Eco-Design of Food packaging

Session 1: Challenge based lecture

This work has been developed under the ERASMUS-EDU-2022-PI-FORWARD Project "*Glocal Ecosystems and Expanded Knowledge for green skills and capability in the Food Sector*" (**G4F**) - Project n° 101087203.
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Agenda

1. Food contact materials (FCM)

2. Introduction to eco-design

3. Risk assessment and Risk management (Safety)

4. Critical considerations

5. Conclusions

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1. Food contact materials (FCM)

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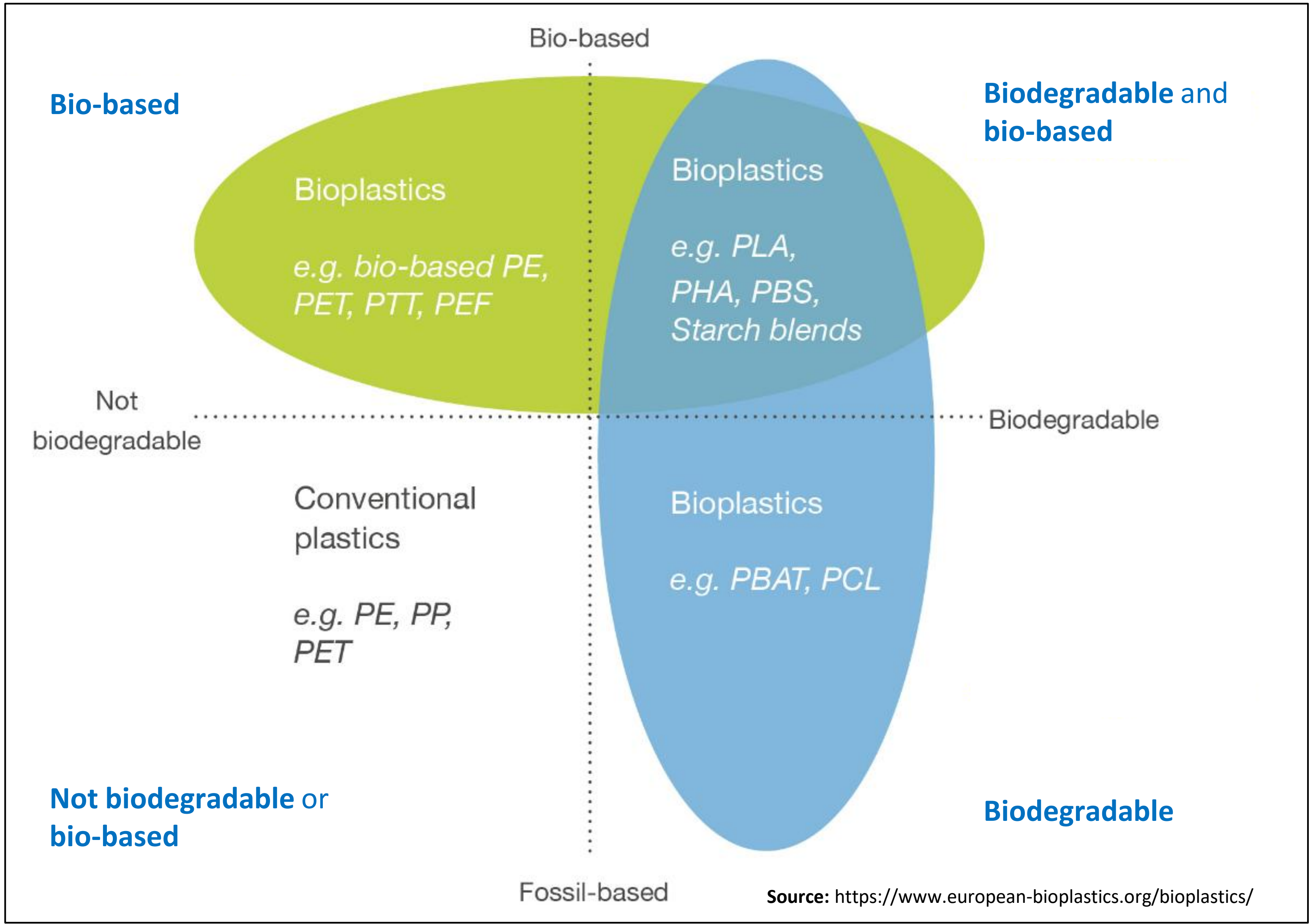
A. What is a FCM?

Food contact materials (FCM) are all materials and articles intended to come in contact with food:

- Packaging and containers, kitchen equipment, cutlery and dishes (e.g., plastics, rubber, paper and metal);
- Materials of processing equipment;
- Production machinery;
- Containers for transport.

B. Types of FCM



Source: https://www.european-bioplastics.org/bioplastics/

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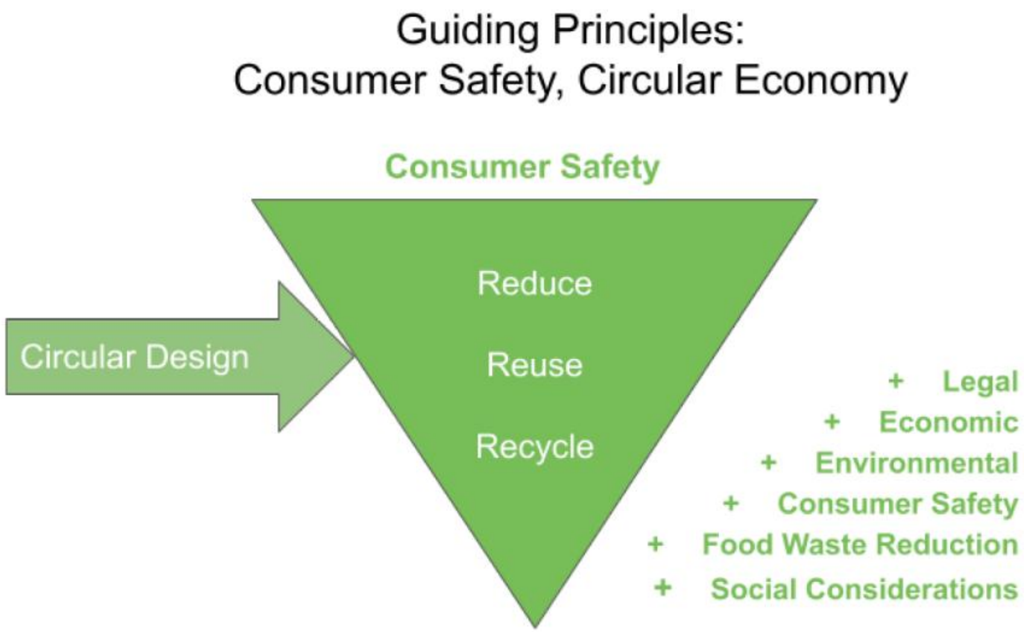
C. Why we need food packaging

- Preservation of food and its quality characteristics.
- Extending shelf life (bacterial growth).
- Facilitate transport.
- Protection of the food (e.g., contamination).
- Avoiding food spoilage (bacterial growth, oxidation).

D. EU strategy/policy for FCM

EU plastics strategy **ALL PLASTIC PACKAGING** placed on the EU market to be **REUSABLE** or **EASILY RECYCLED** by **2030** (only PET at the moment).



E. Current Regulated polymers for FCM at EU level

1. Plastics
2. Silicones
3. Rubbers and elastomers
4. Wood
5. Cork
6. Regenerated cellulose
7. Paper and board
8. Metals and alloys
9. Glass
10. Ceramics and enamel
11. Wax
12. Varnishes and coatings
13. Ion exchange (and adsorbent) resins
14. Printing inks
15. Adhesives

F. EU FCM Regulatory Framework

- **Framework Regulation (EC) 1935/2004** on materials and articles intended to come into contact with food
- **Commission Regulation (EC) 2022/1616** on recycled plastic materials and articles intended to come into contact with foods
- **Commission Regulation (EU) No. 10/2011** on plastic materials and articles intended to come into contact with food
- **Commission Regulation (EC) No 2023/2006** on good manufacturing practice for materials and articles intended to come into contact with food
- **Commission Regulation (EC) 450/2009** on active and intelligent materials and articles intended to come into contact with food.
- **Commission regulation (EU) 2018/213** on the use of bisphenol A in varnishes and coatings intended to come into contact with food
- **Directive 2007/42/EC** on materials and articles made of regenerated cellulose film that come into contact with food
- **Council Directive 84/500/EEC and 2005/31/EC** on the approximation of the laws of the Member States relating to ceramic articles intended to come into contact with foodstuffs
- **Council Directive 84/500/EEC of 15 October 1984** on the approximation of the laws of the Member States relating to ceramic articles intended to come into contact with foodstuffs
- **Council directive (EU) 2019/904** on the reduction of the impact of certain plastic products on the environment (single use plastics)

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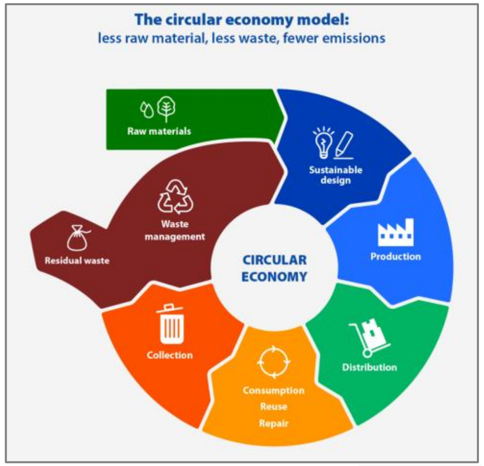
2. Introduction to eco-design

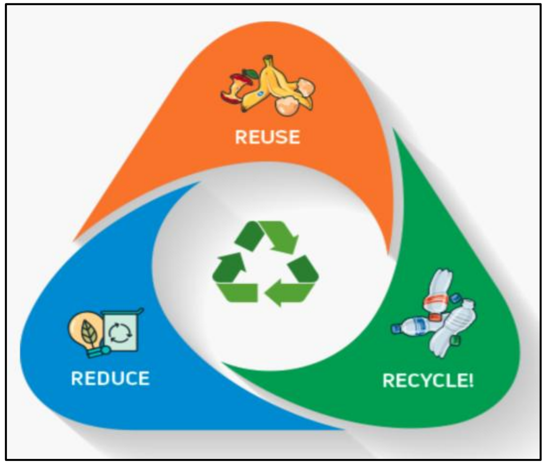
Project n.: 101087203

A. Circular economy

- **Definition**: A circular economy is an economic system aimed at eliminating waste and the continual use of resources through principles like reuse, recycling, and regeneration.
- **Contrast with Linear Economy**: Unlike the "take, make, dispose" model, a circular economy focuses on closing the loop by keeping materials in use for as long as possible.
- **Relevance to Plastics**: Moving away from single-use plastics towards materials that can be recycled, reused, or safely biodegraded or (bio)recycled.

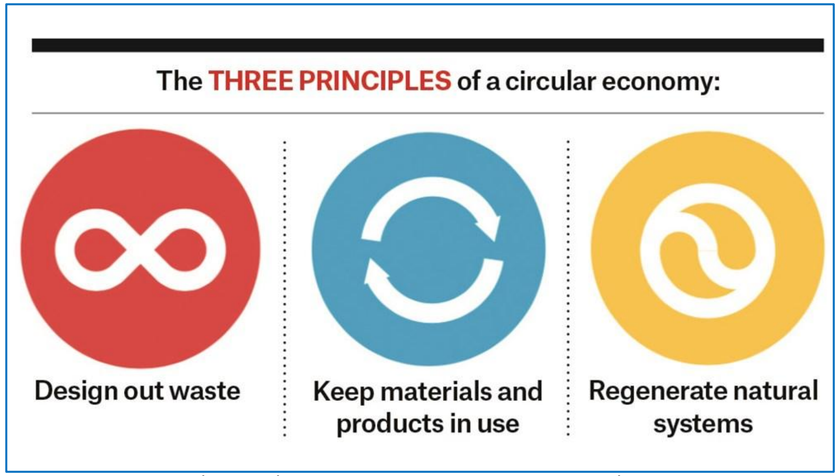


Source: European Parliament Research Service



The 3Rs

- The circular economy **prevents waste** and **regenerates nature**.
- It keeps materials in use through **recycling**, **reuse**, and other methods (**3Rs**).
- Addresses **climate change**, **biodiversity loss**, **waste**, and **pollution**.
- Separates **economic growth** from the **use of finite resources**.



Source: Ellen Macarthur Foundation, 2024 (https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview)

