# Market opportunities:
# Understanding drivers/uncertainties of development to create market scenarios
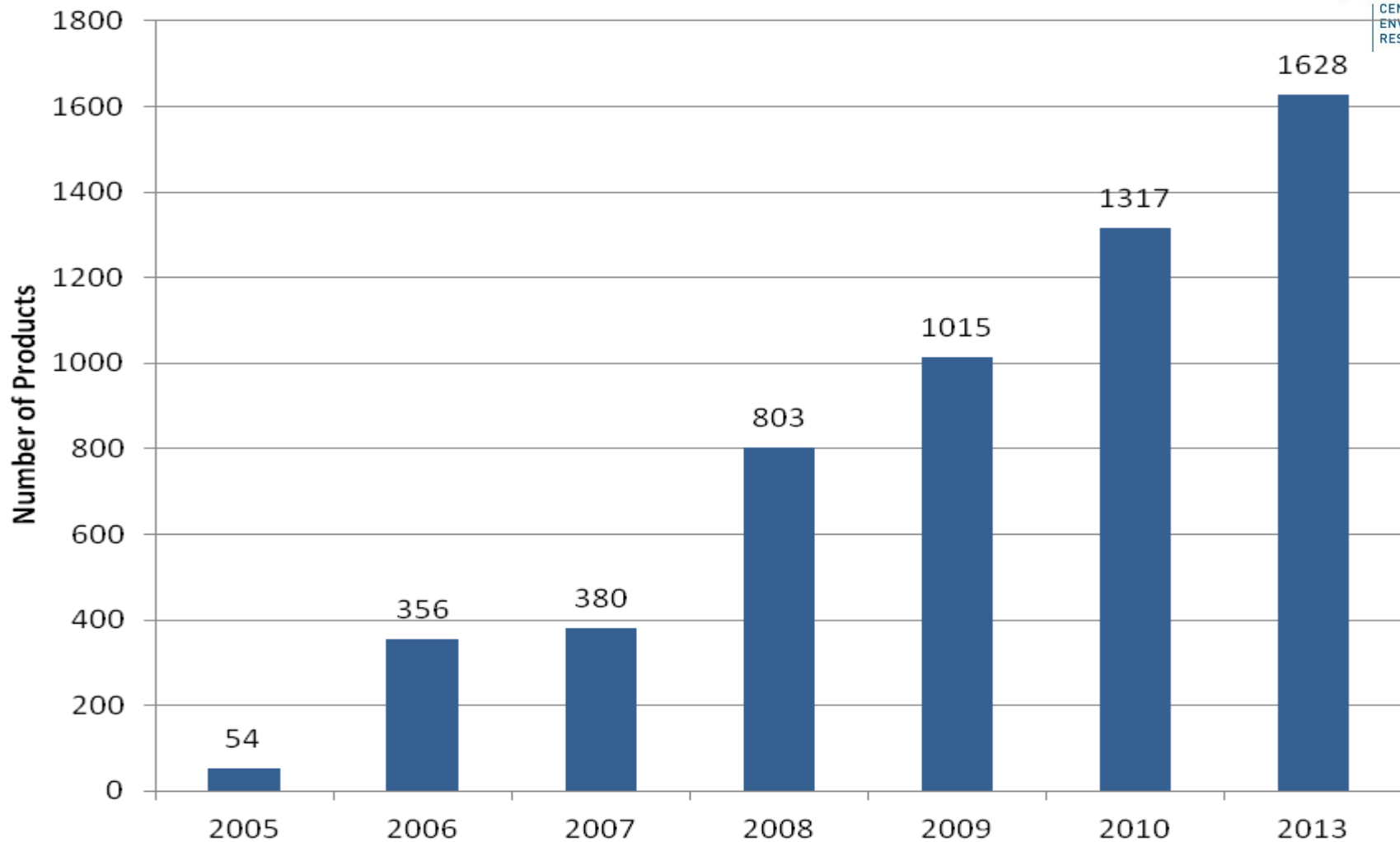
# > 1,800 consumer nano-enabled products



Source: http://www.nanotechproject.org/cpi/

## Total Products Listed



Chart showing Number of Products by year:
- 2005: 54
- 2006: 356
- 2007: 380
- 2008: 803
- 2009: 1015
- 2010: 1317
- 2013: 1628

