PLANETS

Funded by the European Union

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Implementing SSbD in chemicals and materials value chains: Challenges & opportunities

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BNN Annual Forum 2025 – Linz

Disclaimer: no specific details on the content of the cases can be given

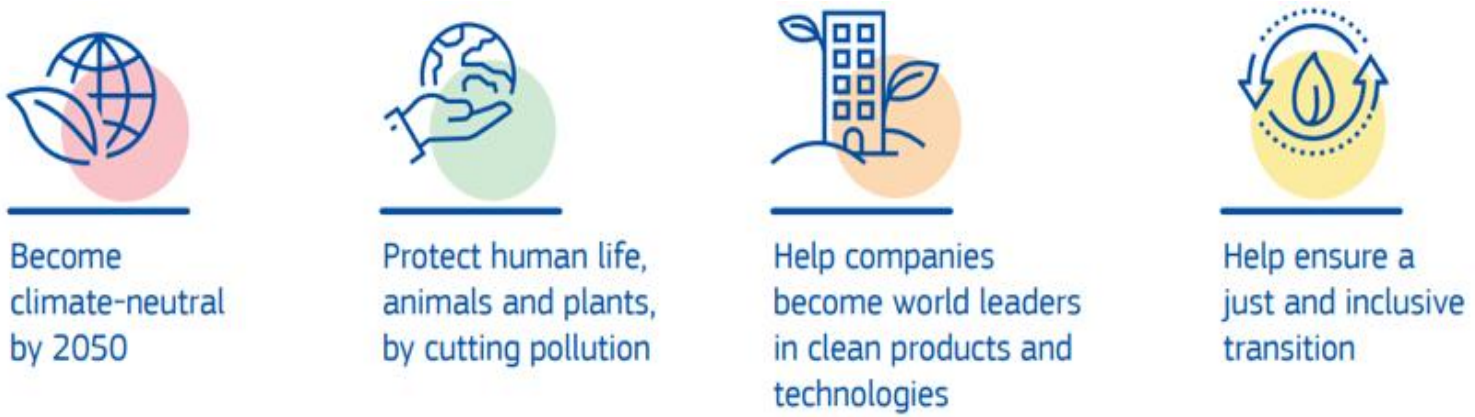
PARIS LODRON UNIVERSITY SALZBURG

Background

Some EU policies:

- Chemicals Strategy for Sustainability
- Zero Pollution Action Plan
- Circular Economy Action Plan
- Biodiversity strategy
- Critical Raw Materials Act
- EU Goals for Air, Soil and Water
- Farm to Fork strategy
- Fit for 55 Package

…call for twin green and digital transition to a sustainable, climate-neutral and circular as well as globally competitive and resilient economy



https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe_en

Background on SSbD

PLANETS will demonstrate the **applicability of the SSbD framework** in 3 **real industrial case studies** (plasticizers, flame retardants, surfactants), developing **safer & more sustainable alternatives** to critical chemical materials!

What is SSbD? → That is the Challenge!

Safe and Sustainable by Design

Hazard x exposure = risks

- Human health effects
- Worker/consumer exposure
- Environmental exposure

Life cycle impacts

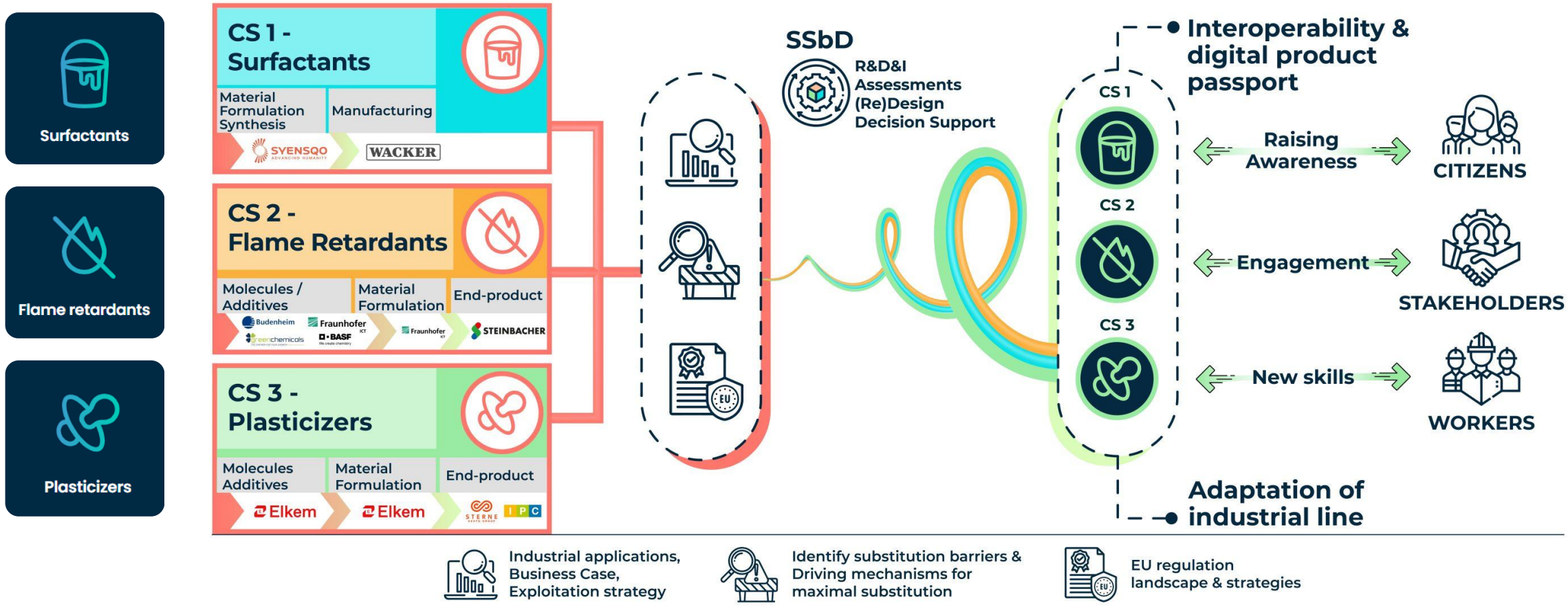
- Environmental (climate, biodiversity, resources, etc.)
- Social (working conditions, human rights, etc.)
- Financial (e.g. TCO, LCC)

