



The engineering office for sustainable refrigeration

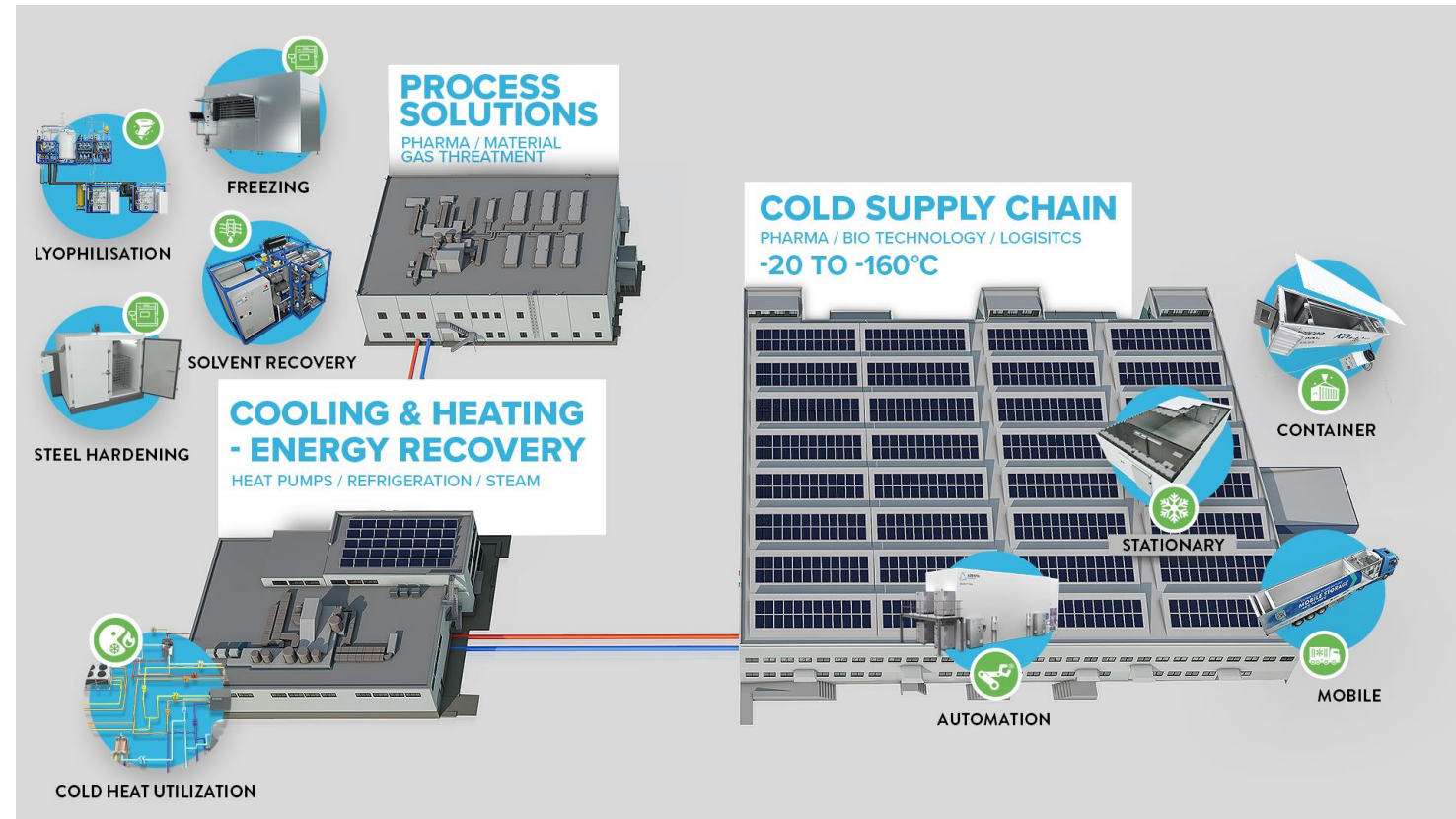
Webinar: Sustainable cooling and heating: F-gas regulation in the pharmaceutical industry



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- Consulting
- Planning
- Special plant construction
- Product development





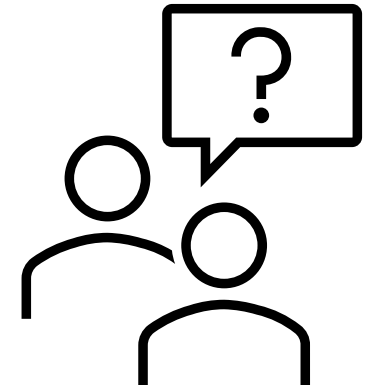
Webinar - Information

➤ Documents

- Webinar will be recorded
- Recording will be published on YouTube
- Slides will be shared on our homepage
- Distribution of links after the webinar (chat and LinkedIn post)



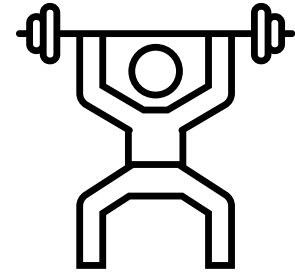
- Questions in the chat at any time
- Questions by mic after each chapter





Motivation

- Information and support for our customers
- Many existing systems in the field
- „The new plant of today is the existing plant of tomorrow “
- Decision today influences for the next decades:
 - Production reliability
 - Long-term planning capability
 - Economic efficiency



- Challenges
 - Shortage of refrigerants
 - Price increases
 - Service bans!
 - Requalification/revalidation
 - Energy demand





Content

1. Challenges in the procurement & operation of refrigeration systems with F-gases

- Overview of relevant laws & legislative proposals

2. Solutions & Recommendations

➤ Focus

➤ Stationary refrigeration systems (>12 kW)

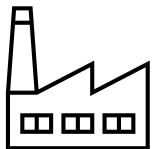
- E.g. Storage rooms & air conditioning/ cleanroom

➤ Chiller (cooling of a secondary coolant)

- Distribution via cold water/brine networks
- Heat dissipation to the environment

➤ +Applications for product temperatures < -50 °C

- Freeze drying (control plates down to -55 °C, ice condenser down to -90 °C)
- Freezing processes
- Reactors, ...





