Precautionary design of new nanomaterials

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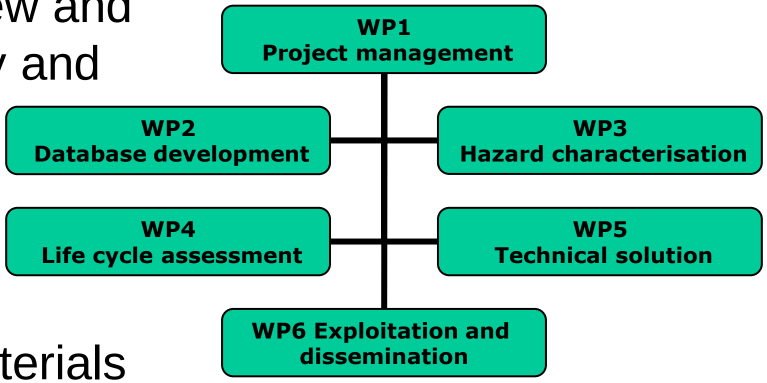
NanoSustain: Objectives and specific nano applications

- Collect and validate existing and generate new and missing data on hazard, exposure, toxicology and ecotoxicology of selected nanomaterials
- Improve and adapt existing methods and develop new approaches, criteria and guide-lines for hazard characterisation, risk and life-cycle assessment appropriate to nanomaterials
- Explore and develop innovative solutions for the sustainable use, reuse, recycling and final treatment/disposal of selected nanomaterials and products



- Our specific nanomaterials and selected (prospective) applications
  - Nanocellulose as paper additive, industrial thickener, rheology modifier
  - Nano-TiO_2 in paint application
  - Nano-ZnO glass coating as UV-Barrier for glass
  - MWCNT in epoxy plates

Nanotechnologies in early phase of development – problems and/or opportunities?

- Collingridge dilemma (double bind problem) between design options and the availability of reliable impact knowledge
  - Information problem: Great uncertainty and lack of knowledge at an early stage in the product development cycle of next generations of nanomaterials, impacts can‘t be easily predicted
  - Power problem: Control or change is difficult when the technology has become entrenched
- Established Risk Regulation and Risk Governance Framework (IRCG 2006) are not enough for the implementation of precautionary principle
- We have great possibilities and opportunities to avoid errors and to avoid possible costs
- Customized/new methods and approaches are needed at an early stage in the product development cycle

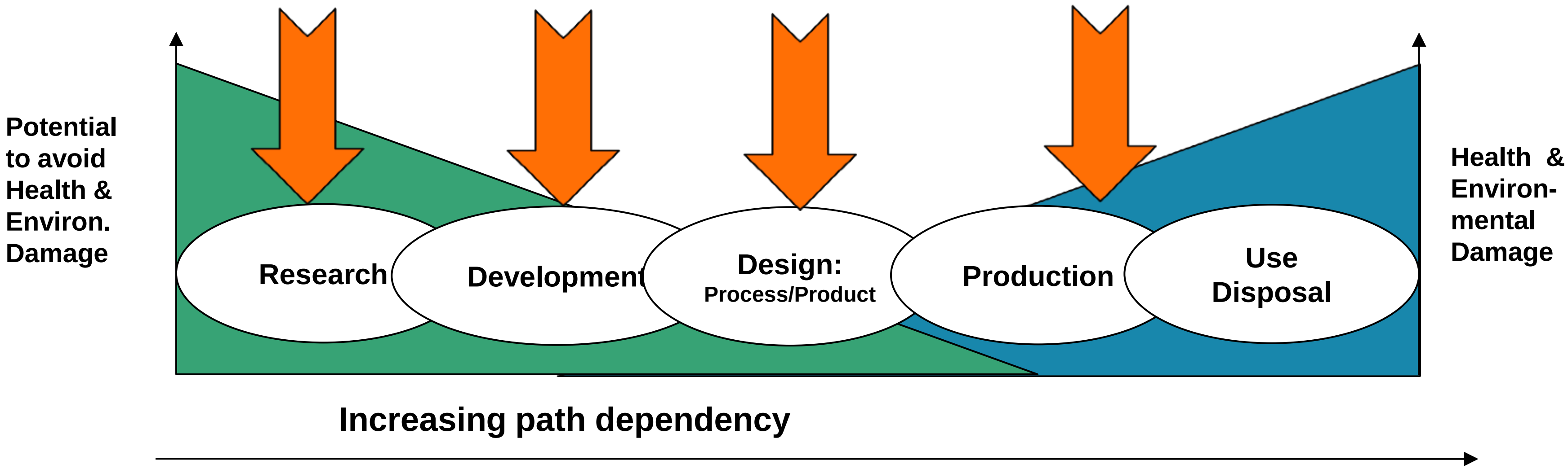
Approaches to technology assessment and engineering design according to the phases of innovation

