

# HFC Mitigation potential and costs under different phase-down scenarios for India

Pallav Purohit

CEEW-IIASA Side Event on 'Economy-wide cost of transition  
for the HFC phase down in India'

38th Meeting of the Open-ended Working Group of the Parties  
to the Montreal Protocol

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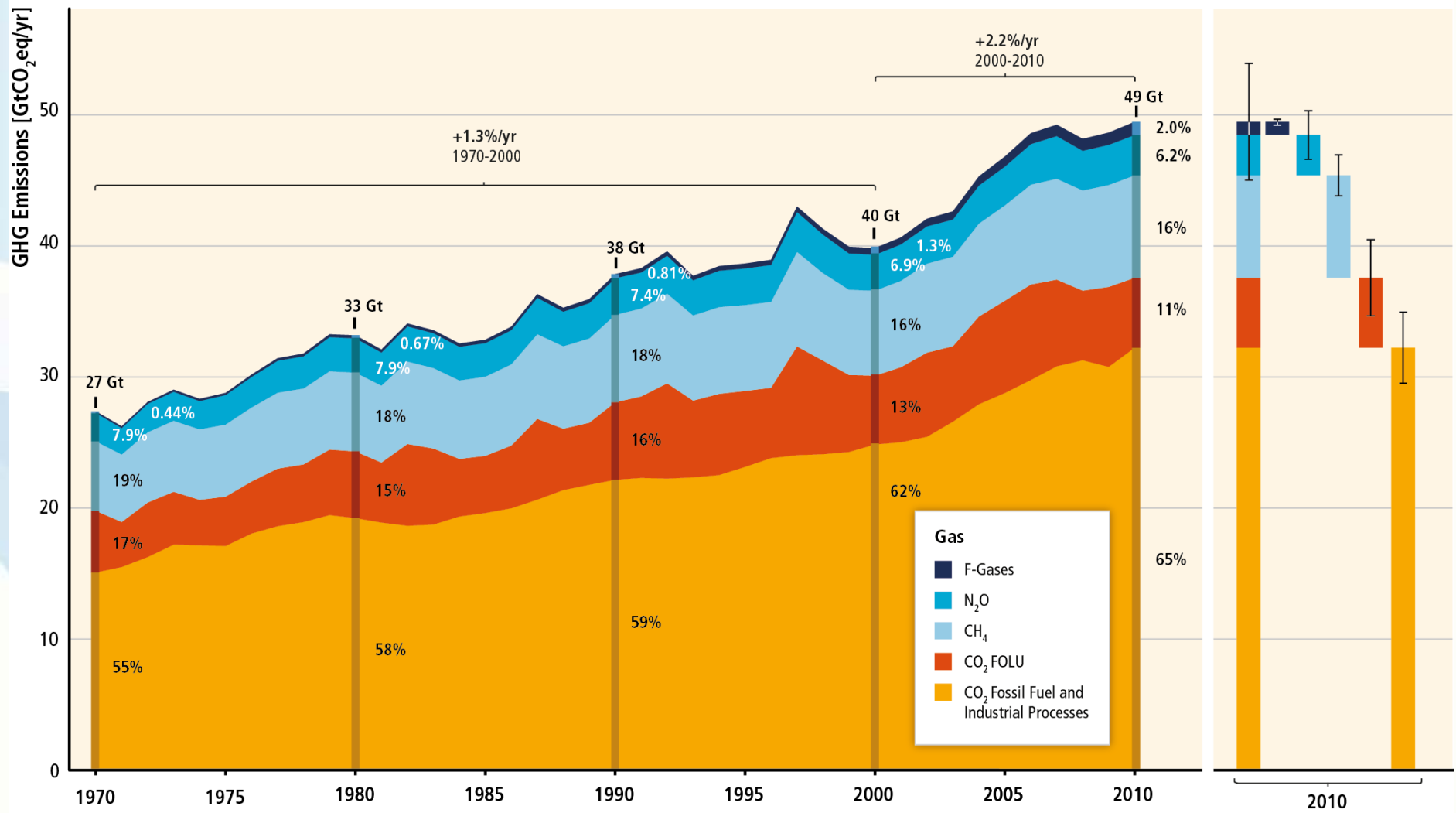
**Research undertaken in collaboration with CEEW**

# Contents

- HFC emissions in the current legislation (CLE) scenario
  - *Key drivers, activities, controls and leakage rates*
- Maximum technically feasible reduction (MTFR) scenario
  - *Alternatives for high-GWP HFC's, removal efficiency, useful life of the equipment*
- Marginal abatement cost curves
- Implications of a global agreement on HFCs
- Summary

# Why HFC's?

Total Annual Anthropogenic GHG Emissions by Groups of Gases 1970-2010



Source: IPCC (2014)

# Global Change Assessment Model (GCAM)-IIMA Model

## Top Down GCAM-IIM Framework

Global and Indian Energy Supply

Economic and Demographic Drivers

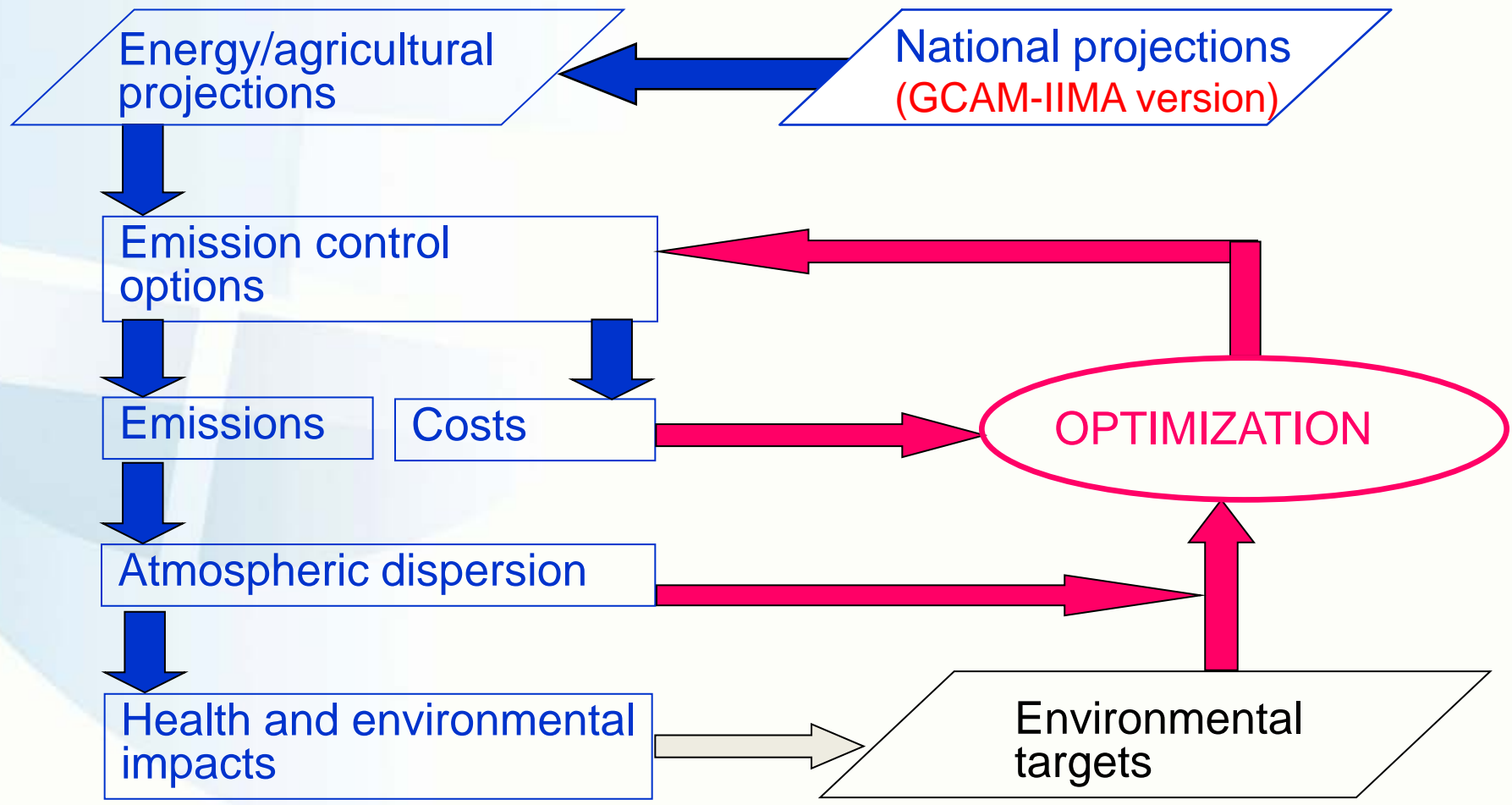
Transportation

Space Cooling

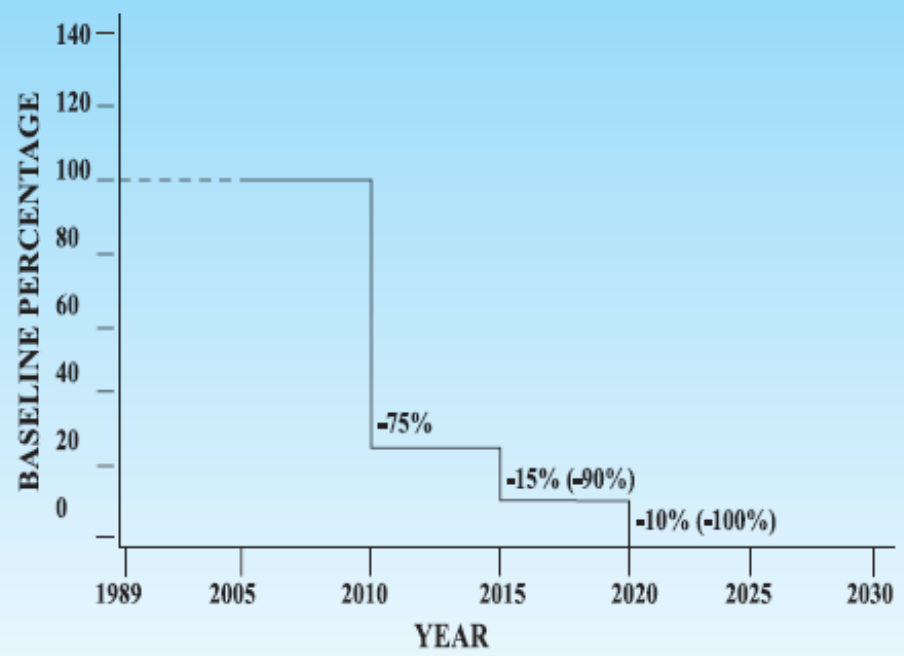
Refrigeration

# Greenhouse gases and Air pollution Interactions and Synergies (GAINS):

*A model to harvest synergies by integrating multiple pollutants and their multiple effects*

