Alternatives to PFAS

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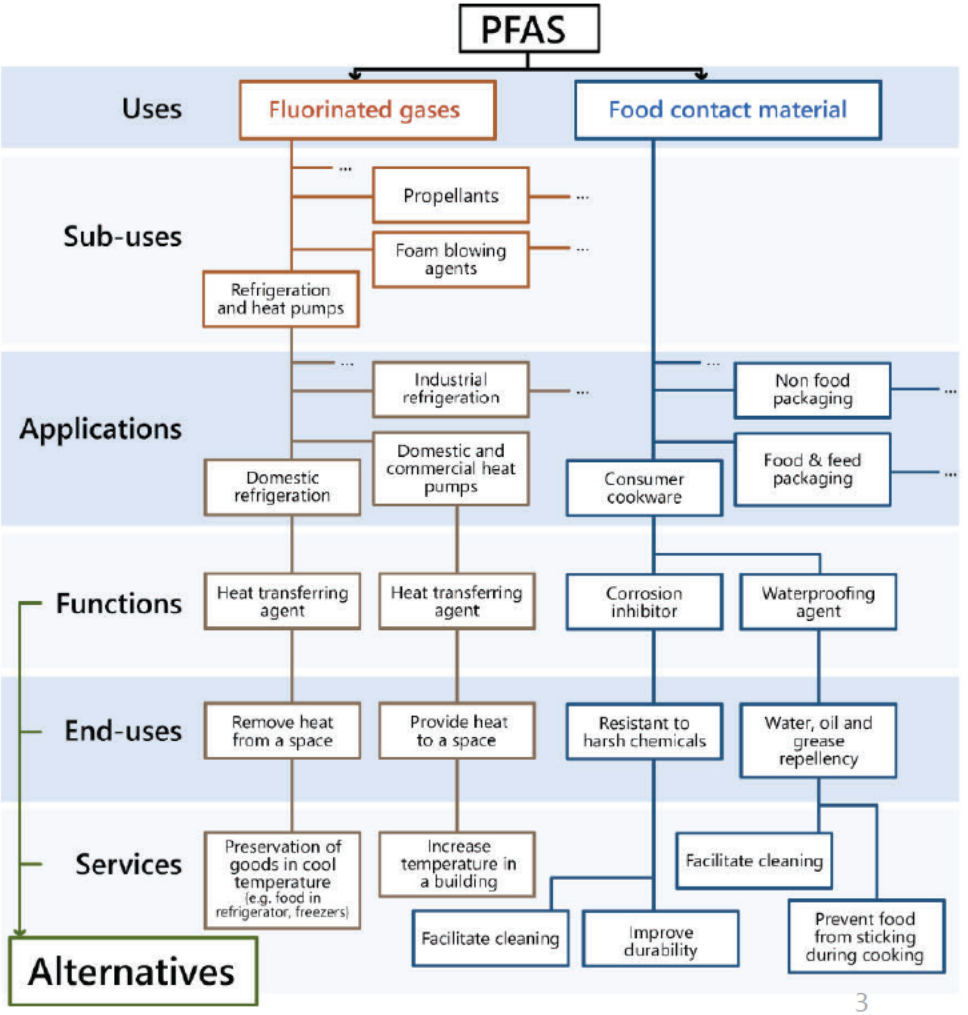
Build a database of potential chemical and functional alternatives

- Online database structured following the concept of functional substitution
  - https://zeropm.eu/alternative-assessment-database/
- PFAS restriction is the main source of information
- Complemented with ChemSec Marketplace, and other specific sources

