Science For A Better Life

Economic Impact of Nanomaterials - CNT

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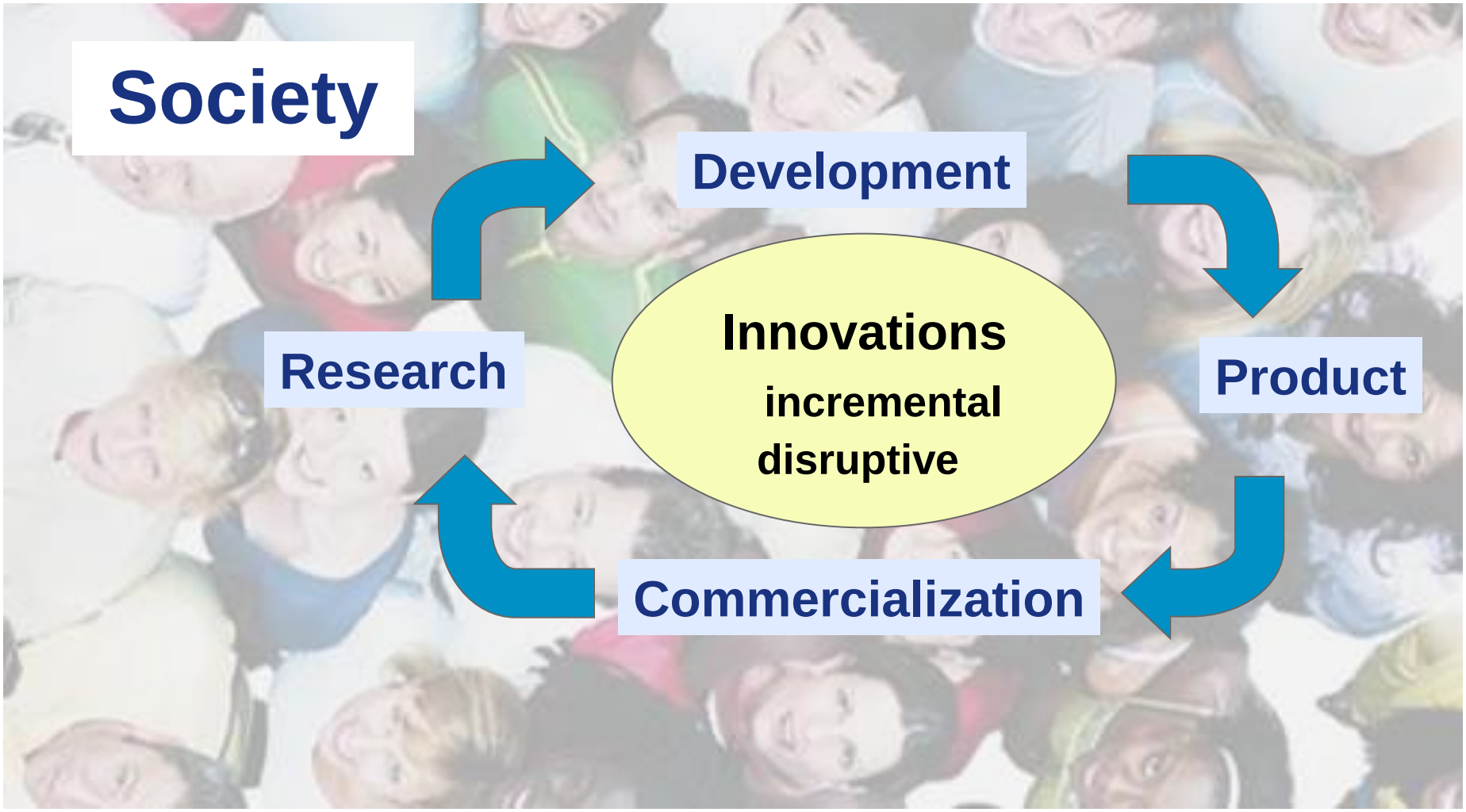
Bayer Working Group Nanotechnology
International Symposium on Assessing the Economic Impact of Nanotechnology
27-28 March 2012, Washington DC

