Cold Hard Facts
3rd Edition

The Refrigeration and Air Conditioning Industry in Australia

A decade of Industry growth

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EXPERTGROUP

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Expert Group - How have we got here.....

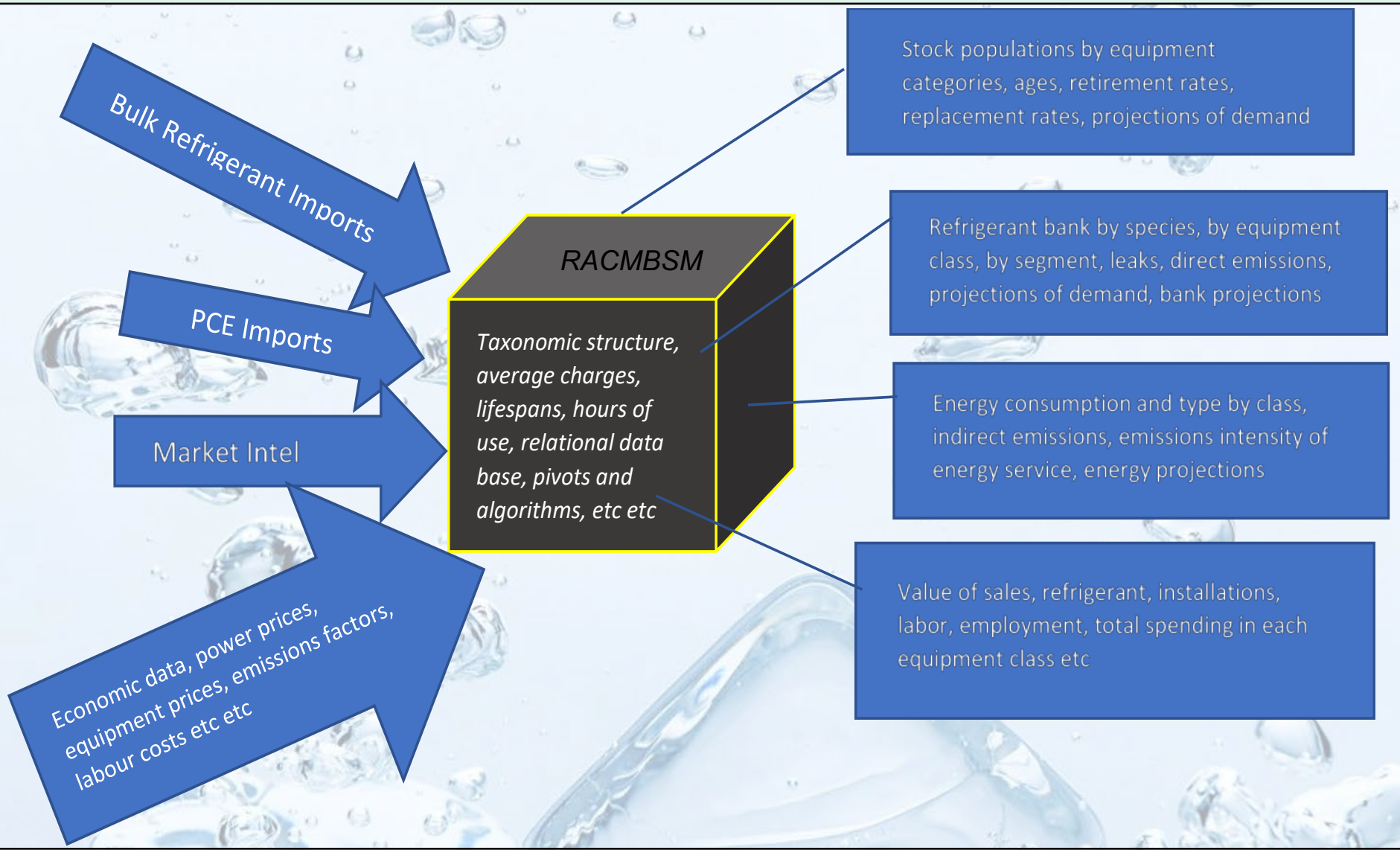
- Authors of the original Cold Hard Facts study in 2006-07, Cold Hard Facts 2 in 2013 and currently finalizing Cold Hard Facts 3.
- Nearly 40 major pieces of research and analysis into almost every aspect of the RAC industry, the technology and the supply chains over the last 10 years

CHF3 – What is it

- A benchmark of an industry moving through a period of dramatic growth, diversification and change
  - How big is it?
    - How much machinery is out there?
      - What is the economic value of all this, employment, spending?
        - How much Refrigerant is involved?
          - How much energy does it all use?
            - What emissions does it produce?
              - And where is it heading?
              - Plan is to publish final report by end of August 2018



RAC Age-Cohort Mass Balance Stock Model



Taxonomy of a Technology

RAC Taxonomy - 4 broad classes – 14 equipment segments and 59 coded products (increase from 50). Stationary AC - Mobile AC - Refrigerated Cold Food Chain - Domestic Refrigeration

Stock model is a mass of data of all equipment using vapor compression refrigeration with the data organized into a:

Taxonomy built on

- **Class**
  - **Segment**
    - **Application**
      - **Product Category**

Item no	Class	Segment	Application	Category Code	Product category
1	Stationary air conditioning (AC)	AC1: Small AC: Self-contained	Window/wall	AC1-1	Non-Ducted: Unitary 0-10 kWr
2			Portable AC	AC1-2	Portable AC 0-10 kWr
3		AC2: Small AC: Split	Single split: non-ducted	AC2-1	Single split system: non-ducted: 1-phase
4			Single split: non-ducted	AC2-2	Single split system: non-ducted: 3-phase

Taxonomy of a Technology – Additions/Changes

- **Expanded Product Category - RCFC – WIC split into two categories, self-contained and three categories of remote, small, medium and large – and then we found a lot more of them – this stock was expanded in 2012 as well.**

Self-contained	RCFC1-7	Walk-in coolrooms: small: Slid-in/Drop-in

- **Expanded Product Category – RCFC – RDCs split into two categories, self-contained and remote.**

Remote	RCFC2-3	Refrigeration cabinets: remote

- **New Product Category - Heat Pump Clothes Dryers – 15,000 units pa for last three years, these things simply did not exist in 2012**

Heat pump clothes dryers	AC5-2	Heat pump clothes dryers

- **Expanded Product Category – Large MAC – MAC2-1, MAC2-2, Buses broken into two size groups, much better data about small buses available**

- **New Product Category - Large MAC – MAC2-5 - Caravans and Motorhomes, there are tens of thousands of them!!**

Vehicles: RV and caravan	MAC2-5	RV and caravan

- **New Product Category - Large MAC – MAC2-7 - Registered Marine Vessel and Pleasure Craft**

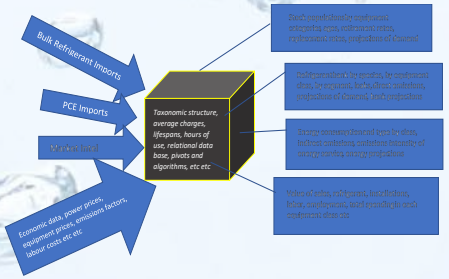
Marine	MAC2-7	Registered marine vessels and pleasure craft.

What data do we collect

TWG

Australian Government:

- Bulk imports by HFC and HCFC species since 2005
- Pre-charged equipment (PCE) imports by HFC species by equipment class since 2005 (insights into new product mix and average charges)
- PCE containing HCFCs (largely banned in 2010)
- Motor vehicle registrations



Market data: - significantly expanded since CHF2

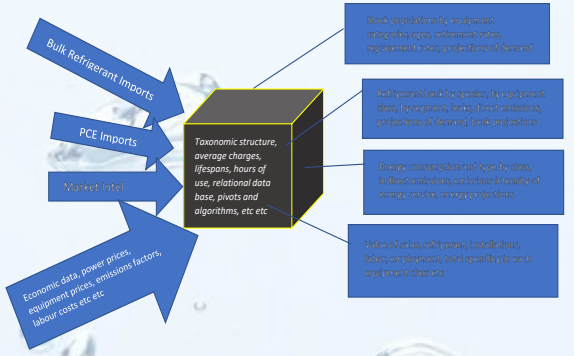
- Monthly sales ($ and quantity) of HCFCs and HFCs by species including refrigerant re-use
- Equipment sales data (air conditioning and refrigeration equipment by type)
- Targeted surveys:
  - Usage of HFC-134a in Mobile AC aftermarket
  - Annual sales of natural refrigerants (HC, CO_2 and ammonia) last 5 years
  - Retail Market Survey of HC in domestic refrigerators on showroom floors
  - Penetration of CO_2 in various equipment categories and applications
- In-confidence interviews:
  - OEM usage of HFCs
  - Emerging technology trends

RAC Age-Cohort Mass Balance Stock Model

TWG

Stock Model Algorithms and parameters:

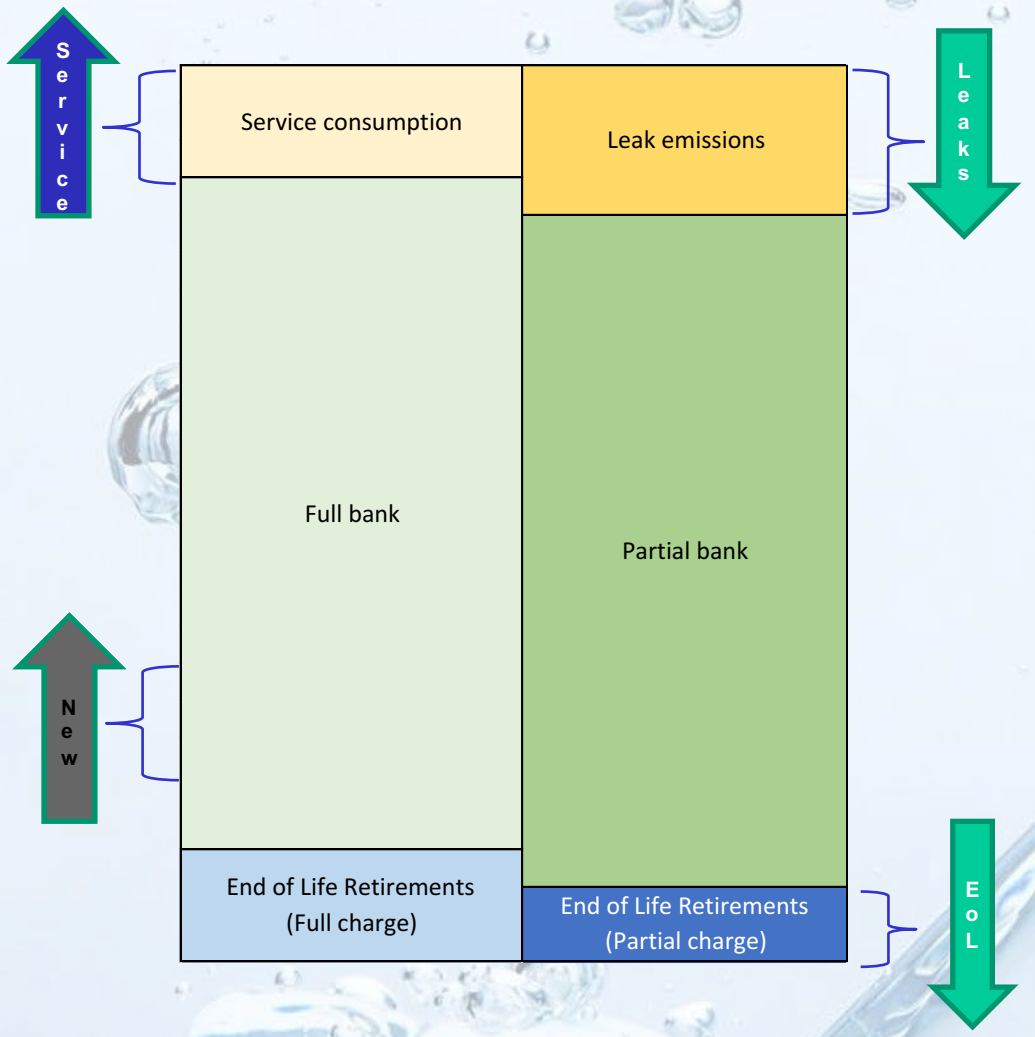
- Average lifespan and survival curves by equipment category
- Average charges by equipment category and changes in charge sizes over time
- HFC usage by species and HFC alternatives (Service, OEM, Retrofit, Local charging of new equipment)
- kW ratings, hours of use, leak rates



Stock Model Outputs:

- Stock populations and age
- Refrigerant use and Service Rate by class and segment
- Direct emissions by equipment category
- End of Life Retirements
- New sales mix projection out to 2030 by equipment category and HFC species
- For example projections of Small AC: Sealed, Small AC: Split, Medium AC: Light commercial and Large AC: Chillers
- Energy use by Class and Segment
- Indirect emissions by Class and Segment

New Capabilities from Model - Refrigerant mass flow concept diagram



Leaks rate > Service rate

EoL charge < 100% of original charge

Partial (Actual) bank is ~92% full
(99% to 82% depending on segment)

Emission to atmosphere =

Leaks + EoL less Recovery

Predict leak rates with high level of confidence:

- HFC Split AC systems (3.6% leak rate, 2% service rate, average lifespan of 12 years and EoL residual of 80%)
- 2.8% leak rate with EoL residual of 90%
- Mobile AC (7% leak rate, 5% service rate, average lifespan of 18.6 years and EoL of 67%)

New Paradigm – leak rates to be cited with EoL assumption

CHF3

The

Big

Numbers

…..Drum Roll …..

RAC Industry Measures of Growth 2012 - 2016

	2012	2016
Metric	Size and proportion	
Employment	173,000 (1.5%) of 11.53 million	298,400 (2.5%) of 12.47 million
Direct spending	$26.2 Bn (1.7%) of $1,522 Bn	$38.11 Bn (2.3%) of $1,679 Bn
Electricity use	59,100 GWh (23.5%) of 251,000 GWh	61,000 GWh (23.6%) of 258,000 GWh
Greenhouse Emissions (direct and indirect)	64.5 Mt CO_2e (11.9%) of 547Mt	68.71 Mt CO_2e (12.4%) of 554Mt
Stock of equipment	45 million pieces	54 million pieces

Stock of Equipment CHF1 vs CHF2 vs CHF3

	2006	2012	2016
Domestic refrigerators and freezers (incl. portables)	13,000,000	17,149,000	19,212,000
Domestic and light commercial air conditioning	5,638,669	11,555,000	14,438,000
Chillers	22,450	24,700	24,900
Volume of cold storage	9,460,000 m^3	13,050,000 m^3	15,000,000 m^3
Supermarkets ($\geq$ 400 m^2)	3,675	3,336	4,072
Extra small supermarkets (<400 m^2)	-	840	570
Convenience stores	-	5,817	6,090
Walk-in coolrooms (WICFs)	22,853	98,100	258,000
Non-domestic refrigeration equipment (excl. WICFs)	821,500	1,055,000	1,396,000
Refrigerated vehicles	16,418	28,900	38,000
Passenger & light commercial vehicles with AC	12,660,000	14,566,000	16,987,000

Employment

Licence type	Number of RHLs	% of RHLs	Employment Multipliers [1]	Total Direct Employment	% of Direct Employment
Automotive AC	28,888	43.60%	2.4	69,331	31.7%
Aviation	188	0.30%	2.0	376	0.2%
Awaiting assessment	361	0.50%	0.0	0	0.0%
Domestic RAC	346	0.50%	1.5	519	0.2%
Marine	169	0.30%	2.0	338	0.2%
Commercial refrigeration	6,019	9.10%	5.0	36,114	16.5%
Commercial AC	18,057	27.20%	5.0	84,266	38.6%
Split systems (up to 18kWr)	11,683	17.60%	2.25	26,287	12.0%
Refrigerant handler	158	0.20%	2.0	316	0.1%
Refrigerant recoverer	307	0.50%	2.0	614	0.3%
Transport refrigeration	118	0.20%	3.0	354	0.2%
Total RHLs	66,294			**218,515**	100.00%
Refrigerated transport	38,284	x	2.0	76,569	
Industry services	1,326	x	0.05	3,315	
Total employment in RAC industry in Australia				**298,398**	

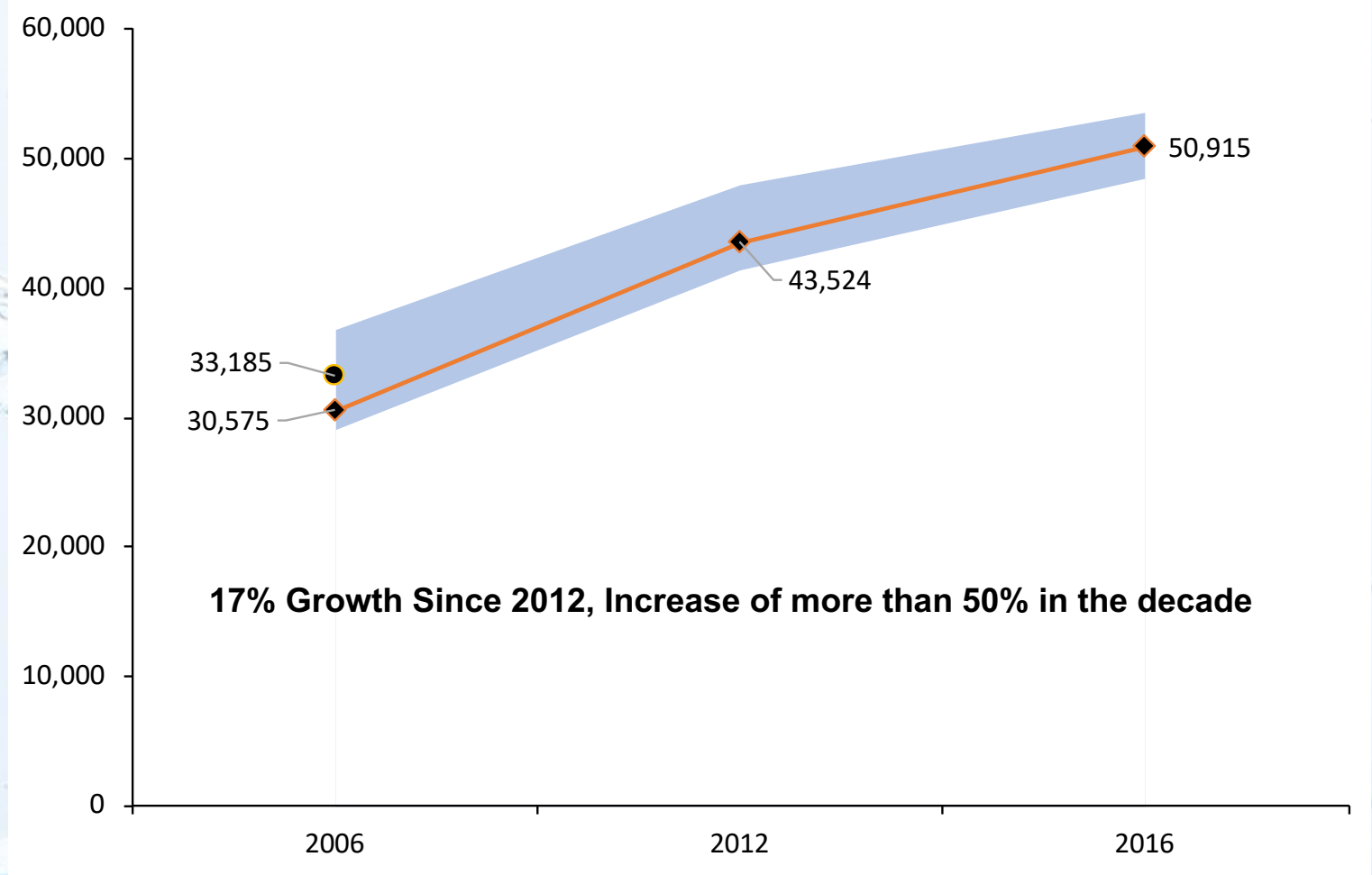
1. Employment multipliers were derived for each class of licence type to provide full time employment numbers