Legal restrictions for refrigeration technology - Overview

➤ F-Gas-Regulation (EU) 2024/573

→ 2024



➤ PFAS restriction proposal via REACH

→ EoF ca. 2027



ANNEX XV RESTRICTION REPORT

PROPOSAL FOR A RESTRICTION

SUBSTANCE NAME(S): Per- and polyfluoroalkyl substances (PFASs)

➤ EU: Energy efficiency law – e.g. in Germany

➤ EU law will be adapted in all member states

→ 2023



Gesetz zur Steigerung der Energieeffizienz in Deutschland
(Energieeffizienzgesetz - EnEFG)



F-Gas-Regulation (EU) 2024/573



Official Journal
of the European Union

EN
L series

2024/573

20.2.2024

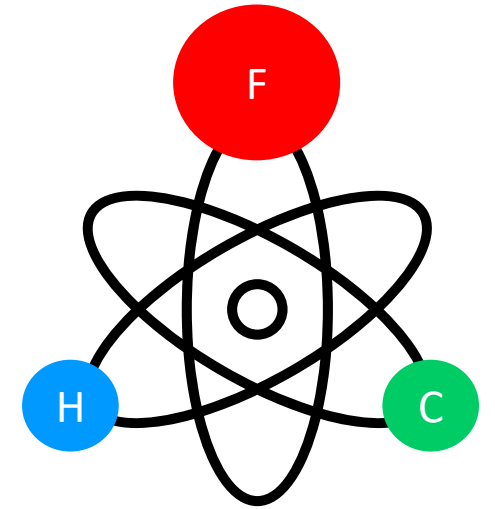
REGULATION (EU) 2024/573 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 7 February 2024
on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU)
No 517/2014

(Text with EEA relevance)



F-Gas-Regulation (EU) 2024/573 - Overview

- 11/03/2024 entered into force
- replaces revision of 2015 (EU)No. 517/2014
- Why?
 - Implementation of various agreements:
 - Kigali Agreement of 2016 on the Montreal Protocol
 - European Green Deal
 - European climate laws
- Goals:
 - Limiting the greenhouse effect of F-gases (CO₂-equivalent)
 - Improvements in implementation & monitoring
 - Adaptation of quotas and bans to market-available alternatives



