Why do we need Safe and sustainable by design chemicals, materials and products?

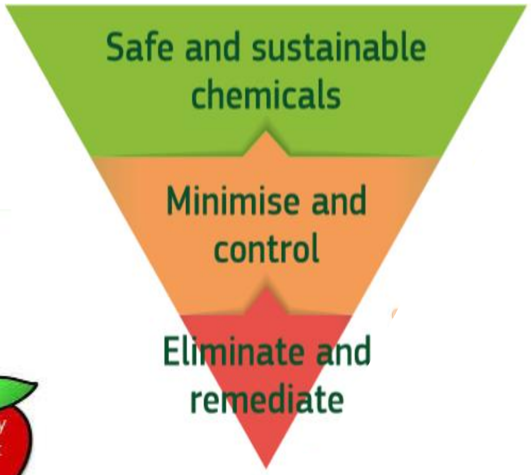
Safe and Sustainable by Design – Quo Vadis?

ZeroPM webinar
November 2nd 2022

Xenia Trier, Associate Professor
Section of Environmental Chemistry and Physics, PLEN, University of Copenhagen

UNIVERSITY OF COPENHAGEN

Why Safe and Sustainable by Design (SSBD)?



- **European Green Deal:**
  Prevent pollution, environmental degradation, biodiversity loss, resource depletion & climate change - at the same time

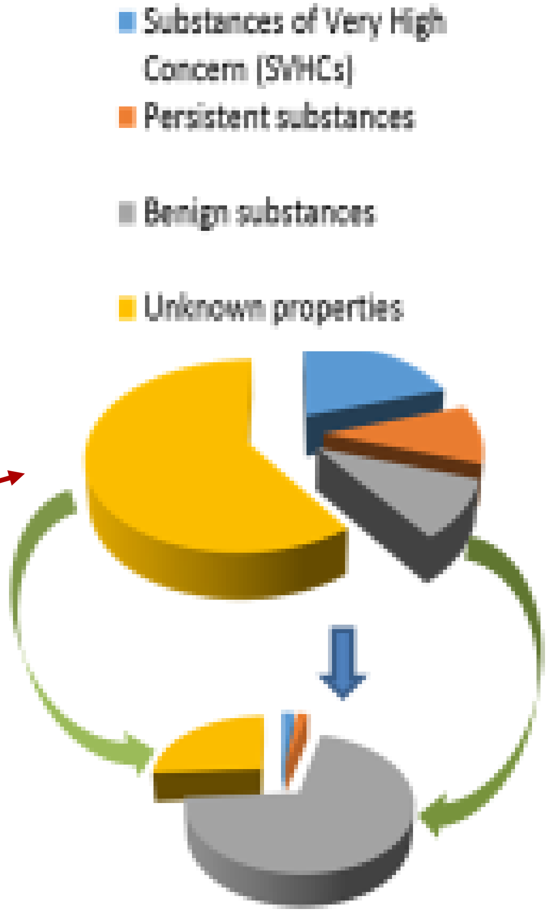
- **Chemical Strategy for Sustainability:**
  - **Aim:** Avoid harm to planet and people
    $\Rightarrow$ *from all chemicals and stressors to reduce absolute harm*
  - **Tool:** *Prevent* pollution by Industrial transition to SSBD

SSBD methodological requirements

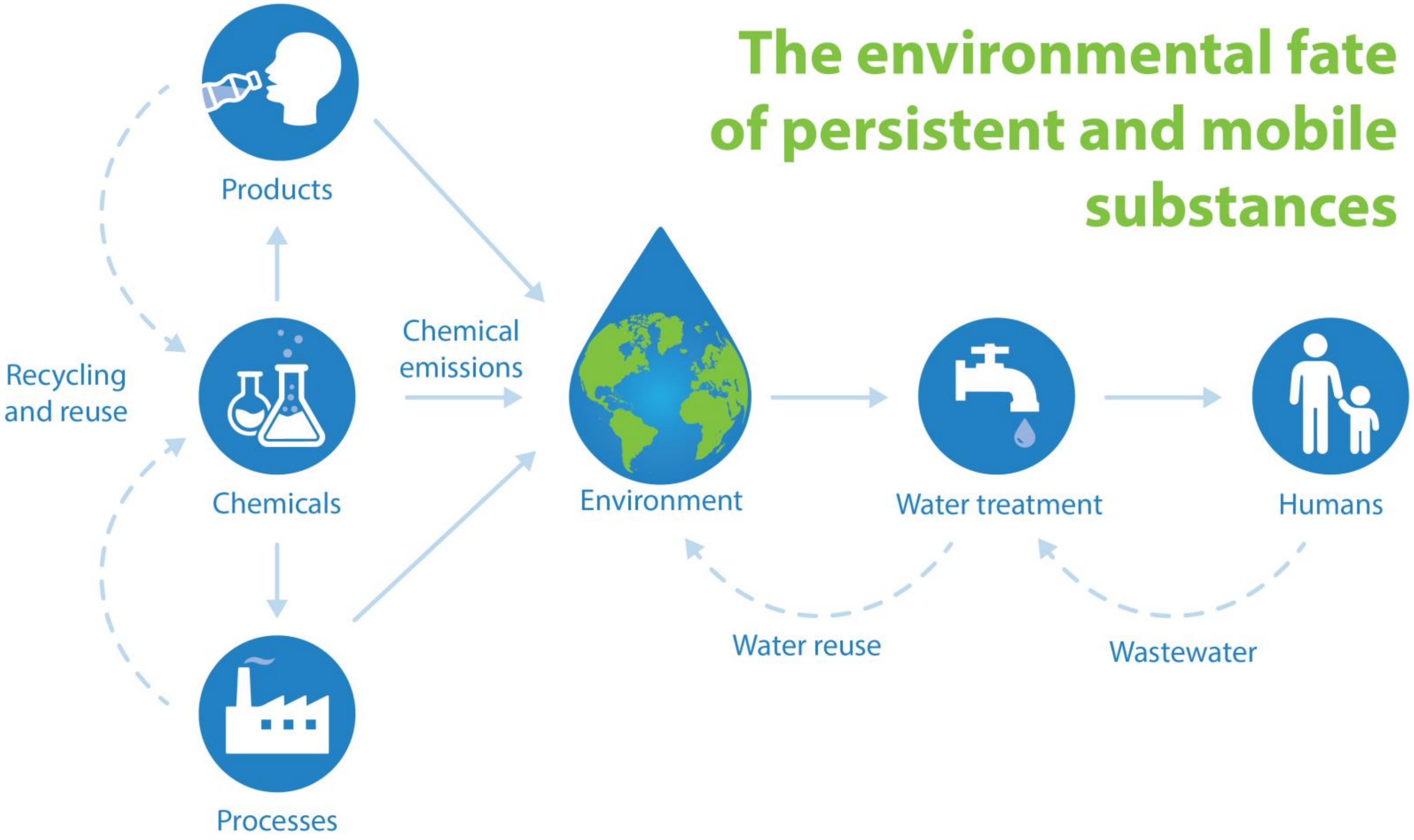
– *in the context of the Chemical Strategy for Sustainability*

CSS aims to *prevent harm to people and planet*

- **Harm:** to humans and the environment
  - Safety (toxicity to humans),
  - Ecosystem health (ecotoxicity, land use, biodiversity),
  - Resources (resource use and circularity),
  - Climate change
  - *Social and economic dimensions are not in the scope of the CSS*
- **Proactive:** avoid use of *known/suspected* substances of concern
  - avoid persistent chemicals that accumulate
- Effective policies and actions: **Reduce *'absolute'* harm** not just relative. Calls for designs that
  - reduce total amount of used chemicals and materials
  - enables reuse/recycling of chemicals, materials, products
  - => calls for ***reducing complexity*** *of chemical diversity, materials and products*

