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94th LCA Discussion Forum

Insights and Learnings from Comparative LCAs on Side Streams in Switzerland

Image source: www.pexels.com (cottonbro studio)

Background

Context

- Swiss action plan against food waste: return side-streams to food cycle + reduce environmental impact

The gap we addressed

- From an environmental perspective, what are the best valorisation or utilization routes for different side streams?
- Comparative LCA commissioned by FOEN

Definitions

- **Valorisation:** processing of side-stream into food for human consumption
- **Utilisation:** processing of side-stream into products not intended for human consumption (energy, feed…)

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Content

1. How we built a comparable frame for assessing 15 side streams
2. What the results show
3. Three learnings for side-stream LCAs

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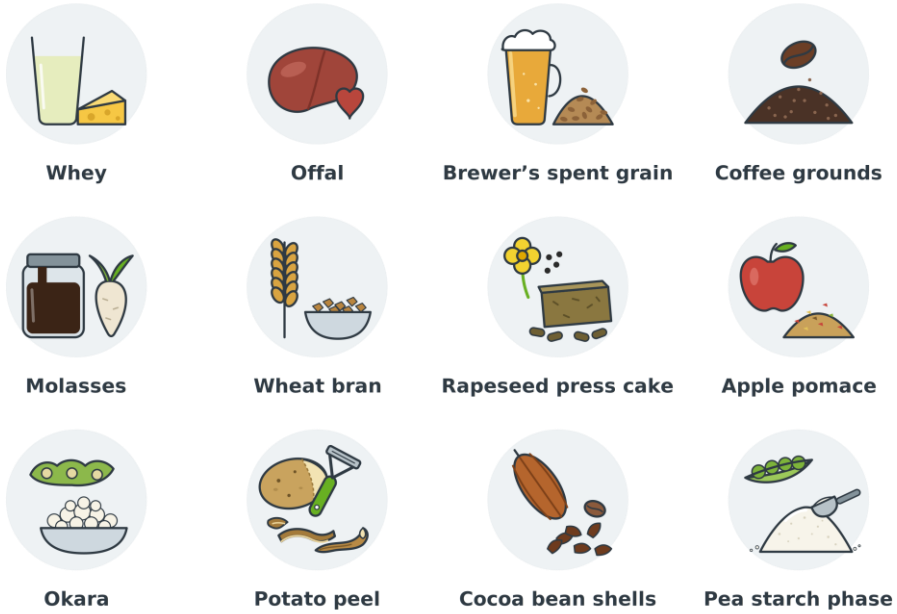
The study at a glance

Scope

- **15 side streams**
- **6 to 9 routes per side stream**: incineration, anaerobic digestion, composting and feeding as standard routes + stream-specific utilisations and valorisations



Method

- Attributional LCA for each route: ISO 14040/44, FOEN data quality guidelines, externally reviewed by ZHAW
- Ecological scarcity method and GWP100
- New inventories integrated into the FOEN LCA database

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How we built a comparable frame



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Functional unit and system boundaries

Functional unit = Valorisation or utilisation of 1 kg side stream (wet mass)

- Input-based: All routes start with 1 kilogram → they deliver different products in different quantities

Comparing routes that deliver different products

- System expansion: to avoid allocation
- Product basket: All routes of one side stream must deliver the same set of functions

