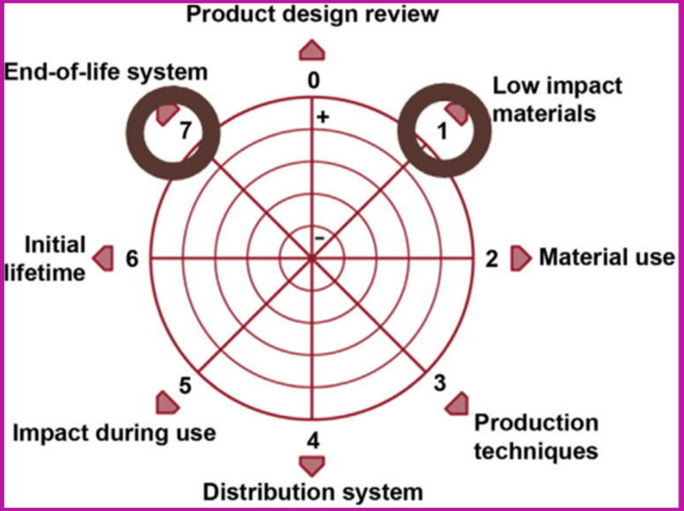
Module D1: Material availability _ and Eco-Design

AAE-E3120 Circular Economy for Energy Storage



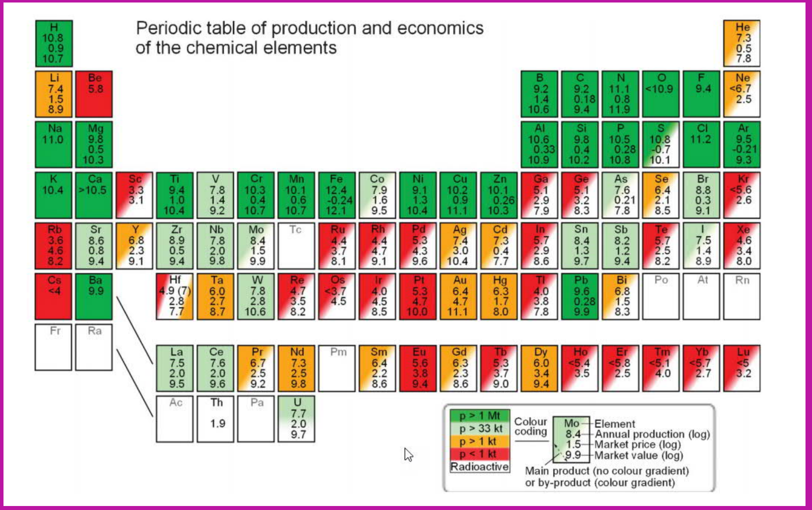
Prof. Annukka Santasalo-Aarnio

Aalto University
School of Engineering

Learning outcomes

- **Develop new design for recycling approach for energy storage application and justify with scientific argumentation**
    - Material availability (Vesburg analysis)
    - Secondary raw material – what is their value
    - Introduction of Eco-design as a concept

