SCIENCE TO ACTION

"From Science to Action" and industrial chemicals guidance for the Stockholm Convention – BRS workshop

Buenos Aires | 28.03 to 03.03 2023

Substituting POPs and avoiding regrettable substitution – science based assessment of alternatives

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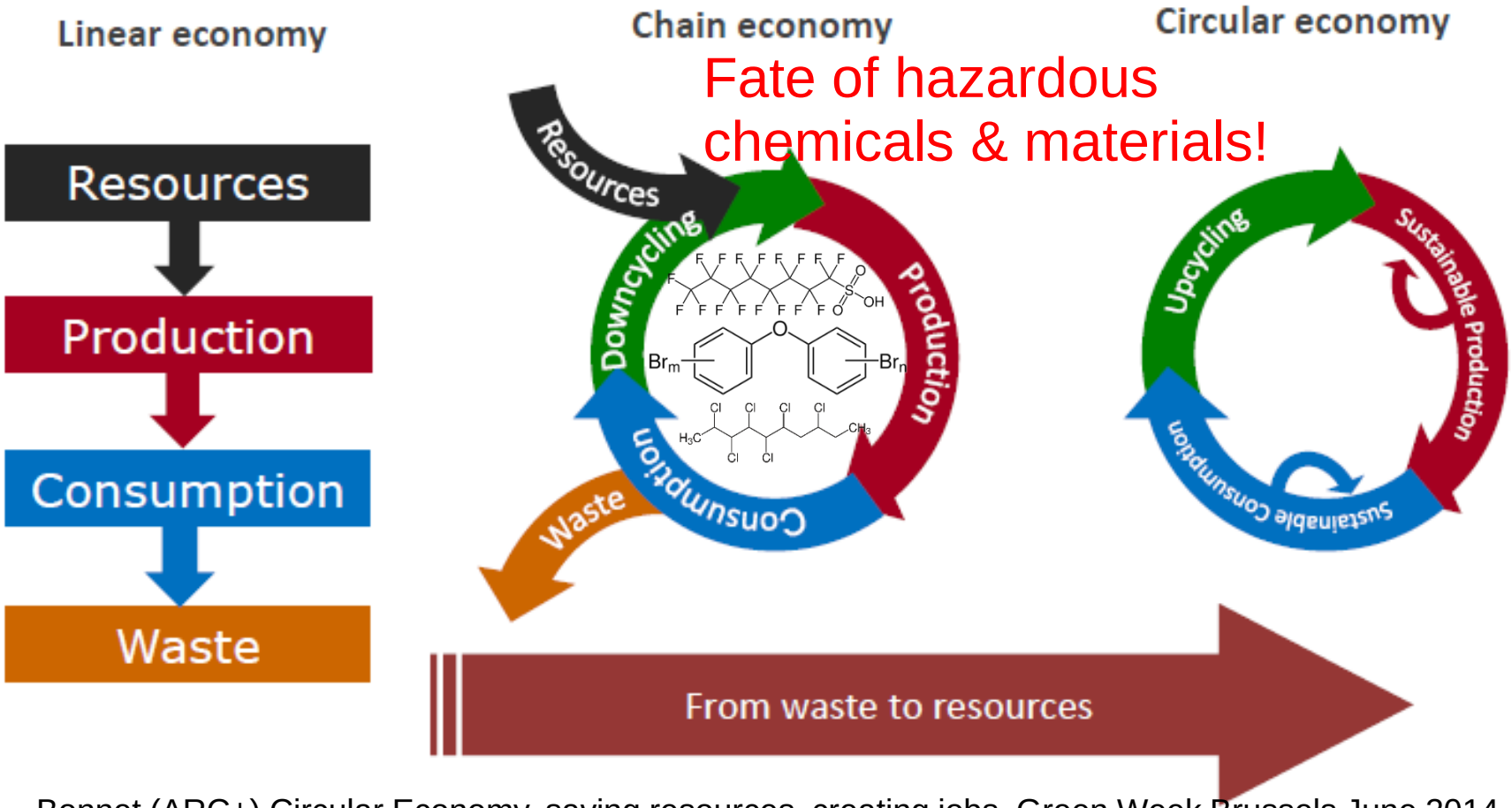
https://scholar.google.com/citations?user=-Cexto4AAAAJ&hl=en

BASEL / ROTTERDAM / STOCKHOLM
CONVENTIONS

Need & challenge to move to Circular Economy

Considering the waste crises and the limit of resources, humanity needs to move to circular economy (stressed by GEF, UNIDO, EU)

http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2015_env_065_env+_032_circular_economy_en.pdf



Bonnet (ARC+) Circular Economy, saving resources, creating jobs, Green Week Brussels June 2014

When moving to a (more) Circular Economy, POPs and other hazardous chemicals need to be controlled and phased out.

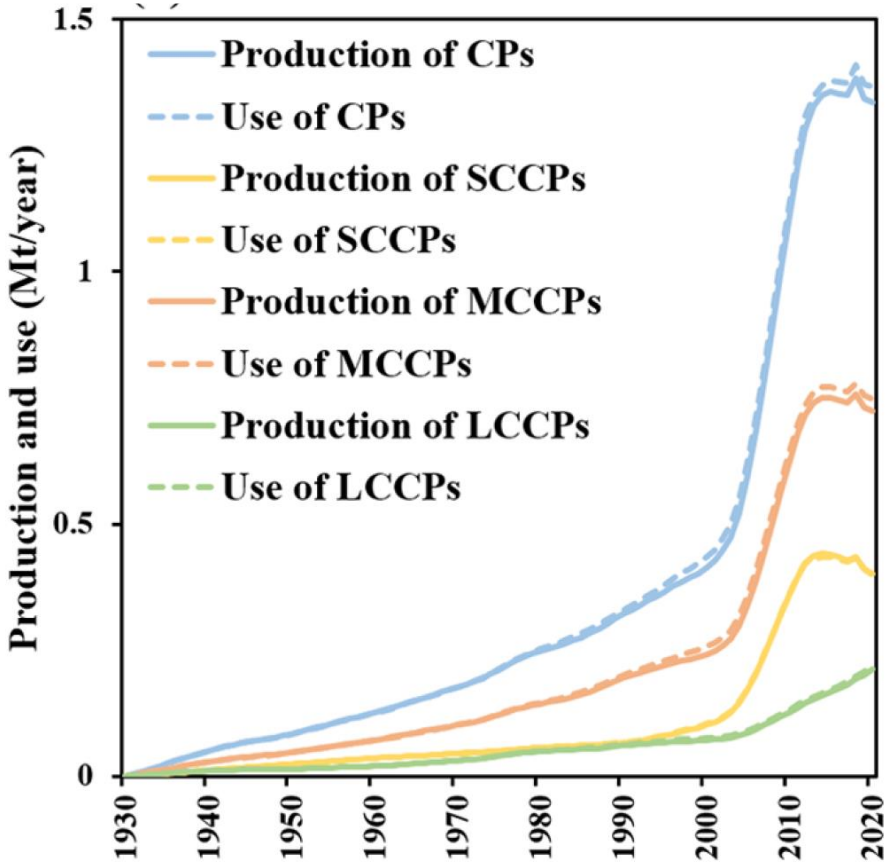
POPs regulatory limits – recycling challenge

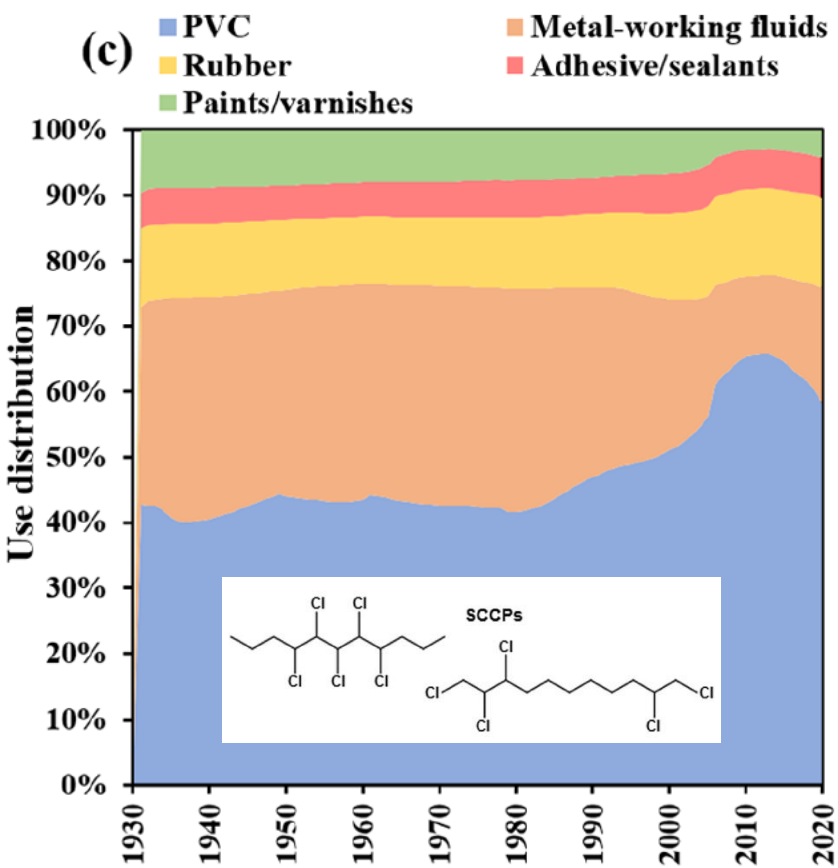
- DecaBDE listed in Stockholm Convention 05/2017 – with exemptions (plastic electronic & vehicles, textiles, polyurethane in construction).
- **No recycling exemption for DecaBDE containing materials.**
- Two provisional Basel Convention low POPs limits pending for decisions (50 ppm and 1000 ppm). **If 50 ppm would become limit** it would have considerable **impact** on **recycling** of WEEE/other plastics.
- When now selecting alternatives for DecaBDE **and other POPs green/sustainable alternatives** need to be chosen which do not threaten but facilitate recycling of affected material flows in future.




Experience with PCB: Future recycling challenge with CPs

- Chlorinated paraffines (CPs) have substituted PCBs in a wide range of applications. (e.g. cutting oils, paints, sealants; flame retardants in plastic).
- SCCPs listed as POPs (05/2017) and MCCP in POPs Review Committee.
- **Large recycling streams are at risk to become contaminated (PVC, rubber, leather, oil, textiles) with future recycling challenge as discovered with PCBs.**

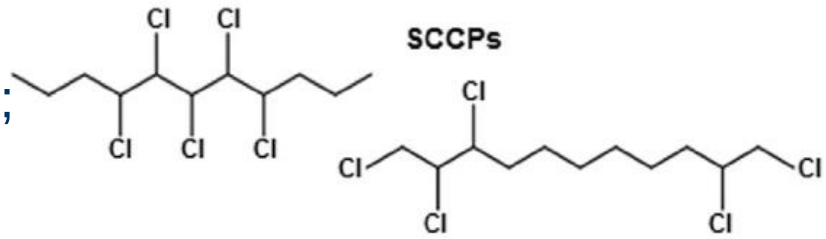




Chen et al. (2022) Environ. Sci. Technol. 56, 7895–7904.