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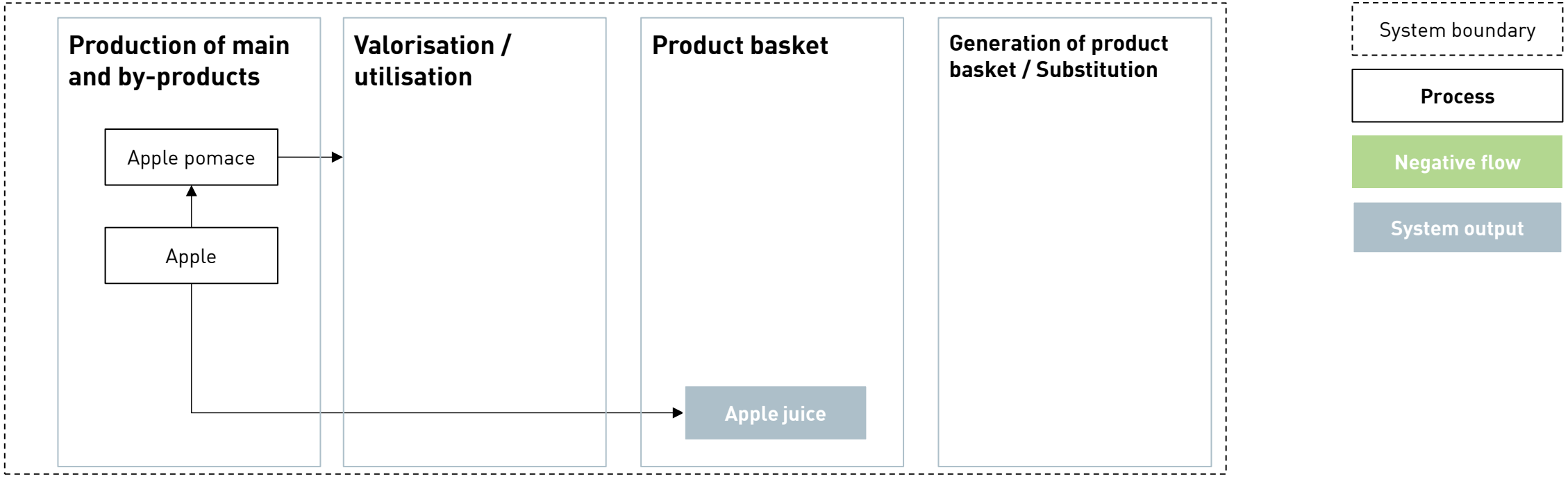
System boundaries: apple pomace example



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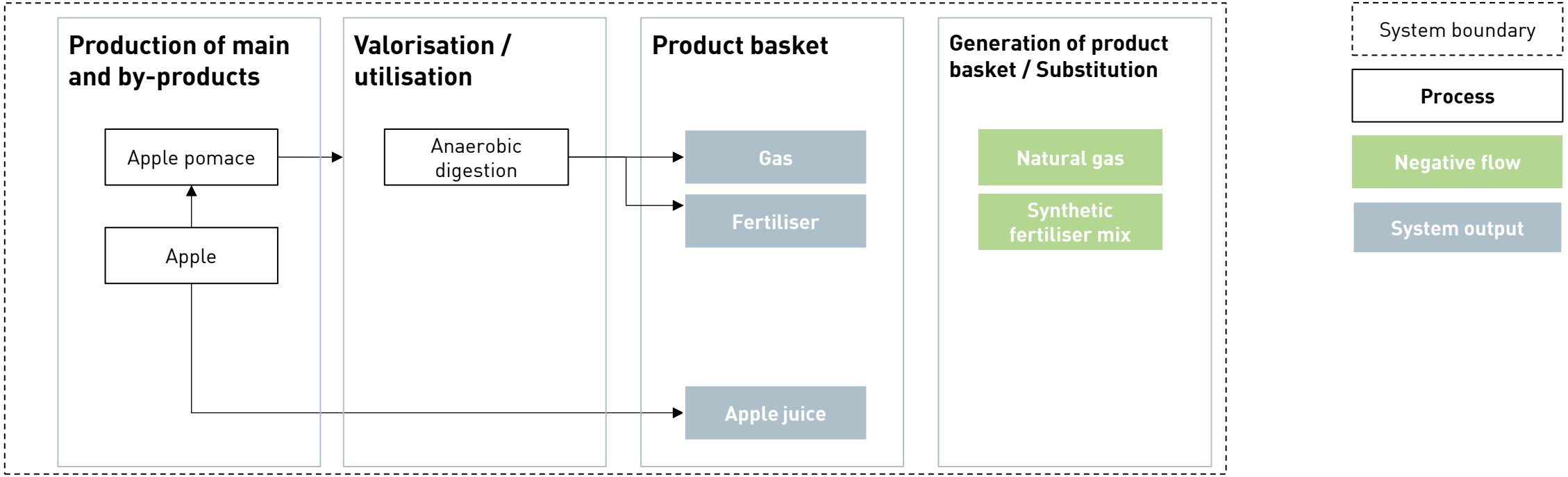

