DISCUSSION FORUM ON LIFE CYCLE ASSESSMENT

Technical University of Denmark

DTU

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Challenges in LCA modelling of multiple loops for aluminium cans

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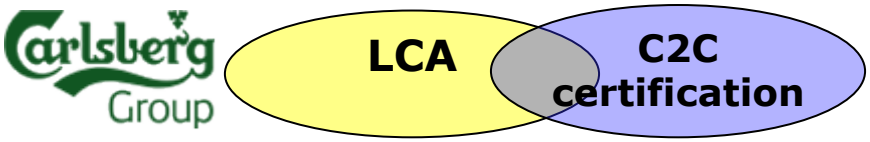
Outline

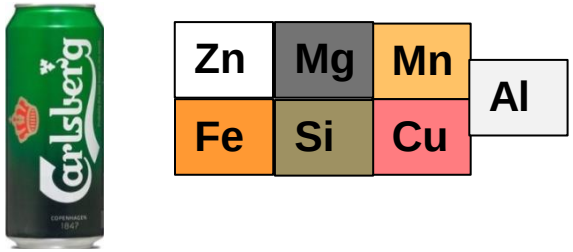
- *Introduction:*

Put the research into context



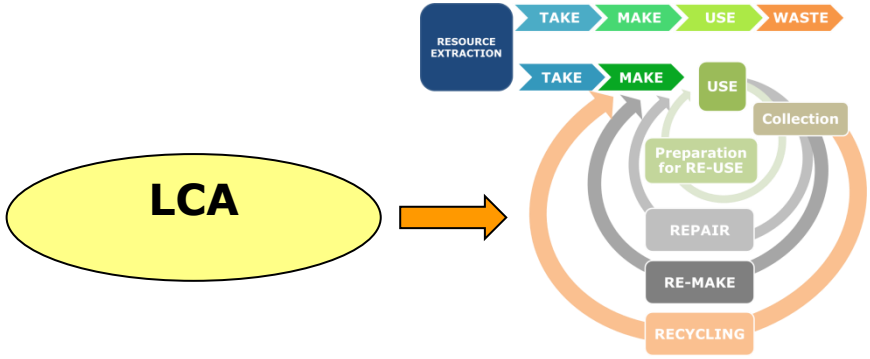
- *Case study:*

LCA modelling of multiple loops for aluminium cans



- *Perspective:*

How can LCA support the circular economy?



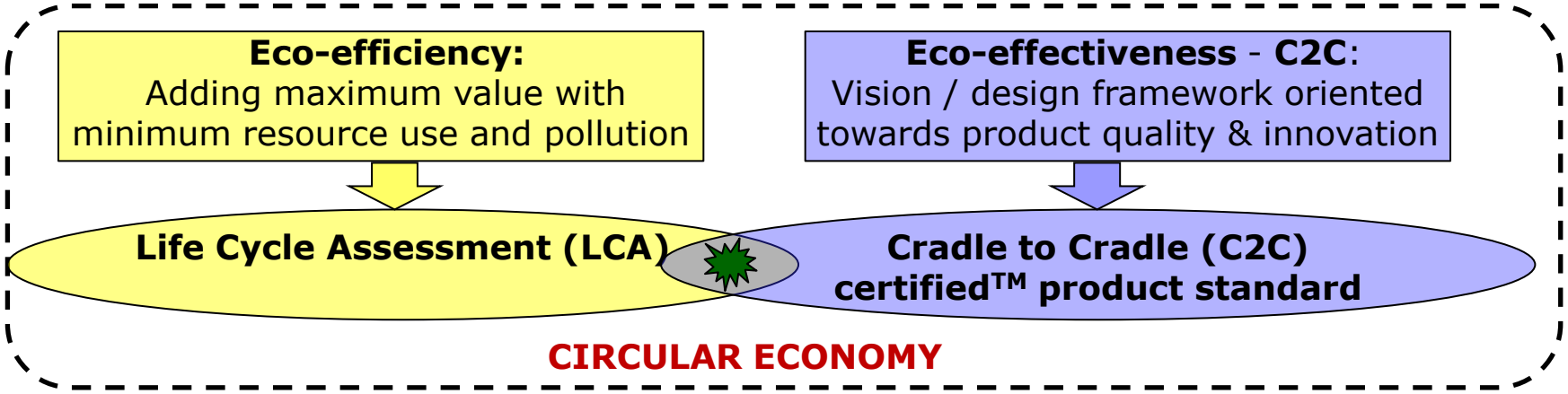
Aim of the project

- ***Vision:***

Support **Carlsberg** in the development of **environmentally sustainable and innovative** beer packaging solutions

