F-Gases: The Biggest Source of PFAS

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eurammon webinar | 31.03.2025

CHEMICAL POLLUTION CRISIS

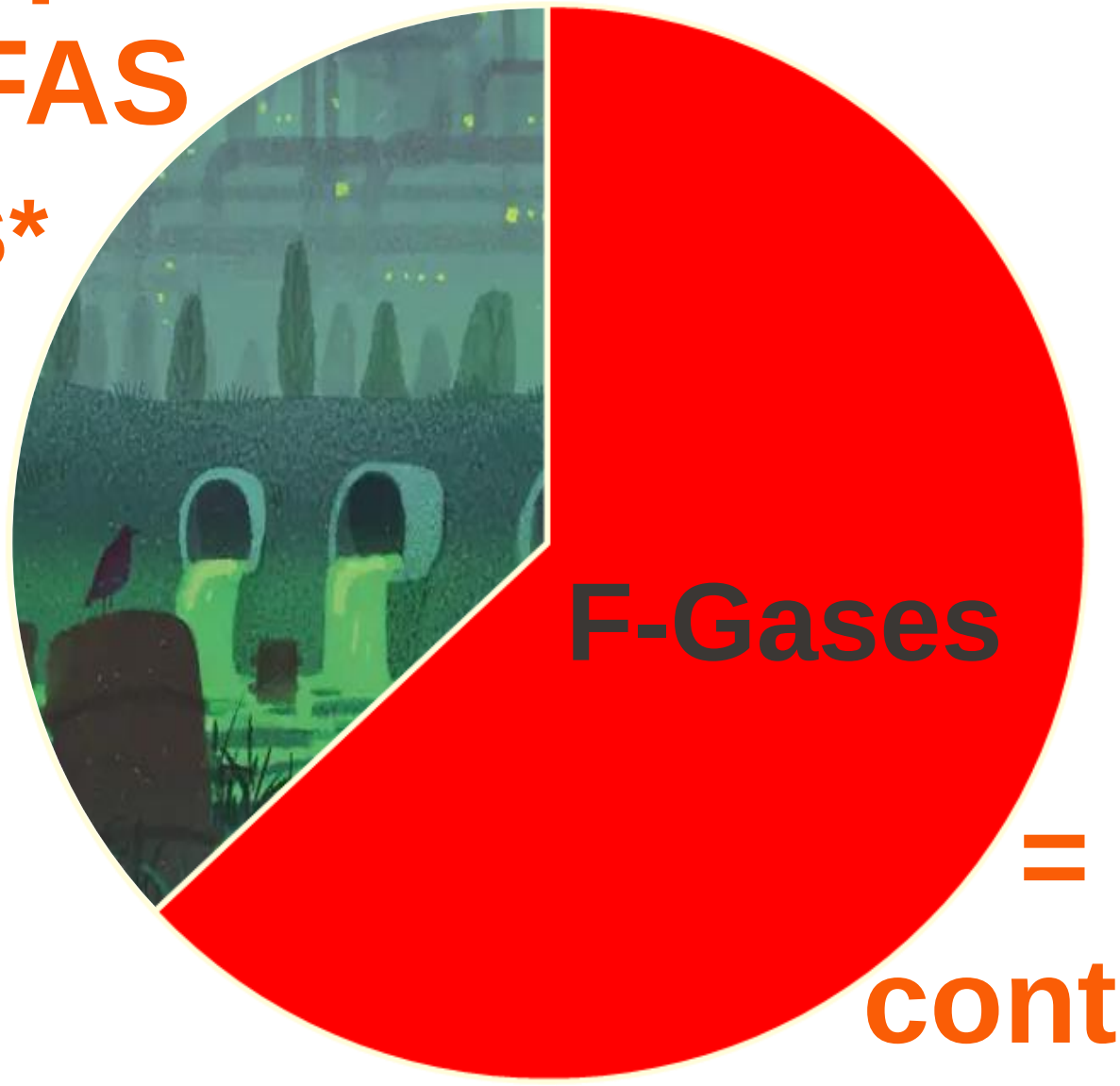
WE PASSED THE SAFE LIMIT FOR HUMANITY

PFAS ARE MAIN CONTRIBUTOR DUE TO PERSISTENCY

Luetzkendorf | eurammon | 31.03.2025

Marcin Wolski

F-gases represent 63 % of PFAS emissions*



= main contributor

* Calculation based on PFAS restriction dossier Annex XI

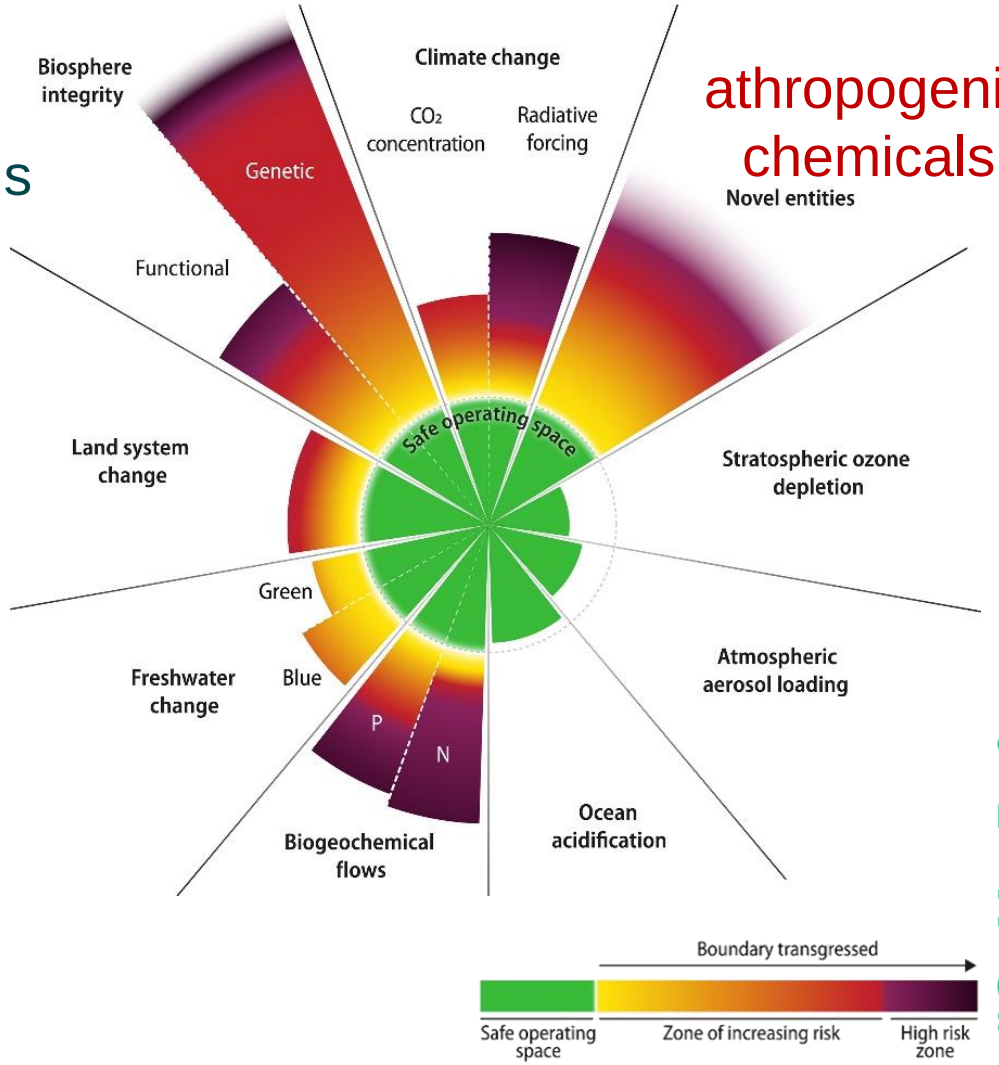
PFAS – *forever chemicals*

= per and polyfluorinated alkyl substances

- chemical group of > 7 million man made chemicals
- wide use in e.g. pans (Teflon), rain jackets, coffee cups, gaskets, as refrigerants
- most F-gases are PFAS
- detected *everywhere* in the world
- cannot degreade in the environment = *persistent*

