Joint NAS / NAE / Leopoldina / IOM / KIT Conference:
Technologically Modified Environment –
Environmentally Modified Technology

Interaction between Environment and Technology: New, Ecologically Compatible Schemes

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Overview

- The paradigm of sustainability
- Designing sustainable products and production
- Environmental engineering as a tool for sustainability
- Examples
- Conclusions

Objective of this approach

- Understanding the development process of **technology based products** under the challenges and requirements of a sustainable future
- Regarding the **interaction** between technical demands, market requirements, economical considerations, legal aspects, and environmental care
- Considering that the various **boundary conditions** and **objectives** are seldom in line and even partly contradictory

How do you feel sustainability?

Hans Carl von Carlowitz (1645-1714)

Oberberghauptmann in Freiberg-Sachsen *(Superior Mining Administrator)*

Sylvicultura Oeconomica
(1713, Leipzig)
Naturmäßige Anweisung
zur Wilden Baum-Zucht

- Improvement of trade and commerce (*"florirende Commercia"*)
- For the wealth of the community
- Sufficient nutrition and living conditions
- Economy has to serve welfare
- Careful interaction with the "*kind nature*"
- Critics on short term benefits

Sylvicultura Oeconomica
(1713, Leipzig)
Naturmäßige Anweisung
zur Wilden Baum-Zucht

- If the forests are finally ruined *" the proceeds will be down for many years … so that an irreparable damage will occur"*
- *" to handle wood with care"*
- You have to use wood *"gentle"* to achieve a balance between growth and harvest
- And therefore the use shall be possible *"perpetually and continually"*
- *" You should not throw away your clothes as waste as long as you have not any new one"*
- *"that there will be a continual, lasting and sustainable use"*

Hans Carl von Carlowitz

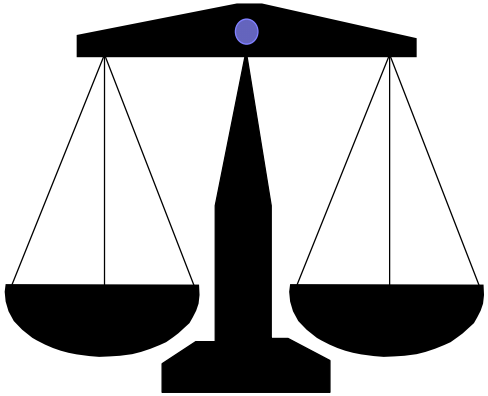
A visionary pioneer in strategies for sustainability - 1713 !

Sustainability - Paradigm of the 21st Century

- Goals of the Rio Summit
- Future Generations shall have Equal Opportunities
- Reasonable Management of Resources, Energy and Environmental Burdens
- Commitment of Governments, Societies and Corporations

Sustainability – Permanently a Balancing Effort

Social dimension



Economic dimension

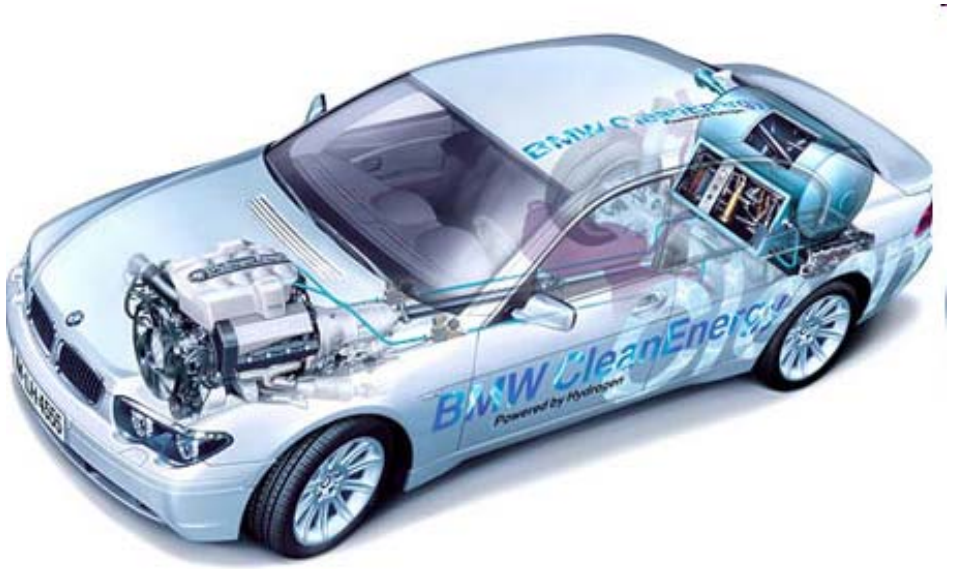
Ecological dimension

Sustainability - Part of a Business Strategy

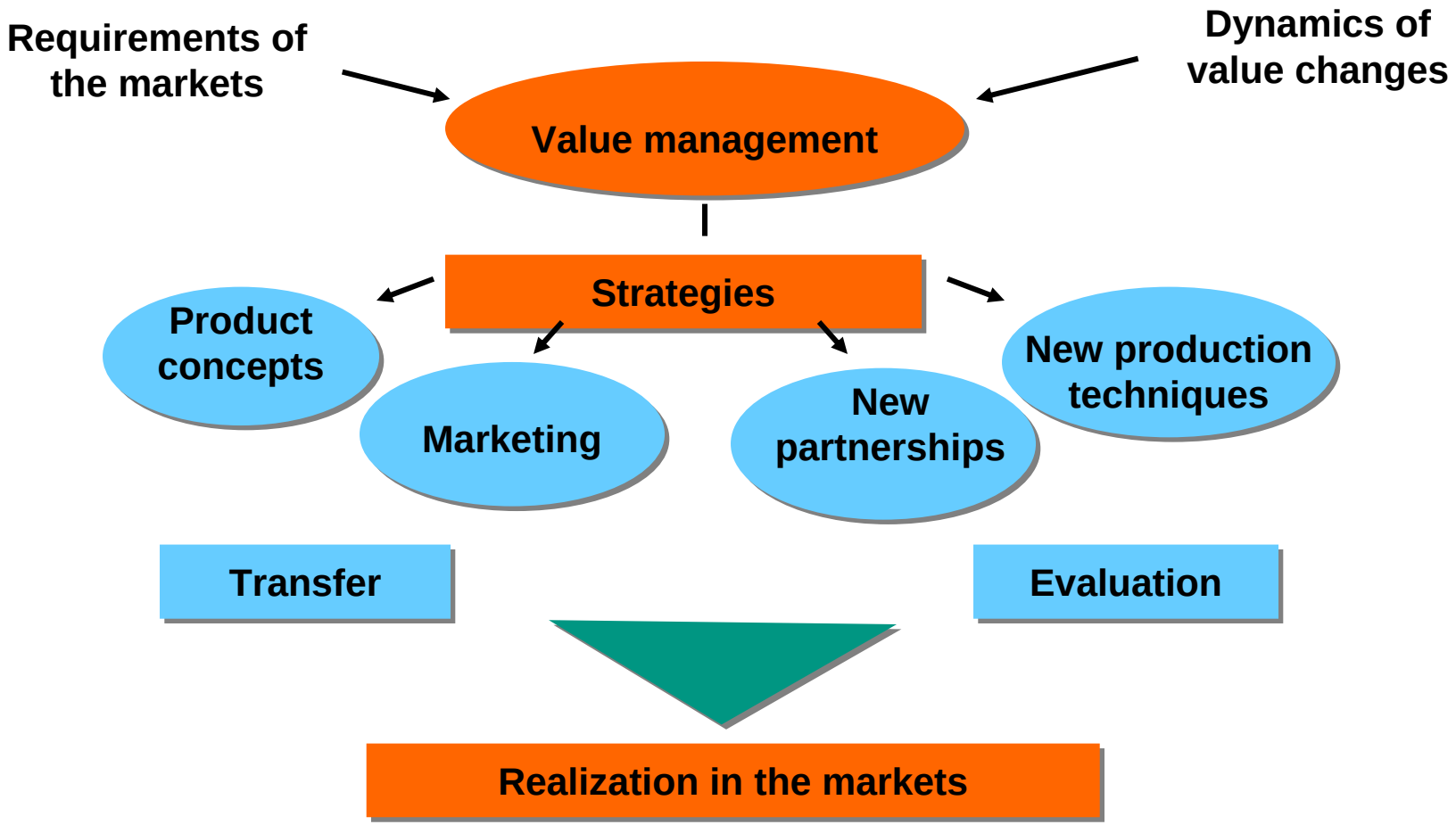
- Corporate strategies: Overall responsibility and new business opportunities
- R & D programs of the European Union and member states
- German research plan for „Production in the 21st century“
- Shareholder value: Dow Jones Sustainability Index