Spending 2016

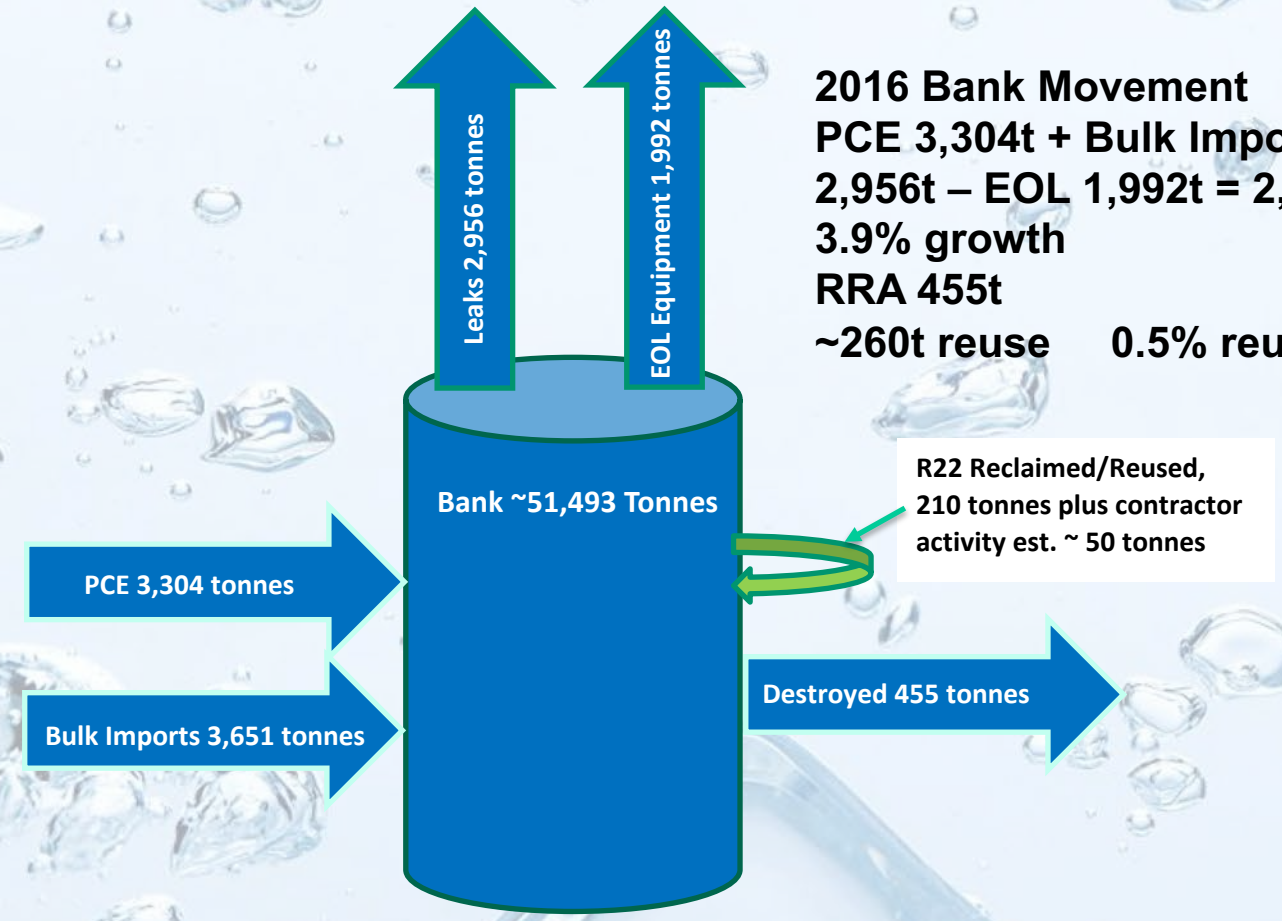
Expenditure by Class	Equipment spend (installed)	Discounted wages cost	Refrigerant cost (end-user)	Energy spend (end-user)	Total spend including Energy
Stationary AC	$4,856	$15,729	$161	$7,349	$38,108
Domestic refrigeration	$1,423			$2,325	
Refrigerated cold food chain: stationary	$798			$2,771	
Refrigerated cold food chain: mobile	$128			$174	
Mobile AC	$977			$1,418	
Total (Millions)	$8,181	$15,729	$161	$14,037	$38,108

Actual wages 2016 estimated to be $23.91 Bn adjusted down by value of installed equipment to avoid double counting

Refrigerant Bank: HCFCs and HFCs, excl. <10 GWP (Tonnes)

