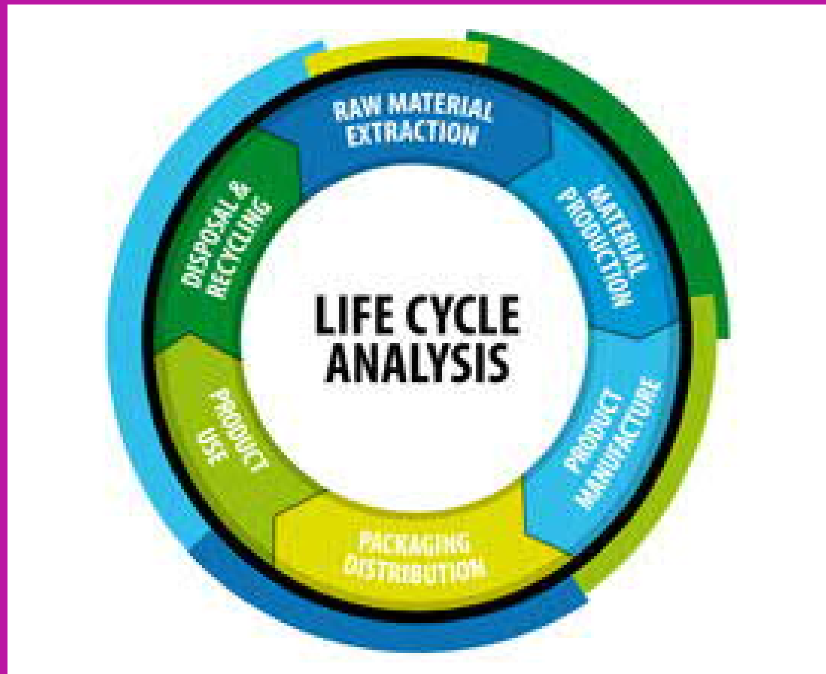
Module A2: LCA and Recycling

AAE-E3120 Circular Economy for Energy Storage

Prof. Annukka Santasalo-Aarnio



http://www.nibe.org/en/services-and-products/research/LifeCycleAssessment

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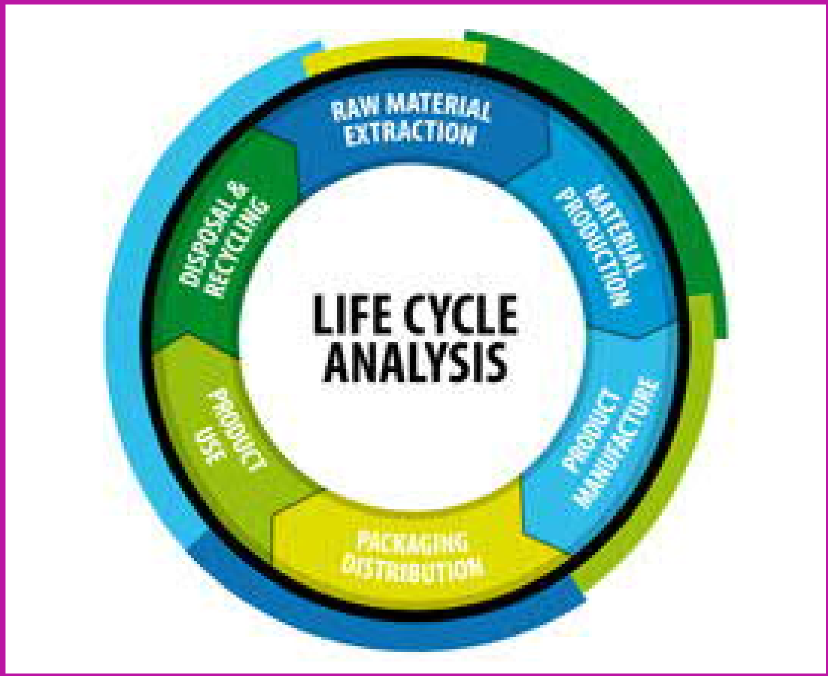
Learning outcomes

- **Identify circular economy concepts and the role of energy in recycling**
  - Introduction to Life Cycle Assesment
  - Introduction to Recycling processes

- **Recognition of the challenge in recycling of multicomponent materials**

Life Cycle Assessment (LCA)