Functional Substitution Level	**Chemical in Product** Bisphenol-a in Thermal Paper	**Chemical in Process** Methylene Chloride in Degreasing Metal Parts
Chemical Function (Chemical Change)	Is there a functionally equivalent chemical substitute (i.e., chemical developer)? **Result: Drop-in chemical replacement**	Is there a functionally equivalent chemical substitute (i.e., chlorinated solvent degreaser)? **Result: Drop-in chemical replacement**
End Use Function (Material, Product, Process Change)	Is there another means to achieve the function of the chemical in the product (i.e., creation of printed image)? **Result: Redesign of thermal paper, material changes**	Is there another means to achieve the function of the process (i.e., degreasing)? **Result: Redesign of the process** (e.g., ultrasonic, aqueous)
Function As Service (System Change)	Are cash register receipts necessary? Are there alternatives that could achieve the same purpose (i.e. providing a record of sale to a consumer)? **Result: Alternative printing systems** (e.g., electronic receipts)	Is degreasing metal parts necessary? Are there other alternatives that could achieve the same purpose (i.e., providing metal parts free of contaminants for other end uses)? **Result: Alternative metal cutting methods**

Structure of the database

- Database divided per use categories of PFAS
- For each use category
  - List of applications of PFAS along with the technical function, end use function and service of PFAS for each application
  - List of PFAS substances identified as being used for each application
  - List of identified potential alternatives to PFAS for each application



