3° workshop
"Rifiuti e Life Cycle Thinking"
Verso un utilizzo circolare delle risorse

Technical University of Denmark

DTU

Combining Life Cycle Assessment and Environmental Life Cycle Costing to assess circular economy strategies: the case of aluminium cans

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Outline

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- *Aim of the study*

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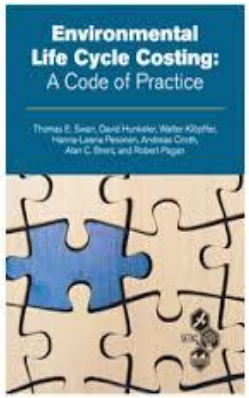
- *Conclusions and perspectives*

https://upload.wikimedia.org/wikipedia/commons/e/e4/Bologna-view.jpg

https://upload.wikimedia.org/wikipedia/commons/1/12/Copenhagen_skyline.jpg

Challenges in implementing Circular Economy

- Circular Econoimy (CE) based on simple concept: «**closing the loop**»
- At which level? Material? Product?
- CE is not only about resource scarcity and environmental impact, but also **economic benefit** *(Lieder & Rashid J Clean Prod 115 (2016) 36–51)*
- Circular economy strategies should be assessed both in terms of **environmental impacts (LCA)** and including **economic implications**



Environmental Life Cycle Costing (LCC): A Code of Practice by SETAC *(Swarr et al., 2011)*
*Life Cycle Costing summarizes all costs associated within the life cycle of a product that are **directly** covered by one, or more, of the actors in the product life cycle*

Types of Life Cycle Costing (LCC)*

a) **Conventional LCC**: represents traditional financial assessments carried out typically by individual companies focusing on their "own" costs

b) **Environmental LCC (E-LCC):** expands the Conventional LCC in order to be consistent with the system boundaries of LCA → on top of the financial assessment from the company perspective includes the costs incurred by all the affected stakeholders

c) **Societal LCC**: further includes externality costs (i.e. it "internalizes" environmental and social impacts by assigning monetary values to the respective effects), by using accounting prices

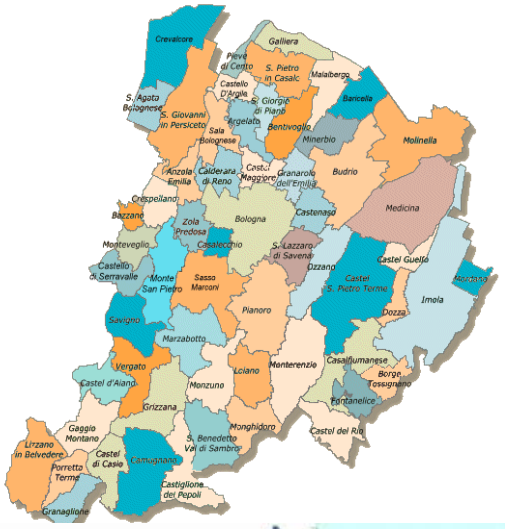
** Martinez-Sanchez, V, Kromann, MA, Astrup, TF, 2015. Life cycle costing of waste management systems: Overview, calculation principles and case studies. Waste Manage 36,343–355.*

Aim of the study

- to **compare** the **environmental** (LCA) and **economic** (LCC) performances of the **full life cycle** of two aluminium beer can systems including purchasing, production and waste management, representative of two specific Italian (**Bologna Metropolitan City Area**) and Danish (**Urban Area of Copenhagen**) situations

