

The Newest Business Case for an HFC Phasedown:

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The Trouble with HFCs

- HFCs, especially R-410A, are inferior technical alternatives to HCFCs:
 - High global warming potential (GWP)
 - Poor energy efficiency and cooling capacity at high ambient temps
 - Restricted in the US, EU, Japan, and other markets soon
 - Requires new infrastructure that must later be abandoned and replaced



HFC Phasedown Well Underway

- Regulations in EU, Japan, and USA alone will achieve at least half of the phasedown of the EU and North American Amendment proposals
- AC technology to achieve EU and US phasedown will likely be manufactured in China and other A5 Parties and might as well be implemented worldwide as soon as available, affordable, and financed

Impressive Market Penetration

- Denmark long ago achieved impressive HFC phasedown with government ambition and industry leadership
- GlZ has implemented HC-290 room AC in China and India, with about 20 projects underway worldwide
- Japan, responding to Indonesia, commercialized HFC-32 room AC that now dominates the Japan market and is gaining market share worldwide
- Foam system houses worldwide now offer an increasing spectrum of low-GWP foam including hydrocarbon, methyl formate, and HFO

Robust Proof:

Technical & Economic Feasibility

- TEAP confirms technical and economic feasibility of multiple options in most applications
- Independent analysis identifies emerging technology beyond that considered by TEAP
- Industry stakeholders in non-A5 Parties endorse stringent phasedown so long as under the Montreal Protocol with markets choosing technology to satisfy the control schedule
- US EPA SNAP roadmap increasingly aggressive

Alternatives to HFCs

HFCs	Applications	Alternatives	
R-404A	Industrial, Commercial, & Transport Refrigeration	R-448A	
		R-449A	
R-507A		R-407A/F	
		R-452A	
HFC-134a		Chillers	HC-290
			CO ₂
			HFO-1234ze
			R-450A
		Mobile AC	R-513A
			HFO-1233zd
	HFO-1234yf		
	HFC-152a		
	Household Refrigerators	CO ₂	
		HC-290	
		HC-600a	

Alternatives to HFCs

HFCs	Applications	Alternatives
R-410A	High-pressure chillers, portable AC, mini-split AC, central AC, light commercial AC, heat pumps	HFC-32
		"DR-55"
HFC-134a, HFC-245fa, HFC-365mfc, HFC-227ea	Foams	HFO-1234ze
		HFO-1233zd
		Not-in-kind: CO ₂ , hydrocarbons, methyl formate, water, and more
HFC-125, HFC-227ea	Fire Suppression	Inert gas
		Perfluorinated Ketone

Planning for Manufacturers

- The MLF can finance flexible manufacturing facilities, capable of working with current and future alternatives for great flexibility for the HCFC phaseout and HFC phasedown
- Component and knock-down assembly kit companies can offer upgrades to HC-290 and HFC-32
- Chemical producers can explore effective joint ventures with foreign enterprises

Room AC at High Ambient Temperature

- Oak Ridge National Laboratory tested room AC alternatives at high ambient temperatures (52°C & 55°C)
- HC-290 and HFC-32 are superior to R-410A

	R-410A	HFC-32	HC-290
Cooling Capacity	Low	High	Medium
Energy Efficiency	Low	High	High
GWP	High	Medium	Low
Flammability	Low	Medium	High

India Room AC Headstart

- First at HFC-32 ACs
 - Mid-GWP with lower-charge
 - High energy efficiency
 - For use in larger units
- First at HC-290 ACs
 - Low-GWP
 - High energy efficiency
 - For use in smaller units



Case Study: HC-290 Room AC

- HC-290 is GWP <5, highly flammable, low toxicity, and superior energy efficiency even at high ambient temperatures
- Satisfies EU regulation; ASHRAE/ISO Class A3
- HC-290 is manufactured and marketed in India and China but has not yet satisfied national safety standards in most countries except for models with small charge and cooling capacity
- China has revised its HPMP with at least 17 companies planning to replace HCFC-22 in room ACs with HC-290 rather than R-410A

HC-290 Superiority

- First choice wherever cooling capacity, energy efficiency and safety are satisfied
- Endorsed by many environmental NGOs and natural refrigerant advocacy organizations
- Promoted by GIZ with years of experience and impressive technical support at all levels (design, manufacture, installation, and service)
- Path-breaking in motivating reconsideration of how flammable refrigerants can be safely used