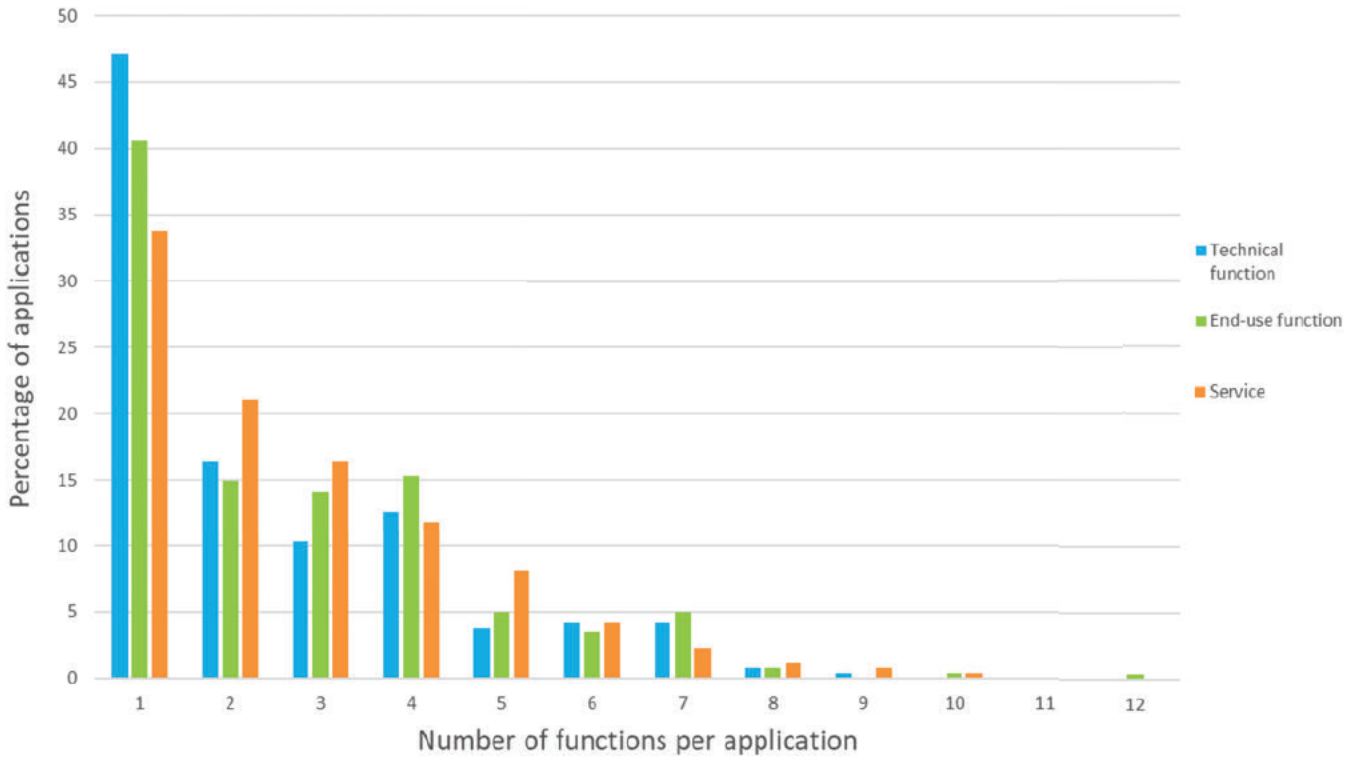
Uses and functions of PFAS

- 18 use categories of PFAS included in the database
- Waterproofing agent, heat stabilizer and corrosion inhibitor are the most common technical functions
- PFAS often used for enhancing durability

Use categories	Sub-uses	Applications	Technical functions	End-use functions	Services
Active pharmaceutical ingredients	2	13	1	24	21
Biocides	1	4	1	4	4
Building and construction products	8	16	14	18	30
Consumer mixtures	6	13	6	9	9
Cosmetic products	5	30	9	12	6
Electronics and semiconductors sector	3	31	17	24	41
Energy sector	12	21	18	20	25
Firefighting foams	1	5	1	1	3
Fluorinated gases	7	32	8	14	30
Food contact materials	3	5	4	4	10
Lubricants	3	27	11	13	19
Manufacture of fluoropolymers	1	7	1	1	3
Medical products	13	20	13	17	29
Metal plating and metal products manufacture	2	4	8	10	14
Petroleum and mining	2	8	10	13	15
Plant Protection Products	1	5	1	5	2
Textile, upholstery, leather, apparel, and carpets	6	16	9	13	19
Transport sector	11	37	18	29	61
Grand Total	**80**	**261**	**37**	**110**	**201**

