Hydrofluorocarbon Emissions in China: An Inventory for 2005– 2013 and Projections to 2050

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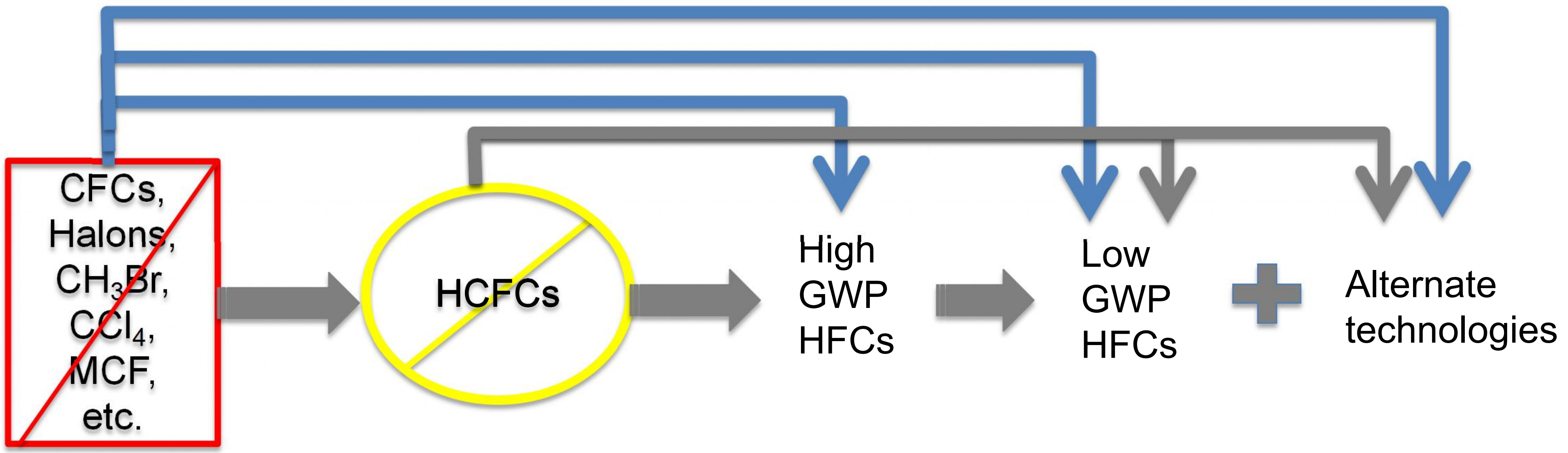
CFCs/HCFCs/HFCs

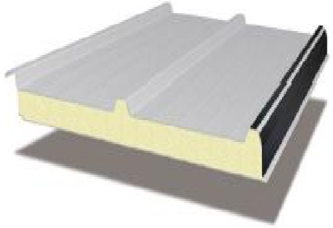


- MP successfully phased out CFCs and is phasing out HCFCs.
- Phase out done via use of substitute chemicals or other approaches.

Burkholder, Cox, and Ravishankara, 2015

Laminated boards

XPS board



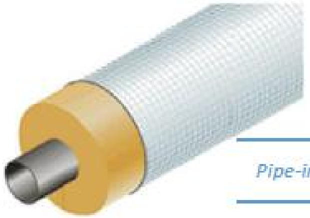
Steel-faced panel

Metered dose inhaler (MDI)