Case Study: HFC-32 Room AC (1)

- HFC-32 is GWP 675 with 30% lower charge, slightly flammable, low toxicity, and superior cooling capacity and energy efficiency even at high ambient temperatures
- SNAP listed, satisfies EU regulation, ASHRAE/ISO Class A2L
- At least five Parties (Algeria, China, Indonesia, Thailand, & Tunisia) have revised their HPMPs to replace HCFC-22 in room ACs with HFC-32 rather than R-410A

Case Study: HFC-32 Room AC (2)

- Every Japanese manufacturer shifted from HFC-410A to HFC-32 for sales in Japan and all have achieved high energy efficiency
- HFC-32 Room ACs are manufactured in China, India, Indonesia, Japan, Malaysia and soon Thailand and are sold in 47 countries: Albania, Australia, the European Union 28, India, Indonesia, Japan, Malaysia, Montenegro, New Zealand, Norway, Philippines, Russia, Saudi Arabia, Singapore, Taiwan, Thailand, Turkey, UAE, Ukraine and Vietnam (millions already sold)

HFC-32 Room AC:

Multiple Brands in Many Markets

- **Australia:** Daikin, Electrolux, Fujitsu General, Gree, LG, Midea, Mitsubishi, & Panasonic
- **European Union:** Carrier, Daikin, Haier, Midea, Panasonic, & Toshiba
- **India:** Bluestar, Daikin, Fujitsu General (joint venture), & Mitsubishi
- **Indonesia:** Daikin, Panasonic & Sharp
- **Japan:** All Japanese AC manufacturers
- **Thailand:** Daikin & Panasonic (Saijo Denki soon)
- **Vietnam:** Daikin & Fujitsu General

Room AC Super-Efficiency Challenge

- Super-Efficient Room ACs manufactured in China, Europe, Japan and the Republic of Korea are offered only in selected markets
- The Room ACs offered in most developing countries are far less energy efficient despite often high electricity price, inadequate electricity supply, and long cooling seasons
- The added cost of lower carbon footprint could be financed, complemented by energy standards, labeling, and consumer education

Backup Slides

Take Home Messages

- Plenty of alternatives in foam, room AC, refrigeration and other applications immediately available once the Amendment and A5 finance is in place
- Non-A5 domestic regulations and Amendment phase-down schedules will commercialize more options well in advance of A5 schedules
- Energy savings from Super-Efficient room ACs can avoid new power plant construction, offset added product costs and provide co-benefits including clean air, human health, and productivity

Case Study HFO-1234yf in MACs

- Every automobile manufacturer has selected HFO-1234yf to replace HFC-134a in MACs by 2017 in EU and 2021 in USA; dozens of models, millions sold
- Automobile manufacturers in China and India have built successful HFO-1234yf prototypes and are ready when MLF finance is available
- Navin Fluorine and Honeywell just announced a licensing agreement with production in India by year's end
- Carbon dioxide will be introduced by Daimler and HFC-152a is under consideration for heavy trucks, off-road and in automobiles with secondary-loop systems

Funds and Financing

- Canada and USA have pledged phase down financing as soon as the HFC Amendment is signed
- Fast Action Funds can:
 - Strengthen the national ozone unit, industry associations, and standards organizations
 - Train technicians and provide tools to reduce HFC emissions from current sources like MACs
 - Link appliance manufacturers with suppliers of next-generation, climate-friendly components

