

Pyrometallurgical Recycling Process Routes – Distribution analysis of valuable metals and the economic consequences

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Recycling of Lithium-Ion Batteries and their Economic Efficiency

Development trend of cathode material of LIB:
from LCO to mixed oxides to cobalt-free spinels and phosphates
→ **economic feasibility of recycling may become increasingly difficult because of lower valuable metals content**

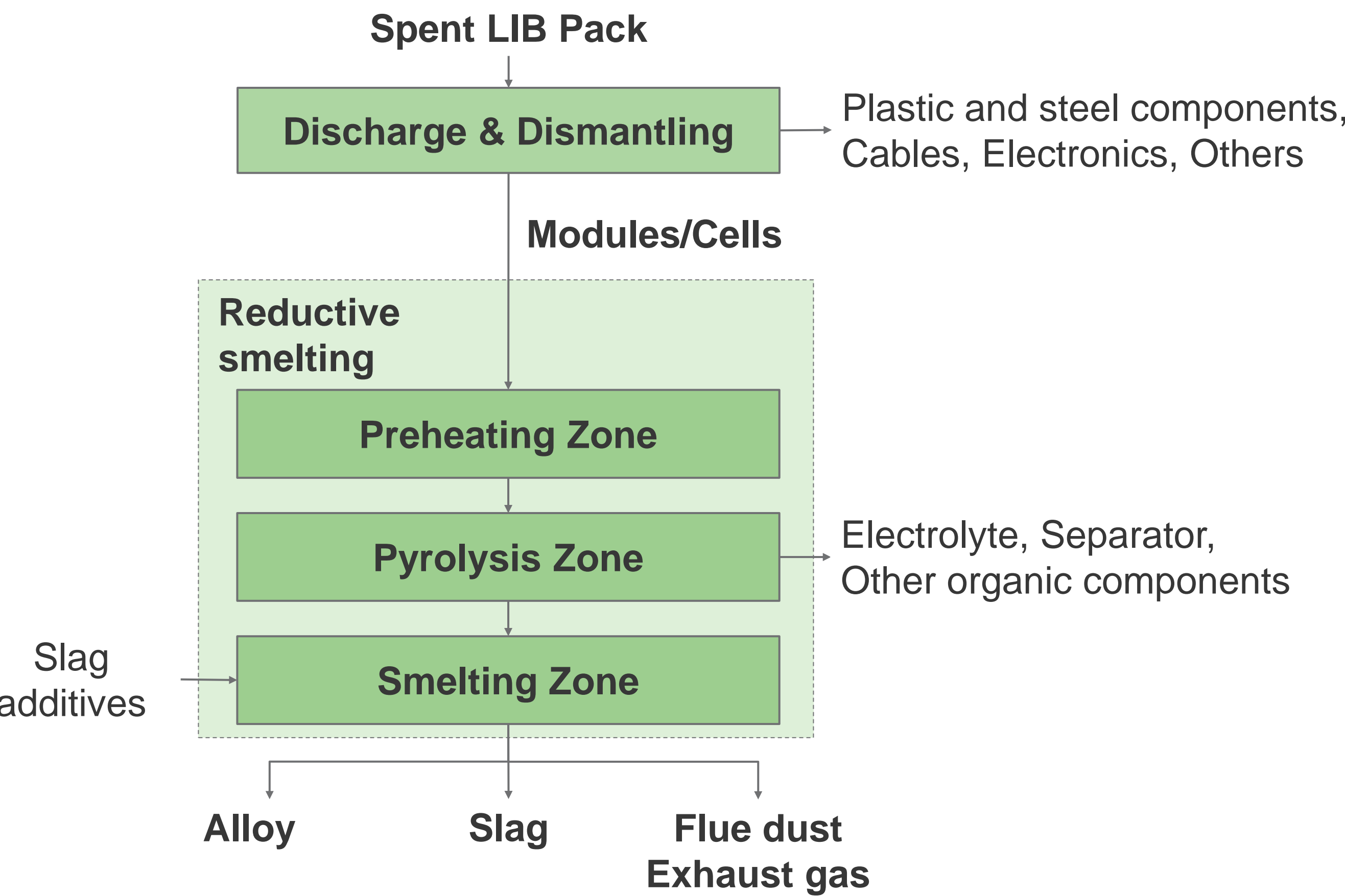
Considered Lithium-Ion Batteries

Fictitious modeling of the recycling of batteries mainly consisting of the following cell chemistries as feed in pyrometallurgical recycling processes