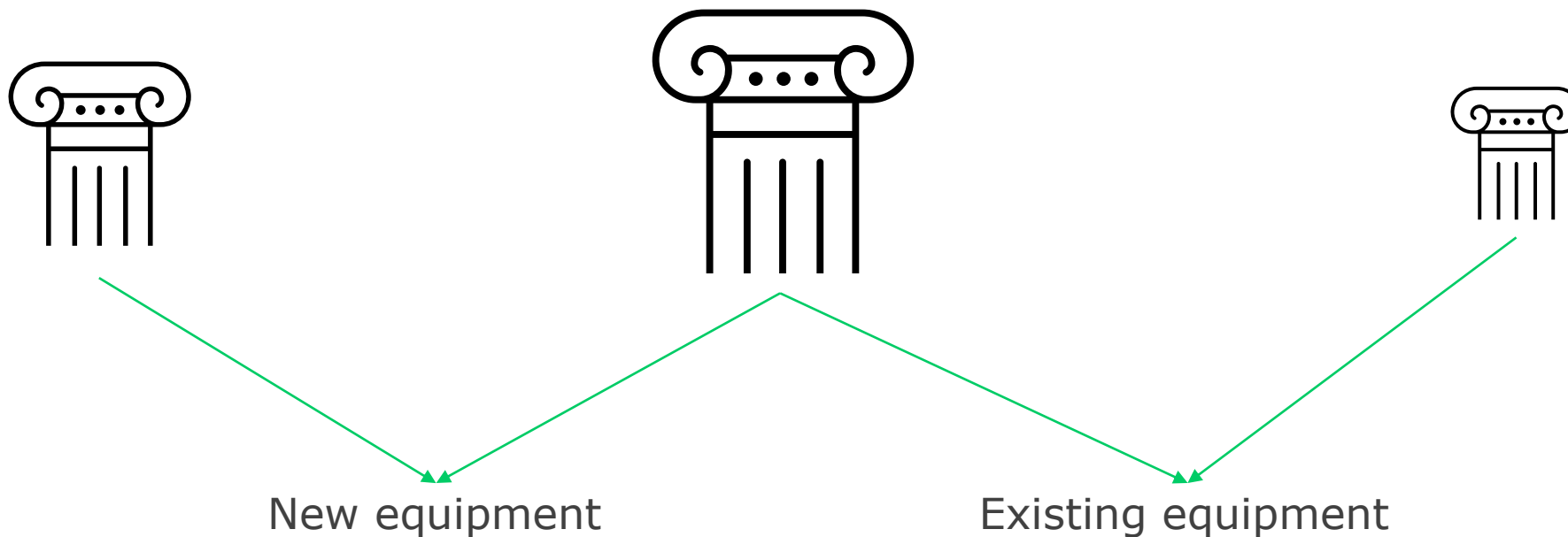


F-Gas-Regulation (EU) 2024/573 - Overview

2. Prohibitions on placing new equipment on the market

1. Quotation of the available refrigerant

3. Prohibitions (e.g. service) and duty (e.g. leakage checks)

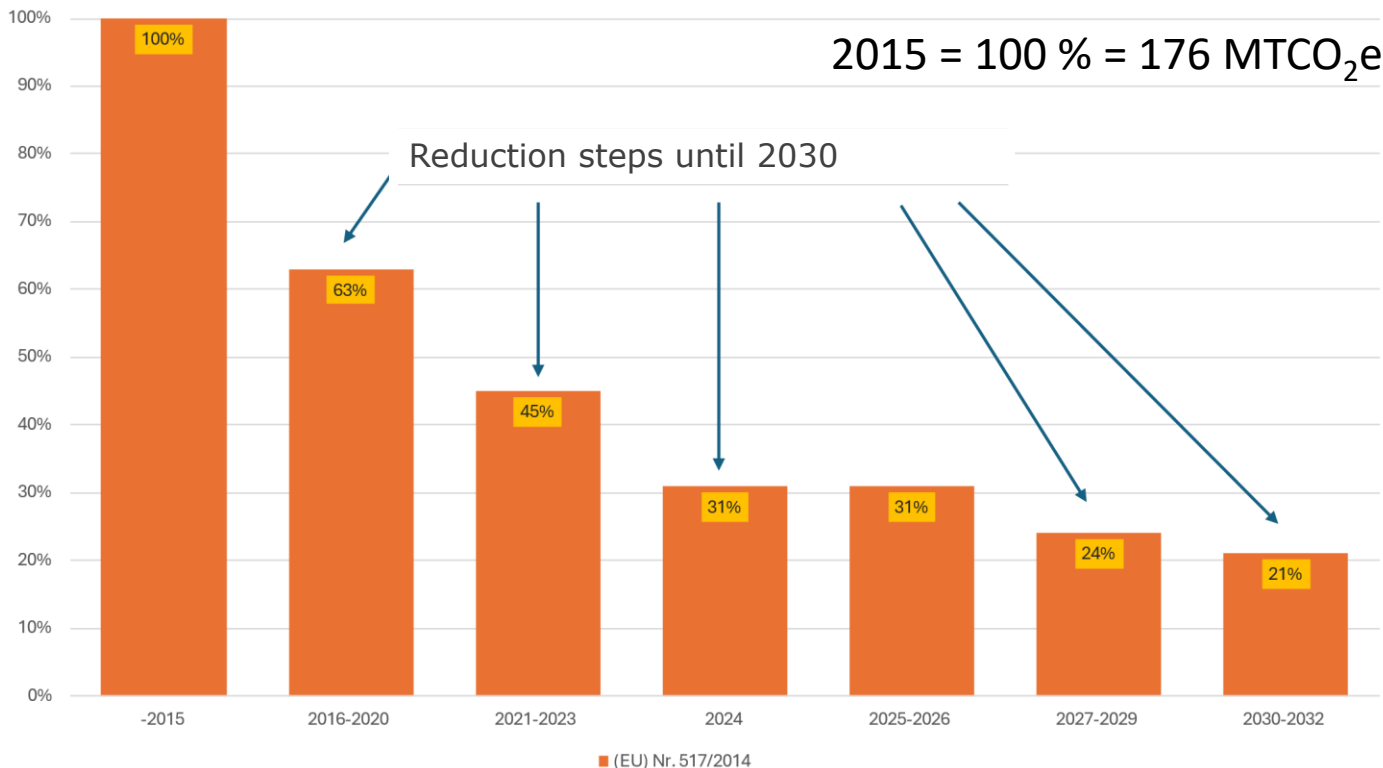




F-Gas-Regulation (EU) Nr. 517/2014– Phase-Down of GWP

Basis from 2015

Mean consumption from 2009 to 2012



2015 = 100 % = 176 MTCO₂e

Reduction steps until 2030

Available CO₂ equivalents in % for placing HFC refrigerants on the market

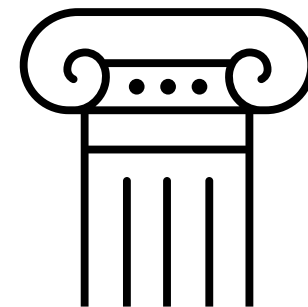
Phase-Down

(EU) No 517/2014 - Article 16:

- Phase-Down of HFC (Appendix I, Group I)
- GWP = Global Warming Potential
- Specified in CO₂ equivalent
 - CO₂ = GWP of 1
 - According to 4th assessment report IPCC
- Exceptions including MDI (metered dose inhalers)

GWP of common refrigerants:

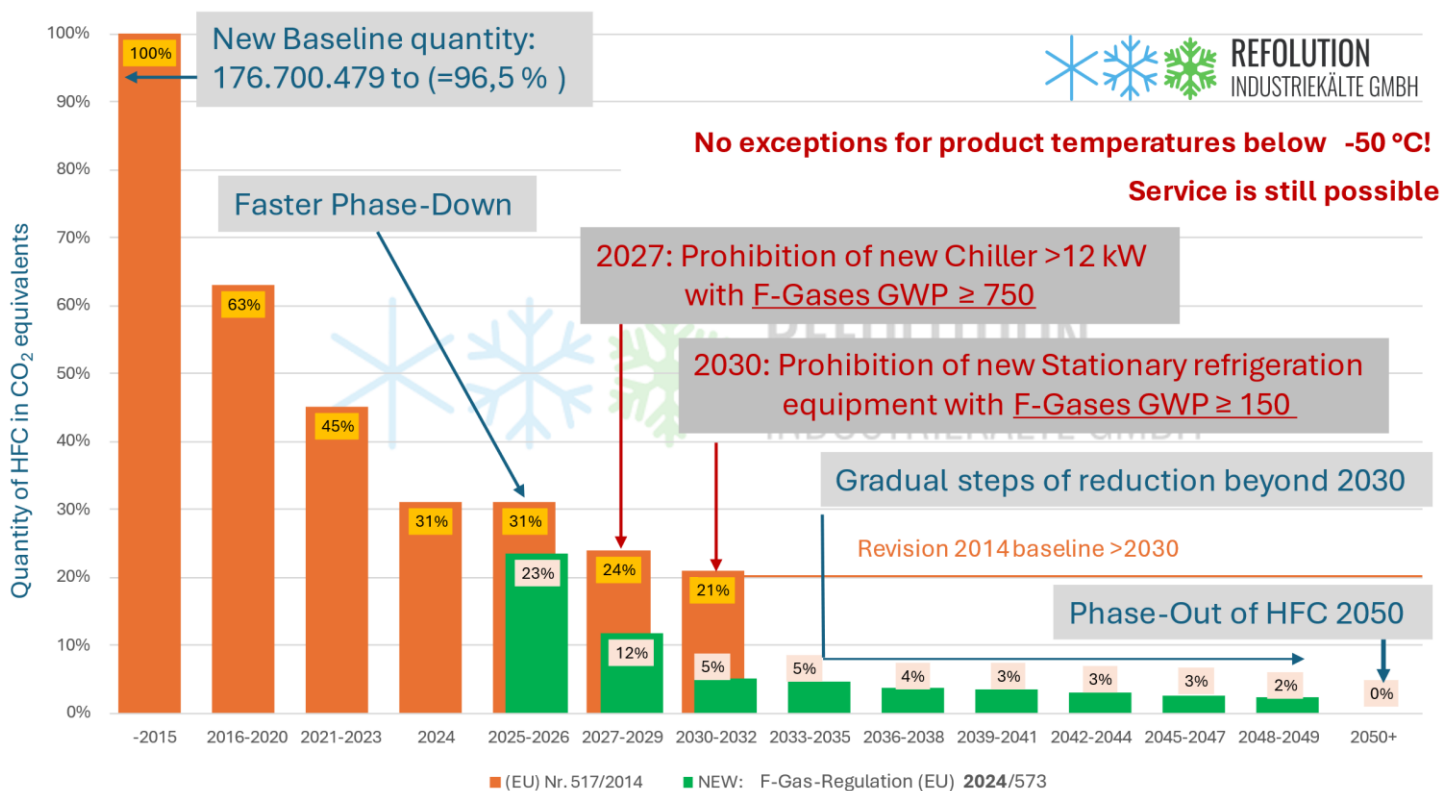
- R32 – GWP 675
- R410A – GWP 2088
- R452A – GWP 2140
- R404A – GWP 3922
- R23 – GWP 14800