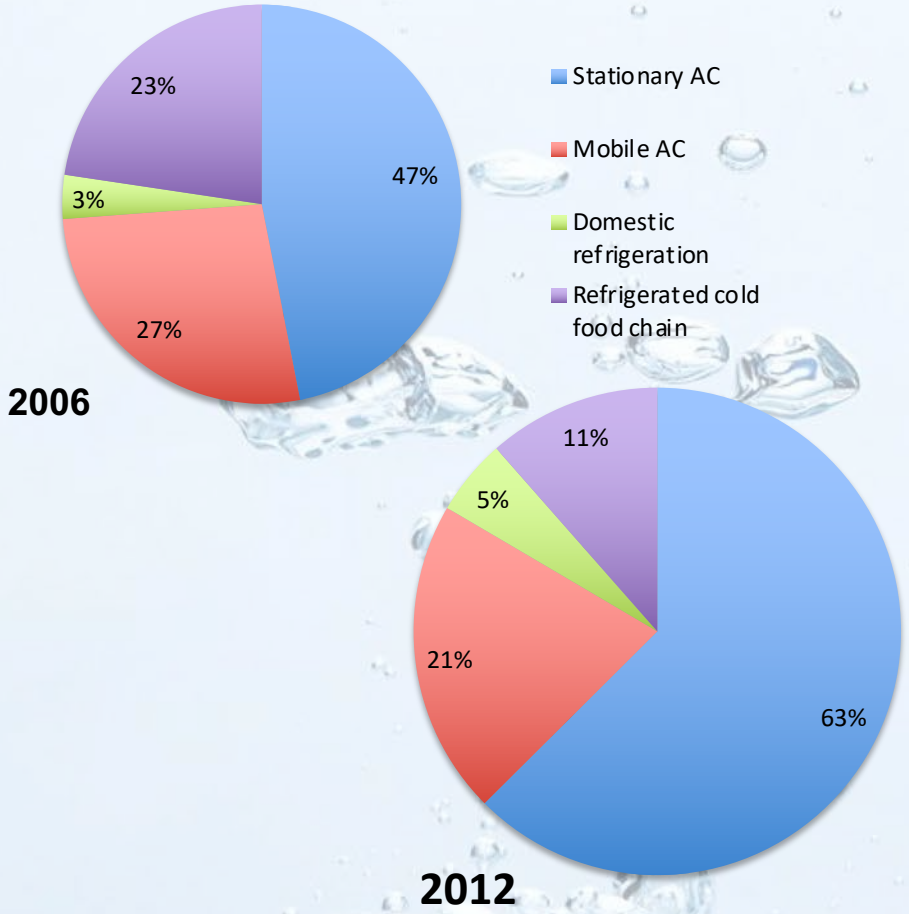


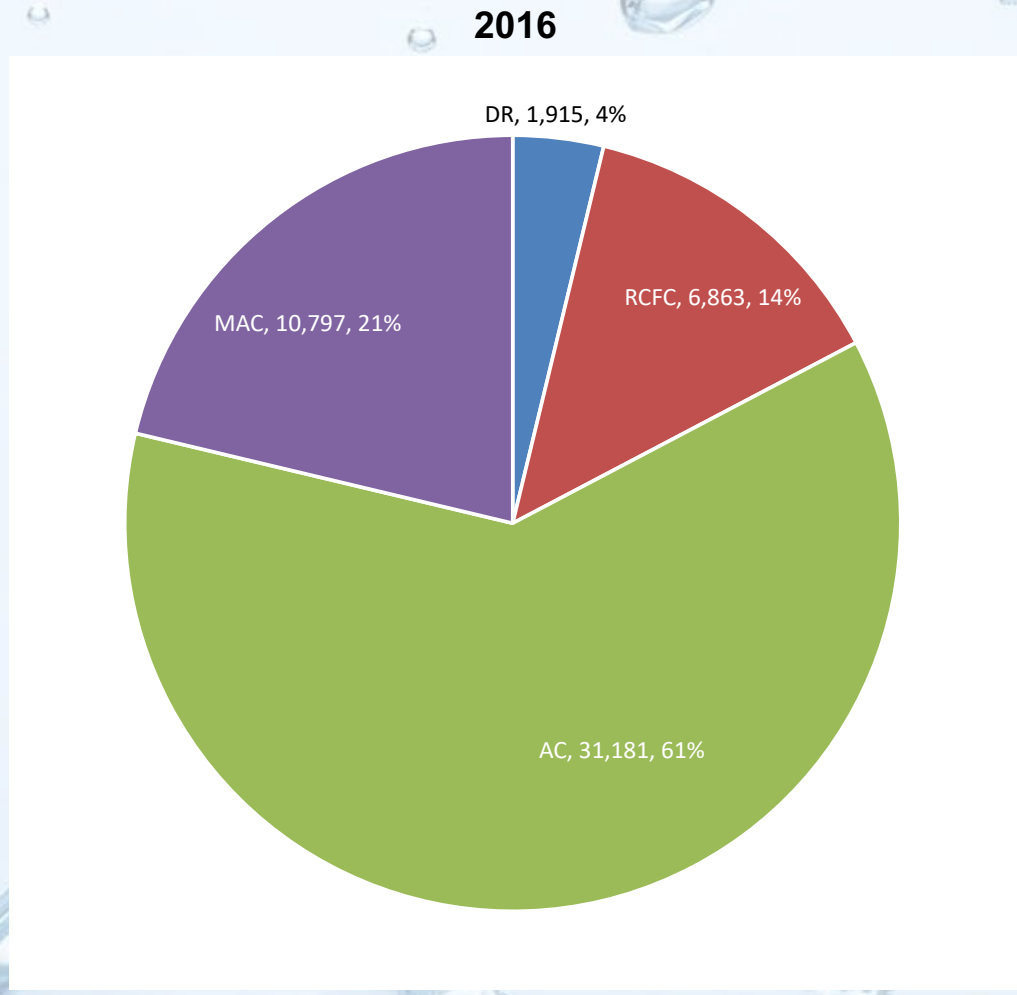
2016 High GWP Bank Mass Flows



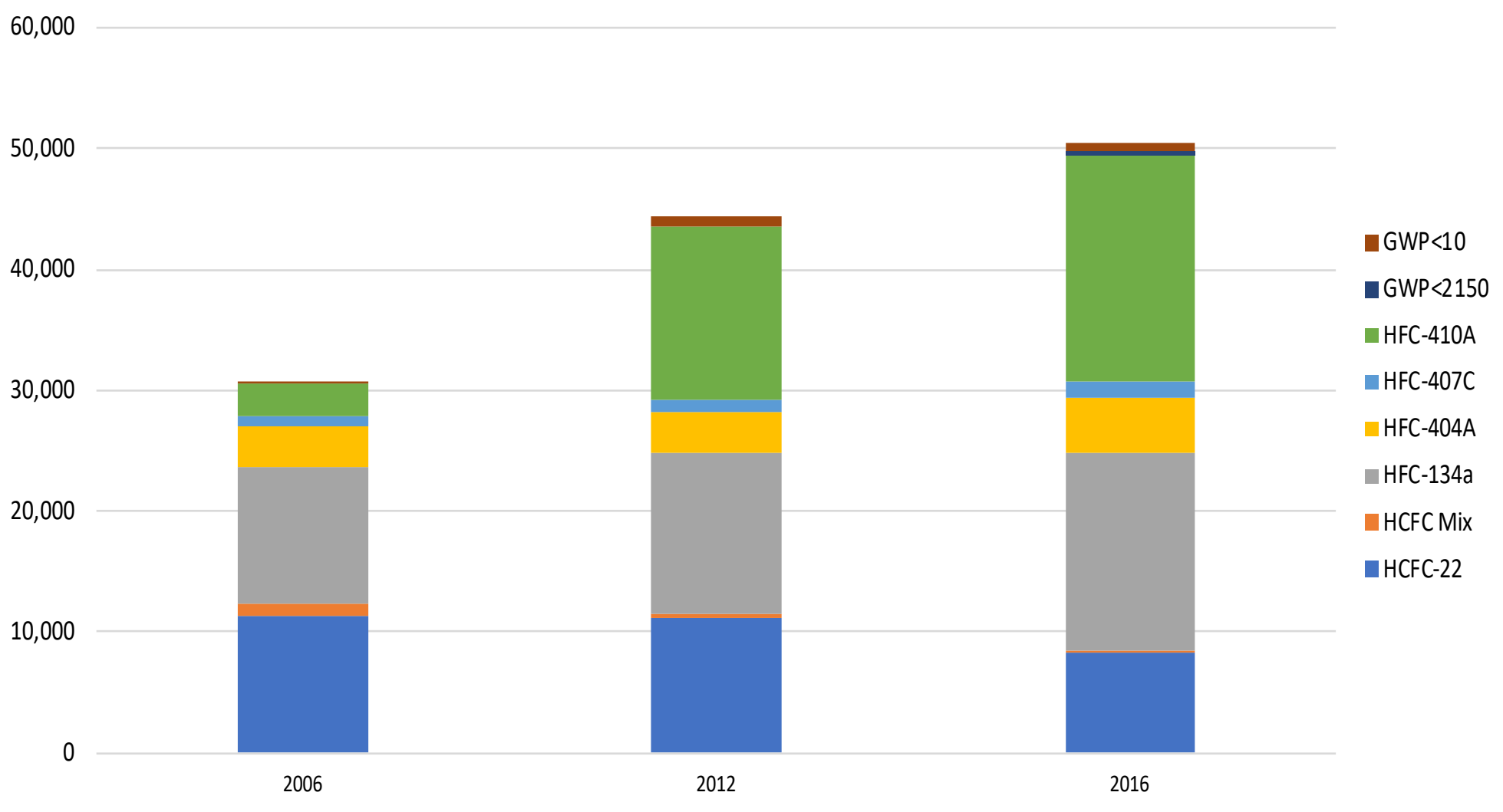
2016 Bank Movement
PCE 3,304t + Bulk Imports 3,651t – Leaks 2,956t – EOL 1,992t = 2,007t
3.9% growth
RRA 455t
~260t reuse 0.5% reuse

Bank of Refrigerant by Major Class of Equipment (Tones and %)

