

Everything You Need to Know About the Coming Changes in the Global, Federal, and State Refrigerant Landscape

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Big Changes Coming

➤ HFCs will be phased down

➤ Drivers:

- Montreal Protocol Amendment and coming phase-down framework
- EPA SNAP Program / Climate Action Plan
- F-gas regulations in Europe
- California HFC proposals
- Canada HFC activities

➤ The good news: Our industry will be prepared

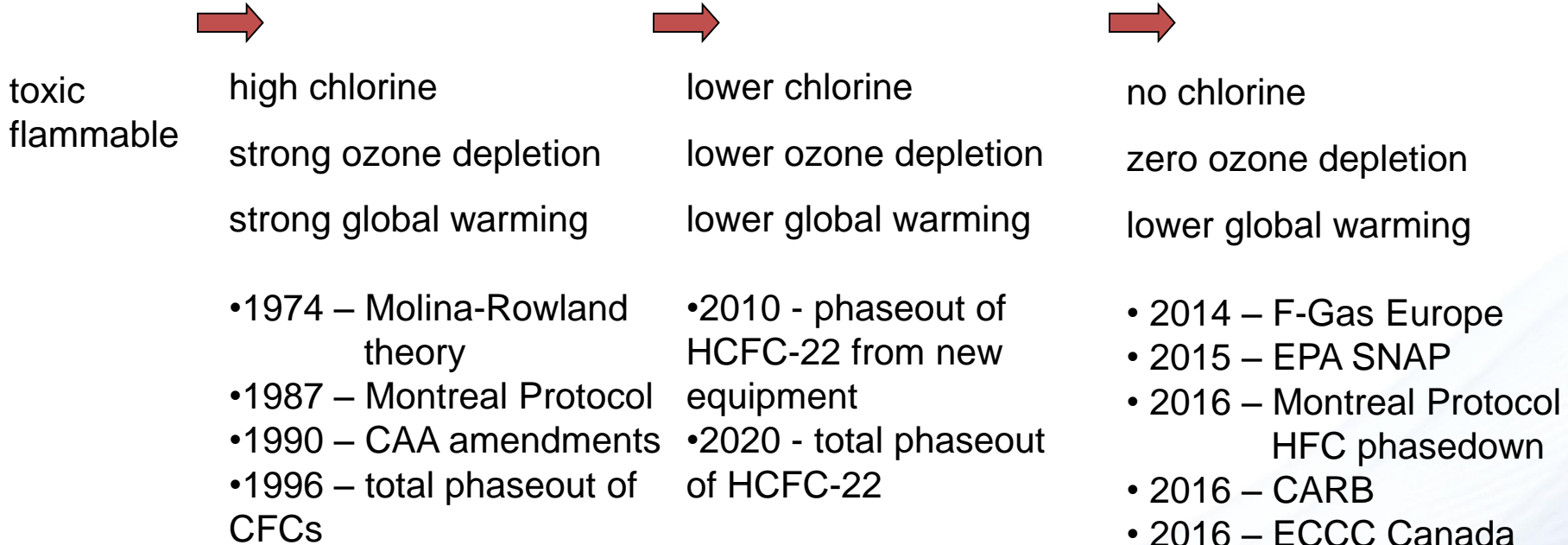
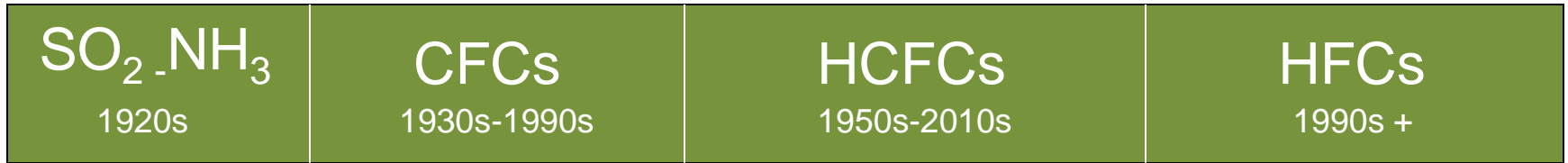


For Discussion Today

- **Where we are right now**
- **What is likely to occur, and when?**
 - Regulations
 - Research
 - Code changes
- **How will our industry respond?**
 - We have been preparing for this for a long time
 - There is still a lot to do

