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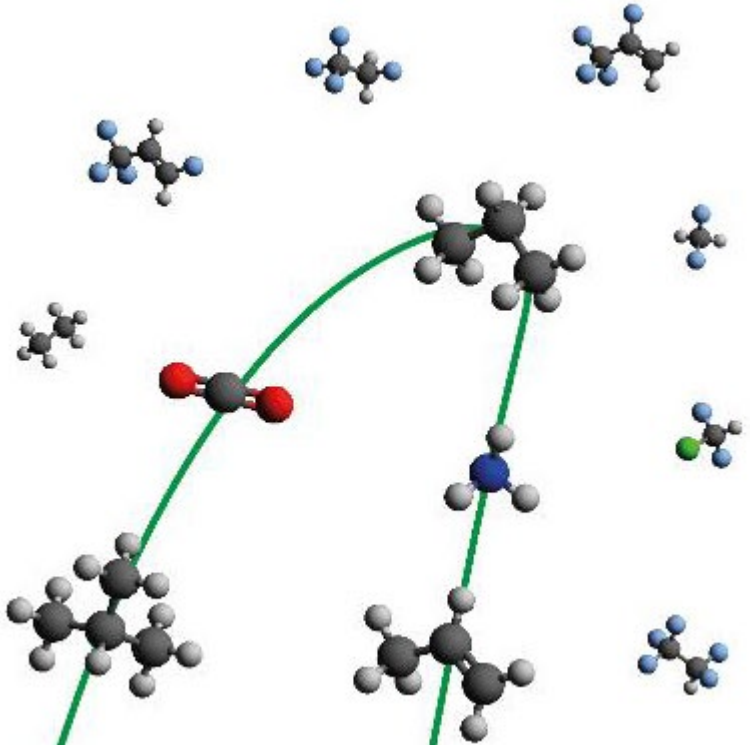
Driving the change for the FUTURE of HVAC & Pumping machines

Future Refrigerants: situation in the EU

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Content

- Look for long term available refrigerants
- EU F-Gas Regulation
- PFAS restriction under REACH
- Regulations outside the EU
  → Present situation in US
- What can be the path?



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Long term available refrigerants

Horizon of 12 to 15 years and more

- Refrigerants that shall be available in large amounts for widely used applications will have to fit into a sustainable economic system and have an environmental impact as low as possible
  - ODP = 0, GWP as low as possible (GWP<10)
  - High energy efficiency
  - Very low to no amount of breakdown products harmful to environment
  - Very low production effort and production waste generation (see Bitzer Refrigerant Report)
- So, what is left?
  - Naturally appearing substances, so called natural refrigerants
    - R744 (carbon dioxide), R290, R1270, R600a etc.(hydrocarbons), R717 (ammonia), R718 (water), R729 (air), …
  - Maybe a few other low GWP refrigerants (HFOs, …)

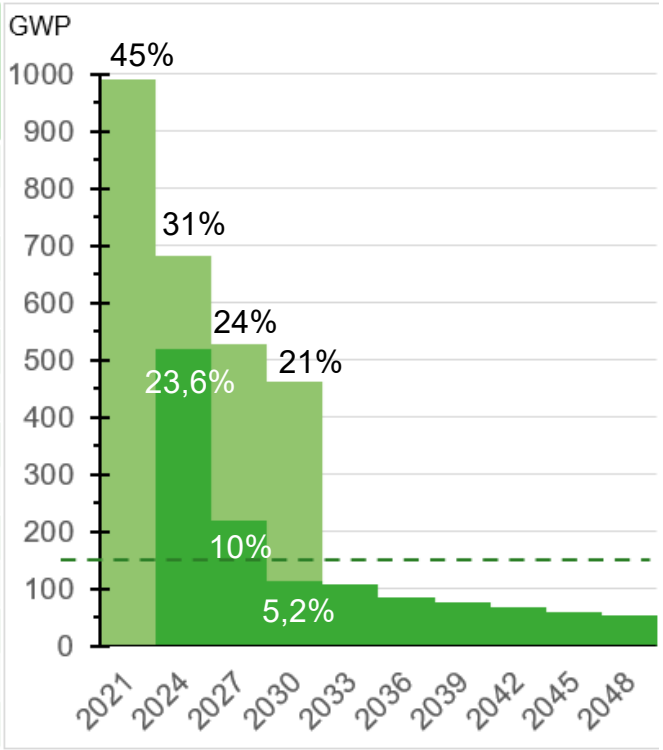
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Revision of EU F-gas regulation