Product Categories

Source: http://www.nanotechproject.org/cpi/about/analysis/

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Region of Origin

Source: http://www.nanotechproject.org/cpi/about/analysis/
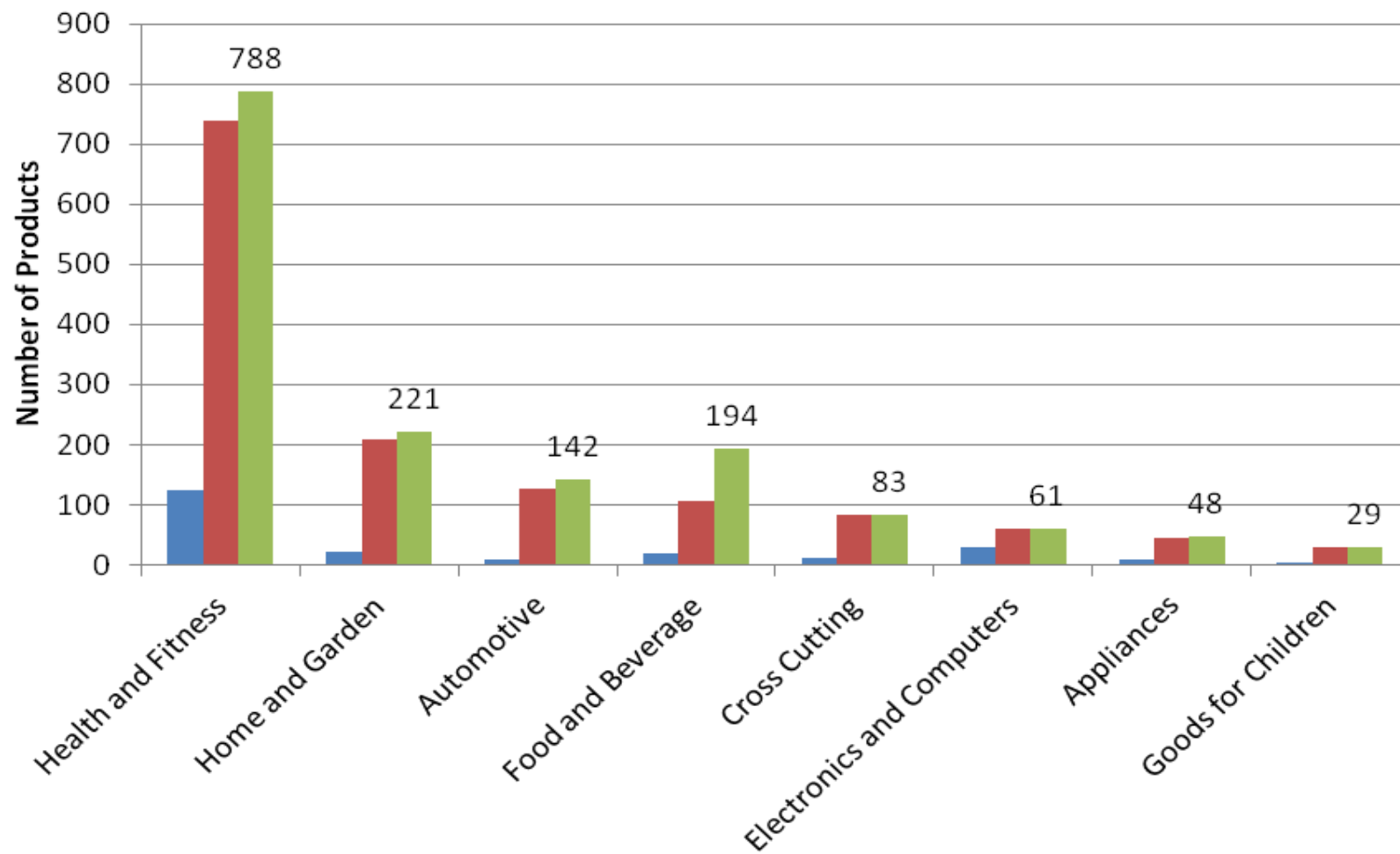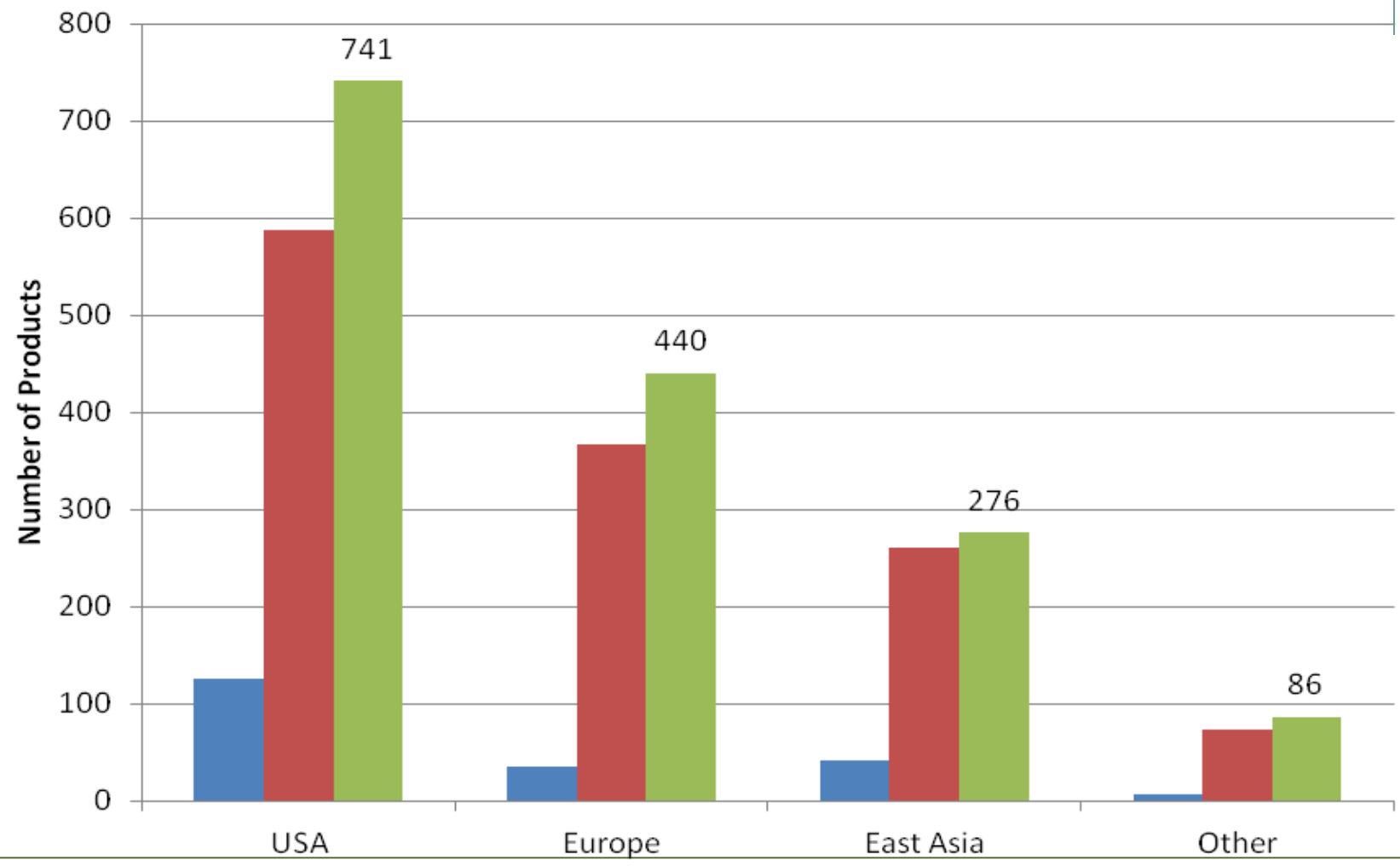
# Sales and profits of typical product life cycle stages
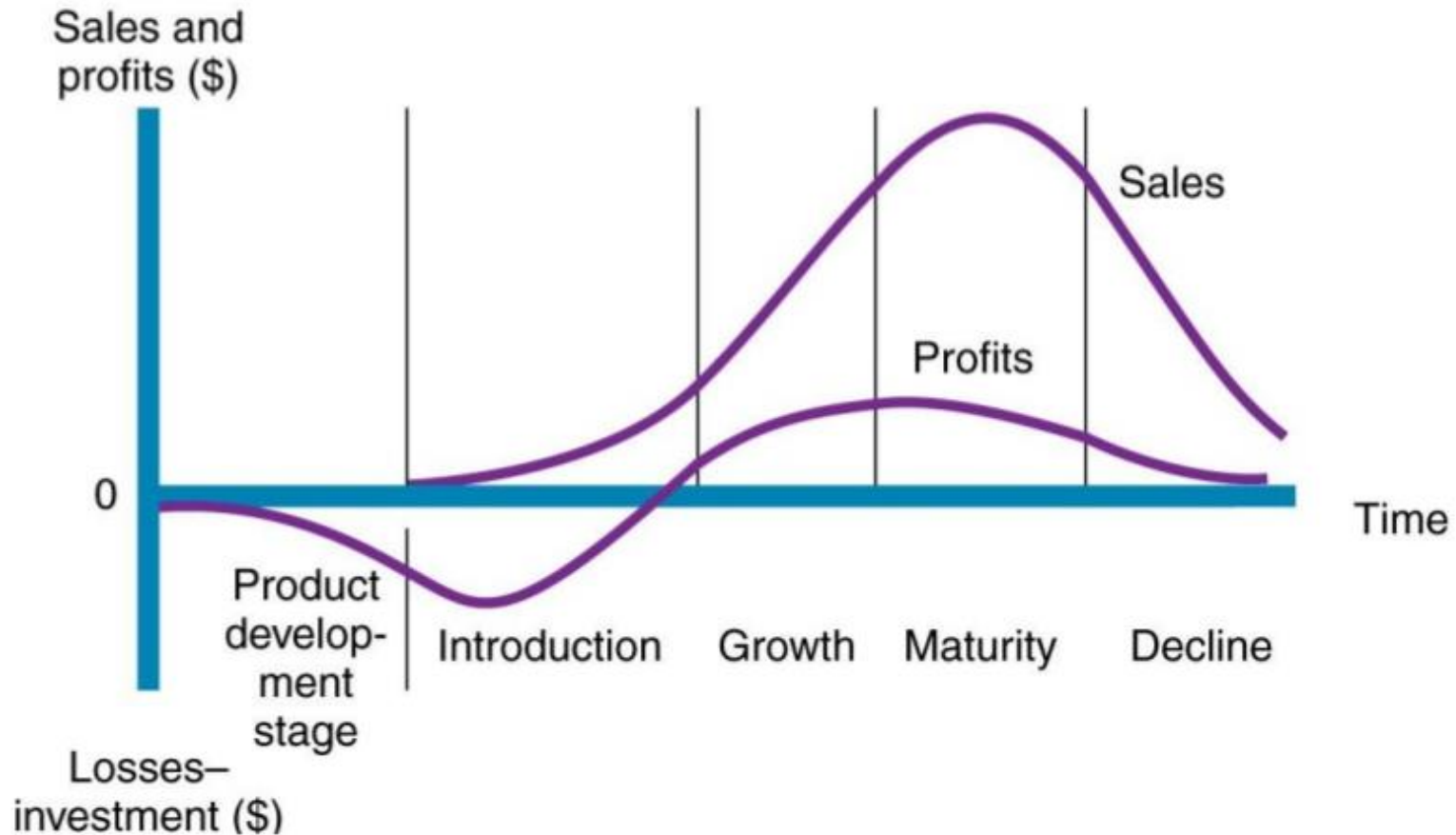
# Challenges in general Nano-Technology