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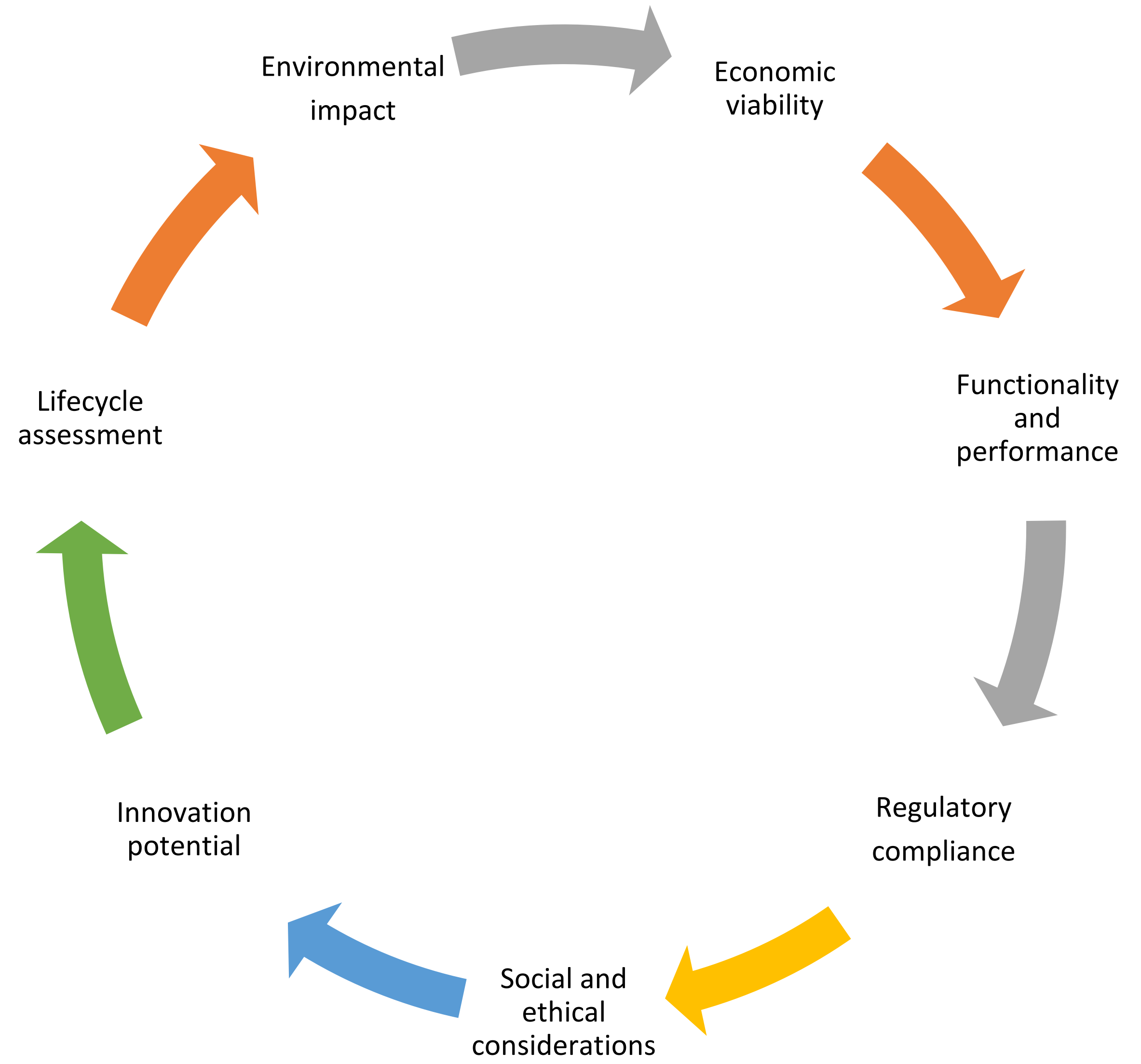
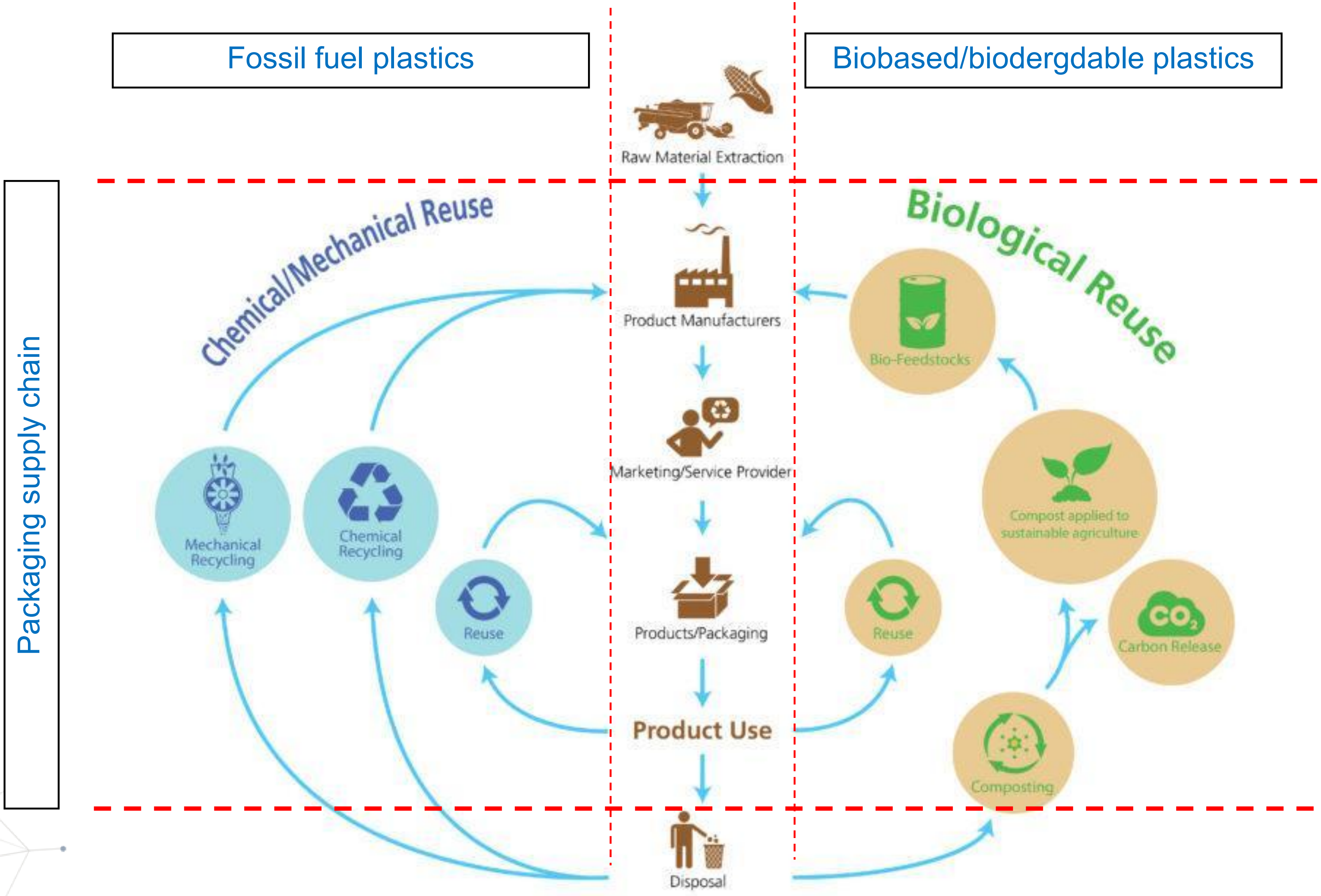
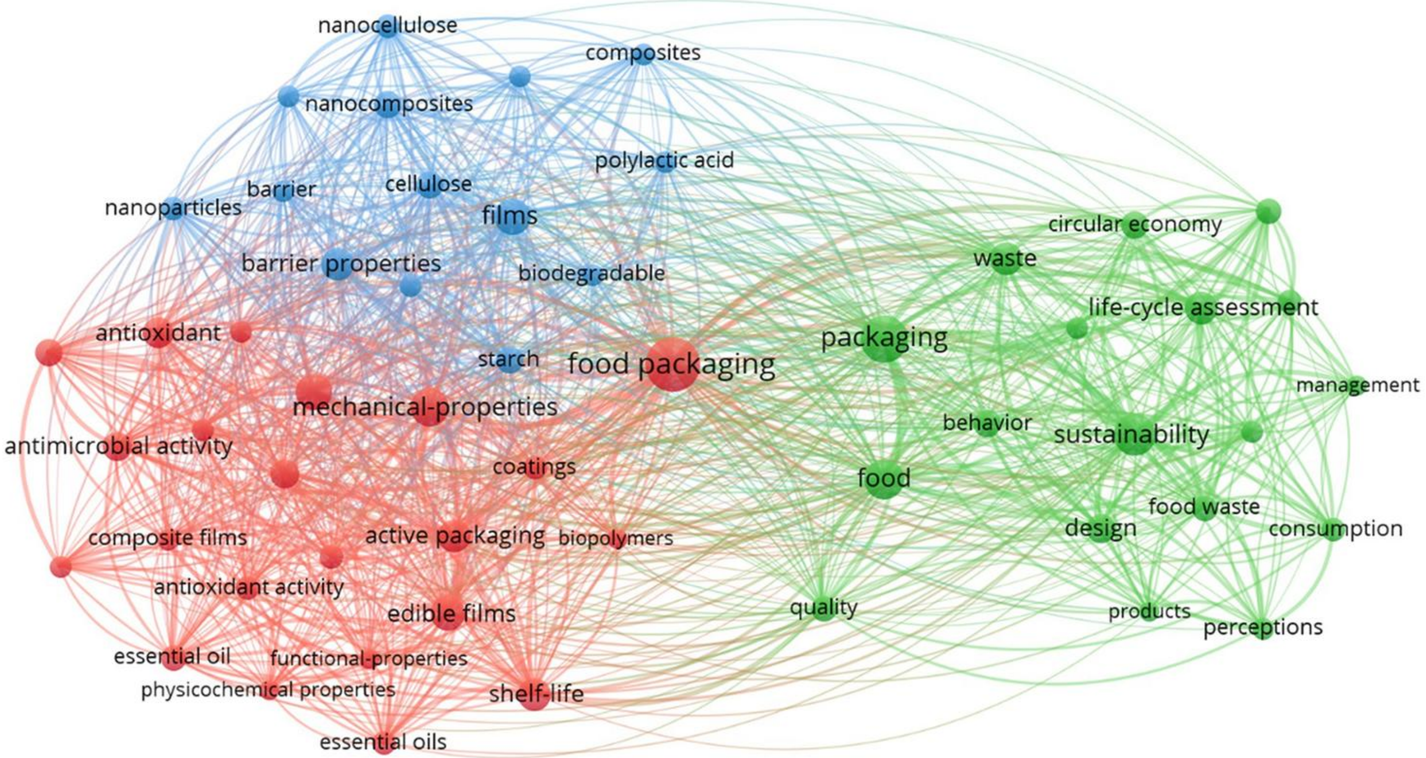


B. Circular and eco-designed packaging



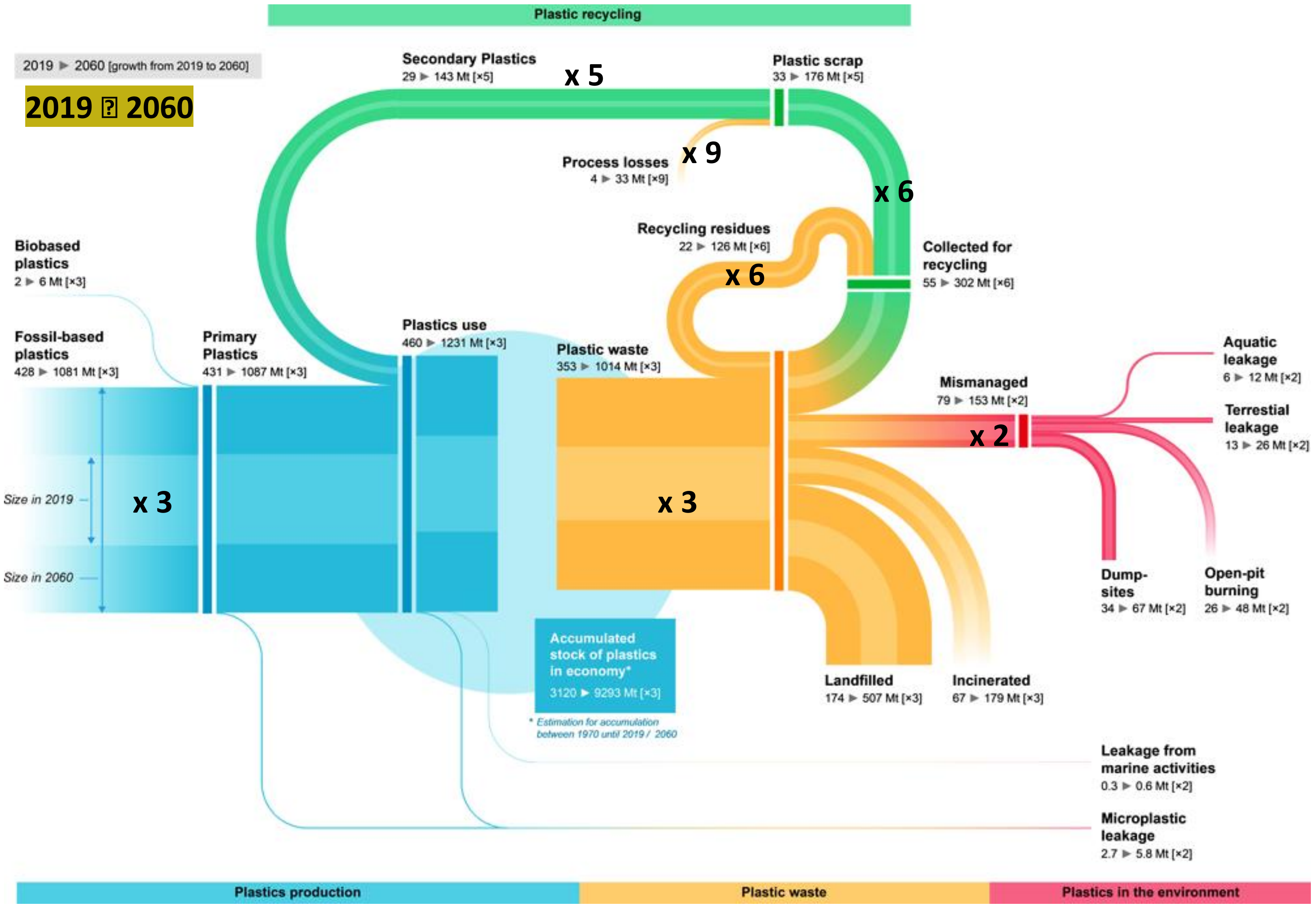
C. Eco-design and sustainable packaging

- **<u>Definition:</u>** *Sustainable food packaging is an optimized, measured (quantified) and validated solution, which takes into consideration the balance of social, economic, ecological and safe implementations of the circular value chain, based on the entire history (life cycle) of the food product-package unit.*



Source: Dornyei et al 2023, Front. Sustain. Food Syst. 7:1119052. https://10.3389/fsufs.2023.1119052

D. Challenge for Sustainable Packaging in a Circular Economy



Sources: [1] OECD/Global Plastics Outlook – Policy Scenarios to 2060

[2] OECD (2022), *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options*, OECD Publishing, Paris, https://doi.org/10.1787/de747aef-en.

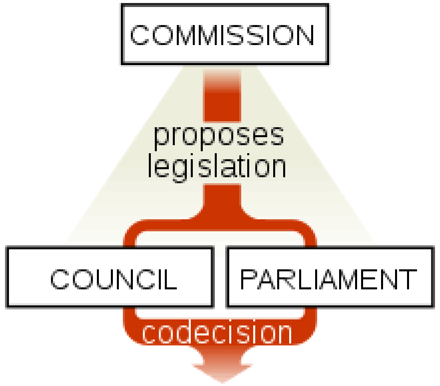
3. Risk assessment and Risk management (Safety)

Risk management

European Commission
Directorate-General for Health and Food Safety (DG SANTE)