Driving forces for Innovation: Technology challenges of the society

- Environment/Climate
- Resources
- CO_2-Prevention
- Energy:
  - Conversion
  - Storage
  - Saving
  - Transport
- Mobility
- Health Care
- Nutrition
- Security
- Information/ Communication

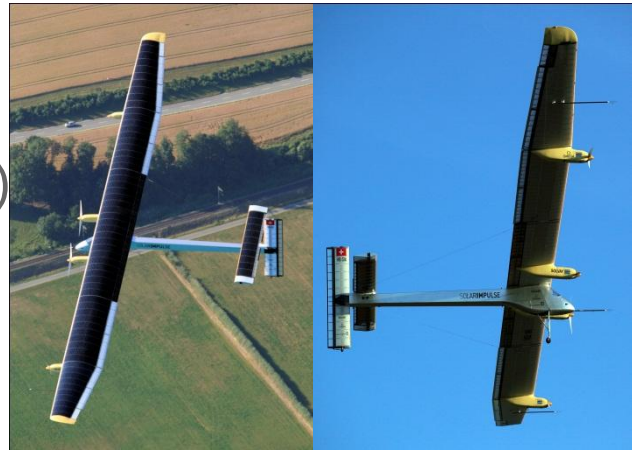
What are Innovations?
Innovation is consisting of: Research, development, viable commercialization:



Approaches to address challenges and needs of the society

Optimized use and combination of existing established technical solutions

Solar Impulse (B. Piccard, www.solarimpulse.com)
Once around the world in a manned airplane powered only by solar energy.

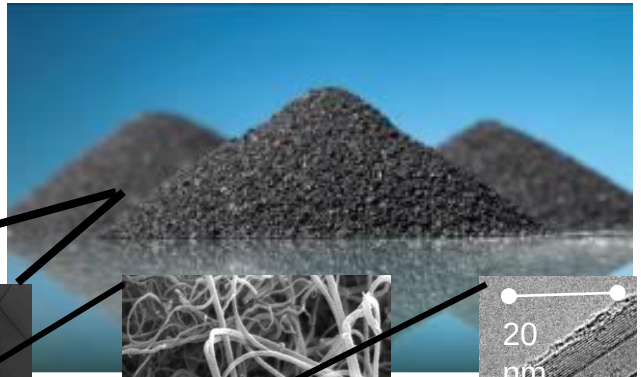


Need for efficient energy

- conversion (photovoltaic),
- storage (battery),
- use (light weight)

Develop new technology options for relevant applications

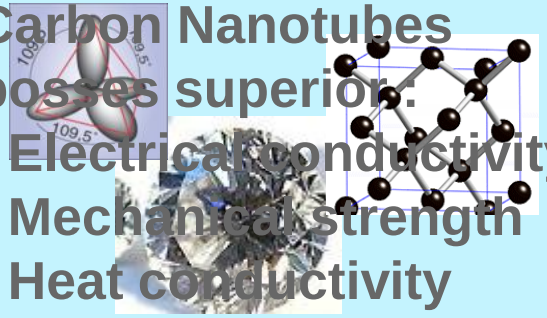
- **Nanotechnologies**
  - Materials technology