F-Gas-Regulation (EU) 2024/573 – Phase-Out of GWP

Revision 2024 of the (EU) F-Gas Regulation and Phase-Out of HFC

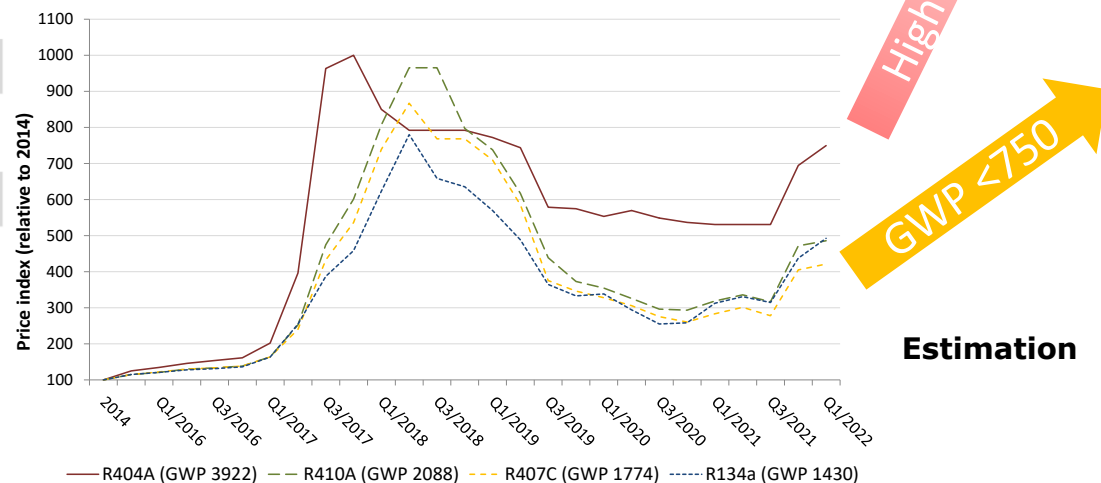


Available CO₂ equivalents for placing HFC refrigerants on the market

New: Phase-Down → Phase-Out

(EU) 2024/573 - Article 17:

- Phase-out of HFCs (Annex I, Group I)
- HFO and natural refrigerants not in quota
- Applications such as MDIs are integrated into quota
- 2024: 31% falls to 5% in 6 years (2030)
- Less supply meets greater demand
- Service permitted, but possibly uneconomical

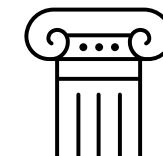
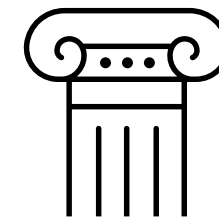
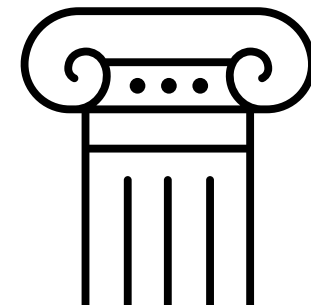


Öko-Recherche (2022) on behalf of the European Commission



F-Gas-Regulation (EU) 2024/573– Prohibitions & requirements

- Definitions:
 - HFC: hydrofluorocarbons (Appendix I, Group I & mixtures) → Affected by phase-out
 - F-Gas: HFCs, HFOs and others (Annex I, II, III)
- Prohibitions on placing new equipment on the market
 - Criterias
 - Application
 - Cooling capacity
 - GWP
 - Partial exemptions ('compliance with safety requirements on site')
 - **New: Bans on HFO and mixtures containing HFO → "fluorinated greenhouse gases"**
- Maintenance & Service
 - Criterias
 - Application
 - GWP
 - 2030: General ban on servicing with GWP >2500 (any refrigeration systems, AC:2032)
 - 2032: Ban on servicing with GWP >750 (stationary refrigeration with exemption: chillers)
 - Exception: Recycled and reconditioned refrigerants with GWP >750

