Sustainable Nanotechnology Organization: Plenary V, Societal and Policy Considerations

Shaping Sustainable Nanotechnology Futures

6 November 2012

Arlington, VA

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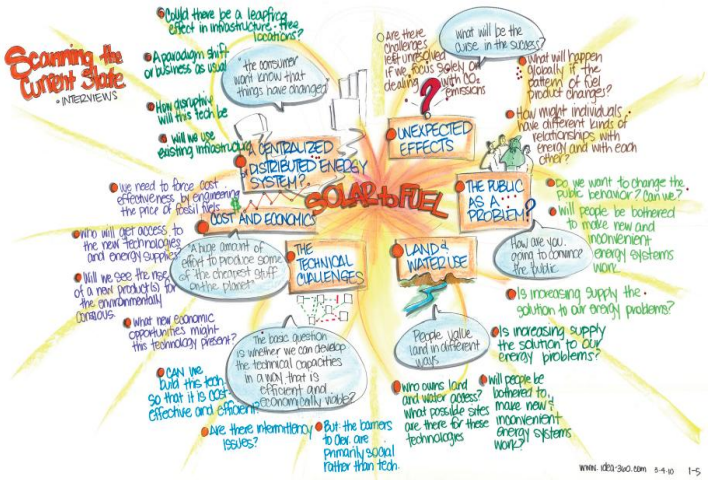
NSEC/Center for Nanotechnology in Society at Arizona State University



- **Research** the societal implications of nanotechnologies
- **Train** a community of scholars with new insight into the societal dimensions of nanoscale science & engineering (NSE)

- **Engage** the public, policy makers, business leaders, and NSE researchers in dialogues about the goals and implications of NSE
- **Partner** with NSE laboratories to introduce greater reflexiveness in the R&D process

US Political Context for Sustainable Nano Research

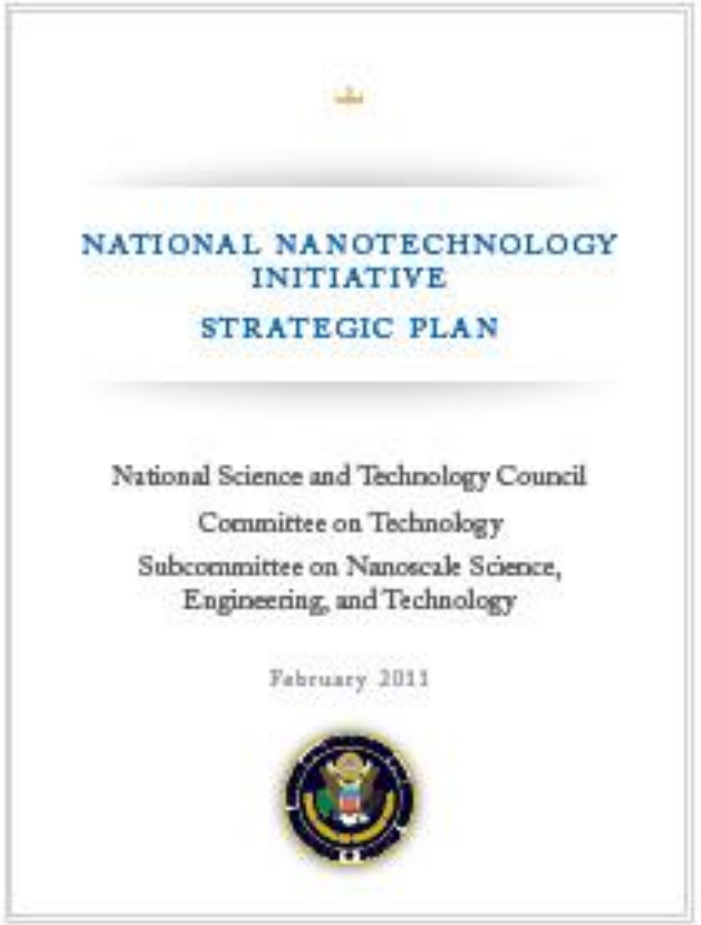
21st Century Nanotechnology R&D Act of 2003 (PL 108-153)

Sec 2(b)(10):

- Establishes societal implications research program
- Requires nano research centers (NSECs) to address societal implications
- ***Integrates societal, ethical, environmental concerns with nano R&D***
- Ensure advances in nanotech lead to quality of life improvements for all
- Provides for public input

US Budget & Strategic Context for Sustainable Nano Research

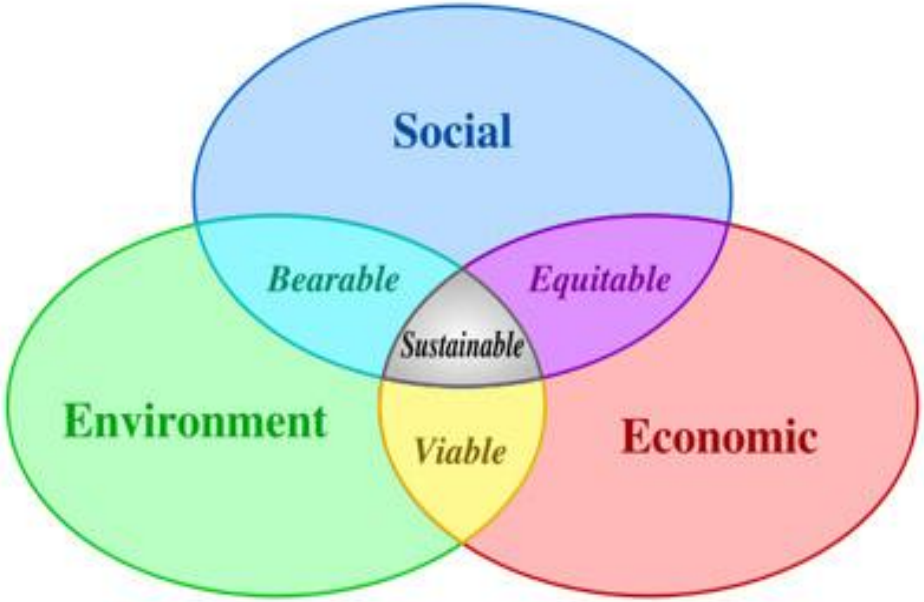
NNI FY 02-13: ~ $17 B
EHS FY 06-13: ~ $612 M (<5%)
NNI FY 13 request: ~ $1.77 B
PCA 7 (EHS) FY 13: ~ $105 M
ED/ELSI since FY 05: ~ $390 M



NNI Strategic Goal #4:
"Support Responsible Development of Nanotechnology"