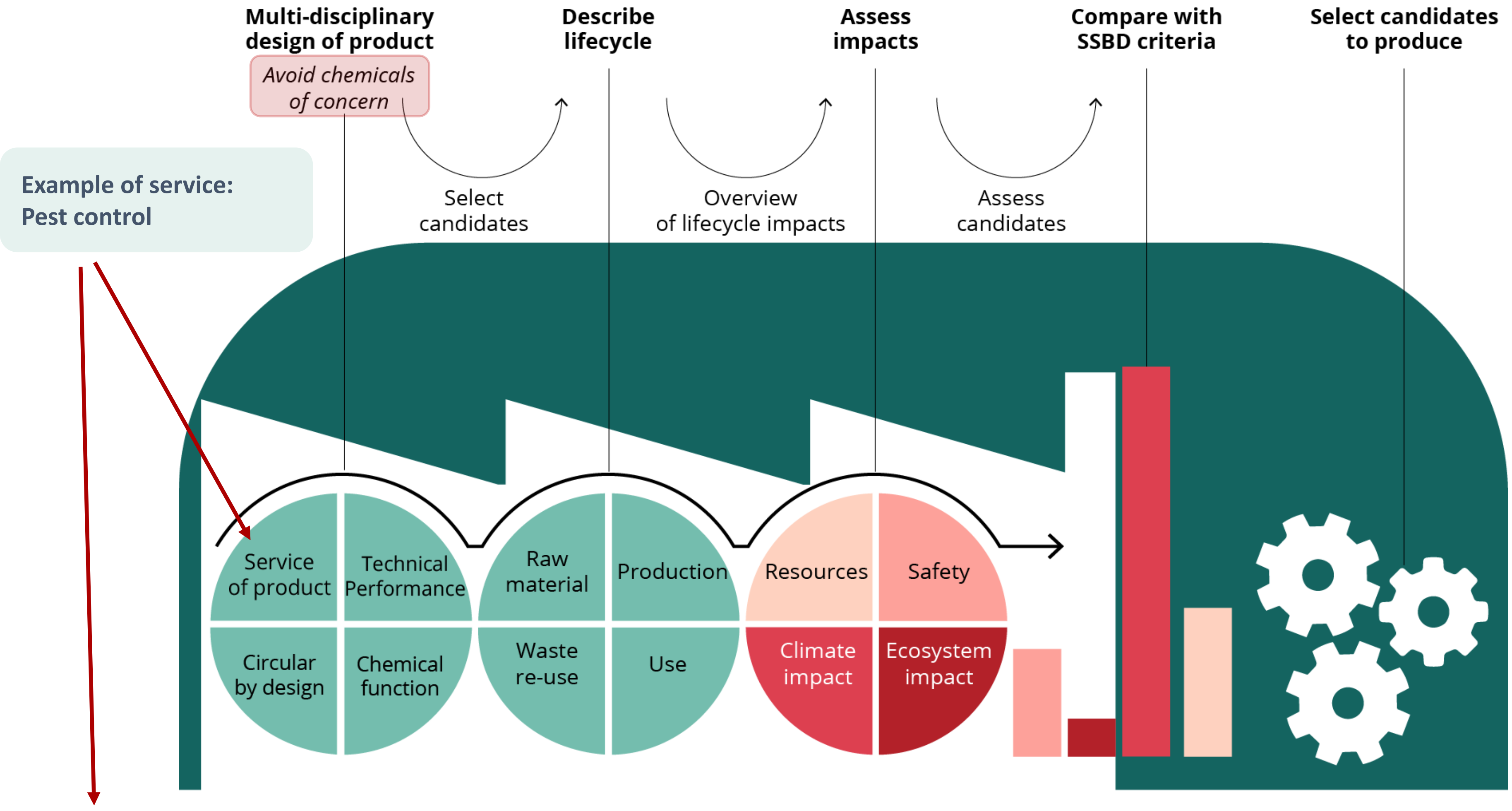


Persistent and Mobile substances ..



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036756

Safe and Sustainable by Design premarket design

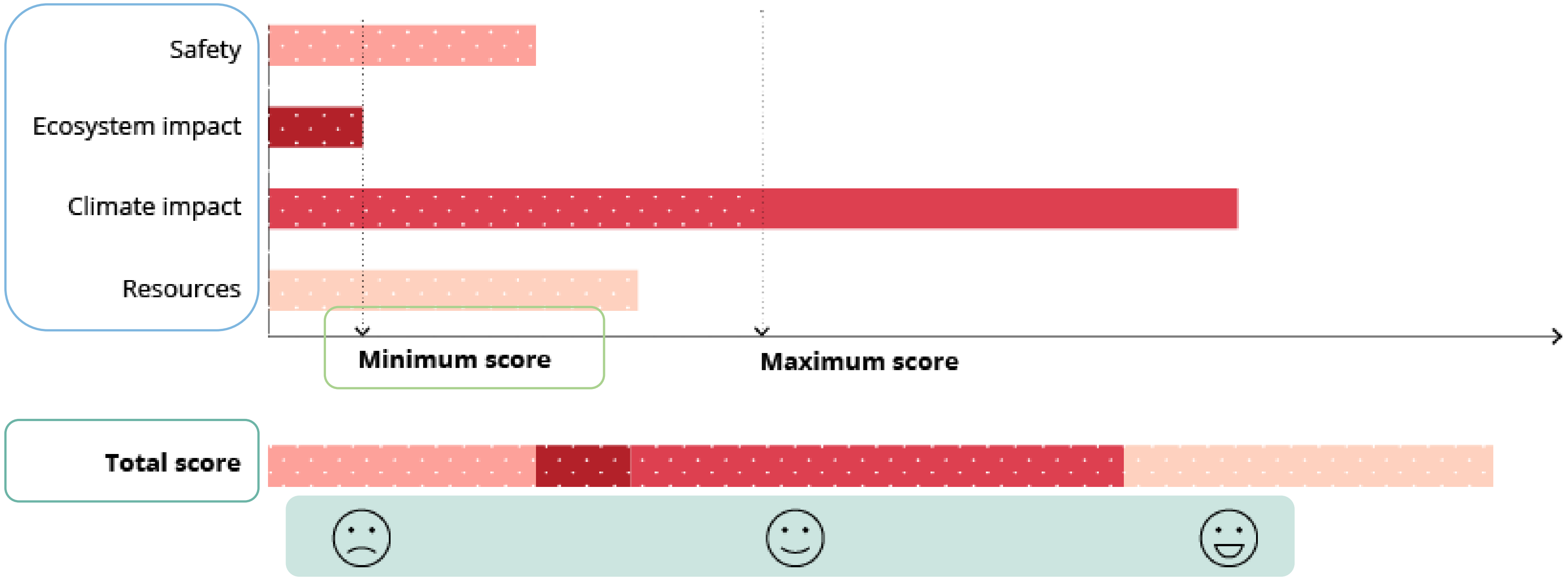


Service (pest control) delivered by:
- Chemical pesticides?
- Physical removal?
- Biological methods?

Focus on *chemicals and materials* alone limits innovation,
e.g. to drop-in chemical substitution
=> apply SSBD on products and processes as well

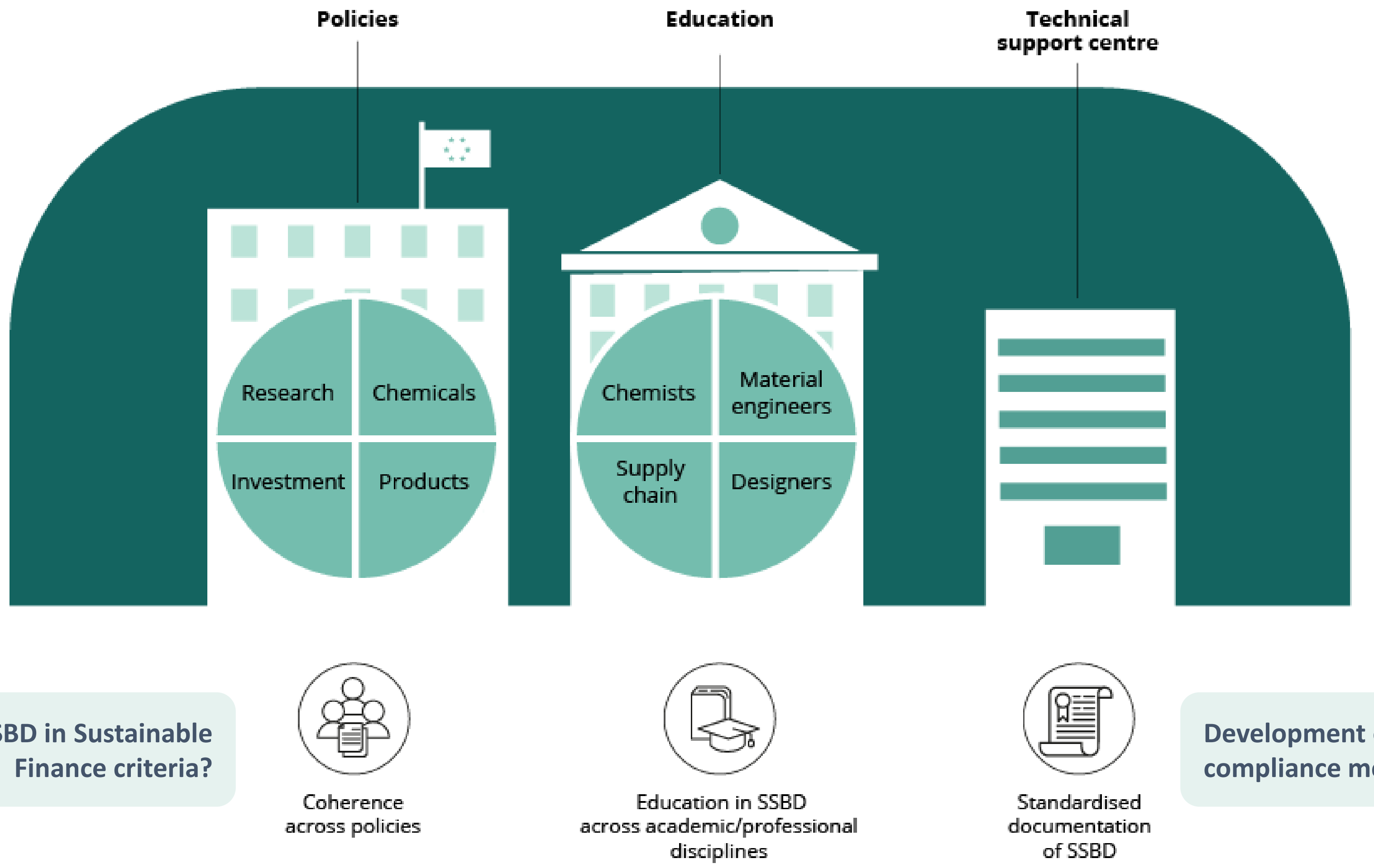
Assessing Safe and Sustainable by Design

- **Meet sustainability goals -** *without compromising* ***safety..***
- **Set min scores** to avoid burden shifting and to **create trust in SSBD**
- **(Societal) Protection goals can inform minimum and total scores**



EEA 2021: Web-briefing on SSBD: https://www.eea.europa.eu/publications/designing-safe-and-sustainable-products-1