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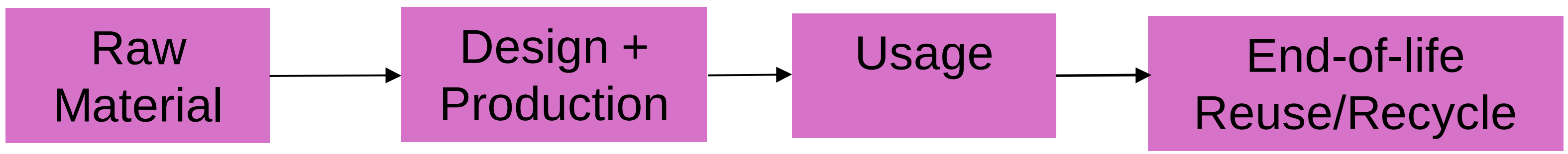
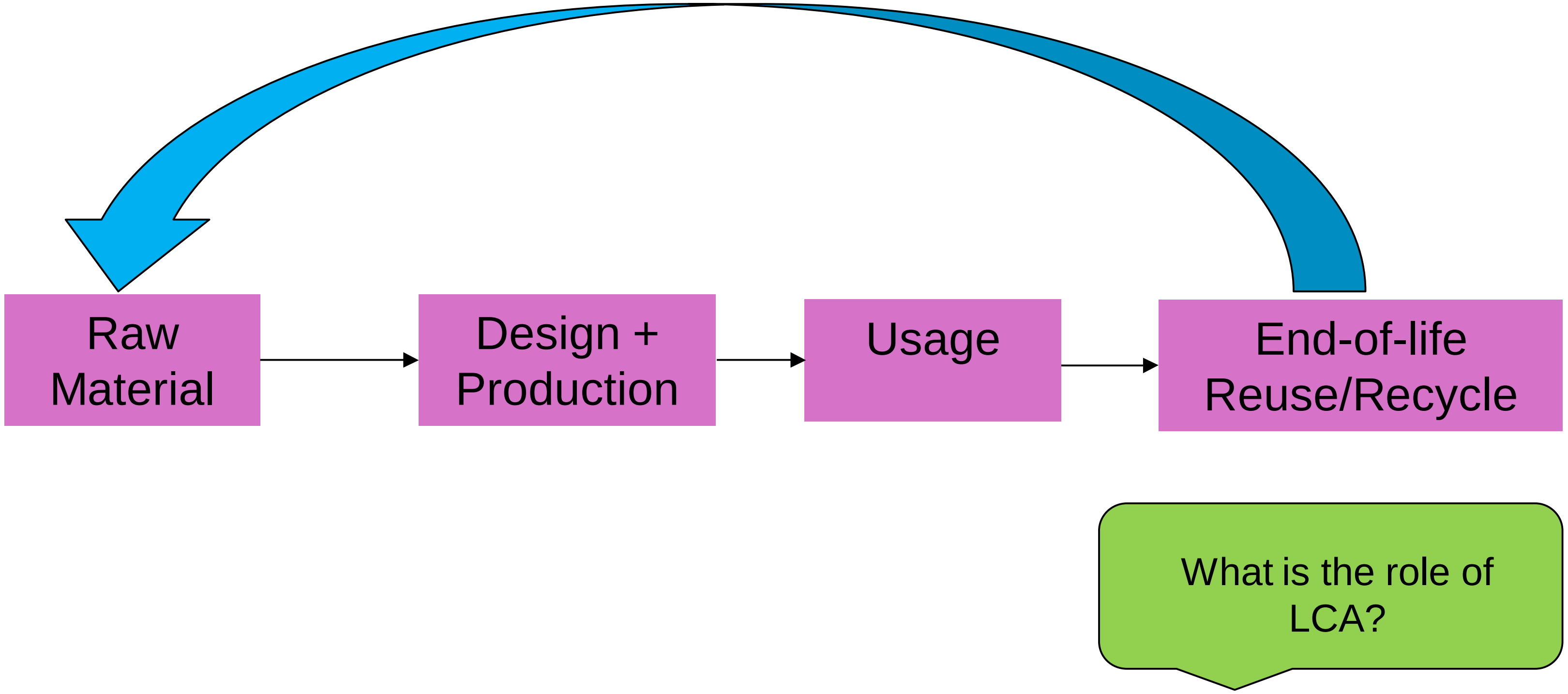
Product development