Risk Assessment

efsa
European Food Safety Authority



A. FCM from mixtures of natural sources

Input from natural origin for food packaging


Technical Report

efsa SUPPORTING PUBLICATIONS

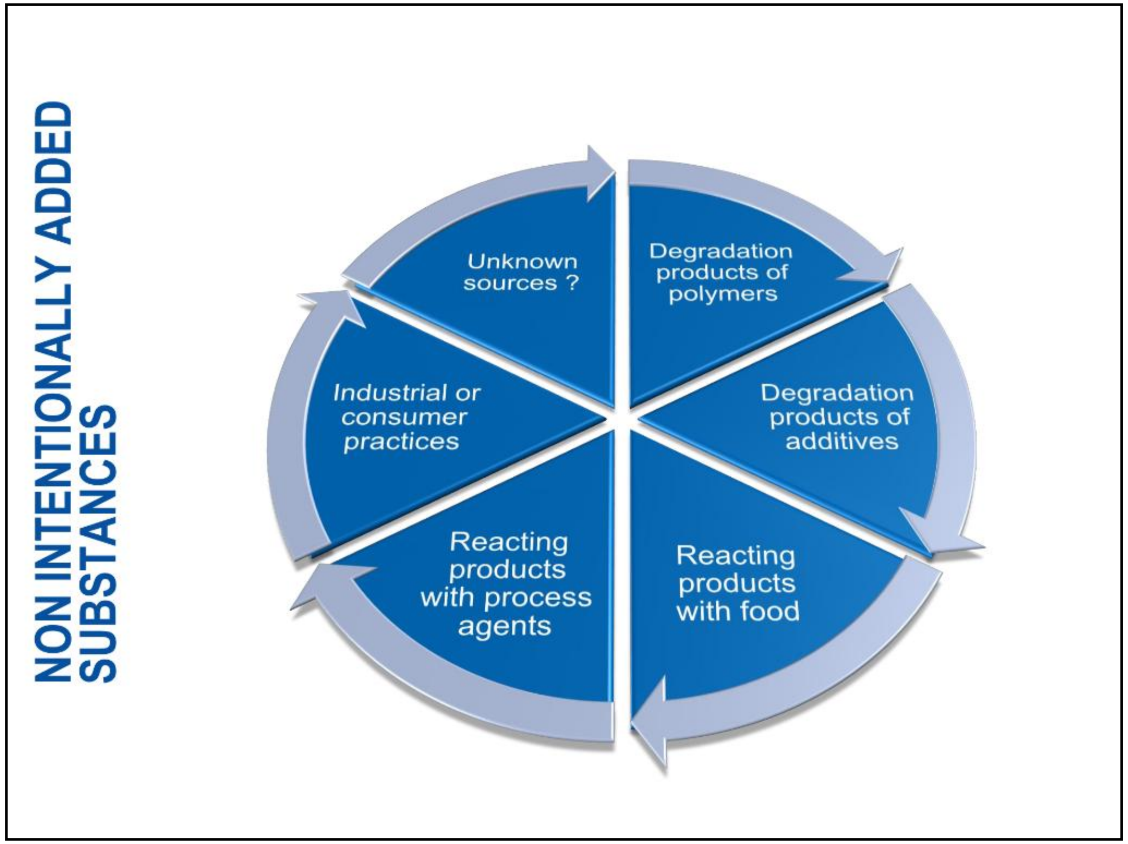
APPROVED: 20 October 2023
doi: 10.2903/sp.efsa.2023.EN-8409

Principles that could be applicable to the safety assessment of the use of mixtures of natural origin to manufacture food contact materials

European Food Safety Authority (EFSA),
Eric Barthélémy, Claudia Bolognesi, Laurence Castle, Riccardo Crebelli, Emma Di Consiglio, Roland Franz, Konrad Grob, Nicole Hellwig, Claude Lambré, Evgenia Lampi, Stefan Merkel, Maria Rosaria Milana and Gilles Rivière

&

NIAS



B. IAS and NIAS

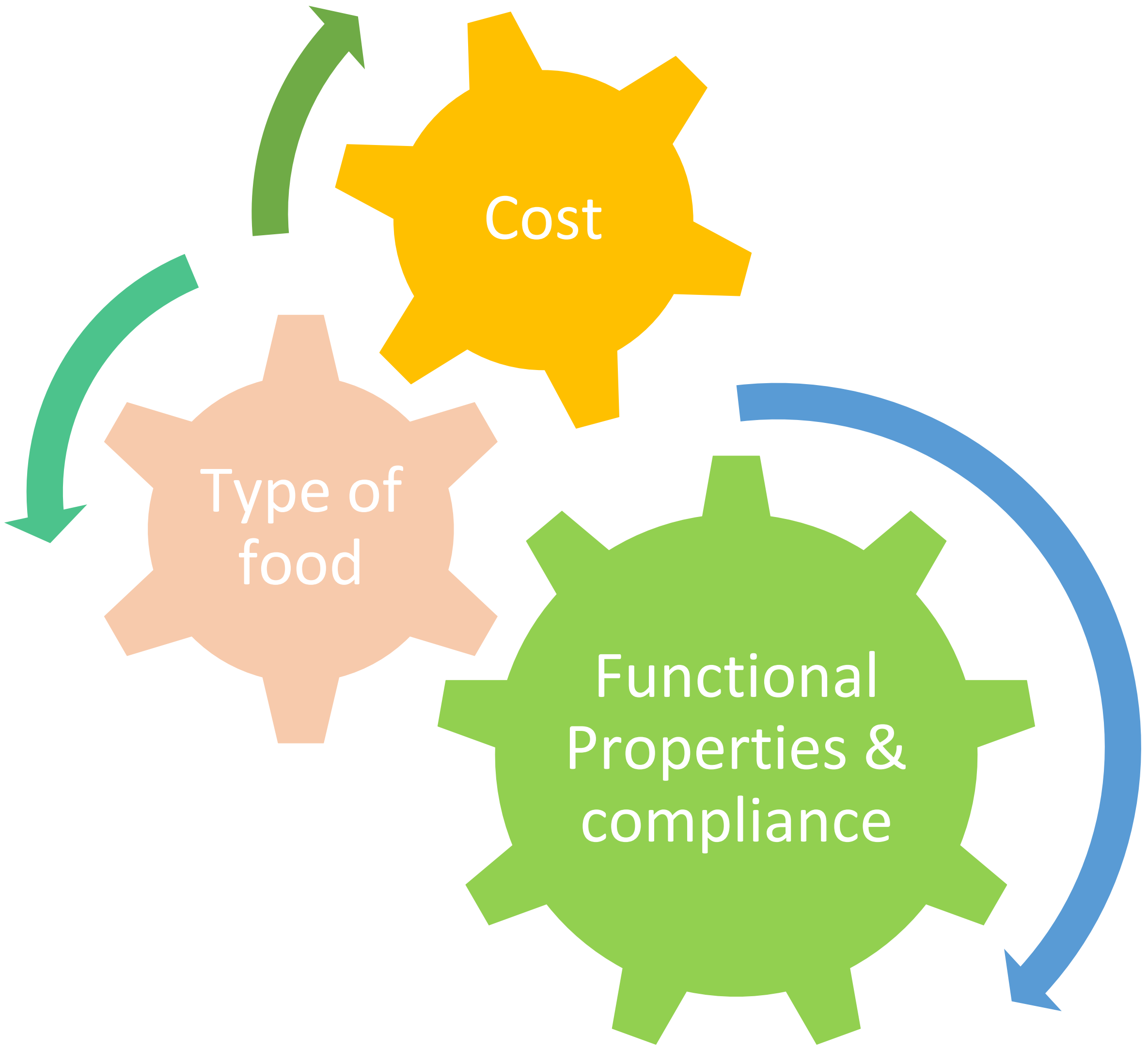
- **IAS - "Intentionally Added Substances"**
- *Regulated chemical substances (monomers, additives, stablizers, nucleating agents, platicisers, etc) that are risk assessed!*

- **NIAS – "Non-intentionally added substances**
- *Substances that may be originated through several paths and they are not regulated (sometimes not even risk assessed!)* → not regulated

→ the majority remains **unknown** and NOT risk assessed.

Source: Geueke et al. et al. *Crit. Rev. Food Sci*.. **2022** (https://doi.org/10.1080/10408398.2022.2067828)

4. Critical considerations


Cost
Type of food
Functional Properties & compliance

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5. CONCLUSIONS

1. Plastic alternatives in a circular economy are of great importance.

2. Sustainability will increase together with Plastic waste → recycling NOT enough.

3. Extensive research exists to develop plastic alternatives. But:
    a. Scaling up is needed (cost reduction)
    b. Low CO_2 fingerprint processes are still at a premature phase
    c. High costs (compared to fossil-fuel).
    d. End-users training and education (e.g. professionals, consumers).

4. Recycling technologies not covering all materials (only PET).

5. Policies (Risk managers) are making progress….(slow).

6. A single solution approach is not enough.

CHALLENGE???

- To minimize the waste of plastic!
- How??
- Requirements?
- Legislation

Thank you

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Eco-Design of Food packaging

Session 2:

Eco-design principles and Safe and Sustainable by Design (SSbD)

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Agenda

1. Introduction to eco-design principles and sustainable by design (SSbD)
2. Benefits of eco-design and SSbD
3. Implementation of SSbD: State-of-the art and challenges
4. Discussion/Q&A

1. Introduction to eco-design principles and sustainable by design (SSbD)

A. Eco-design key principles:

1. **Material Optimization:** Use fewer resources and prioritize renewables.
2. **Energy Efficiency:** Minimize energy use in production and operation.
3. **Longevity:** Design for durability, reuse, or repair.
4. **Recyclability:** Simplify recovery of materials at end-of-life.
5. **Reduce Toxicity:** Eliminate hazardous substances from the design.
6. **Circularity:** Enable closed-loop systems through design.

B. SSbD

1. What is it ?

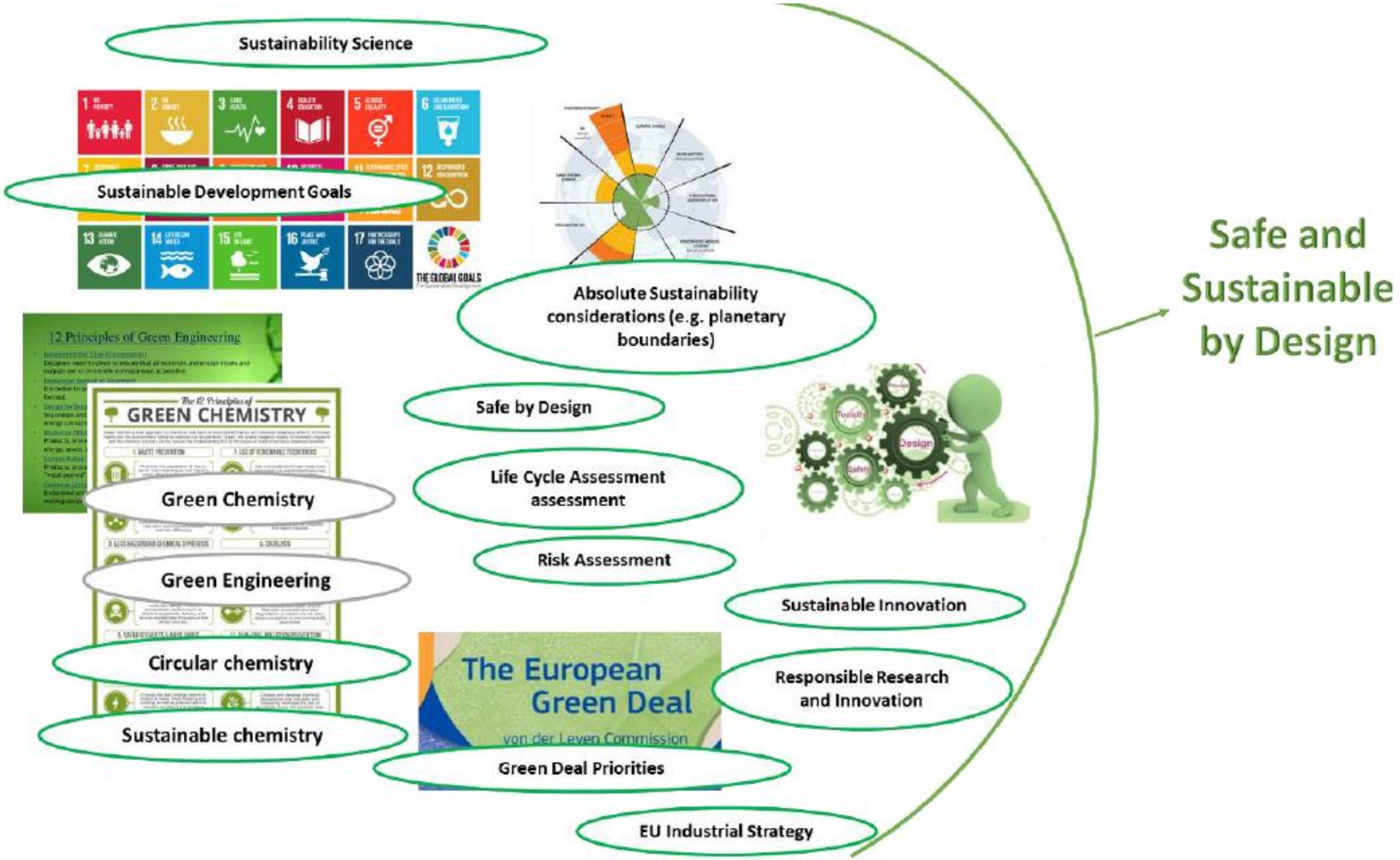
"A framework ensuring that products are safe for human health and the environment while being sustainable."

2. Pillars of SSbD:

1. **Safety:** No harmful chemicals or materials.
2. **Sustainability:** Minimal ecological footprint throughout the lifecycle.
3. **Functionality:** Meets user and performance needs.

3. Steps in SSbD

1. **Hazard Identification:** Assess materials for toxicity and environmental risks.
2. **Impact Assessment:** Evaluate lifecycle impacts (carbon footprint, waste).
3. **Design Integration:** Incorporate safer, sustainable alternatives.
4. **Testing and Validation:** Verify safety and functionality standards


Sustainability Science
Sustainable Development Goals
THE GLOBAL GOALS
Absolute Sustainability considerations (e.g. planetary boundaries)
12 Principles of Green Engineering
The 12 Principles of GREEN CHEMISTRY
Green Chemistry
Green Engineering
Circular chemistry
Sustainable chemistry
Safe by Design
Life Cycle Assessment assessment
Risk Assessment
Design
Safety
Sustainable Innovation
Responsible Research and Innovation
The European Green Deal
von der Leyen Commission
Green Deal Priorities
EU Industrial Strategy
Safe and Sustainable by Design