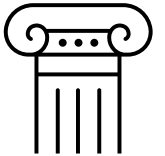




F-Gas-Regulation (EU) 2024/573– Prohibitions & requirements

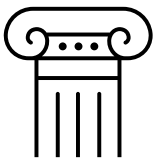
➤ Further prohibitions and requirements:

- Leak tests also for systems with HFO
- Certifications, including for natural refrigerants (No final execution instruction yet)



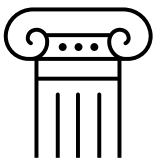
➤ F-gas portal & Import/export bans

- From 2025: Ban on the export of systems and system components with GWP \geq 1000
- Exception: Placing on the market is permitted in the EU
- From 2028: Ban on exports to countries that have not ratified the Kigali Agreement



➤ Review 2030 with tightening and/or easing

- Can phase-out take place as planned? Are there enough alternatives on the market?
- If necessary, also adjustments of GWP values to more recent IPCC reports (e.g. R32 4th report: 675, 6th report 771)
- Current studies: e.g. HFO-1234ze can produce R23 during atmospheric degradation, thus possibly GWP > 150
- <https://naturalrefrigerants.com/study-links-hfos-to-formation-of-super-greenhouse-gas-hfc-23/>





F-Gas-Regulation (EU) 2024/573 – -50 °C Applications

➤ Prohibitions on placing new equipment on the market

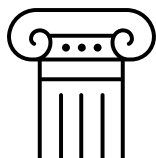
New: No exception for -50 °C

➤ From 2027

- Ban on the placing on the market of coolers/chillers with F-gases $GWP \geq 750$
- including for freeze dryers (control panels) and freezers
- No more new systems with F-gas, as no low-temperature refrigerant with $GWP < 750$

➤ From 2030

- Ban on refrigeration systems (direct evaporation) with $GWP \geq 150$
 - Including storage rooms and freeze dryers (ice condenser) without exception for low temperatures!
 - Exception for coolers/chillers



➤ Service

➤ Exception <-50 °C still valid

- 2030: $GWP \geq 2500$ (Article 13 paragraph (3))
- 2032: $GWP \geq 750$ (Article 13 paragraph (5))
- Fresh and recycled/reprocessed refrigerants permitted

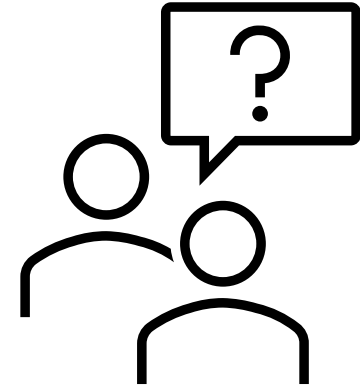
➤ However, availability and price of high-GWP refrigerant questionable ($GWP \geq 2500$)

- Exception for service with recycled/reprocessed refrigerants from 2030 no longer applies (for ≥ -50 °C)
- Reprocessing (within the EU) or procurement (outside the EU) may not be attractive for the small market <-50 °C





Questions?





PFAS restriction proposal via REACH



ANNEX XV RESTRICTION REPORT

PROPOSAL FOR A RESTRICTION

SUBSTANCE NAME(S): Per- and polyfluoroalkyl substances (PFASs)



PFAS restriction proposal (REACH)

Pure substances from proposal

ANNEX XV RESTRICTION REPORT – Per- and polyfluoroalkyl substances (PFASs)

Table A.96. List of specific fluorinated gas substances identified in different commercial applications.

Entry	Substance	Code	Structure
1	Fluoroform (trifluoromethane)	HFC-23 (not in scope)	CHF3
2	Difluoromethane	HFC-32 (not in scope)	CH2F2
3	1,1,1,2,2,3,4,5,5,5-Decafluoropentane	HFC-43-10mee	CF3-CF2-CHF-CHF-CF3
4	Pentafluoroethane	HFC-125	CF3-CHF2
5	1,1,1,2-Tetrafluoroethane	HFC-134a	CF3-CH2F
6	1,1,1-Trifluoroethane	HFC-143a	CF3-CH3
7	1,1-Difluoroethane	HFC-152a (not in scope)	CHF2-CH3
8	1,1,1,2,3,3,3-Heptafluoropropane	HFC-227ea	CF3-CHF-CF3
9	1,1,1,3,3,3-Hexafluoropropane	HFC-236fa	CF3-CH2-CF3
10	1,1,1,3,3-Pentafluoropropane	HFC-245fa	CF3-CH2-CHF2
11	1,1,1,3,3-Pentafluorobutane	HFC-365mfc	CF3-CH2-CF2-CH3
12	1-Chloro-1,2,2-tetrafluoroethane	HCFC-124	CHClF-CF3
13	1,1-Dichloro-1-fluoroethane	HCFC-141b (not in scope)	CCl2F-CH3
14	3,3-Dichloro-1,1,1,2,2-pentafluoropropane	HCFC-225ca/cb	CF3-CF2-CHCl2
15	1,1-Difluoroethylene	HFO-1132a (not in scope)	CH2=CF2
16	1-Chloro-2,3,3,3-tetrafluoropropene	HFO-1224yd(Z) *	CHCl=CF-CF3
17	1-Chloro-3,3,3-trifluoro-1-propene	HFO-1233zd(E) **	CHCl=CH-CF3
18	2,3,3,3-Tetrafluoropropene	HFO-1234yf	CH2=CF-CF3
19	Trans-1,3,3,3-tetrafluoroprop-1-ene	HFO-1234ze(E) ***	CHF=CH-CF3
20	1,3,3,3-Tetrafluoropropene		
21	Trans-1,1,1,4,4,4-hexafluorobutene		
22	Cis-1,1,1,4,4,4-Hexafluoro-2-butene		
23	(Z)-1-Chloro-2,3,3,3-tetrafluoropropene		
24	Trans-1-chloro-3,3,3-trifluoropropene		
25	2-Bromo-3,3,3-trifluoroprop-1-ene		

Most mixtures affected:
R404A, R410A
R42X & R43X & R44X & R45X
& R46X & R47X & R507A & R513A