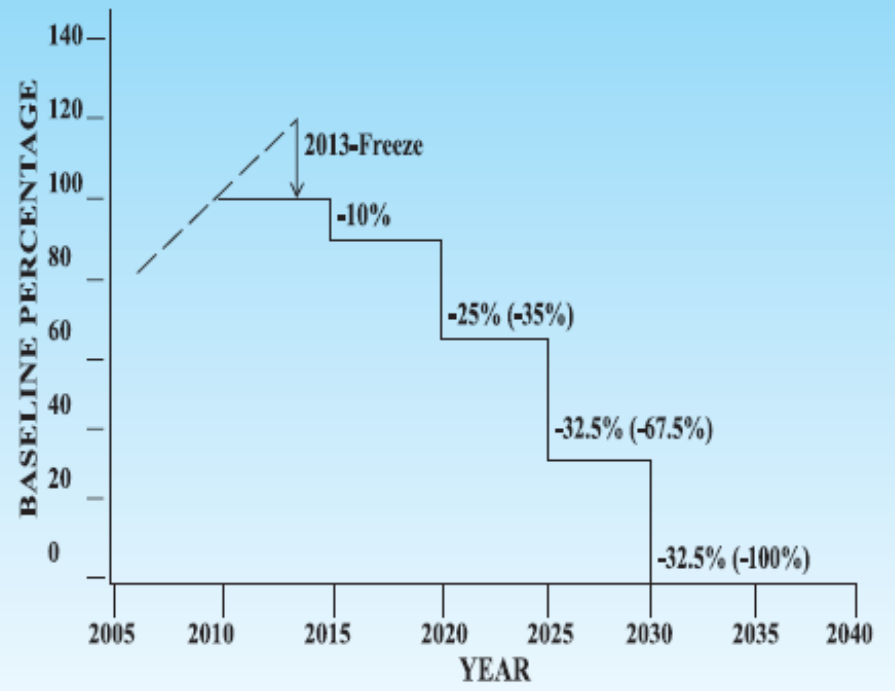


# HCFC phase-out schedule for parties (revised MP)



\* Allowing 0.5% for servicing for the period 2020-2030

Non-Article 5 Parties



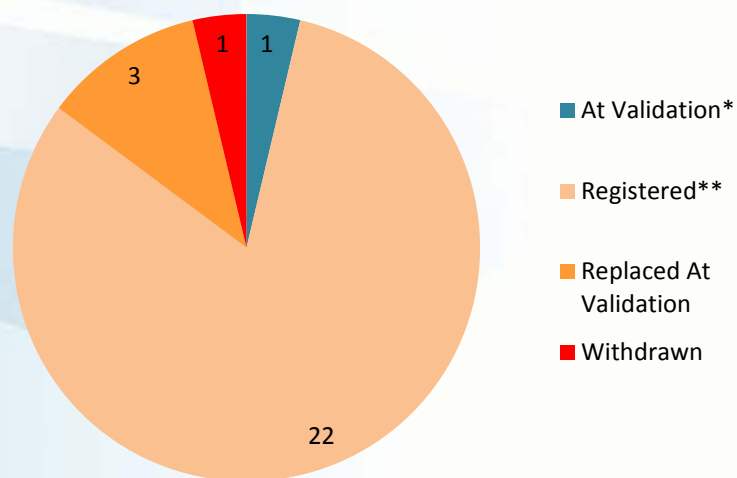
\* Allowing for servicing an annual average of 2.5% during the period 2030-2040

Article 5 Parties

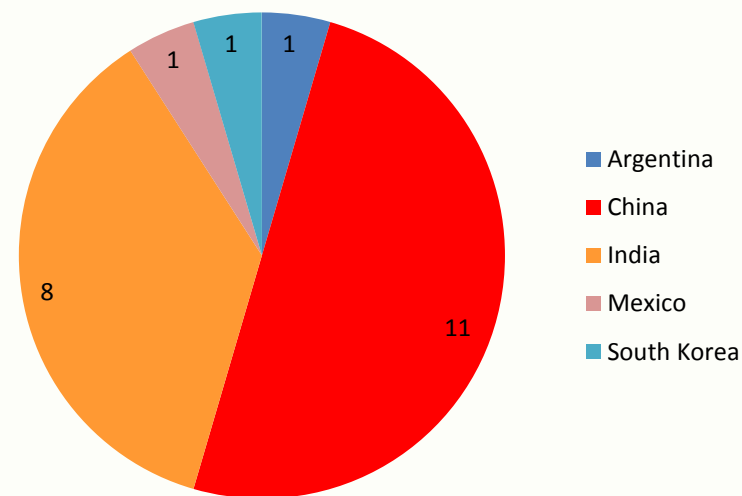
# Control technologies in the baseline Scenario

- Clean Development Mechanism (CDM)

Status of HFC projects under CDM  
(Total = 27)



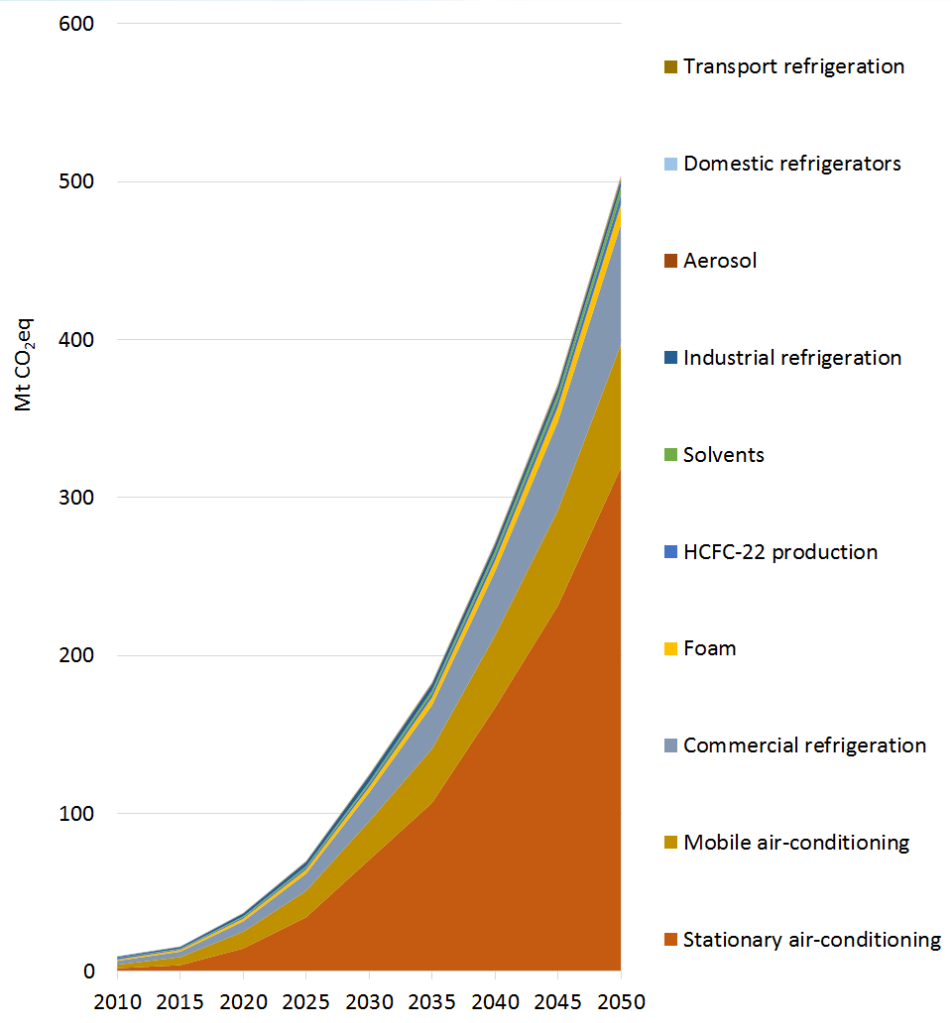
Number of registered HFC projects by country (Total = 22)



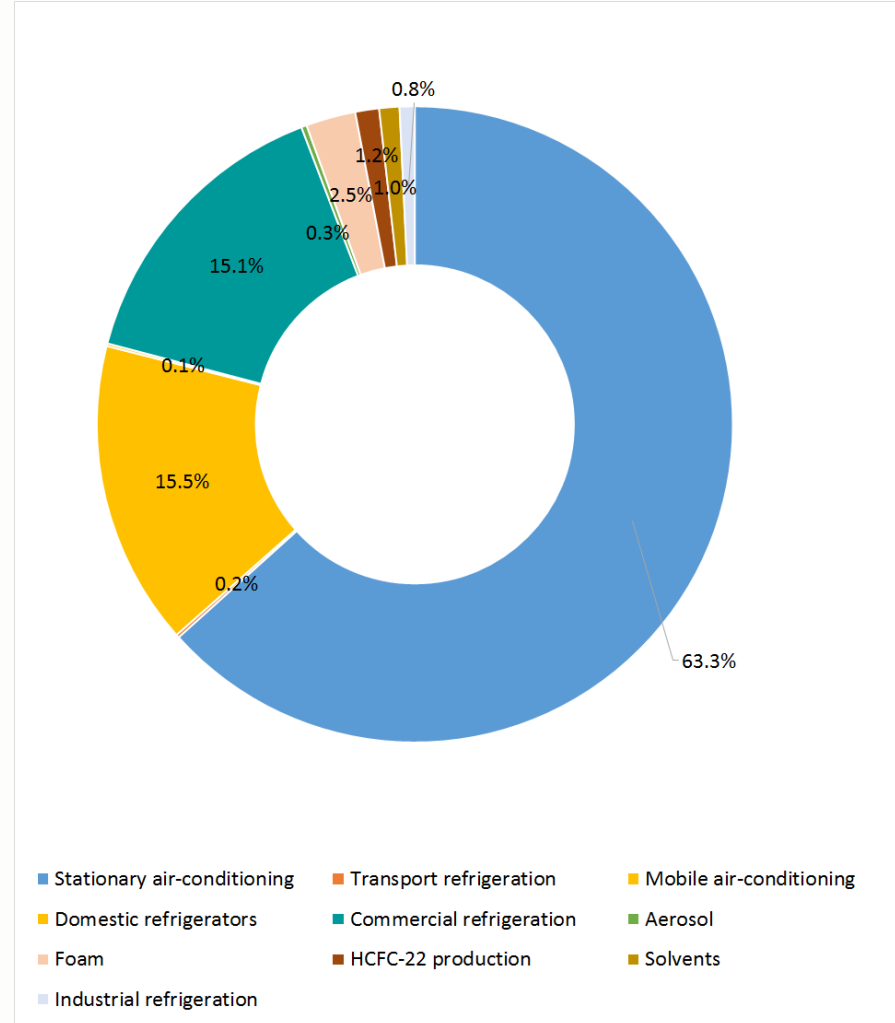
- 5 projects on thermal oxidation of HFC-23 from India (19 projects at global level)
- 3 projects on rigid poly urethane foam (PUF) manufacturing from India