- ***Objective:***

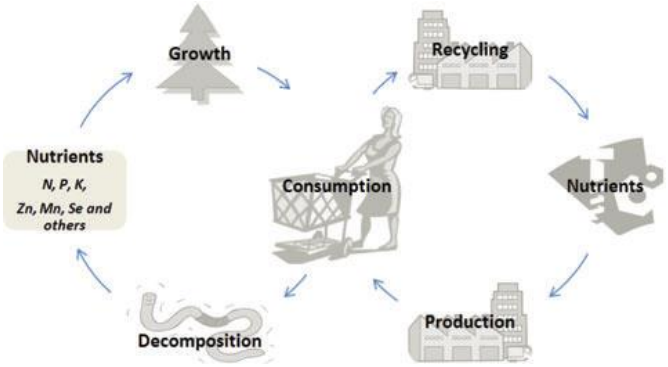
Combine **Life Cycle Assessment (LCA)** and **Cradle to Cradle® (C2C) design framework** towards **continuous loop** packaging systems



How can the C2C vision inspire LCA?

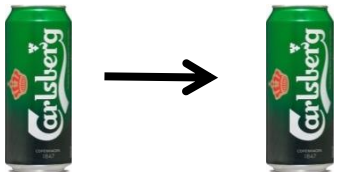
C2C vision aims *to generate cyclical, cradle-to-cradle "metabolisms" that enable materials to maintain their status as resources*

Braungart et al. (2007)



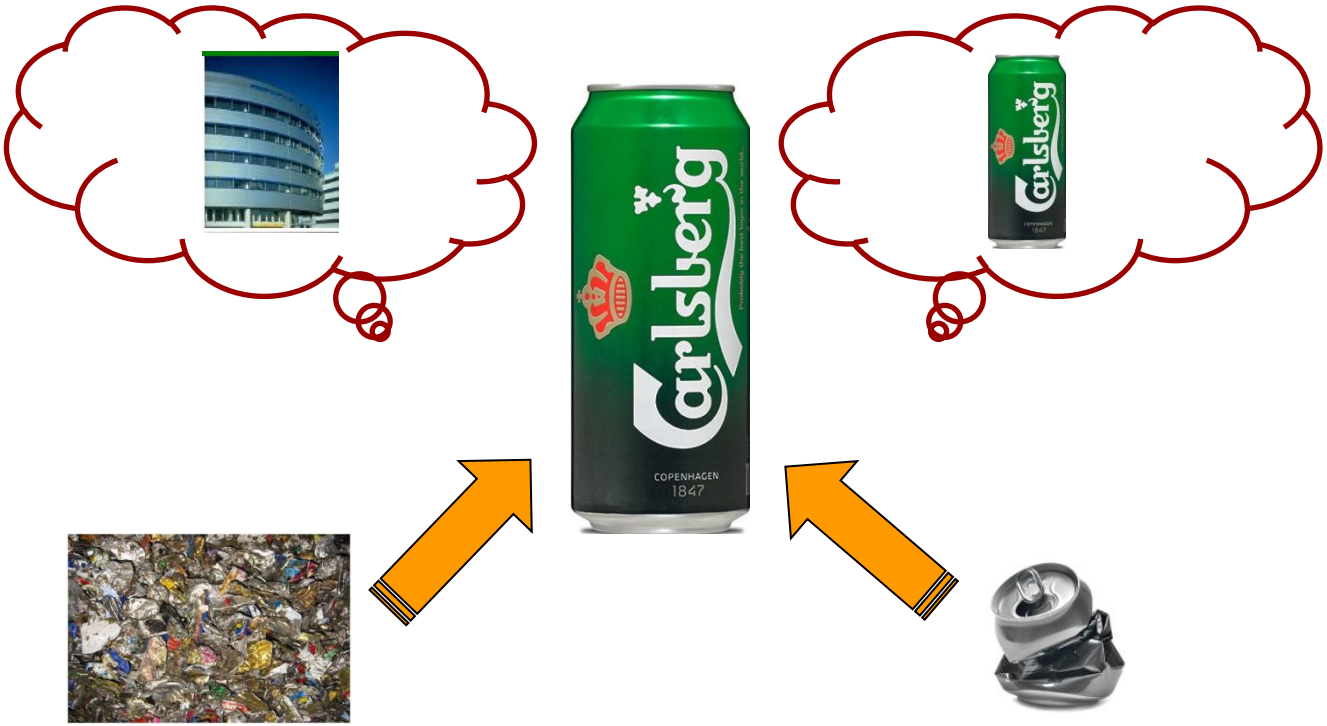
Bjørn & Hauschild (2013) J Ind Ecol 17(2) 321-332

