International Workshop on Life Cycle Assessment and Metals

Comparative Analysis of Several Non-ferrous Metals LCAs

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Presentation Overview

- Key methodological differences and similarities of four metal LCA studies 28 Ni 29 Cu 30 Zn 82 Pb
  - Data categories
  - System boundaries
  - Allocation choices
  - Results reporting
- Recycling 82 Pb
- Practical challenges users must face

Overview of Four ISO-Compliant LCA Studies

What is assessed at the workshop

Impact Assessment | Impact Assessment

Cradle-to-"Refinery Gate" Inventory | Adding on Gate-to-Grave to make Cradle-to-Grave Inventory

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28 Ni — Nickel Study Scope

Impact Assessment of Nickel Products

Cradle-to-Gate Inventory of Nickel Products

29 Cu — Copper Study Scope

Impact Assessment of Copper Tube

Cradle-to-Gate Inventory of Copper Cathode | Cradle-to-Grave Inventory of Copper Tube

82 Pb — Lead Study Scope

Cradle-to-Gate Inventory of Lead Ingot | Cradle-to-Grave Inventory Study of a Lead-Acid Battery

30 Zn — Zinc Study Scope

Cradle-to-Gate Inventory of Zinc Ingot

Data Categories Determination

- Categories include material inputs, water inputs, energy, air emissions, water effluents, solid waste
- Old approach to determine categories:
  - Establishment of complete mass and energy balance, providing a quantification of all existing flows
- Current approach:
  - The flows identified by customers (i.e., for their information or for their own LCI studies) or cause of concern vis-à-vis customers;
  - Environmental policies and priorities within the given industry;
  - Regulatory issues within the given industry; and
  - Flows required for current or future LCIA calculations.

Data Categories: Elementary Material Inputs

30 Zn

- Comprehensive listing of raw materials: captures all materials extracted from the earth, including air, nitrogen, and oxygen
- Abbreviated list to focus on largest contributors
  - Examples materials: nickel (in ore), iron (in ground), limestone (in ground)
  - energy: coal (in ground), natural gas (in ground), uranium (in ground), fuel oil.

28 Ni

29 Cu

82 Pb

- All studies: metal from the ground (as a kg of metal), not metal ore as a kg of ore

Data Categories: Energy

- Energy in the studies has been expressed in the following ways:
  - By total primary energy, in energy units
    - further broken into *feedstock/fuel, non-renewable/renewable*
  - By primary fuels, in mass and/or energy units
  - By energy and fuel *sectors*, to present contributions of the fuel producing industry
  - By energy categories: fuel production energy, fuel use energy, transportation energy, etc.
- Energy values have been calculated based on *net* (28 Ni 29 Cu 82 Pb) and *gross* (30 Zn) calorific values

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Data Categories: Air Emissions

- Several air emissions categorization and reporting issues
  – Metals (unspecified)
  – Hydrocarbon grouping
  – Stack vs. fugitive
  – PM10 distinction
  – … and onward as regulations, priorities change

Data Categories: Water Effluents

- Water effluent reporting issues
  - *Total* vs. *dissolved* metals reporting
  - *Net* vs. *after treatment* reported value
  - Similar categorization issues as air effluents

Data Categories: Solid Waste (1/2)

- Categorizing and reporting solid waste:
  - Who identifies and defines solid waste categories (site staff or higher level EH&S manager or personnel)
  - What happens with beneficially-used waste? Examples:
    - Not reported in any waste category
    - Modeling: no allocations made to beneficially used waste
    - Incinerated waste reported as its own category

Data Categories: Solid Waste (2/2)

Waste			
Nickel 28 Ni	**Copper** 29 Cu	**Lead** 82 Pb	**Zinc** 30 Zn
Waste rock and backfill	Mine tailings	Mine tailings	Mineral Waste
Tailings and other process residues	Mine overburden	Slag and ash (unspecified)	Slags/ash
Other waste	Slag and ash (unspecified)	Unspecified waste	Mixed industrial
	FGD sludge	Non-hazardous waste	Inert chemical
	Furnace slag	Hazardous waste	Regulated chemical
	Waste (total)		To incinerator

System Boundaries Differences

- Cut-off Criteria
- Final Product Packaging
- Exclusions from System Boundaries

System Boundaries: Cut-Off Criteria

- All studies: cut-off criterion was based primarily on ~99% mass of inputs (also some on energy inputs, high purchasing price, environmentally relevant inputs)
- Distinction in the denominator:

30 Zn 82 Pb 29 Cu
  – Cut-off criteria includes collective mass of major inputs

28 Ni
  – Cut-off criteria is defined in 2 ways
    - includes collective mass of major inputs
    - includes only ancillary materials

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System Boundaries: Final Product Packaging

For all studies:

- Packaging was not included in the baseline results, with the expectation that the impact of packaging material over the life of the metal products would be negligible over the life cycle.
- A sensitivity analysis (28 Ni) assessing two typical packaging types proved this to be the case.