Source: Fenhann (2015)

# Sectoral development of baseline HFC emissions 2010-2050



Sectoral development of HFC emissions



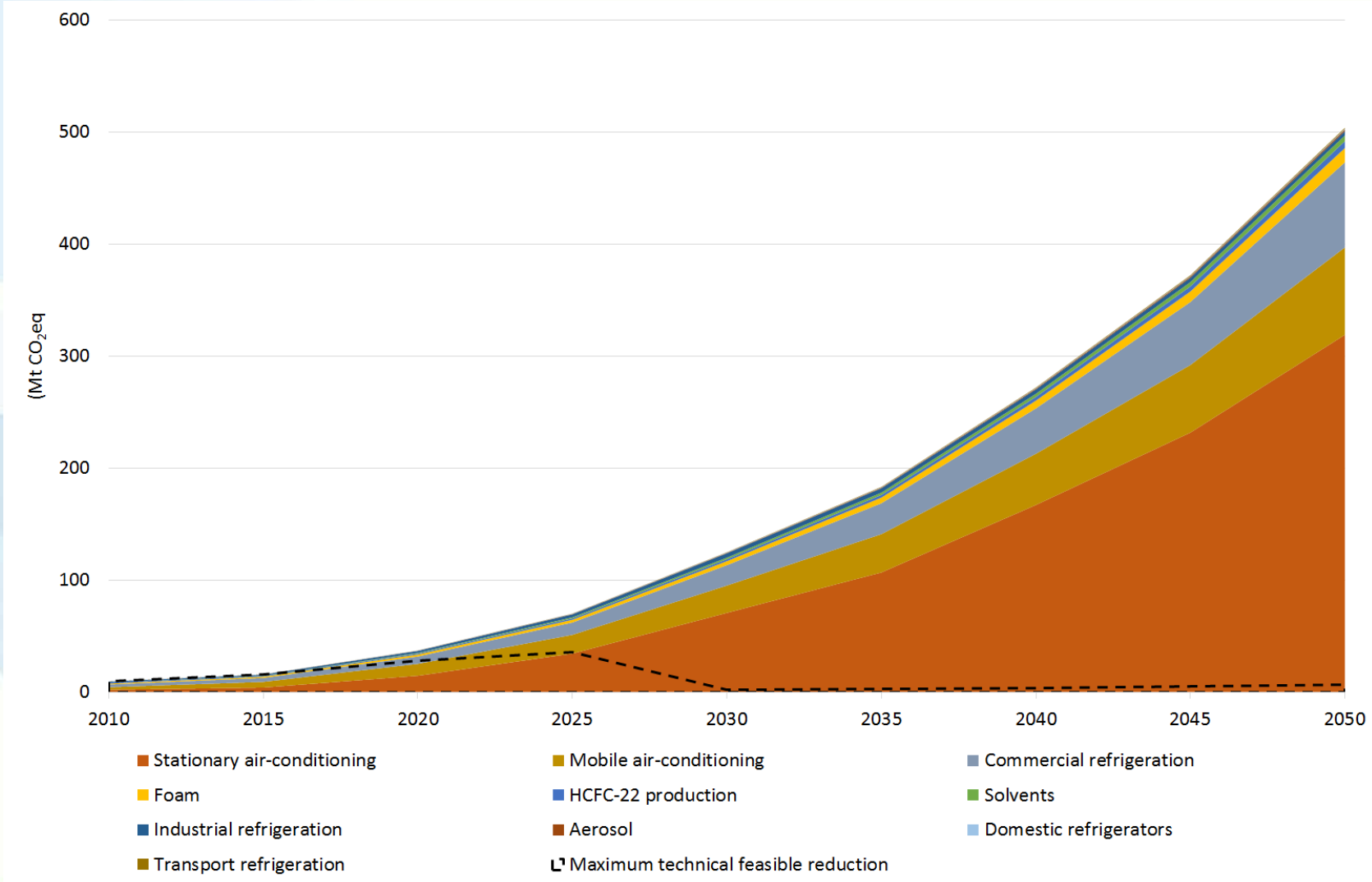
HFC emissions in 2050 by sector



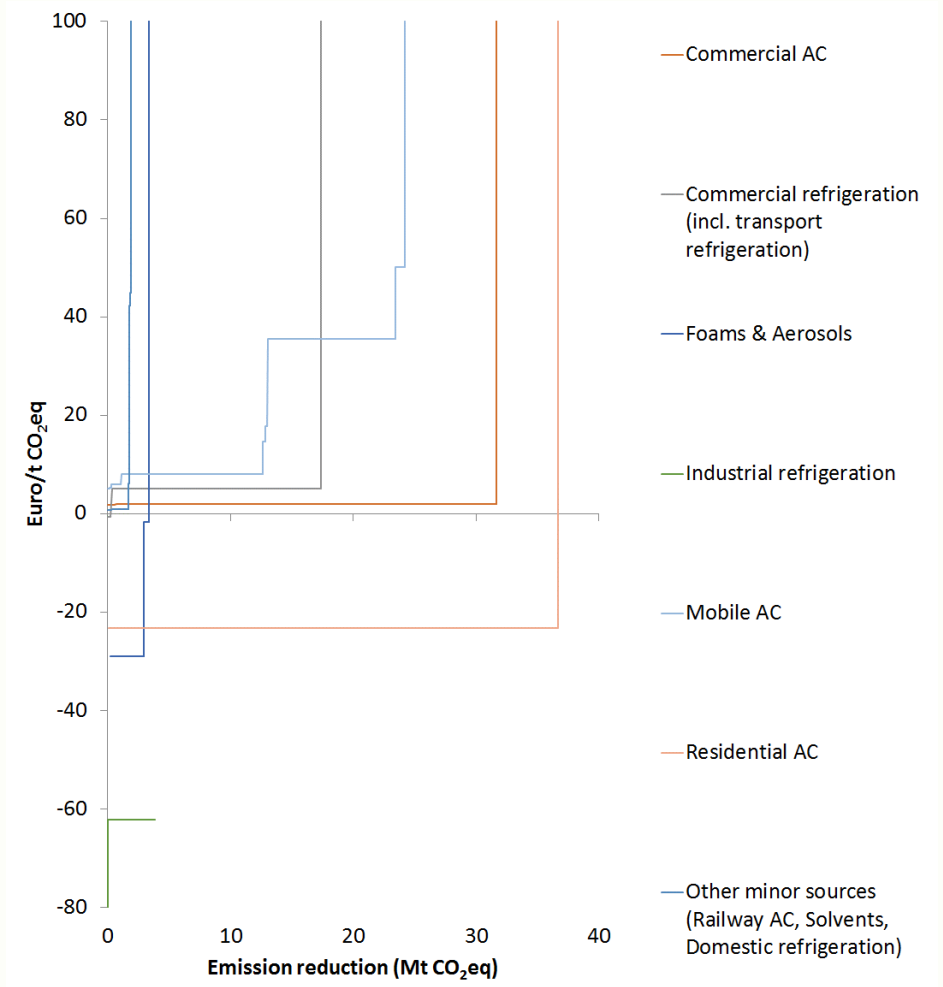
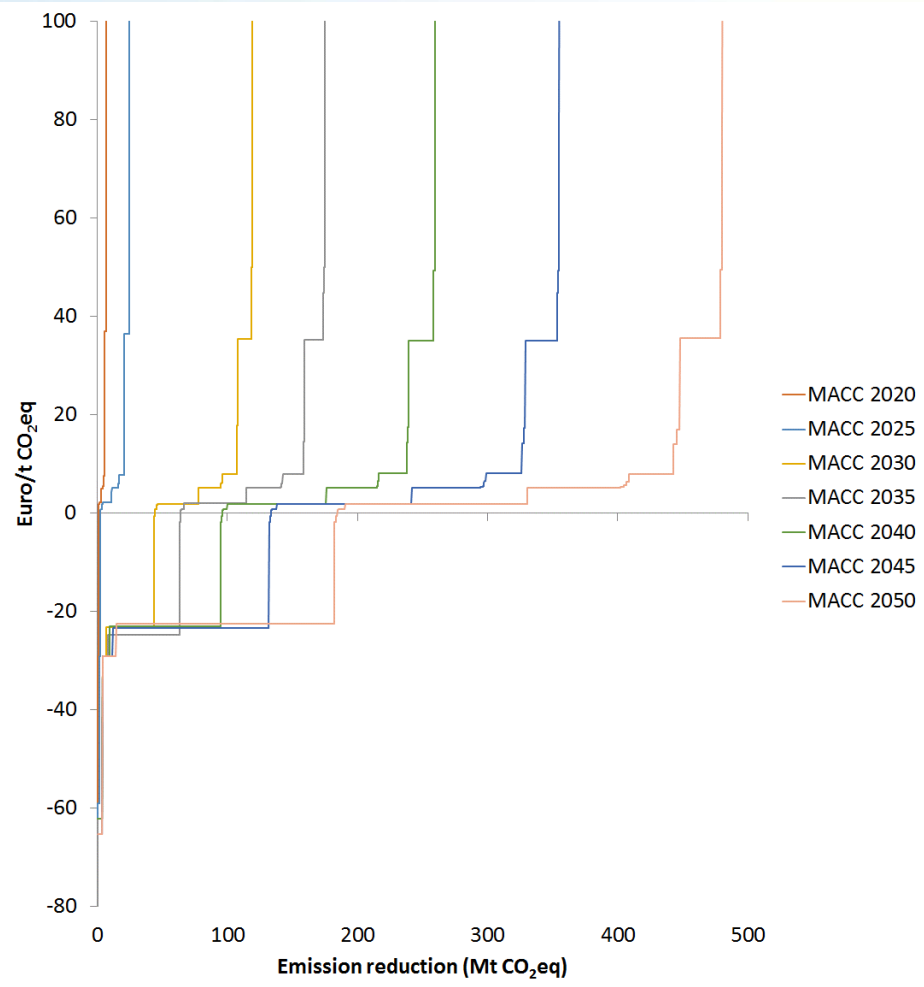
# Low-GWP HFC options at sectoral level