- Paradigm analysis
- Technology characteri-sation

- Preliminary Assessment
- ‘Concern’/‘No Cause for Concern’-Criteria
- Guiding principle (Leitbild)
- Benign by Design Criteria

- Prospective Techno-logy Assessment
- Prospective Exposure Assessment
- Prospective Effect Assessment
- Prospective LCA

- Established Risk Management
- Toxicological analysis R= f(Exposition, impact potencial)
- Risk analysis R = E x S
- Life Cycle Assessment



- Capital investment (sunk costs)
- Increasing vulnerability in case of unintended consequences
- System inertia
- Bounded interests

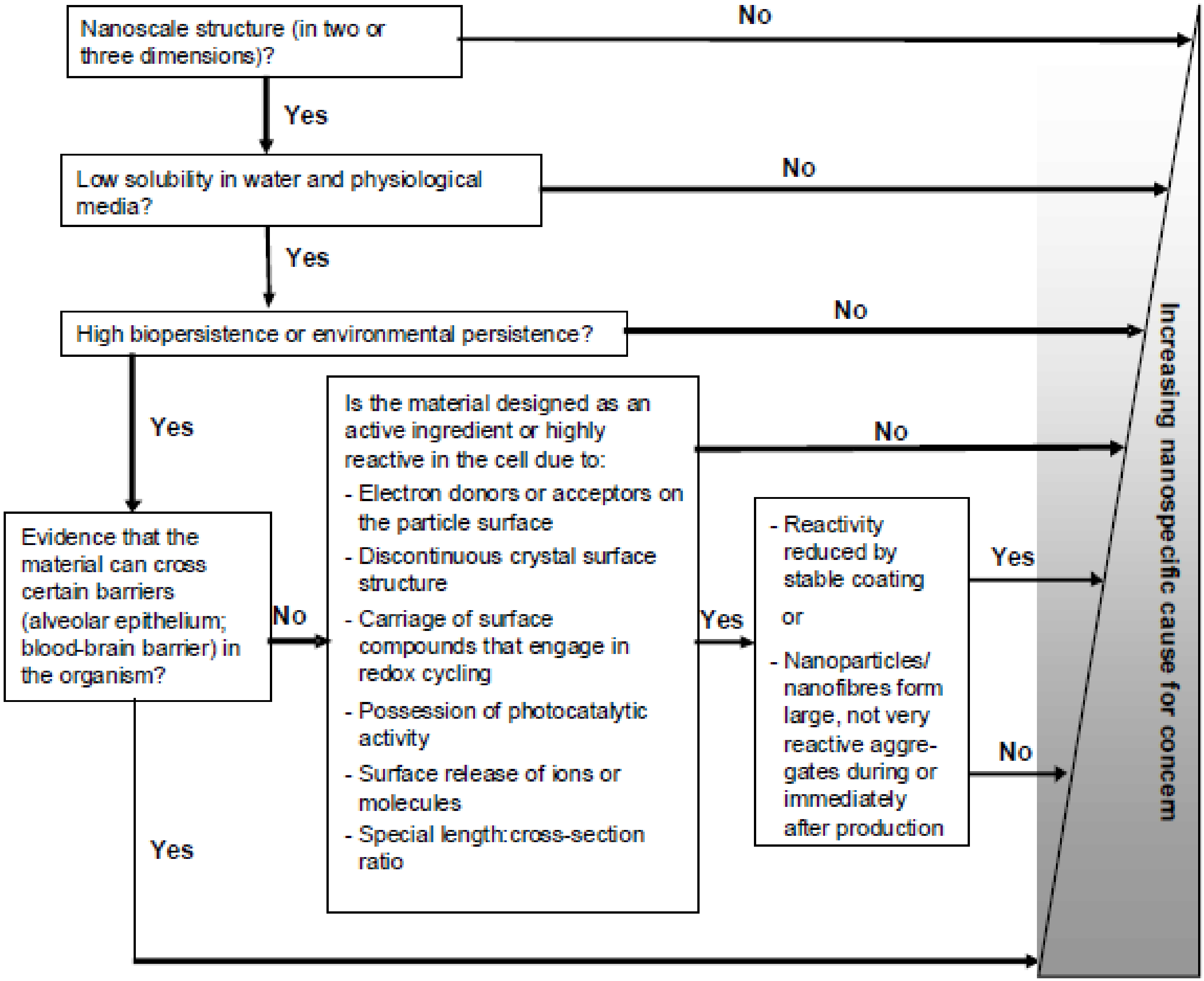
Criteria for precautionary design and for improved eco efficiency of engineered nanomaterials I