System Boundaries: What is Excluded

For all studies:

- Capital equipment
  - Burdens expected to be small
  - Capital equipment replaced yearly was included within the cut-off criteria
- Human-related activities

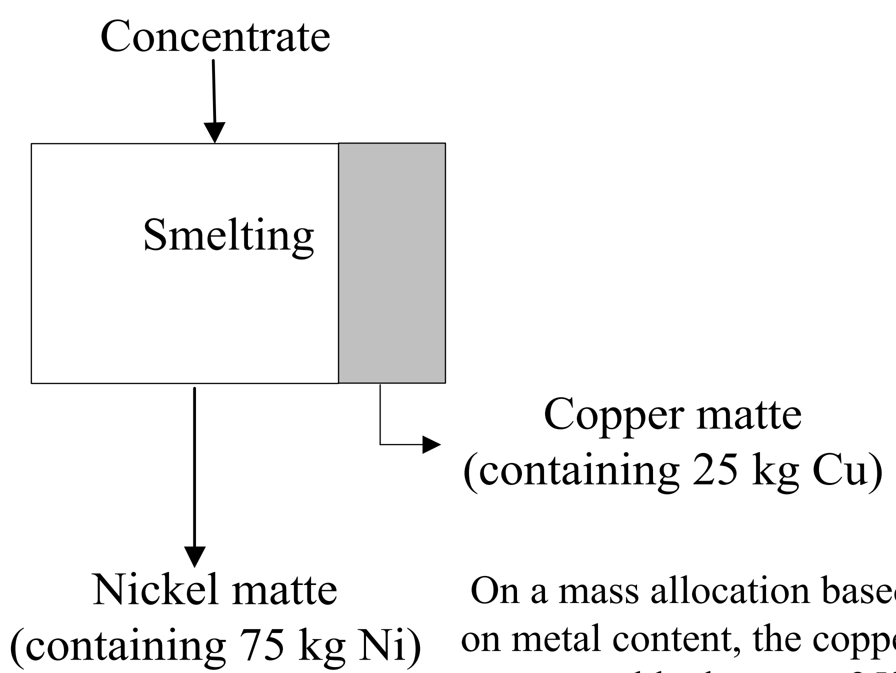
Coproducts and Allocation: General Allocation Decisions

28 Ni 29 Cu 30 Zn 82 Pb

General Decisions

- Allocations made on a mass basis (not economic) of the metal in the co-products
  - Mining and beneficiation: total mass
  - Subsequent stages: mass of metal in the coproducts
- Wherever possible, allocations made by partitioning, and not substitution