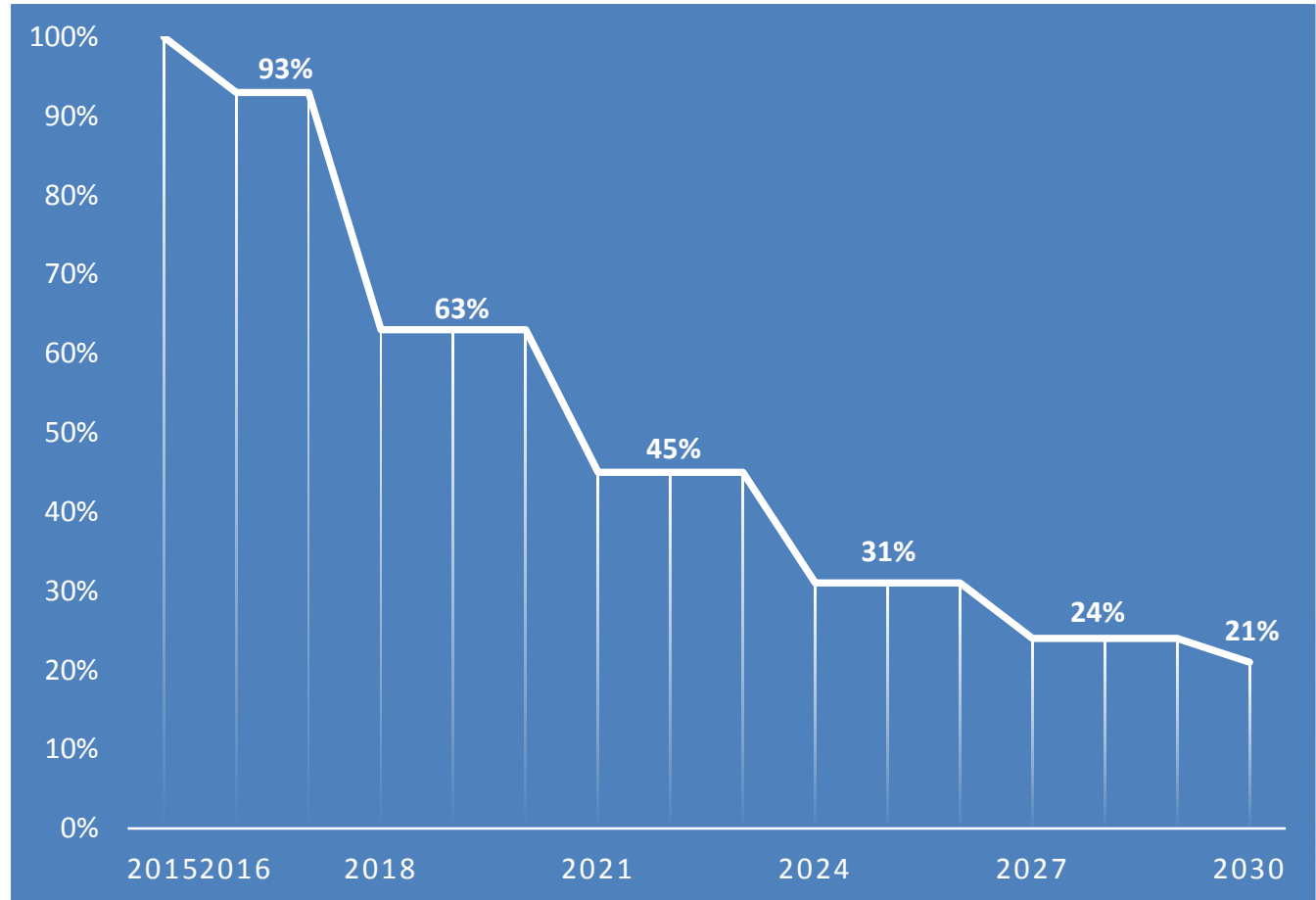


Refrigerant Transition



European F-Gas Regulations: Phase-down steps

Year	Reduction by
2015	100% (Freeze)
2016-17	93%
2018-20	63%
2021-23	45%
2024-26	31%
2027-29	24%
2030	21%