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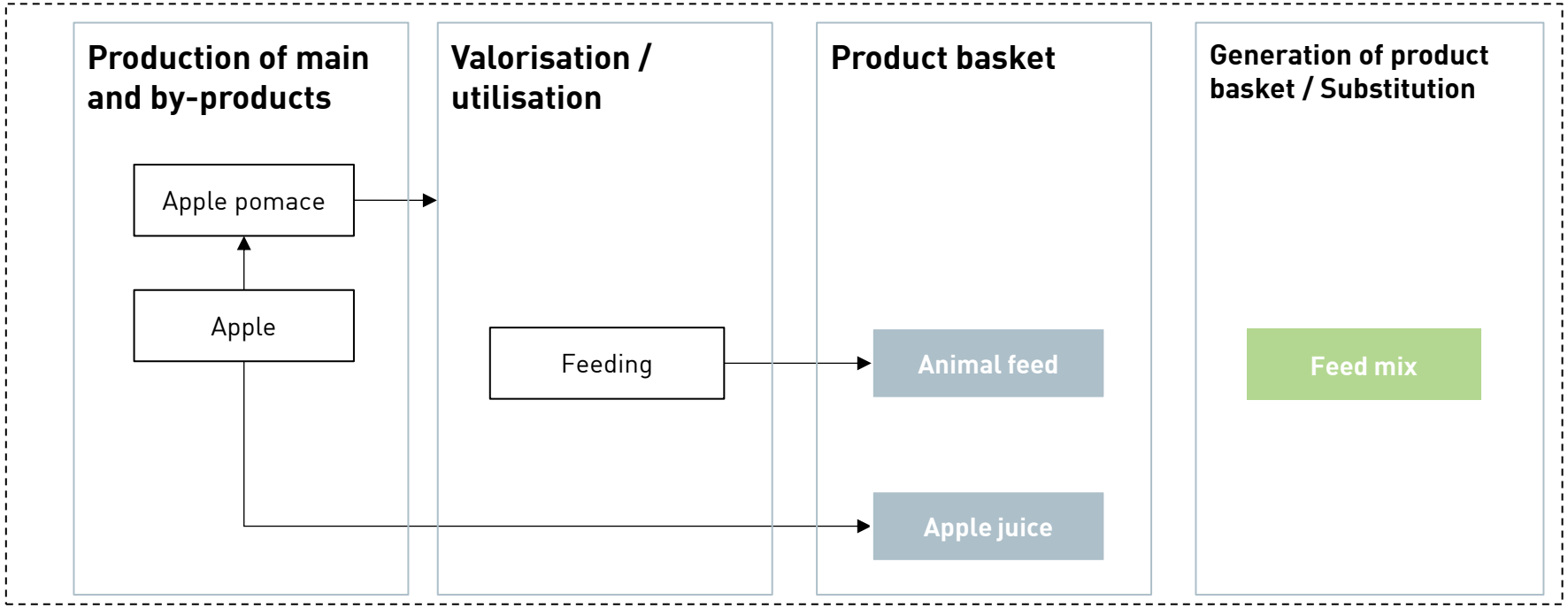

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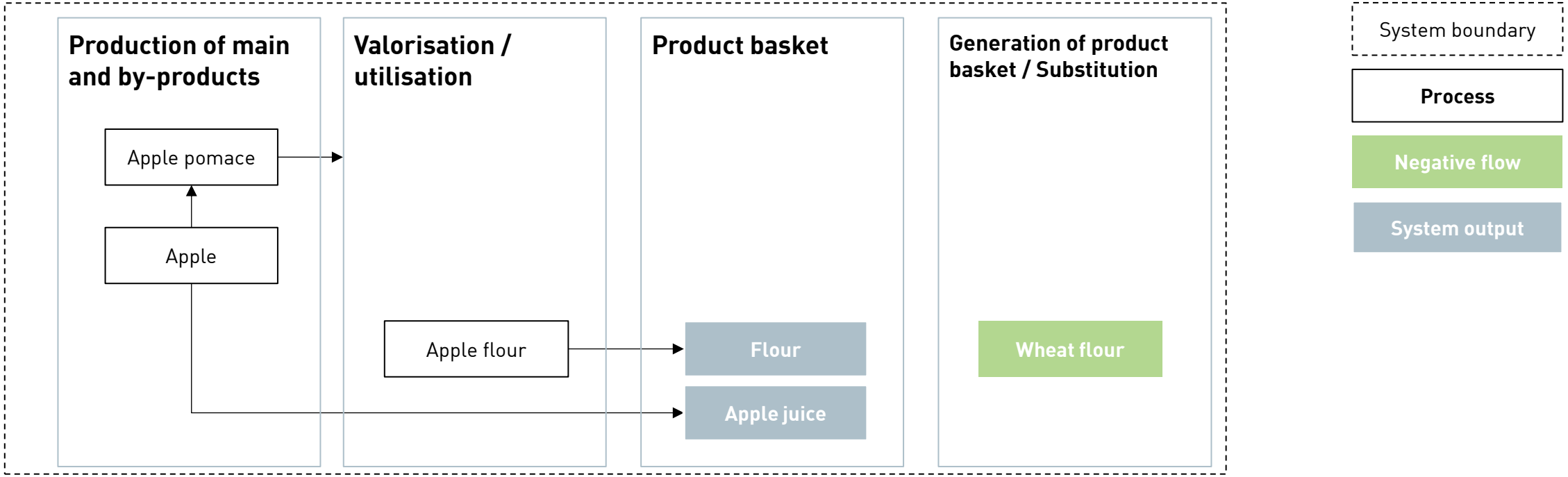