Safe and Sustainable by Design – creating an enabling environment

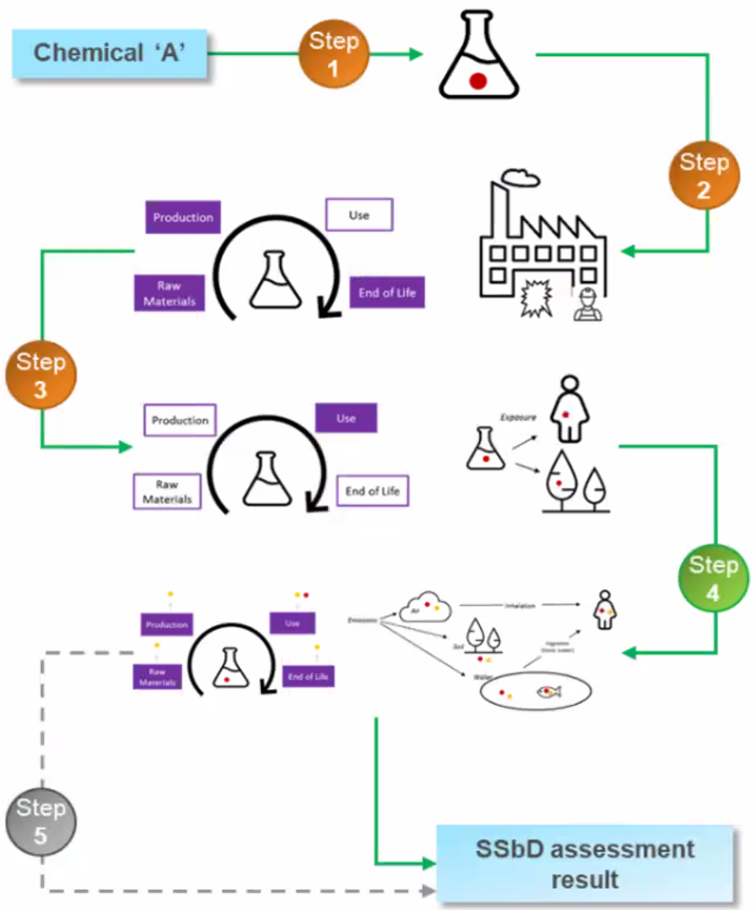


SSBD in Sustainable Finance criteria?

Development of compliance methods

EEA 2021: Web-riefing on SSBD: https://www.eea.europa.eu/publications/designing-safe-and-sustainable-products-1

SSbD JRC Framework



Step 1: Safety of chemical and material
(hazard-based approach)
Cut-off criteria

Step 2: Chemical or material processing safety
(occupational safety and health aspects)

Step 3: Human health and environmental effects from the use phase
(direct exposure)

Step 4: Environmental sustainability assessment
(Life Cycle Assessment)

Step 5: Social and economic assessment

How to foster a transition to Safe and Sustainable by Design?

- **Trustworthy**
  => standardised methodology to avoid greenwashing
- **Build on existing methodologies**, if possible
  - start with what exists, e.g. safety: avoid *substances of concern.*
  - add sustainability components when they are ready
  - expand methods and models on
    - life-cycle assessment for chemicals,
    - (generate) environmental) monitoring data to validate models
    - ensure access to data/statistics on uses, volumes, chemical identity needed to fill the models
    - use standardised methods to fill data-gaps
- **Education and involvement of stakeholders**
  - educate and involve stakeholders along supply chains
  - educate on methodologies and interdisciplinary design processes

How to foster a transition to Safe and Sustainable by Design food systems?

- **Implementable**:
  - develop fast, cost-efficient compliance methods
  - create a level playing field for European and imported products
  - Technical Support centres to assist businesses
- **Strong incentives needed for broad uptake of SSBD by industry** – sticks and carrots:
  - legal obligations, e.g. to include SSBD into risk assessment?
  - financial incentives – e.g. Financial taxonomy for investments, taxes, fees?
  - public and private procurement?

Thanks to you for listening!

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Thanks to the European Environment Agency (EEA)

Xenia Trier
Associate Professor
University of Copenhagen
Department of Plant and Environmental Sciences
Section for Environmental Chemistry and Physics
Thorvaldsensvej 40
Frederiksberg C
DIR +45 35 33 51 63
xt@plen.ku.dk

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Willkommen
Welcome
Bienvenue

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Operationalizing Safe and Sustainable by Design: JRC's Framework and Some Personal Thoughts

Zhanyun Wang

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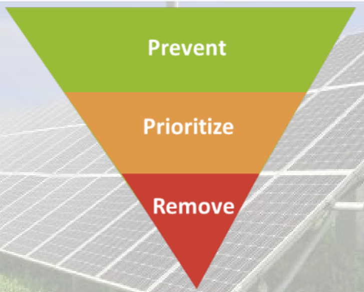

JRC's Work on SSbD

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European Commission

JRC TECHNICAL REPORT

Safe and Sustainable by Design chemicals and materials

Review of safety and sustainability dimensions, aspects, methods, indicators, and tools

Caldeira, C. Farcal, R., Moretti, C., Mancini, L., Rauscher, H., Rasmussen, K., Riego Sintes, J., Sala, S.

2022

EUR 30991 EN


European Commission

JRC TECHNICAL REPORT

Safe and Sustainable by Design chemicals and materials

Framework for the definition of criteria and evaluation procedure for chemicals and materials

Caldeira, C. Farcal, R., Garmendia Aguirre, I., Mancini, L., Tosches, D., Amelio, A., Rasmussen, K., Rauscher, H., Riego Sintes, J., Sala, S.

2022

EUR 31100 EN

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Intgration of SSbD in the Innovation Cycle

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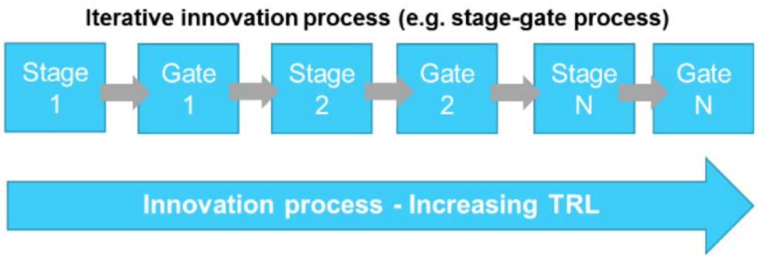

Intgration of SSbD in the Innovation Cycle

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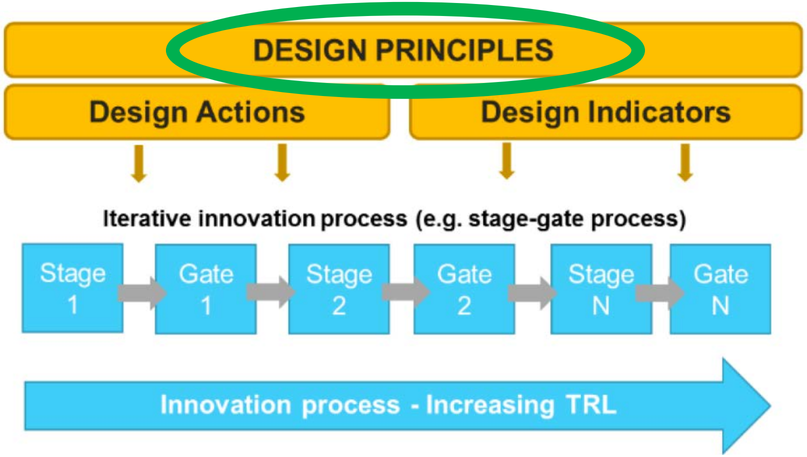

Proposed Design Principles

Material efficiency	Minimise the use of hazardous chemicals/materials	Design for energy efficiency	Use renewable sources
Prevent and avoid hazardous emissions	Reduce exposure to hazardous substances	Design for end-of-life	Consider the whole life cycle

Intgration of SSbD in the Innovation Cycle

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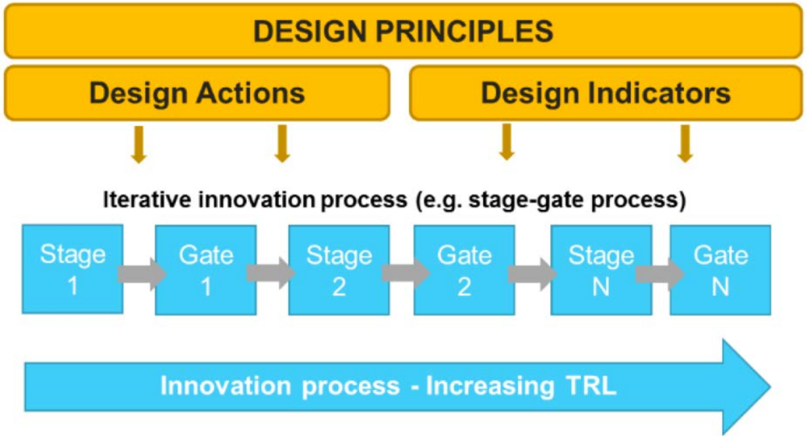