Proposal of April, 2022

- Main tool: stricter phase-down
  - 2024 – 23.6 %
  - 2030 – 5.2 %
  - 2048 – 2.4 %
  - → Result of model calculation: Presumably in 2027, latest in 2030 all available HFCs will be needed for service of existing units
- European Parliament proposes F-gas phase out for AC, R and HP until 2050
- Secondary tools: application bans
  - Still discussed in EU trialogues next trialogue: October 5th

year	% 517/ 2014	Avg GWP 517/ 2014	% Rev. prop.	Avg GWP prop.
2015	100	2200		
2016	93	2046		
2018	63	1386		
2021	45	990		
2024	31	682	23,6	519
2027	24	528	10	220
2030	21	462	5,2	114
2033			4,8	106
2036			3,8	84
2039			3,5	77
2042			3,1	68
2045			2,7	59
2048			2,4	53



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Selected bans for refrigeration, AC and HPs

In revision Commission proposal of April 2022

Year	Application	Ban mat + GWP
2024	Commercial refrigerators and freezers	FGG >150
2024	Stationary refrigeration equipment, excl. product storage temperatures <-50°C	FGG >2500
2025	Any self-contained refrigeration equipment	FGG >150
2025	Plug in room air conditioners and heat pumps	FGG >150
2025	Single split AC and HP up to 3 kg charge	FGG >750
2027	Split systems <=12 kW AC + HP, except when required to meet safety standards	FGG >150
2027	Split systems >12 kW AC + HP, except when required to meet safety standards	FGG >750
2030	Service with recycled material	FGG >2500
From validity	Recovered refrigerant without recycling or reclaim	

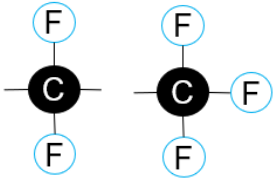
FGG: fluorinated greenhouse gases

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PFAS under REACH– What is it about?

Restriction on PFAS (per- and polyfluorinated alkyl compounds)

- 2021-07-15: RoI - Registration of Intend under REACH Regulation
  - Defines compounds with at least one CF_2-group or CF_3-endgroup as potentially dangerous for health or environment
    - Approx. 4000 to 15000 substances
- 2023-04 publication of complete report (PFAS Dossier)
  - Detailed assessments per substance/small substance group
- 2023-05 until 2023-09: Possibility for statements of stakeholders
  - response input by individual companies and associations
- 2023-09 ECHA committees on impact on environment, economy and society
- 2025-… coming possibly into force: control measures, bans, restrictions …





R1234yf
R1234ze
R134a
R125
R227ea
R245fa
R365mfc …

Outside PFAS definition:

R32, R152a, …

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Examples for PFAS containing products

- Fluorinated gases, like refrigerants
- Low friction and emergency lubrication coating in bearings
- Fluoropolymers for gaskets, vibration damper, bearing bushes
- Electrical insulation for high temperature
- Additives in motor oil, hydraulics oil
- Non-stick coating in cookware, one-way food packaging
- Breathing membranes in outdoor wear
- Textile production, impregnation for outdoor wear, personal protective equipment, …
- Dirt, oil, water repelling coating
- Low friction coating für fibres/threads, easy ironing prep
- Leather surface protection
- Cosmetics additives







