Nestlé Good food, Good life

PET Monomer Recycling
A Brand Owner Perspective

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PET Monomer Recycling: A Brand Owner Perspective

Nestlé's Vision for Sustainable Packaging

Recycling: a key enabler for PET Packaging Circularity

PET: A Polymer Designed for Recycling

Comparison between Mechanical and Monomer Recycling for PET

Conclusions

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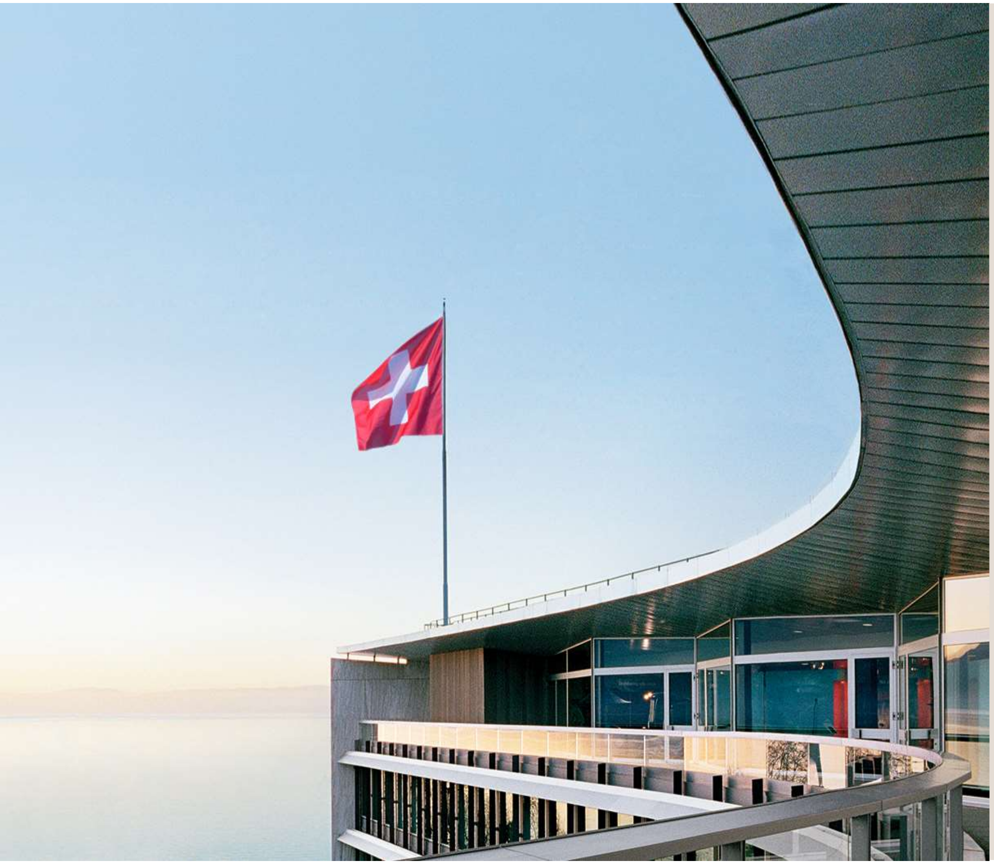
Nestlé's Vision for Packaging Sustainability



Our long-term vision

- None of our packaging ends up in landfill or as litter

Our commitments for 2025

- 100% of our packaging will be recyclable or reusable
- We will reduce our use of virgin plastics by 33%

Our packaging sustainability journey

April 2018
- Launched **global commitment on recycling and reusable packaging** for 2025

September 2019
- Inaugurated **Nestlé Institute of Packaging Sciences**

January 2020
- Pledged **1.5b CHF toward food-grade recycled plastics**
- Committed to **reduce virgin plastic** use by 1/3 by 2025