Intgration of SSbD in the Innovation Cycle

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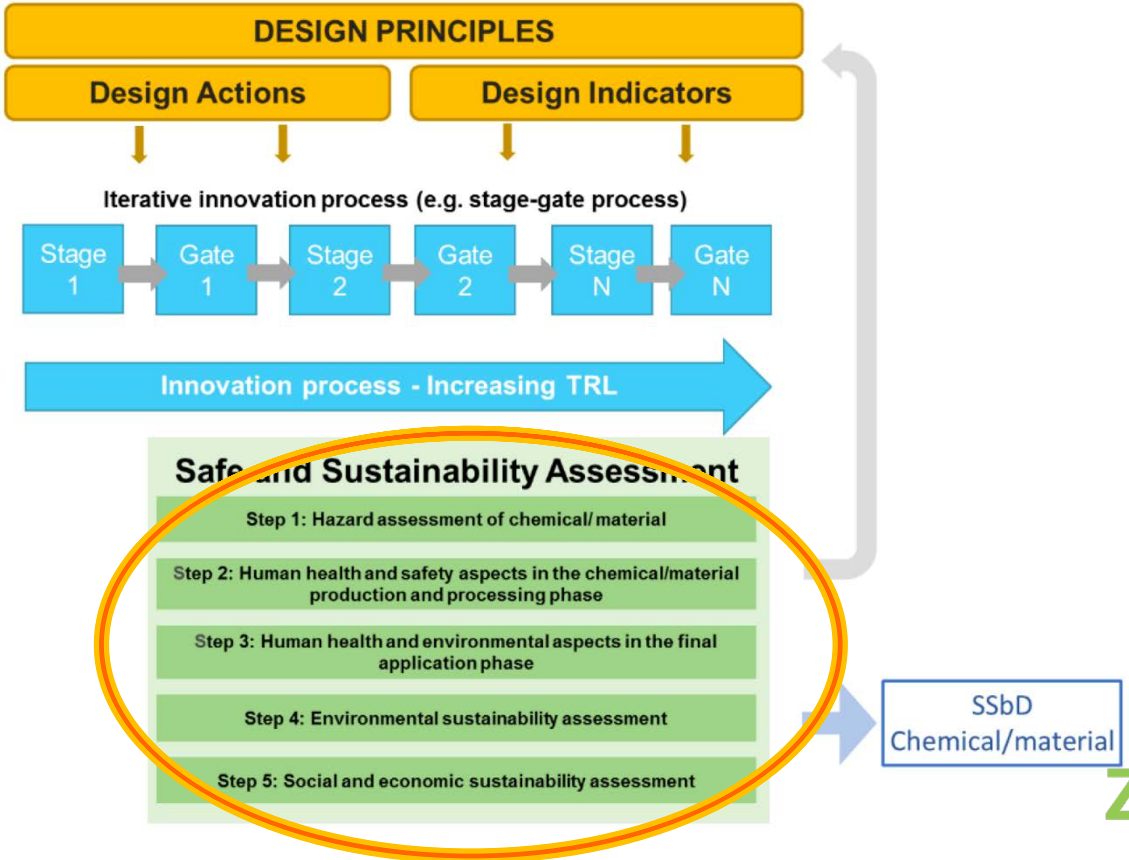

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Safety and Sustainability Assessment

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Safe and Sustainability Assessment

Step 1: Hazard assessment of chemical/ material

Step 2: Human health and safety aspects in the chemical/material production and processing phase

Step 3: Human health and environmental aspects in the final application phase

Safety dimension

Step 4: Environmental sustainability assessment

Step 5: Social and economic sustainability assessment

Sustainability dimension

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Step 1. Hazard Assessment

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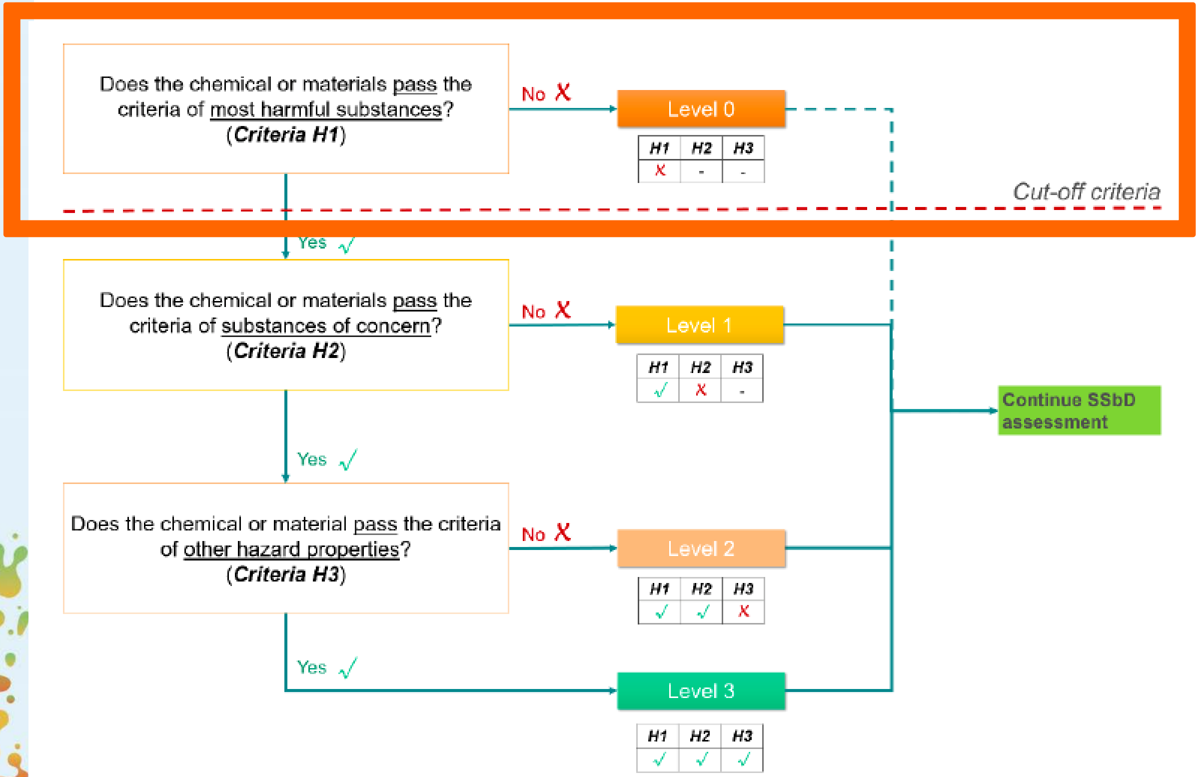

- H1 = Substances of Very High Concern (SVHCs) + EDCs Cat. 1 +PMT/vPvM +STOT RE Cat. 1 (incl. immunotoxicity + neurotoxicity)
- H2 = substances of concern, including skin sensitization, CMR cat. 2, STOT (RE Cat. 2, SE Cat. 1&2), EDCs Cat. 2, ozone-depletion + chronic aquatic toxicity
- H3 = other hazard classes

Step 2. Occupational Safety and Health

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- Including raw material extraction, production, and end-of-life treatment
- Including the chemicals used in all the production and processing steps

Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Safety	
4	4	5	5	5	21-25	Negligible risk
3	3	4	4	5	16-20	Low-risk
1	2	3	3	4	11-15	Medium-risk
1	1	2	2	3	6-10	High-risk
1	1	1	1	1	0-5	Very high risk

?

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Step 3. Safety during Use

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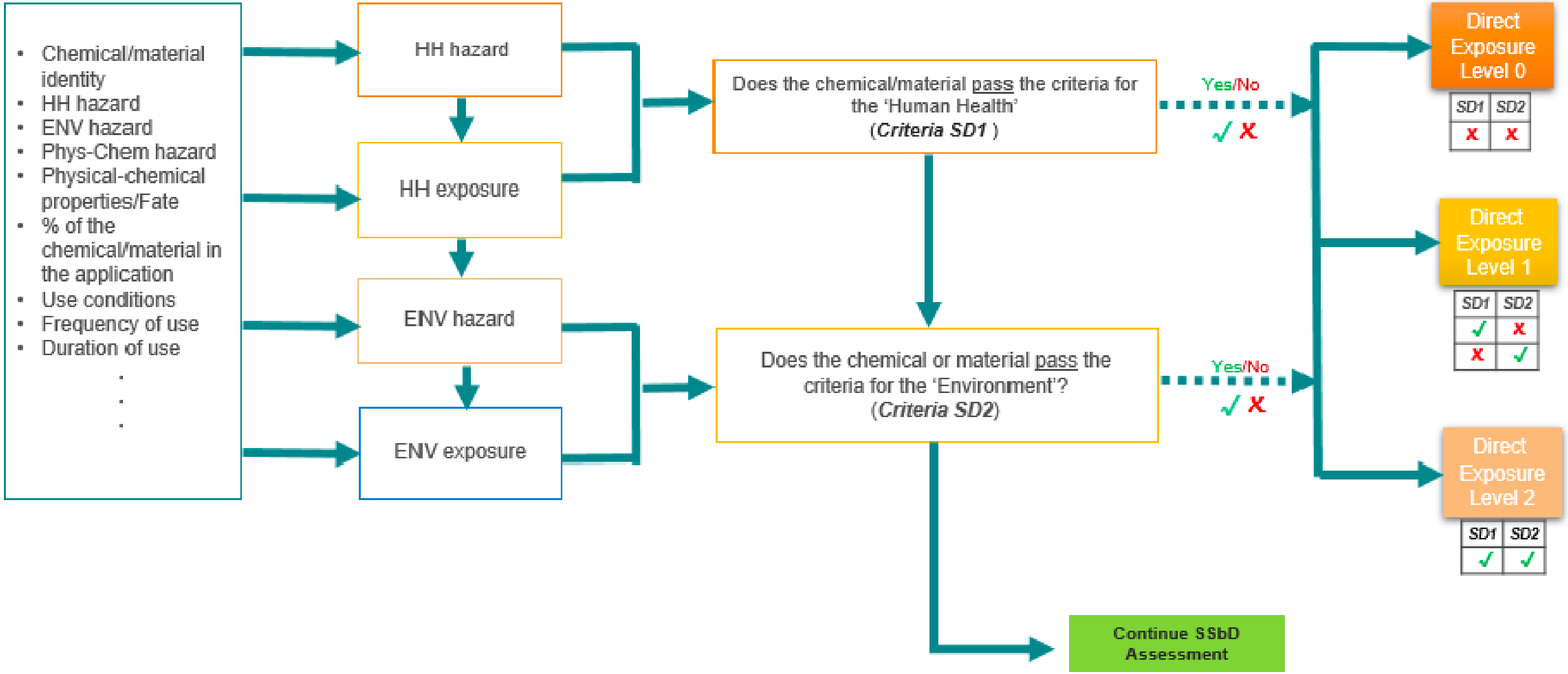