Products and Processes Aiming on Sustainability

"It is the aim to develop new or optimized **products**, **processes** and **services** which use the opportunities and chances of a strategic re-orientation towards the **paradigm of 'sustainability'**"



Sustainable Value Management for Market Success



Product Concept and Market Success

Product characteristics

- Design
- Performance
- Easy operation
- Functionability

Product advantages

- Low operating costs
- High reliability
- Better than competitors

Customers benefit

- Fulfills requirements
- Satisfies wishes
- Provides attitude and prestige

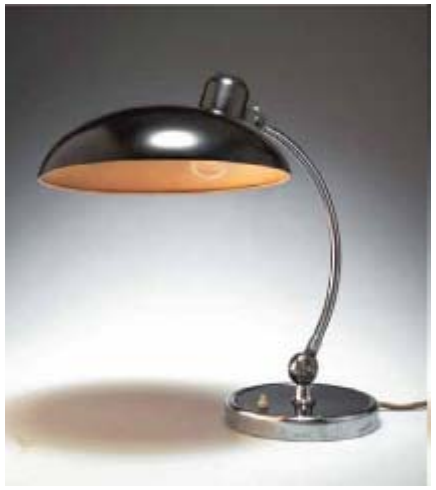
Market success

Life-time of products

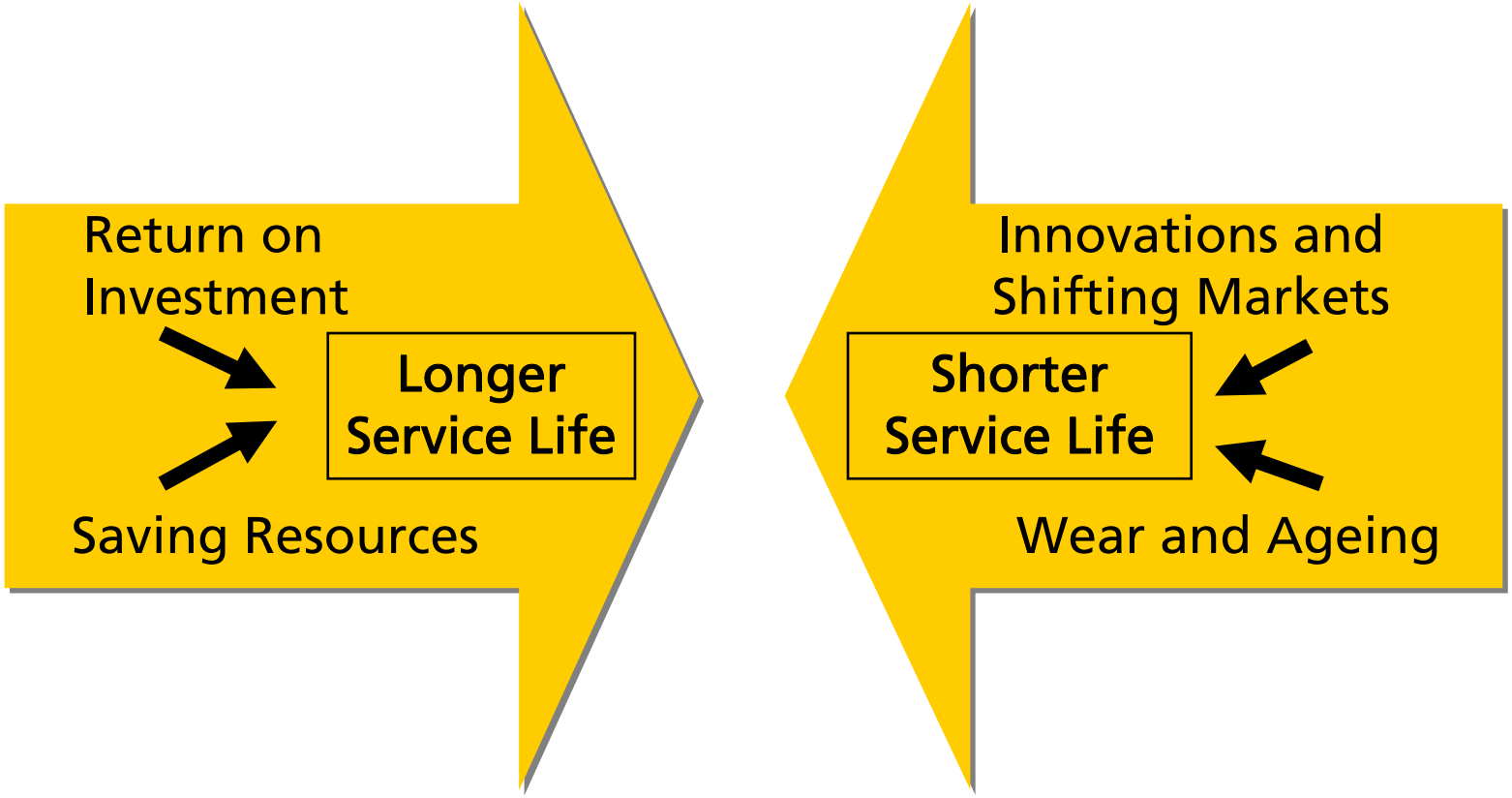
- Factors of service-life limitation: technical, economical, ecological
- Strategies for service life extension
- Variability of design; integration of changing tastes
- How have short-dated products to be designed under the aspect of sustainability?

Design for Sustainability

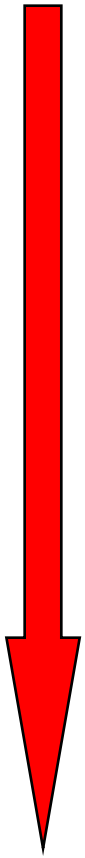
- How does visual impression and taste of the consumer influence the durability of a product?
- Design for sustainability- does this exist?
- What is a “timeless” design and when is it successful?



Conflict: Longer versus Shorter Life Time



Product Development Process



- Product specifications
- Materials selection
- Design – the creative step
- Manufacturing planing: consideration of production and assembly needs
- Prototyping and virtual development
- Testing
- Design freeze & verification
- Product acceptance & start of production

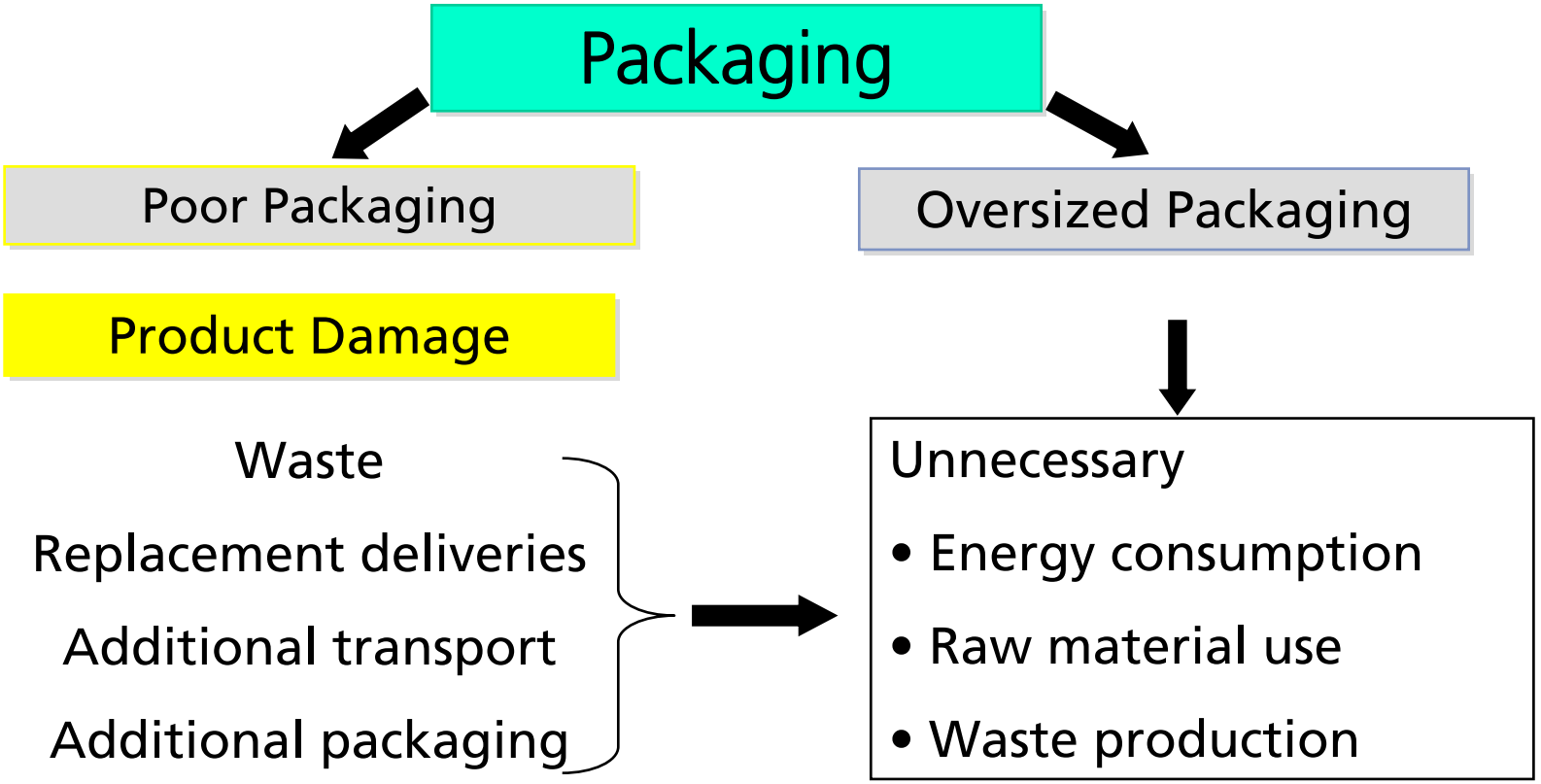
Guidelines for Sustainable Product Design

