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Volumes and Life Cycle of CeO_2 , SiO_2 and Ag Nanomaterials – Knowns and Unknowns

Project ‚DENANA‘ - Design Criteria for Sustainable Nanomaterials

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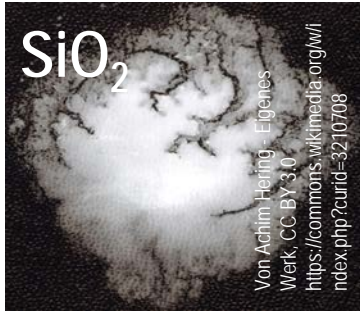
Fadri Gottschalk

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Products and processes containing SiO_2 , CeO_2 , and Ag-ENM



coatings, textiles, building materials, polyesters, epoxy resins, adhesives, sealants, putty, lubricants
cosmetics, toothpaste, foodstuffs, medicines, ...
plastics, elastomers (silicone elastomers, tires, soles)
colors, inks, carrier material for chemicals/ingredients
absorption and drying agents



catalyst material
fuel additive (catalyst)
varnishes and coatings
polishing agents for glass and silicon wafers
nickel metal hydride (NiMH) batteries

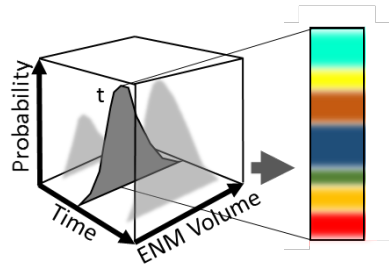


coating, plastics
detergents, filters, spray, cosmetics, medicine, foodstuffs
consumer electronics, computers
textiles

Modeling approach

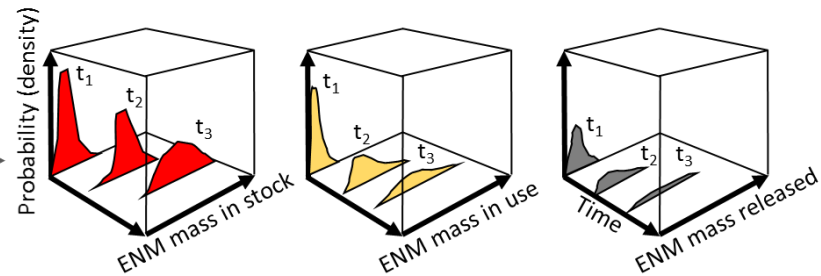
Market analysis

1. Production Volume at time t
2. Shares of applications

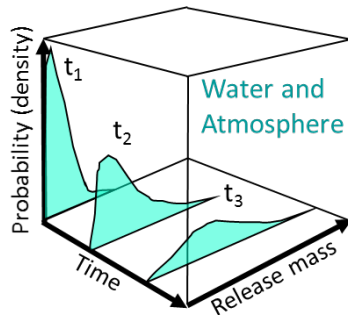


Life cycle modeling

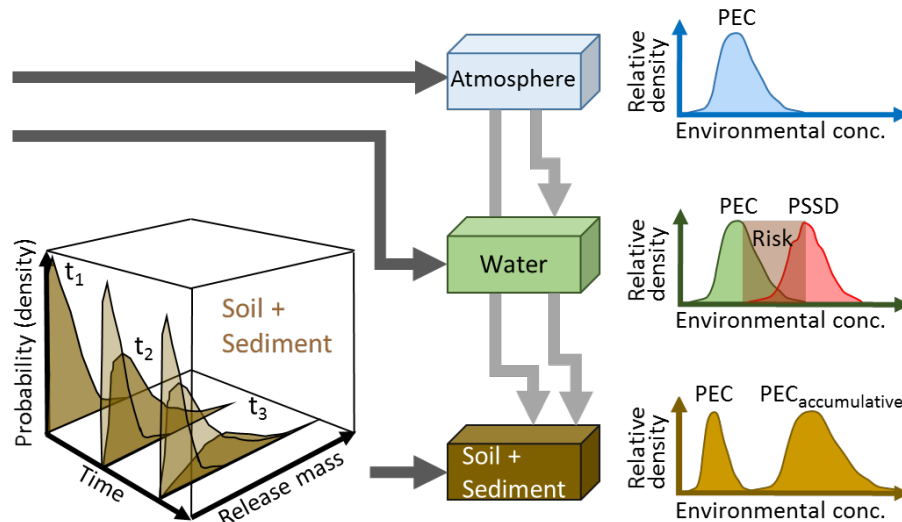
3. Time dependent development of used volumes



