Sustainable Manufacturing

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- largest Technical University in Germany
- one of the leading universities in engineering education in Europe
- wide range of subjects (Engineering, Economics, Humanities & Arts)
- highest rate of foreign students in German universities (20%)
Motivation and approach:

- Global social, ecological and economical challenges
- Exploiting engineering potentials to cope with challenges
- Empowering innovation and mediation for sustainable development
- Focus on technology and management within sustainability reference frame
- Expanding global networking in developed and emerging countries
- Convincing global citizens about superiority of sustainable manufacturing
Challenge of Wealth Distribution

- World population is represented by 20 persons
  - 4 Persons have no clean potable water
  - 7 Persons have no sanitary facilities
  - 10 Persons live on <2 US$ a day, have no telephone, no electricity
  - 4 Persons own 64% of wealth
  - 1 Person owns 25% of wealth
  - 1 Person has a PC
  - 1 Person has taken flight

Source: S. J. Skerlos
Challenges in Economics, Ecology and Society

Country size in relation to GDP in US$

Country size in relation to emission of Greenhouse Gas

Country size in relation to Population
Challenge of resource efficiency and energy conversion

- Keeping non-renewables in product and material life cycles without disposal
- Substituting non-renewables by renewables
- Consuming renewables only to the extent that they can be regained

Primary Energy Resources

- ~30% Oil
- ~20% Natural Gas
- ~25% Coal
- ~10% Biomass
- ~6% Nuclear Energy
- ~9% Other

Conversion through Processes and Equipment

- Direct Use
  - Engines
  - Chemical plants
  - ~60%

- Use as
  - Electricity
  - Drives
  - Heating
  - Cooling
  - Light
  - Electronics
  - ~40%

- Process Heat
  - Chemical plants
  - ~50%

- Other
  - ICT, Light
  - ~15%

Useful Energy Applications

- ~35% Movement
  - Vehicles
  - Machinery

- ~34% Process Heat
  - Chemical plants

- ~40% Infrastructure
  - Food
  - Building
  - ICT
  - Light
  - Heating

- ~13% Personal Transport
- ~13% Goods Transport

100% global annual primary energy resources correspond to about 500 EJ [Exajoule = \(10^{18}\) Joule] or 140 PWh [Petawatt hours = \(10^{15}\) Watt hours]

based on Cullen, Allwood (2010), VDI (2010)
From saturated markets ............bridging the gap ............... to hungry markets.

Challenges:
- How to design and manufacture products and services
  - opening up hungry markets,
  - avoiding bad investments in saturated markets,
  - increasing human wealth in global level within conditions of ecological resource availability.
- Change in existing process paradigms
  - from economies of scale to economies of scope,
  - to more benefit for more people with less resources.
Approach to cope with the challenge

Network Consisting of Modules

horizontal integration

vertical integration

Cooperation Competition

Module Consisting of Value Creation Factors

Criteria of Sustainability

Areas of Human Living

Energy

Production

Mobility

Infrastructural Conditions

Developing countries

Emerging countries

Developed countries
Project Goal: Providing the targeted markets with safe drinking water.

User-defined Filter Device

- **Targeted Market:**
  - Kenya
  - India

- **Product Facts**
  - Natural and recycled materials
  - Output 2 litres/hour
  - Costs: 33 $
  - System life-cycle: < 2 years
  - Filter material change up to every month

Filter Device attachable to a Bicycle

- **Targeted Market:**
  - Uganda
  - Inner Mongolia

- **Product Facts**
  - Output 60 litres/hour
  - Storage capacity 40 litres
  - Costs: < 30 $
  - Bicycle required

Adjusted Purification System

- **Targeted Market:**
  - India
  - Vietnam

- **Product Facts**
  - Output 25 litres/hour
  - Storage capacity 400 litres
  - Costs: < 376 $
  - System life-cycle: > 5 years

UV Filtration System

- **Targeted Market:**
  - China
  - Myanmar

- **Product Facts**
  - Output 30 litres/hour
  - Storage capacity 50 litres
  - Costs: 80 $
  - System life-cycle: > 5 years
  - Filter material change every 5 months
Global Cooperation in Education
Project Examples

**Project Goal: Providing the targeted markets with mobility devices.**

**Device for disabled and landmine victims**
- **Targeted Market:** Kenya, Vietnam
- **Product Facts:**
  - Offroad wheelchair
  - Costs: 33 $
  - Payload 65 kg
  - Life-cycle: up to 36 years

**Bamboo Bicycle**
- **Targeted Market:** Tanzania, South Africa
- **Product Facts:**
  - Natural and recycled materials, Bamboo or Muhu
  - Costs: 24 $
  - Payload 250 kg
  - Life-cycle: > 5 years

**Projekt Goal: Providing the targeted markets with working devices.**

**Low Cost Wash System**
- **Targeted Market:** China, India
- **Product Facts:**
  - Barrel Volume 45 litre
  - Manual wash cycle 30 min
  - Costs: 13 $
  - Life-cycle: 15 years

**Low Cost Seeder**
- **Targeted Market:** Tanzania, India
- **Product Facts:**
  - Natural and recycled materials
  - Adaptable to Millets and Beans
  - Costs: < 20 $
  - Life-cycle: 5 years
Sustainable Manufacturing Community

- Emerging sustainable value creation
- Knowledge utilization and creation
- Open community for ubiquitous access

Exploiting potentials for proving superiority of sustainable manufacturing
- Cooperation and competition driving contributions and progress

Module Consisting of Value Creation Factors

Laboratory for Sustainable Manufacturing

Network Consisting of Modules

Workplace

CAX for Product Creation

Product

Turbo charger

Downsized engine

Sustainable mobility

Product Planning & Control

Automated Manufacturing

Manual (Dis-)Assembly

Cooperation

Competition

Criteria of Sustainability
Sustainable Manufacturing towards housing (Seliger, Palacios)

Smart Metering: Resources’ consumption monitoring.

Energy efficiency: implementing renewable energies

Recycling and reuse: low cost water treatment
Goal: Find transfer scenarios for decentralized value creation driven by micro entrepreneurship

Mini factory for micro entrepreneurship in Africa (Seliger, Postawa)

► Value creation network
  ► Economic motivation is based on a flexible production (variants, quantity)
  ► Economic-ecological reasons are shorter ways of transportation and so related reduction of cost and environmental impact
  ► Independent value creation, even in socially and geographically isolated regions, added by higher teaching productivity and new perspectives can lead to an actively designed, independent life for humans in developing countries by income generation.

► Mini factory for micro entrepreneurship