- Modular design: Grouping of devices with similar service life
- Identification and definition of interfaces
- Standardization
- Discrete functional units (e.g. energy converter, control unit, mechanical parts, housing)
- Fast and easy dismantling potential
- Easy software up-grading
- Self-diagnostic capability
- Easy repair

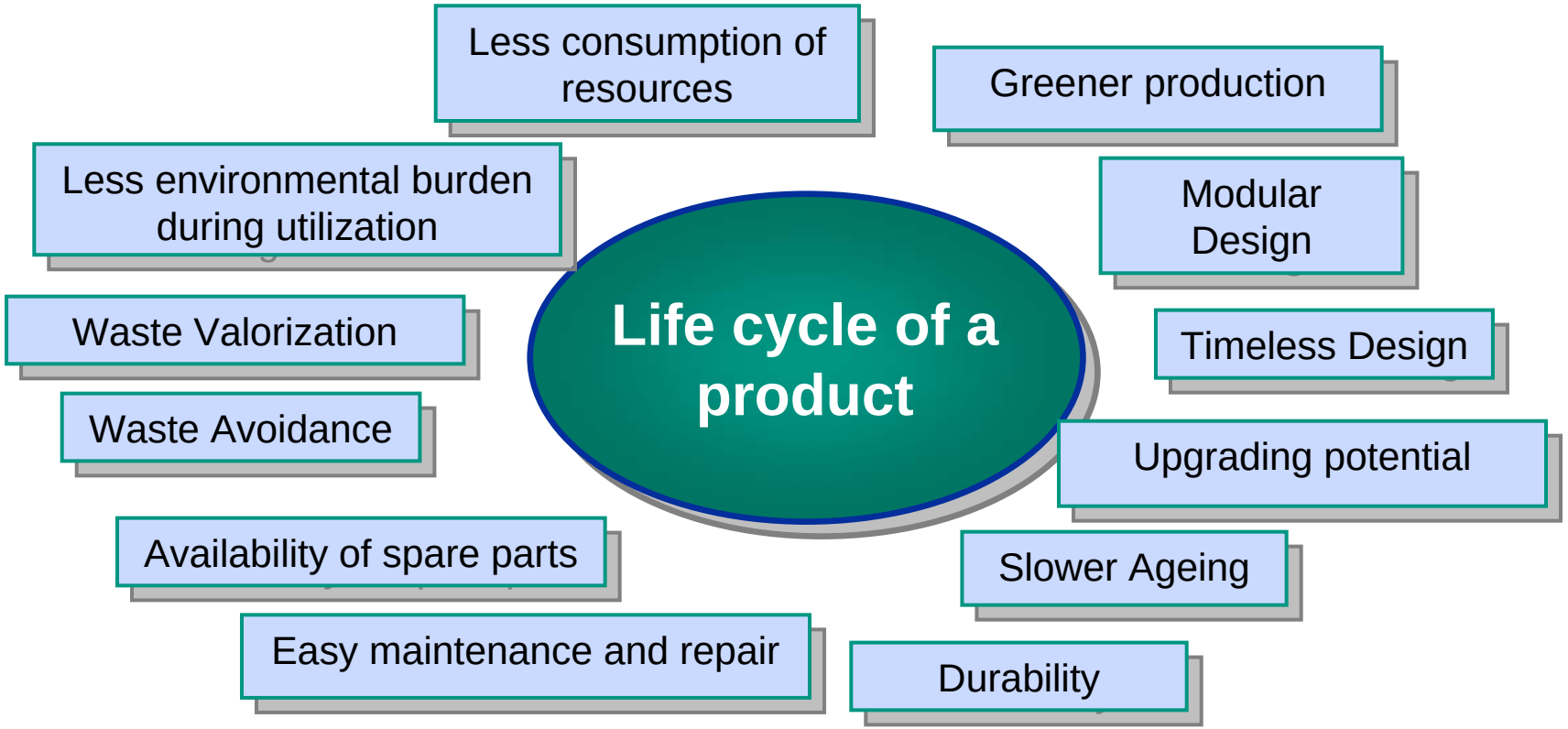
Sustainability Parameters related to Product Development

- Durability and reliability
  - Weathering resistance
  - Ageing stabilization
  - Decrease of wear-out
  - Minimize defects
- Avoidance of waste
- Tailored packaging
- Careful management of resources
- Minimized emissions along the life cycle

Sustainability Issues of Packaging



Sustainable Issues Related to the Life Cycle



Design-to-Life

Streamlining durability and reliability of

- Materials
- Components
- Microelectronics
- Sensors
- Optics
- Display technology
- Power supply
- Other relevant components

With respect to product application and intended service life considering

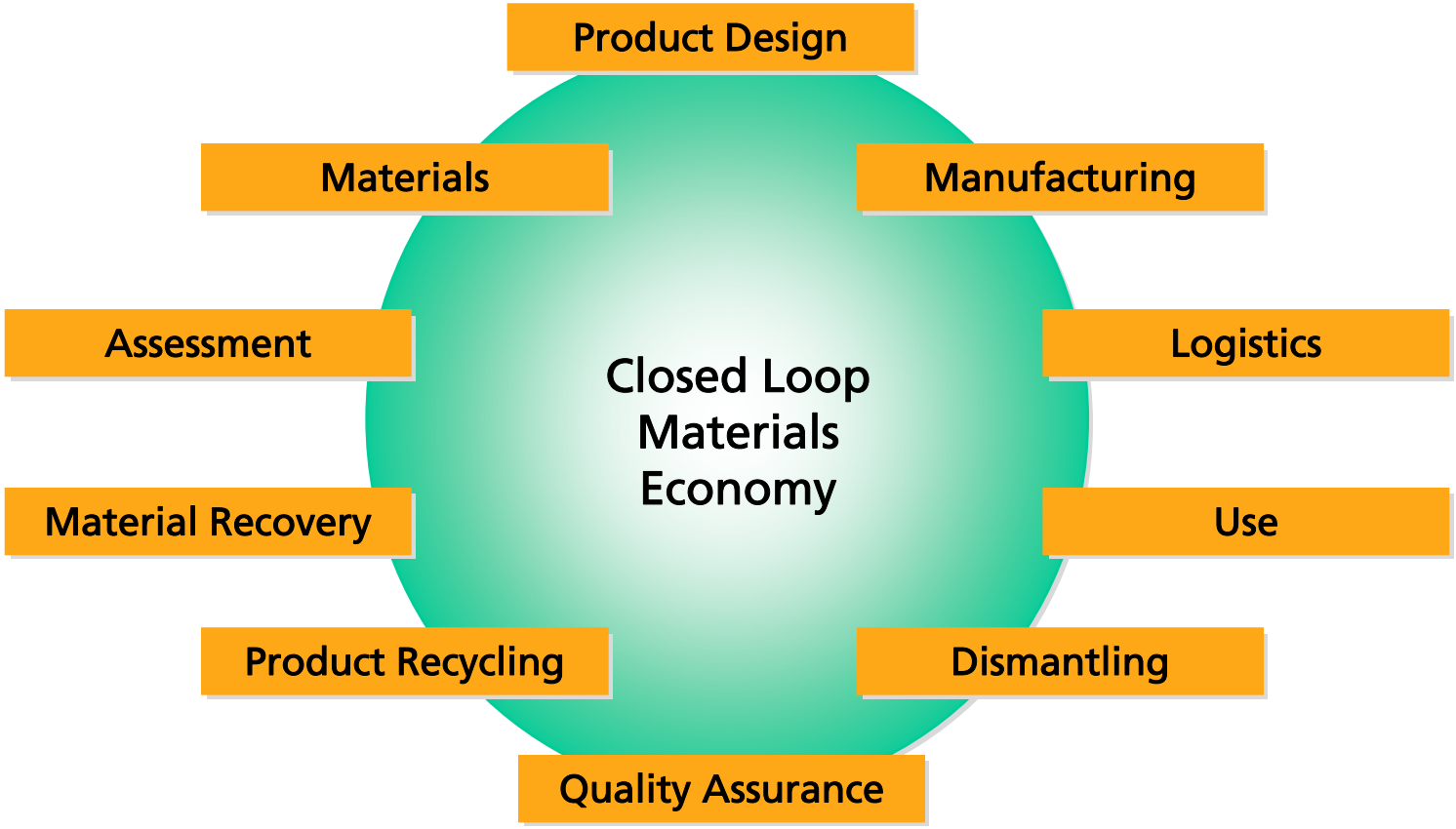
- Maintenance and service
- Upgrading
- Product improvement strategies

