

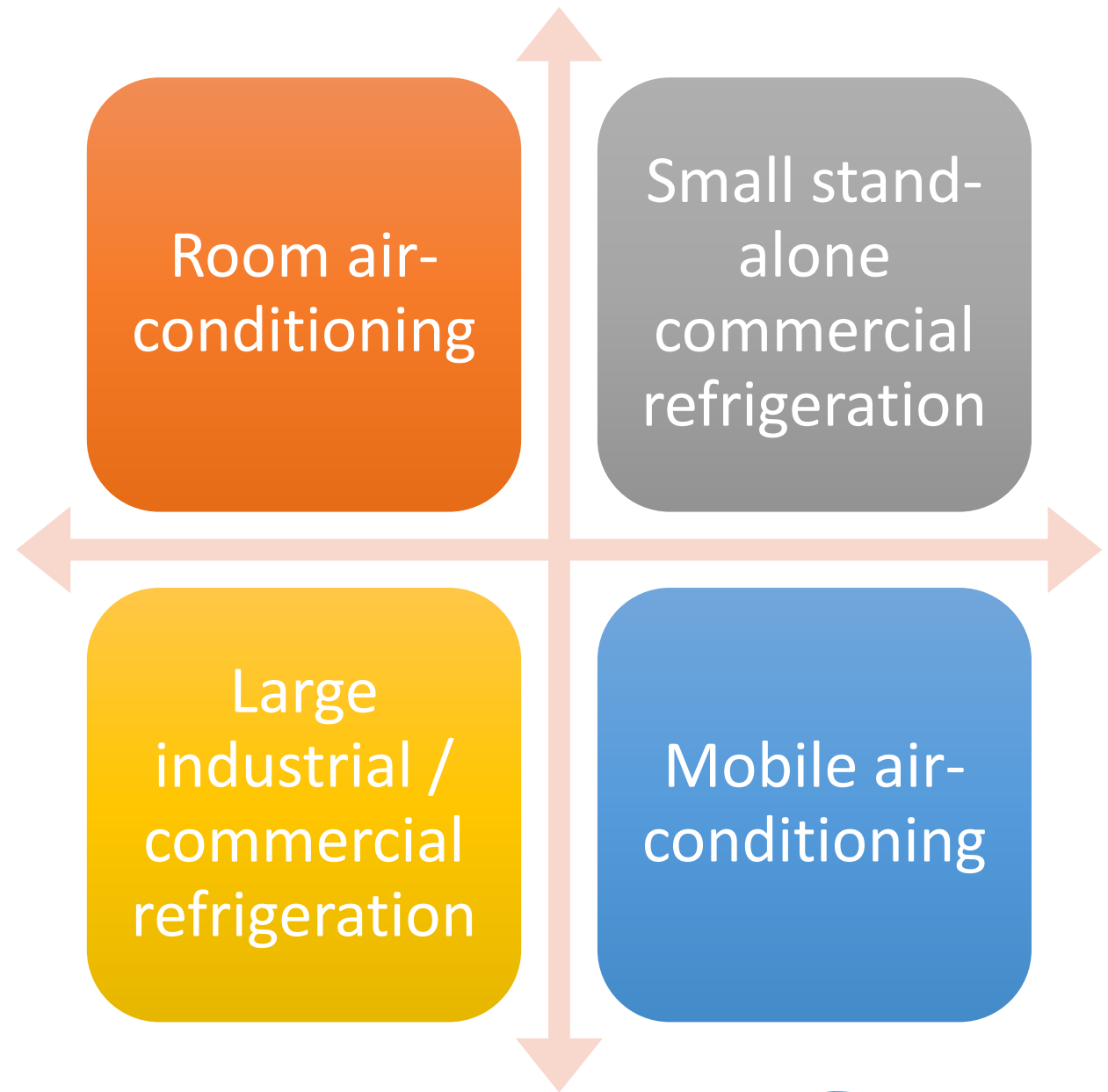
WB Funding Needs and Options for HCFC and HFC Phase-out: Results from modeling impact, co-benefits and costs

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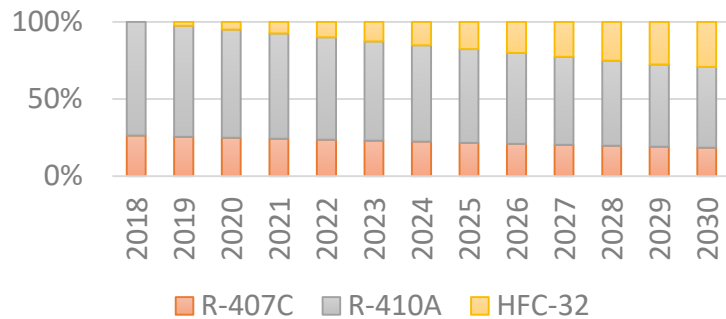
International Sustainable Cooling Conference & 5th COOL Workshop, 28-30 November 2018

