Modelling sustainable futures for materials

Towards fossil-free packaging by 2050

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TNO, Circularity & Sustainability Impact
10 December 2024

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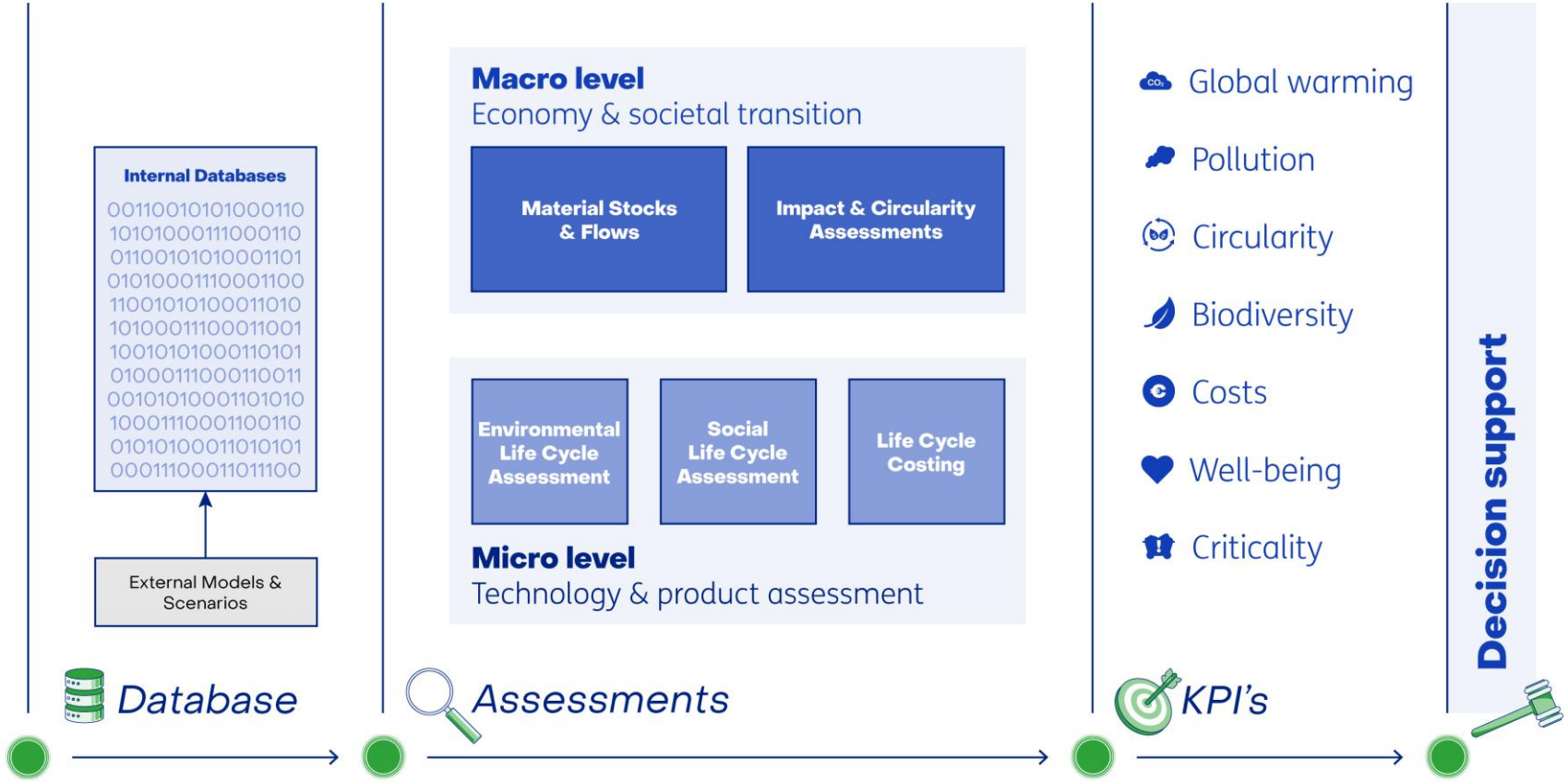
TNO – Circularity & Sustainability Impact (CSI)