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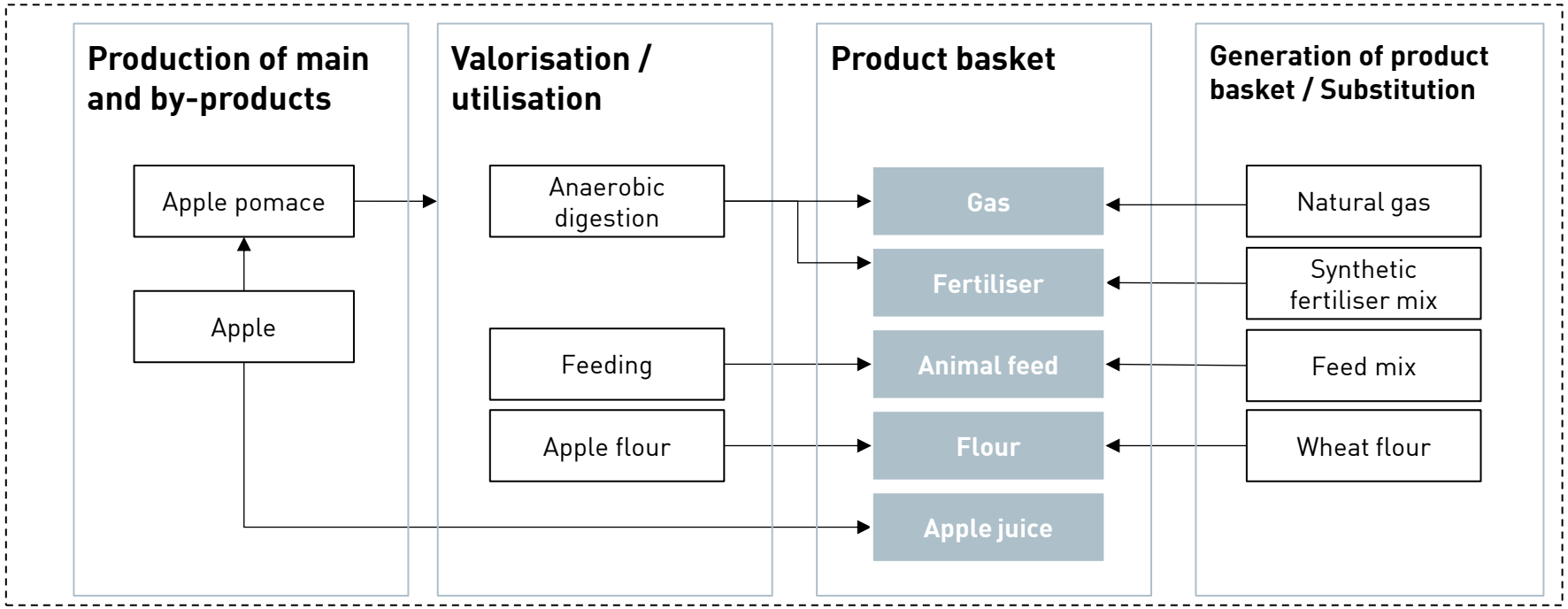