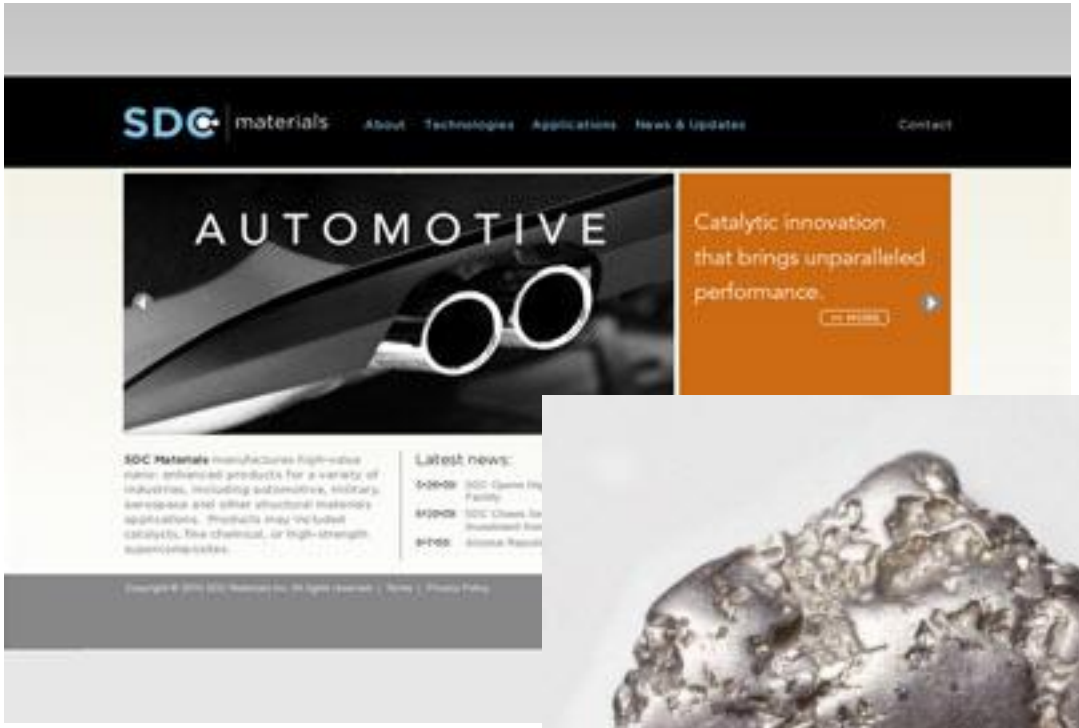
Nano-related EHS research strategy is key to integrate responsible development across NNI

Sustainable Development: “Development that meets the *needs of the present without compromising* the ability of future generations to *meet* their own needs.”



Sustainability is a realm of wicked problems and few “solutions”

Wiek et al. *JNR* (2012)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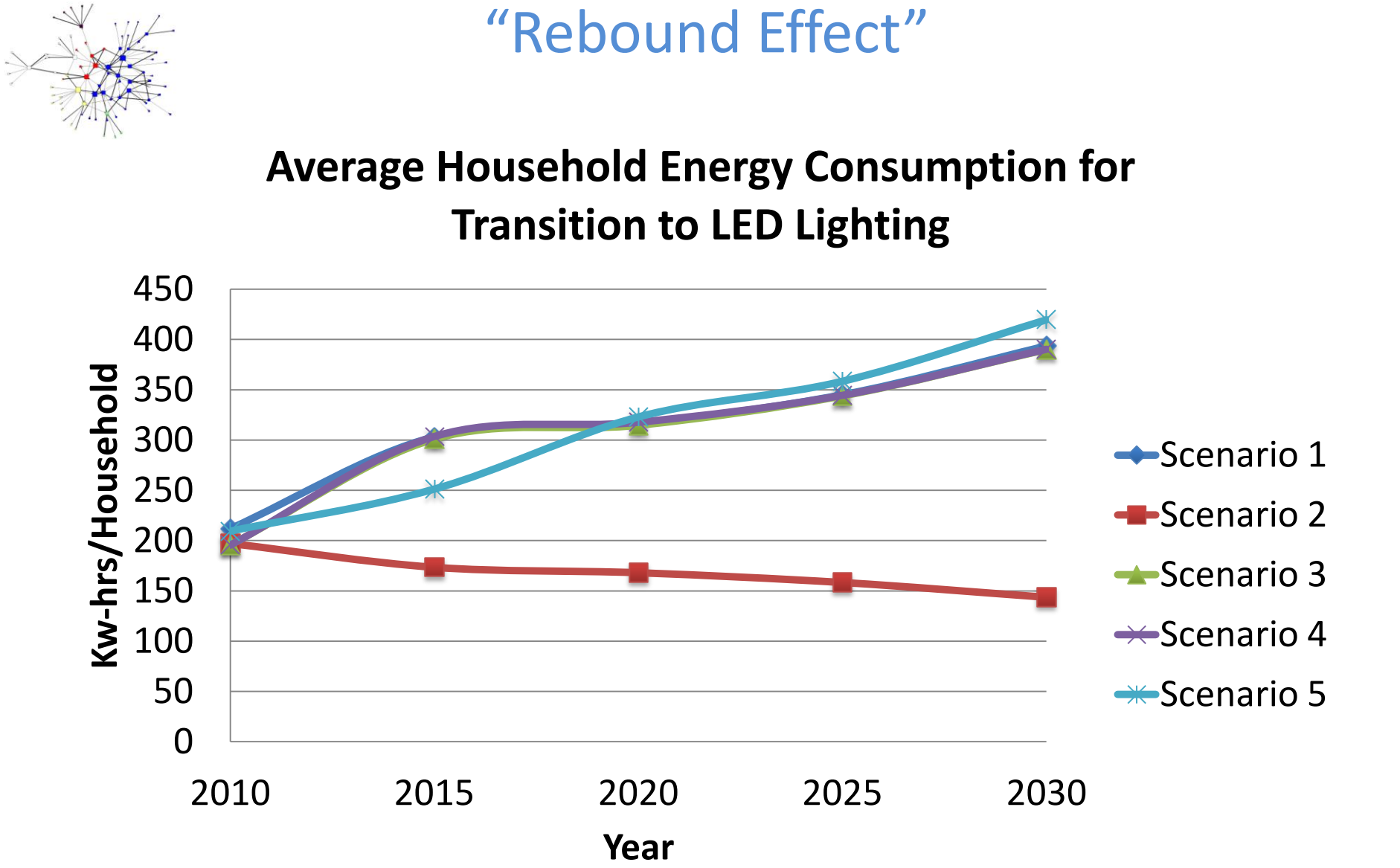
EPA/STR/LANDOV

“Rebound Effect”