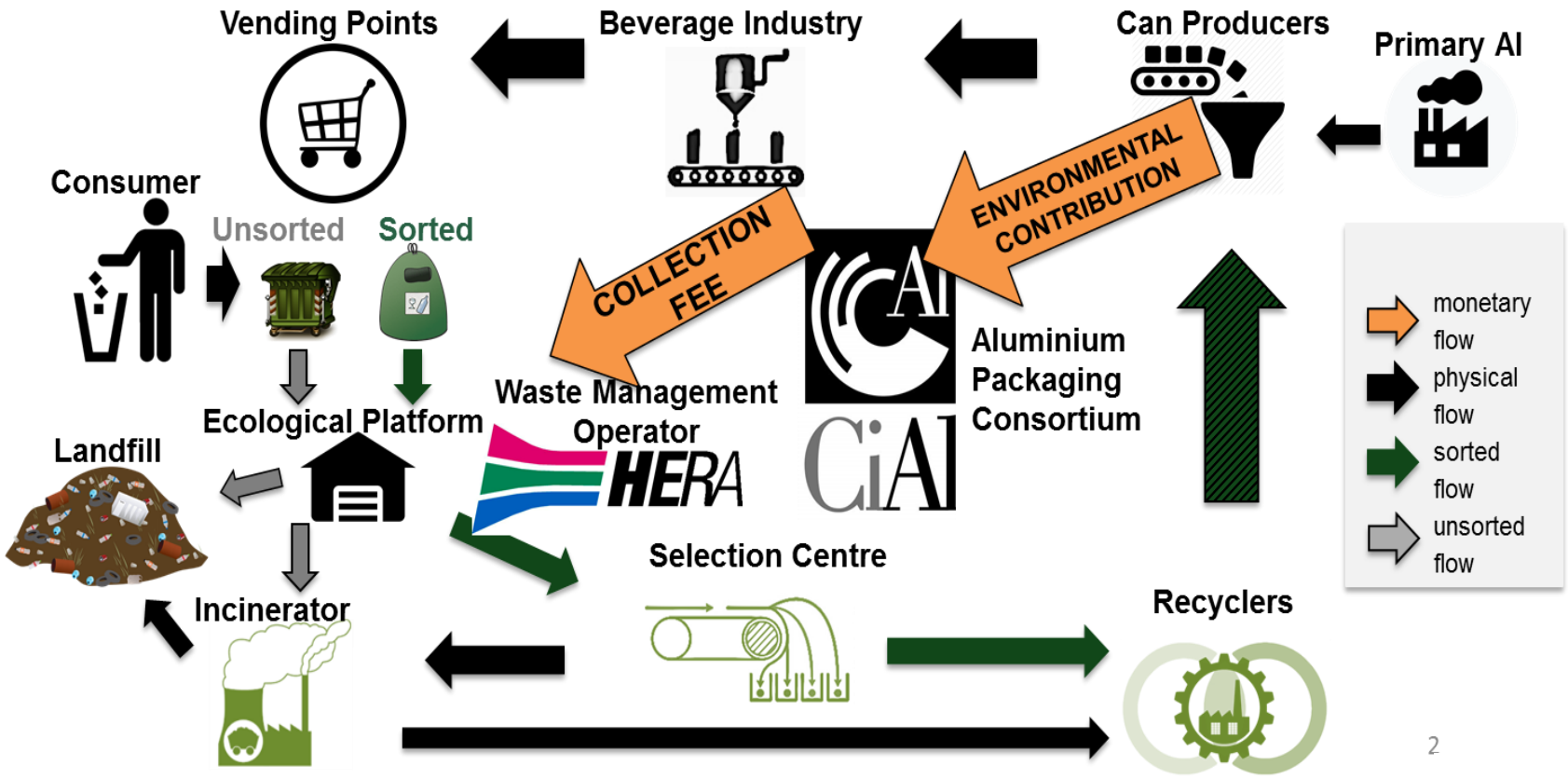
- including three main **perspectives**: consumers, producers and waste management operators

- to identify **challenges in closing the loop** in different geographical areas and **potential trade-offs** in the integrated LCA-LCC analysis