Sector	Alternative low-GWP refrigerants
Aerosol	HFO-1234ze, HFC-152a, Hydrocarbons (i.e. R-290)
Commercial refrigeration	Hydrocarbons (i.e. R-290, R-600a), CO <sub>2</sub> (R-744)
Domestic refrigerators	Hydrocarbons (i.e. R-600a), HFC-1234yf, CO <sub>2</sub>
Fire-extinguisher	FK-5-1-12, FM200, CO <sub>2</sub> , ABC powder
Foam	CO <sub>2</sub> , Hydrocarbons, HFC-152a, HFC-1234ze
Ground source heat pumps	CO <sub>2</sub> , Hydrocarbons
Industrial refrigeration	NH <sub>3</sub> (R-717), CO <sub>2</sub>
Solvents*	Iso-paraffin/siloxane (KC-6)
Mobile air-conditioning	HFO-1234yf, CO <sub>2</sub> , HFC-152a
Commercial air-conditioning	Propylene (R-1270), Hydrocarbons (i.e. R-290), CO <sub>2</sub>
Residential air-conditioning	Hydrocarbons (i.e. R-290), HFC-32, CO <sub>2</sub>
Transport refrigeration	Hydrocarbons, CO <sub>2</sub>

# India's HFC emissions in MTRF (left panel) and HFC phase-down (right panel) scenarios for India



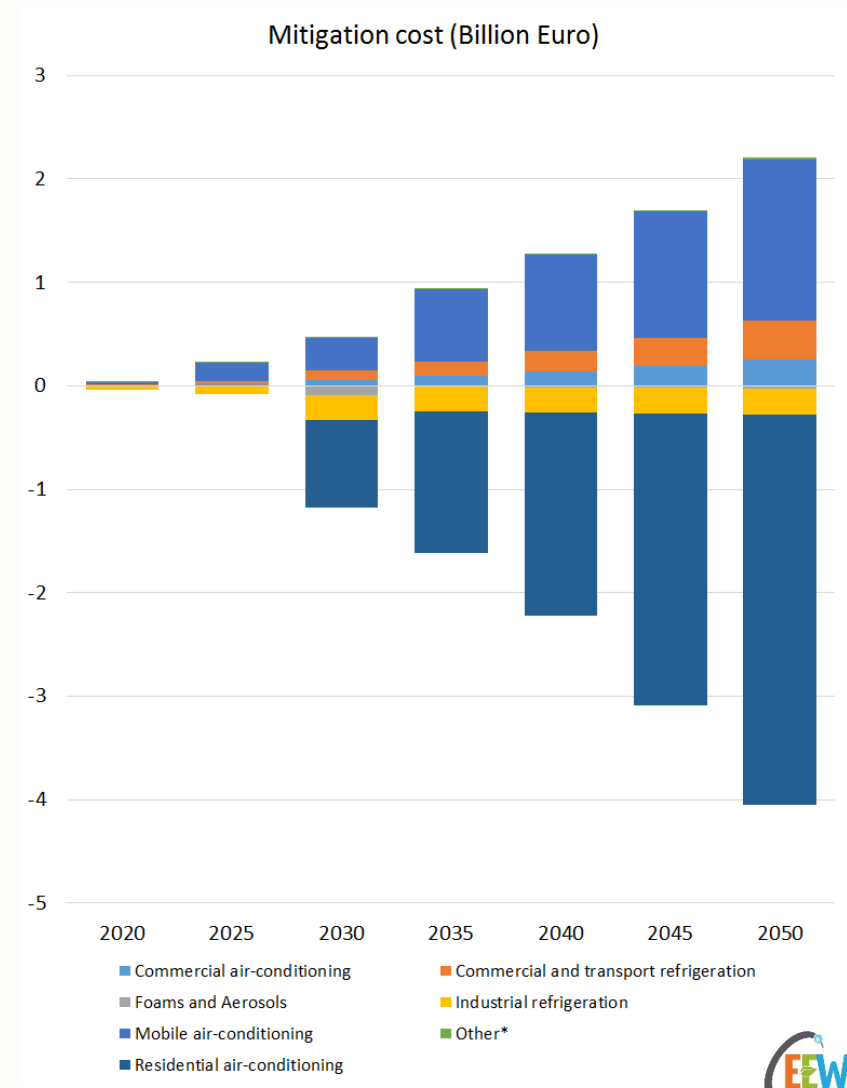
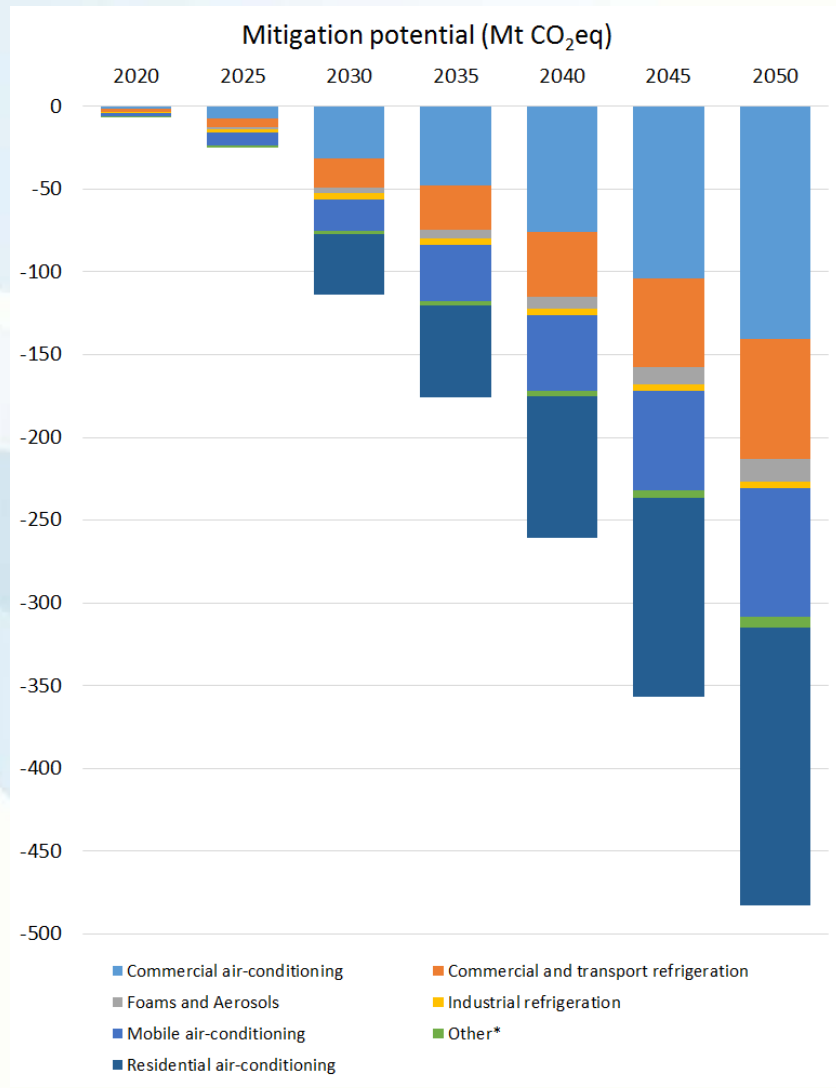
# Marginal abatement cost curves



# HFC phasedown schedule and baseline for Article-5 parties

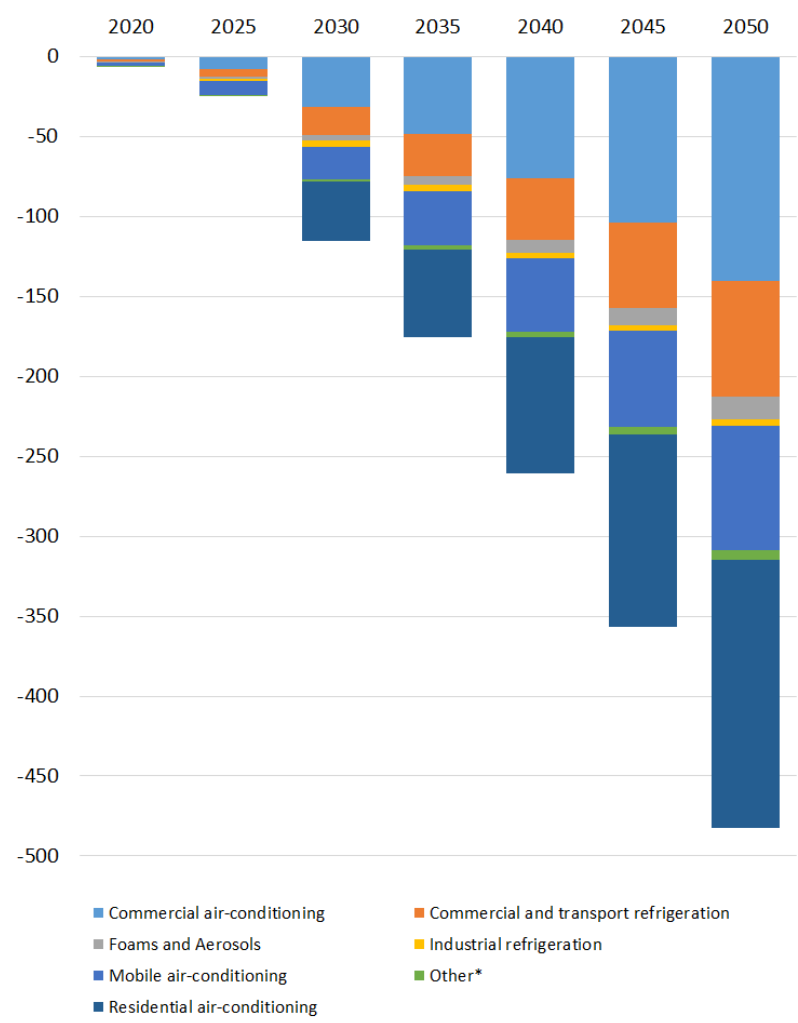
Baseline	
<i>North American proposal</i>	100% of HFCs + 50% of HCFC (avg. from 2011-2013)
<i>European Union proposal</i>	100% of HFCs + 100% of HCFC (con avg. from 2015-16)
<i>India proposal</i>	100% of HFCs (avg. from 2028-2030) + 32.5% HCFC baseline
<i>Small Island Developing States (SIDS) proposal</i>	100% of HFCs (avg. from 2015-2017 + 65% HCFC baseline)
Control measures (% of baseline)	
<i>North American proposal</i>	2021 – 100% 2026 – 80% 2032 – 40% 2046 – 15%
<i>European Union proposal</i>	Consumption: 2019 – 100% Production: 2019 – 100%; 2040 – 15% Further and intermediate steps agreed by 2020
<i>India proposal</i>	2031 – 100%; 2050 – 15% National phase down steps are to be decided 5 years in advance for the next 5-year period
<i>Small Island Developing States (SIDS) proposal</i>	2020 – 85% 2025 – 65% 2030 – 45% 2035 – 25% 2040 – 10%