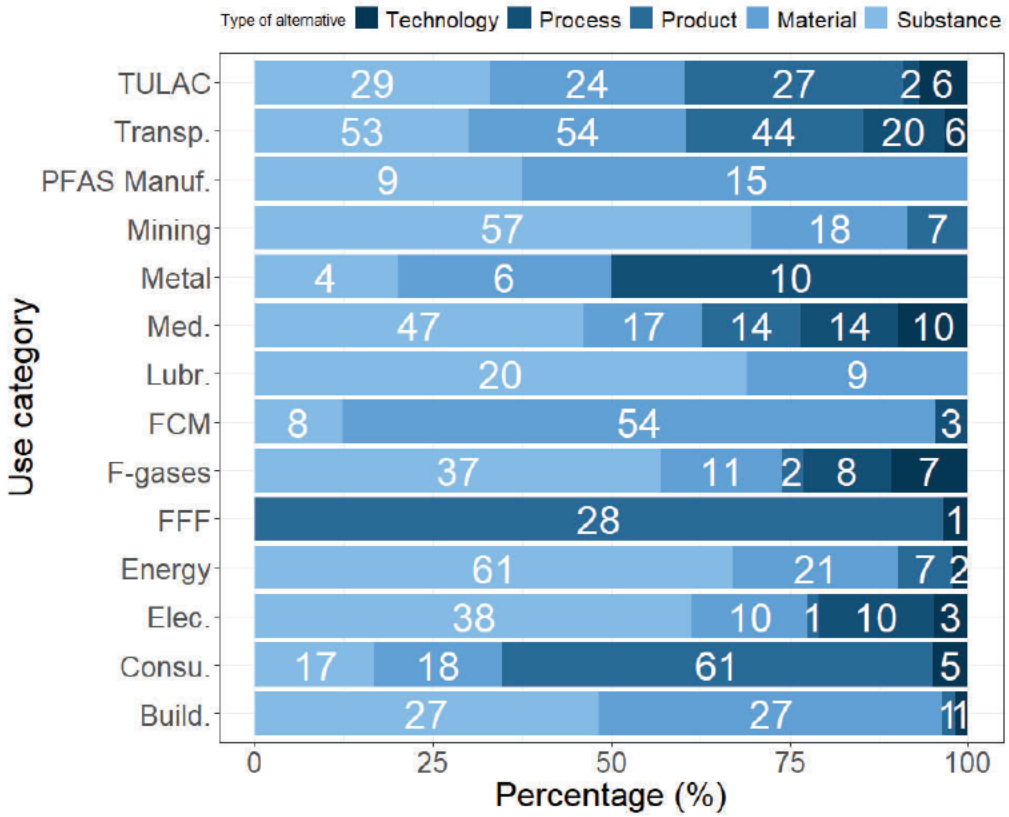
Uses and functions of PFAS

- PFAS deliver more than one function in many applications
- 12 different functions in one application