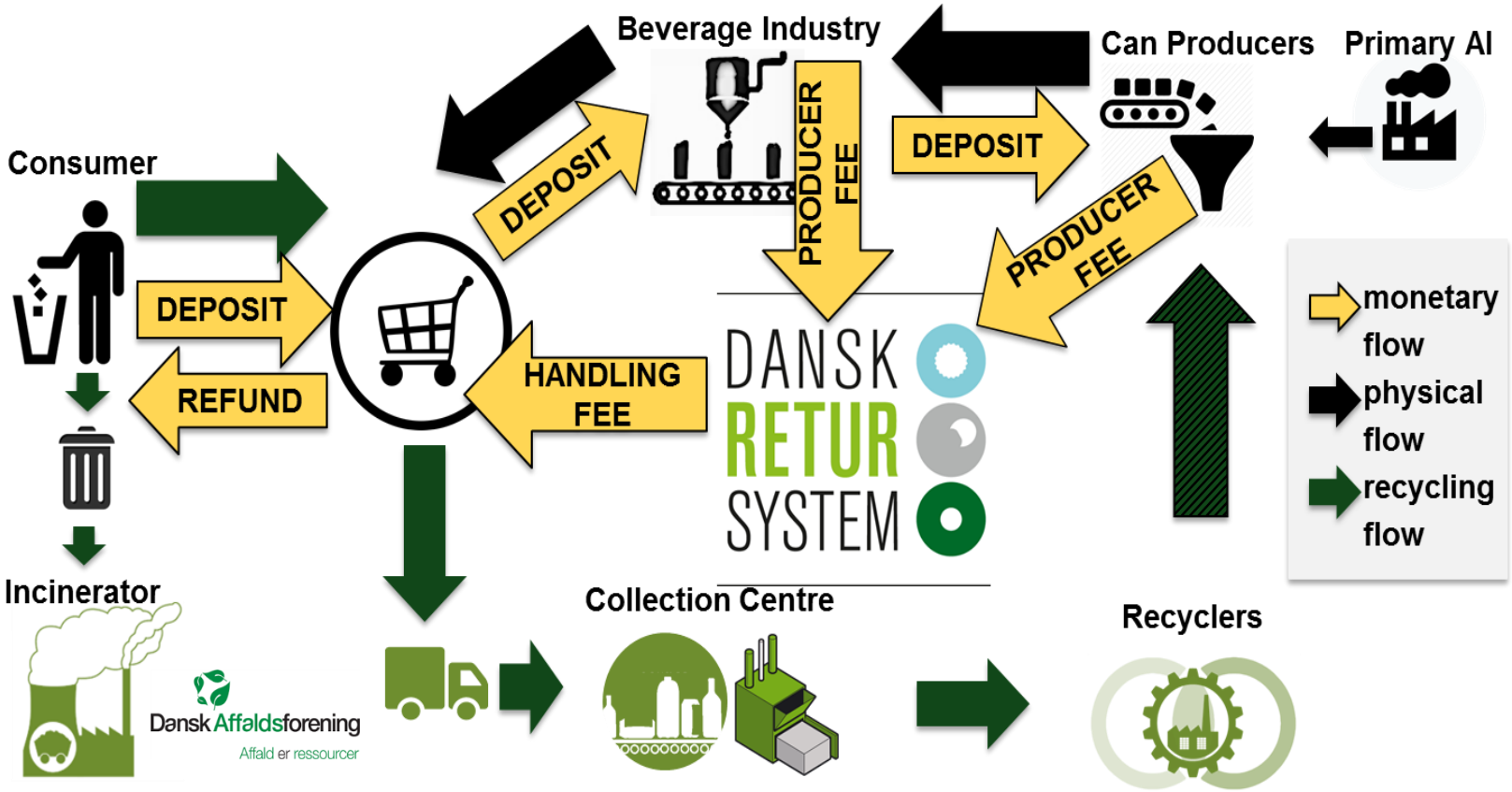
System description: Bologna

- Bologna Metropolitan City Area = former Province of Bologna 55 municipalities, total population of 1.004.323 inhabitants in 2015 (ISTAT, 2015)



System description: Copenhagen

- Urban Area of Copenhagen (Hovedstadsområdet in Danish) 10 areas, total population of 1.263.698 in 2015 (Statistics Denmark, 2015)



Goal and scope definition LCA & LCC

- **Goal**: to quantify the environmental impacts and costs carried by different **actors** in the value chain of the two Al can systems