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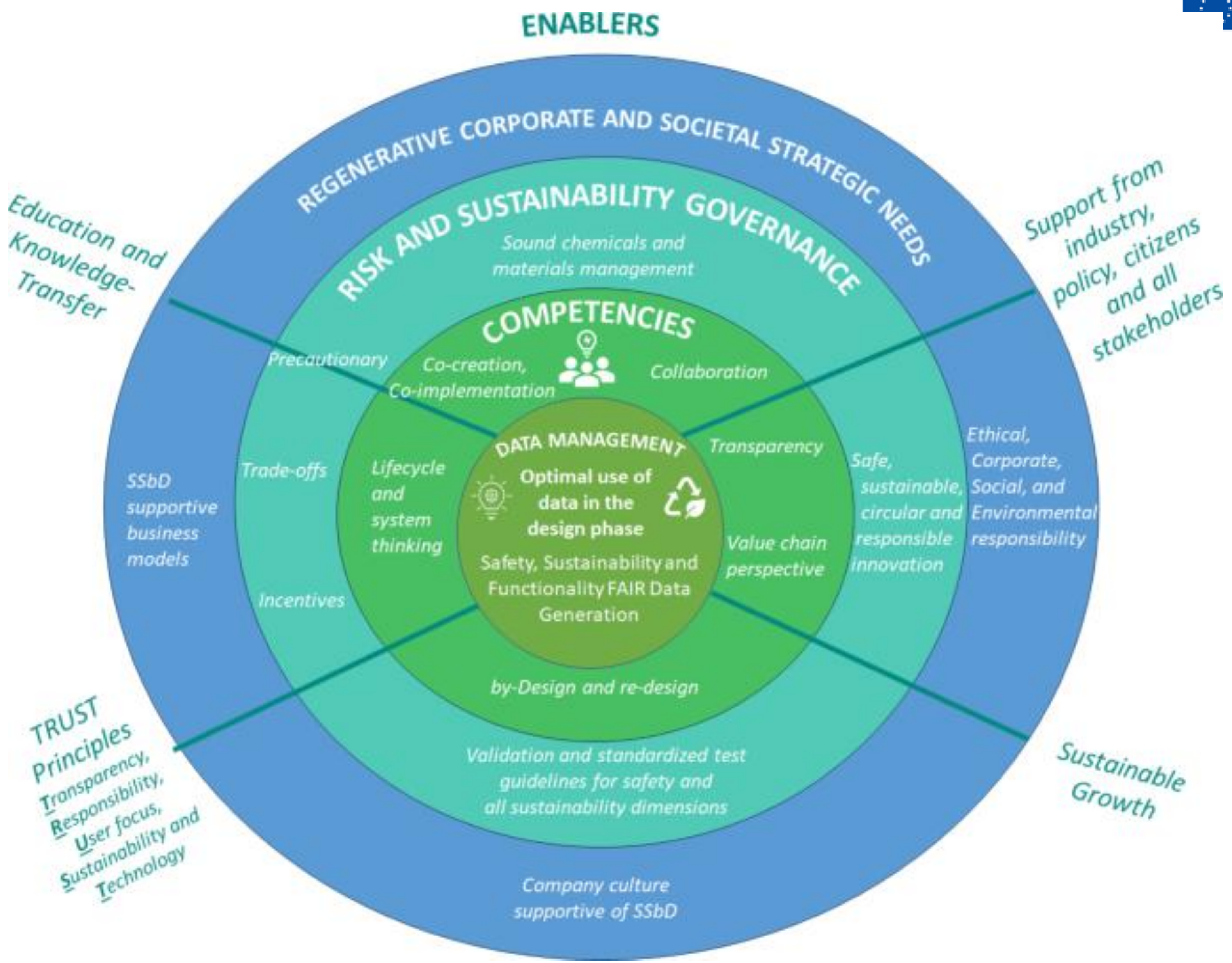
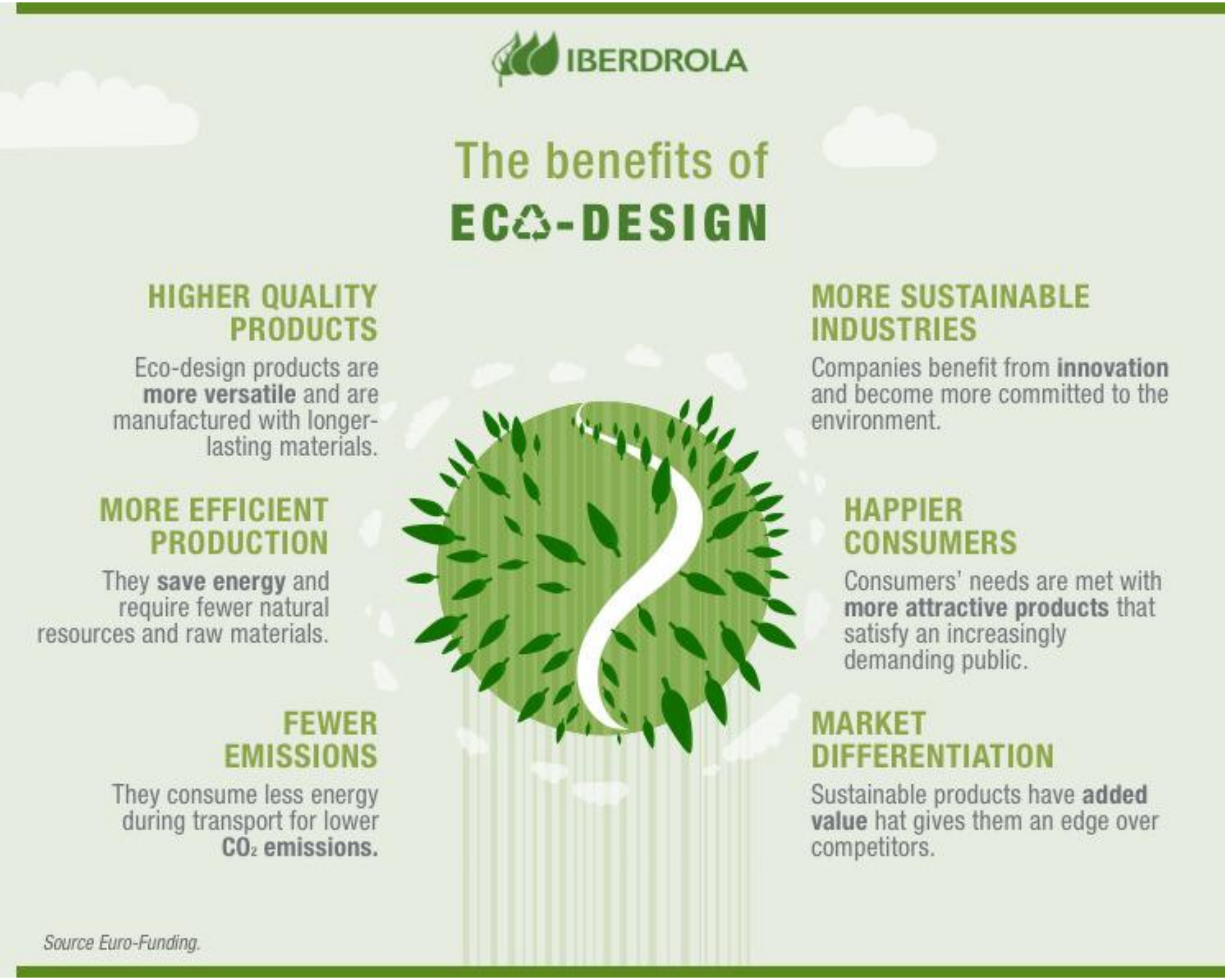


Source: Lya G. Soeteman-Hernández et al. 2024, Envir. Sustain. https://doi.org/10.1007/s42398-024-00324-w

2. Benefits of eco-design and SSbD

A. Eco-design


IBERDROLA
The benefits of
ECO-DESIGN
HIGHER QUALITY PRODUCTS
Eco-design products are **more versatile** and are manufactured with longer-lasting materials.
MORE EFFICIENT PRODUCTION
They **save energy** and require fewer natural resources and raw materials.
FEWER EMISSIONS
They consume less energy during transport for lower **CO_2 emissions.**
MORE SUSTAINABLE INDUSTRIES
Companies benefit from **innovation** and become more committed to the environment.
HAPPIER CONSUMERS
Consumers' needs are met with **more attractive products** that satisfy an increasingly demanding public.
MARKET DIFFERENTIATION
Sustainable products have **added value** hat gives them an edge over competitors.
Source Euro-Funding.

B. SSbD

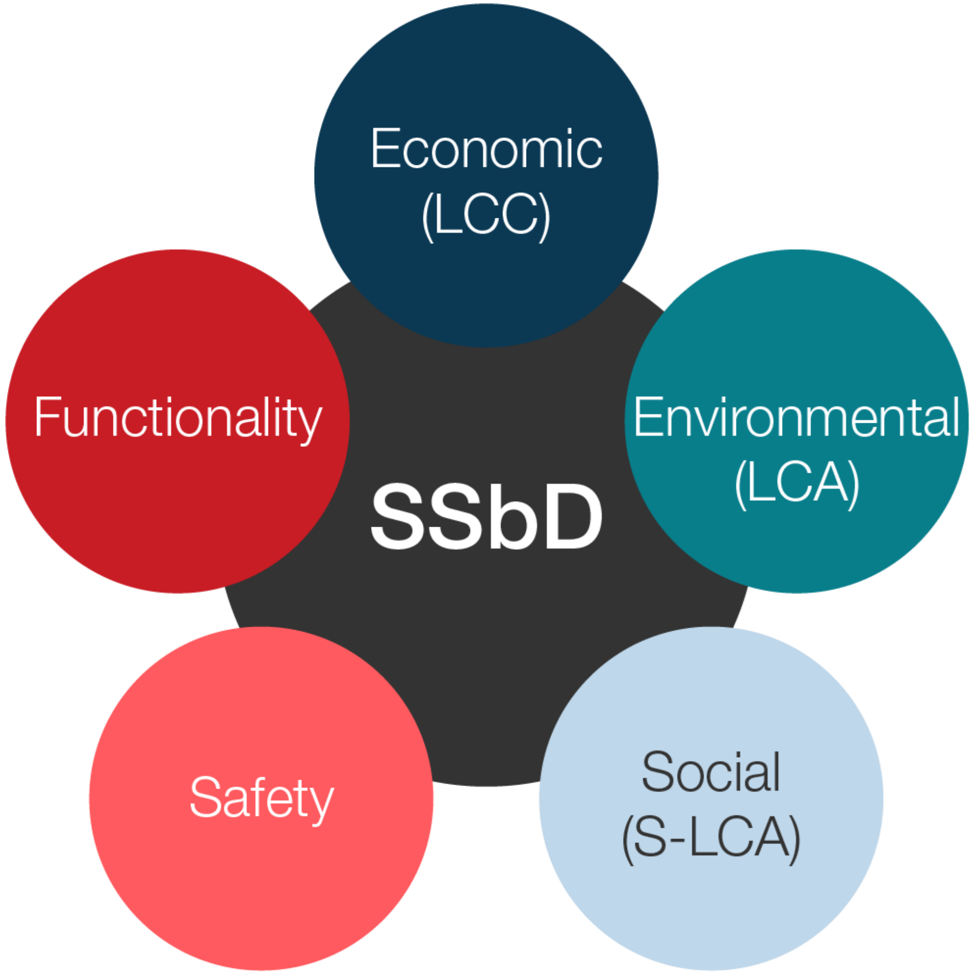
1. **Environmental:**
    - Reduced waste and emissions.
    - Improved recyclability and resource efficiency.

2. **Economic:**
    - Cost savings through material efficiency.
    - Competitive advantage in eco-conscious markets.

3. **Social:**
    - Healthier products for consumers.
    - Positive brand reputation.

4. **Safety**
    - Safe products for consumers.
    - Reduced exposure to chemicals

5. **Functionality**



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3. Implementation of SSbD: State-of-the art and challenges

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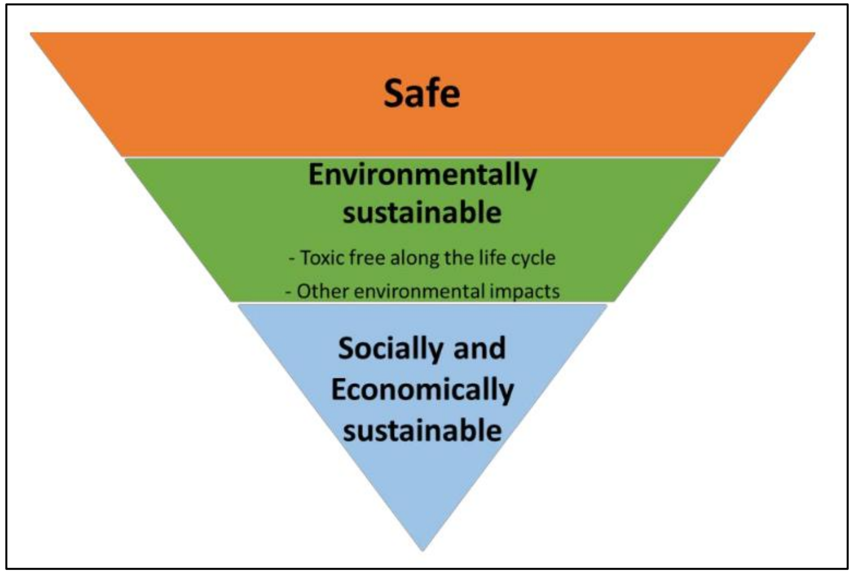

Table 1. Non-exhaustive list of potential benefits and challenges of the adoption of the SSbD approach from a technological and a legal perspective.

	Potential Benefits	Potential Challenges
T	*Ex ante* safety and sustainability	Lack of knowledge about technological risk
E	Active risk awareness	Complexity of implementation
C	Fostering innovation	Conflicts between safety and sustainability
H	Flexible principles-based regulation	Legal uncertainty
L	Simpler rules and standards	Compliance and enforcement
E	Transparency of legal objectives	Legitimacy and accountability
G	Wider scope of application	Regulatory capture
A	Management of regulatory challenges	Liability*
L	Compliance with existing rules	Potential clashes with WTO rules*

*Liability and potential clashes with WTO rules are outside of the scope of this paper because that domain is so complex that it would require a separate investigation.

Source: Reins and Wijns, 2024, Euroep[an Journal of Risk Regulation; 1-18; doi: 10.1017/err.2024.29

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4. Discussion/Q&A

"How can businesses overcome barriers to adopting SSbD?"

Thank you

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Eco-Design of Food packaging

Session 3:

Safety and risk assessment of eco-designed food packaging

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Agenda

1. Basic terms
2. Introduction to safety
3. Regulatory framework
4. Risk assessment framework

1. Basic terms

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Basic concepts

1. Migration
2. Polymeric materials
3. Types of polymeric materials
4. Supply chain
5. Contamination sources

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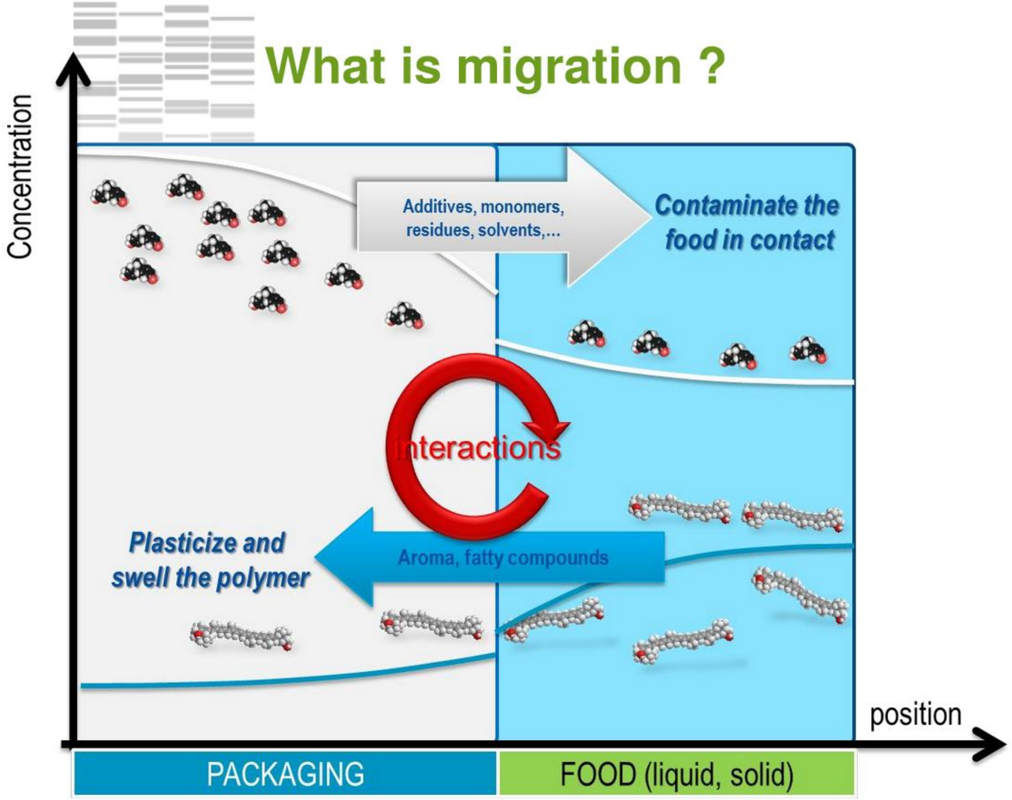
1. Migration

- Complex physicochemical phenomenon
- Diffusion
- Based on Fick's 2nd law

Migration (Migration)
The phenomenon that describes the transfer of substances (chemicals) from packaging to food or vice versa (food to packaging).