Product development to CE



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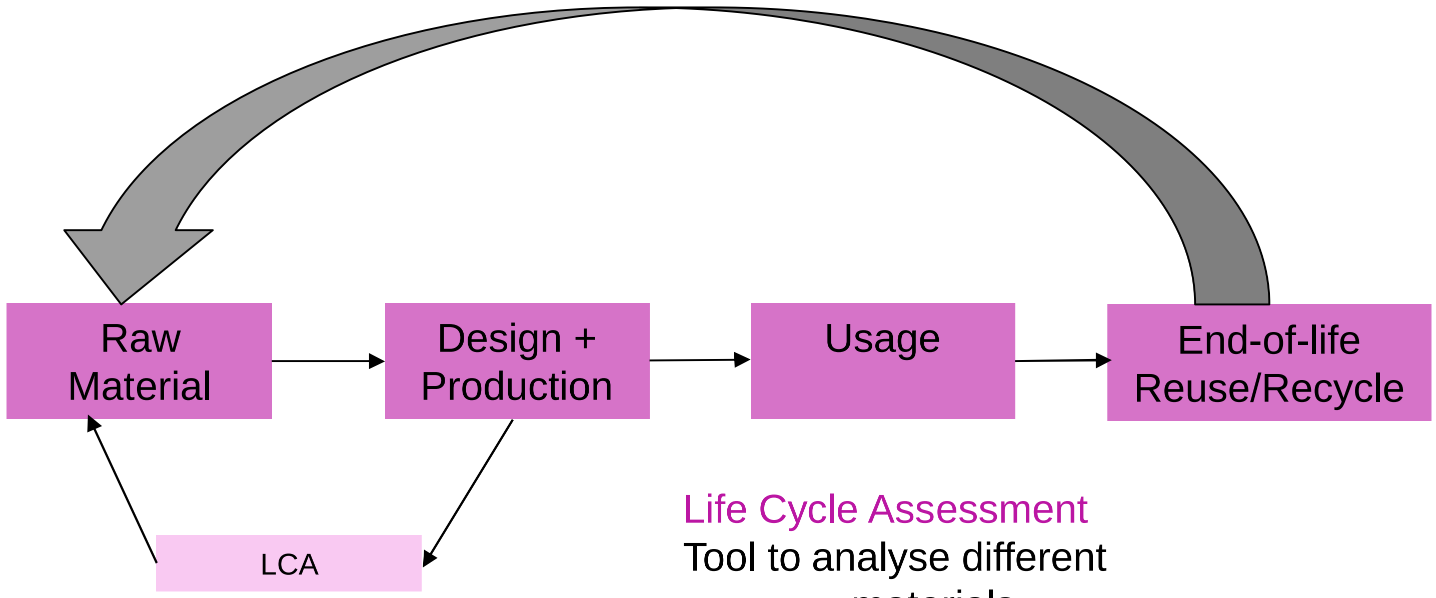
Role of Life Cycle Assessment



Life Cycle Assessment
Tool to analyse different
- materials
- preparation methods

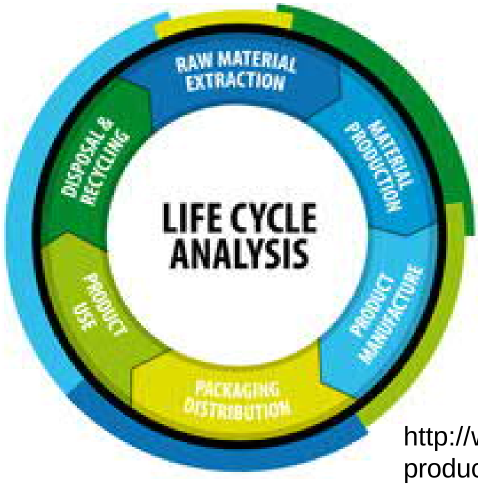
Life Cycle Assessment/analysis

Objective

“to understand the environmental impact

of a product over its lifetime”

ISO14040 guidelines



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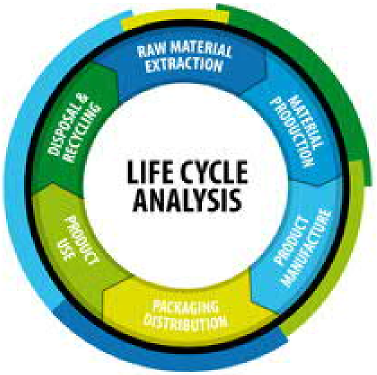
LCA: Can Reveal



Can reveal:

What is the largest energy sink

Where does the largest impact to environment come from?

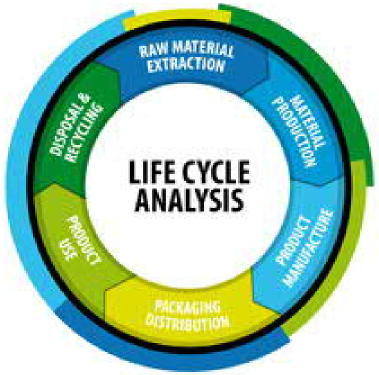
Which material production method has lowest consumption energy/smallest footprint to environment?