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Step 4. Environmental Sustainability

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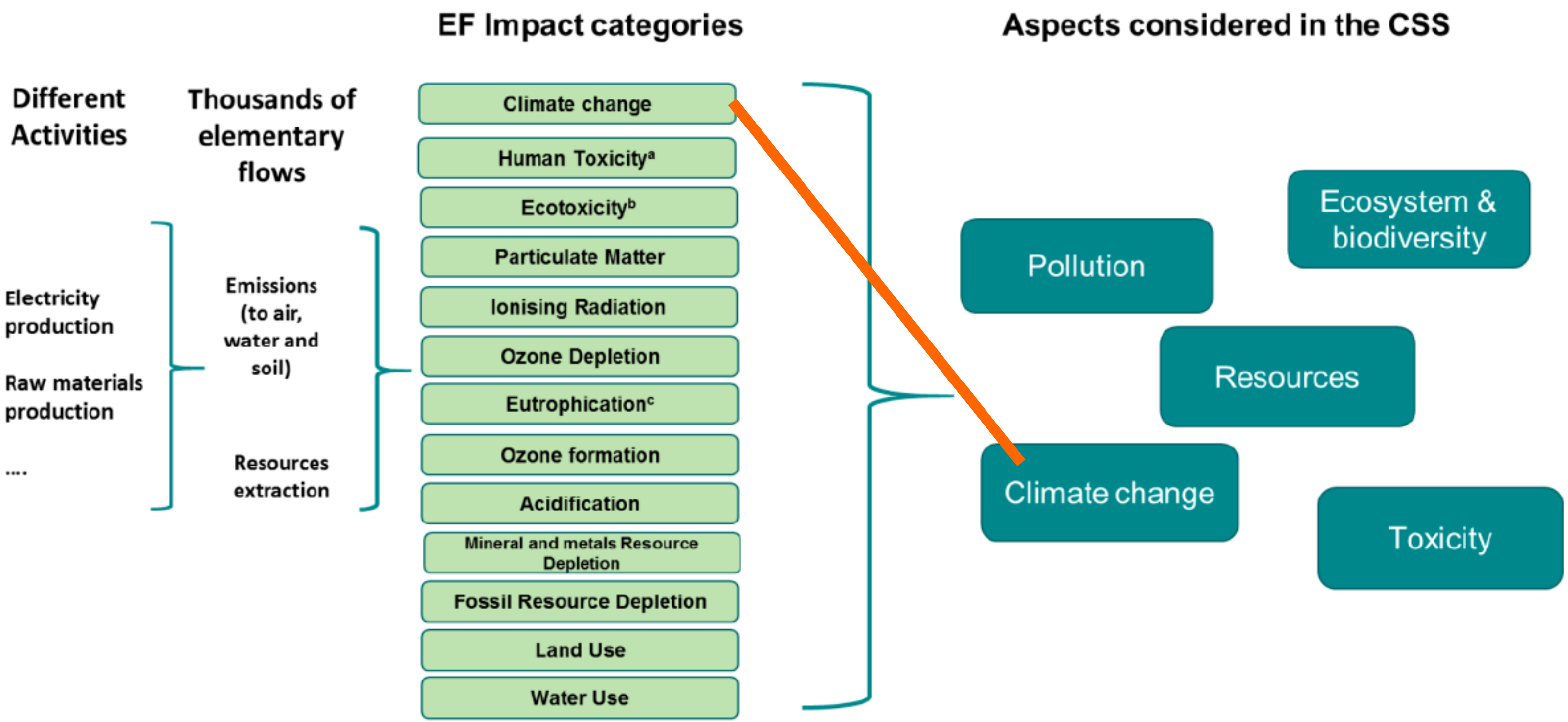

[a] two impact categories: cancer and non-cancer; [b] freshwater; [c] three impact categories: terrestrial, freshwater, and marine eutrophication

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Step 4. Environmental Sustainability

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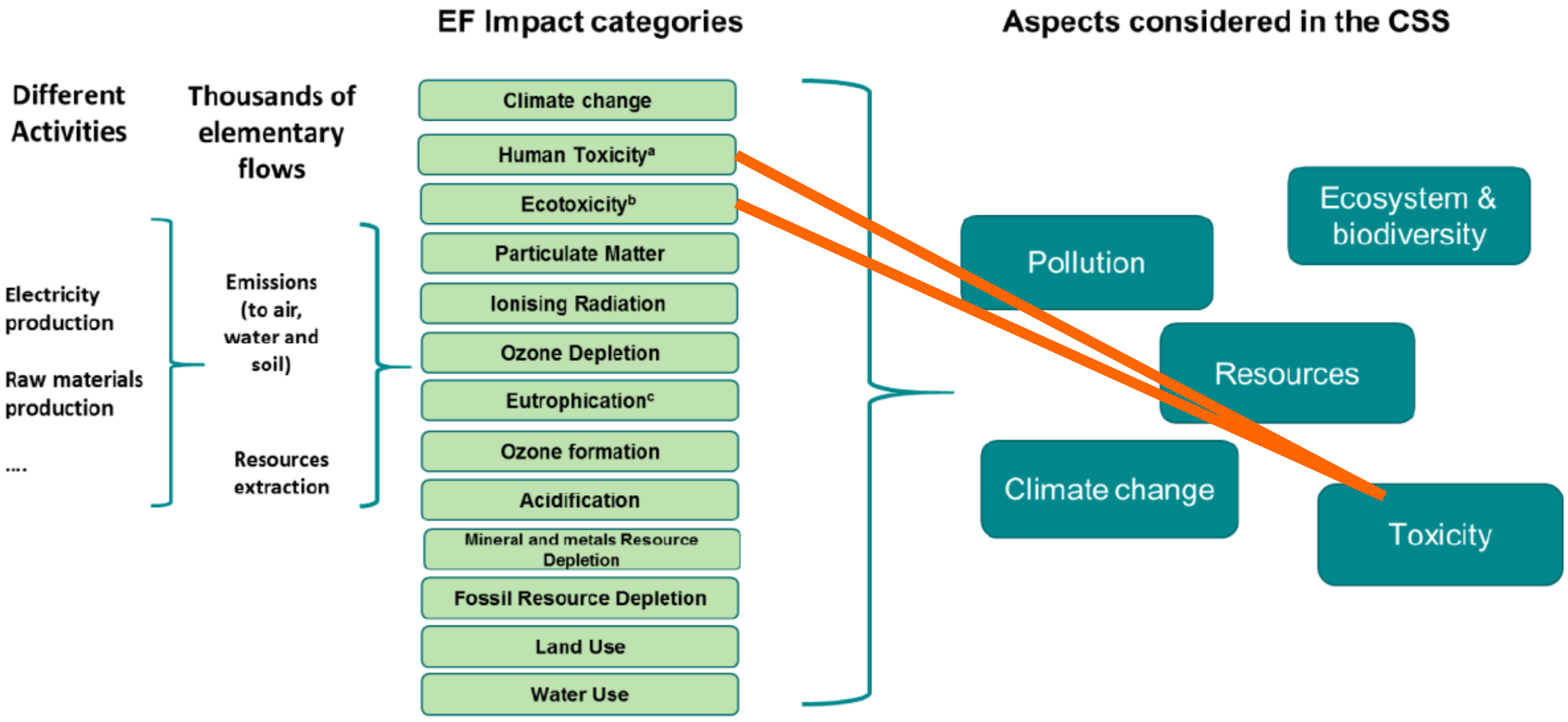

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Step 4. Environmental Sustainability

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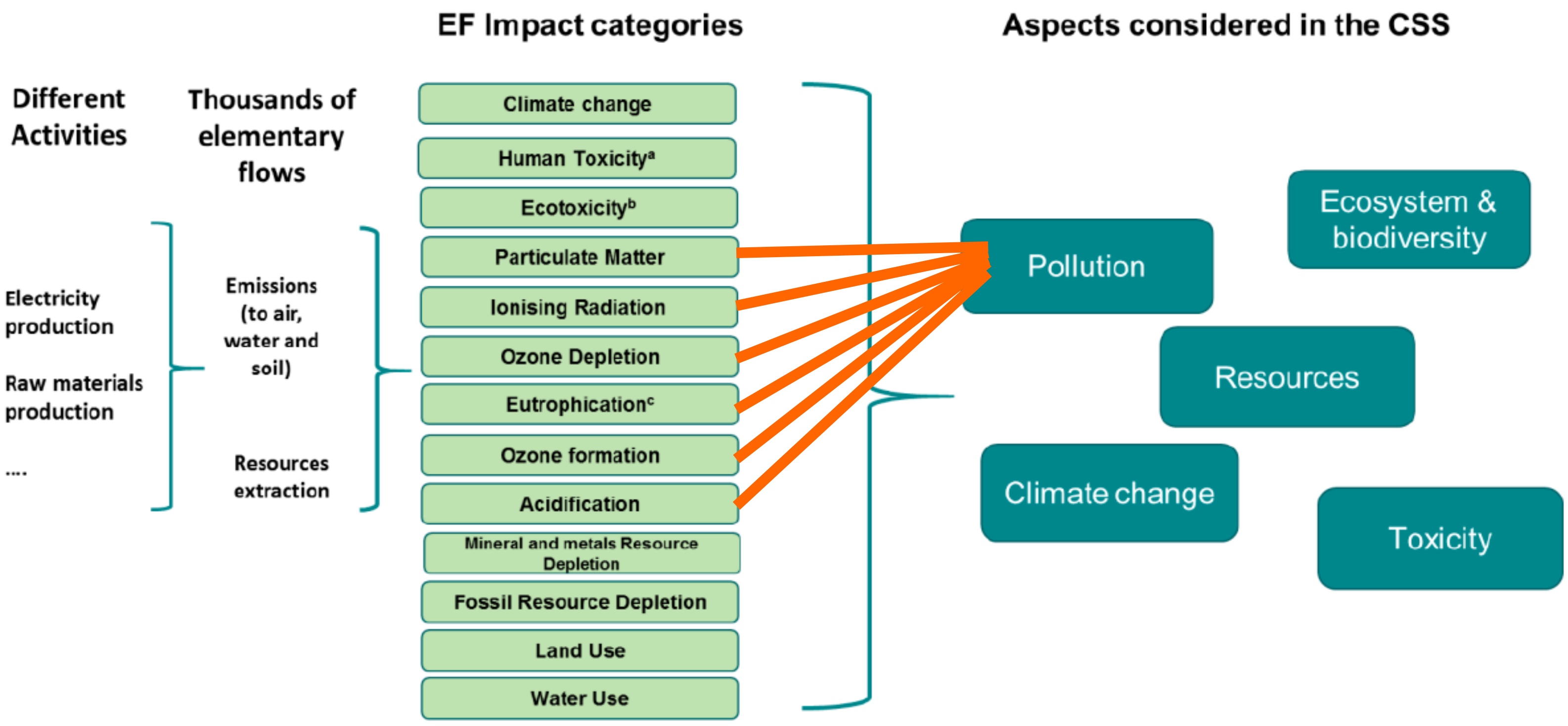