December 2020
- Published **Net Zero Emissions roadmap**

Our need: Fit-for-purpose food-grade packaging

Delivering safe and nutritious food

Safety & quality

Pre-portion

Avoid food waste

Information

Adapting to product and geography

Product sensitivity

Climate

Route-to-market

Legislation

Our sustainable packaging 5 pillar strategy

Packaging Reduction / Elimination

Reusable / Refillable Packaging Systems

Materials innovation for recycling and composting

Recycling and waste management infrastructure

Rethinking behaviors of Nestlé, retail partners and consumers

Remove & Reduce, Reuse, Recycle
& Rethink the system

Nestlé Institute of Packaging Science

- **50 scientists** conducting cutting edge research for **safety and performance** of new materials
- Refillables, redesigning multi-material to mono-material, high-performance paper barriers and recycled content
- Part of a larger ecosystem of Nestlé **global R&D network**

Technology: Building a vibrant ecosystem for packaging innovation

Start-ups and entrepreneurs

The Accelerator
Powered by Nestlé R+D

Material suppliers and converters

danimer scientific llc

NATURALL BOTTLE ALLIANCE

SWISS FOOD & NUTRITION VALLEY

Universities and research institutes

FUTURE FOOD
A SWISS RESEARCH INITIATIVE

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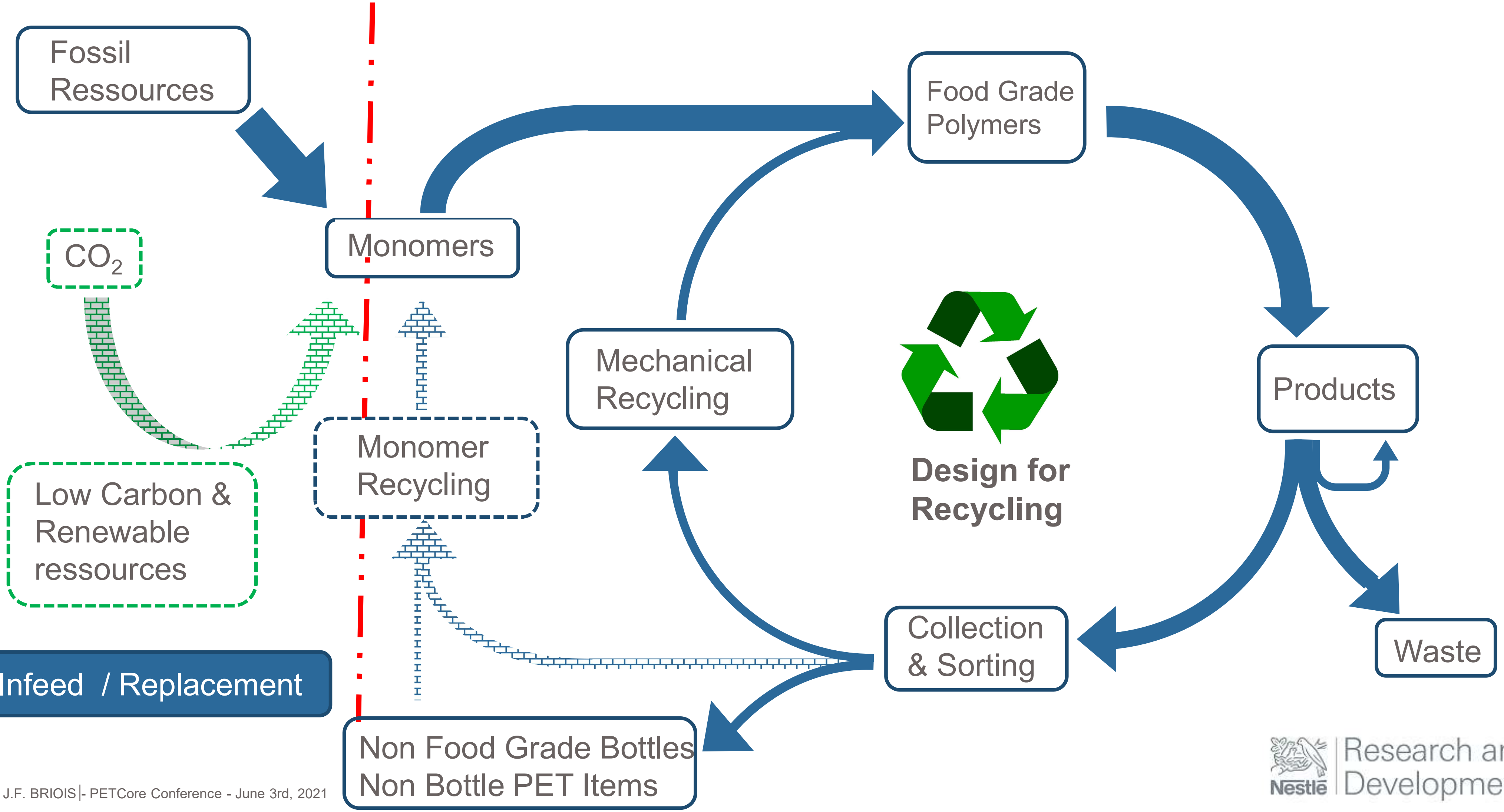
Recycling is a key enabler of the circularity of PET packaging