# Mitigation potential and costs under North American (NA) proposal

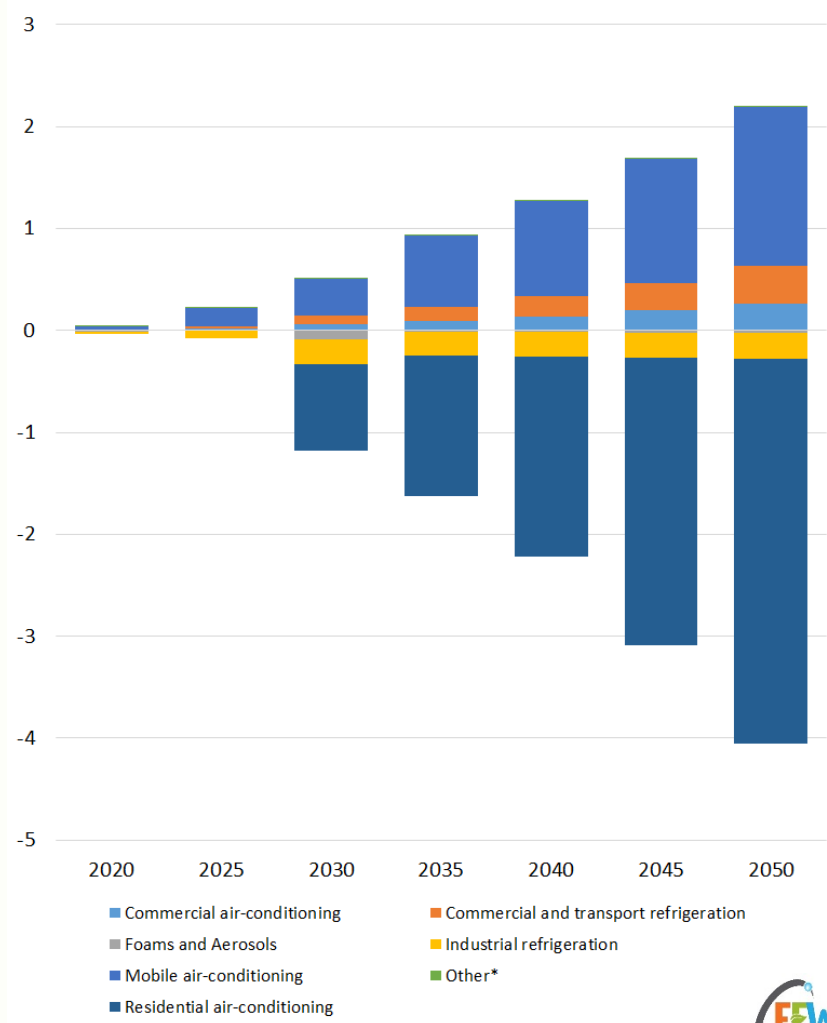


# Mitigation potential and costs under European Union (EU) proposal

Mitigation potential (Mt CO<sub>2</sub>eq) under EU proposal

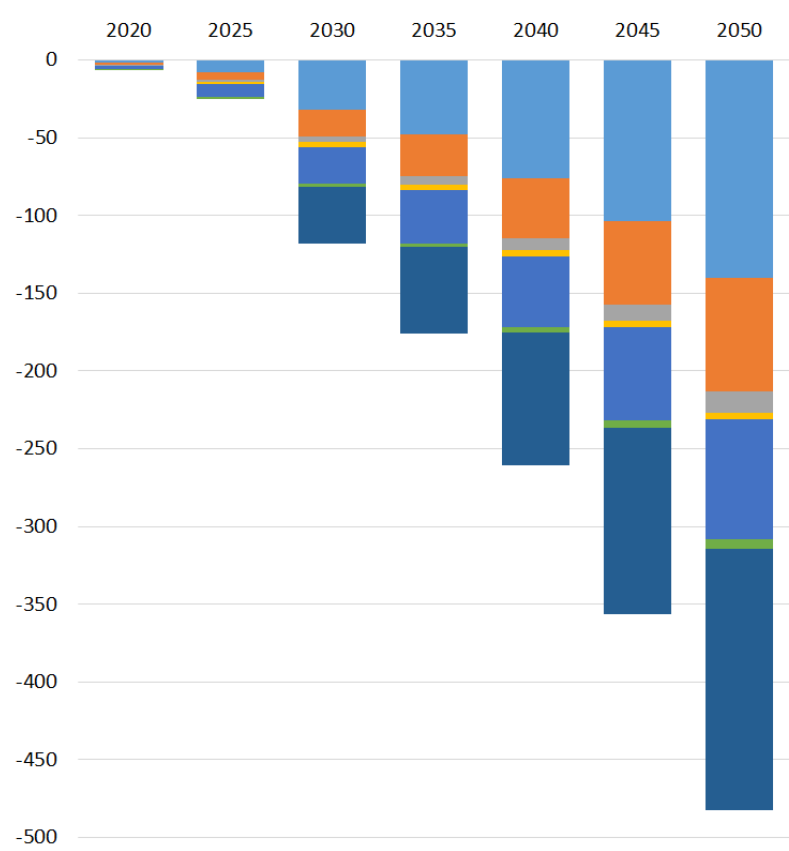


Mitigation cost (Billion Euro) under EU proposal



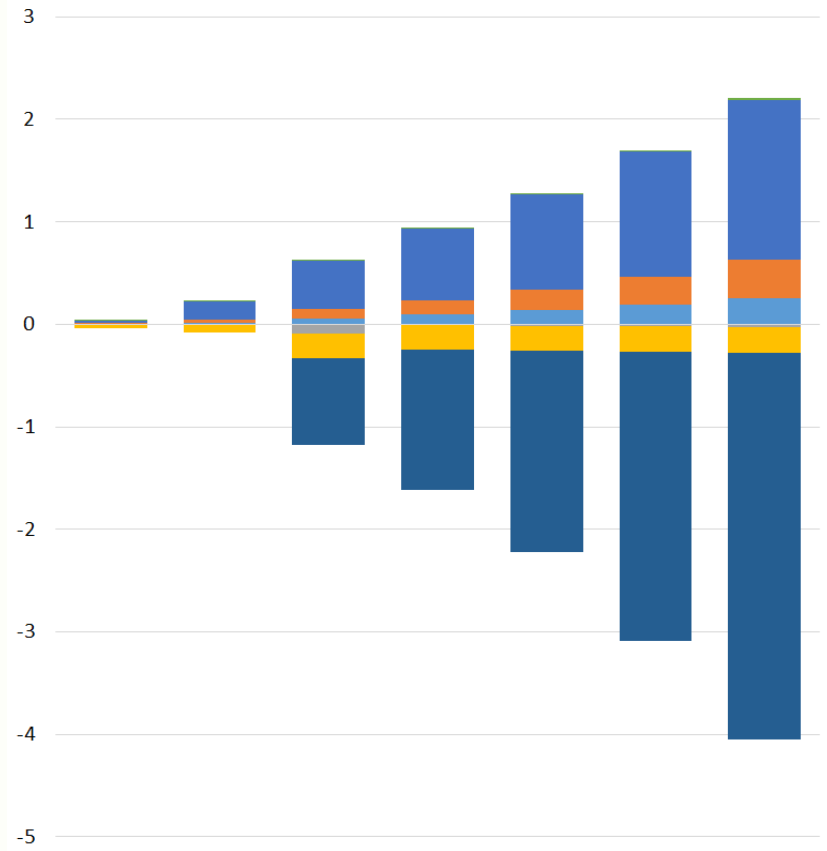
# Mitigation potential and costs under Small Island Developing States (SIDS) proposal

Mitigation potential (Mt CO<sub>2</sub>eq) under SIDS proposal



- Commercial air-conditioning
- Commercial and transport refrigeration
- Foams and Aerosols
- Industrial refrigeration
- Mobile air-conditioning
- Other\*
- Residential air-conditioning