Towards prospective & integrated circularity & sustainability impact assessments



The CITS model

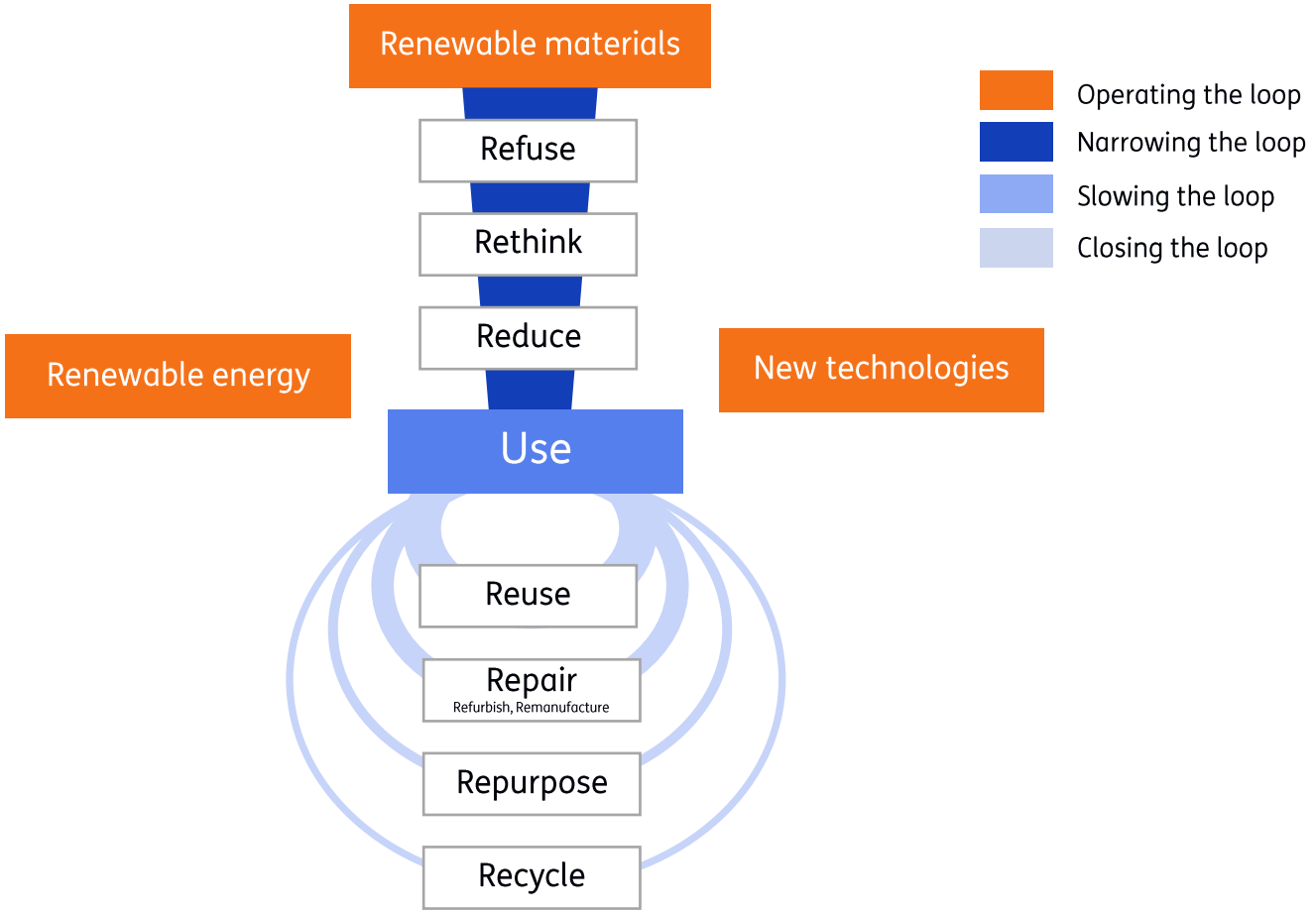
Circular

Industrial

Transformation

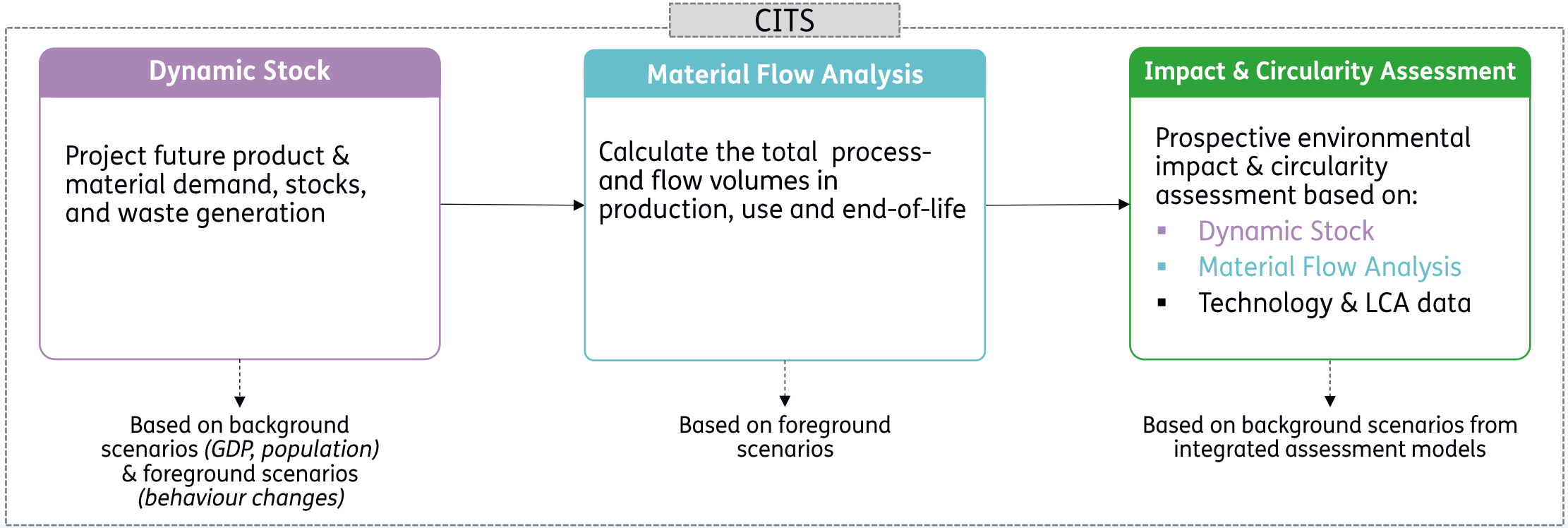
System

Explores the role of materials in the transition towards a circular, carbon neutral and resilient economy, to make informed decisions on strategies and policy measures.



CITS model structure

Dynamic Stock & Material Flow analysis with prospective LCA impact assessment



Background scenarios: Changes external to analyzed sector / product system (GDP, population, energy system, CO_2 price)

Foreground scenarios: Changes within the sector, e.g., longer product use, new technologies, more waste separation)

Scope & resolution

Geographical	27 EU countries
Temporal	2020-2050
Sectoral	Resolution: Sectors, product groups, products (e.g., Packaging, food packaging, PET bottles)
Resources & materials	7 polymers; 4 metals; more in planning (e.g., cement, glass, chemicals)
Life cycle	Whole value chain: Extraction, Production, Use, End-of-life
Technological	Production technologies of all included materials and products; waste collection, sorting & recycling technologies (from PRISM)
Impact categories	18 categories (ReCiPe 2016 methodology) + circularity indicators

Circularity and greenhouse gas assessment of the plastic packaging and beverage carton system in the Netherlands until 2050

Commissioned by PBL, coordinated by RIVM, in cooperation with Rijkswaterstaat and Utrecht University