Refrigerated trailer with dedicated diesel engine and cooling system

Stand-alone hermetically sealed systems

Spray foam installation



Pipe-in-pipe insulation

sol configuration

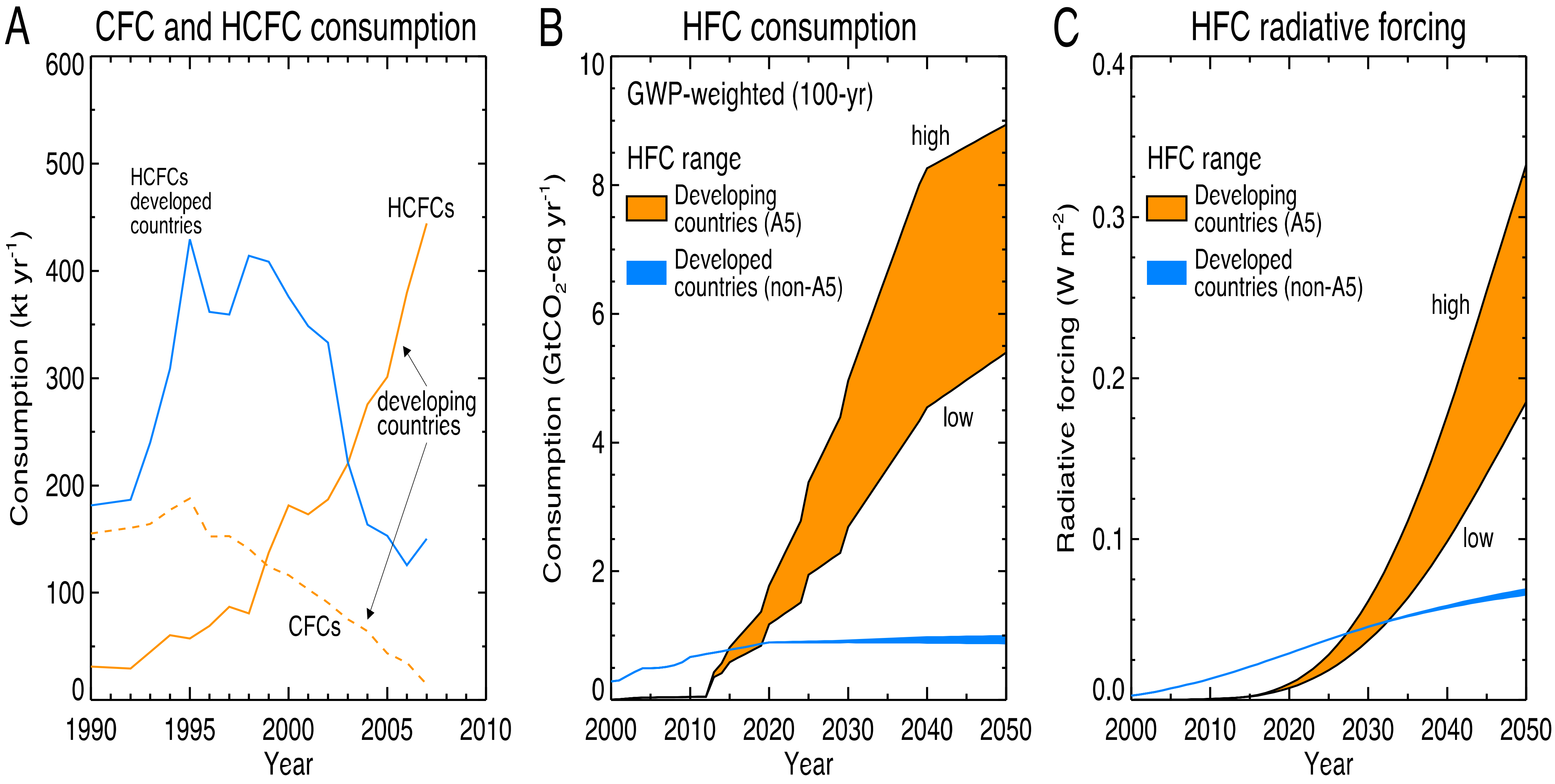
Intermodal container with dedicated cooling system