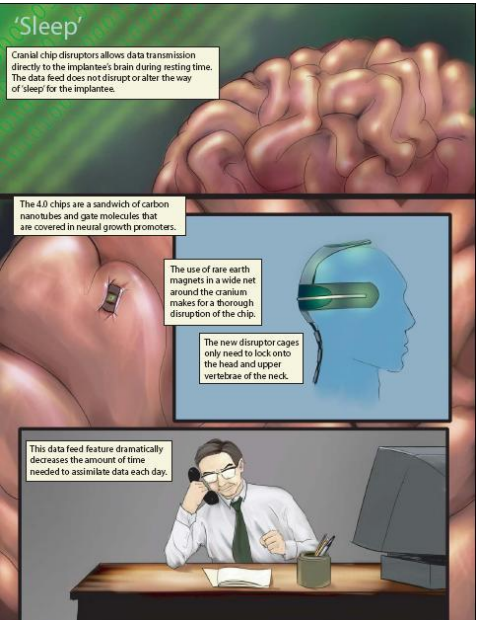
The Strategic Vision

Anticipatory Governance

1. Foresight
   - All governance requires a disposition toward future
2. Engagement
   - Crucial normatively, strategically, pragmatically
3. Integration
   - Scientists know things we don't, and vice versa
4. Ensemble-ization
   - Because none of these works in isolation

Guston, *Nature*, 454:940-41 (2008); Barben et al. *STS Handbook* (2008)

Anticipatory Governance…



Anticipate: from *ante-* and *capere*, "to take [into possession]" "beforehand"; related to capable and capacity and not a synonym for "expect," "predict," or "foresee"

…is a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible.

The pumpkin or the tiger? If science is puzzle-solving, when do we begin to pay attention?

Anticipatory *Governance* – Not Government

- Not "do" or "ban"
  - "Science finds, genius invents, industry applies, man adapts"
  - Moratoriums proposed by ETC Group and Friends of the Earth
- Wide array of mechanisms
  - Regulation
  - Licensing/restrictions
  - Liability/indemnification
  - Intellectual property
  - R&D funding & tax credits
  - Testing
  - Treaties
  - Public Understanding of Science
  - Informal Science Education
  - Public engagement
  - Public action
  - Priming
  - Routinization
  - Codes of conduct
  - Standards
  - Laboratory decisions

Research and Innovation Systems Analysis

Define and Characterize Nano (EHS) Research

- Begins with Global Nano Database
  - Nanotechnology publications: 1.6 million publication records (741,000 from Web of Science)
  - Porter et al. *J Nanoparticle Research* (2008)
- Nano EHS yield
  - 136/50,300 in 2004
  - 714/93,200 in 2009

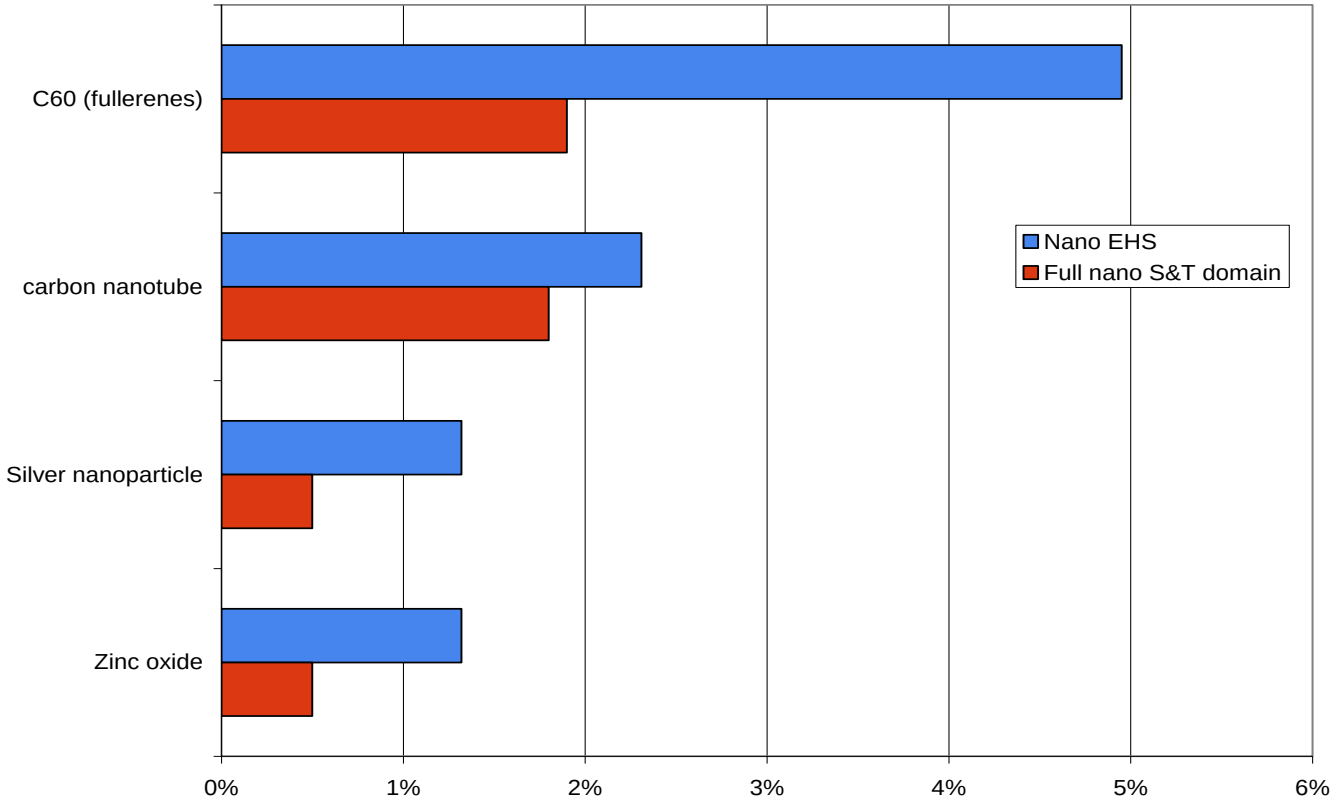
Integration of Nano EHS Research

Pub Year	% Nano EHS citing Nano EHS	% All Nano citing Nano EHS
2000	28%	0.02%
2001	22%	0.03%
2002	23%	0.04%
2003	31%	0.06%
2004	26%	0.07%
2005	51%	0.16%
2006	51%	0.21%
2007	70%	0.31%
2008	79%	0.52%
2009	91%	0.70%