- People do not buy technology; they buy products – Robust product development is critical to realize the potential

- Early and periodic wins needed to keep investor confidence high

- Venture community (research, entrepreneurs, …) behavior will determine the fate

- Integration of this emerging field into engineering and science curriculum is important to prepare the future generation of scientists and engineers

Source: Meyyappan 2009

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# What about the NanoRem specific landscape?



| Source | Pathway | Receptor |
|---|---|---|
| Iron nanoparticles directly injected | Migration within groundwater flow. | Groundwater quality |
| Iron nanoparticles contained in a structure (e.g. Barrier ) | | |
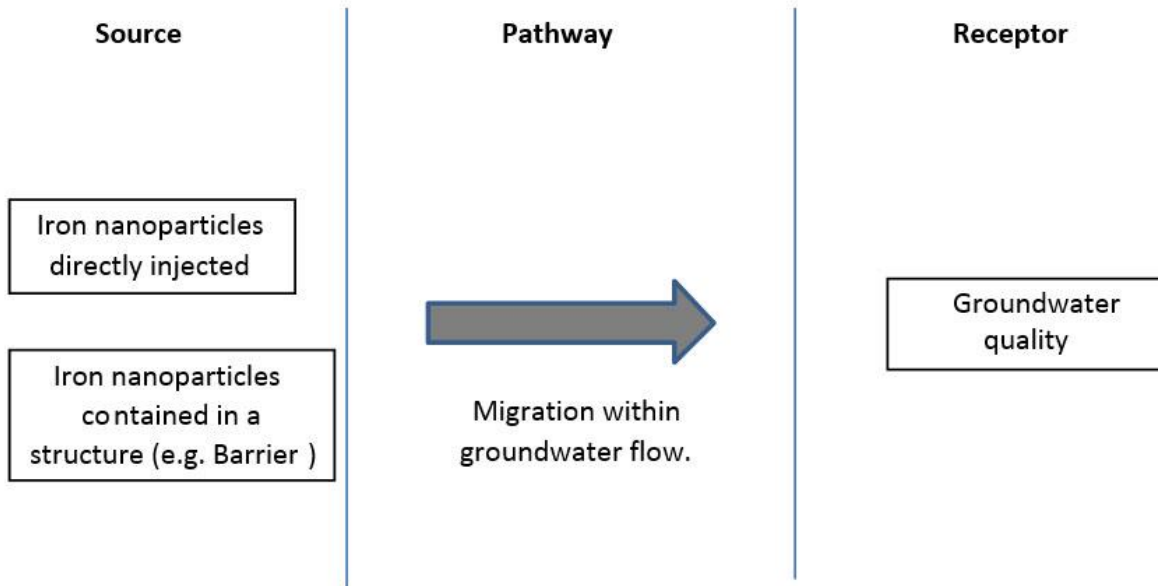
Source: www.nanorem.eu