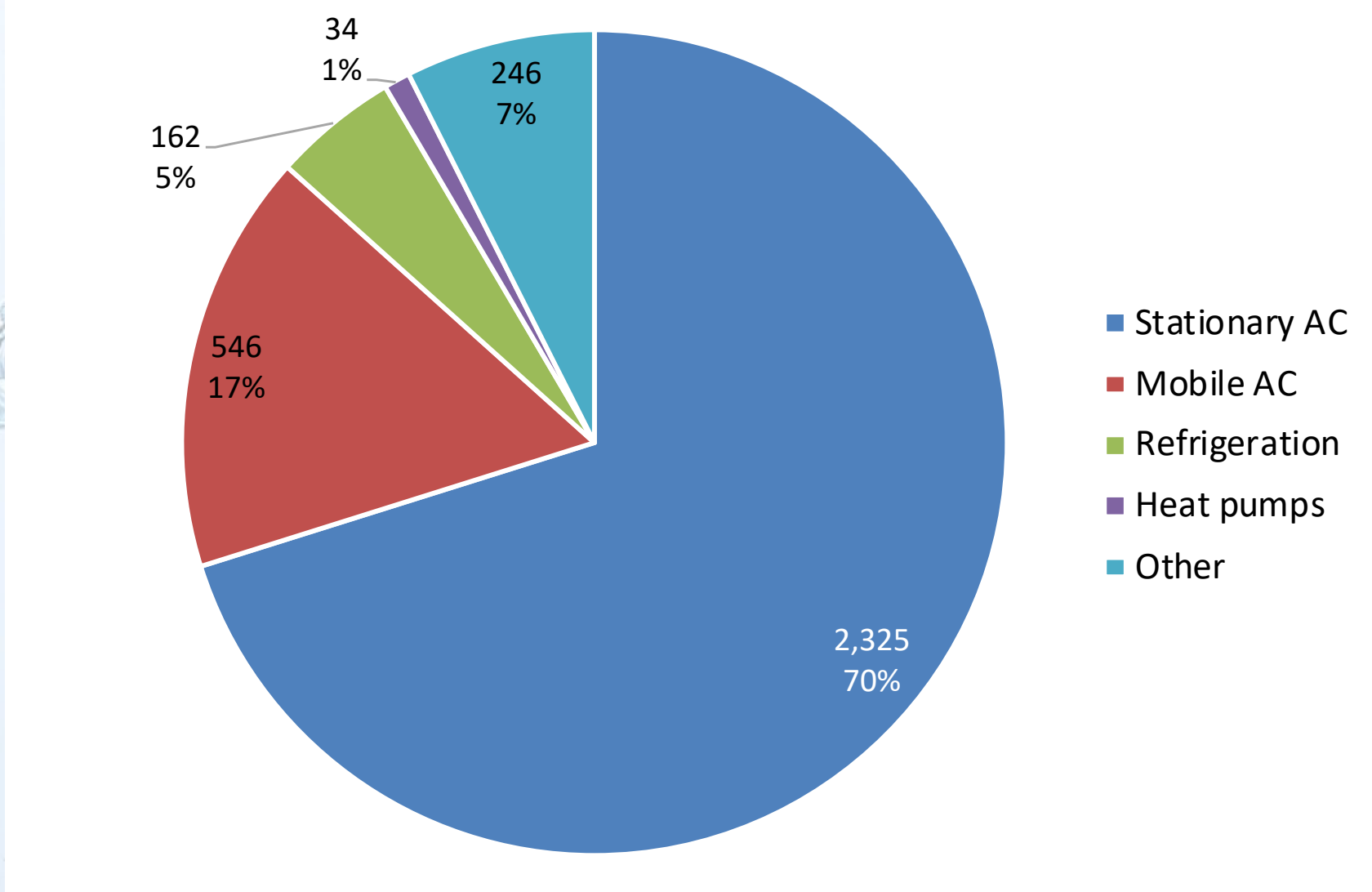




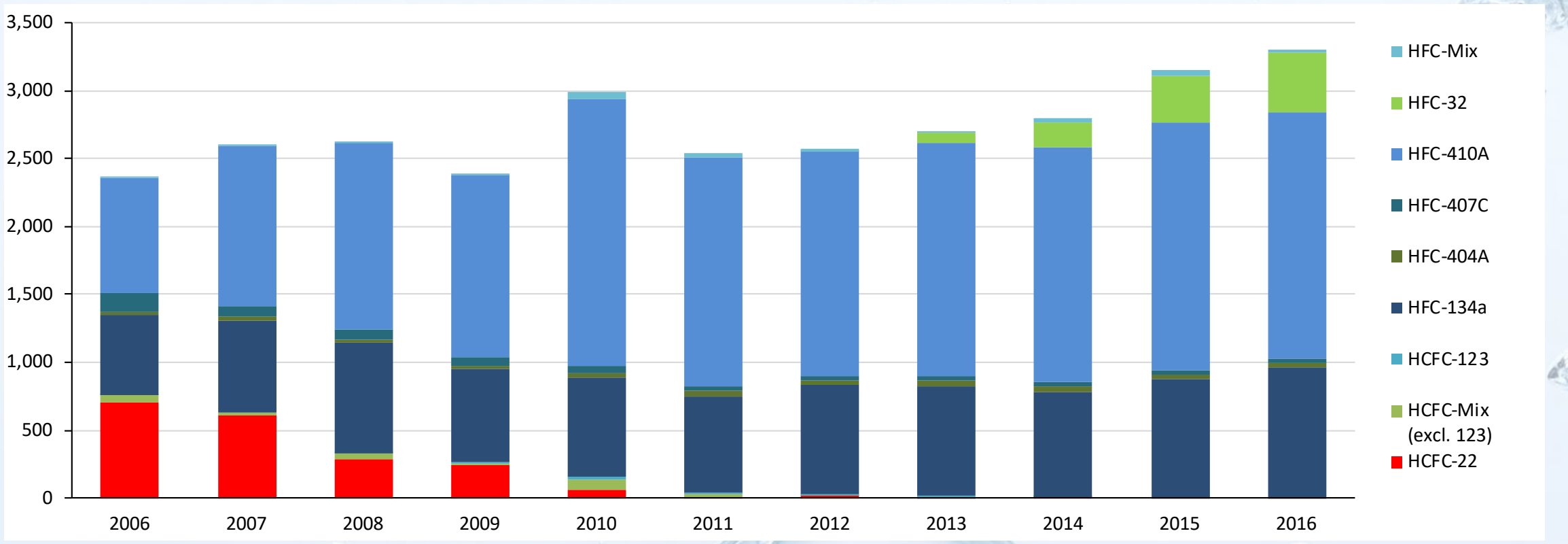
Bank of Refrigerant by Species 2006 – 2012 – 2016 (Tonnes)



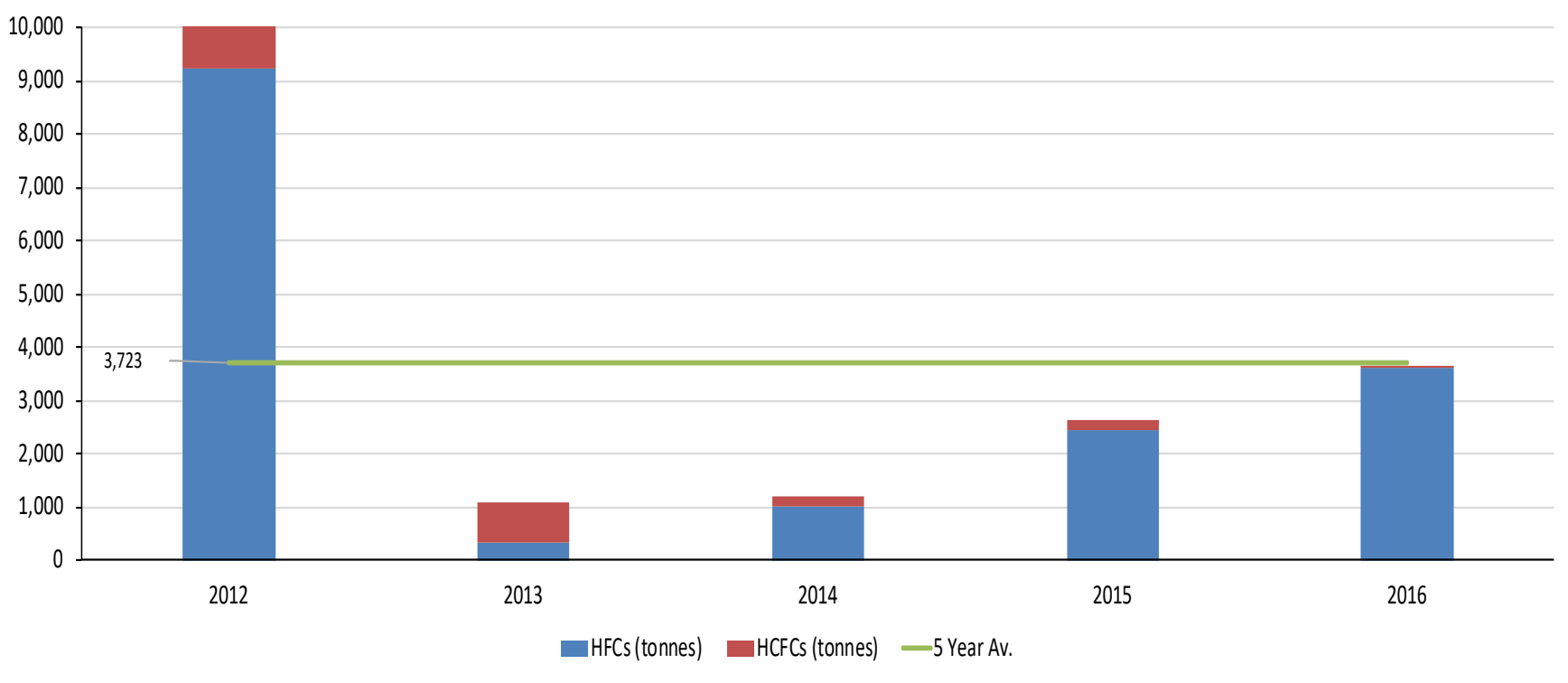
PCE imports by application in 2016 (Tonnes and %)