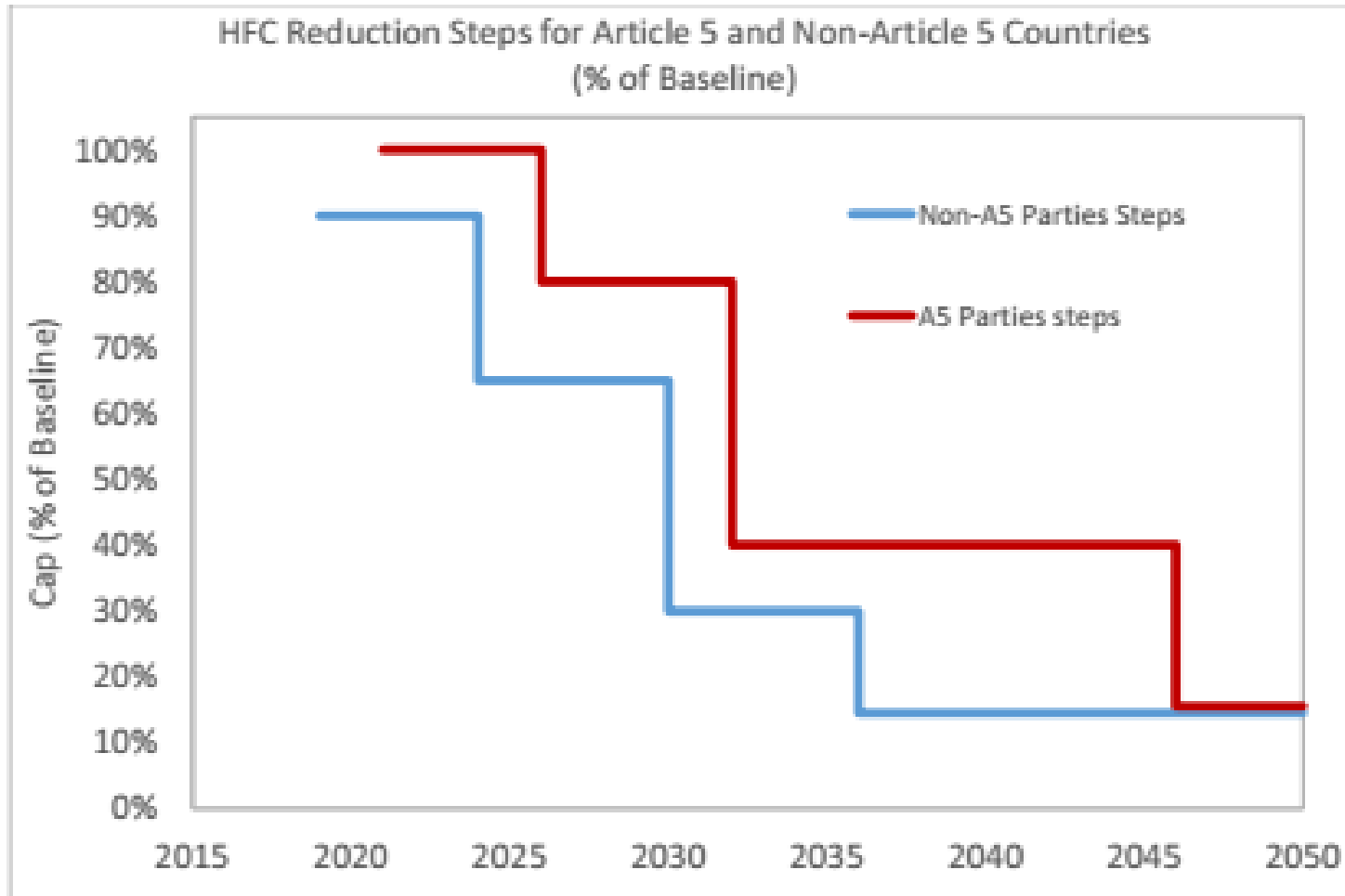


F-Gas Regulations - GWP limits

- **2020/2022** **GWP 2500 and 150** **Hermetically sealed systems (Refrigerators and Freezers)**
- **2020** **GWP 2500** **Stationary refrigeration equipment**
- **2022** **GWP 150 and 1500** **Large commercial refrigeration systems**
- **2020** **GWP 150** **Movable room a/c appliances**
- **2025** **GWP 750** **Small split a/c systems**

11. Refrigerators and freezers [...] for commercial use (hermetically sealed systems)	that contain HFCs with GWP of 2500 or more	1 January 2020
	that contain HFCs with GWP of 150 or more	1 January 2022
11a. Stationary refrigeration equipment, that contains, or that relies upon for its functioning HFCs with GWP of 2500 or more except equipment intended for application designed to cool products to temperatures below -50°C		1 January 2020
11b. Multipack centralised refrigeration systems for commercial use with a capacity of 40kW or more that contain, or that rely upon for their functioning, fluorinated greenhouse gases with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1500 may be used		1 January 2022
12. Movable room air-conditioning appliances (hermetically sealed equipment which is movable between rooms by the end user) that contain HFCs with GWP of 150 or more		1 January 2020
12a. Single split air-conditioning systems containing less than 3kg of fluorinated greenhouse gases, that contain, or that rely upon for their functioning, fluorinated greenhouse gases with GWP of 750 or more		1 January 2025

North American HFC Phase Down Proposal – Montreal Protocol



Climate Change Developments

- **HFC phasedown agreement likely in 2016**
- **37th OEWG, Geneva, Switzerland, 4 - 8 Apr 2016**
 - High Ambient Temperature (HAT) exemption
 - List of countries
 - List of products
 - Multi-split air conditioners for commercial and residential
 - Split ducted air conditioners (residential and commercial)
 - Ducted commercial packaged (self-contained) air-conditioners
- **38th OEWG, Vienna, Austria, 18 - 21 July 2016**
- **Third Extraordinary Meeting of the Parties to the Montreal Protocol, Vienna, Austria, 22 - 23 July 2016**
- **28th Meeting of the Parties to the Montreal Protocol, Kigali, Rwanda, 10 - 14 Oct 2016**

U.S. Regulatory Activities on HFCs – EPA SNAP

➤ **President Obama's Climate Action Plan**

- EPA to use SNAP program to encourage use of climate friendly alternatives

➤ **Two rulemakings finalized in 2015**

- First rule added new low GWP refrigerants (subject to use conditions because of flammability)

Refrigerants	End Use and Application Considered by EPA				
	Retail Refrigerator Stand-alone	Vending Machines	Very Low Temperature Refrigeration	Heat Transfer	Home AC – Self-Contained
Ethane			✓	✓	
Isobutane	✓	✓			
Propane		✓			✓
R-441A	✓	✓			✓
R-32					✓

- R-32 not approved in residential central AC, mini-splits and multi-splits

EPA SNAP 2015 Final Rule – Commercial Refrigeration

Phase-Out Candidates and Dates

Phase-Out Refrigerant	Super-market New	Super-market Retrofit	Remote Cond. Unit New	Remote Cond. Unit Retrofit	Stand-Alone			
					MT <2,200 BTU/hr. and not contain flooded evap. New	MT ≥2,200 BTU/hr. with or without flooded evap. New	LT New	LT and MT Retrofit
R-404A/507A	Jan 1, 2017	July 20, 2016	Jan 1, 2018	July 20, 2016	Jan 1, 2019	Jan 1, 2020	Jan 1, 2020	July 20, 2016
R-410A	OK	-	OK	-	Jan 1, 2019	Jan 1, 2020	Jan 1, 2020	-
R-407A/C/F	OK	OK	OK	OK	Jan 1, 2019	Jan 1, 2020	Jan 1, 2020	OK
HFC-134a	OK	OK	OK	OK	Jan 1, 2019	Jan 1, 2020	OK	OK