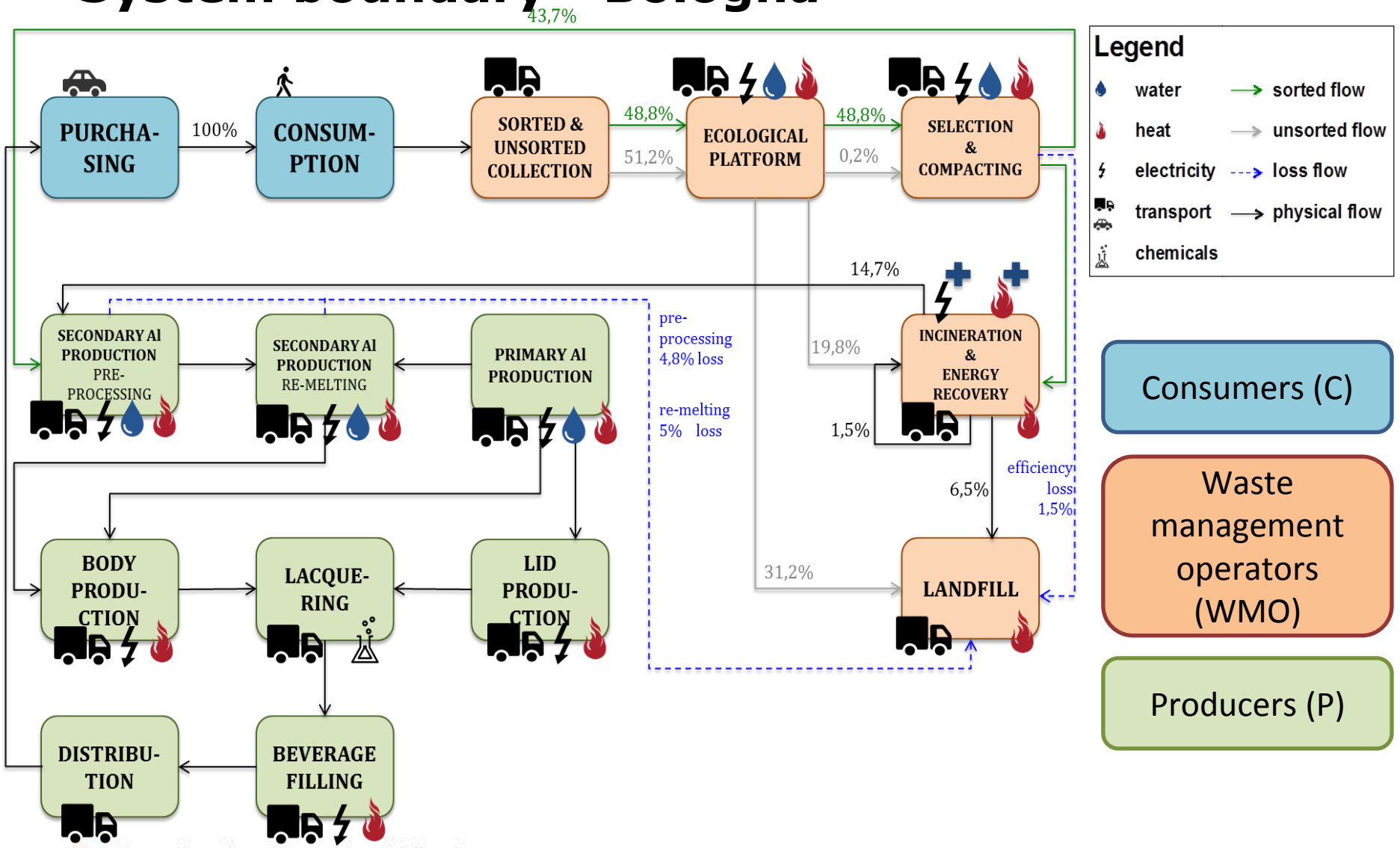
- **Scope**:

- **Function** of the system = the delivery of beer to consumers in the Urban Area of Copenhagen and Bologna Metropolitan Area in 2013 by means of 33cl aluminium cans and the recovery of the Used Beverage Cans (UBC) assuming a closed loop system

- **Functional unit (FU)** = delivery of 1 hl of beer and recovery of 303 units of 33cl aluminium cans in Bologna/Copenhagen in 2013

- **Exclusion** for both LCA and LCC: beer production, refrigeration, bins production, R&D costs