Nestlé Research and Development

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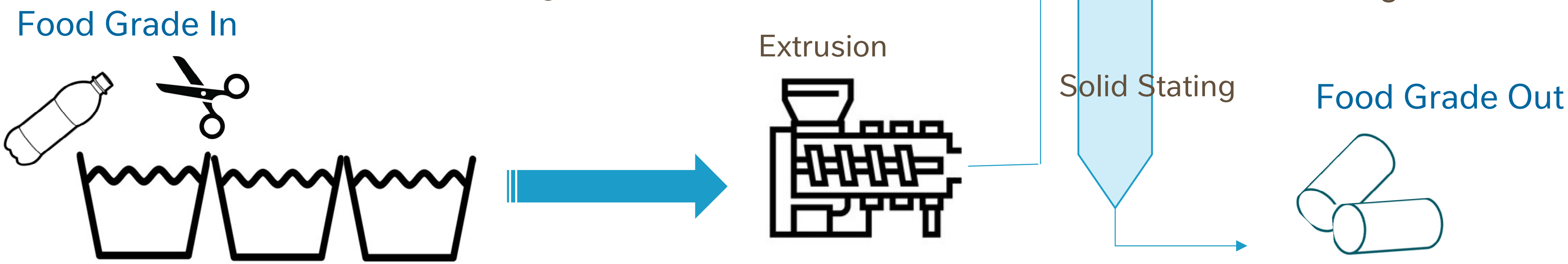
PET: A Polymer Designed for Recycling !

PET is a thermoplastic polymer which requires little additives to serve many functions:

- ➢ It is available at scale and can be recycled mechanically
- ➢ It must be sorted from other materials, washed, ground and then extruded & « devolatilized »

<u>Feedstock Preparation</u>:
- Sorting
- Washing
- Grinding

<u>Recyclate production</u>:
- Extrusion
- Decontamination
- Pelletizing



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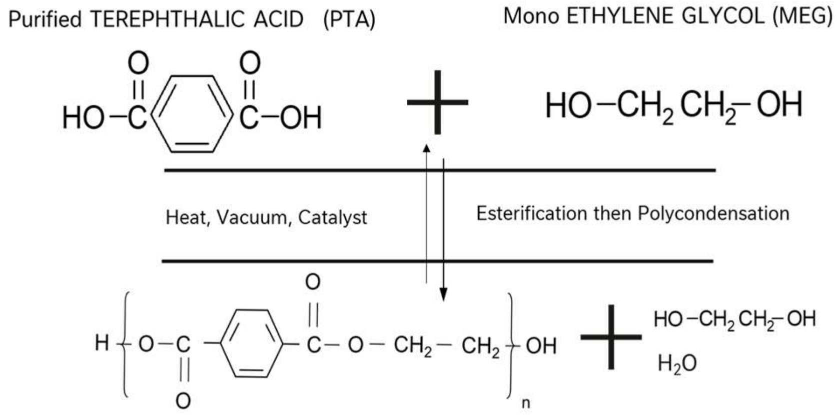
PET: A Polymer Designed for Recycling !

PET is derived from a reversible polycondensation reaction

- It can be depolymerised to intermediates and monomers, then purified, then repolymerised again to a virgin like Polymer
- Unlike polyolefins, the output of PET Monomer Recycling can only be used for making PET not energy….