"There is no dilution to persistent pollution."
Hans Peter Arp

crossing planetary boundaries



athropogenic chemicals

Richardson et al. (2023)

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Widespread PFAS pollution

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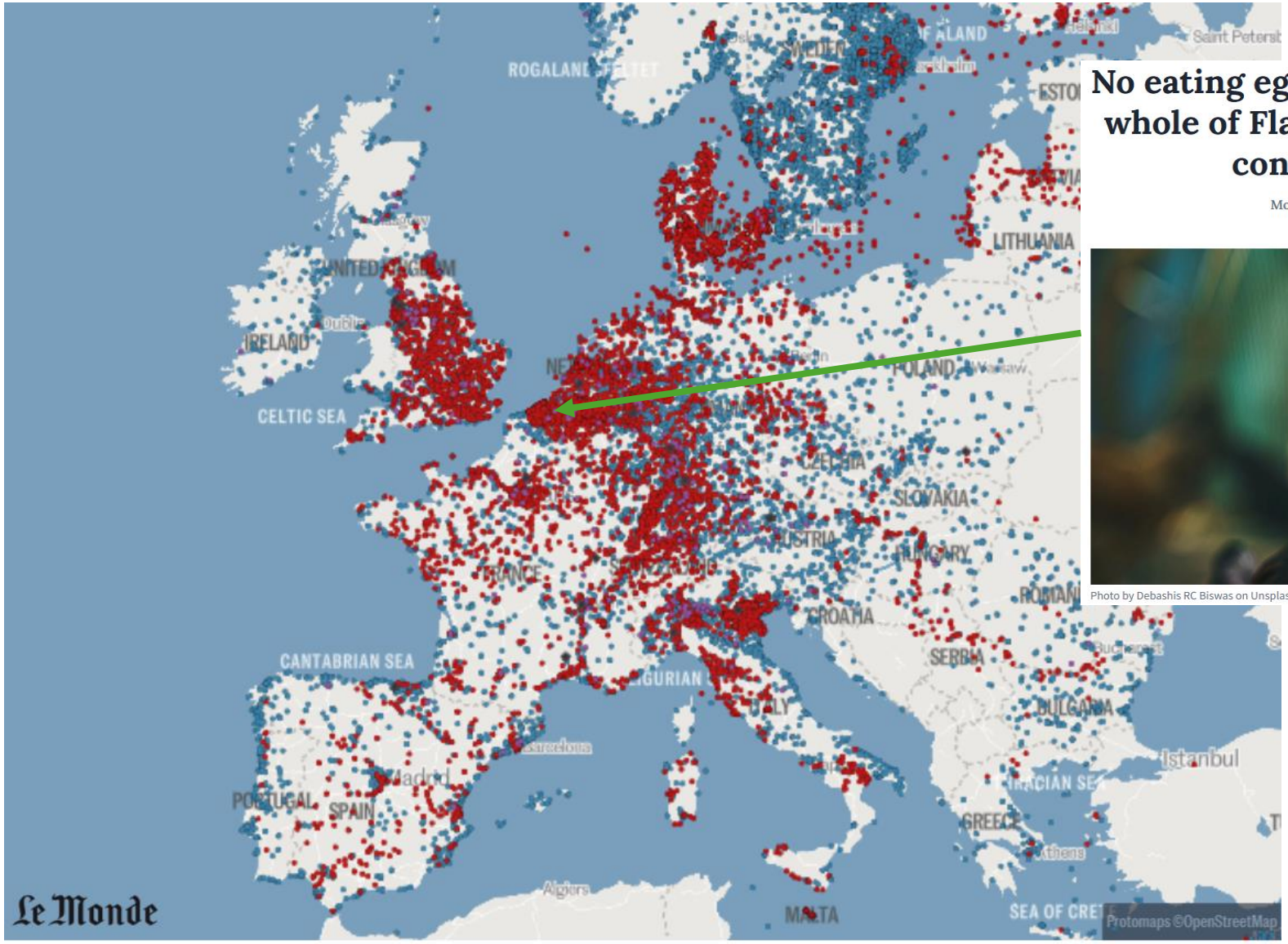

Known contamination Known PFAS User Presumptive contamination PFAS manufacturing facility

No eating eggs from hens 'in the whole of Flanders' due to PFAS contamination

Monday, 7 February 2022

By Helen Lyons

Photo by Debashis RC Biswas on Unsplash

The Brussels Times

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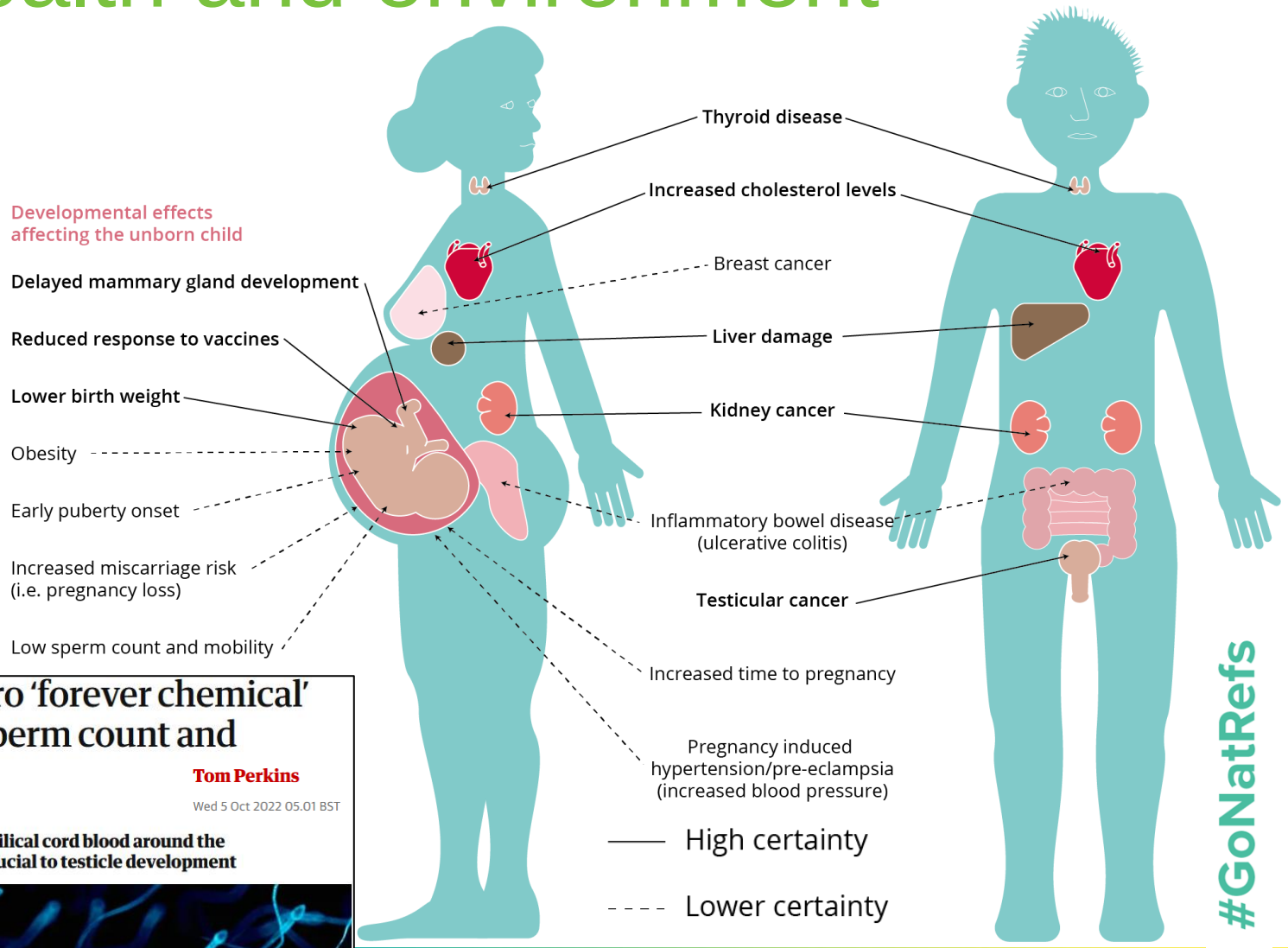
PFAS – threat to health and environment