System boundary - Bologna

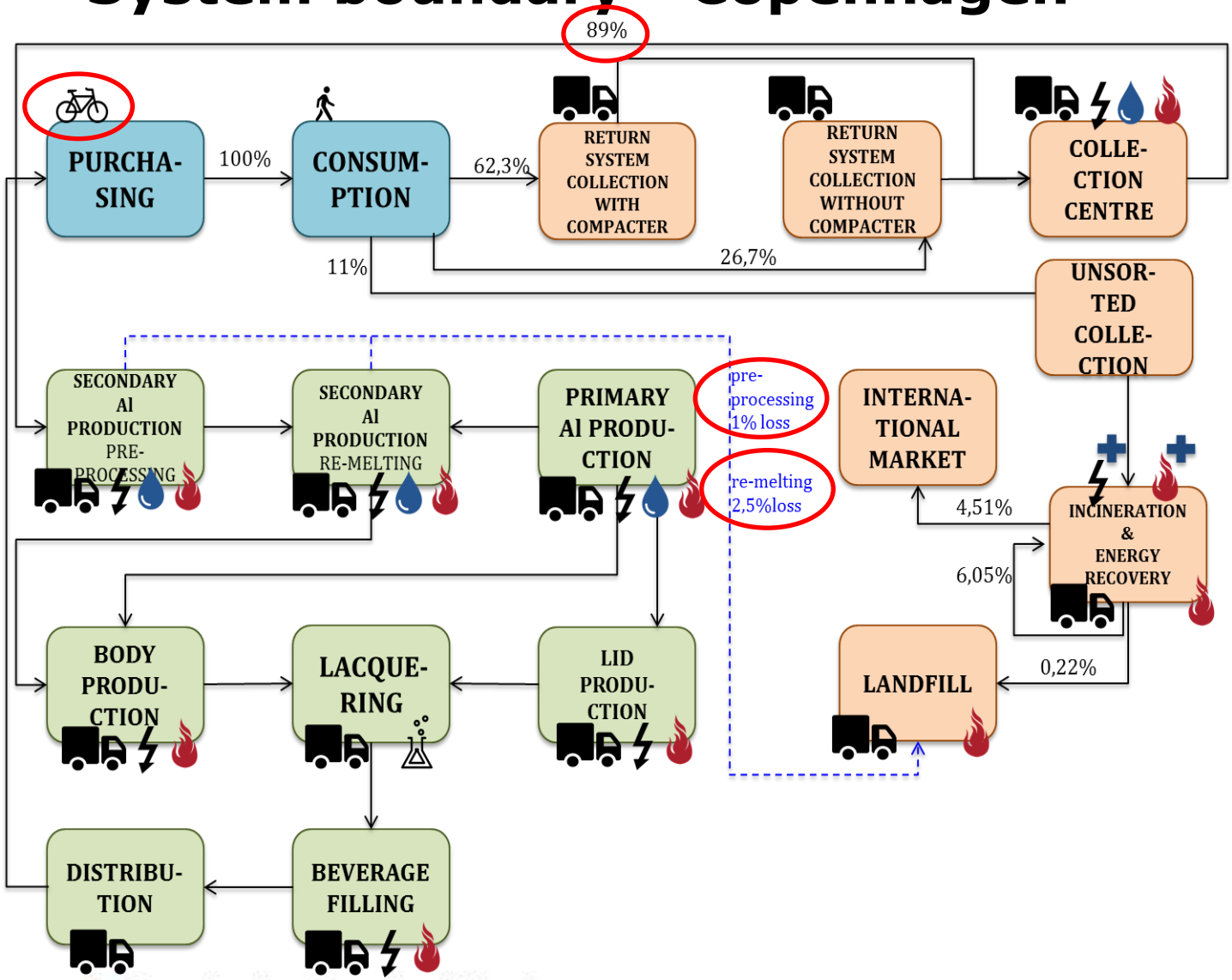


Consumers (C)

Waste management operators (WMO)

Producers (P)

System boundary - Copenhagen



Legend

- water
- heat
- electricity
- transport
- chemicals
- loss flow
- physical flow

Consumers (C)

Waste management operators (WMO)

Producers (P)

Life Cycle Inventory - main assumptions

- **Purchasing:** 1 km (bike @CPH; car @BO) – 4 cans
- **Consumption:** 200 m (distance home-bin) – 10 cans thrown away
- **Costs CONSUMER:** can + transport + waste fee + refund (CPH)

Consumers (C)

- **Al (primary and secondary), Body and lid, lacquering, filling, distribution**
- **Costs PRODUCER:** Al production (primary and secondary) + electricity + heat + transport + environmental fee (BO, Al and can manufacturers) producer fee (CPH, can manufacturer and filler)

Producers (P)

