“Engineers of the 21st century”

Challenges, Opportunities and Risks

13.5.2022, 09.15 - 11:45 am

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SMART SOC Education of Future ICT Experts Based on SMART Society Needs

Co-funded by the Erasmus+ Programme of the European Union

Brainstorming “Engineer of the future“

Which challenges do you see in the future?

Earth Oversoot Day (EOD)

- On 22.July 2021 we have «celebrated (?)» the EOD (1 month before 2020)
- EOD marks the date when humanity's demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year
- EOD has been founded by the NGO «Global Footprint Network» in the 1970s (https://www.overshootday.org/)
- In 1971 the EOD was on December 21th
- When will it be in 2022? In Germany it was the 4.5.2022 already
- EOD has to be understood as a day of action

Agenda

PART I

- What means Sustainability and Sustainable Development?
- Recent Global Sustainability Policies and Goals

PART II

- Engineering for Sustainability:
  - Exemplary Fields of Action
  - Relevance of Technology Assessment and Life-Cycle-Thinking

EXERCISE

Profile of “Future Engineers“

Sustainability: An Economic Core Principle

- In 1713, H. Carl von Carlowitz described first management rules for sustainability in the forestry
- “Sustainability” means only cutting down as much timber as can grow again: living from the yield and not from the substance
- Reaction on the severe deforestation at the beginning of the 18th century in Germany
- **Carlowitz already combined both: economic thinking and care for future generations!**

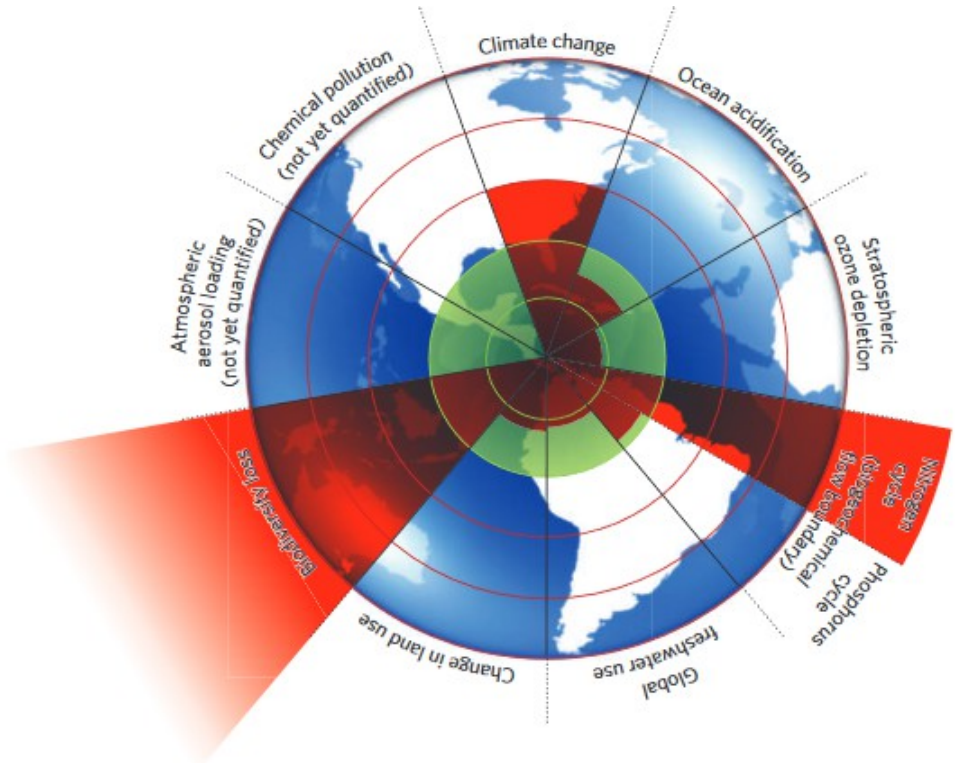

Hannß Carl von Carlowitz
SYLVICULTURA OECONOMICA,
Haußwirthliche Nachricht und Naturmäßige
Anweisung
Wilden Baum-Sucht
Gründlicher Darstellung
Grossen Holtz-Mangel,
Gefundenen Turff
Julio Bernhard von Rohr
Leipzig,

Sustainability today: Planetary boundaries!

