



# SURPASS

## Case study on “SSbD Food Packaging”

### SSbD in Practice: The Industrial Perspective

Virginia Cazzagon, LEITAT  
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**This project has received the funding from the European Union’s Horizon Europe research and innovation program under grant no. 101057901**

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# Contents:

- Introduction on the SURPASS project and the case studies
- Food packaging case study
- SURPASS SSRbD integrated approach
- SURPASS SSRbD methodology in the food packaging case study





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- Introduction on the SURPASS project and the case studies



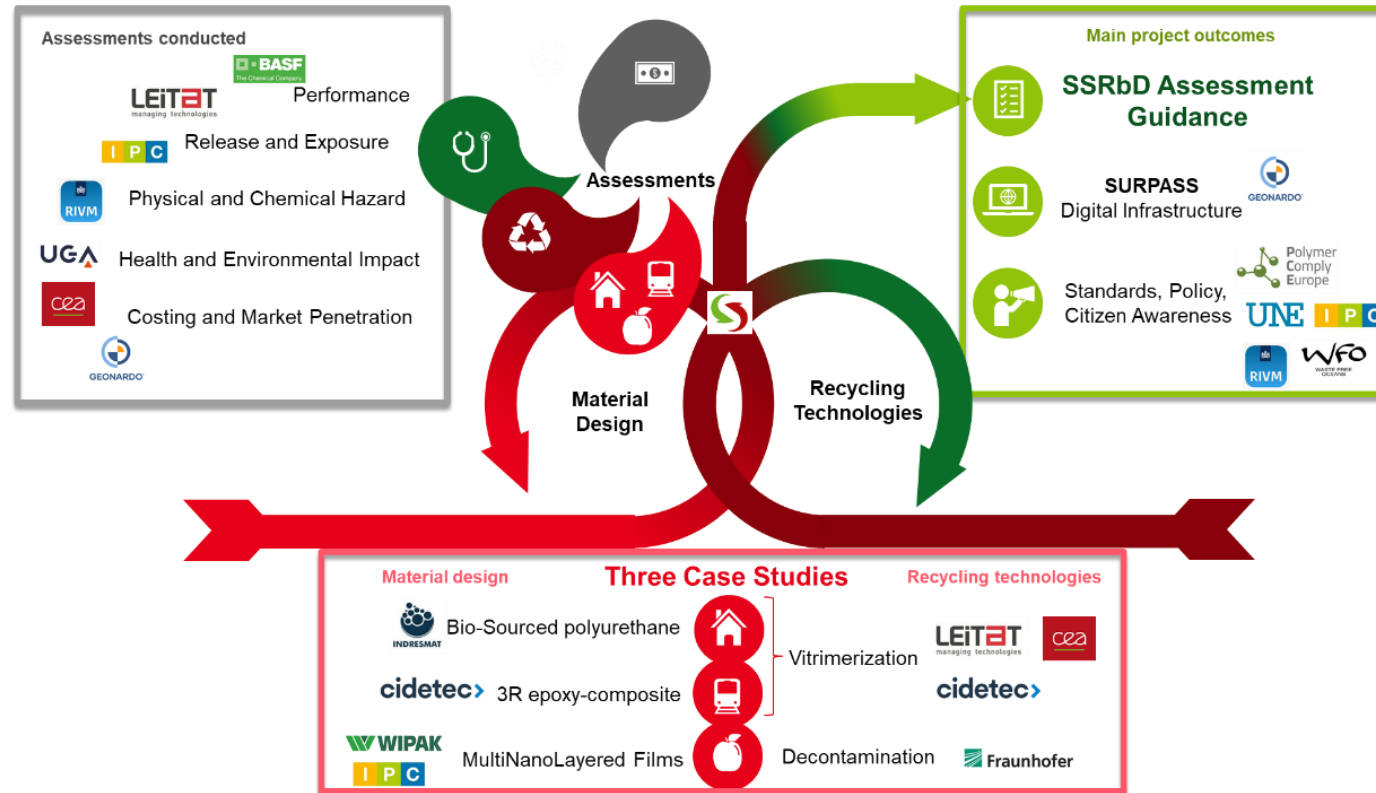
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# Approach and methodology



**Safe-, sUstainaSafe-, sUstainable- and Recyclable-by design Polymeric systems**  
**A guidance towards next generation of plasticS**



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# Case studies



## Building

Bio-sourced polyurethane resins (PU) with enhanced vitrimer properties to replace Polyvinyl chloride (PVC) for window frames

cidetec>



## Transport

Lightweight epoxy-vitrimer to replace metal parts of the train structure

I P C



## Packaging

MultiNanoLayered films to replace currently non-recyclable multi-layers films used in food packaging



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# Case studies in the context of SSbD Framework



## Building

Bio-sourced polyurethane resins (PU) with enhanced vitrimer properties to replace Polyvinyl chloride (PVC) for window frames

→ **Use of safer substances** (safer foaming agents and stabilizers) and bio-based material

cidetec>



## Transport

Lightweight epoxy-vitrimer to replace metal parts of the train structure

→ Develop **safer products** (using a halogen free flame retardant)  
→ **Improve sustainability** (replacing a heavy metal-based material with a polymeric)

I P C



## Packaging

MultiNanoLayered films to replace currently non-recyclable multi-layers films used in food packaging

→ Develop **safer products** (without harmful compatibilizers)





# Case studies in the context of SSbD Framework



cidetec>



I P C



## Building

Bio-sourced polyurethane resins (PU) with enhanced vitrimer properties to replace Polyvinyl chloride (PVC) for window frames

- **Use of safer substances** (safer foaming agents and stabilizers) and bio-based material
- **Improve recyclability** (through vitrimerization)

## Transport

Lightweight epoxy-vitrimer to replace metal parts of the train structure

- Develop **safer products** (using a halogen free flame retardant)
- **Improve sustainability** (replacing a heavy metal-based material with a polymeric)
- **Improve recyclability** (using a recyclable composite)

## Packaging

MultiNanoLayered films to replace currently non-recyclable multi-layers films used in food packaging

- Develop **safer products** (without harmful compatibilizers)
- **Improve recyclability** (replacing not recyclable multilayers with recyclable multi nanolayered films)

SURPASS specificity is the addition of an extra component : **Recyclable-by-design**



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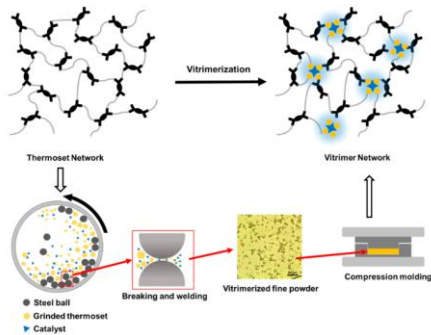


