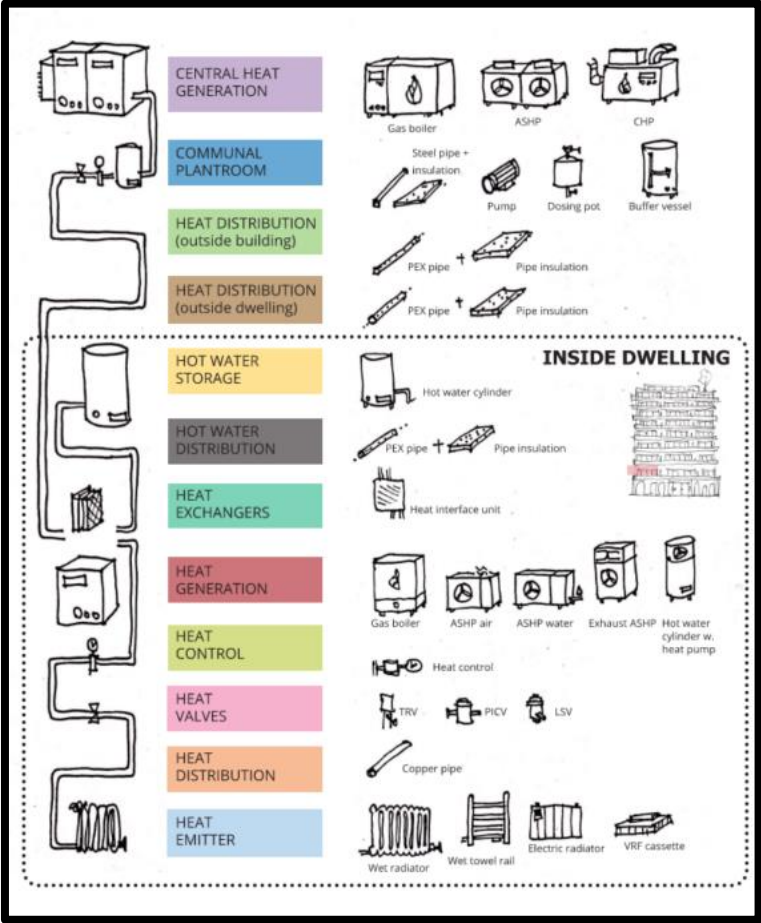


CIBSE TM65.1

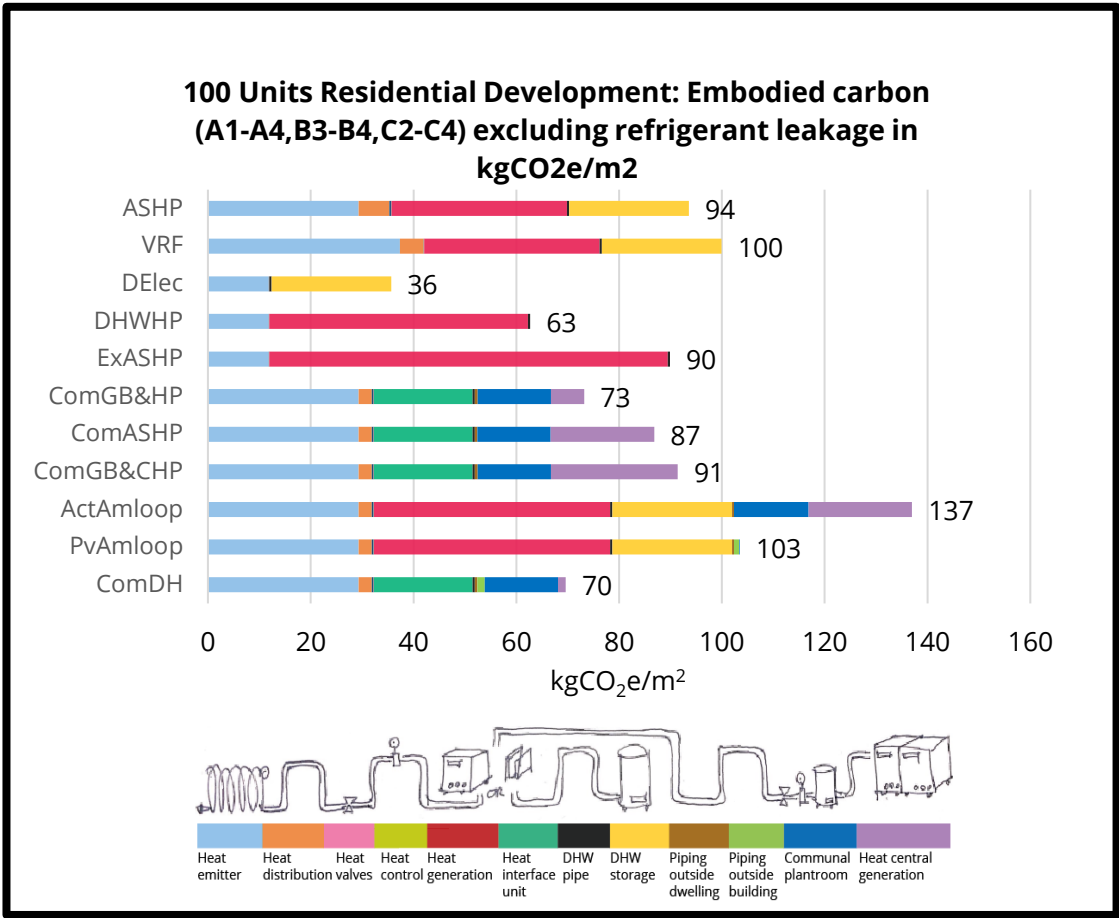
AIM & SCOPE

Aim - Explore embodied carbon of residential heating

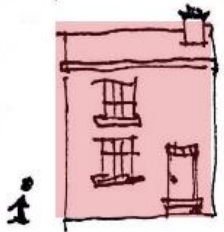
30 products



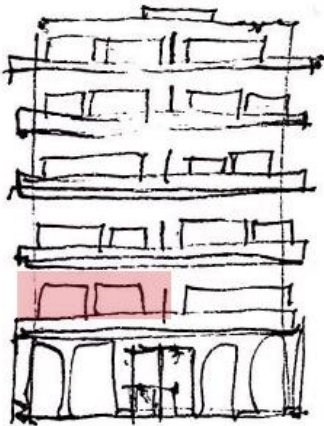
13 design strategies



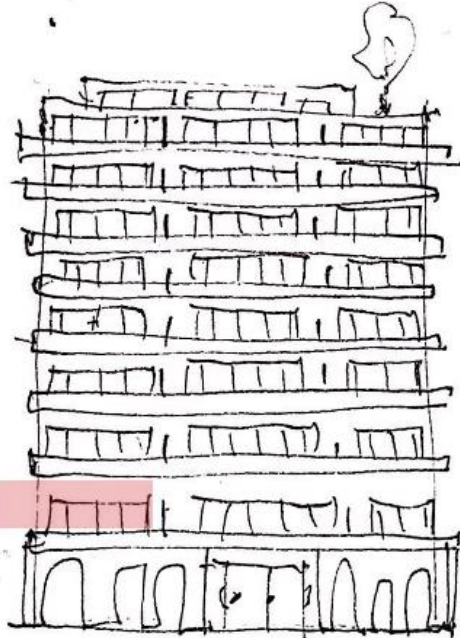
Scope - Residential Typologies



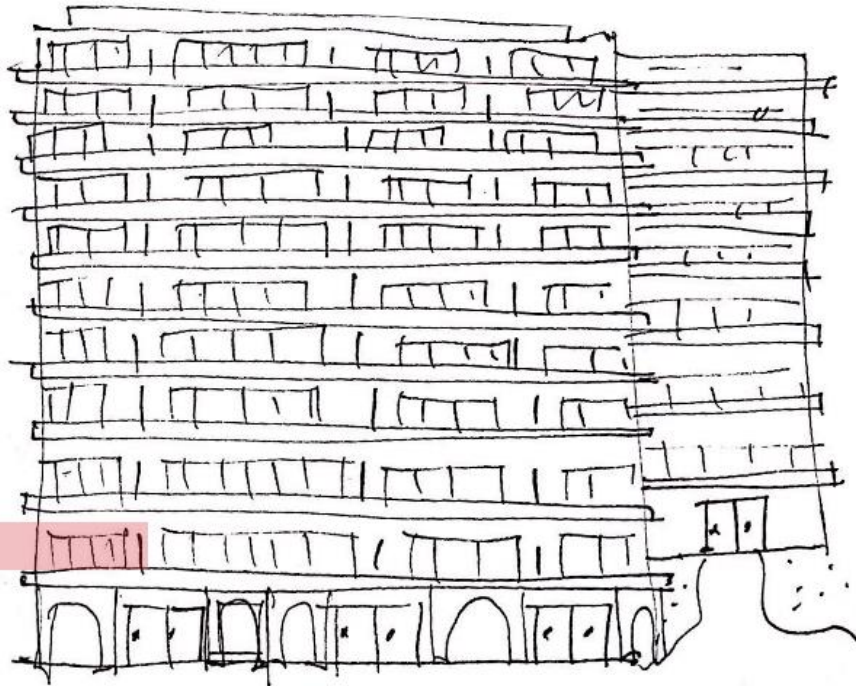
Terraced house
3bd - 96m²



15 units dev.
2bd - 61m²



100 units dev.