Rockström et al. (2009) identified **nine ecological systems** which are crucial to sustain

„A safe operating space for humanity“

Balancing **economic, social and ecological aspects for long-term viability**, thus balancing human needs and “planetary boundaries” (Rockström et al. 2015)



Rockström et al. (2015)

Milestones of Global Sustainability Policy (I)

- **1987:** World Commission on Environment and Development: "Our Common Future", first broadly accepted "definition" of sustainable development

"Humanity has the ability to make **development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.**" (WCED 1987)

- **1992: Famous "Earth Summit" in Rio de Janeiro**: United Nations Conference on Environment and Development (UNCED): Rio Declaration on Environment and Development, adoption of Agenda 21

Milestones of Global Sustainability Policy (II)

- **2000:** Adoption of **Millennium Development Goals**
- **2012:** Rio+20 Conference (much less famous and successful as its predecessor);
  main result: **decision to develop** a
  Post 2015 Development Agenda
- **2015:**
  - Adoption of **Agenda 2030** and of
  17 Sustainable Development Goals (SDGs)
  - Paris 2015 World Climate Summit (1,5 °C-Goal)

THE GLOBAL GOALS
For Sustainable Development

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

And now?

- Development of **SDG indicators**
- New **UN bodies** established
- **Regular monitoring** of implementation at the UN General Assembly
- Basis for national, local and organizational **sustainability strategies**

http://www.un.org/sustainabledevelopment/sustainable-development-goals/

The European Green Deal

European Commission, 2009
'Green Deal is our man-on-moon moment'

- Most prominent goal: **Climate neutrality** by 2050 (first continent)
- **Fundamental restructuring** of the European economic system in various industrial sectors
- Direct reference to the UN Sustainable Development Goals

Horizon (2020 & Europe) and the European Green Topics

- Increasing climate ambitions
- Clean, affordable and secure energy
- Energy and resource efficient buildings
- Sustainable and smart mobility
- Farm to fork
- Biodiversity and eco systems service
- Towards zero-pollution, toxic-free environment
- Strengthening our knowledge in support of the **European Green Deal**
- Empowering citizens for the transition towards climate-neutral sustainable Europe

Horizon Europe (2021 - 2027)
Investing to shape our Future

The EU's key funding program for research and innovation:

- Tackles climate change
- Helps to achieve the UN's Sustainable Development Goals
- Boosts the EU's competitiveness and growth
- Facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges
- Supports the creation and better diffusion of excellent knowledge and technologies
- Creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimizes investment impact within a strengthened European Research Area

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General terms: Digitization/Digitalization

- *Digitization:* Transitioning from analog information to (numeric) digital format
- *Digitalization*: Integration of digital technologies into everyday life by the digitization of everything that can be digitized
- *Digital transformation*: Taking advantage of digitalization to create completely new business concepts

Opportunities of sustainable oriented Digitalization

- It can interconnect renewable energy sources and support the energy transition (“smart grids”).
- It can link bicycles, buses, cars and trains both inside and outside of cities.
- It can help us fertilise our crops precisely and thereby also protect biodiversity.
- It can provide transparency in supply chains and for consumers.
- It can help bring about a true circular economy.
- It will help us better evaluate the sustainability of financial investments.