What is the effect on packaging/transport

Product use

Disposal and recycling

LCA: Results



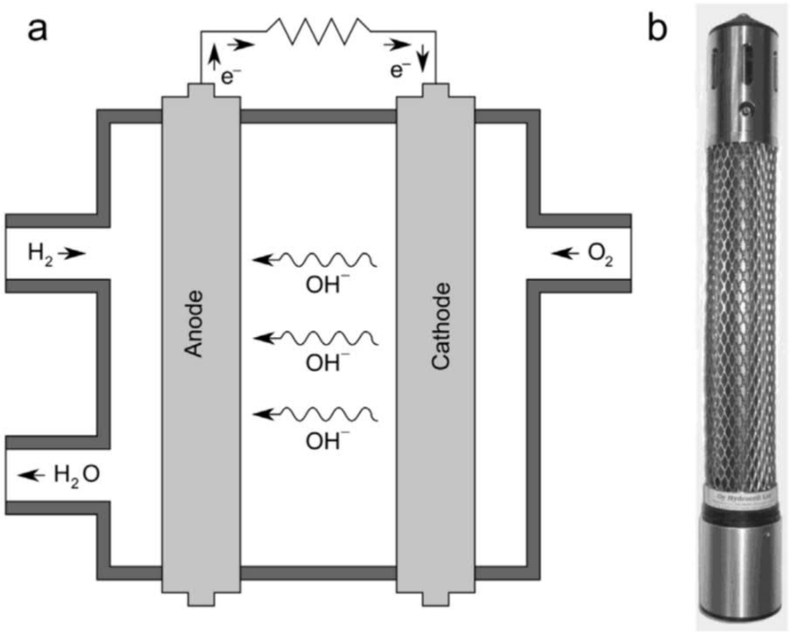
Answer can be

Comparison of different index

- Energy consumption
- Global Warm Potential (GWP) [CO_2 emissions]
- Acidification Potential (AP)
- Human toxicity (cancer)
- Eutrification potential (EP)
- Photochemical ozone creation potential (POCP)

M. Reuter, Int J Life Cycle Asses (2015) , DOI 10.1007/s11367-015-0860-4
Copper production with two different refining methods.

LCA: Case Alkaline Fuel Cell



Catalyst options for anode:
- Pt
- Raney Ni (Gas atomized)
- Raney Ni (Cast & Crush)

Which material has the largest effect on environment? Provide reasoning.

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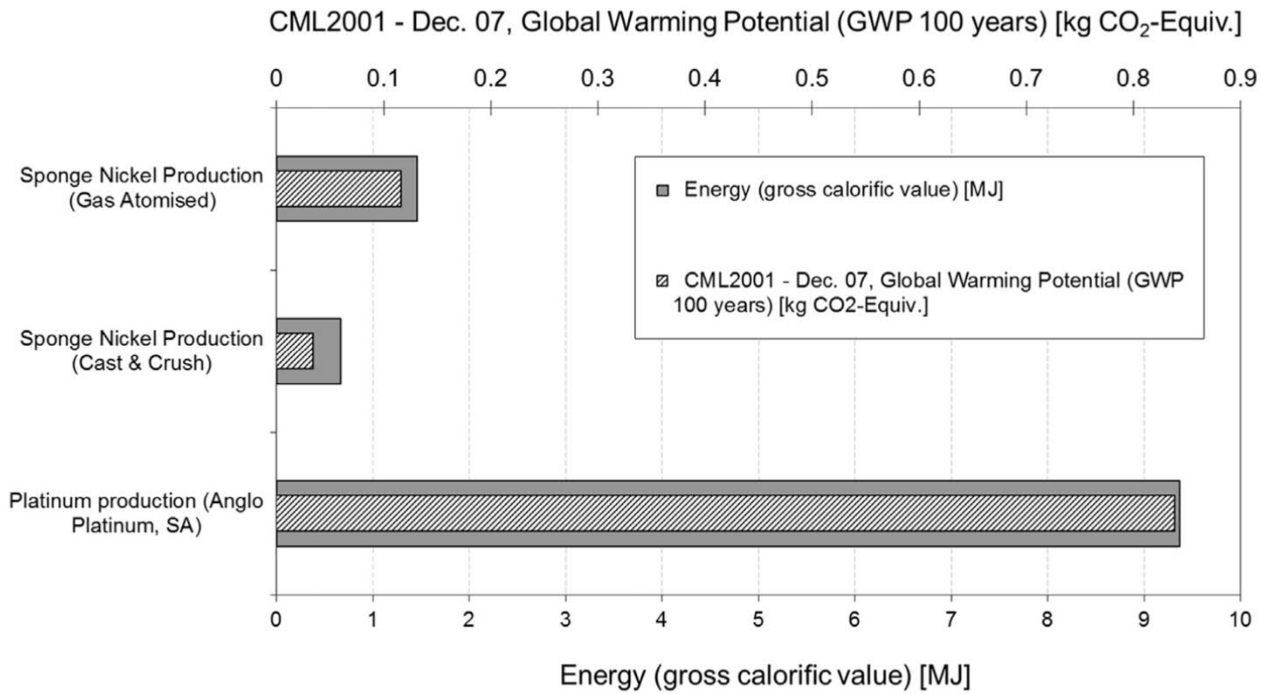
B.P. Wilson et al. / Journal of Power Sources 243 (2013) 242-252