RAC sectors identified for short-term action and scale-up

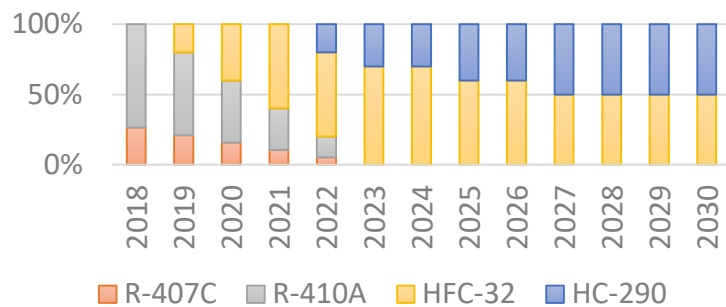


What-if impact on refrigerant transition and EE penetration with targeted interventions

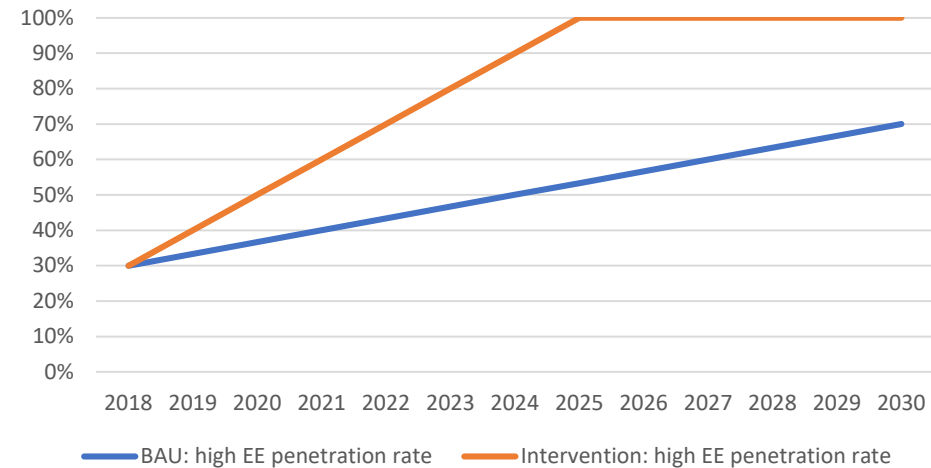
Refrigerant Transition - BAU



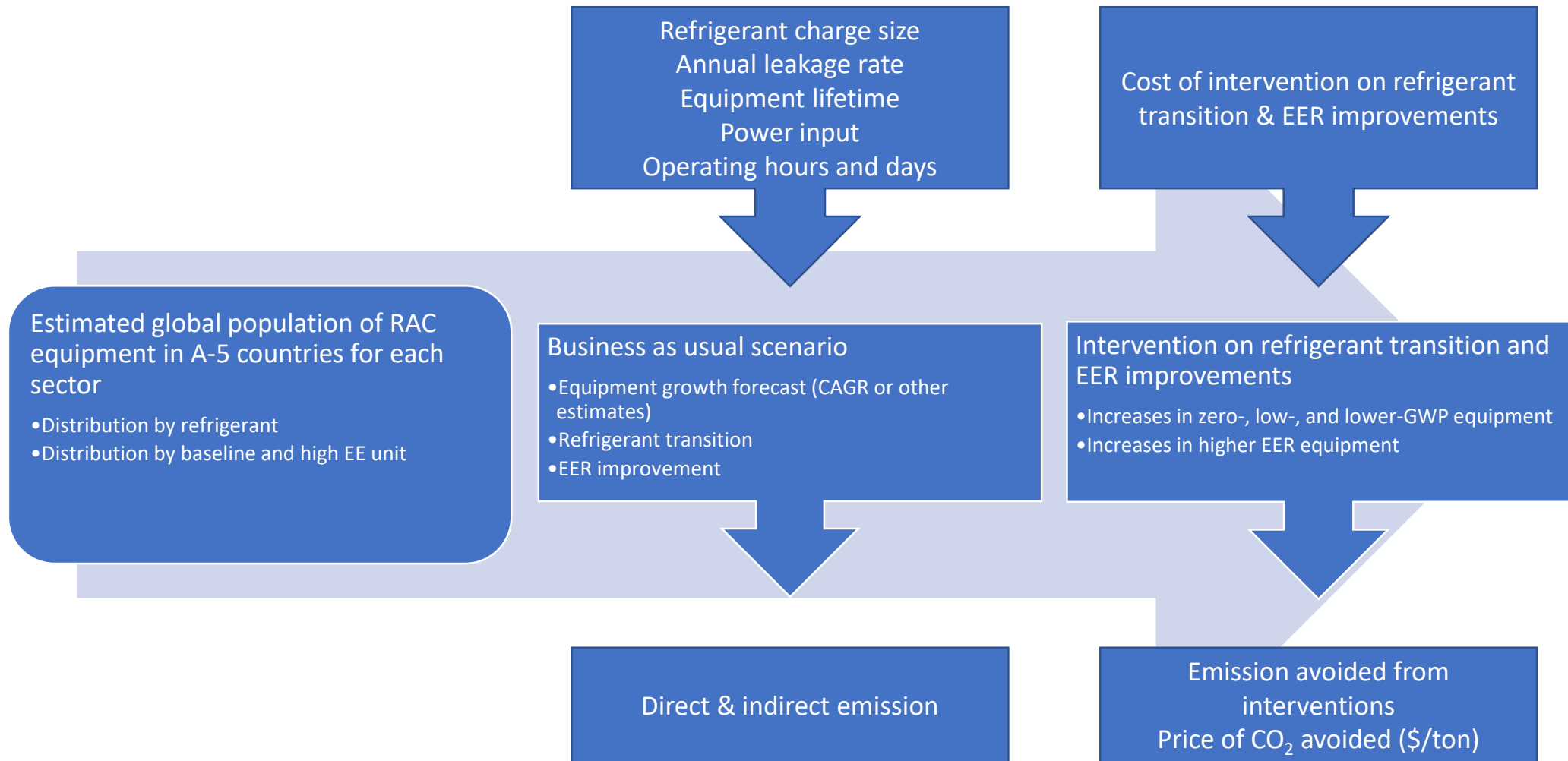
Refrigerant Transition - Intervention



High EE Penetration Rate



Modeling framework



Baseline data & assumption

	Room AC	Stand-alone commercial refrigeration	Large industrial / commercial refrigeration	MAC
Baseline model	12,000 BTU/hr	Small stand alone unit	500 ton chiller	Direct expansion
Annual production	145 million 74% R-410A 26% R-407C	9.2 million 50% R-134a 50% R-404A	9,200 100% R-134a	43 million 99% R-134a 1% R-1234yf
Growth rate (%)	8	5.3	5	3
Charge size (kg)	1	1	500	0.5
Annual leakage rate* (%)	18	18	6	34
Power input (kW)	1.21	6.1	300	Fuel consumption 10.5 km/l
Operating hours/days	8/200	24/365	16/200	Annual mileage 7,800 km/year
Lifetime (years)	12	15	25	11
Low-GWP alternatives	R-32, R-290	R-600a, R-513A	R-513A, HFOs	R-1234yf, SL (152a, 1234yf)

* Including no recovery of refrigerant at end-of-life disposal

Funding Needs and Options for Additional Co-benefits