➤ Definition PFAS:

- per- and polyfluorinated alkyl substances (approx. 10.000 substances)
- „forever chemicals“

➤ How are refrigerants affected:

- F-gases mostly PFAS by definition
- PFAS as a degradation product in the atmosphere: TFA (trifluoroacetate)

➤ Why a ban:

- High persistence and hardly any natural degradability
- Partly toxic or effects on humans and the environment not conclusively researched
- Example TFA:
 - Very persistent substance
 - Not naturally degradable
 - Technically degradable only with great effort
 - Accumulation in the environment measurable

➤ Objective of the restriction proposal:

- Complete ban on the use of PFAS
- Exemptions and transitional arrangements depending on the availability of alternatives



PFAS restriction proposal (REACH)

Timeline for refrigerants:

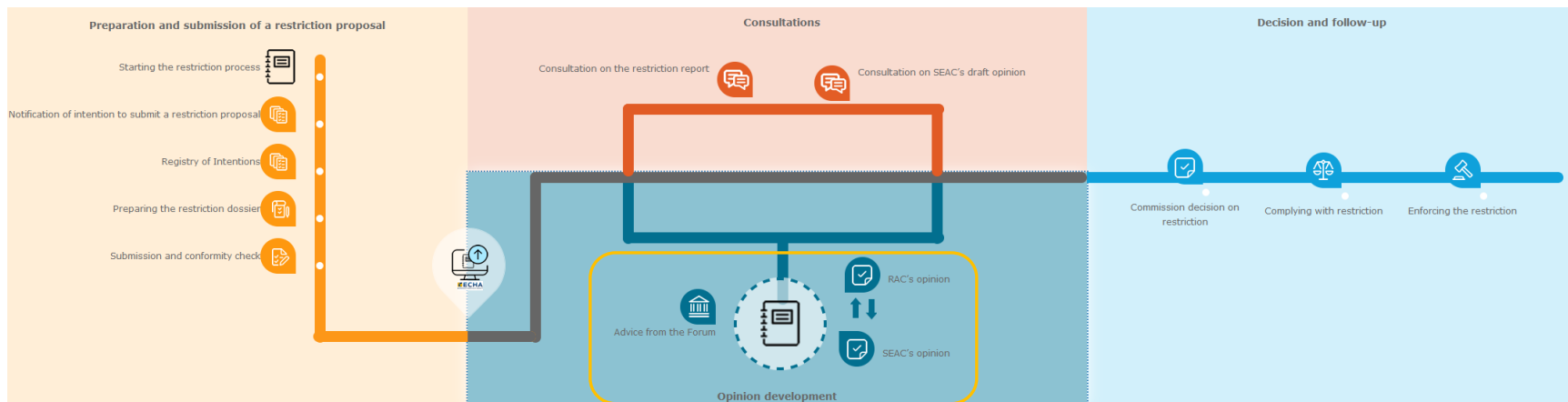
- 2024 and 2025: Consultations on various areas of application (no date yet known for KM)
- Possible entry into force approx. **2026/2027**

Consequence and bans for refrigerants from the proposal:

- Relevant exemptions for **service** with affected refrigerants for 12 years (until approx. 2040)
- Relevant exemptions for new systems only to a very limited extent:
 - Only if safety requirement need to be fulfilled (permanent exemptions)
 - Below -50 °C (5-year exemption = until approx. 2033)

Selection of PFAS refrigerants

R1234ze
R1234yf
R134a
R404A
R410A
R448A,B,C
R452A,B,C
R513A
R507A



<https://echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea>



PFAS restriction proposal (REACH) - Summary

- PFAS restriction proposal via REACH
 - Target: Complete ban on the use of approx. 10,000 substances = PFAS
 - Almost all F-gases would be affected

- Possible entry into force **around 2026/2027**.
 - Until then, great uncertainty about scope, timeline, exceptions
 - Economic impact vs. environmental impact
 - Various stakeholders

- Proposal for exceptions for service with affected refrigerants for 12 years
 - I.e. service ban from approx. 2040

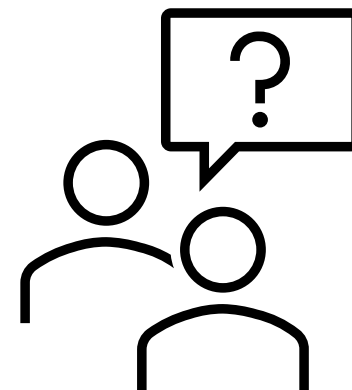
2027



2040

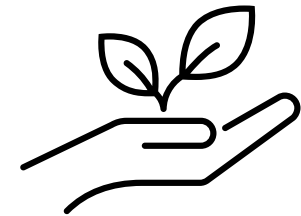
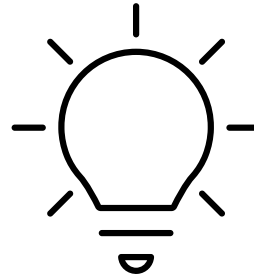
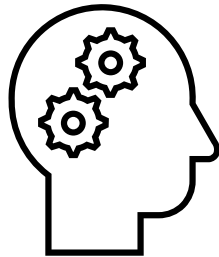


Questions?





