



Broadening our view on nanomaterials:

Highlighting potentials to contribute to a sustainable materials management in preliminary assessments

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Outline

- Background
- Role of Nanotechnology
- Sustainable Materials Management
- Framework for preliminary assessment
- Case studies
- Conclusion







Increasing use of a variety of elements

Background and need for sustainable Materials Management

• Economic growth is related with increasing resource consumption



Global extraction of materials resources (OECD 2008)





Role of nanotechnology

- Nanotechnology offers many opportunities
 - New and enhanced functionalities
 - Contribution to higher efficiency (less material per product)

— ...

- ...but can also add higher complexity to products
 - Low amount of material
 - Higher variety of materials
 - New challenges in recycling at the end-of-life
- Need for integrating further sustainability aspects in a comprehensive assessment
- \rightarrow Sustainable Materials Management in preliminary assessments





Sustainable Materials Management

"...approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life cycle of materials, taking into account economic efficiency and social equity" (OECD 2010)

Aiming at:

- Less use of primary resources
- Circular economy
- Entire life cycle

Gained political relevance

- EC: "Towards a circular economy: a zero waste programme for Europe"
- Germany: Circular economy









Challenges in early innovation stages



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Proposed Framework categories

- Framework categories proposed to consider sustainable materials management:
 - Resource efficiency
 - Criticality
 - Dissipation and Release







Category Resource efficiency

- Different definitions exist
 - Often narrow focus: material efficiency per functional unit
- Here: use of a broader understanding of resource efficiency:
 - Material and energy inputs,
 - Entire product life cycle including recycling, and
 - Related environmental impacts (i.e., emission of greenhouse gases, not comprehensively considered).







Category Criticality

Criticality is commonly understood as a function of a material's supply risk and its (economic) importance.

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Several studies exist Differing in

- Scope
- Time horizon
- Methodological aspects





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Category Dissipation and Release



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Scoring in the Framework categories

Inspired by NanoRiskCat (EHS) by Hansen et al. (2014)

Probably *significant improvement* by applying NM.

Probably <u>no</u> significant improvement by applying NM. Probably significant deterioration by applying NM.

Insufficient information

categorization, further

research needed

available for a reasonable



First indication given for the category, but *further investigations* for confirmation *needed.*

Scoring in the categories:

- Analogous assumptions
- Precautionary manner
 Focus on the product

Wigger et al. (2014)

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Case studies

Photovoltaics

- Permanent magnets (substitution of rare earth elements)
- Magnetic resonance imaging (substitution of gadolinium)
- Concrete (substitution of cement)

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Preliminary evaluation

Photovoltaic	Resource efficiency	Criticality	Dissipation & Release			
Improved solar cell by plasmonic NP (Au or Ag)						
Rare earth elements-doped nanocrystals solar cells						
Si-nanowires arrays in thin film solar cells						
Substitution of gallium and indium with zinc and tin nanocrystals in thin film solar cells						
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Conclusions

- Need to broaden the view on nanomaterials
- Proposed framework for orientation can be used especially in preliminary assessments
- Dissipation and release not improved at all in the considered case studies
- Future studies should
 - also include other sustainable aspects (societal, economical) and
 - consider a weighting of the categories







Discussion & Contact Thank you for your attention!



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Further reading:









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Other preliminary results

Case study	Resource efficiency	Criticality	Dissipation & Release
Permanent magnets (Substitution of rare earth elements)			
Magnetic resonance imaging (Substitution of gadolinium)			
Concrete (reduced cement use through carbon nanotubes)			



Wigger et al. (2014)