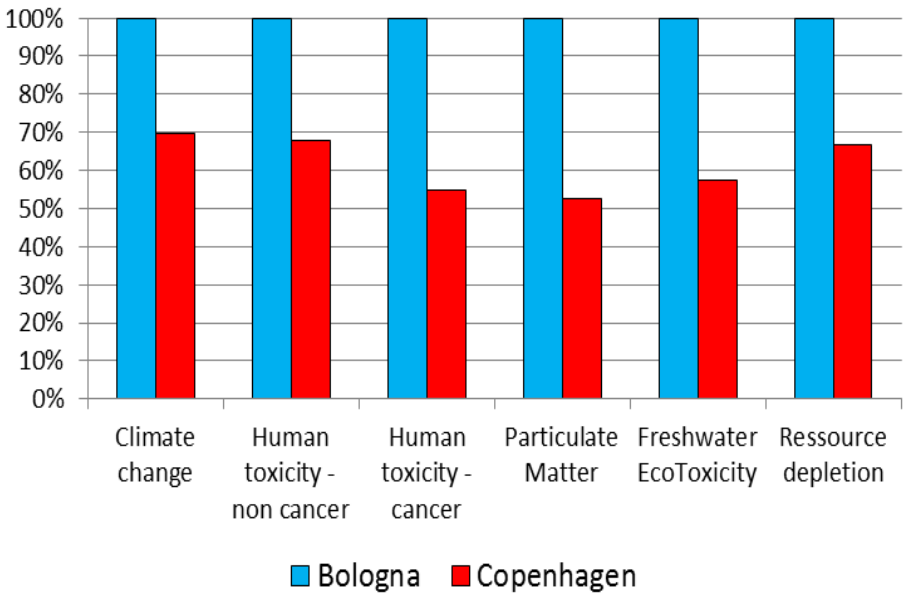
- **Costs Separated Collection, Selection and Compacting, Incineration, Landfill**
- **Ecological Platform** (BO), **DRS operating costs + Reverse Vending Machines** (CPH)

Waste management operators (WMO)

Results 1/2

Life Cycle Impact Assessment

(ILCD recommended v.1.06)

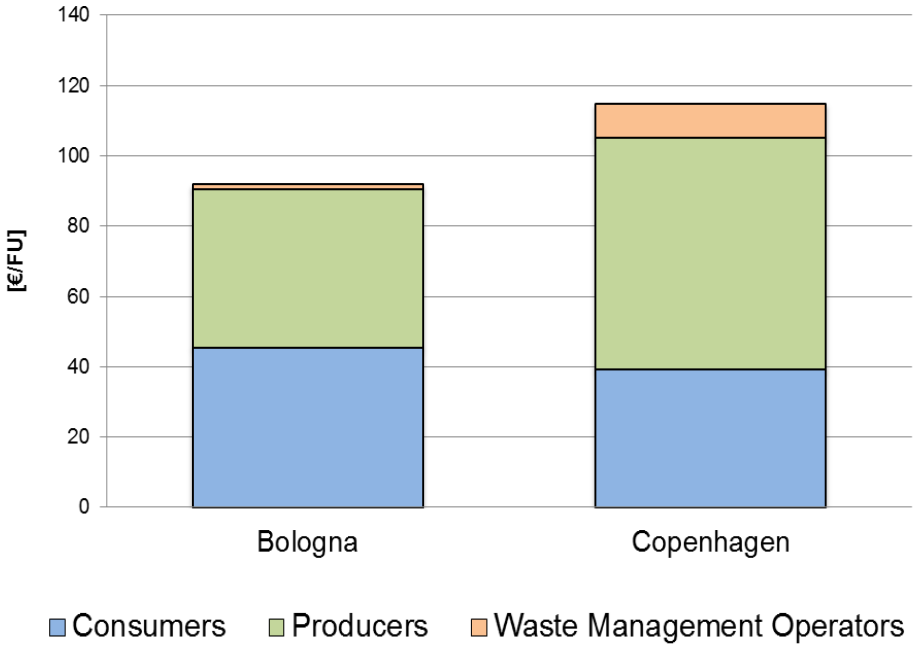


→ Lower impact for Copenhagen, due to lower use of primary Al in can manufacturing

→ **higher recycling rate** in CPH for Al cans (89%) compared to BO (48,8%)