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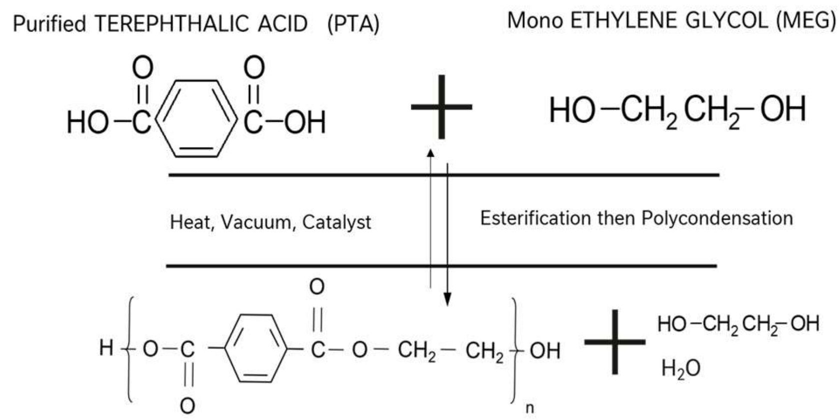
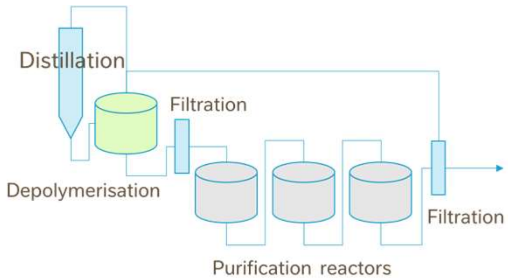


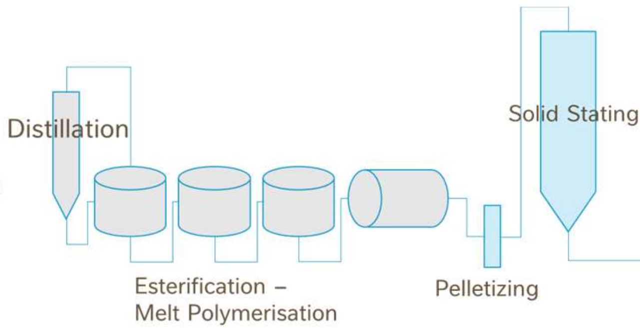
Mixed Quality Grades In

Feedstock Preparation:

- Sorting
- Washing
- Grinding



Depolymerisation & Monomer Purification



Food Grade Out

Polymerisation & Polymer purification

PET: A Polymer Designed for Recycling !

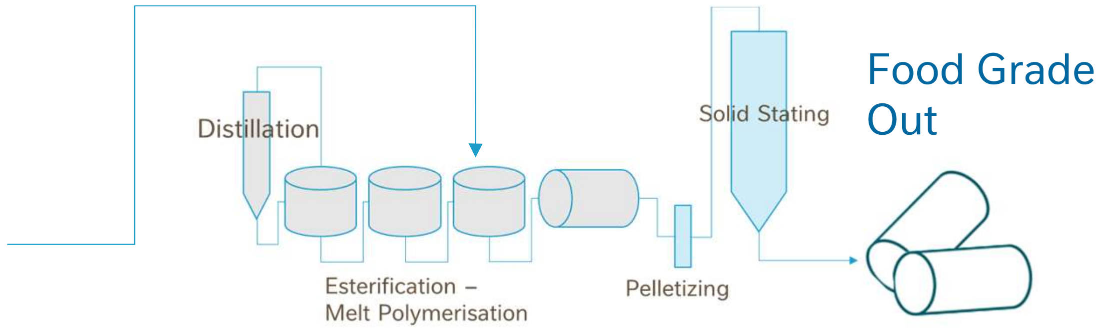
Partial depolymerisation without intermediate purification step is also possible with PET:
Semi chemical-recycling