- Basis: Literature search to criteria of precautionary design, risk assessment, and recyclability especially guidelines of
  - SRU (German advisory council on the environment),
  - German Nanocommission,
  - Switzerland (Federal Office of Public Health FOPH and Federal Office for the Environment FOEN),
  - German Oeko-Institut,
  - Concept studies of criticality (EU, D, US)
- Set of criteria is derived from the approaches and is supplemented with environmental impact categories of Life Cycle Assessment

Criteria for precautionary design and for improved eco efficiency of engineered nanomaterials II

Categories and aspects	Data quality	Source
Precautionary risk aspects		
Decision tree of risk categorisation	Qualitative	German SRU to precautionary strategies for managing nanomaterials
Potential exposure of humans	Semi-quantitative	Swiss precautionary matrix for synthetic nanomaterials
Potential input into the environment	Semi-quantitative	Swiss precautionary matrix for synthetic nanomaterials
Potential of incident	Semi-quantitative	German ÖI Sustainability check, orientation on Swiss precautionary matrix
Ressource aspects		
Criticality	Qualitative, Semi-quantitative	EU concept of criticality
Recycling capability / tendency to dissipation	Qualitative	In orientation on German ÖI Sustainability check
Abiotic ressource requirement	Quantitative	Based on Life Cycle Assessment
Other LCA impact categories		
Energy requirement	Quantitative	Based on Life Cycle Assessment
Global warming potential	Quantitative	Based on Life Cycle Assessment
Toxicological potential, but not nanospecific	Quantitative	Based on Life Cycle Assessment
Ecotoxicological potential, but not nanospecific	Quantitative	Based on Life Cycle Assessment

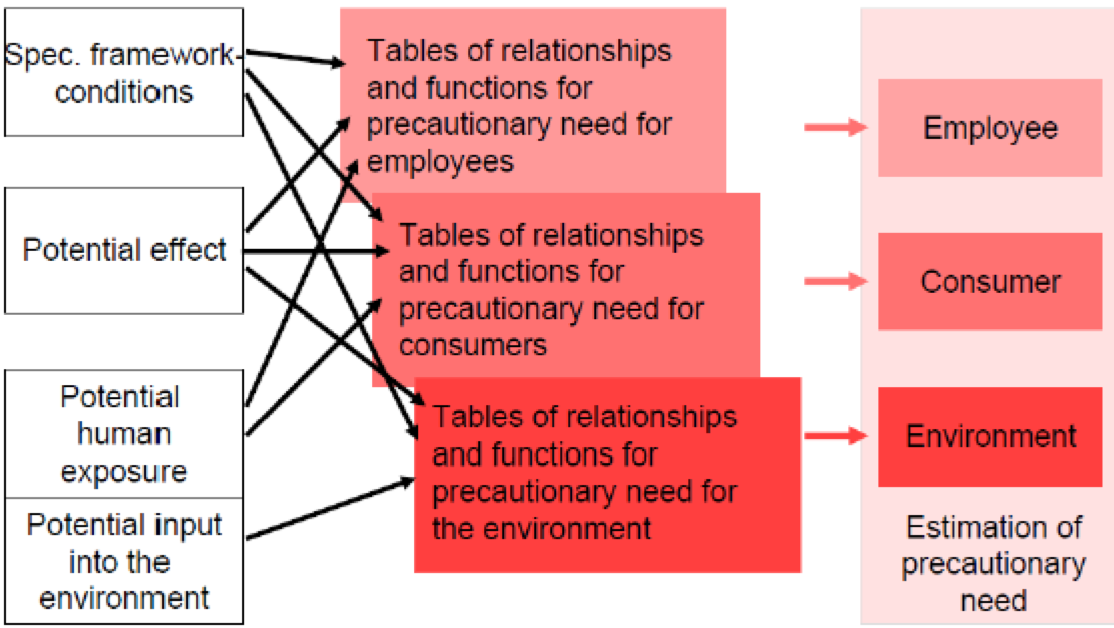
Precautionary Strategies for managing nanomaterials