# Reprocessing technologies

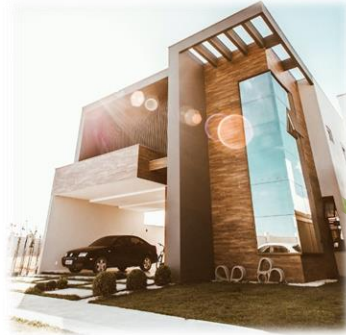


## Building

Vitrimerization of PU based window frame and reversible curing resin system

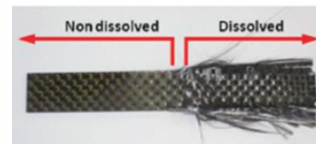


Vitrimerization



## Transport

Reversible and intrinsically fire-retardant curing resin

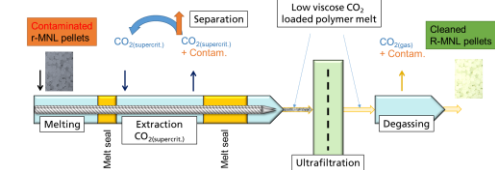


Chemical Recycling



## Packaging

MNL reprocessing



Mechanical Recycling



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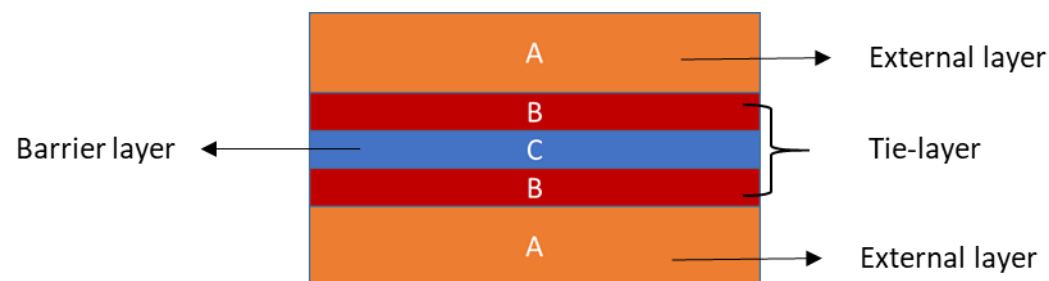
# Food packaging case study



## Main objectives:

- Develop a **recyclable Multi-nanolayer** films to replace multi-layer films for food packaging
- **Reducing** drastically the concentration of **compatibilizers** (Tie-layers)

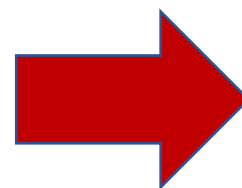
## Scheme of the *structure of multilayer films* containing five layers



*Layer A: polyolefin polymer*

*Layer C: PA (polyamide) or EVOH (Ethylene and Vinyl Alcohol copolymer)*

*Layer B: compatibilizer*



## Applications



*Thermoforming films for meat with/without bones*



*Thermoforming films for cheese bloc*

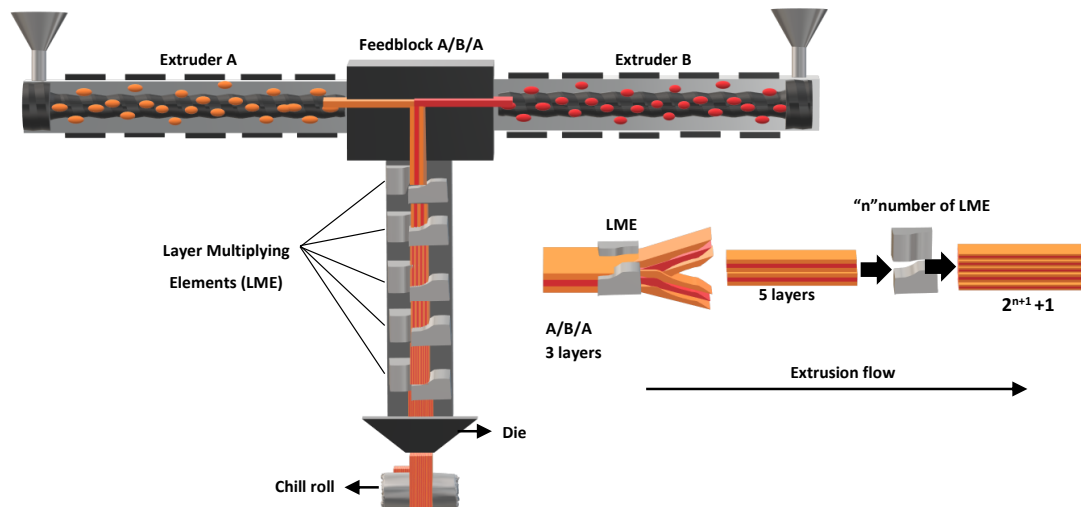




# Design multi-nanolayer film



## *Multinanolayer co-extrusion process (MNL)*



When the **film thickness decreased**:

- Morphology passed from continuous and homogeneous to irregular → change the elongation at break
- Improvement of the diffusion pathway

### Material's selection

Formulations with different % compatibilizers (0-15%)

### MNL coextrusion

- Number of layers
- Layer's composition
- Pilot scale (20kg/h)



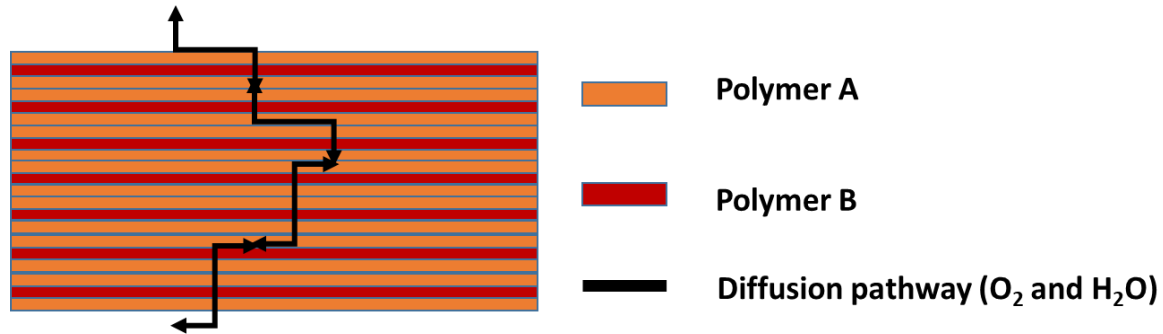
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# Characterize multi-nanolayer film



## *Barrier thin film architecture*



### Characterization of the product through:

- Mechanical and optical properties (e.g., elongation at break, transparency)
- Barrier properties (e.g, Oxygen Transmission Rate, Water Vapor Transmission Rate)

### Material's selection

Formulations with different % compatibilizers (0-15%)

### MNL coextrusion

- Number of layers
- Layer's composition
- Pilot scale (20kg/h)

### Characterization

- Mechanical properties
- Barrier properties (WTVR, OTR)