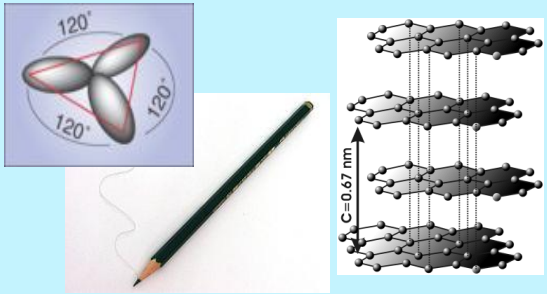
Nanomaterials, CNT

Carbon Structures

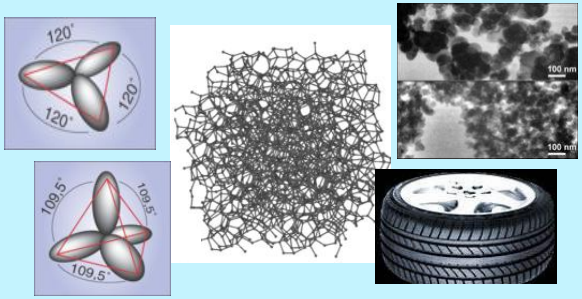
Diamond



Graphite



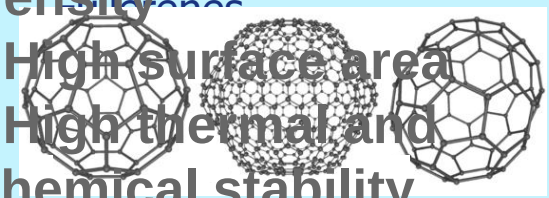
Amorphous carbon



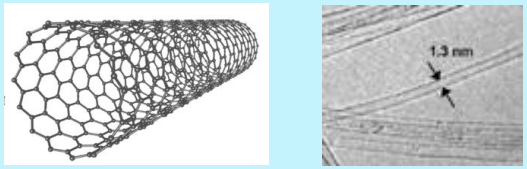
Carbon Nanotubes posses superior:

- Electrical conductivity
- Mechanical strength
- Heat conductivity
- Low macroscopic density
- High surface area
- High thermal and chemical stability

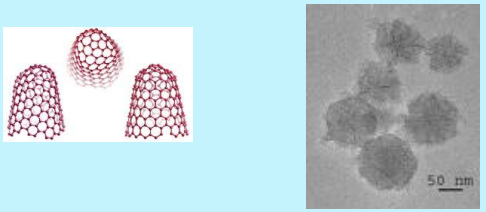
Buckminster



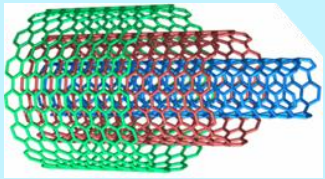
Single Wall Carbon Nanotubes

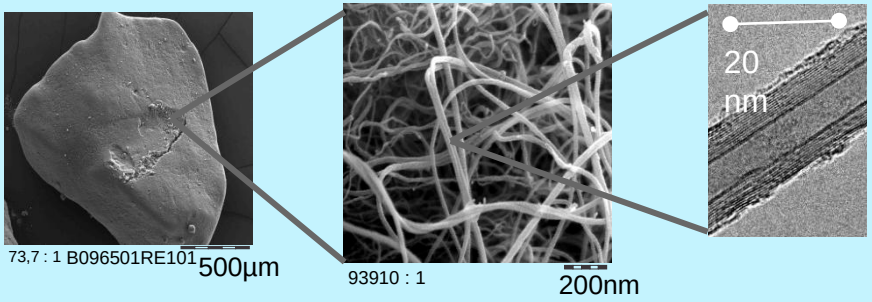


Carbon nanohorns



Multi Wall Carbon Nanotubes

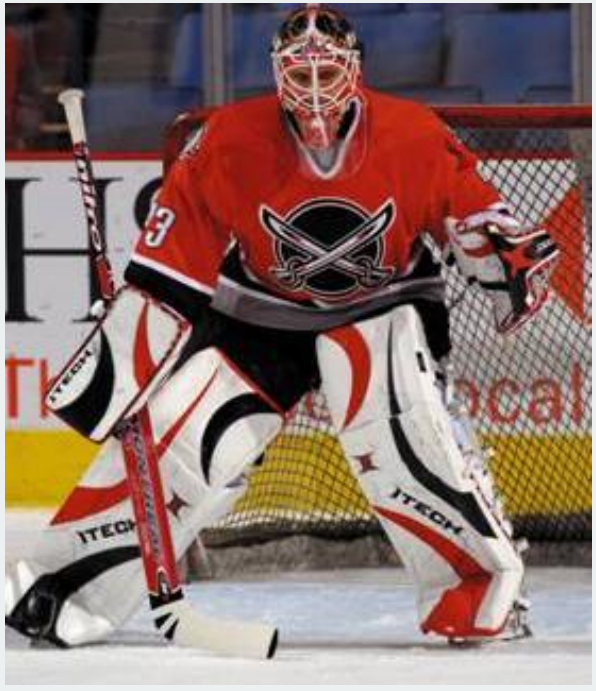




Carbon nanotubes - on industrial scale

Commercialization requirements:

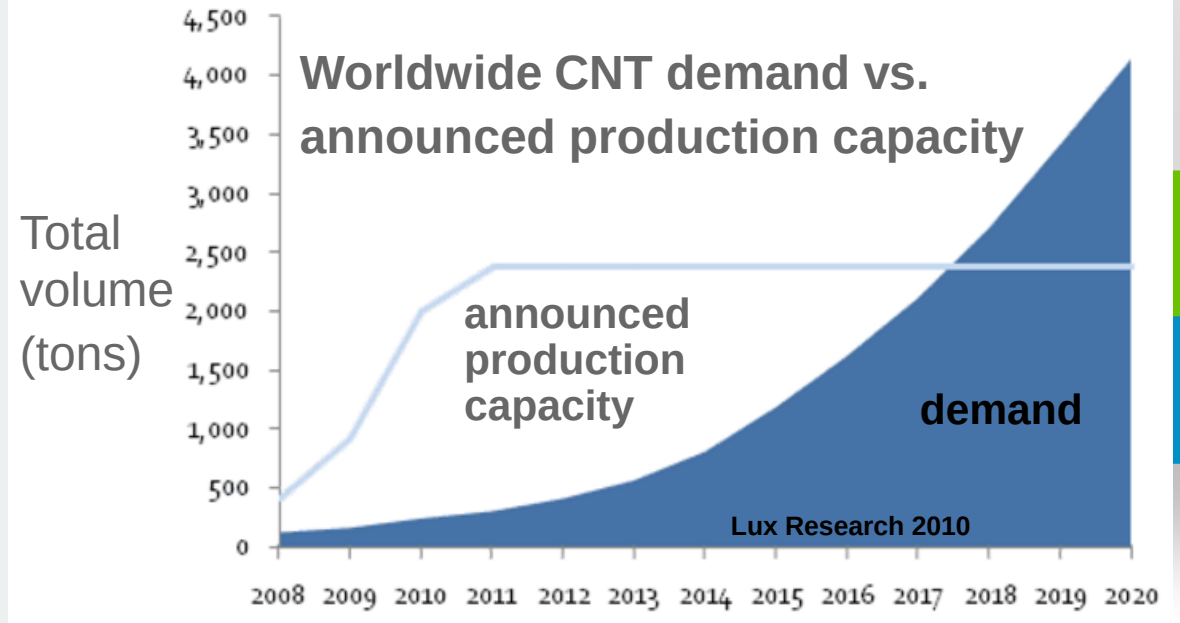
- Cost-effective manufacturing process
- High product purity even without post-purification
- Reproducible quality
- Reliable supply situation (incl. HSE)



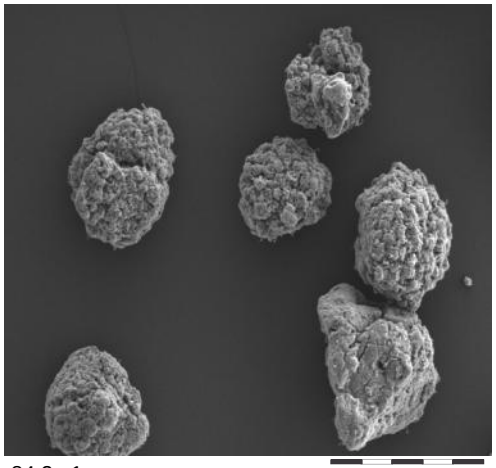
Ice hockey sticks from Montreal Sports Oy made of composite material based on CNT

Status:

- Estimated world wide production capacities for SWCNT in the range of few t/y
- Main players for MWCNT: Arkema (F), Bayer MaterialSciences (D), CNano (US/Ch), Hyperion (US), Nanocyl (B), Schowa Denko(J)
- Target: Development of hybrid materials with extraordinary mechanical, electrical, thermal and physico-chemical properties