Material availability VESBORG analysis



P. Vesborg et al. RSC Advances, 2012, 2, 7933–7947DOI: 10.1039/c2ra20839c

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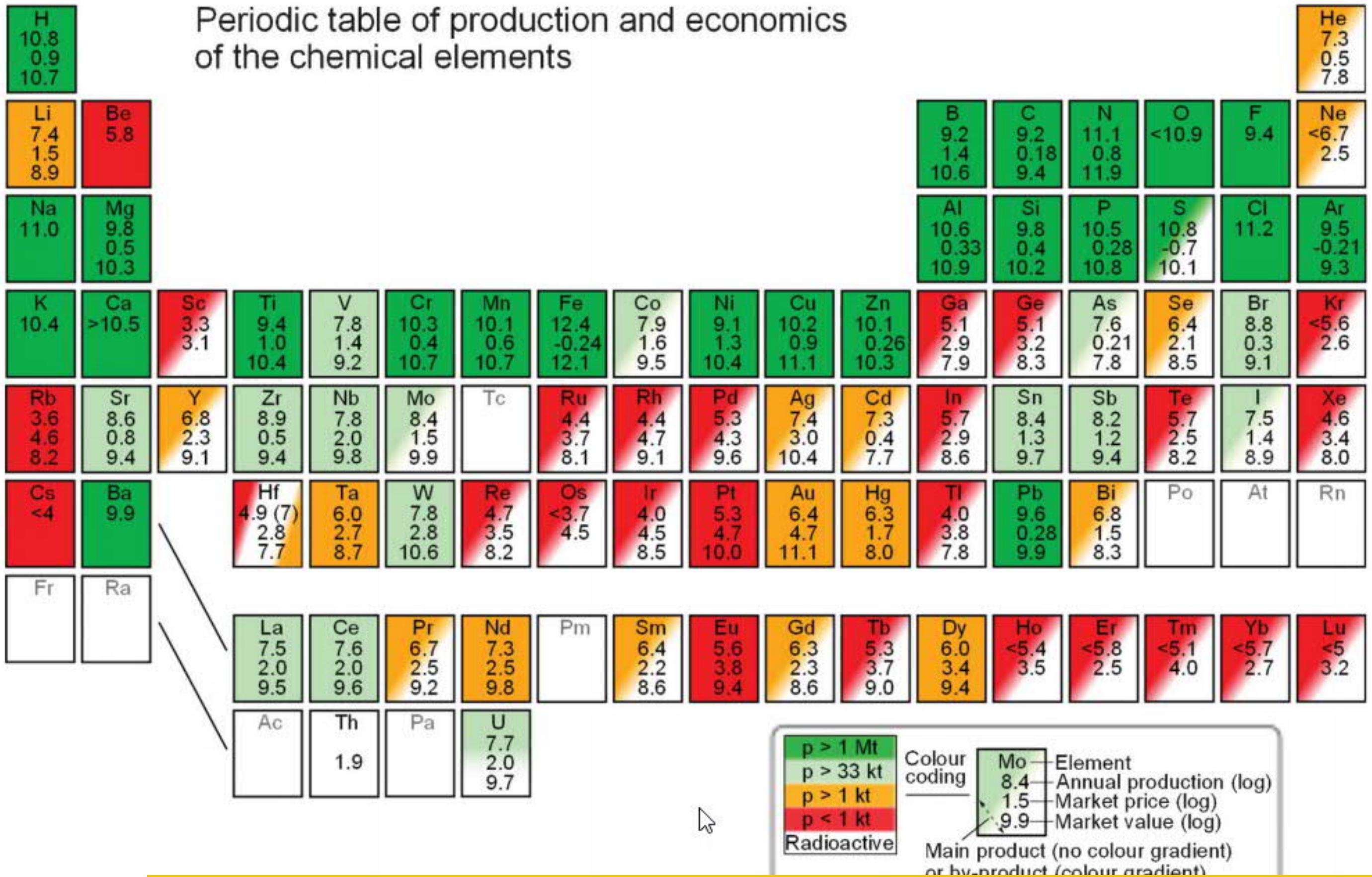
Element availability