Functionality

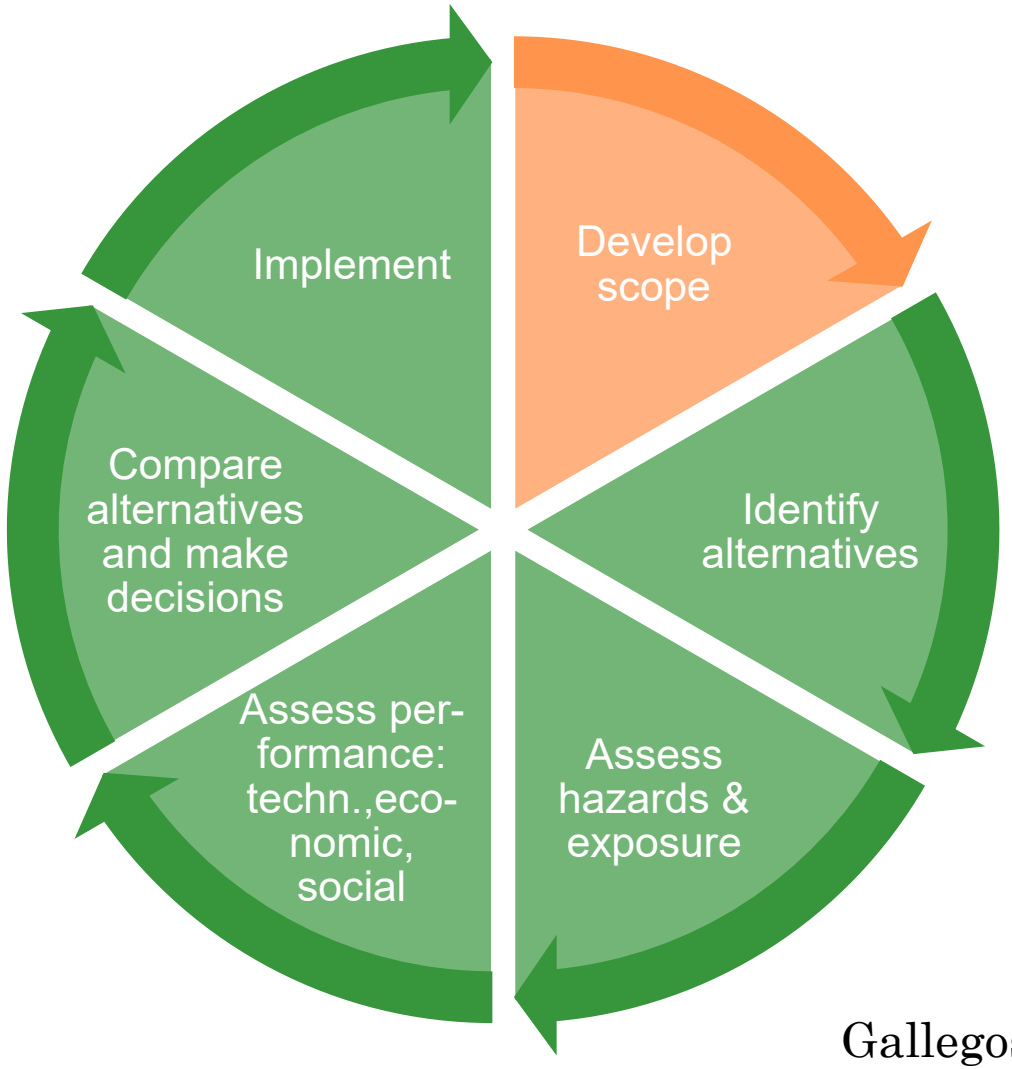
- Chemical, material, product, process, etc.
- Trade-offs between dimensions
- End-of-life

SSbD → holistic view, entire product lifecycle

PLANETS' case studies for implementing SSbD



For SSbD you need a plan → Scoping



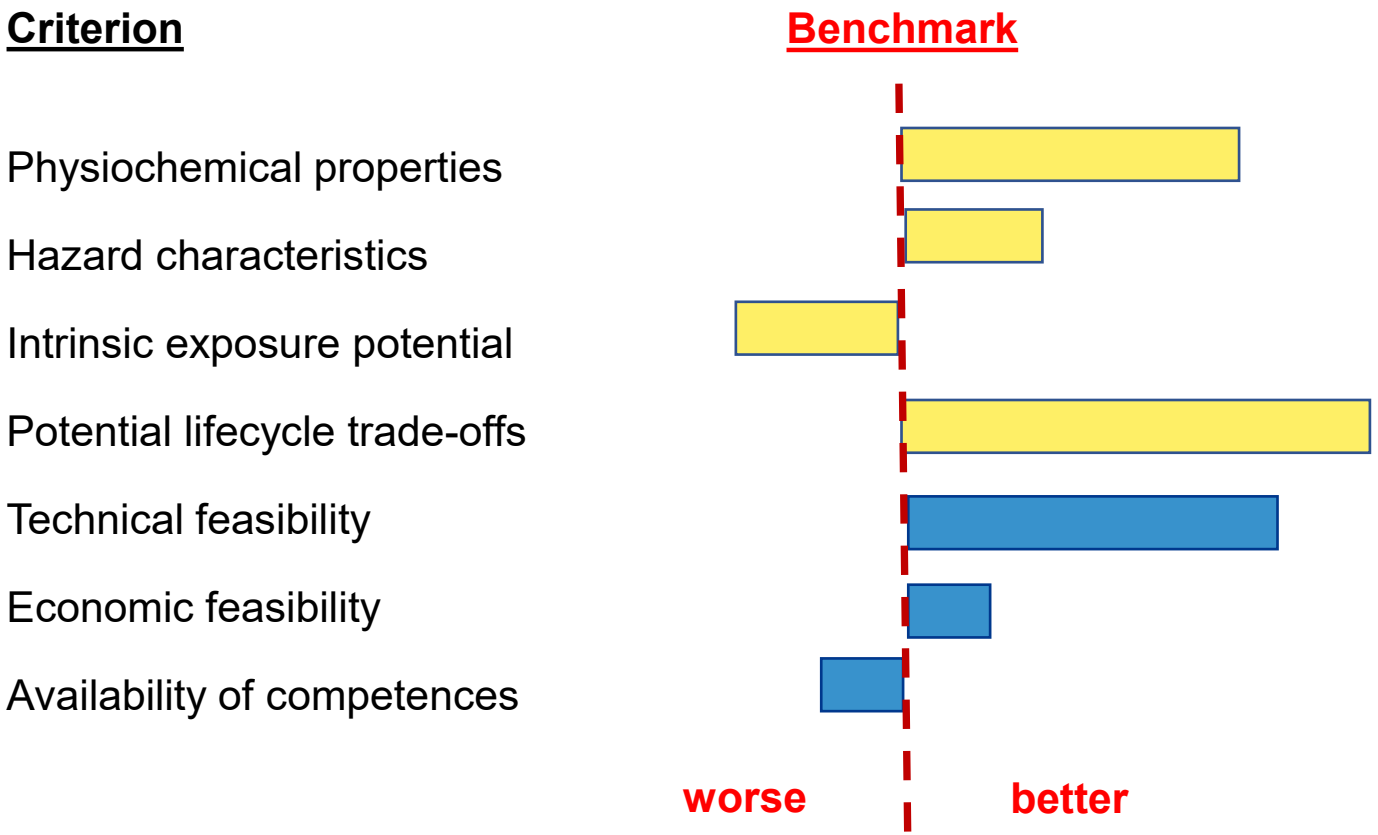
The scoping analysis determines the boundaries and provides focus for the SSbD assessment by answering the questions:

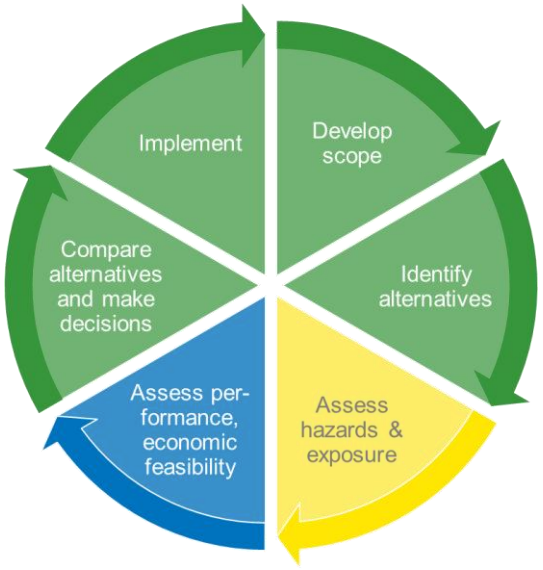
- (Re)design definition: **WHY** (**WHAT**)
- System definition: **WHAT**
- Actors in the life cycle: **WHO**
- The assessment: **HOW**

Gallegos GML, *et al.*, 2025, https://doi.org/10.1016/j.csbj.2025.07.030

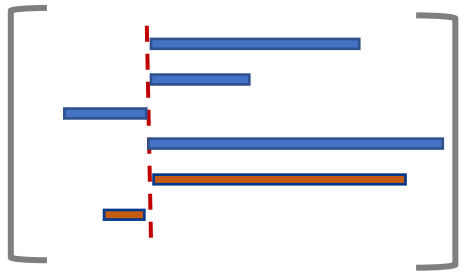
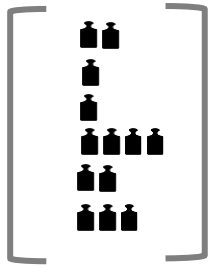
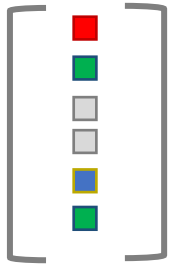
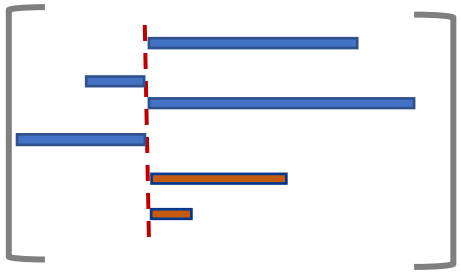
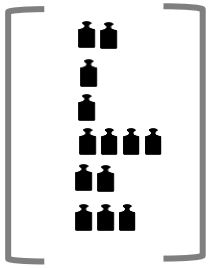
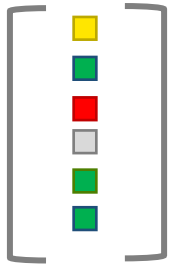
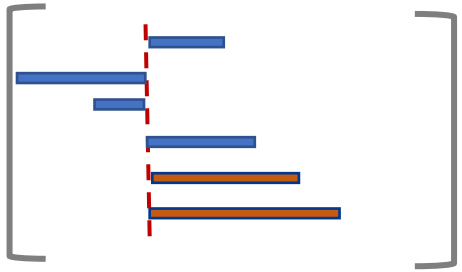
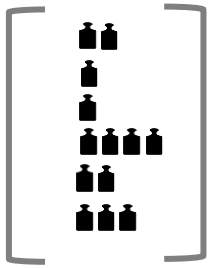
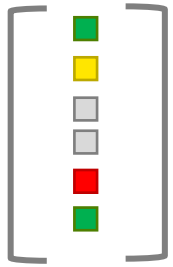
Decision on acceptable alternatives