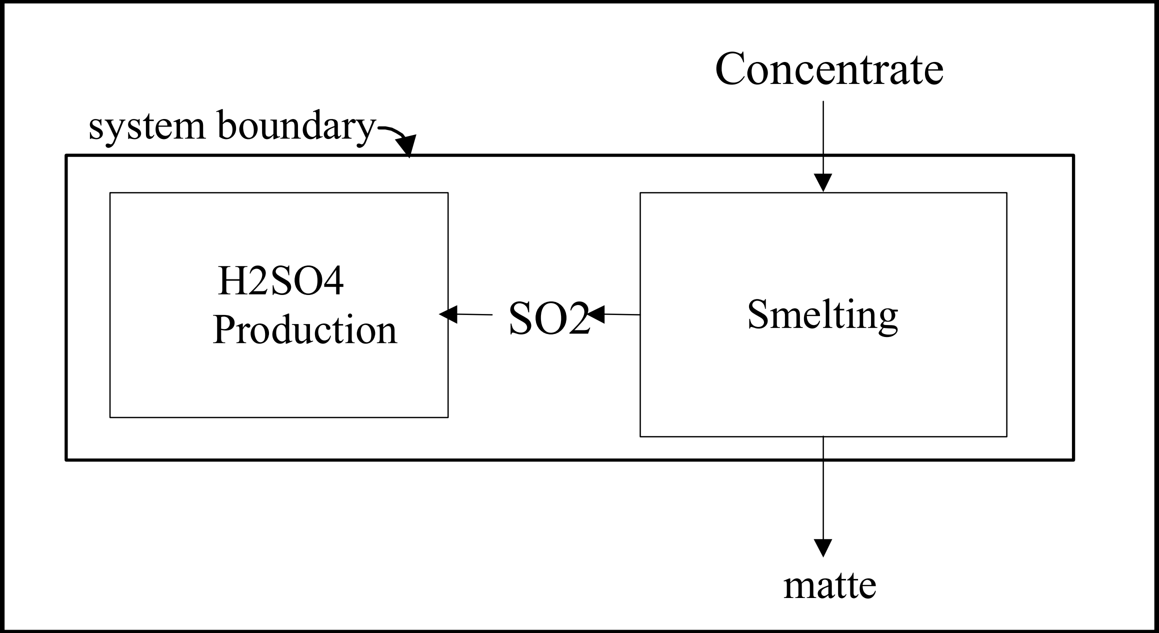
Metal Coproduct Allocation: Example



On a mass allocation based on metal content, the copper matte would take away 25% of the flows.

Non-Metal Coproduct Allocation: one method

28 Ni
29 Cu
82 Pb



- Acid production processes included in metal system
- Assumption: acid production is the control technology
- Conservative for metal system

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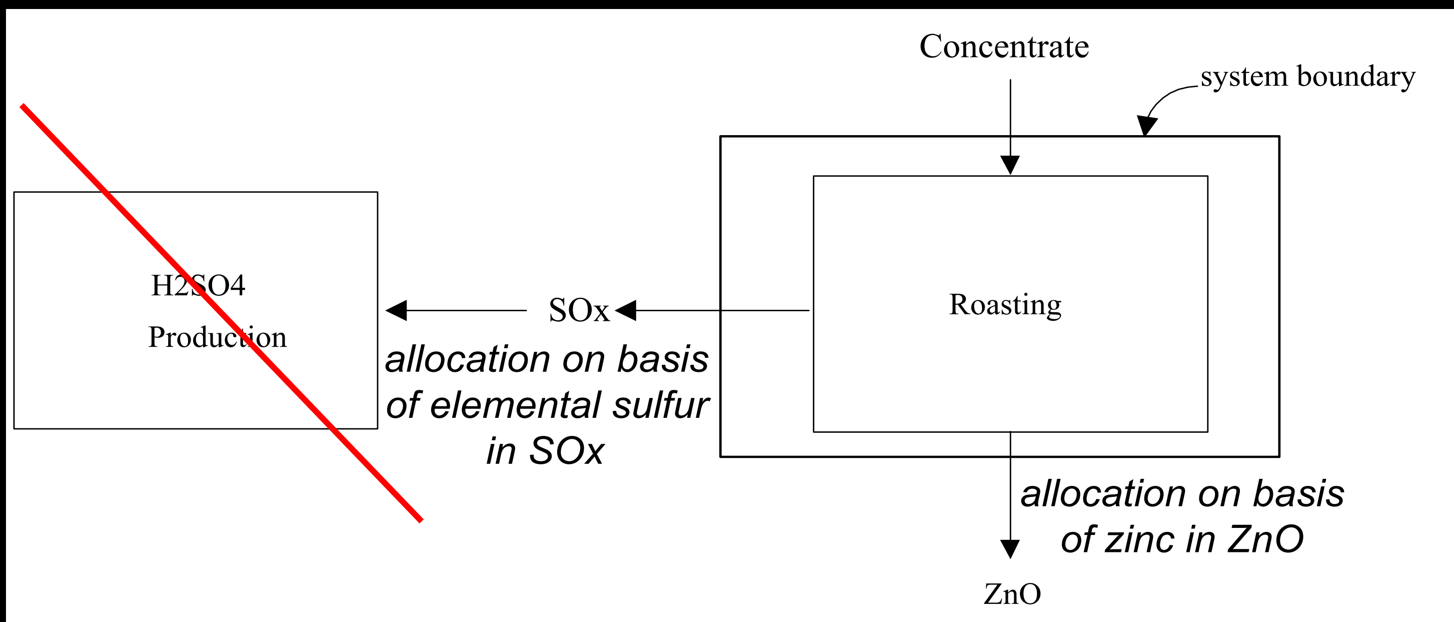
Non-Metal Coproduct Allocation: another method