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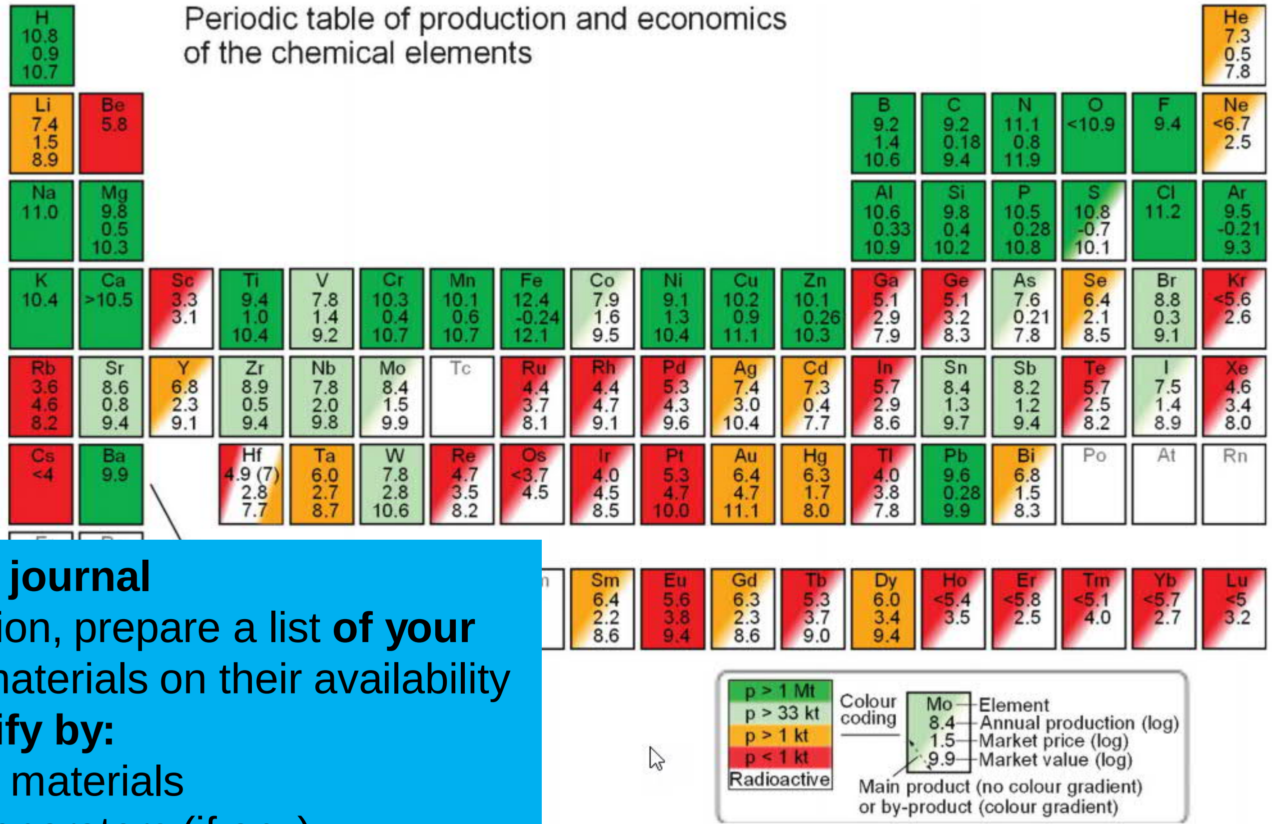
Element availability



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Using Vesborg classification, prepare a list **of your application's** state-of-art materials on their availability

Classify by:

1) Active materials
2) Electrolyte/separators (if any)
3) Supportive materials

P. Vesborg et al. RSC Advances, 2012, 2, 7933–7947DOI: 10.1039/c2ra20839c

Element availability

Active materials:

Most critical elements use in theses

Separators/electrolytes:

Some of them are critical, some rare, some common

Support materials:

Normally more common

What are the most challenging elements in

YOUR application

-> is it possible to replace them with some others?

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Secondary raw materials (value after recycling)

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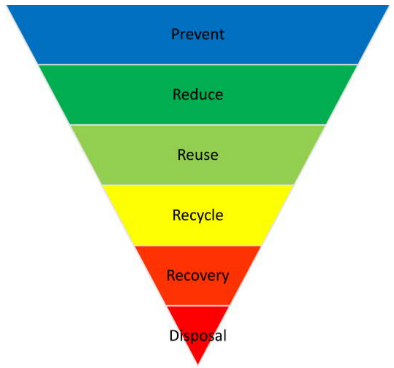
Secondary materials (recycled) – can they be used in high demand applications?