- Refer to Tables 4, 5 and 6 of Final Rule for complete details
- Source: Rajan Rajendran Emerson



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EPA SNAP Proposed Rule – April 2016

Phase out Refrigerant	Chillers (new)	Cold Storage Warehouse (new)	Retail Food Refrigeration – Food Processing & Dispensing (new)
R-134a	Jan 1, 2024	OK	OK
R-404A	Jan 1, 2024	Jan 1, 2023	Jan 1, 2021
R-407 A&B	-	Jan 1, 2023	Jan 1, 2021
R-407C	Jan 1, 2024	-	Jan 1, 2021
R-410A	Jan 1, 2024	Jan 1, 2023	Jan 1, 2021
R-507A	Jan 1, 2024	Jan 1, 2023	Jan 1, 2021

US EPA: Additional Change of Status

PROPOSED ACCEPTABLE ALTERNATIVES, WITH USE CONDITIONS

End-Uses	Substitutes	Proposed Effective Date
Refrigeration		
Commercial ice machines (new)	Propane	30 days after publication of a final rule
Water coolers (new)	Propane	30 days after publication of a final rule
Very low temperature refrigeration equipment (new)	Propane	30 days after publication of a final rule
Motor Vehicle Air Conditioning (MVAC)		
Medium-duty passenger vehicles (MDPVs), heavy-duty (HD) pickup trucks, and complete HD vans (newly manufactured)	HFO-1234yf	30 days after publication of a final rule
Fire Suppression and Explosion Protection		
Total flooding agent for use in engine nacelles and auxiliary power units (APUs) on aircraft	2-BTP	30 days after publication of a final rule
Streaming agent for use in aircraft	2-BTP	30 days after publication of a final rule

<https://www.epa.gov/snap/snap-regulations>

US EPA: Additional Change of Status

PROPOSED UNACCEPTABLE ALTERNATIVES

End-Uses	Substitutes	Proposed Effective Date
Air Conditioning (AC)		
Residential and light commercial AC and heat pumps – unitary split AC systems and heat pumps (retrofit)	All ASHRAE Flammability Class 3 Refrigerants ^a	30 days after publication of a final rule
Residential and light commercial AC and heat pumps (new)	Propylene, R-443A	30 days after publication of a final rule
Centrifugal chillers and positive displacement chillers (new)	Propylene, R-443A	30 days after publication of a final rule
Refrigeration		
Cold storage warehouses (new)	Propylene, R-443A	30 days after publication of a final rule

^a All refrigerants identified as and meeting the criteria for flammability Class 3 in American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 34–2013. All refrigerants meeting the criteria for flammability Class 3 include, but are not limited to, refrigerant products sold under the names R-22a, 22a, Blue Sky 22a refrigerant, Coolant Express 22a, DURACOOOL-22a, EC-22, Ecofreeeze EF-22a, EF-22a, Envirosafe 22a, ES-22a, Frost 22a, HC-22a, Maxi-Fridge, MX-22a, Oz-Chill 22a, Priority Cool, and RED TEK 22a.

Environment & Climate Change Canada (ECCC) Proposal

- **Mar 23, 2016 ECCC issued a consultation document on proposed regulatory measures on HFCs – Objective harmonize with the U.S. SNAP**

Application	GWP Limit and Effective Date
Ref – Stand alone MT	Max 650 GWP; Jan 1, 2020
Ref – Stand alone LT	Max 1500 GWP; Jan 1, 2020
Ref – Central systems (racks, both MT/LT)	Max 1500 GWP; Jan 1, 2020
Foams	Max 150 GWP; Jan 1, 2021
AC – Chillers	Max 700 GWP; Jan 1, 2025

- **Phase-down (North American Proposal) option also proposed (2019-90%; 2024-65%; 2030-30%; 2036-15%; baseline 2011-2013)**
- **Comment period ended April 29, 2016; final rule expected later this year or early in 2017**

* <https://www.ec.gc.ca/ozone/default.asp?lang=En&n=77A94123-1>

California Short-Lived Climate Reduction Strategy

➤ **Proposed strategy issued on April 11, 2016**

- Reduce HFC emissions by 40% by 2030

➤ **Strategy includes:**

- Incentive programs to defray cost of low-GWP
- California HFC phasedown if Montreal Protocol not successful in 2016
- Ban on sale of high GWP refrigerants $\geq 2,500$ and

Stationary Refrigeration or Stationary Air-Conditioning Sector	Refrigerants Prohibited in New Equipment with a 100-year GWP Value:	Proposed Start Date
Non-residential refrigeration	150 or greater	January 1, 2020
Air-conditioning (non-residential and residential)	750 or greater	January 1, 2021

➤ **Next steps**

- Public hearing April 26, 2016
- Board hearing May 19, 2016
- Comments due on May 26, 2016

Low-GWP AREP

- **Cooperative research & testing program to identify suitable alternatives to high GWP refrigerants**
- **Evaluation of candidates strongly desired by OEMs**
- **The program is NOT to prioritize refrigerants, rather test and present objective results in a consistent manner**
- **Phase I was completed at the end of 2013.**
 - 38 refrigerants were evaluated in Phase I
 - AHRI published 40 test reports
- **Phase II started in 2014, testing concluded in Dec.2015**
 - 17 new refrigerants, high ambient testing
 - 34 additional reports were published
- **Final reports available to the public**
- **<http://www.ahrinet.org/site/514/Resources/Research/AHRI-Alternative-Refrigerants-Evaluation>**



