

## Refrigeration/Air Conditioning (AC) Sector “Cheat Sheet”

This document summarises the methods and assumptions used to (a) develop bottom-up bank estimates and (b) assess technical and economic feasibility in the refrigeration/AC sector. References cited refer to those listed in the draft report prepared by ICF International for the European Commission, *Identifying and Assessing Policy Options for Promoting the Recovery and Destruction of Ozone Depleting Substances (ODS) and Certain Fluorinated Greenhouse Gases (F-Gases) Banked In Products and Equipment* (March 2010). For more detailed information on methodology/assumptions used, please see Annex A of the draft report.

### Methods & Assumptions Used to Develop Bottom-Up Bank Estimates

The two tables below present the summary assumptions used to develop the refrigeration/AC end use characteristics, as well as the data/methods for estimating stock (number of units) by end use and by Member State.

Refrigeration/AC End Use Characteristics: Summary Assumptions

End-Use	Charge Size (kg)	Lifetime (yrs)	Growth Rate		Refrigerant Transitions in Banks (i.e., equipment <i>in use</i> )
			2009-2020	2020-2050	
<b>Refrigeration</b>					
Refrigerators/ Freezers	NA	15	1.0%	0.5%	5% HFCs, 15-30% CFCs today; will transition almost fully to HCs by 2020
Small Commercial	2 - 3	12	3.0%	1.5%	75% HFC, 20% HCFC, 5% CFC today; continued reliance on HFCs through 2020 (>90%), gradual decrease through 2050 (50%)
Medium/Large Commercial	255- 300	15	3.0%	1.5%	85% HFC, 15% HCFC today; increased reliance on HFCs through 2002 (>95%), gradual decrease through 2050 (50%)
Land Transport	5	25	6.0%	3.0%	80% HFC, 15% HCFC, 5% CFC today; increased reliance on HFC through 2020 (95%), gradual decrease through 2050 (65%)
Ships Transport	1,500- 2,000	25	2.0%	1.0%	75-85% HCFC, 10-15% HFC, 5-10% natural refrigerants today; by 2020, increasing shift to HFC (30%), with gradual shift to natural refrigerants (50% by 2050)
Industrial Refrigeration	850- 1,000	20	1.0- 2.0%	0.5- 1.0%	10% HCFC, 15% HFC, remainder natural refrigerants today; HFC banks rise to 20% by 2020 but decline to 5% by 2050
<b>Mobile AC</b>					
Passenger Cars	0.75 - 0.85	14	2.0- 3.5%	1.0- 1.75%	98% HFC, 2% CFC today; 70% HFC in 2020, 0% in 2050 (full transition to alternatives)
Buses	6- 7	14	0.5- 1.75%	0.25- 0.75%	98% HFC, 2% CFC today; 95% HFC in 2020, 0% in 2050 (full transition to alternatives)
<b>Stationary AC</b>					
Small	3- 3.5	10	3.5- 8.0%	1.75- 4.0%	65-85% HFC, 15-35% HCFC today; continued reliance on HFCs through 2020 (98% of stock), then transition to alternatives to reach 50% HFC by 2050
Large (Chillers)	210- 250	15	5.5%	2.75%	65-75% HFC, 20-30% HCFC, 5% CFC today; continued reliance on HFCs (95%) in 2020, with 5% remaining HCFC; transition to alternatives reduces HFC banks to 75% in 2050

NA= Not available; only charge *recoverable* at EOL was estimated, assumed to be 0.06 - 0.15 kg (depending on country).

Data/Methods for Estimating Stock (Number of Units) by Country: Summary of Assumptions

