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THE VOICE OF FOOD RETAIL

Refrigerants: a Roadmap for Efficiency and Sustainability

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  - Current Policy Landscape
  - Likely Paths Forward
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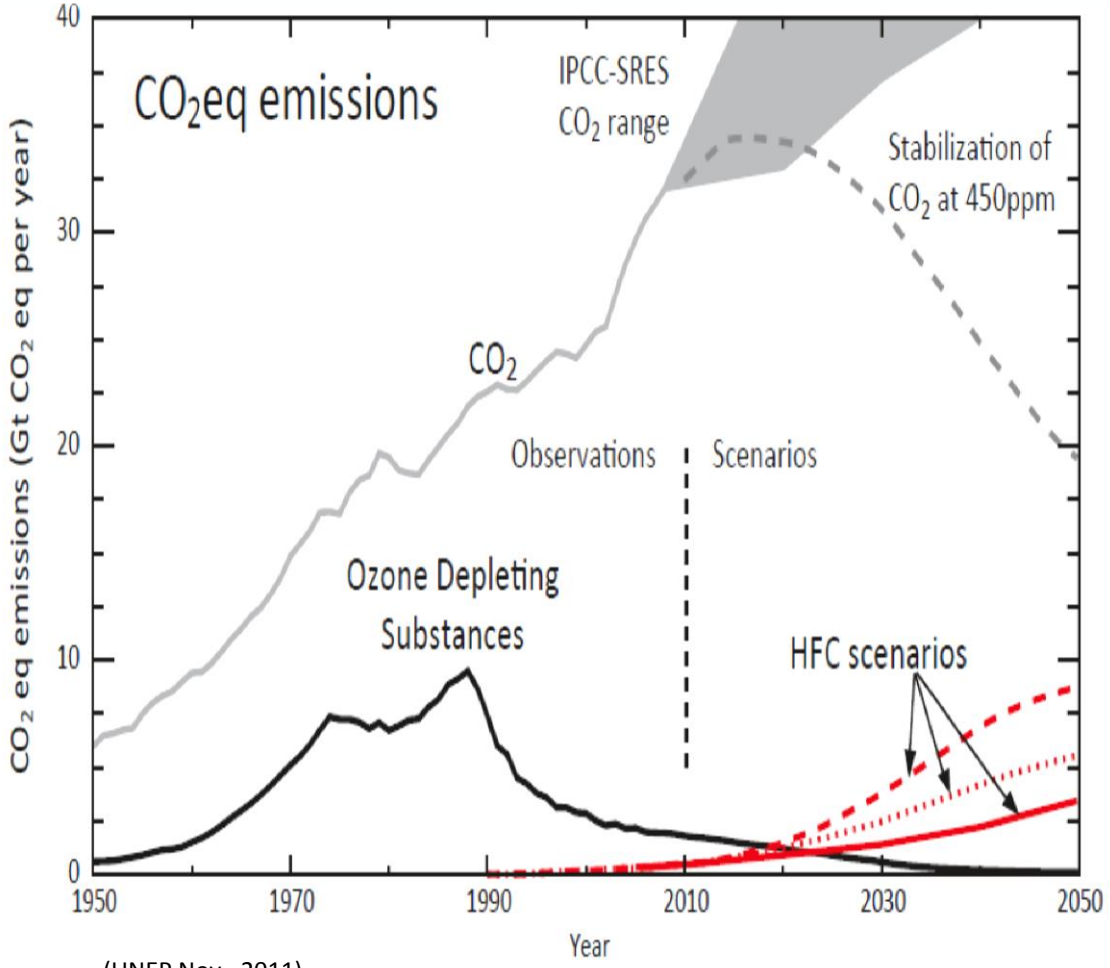
  - Policy Implications for Decisions Today and Tomorrow
  - Recommendations Based on Available Technical Solutions