2bd - 61m²

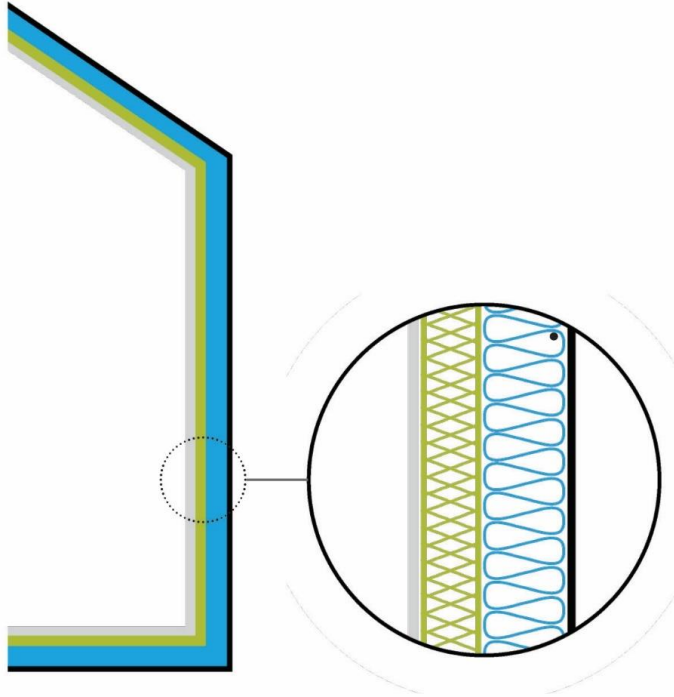


10 blocks of 200 units dev.
2bd - 61m²



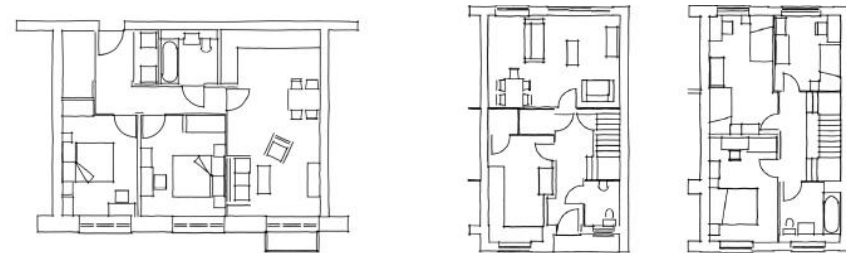
Scope – building fabric & system sizing

Ultra-low energy building fabric (Passivhaus level)

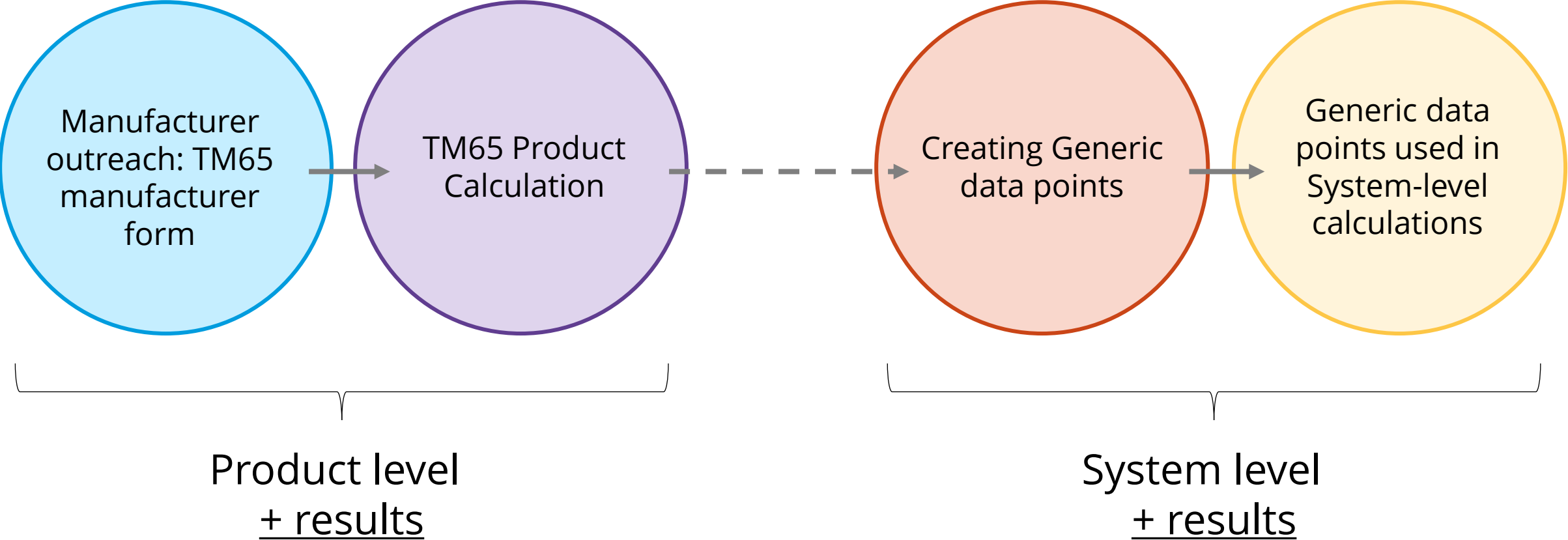


Thermal performance

- U-value walls: 0.13 W/m²·K
- U-value roof: 0.10 W/m²·K
- U-value ground: 0.08 W/m²·K
- U-value windows: 0.8 W/m²·K
(triple glazing)
- air permeability: <1 m³/h·m² at 50 Pa.