Ref/AC End-Use	Stock Data	Data Sources	Disaggregation by Member State
Refrigerators/ Freezers	Stock data for EU-25 for 2000 & 2005	LOT:13 Domestic Refrigerators and Freezers Final Report (2007)	Disaggregated units by population; used average ratio of units/population for Bulgaria & Romania
Small Commercial Refrigeration	Number of minimarkets & supermarkets in the Netherlands in 2000, assuming average of 10 units per store, each with 2-3 kg charge	GAIN Report on the Netherlands Retail Food Sector (USDA, 2000)	Scaled estimates for the Netherlands based on population
Medium/ Large Commercial Refrigeration	Number of supermarkets in the Netherlands in 2000, assuming average charge size of 250-300 kg per store	GAIN Report on the Netherlands Retail Food Sector (USDA, 2000)	Scaled estimates for the Netherlands based on population
Land Refrigerated Transport	EU-27 stock estimates for road (in 2005), rail (in 2002), and intermodal container refrigerated transport (1990-2004)	RTOC (2006) and the GDV (2009)	Stock estimates scaled based on GDP
Ships Refrigerated Transport	Stock estimates for reefer ships (2009) & merchant marine/ naval/ fishing vessels (2003)	Stock from Lloyd's Maritime Intelligence Unit (2009), RTOC (2006); DWT from United Nations Conference on Trade and Development on the world merchant fleet by flag of registration and type of ship (UNCTAD, 2007)	Scaled based on total dead weight tonnes (DWT) for merchant fleets
Industrial Refrigeration	Approximately 100,000 HCFC-containing IPR systems in the EU in 2009, another 185,000 IPR systems containing HFCs	ICF (2006)	Disaggregated stock by GDP
Passenger cars	Historical data on passenger cars by Member State from 1990 – 2004	Eurostat	Not applicable (data already disaggregated by country)
Buses	Historical data on the stock of motor coaches, buses, and trolley buses by Member State from 1990 – 2004	Eurostat (2009b)	Not applicable (data already disaggregated by country)
Small Stationary AC	Number of units based on EU-15 data on room AC units & centralized AC units	Armines (1999, 2003)	EU-10 estimates based on average ratio of units per capita for EU-15
Large Stationary AC	EU-15 data on centralized AC units	Armines (2003)	EU-10 stocks based on average ratio of units per capita in the EU-15

## Methods & Assumptions Used to Assess Technical & Economic Feasibility

### 1) Projecting Banks Reaching EOL

- Various sources were used, as available:
  - i. Domestic refrigerators: DUH (2007), RAL (2007), ICF (2008)
  - ii. Passenger cars: EC (2003)
  - iii. Transport refrigeration: California Air Resources Board (2008)
  - iv. Others: expert opinion/assumptions

### 2) Estimating Refrigerant Recoverable at EOL

- Recovery efficiency assumed to be 90-95% across all end uses

#### Recovery Potential from Refrigeration/AC Equipment

Sub-Sector	End-Use	% Refrigerant Remaining at EOL		Refrigerant Technically Recoverable at EOL	Total % Potentially Recovered at EOL		Total Charge Recoverable at EOL per Unit (kg)			
		EU-15	EU-12		EU-15	EU-12	ODS		HFC	
							EU-15	EU-12	EU-15	EU-12
Mobile AC	Passenger Cars	60%	50%	90%	54%	45%	Not applicable		0.4	0.3
	Buses	60%	50%	90%	54%	45%	Not applicable		2.4	2.0
Refrigeration	Domestic Refrigerators & Freezers	Not applicable <sup>a</sup>		90%	Not applicable		0.06- 0.13		0.05- 0.12	
	Small Commercial	90%	80%	90%	81%	72%	2.4	2.2	1.6	1.4
	Medium/ Large Commercial	70%	60%	95%	67%	57%	199.5	171.0	169.6	145.4
	Refrigerated Transport—Land	70%	60%	90%	63%	54%	3.2	2.7	2.8	2.4
	Refrigerated Transport—Ships	60%	50%	95%	57%	48%	1140.0	950.0	855.0	712.5
	Industrial Refrigeration	60%	50%	95%	57%	48%	570.0	475.0	485.0	404.0
Stationary AC	Small Stationary	90%	80%	90%	81%	72%	2.8	2.5	2.4	2.2
	Large Stationary (Chillers)	80%	70%	95%	76%	67%	190.0	166.3	159.6	139.7

<sup>a</sup> For domestic refrigerators/ freezers, assumptions on refrigerant remaining at EOL are not based on percentages but on absolute values based DUH (2007) and consideration of other sources (ICF, 2008a; RAL, 2007a; 2007b). The quantity of charge assumed to remain in CFC units at EOL ranges from 0.065 kg to 0.145 kg depending on country; the quantity of assumed to remain in HFC units at EOL ranges from 0.06 kg to 0.13 kg.