Carley and Porter, *Research Evaluation* 2011

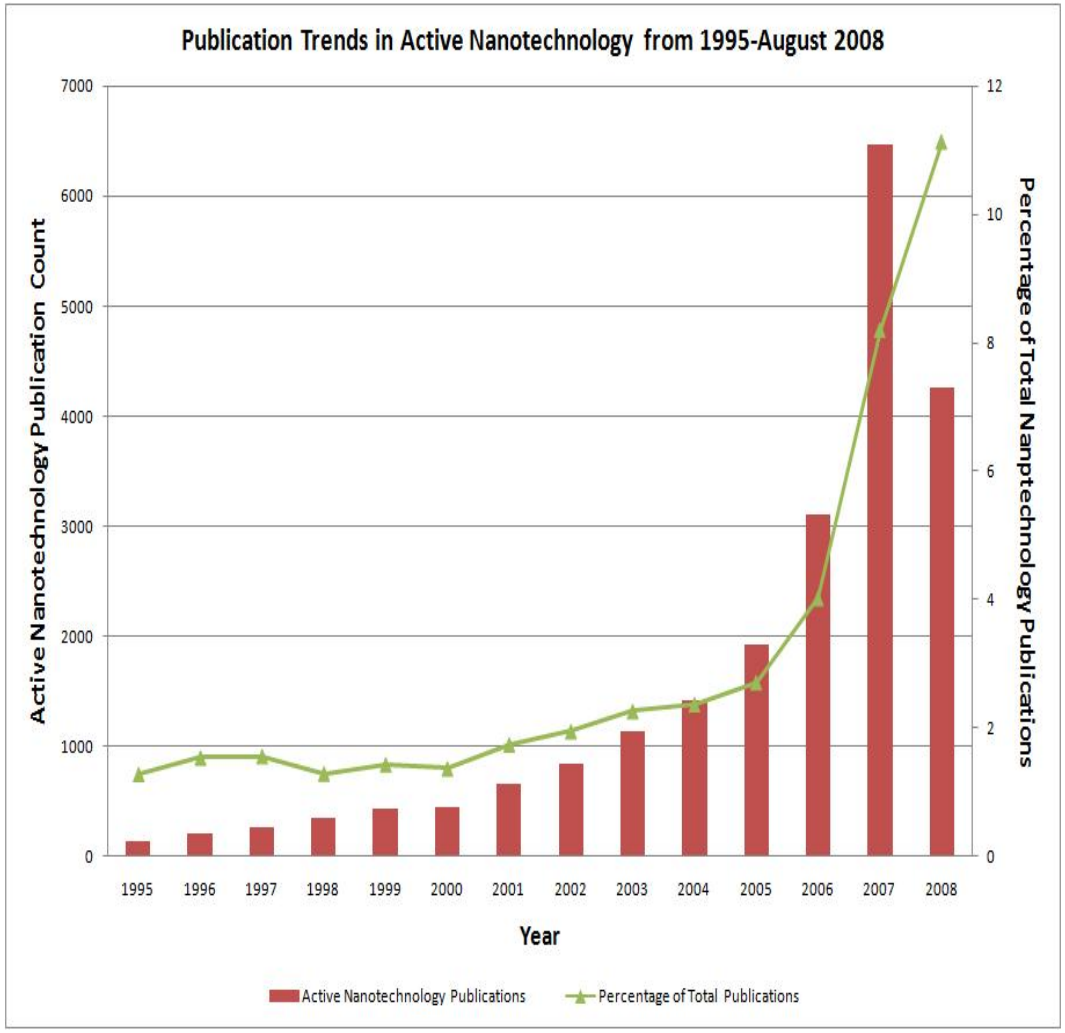
Use of EHS Research in Nano

- Nano EHS pubs by ENP

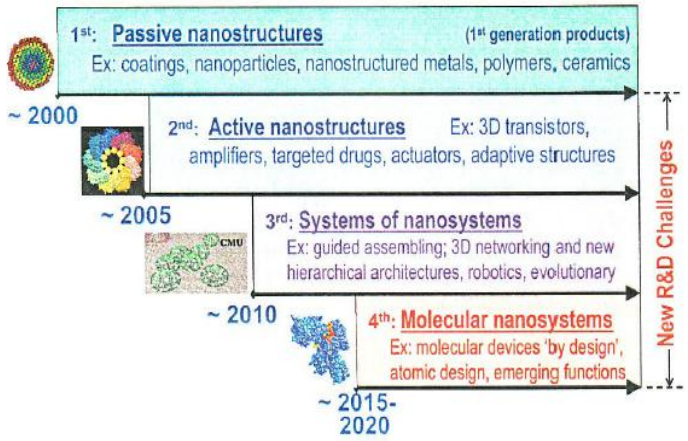


Youtie et al.
J. Nanosci. Nanotechnol
11:1-9
(2011)

Active Nanostructures and EHS



- Active nano less engaged with EHS than all nano (0.12% of active nano publications vs. 0.36% of all nano)
- Nano EHS is less engaged with the different risk profile of active nanostructures



Subramanian et al. *J Nanoparticle Res* 12(1):1-10 (2008)

Anticipatory Governance of Complex Engineered Nanomaterials

- Cooperative Research
  - PIs Guston (ASU) and Eggleson (UND)
- Participation from
  - CNS-UCSB
  - CEINT (Duke)
  - UC-CEIN (UCLA)
  - NSRG (Northeastern)

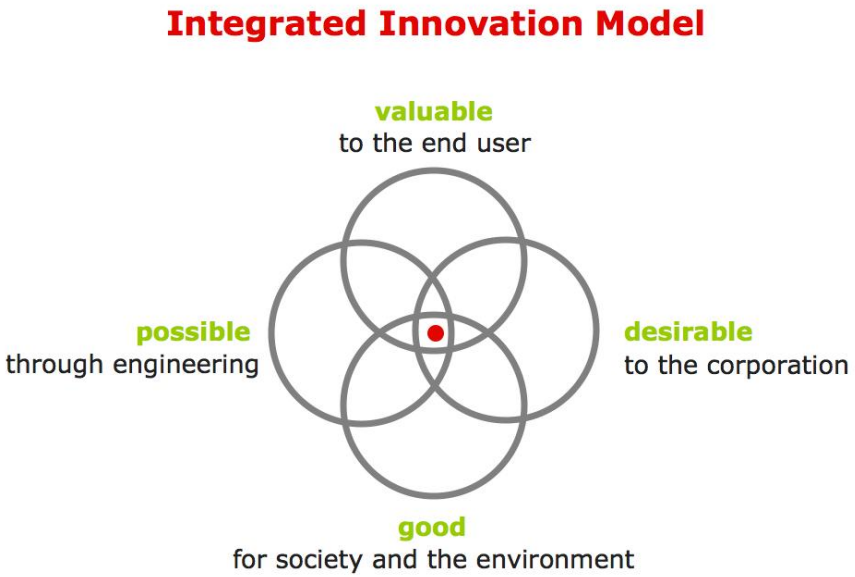
"Let's not get surprised twice!"

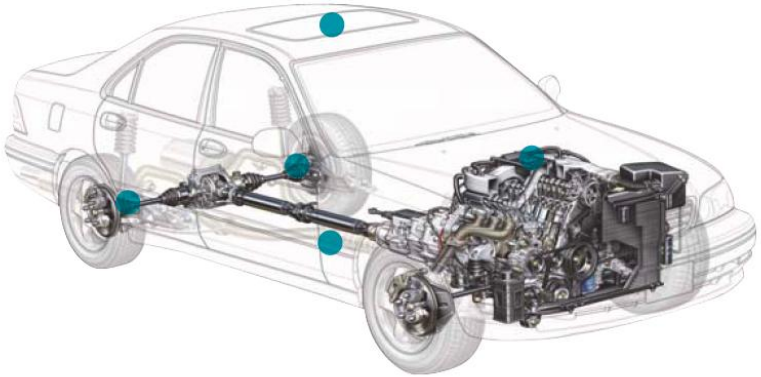
How Green is Nano?