Opportunities: Three Examples

- **Digitalization and Circular Economy**
- Sharing Economy and Prosumption
- Smart (Precision) Farming

Digitalization and Circular Economy (I)

Linear Economy:

Inefficient use of raw materials and negative side effects
(→ planetary boundaries)

- Only approx. 14 % of the raw materials used come from recycling (IDW 2010)
- Inefficient use of raw materials and increasing disposal problems (e.g. plastics)
- Increasing supply risks, ecological and social impacts of raw material extraction

Digitalization and Circular Economy (II)

Cyber Physical Systems

- Products/load carriers with actuators and sensors
- Information recording/storage over entire life cycle
- Technical information for recycling and reuse/repair etc.

Block chain technology

- Anonymous and coded information transfer
- Privacy and protection of trade secrets

Sensoring

- Real-time data on waste generated (time/location/composition)
- Recycling/production process planning

Market/logistics platforms

- Reduced search and transaction costs
- Matching of supply and demand of secondary raw materials
- "Uber for waste"

Heberg and Sipka (2021)

„Think Recycle“ Feedback-System„Smart Reusable Cup“

https://rainycitydesign.com/think-recycle-the-recycling-feedback-system


Los Angeles Times

BUSINESS

McDonald's and Starbucks are developing 'smart' reusable to-go cups

Many paper cups are coated with a plastic lining that makes them almost impossible to recycle. Starbucks and McDonald's alternate idea: reusable plastic cups are supposed to be dropped off at sites around a city for the chains to reuse. (Dreamstime)

CORONAVIRUS

Is California reopening too quickly? Newsom explains the state's strategy for slowing coronavirus while boosting economy

Column One: A coronavirus commune with 16 people? 'Who's to say we're not family?'

Scientists to choirs: Group singing can spread the coronavirus, despite what CDC may say

Gilead says drug helped moderately ill coronavirus patients

Tracking California's path to reopening, plus news, advice and distractions (free)

Cases statewide »

115,107 confirmed

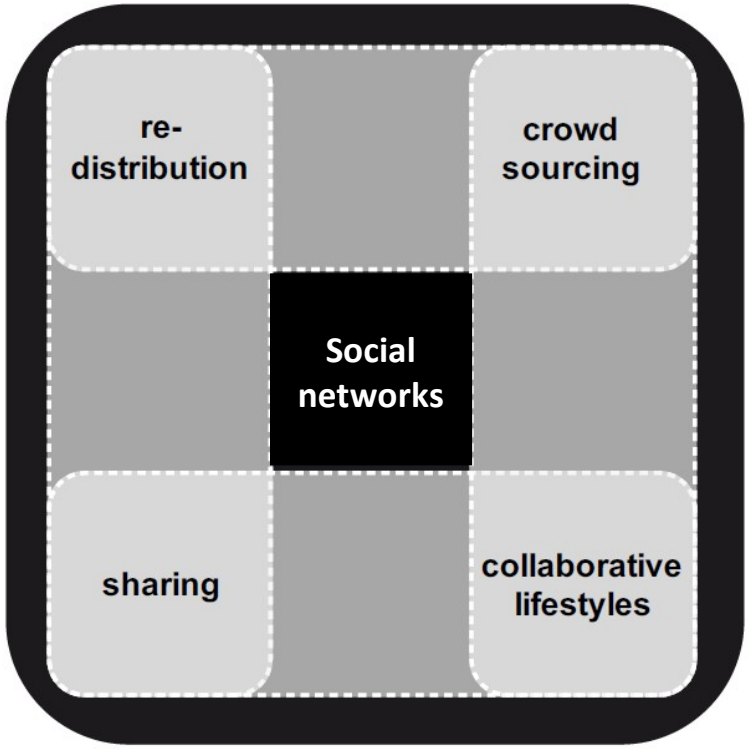
4,221 deaths

https://www.latimes.com/business/story/2020-02-18/mcdonalds-starbucks-reusable-to-go-cups

Opportunities: Three Examples

- Digitalization and Circular Economy
- **Sharing Economy and Prosumption**
- Smart (Precision) Farming

Sharing Economy and Prosumption (I)



Foit (2018)