- Modeling scenarios in 4 subsectors confirms that energy and climate benefits of accelerating conversion are substantial: a conservative estimated price ranging from \$11/ton of carbon in small commercial refrigeration to \$36/ton in MAC.

Subsector/ Application	Total HFCs at Baseline (kTon)	Conversion Cost (US\$ m)	Total EE Units by 2030 (million)	Total IOC (consumer) (US\$ m)	Total CO2 Emissions Avoided 2018-30 (M tCO2)	Price of CO2 (US\$/ton)
	Manufacturing		Demand			
Room Air-conditioning	100.94	1,255	513	56,453	3,025	19
Small Stand-alone Commercial Refrigeration	26.10	842	87	39,119	3,596	11
Large Industrial/ Commercial Refrigeration	11.71	186	0	1,018	78	13
Mobile air-conditioning	32.60	405	309	3,092	85	36

Funding Needs and Options for Additional Co-benefits

- 30% EE improvement with transition to lower-GWP refrigerant: MP, Climate Benefits and **Energy Savings 2018-30**

Subsector/ Application	Sectors and Areas of Use	HFCs Phased Down (ktonnes) Annually	Cumulative CO ₂ Emissions Avoided (Direct & Indirect) m ton	Cumulative Energy Savings (2018-2030) (GWh)	Avoided Cost of New Power Generation (US\$ b)*
Room Air-conditioning	Urban, Buildings, Households	100.94	3,025	4,246,728	142.66
Small Stand-alone Commercial Refrigeration	Urban, Food Cold Chain	26.10	3,596	8,270,298	283.048
Large Industrial/Commercial Refrigeration	Agriculture, Food Cold Chain, Industry	11.71	78	145,833	5.00