Flake ice making system for a fishing trawler

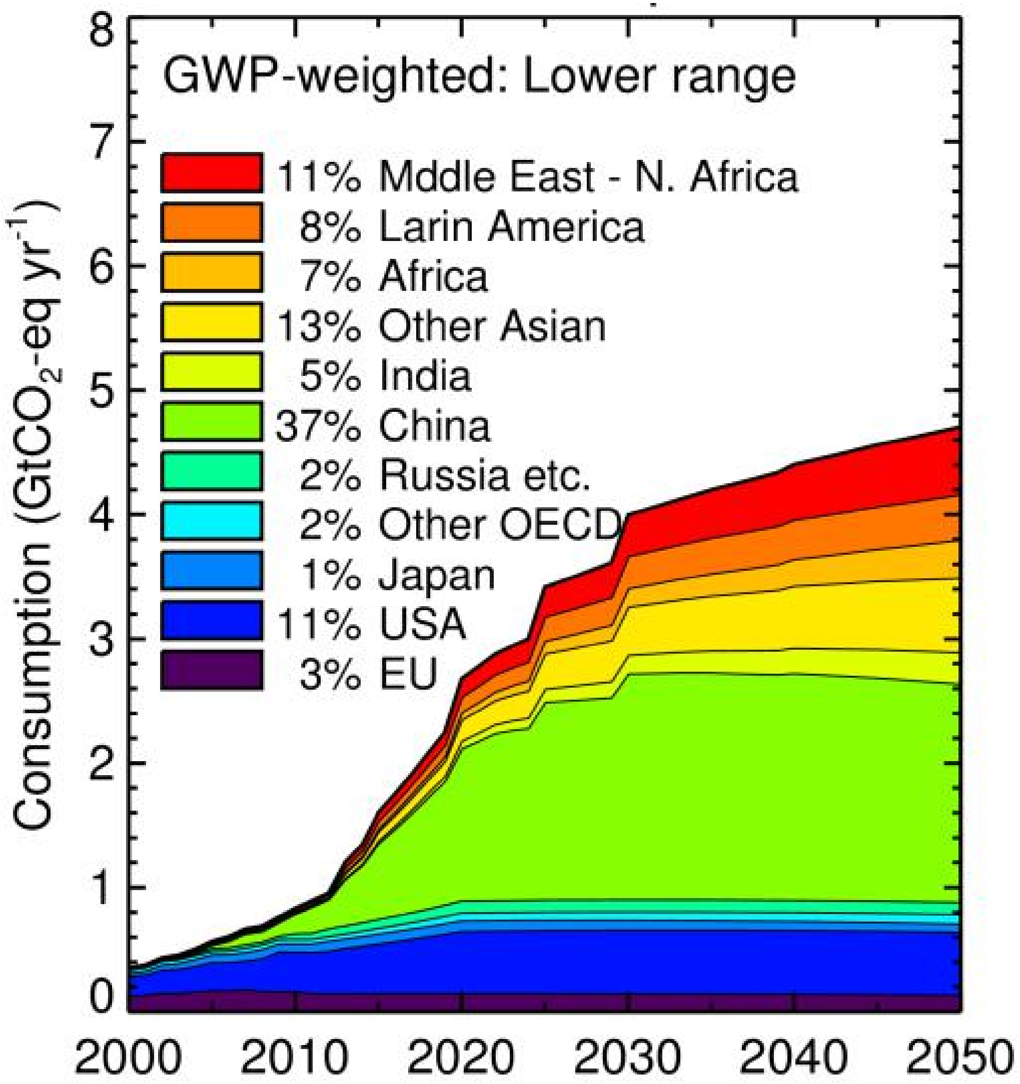
Integral skin foam products

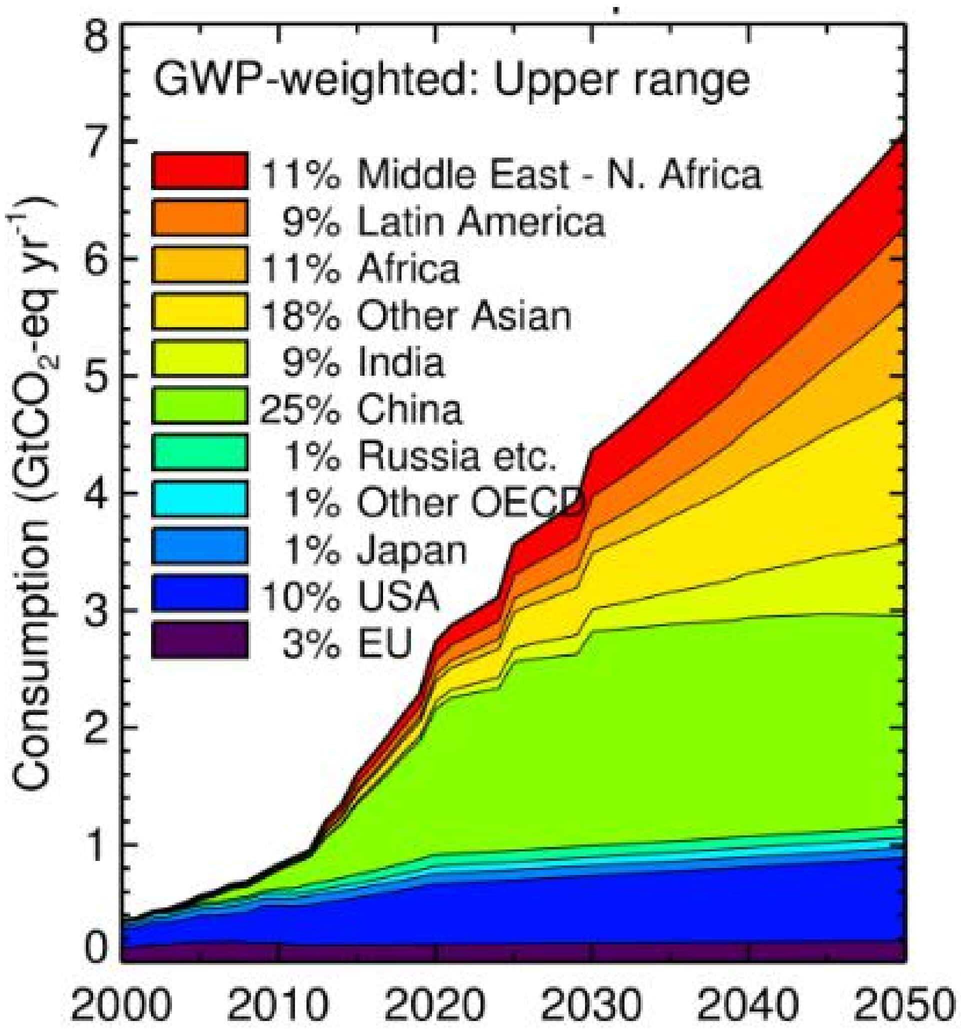
Small refrigerated truck, compressor located by main vehicle engine