- Material demand for **HIGH activity and Durability**

- Must maintain mechanical and chemical properties
  - During use
  - During dismantling and recycling process



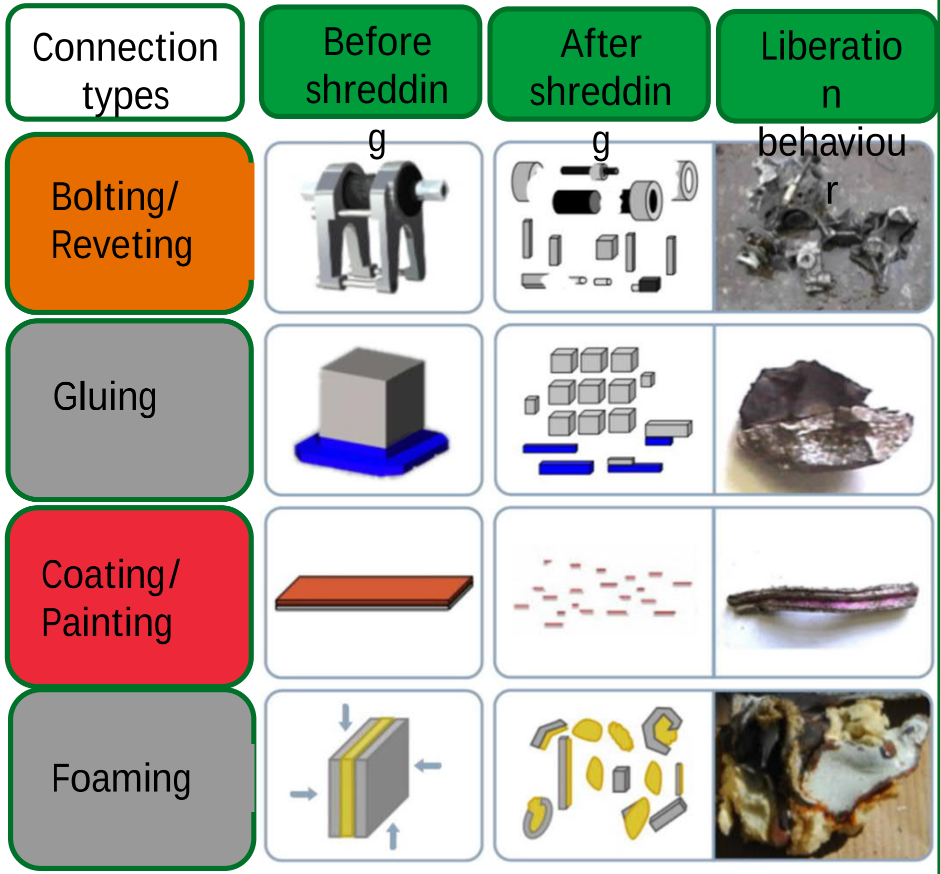
- Can not lower the Lifetime of the system
  - No point of preparing high energy intensive application for lower lifetime

Secondary materials (recycled) – can they be used in high demand applications?

- Secondary raw materials (recycled)
  - Currently used in less demanding application
  - Can they be used solely or mixture with virgin materials?
  - Impurities? What level of purity is required?
  - Durability issues?
    - Research still needs to be prepared in real application and in their performance (for long time)
    - Proof of concept case, so that the manufacturers will be able to take these into their applications

Material Liberation

Reuter, M.A.; Hudson, C.; van Schaik, A.; Heiskanen, K.; Meskers, C. & Hagelüken, C. 2013. UNEP Metal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International. United Nations Environment Programme. 320 s. ISBN: 978-92-807-3267-2.