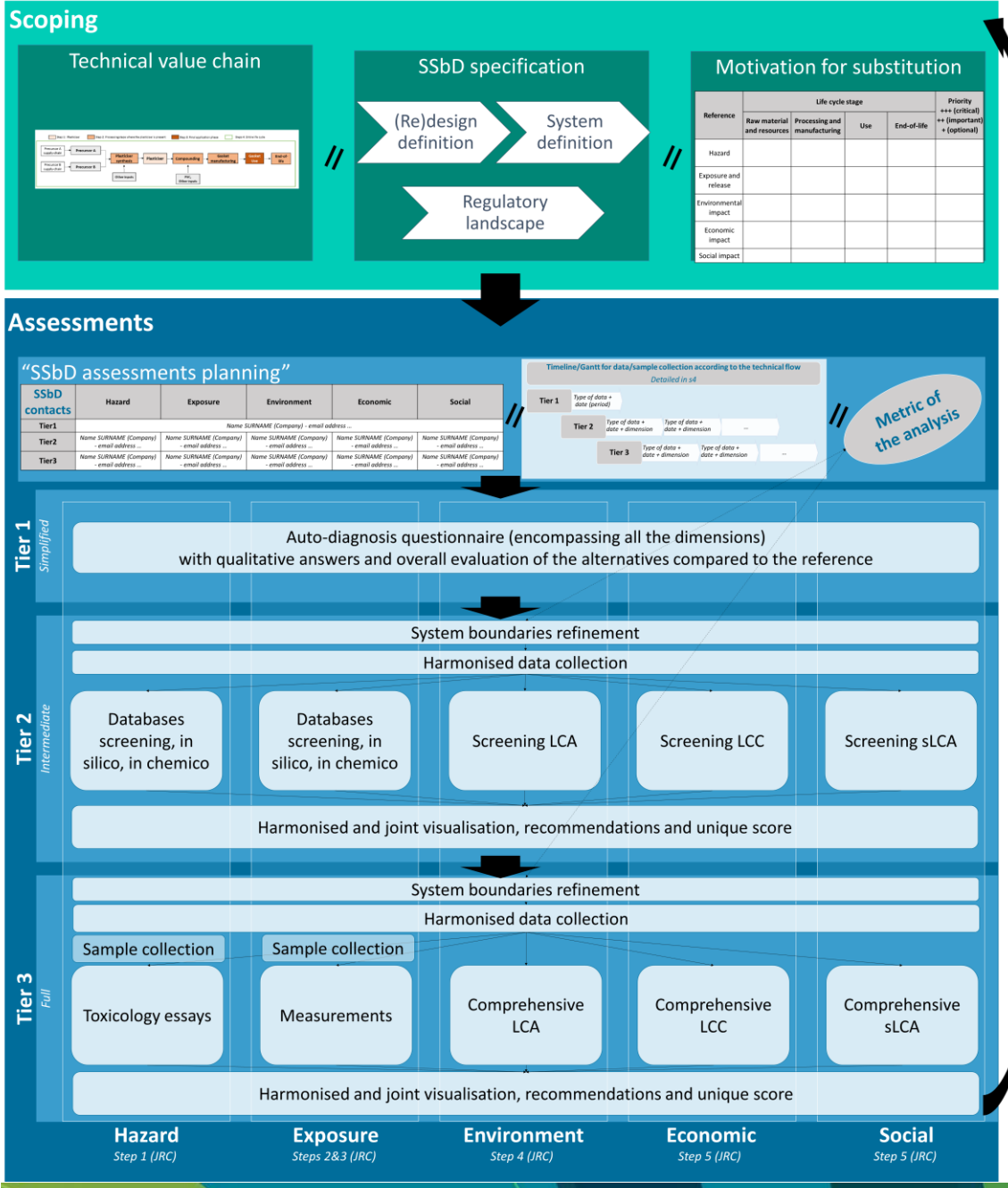
… a process of integrating information; a multi-criteria approach





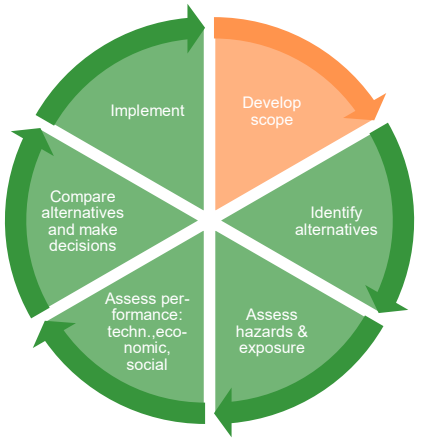
Assess trade-offs & consider data gaps/quality

Alternative	Evaluation criteria		Weights		Data gaps / quality		Score	Total	Ranking
A1		x x x x x x		x x x x x x		= = = = = =	1 2 2 0 3 -1	1	2
A2		x x x x x x		x x x x x x		= = = = = =	3 1 2 -2 3 2	3	1
A3		x x x x x x		x x x x x x		= = = = = =	2 -2 2 0 0 3	0	3



WHY? WHO? WHAT?

How?