LCA: Case Alkaline Fuel Cell



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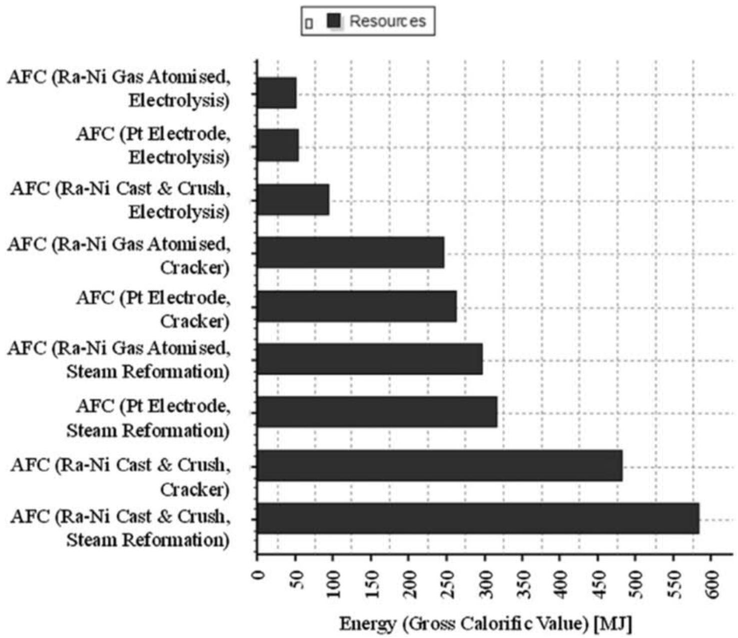
B.P. Wilson et al. / Journal of Power Sources 243 (2013) 242-252

LCA: Case Alkaline Fuel Cell

Overall energy required during the whole lifetime of AFC
Effect on the hydrogen production?

- Electrolysis
- Hydrocarbon cracking
- Steam reforming



Note:
-Gas atomised Ra-Ni had higher durability in AFM lifetime!
-> decreases energy required

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LCA: Case Polymers

Polymer component are used almost in all applications

- PLA (polylactide), biobased polymer

www.technologystudent.com

www.corporatevending.com

- PP (polypropane), oil based polymer

Reflect to your lecture journal

Which one has the lowest effect on environment? Provide reasoning.

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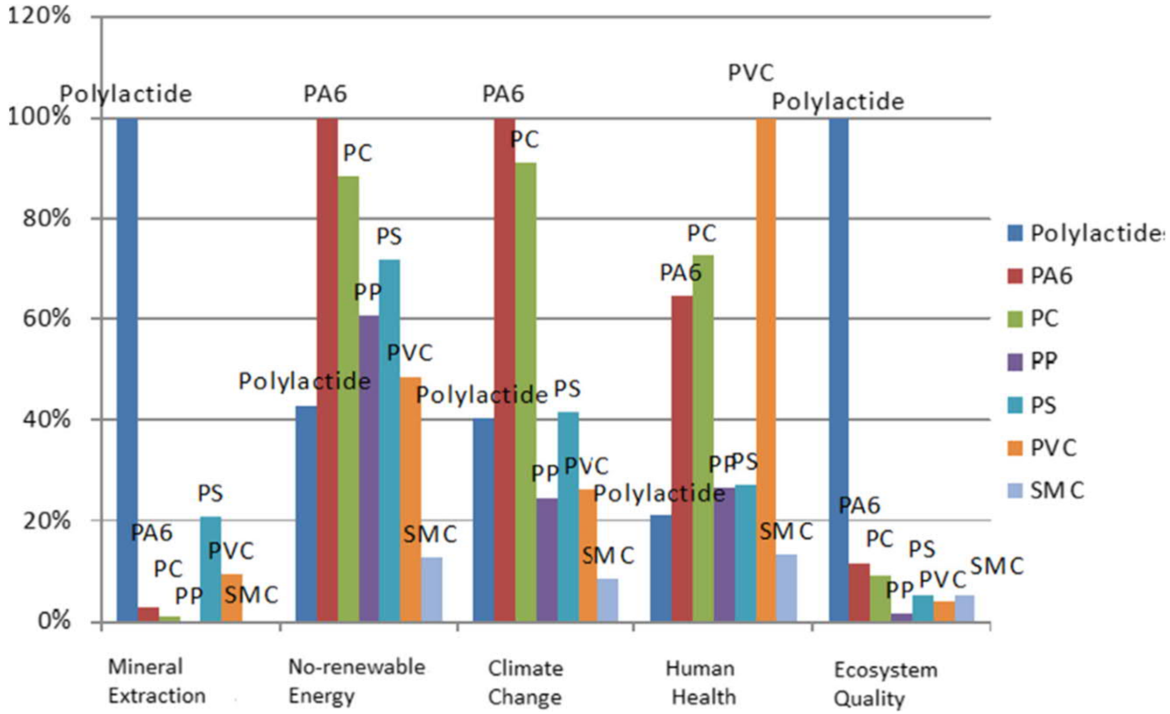
LCA: Case Polymers