Waste

- Wasting of time…
- Wasting of energy…
- Wasting of ideas…
- Wasting of resources…

- **Waste is the enemy of sustainability**

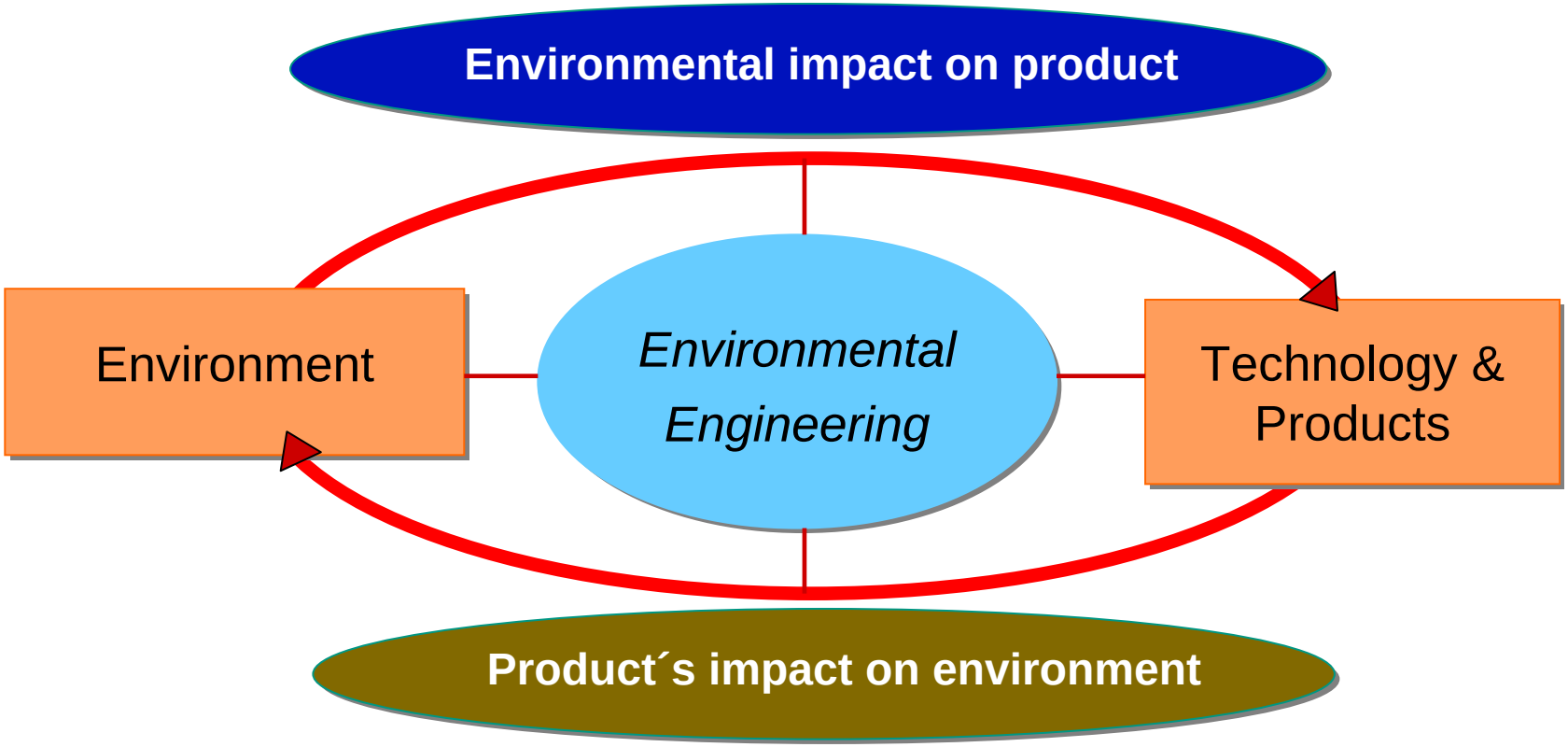
Closed Loop Materials Management



Environmental Engineering

- Environmental Engineering deals with the **interaction** between an **object** (product, process, creature) with its immediate or remote **environment**
- Environmental Engineering helps to **minimize mutual negative influences** between object and environment