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Goal

Quantification of

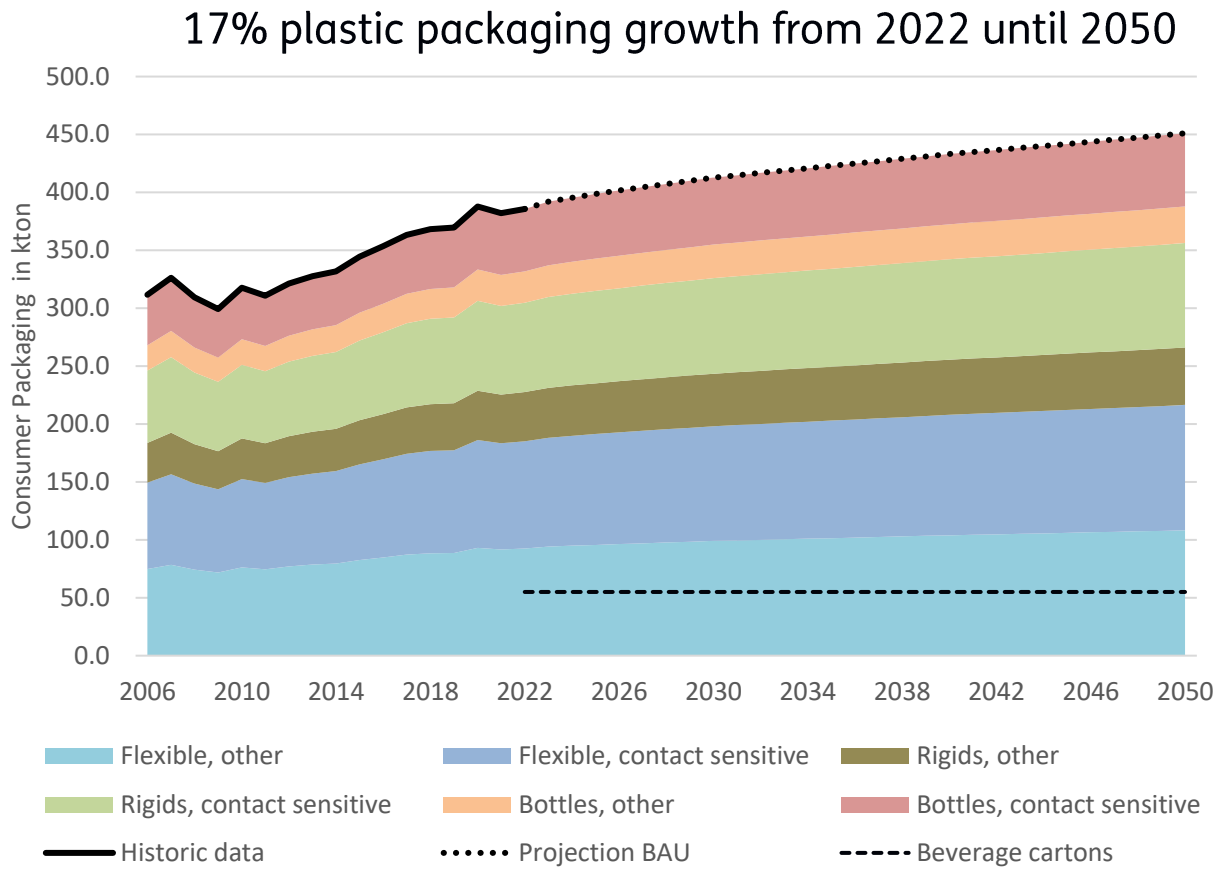
- the circularity (= avoided primary material)
- and the Greenhouse gas emissions

of the consumer packaging system in the Netherlands, for a

- business as usual (BAU) scenario,
- and a circular scenario

until 2050.

(Plastic) packaging growth in the Netherlands



Scenarios

- **BAU:** continuation of historic packaging consumption patterns, current waste management system
- **Circular scenario:** optimistic, but technically feasible circular scenario for plastic packaging and beverage cartons.
  - Based on expert workshop
  - For each packaging category, structured in 4 strategies

Assessed scenarios

BAU business as usual - Continuation of our consumption patterns & waste management.

Circular scenario Combination of all circular strategies.

Assessed circular strategies

Refuse and reduce
Refuse e.g.' eliminate packaging that does not fulfil any customer needs but only marketing purposes. Reduce: using less packaging per product, e.g., reducing empty space in packaging.

Material substitution Using a different material, e.g., to reduce packaging weight or increase recyclability.

Reuse e.g., refilling of bottles.

High-quality recycling Improved collection, sorting, & recycling of waste, incl. chemical recycling technologies.

Primary material use & GHG-emissions for plastic packaging & beverage cartons in the Netherlands