Velders, 2009



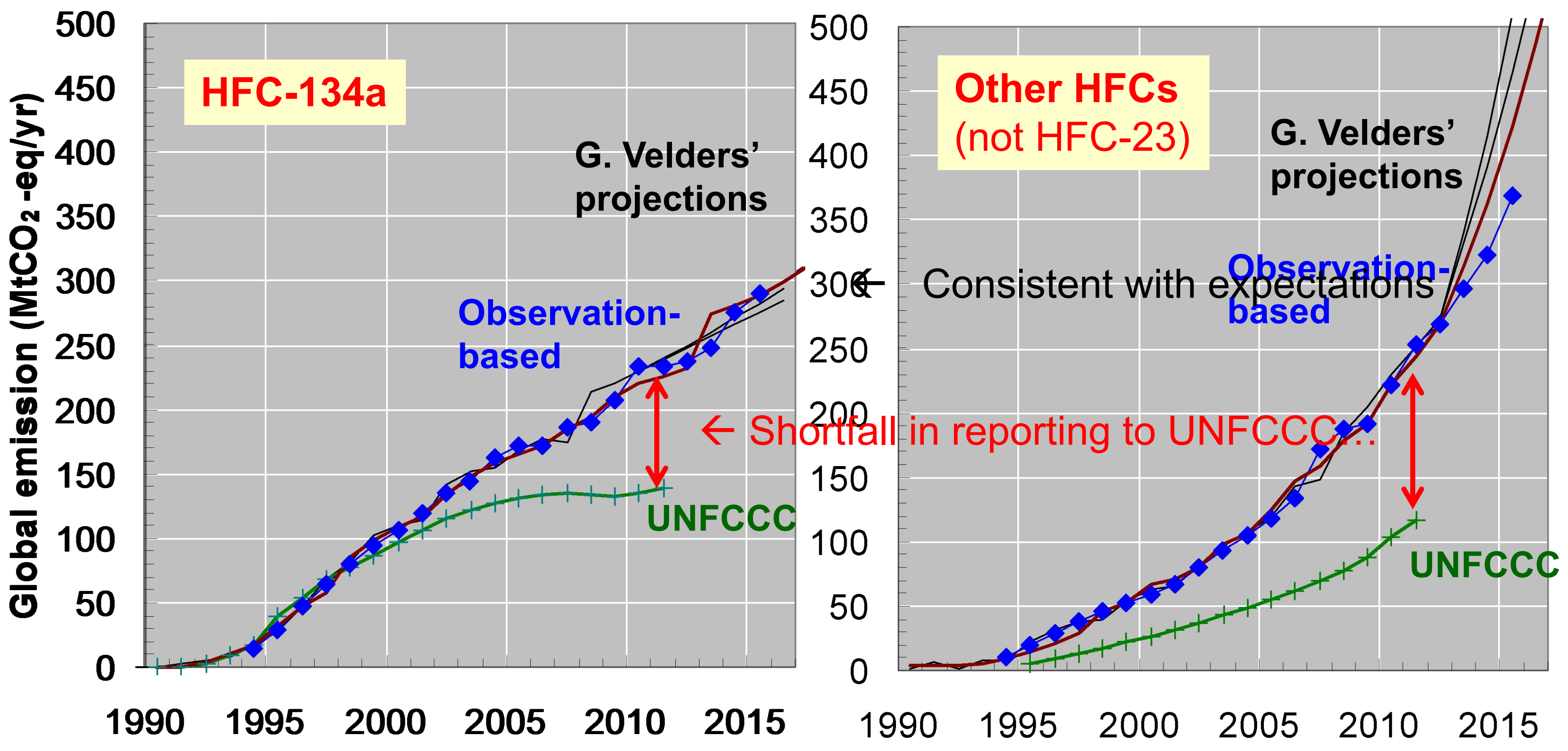
Business-as-usual consumption





Guus Velders, April 22, 2015

Are observed changes happening as expected?