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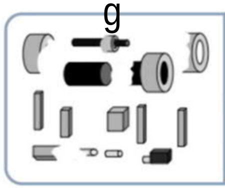
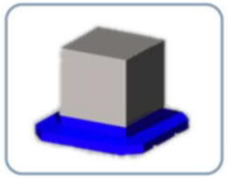
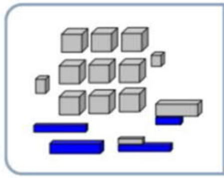
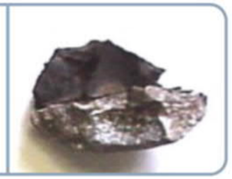
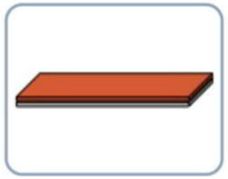
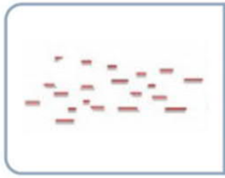
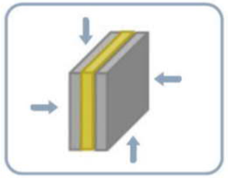
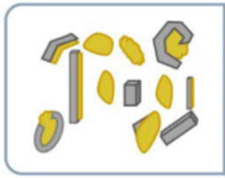
How easy are these different liberation steps?

Material Liberation

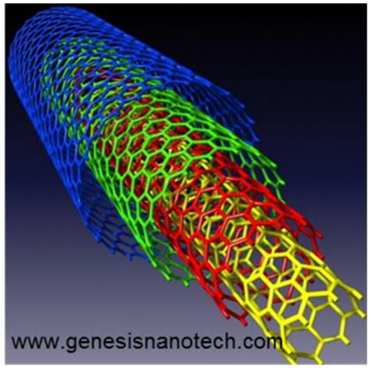
Reuter, M.A.; Hudson, C.; van Schaik, A.; Heiskanen, K.; Meskers, C. & Hagelüken, C. 2013. UNEP Metal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International. United Nations Environment Programme. 320 s. ISBN: 978-92-807-3267-2.

Connection types	Before shredding	After shredding	Liberation behaviour	
Bolting/ Reveting				High liberation High randomness
Gluing				Medium liberation Medium randomness
Coating/ Painting				Low liberation
Foaming				Medium liberation Medium randomness

Secondary materials

NanoWaste

Utilization of **high activity nanomaterials**



-> What happened after their lifetime?

No studies done on how effect on environment (yet)?

No LCA possible (no data exist)

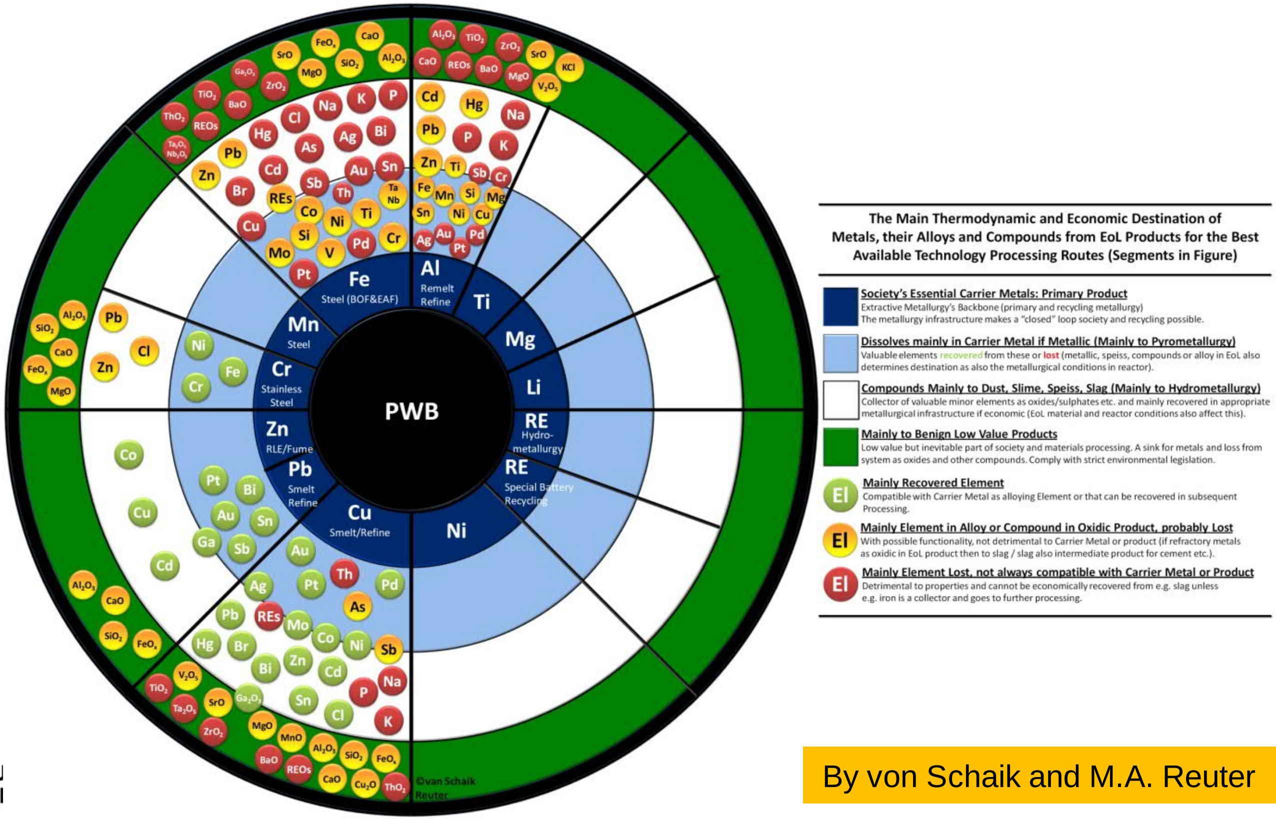
Only thing known that have some effects on human/animal health