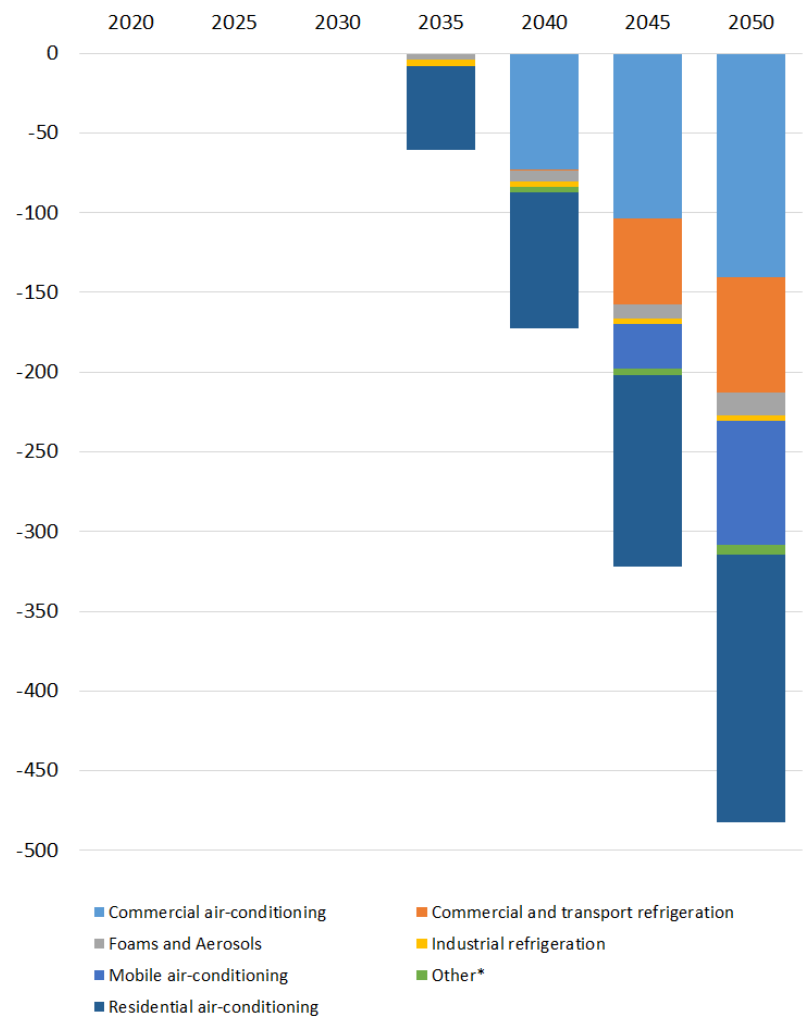
Mitigation cost (Billion Euro) under SIDS proposal



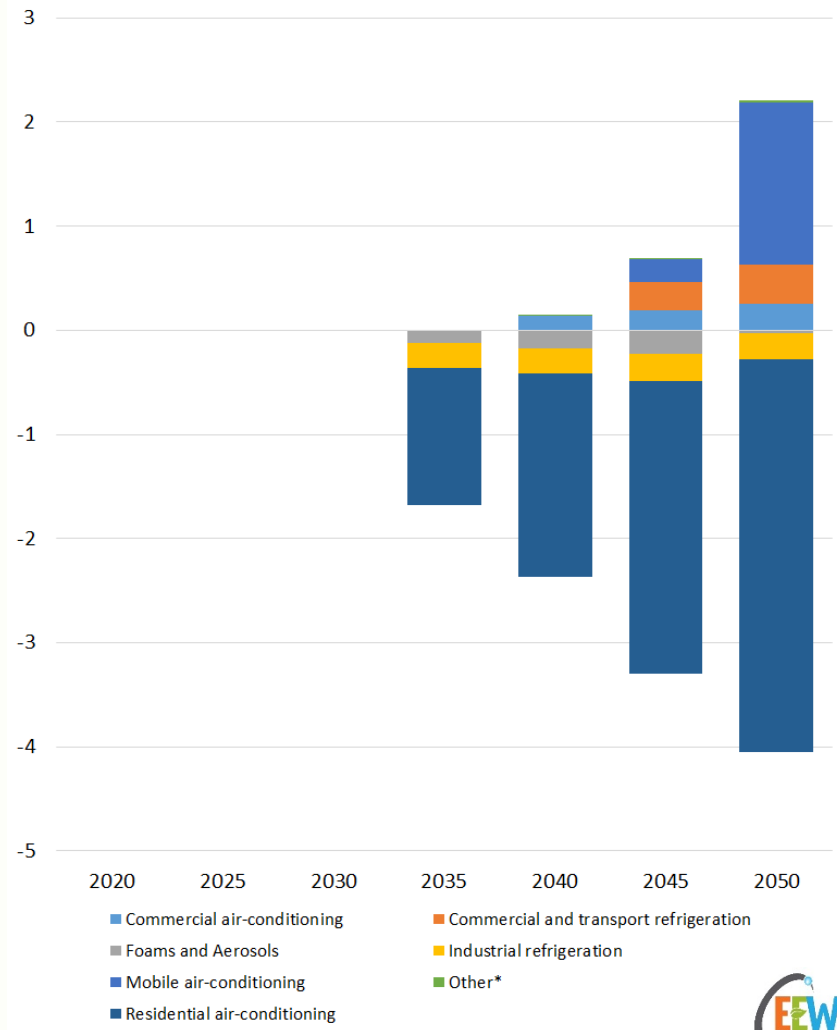
- Commercial air-conditioning
- Commercial and transport refrigeration
- Foams and Aerosols
- Industrial refrigeration
- Mobile air-conditioning
- Other\*
- Residential air-conditioning

# Mitigation potential and costs under India proposal

Mitigation potential (Mt CO<sub>2</sub>eq) under India proposal



Mitigation cost (Billion Euro) under India proposal

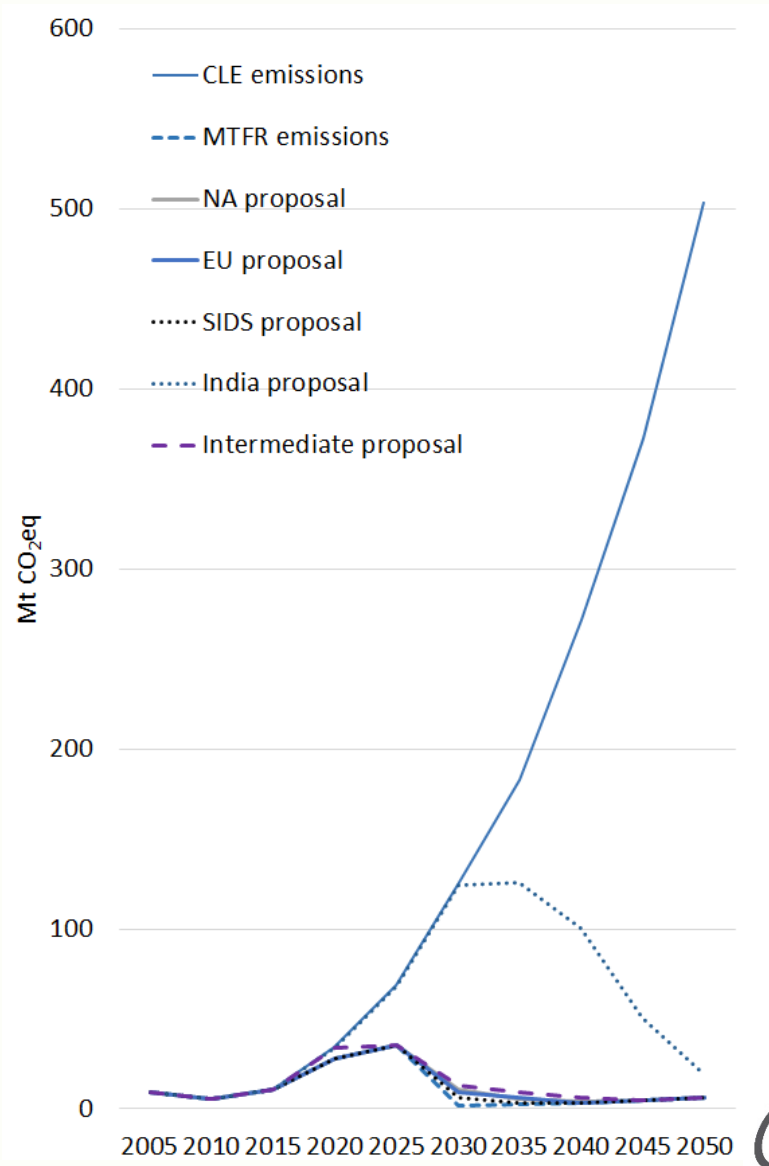
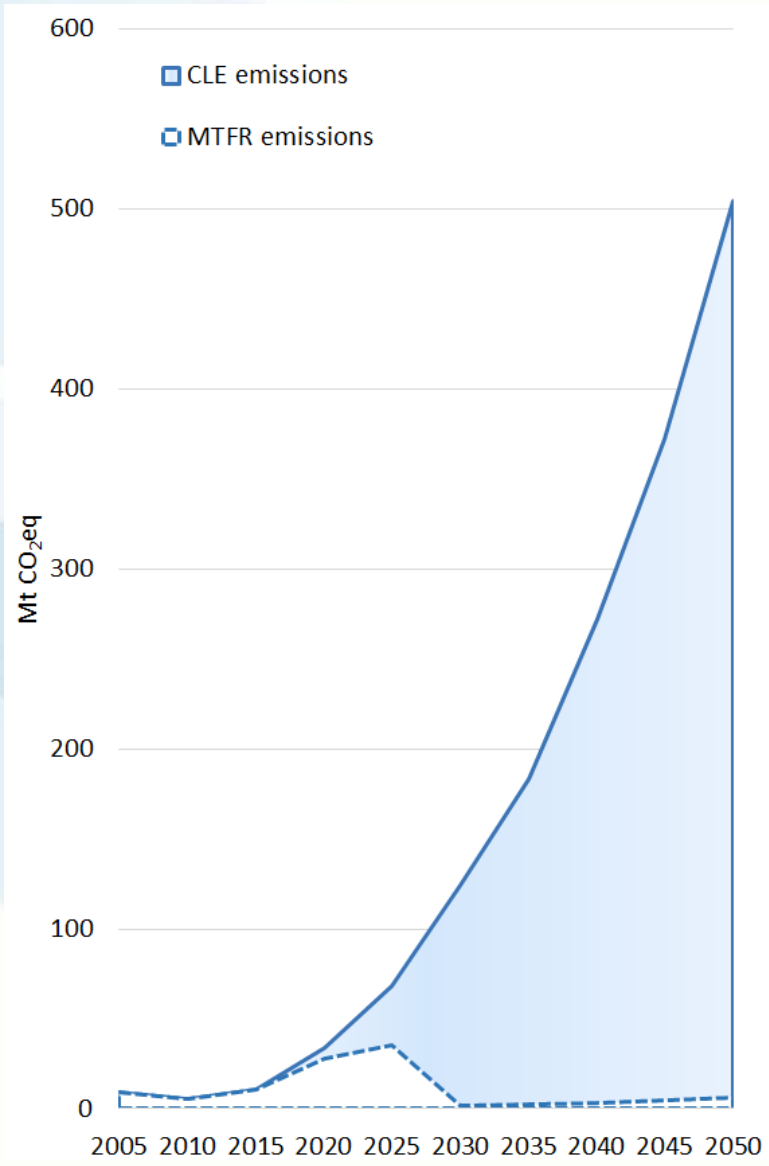