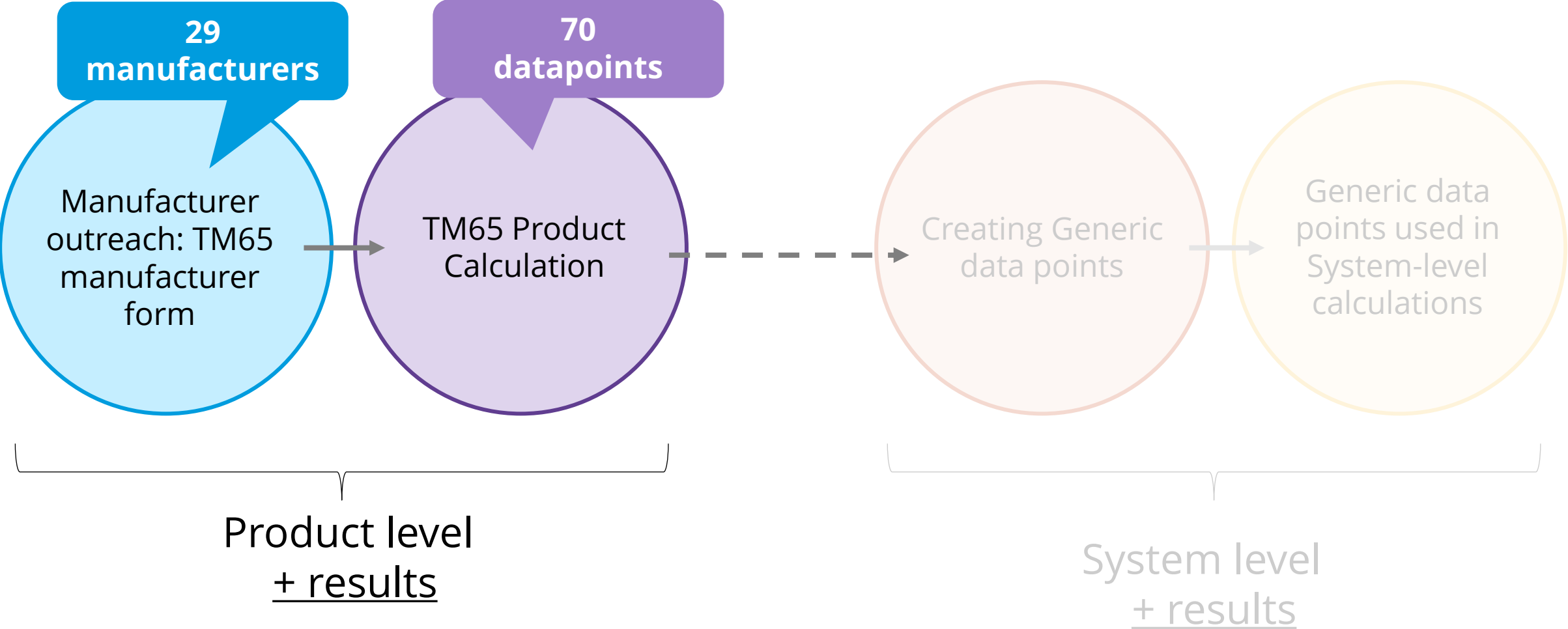


Process



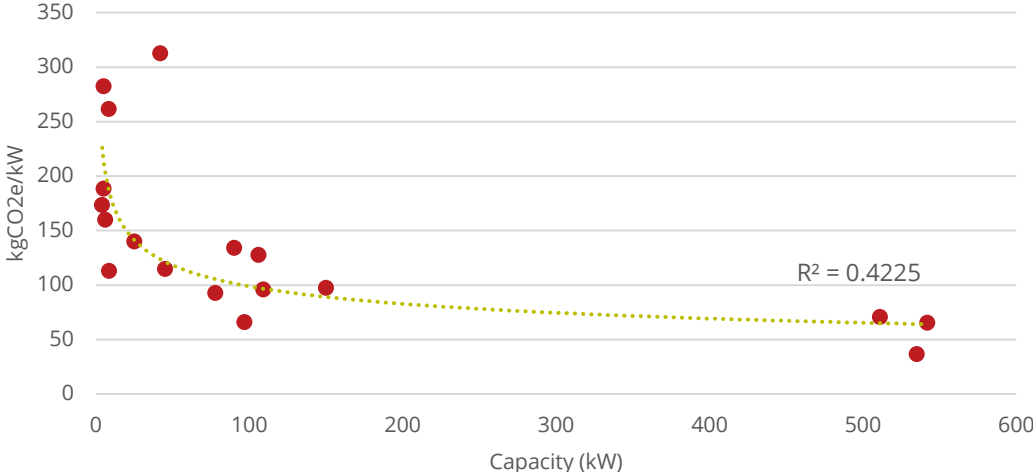
**CIBSE TM65.1
PRODUCT
FINDINGS**

Process

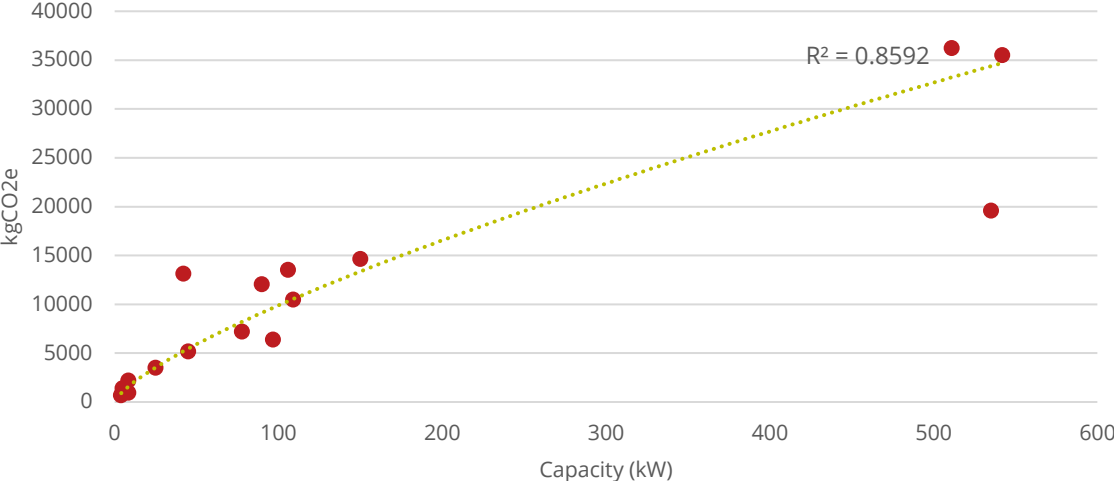


ASHP 2-pager

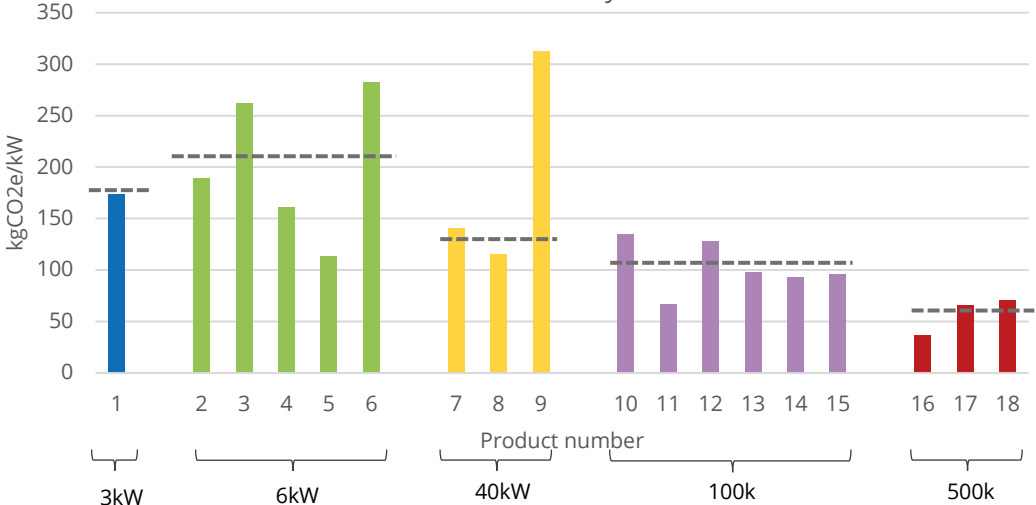
1. ASHP - Results by kW



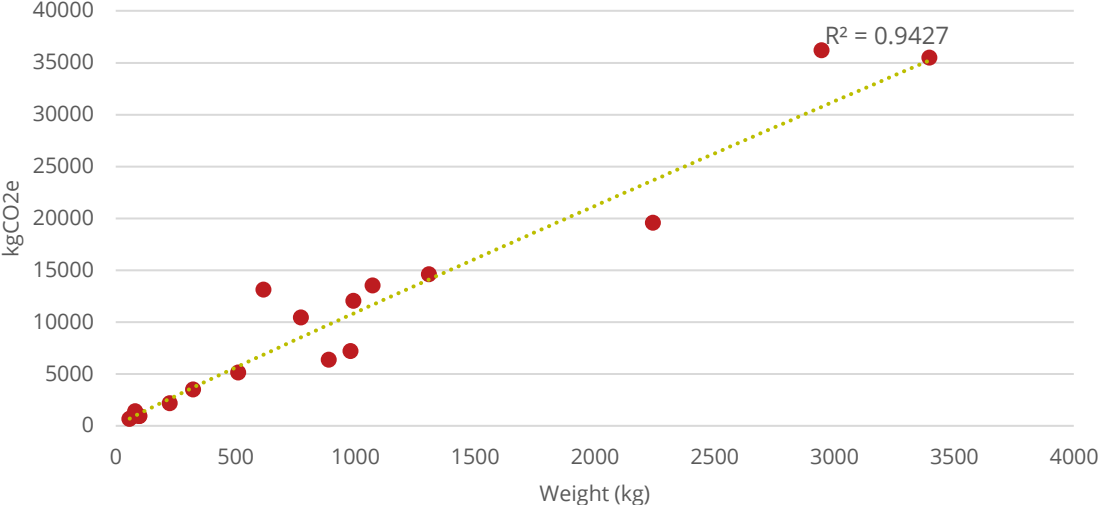
3. ASHP - Absolute results against capacity (kW)