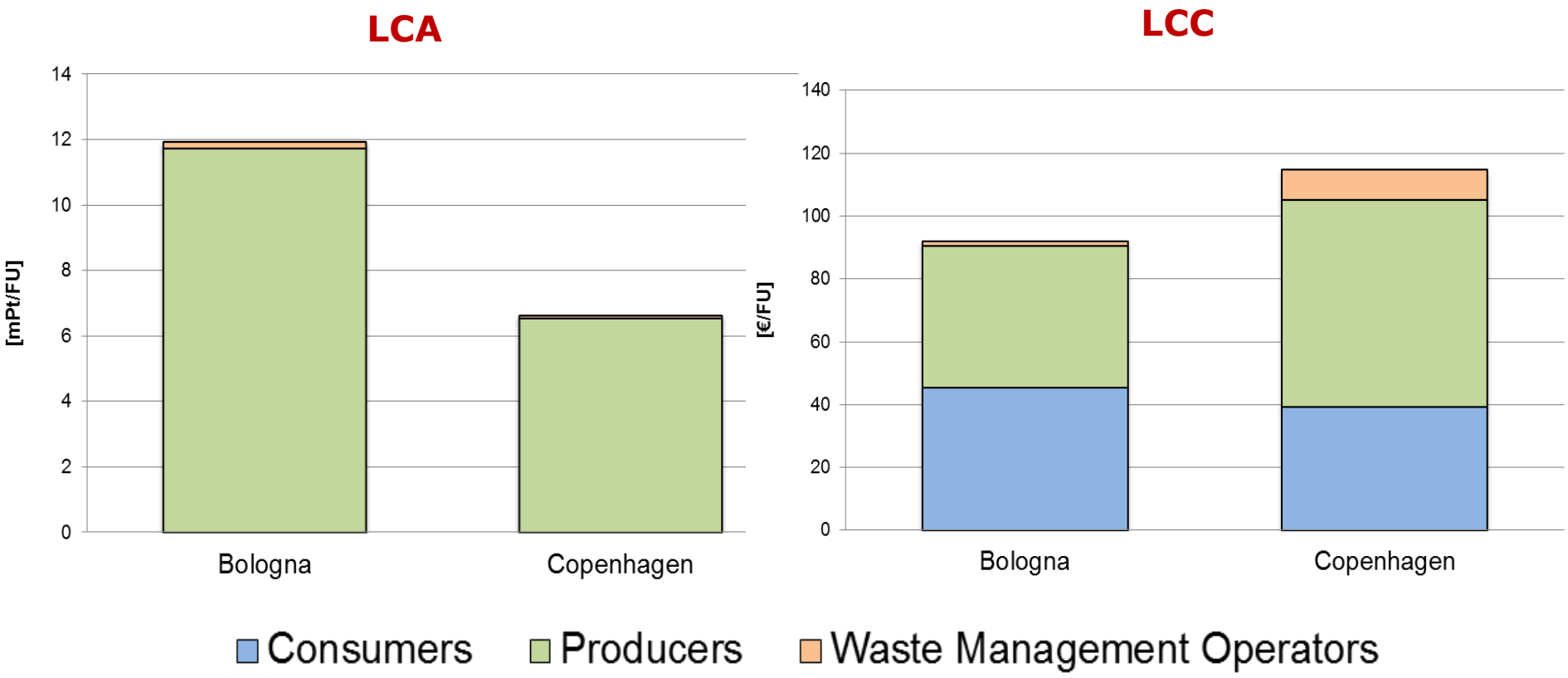
Environmental Life Cycle Costing

(Swarr et al. 2011)



→ higher costs in CPH compared to BO, due to **high handling costs** of the Reverse Vending Machines (RVM) at retailers and **operating costs** of the Danish Return System (DRS)

Results 2/2



→ A **misalignment** in the **contribution** to the life cycle environmental impacts and economic costs can be identified

→ For CPH **better environmental performances** mean **higher costs** for all actors in the value chain compared to BO, except consumers

Conclusions and perspectives

- Comparative analysis of production, use & recycling of aluminium cans in Bologna and Copenhagen showed that **trade offs exist**:
  - best option from an environmental point of view also leads to higher costs
  - alignment of interests of different actors in the value chain

- Evaluation of circularity strategies should be performed from **environmental life cycle perspective** and including **economic considerations**

Take home message:
IN ASSESSMENT OF CIRCULAR ECONOMY STRATEGIES TRADE-OFFS BETWEEN ENVIRONMENTAL BENEFITS AND ECONOMIC COSTS NEED TO BE CONSIDERED
→ LIFE CYCLE PERSPECTIVE NEEDED!

Acknowledgements

CARLSBERGFONDET

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