Chlorinated paraffines - PBT alternatives for PCBs in use

- The Stockholm Convention listing of SCCP (05/2017) included a wide range of exemptions (basically all major uses):
  - Additives in the production of transmission belts in the natural and synthetic rubber industry;
  - Fatliquoring of leather;
  - Lubricant additives, in particular for engines of automobiles, electric generators and wind power facilities, and for drilling in oil and gas exploration, petroleum refinery to produce diesel oil;
  - Tubes for outdoor decoration bulbs;
  - Waterproofing and fire-retardant paints;
  - Adhesives;
  - Metal processing;
  - Secondary plasticizers in flexible polyvinyl chloride, except in toys and children's products.



⇒ SCCP further produced and used and will impact recycling/circular economy.

⇒ Therefore assessment/development of alternatives and substitution needed with more green and sustainable chemicals.

PFOA - Specific Exemptions SC (Annex A)

Several exemptions(Alternatives needs phase-in 5 year)

- Firefighting foam;
- Textiles for oil- and water-repellency for the protection of workers from dangerous liquids that comprise risks to their health and safety (surgical coat);
- Photographic coatings applied to films;
- Invasive and implantable medical devices;
- Photolithography or etch processes in semiconductor manufacturing;
- Manufacturing plastic accessories for car interior parts; and
- Manufacturing electrical wires
- Manufacturing fluorinated polymers;
- Manufacturing perfluoropolymers







Therefore efforts and assessment needed to substitute with better alternatives

Substitution of POPs is essential aim of the Stockholm Convention

- **One of the essential aims of the Stockholm Convention is to support the transition to safer alternatives.**
- Many of the POPs targeted by the Stockholm Convention are already obsolete. They have been banned and are not produced any more. Replacement chemicals and techniques are in place.
- But with POPs with exemptions, **the transition to safer alternatives require effort**. Alternatives may be more expensive and their manufacture and use more complicated. That could put developing countries in an awkward spot – struggling from day to day, the world's poor tend to use what they can afford and what is available.
- Parties also need to make sure the alternatives **do not** have POPs or CMR properties or other. Although it is difficult to fully evaluate potential risks of alternatives**, the replacement of POPs should not result in creating other problems but solutions!**

Source: Stockholm Convention Website on "Alternatives"
http://chm.pops.int/Implementation/Alternatives/Overview/tabid/5834/Default.aspx

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Substitution of chemicals: Definition

There is no standard definition of substitution of chemicals but different stakeholders made statements.

- Substitution is *"...the replacement of one substance by another with the aim of achieving a lower level of risk."* - *CEFIC*
- *"… the replacement or reduction of hazardous substances in products and processes by less hazardous or non-hazardous substances, or by achieving an equivalent functionality via technological or organisational measures."* - *Lohse/Lissner (2003)*
- *"The Principle of Substitution states that hazardous chemicals should be systematically substituted by less hazardous alternatives or preferably alternatives for which no hazards can be identified."* - *Greenpeace*

Some examples of substitution of chemicals

- PFAS by less persistent chemicals in hydrophobing textiles
- HBCD by polymeric flame retardant
- Nickel-cadmium batteries by lithium-ion batteries
- Asbestos by bio-soluble mineral fibers
- Dichloromethane as paint stripper by esters
- High volatile cleaner by low volatile cleaners
- Laboratory solvent hexane by heptane
- Lead-free soldering in the electronics industry

Why is substitution necessary?

- Legal requirements (occupational safety, environmental protection, consumer protection).
- For more environmentally sound recycling and disposal.
- For more favorable safety measures – handling, storage and use.
- Requirements within the supply chain.
- Green and innovative company image as a competitive advantage.

Why is substitution of chemicals necessary?
Legal Requirements: Industrial chemicals

Global Chemical Conventions:

- Stockholm Convention listing as POPs
- Rotterdam Convention listing for Prior Informed Consent

The EU Chemical Regulation REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) has two relevant lists of chemicals for restriction/control:

- ECHA: **Candidate List of Substances of Very High Concern** for Authorization (currently 173 substances; 05/2017) https://echa.europa.eu/candidate-list-table
- ECHA: Candidate List for inclusion in the Authorization List (Annex XIV of REACH)

- **Entire group of substances like PFAS (substitution task)!**

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POPRC development "Risk Management Evaluation" – assessment alternatives

- **RME is developed based on information specified in Annex F submitted by Parties and others**
  - Efficacy and efficiency of possible control measures in meeting risk reduction goals
  - **Alternatives (products and processes)**
  - Positive and negative impacts on society of implementing possible control measures
  - Waste and disposal implications
  - Access to information and public education
  - Status of control and monitoring capacity
  - Any national or regional control actions taken

Annex F: Information on socio-economic consideration

- **Alternatives (products and process)**
  - Technical feasibility
  - Costs, including environmental and health costs
  - Efficacy
  - Risk
  - Availability
  - Accessibility

Other provisions on alternatives in the Stockholm Convention

- ***Article 9:*** Parties facilitate or undertake **information exchange** relevant to alternatives to POPs, including information related to their risks as well as economic and social costs

- ***Article 10:*** Parties promote and facilitate development and implementations of **educational and public awareness programmes** on POPs and their alternatives

- ***Article 11:*** Parties encourage or undertake appropriate **research, development, monitoring and cooperation** pertaining to POPs and their alternatives and candidate POPs.

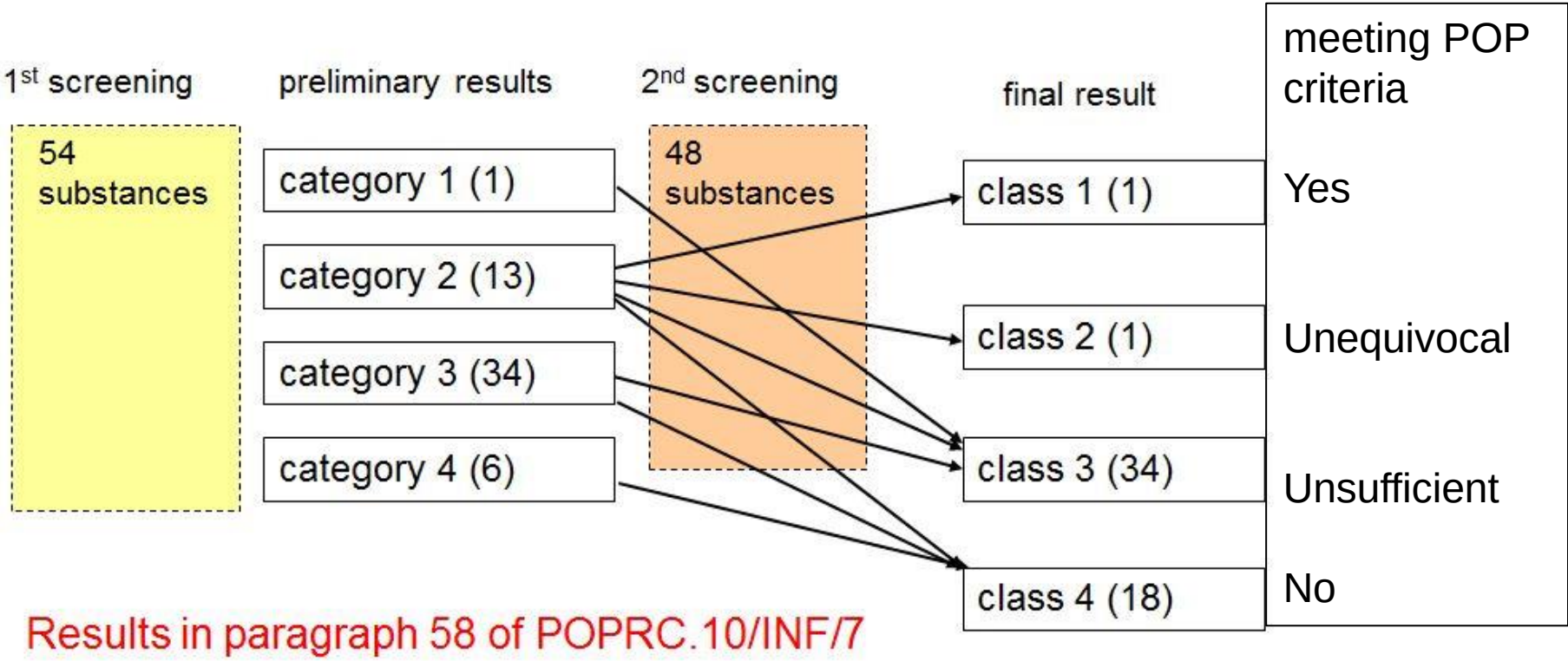
Experience in the Stockholm Convention on alternatives

General guidance on considerations related to alternatives and substitutes for listed persistent organic pollutants and candidate chemicals (UNEP/POPS/POPRC.5/10/Add.1, 2009)

- **Fluorinated chemicals:** PFOS, its salts and PFOSF and PFOA and related compounds
- **Brominated flame retardants:** DecaBDE, HBCD
- **Other industrial chemicals:** SCCPs and now MCCPs and UV-328
- **Pesticides** (in particular DDT, Lindane, Endosulfan, Pentachlorophenol…)

PFOS – Evaluation of alternatives for all exempted applications

- Identification alternatives
- Screening procedure 1. databases P+B 2. in depth
- Results against POP criteria



Results in paragraph 58 of POPRC.10/INF/7

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Challenges in assessing & documenting information on alternatives

- Limited information, scientific uncertainly
  - Information can become outdated fairly quickly, situation continuously changes
- **Limitation in expertise**
  - Building consensus on pros and cons of various alternative products and processes
  - Evaluating socio-economic impacts of introducing alternatives in various sectors
  - Deciding a global policy, taking into account different situation/capacity in different parts of the world

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Challenges in introducing alternatives