# NanoRem potentials

- Improving the speed of contaminant destruction
- Improving the extent of contaminant destruction
- Extending the treatable range of contaminants
- Limited longevity of action
- Compatibility with other treatments

Source: www.nanorem.eu

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# Nanotechnology risk landscape

**Regulatory Risk**

- Many voluntary data-gathering systems but no

  - international nomenclature

  - practical guidelines

Source: Bruch 2012

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# Nanotechnology risk landscape

**Production Risk**

**Regulatory Risk**

- Most of the products seems to be safe

- Number of risk studies is increasing but

  - no clear answers on safety profile of nanoparticles and nanoproducts

  - The more risk studies we see the higher the (un)certainty gets(?) – disputes among experts can be the basis for future claims

Source: Bruch 2012

# Nanotechnology risk landscape

**Perceptual Risk**

**Production Risk**

**Regulatory Risk**

Highest impact on the overall risk, due to the lack of

- qualified hazard and exposure data

- strong legal framework

- harmonised public risk communication (risk-benefit approach)

Source: Bruch 2012

# Nanotechnology risk landscape

## Nanotechnology risks: The new asbestos?
**The safety risks of nanotechnology use by the food industry could make it "the we asbestos"….**

## Nanofibres could be as harmful as asbestos
**Experts have said that inhaling nanofibres could be equally as damaging as breathing asbestos.**

## Nanomaterials, sunscreens and cosmetics: Small ingredients, big risks
**Friends of the Earth's report "Nanomaterials, sunscreens and cosmetics: Small ingredients, big risks" details the extensive use of nanomaterials in 116 products, from sunscreens and anti-aging creams to shampoos and toothpastes, despite preliminary scientific evidence that many types of nanoparticles can be toxic.**

## Nanotech-based products offer great potential but unknown risks
**Some experts push cautious approach as market keeps expanding**

## What is the influence of the perceptual risk on nano-technology?

## The dangers of nanotechnology, a warning to consumers
**Although there is potential benefit to consumers, nanomaterials can also pose new threats to human health and the environment - warns consumer group.**

Source: Bruch 2012

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# Multi-level complexity of technology transition in socio-technical systems

- Geels (2002, 2010) 3 analytical levels: **niches as locus for radical innovations**, socio-technical regimes and exogenous socio-technical landscape.

- Transitions do not come about easily, because **existing regimes are characterized by lock-in and path dependence**, and oriented towards incremental innovation along predictable trajectories.

- Radical **innovations** emerge in niches, where dedicated actors nurture development on multiple dimensions to create 'configurations that work'.

- These niche-innovations may break through more widely if external landscape developments create **pressures on the regime** that lead to **windows of opportunity**.

- Subsequent struggles between niches and regimes, and possible replacement, take place on **multiple dimensions** (e.g. markets, regulations, cultural meanings, infrastructure).

Source: Geels 2010

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# Multiple actors in the socio-technical regime
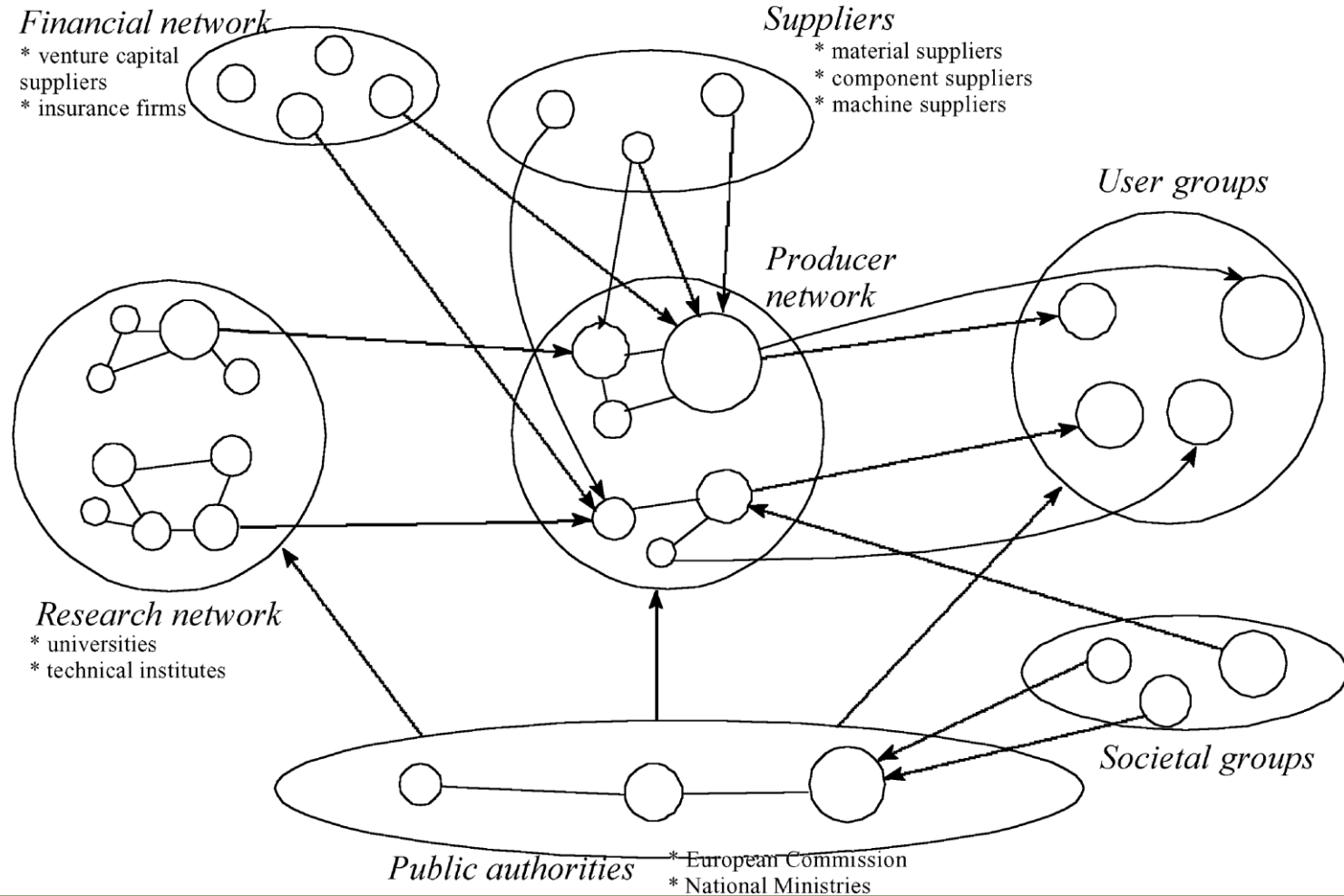