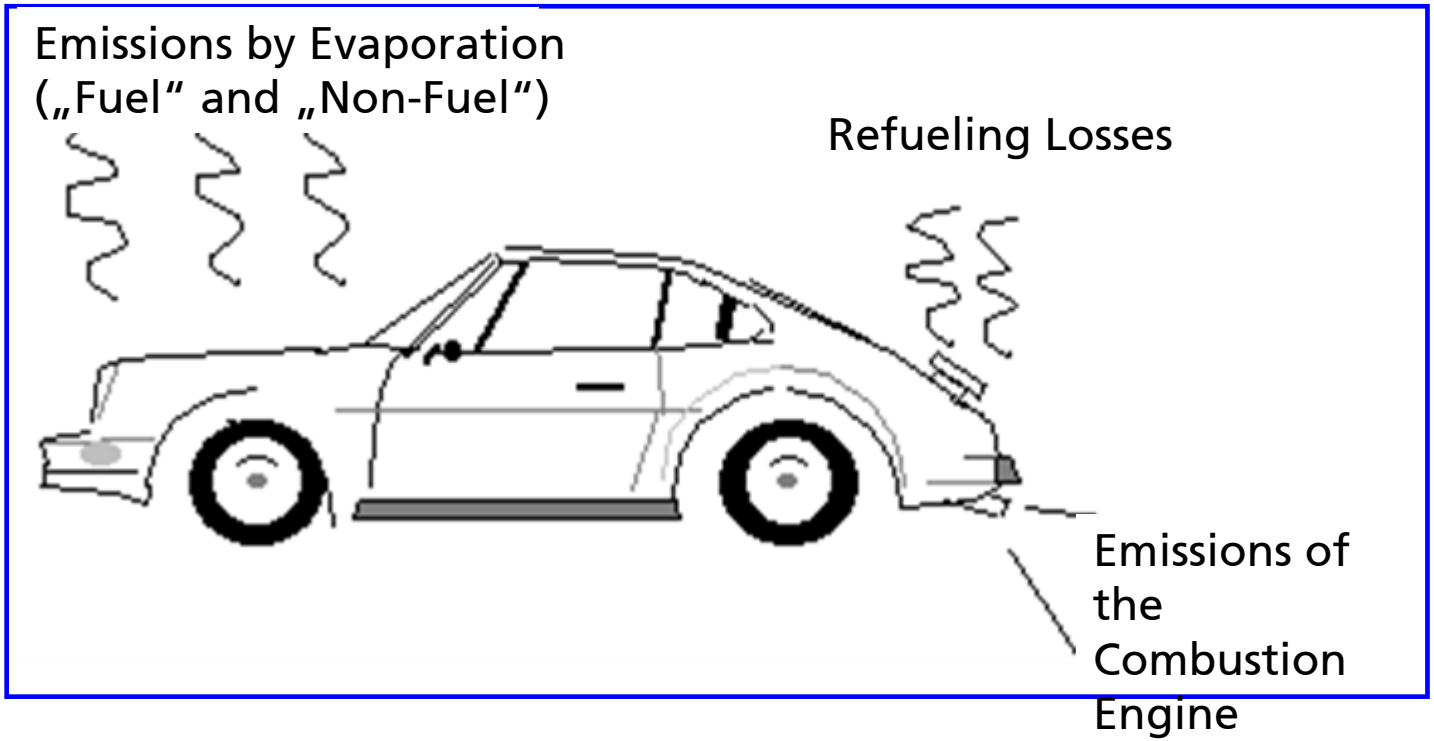
Environmental Engineering



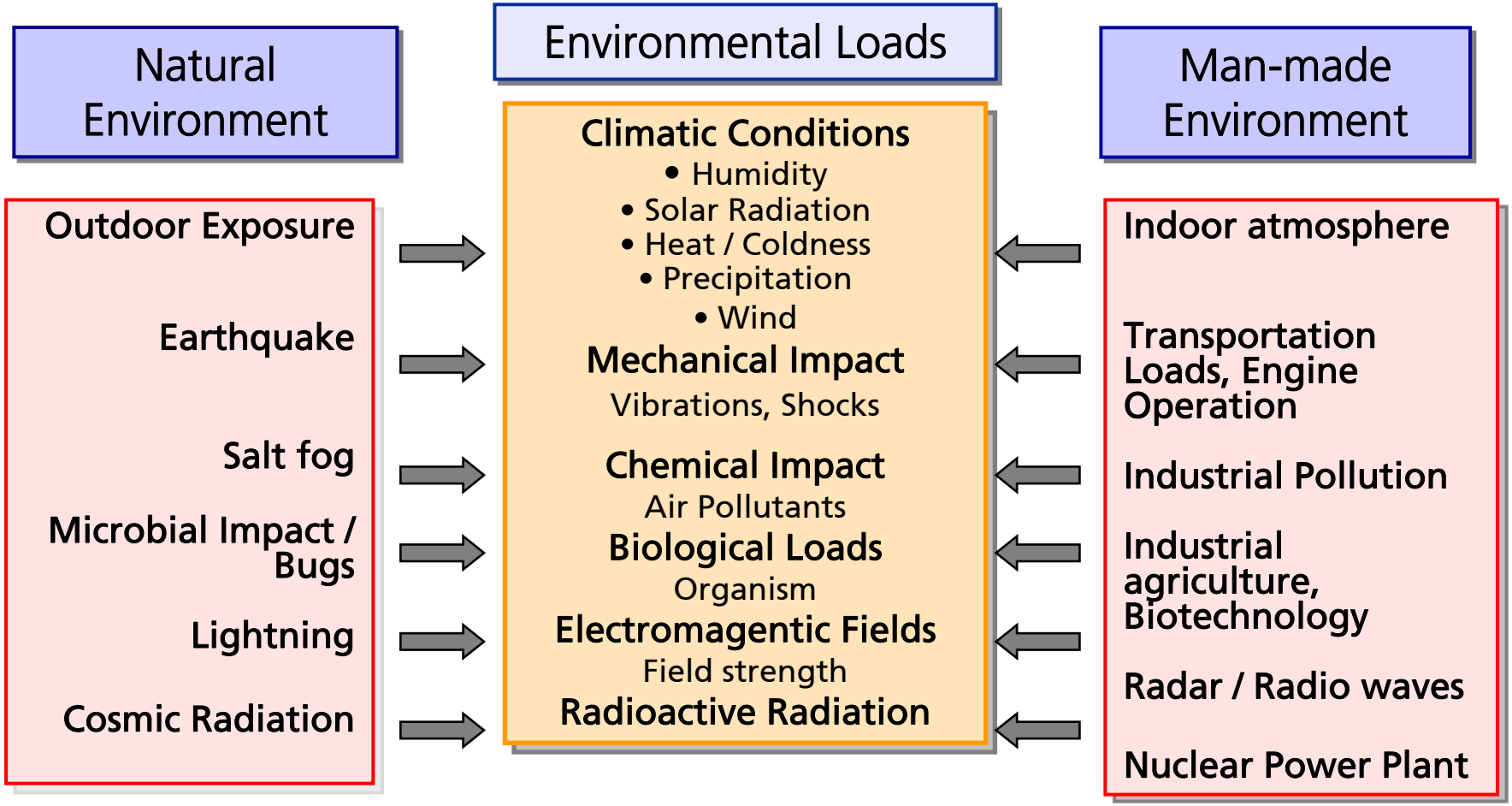
Holistic Approach: All Interactions between Product and its Environment

- Overall performance of the product
- Design concept
- Selection of materials
- Manufacturing techniques and assembly strategies
- Recycling, recovery, reuse and final disposal

Product‘s Impact on the Environment – Example: Sources of Emissions of Automobiles



Environmental Influences and Related Loads



Environmental Engineering - a Powerful Tool to Enhance Product Performance

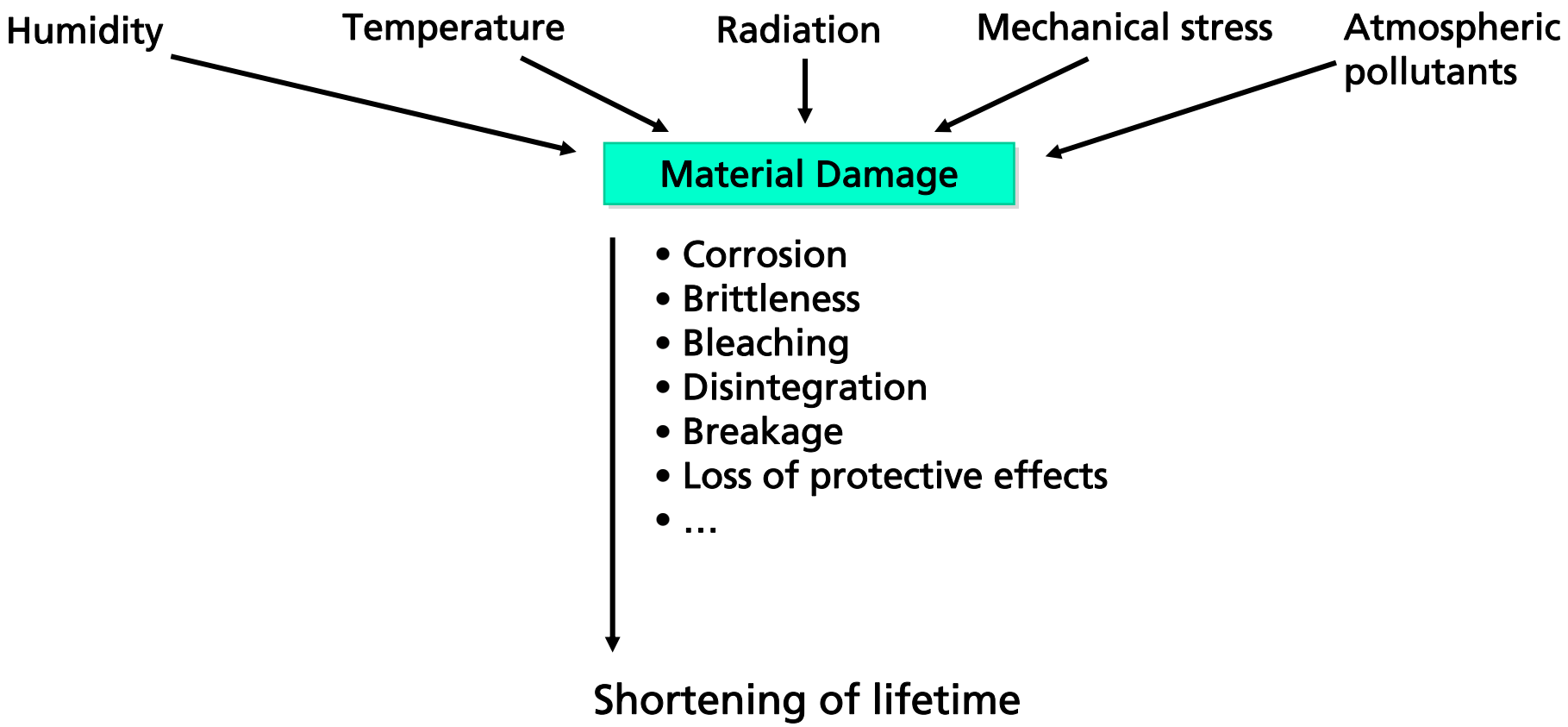
- Analysis of the life cycle profile
- Investigation of environmental effects and interaction
- Environmental design criteria
- Environmental testing
- Qualification and evaluation