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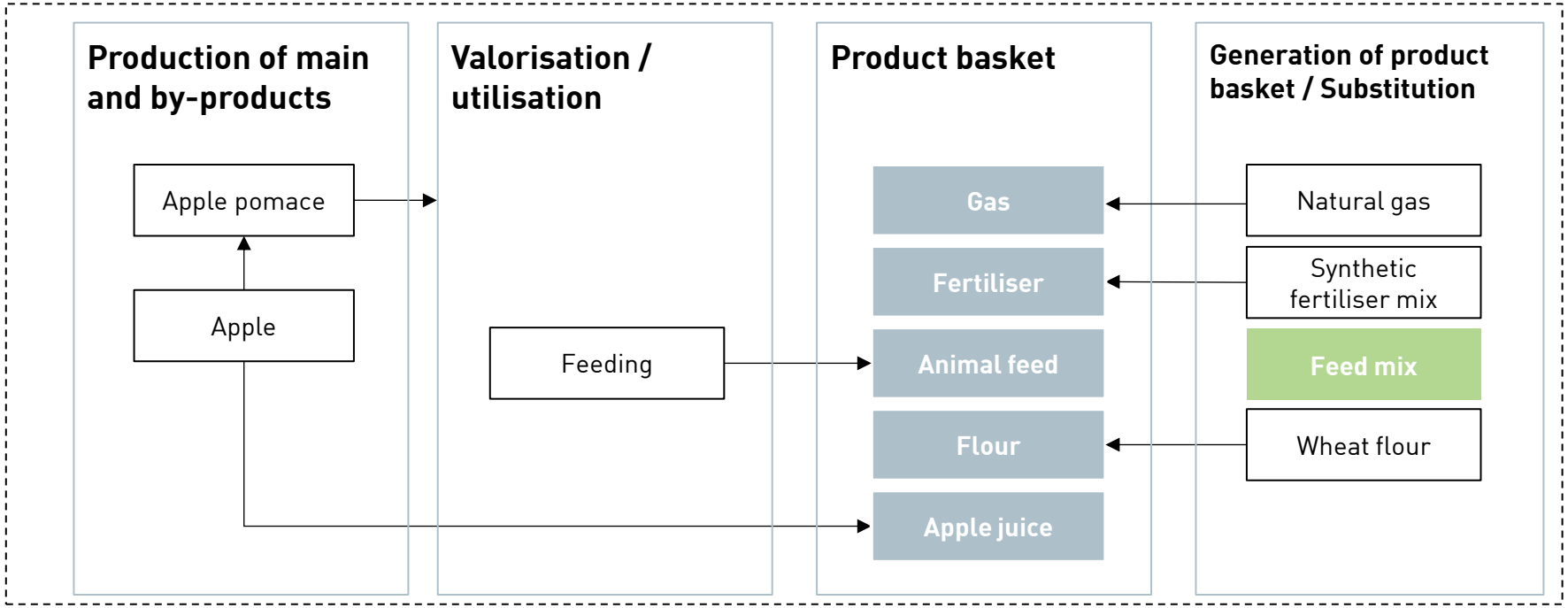

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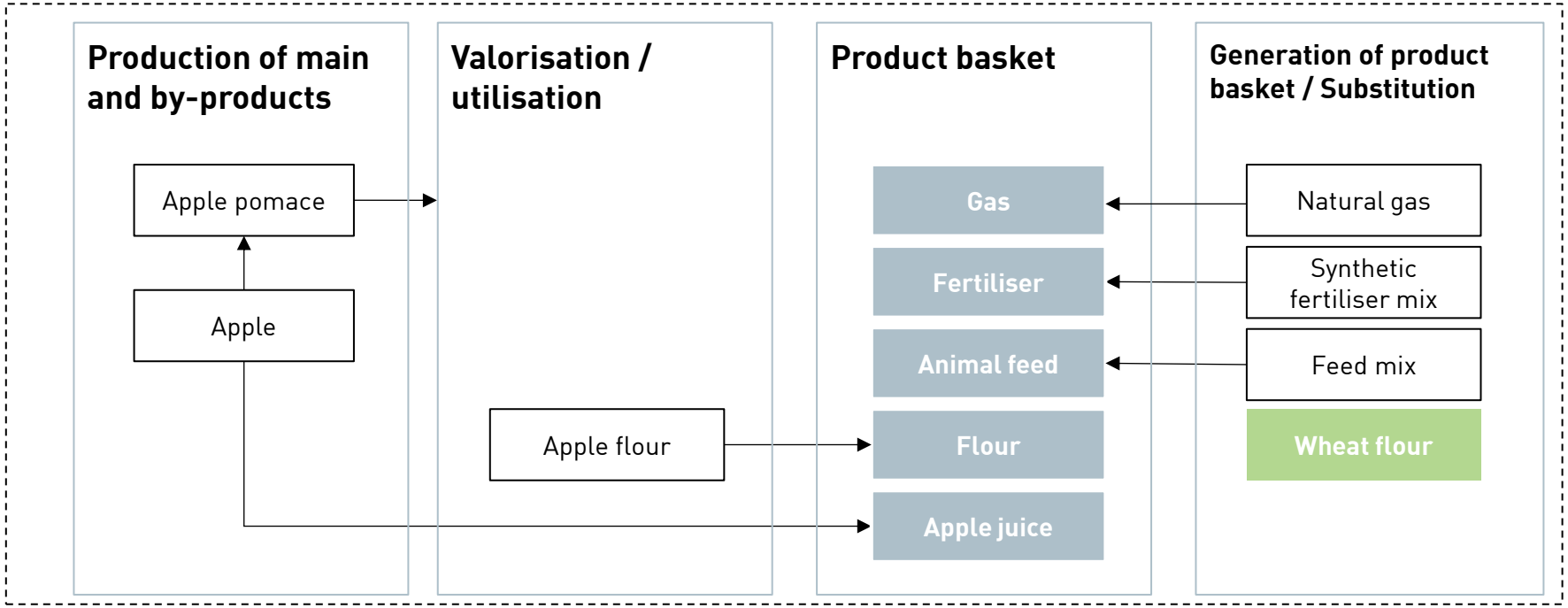