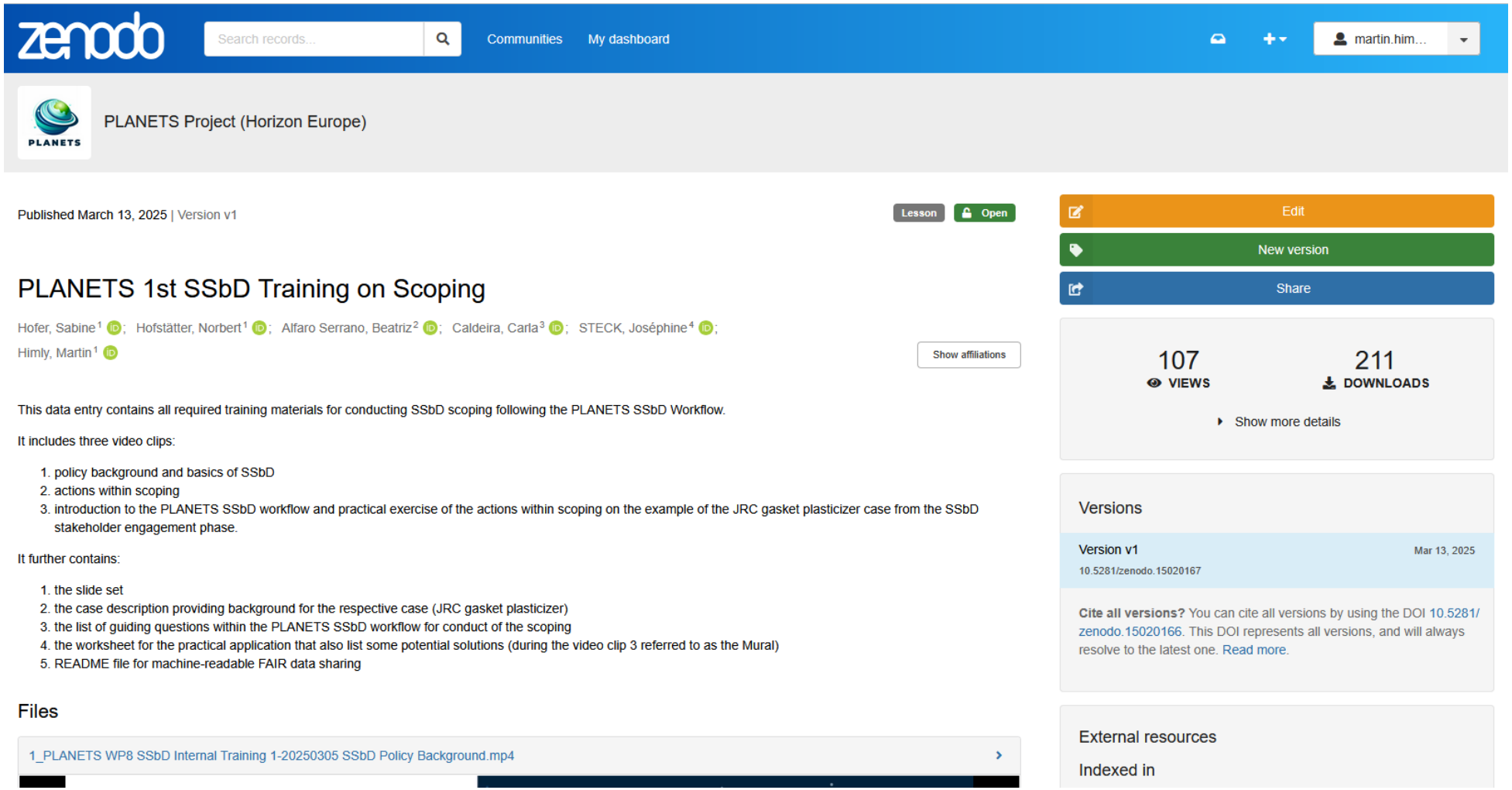


The PLANETS generic SSbD workflow

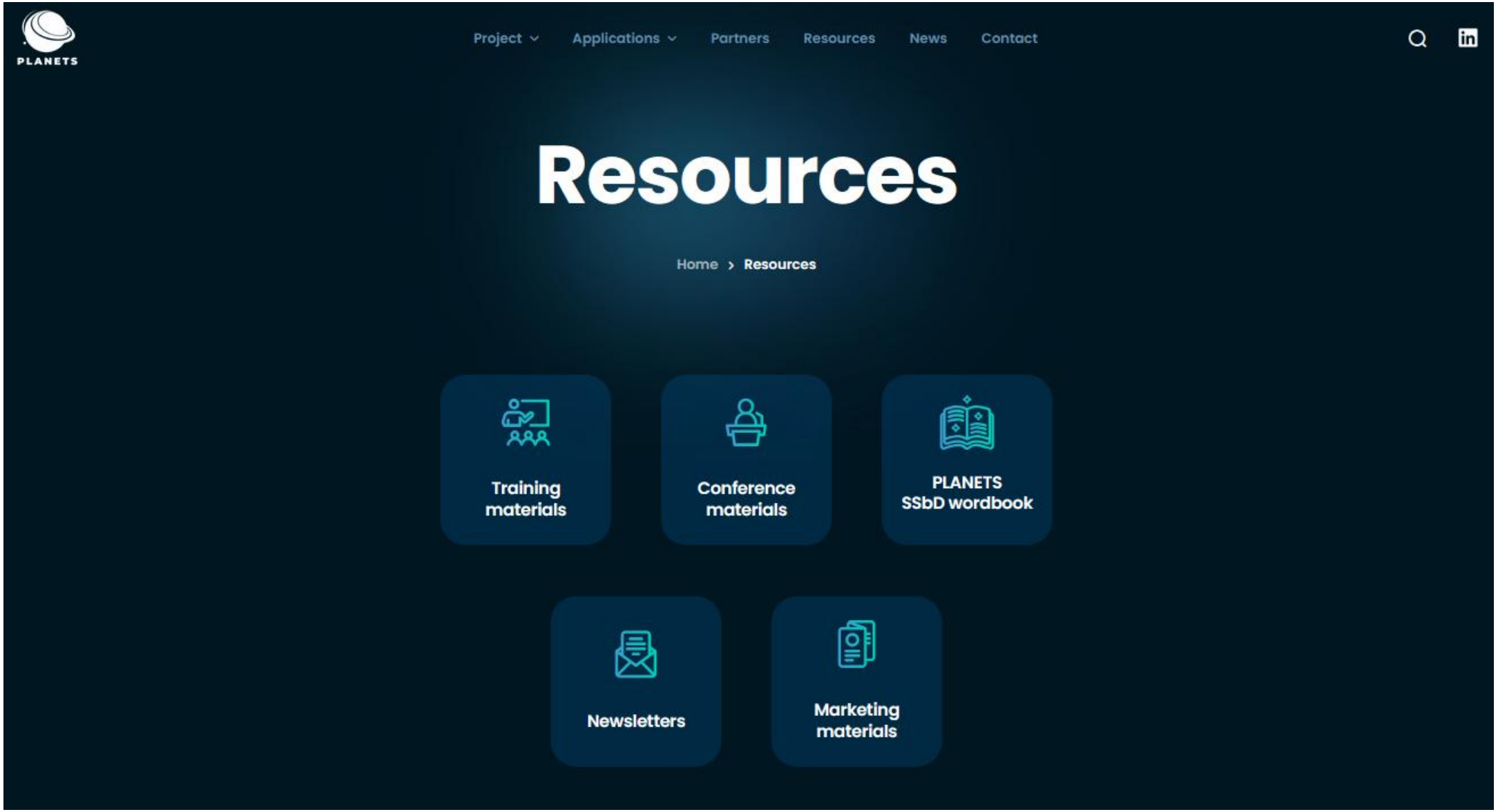
A two phases approach aiming to guide the CS through SSbD:

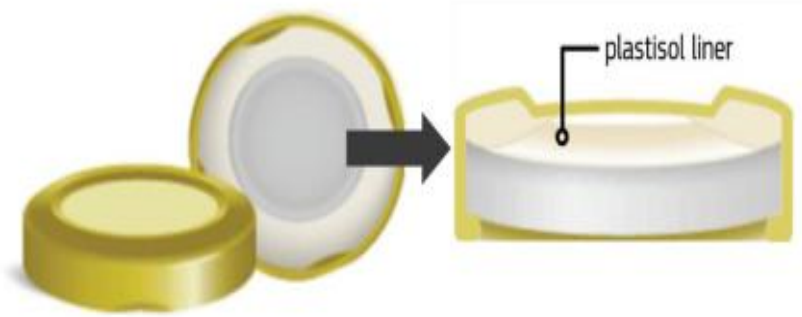
- **Scoping** – Formalise the system under study to ensure efficient SSbD assessments
- **Assessments** – Conduct evaluations of the alternatives in comparison to a benchmark

PLANETS' Scoping workflow at Zenodo

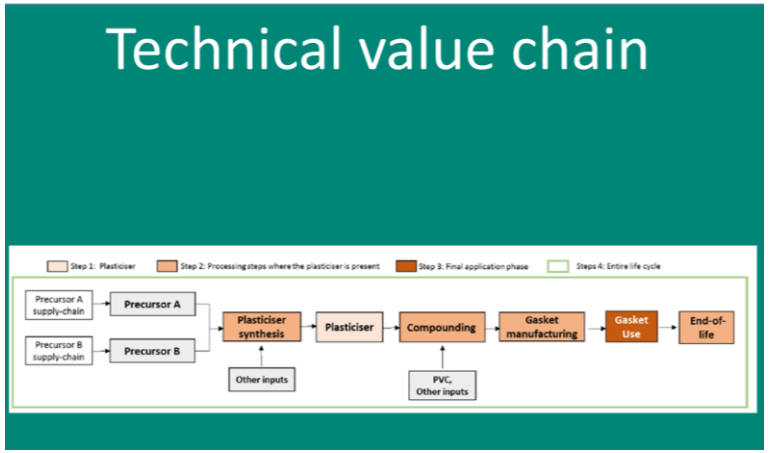


Hofer, S., Hofstätter, N., Alfaro Serrano, B., Caldeira, C., Steck, J., & Himly, M. PLANETS 1st SSbD Training on Scoping. https://doi.org/10.5281/zenodo.15020167


PLANETS
Project
Applications
Partners
Resources
News
Contact
Resources
Home › Resources
Training materials
Conference materials
PLANETS SSbD wordbook
Newsletters
Marketing materials



Objective 1: Define the technical value chain



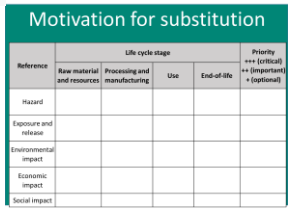
The technical value chain refers to the **series of interconnected processes** and **stakeholders that contribute to the creation, development, and delivery of the final product.**

It defines the **roles of technical actors** and **outlines their contributions at each stage of the product life-cycle**, from initial concept through design, production, and maintenance. Each link in the chain adds technical value by refining processes, improving efficiency, and ensuring the quality and functionality of the end product.

Link to material: https://doi.org/10.5281/zenodo.15020167

Objective 2: Motivation for re-design



Reference	Life cycle stage				Priority +++ (critical) ++ (important) + (optional)
	Raw material and resources	Processing and manufacturing	Use	End-of-life	
Hazard					
Exposure and release					
Environmental impact					
Economic impact					
Social impact					

Link to material: https://doi.org/10.5281/zenodo.15020167

Objective 3: (Re)Design and system boundaries definition

1/3

Purposes	What are the goals of your innovation: • Development of a new chemical /material • Finding of chemical /material alternative(s) • Developing a new process • Improvement of the production processes • Developing a new product • Improving the functionality of the product /application • Other	• Reduction of the hazard properties of the chemical /material • Increase of the safety of production and processing of the chemical /material • Increase of the safety of the chemical /material during the application • Improvement of the environmental sustainability of the chemical /material • Improvement of the socio-economic sustainability of the chemical /material • Other

Link to material: https://doi.org/10.5281/zenodo.15020167

Objective 3: (Re)Design and system boundaries definition

2/3

Principles	What are the SSbD principles relevant for your CS that should be assessed: • Material efficiency • Minimise the use of hazardous chemicals or materials • Design for energy efficiency • Use renewable sources • Prevent and avoid hazardous emissions • Design for end of life • Consider the whole life cycle • Other principles (please specify)