Design for recycling

- EU legislation
  - Design to facilitate proper disabling (coming)
  - Are we allow to use secondary components and materials in these applications?
- **What should be avoided:**
  - **Hybrid materials** (especially mixture of different material classes)
  - Especially **metal parts in plastics** (can not be recycled as plastics nor as metals)
  - **Black colour plastics** (can not be detected in plastic separation, at current technologies)

Design for recycling –

when combining metallic parts



By von Schaik and M.A. Reuter

Eco-Design
"Design for recycling"

WEE shrered waste – image by Suvi Airola

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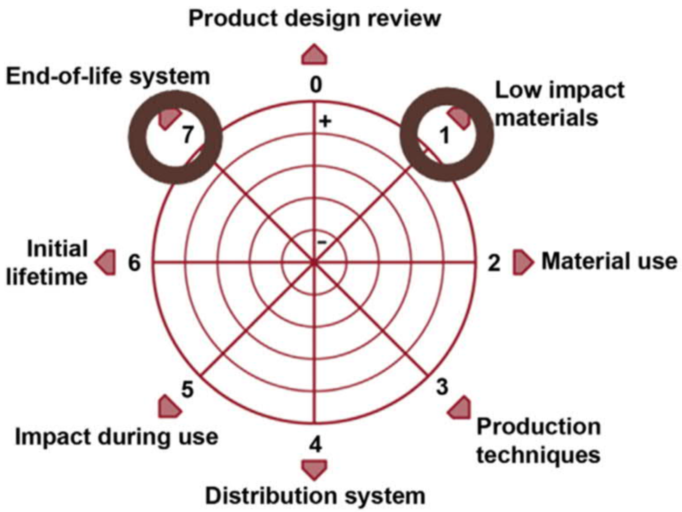
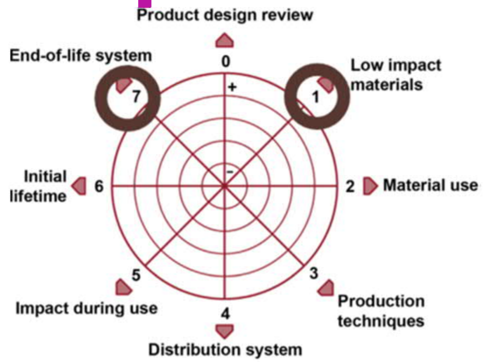
Eco-Design