30 Zn



- Allocation on elemental sulfur but do not include acid production
- Not as conservative for metal system

Treatment of Lack / Imperfect Data

- Tailings effluent modeling
  - 28 Ni 29 Cu – Simple model: effluents measured in a given year are assigned to that year's production, with no attempt made to account for the temporal aspects
  - 82 Pb – Complex model based on release of effluents for different periods over the life of the mine and after closure
- Missing data: unknown/lack of production data for metal-based inputs
  - Examples: Lead cake (82 Pb), "miscellaneous nickel inputs" (28 Ni)

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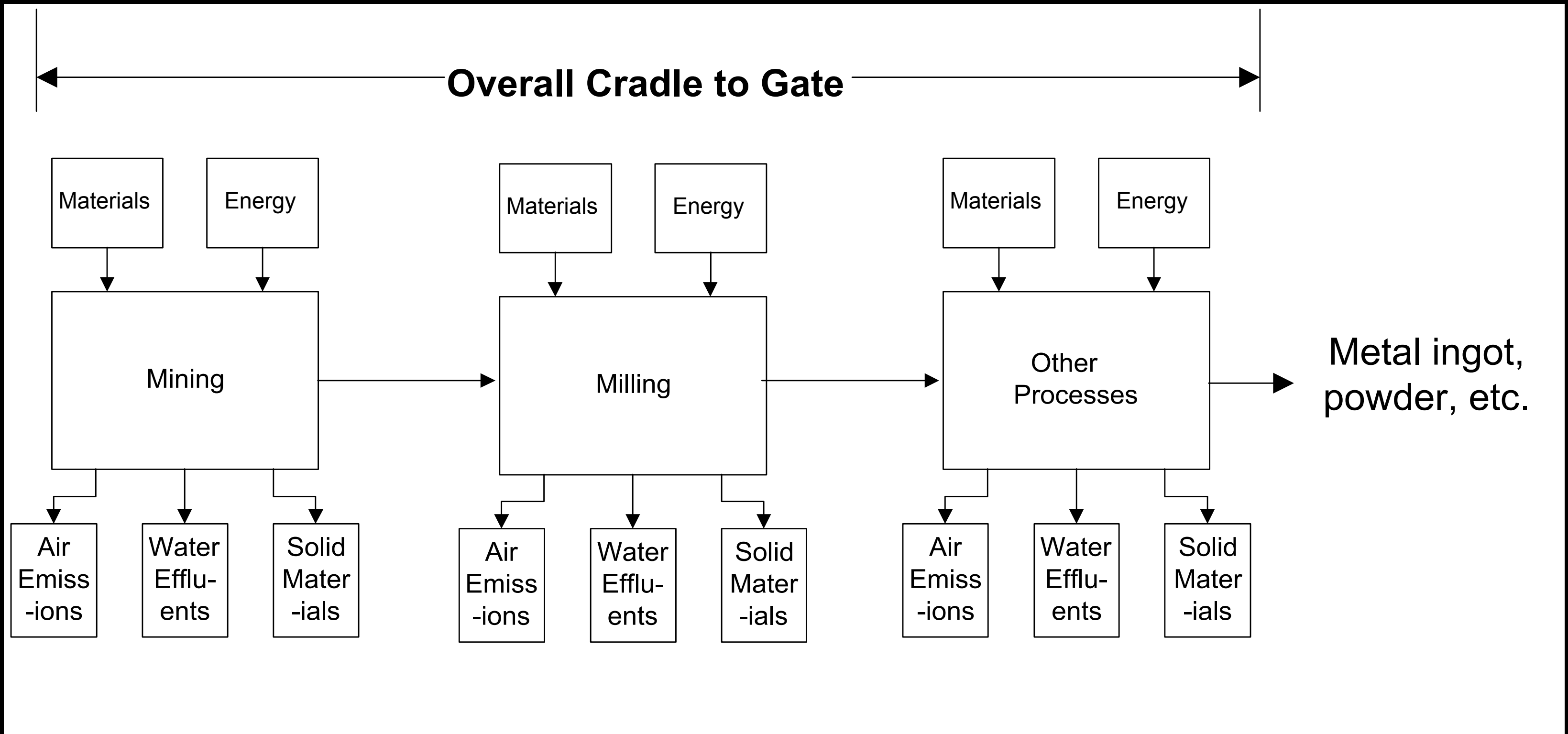
Results Reporting: Overall to More Detailed