Different polymers have different **ecological challenges**

H. Warrel, M.A. Reuter, *Handbook of Recycling*, Chapter 27.

Mechanical Recycling
“The clean business”

WEE shrered waste – image by Suvi Airola

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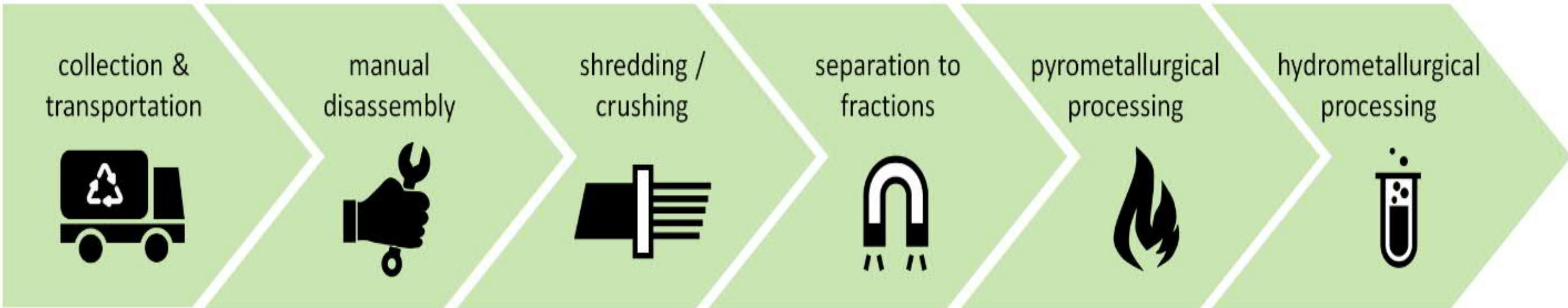
Challenges in multicomponent Recycling

- Cup
- Spoon
- Coffee
- Water
- Milk
- Sugar

How would you separate these components?

Example by Prof. Markus Reuter, Helmholtz institute

The path of Recycling for Energy Storage Systems



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K. Miettunen, A. Santasalo-Aarnio, “Eco-design for dye solar cells: from hazardous waste to profitable recovery” J. Cleaner Production. Submitted

What is mechanical recycling?

Reflect to your lecture journal

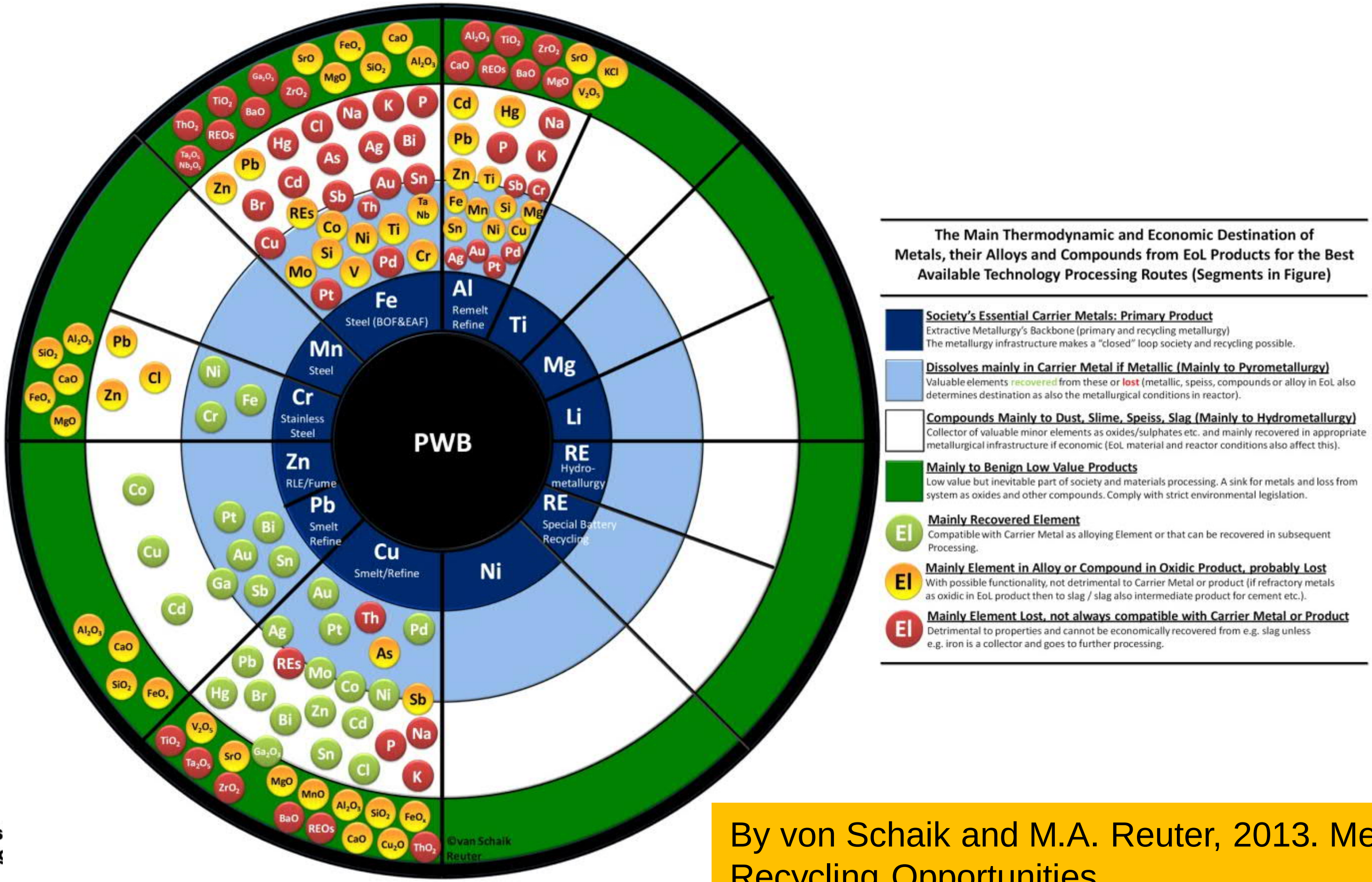
Did this reflect to your idea what metal's recycling process might be? If not – what was your initial impression?