Decision tree for risk categorisation of nanoparticles and nanofibres

Source: SRU (2011b, 16)

Precautionary Matrix for Synthetic Nanomaterials



Example: Hardening accelerator X-SEED (BASF SE)

	Scores
Potential exposure of humans →Precautionary need for workers →Precautionary need for consumers reaches	 8.1 0.5
Potential input into the environment →Precautionary need into the environment	 9.0
Potential of accident →Precautionary need for workers →Precautionary need for the population	 4.5 0.23

Source: Möller et al 2012

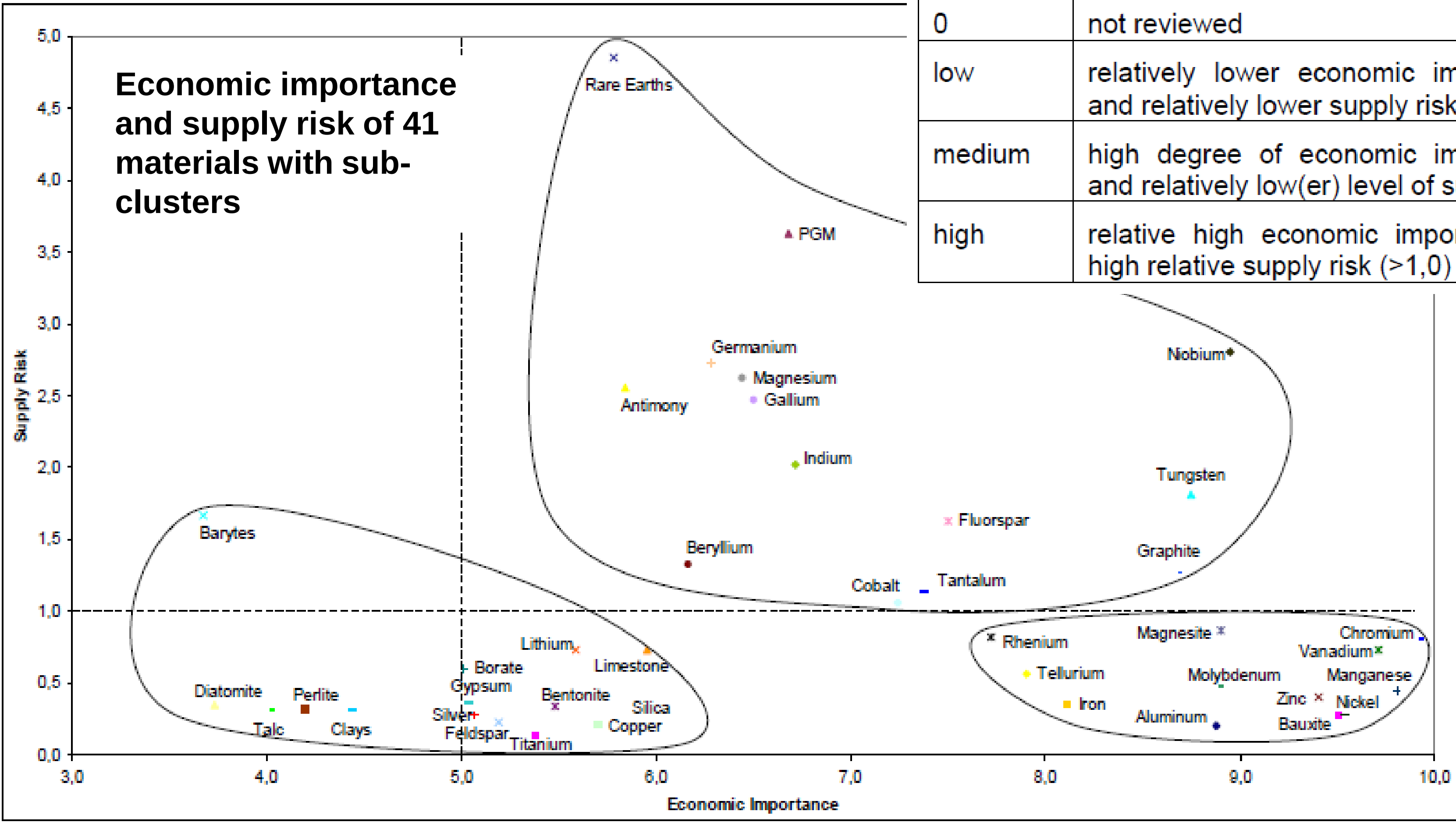
Parameters for estimating the precautionary need