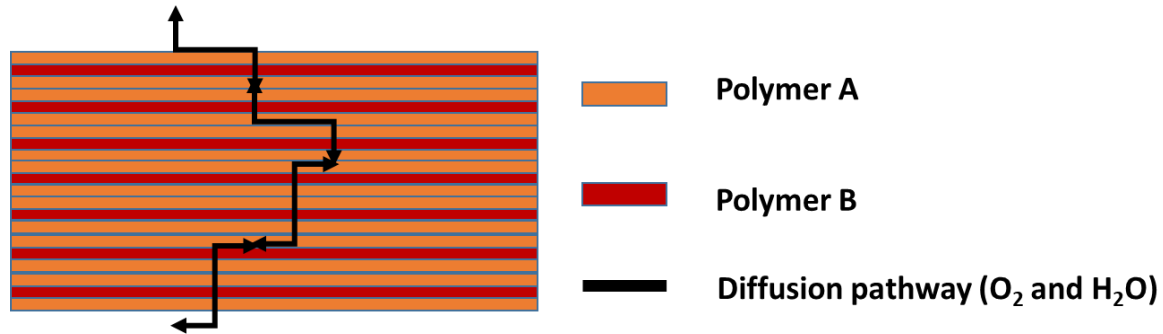
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# Characterize multi-nanolayer film



## *Barrier thin film architecture*



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### Characterization

- Mechanical properties
- Barrier properties (WTVR, OTR)

### Recycling

- Mechanical recycling process
- Reclass certification



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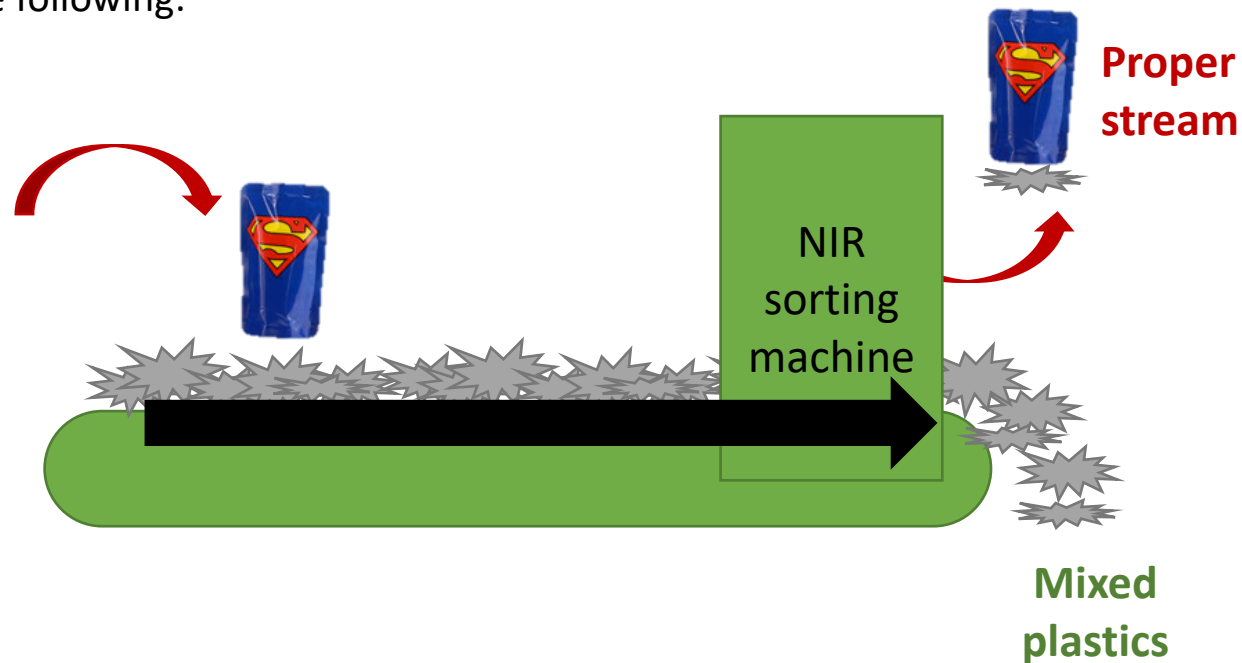


# Evaluate recycling of packaging film

## Description of Sorting (NIR) Protocol – Following Recyclclass protocol

- ➔ IPC has access to a Post-consumer waste stream that has been collected internally at IPC for 1 month. This waste stream can be used as a “reference” since it represents a small version of a “real” post-consumer waste stream.
- ➔ The process will be the following:

- ✓ **Known number of packaging units to test**
- ✓ (Model) packaging post-consumer waste stream



*Camera or eye control, counting the number of tested packaging units going in the proper stream*



**Calculation method:**

$$Ete_i = \left( \frac{Pe - W}{Pf} \right) \times 100$$

*W* = weight of a fully empty packaging (without product inside)  
*Pf* = declared net weight of content (in case of volume it must be converted in weight)  
*Pe* = average weight of empty packaging after normal use, in minimum 10 emptying tests.

- ➔ Sample selection:  
**50 to 100 samples**



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# SSRbD concept in food packaging case study



## Safe and Sustainable and Recyclable by Design

### Material's selection

Formulations with  
different %  
compatibilizers (0-15%)

### MNL coextrusion

- Number of layers
- Layer's composition
- Pilot scale (20kg/h)

### Characterization

- Mechanical properties
- Barrier properties  
(WTVR, OTR)

### Recycling

- Mechanical recycling  
process
- Recyclclass certification



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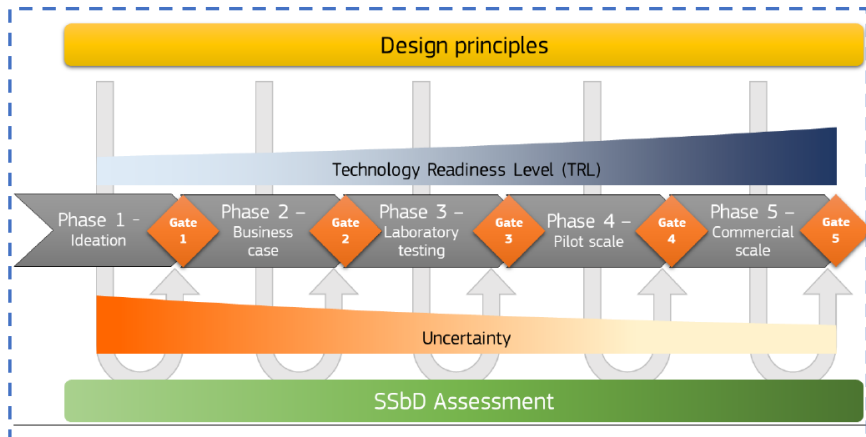