**Financial network**
* venture capital suppliers
* insurance firms

**Suppliers**
* material suppliers
* component suppliers
* machine suppliers

**User groups**

**Producer network**

**Research network**
* universities
* technical institutes

**Societal groups**

**Public authorities**
* European Commission
* National Ministries

Source: Geels 2003, p. 1260

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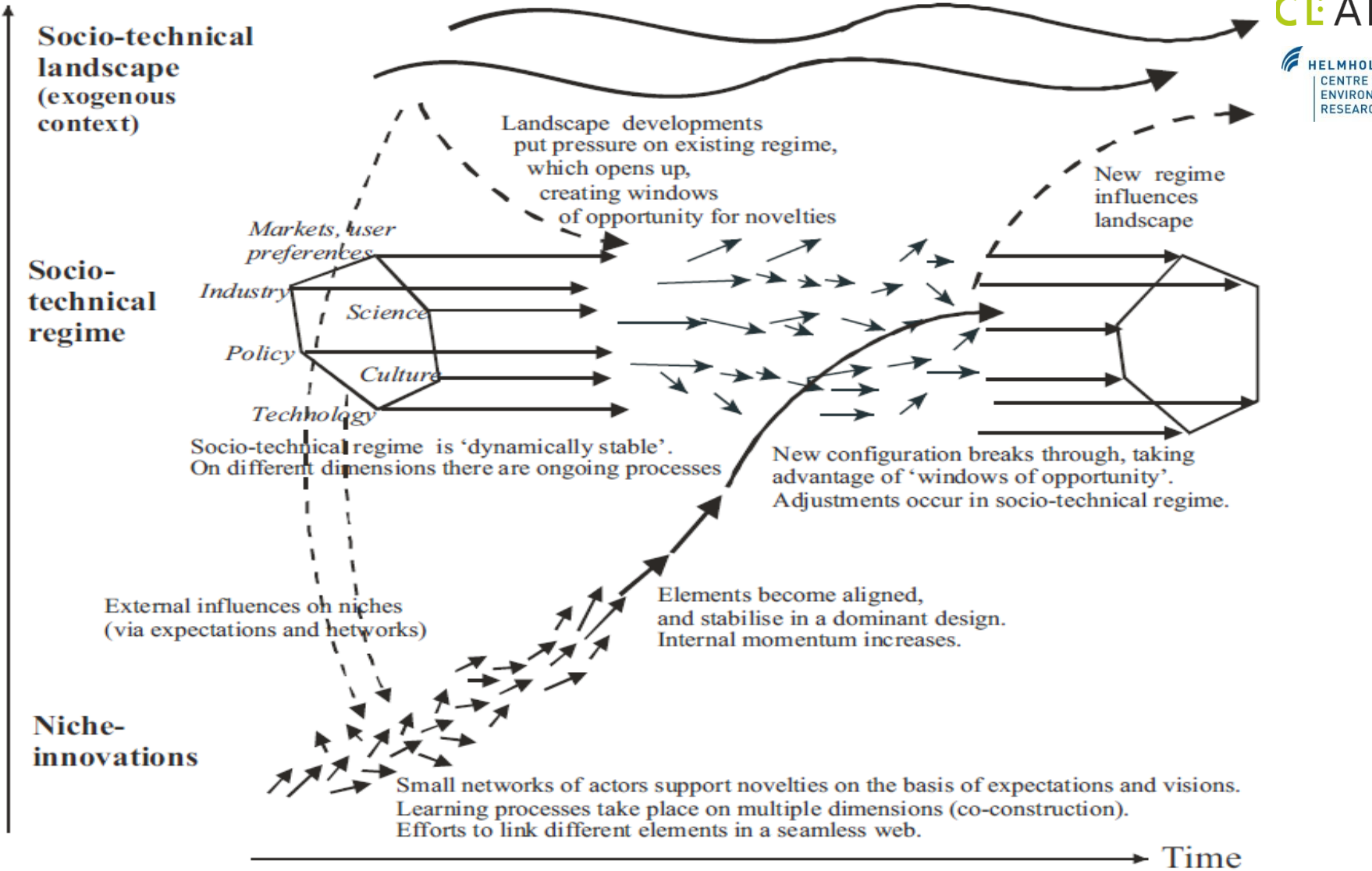
Source: Geels 2011, p. 28

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# Approach to understanding
# pull- and push factors / uncertainties

- Instead of market assessment on dubious assumptions,
  we strive at a better understanding of drivers
  of the nano-remediation market through scenario analysis

- **Scenarios are**

**"internally consistent stories
about ways that a specific system
might evolve in the future"**

(March et al 2012: 127)

# Why scenarios?

- Advantages, risks and further developments of the remediation market are **uncertain**