Solutions & recommendations





Overview: The future of refrigerants

Recommendation:

Category:		HFKW	HFKW & HFO-Mischungen		HFO	Natural refrigerants		
GWP:		>2500	<2500	<750		<150		
Properties	Examples	R23 (A1) R404A (A1) R407C (A1) R507A (A1)	R410A (A1) R132a (A1) R452A (A1)	R32 (A2L) R452B (A2L) R454B (A2L)	R1234yf (A2L) R1234ze (A2L) R133ze (A1) R1336mzz (A1)	R729: Air R744: CO ₂ R718: Water Noble gases	Hydrocarbons (A3): R290, R170, R1270, R1150, R600... Ammonia (B2L)	
	PFAS	Ja (bis auf R23, R32, R152a)				No		
	Degradation products	Trifluoracetat (TFA) & R13 Ausnahmen: R22, R125, R152a				None		
	Class	A1	A1	A1/A2L	A1/A2L	A1	B2L/A3	
Economic efficiency	Future viability/ risks	Ban via F-Gas Regulation	Price development F-Gas Regulation PFAS ban		PFAS ban?		Available in the long term A3 requirements are manageable	
	Investment (CAPEX) Efficiency (OPEX)	Ban	CAPEX: Low, but risk of shortened service life (PFAS service ban possibly from approx. 2040) OPEX: Rising trend (HFC refrigerant prices)			Partially higher CAPEX is compensated by lower OPEX		



Refolution Portfolio – Recommendation for Refrigerant

< -160 °C or low utilization:
LN2

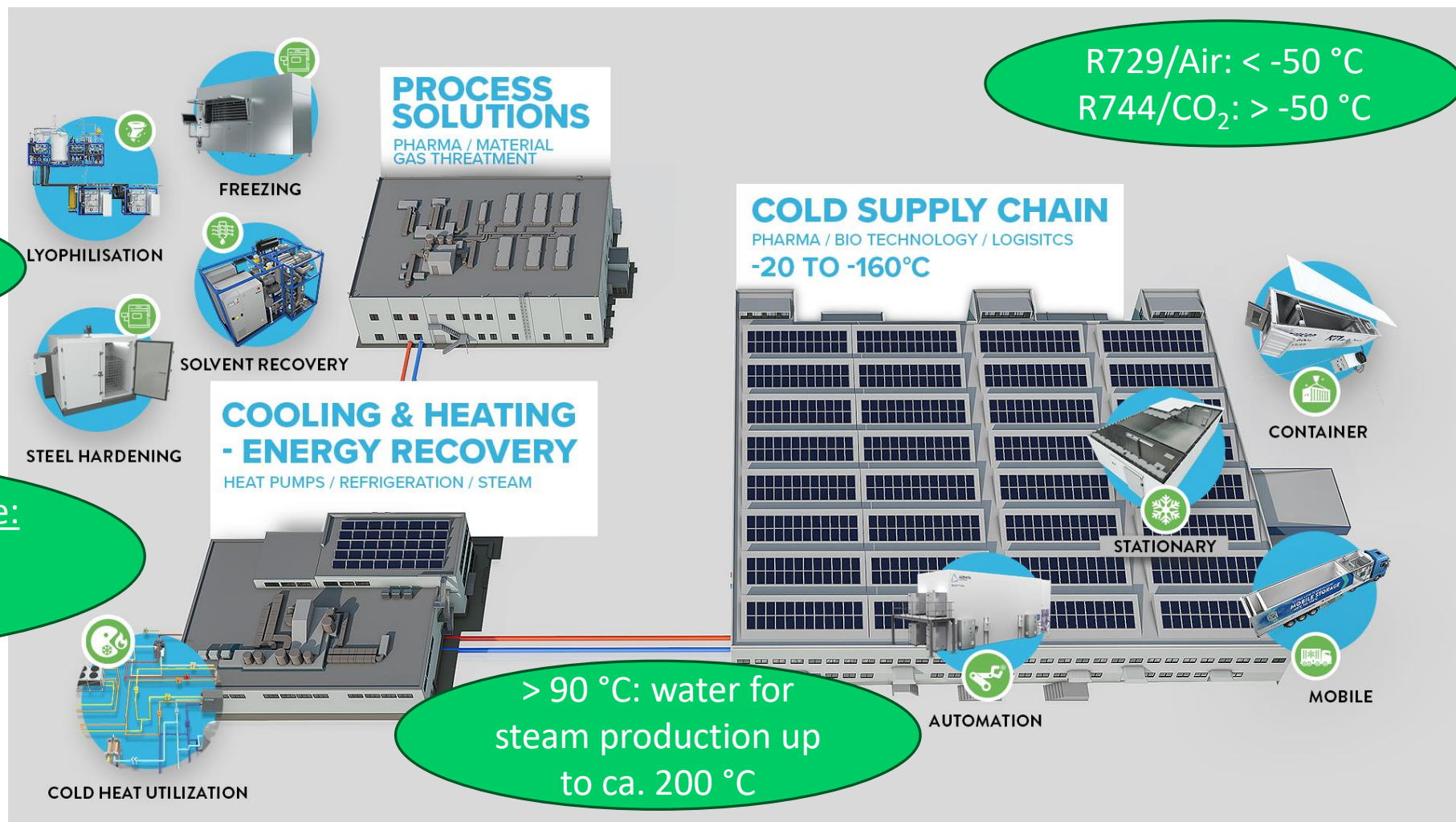
< -50 °C: R729/Air

> -40 °C & Large capacity:
Ammonia/R717

> -50 °C: R744/CO₂

All temperatures & low charge:
Hydrocarbons
R290/ R1270 / R170/R600...