Policy Perspective

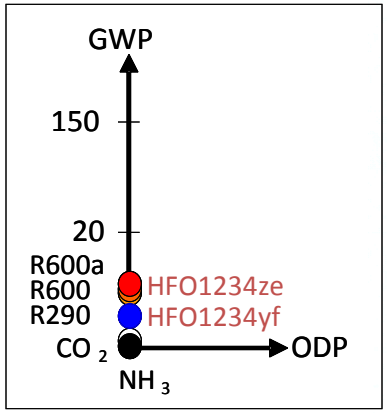
Montreal Protocol Uniquely Successful

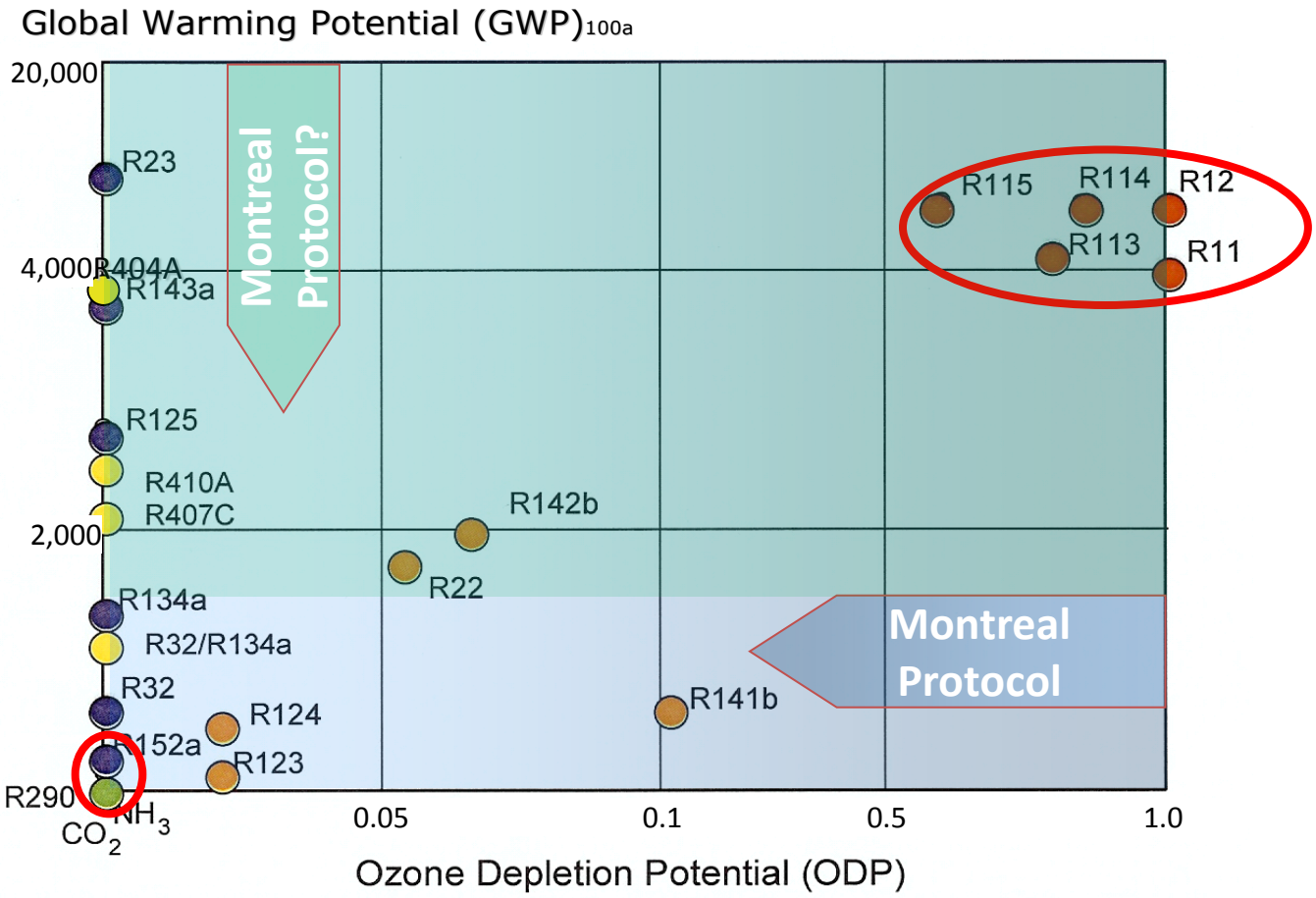


(UNEP Nov., 2011)

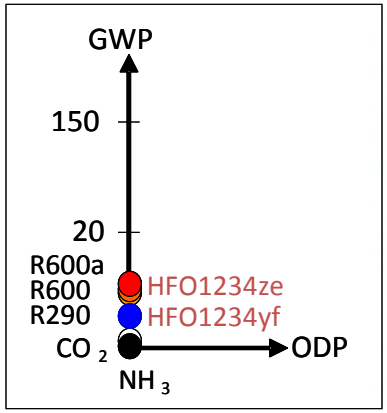
- Global cooperation
- Dual results achieved
  - Ozone depletion
  - CO_2 equivalence
- HFC growth could offset gains already achieved
- Global consensus growing
- HFC phase down likely but timing is uncertain.