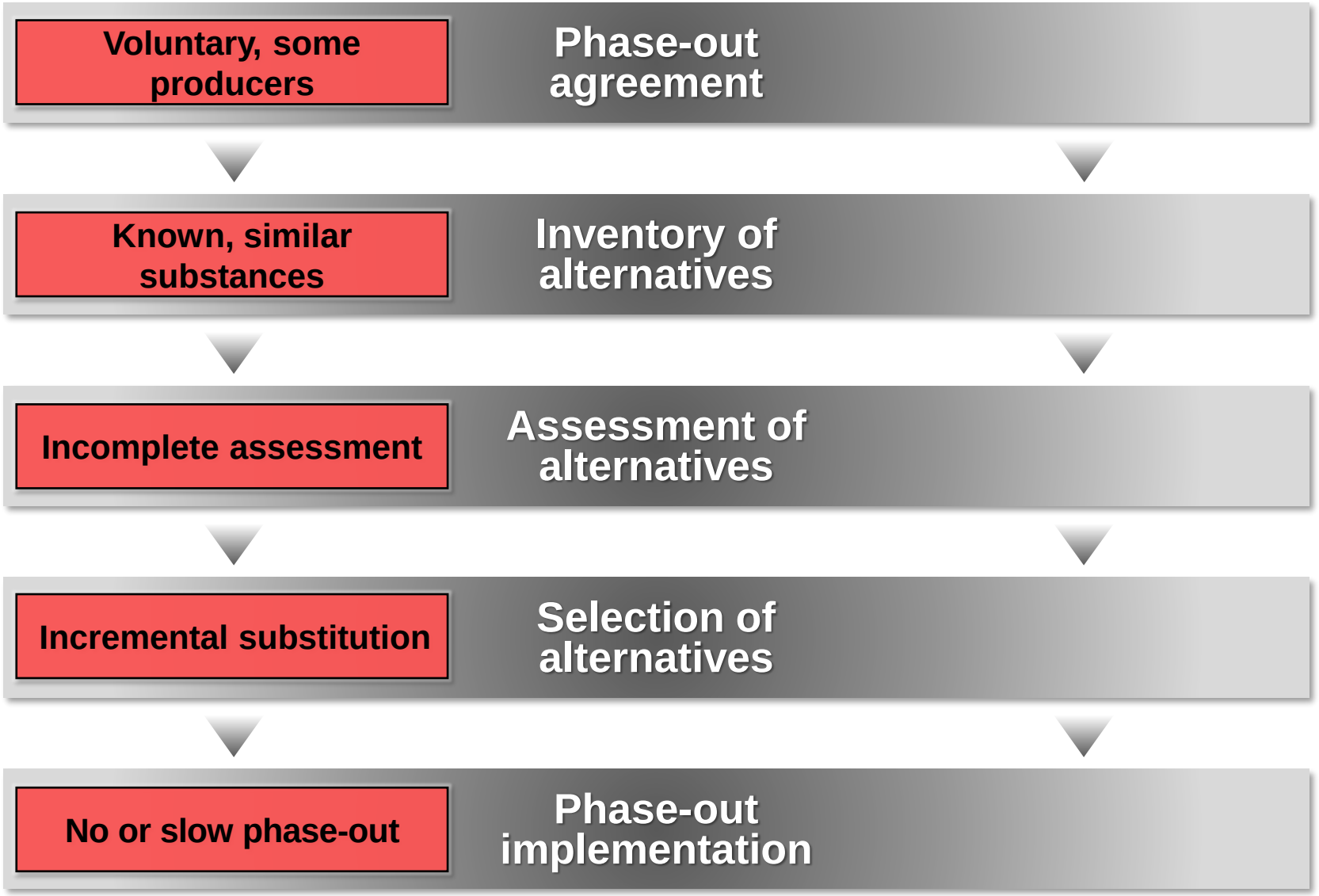
- Cost implications, technical feasibility, time required
- Long shelf-life/turn-over of products
  - Fire-fighting foam;
  - Insulation materials in buildings;
  - Wood preservatives used in utility poles
- Long service-life and need for spare parts
  - Automotive industry; Aerospace industry
- Stringent regulations, standards to meet
  - E.g. Flammability standards; medical devices
  - Go through standardisation procedure

Learnings from the experiences of the Stockholm Convention

- Similar chemicals, similar applications/sectors, similar alternatives, similar problems, better solutions
- Information and engagement of stakeholders is essential
  - Industry, Academia, Civil Societies, Government, International Organizations…
  - Information exchange platform: Clearing House Mechanism
- Green & sustainable chemistry, life-cycle consideration, avoid regrettable substitutions
- Review, update, adjust, learn from lessons
- Communicating findings (science-policy interface)

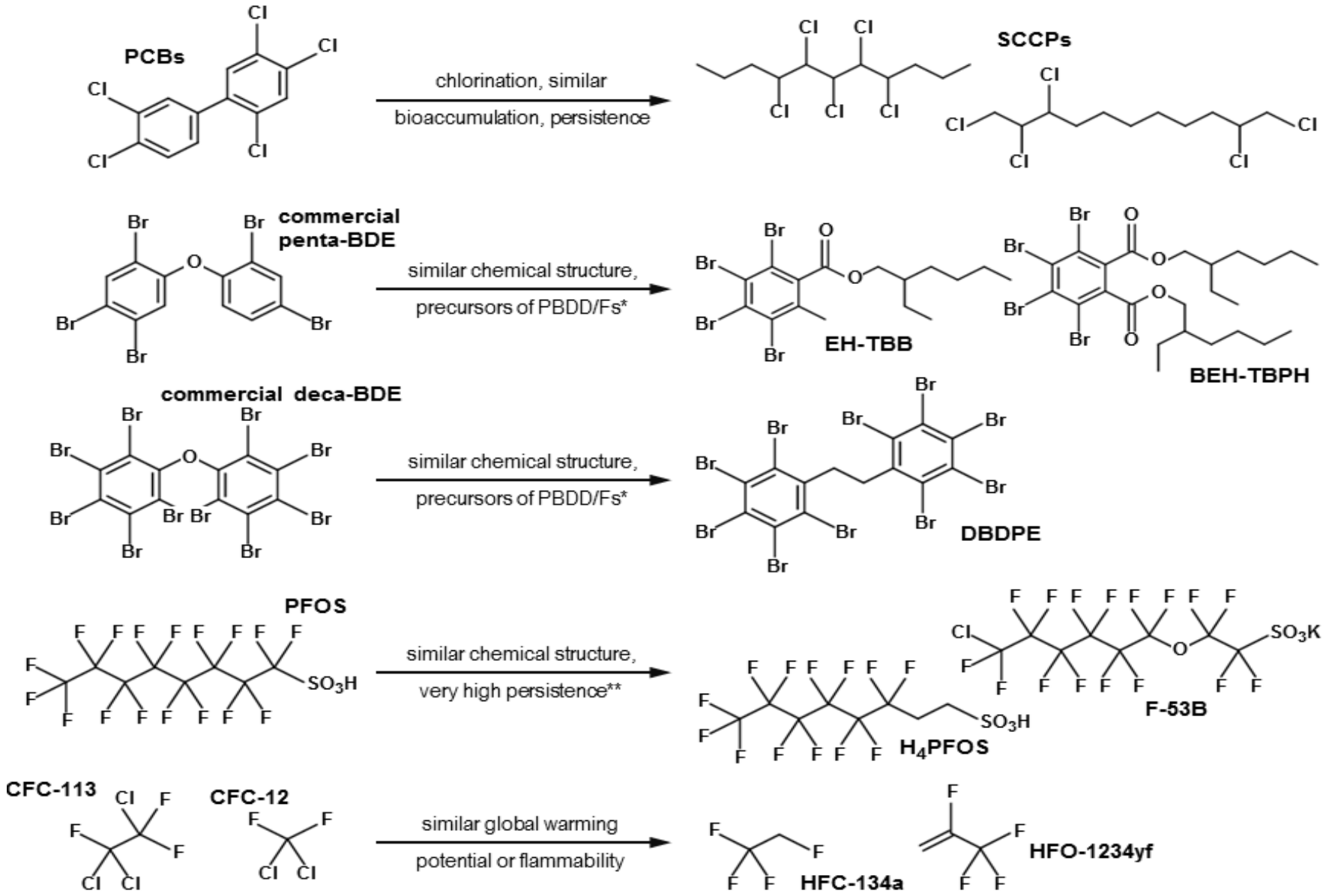
Current and recommended substitution practice

Current practice



Fantke Weber & Scheringer (2015) Sustainable Chemistry and Pharmacy 1, 1-8

Archetypal cases of incremental substitution for selected phase-out chemicals



Fantke et al. (2015) Sustainable Chemistry and Pharmacy 1, 1-8

POP-BFR were substituted by other BFRs

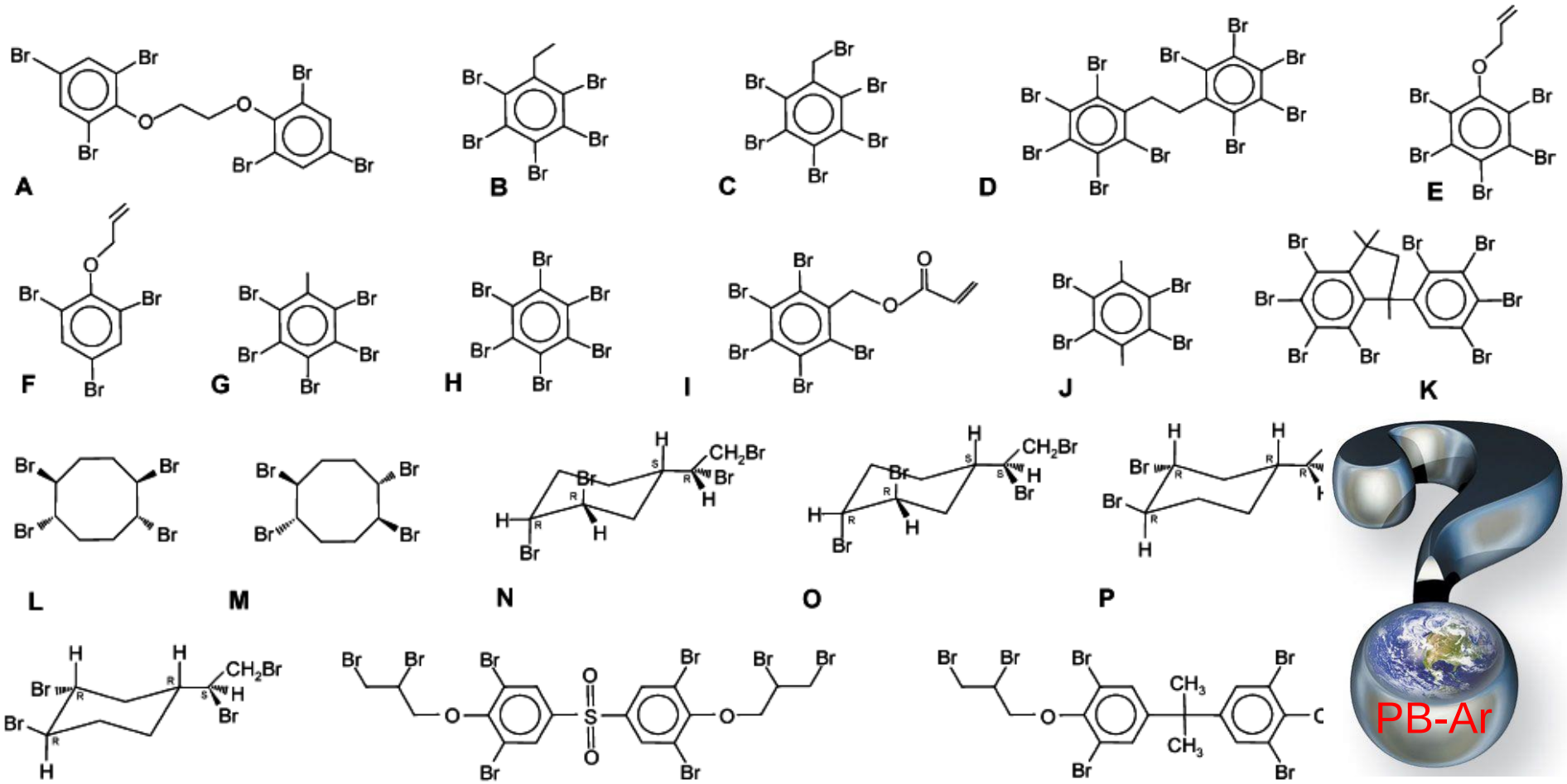
When looking to substitution history of PBDEs we find that partly chemical alternatives were chosen which are now also listed as POPs. Examples of regrettable substitution where alternative assessment have failed.