4. Time dependent development of exposure



5. Environmental concentrations and risks



Modeling of ENM spread

Risk profile

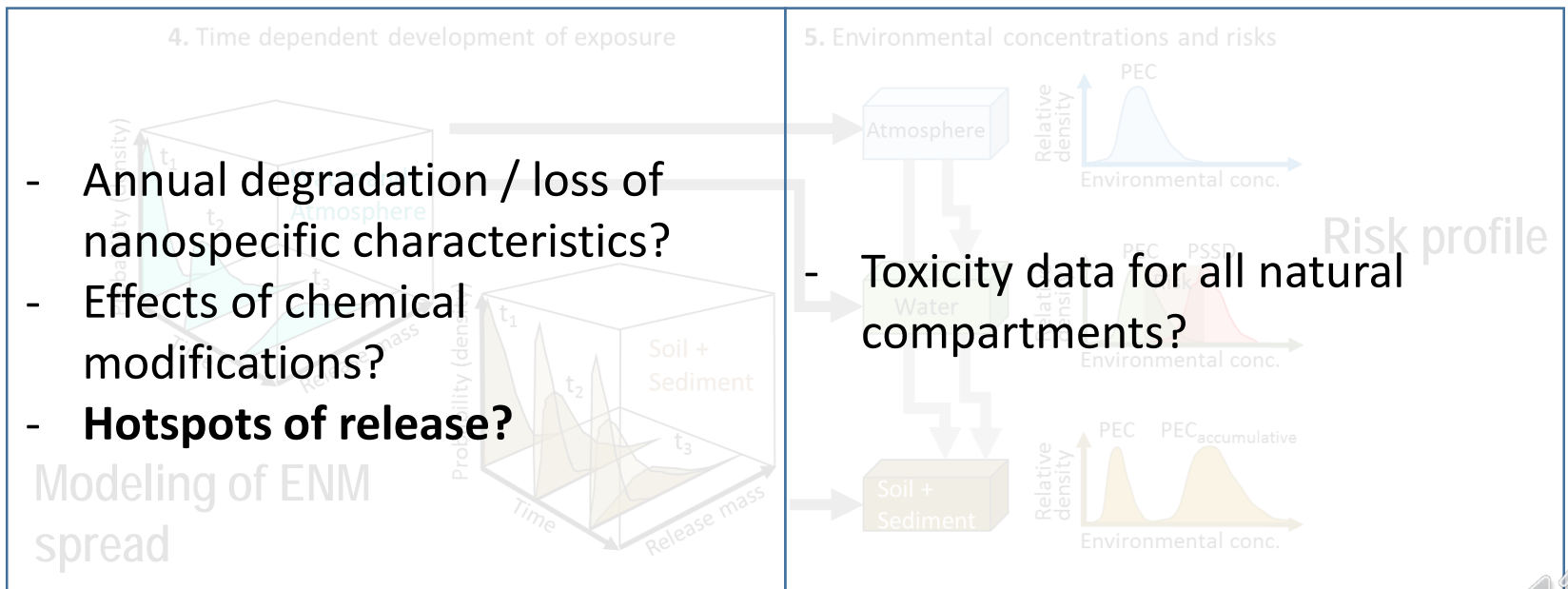
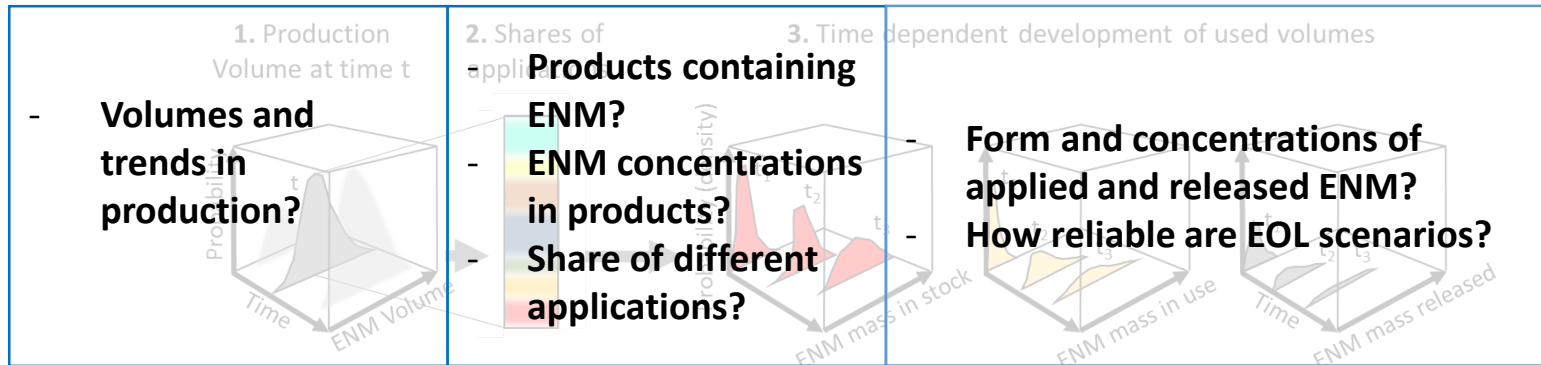
PEC = Predicted Environmental Concentration