Link to material: https://doi.org/10.5281/zenodo.15020167

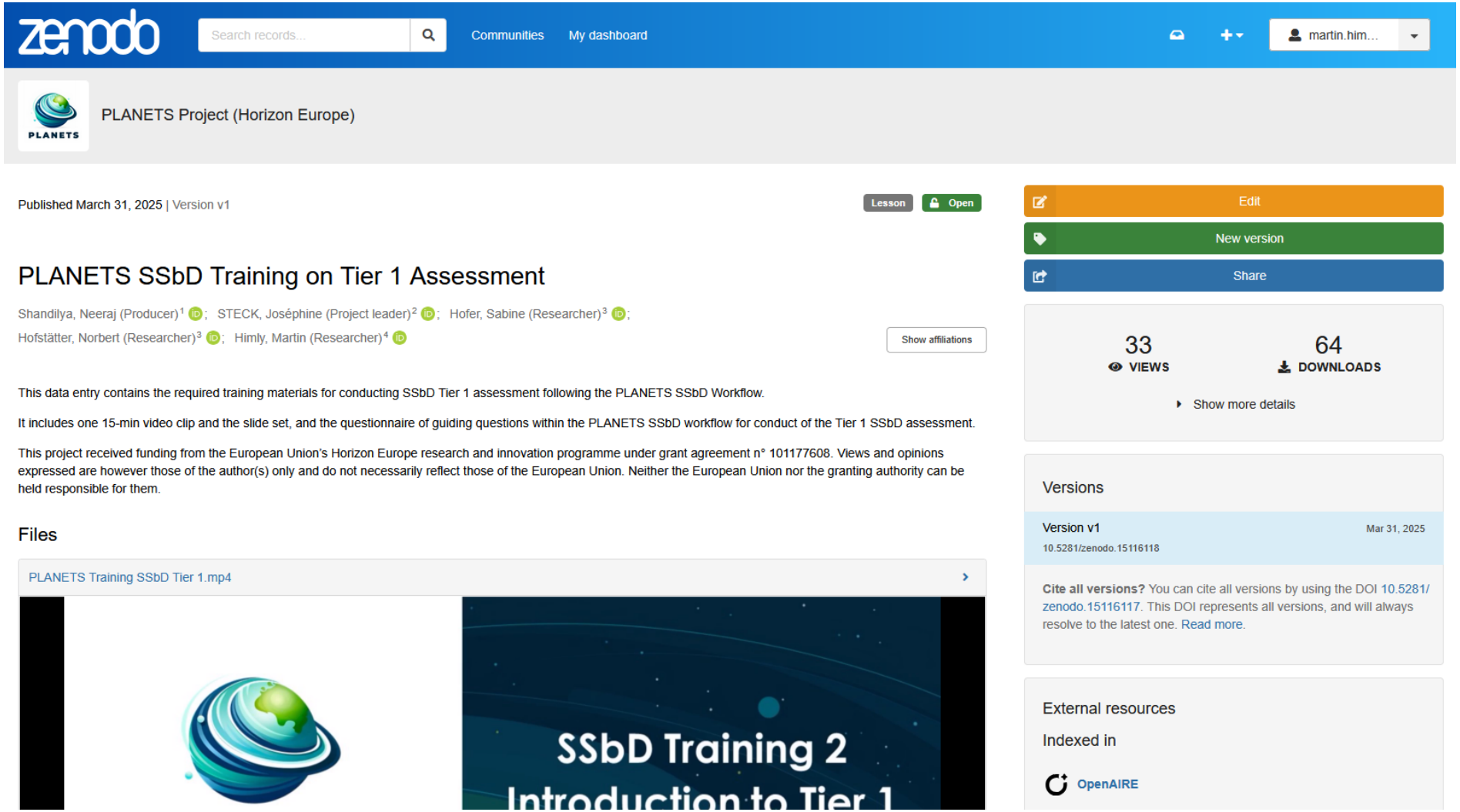
Objective 3: (Re)Design and system boundaries definition

3/3

Molecular (re)design	Process (re)design	Product (re)design
Is there any existing chemical/material that can be used as a reference to compare the results of the SSbD study? If no reference chemical/material has been selected, the reference might be chosen with one of the following aspects: • Chemical/material with similar structure • Chemical/material fulfilling the same function • Representative Chemical/material as for the definition of Representative Product in the PEF method • Other criteria to define the benchmark At which Technology Readiness Level (TRL) is chemical/material under development?	Does the improvement of the process require a new technology? If yes, at which Technology Readiness Level (TRL) is the new technology(ies) for the process improvement? Provide information about the new technology needed for the improvement of the process, for instance the characteristics, the energy and auxiliaries consumed, its emissions and waste generated…	Does the (re)design of the product/application involve a new application? If yes, at which Technology Readiness Level (TRL) is the new technology(ies) for the process improvement? Provide information about the new technology needed for the improvement of the product/application

Link to material: https://doi.org/10.5281/zenodo.15020167

PLANETS' Tier 1 at Zenodo



Shandilya, N., Steck, J., Hofer, S., Hofstätter, N., & Himly, M. PLANETS SSbD Training on Tier 1 Assessment. https://doi.org/10.5281/zenodo.15116118

Tier 1 assessment tool

	Dimension	Reference	Alternative 1	Alternative 2	Alternative 3
	1: Hazard				
1.1	Is the human and/or environmental release of hazardous substances (Substances of very high concern, Equivalent level of concern, Substances of concern, or hazard band C, D, or E) likely at any stage of the product's life cycle?	Yes	Unknown	No	No
1.2	Is it likely that the CLP limit for hazardous substances will be exceeded in the final application, with a concentration greater than 0.1% w/w?	Unknown	No	No	No
1.3	Are substances which are relevant for upcoming regulations and/or industry/customer specific requirements likely to be present? e.g. SoCs present in ESPR relevant products, substances on Restriction Road Map (https://ec.europa.eu/docsroom/documents/49734) or on the chemicals convention list.	No	Yes	No	Unknown
	2: Release and exposure				
2.1	Do you identify the potential use/applicability of the final material/product?	No	Yes	Yes	Unknown
2.2	At any life cycle stage, is your material or product in powder form and/or is it possible that dust or aerosols are released?	No	No	Yes	No
2.2a	If yes, does your material contain rigid, persistent fibres (length > 5 µm and diameter < 3 µm)?	Unknown	Unknown	Unknown	No
2.3	Is your material, product multi-component?	Yes	Unknown	No	Yes
2.4	At any life cycle stage, is your material or product in a liquid/vapour (with vapour pressure > 1 Pa) and/or is it possible that vapours are released?	No	Yes	No	Yes
2.5	Is there a possibility of substantial material breakdown during production, use and/or end of life?	No	Yes	No	Yes
2.6	Is there a possibility of (in)direct contact with worker and/or consumer skin?	No	No	Yes	Yes
2.7	Are there any exposure prevention measure(s) applied at the workplace?	No	Yes	Yes	Unknown
2.8	Is there a possibility of oral consumer exposure?	Unknown	Unknown	Unknown	Unknown
	3: Environmental impact				
3.1	Are non-sustainable renewable raw materials or conflicting minerals or critical raw materials used during production?		No	Yes	No
3.2	What is the impact of the new material or product compared to the conventional material or product on the following sustainable development category: Climate change mitigation & energy conservation?* (Click on this cell for more information)		Equal	Equal	Positive
3.3	What is the impact of the new material or product compared to the conventional material or product on the following sustainable development category: Circular economy?* (Click on this cell for more information)		Negative	Unknown	Unknown
3.4	What is the impact of the new material or product compared to the conventional material or producton on the following sustainable development category: Resource efficiency?* (Click on this cell for more information)		Unknown	Unknown	Unknown
3.5	What is the impact of the new material or product compared to the conventional material or producton on the following sustainable development category: Pollution reduction?* (Click on this cell for more information)		Equal	Equal	Negative
3.6	What is the impact of the new material or product compared to the conventional material or producton on the following sustainable development category: Water protection?* (Click on this cell for more information)		Negative	Equal	Positive
3.7	What is the impact of the new material or product compared to the conventional material or product on the following sustainable development category: Biodiversity protection?* (Click on this cell for more information)		Equal	Equal	Equal
3.8	What is the impact of the new material or product compared to the conventional material or product on the following sustainable development category: Health safety?* (Click on this cell for more information)		Equal	Unknown	Unknown
	4: Economic performance				
4.1	Is the marketability of the new material or product better or equal to the benchmark due to, for instance, improved or new functionality or a clear image advantage? (Click on this cell for more information)		Yes	No	No
4.2	Is the foreseen production tonnage of the new material or product ≥ 1 tonne per year? Calendar year is from 1 Jan to 31 Dec.		No	Yes	No
4.3	Is the foreseen market potential of the new material or product ≥ 1M€ in Europe?		Unknown	Unknown	Yes
4.4	Is the (expected) purchase price per unit of the new material or product lower or equal to the benchmark?		No	No	Yes
4.5	Are the capital expenditures and operational costs (e.g. maintenance, energy use) during the production and/or use phase of the new product or application lower or equal to the benchmark?		No	Yes	No
4.6	What is the aggregated probability of success to manufacture of the new product on a commercial scale?		>50%	10% to 50%	<10%
	5: Social				
5.1	Compared to the benchmark, does the new material or product development lead to the **deterioration** of basic rights & needs of the workers, consumers, including children, and on the local community? (Click on this cell for more information)		No	No	No
5.2	Compared to the benchmark, does the new material or product development lead to an **improvement** in creating new jobs, development of new skills, knowledge and employability, society's economic/technologic/sustainable development?		Yes	No	Unknown
5.3	Compared to the benchmark, does the new material or product development **allow** for fair competition, good supplier relationships and respect of intellectual property rights?		No	Yes	Yes
5.4	What is the impact on the following sustainable development category: zero hunger?* (Click on this cell for more information)		Unknown	Equal	Positive