Score	Classification	Importance
0 - 20	A	The nanospecific need for action can be rated as low even without further clarification.
>20	B	Nanospecific action is needed. Existing measures should be reviewed, further clarification undertaken and, if necessary, measures to reduce the risk associated with manufacturing, use and disposal implemented in the interests of precaution.

Source: BAG/BAFU 2011

Criticality of raw materials

Criticality	Position in the figure
0	not reviewed
low	relatively lower economic importance (<6,0) and relatively lower supply risks (<1,0)
medium	high degree of economic importance (>7,5) and relatively low(er) level of supply risk (<1,0)
high	relative high economic importance (>5) and high relative supply risk (>1,0)

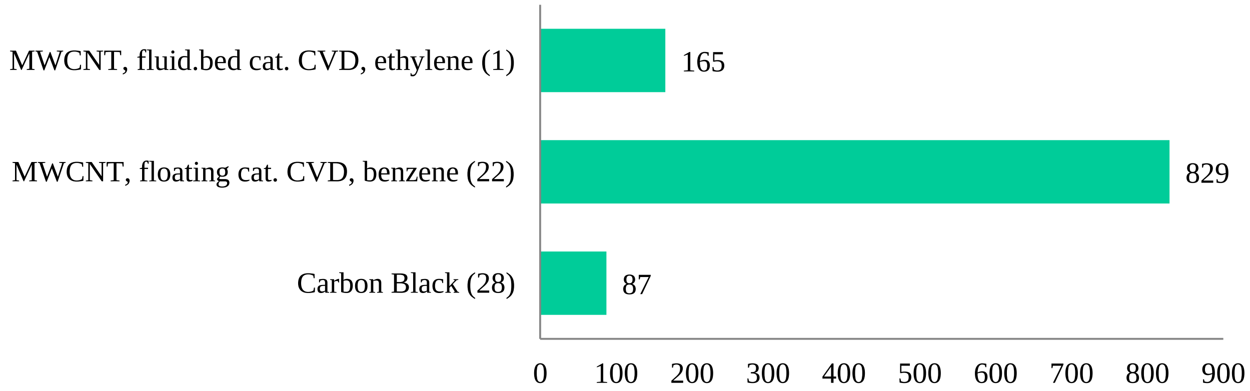


Source: European Commission (2010a 34)