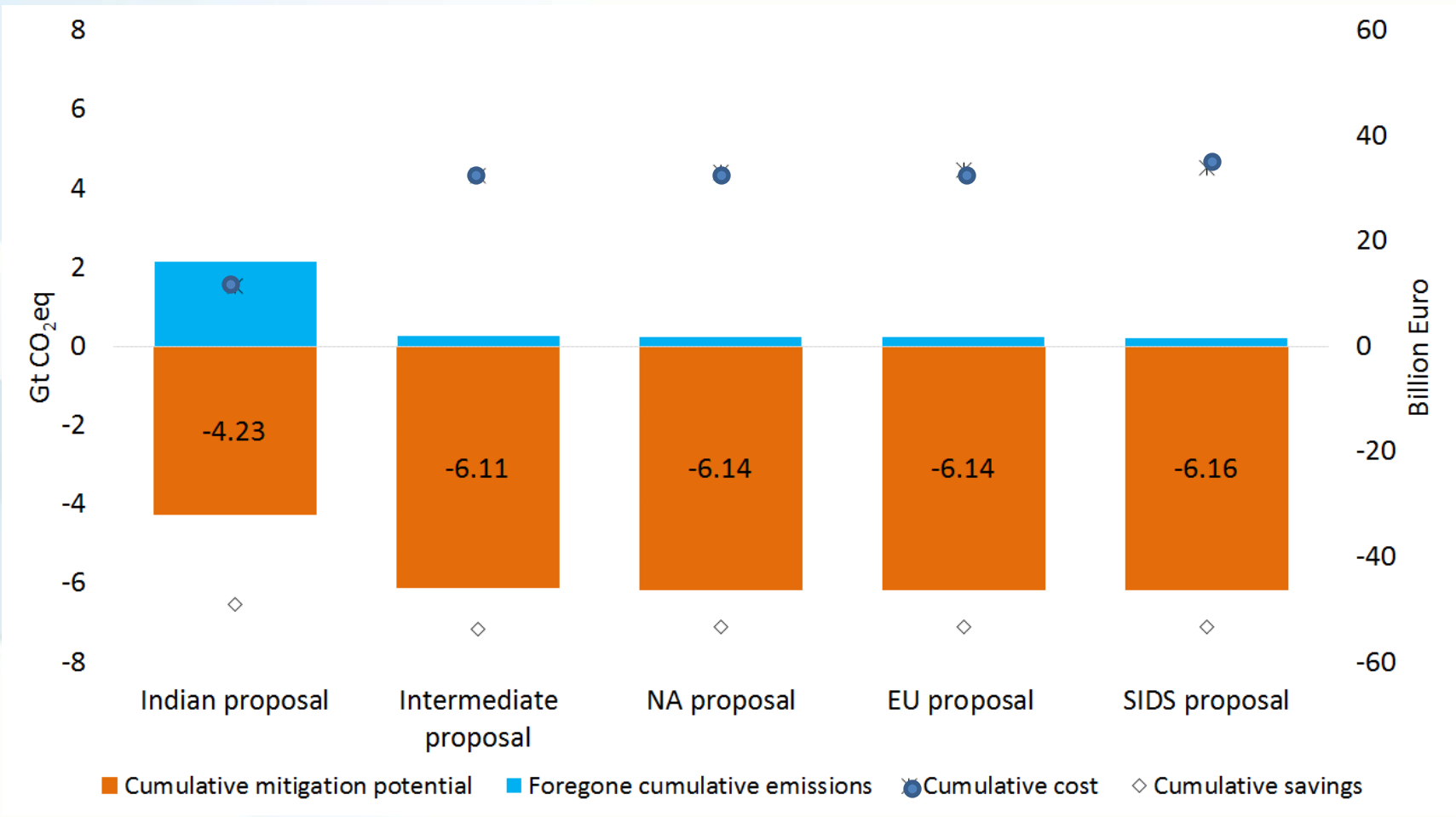
# Sensitivity analysis using different phase-down schedules for the Indian proposal

Year	HFC phase-down steps		Mitigation potential (Mt CO <sub>2</sub> eq)		Mitigation cost (Million Euro)	
	Existing	New	Existing	New	Existing	New
2035	100%	80%	60.9	84.2	0.0	36.9
2040	80%	60%	172.7	198.2	138.5	258.8
2045	40%	40%	322.2	322.2	683.7	683.7
2050	15%	15%	482.4	482.4	2492.2	2492.2

# India's HFC emissions in MTRF (left panel) and HFC phase-down (right panel) scenarios for India



# Mitigation potential (cum.), foregone emissions (cum.), cumulative costs and saving under different HFC phase-down scenarios



# Way forward

- Low-GWP and “not-in-kind” alternatives are commercially available for most of the sectors. Switching to low-GWP and “not-in-kind” alternatives can reduce not only HFCs, but also CO<sub>2</sub> emissions from energy consumption.
- More than a third of the mitigation potential is attainable at zero or below zero marginal cost primarily due to inexpensive low-GWP alternatives and energy efficiency benefits.
- Appropriate domestic policies and tracking energy efficiency opportunities can help achieve and accelerate transition to low-GWP and not-in-kind alternatives.
- The cumulative costs in different HFC phasedown scenarios are estimated at nearly 33-34 billion Euro particularly in (mobile air-conditioning, commercial refrigeration and air-conditioning, etc.) in the NA, EU, SIDS and intermediate proposal that is less than 0.02% of India’s expected cumulative GDP from 2015 to 2050.
- A phase-down of HFCs is likely to be a cost-effective option for India to contribute to the global climate target that limits temperature increase to 2°C above pre-industrial levels.

# Key messages from our modelling research

**Vaibhav Chaturvedi**

Council on Energy, Environment and Water

OEWG 38 Side Event

Vienna, 19<sup>th</sup> July 2016

# Modelling for insights, not numbers!

- Results from any analysis is contingent on the best currently available information
- The MAC curves and cost numbers that we highlight also reflect this
- If the cost of existing alternatives declines, then our sectoral numbers will change
- But future is uncertain, and continuously evolving
- We have to move forward give the uncertainties
- Through modelling, we seek to better understand the uncertainties
- To devise strategies for maximising the chances for a positive outcome

# An informed view on long term refrigerant prices

- Currently, only one generally acceptable alternative for the MAC sector, highly expensive compared to existing option
- Safeguarding **all sectors** and final consumers in developing countries from any financial shocks from any new and expensive alternative being forced on them is critical
- Why should a developing country pay more for a refrigerant when cheaper mitigation options are available in other sectors?
- Expectations of long term price of 1234yf are uncertain at best:
  - Currently in India, cost of 1234yf almost 20 times compared to 134a
  - Will it be 7-8 times when patents expire and economies of scale kick in?
  - Or will it be 1.5-2 times only?
  - Are there alternative process that can drive the price down?
- How to eliminate monopoly rents and IPR related costs to minimize the incremental cost, and can MLF influence this process?

# Enhanced R&D for R-290 applications

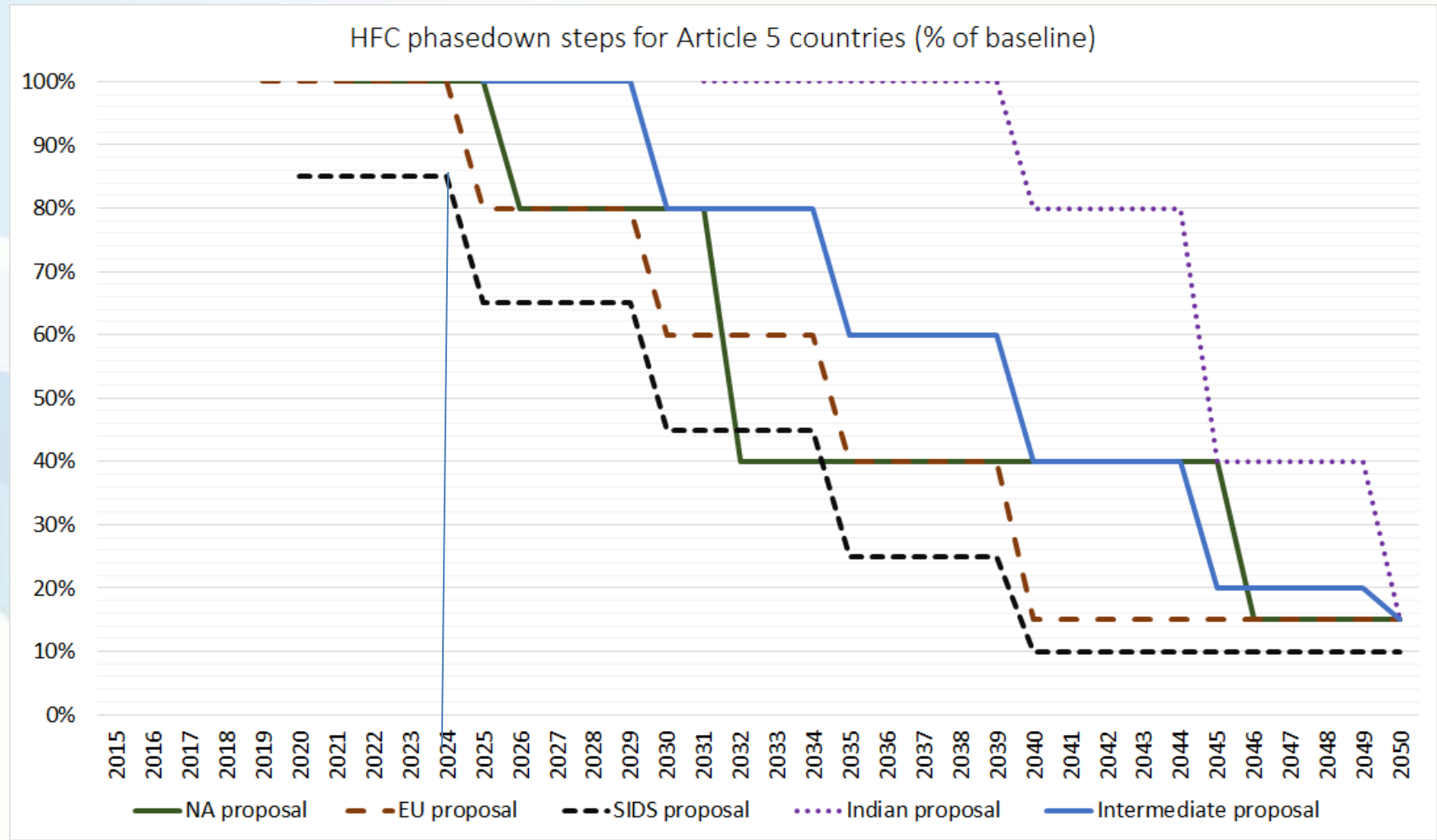
- R-290 currently the only low GWP alternative that is in the market for the residential AC sector
- Though huge potential for energy efficiency exists, technical challenges remain
- R&D for domestic applications of R-290 is critical
- For a phase down, existence of a low GWP alternative is critical. If not R-290, it will have to be some other low GWP alternative
- Any other alternative could be a patented alternative with high price even if it is energy efficient
- The best strategy is to improve upon an existing unpatented alternative