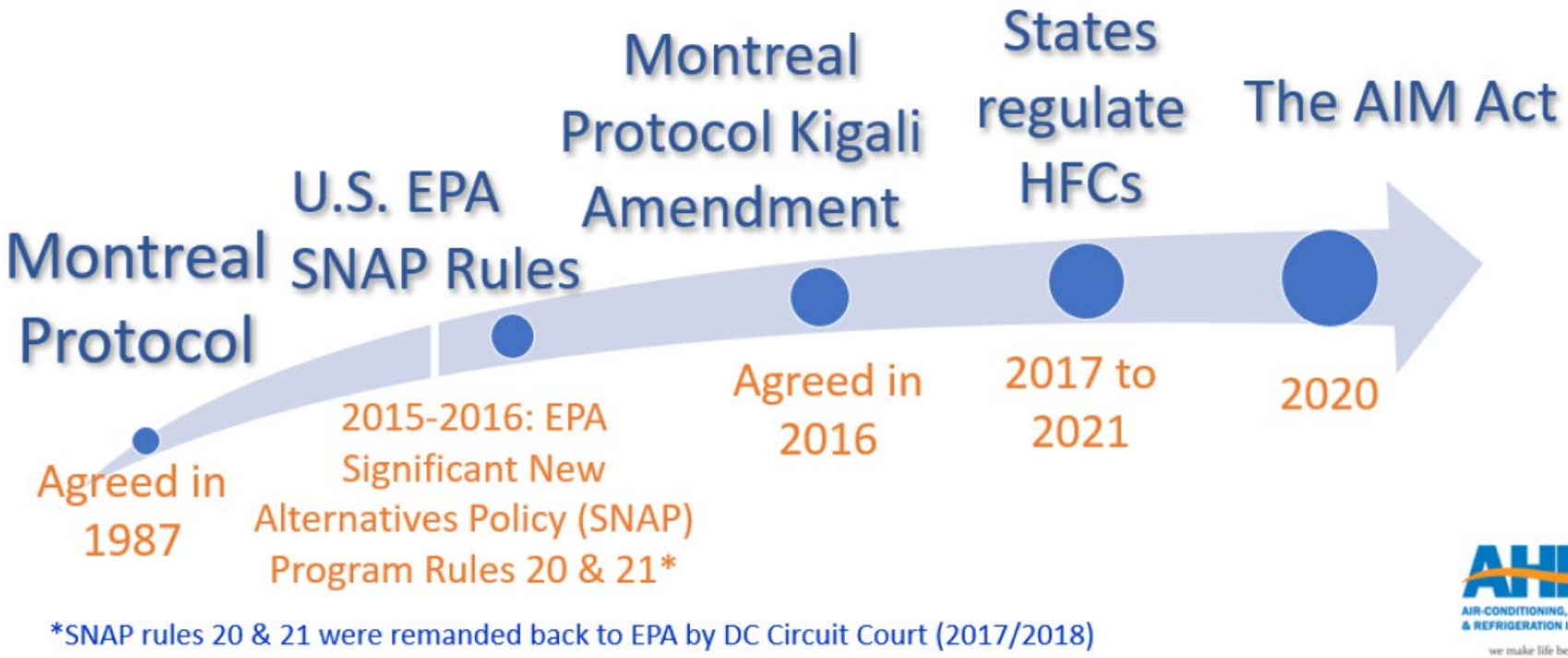




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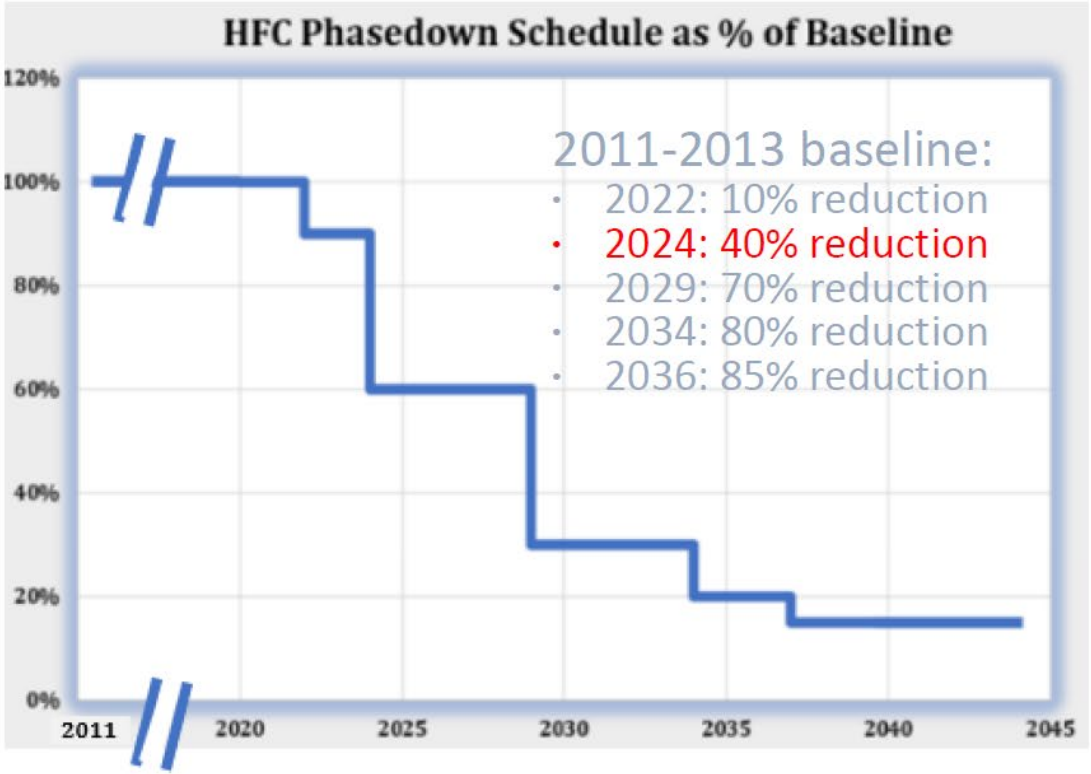
Fluorocarbon transitions in the US