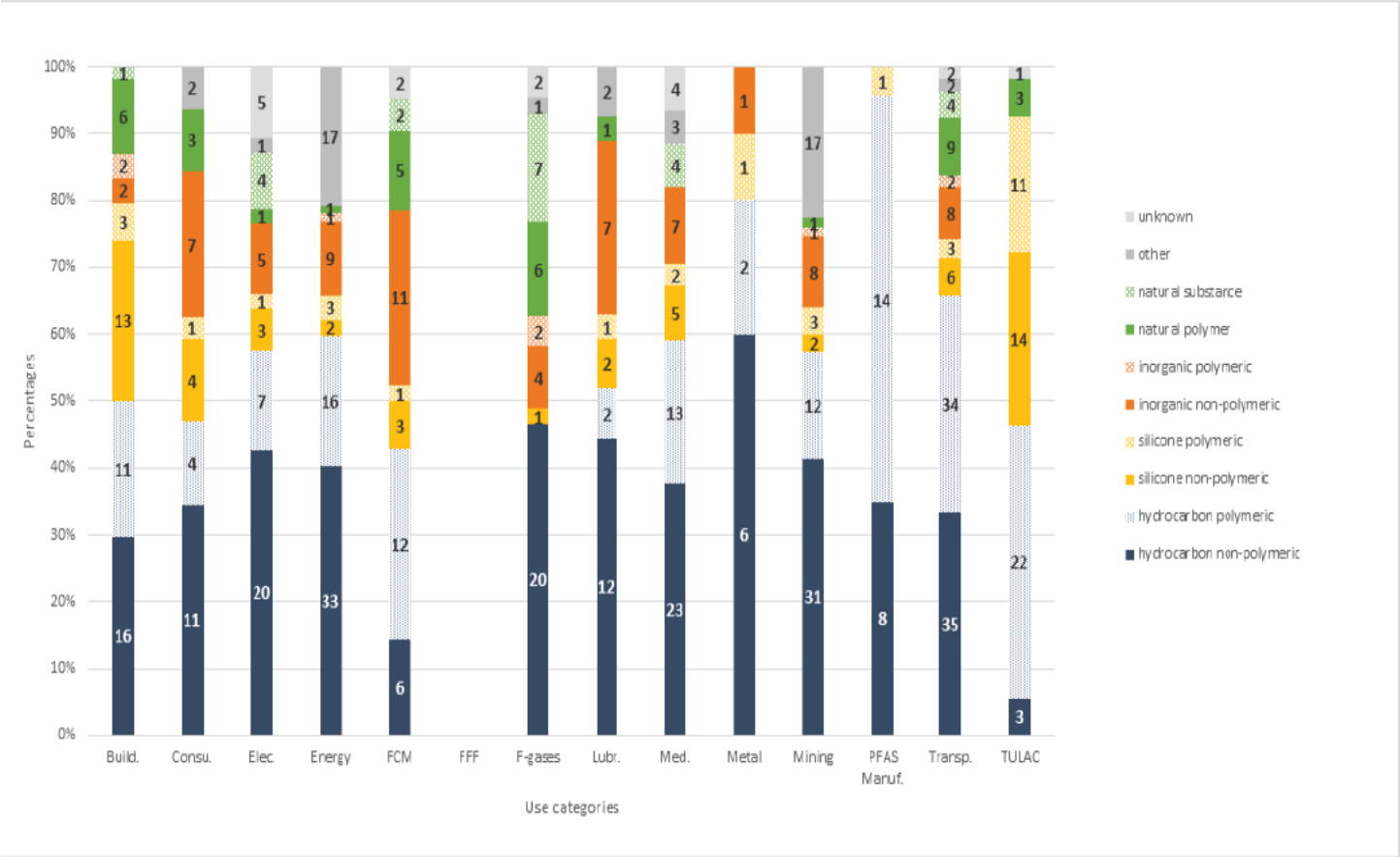
Alternatives to PFAS

- Database includes 563 different potential alternatives across 15 use categories
  - 98 alternatives in Marketplace
  - Unfortunately, suppliers of alternatives confidential in restriction proposal
- No alternatives found for 50 applications



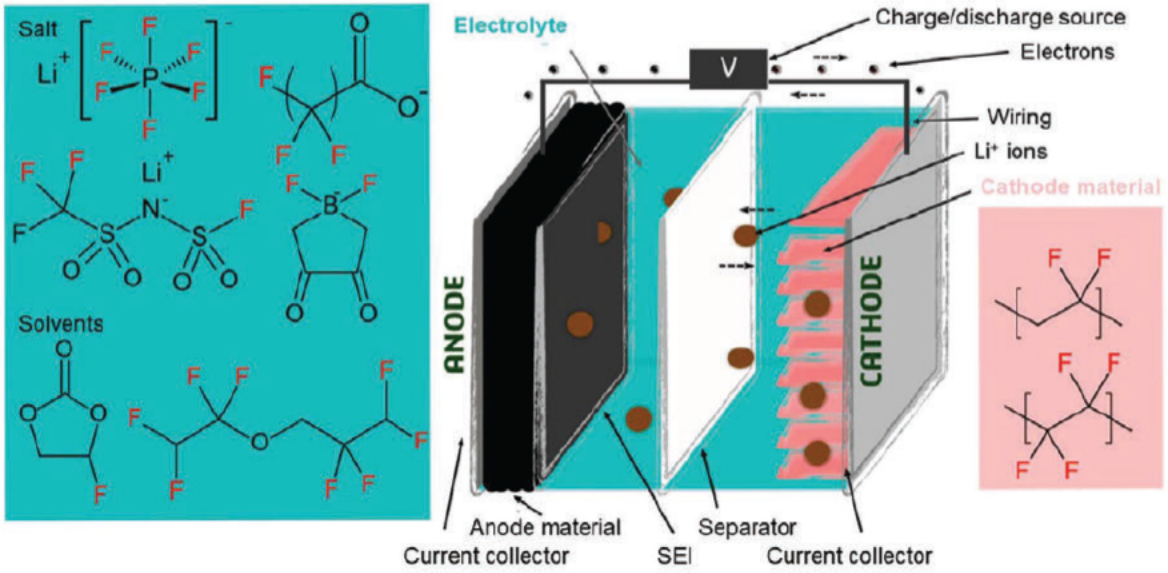
Nature of alternatives to PFAS

- Only data on alternative substances and materials included
- Similar analysis will be done for alternative products
  - E.g. FFFs



Are PFAS necessary for the green energy transition?

PFAS in Lithium-Ion Batteries (LIBs)



Persistent and mobile ionic liquids

Fluoropolymers (especially PVDF)

Environmental Science Processes & Impacts

ROYAL SOCIETY OF CHEMISTRY

CRITICAL REVIEW

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Lithium-ion battery recycling: a source of per- and polyfluoroalkyl substances (PFAS) to the environment?