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Step 4. Environmental Sustainability

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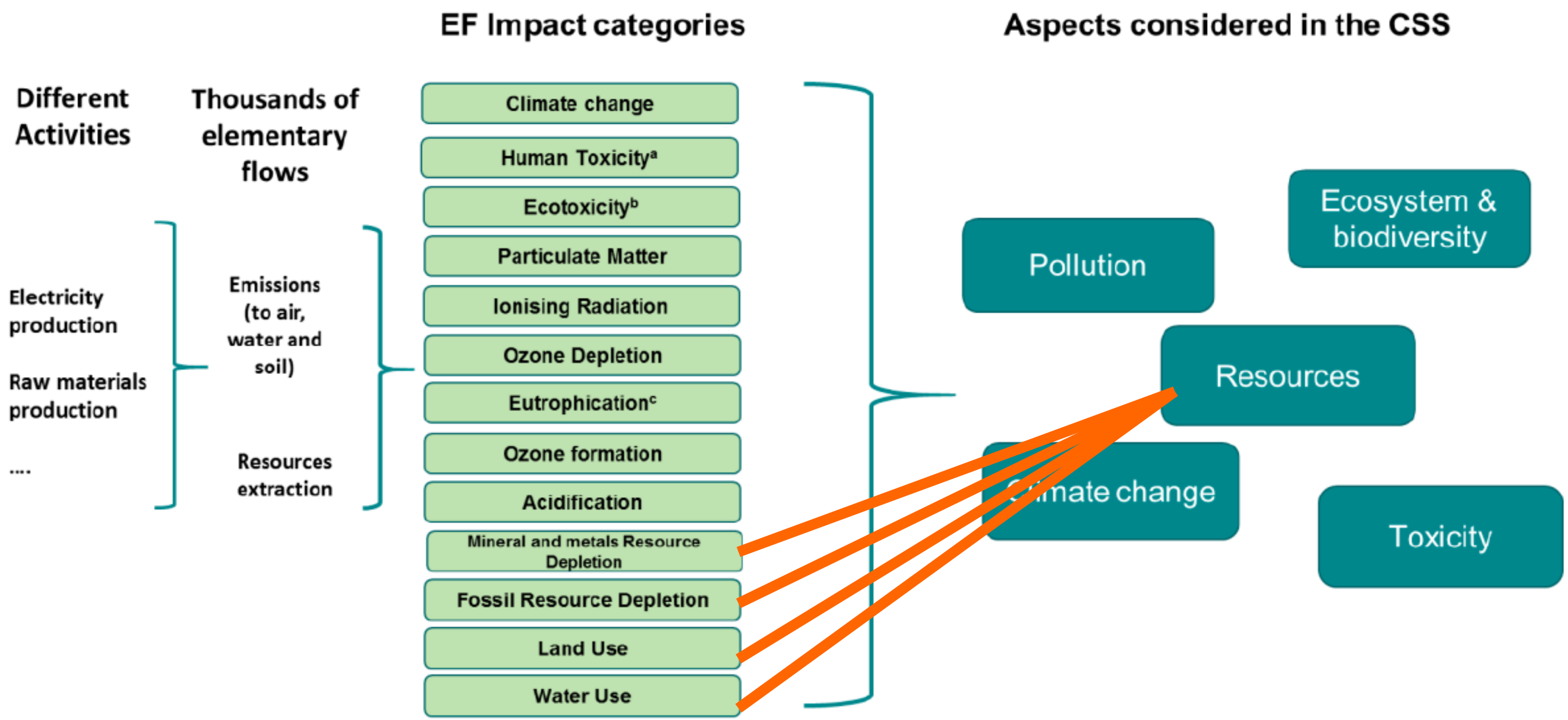

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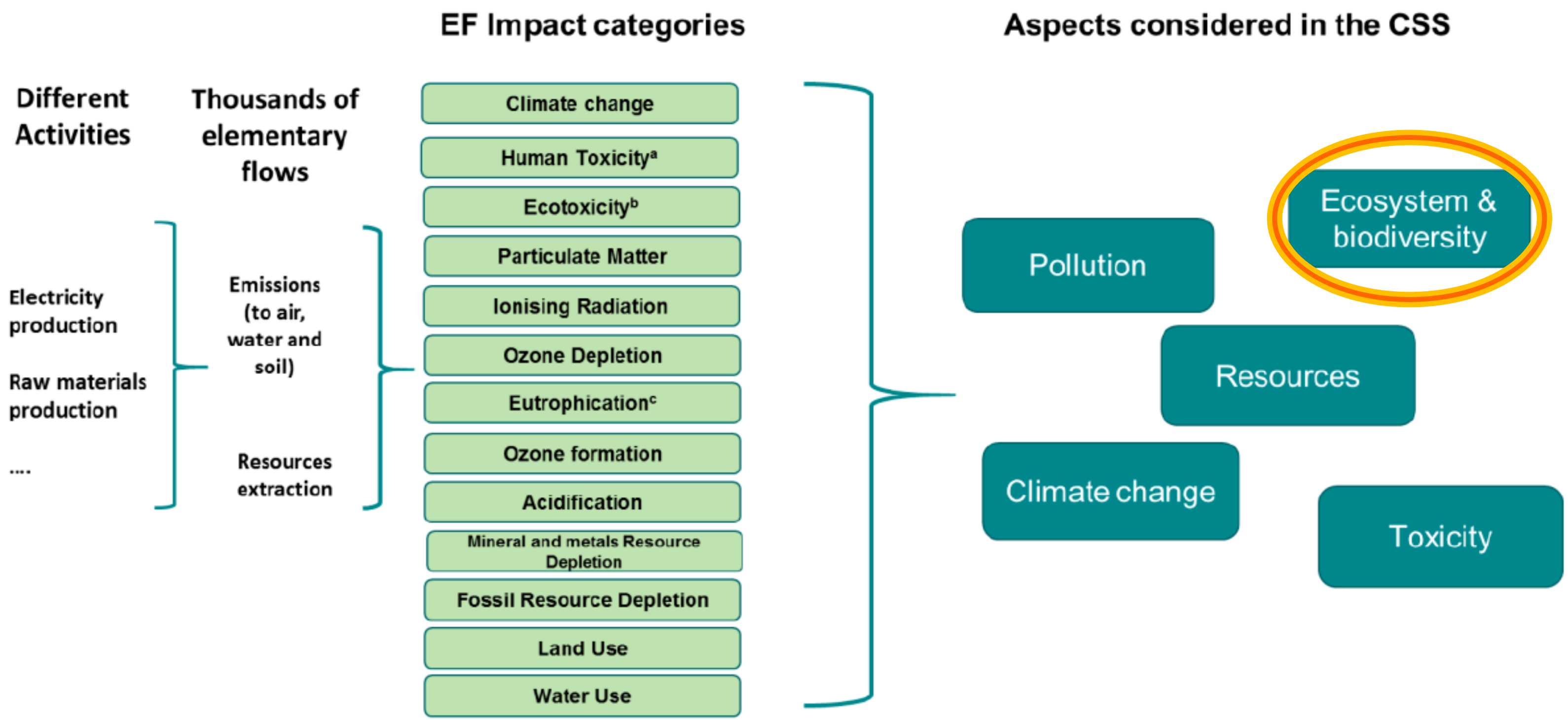

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Step 4. Environmental Sustainability