Polymer	Content [%]	POP-BFRs 2009	Alternative introduced
High impact polystyrene	11–15	OctaBDE	DecaBDE, Br-polystyrene Ethane 1,2 bis(pentabromophenyl)
Epoxy resin	0-10	PentaBDE	TBBPA
Polyamides	13–16	OctaBDE	DecaBDE, Br-polystyrene
Polyolefins	5–8	OctaBDE	DecaBDE, propylene dibromo styrene
Polyurethanes	10-18	PentaBDE	Brominated polyols
Polyesters	8–11	OctaBDE	Brominated polystyrene
Unsaturated polyesters	13–28	PentaBDE	TBBPA
Textiles	12–15	PentaBDE	DecaBDE, HBCD

- HBCD & DecaBDE are meanwhile listed in the Stockholm Convention.
- **DecaBDE has been listed with a range of specific exemptions.**

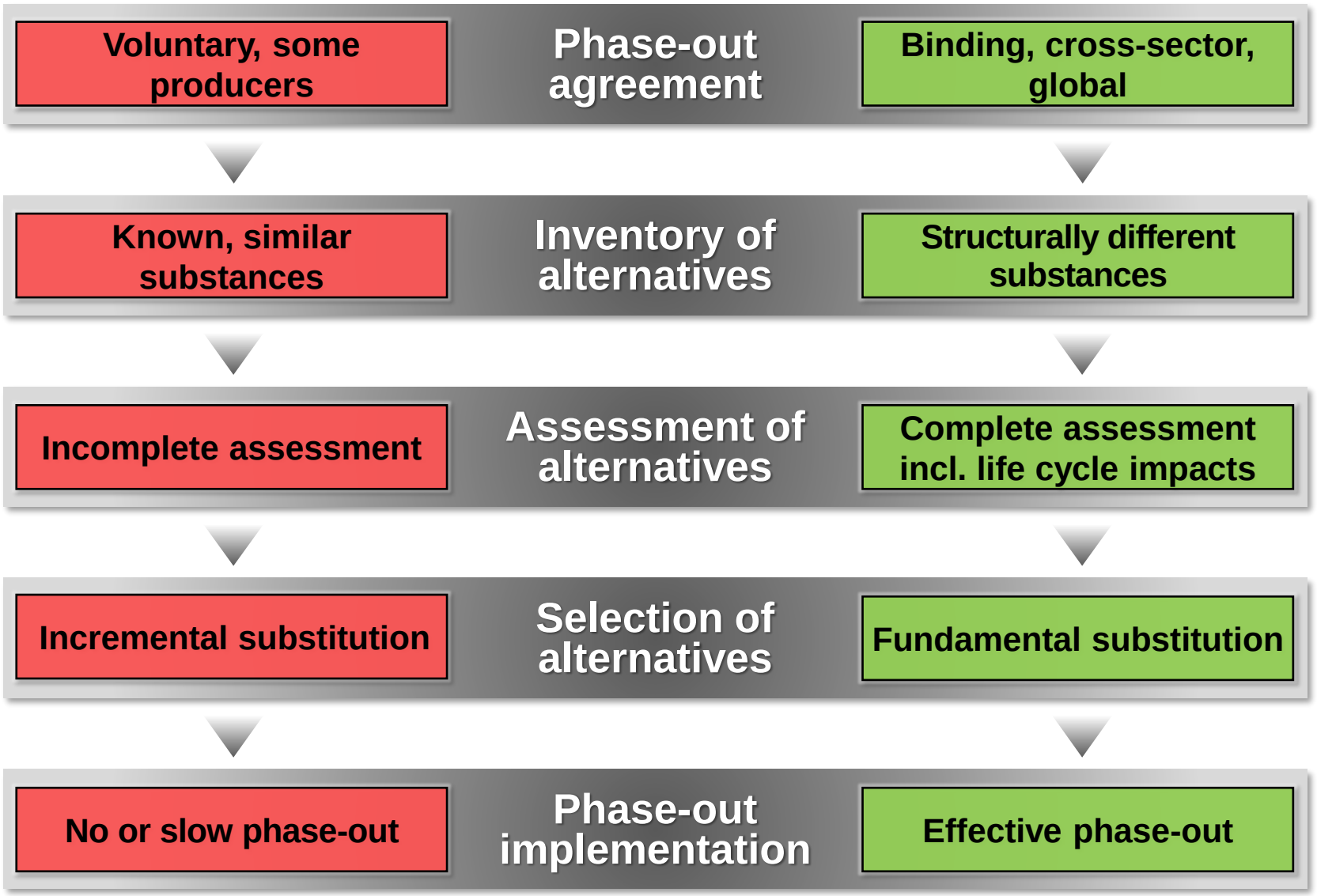
Other Brominated Flame Retardants (BFRs)

- Approx. 75 BFR were on the market as alternatives to PBDEs (Fisk et al 2003).
- Many of them are persistent polybrominated aromatic chemicals



Structures of BFRs addressed by Gauthier (Gauthier, Potter *et al.* ES&T 2009)

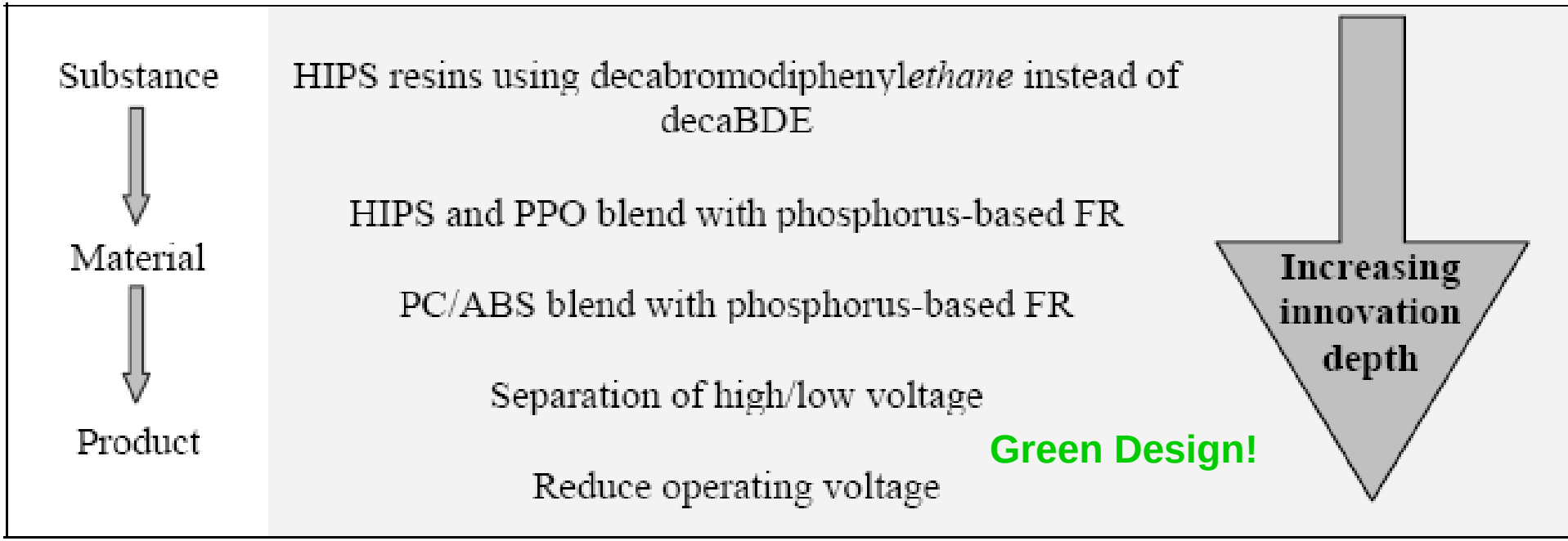
Current and recommended substitution practice



Fantke, Weber & Scheringer (2015) Sustainable Chemistry and Pharmacy 1, 1-8

DecaBDE substitution in plastic resin in electronics

DecaBDE substitution strategies for plastic used in electronics considering substance and material substitution and re-design.