PCE imports by major species from 2006 to 2016

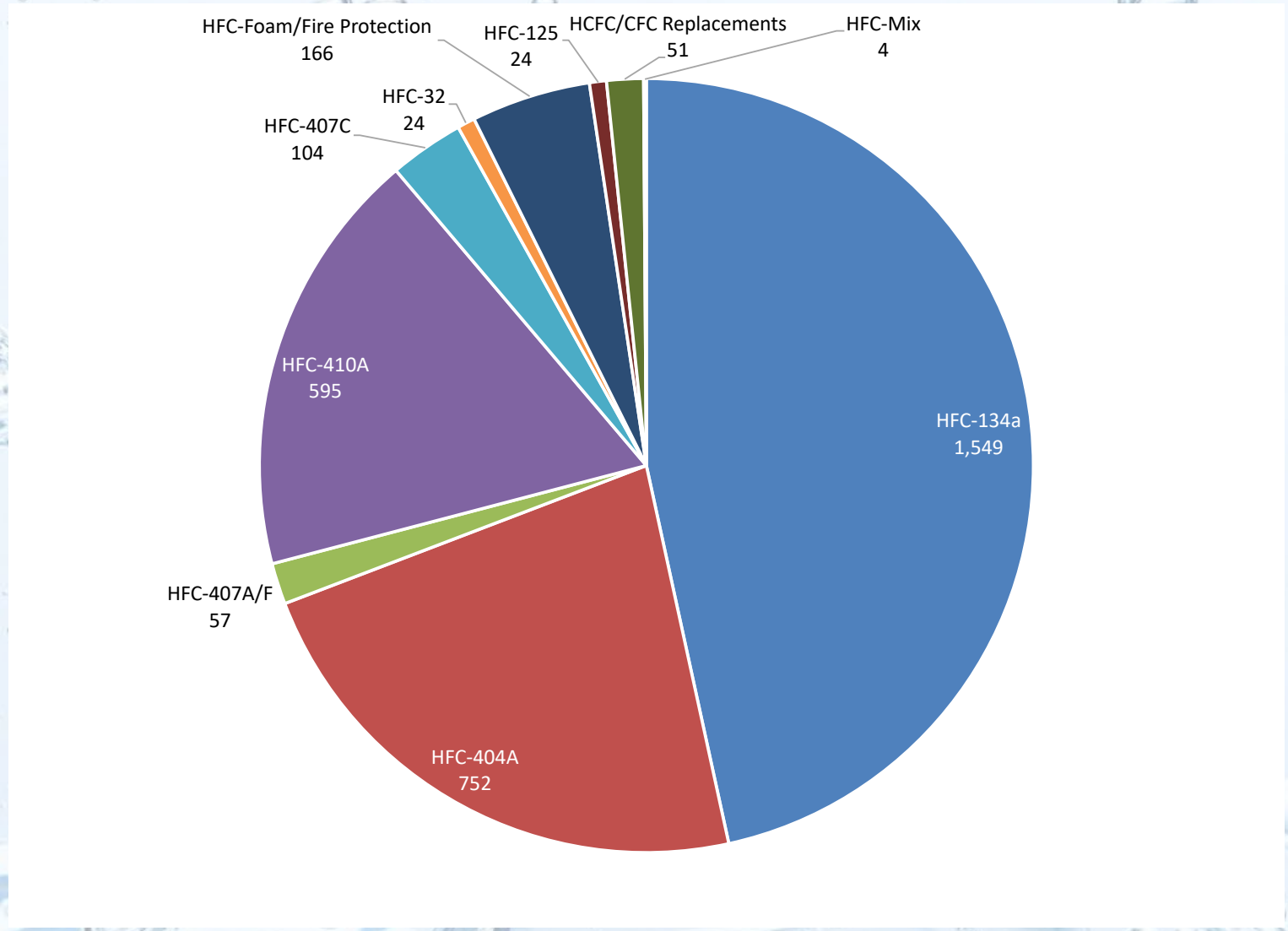


Bulk imports of HFCs and HCFCs from 2012 to 2016 (Tonnes)



Bulk Imports by Species: 5 Year average (% by tonnes)

RA



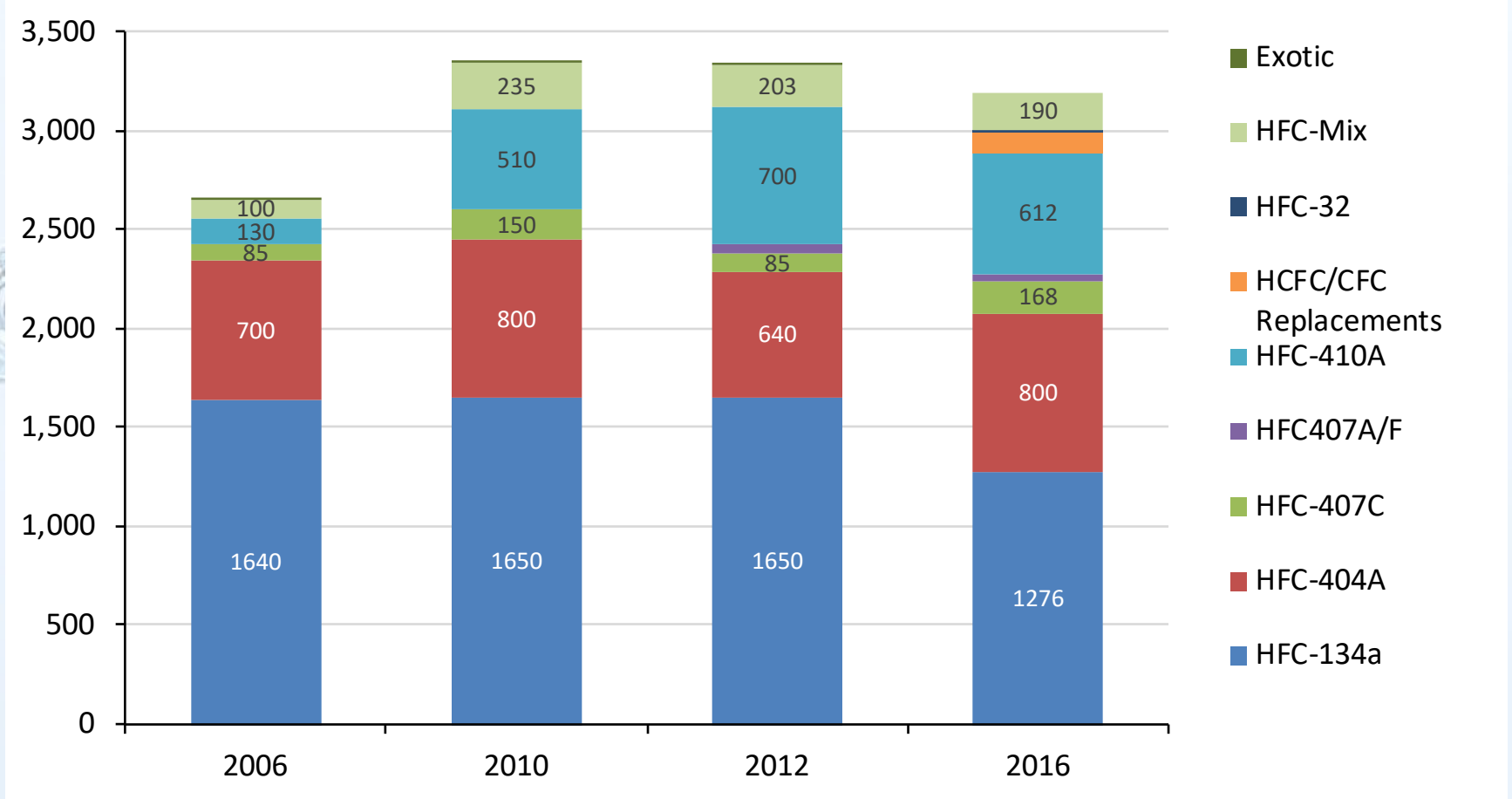
Tonnes
2016: 3,606.1
2015: 2,439.7
2014: 1,017.6
2013: 315.5
2012: 9,244.2
5 Yr average: 3,324.6

HCFCs and HFCs (excl. <10 GWP) refrigerant use in 2016

Species	Usage (Tonnes)
HCFC-22 (1)	255
HFC-134a	1,276
HFC-404A	800
HFC-407C	168
HFC-407A/F	33
HFC-410A	612
HCFC/CFC Replacements	99
HFC-32	16
HFC-Mix	190 (2)
Total	3,449

1. Maximum imports for 2016 are capped at 2.5 ODP tonnes, which equates to 45.5 metric tonnes of HCFC-22. The additional 210 tonnes refrigerant has been recycled to AHRI 700 standard and resold. There would be additional HCFC-22 recovered by contractors and re-used (not included in above, estimated ~50 tonnes).
2. Majority comprises used in Foam and Fire Protection applications as well as 24 tonnes of HFC-125 that could be used in refrigerant blends.

HFC Usage by Species 2006, 2010, 2012, 2016 (Tonnes)



Refrigerant Bank: Natural

Species	Bank 2012 (Tonnes)	Bank 2016 (Tonnes)	Change (%)
CO_2	80	127	59%
Ammonia (R717)	4,400	4,800	9%
Hydrocarbons (HC)	320	566	77%
Total	4,800	5,366	14%

Sources: In-confidence market survey of all major participants provided actual 2016 market volumes, which was used to derive estimates of the natural refrigerant bank by type.

Volumes of natural refrigerants sold by calendar year (Tonnes)

	2014	2015	2016
Ammonia (R717)	837.1	712.4	577.2
Hydrocarbons (HC)	82.1	75.3	72

The volume estimates for ammonia and HC were the aggregated supply from in-confidence market survey of all major participants.

The CO_2 refrigerant supply chain is more complex. The average sales volume over the last three years is approximately 120 tonnes per annum (CHF2 ~70 tonnes per annum).

Automotive Aftermarket Survey

	2014	2015	2016
HFC-134a	557,429 kg	563,655 kg	569,996 kg

Survey notes:

1. Excludes volumes supplied to major OEMs (i.e. Toyota, Holden, Ford) for the manufacture of vehicles.
2. HFC-134a including all variants such as R134a UV plus.
3. Survey participants includes Ashdown-Ingram, Cooldrive, Burson, Repco, JAS Oceania, Highgate, BOC, Heatcraft, Actrol and an allowance of 10 tonnes for Ready Gas, and miscellaneous independent wholesalers.