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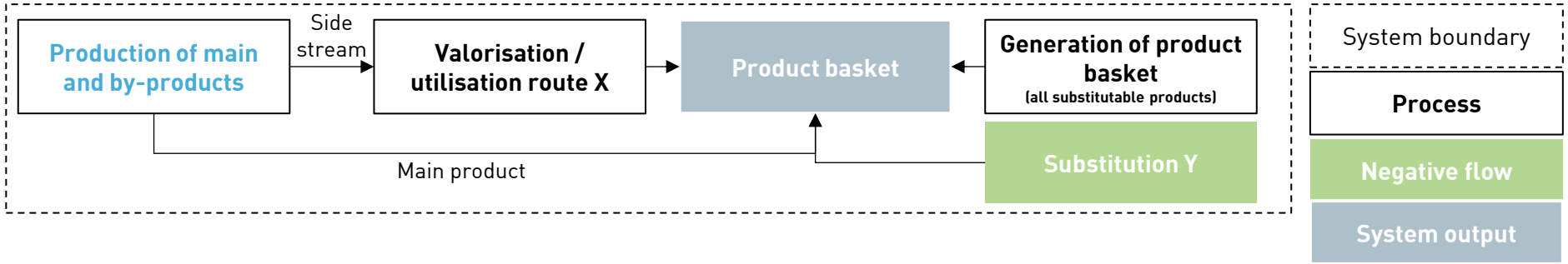
Calculating the environmental impact



Total environmental impact = *Production* + *Valorisation* + *Product basket* - *Substitution*

- How much environmental impact can be reduced compared to other routes?

Net balance = *Valorisation* - *Substitution*

- How much does each route reduce the environmental impact?
  - Net balance ‹ 0 → route reduces environmental impact
  - Net balance › 0 → route adds environmental impact

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Modelling steps and data basis

Modelling step	Data basis
Define valorisation/utilisation routes:	industry experts, FOEN and desk research
LCI of valorisation/utilisation process:	primary data from Swiss producers, literature and LCA databases
Define substituted product:	industry experts, FOEN and desk research
LCI substituted product:	LCA databases

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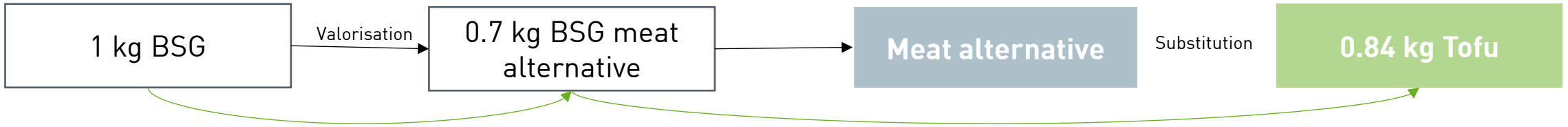
Development of LCI for routes

Example meat alternative from Brewer's Spent Grain (BSG)



$$* yield = 0.7 \frac{kg\ BSG\ meat\ alternative}{kg\ BSG}$$

$$* Substitution\ factor = 1.2 \frac{kg\ Tofu}{kg\ BSG\ meat\ alternative}$$

What the results show



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Main results across 15 side streams

Food-feed-fuel principle: largely confirmed

- Almost all valorisation and utilisation routes reduce environmental impact
- Feed can have similar reductions to valorisation, depending on the side stream