A) Recent projections: accurate for HFC-134a, overestimating other HFCs…

B) Shortfall: ~100 Mt CO_2-eq for HFC-134a

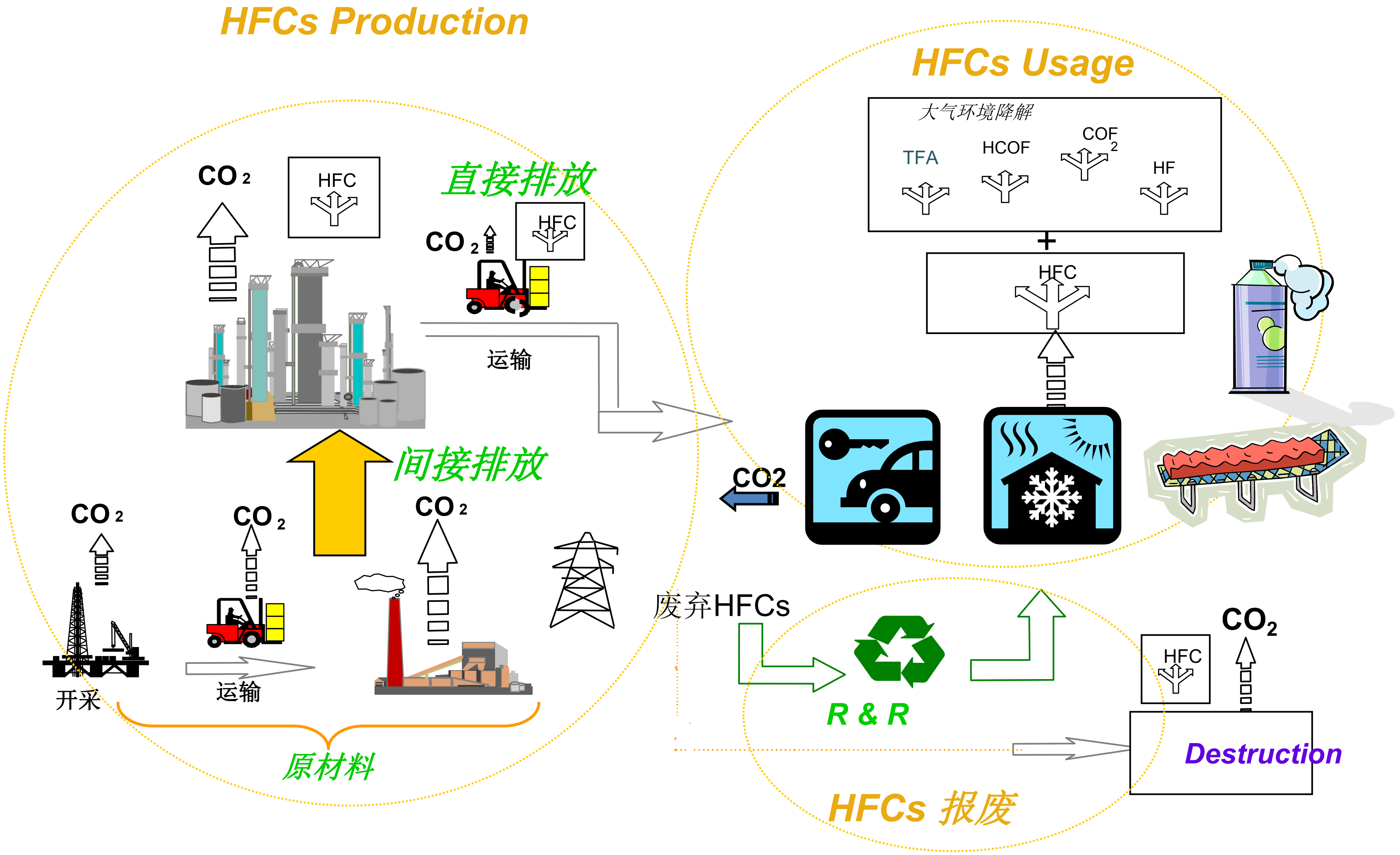
~150 Mt CO_2-eq for other HFCs

This result has been noted independently by results from both networks

Data

- Production and sales data for 2005-2010 collected from enterprises
- Production and sales data after 2010 bought from POL

Acceptability Metric



Estimation of Emissions from Consumption

- Emissions are calculated as constant fractions of HFCs released annually from identified banks. The annual bank of HFCs is equal to the sum of the bank and consumption in the previous year, minus the emissions in the previous year. The methodology is shown in Equations 1 and 2.

$$E_t = f \times (B_t + C_t) \tag{1}$$

$$B_t = B_{t-1} + C_{t-1} - E_{t-1} \tag{2}$$

Here, B_t and B_{t-1} represent the HFC banks in the year t and $t\text{-}1$, respectively, C_t and C_{t-1} are HFC consumption in the year t and $t\text{-}1$, respectively, E_t and E_{t-1} are HFC emissions in the year t and $t\text{-}1$, respectively, and f is emission factor for each HFC.

Estimation of mixing ratio and radiative forcing

- The surface global mean mixing ratio of specific HFC i in year j was calculated from global annual HFC emissions, HFC lifetime, HFC molecular weight, number of molecules in the global atmosphere, and other input data (see equations (1), (2) and (3)). Atmospheric surface global mean mixing ratios of HFC were multiplied by their radiative efficiency values (Table S1) to obtain radiative forcing (equations (4)).

$$\frac{dC_i}{dt} = F_i \times E_i - \frac{C_i}{\tau_i} \qquad (1)$$

Integrate the equation, which yields:

$$C_{i,j} = C_{i,j-1} \times \exp\left(-\frac{1}{\tau_i}\right) + F_i \times E_{i,j-1} \times \tau_i \times \left(1 - \exp\left(-\frac{1}{\tau_i}\right)\right) \qquad (2)$$

Here $C_{i,j}$ and $C_{i,j-1}$ are the mean surface mixing ratios (ppt), τ_i is the lifetime (years), $E_{i,j-1}$ is the global annual emissions (kg yr^{-1}), and F_i (ppt kg^{-1}) is a factor that relates the mass emitted to the global mean surface mixing ratios.

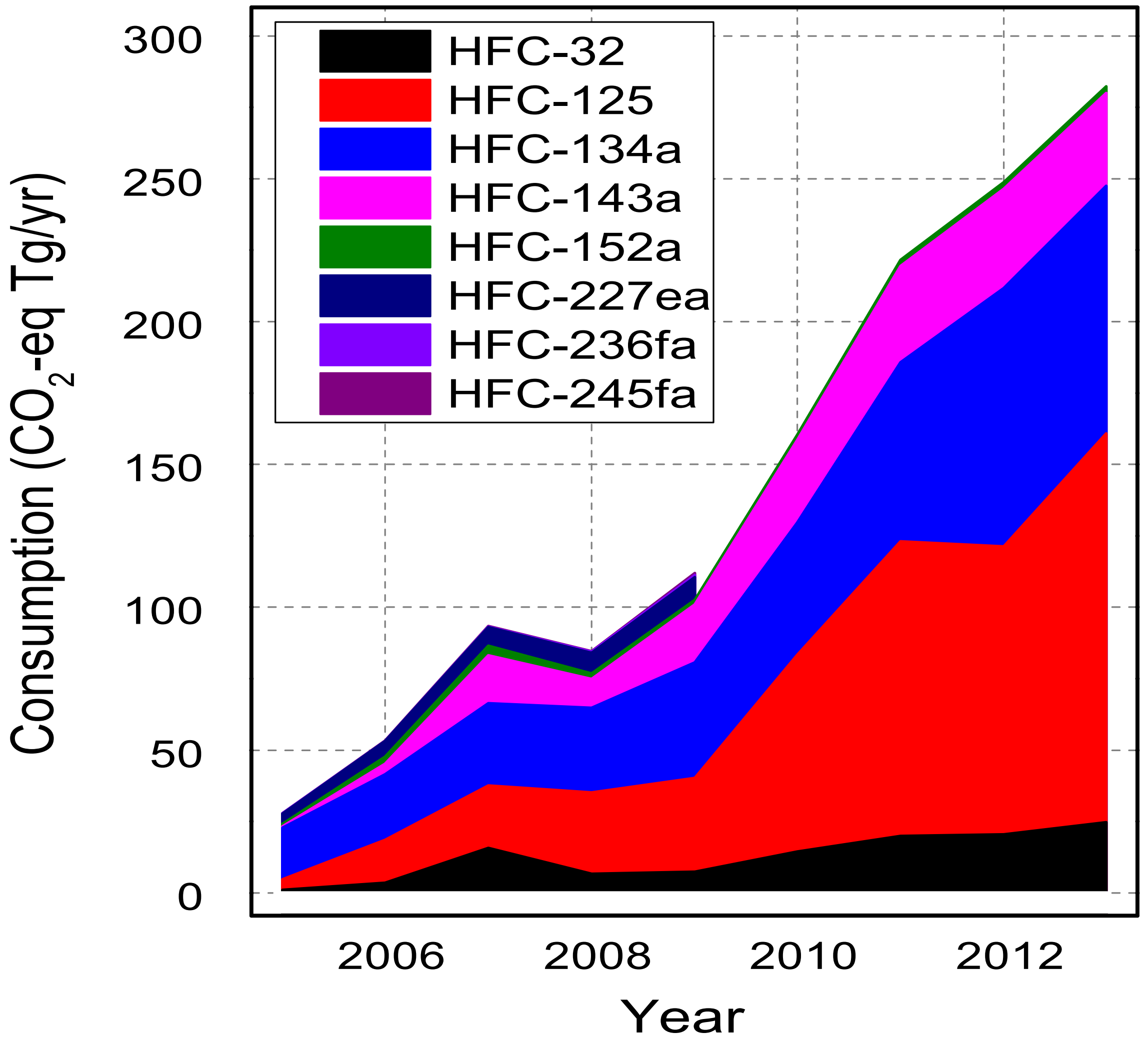
$$F_i = \left(\frac{N_A}{N_a}\right)\frac{F_{surf}}{M_i} = 5.68 \times 10^{-9}\frac{F_{surf}}{M_i} \qquad (3)$$