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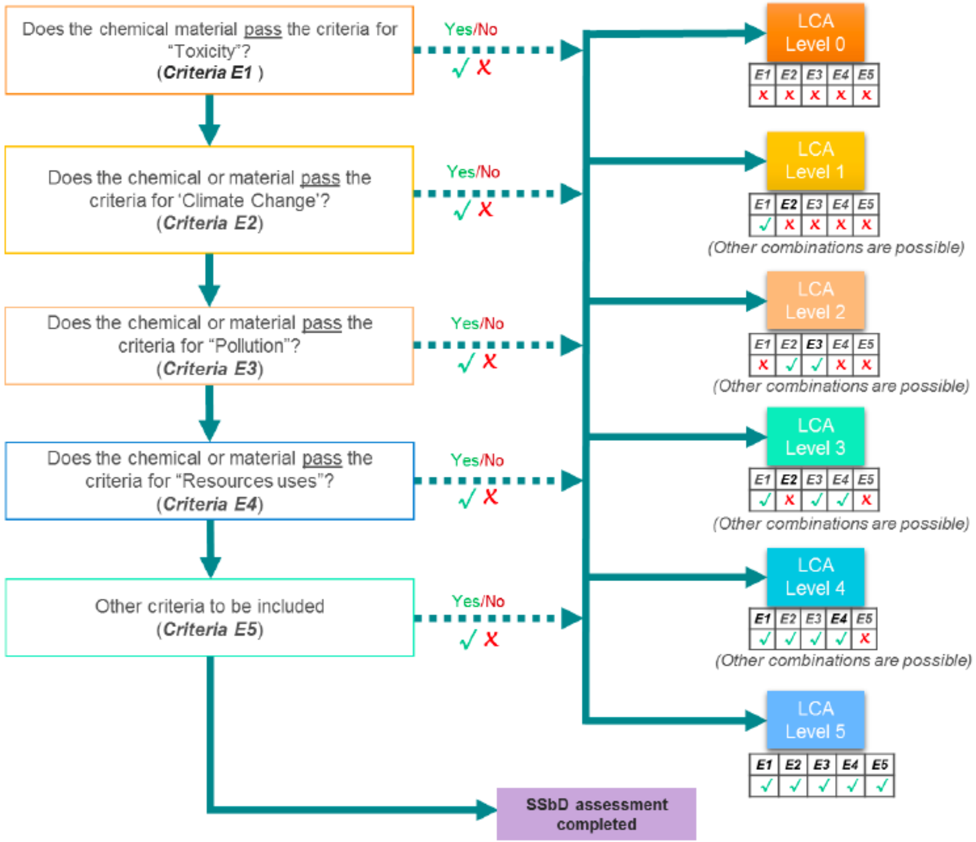

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

vs. absolute sustainability?

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Step 5. Social and Economic Sustainability

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- Can rely on existing life-cycle-based methodologies, namely the Life Cycle Costing (LCC) and the Social Life Cycle Assessment.

- However, they are less mature than the environmental one.

Table 10. List of stakeholder categories, social aspects and occurrence in the social frameworks under investigation

Stakeholder category	Social aspect	Number of frameworks including the aspect
Workers	Child labour	8
	Fair salary	8
	Forced labour	8
	Health and Safety	8
	Freedom of association and collective bargaining	7
	Working hours	7
	Equal opportunities / discrimination	7
Local community	Community engagement	6
	Local employment	6
Consumers	Health and safety	7
	Responsible communication	6

→ Further work is needed in order to ensure applicability in SSbD: e.g., quantiative assessment vs. social safeguards

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Overall Evaluation

Adherence with SSbD design principles

SSbD Design principles	
SSbD 1, Indicator 1.1	✓
SSbD 2, Indicator 2.1	✓
SSbD 3, Indicator 3.2	✓
...	

Safety and Sustainability Assessment

Dimension	Aspect	Results (Life Cycle Stage, if applicable)				Criteria
		Raw material	Production	Use	EoL	
Hazard properties	H1 ...					
Human health and safety aspects (production & processing phase)	OSH1 ...					
Human health and environmental aspects (application phase)	SD 1 ...					
Environmental sustainability	E1 ...					
Social & Economical Sustainability						

This table contains the detailed assessment

Safe and sustainable by design (SSbD) Dashboard

Dimension	Aspect	Level	Score
Hazard properties	H1	✓	3
	H2	✓	2
	H3	✓	3
Human health and safety aspects (production & processing phase)	OSH1	✓	4
	OSH2	✓	4
	OSH3	✓	4
	OSH4	✓	4
	OSH5	✓	4
Human health and environmental aspects (application phase)	SD1	✓	4
	SD2	✗	1
Environment Sustainability	E1	✗	1
	E2	✓	3
	E3	✗	1
	E4	✓	3
Social & Economical Sustainability		✗	1

SSbD Level

or

SSbD Score

Question 1: When to Do What Assessment?

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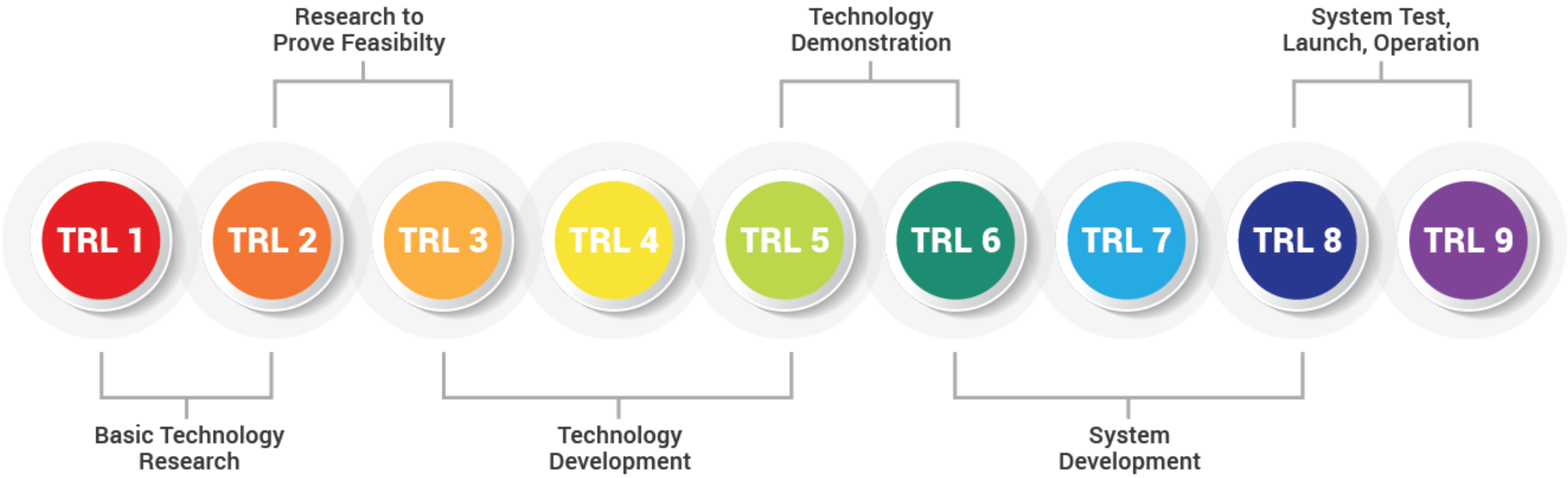

- Should we always follow the five steps, or have varied combinations for different TRL with appropriate tools?

https://www.abaco.com/technology-readiness-level

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Question 1: When to Do What Assessment?

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≥ 1000 t/year (annexes VII + VIII + IX + X)

100-1000 t/year (annexes VII + VIII + IX)

10-100 t/year (annexes VII + VIII)

1-10 t/year (annexe VII)

Toxicological information

- Skin irritation or skin corrosion *(in vitro)*
- Eye irritation *(in vitro)*
- Skin sensitisation
- Mutagenicity (*in vitro*, gene mutation bacteria)
- Acute toxicity (oral route)

- Skin irritation (*in vivo*)
- Eye irritation (*in vivo*)
- Mutagenicity (*in vitro*, cytogenicity mammalian cells or micronucleus)
- Mutagenicity (*in vitro*, gene mutation mammalian cells)
- Acute toxicity (inhalation)
- Acute toxicity (dermal route)
- Repeated dose toxicity (28 days, one species)
- Reproductive toxicity (screening, one species)
- Toxicokinetics (assessment from available information)

- Repeated dose toxicity (28 days, one species)*
- Repeated dose toxicity (90 days, one species, rodent)
- Reproductive toxicity (pre-natal development, one species)
- Reproductive toxicity (two generations, one species)

- Reproductive toxicity (developmental, one species)
- Reproductive toxicity (two generations, one species)*
- Carcinogenicity study

** These studies have to be carried out if they have not been completed for the lower tonnage band because of waiving*

https://contactpointnano.ch/wp-content/uploads/2018/12/03_Contactpointnano_Studer.pdf

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Question 1: When to Do What Assessment?

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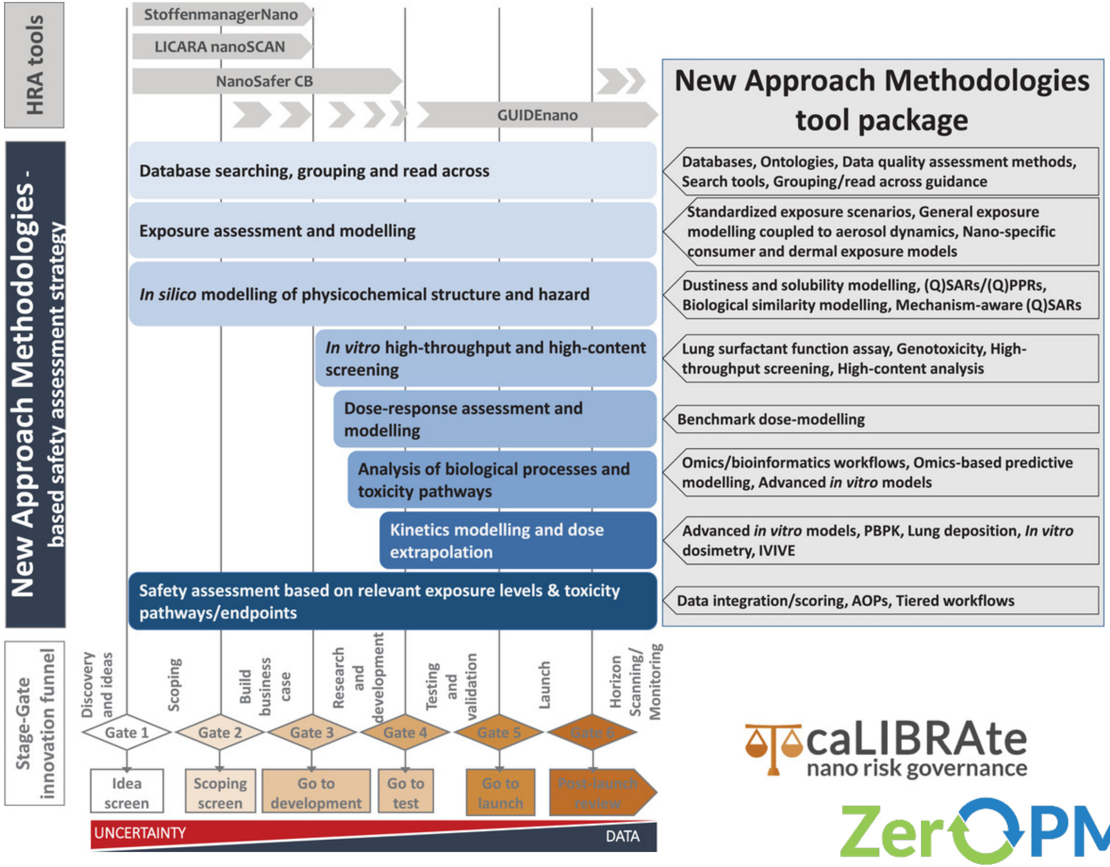
Should the low TRL already include in silico screening for hazards and environmental sustainability?



https://onlinelibrary.wiley.com/doi/full/10.1002/smll.201904749

caLIBRAte nano risk governance

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Question 1: When to Do What Assessment?

