Embodied Carbon of Heating, Ventilation, Air Conditioning and Refrigerants (HVAC+R) Systems. Barbara X. Rodriguez Droguett

This dissertation provides a new simplified method to assess the embodied carbon (EC) across the life cycle of Heating, ventilation, air conditioning and refrigerant systems that can assist design teams to assess the overall EC impact of HVAC+R systems in early stages of design. A method such as this one would contribute to reduce four important barriers in WBLCA practice that prevent a better understanding of embodied carbon in buildings: 1) the time consuming process behind most LCA methods; (2) limited availability of building LCA data; (3) limited availability of material quantity data, and (4) a focus on structural, foundation and enclosure systems in the building scope of most WBLCA studies. Table 1 summarizes the embodied carbon estimates for each HVAC+R system type.

Table 1 Embodied carbon estimates for equipment and distribution systems according to each HVAC+R system type

Building type	System type	Equipment	Distribution	Total ($kgCO_2e/m^2$)
Standard	Packaged rooftop AC + Furnace	9.8	25.6	**35.4**
	Packaged rooftop heat pump	18.0	39.2	**57.3**
	VAV AHU w/ PFP Terminals	66.8	61.0	**127.8**
	WSHP	40.1	44.8	**85.0**
High performance	DOAS + Chilled Beam	38.7	21.3	**60.0**
	DOAS + VRF	22.2	17.6	**39.8**
	DOAS + WSHP	64.7	51.2	**115.9**
	DOAS ERV + Packaged Rooftop Heat Pump	30.2	52.0	**82.3**
	DOAS ERV + VRF	48.2	39.3	**87.5**

In line with these findings, this study exemplifies that while HVAC+R system represent a relatively small share compared to other systems (i.e structural), with recurring instalments and lack of refrigerant management across the typical 60 year lifespan of the building, this initial impact can add up overtime and surpass the embodied carbon of other systems as shown in Table 2 and Figure 1.

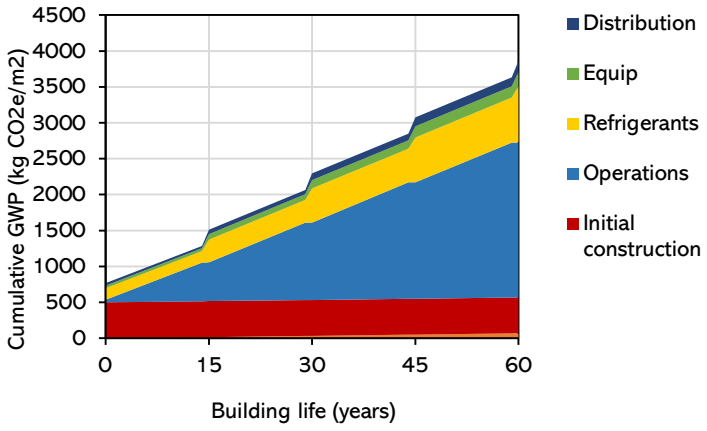

Figure 1 Embodied Carbon (EC) vs Operational Carbon in HVAC+R Systems a high impact worst-case scenario (no refrigerant management)