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Alternatives to PFAS in LIBs

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

Use sector (with sub-uses)	Alternatives	Cost impact
	PEEK). These alternatives are however also claimed to be less durable, e.g. due to lower chemical resistance. Given the good gas-permeability and lower cost, replacement of substituted elastomers is reported to be desirable when possible. In addition, there is weak evidence pointing to lower flame-retardant properties. As such, alternatives might not be technically feasible for applications with particularly high stability, and durability and flame-retardance requirements. Weak evidence, based on information from one stakeholder, that alternatives for gasket material for nuclear power plants exist but are less durable. Weak evidence that technically feasible alternatives exist for gaskets, tubes, and inliners of pipes/tanks used in relation to non-PEM electrolysis technologies. Weak evidence that alternative batteries, e.g. PFAS-free solid-state batteries could be used as a substitute for lithium-ion and flow batteries. While stakeholders report that there might be alternatives to PFASs for use in solid-state batteries, the feasibility of using such batteries as a replacement for flow batteries is still investigated. Inconclusive evidence for uses not mentioned above: Several stakeholders point out that alternatives are not available. However other stakeholders confirm that it is likely that alternatives are already available or might be found for a lot of components depending on concrete circumstances for each use.	

107

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

Use sector (with sub-uses)	Alternatives	Cost impact
	Conclusion: • High substitution potential at EiF for photovoltaic cells [sufficiently strong evidence] • High substitution potential at EiF for at least some applications of sealing materials in PEM fuel cells [sufficiently strong evidence] and for gasket material for nuclear power plants and gaskets, tubes and inliners used in relation to non-PEM electrolysis technologies [weak evidence] • High substitution potential at EiF for at least some battery applications [weak evidence] • Low substitution potential at EiF for membrane applications and reinforcement materials in PEM fuel cells [sufficiently strong evidence] • Unclear substitution potential at EiF for all other uses [inconclusive evidence]	

Industry claims **fluoropolymers** are needed, especially for the green transition

They say that there are no viable alternatives

And deny that the types of PFAS used cause any problems

RECHARGE

ADVANCED RECHARGEABLE & LITHIUM BATTERIES ASSOCIATION

PFAS restriction proposal

RECHARGE statement for 2nd Call for Evidence – October 2021

KEY MESSAGES:

- A sustainable and competitive batteries industry is essential in Europe's energy transition and in reaching the EU 2050 climate goals.
- No alternatives are available for the use of PTFE and of PVDF in primary Lithium and Lithium-ion technologies and these fluoropolymers will also be used in solid-state batteries.
- RECHARGE advocates for the segmentation of the PFAS family of substances before performing any grouping-based assessment.
- Environmentally stable compounds such as Fluoropolymers Products needs to be placed in a separate category so they can continue to contribute to a sustainable and competitive batteries industry, critical for the EU Green Deal's goals.
- There should be only restrictions in the case of unacceptable risks (REACH art 68).

Alternatives to PFAS in LIBs

- Talked to people from industry and academia
- Focused on binder material and electrolyte

Binder

3 alternatives:
- water-soluble polymeric binders
- 3D nanocarbon binding structure
- binder-free technology

- Unclear about large scale potential
- PVDF still dominating

Next generation technologies

- Solid state batteries (e.g. fluoropolymers)

Electrolyte

- PFAS salts at low concentrations improve performance
- $LiPF_6$ sufficient as main salt
- Electrolyte composition depends on performance requirements

Conclusions

- Encouraging that so many alternatives to uses of PFAS already available and transitions have occurred or happening
- Challenges remain:
  - Unique properties of PFAS offering multiple functions
  - Some applications with no available alternatives currently available
  - Ensuring no regrettable substitutions (alternatives assessment)
  - Resistance from some industries
- Green energy transition being used as a "free pass" for derogations
  - Denying the problems with PFAS
  - Claims that no alternatives to PFAS when there clearly are
  - Adaption to new processes and materials likely costly and time consuming
- PFAS restriction is an opportunity for innovation and for Europe to be world leaders