- Eco-design (currently) is a design that take into consideration more ecological design at any part of the product life:

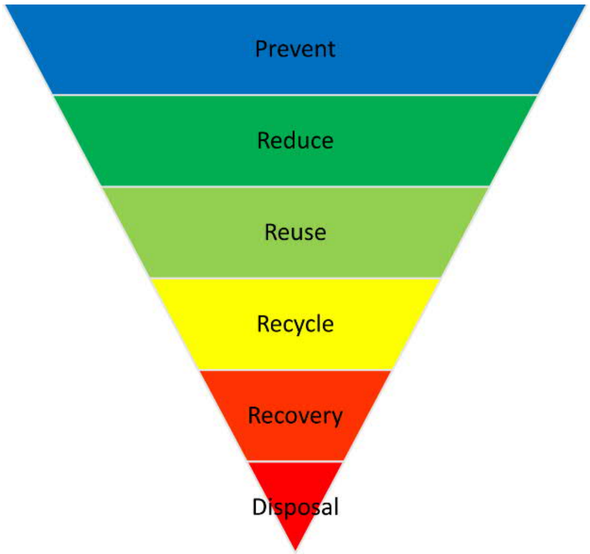


M.R.R.R Crul et al. (2009) Division of Technology, Industry and Economics.

Eco-Design – Product development



1) Prevent (use of any material)
2) Reduce (amount of materials)
3) Replace
   - Less environmental hazardous (Pb, Hg…)
   - Lower environmental footprint materials
   - Difficult to recycle (the metal wheel)
4) Reduce Complexity (hybrid materials)
5) Easy dismantling for recycling
6) Guidelines for dismantling



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Where can we use LCA?

Eco-Design – Product development

1) Prevent (use of any material)
2) Reduce (amount of materials)
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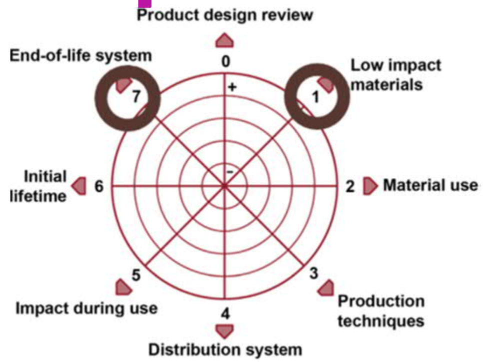
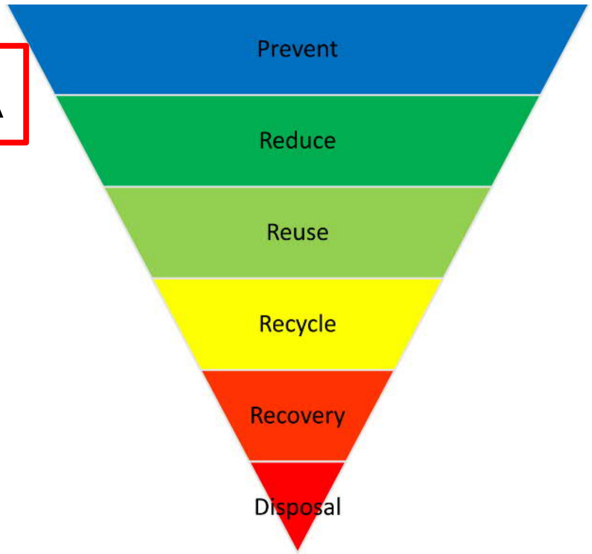
LCA