List of Low GWP Candidates in Phase I

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R22	ARM-32a	R-32/R-125/R-134a/R-1234yf	(25/30/25/20)	A1	1577
	LTR4X	R-32/R-125/R-134a/R-1234ze(E)	(28/25/16/31)	A1	1295
	N20	R-32/R-125/R-134a/R-1234yf/R-1234ze(E)	(12.5/12.5/31.5/1 3.5/30)	A1	975
	D52Y	R-32/R-125/R-1234yf	(15/25/60)	A2L	979
	L20	R-32/R-152a/R-1234ze(E)	(45/20/35)	A2L	331
	LTR6A	R-32/R-744/R-1234ze(E)	(30/7/63)	A2L	206
	R290	R290	100	A3	11
	R1270	R1270	100	A3	11
R-134a	AC5X	R-32/R-134a/R-1234ze(E)	(7/40/53)	A1	622
	ARM-41a	R-32/R-134a/R-1234yf	(6/63/31)	A1	943
	D-4Y	R-134a/R-1234yf	(40/60)	A1	574
	N13a	R-134a/R-1234yf/R-1234ze(E)	(42/18/40)	A1	604
	N13b	R-134a/R-1234ze(E)	(42/58)	A1	604
	XP-10	R-134a/R-1234yf	(44/56)	A1	631
	AC5	R-32/R-152a/R-1234ze(E)	(12/5/83)	A2L	92
	ARM-42a	R-134a/R-152a/R-1234yf	(7/11/82)	A2L	117
	R1234yf	R1234yf	100	A2L	4
	R1234ze	R1234ze	100	A2L	6
	R600a	R600a	100	A3	11
	R290/R600a	R290/R600a	(40/60)	A3	11

List of Low GWP Candidates in Phase I

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R404A	ARM-32a	R-32/R-125/R-134a/R-1234yf	(25/30/25/20)	A1	1577
	DR-33	R-32/R-125/R-134a/R-1234yf	(24/25/26/25)	A1	1410
	N40a	R-32/R-125/R-134a/R-1234yf/R-1234ze(E)	(25/25/21/9/20)	A1	1346
	N40b	R-32/R-125/R-134a/R-1234yf	(25/25/20/30)	A1	1331
	ARM-30a	R-32/R-1234yf	(29/71)	A2L	199
	ARM-31a	R-32/R-134a/R-1234yf	(28/21/51)	A2L	491
	D2Y65	R-32/R-1234yf	(35/65)	A2L	239
	DR-7	R-32/R-1234yf	(36/64)	A2L	246
	L40	R-32/R-152a/R-1234yf/R-1234ze(E)	(40/10/20/30)	A2L	285
	R-32	R-32	100	A2L	675
	R-32/R-134a	R-32/R-134a	(50/50)	A2L	1053
R290	R-290	100	A3	11	
R410A	ARM-70a	R-32/R-134a/R-1234yf	(50/10/40)	A2L	482
	D2Y60	R-32/R-1234yf	(40/60)	A2L	272
	DR-5	R-32/R-1234yf	(72.5/27.5)	A2L	490
	HPR1D	R-32/R-744/R-1234ze(E)	(60/6/34)	A2L	407
	L41a	R-32/R-1234yf/R-1234ze(E)	(73/15/12)	A2L	494
	L41b	R-32/R-1234ze(E)	(73/27)	A2L	494
	R32	R32	100	A2L	675
	R-32/R-134a	R-32/R-134a	(95/5)	A2L	713
	R-32/R-152a	R-32/R-152a	(95/5)	A2L	647

Notes:

- Refrigerants' classifications or intended classifications according to the ASHRAE Standard 34 (ASHRAE, 2010).
- Estimated GWP values from chemical producers

List of Low GWP Candidates in Phase II

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R22/R-407C	DR-93	R-32/R-125/R-1234yf/R-134a	20/20/31/29	A1	1251
	N-20b	R-32/R-125/R-134a/R-1234yf	13/13/31/43	A1	988
	R-449B	R-32/R-125/R-1234yf/R-134a	25.2/24.3/23.2/27.3	A1	1412
	ARM-20b	R-32/R-1234yf/R-152a	35/55/10	A2L	251
	DR-3	R-32/R-1234yf	21.5/78.5	A2L	148
	L-20a (R-444B)	R-32/R-1234ze/R-152a	41.5/48.5/10	A2L	295
R404A	ARM-35	R-32/R-125/R-1234yf	12.5/61/26.5	A1	2220
	DR-34 (R-452A)	R-32/R-125/R-1234yf	11/59/30	A1	2140
	N-40c (R-448A)	R-32/R-125/R-134a/R-1234yf/R-1234ze	26/26/21/20/7	A1	1387
	ARM-20a	R-32/R-1234yf/R-152a	18/70/12	A2L	139
	HDR110	R-32/R-1234yf/CO2	21.5/75.5/3	A2L	148
	ARM-71a	R-32/R-1234yf/R-1234ze(E)	68/26/6	A2L	460
R410A	DR-5A (R-454B)	R-32/R-1234yf	68.9/31.1	A2L	466
	DR-55	R-32/R-125/R-1234yf	67/7/26	A2L	698
	HPR2A	R-32/134a/1234ze(E)	76/6/18	A2L	600
	L-41-1 (R-446A)	R-32/R-1234ze/Butane	68/29/3	A2L	461
	L-41-2 (R-447A)	R-32/R-1234ze/R-125	68/28.5/3.5	A2L	583

Notes:

- Refrigerants' classifications or intended classifications according to the ASHRAE Standard 34 (ASHRAE, 2013).
- GWP values are calculated based on IPCC AR-4 100 year.