Climatic Environmental Conditions

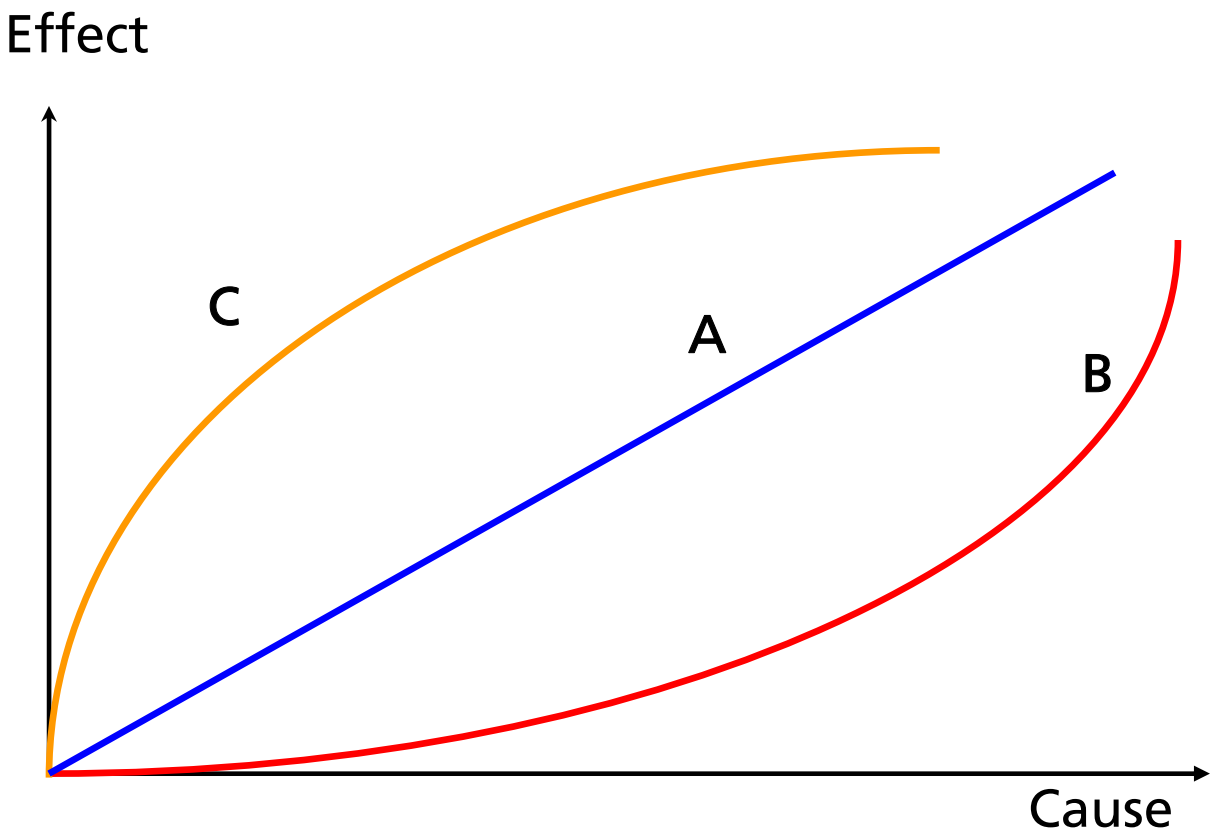
Lightning and its possible Effects

Water and Sand/Dust

Damage of Materials is Caused by the Synergistic Effects of Various Environmental Influences



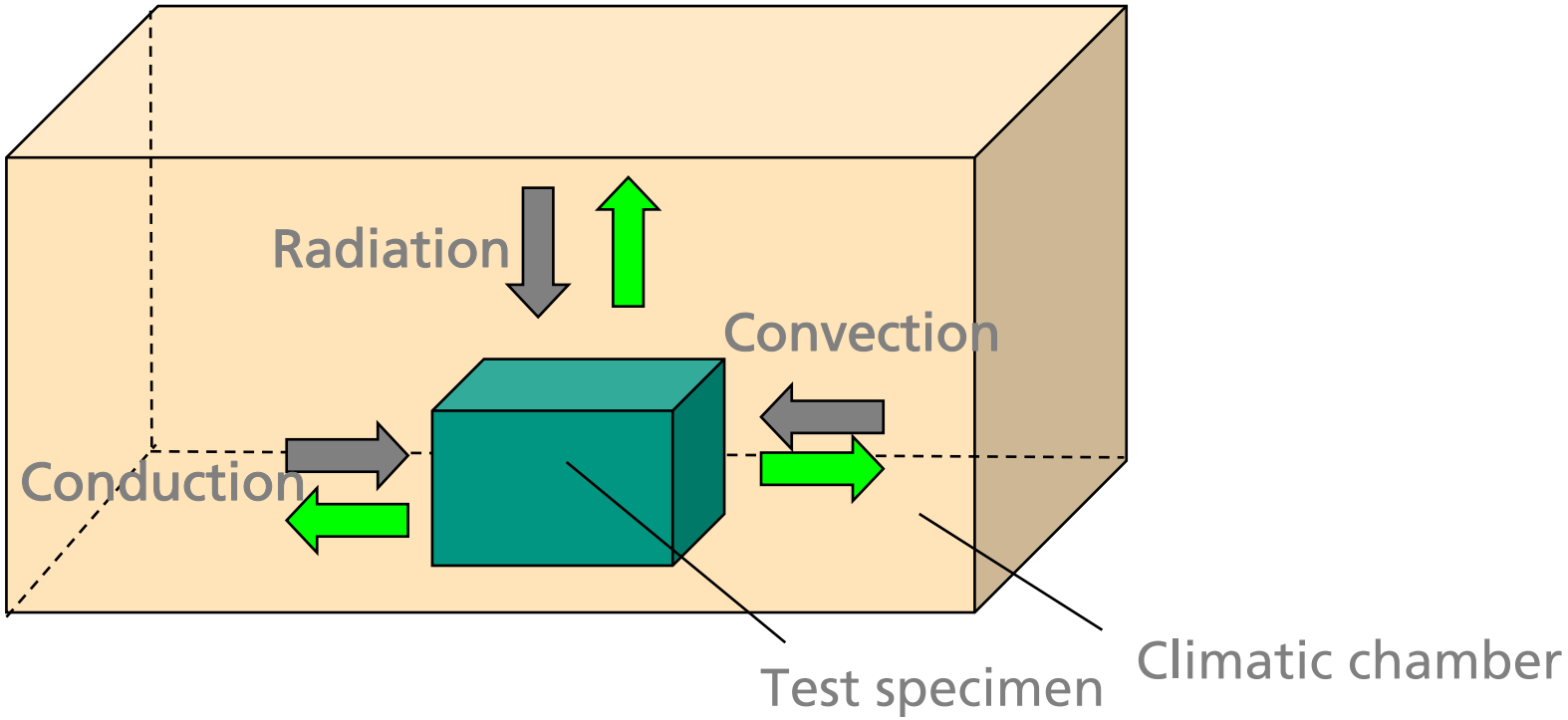
Basic Approach: Cause-Effect-Relationships