Feedstock Preparation:
- Sorting
- Washing
- Grinding

Partial depolymeraisation:
- Extrusion
- Injection into melt polymerisation unit

Melt Polymerisation & Polymer purification

Food Grade In



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Comparison between Mechanical & Monomer Recycling

Attributes	Mechanical Recycling	Monomer Recycling	
Process Simplicity & Robustness			Process Principle
Energy & LCA Efficiency (GHG)			
Feedstock Versatility (Color, D4R)			Quality of Recyclate
Ability to produce Food Grade Resin with non Food Grade Feedstock			
Multi loop recycling			
Ecology & Economy of scale			Costs
CAPEX per metric ton			
OPEX per metric ton			
Feedstock Collection (& Availability)			Externalities
Regulation			

Comparison between Mechanical & Monomer Recycling

Attributes	Mechanical Recycling	Monomer Recycling	
Process Simplicity & Robustness	+ + + + +	+ ?	Process Principle
Energy & LCA Efficiency (GHG)	+ + + + +	+ +	
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Feedstock Versatility (Color, D4R)	+ +	+ + + + +	Quality of Recyclate
Ability to produce Food Grade Resin with non Food Grade Feedstock	+	+ + + + +	
Multi loop recycling	+ + +	+ + + + +	
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Feedstock Collection (& Availability)	+ + +	+	Externalities
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PET Mechanical and Monomer Recycling are complementary

Attributes	Mechanical Recycling	Monomer Recycling	
Process Simplicity & Robustness	+ + + + +	+ ?	Process Principle
Energy & LCA Efficiency (GHG)	+ + + + +	+ +	
Feedstock Versatility (Color, D4R)	+ +	+ + + + +	Quality of Recyclate
Ability to produce Food Grade Resin with non Food Grade Feedstock	+	+ + + + +	
Multi loop recycling	+ + +	+ + + + +	
Ecology & Economy of scale	+ + + + +	+ + ?	Costs
CAPEX per metric ton	+ + + +	− ?	
OPEX per metric ton	+ + + +	+ ?	
Feedstock Collection (& Availability)	+ + +	+	Externalities
Regulation	+ + +	?	

- Mechanical recycling:
  - Is the most environmentally and economically efficient Recycling Process

But

- Has limits
  (Feedstock purity, Polymer degradation after multiple cycles…..)

- Monomer recycling
  - Can turn current PET wastes into new resources
  - Allow better purification and limit degradation reactions:
    - It can turn non food grade items into food grade
    - It maintains PET bottle feedstock quality