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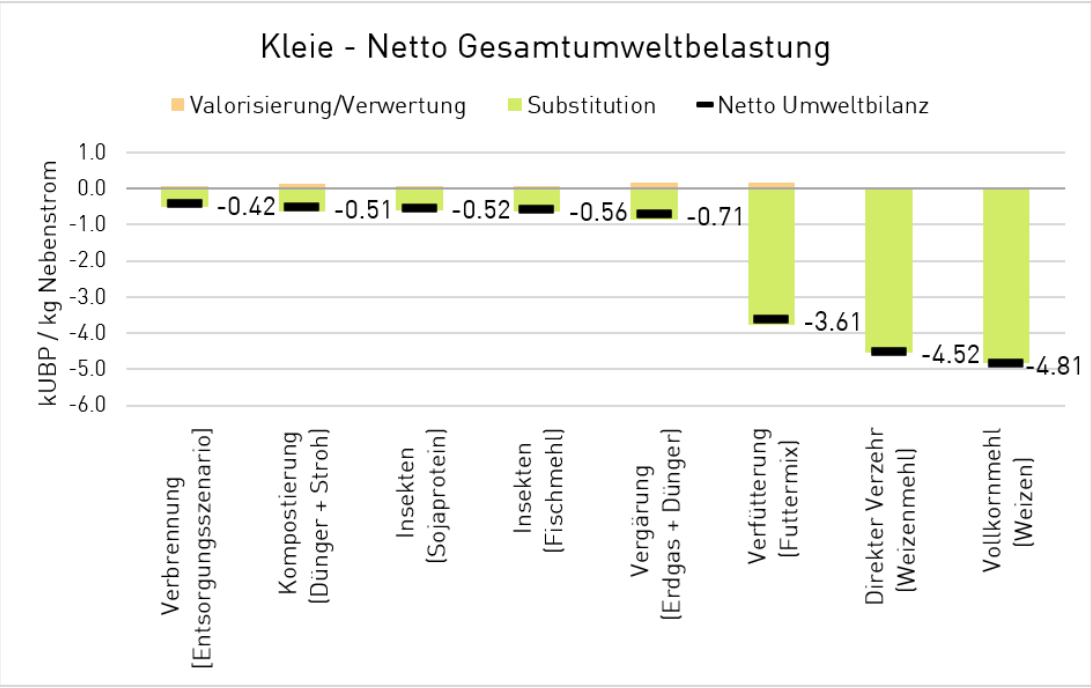
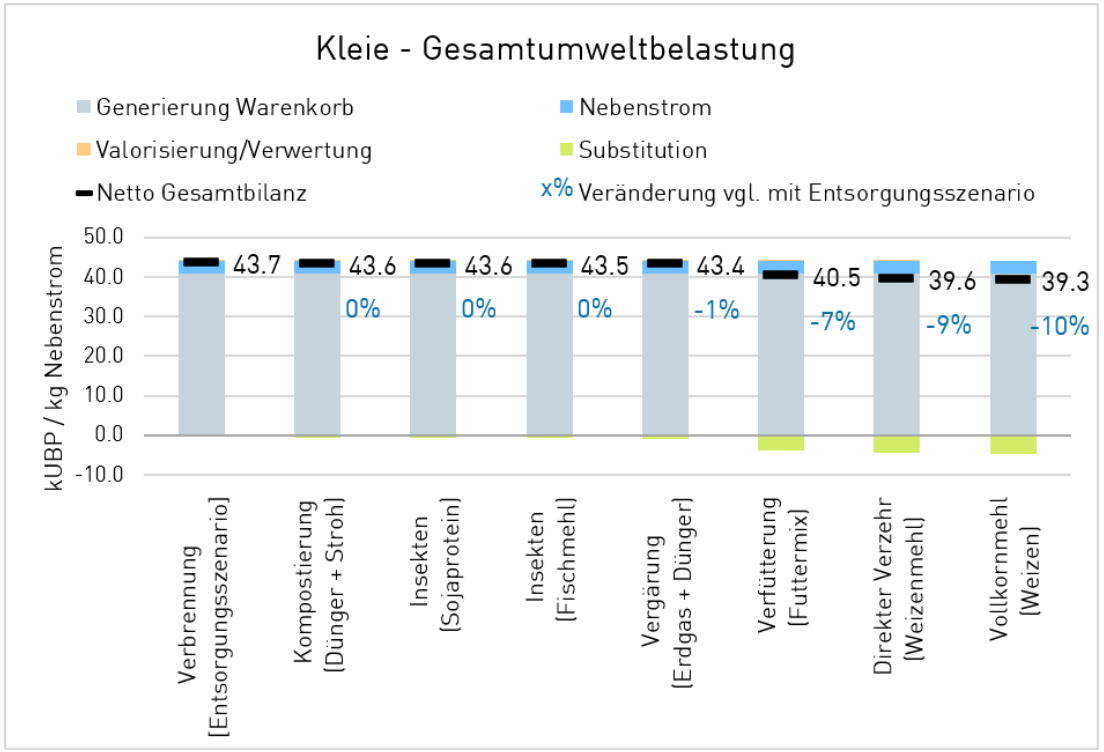
Example results: Wheat bran