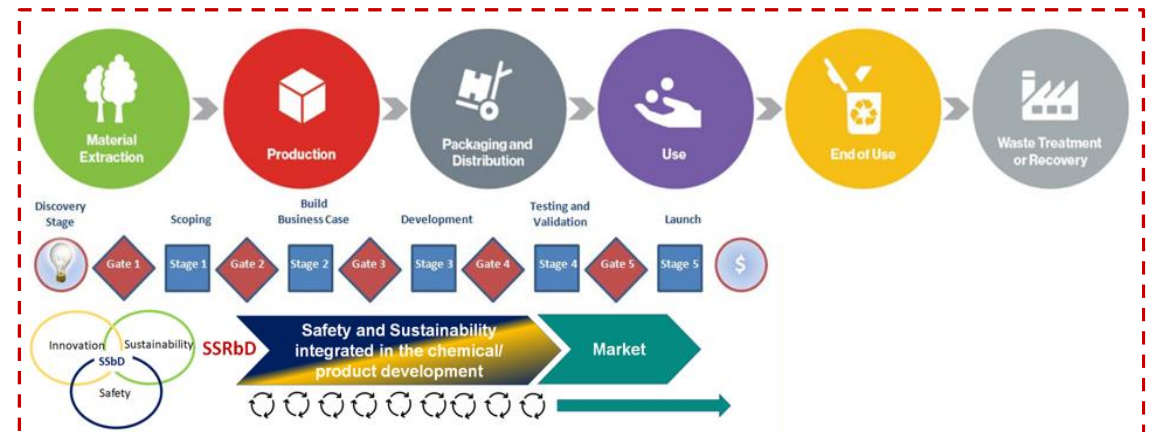
# Behind the SURPASS SSRbD Integrated approach



An iterative process that take into account the TRL



From a life cycle perspective

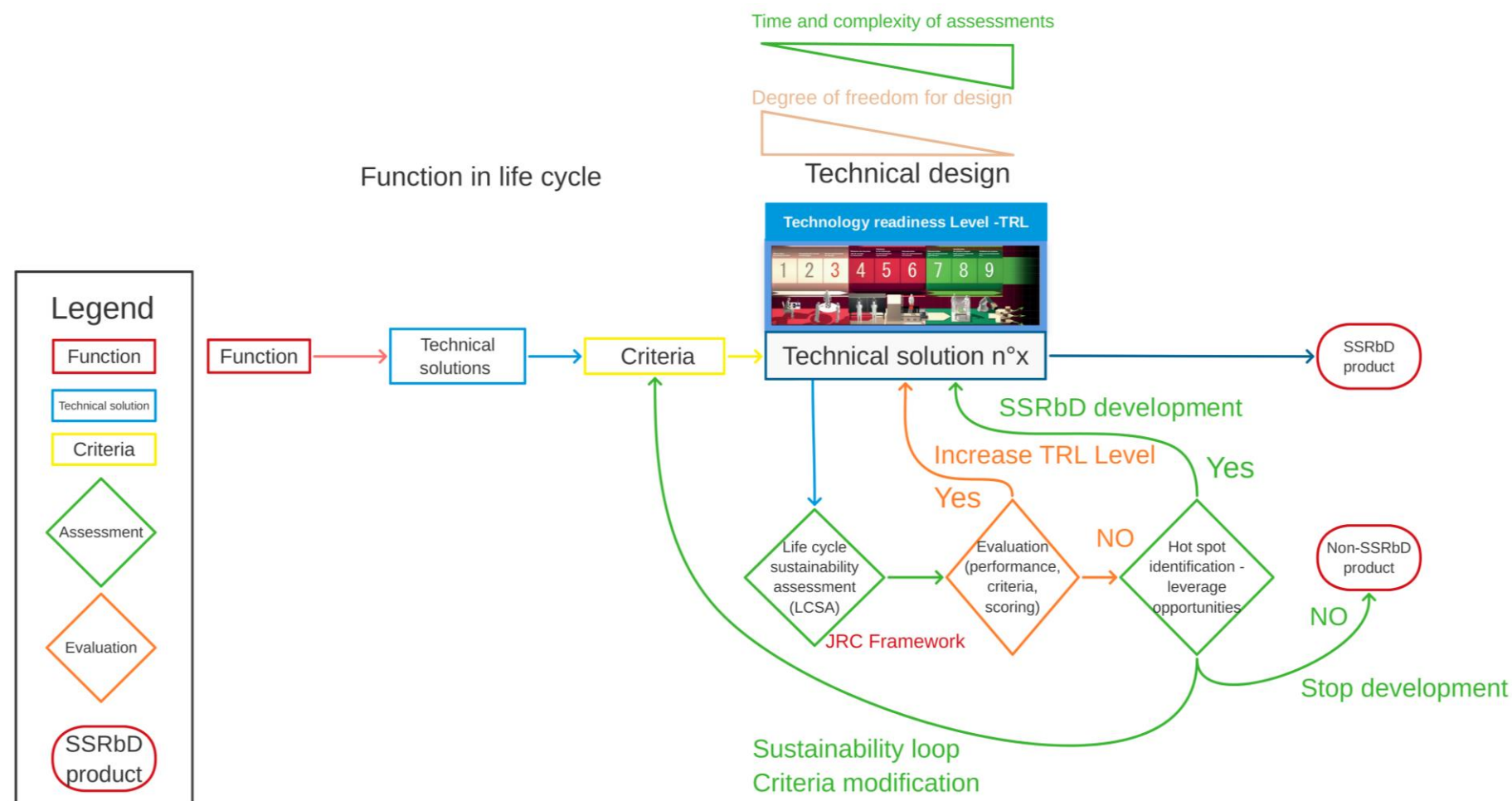


That cover the JRC assessments





# SURPASS SSRbD Integrated approach



- **3 assessment loops** at early, mid and late stage of the innovation process.
- The assessments follow the JRC SSbD framework, including the **performance evaluation**.
- **Parallel** functionality, safety and sustainability **assessments**