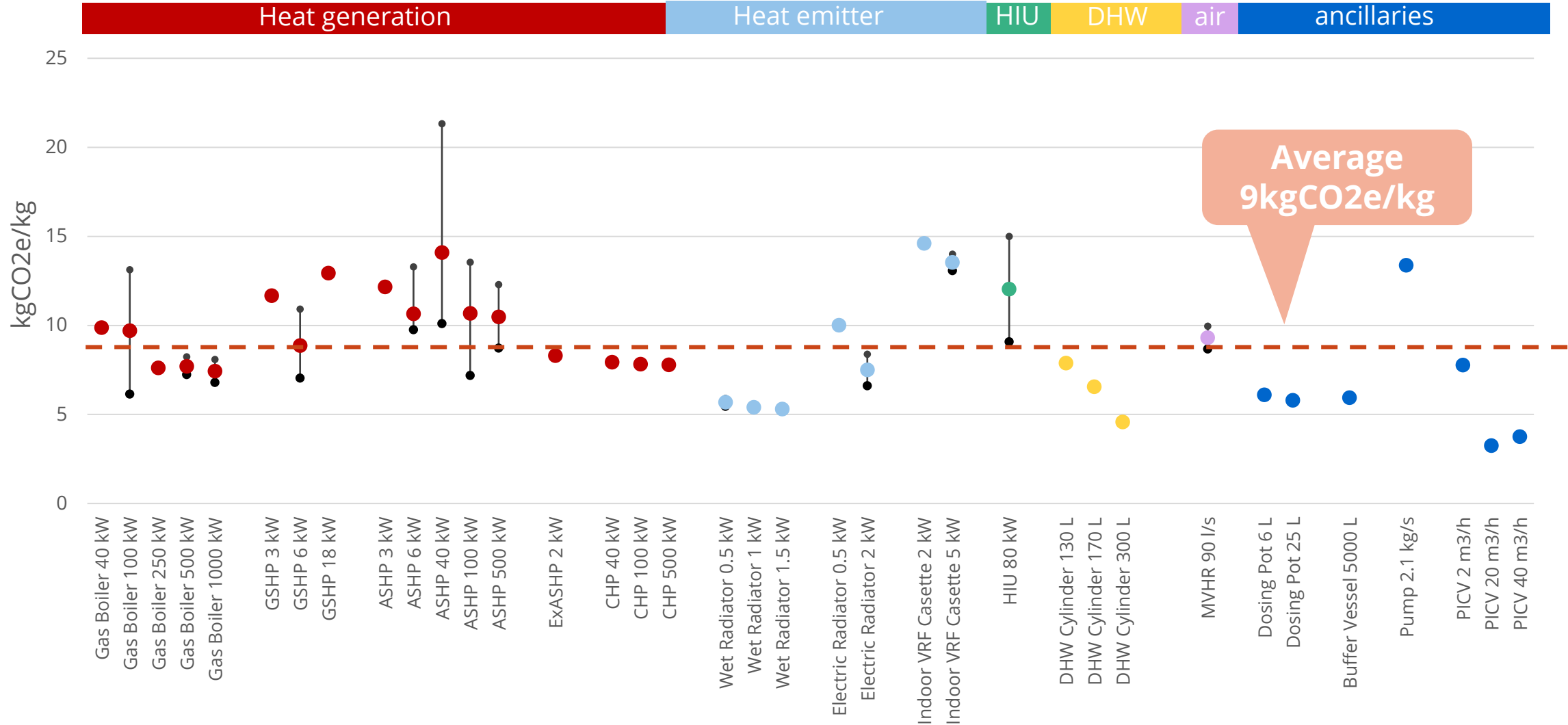
2. ASHP - Results by kW



4. ASHP - Absolute results against weight (kg)

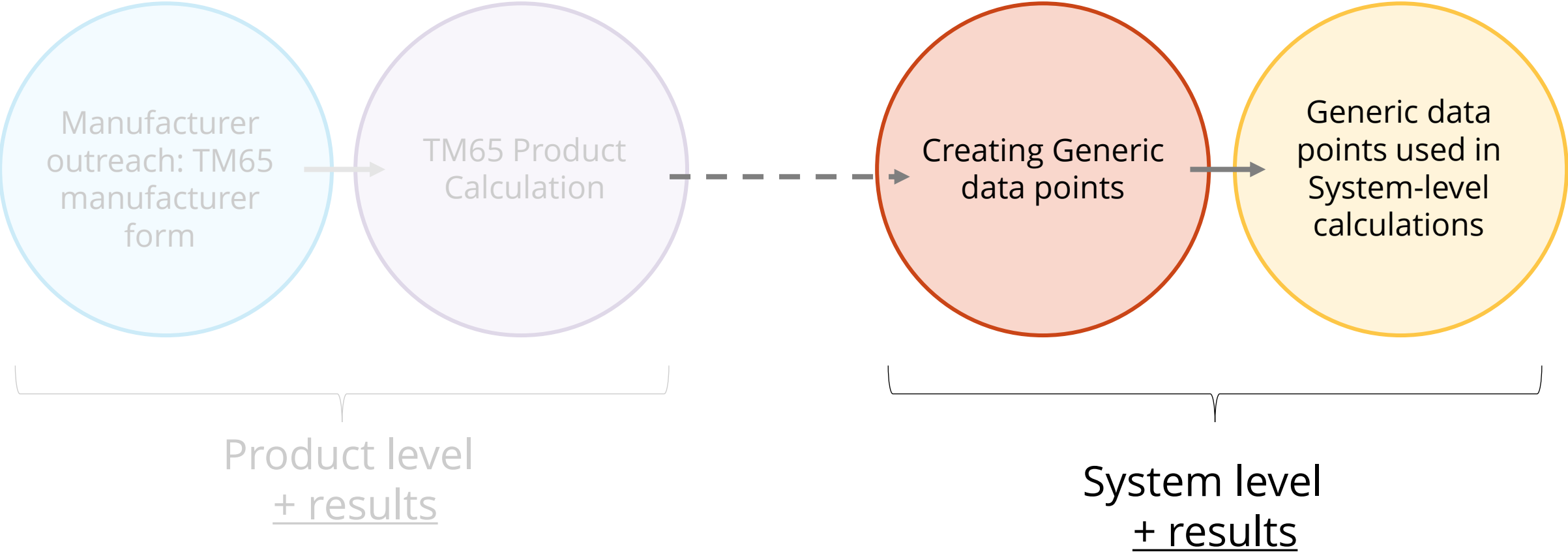


Products findings - Average kgCO2e/kg

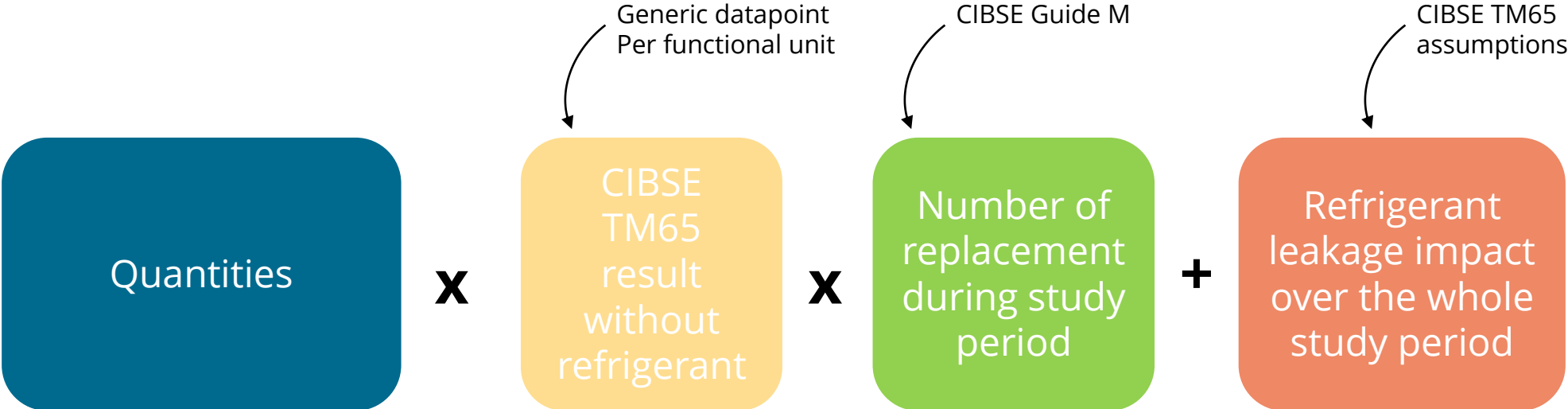


**CIBSE TM65.1
SYSTEM
FINDINGS**

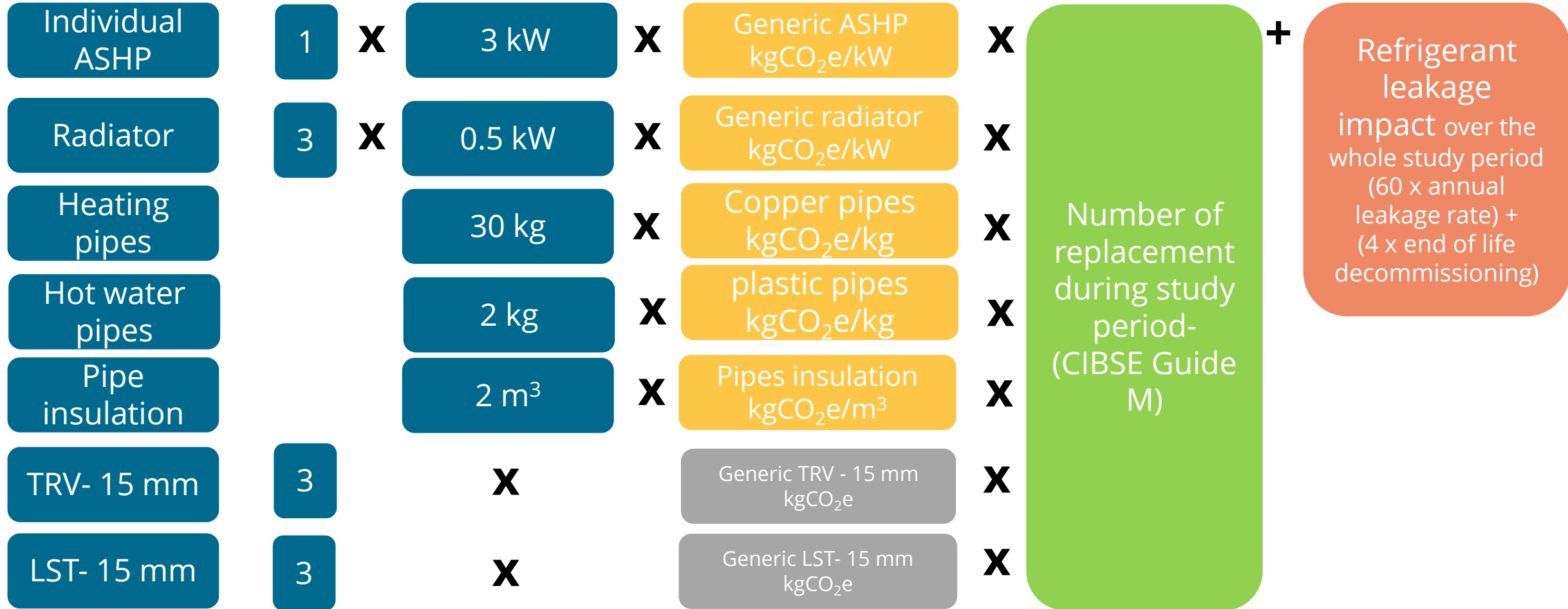
Methodology - Creating generic data points