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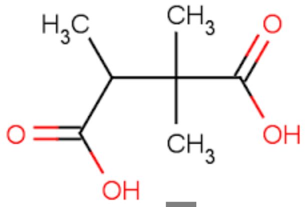
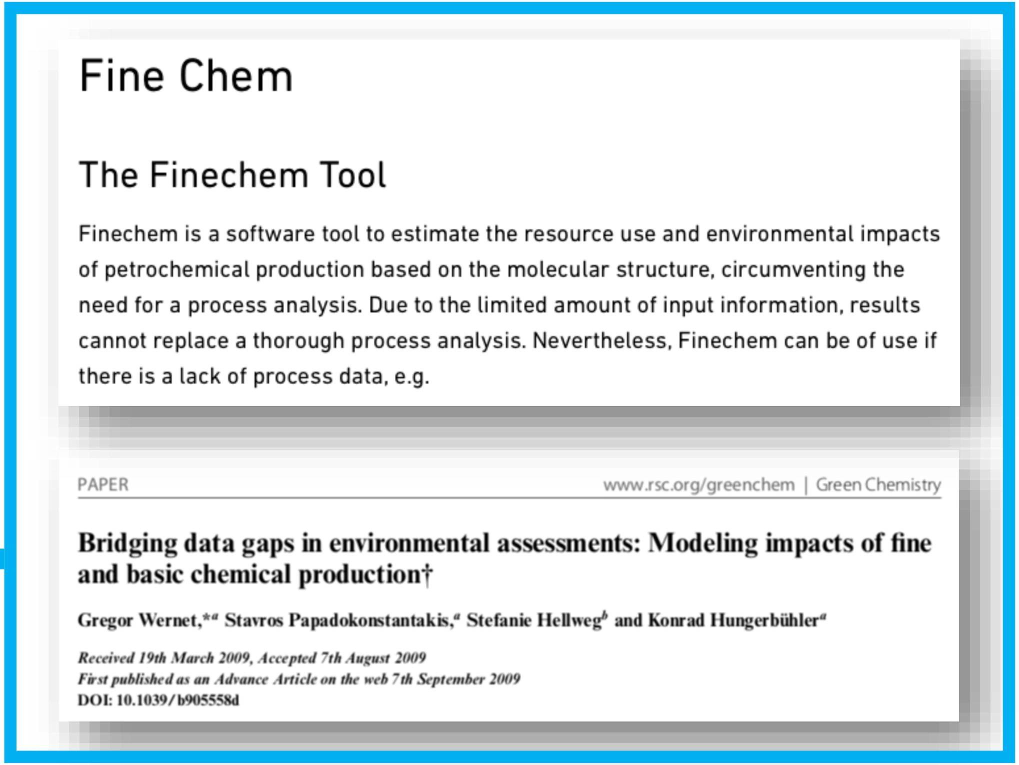


10 molecular descriptors, e.g.,

- molecular weight
- number of nitrogen/halogen atoms
- number of total functional groups

Life cycle environmental impacts

- cumulative energy demand (CED) ✓
- global warming potential (GWP) ✓
- eco-indicator 99 ✓



Fine Chem

The Finechem Tool

Finechem is a software tool to estimate the resource use and environmental impacts of petrochemical production based on the molecular structure, circumventing the need for a process analysis. Due to the limited amount of input information, results cannot replace a thorough process analysis. Nevertheless, Finechem can be of use if there is a lack of process data, e.g.

PAPER | www.rsc.org/greenchem | Green Chemistry

Bridging data gaps in environmental assessments: Modeling impacts of fine and basic chemical production†

Gregor Wernet,*[a] Stavros Papadokonstantakis,[a] Stefanie Hellweg[b] and Konrad Hungerbühler[a]

Received 19th March 2009, Accepted 7th August 2009
First published as an Advance Article on the web 7th September 2009
DOI: 10.1039/b905558d

https://emeritus.setg.ethz.ch/research/downloads/software---tools/fine-chem.html

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Question 1: When to Do What Assessment?

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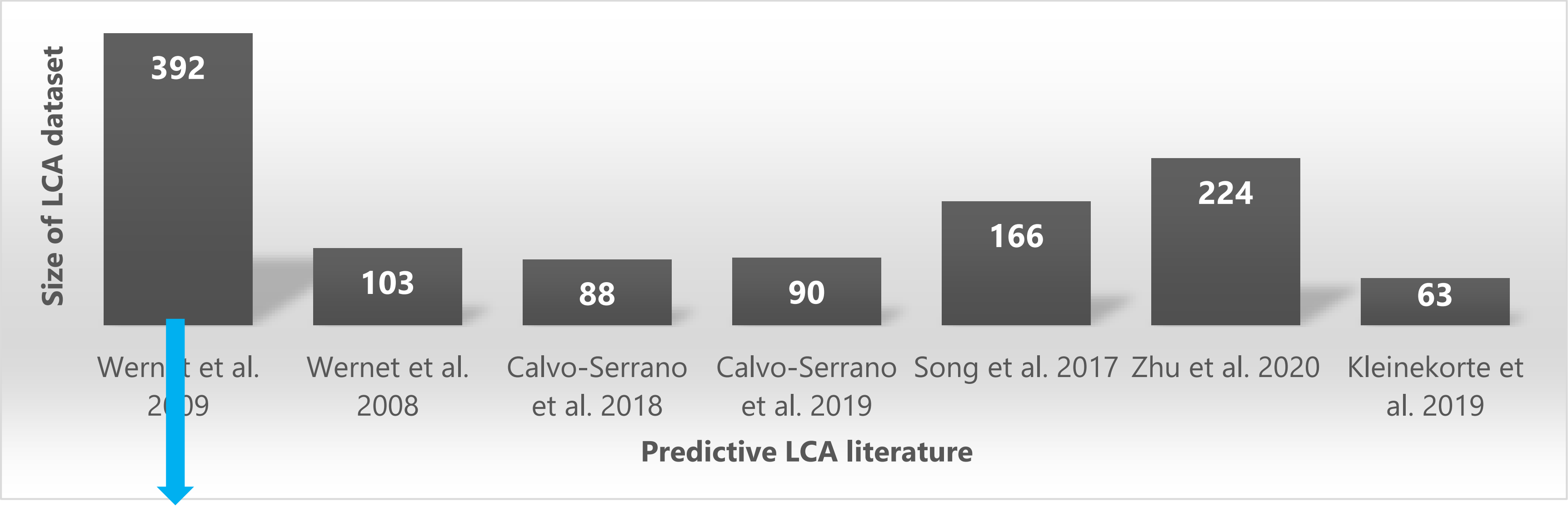

- A small training set: mostly small molecules (average molecular weight 160 g/mol); all based on petrochemical synthesis; old energy mixtures
- Does not take different synthesis routes into consideration
- Old machine learning algorithms

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Question 2: How to Balance the Criteria

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Safe and sustainable by design (SSbD) Dashboard

Dimension	Aspect	Level	Score
Hazard properties	H1	✓	3
	H2	✓	2
	H3	✓	3
Human health and safety aspects (production & processing phase)	OSH1	✓	4
	OSH2	✓	4
	OSH3	✓	4
	OSH4	✓	4
	OSH5	✓	4
Human health and environmental aspects (application phase)	SD1	✓	4
	SD2	✗	1
Environment Sustainability	E1	✗	1
	E2	✓	3
	E3	✗	1
	E4	✓	3
Social & Economical Sustainability		✗	1

How to weigh the criteria? Who decides?

	LDPE average, reused as waste bin bag	
	Climate Change	All indicators
LDPE simple, reused as waste bag	0	1
LDPE rigid handle, reused as waste bag	0	0
Recycled LDPE, reused as waste bag	1	2
PP, non-woven, recycled	6	52
PP, woven, recycled	5	45
Recycled PET, recycled	8	84
Polyester PET, recycled	2	35
Biopolymer, reused as waste bag or incinerated	0	42
Unbleached paper, reused as waste bag or incinerated	0	43
Bleached paper, reused as waste bag or incinerated	1	43[4]
Organic cotton, reused as waste bag or incinerated	149	20000
Conventional cotton, reused as waste bag or incinerated	52	7100
Composite, reused as waste bag or incinerated	23	870

https://medium.com/@parkpoomkomet/breaking-down-the-danish-study-on-the-environmental-impacts-of-grocery-carrier-bags-b8c97eb6c8fb

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Thank you for listening!

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Feedback and inputs are more than welcome!

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