Video link available at Course pages

HOW IT WORKS - Computer Recycling

– Youtube: https://www.youtube.com/watch?v=zU62hh3DBfg

The metal wheel



By von Schaik and M.A. Reuter, 2013. Metal Recycling Opportunities.

Challenge in recycling

- We discuss End of Life conditions
- Must be economically viable (business/legislation)
- Needs large volumes

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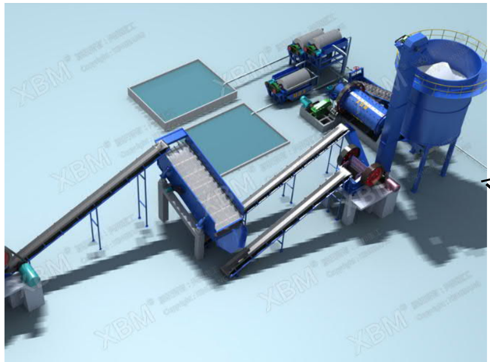
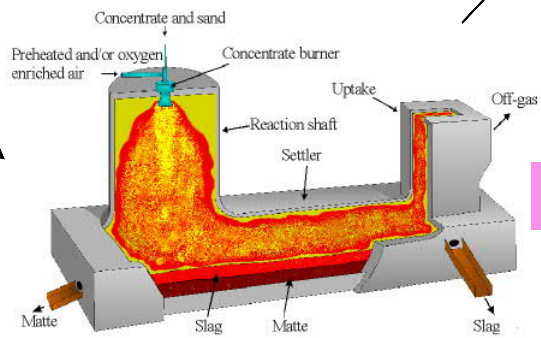
Photos of Severi Ojanen at MeTYK-project 2017