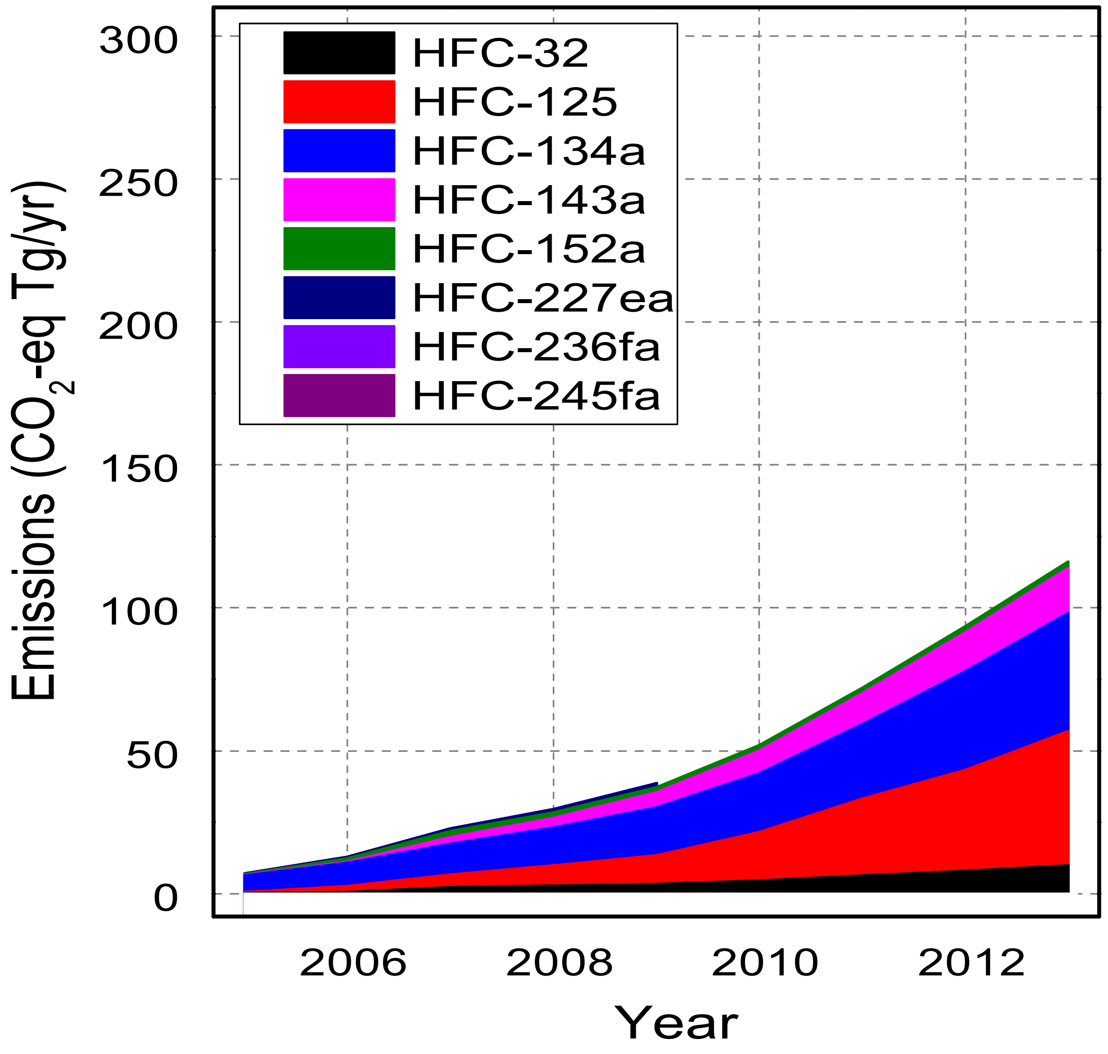
Here M_i is the molecular weight (kg $mole^{-1}$), N_A is the Avogadro constant, N_a is the number of molecules in the global atmosphere, and F_{surf} is a factor relating the global mean surface mixing ratio to the global mean atmospheric mixing ratio. F_{surf} was taken to be 1.07 for all HFCs.[25, 26]