- exposure via food, water, air, PFAS-containing products
- causing/connected to health risks and environmental pollution
- full consequences of exposure unknown due to high variety and limited studies

Movie tip: Dark Waters (2019)



Study links in utero 'forever chemical' exposure to low sperm count and mobility

Tom Perkins

Wed 5 Oct 2022 05.01 BST

PFAS, now found in nearly all umbilical cord blood around the world, interfere with hormones crucial to testicle development

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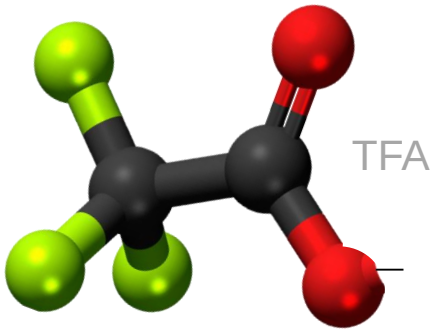
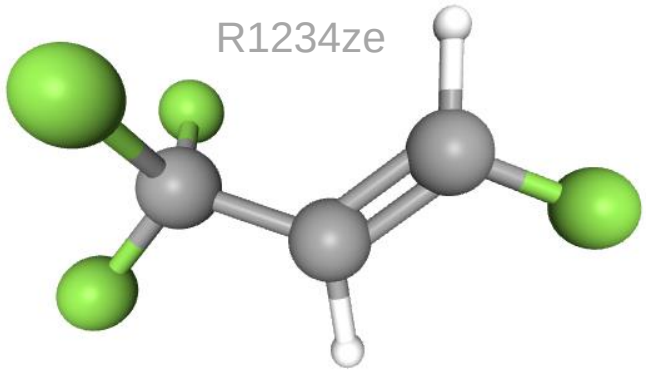
https://www.eea.europa.eu/publications/emerging-chemical-risks-in-europe

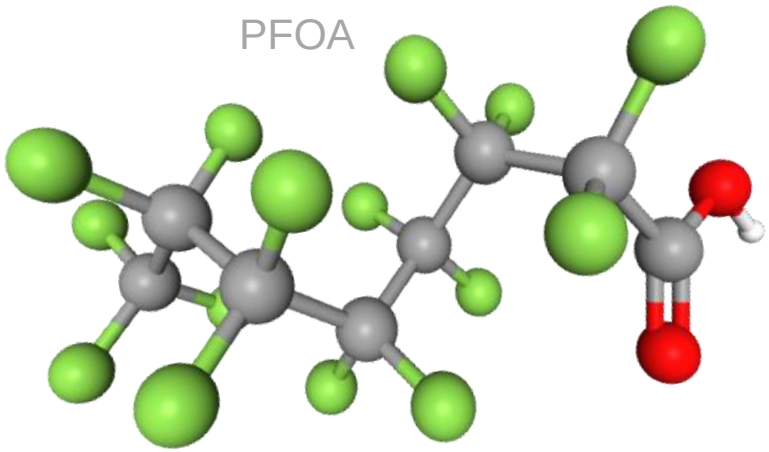
PFAS – *forever chemicals*

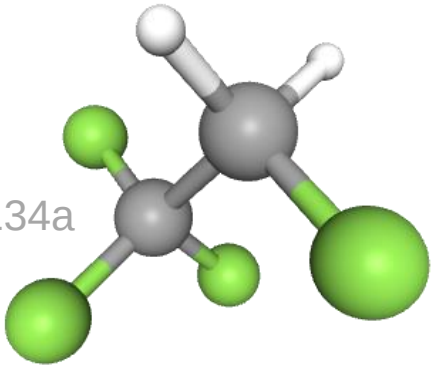
= per and polyfluorinated alkyl substances

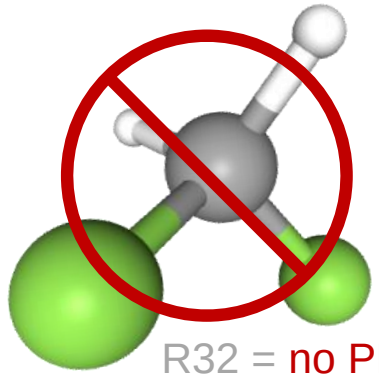
(organic carbon chain with fluorine atoms [simplified])











carbon
hydrogen
oxygen
fluorine

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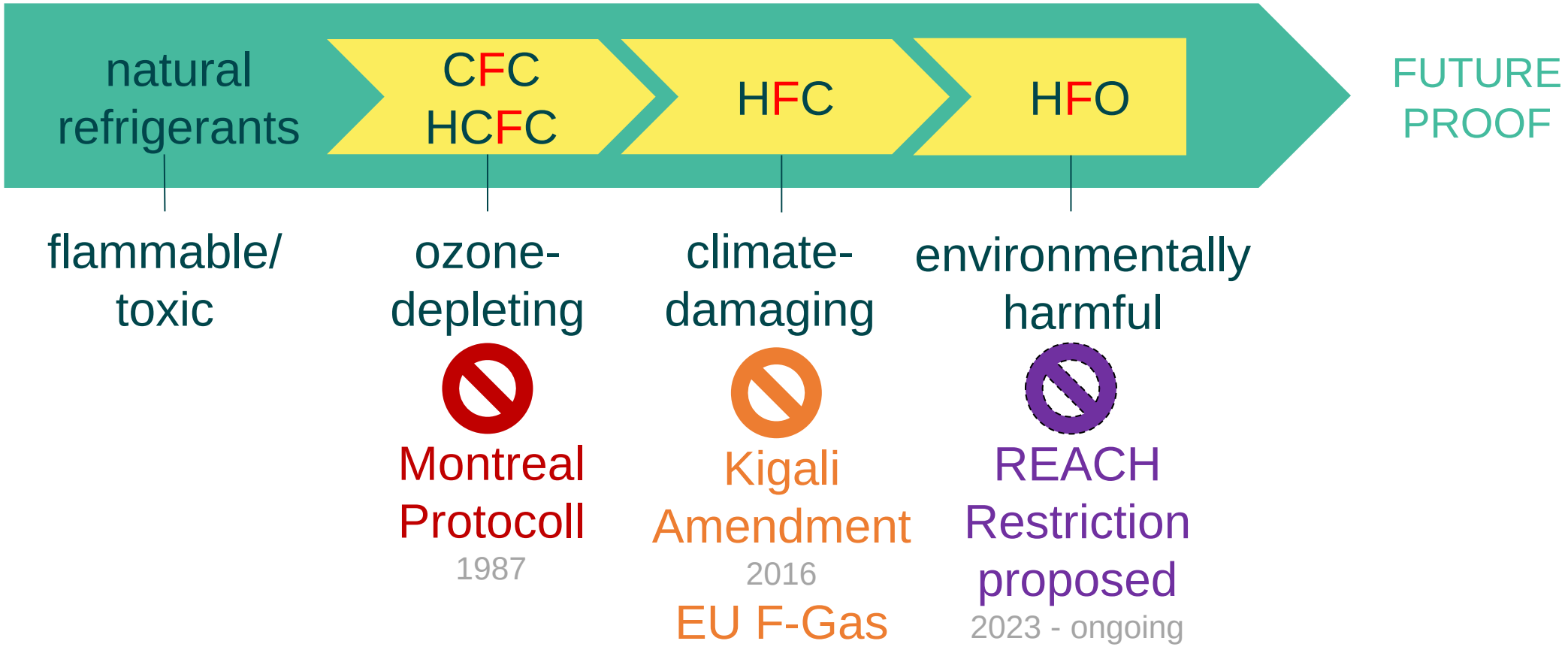
The use of F-gases:
A story of regrettable substitution