Recycling Processes

Mechanical separation



Hydrometallurgy



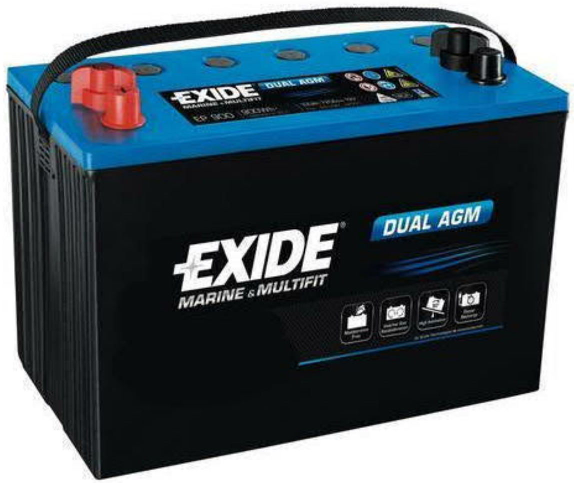
Pyrometallurgy

www.totalmateria.com

Example: Lead Acid battery recycling

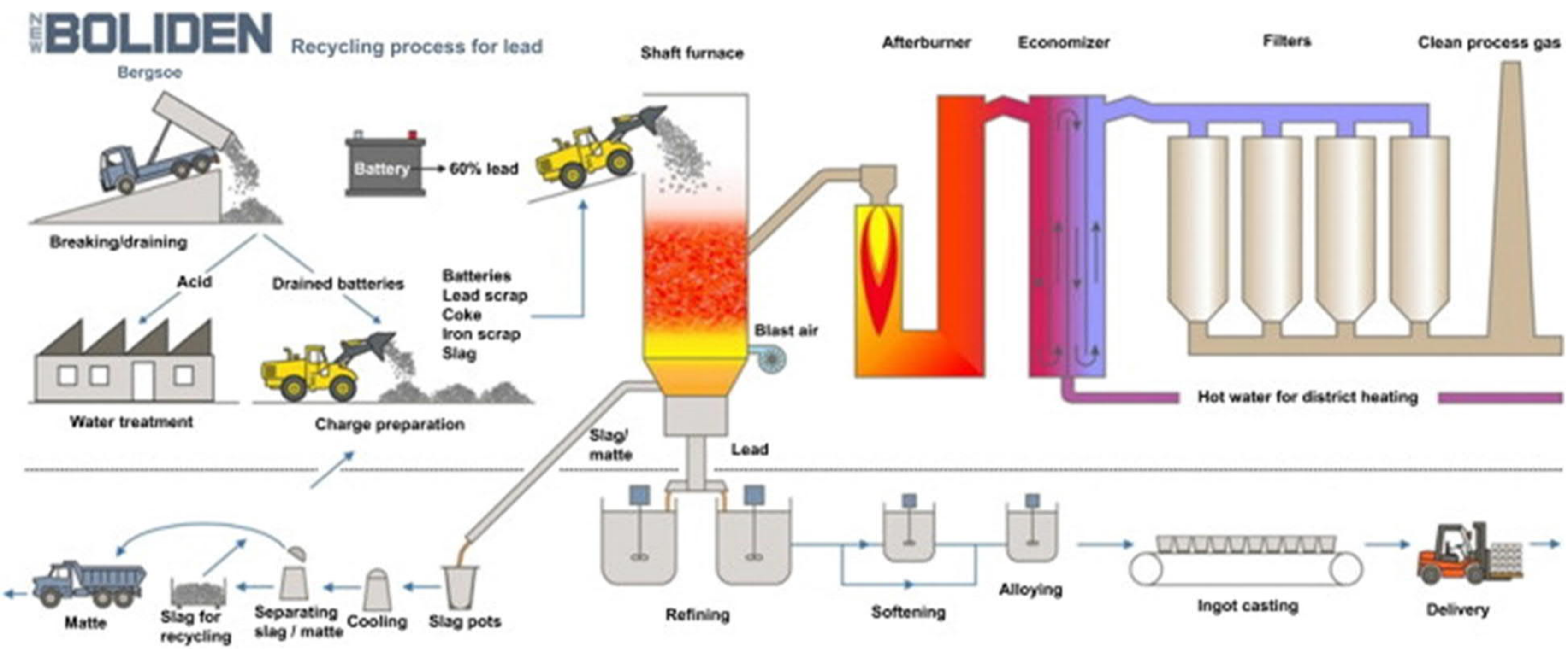
- Well working system
- Commercially feasible

- **Simple energy system**:
  1. Lead electrodes
  2. Sulphuric acid electrolyte
  3. Plastic casing



Indiamart.com

Example: Lead Acid battery recycling



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Eco-Design

How do we address the challenges of

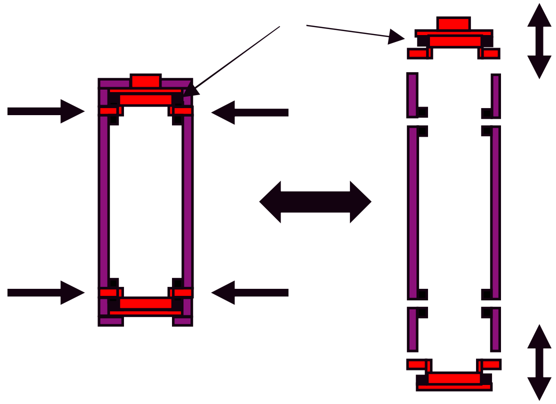
Recycling multimaterial systems

-> This needs to be done at the

Design level of these systems

How to apply this for

Energy storage systems?



Eco-design Li-ion battery
Innovation at
Materials for Renewable Energy
course by students 2017

Take a home message

“Multimaterial component system recycling is challenging IF this was not taken into account at the design phase.”

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