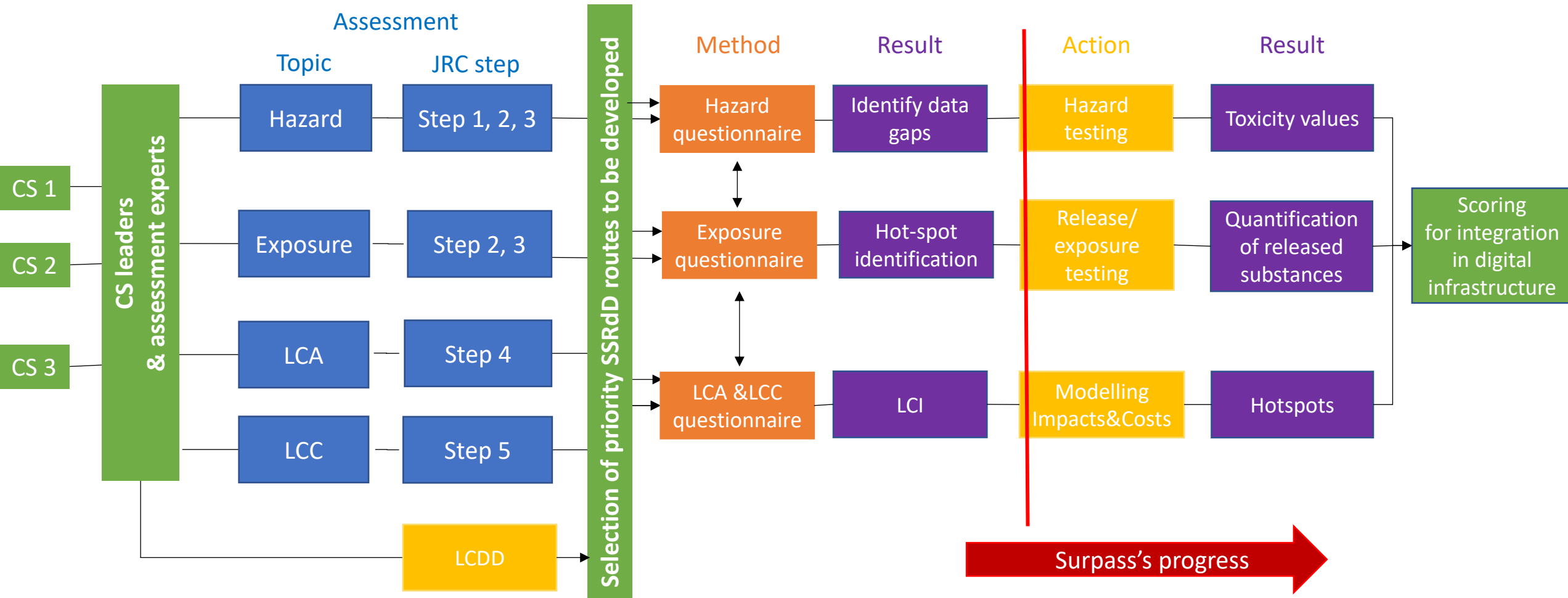
→ If the whole process evaluation is successful, the **product TRL increases**

→ If not, **hotspots and leverage opportunities** are identified and different criteria can be considered





# SURPASS SSRbD Integrated approach in practice





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# Identification of value chain safety & sustainability challenges for food packaging case study



	Life cycle stage			
	Raw material and resources	Processing and manufacturing	Use	End-of-life
Environmental impact	Climate Change: Emission of Greenhouse Gases  Fossil feedstock  Water use environmental indicator (PEF)	Energy use - fossil fuels (MJ)  Water use environmental indicator (PEF)  Waste generation (kg/kg)  Release of monomers and Volatile Organic Compounds (VOC)	Single Use product  Information for consumer awareness on environmental impacts	Complex Waste Collection and sorting system  Recycling efficiency/recovery rate (%)  Amount of waste to landfill (kg/kg)  Critical extract from decontamination processes
Social impact	Child labour  Creation of employment	Creation of employment  Assessment of accident at work	Awareness about the overconsumption  Pollution in third world countries (export of critical residues)  Creation of employment (recycling)	
Health-safety impact	Absence of most harmful substances according to CSS (EC, 2020) and SVHC of REACH Art. 57 (EU, 2006)  Food contact allowed materials	List of chemicals used: apply the ECHA guidance Chapter R12 Use description  Risk assessment at the workplace	Likelihood of human exposure and potential route (inhalation, dermal, ingestion)  Environmental hazard: Specific Environmental Release Categories (SpERCs)	Potential presence of contaminants or hazardous substances in product waste  Existing recycling and treatment of contaminated packaging
Economic impact	Economic crisis impact on fossil prices	Economic crisis impact on fossil prices → Higher raw material's prices → Higher final product prices		
				Value of recycled materials vs. undesired effects limiting the value of the PE waste stream



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# SURPASS SSRbD Integrated approach in food packaging case study

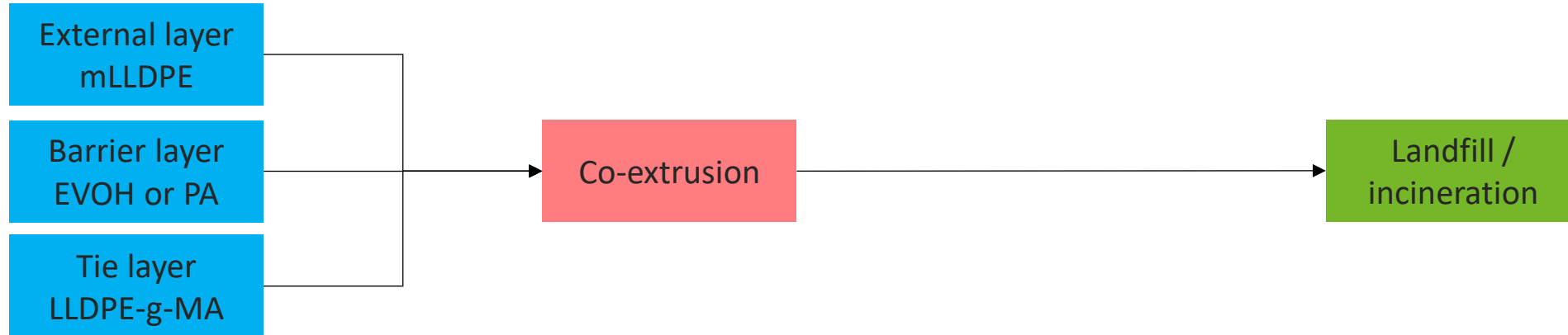


Step 1: Material design

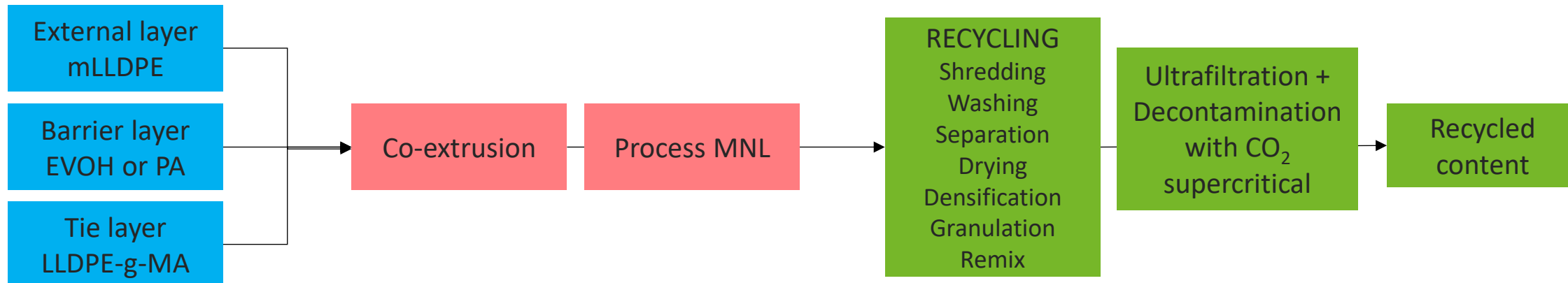
Step 2: Process & Construction

Step 5: End of Life

**Reference product**



**SURPASS SSRbD solution**



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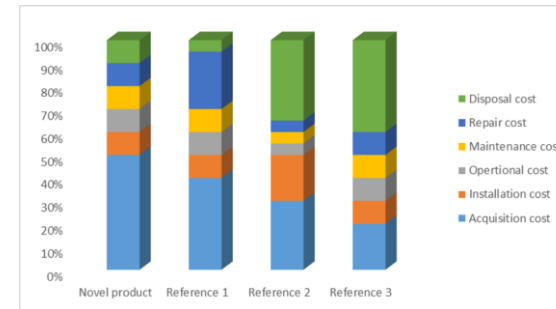