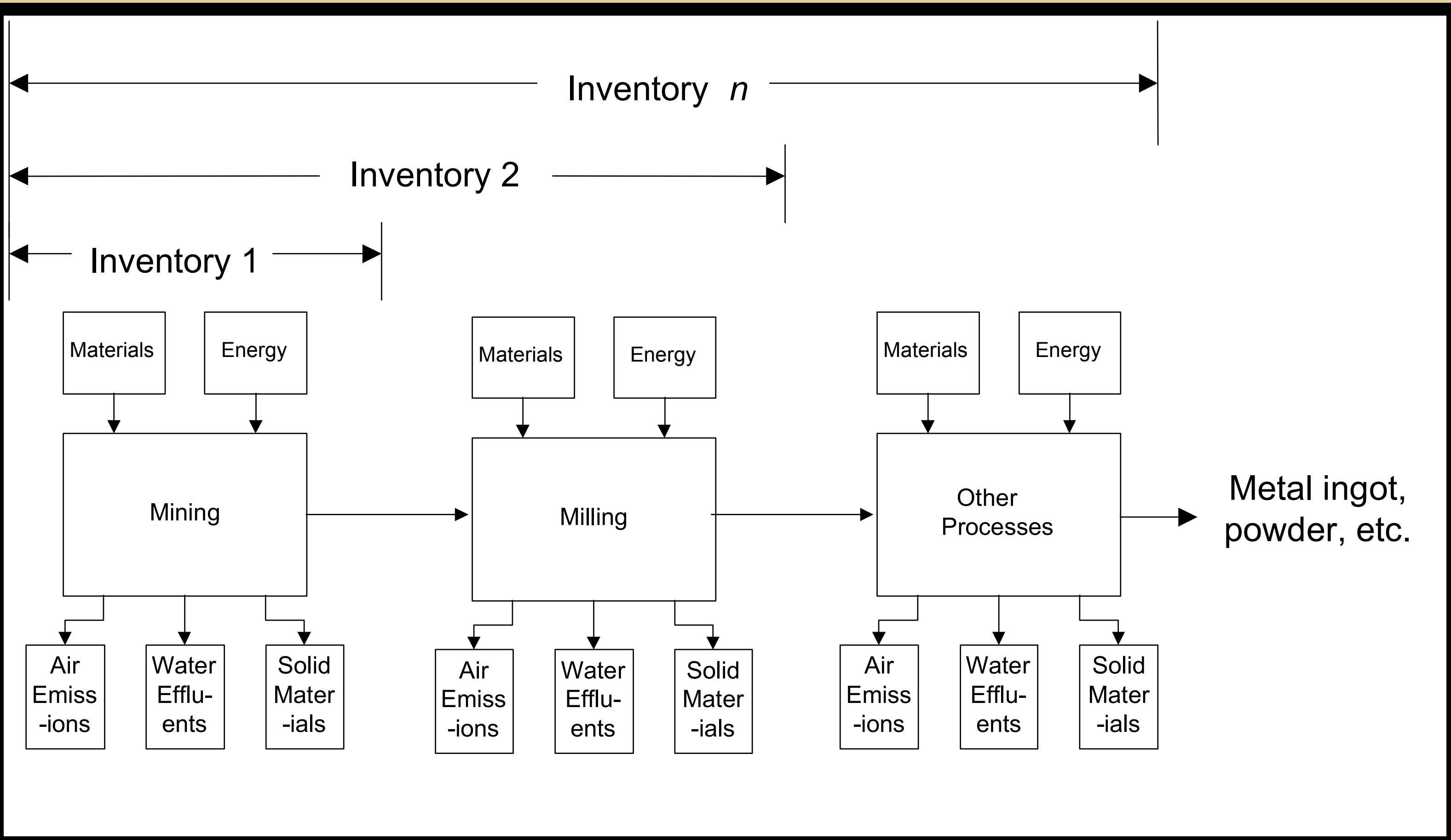
28 Ni
29 Cu
82 Pb



- Overall cradle-to-gate broken into % contribution of each unit process stage
- Additionally, gate-to-gate inventories presenting: plant emissions, electricity consumption, energy consumption, upstream materials, transportation

Results Reporting: Accumulation by Process

30
Zn



- Cradle-to-gate accumulations broken into fuel production, fuel use, biomass, transportation, and process