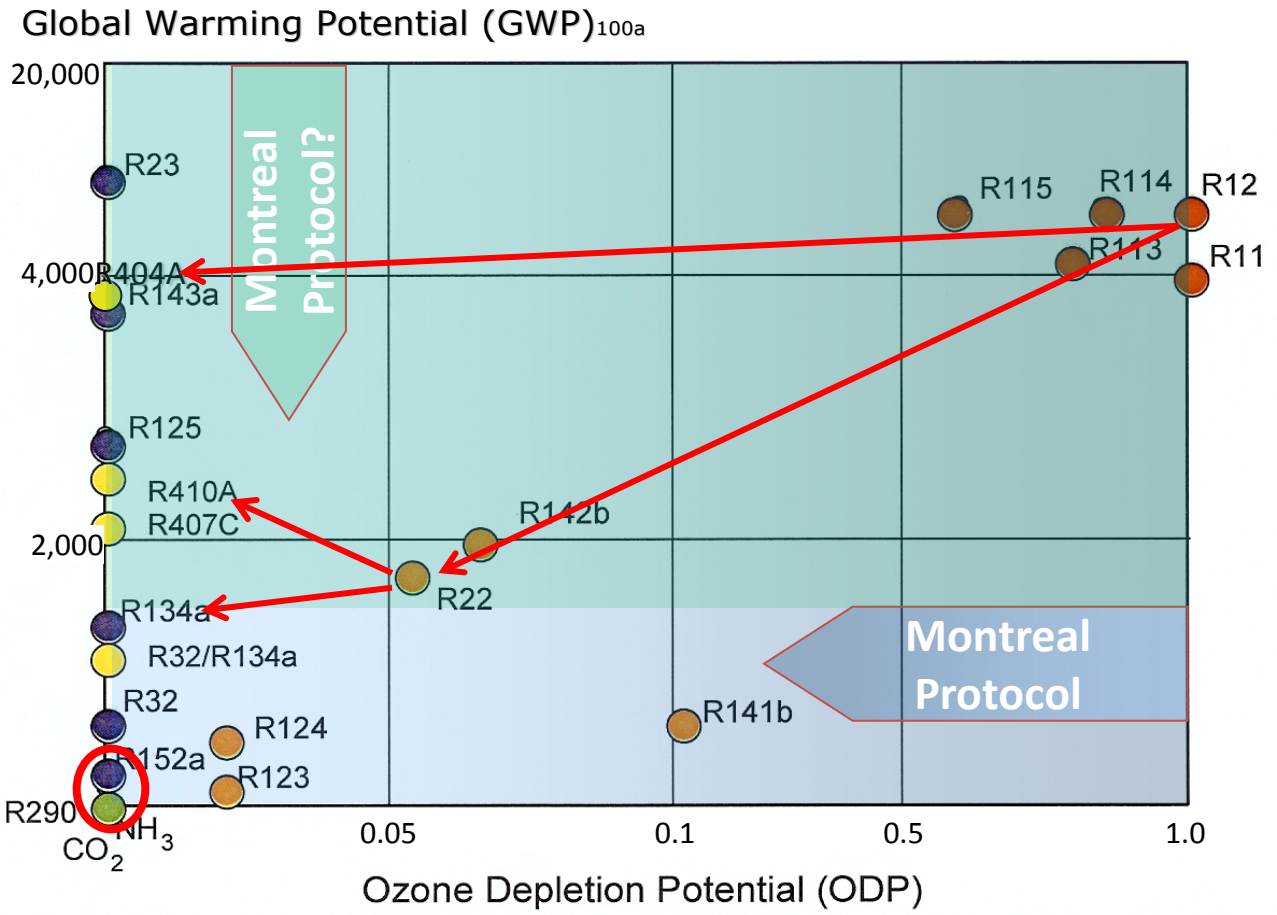
Ozone Depletion and Global Warming





Ozone Depletion and Global Warming





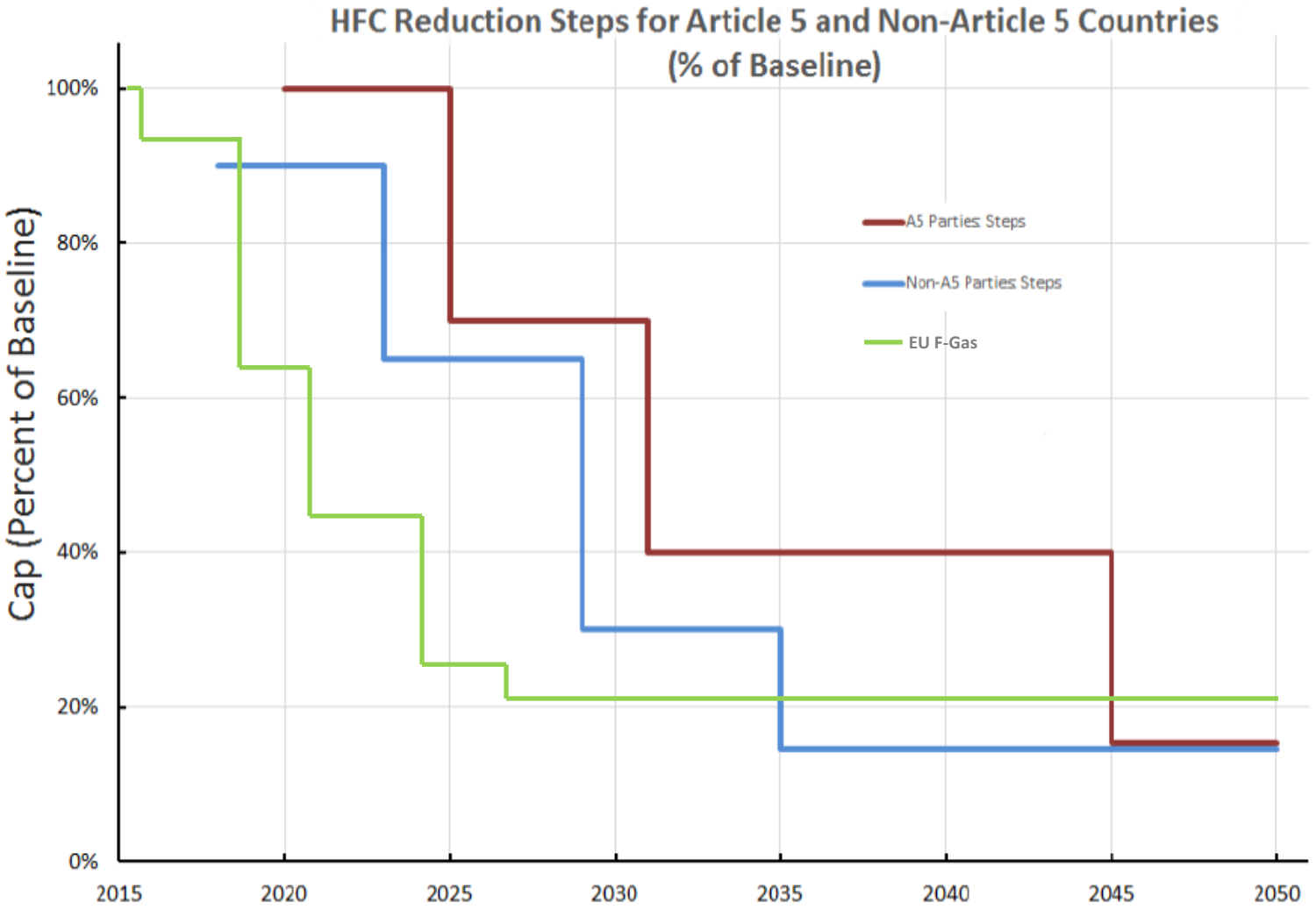
European F-Gas Regulation Now Approved

- HFC Phasedown: 2015-2030
  - Cap and trade system
  - Supplementary bans
    - Esp. R404A & R507 with very high GWPs
  - Other: leak detection, reporting requirements, etc.
- Future is beginning to unfold.
  - Traditional HFCs now under increasing pressure
  - Natural refrigerants and other low-GWP refrigerants will grow
  - Intermediate solutions like R407A/F
  - R32 might be used in cascade CO_2 systems
  - New blends and solutions might arise
- Influences policies in USA and rest of world