- C2C supports **continuous material loop** ≠ closed material loop
- From C2C analysis aluminum is a "technical nutrient" = a material suited to remain in a **closed-loop system** maintaining its highest **value** through many product life cycles



Objective of the LCA study

→ To answer the Hamlet dilemma for aluminium cans in a circular economy:
to be or not to be - in a closed product loop?



Implications for functional unit definition

→ *"Traditional"* functional unit (FU): **containment** of 1 hl of beer

BUT a circular economy aims to use **materials in continuous loops** therefore this is not the only function...

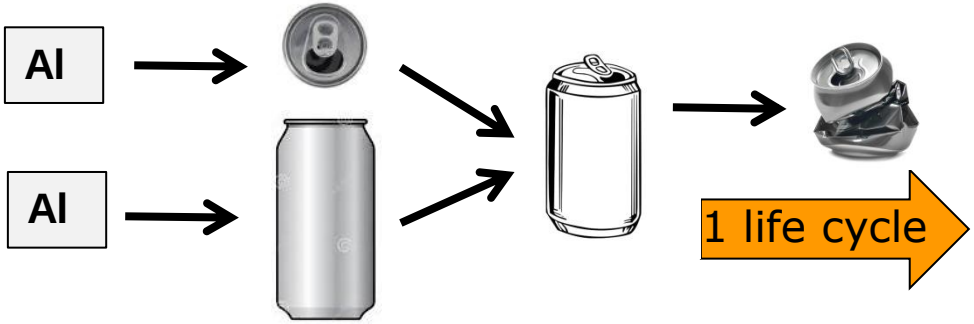
From ILCD Handbook, Annex C, p. 351 → an aluminium beverage can:

- 1st co-function: to **carry and protect** the beverage it contains
- 2nd co-function: the aluminium scrap (i.e. the end-of-life can) it provides as **secondary resource** for subsequent product systems