A2/A2L KM: R152a, R32,
R1234ze with risks
2030/2040



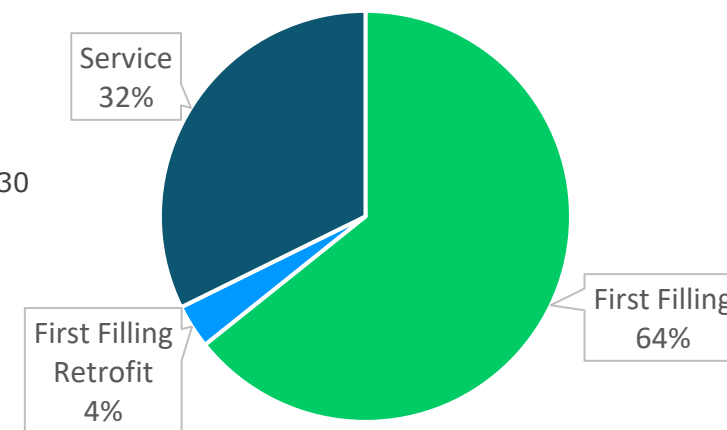


Recommendation for new systems / selection of refrigerant

- All applications can be realised with natural refrigerants
 - Few exceptions, but solutions are also available here after a few years of development
 - Contact us if you have one of these applications
- Possible alternatives with risks:
 - No A1 F-Gas with low GWP available
 - A2L/A2 only limited advantages over A3 refrigerant
 - Recommendation: → Switch directly to A3
- R32 Chiller:
 - Still significant GWP (675)
 - Future demand for refrigerant for servicing → puts pressure on the quota for existing systems
 - Only GWP <150 → Chance that enough HFCs will remain available for existing systems even after 2030
- R1234ze Chiller:
 - Risk of a service ban (according to the current REACH proposal around 2040))
- LN2 e.g. for freeze dryers and storage rooms
 - Factor 5x-10x for operating costs
 - Not recommended for high capacity utilisation (e.g. of production facilities)



HFC 2022 in Germany in t



Öko-Recherche (2022)



Recommendation for existing systems/ Retrofit

- General recommendation
 - Regular leak test
 - Care when servicing/decommissioning refrigeration systems: Separate refrigerants by type for “recycling”
 - Feasibility studies::
 - Retrofit
 - Modification of procedures/processes
 - Attention:
 - Refrigeration system manufacturers' capacities for retrofits will be heavily utilised by 2030 at the latest
 - Check and implement early!

- Recommended action depending on GWP
 - **High GWP**
 - Check retrofit for PFAS-free refrigerant
 - Implementation by **2030**
 - Emergency solution with possibly limited service life: PFAS refrigerant with GWP <750

 - **GWP > 750 and/or PFAS refrigerant**
 - Check retrofit to PFAS-free refrigerant
 - Wait for REACH regulation, but it is currently unclear when it will actually be adopted





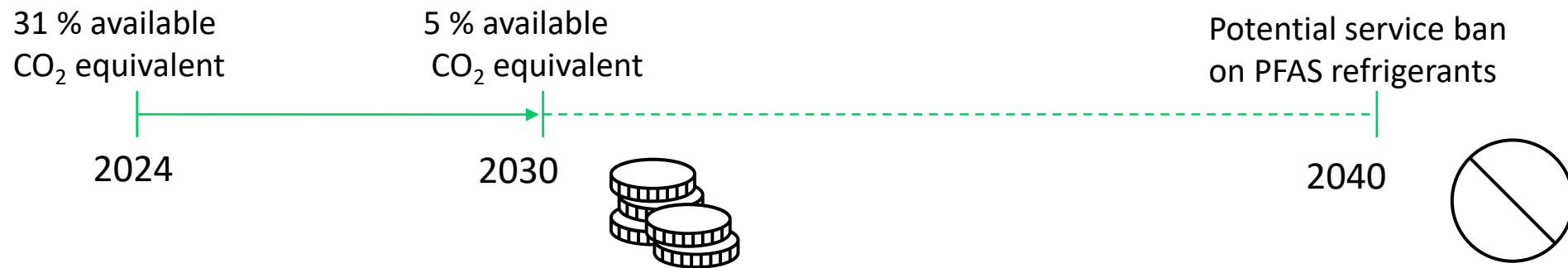
Summary

F-Gase-Regulation (EU) 2024/573

- Sharp price increase for HFC refrigerants with high and medium GWP
- Limited availability of refrigerants with very high GWP
- Obligations & service bans

PFAS-Restriction proposal

- Risk of service bans 12 years after entry into force





Conclusion

Freedom of Operation

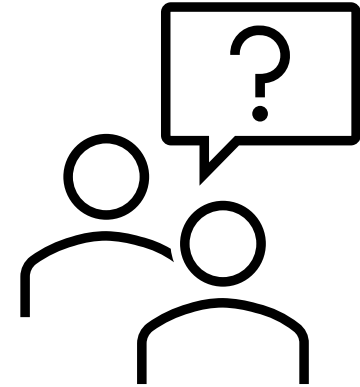
Only possible with long-term available and permitted refrigerants

Natural refrigerants without unpredictable risks

For new systems and conversion measures: Check/plan for waste heat utilization



Questions?





Contact & further offers

We offer:

- In-house seminars
 - On-site or via online training
- Consultancy & planning
 - Support with the categorisation of existing systems in the context of the F-Gas Regulation & PFAS issue
 - Selection of the refrigerant
 - Efficient new systems and retrofits customised to your process
 - Concepts and potential analyses for waste heat utilisation
- Customised system construction & product development
 - Joint development of products, processes and solutions
 - Turnkey refrigeration systems and cryogenic storage rooms



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F-Gas-Verordnung (EU) 2024/573 – Zeitschiene

Year	Service and more
2024	11.03.2024: Entry into force and first obligations for operators (e.g. HFO leakage check)
2025	Export ban on systems and parts for KM with GWP >1000. Exception: If placing on the market in the EU is still permitted.
2026	Service ban: F-gases as fresh HFCs with GWP ≥ 2500 without CO ₂ eq. limit Previously only HFCs from 40 tonnes CO ₂ eq. Exceptions: chillers and products <-50 °C and recycled KM
2030	<ul style="list-style-type: none"> • Exception Service with recycled KM with GWP ≥2500 not applicable • Service for product temperature <-50 °C still permitted • Review of the F-Gas Regulation
2032	Service ban: Fresh KM with GWP ≥ 750 Exceptions chillers and products <-50 °C and recycled KM
2050	Totaler Phase-Out von HFKW-Kältemittel (HFO und natürliche KM nicht betroffen)

Year	Placing on the market prohibitions
2025	Start of new stricter marketing bans Gradual introduction until 2035
2027	Cooler/chiller application with secondary circuit with >12 kW and F-gas GWP ≥750! With no exception for <-50 °C!
2030	Refrigeration systems (except chillers) with F-gas GWP ≥150 With no exception for <-50 °C!