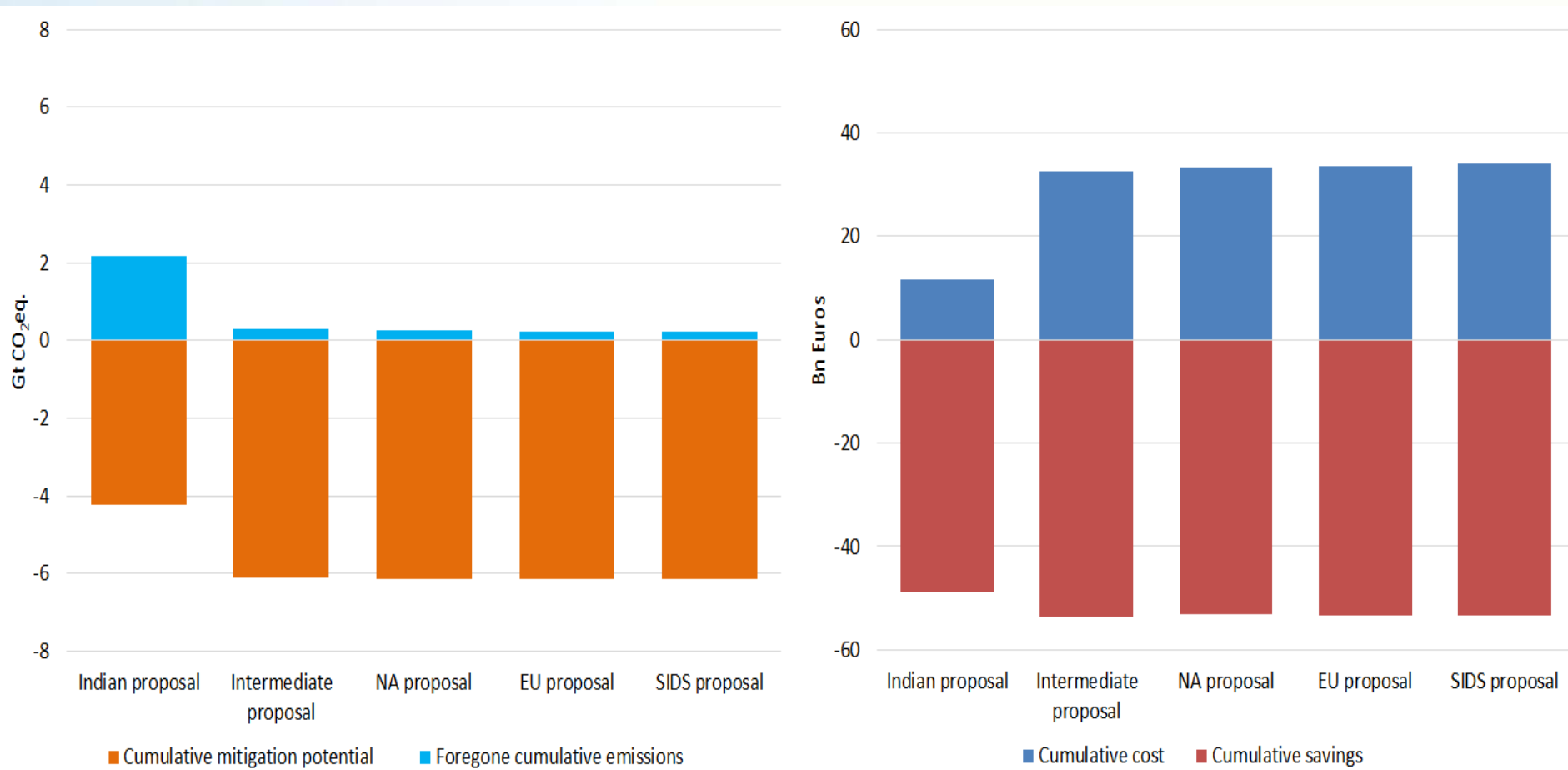
## Moving towards amendment with adequate safeguards and aligning with development objectives

- Irrespective of the amendment proposal, there will be a cost of phasing down HFCs, **this is different from the way MLF views the cost**
- Understanding trade-offs are critical for moving ahead with the amendment
- Mitigating High GWP HFCs is critical but phase down needs to align with India's development goals
- Safeguarding different interests are a useful way for bringing all stakeholders on board

# HFC phase-down steps for Article 5 countries

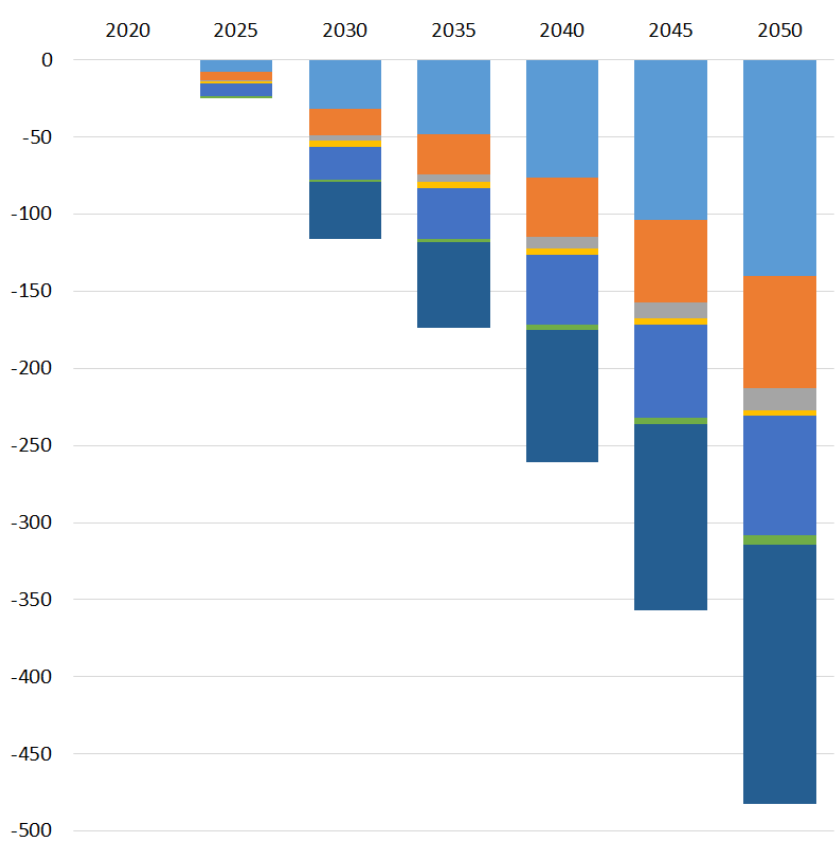


# Mitigation potential (cum.), foregone emissions (cum.) and cumulative costs and saving under different HFC phase-down scenarios from 2015 to 2050



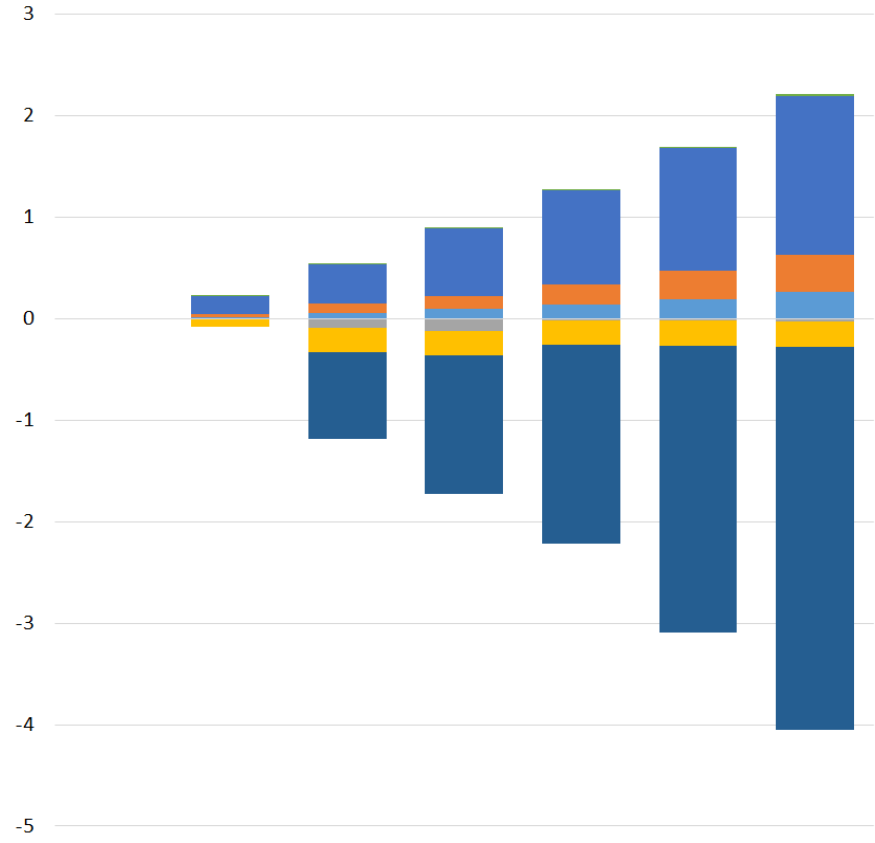
# Mitigation potential and costs under Intermediate proposal

Mitigation potential (Mt CO<sub>2</sub>eq) under Intermediate proposal



- Commercial air-conditioning
- Commercial and transport refrigeration
- Foams and Aerosols
- Industrial refrigeration
- Mobile air-conditioning
- Other\*
- Residential air-conditioning

Mitigation cost (Billion Euro) under Intermediate proposal



- Commercial air-conditioning
- Commercial and transport refrigeration
- Foams and Aerosols
- Industrial refrigeration
- Mobile air-conditioning
- Other\*
- Residential air-conditioning