Source: Öko-Institute 2003

Overview Table Non-Halogenated FR In the Whole Application Range

Application options non-Hal-FR; PINFA Version 5.0 (12/2009)

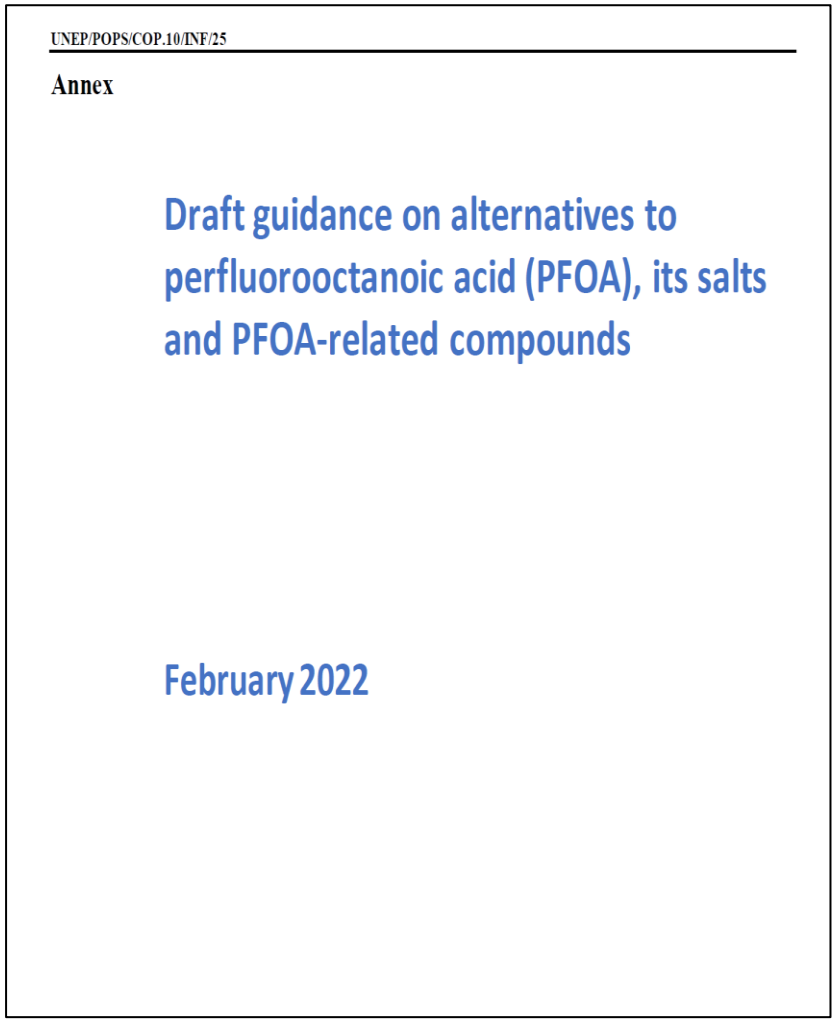
Version 5.0; Status: 2009-12-01

Chemical name	CAS #	Solid Thermoplastics: ABS	EVA-copolymers	HIPS	PET	PBT	PA - Polyamide	PP - Polypropylene	PE - Polyethylene	PC - Polycarbonate	PC / ABS	HIPS / PPO	SAN	Thermoplastic elastomers	PVC rigid	Foams: EPS foam	XPS foam	PUR flexible foam	PUR Rigid foam	PP – Phypropylene foam	PE – Polyethylene foam	PVC / nitrile foam	Rubbers / Elastomers	Textiles, Paints, Adh: Textile backcoating	Wool	Polyester fibres	Viscose	Cotton	Other textile fibers	Hot melts	Intumescent Coatings	Paints	Latex / adhesives	Thermosets: Epoxy Resins	Phenolic Resins	Unsaturated polyesters	Vinyl esters	Acrylic resins	Wire/cable: Silicone	PVC flexible	EPDM	PP - Polypropylene	TPU	PE / EVA	Paper / Wood	Chip / Particle boards
2,2'-Oxybis[5,5-dimethyl-1,3,2-dioxaphosphorinane]2,2'disulphide	4090-51-1																										X																			
APP Ammonium Polyphosphate	68333-79-9							X	X					(x)				X	X				(x)	(x)					X		X		(x)	X	X	X	(x)	X							(x)	
APP Ammonium Polyphosphate (coated)	68333-79-9																	X	X											(x)	X			X		X								X	
APP Ammonium Polyphosphate (with synergists)	68333-79-9		X					X	X					(x)				X	X				(x)	X						(x)	X		(x)	X		X	(x)	(x)						X	(x)	
ATH - Aluminium tri-hydroxide	21645-51-2		X						X					X							X	X	X	X						X		X		X	X	X	X	X						X	(X)	
BDP - Bisphenol-A bis(diphenyl phosphate)	181028-79-5									X	X	X																	X															X			
Boehmite (Aluminiumhydroxideoxide)	1318-23-6	X	X	X	X	X	X	X	X	(X)	X	X		X	X			X	X	X	X	X	X		X									X	X	X	X	X	X	X	X	X	X	X		
CDP - Cresyldiphenyl phosphate	26444-49-5										X	X		X				X				X	X							X		X	X		X							X				
Diethylphosphinate, aluminium salt	225789-38-8				X	X	(x)							(x)															(x)					X				(x)					X				
Diethylphosphinate, aluminium salt (with synergists)	225789-38-8				(x)	(x)	X							(x)															(x)														X				
Hypohosphite, calcium salt	7789-79-9									X	X																																				
Hypohosphite, calcium salt (with synergists)	7789-79-9			X		X		X		X	X	X					(x)			X																									X			
Hypophosphite, aluminium salt (with synergists)	7784-22-7					X		X				X								X														(x)	(x)	(x)							X	(x)		
DMPP - Dimethyl propane phosphonate	242-555-3																		X													X				X										
Diphenyl (2-ethylhexyl) phosphate	1241-94-7																					X	X									X							X							
IPPP - Isopropylated phenol phosphate	68937-41-7														X																			X												
MDH - Magnesium di-hydroxide	13760-51-5		X				X	X	X					X						X	X	X	X		X											X	X	X	X	X	X	X				
Melamine	108-78-1																	X														X														
Melamine Cyanurate	37640-57-6			X		X	X	X				X												X						X	X				X							X	X		
Melamine Phosphate	41583-09-9							X	X															X							X	X		X	X	X							X			
Melamine Polyphosphate	218768-84-4			X	X	X	X	X				X																			X			X	X	X		X							
Melamine Borate	53587-44-3																											X			X			X												
Monomeric N-alkoxy hindered amine	191680-81-6							(X)																					X																
N,N-(bis)-hydroxyethyl-aminomethane phosphonic acid diethyl ester	2781-11-5																	X	X															X												
Phosphorus polyol	proprietary																	R	R										(x)					R												
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7			X	X	X	X			X	X	X																																		
RP Red phosphorus	7723-14-0						X																(x)											X												
RP Red phosphorus (concentrates)	7723-14-0						X	(x)	(x)																				(x)																
RP Red phosphorus (dispersions)	7723-14-0																		X				X						X	(x)			X	X	(x)	(x)									
TEP - Triethyl phosphate	78-40-0																		X																	X										
TCP - Tricresyl phosphate	1330-78-5																	X																							X						
TPP - triphenyl phosphate	115-86-6										X	X																						X	X											
Tris-(2-ethylhexyl) phosphate	78-42-2																						X																	X	X					

Source: The non-halogenated phosphorus, inorganic and nitrogen FR organisation (PINFA), 2010

Guidance on alternatives to POPs with exemption

- Within the Stockholm Convention, guidance documents on alternatives to individual POPs with exemptions were developed.
- Currently no particular assessment of the alternatives.

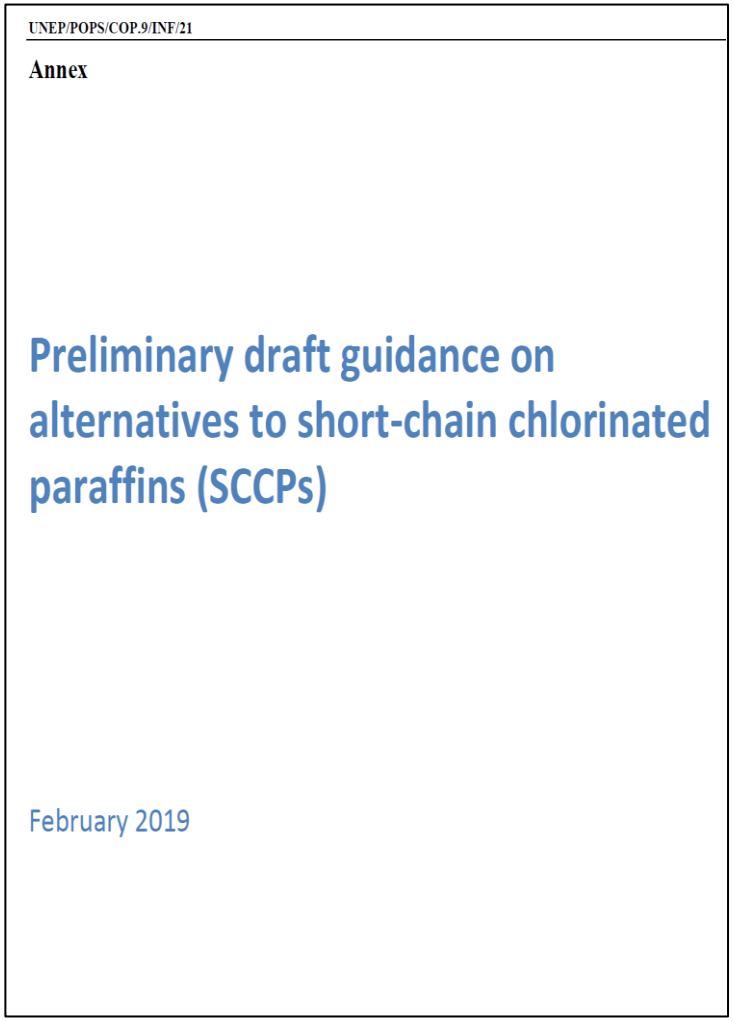


UNEP/POPS/COP.10/INF/25

Annex

Draft guidance on alternatives to perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds

February 2022



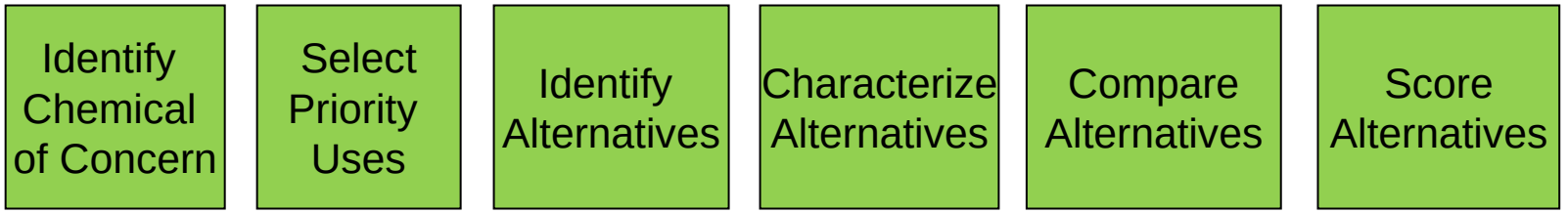
UNEP/POPS/COP.9/INF/21

Annex

Preliminary draft guidance on alternatives to short-chain chlorinated paraffins (SCCPs)