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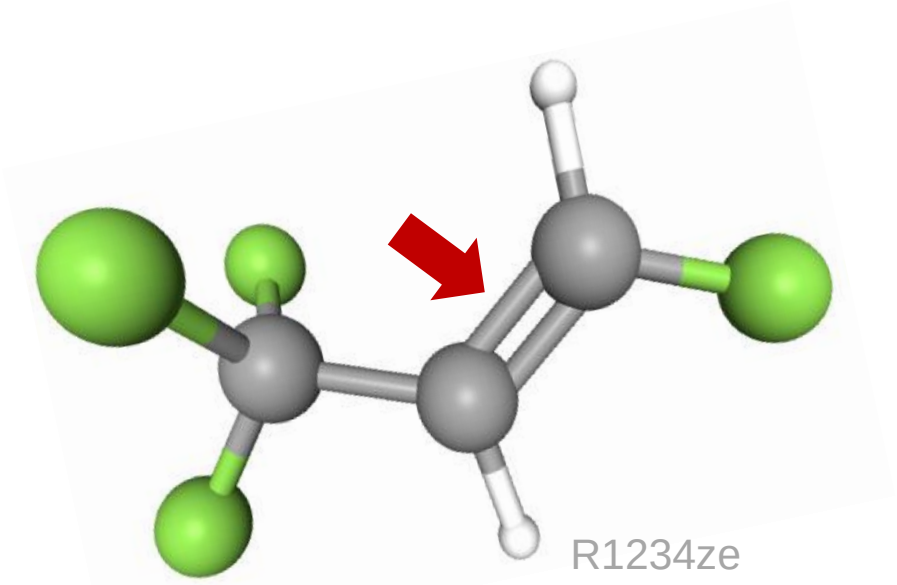
HFOs: instable F-gases

= hydrofluoroolefins

(hydrofluorocarbons with double bond)



Double bond decreases stability of molecule

- lower global warming potentials
- disintegration into stable degradation products (TFA)

➡ Burden shifting: climate → environment

carbon
hydrogen
fluorine

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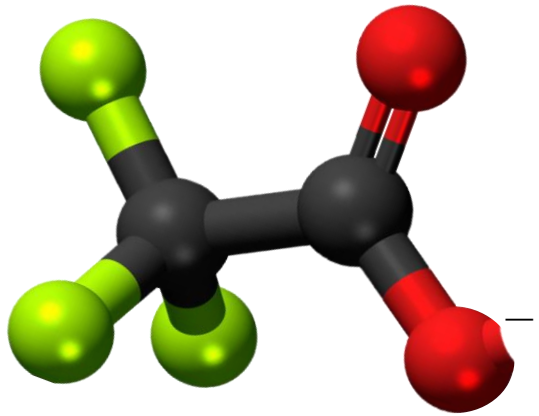
TFA properties

found *everywhere*
most abundant PFAS in environment – in all water bodies, plants, wine, beer, humans, …

degradation product of F-gases
amongst others i.e. pesticides

increasing concentrations
several studies, reviewed in Arp and Gredelj et al.2024



anthropogenic
insufficient evidence for natural TFA: Joudan et al. 2021

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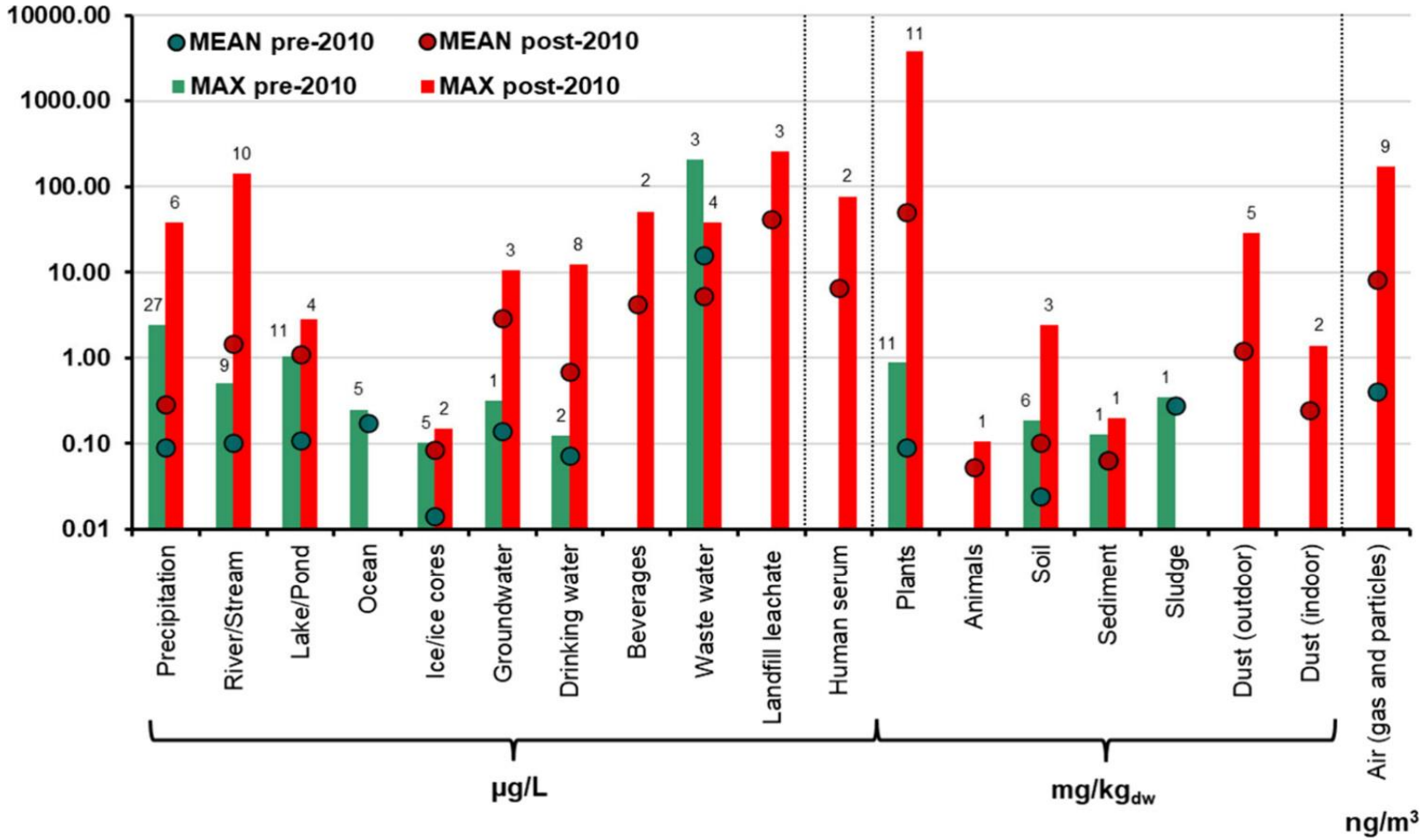
Increasing TFA concentrations



Arp and Gredelj et al.2024:

- comparing pre/post 2010 concentration data in different media
- **significant increase in TFA is evident**
- F-gas „Fun Fact“: increase in deposited TFA after Montreal Protocol measureable
- more data from other media show widespread TFA contamination