- Vehicle sales in the Small MAC segment have grown at 2.8% per annum for the past 20 years from around 650,000 in 1996 to 1,178,100 in 2016 (ABS 9314.0 2017).
- Total registrations including passenger vehicles, light commercial vehicles, trucks and buses published at the end of Jan 2017 was 17,826,388

Stock of AC Equipment CHF2 vs CHF3

Application	Product category	Total (Units) 2012	Total (Units) 2016	Change (%)
Window/wall	Non-Ducted: Unitary 0-10 kWr	1,915,000	1,592,000	-17%
Portable AC	Portable AC: 0-10 kWr	606,000	827,000	+36%
Single split: non-ducted	Single split system: Non-ducted: 1&3-phase	7,145,000	9,238,000	+29%
Domestic & light commercial	Single split system: Ducted: 1&3-phase	1,304,000	1,900,000	+46%
Light commercial	RT Packaged systems	70,000	126,000	+80%
Domestic & light commercial	Multi split	276,000	317,000	+47%
Light commercial	VRV/VRF split systems		88,000	
Light commercial	Close control	11,500	21,000	+83%
Light commercial	HW heat pump: commercial	1,000	1,800	+80%
Domestic & light commercial	Pool heat pump	28,000	38,000	+36%
Chillers	<350 kWr	20,200	8,200	-40%
Chillers	>350 & <500kWr		3,900	
Chillers	>500 & <1000 kWr	7,200	7,200	0%
Chillers	>1000 kWr	1,100	3,300	200%
HW Heat pump	HW heat pump: domestic	170,000	206,000	21%
Heat pump clothes dryers	Heat pump clothes dryers	NA	64,000	NA

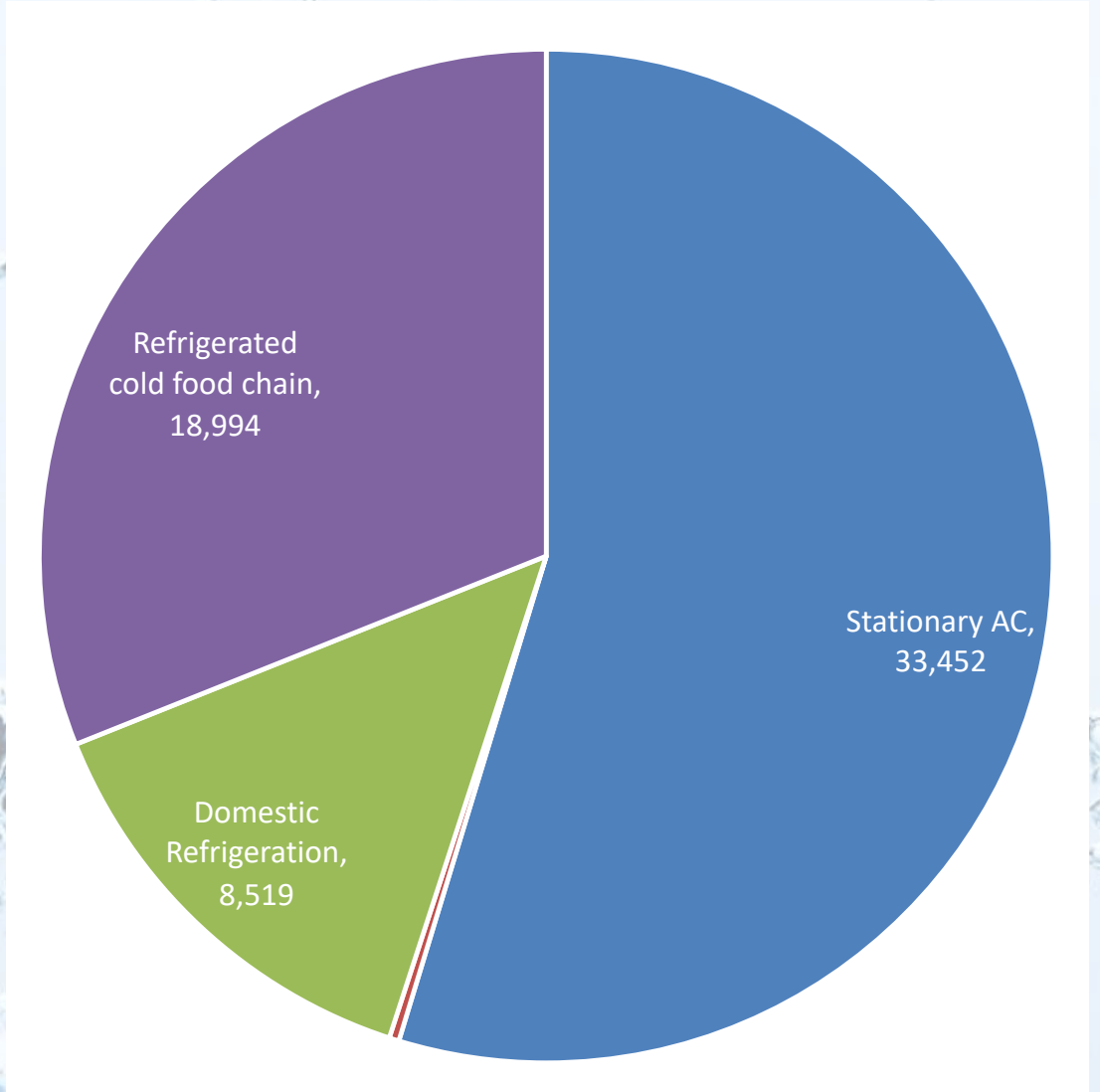
PCE equipment: > 800g & < 2.6 kg

	2014		2015		2016	
	Units	Refrigerant (Tonnes)	Units	Refrigerant (Tonnes)	Units	Refrigerant (Tonnes)
HFC-410A	547,523	796	547,784	788	485,774	708
HFC-32	154,913	168	270,704	314	348,333	412
Total	702,436	964	818,488	1,102	834,107	1,120
Proportion HFC-32	22%	17%	33%	28%	42%	37%

PCE equipment: > 2.6 kg

	2014		2015		2016	
	Units	Tonnes	Units	Tonnes	Units	Tonnes
>2.6 kg and ≤10 kg						
HFC-410A	187,137	661.3	195,161	730.0	199,596	773.5
HFC-407C	291	1.2	137	0.8	46	0.2
Sub-total	187,428	662.5	195,298	730.8	199,642	773.7
>10 kg and ≤ 60 kg						
HFC-410A	6,338	77.1	9,482	111.5	12,522	147.5
HFC-407C	132	3.4	91	2.4	72	2.0
Sub-total	6,470	80	9,573	114	12,594	149
> 60 kg						
HFC-410A	79	8.2	92	8.9	129	19.7
HFC-407C	30	3.9	19	2.0	33	7.7
Sub-total	109	12.2	111	10.9	162	27.4
>2.6 kg (includes all of the above categories)						
HFC-410A	193,554	746.6	204,735	850.5	212,247	940.7
HFC-407C	453	8.5	247	5.2	151	9.9
Total	194,007	755.2	204,982	855.6	212,398	950.6

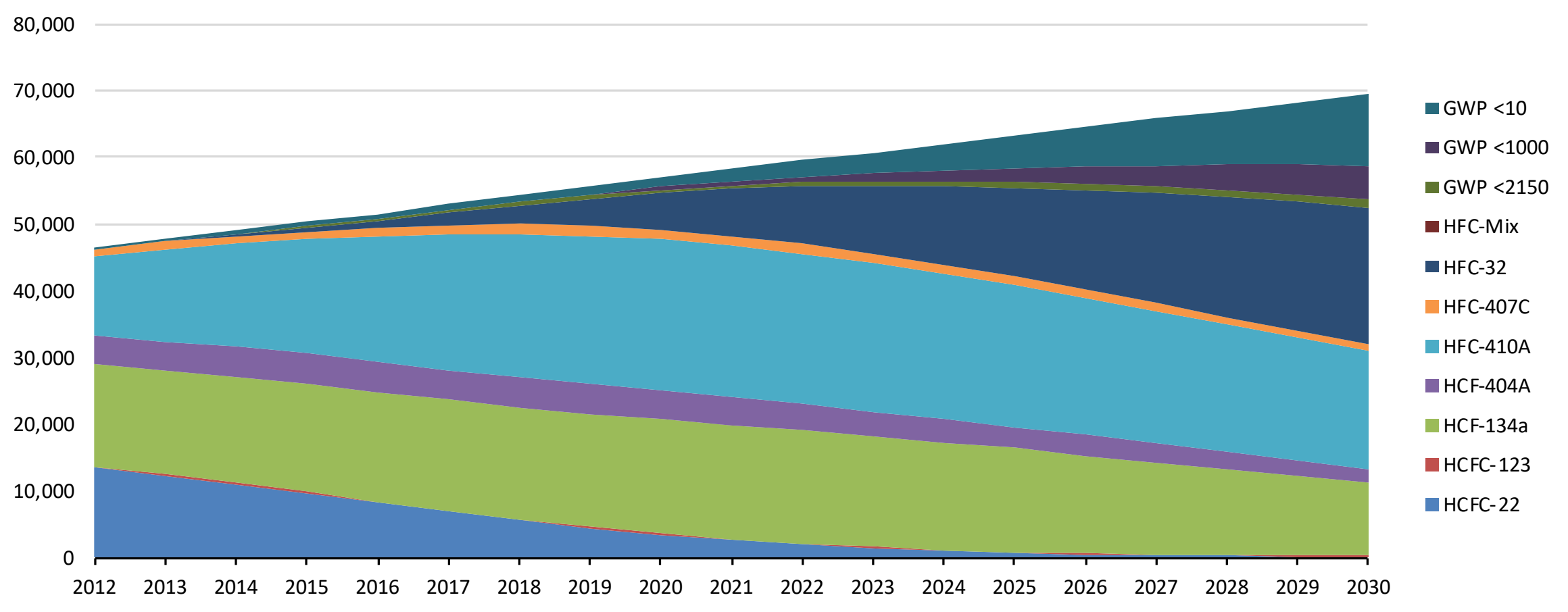
Electricity Consumption (GWh) by Class 2016