Eco-Design – In practise

How do we address the challenges of

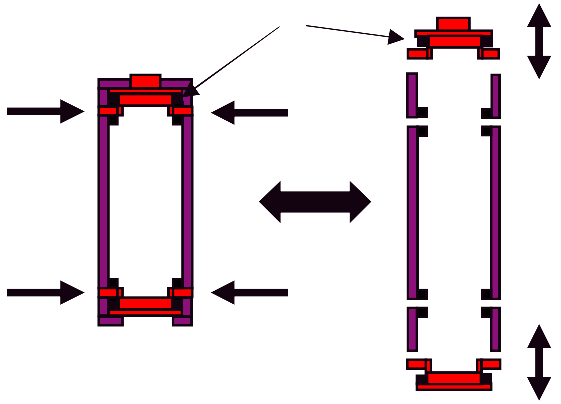
Recycling multimaterial systems

-> This needs to be done at the

Design level of these systems

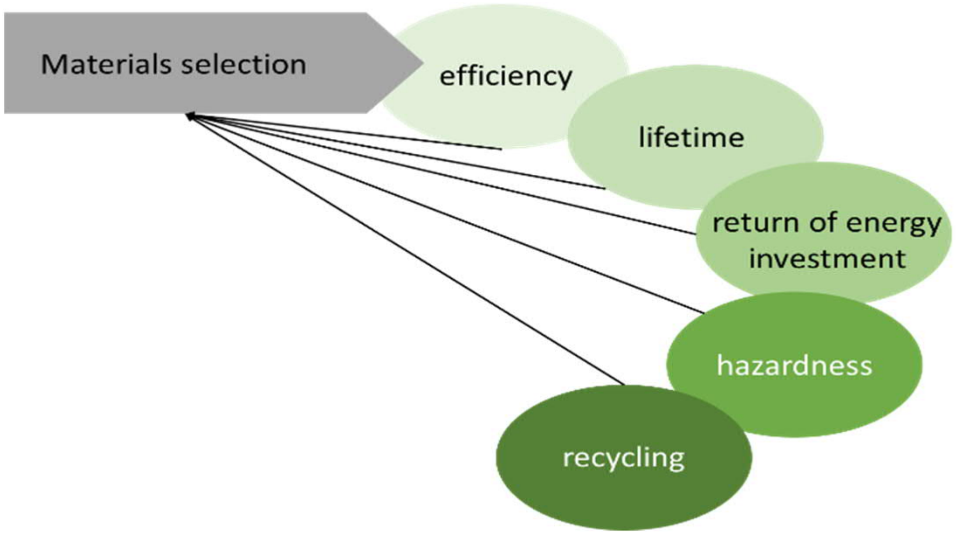
How to apply this for

Energy storage systems?



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

Material selection for Energy Systems -> Case study



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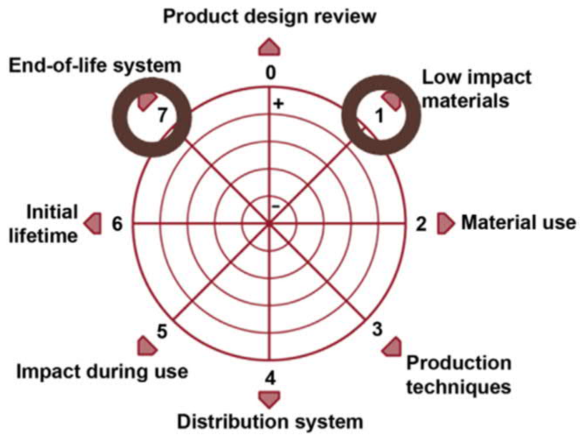
K. Miettunen, A. Santasalo-Aarnio, “Eco-design for dye solar cells: from hazardous waste to profitable recovery” J. Cleaner Production. Submitted

Eco-Design – Product lifetime

1) Increasing the product lifetime (durability)
2) Select process technology for materials
3) Logistics
4) Usage
   knowledge to the customers how to use
   Equipment properly
5) End-of-Life
   easy reuse/recovery/dismantling



Lecture Journal
Where can we use LCA?

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Take a home message

“Balancing between the **activity/durability/recyclability** is challenging but needed in the new energy storage device design.

How to take this properly account?