February 2019

Six Steps for Alternatives Assessment



Ken Geiser (Lowell Center for Sustainable Production)

Six Steps for Alternatives Assessment

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	Compare Alternatives	Score Alternatives

Identify Chemicals of Concern

Criteria for selection

- CMRs, PBTs
- Bio-monitoring evidence
- High public concern

Ken Geiser (Lowell Center for Sustainable Production)

Six Steps for Alternatives Assessment

Identify Chemical of Concern → **Select Priority Uses** → Identify Alternatives → Characterize Alternatives → Compare Alternatives → Score Alternatives

Select Priority Uses

Criteria for selection

Large percentage of use
High likelihood of exposure
(e.g. food contact materials; open uses)

Ken Geiser (Lowell Center for Sustainable Production)

Six Steps for Alternatives Assessment

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	Compare Alternatives	Score Alternatives

Identify Alternatives

Criteria for selection

- Alternatives on the market
- Alternatives likely to enter the market
- Alternatives used by competitors

Ken Geiser (Lowell Center for Sustainable Production)

Six Steps for Alternatives Assessment

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	Compare Alternatives	Score Alternatives

Characterize Alternatives

Assemble available data

- hazard end points
- human exposure potential
- potential environmental effects

Address data gaps

- lack of data considered high hazard

Establish hazard profiles

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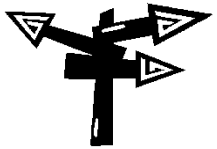
Six Steps for Alternatives Assessment

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	Compare Alternatives	Score Alternatives

Compare Alternatives

Compare hazard profiles

Use available screening tools

TURI's P2OASys
CPA's Green Screen
HBN's Pharos

Design for the Environment U.S. EPA

GREEN SCREEN FOR SAFER CHEMICALS

Pharos

optimized by MBDC

ToxCast™

TiPED Tiered Protocol For Endocrine Disruption

SUSTAINABILITY CERTIFIED NSF

UL

eiolca.net
Economic Input-Output Life Cycle Assessment

iSUSTAIN™ Green Chemistry Index

GaBi Software

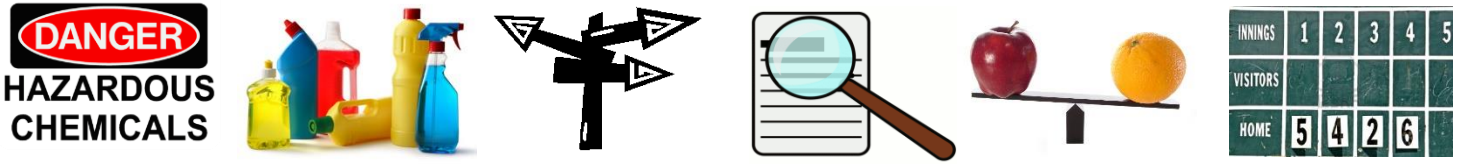
GUIDE ON SUSTAINABLE CHEMICALS

Ken Geiser (Lowell Center for Sustainable Production)

Six Steps for Alternatives Assessment

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	Compare Alternatives	Score Alternatives

Rank & select Alternatives



Use qualitative rating tools

- Benchmarks
- Comparison tables
- Color charts

GUIDE ON SUSTAINABLE CHEMICALS

Economic Input-Output Life Cycle Assessment

Ken Geiser (Lowell Center for Sustainable Production)

Substitution Support Portal “SUBSPORT” - Moving towards safer alternative

SUBSPORT is a free-of-charge, (multilingual) platform for information exchange on alternative substances and technologies, as well as tools and guidance for substance evaluation and substitution management.

Substitution Support Portal SUBSPORT - Moving towards safer alternative

- SubsPort portal contains 15,166 chemical substances generated from 34 lists with chemicals of concern according to different criteria (e.g. SVHC; SIN list, lists from industries).

15166 [illegible]

OPTIONS

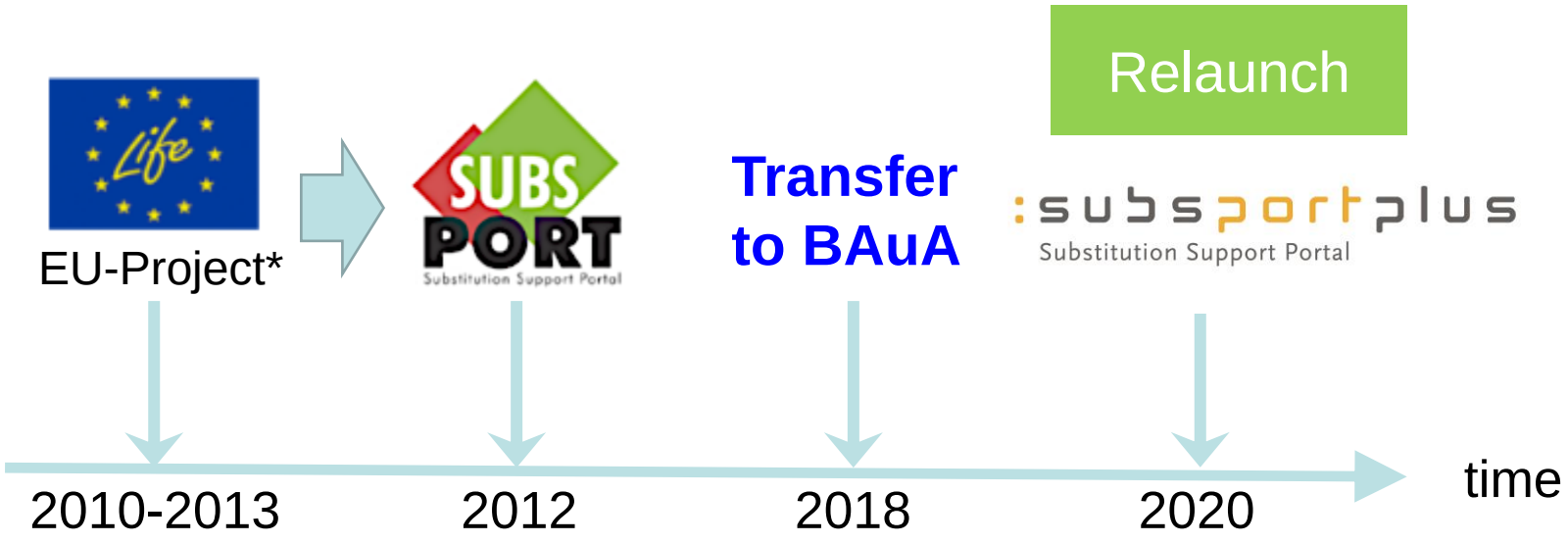
1. Order the search results by CAS or EC no. using the green triangles.
2. Use the "description of list" icon to the right of a list name to get more information on a list, which list version is presented here and the link to the original source.
3. Click on list name in a certain row to get to this entry in the single list view.
4. Click on a CAS or EC no. to search for it in all 34 lists.
5. Substance names were taken from the original sources and could not be harmonised. Search also by CAS or EC no. in order not to miss information.

COLOUR CODE

SUBSPORT
International Agreement
EU Regulatory List
Governmental List
NGO or Trade Union List
Company or Sector List

No.	Substance/group name	CAS No.	EC No.	List of Substances
1	((4-PHENYLBUTYL)HYDROXYPHOSPHORYL)ACETIC ACID	83623-61-4	412-170-7	Nokia SUBSPORT SDSC SUBSPORT SDSC Nokia Nokia
2	((P-TOLYLOXY)METHYL)OXIRANE	2186-24-5	218-574-8	Nokia Nokia Nokia
3	(+)-(1S,2S,3S,5R)-2,6,6-trimethylbicyclo[3.1.1]heptane-3-spiro-1'-(cyclohex-2'-en-4'-one)	133636-82-5	430-460-1	SUBSPORT SDSC SUBSPORT SDSC
4	(+)-(1S,2S,3S,5R)-2,6,6-trimethylbicyclo[3.1.1]heptane-3-spiro-1Σ-(cyclohex-2Σ-en-4Σ-one)	133636-82-5	430-460-1	SUBSPORT SDSC SUBSPORT SDSC
5	(+)-R-2-(2,4-dichlorophenoxy)propionic acid	15165-67-0	403-980-1	KEMI PRIO Risk-Reduction KEMI PRIO Risk-Reduction KEMI PRIO Risk-Reduction

SUBSPORTplus: Development & Relaunch



*LIFE08 ENV/D/000027,
more information here: http://www.subsportplus.eu/about-the-portal/subsport-project

Relaunch of SUBSPORT under German Federal Institute for Occupational Safety and Health

:subsportplus
Substitution Support Portal

: BAuA Information Portal for Substitution

https://www.subsportplus.eu/

- Assistance with substitution
  - **Case Stories**
  - Methods/tools of substitution
- Link collection

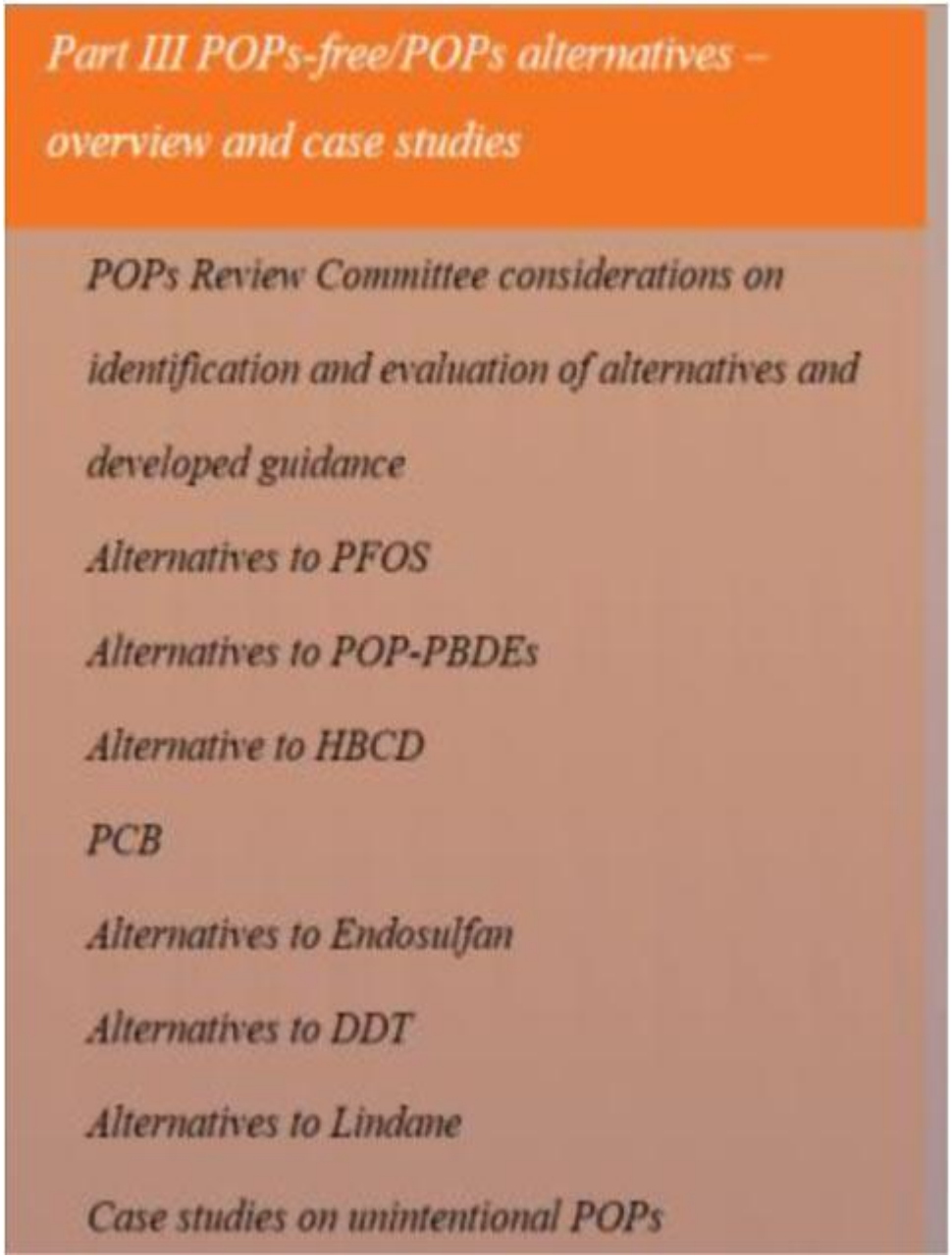
✓ used also for networking and support of initiatives regarding substitution