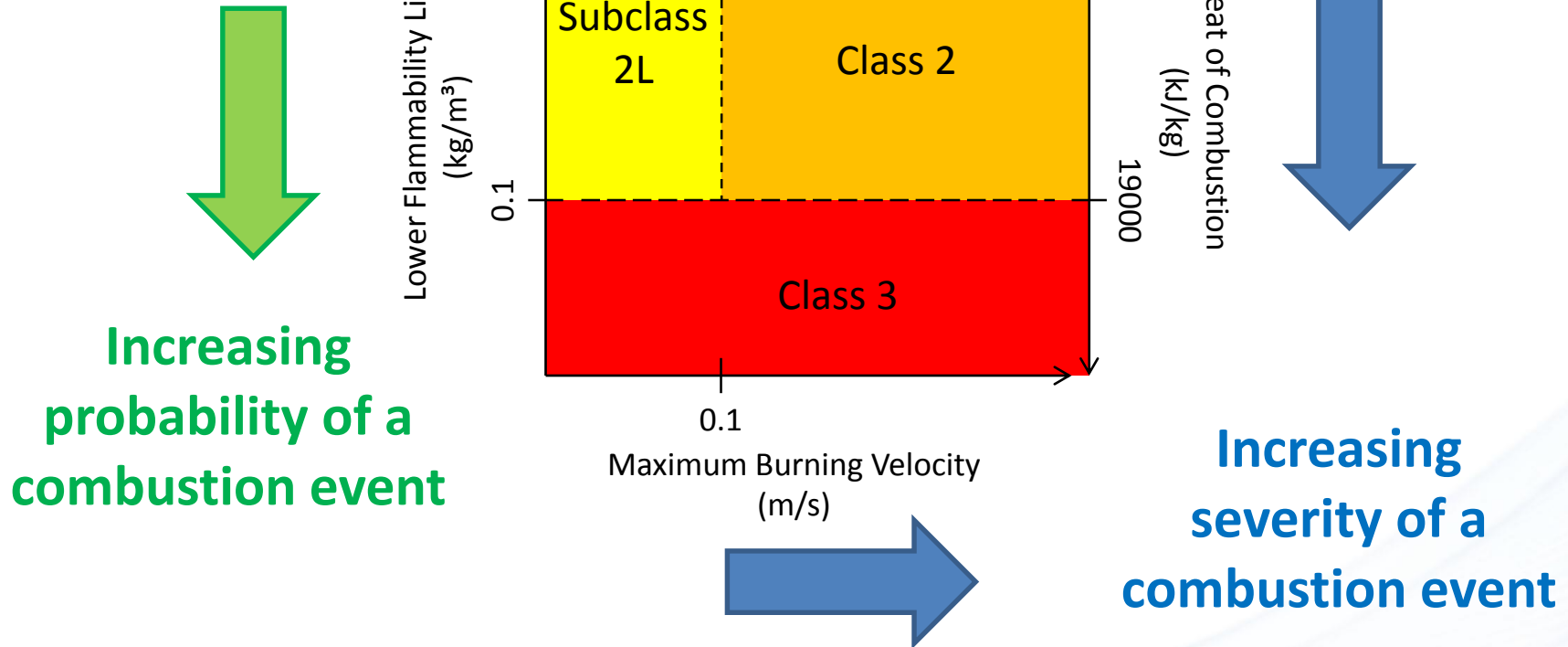
Low-GWP AREP

- **Viable low GWP alternatives exist**
- **Many promising refrigerants are classified 2L under ASHRAE 34 (mildly flammable)**
- **ASHRAE 15 does not currently differentiate between 2 and 2L refrigerants**
- **IEC 60335-2-40 does not currently have requirements for 2L refrigerants**

Risks of Flammable Refrigerants

What are 2L Refrigerants:

- Exhibit flame propagation when tested at 60°C
- LFL > 0.10 kg/m³
- HOC < 19000 kJ/kg
- S_U ≤ 0.1 m/s



Slide Source: P. Johnson, ASHRAE 2012 Annual Meeting Seminar 11

Class 2 & 3 Restrictions

- In general, it is very restrictive
- A2 or A2L refrigerants allowed in self-contained systems with less than 3kg (residential) or 10kg (commercial), depending on location in the building
 - The current Standard 15 does not differentiate class 2 and 2L refrigerants because 2L is the sub-class of class 2
- A3 cannot be used except if allowed by AHJ
 - Exceptions:
 - Laboratories with more than 100 ft² (9.3 m²) area per person
 - Industrial occupancies
 - Portable unit systems containing less than 0.331 lb (150 g) of refrigerant charge