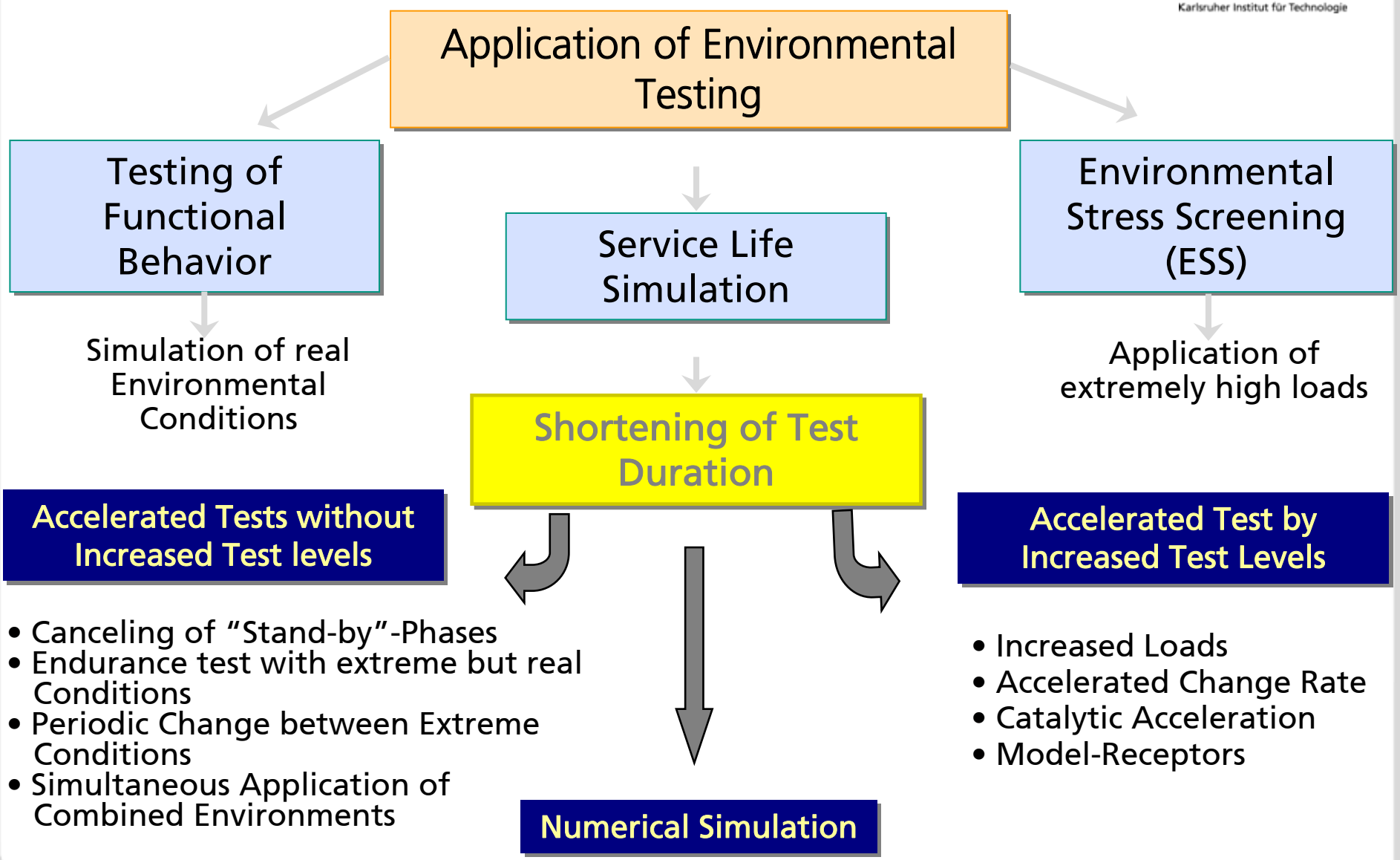
Analysis of Cause-Effect-Relations

- Temperature dependency of chemical reactions
- Humidity dependency of corrosion
- Fatigue behaviour in consequence of circular long-term loading
- Brittleness through solar radiation
- etc.

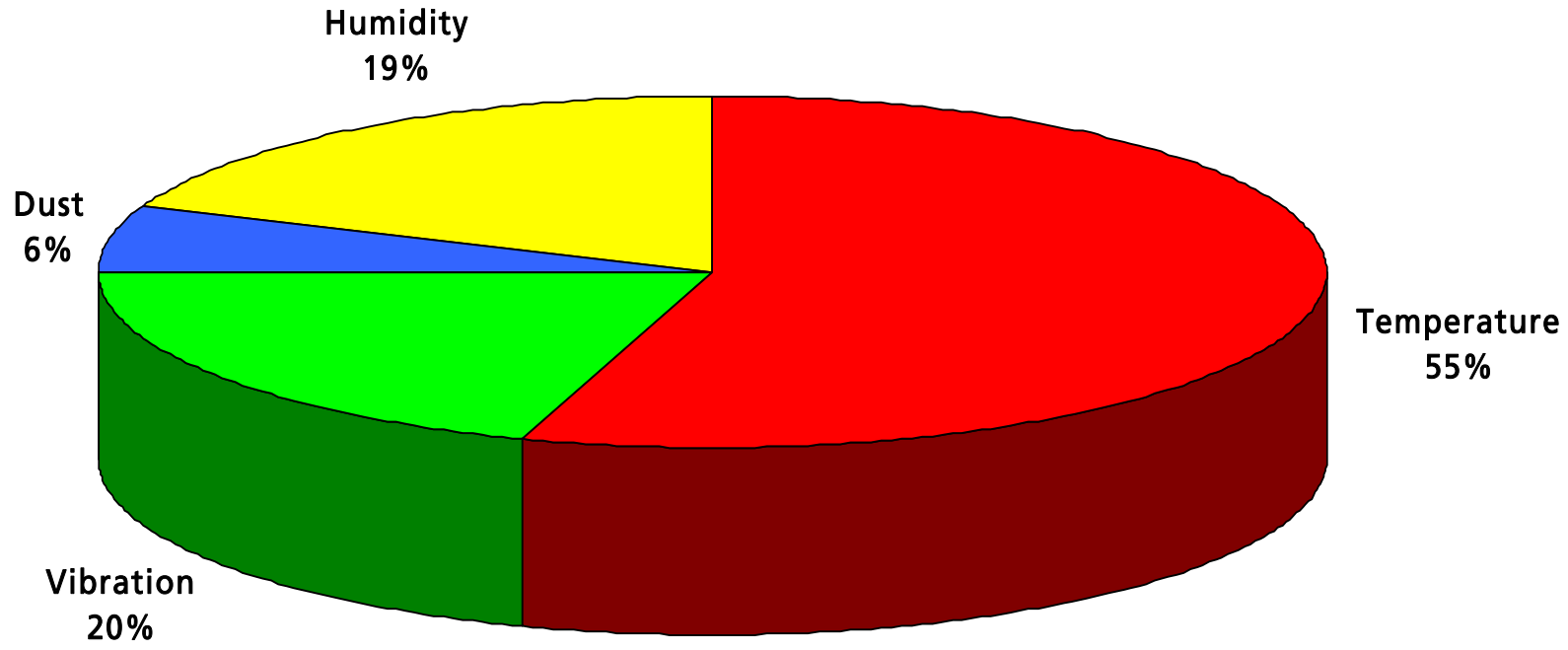
Basics: Heat transfer in the climatic chamber



Strategies for Life-time prediction



Reliability: Main causes of environmental breakdowns of electric systems



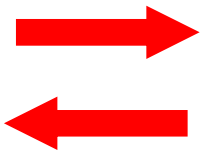
Source: US Air Force Avionics Integrity Programm

KIT Topic: Renewable Energies

- Biomass (BTL)
- Hydrogen produced from wet biomass
- Geothermal energy
- Hydropower
- Wind Power
- Organic Photovoltaics

Wind Power: Two extremes meet each other...