Stockholm Convention POPs free initiative:

- A ‘POPs-free initiative’ has been initiated by the Secretariat of the Stockholm Convention to improve the exchange of information on alternatives/substitutes to POPs.
- Here an electronic publication “*POPs in articles and phasing-out opportunities*” has been developed compiling information on alternatives to POPs & phase out.

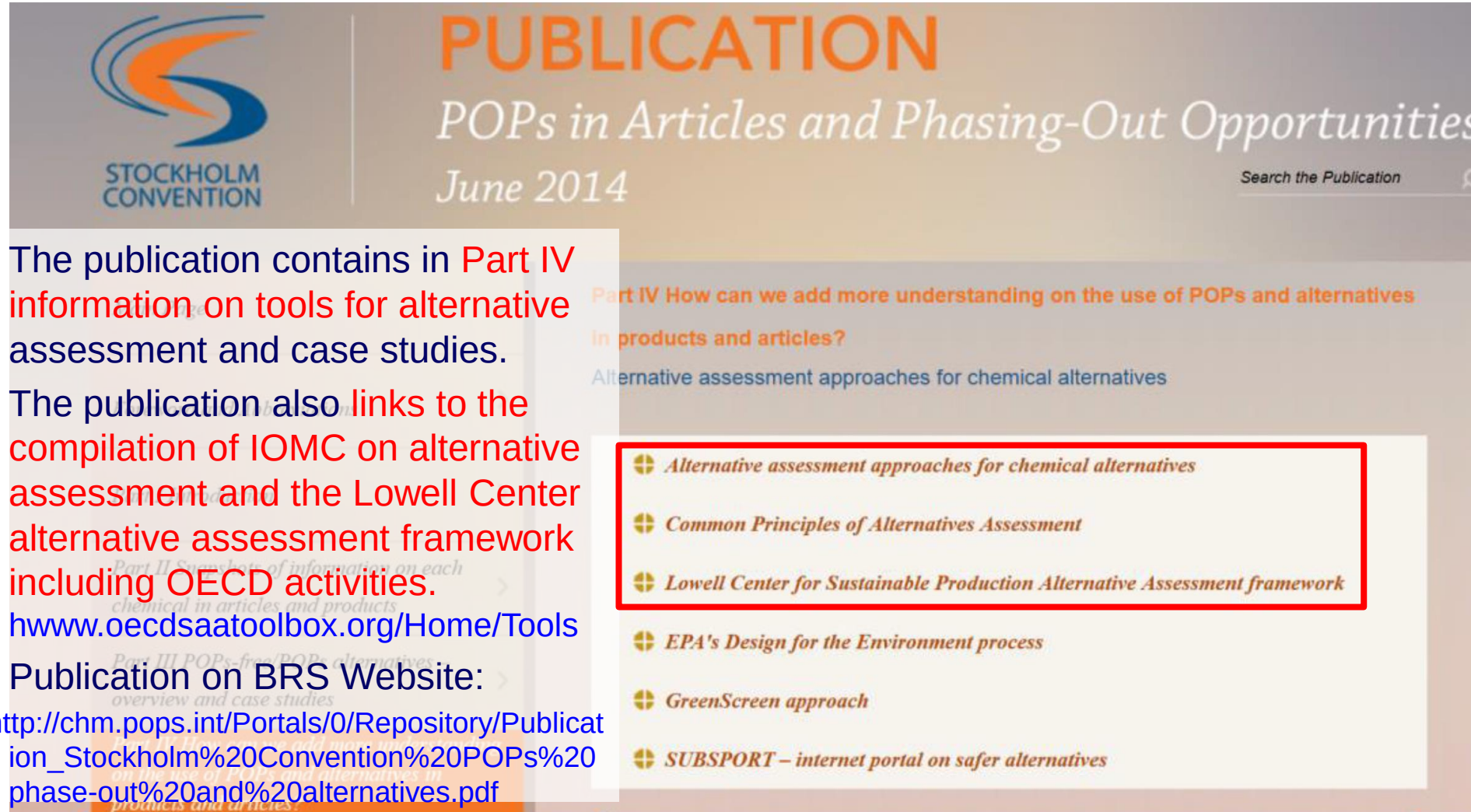
Stockholm Convention POPs free initiative: "POPs in articles and phasing-out opportunities" publication

- Part III of the publication includes information on alternatives to listed POPs which are still in use **(POPs listed up to 2013).**
- Web-version with Basel/Stockholm Convention Regional Centre Asia & the Pacific – stopped since outdated
- The publication/web-platform was considered to be updated for future new listed POPs.



Stockholm Convention POPs free initiative: “POPs in articles and phasing-out opportunities” publication

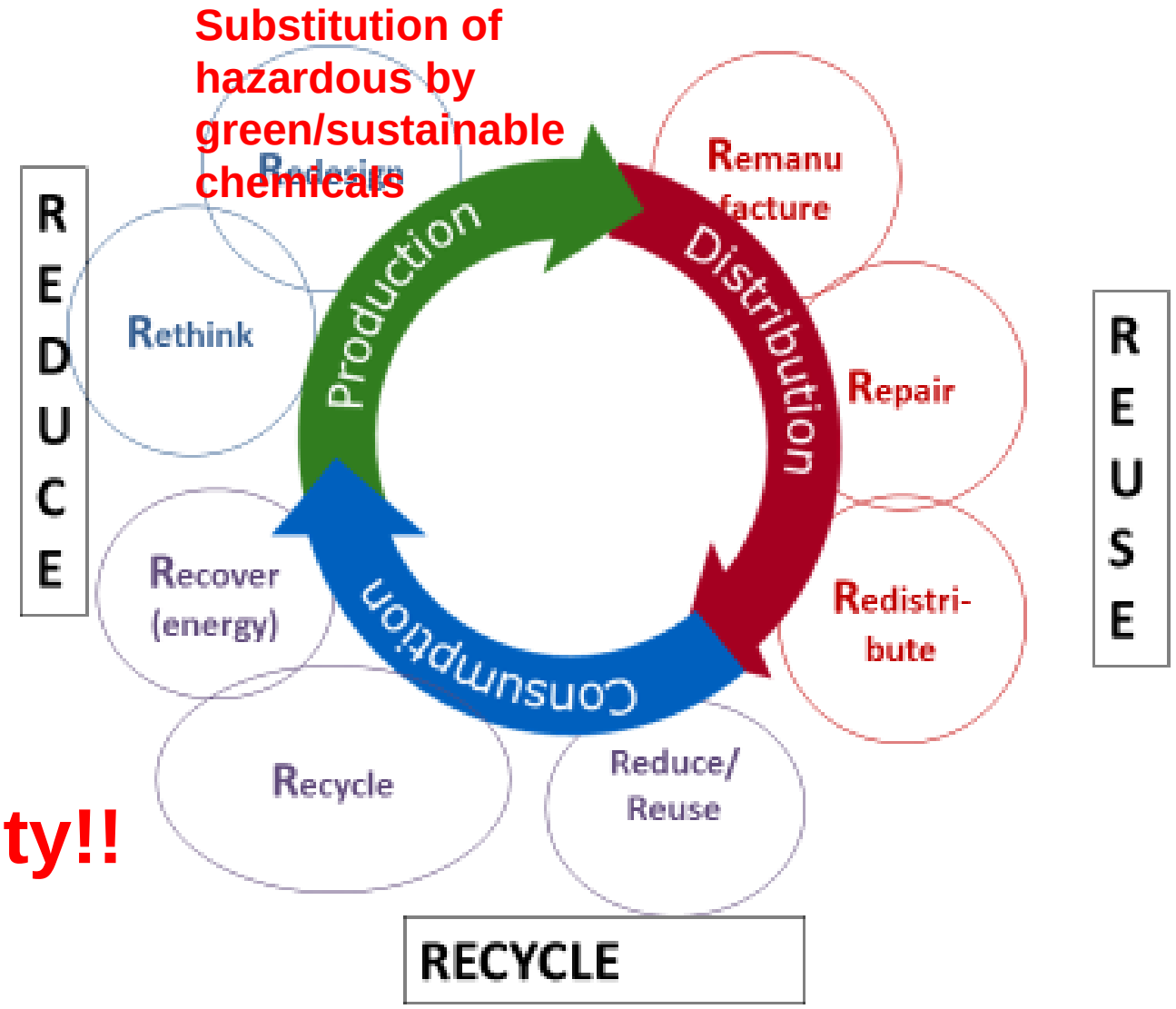
Part IV Include some best practice examples



- The publication contains in Part IV information on tools for alternative assessment and case studies.
- The publication also links to the compilation of IOMC on alternative assessment and the Lowell Center alternative assessment framework including OECD activities.
  hwww.oecdsaatoolbox.org/Home/Tools
- Publication on BRS Website:
  http://chm.pops.int/Portals/0/Repository/Publication_Stockholm%20Convention%20POPs%20phase-out%20and%20alternatives.pdf

Multi-R approach for moving towards circular economy

Substitution of hazardous chemical by more green/sustainable chemicals in the (re-)design phase and for production (Sustain. Cons. & Prod.).