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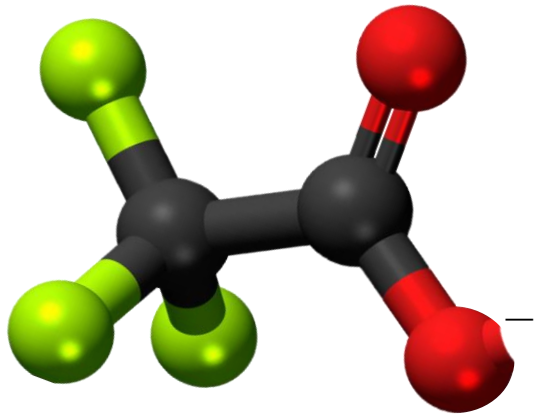
very mobile
high water solubility makes it spread rapidly in water cycle



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cannot be removed
only mechanism is *reverse osmosis*, not feasible, expensive, energy intense, problematic residues, 50 % water loss,…

anthropogenic
insufficient evidence for natural TFA: Joudan et al. 2021

very persistent
cannot degrade naturally, UBA: lifetime practically *indefinite*

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Pavan Chandra

Toxicity of TFA

New animal study with rabbits (2024), TFA given orally

Results:

Offspring showed malformations of the eyes

TFA was toxic on the development of rabbits

TFA = Toxic to Reproduction (*reprotoxic*)

→ Intention by German Authorities to re-classify TFA in CLP

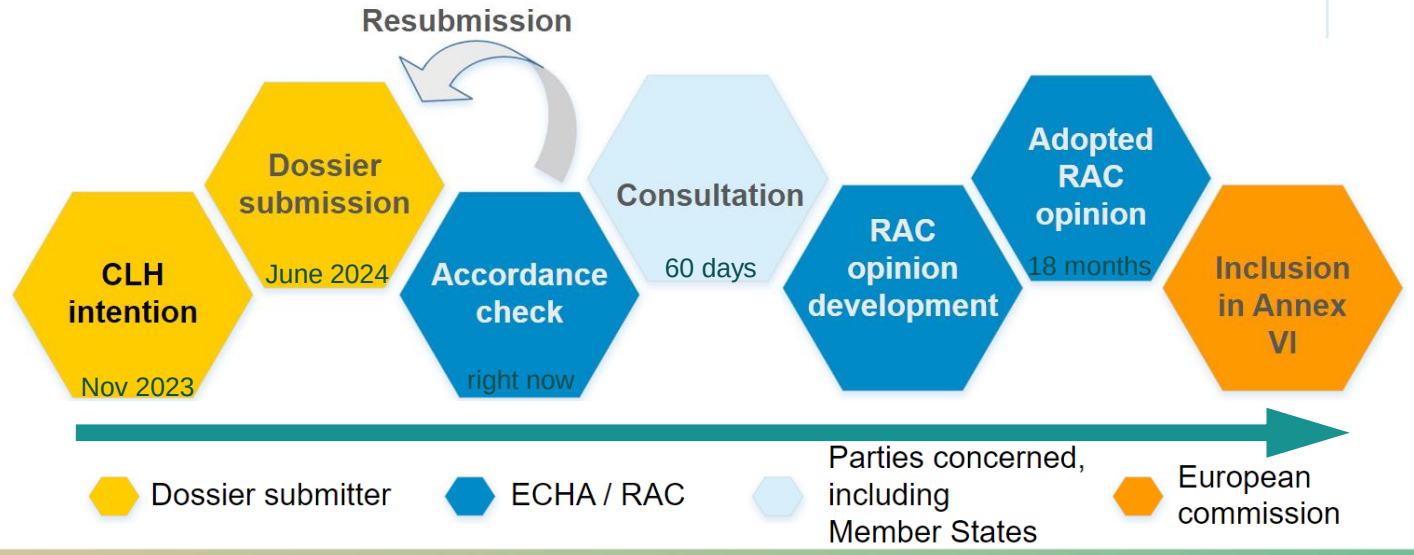
CLP Regulation

EU Regulation 1271/2008 on the **C**lassification, **L**abeling and **P**ackaging of Substances and Mixtures
→ requires manufacturers, importers or downstream users of substances or mixtures to classify, label and package their hazardous chemicals appropriately before placing them on the market

Purpose: hazards presented by chemicals are clearly communicated to workers and consumers

Harmonised classification and labelling (CLH) into different hazard classes:

- Physical Hazards
  (e.g. Flammability)
- Health Hazards
  (e.g. Carcinogenicity)
- Environmental hazards
  (e.g. hazardous to aquatic environment)



CLH intention process

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TFA Re-classification in CLP

Current Classification	Proposed Classification
Acute Toxicity 4, H332 *Harmful if inhaled*	Acute Toxicity 3, H331 *Toxic if inhaled*
Skin Corrosion 1A, H314 *Causes severe skin burns and eye damage*	Skin Corrosion 1A, H314 *Causes severe skin burns and eye damage*
	Reprotoxicity 1B, H360Df *Suspected of damaging fertility; may damage the unborn child*
Aquatic Chronic 3, H412 *Harmful to aquatic life with long lasting effects*	Aquatic Chronic 3, H412 *Harmful to aquatic life with long lasting effects*
	persistent, mobile, toxic (PMT), EUH450 *Can cause long-lasting and diffuse contamination of water resources*
	very persistent, very mobile (vPvM), EUH451 *Can cause very long-lasting and diffuse contamination of water resources*

Consequences for precursors and threshold values in food and drinking water

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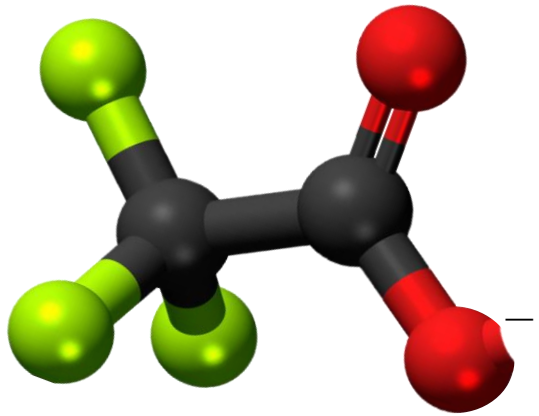

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very mobile
high water solubility makes it spread rapidly in water cycle

anthropogenic
insufficient evidence for natural TFA: Joudan et al. 2021

webinar tip: Dr. Hans Peter Arp

TFA storymap

toxic
classification ongoing
reprotoxic, liver toxicity, incorperation into cells, more research needed – but enough known to restrict!

very persistent
cannot degrade naturally, UBA: lifetime practically *indefinite*

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Interim summary

- PFAS are diverse chemical group, united by their persistence
- PFAS are a threat to people and the environment, crossing planetary boundaries
- F-gases and their degradation product TFA are the main contributor to the PFAS issue

WHAT TO DO?

Marcin Wolski

How to - Restriction of PFAS?