- Uncertainties increase with the **long-term perspective**

- Projections of **extreme versions** of the future to derive **recommendations** for policy makers & entrepreneurs
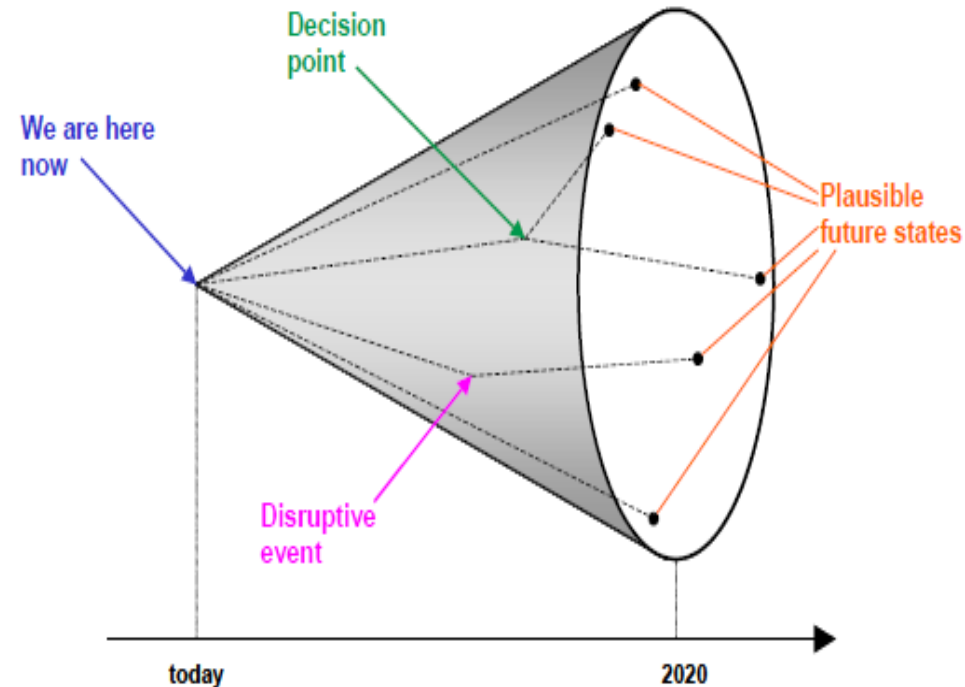


Source: Timpe and Scheepers (2003)

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# Methodology

CL AIRE

HELMHOLTZ | CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

## Scenario development

| Present situation analysis | → | Systematising push and pull factors | → | Projecting development of factors | → | Scenario storylines | → | Deduction → strategies & set screws |

- Step 1:  Analysis of the status quo framework
- Step 2:  Identification of relevant factors - drivers and inhibitors - and analysis of their systemic role
- Step 3:  Projections for condensed list of factors
- Step 4:  Transfer of factors into scenarios that exemplify consistent, possible alternatives of the future
- Step 5:  Interpretation of scenarios to derive recommendations for industry, consultants and politicians

NanoRem

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# Short survey on market factors' relevance

- Considering the **European Union in 2025**, indication of the relevance of factors using the scale:

  (0) **Negligible relevance** – the factor is not an important driver or inhibitor.

  (1) **Minor relevance** – the factor might have a limited but not so important effect.

  (2) **Considerable relevance** – the factor is likely to have a notable (indirect) effect.

  (3) **Key relevance** – this factor is most certainly among those of utmost importance to push or pull the nano-remediation market development.

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# Top important factors (>2.00)

1. Innovation on treatment of known contaminants with NP (2.48) – Technology

2. Regulation of nanoparticles (2.45) – Policy

3. Validated information on NP application potential (2.40) – Communication

4. Costs of competitive technologies (2.35) – Economy

5. Standardization for nanoparticles (2.20) – Policy

6. Innovations along NPs production chain (2.18) – Technology

7. Environment (especially soil) protection policies (2.10) – Policy

8. Synergies with other technologies (2.05) – Technology

9. Public stakeholder dialogue (2.00) – Communication

# Less important factors (<2.00)

10. NP treatment of emerging contaminants (1.95) – Technology
11. Public perception of NPs in general (1.93) – Society
    Science-Policy-Interface (1.93) – Communication
13. Technology and research policies (1.75) – Policy
14. Growing number of nanoparticles suppliers (1.73) – Economy
15. Real estate market development (1.68) – Economy
16. Innovation attitude (1.60) – Society
17. Environmental awareness (1.55) – Society

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# Minor relevant factors (<1.50)

18. EU economic development (1.50) – Economy
19. Globalization (1.20) – Megatrend
20. Industrial and military land use (1.00) – Society
21. Climate change (0.70) – Megatrend
22. Demographic change (0.60) – Megatrend

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# Summary: Relevant factors

- We find **no "key factor"** with > 2.50 scoring,
  indicating that no factor alone is of utmost importance
  to push or pull the nano-remediation market development

- We find **a wider set of considerably important factors** that
  might be subsumed to the following categories:
  - **Technical** | **– Policy** | **– Communication**
  - **Society** | **– Economy**

- Factors belonging to the "Megatrends" category were found to
  likely have only minor relevance. Moreover, some factors from
  "Economy" and "Society" were not found to be decisive.

# Preliminary conclusions from scenario exercise

- **Driving factors** of the NanoRem market **are diverse**, i.e. development depends not only on technology, but also on political (dis)incentives, societal' preferences and the attitude of the industry

- Several driving factors are **difficult to predict** and to influence such as public perception of NPs in general or soil protection policies

- **Interdependencies** with other fields such as finance and regional development, technology and nature protection are ample

# Understanding factor interactions in the EU till 2025

- To create scenarios, we next need to learn about the interdependencies of the identified important factors.

- **Expert groups will assess in a <u>next step</u> the relevance of the development of one factor on the development of all other factors.**

- After the specilists' assessments, the others will review the results.

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# Format for discussion

- There will be **five groups** – one for each dimension identified in the previous step.

- Each group will discuss a specific **subset of factors** to assess the impact from one factor on each of the remaining factors (45 min).

- Than in a **World Café style**, groups rotate to the next tables and have quick reviews of results obtained there.

- **Facilitators** and note-keepers stay at their tables and will report back to the plenum the conclusions of the process.