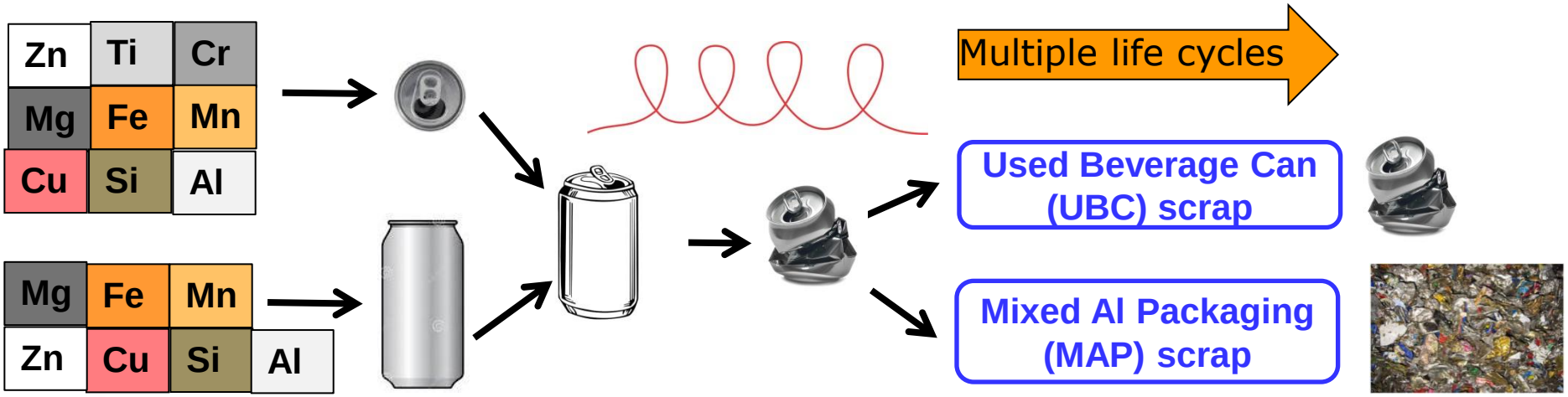
→ "*Circular economy-inspired FU*": **containment** of 1 hl of beer **and supply** of resources after its use stage for **30 loops**
1 recycling loop = 60 days *(EAA, 2015)*

Implications for LCI modelling

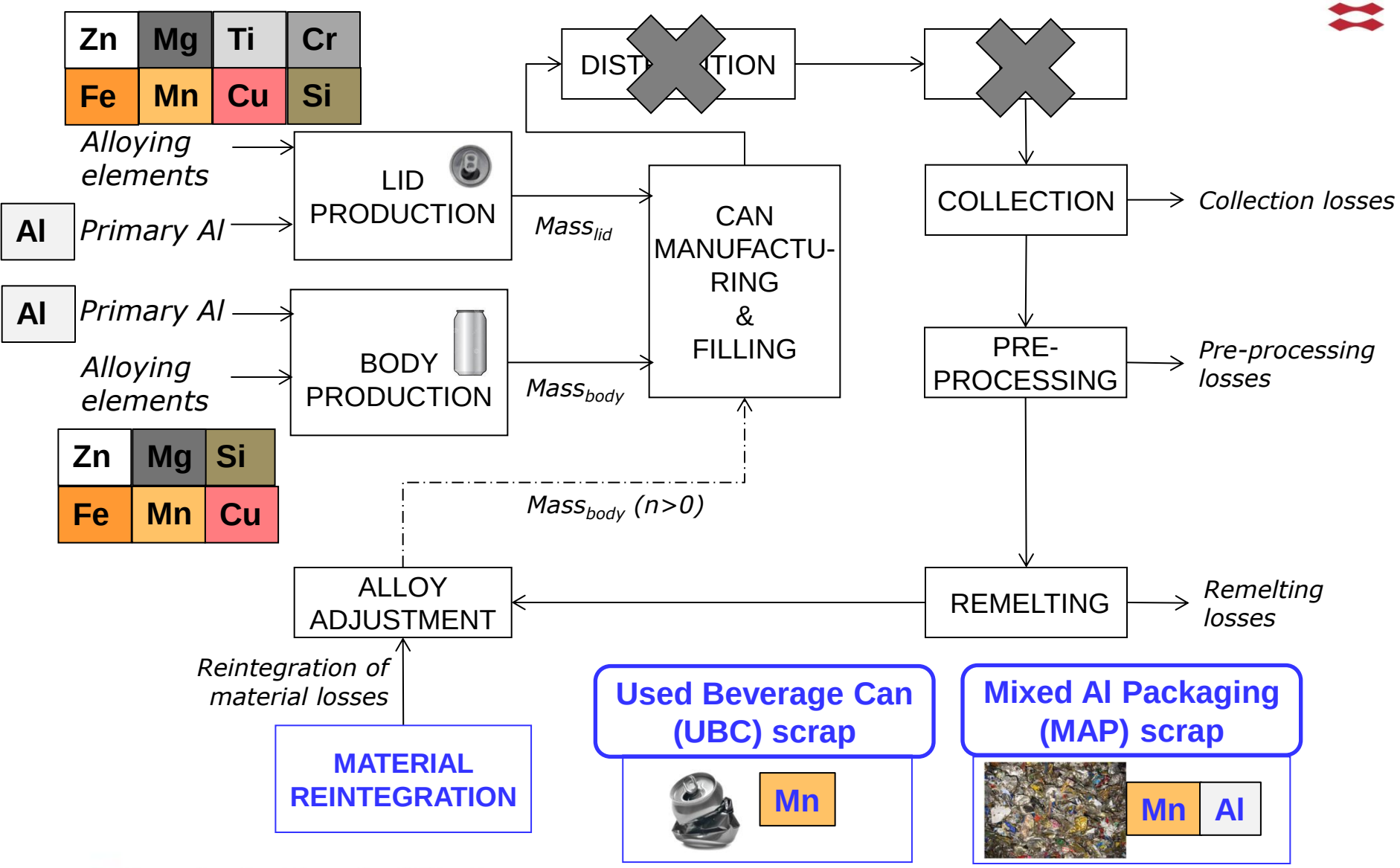
- Conventional LCA studies of aluminium products → based on a pure Al flow *(EAA, 2013)* **neglecting the presence of alloying elements**