ASHRAE Standard 15 Recent Activities

- **2L Working Group (WG) was tasked to propose requirements on equipment using 2L refrigerants. The WG recent activities include:**
 - use of A2L refrigerants for human comfort with certain restrictions
 - requirements for refrigerant leak detectors (definition, reliability, response time, etc.)
 - ventilation requirements for the use of A2L refrigerants in machine room (current focus) and occupied space (later stage).
- **15.2 Subcommittee was created to address residential applications.**

ASHRAE Standard 15.2 Subcommittee

➤ **Proposed equipment coverage:**

- split system AC&HPs and single package AC&HPs
- whole house dehumidifiers, whole house dehumidifiers/ventilators, and
- permanently connected heat pump water heaters

➤ **Proposed scope:**

- one- and two-family dwellings
- multi-family structures with individual dwelling units, where each dwelling unit has its own dedicated heating and air-conditioning system
- detached outbuildings (and garages , guest houses, pool houses, etc.) located on the same private property defined above

ASHRAE SSPC-15 Update

- **ASHRAE 15.2, *Safety Standard for Air conditioning and Heat Pump Systems in Residential Applications***
 - Target an Advisory Publication Review (APR) by the end of 2016
 - Plan Two Publication Public Reviews (PPR) in 2017
 - Standard to be approved by the end of 2017
- **ASHRAE 15:**
 - Issued an APR related to A2L refrigerants. The Committee is working on addressing received comments.
 - Target the new edition including A2L language approved by the end of 2017

State of Standards and Codes – Global View

- Increasing charge limits for flammables is global trend
- Expect safety standards in 2017; codes follow standards

	Refrigerant Classification	Usage Restriction	Application		
United States	ASHRAE34 Refrigerant Designation & Safety Classification UL2182	ASHRAE15 Safety Standards for Refrigeration Systems 2015-2018	UL1995 Heating and Cooling Equipment 2014-2015	UL471 Commercial Refrigerators and Freezers 2015-2019	UL621 Ice Cream Makers 2015-2019
			UL60335-2-40 Heating and Cooling Equipment -2017	UL60335-2-89 Commercial Refrigeration -2018	
	Refrigerant Classification	Usage Restriction	Application		
International	ISO817 Refrigerant Designation & Safety Classification (2013-2014)	ISO5149 Safety and Environmental Requirements, Phase 1 Phase 2 2014-2015	IEC60335-2-40 Heating and Cooling equipment 2015-2017	IEC60335-2-89 Commercial Refrigeration 2015-2019	IEC60335-2-24 Refrigerating appliances Ice and Ice Cream Makers 2015-2019