- A few single PFAS bans already in place → restricting single substances e.g. PFOS, PFOA, PFHxS
- Some national bans (Denmark, recently France) banning single applications of PFAS in e.g. food packaging materials, textiles, ski wax
- EU F-Gas Regulation: only very few full F-gas bans = insufficient → climate focus

- Doesn‘t catch the whole problem
- Therefore…

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PFAS Restriction Proposal

- under **REACH**, initiated by 5 EU member states (DE, NL, DK, NO, SE) in 2020
- Restriction on the manufacture, placing on the market and use of PFAS
- > 14 sectors covered
- special: grouping approach for the first time = restriction of whole chemical group
- Proposal includes:
  - Chemical identity of PFAS
  - Hazards, risks, effects
  - Applications
  - Availability of alternatives
  - Socioeconomic analysis impact assessment
  - Draft restriction entry

REACH = Registration, Evaluation, Authorisation and Restriction of Chemicals

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https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

Relevance of F-gases in PFAS Restriction

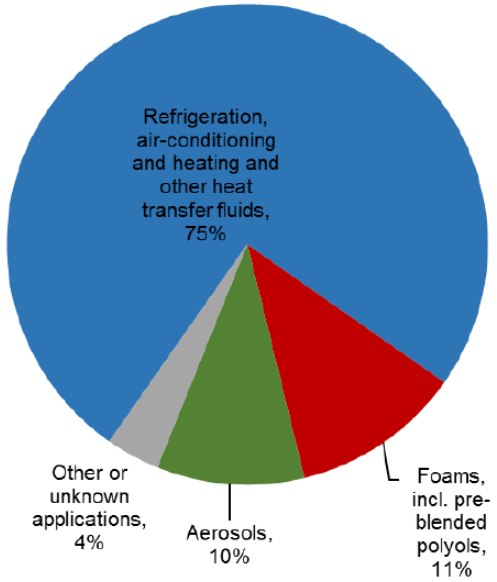
Application	Tonnage range	Emission range % emitted in manufacturing and use phase	Emission contribution Contribution to total emission
Applications of fluorinated gases	5	2	5
TULAC	5	2	4
Medical devices	5	2	3
Manufacture	5	1	2
Food contact materials and packaging	5	1	1
Transport	5	1	1
Construction products	4	3	2
Electronics and semiconductors	4	2	1
Lubricants	4	2	1
Petroleum and mining	4	1	1
Energy sector	4	1	1
Metal plating and manufacture of metal products	3	1	1
Cosmetics	2	5	1
Consumer mixtures	2	4	1
Ski wax	1	3	1

Table legend

Tonnage range (t/y)		Emission range (%)		Emission contribution (%)	
1	0 – 10	1	0 – 5	1	0 – 1
2	10 – 100	2	5 – 25	2	1 – 5
3	100 – 1 000	3	25 – 75	3	5 – 10
4	1 000 – 10 000	4	75 – 95	4	10 – 50
5	>10 000	5	>95	5	>0 – 50

PFAS Restriction Proposal, Annex VX,
Table 4: *Tonnages and emissions of major use sectors and manufacture for 2020*

F-gases constitute the largest proportion of PFAS –
by quantity and emissions!



F-gases are mainly used as refrigerants

European Topic Centre on Climate change mitigation:
ETC CM Report 2022/3 on Fluorinated greenhouse gases 2022

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F-gase in scope of PFAS restriction 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-1,2,2,2-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	HFO-1234ze(E) ***	CHF=CH-CF3
21	Trans-1,1,1,4,4,4-hexafluorobut-2-ene	HFO-1336mzz(E)	CF3-CH=CH-CF3
22	Cis-1,1,1,4,4,4-Hexafluoro-2-butene	HFO–1336mzz(Z)	CF3-CH=CH-CF3
23	(Z)-1-Chloro-2,3,3,3-tetrafluoropropene	HCFO-1224yd *	CHCl=CF-CF3
24	Trans-1-chloro-3,3,3-trifluoropropene	HCFO-1233zd(E) **	CHCl=CH-CF3
25	2-Bromo-3,3,3-trifluoroprop-1-ene	BTP, 2-BTP, Halotron BrX	CH2=CBr-CF3

- includes almost all F-gases
- discussions about derogations and transition times

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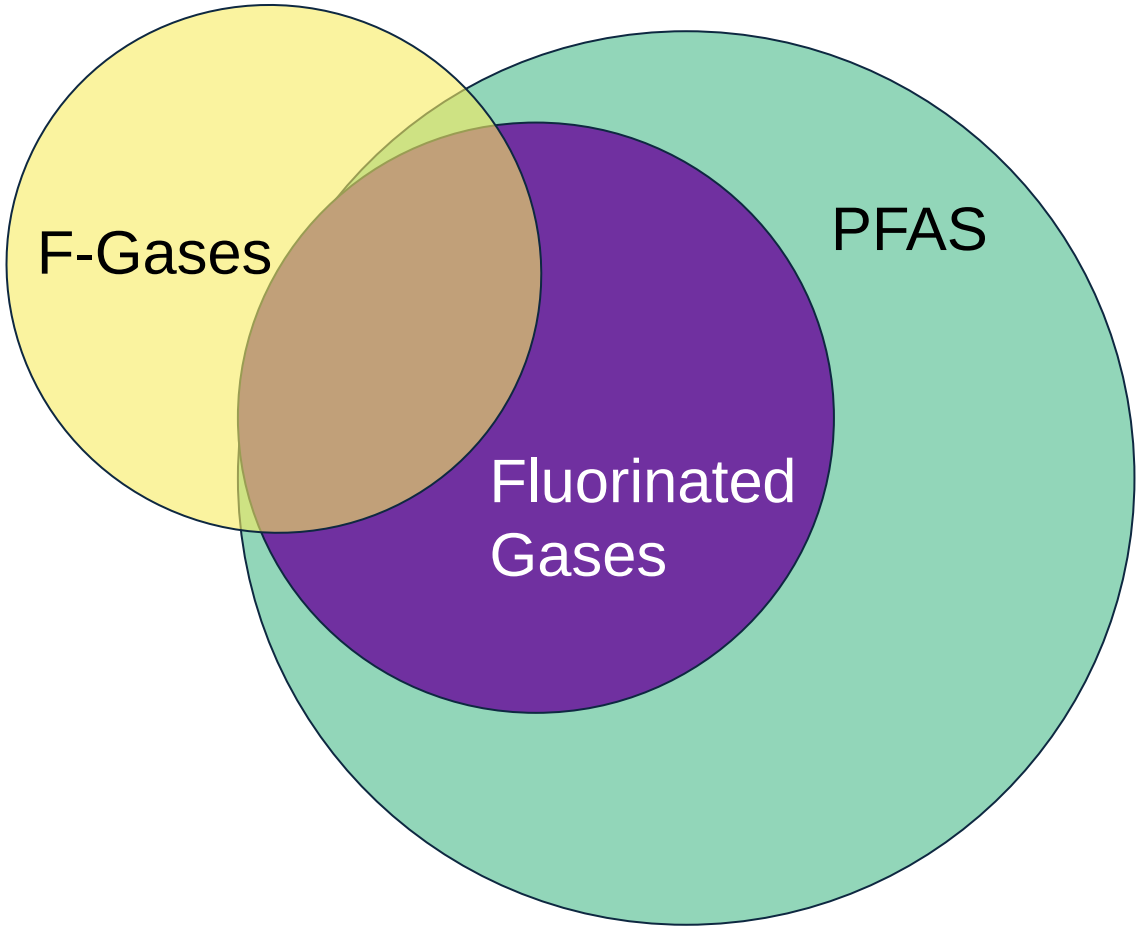
Fluorinated Gases in PFAS restriction



- *F-Gases*:
  restricted in EU F-Gas Regulation
  (e.g. HFCs, HFOs, SF6, NF3, SO2F2, …)
- *Fluorinated Gases*:
  in scope of uPFAS restriction (HFCs, HFOs, monomers for fluoropolymer production)

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ECHA (2023) uPFAS Annex XV dossier, annex a Figure A.5.