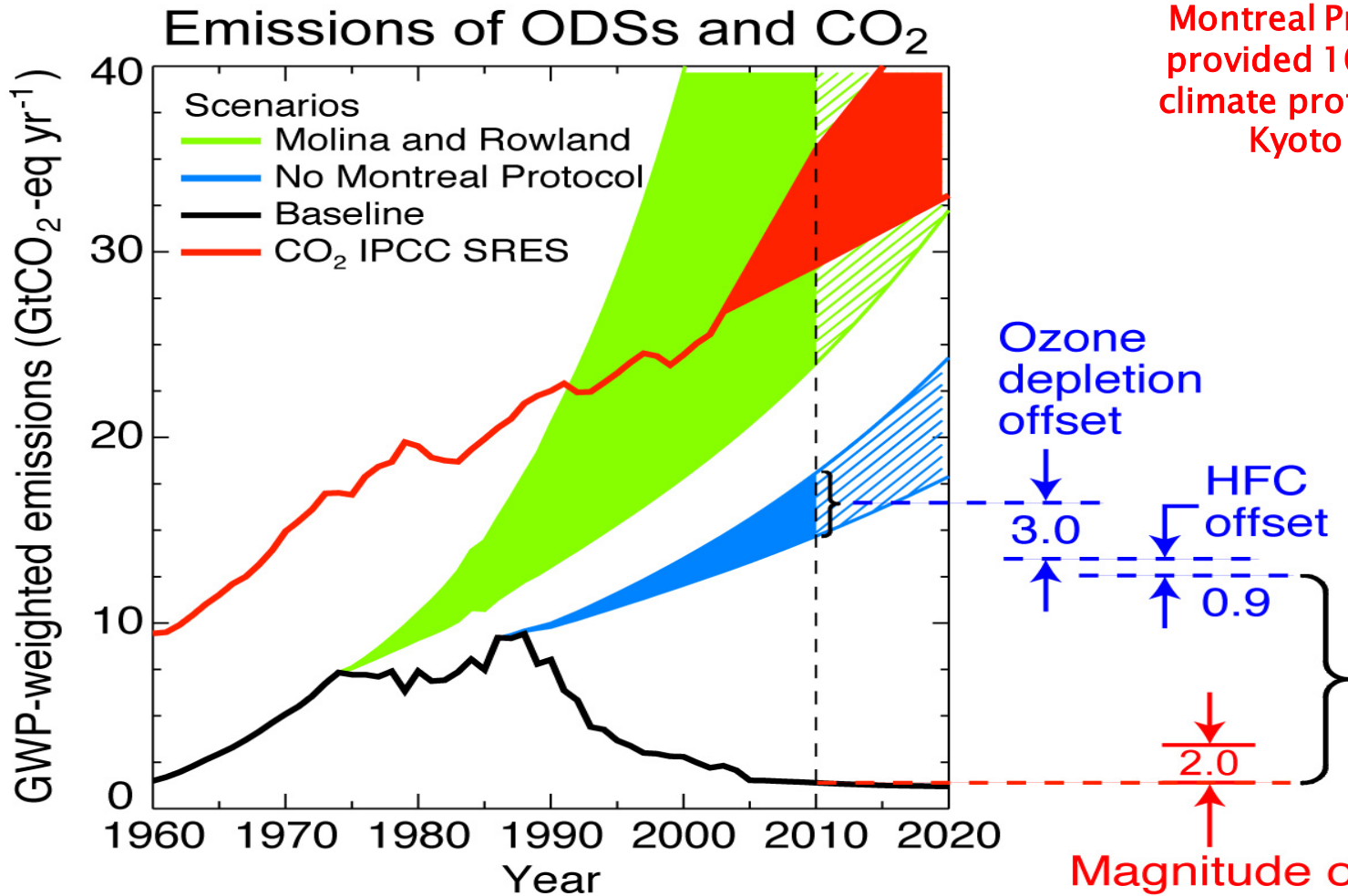
Patent Protection of Room ACs

Refrigerant	Production Patent?	Application Patent?	Relative Price
R-410A	Mostly Expired	Mostly Expired	High
HFC-32	Expired	Released	Medium
HC-290	Expired	None	Low
HFO blends	Yes	Yes	High

Selected References (1)

- 1) Zieger, Bastian. *“Co-benefits of RAC Sector Transformation.”* Oeko-Recherche. New Delhi, India, 7 November 2014.
- 2) Abdelaziz, Omar et al. *Alternative Refrigerant Evaluation for High-Ambient-Temperature-Environments.* Oak Ridge National Laboratory. October 2015.
- 3) Andersen, Stephen O. et al. *The Business Case for Phasing Down HFCs in Room and Vehicle Air Conditioners.* CEEW, IGSD, NRDC, and (TERI) June 2013.
- 4) Carvalho, Suely, et al. *Alternatives to High-GWP Hydrofluorocarbons.* IGSD and OzonAction 2014.

Montreal Protocol Protects Climate!



Montreal Protocol has provided 10-11 times climate protection that Kyoto seeks

Magnitude of Kyoto Protocol reduction target (1st commitment period)

From: Velders Guus J. M., Stephen O. Andersen, John S. Daniel, David W. Fahey, and Mack McFarland, *The importance of the Montreal Protocol in protecting climate*; Proceedings of the National Academy of Sciences, published online Mar 8, 2007.

Low-GWP Substitutes Help Avoid Irreversible Climate Change