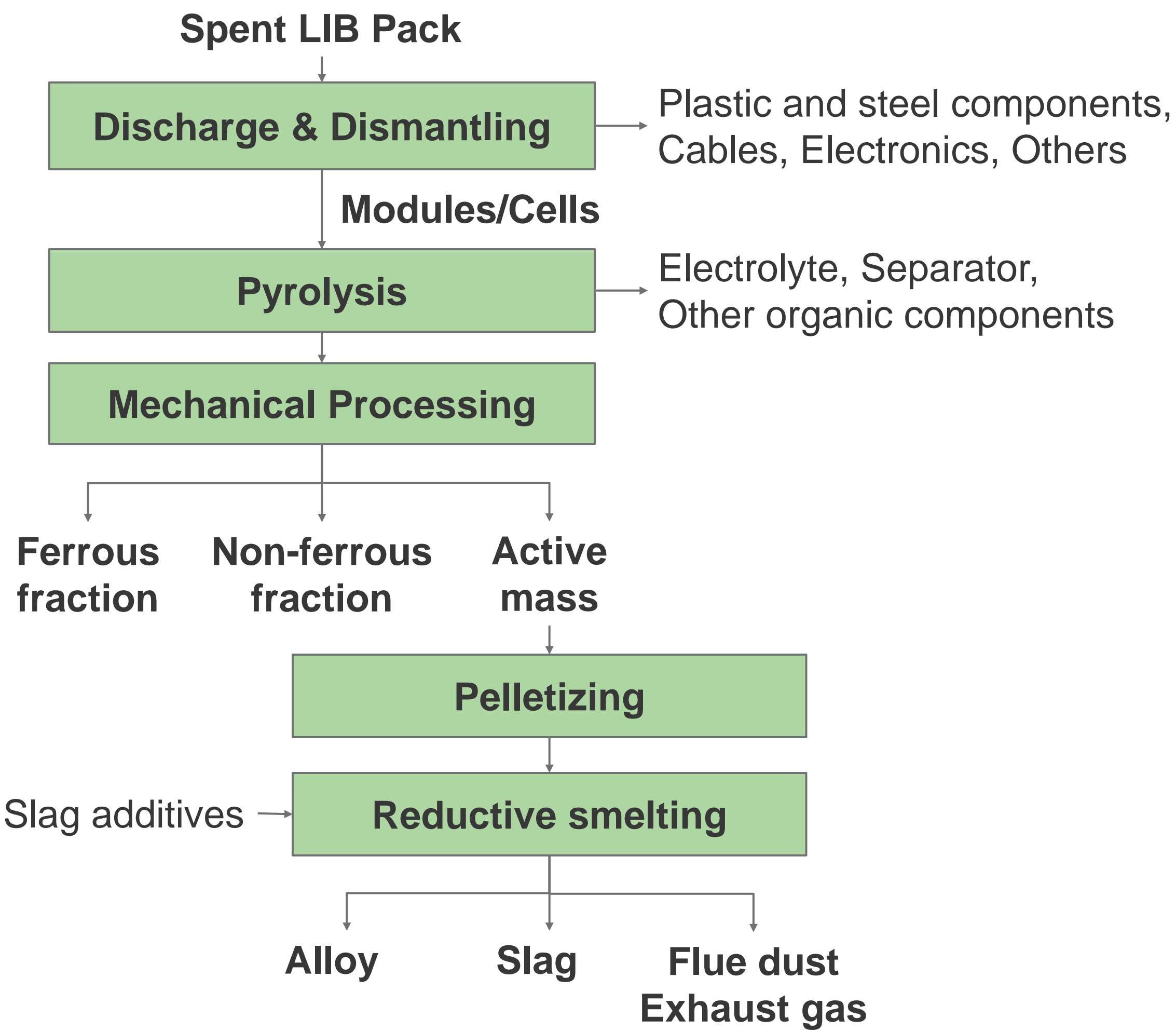


Considered Pyrometallurgical Recycling Process Routes

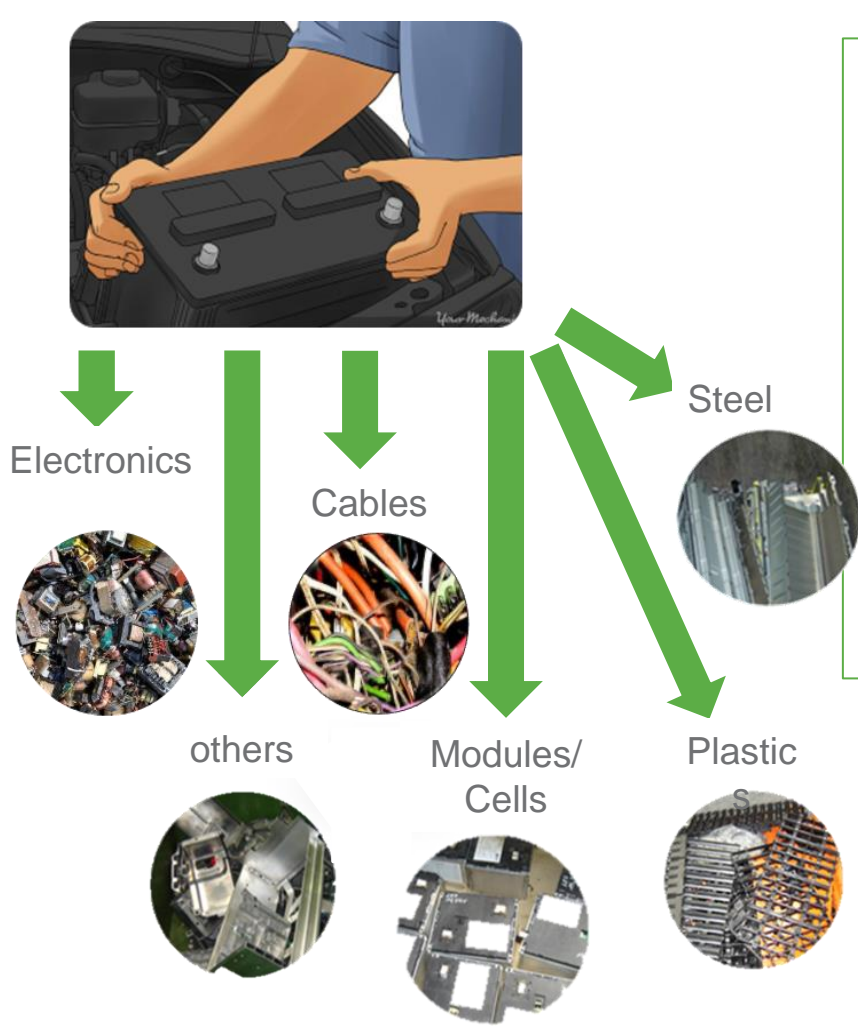
Direct



Multi-Step



Dismantling from Pack to Module/Cell Level



Obtained fractions not affected by treating different LIB cathode materials

Mechanical Processing of thermally treated LIB Cells

By utilizing different properties of the components contained in the material flow, concentrated fractions can be obtained in the Multi-Step recycling process, such as

- Ferrous Fraction (Fe)
- Non-ferrous Fraction (Cu, Al)
- Active mass



Smelting of Cells/Active mass

- Lithium, Graphite, Manganese, Aluminum are not recovered pyrometallurgically regardless the chosen process route