- The **actual material composition** needs to be taken into account while addressing the use of aluminum in continuous loops

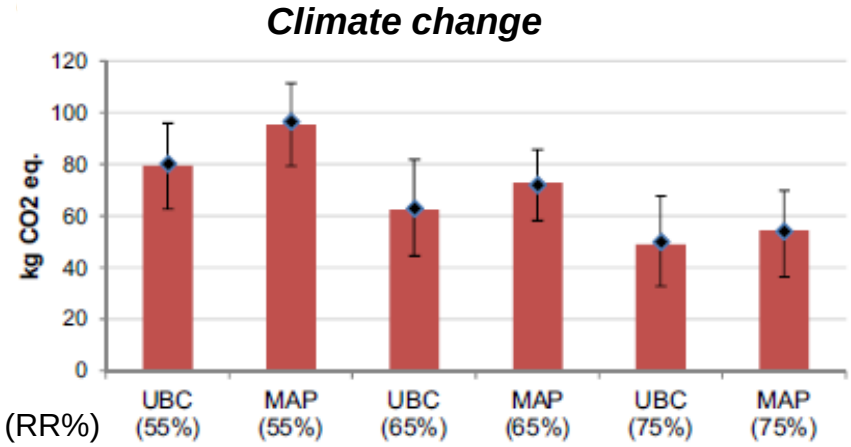


Mass Balance of alloying elements

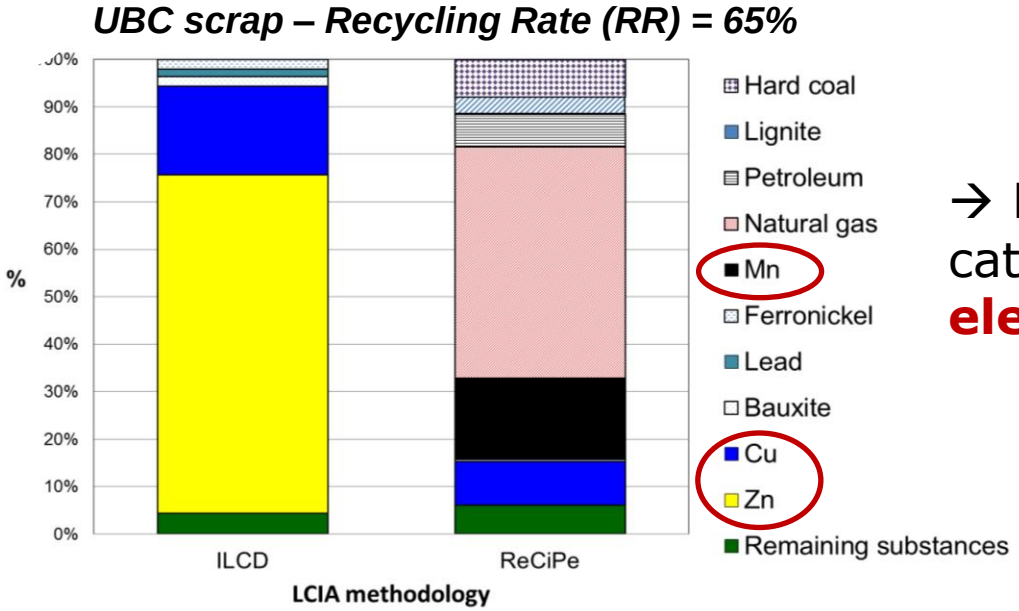


Source: Elaboration from Niero and Olsen (2016) Resources Conservation & Recycling 114: 18-31