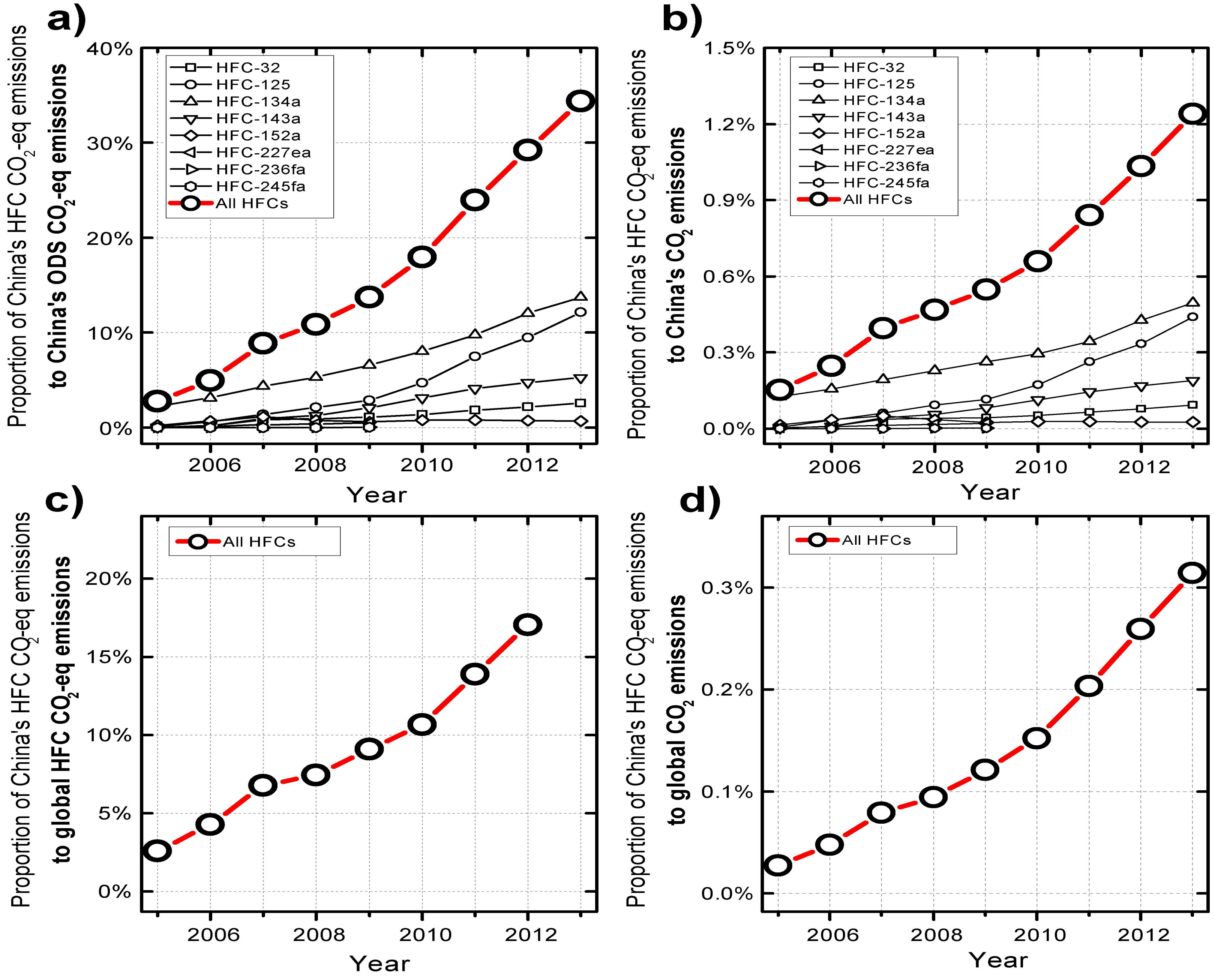
$$RF_{i,j} = C_{i,j} \times RE_i \,/\, 1000 \qquad (4)$$

Here $RF_{i,j}$ (W m^{-2}) is the radiative forcing, and RE_i is the radiative efficiency (W m^{-2} ppb^{-1}; listed in Table S1).

HFCs consumption and emission in China







a), b), c) and d) show proportions of China's HFC CO_2-eq emissions to China's ODS CO_2-eq emissions,[27] China's CO_2 emissions,[28] global HFC CO_2-eq emissions[6] and global CO_2 emissions,[33] respectively. China's emissions for HFC-227ea, HFC-236fa and HFC-245fa were not estimated for 2010–2013

BAU Scenario

- the HCFC consumption in China during 2011–2050 is assumed to grow in proportion to the gross domestic product (GDP) scenarios from Shared Socioeconomic Pathway (SSP)projections.[21]
- The high and low ends of the range for GDP growth follow the SSP5 and SSP3 scenarios (the five datasets (SSP1 to 5) quantified by the OECD as illustrative SSPs),[21] respectively.
- Due to the Montreal Protocol, HCFC consumption in China was frozen in 2013 at the baseline of an average of the 2009–2010 level, and will be reduced by 10% in 2015, 35% in 2020, 67.5% in 2025, and 97.5% by 2030.[22] We assume that the HFCs and not-in-kind replacements (the replacement pattern is shown in Table S4) make up for the differences between the HCFC demand and the lower HCFC consumption to comply with the Montreal Protocol.