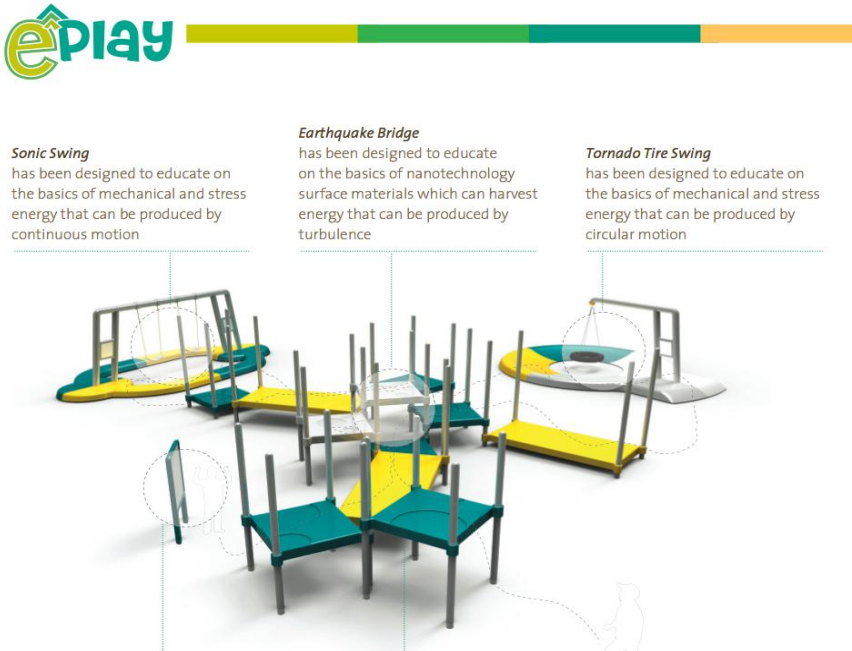
- Three “Green” technology definitions implemented: USPTO Green Technology definition, augmented classification, USPTO-IPC concordance map
- Using data on granted patents January 1975 to October 2012
  - Total # USPTO patents: 4,894,524
  - Total # green patents: 328,962 (7%)
  - Total # nano patents: 8243 (0.2%)
  - Total # green nano patents: 1424 (17% of all nano)
    - Solar/PV 475 (32%)
    - Fuel 588 (40%)
    - Wind 86 (6%)
    - Batteries 496 (33%)

Strumsky and Lobo Green Patenting Project

Anticipation and Deliberation InnovationSpace



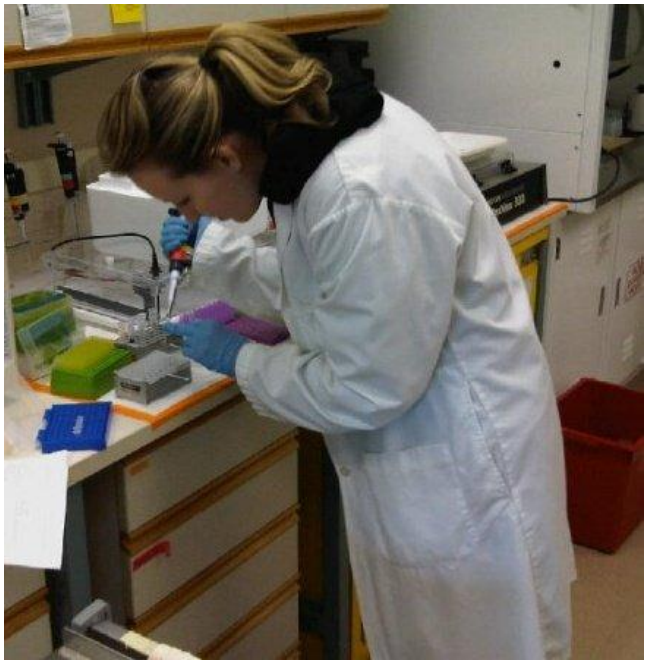




Boradkar and Selin. *J Nano Education* (2010)

Reflexivity and Integration

STR
Socio Technical Integration Research



Protocol

Opportunity: “What are you doing?”

Considerations: “Why are you doing it?”

Alternatives: “How might you do it?”

Outcomes: “Where might this lead?”

STIR Results

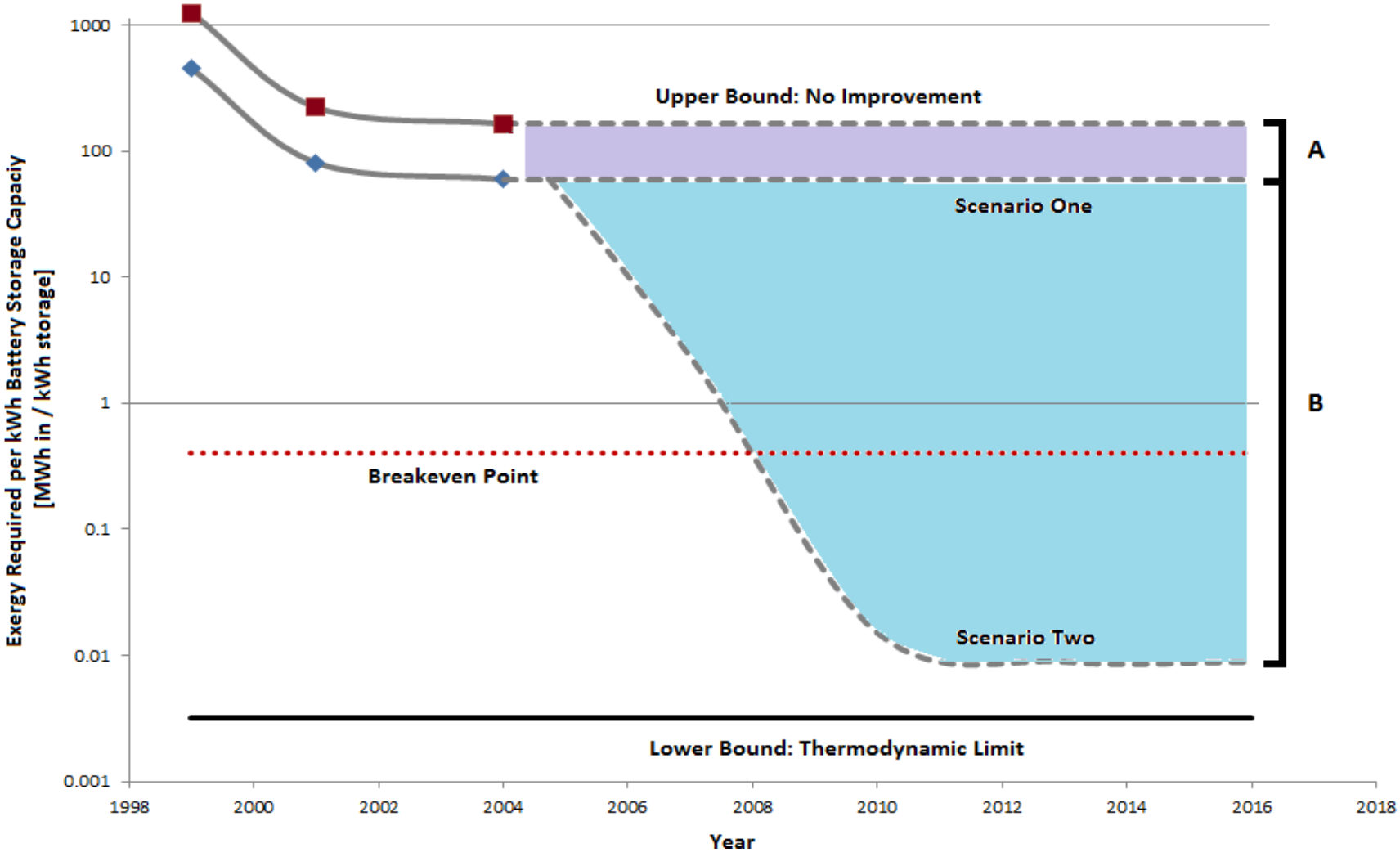
- Reflexive awareness
  - Laboratory researchers realize that there are inconsistencies in their views about the role of science in society
- Changes in practice
  - Interactions trigger deliberations, spark new research ideas, catalyze outreach activities, and occasion changes in material practices
- Residual effects
  - Laboratory participants return to contact STIR investigators with further observations and invitations to participate in further activities