Migrating chemical compounds (migrants)
Compounds that are transferred from the packaging to the food as a result of contact or interaction between the food and the packaging material.

Migration limits
Defined by European Regulations or national legislation.



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2. Types of migration

A. Overall migration(OM- limit 60 mg/kg of food or 60 mg/dm^2 plastic)

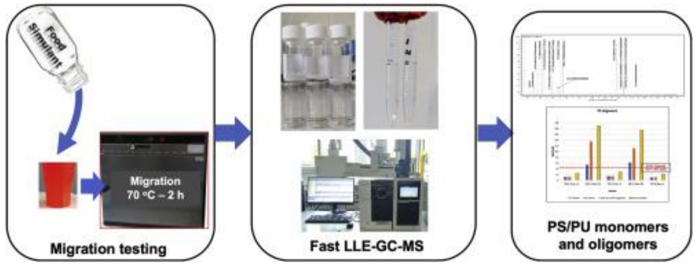
OM is the maximum permitted total amount of non-volatile substances that can migrate from a food packaging material or food container into the food.

Gravimetric method

B. Specific migration (SM- specific migration limit- mg/kg of food - Annex I, Reg. 10/2011)

The specific migration limit (SML) is the maximum permitted amount of a particular substance that can migrate from a food packaging material or food container into food. It is a safety limit derived from toxicological studies.

Instrumental analytical techniques



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3. Compliance testing/exposure

Table 1

List of food simulants

Food simulant	Abbreviation
Ethanol 10 % (v/v)	Food simulant A
Acetic acid 3 % (w/v)	Food simulant B
Ethanol 20 % (v/v)	Food simulant C
Ethanol 50 % (v/v)	Food simulant D1
Vegetable oil (*)	Food simulant D2
poly(2,6-diphenyl-p-phenylene oxide), particle size 60-80 mesh, pore size 200 nm	Food simulant E

Table 2

food category specific assignment of food simulants

(1)	(2)	(3)					
Reference number	Description of food	Food simulants					
		A	B	C	D1	D2	E
01	**Beverages**						
01.01	Non-alcoholic beverages or alcoholic beverages of an alcoholic strength lower than or equal to 6 % vol.:						
	A. Clear drinks:		X(*)	X			

Compliance testing/ exposure

Table 1

Contact time

Contact time in worst foreseeable use	Test time
t ≤ 5 min	5 min
5 min < t ≤ 0,5 hour	0,5 hour
0,5 hours < t ≤ 1 hour	1 hour
1 hour < t ≤ 2 hours	2 hours
2 hours < t ≤ 6 hours	6 hours
6 hours < t ≤ 24 hours	24 hours
1 day < t ≤ 3 days	3 days
3 days < t ≤ 30 days	10 days
Above 30 days	See specific conditions

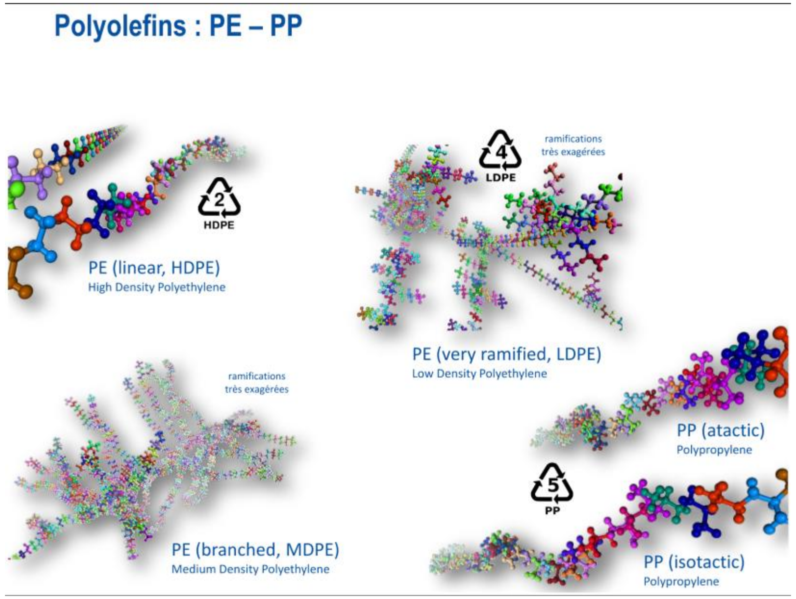
Table 2

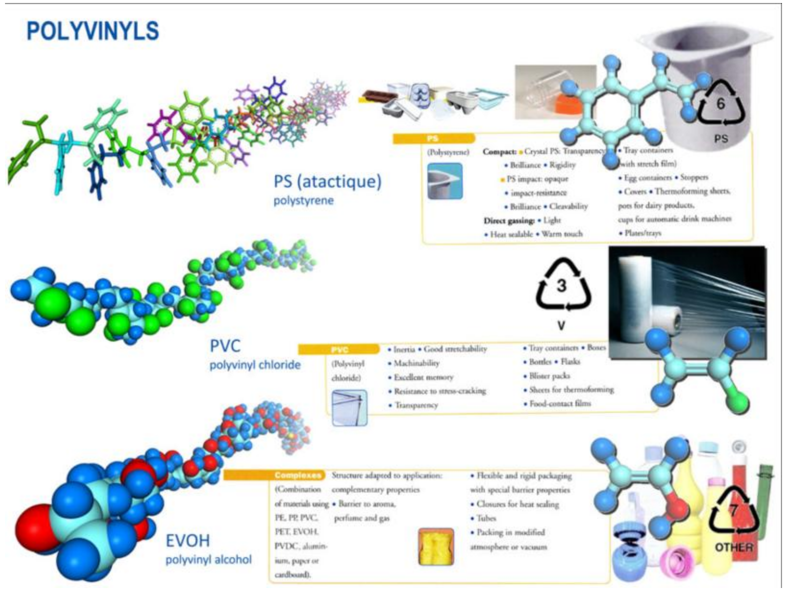
Contact temperature

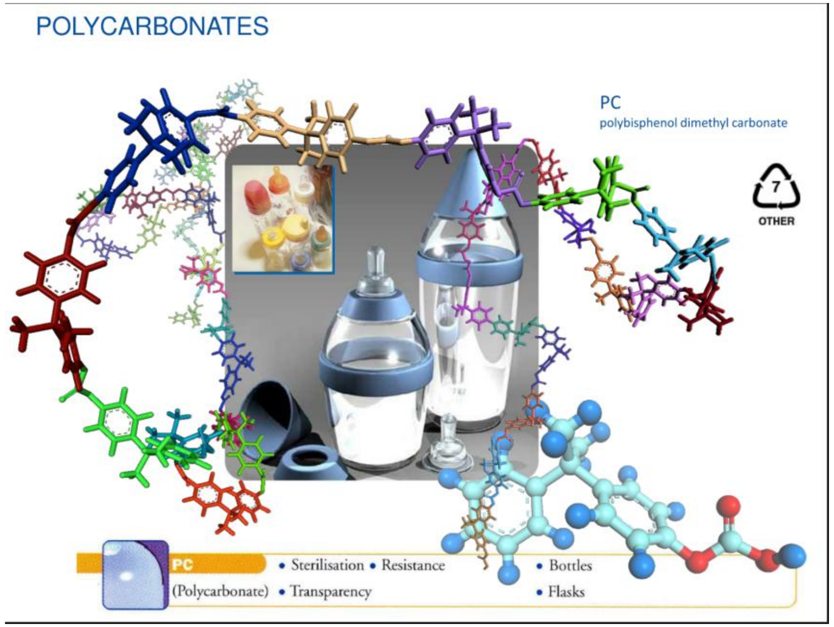
Conditions of contact in worst foreseeable use	Test conditions
Contact temperature	Test temperature
T ≤ 5 °C	5 °C
5 °C < T ≤ 20 °C	20 °C
20 °C < T ≤ 40 °C	40 °C
40 °C < T ≤ 70 °C	70 °C
70 °C < T ≤ 100 °C	100 °C or reflux temperature
100 °C < T ≤ 121 °C	121 °C (*)
121 °C < T ≤ 130 °C	130 °C (*)
130 °C < T ≤ 150 °C	150 °C (*)
150 °C < T < 175 °C	175 °C (*)
T > 175 °C	Adjust the temperature to the real temperature at the interface with the food (*)

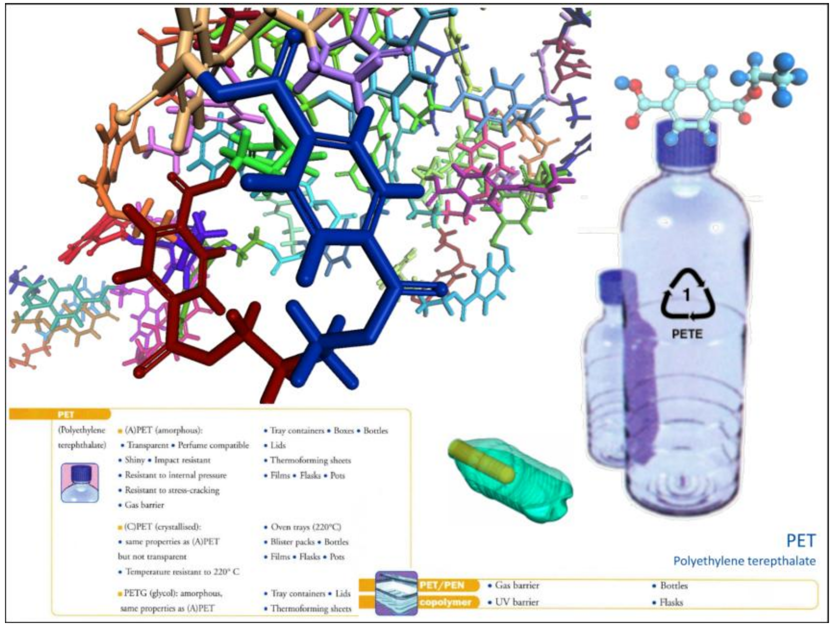
(*) This temperature shall be used only for food simulants D2 and E. For applications heated under pressure migration testing under pressure at the relevant temperature may be performed. For food simulants A, B, C or D1 the test may be replaced by a test at 100 °C or at reflux temperature for duration of four times the time selected according to the conditions in Table 1.

2. Type of polymers









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3. Type of polymeric materials

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4. Supply chain

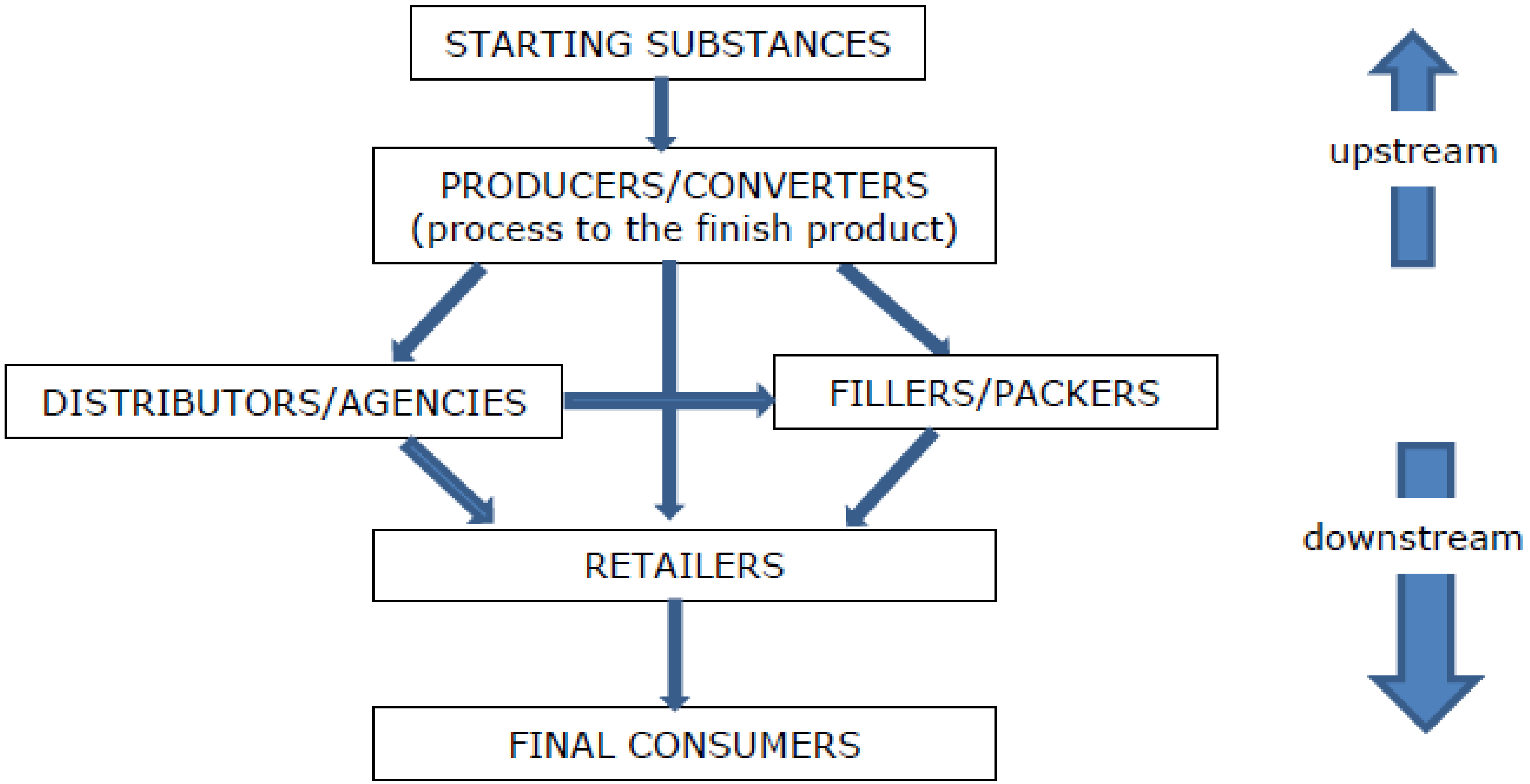

Figure 1: Simplified structure of the organisation of the FCM supply chain

5. Contamination sources

Polyurethane based
Sylil terminated polyether based
Butyl rubber based
Natural rubber water-based adhesives
Carboxylated-SBR water-based adhesives
Epoxies
Modified acrylics
Cyanoacrylates

Component	Formulation level	Exposed contact surface	Interaction with food	Contaminatio n risk
Plastic layer in contact withfood	+++	+++++	+ to +++	+++++
Layer non-intented to be in contact with food	+++	+++++	-	+++
Cap, lid	+++	++	- to +	++
Gasket	+++++	+	- to +	+ to ++
Varnish	+++ to +++++	+++++	-	+++
Ink	+++++	+ to +++	-	+ to +++