Methodology – system level calculations



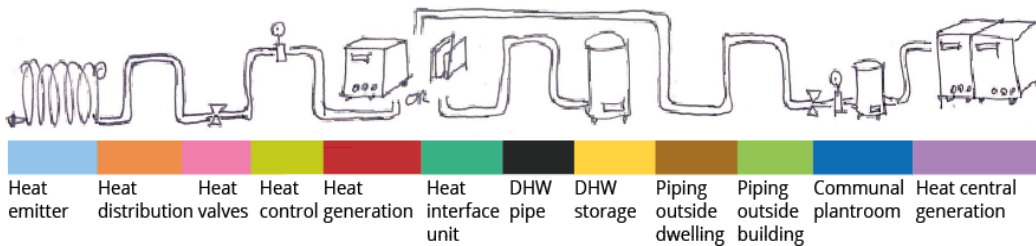
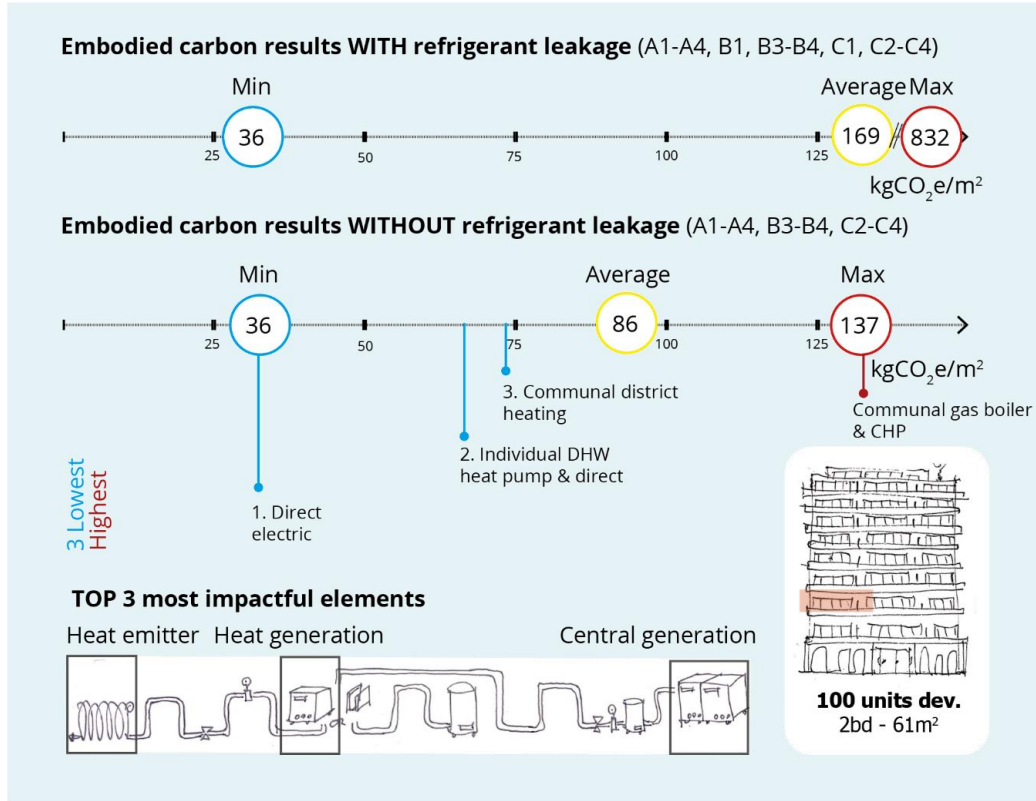
Methodology - example



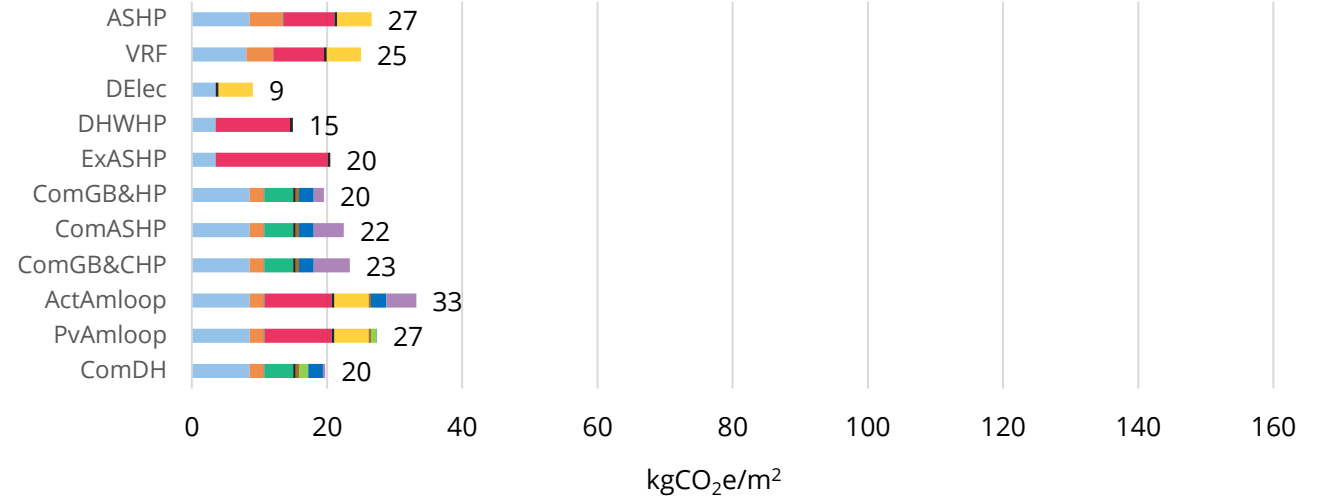
Results and findings



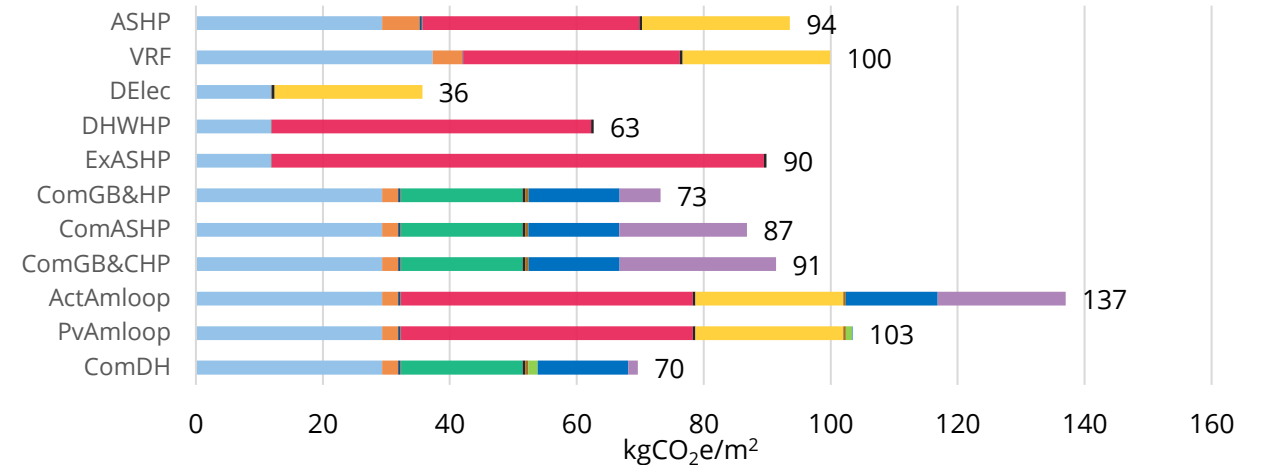
Results - 100 unit multi residential scheme