Montreal Protocol Amendment Proposals

- North American phase down proposal (Canada, Mexico and USA)
  - Resubmitted May 9, 2014
  - Some changes to baseline and timing of phase down
- Alliance for Responsible Atmospheric Policy has made a public statement of support for the first time
- Debated at Montreal Protocol OEWG meetings July 14 – 18
  - Little change from prior year
  - 110 (80%) of countries have signed a declaration of support
  - India has been strongest opponent
- Prospect for annual Montreal Protocol Meeting of the Parties (Paris, Nov. 17-21)
  - Not likely to pass this year
  - Some discussion of alternative approaches through Montreal Protocol

Regulatory – Phase-down Schedules and Proposals



US Legislative and Regulatory Developments

- Legislation highly unlikely due to political gridlock

  (even if most industry prefers legislation over regulation)

- President Obama's Climate Action Plan

  (Two EPA SNAP proposals seek to do what could be done without legislation)

  - 1. Proposes to approve new low-GWP refrigerants
    - Hydrocarbons in domestic and light commercial refrigeration
    - R32 in some a/c systems
  - 2. Proposes "de-list" HFCs when lower GWP solutions developed
    - R134a in automotive A/C, some refrigeration, R404A
    - January 1, 2016 timing is the biggest issue to industry

US Manufacturer Initiatives

- Generally supportive of a “planned orderly phase down”
  - Uses market forces to allocate production
  - Avoids “command and control” regulatory tactics
- Manufacturers oppose “over reliance” on SNAP mechanism
  - Less effective
  - Creates regulatory uncertainty
- Petitioned EPA to tighten “responsible use” regulations
  - Aligned with regulations of CFCs and HCFCs
  - Important to reduce emissions, especially from existing equipment
- Manufacturers have proposed voluntary commitments to reduce HFC

2014 Is Becoming an Eventful Year

- February: The Alliance for Responsible Atmospheric Policy announced support (rather than commendations) for Montreal Protocol amendment
- April: EU F Gas regulation raises pressure on HFCs worldwide
- May: US, Canada and Mexico resubmit global phase down proposal
- June: President's Climate Action Plan
- Spring: EPA/Industry/State Department discussions
  - EPA SNAP NOPRs for listings and de-listings
- July: Montreal Protocol OEWG meetings in Paris
- September: Possible industry announcements
- September: UN Climate Summit in New York with HFC track
- November: Montreal Protocol Meeting of Parties in Paris

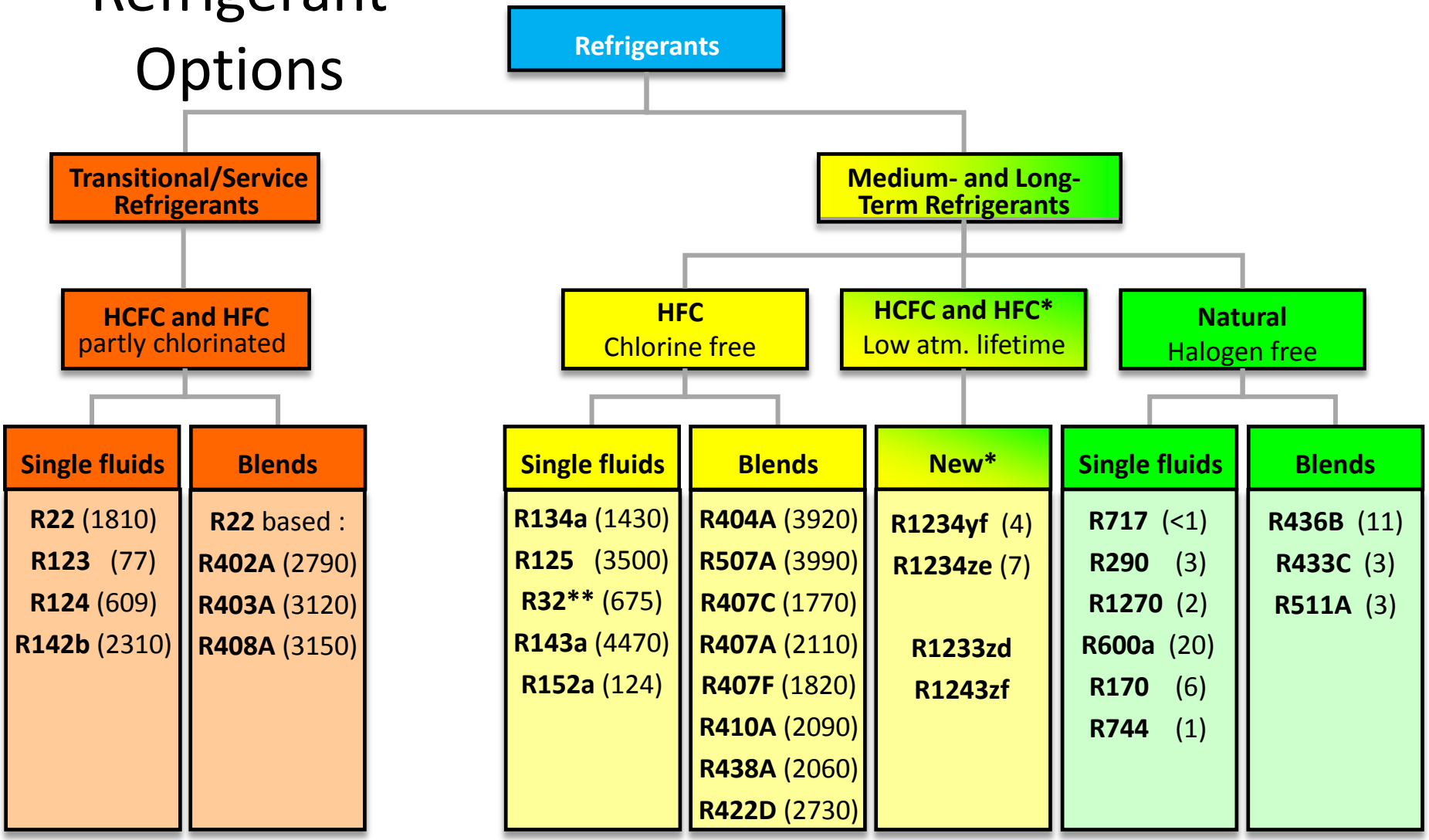
Policy Implications on Supermarket Industry