# SURPASS SSRbD Integrated approach in food packaging case study



## LCA/LCC

1. Environmental and cost hotspots identification
  - Impact categories
  - Cost categories
  - Contributing flows (matters, energy, waste, emissions)
2. Comparison between SSRbD alternatives



## Release/exposure

1. Identification of release hotspots for each life cycle stage.
2. Investigation of product/materials transformation processes along the life cycle.
3. Quantification of materials released.



## Hazard

1. Data collection on (eco)toxicological values.
2. Identification of data gaps.
3. Selection and execution of hazard testing.

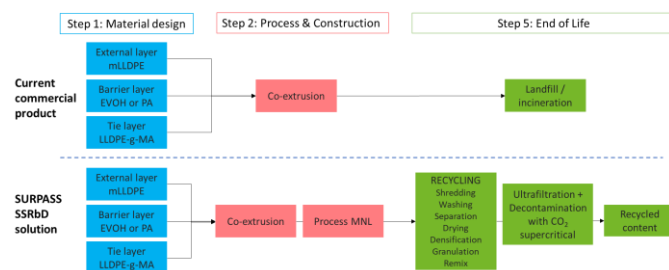




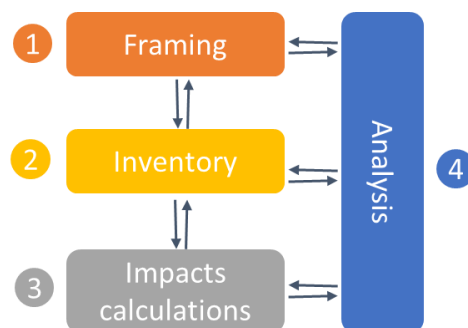
# SURPASS SSRbD Integrated approach in food packaging case study – LCA/LCC



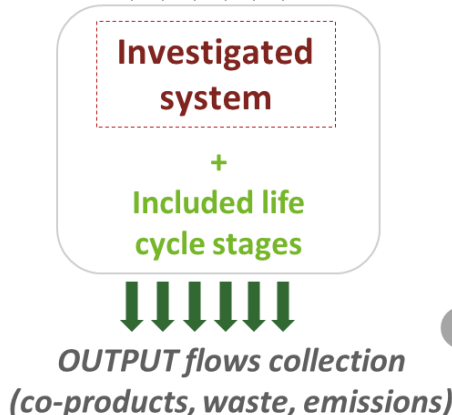
## Life cycle & DEVELOPMENT DIAGRAM (reference and SURPASS SSRbD solution)



## ISO 14040-44, 4-step iterative method for multicriteria and multistage assessment



## 2 Inventory INPUT flows collection (mater, water, energy, cost)



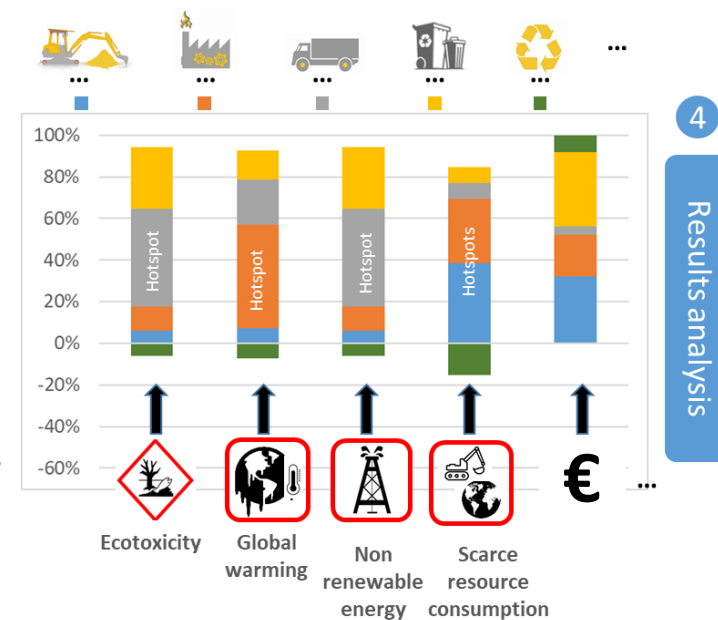
To quantify environmental impact and costs, identify hotspots and compare performance of SURPASS SSRbD solution versus reference