100 Units Residential Development: Upfront Embodied Carbon (A1-A4) in kgCO₂e/m²

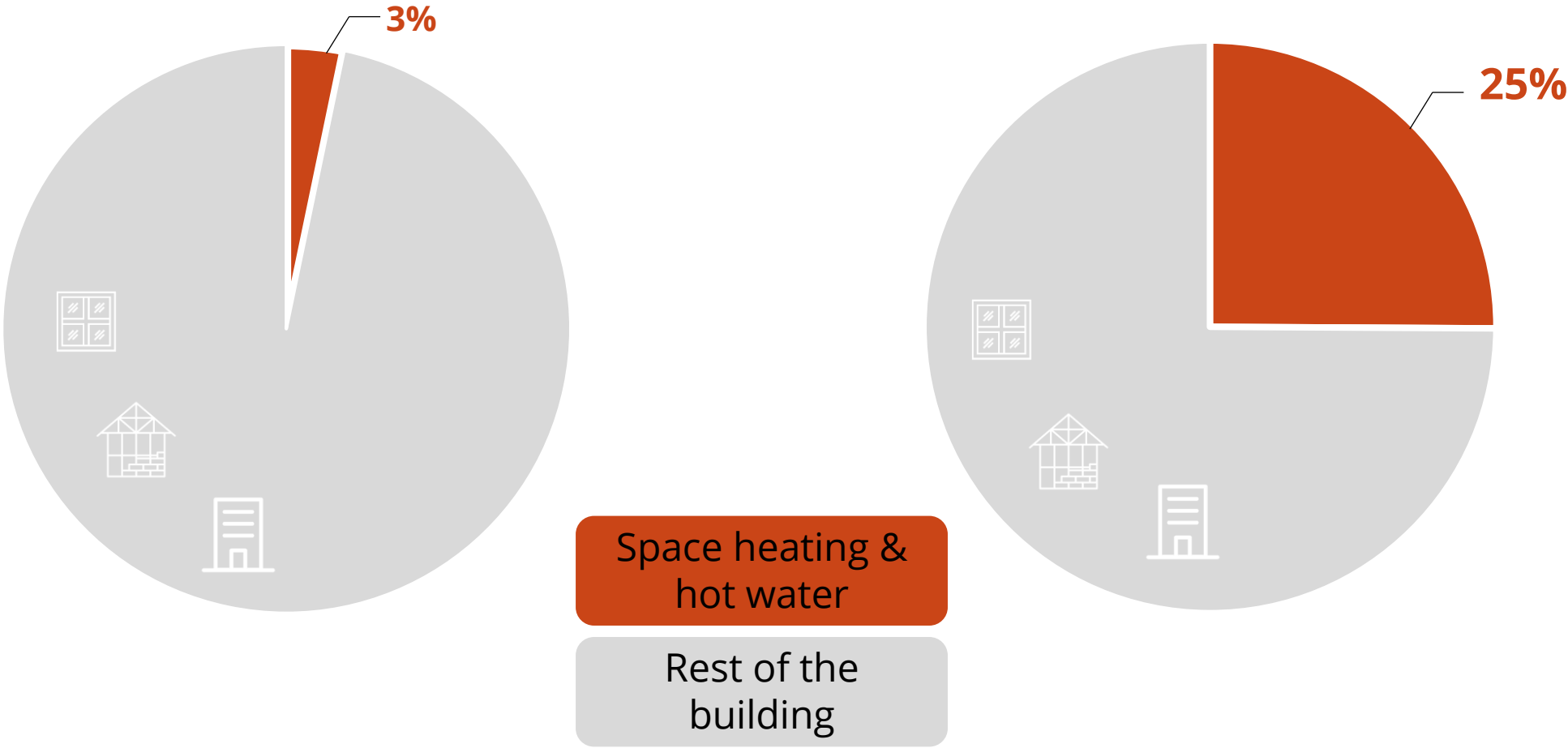


100 Units Residential Development: Embodied carbon (A1-A4, B3-B4, C2-C4) excluding refrigerant leakage in kgCO₂e/m²



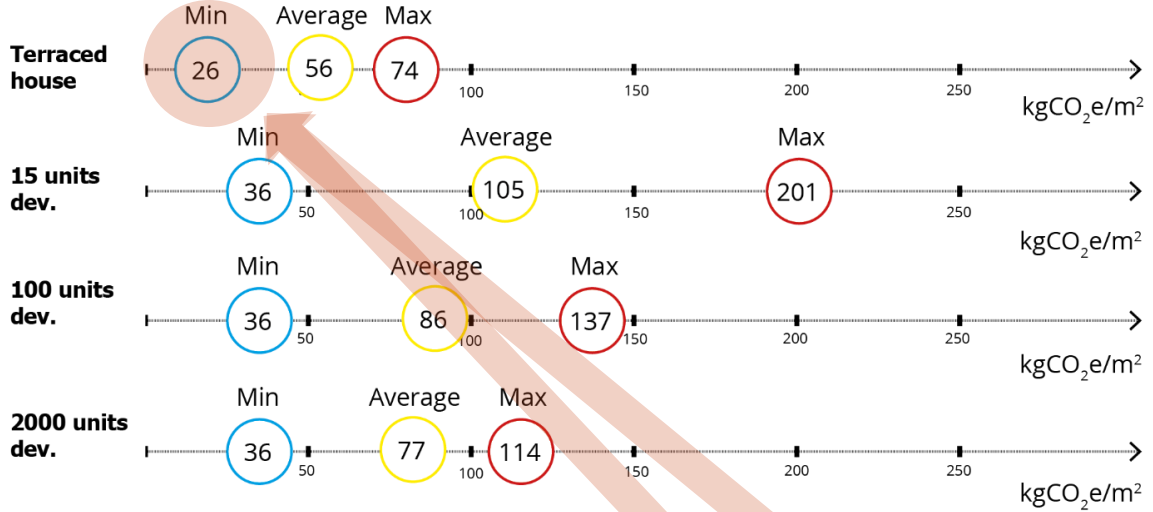
System findings - Embodied carbon of heating design matters

Embodied carbon of heating and hot water systems compared to the whole building (800 kgCO₂e/m²)

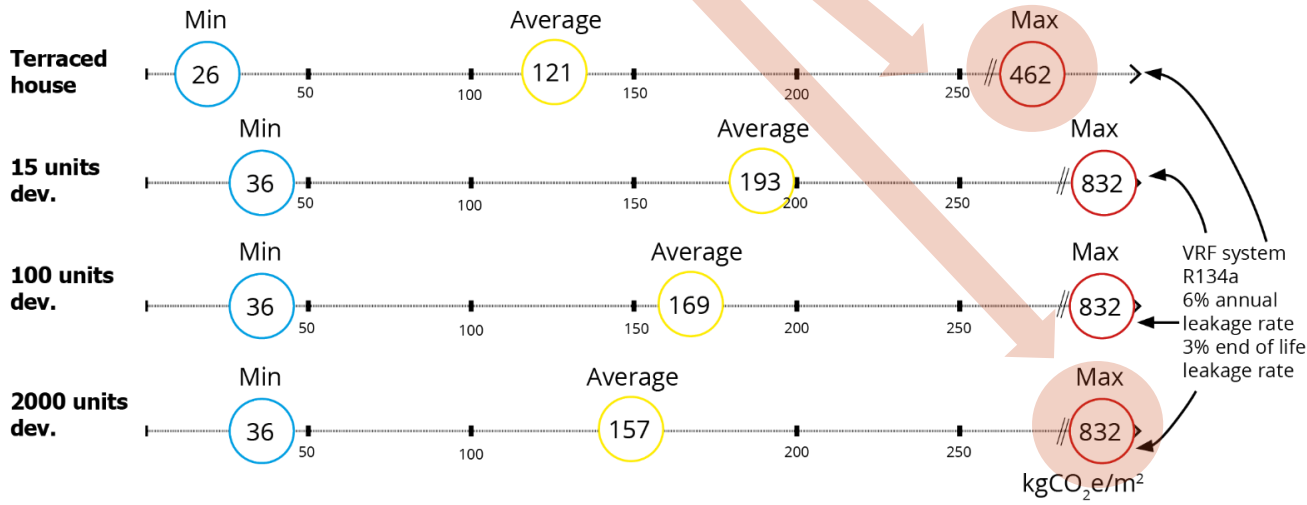


System findings - there is a big impact variance between systems

Embodied carbon results WITHOUT refrigerant leakage (A1-A4, B3-B4, C2-C4)

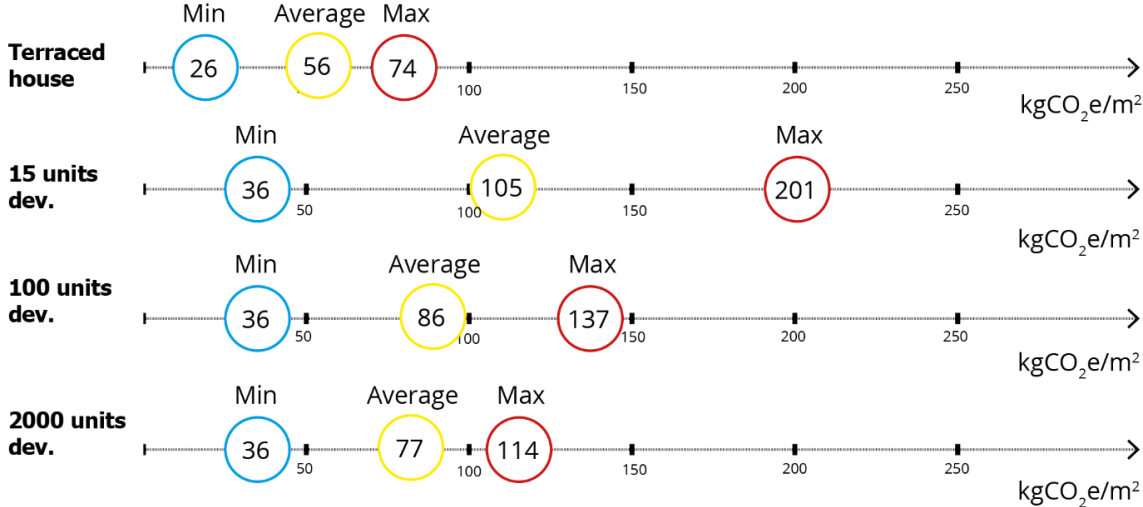


Embodied carbon results WITH refrigerant leakage (A1-A4, B1, B3-B4, C1, C2-C4)