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Learnings



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Learning 1: The substitution is critical

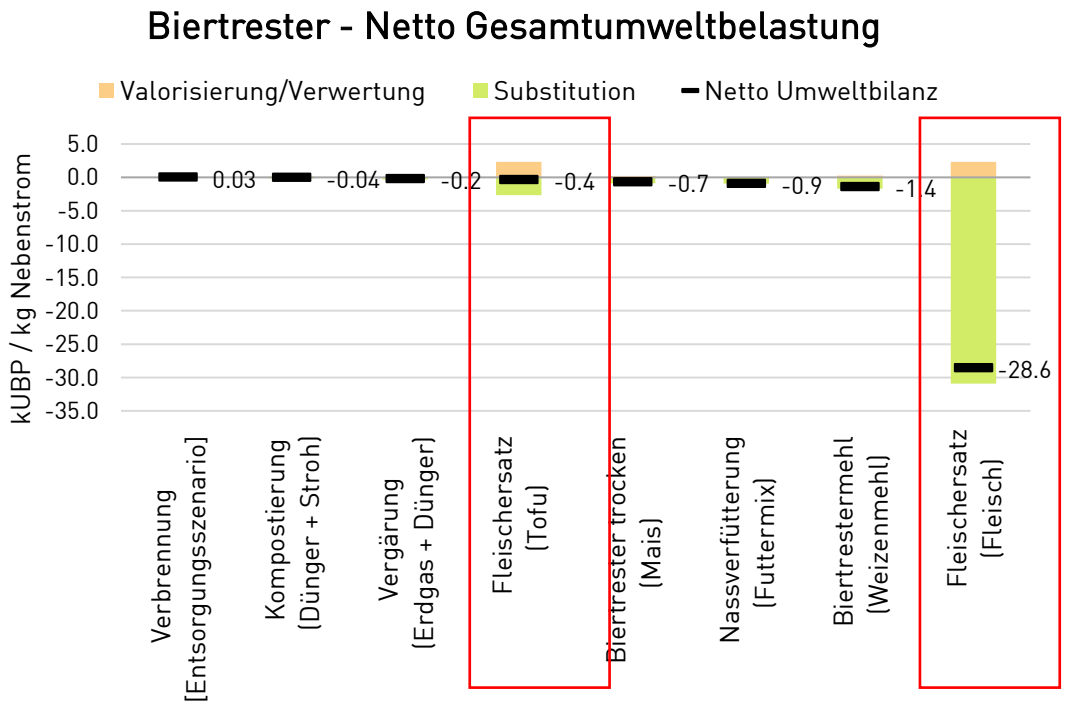
Substituted product determines environmental impact

→ Defining the substituted products is decisive: test the critical ones and report the range

→ Avoid generalisation beyond the assumptions made: interpretation phase becomes all the more important!

Example: Sensitivity Analysis BSG meat alternative

- Replacing tofu vs. replacing meat



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Learning 2: Equivalence is a modelling choice

- Principle: function of side-stream product = function of substituted product

- Food products have multiple use cases and functions: which one matters most?
  - Mass
  - Nutritional values (kcal, protein content, protein quality, micronutrients etc.)
  - Functional properties (gluten, texture, taste, perishability, etc.)

→ Our approach
  - Equivalence of function considered in substitution factor
  - Nutrient-based where one function dominates (e.g., protein concentrates, feed)
  - Mass-based where functions are multiple

→ Future studies could explore this further

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Learning 3: Allocation and background data

- Allocation decides the footprint of side-stream products
  - Burden-free, economic or physical allocation lead to very different results
  - Economic allocation is dynamic: successful valorisation raises the value of the side stream and shifts burden onto it

- Large-scale comparable studies rely particularly on LCA databases
  - Representative, current, comparative and reliable background data for food supply chain is important

→ Continuation of foundational database work enables side-stream analyses at a granular level

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Summary

1. **A consistent frame makes side-stream LCSs comparable:** system expansion, product basket, input-based functional unit

2. **Substitution drives the result:** careful interpretation instead of generalisation

3. **Equivalence of products:** Can be considered through substitution factor, but it's a choice what functions to consider

4. **Allocation and background data matters:** need continued database work - as always

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