PFAS Restriction Options

- Restriction based on risk and socioeconomic analysis + availablility of alternatives
- *Option 1*: full ban of all uses = manufacture, placing on the market and use, transition time 18 months after Entry into Force (EiF)
- *Option 2*: ban with use-specific derogations (18 months + 5 or 12 years)

i.e.:
- maintenance and refilling of existing HVACR equipment put on the market before [18 months after EiF] and for which no drop-in alternative exist until 13.5 years after EiF;
- refrigerants in mobile air conditioning-systems in combustion engine vehicles with mechanical compressors until 6.5 years after EiF;
- refrigerants in HVACR-equipment in buildings where national safety standards and building codes prohibit the use of alternatives (time-unlimited)

ECHA Committees are currently assessing justification of derogations, including evidence from the responses to the Public Consultation → PROCESS

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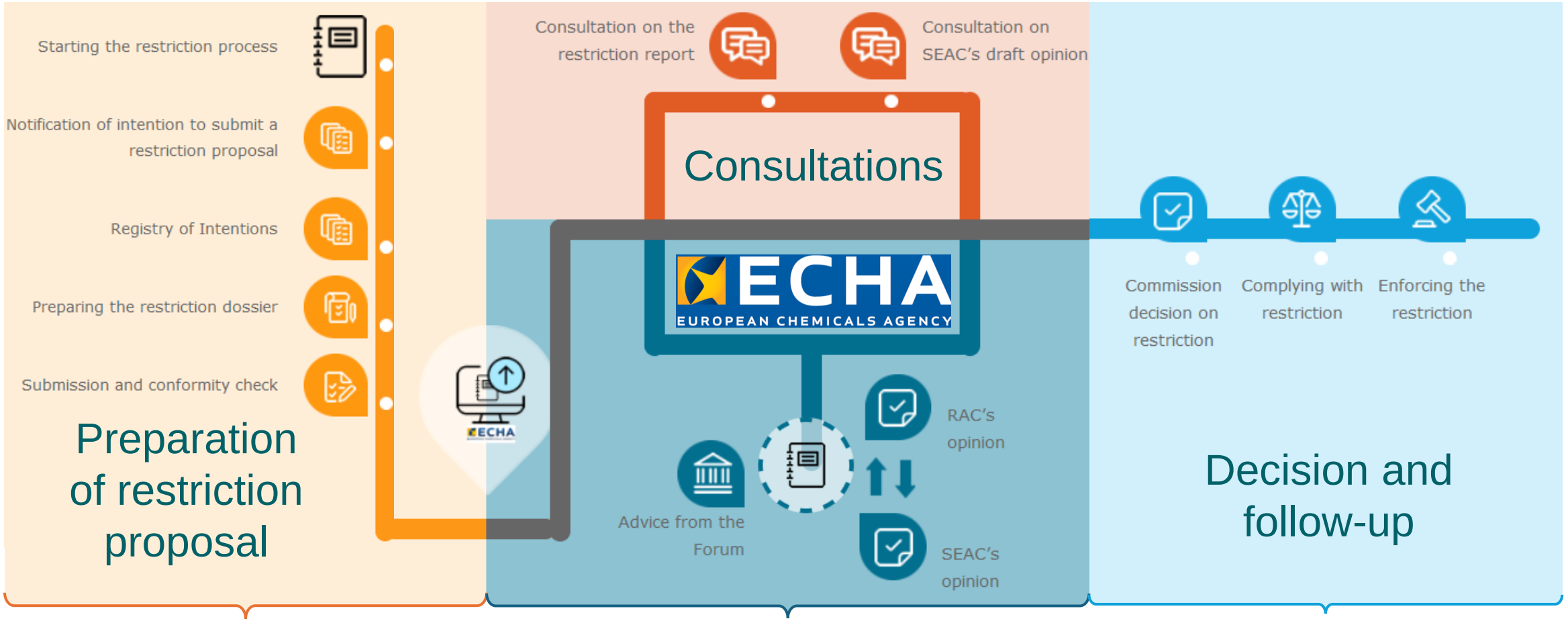
PFAS Restriction Process



Dossier Submitter
(Member States)

EU Chemicals Agency (ECHA)
Not a political body!
No decision making!

EU Commission: REACH Committee (DG GROW, DG ENV)
+ Parliament & Council Scrutiny

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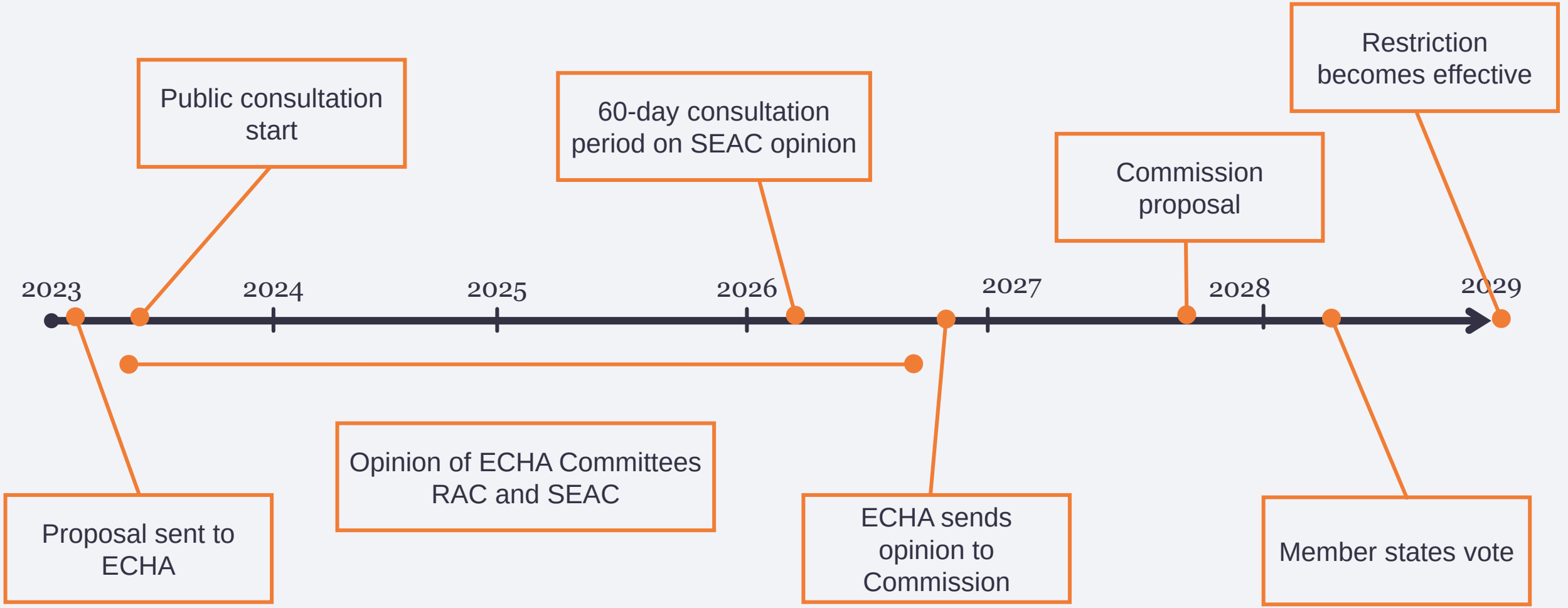
RAC: Risk Assessment Committee, SEAC: Socio-Economic Analysis Committee https://echa.europa.eu/restriction-process

POSSIBLE TIMELINE FOR THE PFAS RESTRICTION?



chemsec
INTERNATIONAL CHEMICAL SECRETARIAT

Summary PFAS Restriction

- not a blanket ban!
- restriction proposal is highly differentiated and considers risks, socioeconomic aspects and availability of alternatives carefully

→ no valid argument against restriction!

- F-gases are insufficiently regulated by EU F-gas Regulation: further restriction under uPFAS restriction in REACH is needed

→ restriction is complementary, not double

ANY OTHER FACTORS BESIDES LEGISLATION?