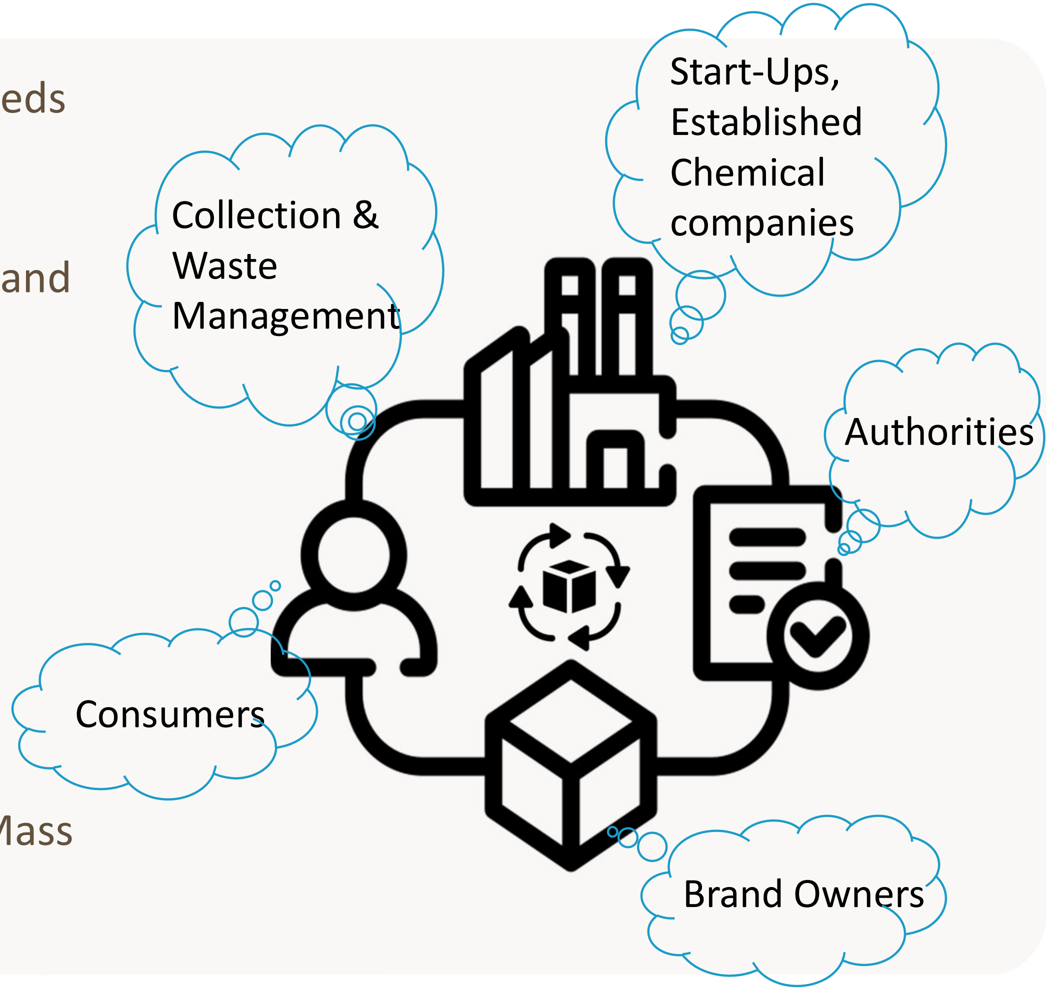
But

- Must be environmentally relevant vs Incineration with energy recovery
- Must be cost competitive with virgin material
- Is technologically more complex to develop and industrialize
- Lacks a clear and relevant regulatory framework

PET Monomer Recycling needs to be supported

- Collection of non mechanically recycled PET items needs to be structured and developed

- Monomer Recycling is more technologically complex and is mostly developed by start-ups. Today Monomer Recycling needs
  - Support at R&D stage
    - To qualify as many feedstocks as possible
    - To define relevant quality specifications
  - Support during scale-up:
    - To guide and fund industrial scale-up
    - To avoid unnecessary production costs through Mass Balance



Role of Mass Balance: « Unit In ➡ Unit Out »

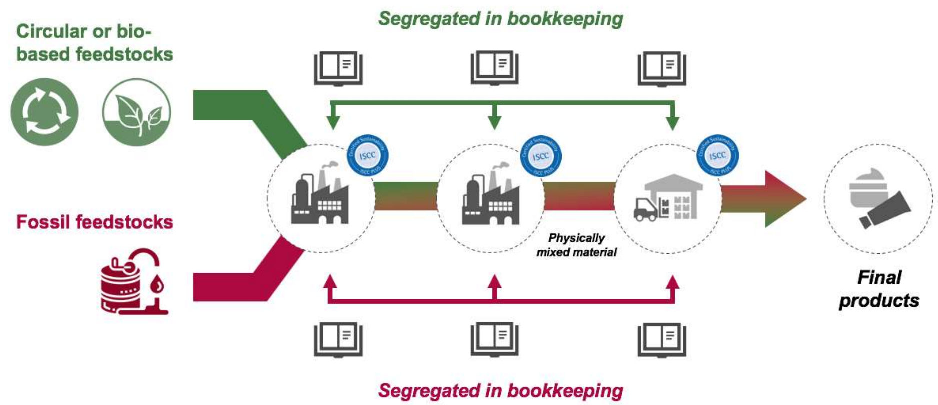
Accounting for material entering and leaving a system, mass flows which might have been unknown can be identified

Mass balance can accelerate the delivery of environmental benefits coming from monomer recycling

1) We expect Mass Balance to reduce :
   - CAPEX: No need for dedicated units likewise to « renewable » electricity
   - OPEX: no campaign production mode