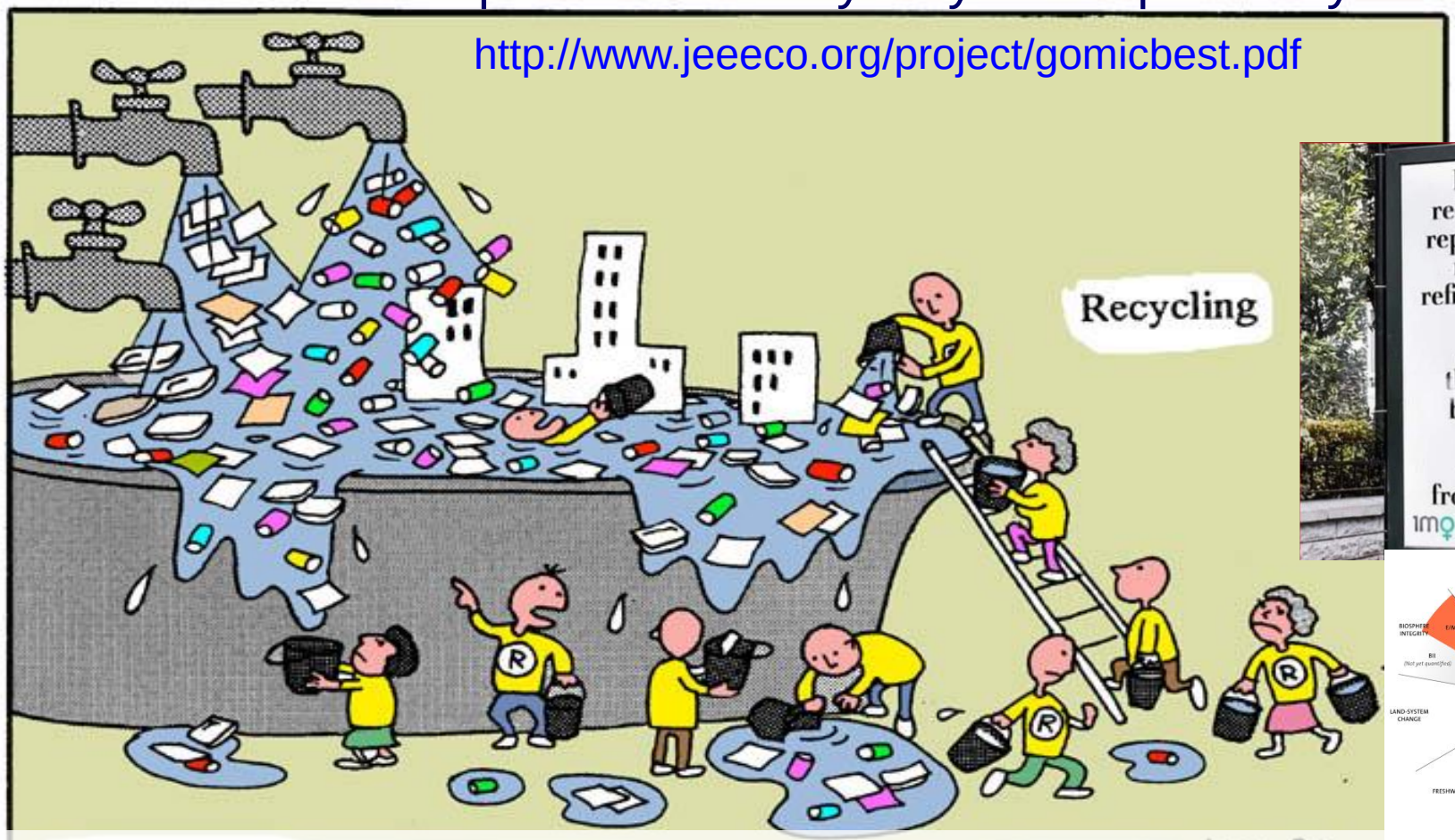


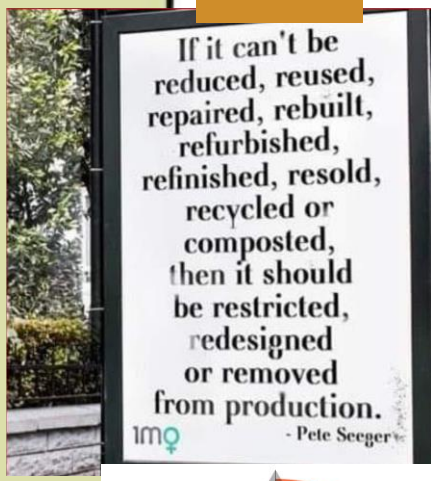
Business opportunity!!

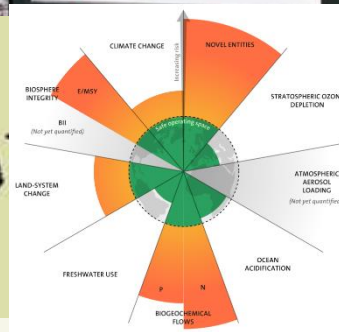
Bonnet (ARC+) Circular Economy, saving resources, creating jobs, Green Week Brussels June 2014

Do we need it at all? Sustainable Consumption!

In addition to substitution & circular economy, **reduction** of **unnecessary chemicals/products need to be a priority** for sustainable consumption (SDG 12). This will result in reduction of chemical release and exposure and contribute that impact of humanity stay within planetary boundaries.



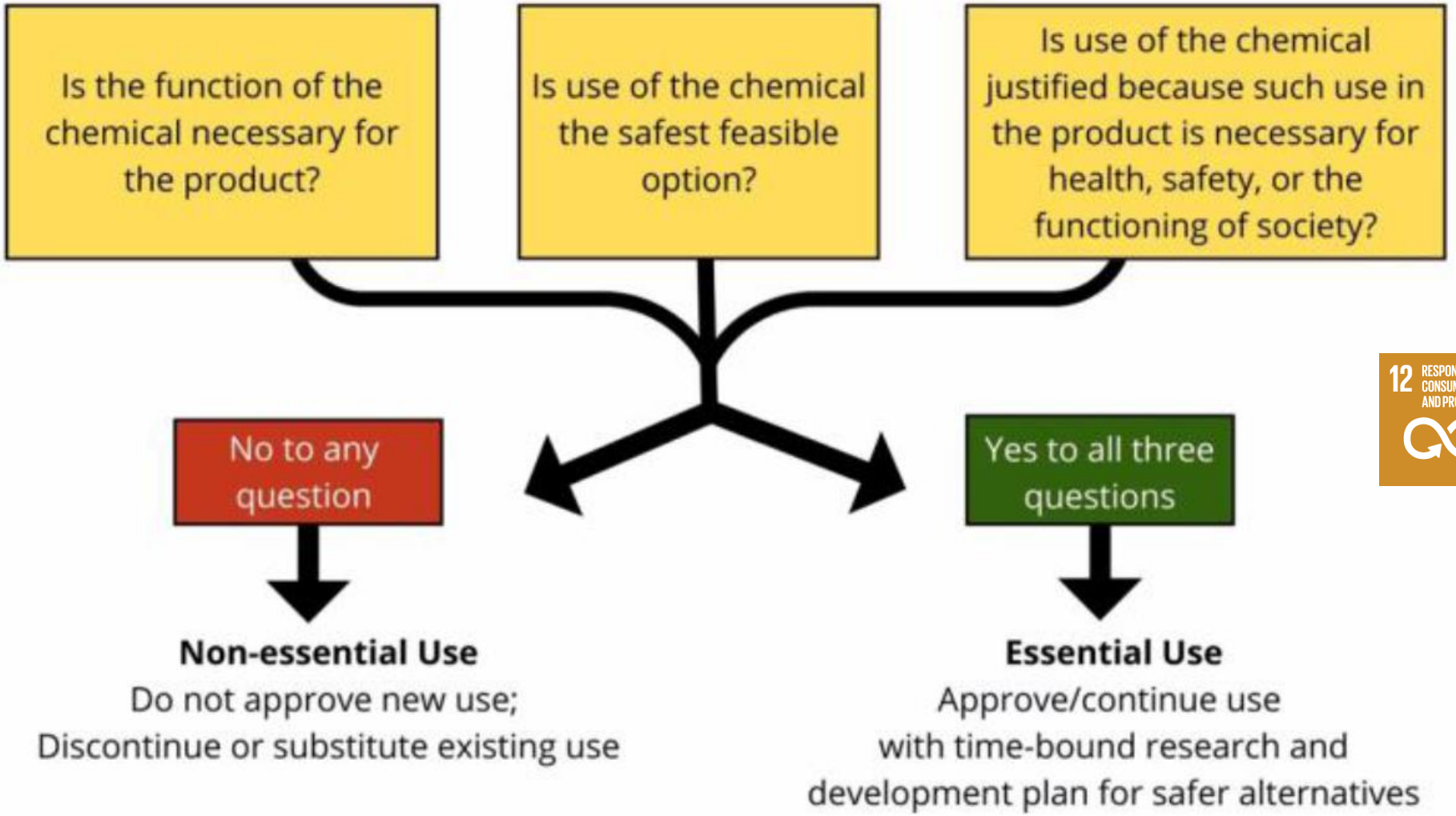




National policies of “Sufficiency Economy” of Thailand or the “Ecological Civilization” of China where sufficiency is/need to be an inherent part.

Do we need it at all? - Essential use concept

Many chemicals and rather products are not needed at all if they are not essential. Suggestion of a strategy to identify non-essential uses:



Balan et al. (2023) Environ. Sci. Technol. 2023, 57, 4, 1568–1575

SCIENCE TO ACTION

Thank you for your attention! Questions?

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BASEL / ROTTERDAM / STOCKHOLM
CONVENTIONS

Thank you for your attention! Questions?

More Information: https://doi.org/10.1007/s44177-022-00031-3

Basel Convention: www.basel.int

Rotterdam Convention: www.pic.int

Stockholm Convention: http://chm.pops.int/

Montreal Protocol/Vienna Convention: http://ozone.unep.org

SAICM: http://www.saicm.org/

POPs phase out & alternatives http://poppub.bcrc.cn/

OECD: www.oecd.org/chemicalsafety/ www.oecdsaatoolbox.org/Home/Tools

Science: www.ipcp.ch; http://greensciencepolicy.org/

NGO: www.ban.org; www.ipen.org; www.ihpa.info; www.chemsec.org

Better-world-links: http://www.betterworldlinks.org/