complete

under revision

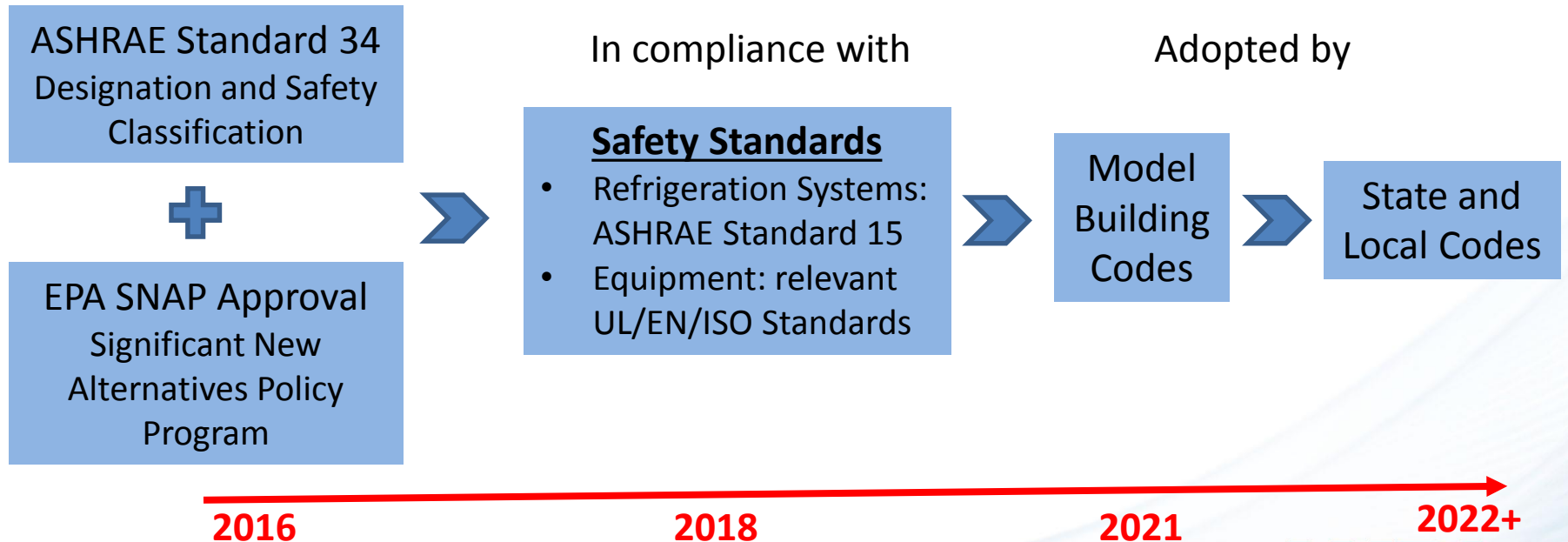
Source: Rajan Rajendran - Emerson

Code Adoption Process of New Refrigerants

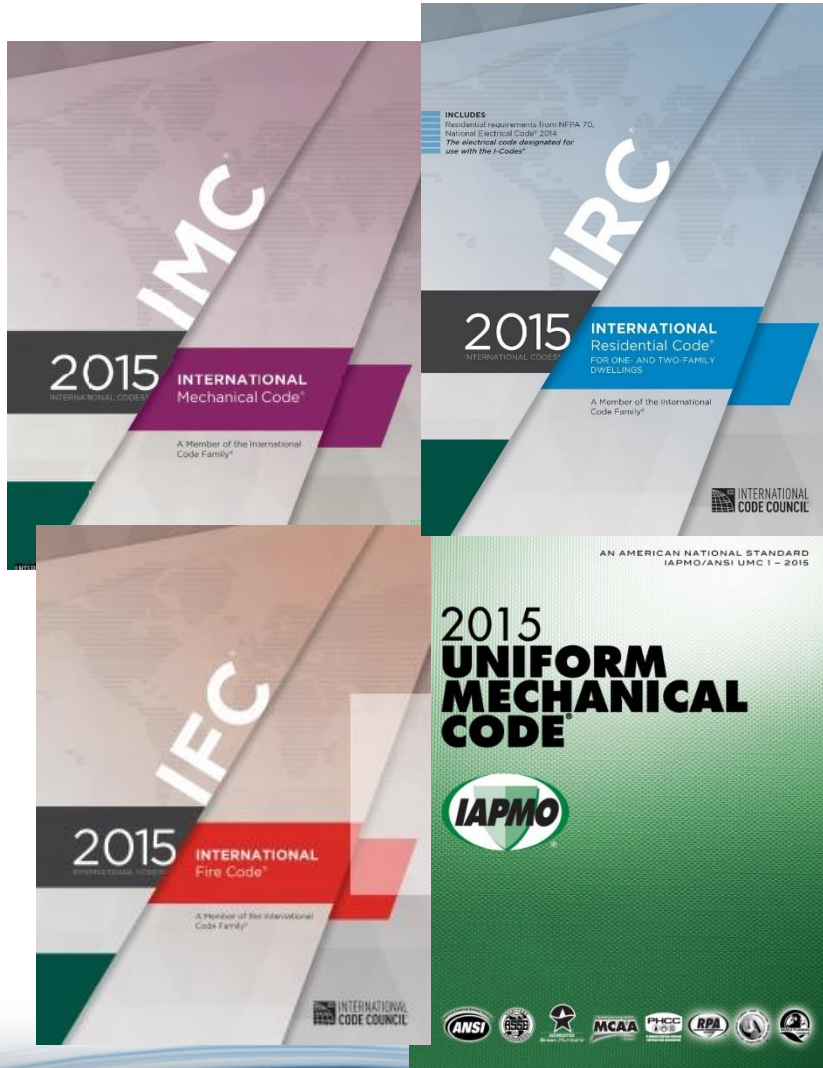
➤ Code adoption process is slow

- Proper safety classification (ASHRAE 34)
- EPA SNAP approval
- Meet relevant safety standards
- Meet relevant building codes

Safety Codes must be modified to ease restrictions on use of 2L and 3 refrigerants



Model Codes addressing Refrigerants



- The ICC International Mechanical Code (IMC) and IAPMO Uniform Mechanical Code (UMC) are the major building codes
 - Used in 48 states
- International Fire Code (IFC)
- International Residential Code (IRC)
- National Fire Protection Association, NFPA 1 – Fire Code

Code Development Cycle

- **Codes are on a 3-year cycle**
- **2018 IMC code cycle over – does not address 2L refrigerants**
- **2018 IFC code cycle underway**
 - Two proposals addressing 2L refrigerants were submitted
 - Final action hearings in October 2016
- **2018 UMC code cycle underway**
 - Several proposals addressing 2L refrigerants submitted
 - AHRI to ask for the formation of a Task Group to develop requirements on 2L refrigerants
 - UMC has an agreement with ASHRAE to reference ASHRAE 15
- **Year 2021 likely to be when 2L refrigerants will be addressed by major codes → Technical issues must be resolved by end of 2017**

AHRI Flammable Refrigerants Research

- **We surveyed relevant codes and standards committees and organizations on:**
 - The main knowledge gaps for the use of 2L flammable refrigerants
 - Any standing issues and gaps that require additional research
 - Current and past research activities on flammable refrigerants
- **Through this survey, we have:**
 - Identified the gaps in existing flammable refrigerant research
 - Developed a roadmap with priorities and a timeline to complete the critical research toward the safe use of flammable refrigerants

AHRI Flammable Refrigerants Research – High Priority

➤ **The top priority research needs are:**

1. Comparing the risks of A2L and A3 refrigerants to what we use today by benchmarking risks through real life leaks and ignition testing
2. Determining the proper basis for setting charge limits of A2L, A2, and A3 for various types of products.
3. Understanding the risk/consequence after the refrigerant is ignited
4. Determining the ignition temperatures for various 2L refrigerants at various ambient conditions

➤ **To do this quickly and safely will cost \$5 million**

Funding Flammable Refrigerants Research

➤ Funding commitments are in from:

➤ U.S. Government: \$3 million

➤ **AHRI**: \$1 million
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➤ **ASHRAE**: \$1 million



Thank you for your attention!