PSSD = Probabilistic Species Sensitivity Distribution

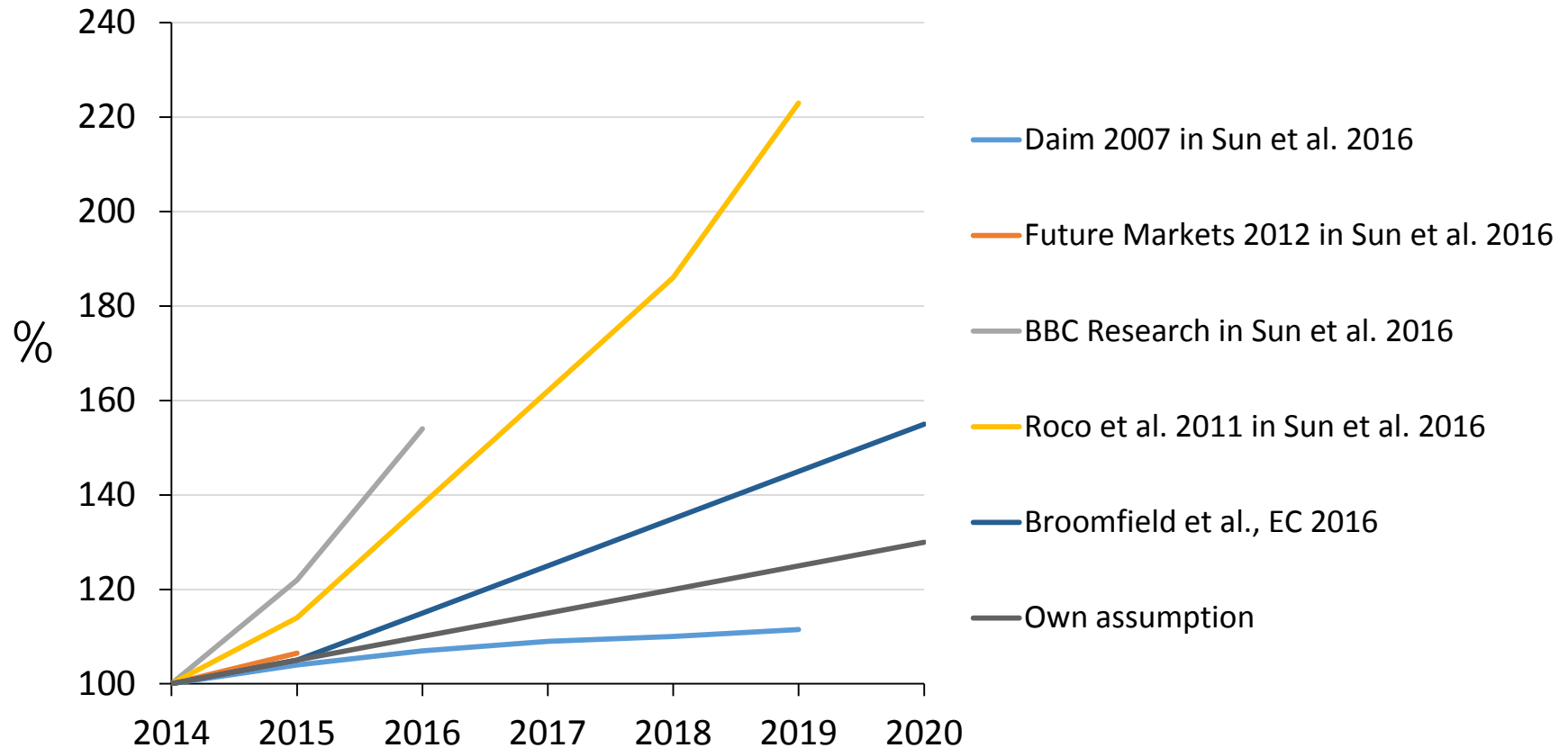
Further questions ...