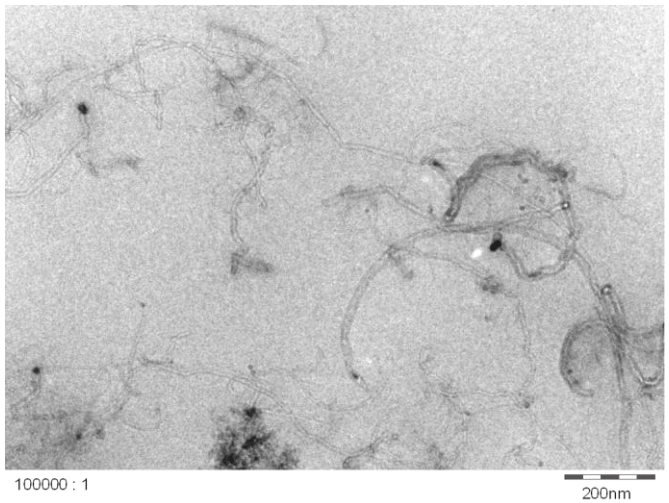


CNT dispersion is key
Challenge across the value chain:



‚as delivered'

Ø= 0,2 - 1 mm



‚in composite'

Ø= 5 - 20 nm, L ≈ 1 µm

CNT Architecture → Agglom. Structure → Surface Chemistry → Dispersion Technology → Stabilization

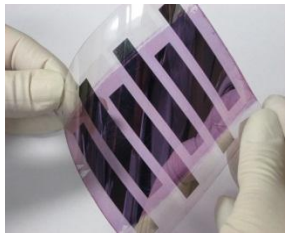
and

Commercial Viable Applications

Potential use of CNT for sustainable supply and use of energy in the future

Energy - Conversion

Efficient use of renewable energy (wind)
Fuel cell membranes
Efficient lighting/displays
Solar cells

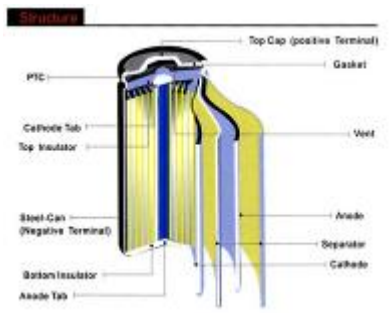


Energy - Transport

Efficient use of heat conductivity
Under-floor heating
Windshield defroster heating
Microwave antennas
Electrical circuits