2) Mass Balance needs aligned rules on claims (ISO 22095 project by ISO/PC 308)

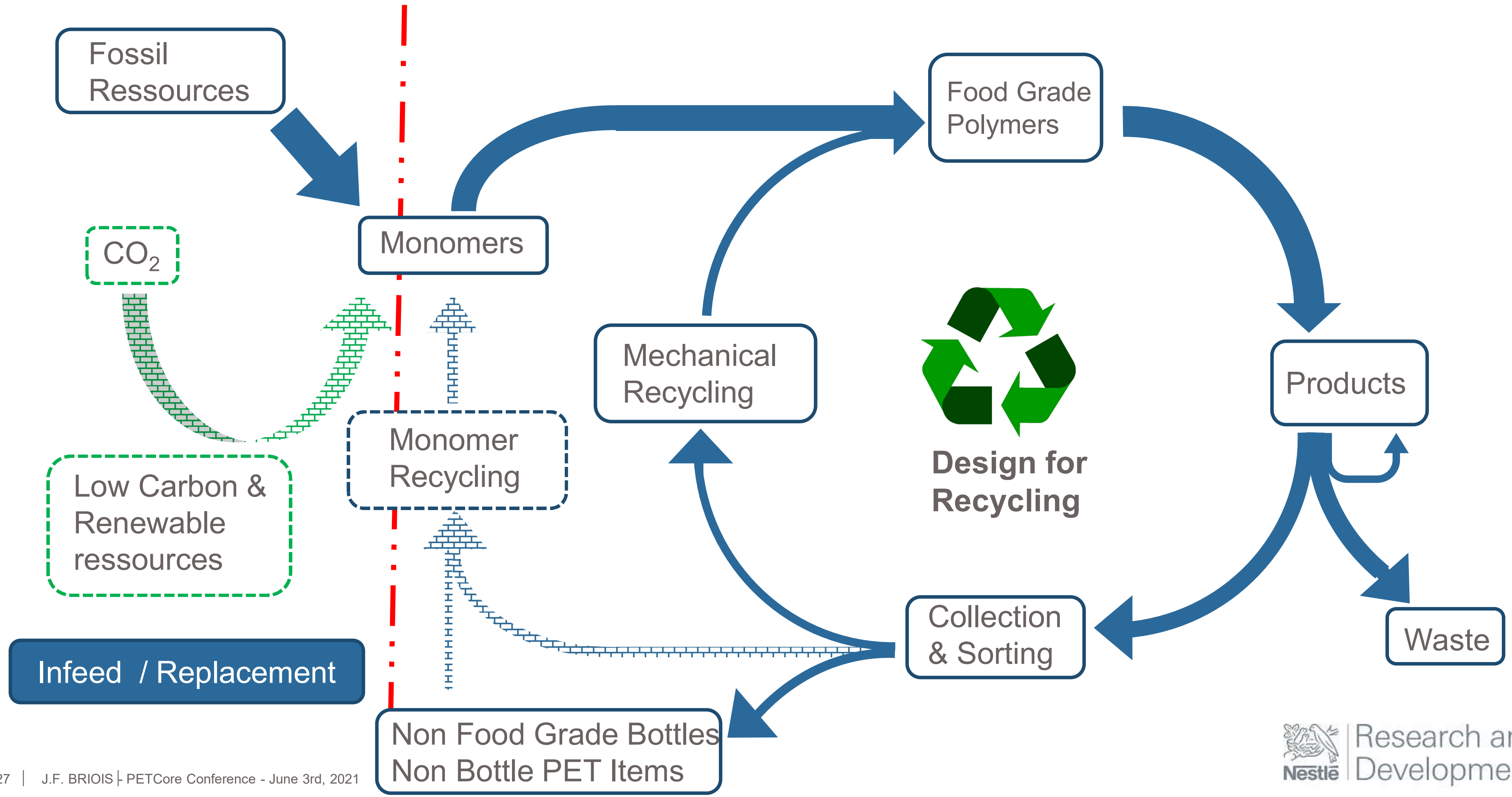
3) Mass Balance needs to be understood and valued by all stakeholders