- Finally, an outlook will be provided in the plenum on the next steps in the scenario development.

# Format for discussion

| Technology | Policy & Regulation | Communication | Economy | Society |
|------------|---------------------|---------------|---------|---------|
| Alan T. | Astrid V. | Erik J. | Anil W. | Brian W. |
| Claire C. | Brian B. **(F)** | Paul B. | Berndt A. | Deborah O. **(N)** |
| Hans-Peter K. **(F)** | Christian MW. | Laurent B. | Craig H. | Judith N. **(F)** |
| Jürgen B. | Dominique D. | Nicola H. **(F)** | Eugen M. **(F)** | Peter V. |
| Julian B. **(N)** | Dietmar MG. | Rick P. | Jeremy B. | Petr B. |
| Steffen B. | Elsa L. **(N)** | Wojciech I. | Johannes B. | Rolf G. |
| Steve E. | Sarah H. | Yevgeniya T. **(N)** | Stephan B. **(N)** | Thomas A. |

- First: 45 minutes to discuss set of factors in your world café house
- Than: Visit other cafés and have quick review (4 x 12 min)
- Back to home café: Revisit assessments (15 min)
- Final: Plenary feedback/report from facilitators (5 x 5 min) and oulook

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# World Café iterations 4 + 8 min

- **Move clockwise to the next café house table**

- Facilitators & note-takers remain at their tables

- Tasks:

  - A brief report on the previous discussion (4 min)

  - Guests: point out surprises and considerable contradictions (8 min)



Image-Source: http://enercon-dach.we-conect.com/cms/media/uploads/events/220/img/wc1215_world-cafe.png

# Final World Café iteration 15 min

- Back at "your" cafè house

- Tasks:

  – A brief report on the previous discussions (5 min)

  – Task (10 min):

    - Revisit assessment

    - Point out remaining open issues

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# Market Opportunities

## Possible futures towards a NanoRem market in Europe in 2025

# Phases of scenario analysis

Scenario development

| **Present situation analysis** | → | **Systematising push and pull factors** | → | **Projecting development of factors** | → | **Scenario storylines** | → | **Deduction → strategies & set screws** |

# Work plan outline

| Scenario preparation |
| :--: |

↓

| Present situation analysis |
| :--: |

↓

| Drivers Identification, sytematising and visioning |
| :--: |

↓

| Scenario storylining |
| :--: |

↓

| Deductive reasoning → strategies & set screws |
| :--: |

**first step (M18-M22)** Jul-Nov'14

**second step (M19-M23)** Aug-Jan'15

**third step (M22-M27)** Dec'14 - Apr'15

**forth step (M26-M29)** Mar-Jun'15

**fifth step (M27-M31)** Apr-Aug '15

**final step (M26-M35)** Mar-Dec '15

- *literature review & key informant interviews*
- *questionnaire project in- & external*
- *workshop & focus group*
- *scenario deduction*
- *focus group & key informant interviews*
- *reporting article preparation*

**Initial collection & categorisation of drivers/ uncertainties**

**Dependency between drivers / interaction matrix**

**Consolidated list of drivers**

**Scenario storylines**

**Recommendations for exploitation strategies**

**Input to DL9.1 and IDL9.3 | Paper**

# Review of drivers; visioning futures

**workshop & focus group**

**first step (M18-M20)** Jul-Sep '14

**second step (M18-M21)** Jul-Nov '14

**third step (M19-M25)** Aug '14 - Feb '15

**forth step (M25-M27)** Feb-Apr '15

**fifth step (M27-M29)** Apr-Jun '15

**final step (M26-M29)** Mar-Jun '15

- Oslo workshop and one focus group to review drivers, and to discuss potential future developments
  - ➤ Discussion and selection of drivers in workshop
  - ➤ Focus group (in early 2015) to validate and augment results towards a consolidated list of drivers and to envision potential developments of factors

**Consolidated list of drivers**

# Review of drivers; visioning futures

**workshop & focus group**

first step
(M18-M20)
Jul-Sep '14

second step
(M18-M21)
Jul-Nov '14

**third step
(M19-M25)
Aug '14 - Feb '15**

forth step
(M25-M27)
Feb-Apr '15

fifth step
(M27-M29)
Apr-Jun '15

final step
(M26-M29)
Mar-Jun '15

**Influence matrix**
Question: »How strong is the impact of factor A (row) on factor B (column)?«

scale:
0 = no impact
1 = weak and delayed impact
2 = medium impact
3 = strong and direct impact

**activity (sum of rows):**
How strong is the impact of a factor on all other factors?

| | 1 buying habits | 2 cashless money transfer | 3 size of purchasing points | 4 home-shopping | 5 buying power | 6 hours of opening | 7 use of credit cards | 8 use of consumer cards | 9 point-of-sale-networks | ... | 35 system of values | 36 growth rate | active sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 buying habits | | 2 | 2 | 3 | – | 1 | 2 | 2 | 1 | | – | – | 13 |
| 2 cashless money transfer | 1 | | – | – | – | – | 3 | 2 | 3 | | – | – | 17 |
| 3 size of purchasing points | – | 1 | | 2 | – | 1 | – | 3 | 3 | | – | – | 13 |
| 4 home-shopping | – | 2 | 1 | | – | – | 3 | – | – | | – | – | 10 |
| 5 buying power | 3 | 2 | – | 1 | | – | – | – | – | | – | 2 | 15 |
| 6 hours of opening | 2 | 2 | 2 | 3 | – | | – | – | – | | – | – | 13 |
| 7 use of credit cards | – | 1 | – | – | – | – | | 1 | 1 | | – | – | 10 |
| 8 use of consumer cards | – | 1 | – | – | – | – | 2 | | 3 | | – | – | 6 |
| : | | | | | | | | | | | | | |
| 35 system of values | 3 | – | – | 1 | – | – | – | – | – | | | 2 | 26 |
| 36 growth rate | 2 | – | – | – | 3 | 1 | – | – | – | | – | | 19 |
| **passive sum** | 30 | 41 | 13 | 31 | 14 | 7 | 25 | 17 | 24 | | 10 | 14 | |

Influence matrix Source: Gausemeier et al. (1998: 119)