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2. Introduction to safety

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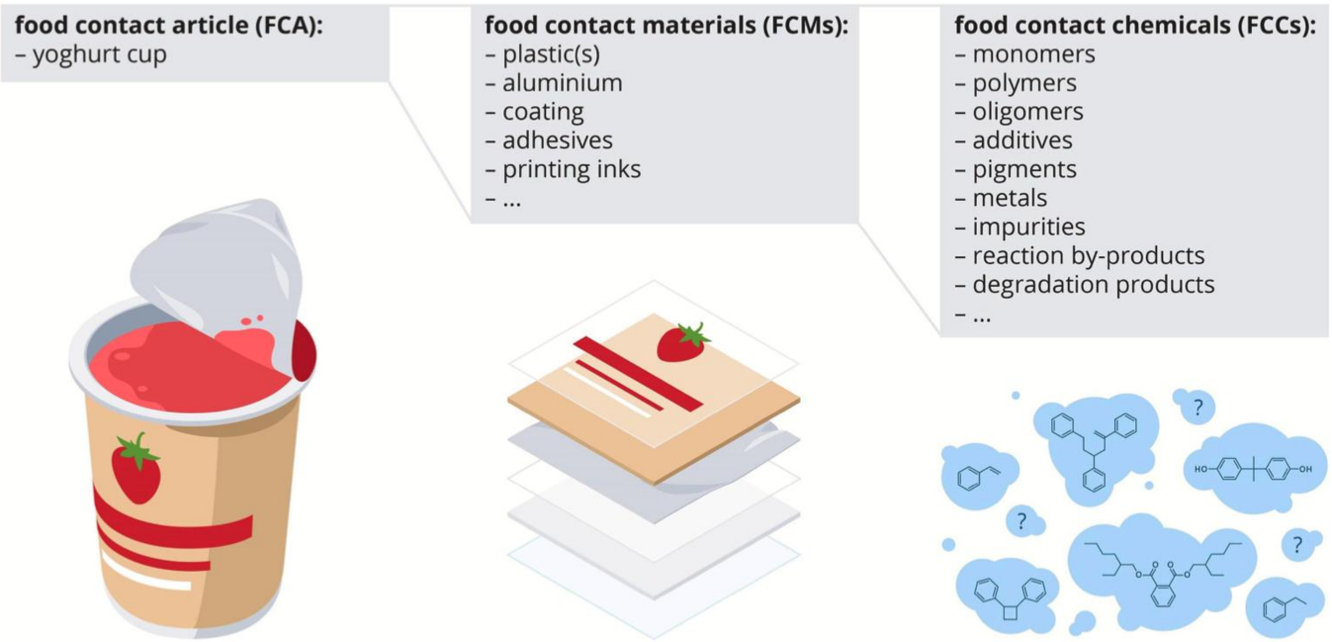

Initial product

Consumer exposure

Chemicals in the FCM (IAS? NIAS?)

Toxicity

Migration = consumer exposure

Intentionally added substances are used for the manufacture of food contact materials.

Toxicity testing of intentionally added substances is focused on genotoxicity and mutagenicity.

Finished food contact articles contain both intentionally added substances and non-intentionally added substances (NIAS).

Multiple chemicals migrate simultaneously from finished food contact articles into foodstuffs and this mixture is known as overall migrate.

Source: Muncke et al. 2023. Envrionmental International; https://doi.org/10.1016/j.envint.2023.108161

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2. Regulatory framework

EU FCM Regulatory Framework

- **Framework Regulation (EC) 1935/2004** on materials and articles intended to come into contact with food
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- **Directive 2007/42/EC** on materials and articles made of regenerated cellulose film that come into contact with food
- **Council Directive 84/500/EEC and 2005/31/EC** on the approximation of the laws of the Member States relating to ceramic articles intended to come into contact with foodstuffs
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- **Council directive (EU) 2019/904** on the reduction of the impact of certain plastic products on the environment (single use plastics)

Risk and Safety assessment

EUROPEAN FOOD SAFETY AUTHORITY

- Guidance
- Criteria for safaety
- Risk assessment
- Scientific opinions


Technical Report

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Principles that could be applicable to the safety assessment of the use of mixtures of natural origin to manufacture food contact materials

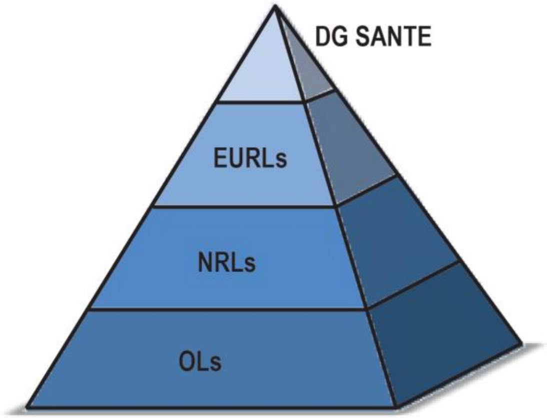
European Food Safety Authority (EFSA),
Eric Barthélémy, Claudia Bolognesi, Laurence Castle, Riccardo Crebelli, Emma Di Consiglio, Roland Franz, Konrad Grob, Nicole Hellwig, Claude Lambré, Evgenia Lampi, Stefan Merkel, Maria Rosaria Milana and Gilles Rivière

Risk management

European Commission

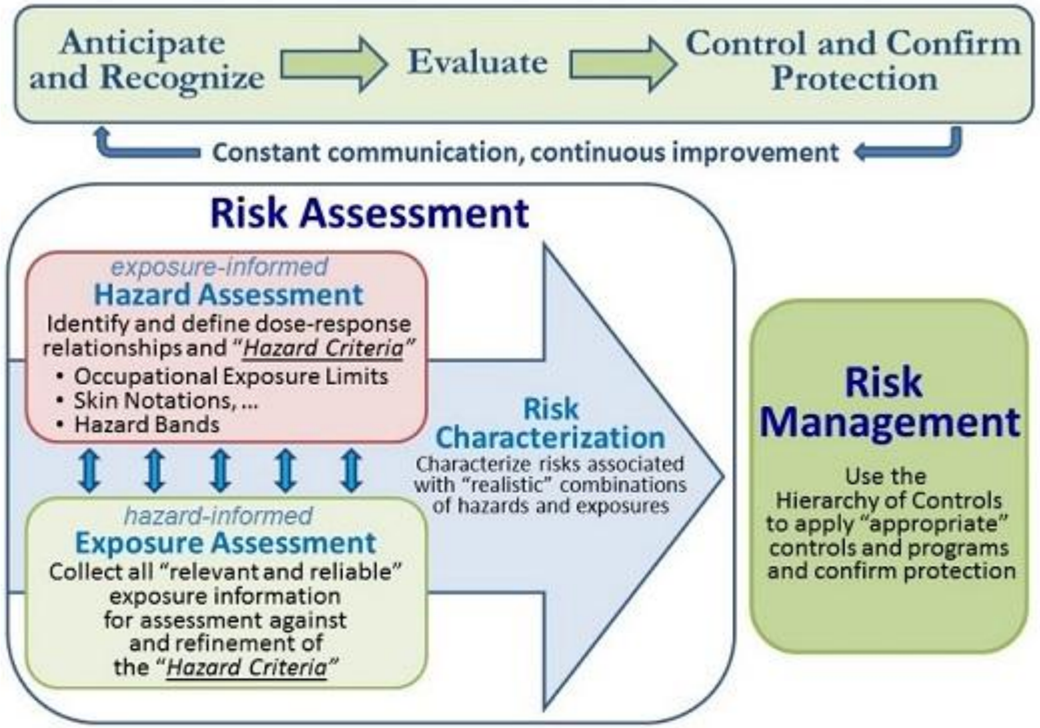
Directorate-General for Health and Food Safety (DG SANTE)

- Regulations;
- Official controls
- Complaince rules
- Authorisations
- Official controls



3. Risk assessment framework

1. Risk, hazard and exposure



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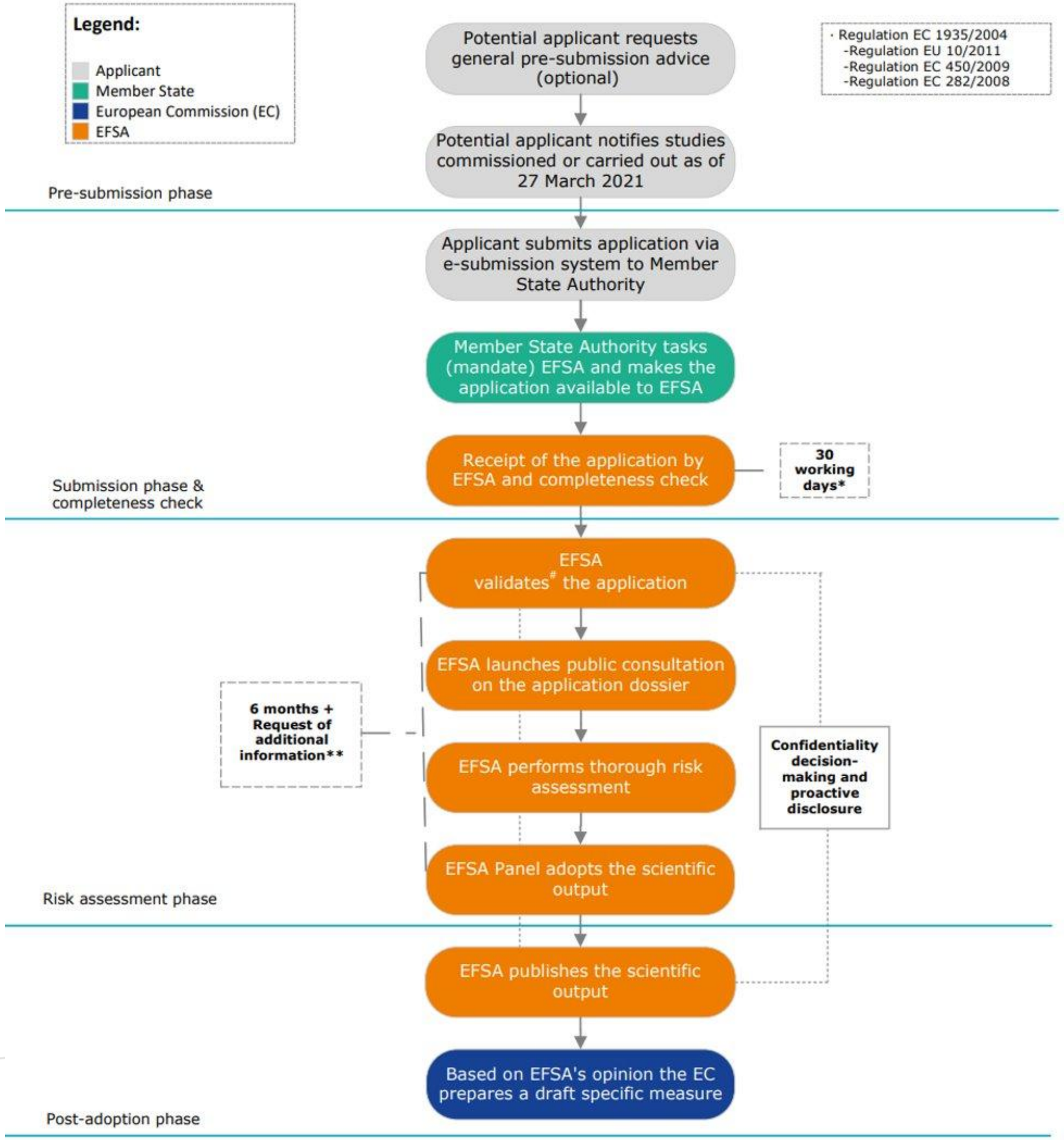
2. Risk assessment of FCM (including eco-designed)



GUIDANCE

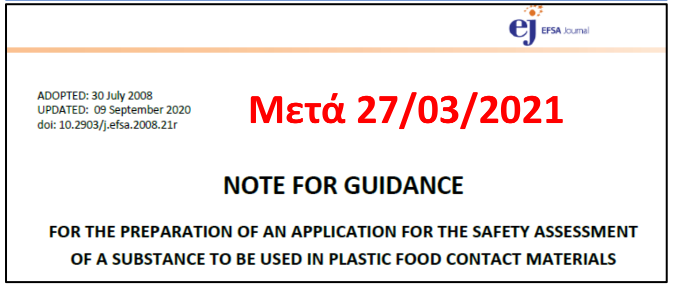
EFSA Journal

ADOPTED: 31 July 2008
UPDATED: 23 March 2017
doi: 10.2903/j.efsa.2008.21r

Πριν 27/03/2021

NOTE FOR GUIDANCE

FOR THE PREPARATION OF AN APPLICATION FOR THE SAFETY ASSESSMENT OF A SUBSTANCE TO BE USED IN PLASTIC FOOD CONTACT MATERIALS



EFSA Journal

ADOPTED: 30 July 2008
UPDATED: 09 September 2020
doi: 10.2903/j.efsa.2008.21r

Μετά 27/03/2021

NOTE FOR GUIDANCE

FOR THE PREPARATION OF AN APPLICATION FOR THE SAFETY ASSESSMENT OF A SUBSTANCE TO BE USED IN PLASTIC FOOD CONTACT MATERIALS

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3. Toxicity (Hazard)

Εκτίμηση τοξικότητας

- **Γενοτοξικότητα, μεταλλαξιγένεση, καρκινογένεση**
  - **In vivo**
  - **In Silico** (QSAR alerts)
- **Άλλα είδη τοξικότητας**
  - **In vivo**
  - **In Silico** (κατηγοριοποίηση/κλάσεις Cramer (I, II, III)

QSAR – Quantitative structure-activity relationship

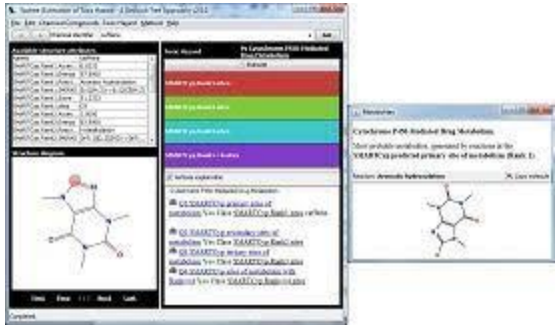
EFSA JOURNAL

Guidance Document | Open Access

Guidance on the use of the Threshold of Toxicological Concern approach in food safety assessment

EFSA Scientific Committee, Simon J More, Vasileios Bampidis, Diane Benford, Claude Bragard, Thorhallur I Halldorsson, Antonio F Hernández-Jerez, Susanne Hougaard Bennekou ... See all authors

First published: 06 June 2019 | https://doi.org/10.2903/j.efsa.2019.5708 | Citations: 14



Υπολογισμένο με μέσο όρο βάρους 60 kg /άτομο.