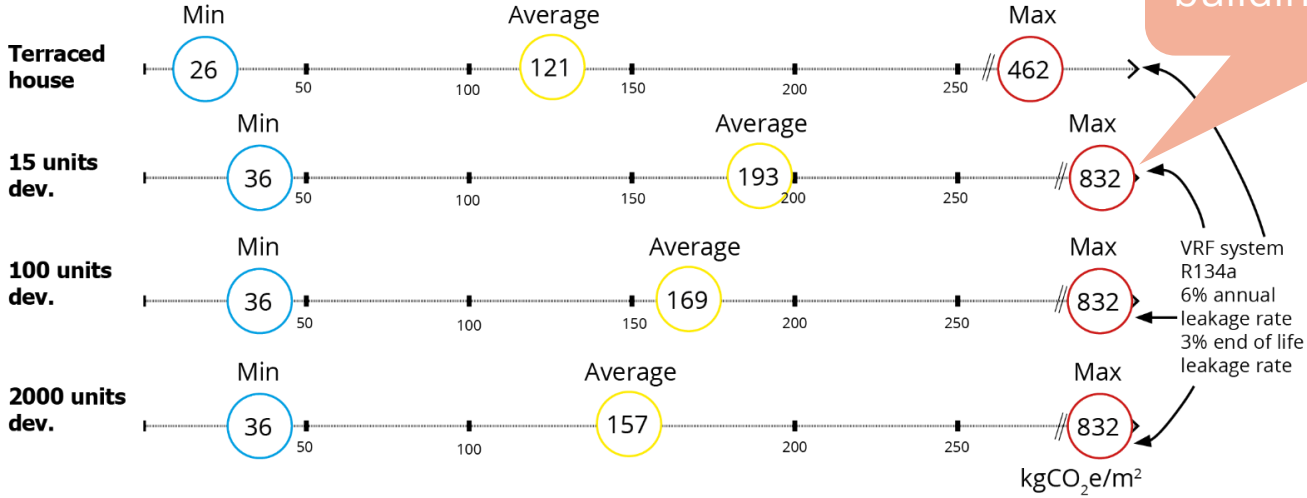


System findings - Refrigerant leakage impact is significant

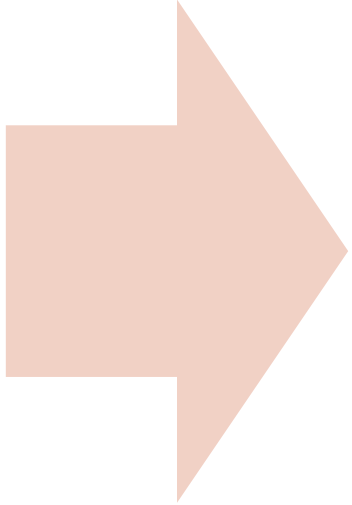
Embodied carbon results WITHOUT refrigerant leakage (A1-A4, B3-B4, C2-C4)



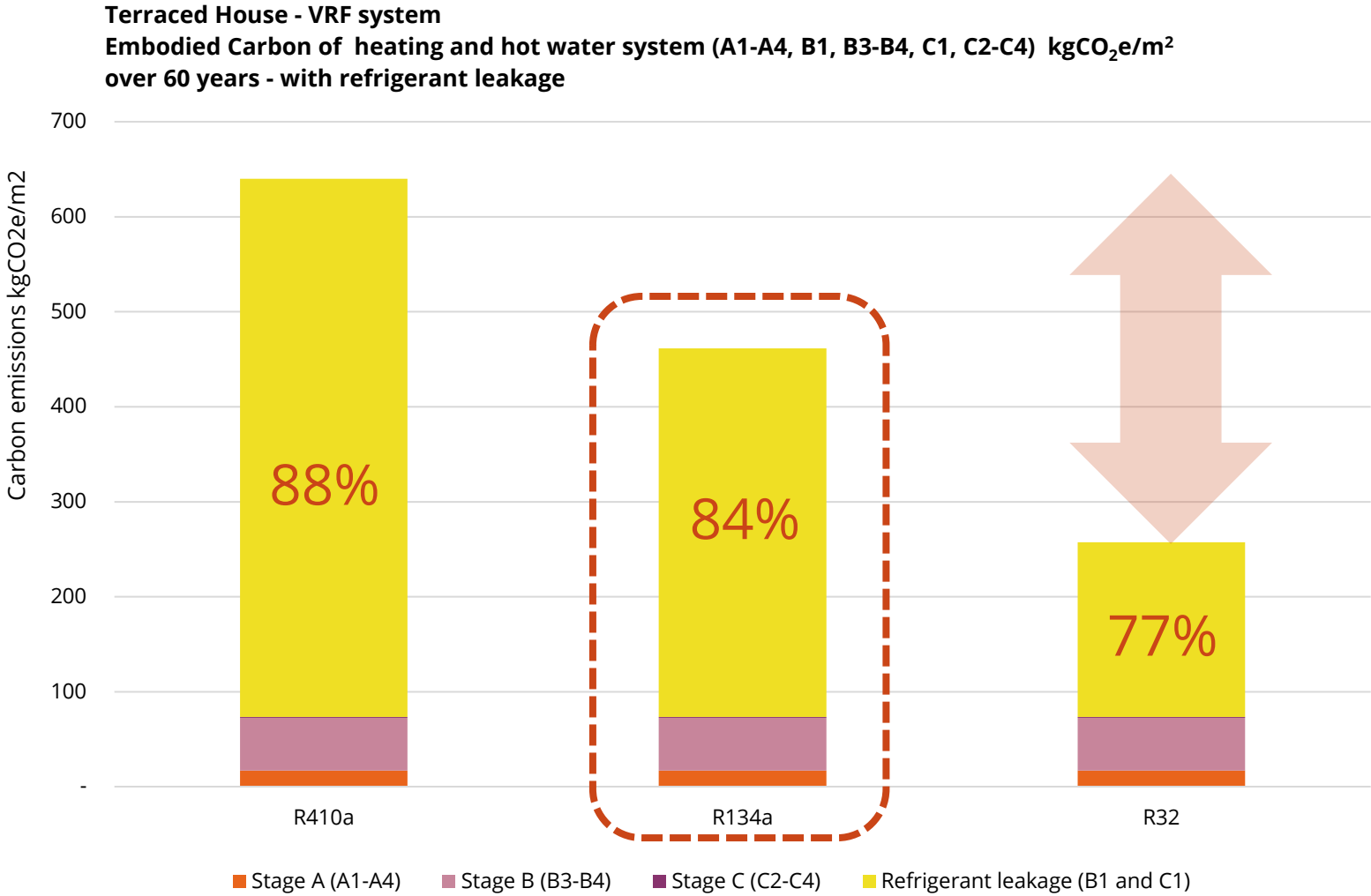
Embodied carbon results WITH refrigerant leakage (A1-A4, B1, B3-B4, C1, C2-C4)



Above our current building target



System findings - Refrigerant leakage impact is significant

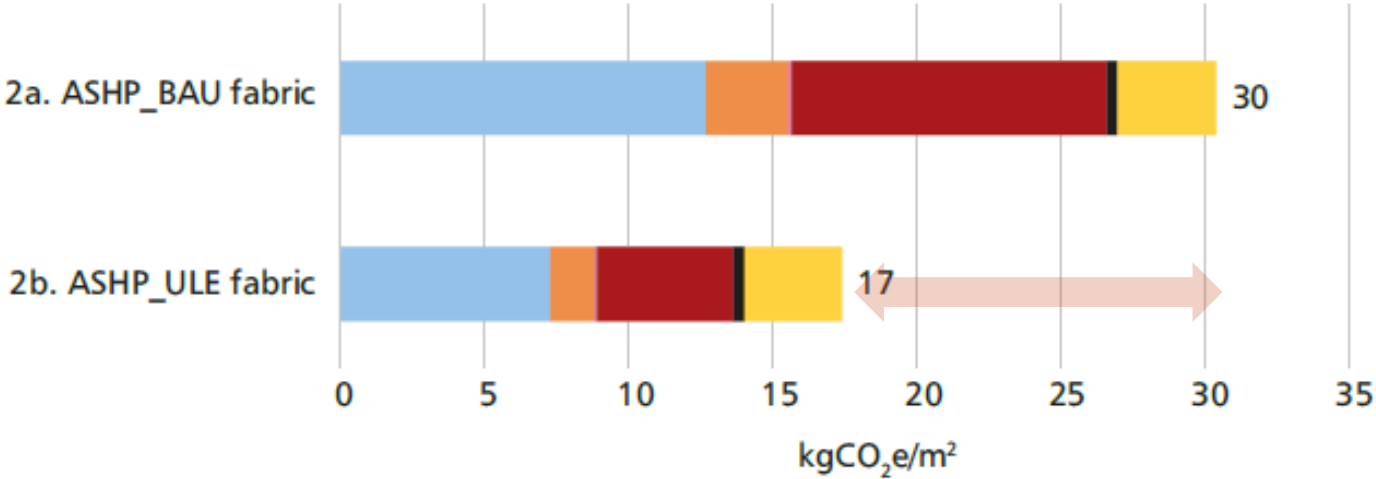


 Go to Appendix D.1

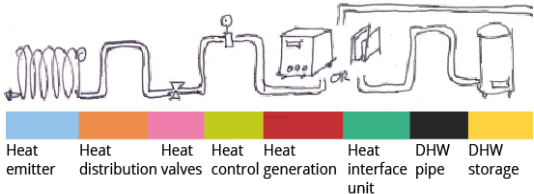


System findings - good building fabric reduces the embodied carbon of your heating system by **40%**

Terraced house
heat pumps in BAU and ULE fabric
upfront embodied carbon (A1-A4)
in kgCO₂e/m²