- HFC Phase down increasingly likely
  - Issue is “when” and “how”, not “if”
- Public opinion may shift due to publicity HFCs is likely to receive

- Change in supermarket industry is likely to accelerate:
  - CO_2 systems: Trans-critical or cascade with HFCs, HFO or maybe HFC32
  - Self-contained equipment: small hydrocarbon charges
    - Building/fire codes coming under pressure to change
  - Legacy HFC systems under increased pressure
    - To reduce leaks
    - To switch to lower-GWP alternatives for highest GWPs (e.g., R404A)
- Supermarkets urged to evaluate alternatives and develop refrigerant management plans

Technical Perspective

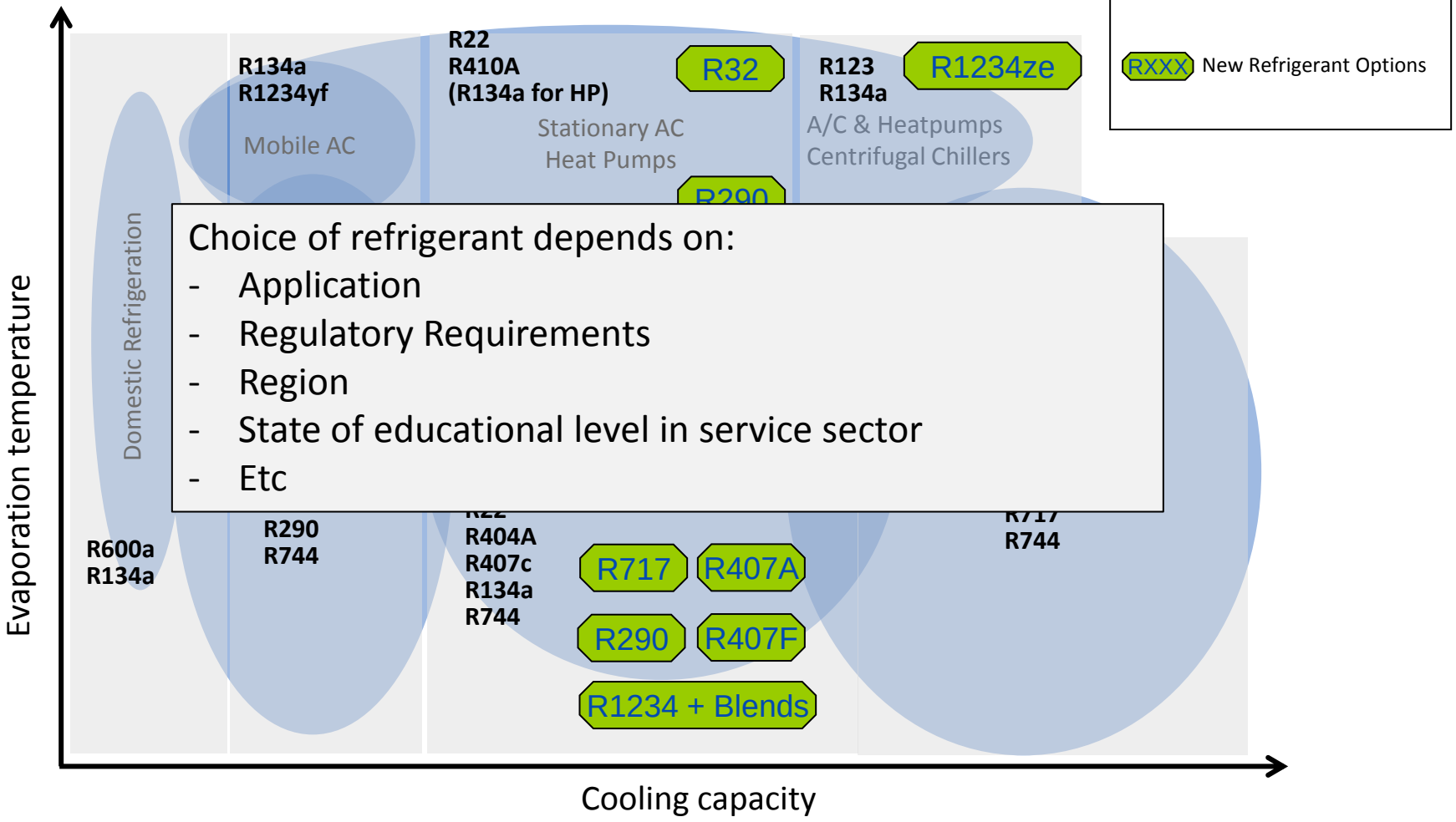
Refrigerant Options



* Also called HFO. Molecules contain weak double bonds causing a fast breakdown in the atmosphere

** R32 (HFC) and many of the new refrigerants are flammable or mildly flammable. Natural refr. are mainly flammable except R744.