Scenario for mitigation of HFCs

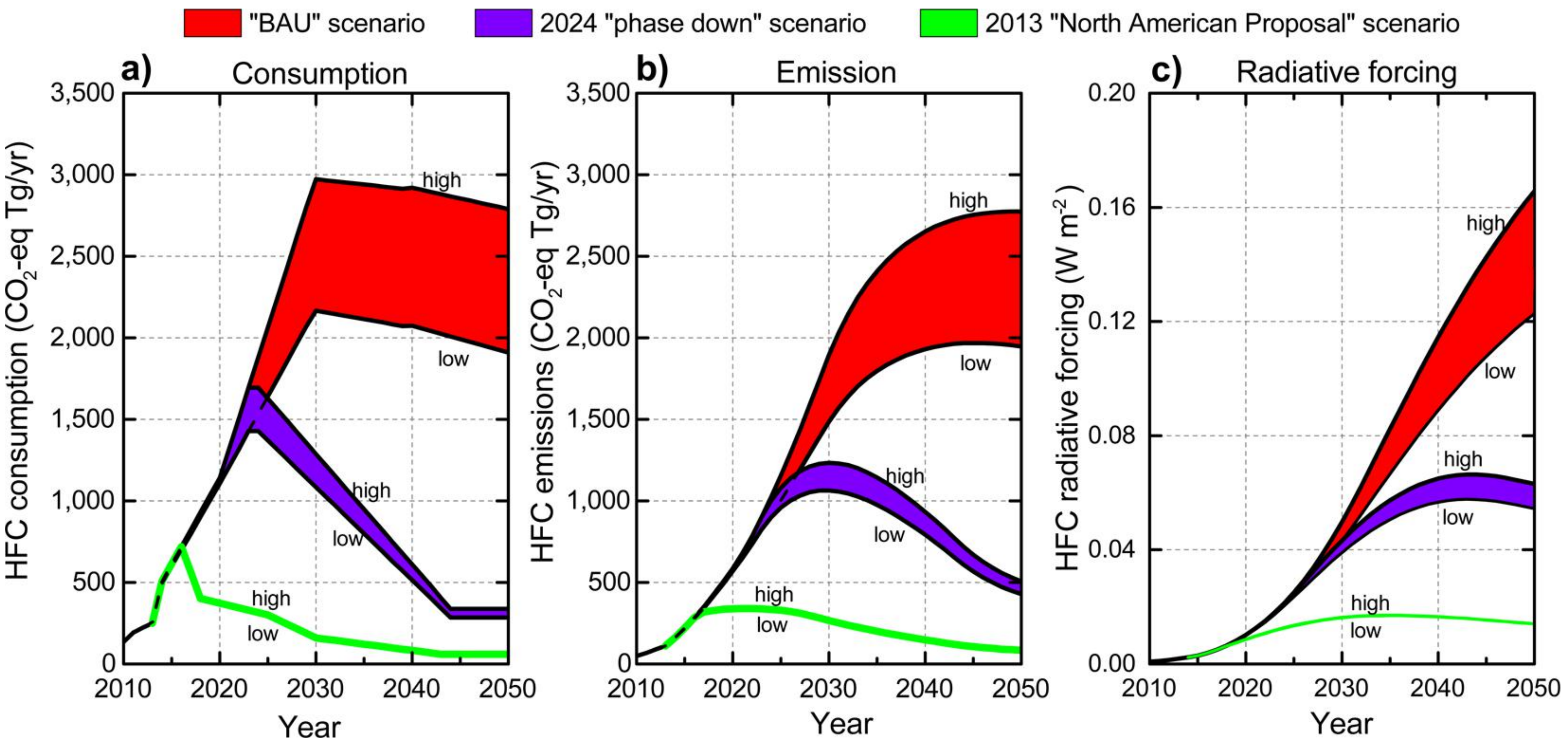
- BAU
- NAP Consumption cap
  - 2018 100%，2025 75%，2030 40%，2043 15%
  - liner reduction in practise
- 2024 reduction scenario

  in 2024 freeze production and consumption at 2023 level

  4% per year （2025-2044），keep 20% of the baseline

  liner reduction

  2044-2050， keep 20% of the baseline



"BAU" scenario
2024 "phase down" scenario
2013 "North American Proposal" scenario
a)
Consumption
HFC consumption (CO_2-eq Tg/yr)
high
low
high
low
high
low
Year
b)
Emission
HFC emissions (CO_2-eq Tg/yr)
high
low
high
low
high
low
Year
c)
Radiative forcing
HFC radiative forcing (W m^{-2})
high
low
high
low
high
low
Year

Key data by 2050 (million tons CO_2 equivalent)

	Accumulated consumption	Accumulated emission	Avoided consumption	Avoided emission
BAU（基线）	74 000 (63 000–85 000)	59 000 (51 000– 67 000)	**China's annual CO_2 emissions: 10, billion tons ? 4-5 years**	
2024	31 000 (29 000–34 000)	29,000 (27 000– 31 000)	43,000 (34 000–51 000)	30,000 (24 000– 36 000)
NAP（北美）	8100 (8000–8100)	8200 (8100–8200)	66,000 (37,000-91,000)	51,000 (27,000-67,000)

谢 谢!