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4. Setting of safety levels (hazard characterisation)

EFSA

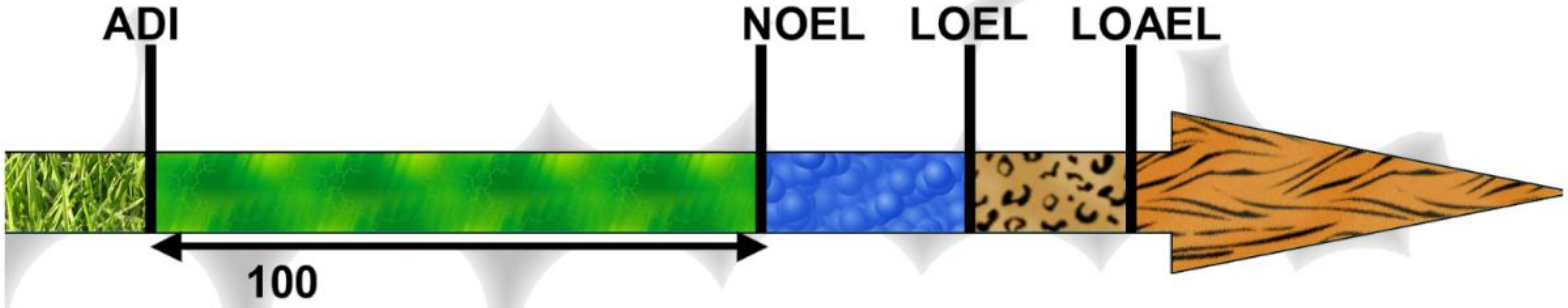
Risk Assessment

ADI = NOEL/100 (per kg body weight)

DG SANTE :

Risk Management

SML= 60 * ADI (mg intake per person per day from an assumed 1 kg packaged food)



ADI = Acceptable Daily Intake

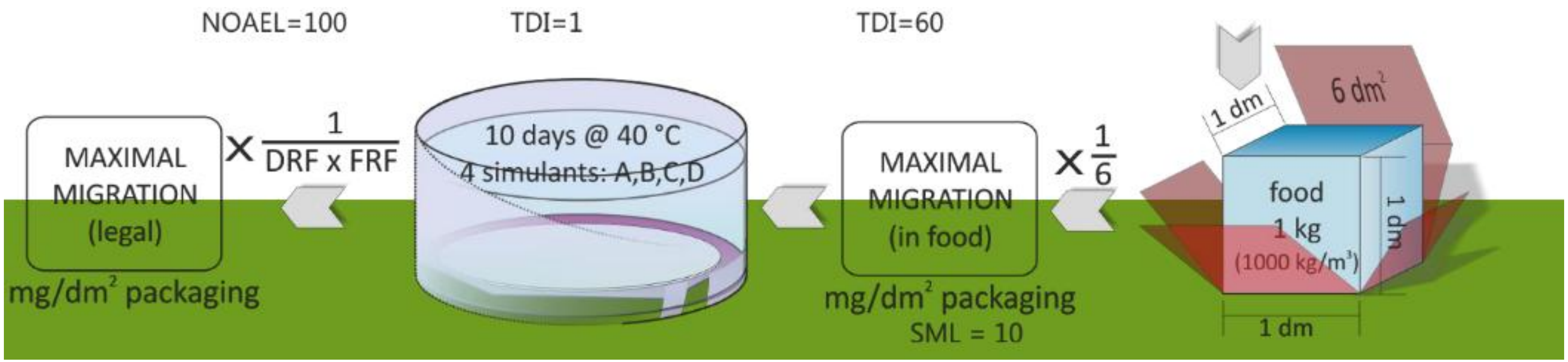
SML = Specific Migration Level

NOEL = No Observed Effect Level

LOEL = Lowest Observed Effect Level

LOAEL = Lowest Observed Adverse Effect Level

4. Setting of safety levels (hazard characterisation)



5. Exposure (migration testing)

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Accelerated conditions → **Worst-case scenario**

Table 1

List of food simulants

Food simulant	Abbreviation
Ethanol 10 % (v/v)	Food simulant A
Acetic acid 3 % (w/v)	Food simulant B
Ethanol 20 % (v/v)	Food simulant C
Ethanol 50 % (v/v)	Food simulant D1
Vegetable oil (*)	Food simulant D2
poly(2,6-diphenyl-p-phenylene oxide), particle size 60-80 mesh, pore size 200 nm	Food simulant E

Table 2

food category specific assignment of food simulants

(1)	(2)	(3)					
Reference number	Description of food	Food simulants					
		A	B	C	D1	D2	E
01	**Beverages**						
01.01	Non-alcoholic beverages or alcoholic beverages of an alcoholic strength lower than or equal to 6 % vol.:						
	A. Clear drinks:		X(*)	X			

Table 1

Contact time

Contact time in worst foreseeable use	Test time
t ≤ 5 min	5 min
5 min < t ≤ 0,5 hour	0,5 hour
0,5 hours < t ≤ 1 hour	1 hour
1 hour < t ≤ 2 hours	2 hours
2 hours < t ≤ 6 hours	6 hours
6 hours < t ≤ 24 hours	24 hours
1 day < t ≤ 3 days	3 days
3 days < t ≤ 30 days	10 days
Above 30 days	See specific conditions

Table 2

Contact temperature

Conditions of contact in worst foreseeable use	Test conditions
Contact temperature	Test temperature
T ≤ 5 °C	5 °C
5 °C < T ≤ 20 °C	20 °C
20 °C < T ≤ 40 °C	40 °C
40 °C < T ≤ 70 °C	70 °C
70 °C < T ≤ 100 °C	100 °C or reflux temperature
100 °C < T ≤ 121 °C	121 °C (*)
121 °C < T ≤ 130 °C	130 °C (*)
130 °C < T ≤ 150 °C	150 °C (*)
150 °C < T < 175 °C	175 °C (*)
T > 175 °C	Adjust the temperature to the real temperature at the interface with the food (*)

(*) This temperature shall be used only for food simulants D2 and E. For applications heated under pressure migration testing under pressure at the relevant temperature may be performed. For food simulants A, B, C or D1 the test may be replaced by a test at 100 °C or at reflux temperature for duration of four times the time selected according to the conditions in Table 1.

Thank you

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Eco-Design of Food packaging

Session 4:
Existing eco-designed food packaging materials. Pros and cons

This work has been developed under the ERASMUS-EDU-2022-PI-FORWARD Project “*Glocal Ecosystems and Expanded Knowledge for green skills and capability in the Food Sector*” (**G4F**) - Project n° 101087203.
It is credited to the G4F Consortium.

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Agenda

1. Introduction
2. Existing eco-designed food packaging materials
3. Pros and cons
4. Conclusions

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1. Introduction

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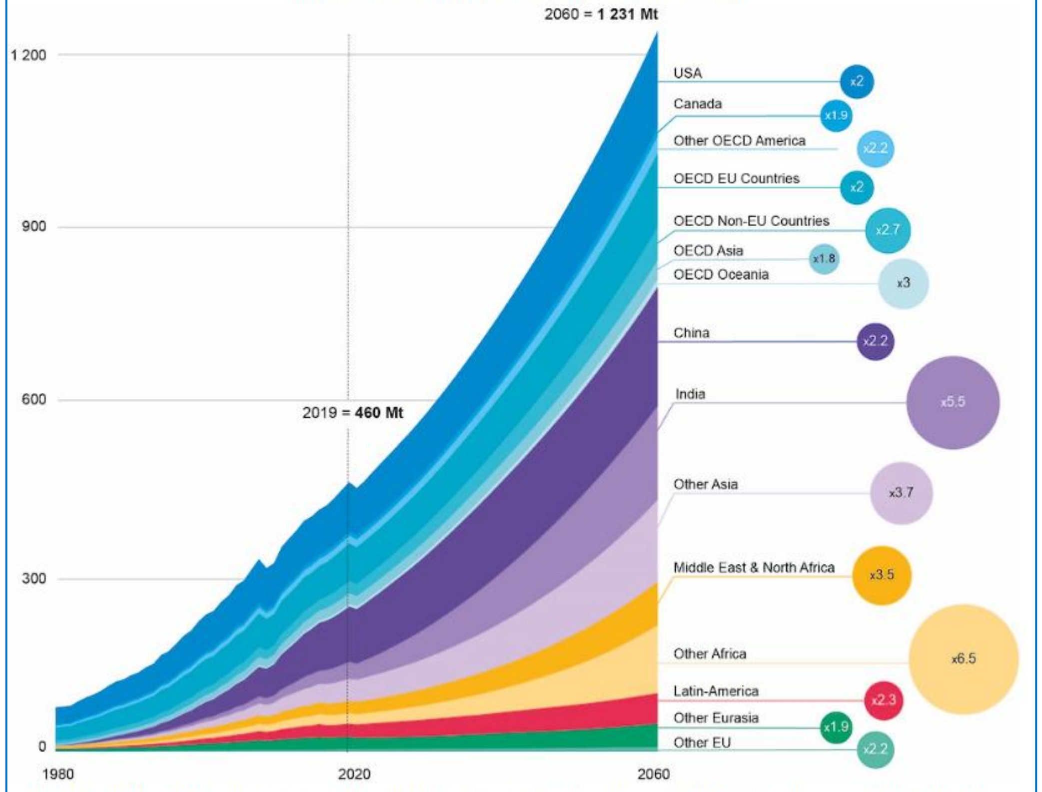
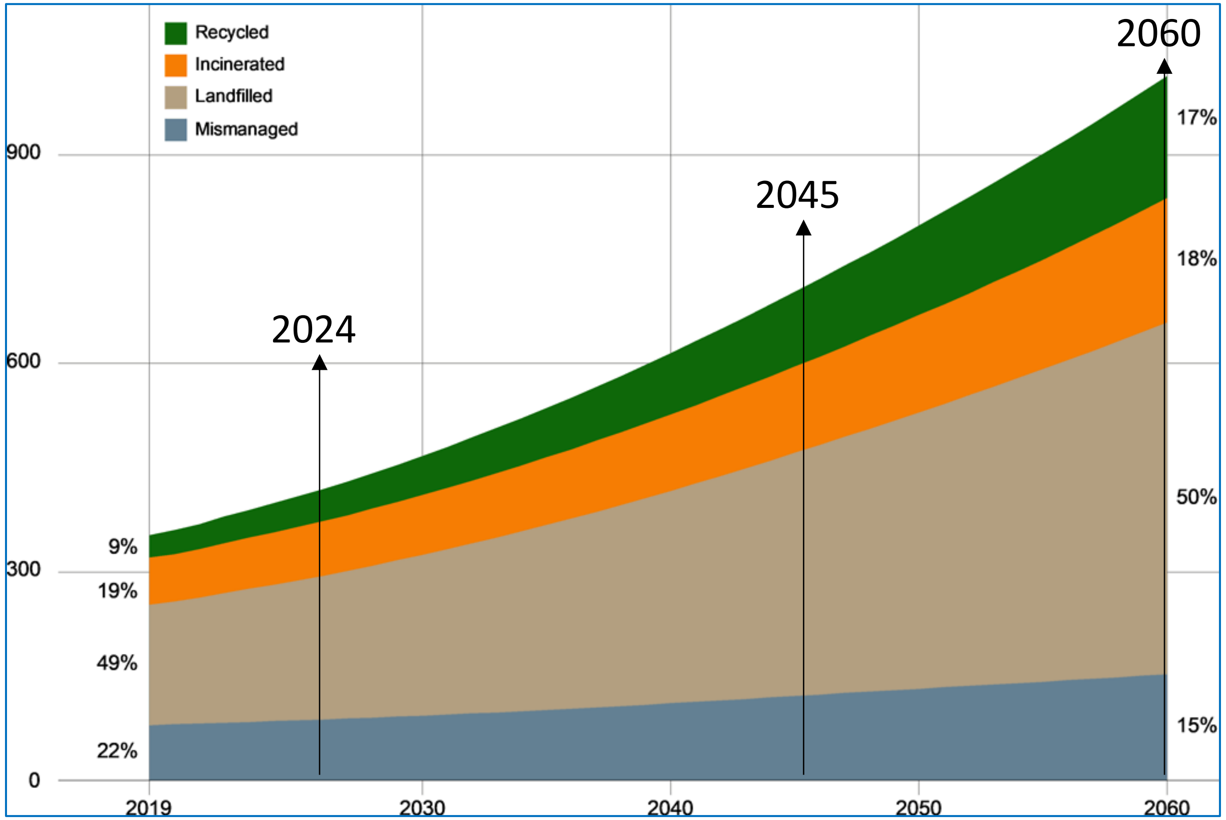
Figure 1.3. **Plastics use will grow fastest in developing and emerging economies in Africa and Asia**

Plastics use in million tonnes (Mt), Baseline scenario



Note: The numbers in the circle on the right-hand side of the graph indicate the growth of plastics use from 2019 (dashed line) to 2060 for each region (e.g. x2 means a doubling of plastics use).

Source: OECD ENV-Linkages model.



Source: OECD ENV-Linkages model.

Production of plastics ⟷ Plastic packaging waste

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Importance of packaging

- Preservation of food and its quality characteristics.
- Extending shelf life (bacterial growth).
- Facilitate transport.
- Protection of the food (e.g. contamination).
- Avoiding food spoilage (bacterial growth, oxidation).

Conventional packaging (i.e. plastic)

- Issues.
- Challenges.
- Persistence in the environment.
- Regulation requirements (Upcoming PPWR).