Topic	Alternative 1	Alternative 2	Alternative 3
Release of hazardous susbtances			
CLP limit exceeded			
Upcoming regulation relevant substances			
HAZARD			
Applicability			
Dust or aerosol generation			
Persistent fibers			
Multi-component			
Vapour release			
Substantial materail breakdown			
Skin (in)direct contact			
Workplace exposure measures			
Oral consumer exposure			
EXPOSURE and RELEASE			
Non-sustainable renewable or critical raw materials or conflicting minerals			
Climate change & energy			
Circular economy			
Resource efficiency			
Pollution reduction			
Water protection			
Biodiversity			
Health safety			
ENVIRONMENT			
Marketability			
Production tonnage			
Financial market potential			
Expected purchase price			
Capital expenditures and operational costs			
Probability of sucess			
ECONOMY			
Human basic rights and needs			
New jobs, knowledge and skills			
Fair competetition and IP rights			
Zero hunger			
SOCIAL			

Corresponding questions	SCORE	Alternative 1	Alternative 2	Alternative 3
3.1 and 1.2	C--		Strong negative	
1.3 and 5.1	C-	Negative		Maybe Negative
3.2 to 3.8 and 5.4	B			
5.2 and 5.3	A+			
5.2 and 5.3	A++			Maybe strong positive
Conclusion to be wirtten by the SSbD expert in charge of the assessment				

Points of attention!!

Human and/or environmental exposure to hazardous substances used or released thr
Unknown

Uncertain potential exposure to released forms and components of the material, whi
Human exposure via inhalation and environmental relase likely
Human and environmental exposure to transformed and/or released forms likely

Dermal occupational and/or consumer exposure is uncertain

Potential economic performance or economic opportunities are uncertain due to unk
Economic performance might suffer or limited economic opportunities due to high pu
Economic performance might suffer or limited economic opportunities due to high CA

Gaps identified & actions prioritized

- **1. Confidentiality** issues of open access tools for hazard assessment (Vega & OECD QSAR Toolbox can be downloaded, instructions how to use); Diamonds tools, Stoffenmanager, *etc*.
- **2. Functionality** inclusion to SSbD assessment procedure
- **3. Methodology:**
  - **Clustering** procedure to be defined (in case of many alternatives)
  - **Integration** of risk assessment with LCA: comparative vs absolute dilemma
  - **Harmonized data collection** (metrics, *etc*.)
  - **Uncertainty management**
  - **Multi-criteria decision analysis** (MCDA): transparent decision points, weighting, optimization under uncertainty, stakeholders, *etc*.

Gaps identified & actions prioritized

- **4. Simplified (Tier 1) assessment refinement:**
  - **Decision tree** needs to be made adaptable (CRM, CLP limits, *etc*.)
  - The simplified assessment is not suitable for **differentiation in narrow design space** (applicability domain); it should be done in project teams of a single stakeholder (*e.g.*, innovators and others, incl. business)
  - Care with **showstoppers**, because it may kick out the whole preselected design space (how to compensate trade-offs ?)
  - Need for **weighting** of aspects carried in from scoping
  - Need for an intra-tier 1 **iterative** assessment approach rather than a straight-forward strategy to follow more closely the intrinsic learning curve of any innovation
- **5. Tools:**
  - Issues of **by-products** to be included in the SSbD assessment (storage, manufacture, *etc*.)
  - Tool for **hazard prediction** of new substances missing (*e.g.*, read-across incl. uncertainty captured; OECD QSAR Toolbox)

Gaps identified & actions prioritized

- **6. Scoping:**
  - **Use phase definition** to be described
  - **Stakeholder perspective** depending on the position in the value chain
  - Concept of **exposure scenarios** not clear enough
  - Better goal description/instructions of "**Motivation for re-design**"
  - Needs a **multi-disciplinary** approach
  - Must capture existing policy hard facts and **minimum requirements**
  - Relies on (and should lead to) a common **understanding** of the system under investigation
  - **Link** between scoping phase and assessment phase → essential outcomes from scoping phase have to directly flow into the assessment phase
  - **Shared mindset** necessary that scoping has a descriptive function of the existing system (value flow, boundaries, policies, priorities, decision rules, weighting), while tiered assessment is investigative going beyond that and with inclusion of the alternatives.

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