The American Innovation and Manufacturing Act (AIM)



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AIM Act – HFC phase-down in US



- Mandates phase-down of HFC supply
  - Environmental Protection Agency (EPA) regulation Oct 1, 2021
- Authorizes sector transitions
- Refrigerant management, including recovery and reclaim

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Application bans base on GWP thresholds in the US

	Refrigeration Equipment (Proposed Compliance Date 1/1/25)	GWP
Industrial Process Refrigeration	Systems with refrigerant charge capacities of 200 pounds or greater	150
	Systems with refrigerant charge capacities less than 200 pounds	300
	High temperature side of cascade systems	300
	Chillers	700
Retail Food Refrigeration	Stand-alone units	150
	Refrigerated food processing and dispensing equipment	150
	Supermarket systems with refrigerant charge capacities of 200 pounds or greater	150
	Supermarket systems with refrigerant charge capacities less than 200 pounds charge	300
	Supermarket systems, high temperature side of cascade system	300
	Remote condensing units with refrigerant charge capacities of 200 pounds or greater	150
	Remote condensing units with refrigerant charge capacities less than 200 pounds	300
	Remote condensing units, high temperature side of cascade system	300
	Vending machines	150
Cold Storage Warehouse	Systems with refrigerant charge capacities of 200 pounds or greater	150
	Systems with refrigerant charge capacities less than 200 pounds	300
	High temperature side of cascade system	300
	Ice rinks	150
	Automatic commercial ice machines – selfcontained with refrigerant charge capacities of 500 grams or lower (Note: Does not align with petition)	150
	Transport refrigeration – intermodal containers	700
	Residential refrigeration	150

Comfort Cooling	GWP	Date
Chillers – comfort cooling	700	1/1/2025
Residential and light commercial air conditioning and heat pump systems	700	1/1/2025
Residential dehumidifiers	700	1/1/2025
Residential and light commercial air conditioning – variable refrigerant flow systems	700	1/1/2026

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What can be the future path? → present insights

- Existing systems: convert to refrigerants with lowest possible GWP
  - F-gases will be allowed for service and repair → but won't be available for new units
    - even for service the available amounts might be limited
- New systems:
  - where ever possible
    - use natural refrigerants like carbon dioxide (R744), hydrocarbons (R290, R1270, R600a…) ammonia (R717)…
  - where not possible
    - use A2L refrigerants with GWP as low as possible (recommended: GWP < 10, at least < 150)
    - A2L and A3 have same pressure equipment categories
  - development of safety standards might later allow A3 refrigerants like R290 (propane) instead of A2L
  - reduction of refrigerant charge per unit
  - improvement of system tightness

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Example: Possible low GWP substitutes for R404A