## 1 Framing

Objectives  
Perimeter  
Functional unit

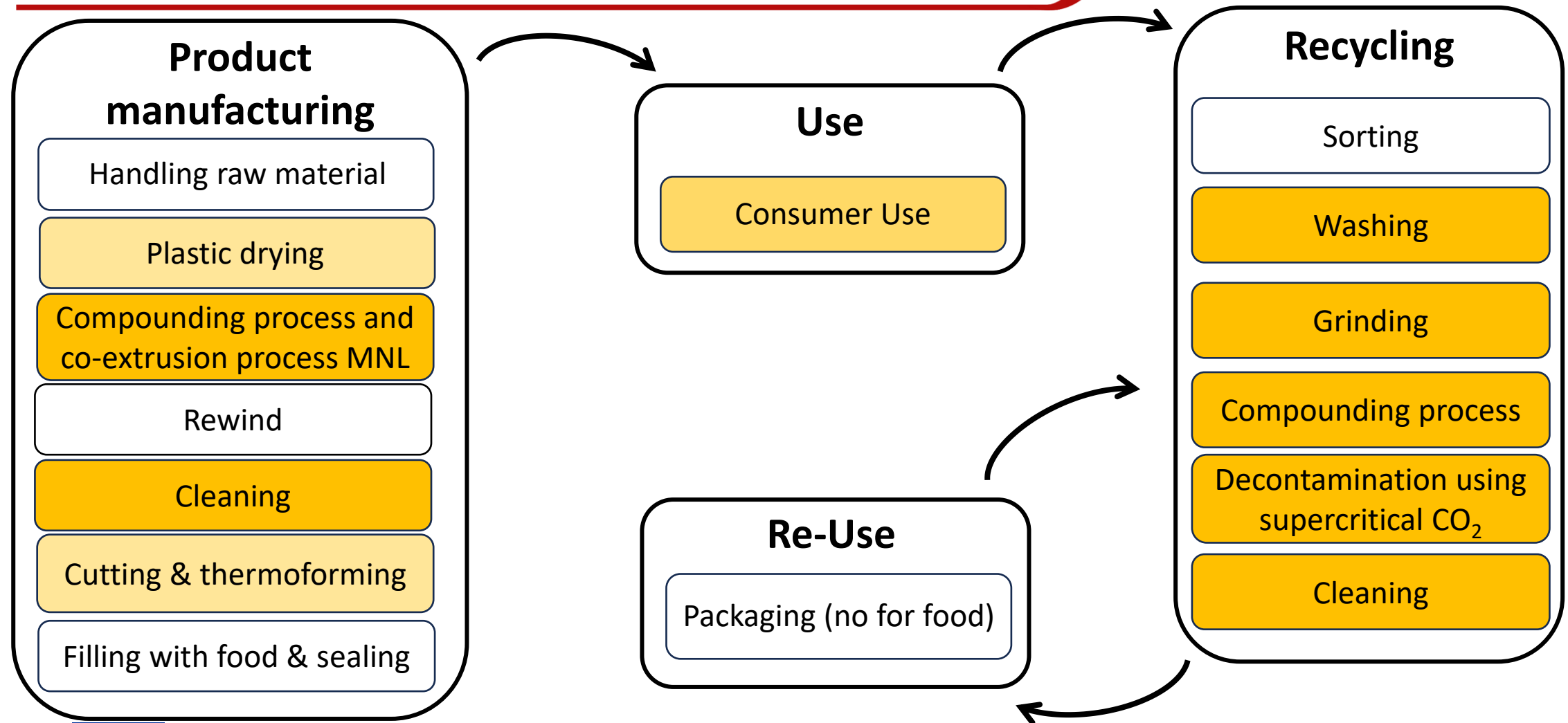
Database  
Modelling software

## 3 Impacts calculations



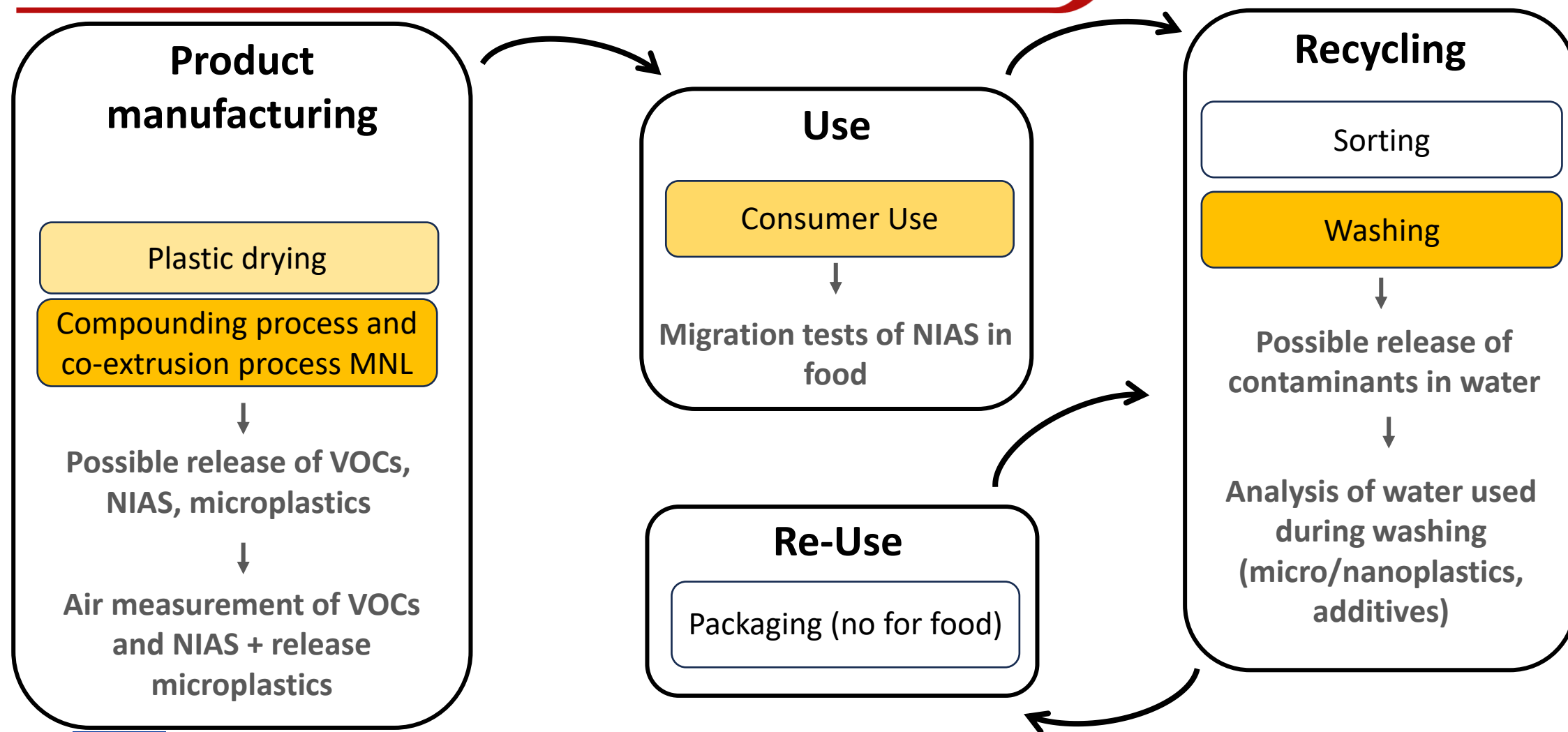


# SURPASS SSRbD Integrated approach in food packaging case study - **RELEASE**





# SURPASS SSRbD Integrated approach in food packaging case study - **RELEASE**





# SURPASS SSRbD Integrated approach in food packaging case study - HAZARD



## 1. Hazard of ingredients from available data

substance	SVHC	CLP Annex VI entry	Data source	Carcinogenicity	Mutagenicity	Reproduction toxicity	Endocrine disruption (human)	Respiratory sensitization	Specific organ toxicity Repeated exposure	Skin Sensitization	Acute toxicity oral	Acute toxicity dermal	Acute toxicity inhalation	Skin corrosion / irritation	Eye damage / irritation	Aspiration hazard	Specific organ toxicity Single exposure
substance 1	No	No	ECHA	NC	NC	NC	MISS	1	1	1A	4	NC	NC	1B	1	MISS	NC
substance 2	No	No	ECHA	NC	NC	NC	MISS	NC	NA	NC	NC	NC	NC	NC	NC	NC	NA
substance 3	No	No	ECHA	NC	NC	NC	MISS	NC	NC	NC	3	NC	NC	NC	NC	NC	NC
substance 4	No	No	ECHA	NC	NC	NC	MISS	NC	NC	NC	NC	NC	NC	NC	NC	1	NC
substance 5	No	No	ECHA	NC	NC	NC	MISS	NC	NC	NC	4	NC	4	2	2	NC	3