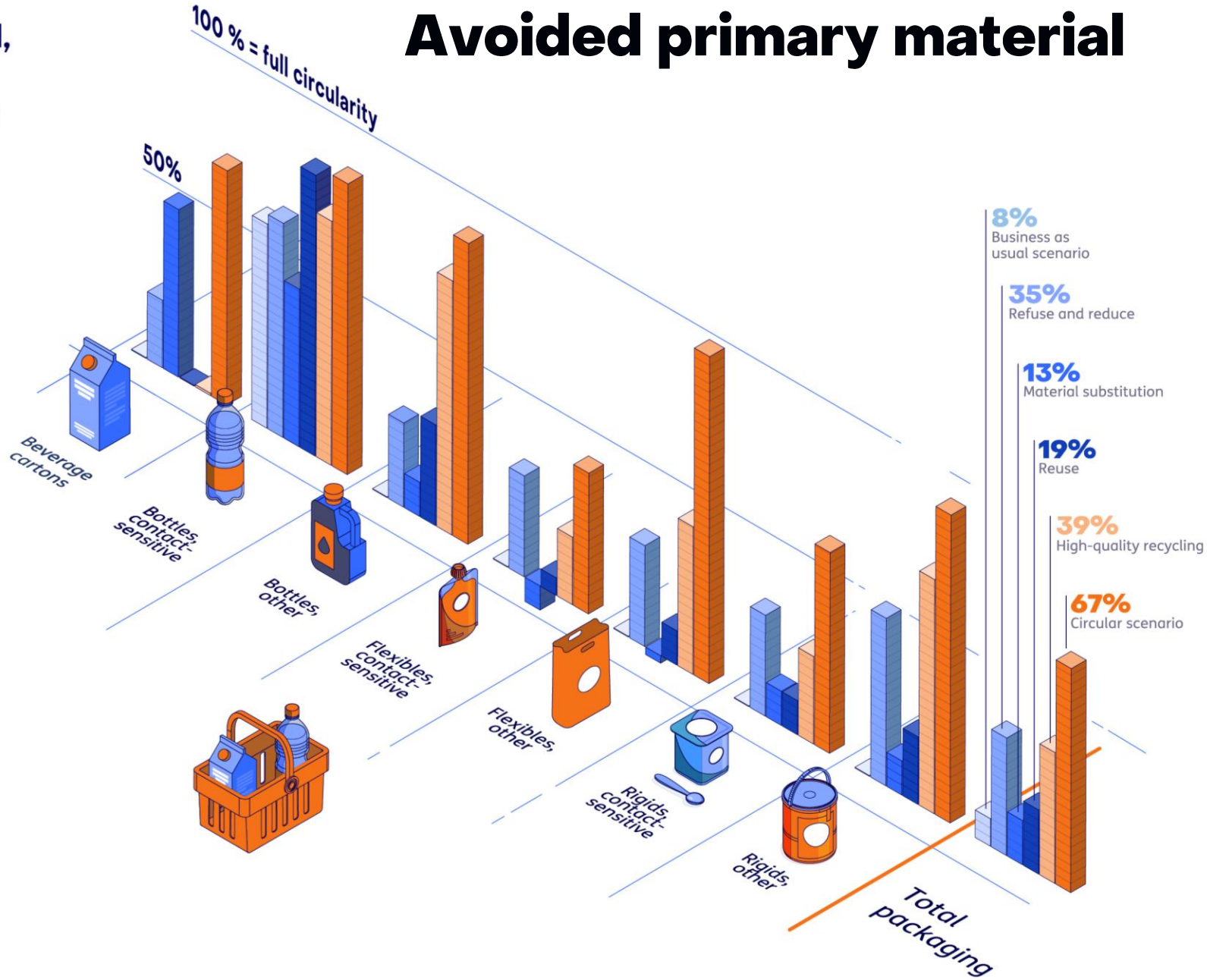
Circular strategies can substantially reduce the impact of consumer packaging

Avoided primary material

All strategies are needed, to come close to the circularity goals by 2050

% Avoided primary material per scenario and packaging type

- Business as usual scenario
- Refuse and reduce
- Material substitution
- Reuse
- High-quality recycling
- Circular scenario



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Conclusions

- Even in the circular scenario, a substantial demand for primary plastics remains → alternative resources such as biomass needed

- Integrated macro-level models such as CITS help us understand
  - The total, long-term impacts of our material consumption on the level of whole economies or industry sectors
  - The effect of external drivers on the respective sectors or product groups (e.g., energy system, CO_2 price, GDP)
  - The potential effects of policies or behavioural changes, especially with regards to circular economy
  - → can guide politics or industries in long-term transitions

Outlook: The future of CITS

Short-term (6-12 months)

- Extension to all European member states
- For all plastic sectors

Medium-term (1-3 years)

- Covering more materials (all metals, critical raw materials, cement, glass,...)
- Improved links with other types of models
- Addition of alternative production technologies (e.g., carbon capture & utilization, bio-based alternatives)

Further reading

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TNO's circular scenario models

Stegmann et al 2024: Circularity and greenhouse gas assessment of the plastic packaging and beverage carton system in the Netherlands until 2050

Schwarz et al 2024: The Circular Industrial Transformation System (CITS) model - Assessing the life cycle impacts of climate and circularity strategies