t_1 "We don't make decisions"
t_2 "I guess this really is a decision"

Nanomaterial disposal sparks debate:
Hazardous waste?
Municipal waste?
Special lab meeting cannot resolve issue
No national or international guidelines
Formulating a call for policy clarification

"Reflections on responsible innovation generated novel ideas for antenna structures and nanoparticle synthesis"

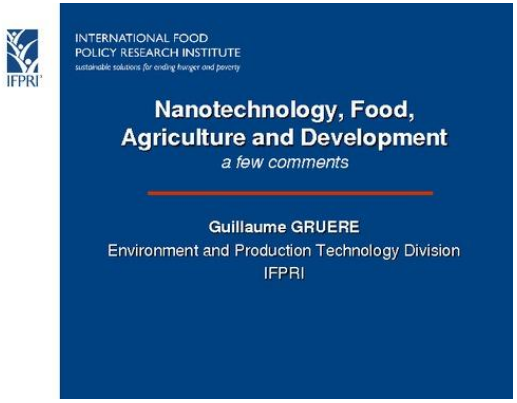
Anticipatory LCA

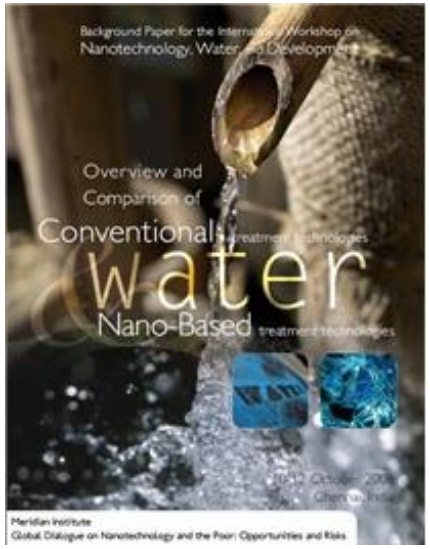


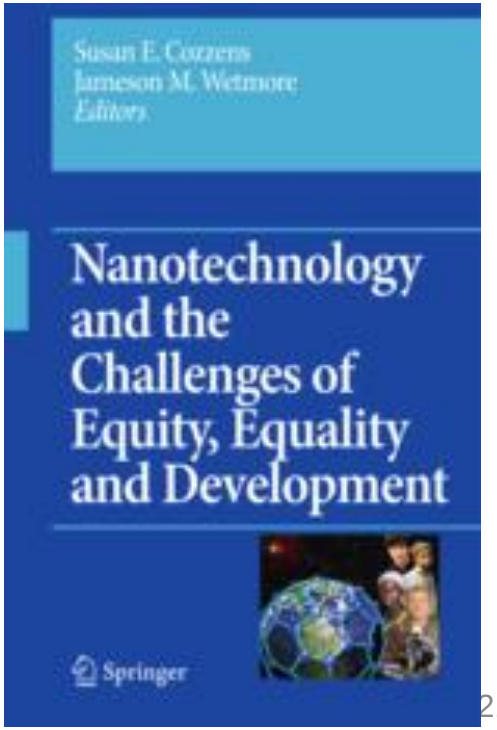
Wender, et. al. In press. *Nano Business and Law*

In Search of Pro-Poor Nanotechnology

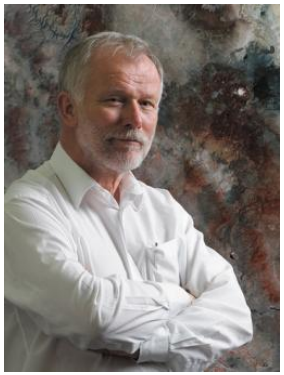
Salamanca-Buentello et al. *PLOS Medicine* (2005)

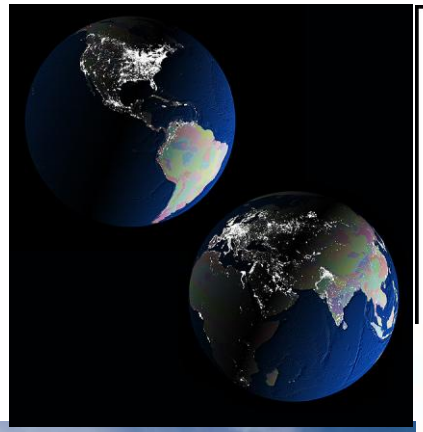


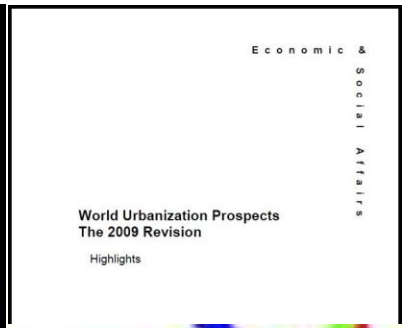




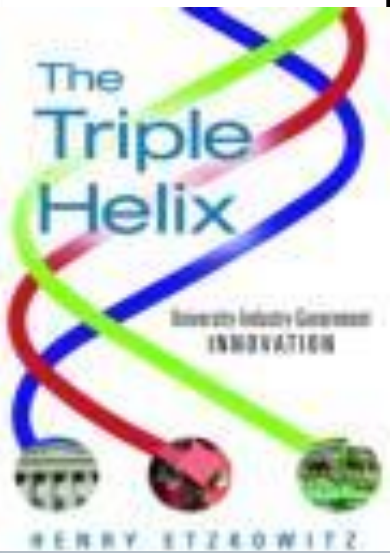
Urban Design, Materials, and the Built Environment (Nano and the City)





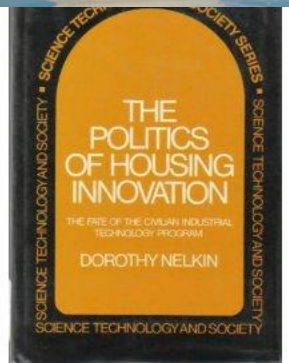


What are the potentials for and limitations of nanotechnologies in fostering sustainable urban development in the future?