2016 Emissions

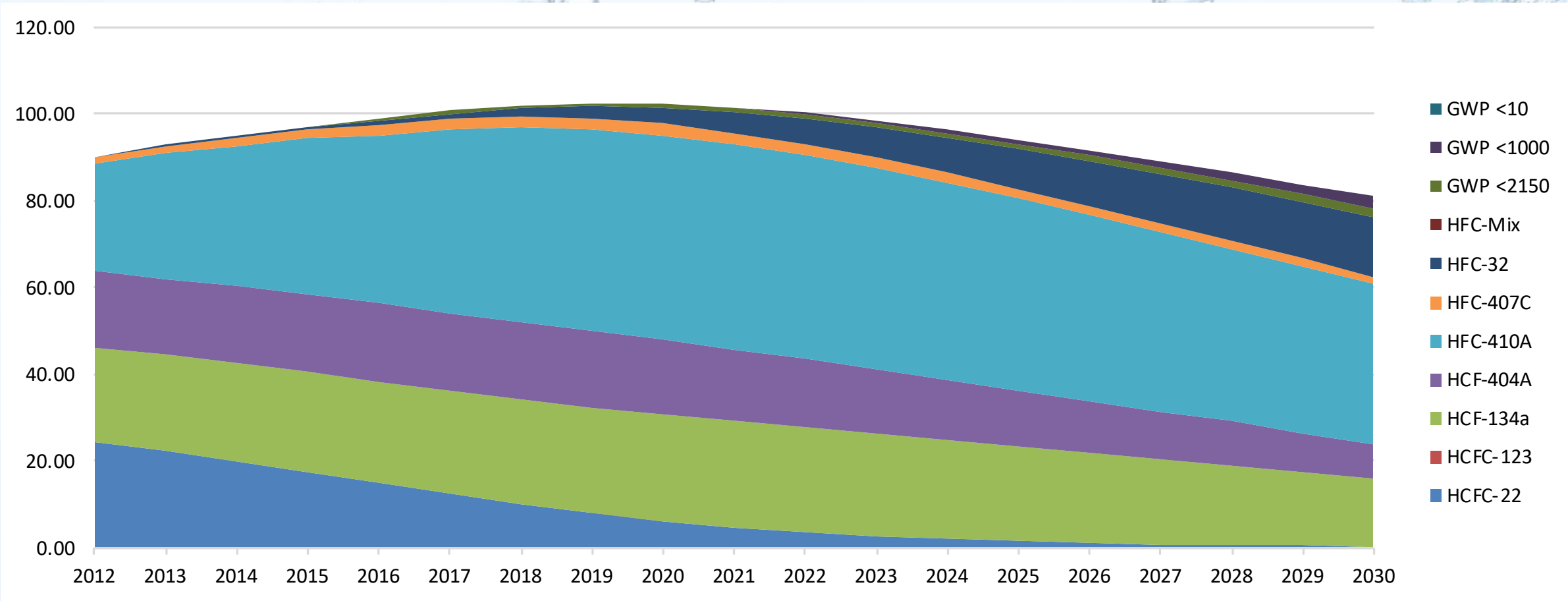
Emissions in Mt CO_2e	Direct emissions		Indirect emissions		EOL Emissions		Total emissions (including EOL)	
Stationary AC	2.19	38%	30.44	52%	2.25	62%	34.88	51%
Mobile AC	1.25	18%	2.96	5%	0.51	14%	4.72	6%
Domestic Refrigeration	0.05	1%	7.77	13%	0.16	4%	7.98	12%
Refrigerated cold food chain	2.91	44%	17.53	30%	0.69	19%	21.13	31%
Total	6.40	9.3%	58.70	85.4%	3.61	5.3%	68.71	100%

Refrigerant Bank 2012 – 2030 (Tonnes)



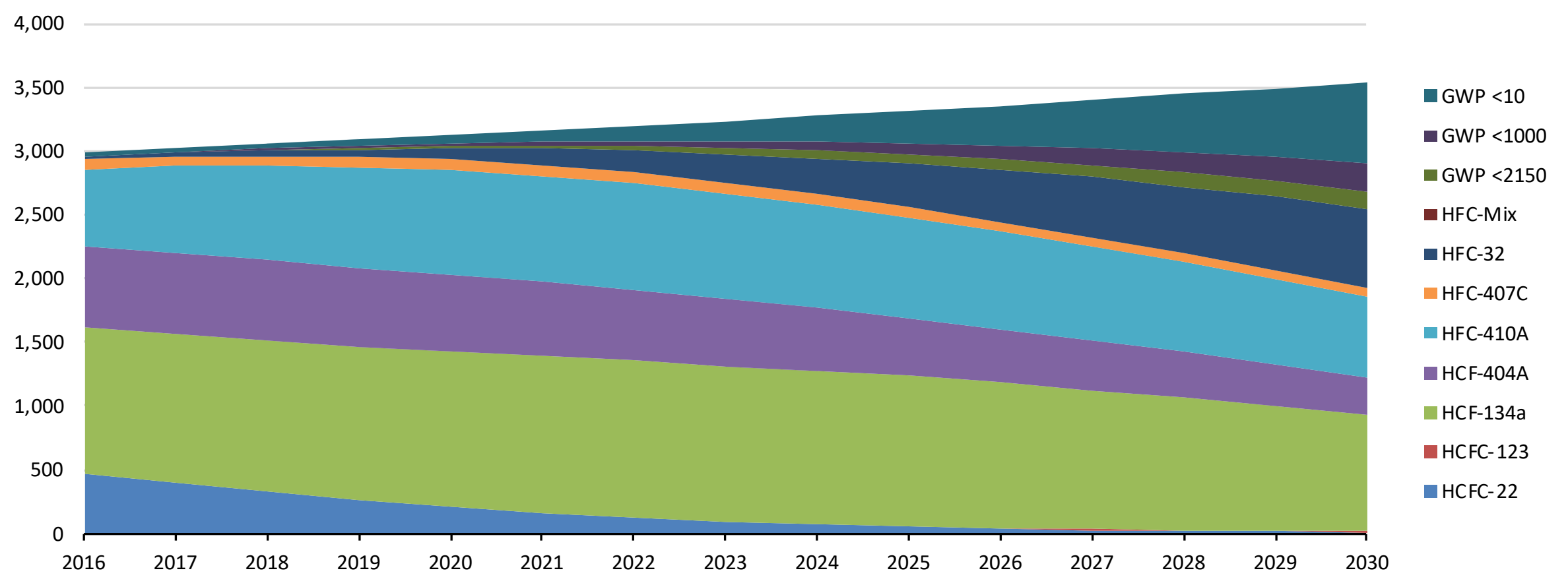
- HFC-410A is to a peak in 2021 and HFC-134a in 2023.
- HCFC-22 in stationary AC is predicted to fall from more than 15% of the bank to virtually zero in 2030.

Refrigerant Bank 2012 – 2030 CO_2e



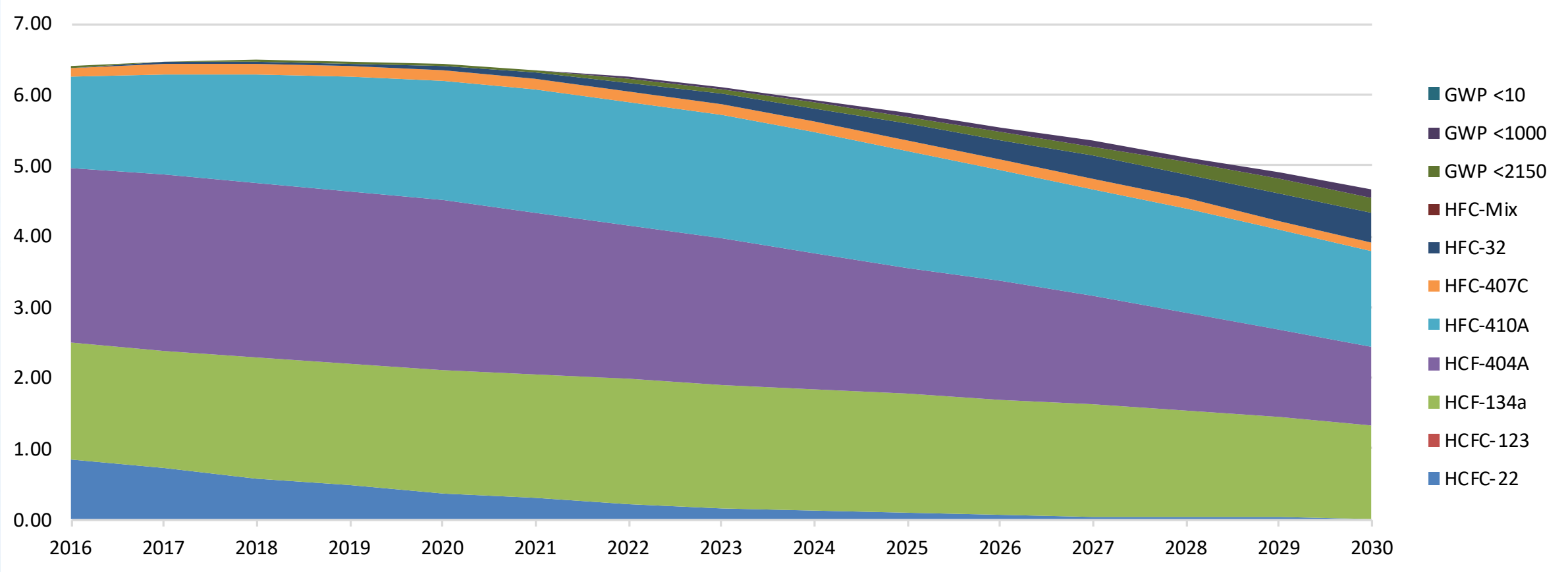
“Peak Bank” in GWP terms around 2019 – 2020.

Direct Emissions SGGs 2016 – 2030 (Tonnes)



Relatively modest Growth in Direct Emissions of just 8% in the period.

Direct Emissions SGGs 2016 – 2030 Mt CO_2e



Fall in CO_2e of Direct Emissions of 27% in the period.