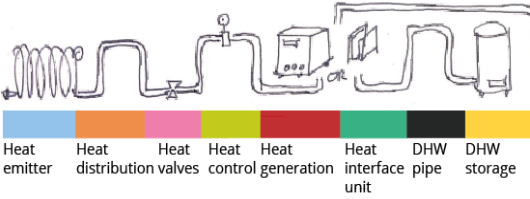
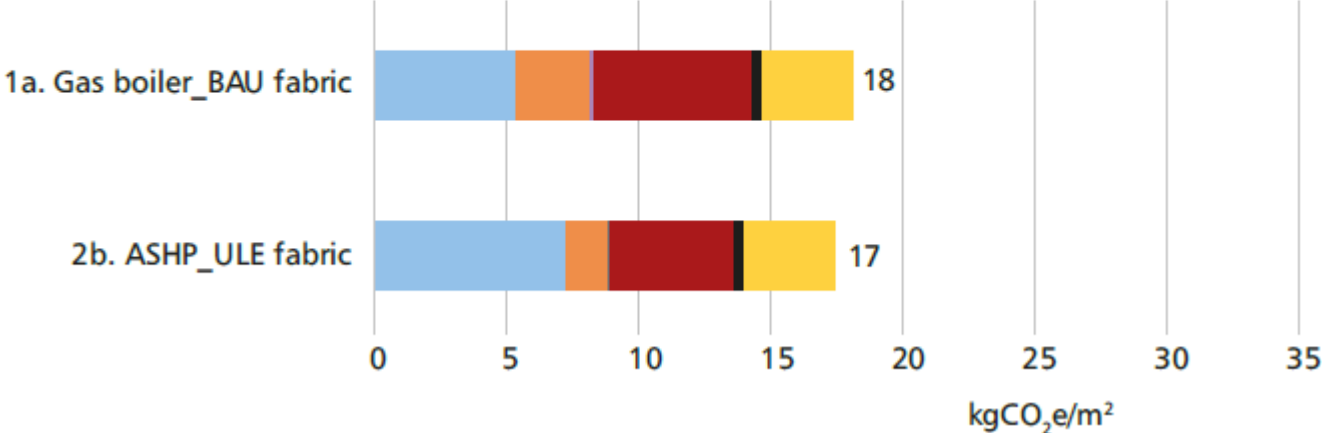


 Go to Appendix D.3



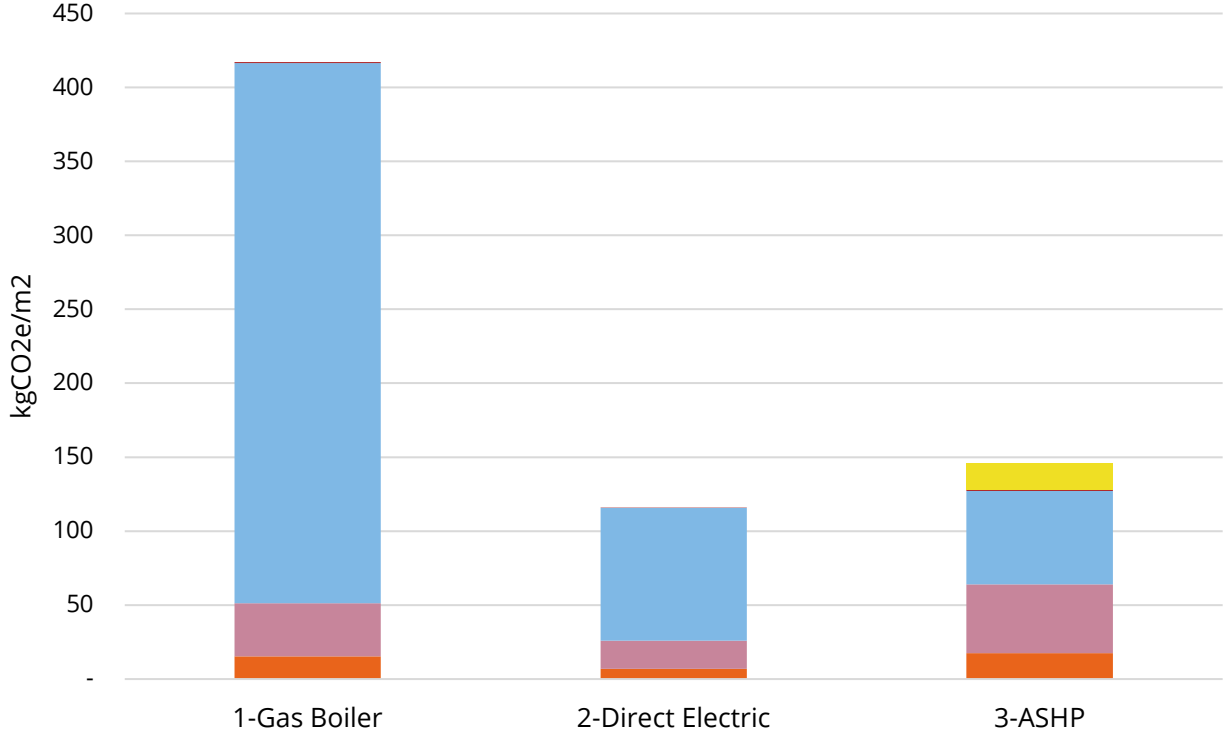
System findings - Increasing the thermal performance of the building fabric can balance out the increase in embodied carbon from gas boiler to heat pump.

Terraced house
 gas boiler BAU compared with ASHP ULE
 upfront embodied carbon (A1-A4)
 in kgCO₂e/m²








System conclusion - both operational & embodied carbon need to be considered when making decisions

Terraced House
Whole Life Carbon (A1-A4,B1, B3-B4,B6, C1, C2-C4)
kg CO₂e/m² - 60 years
Flat lifetime carbon factor



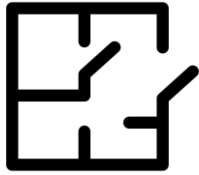
 [Go to Appendix D.4](#)

-  Stage A (A1-A4)
-  Stage B (B6) - operational energy
-  Refrigerant leakage (B1 and C1)
-  Stage B (B3-B4)
-  Stage C (C2-C4)



**CIBSE TM65.2 -
Coming soon**

CIBSE TM65.2 - Aim & scope



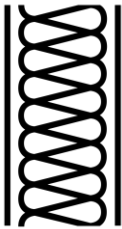
10,000 m² office building



1 person per 8 m²



Heating/Cooling/
Ventilation



Fabric (refurbished to new building regulations standard)

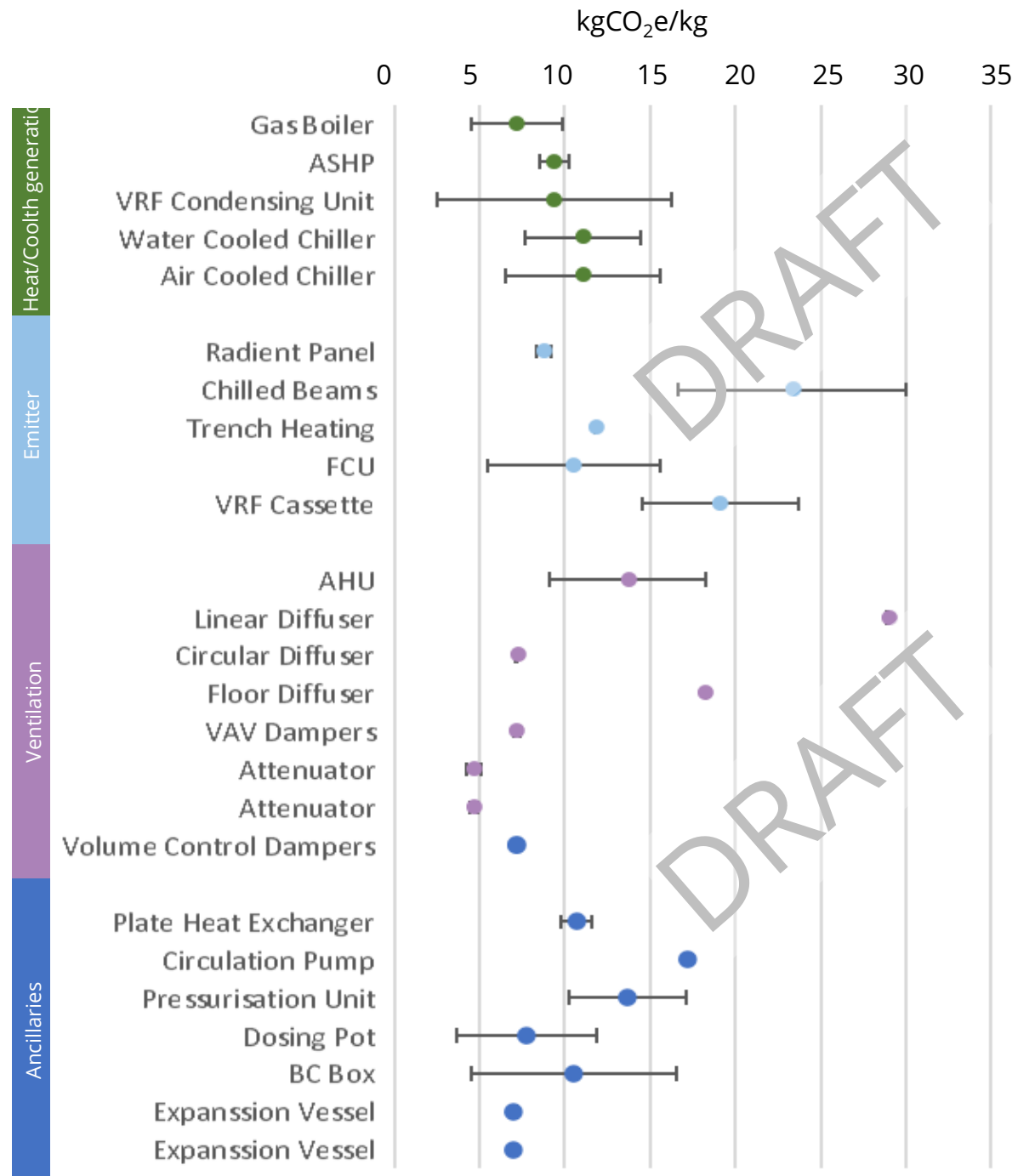


Glazing ratio – 60%



Product level summary

- Dot represents the GWP/kg value for the given product.
- The error bars give an indication of the confidence of the data-point.
- The dots without error bars have too few data points to be able to predict the likely variance of the data-point.



Questions?