Applications & Main Refrigerants



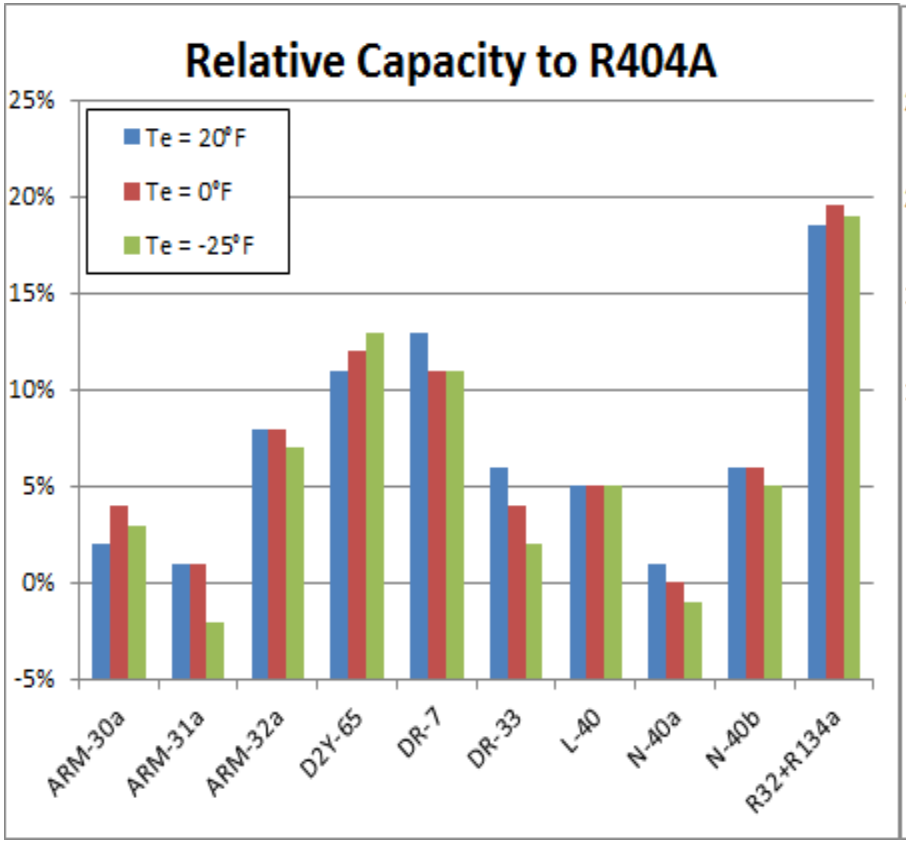
AHRI Alternative Refrigerant Evaluation Program

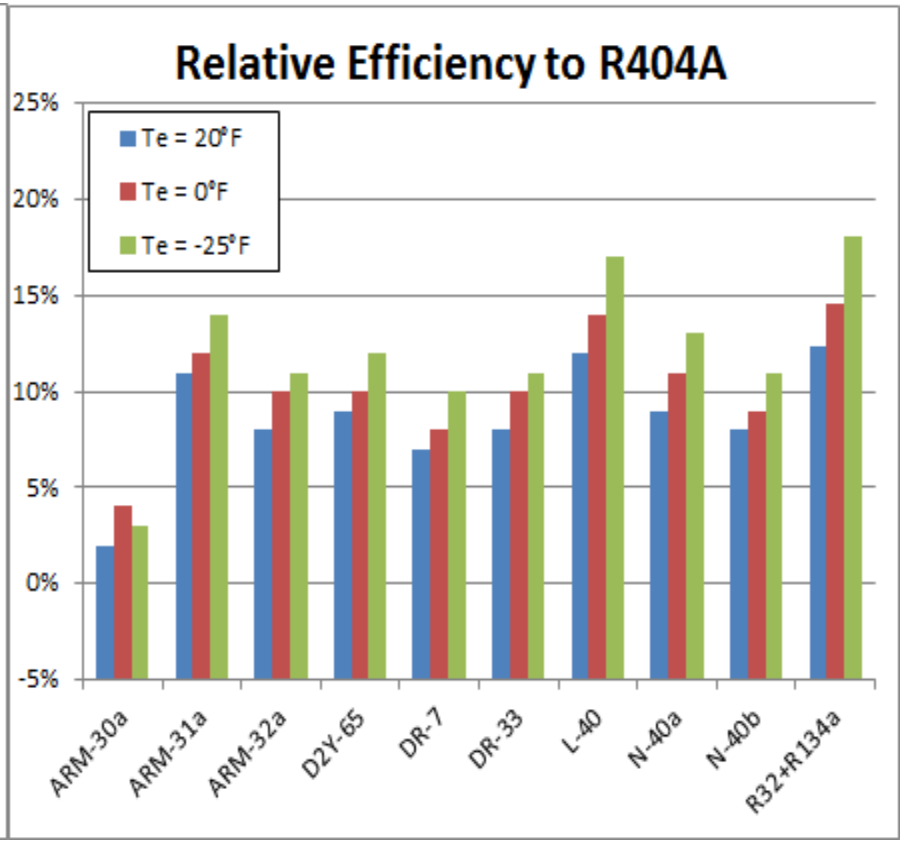
- Testing in various applications complete and ongoing
- No category "winners" yet
- Alternatives for refrigeration

Baseline Refrigerants	Alternative Refrigerant Candidates Classifications according to ASHRAE Standard 34			Others
	A1	A2L	A3	
R-404A	ARM-32a N-40a N-40b DR-33	ARM-31a ARM-30a D2Y-65 L-40 R-32 R-32+R-134a (50%+50%) DR-7	R290	R-744
R-22/R407C	ARM-32a LTR4X N-20	D52Y L-20 LTR6A	R-290	R-1270, R-717