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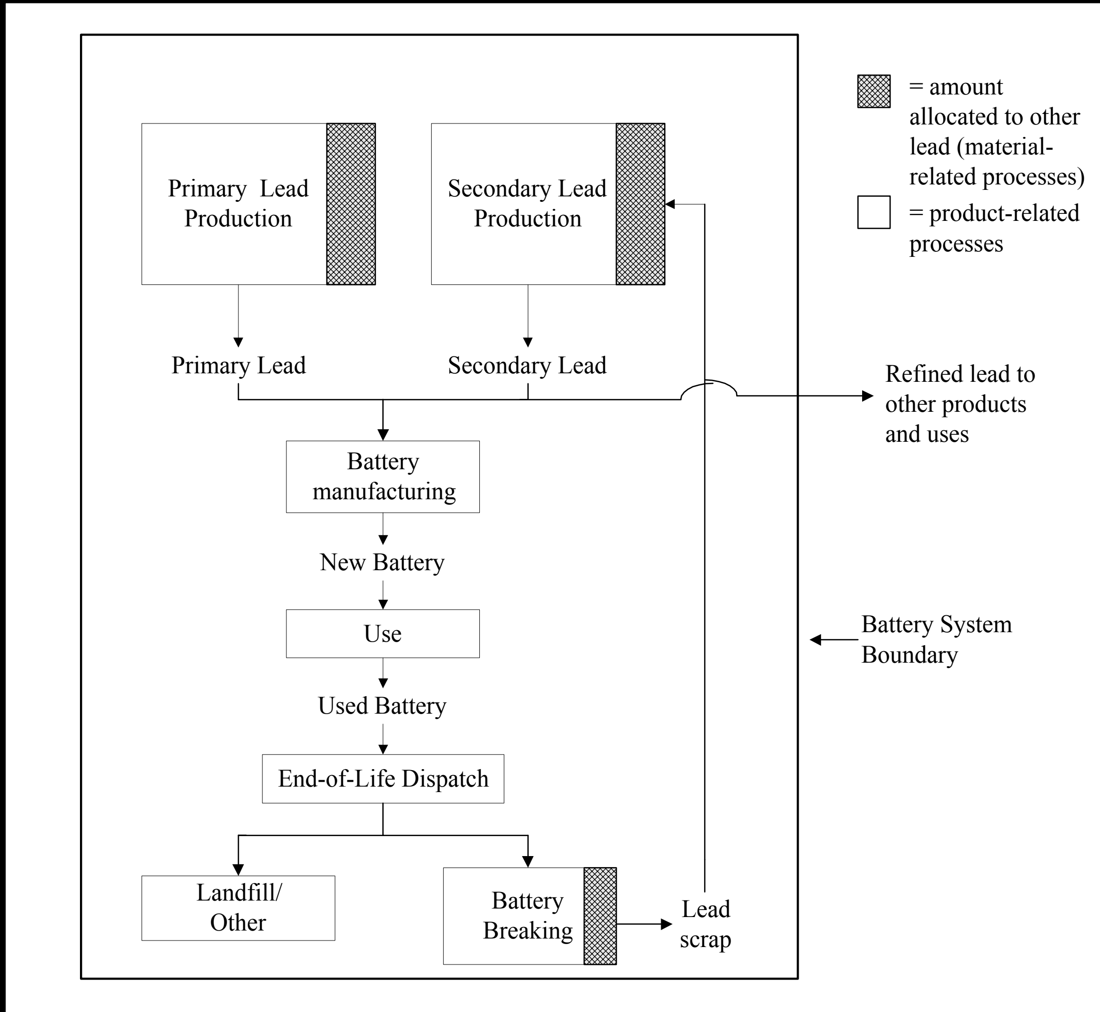
Accounting for Recycling (1/2)

82
Pb

- Product study to put into perspective the effects of recycling
- Several modeling considerations
  - What % of metal in a product is being recycled, what % of metal scrap is in the product
  - <u>Base of allocation</u>: what processes related to the product will be allocated (all processes or material-related)?
  - <u>Allocation factor</u>: Of those processes, what fraction will be allocated?

Accounting for Recycling (2/2)

82
Pb



Conclusions

- Largest discrepancies:
  - Data categories
  - Allocation
- Inconsistencies are tied to:
  - Different goals of study sponsors, industry priorities
  - Developing/evolving methodologies

- There should be a main consensus on methodology choices
- However, some study limitations need to be accepted, as:
  - There will always be some degree of inconsistency amongst individual studies
  - Data will never be “perfect”

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