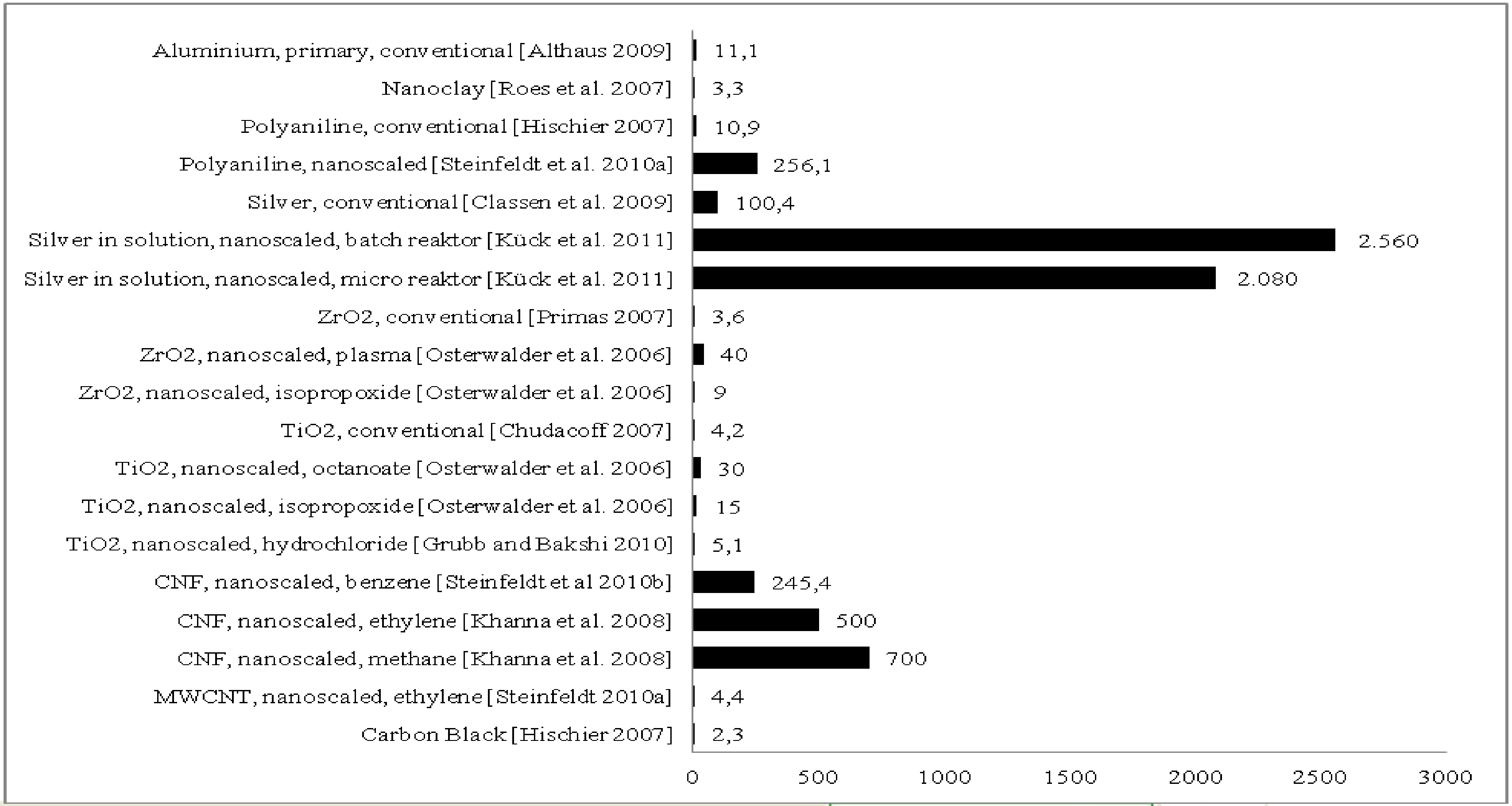
Environmental impacts

		NanoTiO2	TiO2 konv mix
Depletion of abiotic resources	kg Antimon-Eq/kg	0,0353	0,0375
Cumulative energy demand	MJ-Eq/kg	81,95	68,17
Global warming potential	kg CO2-Eq/kg	4,28	4,75
Human Tox potential	kg 1,4-DCB/kg	0,85	0,50
Marine aquatic ecotoxicity	kg 1,4-DCB/kg	2,98	5,07

Comparison of the cumulative energy requirements for various carbon nanoparticle manufacturing processes (MJ-Equivalent/kg material)