Need for eco-friendly alternatives

Eco-design food packaging

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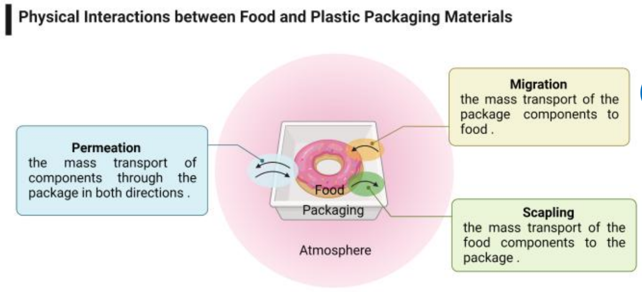
Eco-design food packaging

COMPLIANCE

Type of food

(oxygen, water vapour, carbon dioxide, other gases)



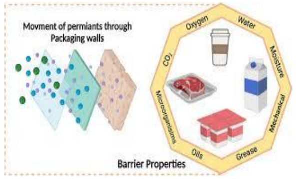
(monomers, additives or IAS, NIAS)

(aroma, fats, organic acids, pigments)

Cost

Functionality

Environmental attributes and impact



Monomaterial (e.g. PHA)

Multilayer material

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2. Existing eco-designed food packaging materials

Categories of eco-designed packaging materials

1. Biodegradable materials

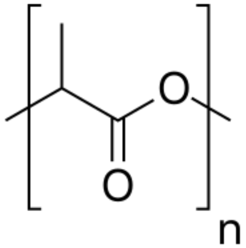
2. Recyclable materials

3. Compostable/edible packaging materials

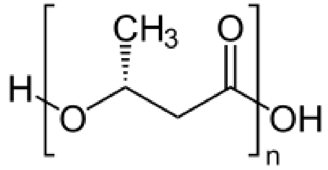
4. Reusable designs

1. Biodegradable materials

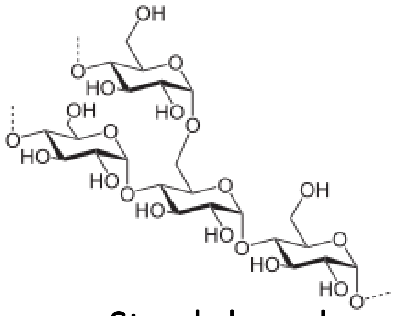
- Polylactic Acid (PLA)
- Polyhroxyalkanoates (PHA)
- Polybutylene succinate (PBS)
- Starch-based plastics
- Chitosan-based materials
- Polycaprolactone (PCL)
- Polyglygolic acid (PGA)



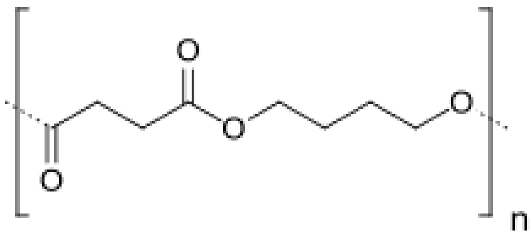
Polylactic Acid (PLA)



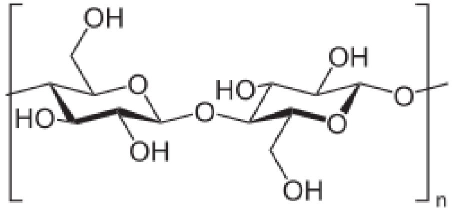
Polyhydroxyalkanoates (PHA)



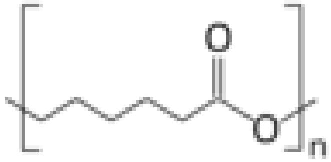
Starch-based plastics



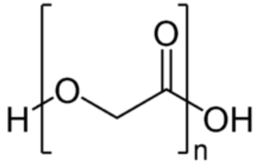
Polybutylene Succinate (PBS)



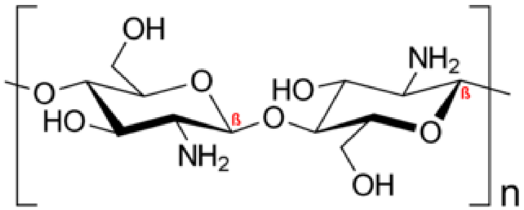
Cellulose-based Plastics (including bacterial cellulose)



Polycaprolactone (PCL)



Polyglycolic acid (PGA)



Chitosan-based materials

Blends and composites….

2. Recyclable materials

- Plastic packaging (PET, PE, PP, etc)
- Paper-based (kraft paper, wax-coared paper, cardboard, laminated paper)
- Bio-PE → from sugarcane ethanol (*not biodegradable*)
- Bio-PET → partially from sugarcane (*not biodegradable*)

Advanced recycling technologies

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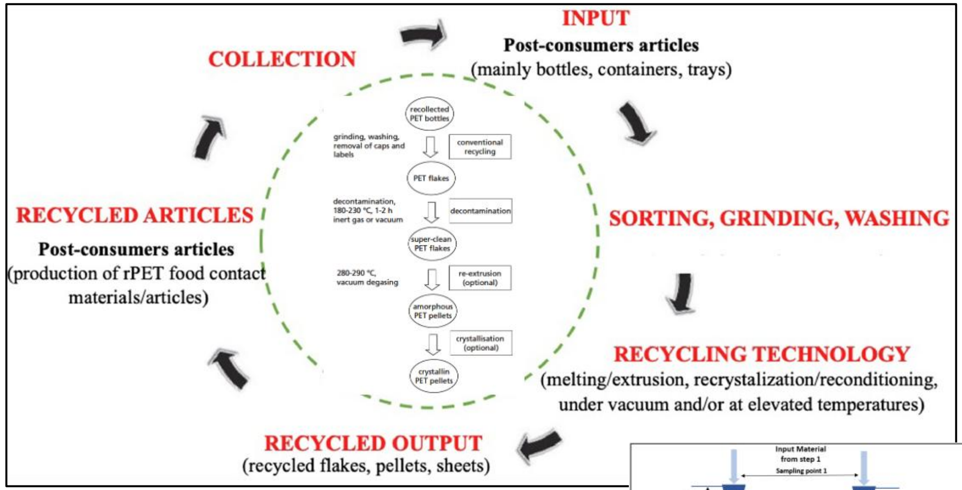
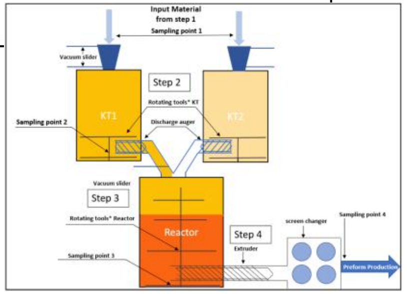
Advanced recycling technologies for FCM uses

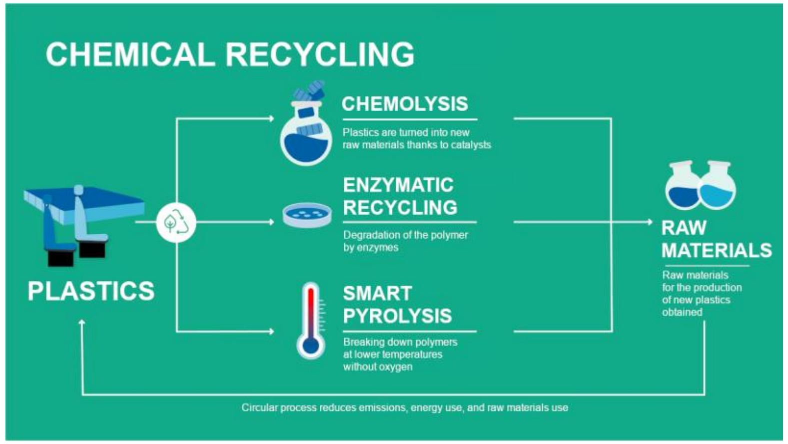
Mechanical Recycling (only PET)





- High energy consumption
- Recycled material MORE EXPENSIVE than virgin.
- It cannot cover all materials (e.g. HDPE excluded).
- Production of high number of micro-/nanoplastics.

Chemical Recycling



- High energy consumption
- Use of solvents.
- For EU is not Recycling but regeneration of monomers → ***PURITY*** shall be declared and risk assessed (NIAS).

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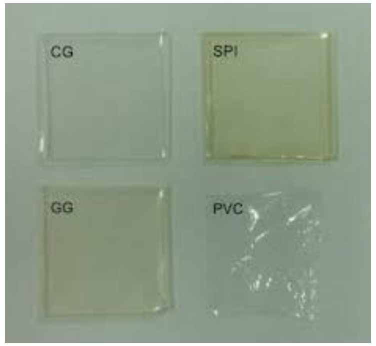
3. Compostable/edible materials

1. **Starch-Based Films** (from starch)
2. **Protein-Based Films** (from proteins like gelatin, casein from milk, whey, soy, or wheat gluten).
3. **Seaweed-Based Films:** Extracted from seaweed or algae.
4. **Polysaccharide-Based Films** (cellulose, chitosan, pectin, or pullulan → edible coatings for fruits, vegetables).
5. **Lipid-Based Films** (e.g. beeswax or carnauba wax).

(1)

(2)



(3)

(4)

(5)

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4. Reusable designs

- Glass Containers
- Stainless Steel Containers
- Silicons??? (Toxic silica oligomers)
- Plastic???
- A-B-A monomaterial polymers (Virgin-recycled/ decontaminated - virgin)

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3. Pros and cons

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1. Biodegradable materials

A. Pros

- **Environmental Benefits:** Breaks down into natural elements under industrial composting conditions.
- **Renewable Resources:** Made from plant-based feedstocks like corn, sugarcane, or potatoes.
- **Versatility:** Suitable for a wide range of applications, including containers, films, and utensils.

B. Cons

- **Limited Infrastructure:** Requires specific composting facilities; may not degrade in natural environments.
- **High Cost:** Generally, more expensive than conventional plastics.
- **Raw material/Resources:** May divert agricultural resources from food production.

Blends and composites….

2. Recyclable materials (bio-Pe, bio-PET; non-biodegradable)

A. Pros

- **Recyclability:** Easily recycled in most systems.
- **Compatibility:** Works with existing recycling systems.
- **Lower Carbon Footprint:** Production reduces reliance on fossil fuels.
- **Performance:** Comparable to traditional plastics in strength and flexibility.

B. Cons

- **Non-Biodegradable:** May still contribute to long-term waste if not recycled.
- **Resource Competition:** Relies on agricultural inputs like sugarcane or corn.
- **Cost:** Generally, more expensive than fossil-based plastics.

2. Recyclable materials (paper)

A. Pros

- **Recyclability:** Easily recycled in most systems.
- **Renewable:** Sourced from trees and agricultural byproducts.
- **Customizable:** Can be shaped, printed, or coated for various uses

B. Cons

- **Water Resistance:** Susceptible to moisture without additional coatings, which can hinder recyclability.
- **Energy-Intensive Production:** Pulp and paper manufacturing requires significant energy and water.
- **Durability Issues:** Less durable compared to plastic alternatives.

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3. Compostable/edible materials (waxed, cellulose-based)

A. Pros

- **Zero Waste:** Can be consumed with the food product.
- **Innovative Appeal:** Offers novelty and aligns with zero-waste principles.
- **Renewable Ingredients:** Uses food-grade and natural components.
- **Compostability/degradability:** Biodegradable in home and industrial composting systems.
- **Resource Efficiency:** Utilizes agricultural byproducts that would otherwise be waste.
- **Wide Applications:** Plates, bowls, and trays for food service industries.

B. Cons

- **Limited Durability:** Not suitable for high-moisture or high-pressure conditions.
- **Cost and Scalability:** More expensive and less available for large-scale applications.
- **Specialized Facilities Needed:** Composting requires controlled conditions.
- **Consumer Acceptance:** May face cultural or regulatory barriers.
- **Moisture Resistance:** Requires coatings to handle wet or oily foods, which may hinder compostability.
- **Cost:** Production can be more expensive compared to plastic alternatives.
- **Durability:** Less sturdy than plastic or metal counterparts.

4. Reusable designs

A. Pros

- **Durability:** Can be used multiple times, reducing overall waste (e/g/ a bottle of beer can be reused more than 60x times!)
- **Recyclability:** Materials like glass and metal are fully recyclable.
- **Consumer Preference:** Increasingly popular for environmentally conscious buyers.

B. Cons

- **Energy-Intensive Production:** Initial manufacturing has a high environmental impact.
- **Weight:** Heavier than single-use options, increasing transportation emissions.
- **Cost:** Higher upfront costs for consumers and businesses.

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4. Conclusions

1. Plastic alternatives in a circular economy are of great importance.
2. Sustainability will increase together with Plastic waste → recycling NOT enough.
3. Recycling technologies not covering all materials (only PET) → new technologies needed
4. Scaling up is needed (cost reduction) → raw materials??? Not sufficient at the moment
5. Low CO2 fingerprint processes are still at a premature phase.
6. High costs (compared to fossil-fuel).
7. End-users training and education (e.g. professionals, consumers).
8. Policies (Risk managers) are making progress….(slow).
9. A single solution approach is not enough.

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Contents

1. Introduction 1
2. CONTENT PART 1 1
3. CONTENT PART 2 2
4. CONTENT PART 3 2

1. Introduction

Question 1: What is the goal of the EU plastics strategy regarding plastic packaging?

- **A)** To increase the use of single-use plastics
- **B)** To make all plastic packaging placed on the EU market reusable or easily recyclable by 2030
- **C)** To reduce the use of biodegradable plastics
- **D)** To promote the use of fossil fuels

Correct answer: B) To make all plastic packaging placed on the EU market reusable or easily recyclable by 2030.

Question 2: What is the definition of a circular economy?

- **A)** An economic system aimed at increasing waste and the use of finite resources
- **B)** An economic system aimed at eliminating waste and the continual use of resources through principles like reuse, recycling, and regeneration
- **C)** An economic system focused on reducing the use of plastics
- **D)** An economic system focused on increasing the use of fossil fuels

Correct answer: B) An economic system aimed at eliminating waste and the continual use of resources through principles like reuse, recycling, and regeneration.

Question 3: What is the main difference between IAS (Intentionally Added Substances) and NIAS (Non-Intentionally Added Substances) in the context of food contact materials?

- **A)** IAS are regulated, while NIAS are not
- **B)** IAS are not regulated, while NIAS are
- **C)** IAS are biodegradable, while NIAS are not
- **D)** IAS are used in food packaging, while NIAS are not

Correct answer: A) IAS are regulated, while NIAS are not

2. CONTENT PART 1

Question 1. What is meant "Sustainable-by-design"

A) A system that is sustainable only after its useful life is over.
B) A framework ensuring safe products for human and the envirnoment.
C) A system that is made from recycled materials.
D) A system that is energy-efficient only.
Correct answer: B)

Question 2: According to eco-design key principles, which of the following is an example of the principle of "Longevity"?
A) Using recycled materials in product manufacturing.
B) Designing a product with durability, reusability and potential to be repaired.
C) Minimizing energy consumption during the product's operation.
D) Eliminating hazardous substances from the product's design.
Correct answer: B) Designing a product with interchangeable parts to facilitate repair and reuse.

3. CONTENT PART 2

Question 1: What is migration in the context of food packaging, according to the document?
A) The transfer of food from packaging to the environment.
B) The transfer of substances (chemicals) from packaging to food or vice versa.
C) The breakdown of packaging materials over time.
D) The recycling of packaging materials.
Correct answer: B) The transfer of substances (chemicals) from packaging to food or vice versa.

Question 2: What is the purpose of setting specific migration limits (SMLs) in food packaging regulations?
A) To establish a minimum amount of chemicals that must be present in food packaging.
B) To set a maximum permitted amount of a particular substance that can migrate from food packaging to food.
C) To determine the type of materials that can be used in food packaging.
D) To establish a standard for packaging design.
Correct answer: B) To set a maximum permitted amount of a particular substance that can migrate from food packaging to food.

Question 3: What is the purpose of the EU's Framework Regulation (EC) 1935/2004 on materials and articles intended to come into contact with food?
A) To regulate the use of recycled plastic materials in food packaging.
B) To establish guidelines for good manufacturing practice in the food industry.
C) To provide a framework for the safety assessment of food packaging materials.
D) To prohibit the use of certain chemicals in food packaging.
Correct answer: C) To provide a framework for the safety assessment of food packaging materials.

4. CONTENT PART 3

Question 1 What are the four categories of eco-designed food packaging materials mentioned in the document?
A) Biodegradable, recyclable, compostable, and reusable
B) Biodegradable, recyclable, compostable, and edible
C) Biodegradable, recyclable, compostable, and bioplastic
D) Biodegradable, recyclable, compostable, and non-biodegradable
Correct answer: A) Biodegradable, recyclable, compostable, and reusable

Question 2 What is one of the cons of biodegradable materials mentioned in the document?
A) High cost
B) Limited infrastructure
C) Non-renewable resources
D) All of the above
Correct answer: D) All of the above (High cost, Limited infrastructure, and Raw material/Resources: May divert agricultural resources from food production)

Question 3: What is one of the pros of recyclable materials (paper) mentioned in the document?
A) Water resistance
B) Energy-intensive production
C) Customizable
D) Durability issues
Correct answer: C) Customizable

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