AREP – Proposed Alternatives for Refrigeration

Thermodynamic cycle calculations





Data and conditions are provided by "Participants Handbook – AHRI Low GWP AREP"

AREP – Proposed Alternatives for Refrigeration

compressor calorimeter testing

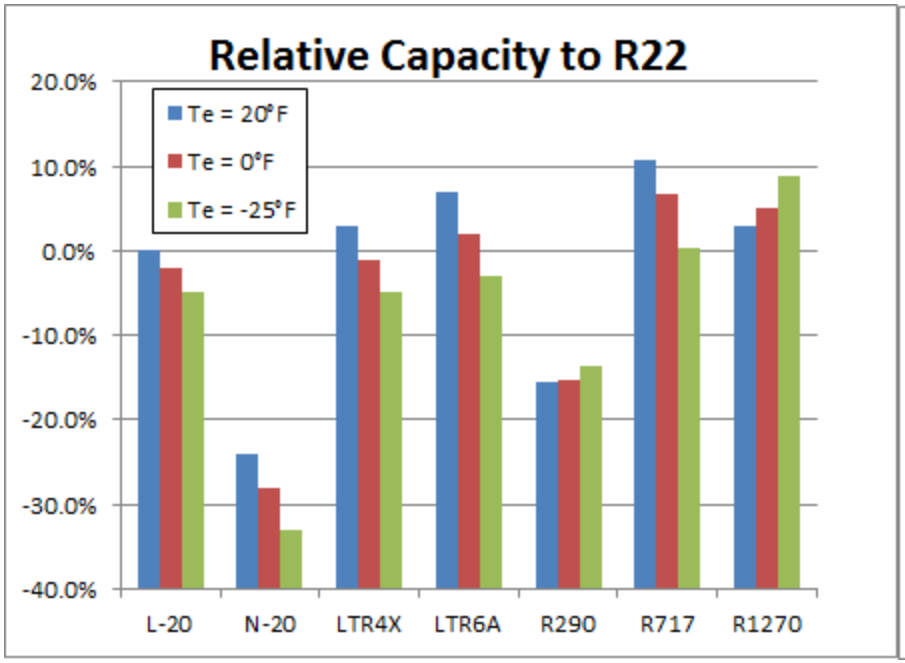
Refrigerant	Test Condition	Deviation from baseline (R-404A)		
		EER (%)	Capacity (%)	Discharge Temperature (°F)
ARM-31a	Evap 20°F/ Cond 120°F	+9.7%	-5.6%	+24
	Over the range	-4.4% to +22.8%	-18.5% to +6.5%	+16 to +36
D2Y-65	Evap 20°F/ Cond 120°F	+6.5%	+0.6%	+26
	Over the range	-4.2% to +14.6%	-11.0% to +9.7%	+18 to +36
L-40	Evap 20°F/ Cond 120°F	+9.8%	-4.9%	+37
	Over the range	-5.4% to +24.7%	-20.0% to +8.9%	+25 to +53
R-32 + R-134a mixture	Evap 20°F/ Cond 120°F	+4.2%	+3.8%	+63
	Over the range	-7.6% to +15.2%	-12.6% to +18%	+38 to +74

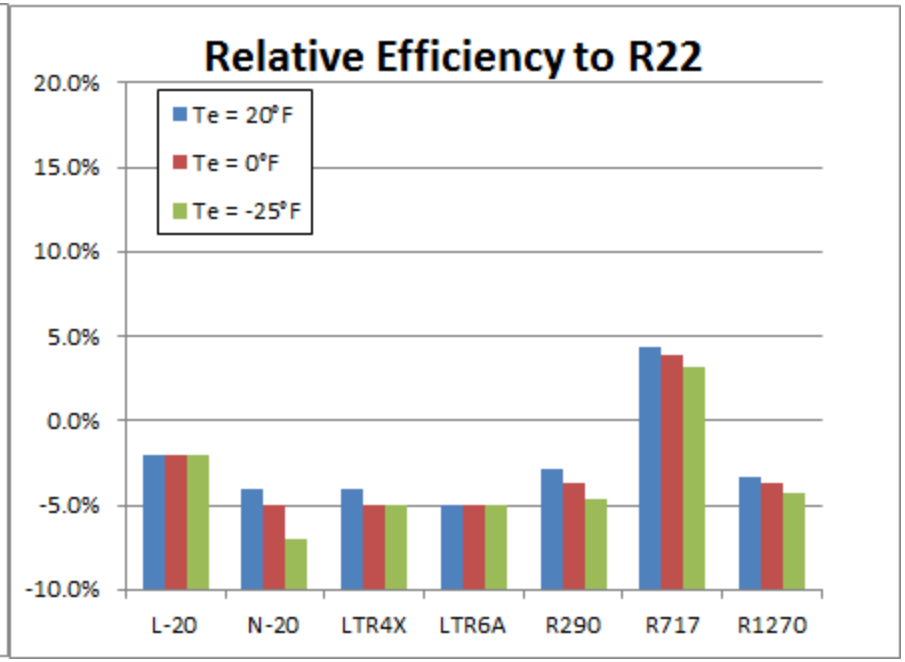
Need to Consider: Actual System Conditions, Discharge Temperatures, Pressure Ratio, and Refrigerant Glide

Data and conditions are provided by AHRI Low GWP AREP "Test Report 21 - Compressor Calorimeter Test of R-404A Alternatives ARM-31a, D2Y-65, L-40, and R-32/R-134a (50/50)" by - Som Shrestha, Vishaldeep Sharma, and Omar Abdelaziz of Oak Ridge National Laboratory

AREP – Proposed Alternatives for Refrigeration

Thermodynamic cycle calculations





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Alternatives for Refrigeration