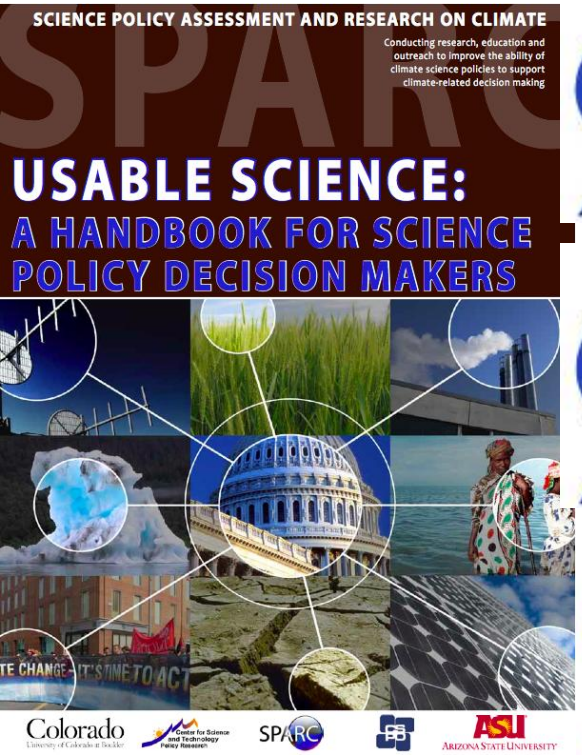
Cities now:

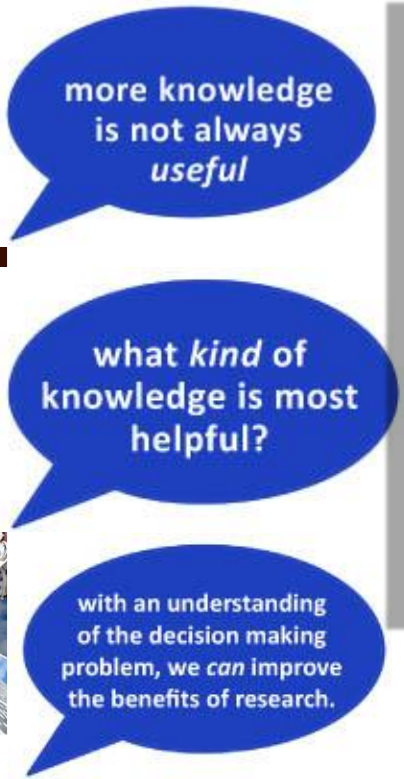
- House majority of humanity
- Foster knowledge-based innovation
- Are nexus of large socio-technical systems
- Are central to sustainability issues
- Used to be an important part of S&T vision

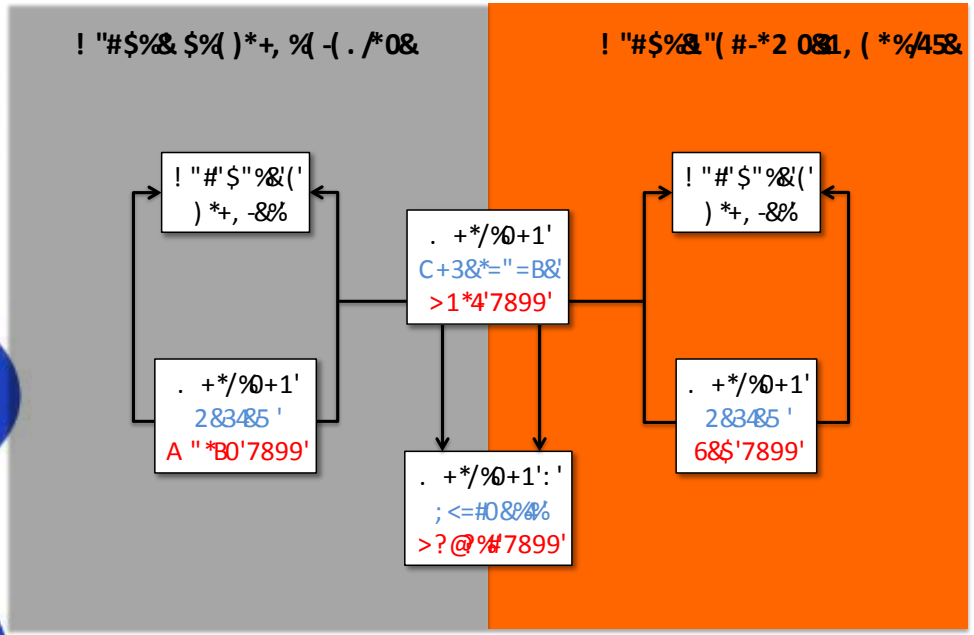


Reconciling Supply & Demand

- Task 1: Understand & articulate demands of urban sustainability
- Task 2: Understand & articulate supply of urban nanotechnologies







Nanotechnology in City Environments (NICE) Database

Expert-reviewed meta-base of research, reports, advertising materials, technical specifications, etc. of nanotechnology to be utilized in urban domains

NICE DB

Nanotechnology in City Environments Database by the Center for Nanotechnology in Society

Search...

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LEDs (Nonacene)

Rider Foley

Print PDF

Light emitting diodes (LEDs) offer significant energy savings compared with traditional fluorescent and incandescent bulbs. LEDs are most commonly constructed with inorganic elements that emit light when a current is passed through the material. The nonacene based LEDs that are being developed are organically based and could be printed onto low cost substrates. Innovacene compounds (in the same chemical family as nonacene) is used in television screens and flat panel displays. The application of this technology could have far reaching impacts in the indoor lighting, display screen, and digital imaging industries.