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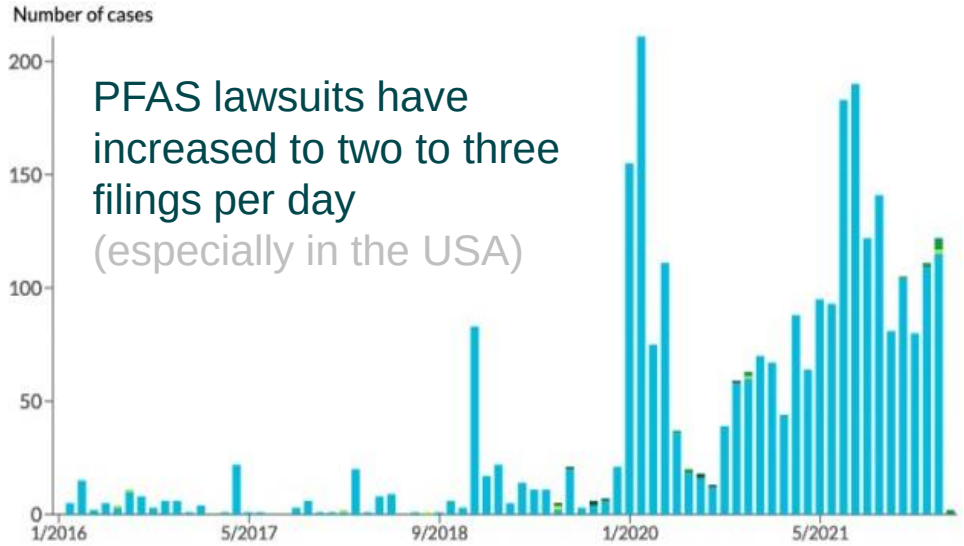
PFAS business risks

- problems with investors, insurance and societal reputation
- limited availability of F-gases (due to different regulations)
- rising costs
- dependence on F-gas producers (mostly outside EU)
- legal certainty no longer given e.g. exponential increase in PFAS lawsuits



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*https://www.insidepandc.com/article/2a67nn7z6vxqd6ujz3fgg/commercial-lines/looming-regulations-on-forever-chemicals-could-create-400bn-in-cleanup-liabilities

A future-proof company

- **Has supply chain management**
  What are we buying /selling?
- **Follow legislative processes**
  What can we buy and sell tomorrow?
- **Can fulfil green customer demands**
  To whom can we sell?
- **Knows its impact on the environment, consumers, workers health**
  We are doing OK
- **Has confident investors and insurers**
  No hesitation due to chemicals risk
- **Has long term planning and potential for innovation**
  The company has a clear role in the future's overall sustainable development

chemsec
INTERNATIONAL CHEMICAL SECRETARIAT

Sustainable Alternatives: *natural refrigerants*

= Gases of natural origin

- ammonia (R717)
- CO_2 (R744)
- hydrocarbons (i.e. propane (R290), butane (R600a))
- water (R718)

- ✓ **climate friendly**: global warming potentials ≤ 1
- ✓ **environmentally friendly**: no derogation products
- ✓ **future-proof**: non-patented, accessible, safe from restriction
- ✓ **efficient**
- ✓ **marked-ready**

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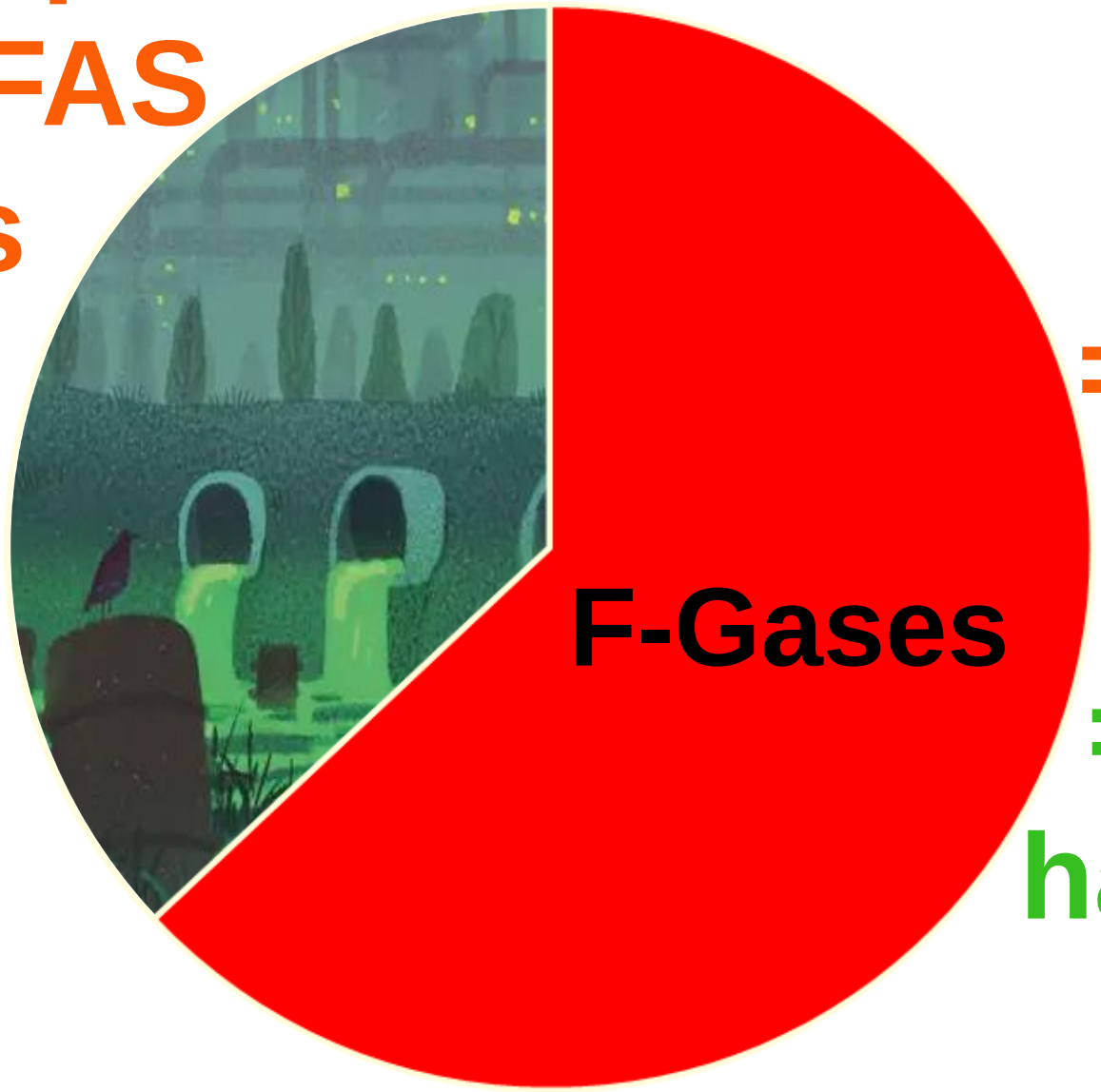
F-gases represent 63 % of PFAS emissions



= main contributor

= low hanging fruit

Deutsche Umwelthilfe

YOU CAN SOLVE THE F-PROBLEM

- Take responsibility: STOP cycle of regrettable substitution of F-gases
- Natural alternatives are technologically possible, available & favourable for almost all F-gas uses + more R&D ongoing
- Don‘t wait on regulations, transition away from F-gases NOW
- Be outspoken + use PFAS free in your advertising

Switching to PFAS-free alternatives is the **WIN-WIN-WIN situation** for people, planet and profit

#GoNatRefs

Thank you for your attention – let‘s #GoNatRefs & #BanPFAS

Questions?

Christine Luetzkendorf
Policy Adviser Fluorianted Gases
Deutsche Umwelthilfe e.V.
luetzkendorf@duh.de

References

- Hans Peter H. Arp and Andrea Gredelj, Juliane Glüge, Martin Scheringer, and Ian T. Cousins: The Global Threat from the Irreversible Accumulation of Trifluoroacetic Acid (TFA), Environmental Science & Technology 2024 58 (45), 19925-19935, *DOI: 10.1021/acs.est.4c06189*
- Hans Peter Arp Webinar on TFA*: https://www.healthandenvironment.org/che-webinars/96949*
- **CLP Intention to re-classifiy TFA**: https://echa.europa.eu/fr/registry-of-clh-intentions-until-outcome/-/dislist/details/0b0236e188e6e587
- **CLH intention process**: https://echa.europa.eu/regulations/clp/harmonised-classification-and-labelling?panel=check#check
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