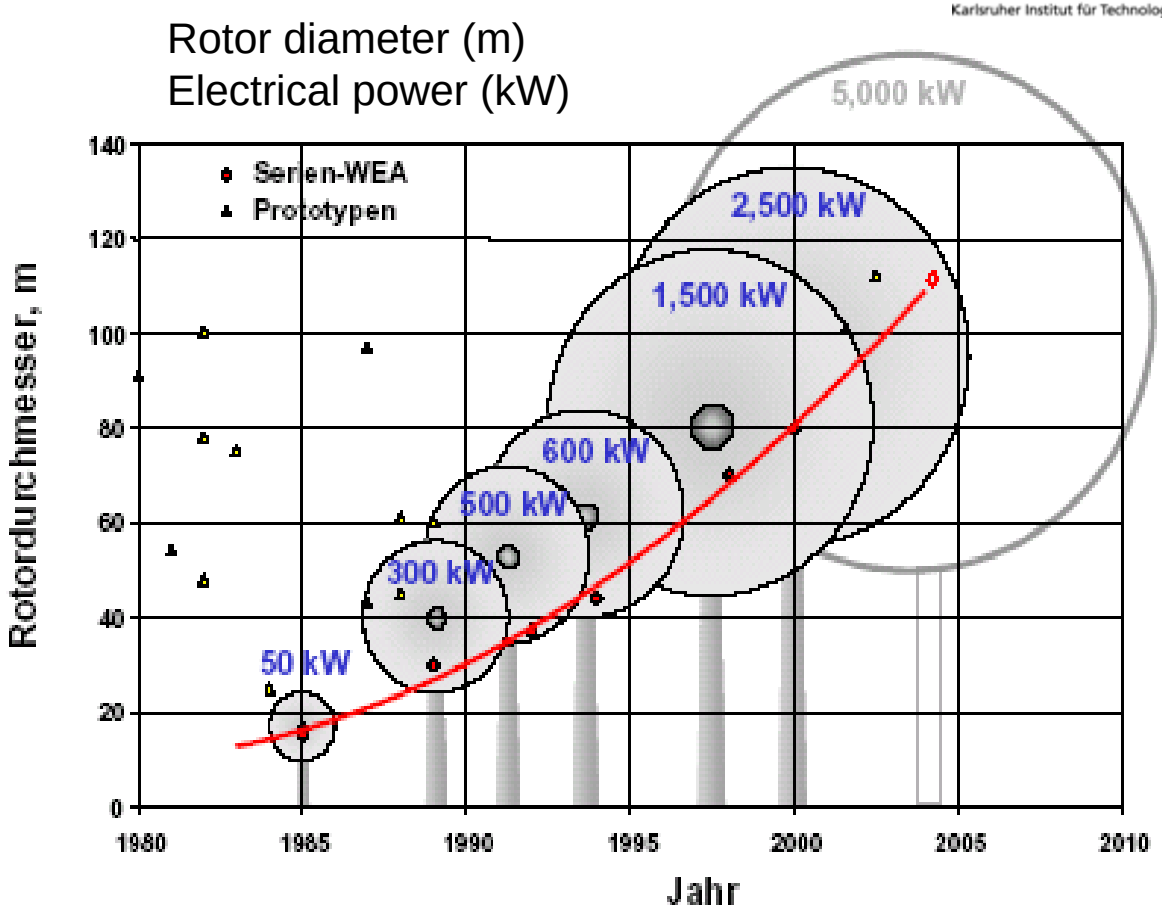
- Highly complex facility
- Large diversity of materials
- Vulnerable electronic control devices
- High electrical power



- Constant operation in a harsh environment
- Expected service life greater than 20 years
- Limited maintenance access

Components and Generator Size

- Rotor
- Blade angle control
- Wind tracking
- Gear box
- Generator
- Stand
- Control electronics
- Electrical power transmission



Source: DEWI

Environmental Loads on Wind Power Equipment

- Heat, cold, humidity and their diurnal and seasonal cycling
- Air speed, wind shear, gust, turbulences
- Rotational vibrations and induced dynamic forces
- Dust, sand, raindrops, hail and ice
- Solar radiation including UV light exposure
- Lightning with respect to damage to materials as well as to electromagnetic pulses
- Maritime environment such as salt mist especially in off-shore sites
- Industrial air pollutants and airborne particles

The bioliq® Two-Stages Principle

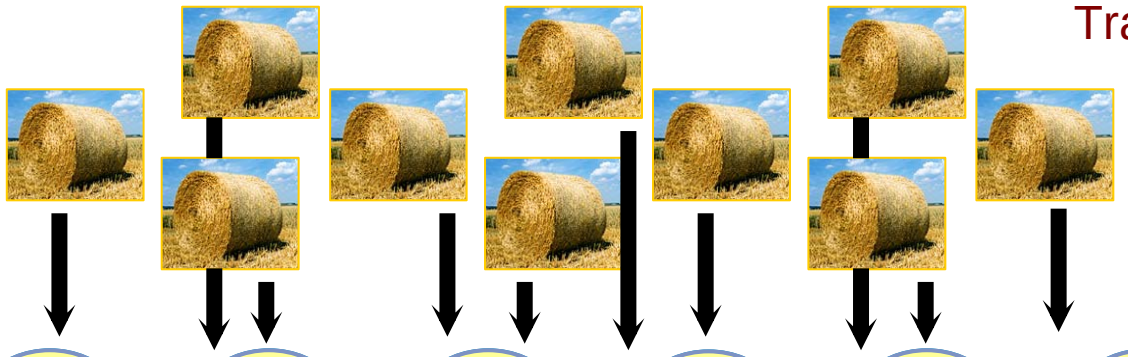
Source: Regional distributed biomass

Energy density [GJ/m³]:

Straw: 1.5

Slurry: 25

Fuel: 36



Transportation distance

~ 25 km

First stage: De-centralized regional production of an energy-rich intermediate product – bioliqSynCrude®

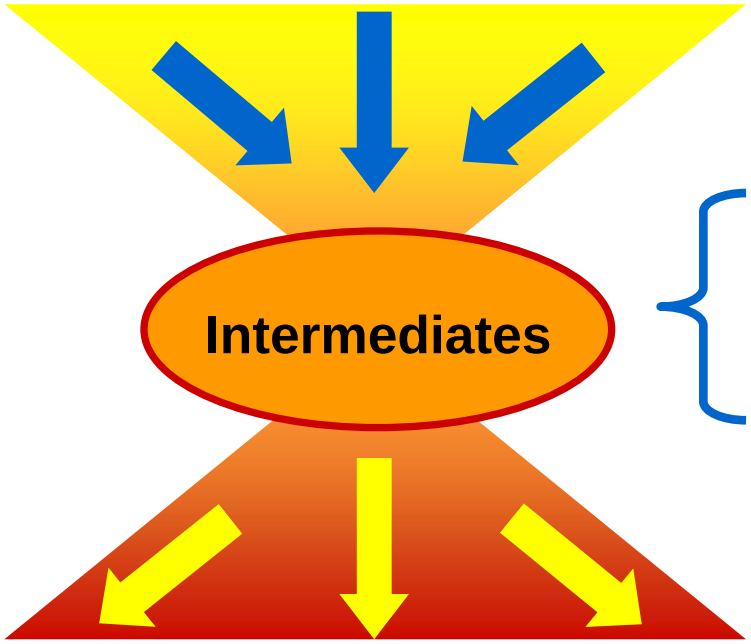
>250 km

Second stage: high pressure entrained flow gasification, syngas cleaning, conditioning and synthesis

Refining of Biomass – General Concept

Feedstock Variety:

Dry Biomass - Wet green Biomass - Algae - Biogenic Waste



- Energy rich
- Storable
- Transportable
- Standardized

Product Variety:

Biofuels - Chemical Products

Environmental Engineering: What we've achieved so far (1)

- Characterization of ambient conditions has improved (more available data, more comprehensive, more detailed)
- Absurdity in time-compression at least partly repressed
- Easier application of mathematic statistical methods due to computers
- Knowledge about procedures in degradation, disintegration, corrosion, fatigue and ageing has improved
- Established dose-response-relationships
- Realistic analysis of corrosive gas

What we've achieved so far (2)

- Considerable progress in measuring and analyzing mechanical dynamical loads (Shock-Answer-Spectra, probability densities, Fatigue-Damage-Spectra)
- Improved loop control of shakers, extensive applications easier to perform (random, random-on-random, sine-on-random tests), shock tests on shakers
- Numerical simulation ("Virtual Testing") increases as screening tool

Future prospects (1)

- Application of environmental testing outside the Hi-Tech-sector (accessible for the middle market with regard to scope, duration and costs)
- Real time monitoring of individual life-cycles (sensors, recorders and processors, on-line/on-board diagnostics, individual product histories, prolongation of life-time)
- Environmental indicator describes interaction with the environment (integrated product assessment)

Future prospects (2)

- Environmental testing as contribution to sustainability (resource saving design of products by further increase of quality, reliability and life-time)
- Numerical simulation / "Virtual Testing" (reduction of the development period, improvement of the predictability) will increase
- Further increase of scientific investigation of environmental engineering

Environmental Engineering

Scientific and technical organizations:

- Confederation of European Environmental Engineering Societies CEEES
- Gesellschaft für Umweltsimulation e.V. (Germany)
- 12 national societies in Europe
- Institute of Environmental Sciences and Technology IEST (USA)
- 10 other organizations worldwide (e.g. China, India, Russia, Korea, Brazil, Australia)

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