Energy - Storage

Li-Ion Batteries
Hydrogen storage

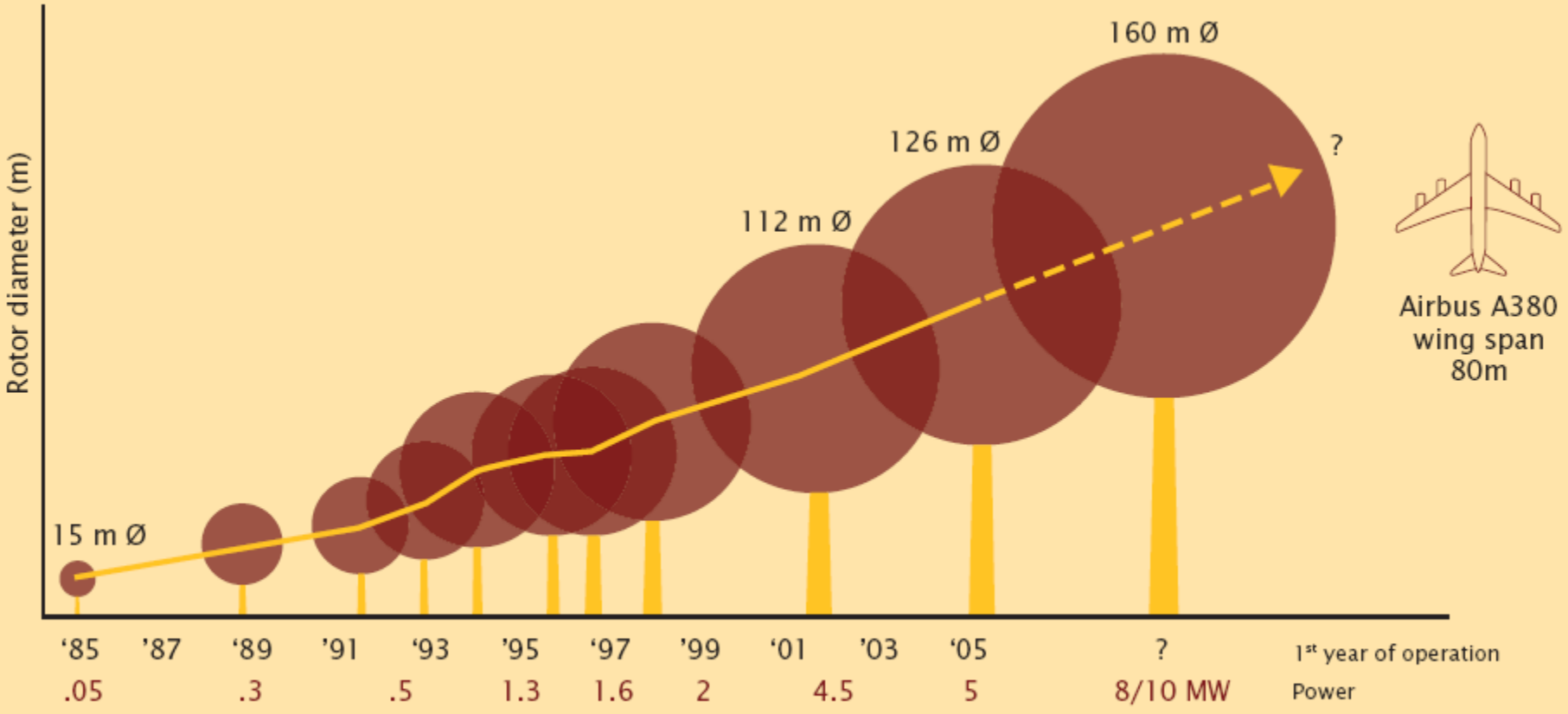


Energy - Saving

Lightweight materials for construction and transportation
Low rolling resistance tires / rubber
Efficient production processes catalysis
Electrostatic coating

Energy efficiency of wind turbines

Increase of efficiency by enlarged span of blades



Evolution of the size of wind turbines

Source: http://ec.europa.eu/research/energy/pdf/renews5.pdf
UpWind Intgrated Project on Windturbine Design

Technical Challange:

The maximum strength of materials limits the size of wind blades

Approach:

Reinforcement of materials by means of mixing with high strength additive, e.g. such as CNT

Approach to address technology challenges for sustainable energy conversion: Wind turbines

Inno.CNT

Synthesis CNT → Surface modification CNT → CNT+ Polymer: Intermediates → Rotor blades → Wind turbines → Energy supply → Cus-tomer

Value chain

Example: Innovation Alliance CNT, www.inno-cnt.de

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Inno.CNT

Innovation Alliance CNT:
Cross-sectional platform technologies as a basic fundament for application projects

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Innovation Alliance CNT- Inno.CNT
Key Figures

- Goals
  - Responsible research and development of basic technologies and applications for CNT based products
  - Contributions to the development of fundaments for sustainable lead markets for CNT based products
- Budget of the Alliance: ca. 90 Mio. €
- Governmental (BMBF) support ca. 50%
- 90 partner from industry and academia
- 27 cross-linked projects
- Runtime: 2008 - 2014

- Information: www.inno-cnt.de

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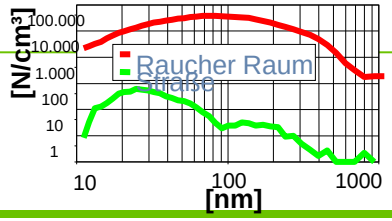
Product Stewardship for Nanomaterials at Bayer



Research and testing for the evaluation of exposure and bio activity profiles

Development and validation of Methods and Characterization

Participation on public supported projects: such as NanoCare, TRACER, CarboSafe

Participation in associations: e.g. DECHEMA, VCI, CEFIC, ACC

Support globally harmonized standardization (ISO, OECD)

Participation on Dialog with Stakeholders

Safety research is an essential part of the innovation - strategy

Summary:

- Nanotech / nanomaterials offer enourmos versatile potential approaches to address societal challenges
- Complexity across the value chains is about system solutions and not only producing nanomaterials and using nanotechnology
- Grand challanges might drive innovations but the customers decide on success
- Life cycle analysis is important but it only makes sense for known application related value chains
- Responsible and safe use of nanotechnologies and nanomaterials to support a sustainable future

Nanotechnology: Hope or Hype…

?

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Thank you
for your attention!