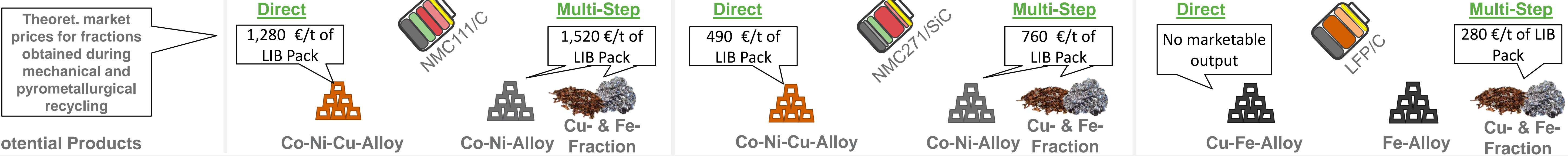
- Graphite as reductant
- Lithium, Aluminum and Manganese in slag

- Valuable Metals: Cobalt, Nickel, Copper



Potential Revenues from Recycling different Cathode Materials

- Calculation based on Input of one ton of LIB packs with different cathode material (idealized), market prices based on data from 2021
- Obtained fractions at dismantling not considered here → **not affected by different cathode materials**
- **Costs incurred during the recycling steps are not considered here**



Economic recycling of batteries is strongly dependent on respective cell chemistry → **disposer fee more important in future**

References

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