Refrigerant	Components	Glide	Pressure Match				
			-20°F	10°F	40°F	110°F	130°F
R-22	22	0	10	33	68	226	297
Look-Alike Blends							
R-417A	125 / 134a / 600	6.5	6	26	59	206	274
R-421A	125 / 134a	8	8	29	63	220	291
R-421B	125 / 134a	8	14	41	83	268	352
R-422A / C	125 / 134a / 600a	4.5	16	43	86	274	358
R-422B	125 / 134a / 600a	6	8	30	65	221	292
R-422D	125 / 134a / 600a	6	10	34	71	238	313
R-424A	125/134a/600a/600/601a	7	6	27	60	210	278
R-427A	32 / 125 / 143a / 134a	13	9	32	69	235	311
R-434A	125/143a/134a/600a	4	14	40	80	268	340
R-438A	32/125/134a/600/601a	6-7	12	36	75	245	320
R-404A (R-507)	125 / 143a / 134a	1.5	16	44	86	271	356
R-407A	32 / 125 / 134a	11	12	37	78	259	345
R-407F	32 / 125 / 134a	10	17	45	90	287	342

Alternatives for Refrigeration – Short List

EPA - <u>Proposed Rule</u> - Protection of Stratospheric Ozone: Change of Listing Status for Certain Substitutes under the Significant New Alternatives Policy Program

For ***new and retrofit retail food refrigeration (including direct supermarket systems and indirect supermarket systems)***, as of January 1, 2016

- HFC-227ea, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, and R-434A as unacceptable.

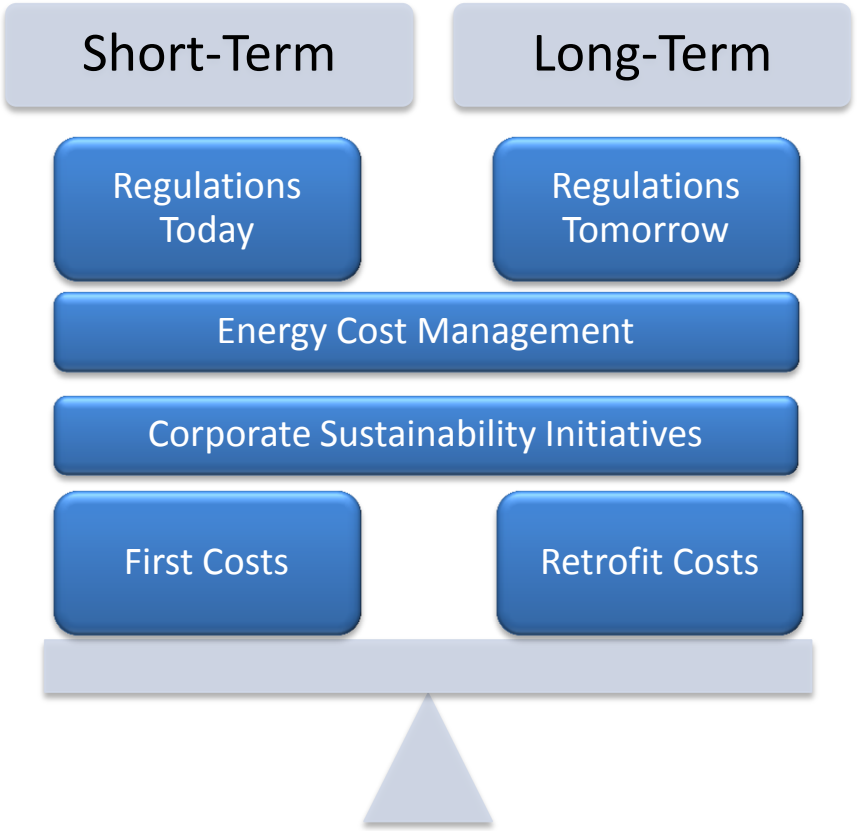
Refrigerant	Components	Glide	Pressure Match				
			-20	10	40	110	130
R-22	22	0	10	33	68	226	297
R-422B	125 / 134a / 600a	6	8	30	65	221	292
R-427A	32 / 125 / 143a / 134a	13	9	32	69	235	311
R-438A	32/125/134a/600/601a	6-7	12	36	75	245	320
R-407A	32 / 125 / 134a	11	12	37	78	259	345
R-407F	32 / 125 / 134a	10	17	45	90	287	342

CO_2 and Other Natural Refrigerant Solutions

- Approximately 4,000 CO_2 systems today- mature technology
- CO_2 technologies developing to overcome current challenges:
  - Efficiency in high ambient conditions
  - Integrated HVACR
  - Smaller formats
- Alternative system architectures are expanding options
- Training initiatives

Conclusions

The Industry Balancing Act:



Considerations of leading versus following

Potential Risks:

- Higher first costs
- Need to change again

Potential Reward:

- Faster ramp-up
- Flexibility with various outcomes
- Short-term competitive advantage
- Avoid need to change again
- Image of innovative leader

Recommendations

- **Policy implications for decisions today and tomorrow**
  - HFC phasedown- matter of time
  - "De-snap" list likely to drive options rather than GWP limits per se
  - Continue to gain knowledge/experience with natural refrigerants
  - Get involved ….. Strengthen industry voice in policy making.
- **Recommendations based on available technical solutions**
  - New stores- consider pilots with new technologies, natural refrigerant options, and alternative system architectures
  - Retrofits- more similar options may make more sense given capital investment needs, but need to weigh multiple factors
  - Develop and/or review your refrigerant management strategy

Questions?

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Find the Danfoss Refrigerant Policy in the Refrigerant Options Now and in the Future (Paper) at http://www.danfoss.com/think