Results: LCA of multiple life cycles



→ Closed product loop option (i.e. UBC scrap) has **lowest impacts** on climate change



→ For resource depletion impact category contribution from **alloying elements** is relevant

Source: Niero M, Olsen SI (2016) - Resources Conservation & Recycling 114: 18-31

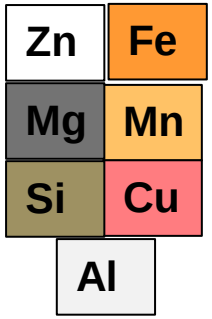
Conclusions

→ **Answer to the Hamlet dilemma of Al can is TO BE in a closed product loop**

- How to implement a **cost-effective** can-to-can recycling system?
- Which are the effects of a closed product-loop strategy on aluminum scrap **market**?
- ….

→ **Multiple product loops can be modelled by LCA**

- Functional unit definition: include both **primary** (containment) and **secondary (supply of resource for next loop)** functions
- Life Cycle Inventory modelling based on the **actual alloy composition**



How can LCA support the CE?

Research activities at DTU Management Engineering, Quantitative Sustainability Assessment (QSA) Division:

- ✓ **Decision support framework** for implementing circular economy strategies at product, organization, and supply chain levels

  Example: **C**losed **L**oop **A**luminium **P**ackaging (Climate KIC pathfinder project):

  - Objective #1: **Combine** state-of-the-art insights from the knowledge pools "Technology", "Business models", and "Sustainability assessment"
  - Objective #2: **Determine potential "paths"** towards **a closed-loop system** for **Al cans** with focus on CO_2 abatement potential and techno-economic feasibility

- ✓ **Risk and sustainability integrated assessment frameworks** for optimal use of chemicals and materials in a circular economy

  Example: Coupling product use exposure with life cycle impacts:

  - Objective #1: Identify **hot spots for CE** to focus risk minimization in multi-loop systems and to ensure both **safe and sustainable** CE development
  - Objective #2: Consistently combine risk and sustainability indicators to **avoid burden shifting** in CE material cycles

Do you want to know the details?

- Niero M, Olsen SI (2016) ***Circular economy: to be or not to be in a closed product loop? A Life Cycle Assessment of aluminium cans with inclusion of alloying elements.*** Resources Conservation & Recycling 114: 18-31
- Niero M (2016) ***How to bridge the gap between the packaging sector and circular economy***. *http://www.carlsbergfondet.dk/en/Research-Activities/Research-Projects/Postdoctoral-Fellowships/Monia-Niero_How-to-Bridge-the-Gap-Between-the-Packaging-Sector-and-Circular-Economy*
- Niero M, Negrelli AJ, Hoffmeyer SB, Olsen SI, Birkved M (2016) ***Closing the loop for aluminum cans: Life Cycle Assessment of progression in Cradle-to-Cradle certification levels.*** Journal of Cleaner Production 126, 352-362.
- Niero M, Hauschild MZ, Hoffmeyer SB, Olsen SI ***Combining eco-efficiency and eco-effectiveness for continuous loop beverage packaging systems: learnings from the Carlsberg Circular Community.*** *Accepted for publication in Journal of Industrial Ecology – Nov 2016*
- Niero M, Olsen SI, Laurent A. ***Renewable Energy and Carbon Management in the Cradle-to-Cradle certification: Limitations and opportunities*** *- Under revision in Journal of Industrial Ecology*

Acknowledgements

CARLSBERG FOUNDATION

eit Climate-KIC

Thank you for your attention!

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