XXX Classified according to CLP criteria

NC Not classified according to CLP criteria

MISS Data lacking

NA Not applicable

## 2. Ingredients are the same for alternative and reference route: testing will aim to fill data gaps

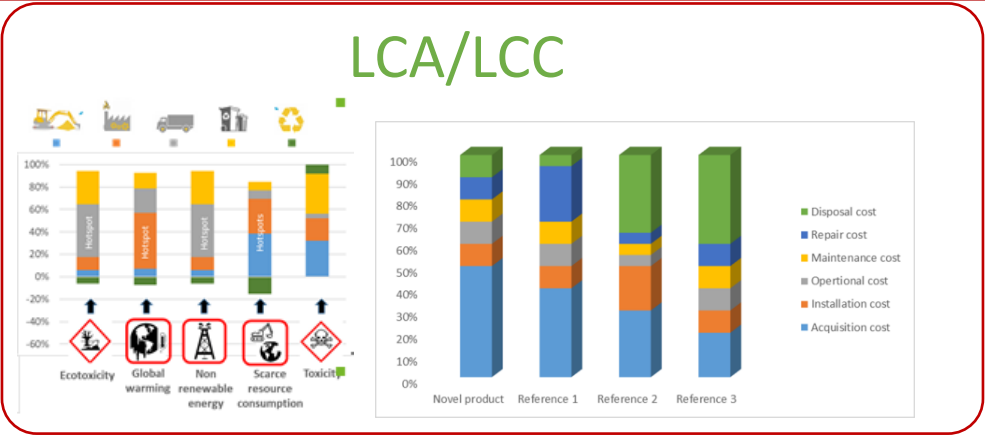


## 3. Many ingredients are polymer pellets, that cannot be tested in in vitro assays: explore testing of leachates

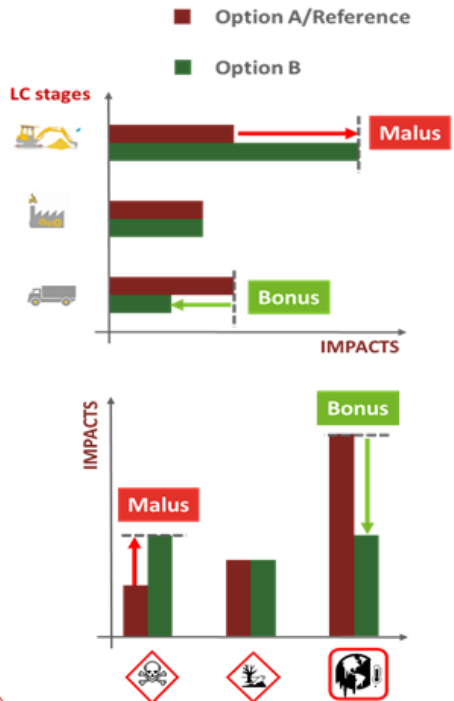




# SURPASS SSRbD Integrated approach in food packaging case study – EXPECTED RESULTS



Comparison between SSRbD option and baseline material using trade-offs



## Release/exposure

Ingestion exposure based on migration tests results (analysis of NIAS)



Inhalation exposure based on air measurement (analysis of VOCs, NIAS, microplastics)

## Hazard

Monomer / substance	Carcinogenicity	Mutagenicity	Reproduction toxicity	Endocrine disruption (human)	Respiratory sensitization	Skin Sensitization	Acute toxicity oral	Acute toxicity dermal	Acute toxicity inhalation	Skin corrosion / irritation	Eye damage / irritation
Substance A	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS
Substance B	NC	NC	NC	NC*	NC	1	NC	NC	NC	2	2
Substance C	MISS	NC	NC	NC*	MISS	1	4	4	4	2	1
Substance D	1B	2	MISS	NC*	MISS	1	3	NC	NC	NC	NC
Substance E	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS	MISS	2*	2*
Classified according to CLP											
XXX criteria											
NC Not classified according to CLP criteria, "data conclusive but not sufficient for classification"											
MISS Data lacking											

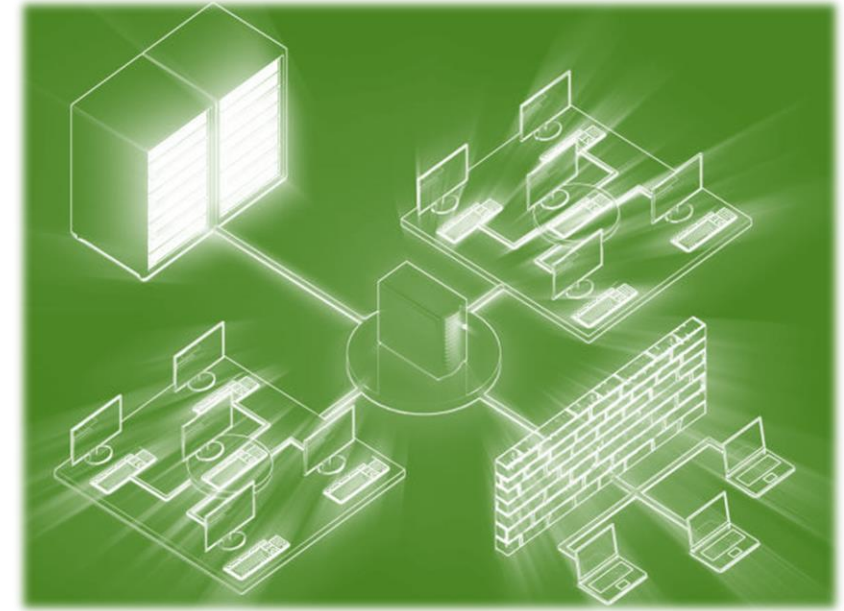
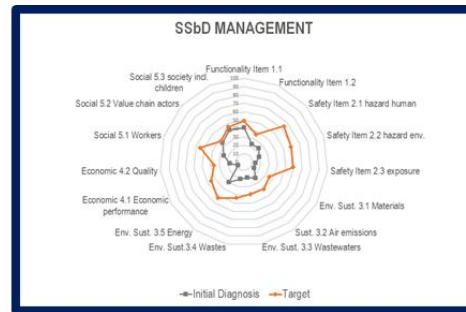
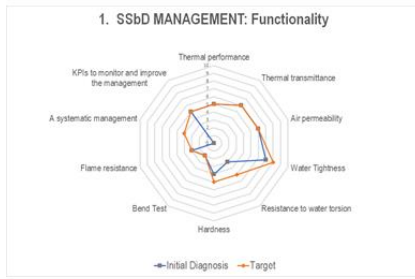




# Final aim of the project



**Scoring-based assessment** to guide stakeholders (e.g., material designers, formulators and recyclers) to design SSRbD polymeric materials, including hazard, health, environmental and economic assessment using the **SURPASS digital infrastructure**



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# SURPASS

<https://www.surpass-project.eu/>

## Thank you for your attention

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