**passivity (sum of columns):**
How strong is a factor impacted by all the others?

**Consolidated list of drivers**

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# Review of drivers; visioning futures



**workshop & focus group**

first step
(M18-M20)
Jul-Sep '14

second step
(M18-M21)
Jul-Nov '14
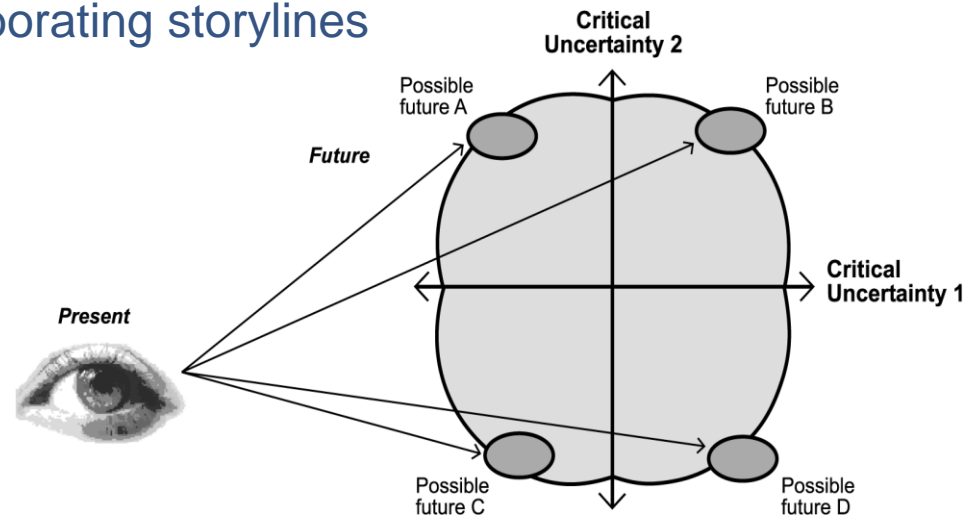
**third step
(M19-M25)
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forth step
(M25-M27)
Feb-Apr '15

fifth step
(M27-M29)
Apr-Jun '15

final step
(M26-M29)
Mar-Jun '15

**Detection of relevant key factors by analysis of interconnections between internal and external factors ...**

**... description of several possible developments of each of them ...**

**... and finally grouping of them for scenarios free of contradictions.**

Influence matrix Source: Gausemeier et al. (1998: 118)

**Consolidated list of drivers**

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# Drafting scenario storylines

**first step**
**(M18-M20)**
Jul-Sep '14

**second step**
**(M18-M21)**
Jul-Nov '14

**third step**
**(M19-M25)**
Aug '14 - Feb '15

**forth step**
**(M25-M27)**
**Feb-Apr '15**

**fifth step**
**(M27-M29)**
Apr-Jun '15

**final step**
**(M26-M29)**
Mar-Jun '15

*Scenario deduction*

- Drafting scenario storylines
  - ➢ Compiling projections of plausible drivers' developments into scenarios
  - ➢ Evaluation of scenarios' consistency
  - ➢ Elaborating storylines



The scenarios' development process based on critical uncertainties.
Source: Kelly et al. (2007: 87).

**Scenario storylines**

# Deductive reasoning

**first step (M18-M20)** Jul-Sep '14

**second step (M18-M21)** Jul-Nov '14

**third step (M19-M25)** Aug '14 - Feb '15

**forth step (M25-M27)** Feb-Apr '15

**fifth step (M27-M29)** Apr-Jun '15

**final step (M26-M29)** Mar-Jun '15

**focus group & key informant interviews**

- Evaluation of scenarios and formulating recommendations
  - ➤ interpreting the scenarios in focus group setting (mid 2015) to identify opportunities and threats in the context of the current situation
  - ➤ formulating recommendations that can serve as a basis for further exploitation strategies being planning-oriented, responsive or proactive
  - ➤ Discussion / Feedback with interview partners (from first step) towards reviewing and augmenting recommendations

**Recommendations for exploitation strategies**

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# Exploitation strategies

*focus group & key informant interviews*

**Recommendations for exploitation strategies**

| | Planning-oriented Strategy | Responsive Strategy Opportunity-seeking / risk-avoiding | Proactive Strategy |
|---|---|---|---|
| **Focussed strategy** (strategy based on one reference scenario) | **Strategy based on the scenario with the greatest probability** Conventional one-dimensio-nal planning is easy to communicate – but: traditional prognoses and most probable scenarios come true less often then planners think. | **Strategy based on the scenario with the greatest opportunities** Powerful but risky strategy to achieve the best possible results. **Strategy based on the scenario with the greatest threats** Risk-avoiding strategy to use in Crisis-Management. | **Strategy based on the desirable scenario** Enterprises create »their own future« – difficult to handle with external scenarios. |
| **Future-robust strategy** (strategy based on several scenarios) | **Safeguarded strategy based on the scenario with the greatest probability** Conventional strategy which is safeguarded by alternative scenarios. | **Strategy concentrating on the maximization of flexibility** Effective strategy to cope with uncertainties – but often not powerful enough. **Strategy concentrating on the minimization of threats** One-sided concentration on risk-minimization. | **Safeguarded strategy based on the desireable scenario** Enterprises create »their own future« and safeguard their strategy by putting the strategy in different environments. |

Main approaches for scenario transfer. Source: Gausemeier et al. (1998: 126)

# Dissemination

**first step
(M18-M20)**
Jul-Sep '14

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**third step
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Aug '14 - Feb '15

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(M25-M27)**
Feb-Apr '15

**fifth step
(M27-M29)**
Apr-Jun '15

**final step
(M26-M29)**
Mar-Jun '15

*reporting
article preparation*

- Report according to DoW + Paper preparation
  - ➤ presenting (preliminary) results
    along with directions of further investigation
    as contribution towards the DL9.1 and IDL9.3
    (both due in M27)
  - ➤ Preparation of a paper for submission
    of the key findings (presumably with focus on
    drivers and stakeholders' needs)
    to a peer reviewed journal

**Input to DL9.1 and IDL9.3 | Paper**

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