Refrigerant	Components	ODP	GWP			Safety Class	Boil. Temp.	Dew Temp.	Temp.-Glide	crit. Temp.	crit. Press.
			AR4	AR5	AR6		°C	°C	K	°C	bar
R290	propane	0	3	3	0,02	A3	-42,1	-42,1	0	97	42,5
R1270	propylene / propene	0	2	2		A3	-47,6	-47,6	0	91	45,6
R717	ammonia	0	0	0		B2L	-33,4	-33,4	0	132	113
R744	carbon dioxide	0	1	1	1	A1	-78,3	-78,3	0	31	73,8
R443A	R1270/ 290/ 600a	0	4	4		A3	-45,2	-42,1	3,1	96,0	44,9
R454C	R32/ 1234yf	0	148	146	166	A2L	-45,6	-37,8	7,8	86	43,2
R455A	R32/ 1234yf/ 744	0	148	146	166	A2L	-52,0	-39,2	12,8	86	46,5
R457A	R32/ 1234yf/ 152a	0	139	139		A2L	-42,6	-35,5	7,1	90	43,1
R457C	R32/ 1234yf/ 152a	0	72	72	82	A2L	-37,3	-32,1	5,2	94,1	39,6
R459B	R32/ 1234yf/ 1234ze(E)	0	144	143		A2L	-45,0	-36,7	8,3	87	43,6
R465A	R32/ 1234yf/ 290	0	145	143	162	A2	-51,7	-40,0	11,7	82	43,4

Example: Possible low GWP substitutes for R410A

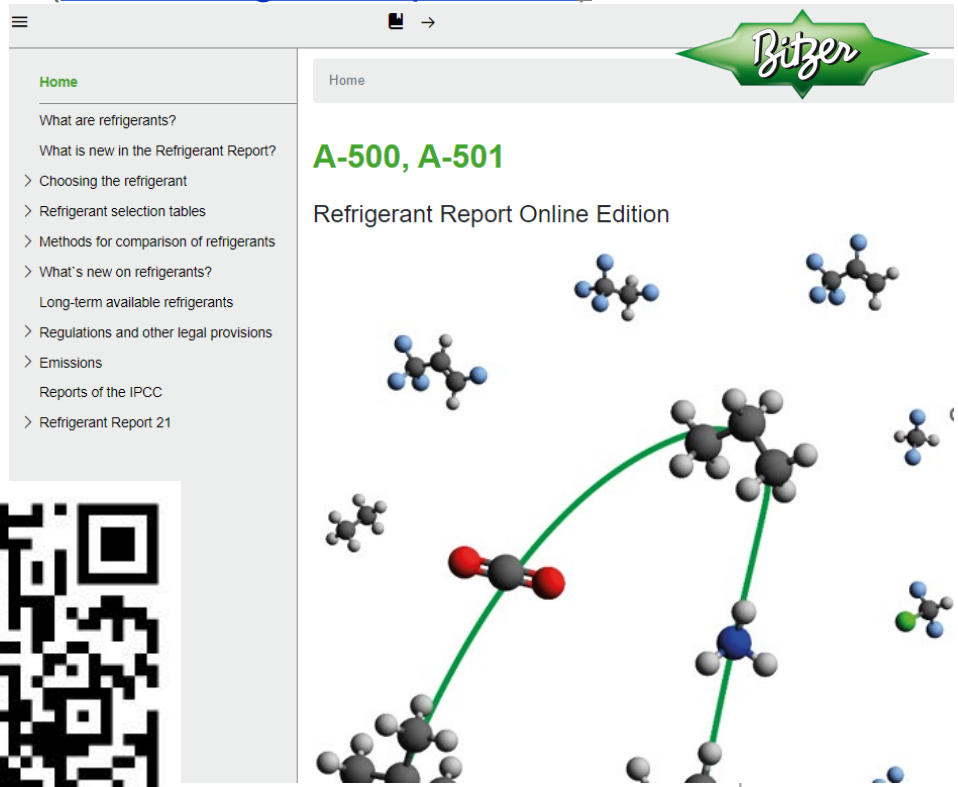
Refrigerant	Components	ODP		GWP		Safety Class	Boil. Temp.	Dew Temp.	Temp.-Glide	crit. Temp.	crit. Press.
			AR4	AR5	AR6		°C	°C	K	°C	bar
R468B	R32/ 1234yf/ 1132a	0			101	A2L	-52,4	-36,8	15,6	85	42,5

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Further information, available refrigerants, …

For example: Digital BITZER Refrigerant Report (bitzer-refrigerantreport.com)

- Available online
- Tables for specific replacement tasks
  - Containing more than 130 refrigerants
  - Tables with filters
- Additional background information
  - EU F-Gas Regulation
  - REACH PFAS process
  - Montreal Protocol, Kigali Amendment
  - ...
- Many links to more information



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Thank you!