Market analysis

Life cycle modeling



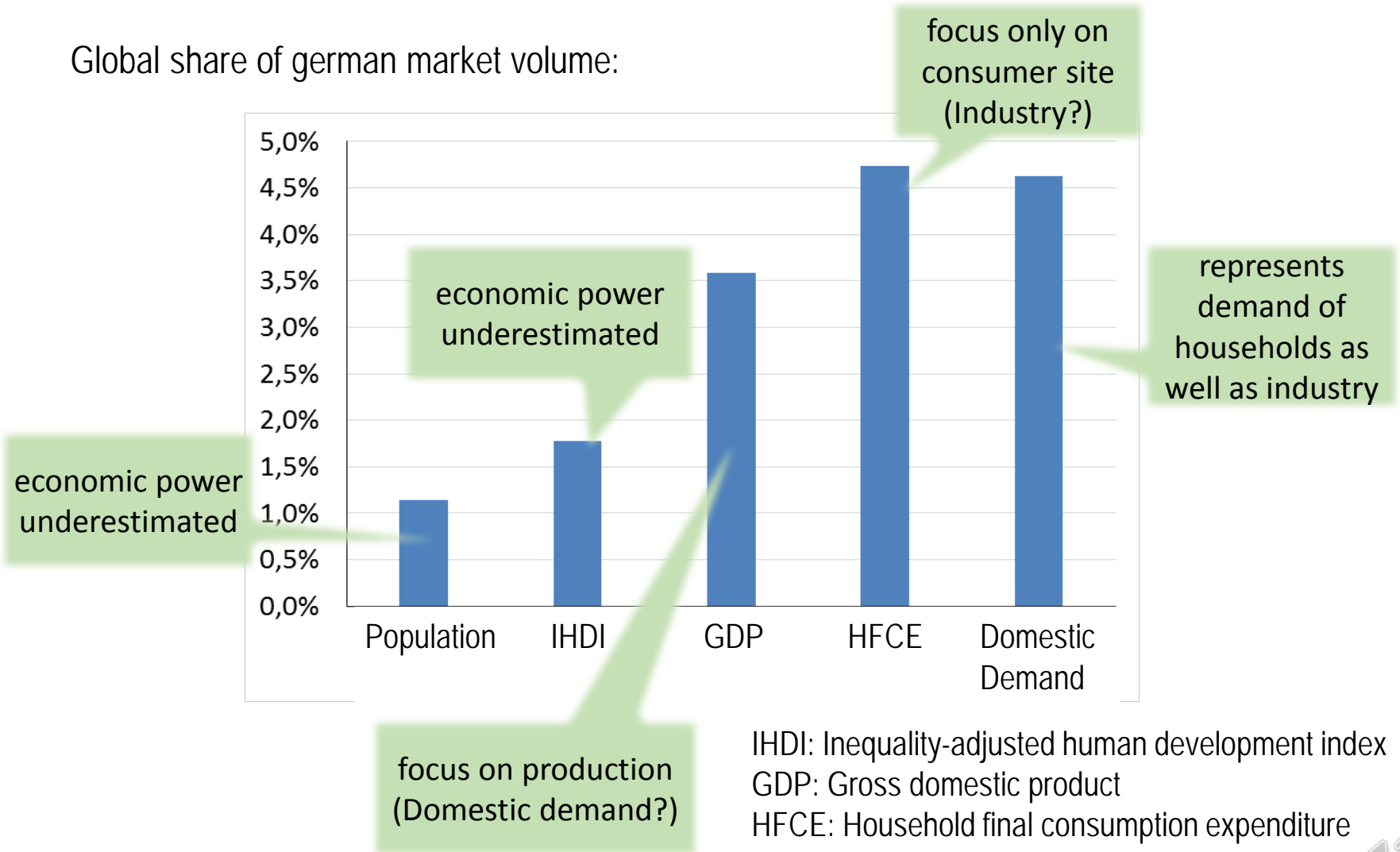
Trend prognosis



Sources: Own survey; Broomfield et al. Support for 3rd regulatory review on nanomaterials – environmental legislation, Project Report for the European Commission DG Environment ENV.A.3/ETU/2015/0030; Sun et al. 2016

How to scale from global to national?

Global share of german market volume:



Mass applications

- Solvay: „Brussels, February 13th, 2013 – [...] invest €75 million to build a new **85,000 ton** per year Highly Dispersible Silica (HDS) plant in Włocławek, Poland. Combined with a further capacity expansion at its site in Qingdao (China) [...] Among other HDS products, the new plant will produce Zeosil® Premium, the latest generation of highly dispersible silica, used by **tire** manufacturers in the production of energy-saving tires.”
- Evonik: May 26, 2015: „Evonik plans to build a new production plant for precipitated silica in the United States [...] **Largest investment** in North America in the past five years [...] Energy-saving **tire** trend drives demand for precipitated silica in North America”
- „Rubber **tyres** are currently the **biggest commercial market** for nanomaterials” (European Commission, 2012 cited in OECD 2016, p18)



Blind spots of NM-databases?

- „The Nanodatabase“ (<http://nanodb.dk>):
among **304** automotive nano-products **1** tyre (silica)
 - Consumer Products Inventory of the Nanotech Project (www.nanotechproject.org):
among **214** Automotive products **1** tyre (silica)
 - most automotive products are repellents, waxes, sealants, paint restorer etc.
 - industrial processes e.g., chemical-mechanical planarization are not covered by databases
- Research on NM-applications is complicated by „hidden“ applications
- Do databases reflect the market volumes for nanomaterials?

Form and concentration of released ENM?

Form:

- Single particle, aggregate, agglomerate or as a composite with other particles and matrix material?
 - E.g., precipitated silica in tyres: Agglomerates with carbon black or/and synthetic rubber?
- Can we consider highly dispersed, precipitated silica released from tyres as a nanoparticle (nano-object) or as a nanostructured material?
- For CeO_2 as fuel additive: Agglomeration in the soot matrix?
(cp. Batley et al. Environmental Toxicology and Chemistry, Vol. 32, No. 8, pp. 1896–1905, 2013)

Concentration:

- What is the exact share of nanoscale particles in fuel additives?



Conclusion

- for a prospective risk assessment based on exposure modeling important informations are still vague (produced volume, products, concentrations)
- dynamic modeling over long time periods is coupled with increasing uncertainty, but:
- even with simplifying assumptions, predictions are already possible
- spatial resolution is needed to determine hotspots of environmental concentrations



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