https://www.iscc-system.org/

Research and Development

PET packaging has the potential to become truly circular: 2021-2025



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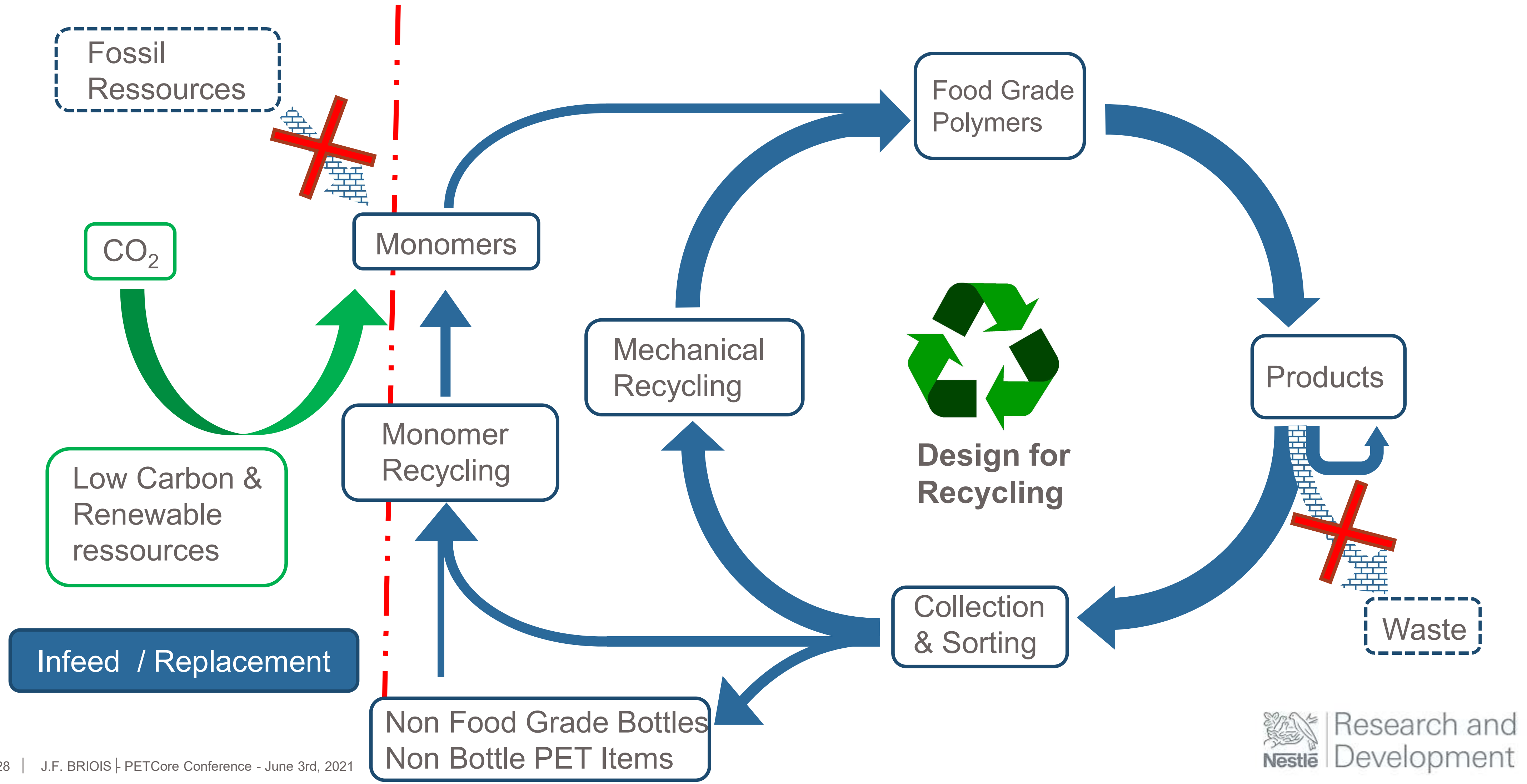
PET packaging has the potential to become truly circular: 2030+



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