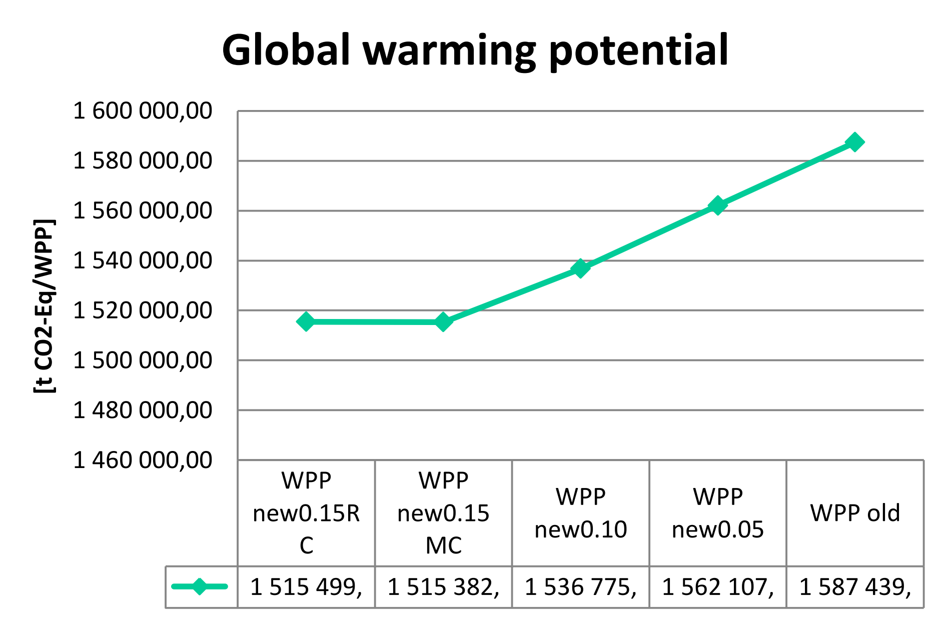
Comparison of the global warming potential for the production of various conventional and nanoscaled materials (CO_2-Equivalent/kg product; in parts own calculation)



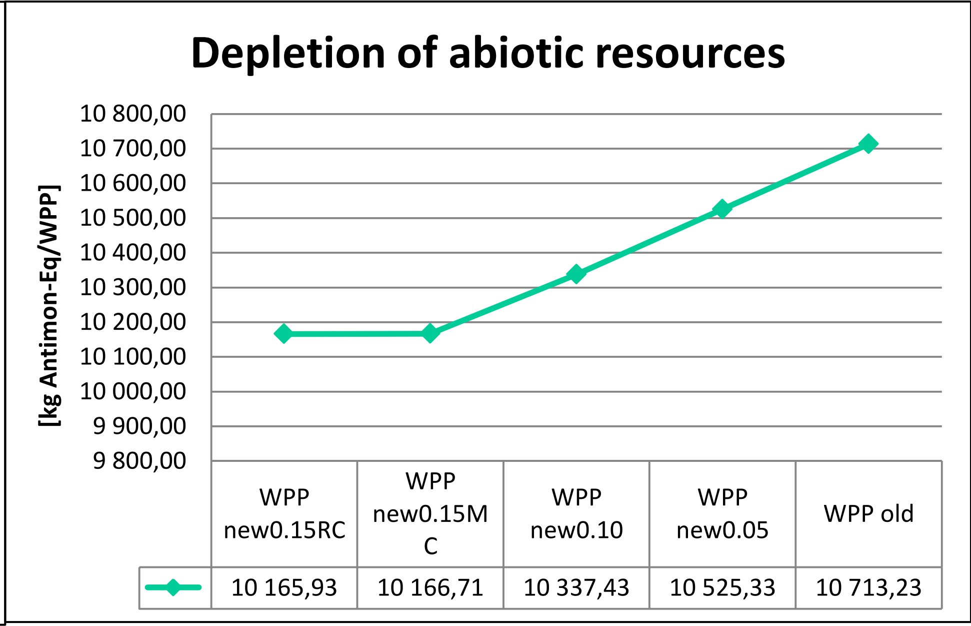
Source: Steinfeldt (2011)

Case study: Prospective CNT Composite material, e.g. as rotor blades of wind power plant

WPP new0.15 versus WPP old : improvement around ca. 5,5%;



WPP new0.15 versus WPP old : improvement around ca. 5,1%



The environmental impact through the multiwalled carbon nanotube (production of CNT, preproduction of the materials etc) has a low influence of the balance.

Conclusions

- We need at an early stage of innovation (research and development) of new sustainable nanomaterials and nanoproducts

  → information to risk potentials of nanomaterial and nanoproducts

  → prospective information to environmental impacts of nanomaterials and to environmental benefits of nanoproducts

- Developed concept includes precautionary risk aspects, ressource aspects, and environmental impact categories

- It‘s an approach for a ‚preliminary assessment‘ of engineered nanomaterials and nanoproducts

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Selected publications:

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