Basic

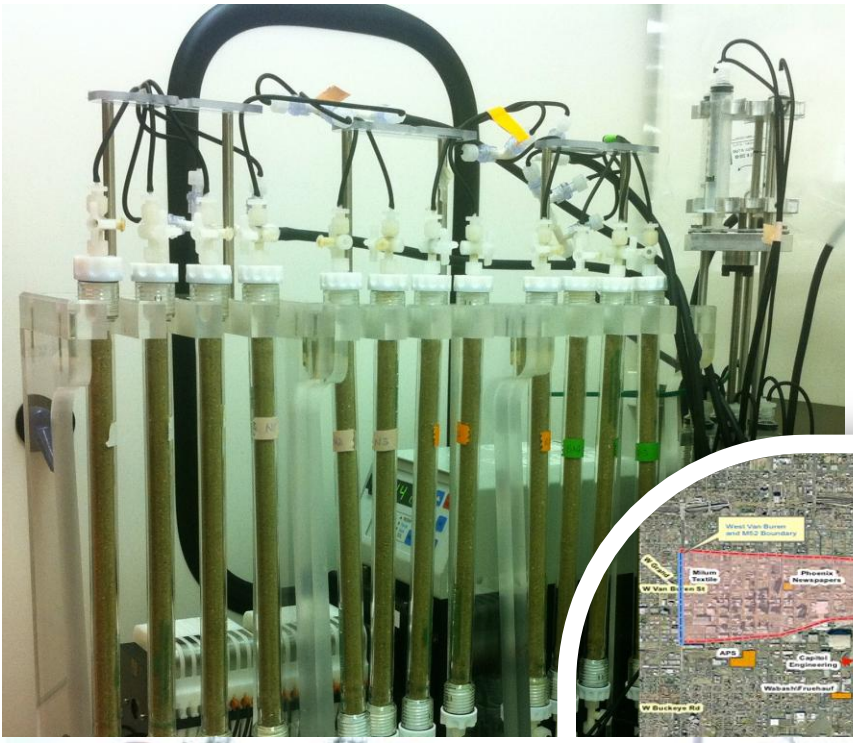
Product Name:
LED (nonacene-based)

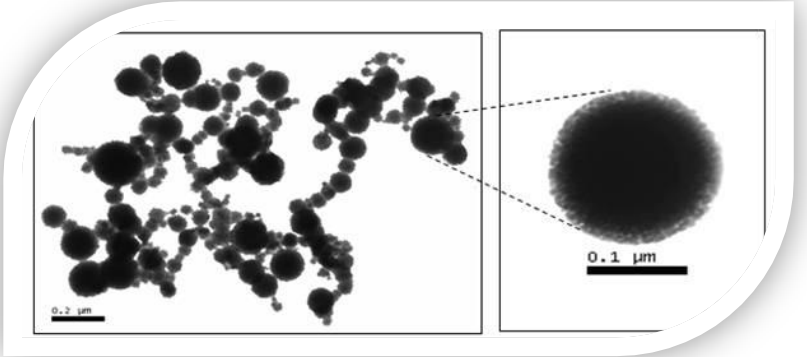
Nanotechnology in City Environments (NICE) Database

Fields:

1. Title
2. Summary
3. Product/Application Name
4. Visual
5. Developmental State (7 Horizons)
6. Nanotechnological Mechanism (Roco's 4-fold roadmap)
7. Function
8. Potential Benefit
9. Potential Hazard
11. Substitute for…
12. Urban Domain
13. Challenge for Urban Sustainability

M52 Superfund Site





Forthcoming. T. Kalinowski. Dupont Summit.

THE TOMORROW PROJECT USA

Thanks!

- Rider Foley.
- SNO Organizers.
- National Science Foundation cooperative agreement #0531194 and #0937591. Any opinions, findings and conclusions are those of the author and do not necessarily reflect the views of the National Science Foundation.

Four Warrants for Anticipatory Governance

1. Stop-gap: until we have prediction
2. Fail-safe: in case we can't get prediction
3. Priority-setting: capacity to predict may not be comprehensive and doesn't tell us how to deploy that capacity
4. Generality: prediction in some areas (nano)doesn't imply prediction in other emerging technologies (syn bio)

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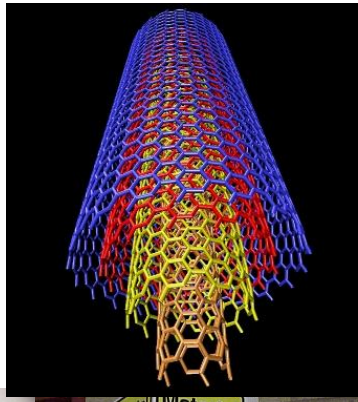
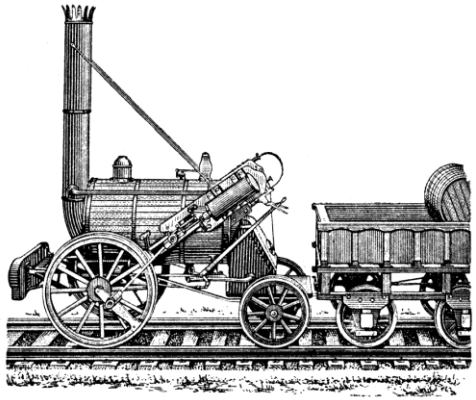
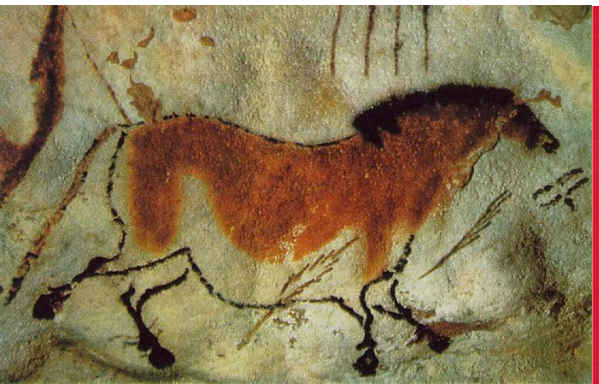
Post-Normal Science and Emerging Technologies

Facts are uncertain: do ENPs pose significant EHS risks?
Values in dispute: getting benefits? avoiding risks?
Stakes high: "next industrial revolution"?
Decisions urgent: $Bs in R&D funds at stake, regulations looming







Key elements:

- Knowledge-based
- Politics of Novelty
- Radically Uncertain Futures

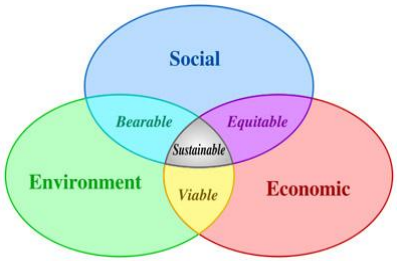
Conversations Under-heard

Sustainability broadly considered

- Sustainability often leaves out emerging technology;
- Emerging technology often leaves out people, social context
- Means we miss systems & behavior

Knowledge Systems

- What are the decision making rules and processes involved in translating your findings to norms, protocols, rules, regulations
- E.g., best measures (number, surface area, mass, etc.)



Geoengineering

- Solar Radiation Management (SRM)
- Carbon Dioxide Removal (CDR)
- NNI Goal 4: Responsible Development

(image from Keith 2008 and Roco et al. 2011)