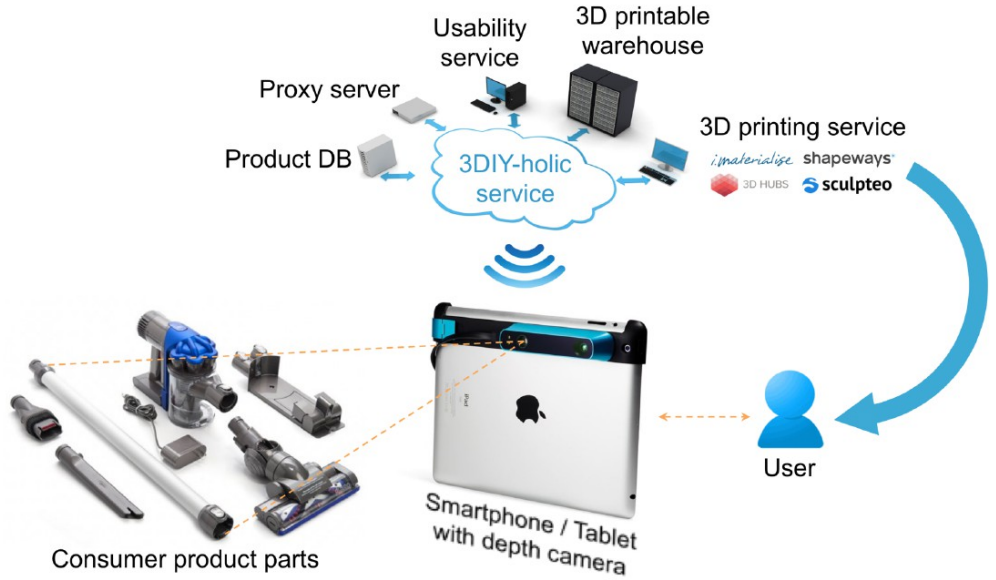
Sharing Economy

- Use, not own (car sharing, repair cafés, etc.)
- Minimize waste and overproduction
- Use swarm intelligence and crowd work
- Build new business models

Sharing Economy and Prosumption (II)

Prosumption

- Consumer is also producer and co-developer
- Decentralized value creation
- Demand-oriented production



Foit (2018)

Example:
3D-printing of spare parts (Additive Manufactoring)

Yoo, Ko, Chun (2016)

Opportunities: Three Examples

- Digitalization and Circular Economy
- Sharing Economy and Prosumption
- **Smart (Precision) Farming**

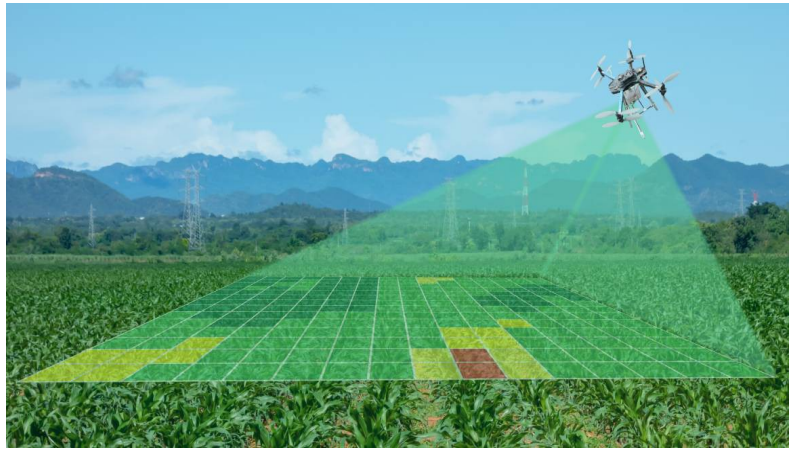
Smart (Precision) Farming (I)

Using digitalization for

- Precise fertilization and pest control
- Smart Water (irrigation management etc.)
- Harvest timing analysis and livestock control

IoT Agriculture

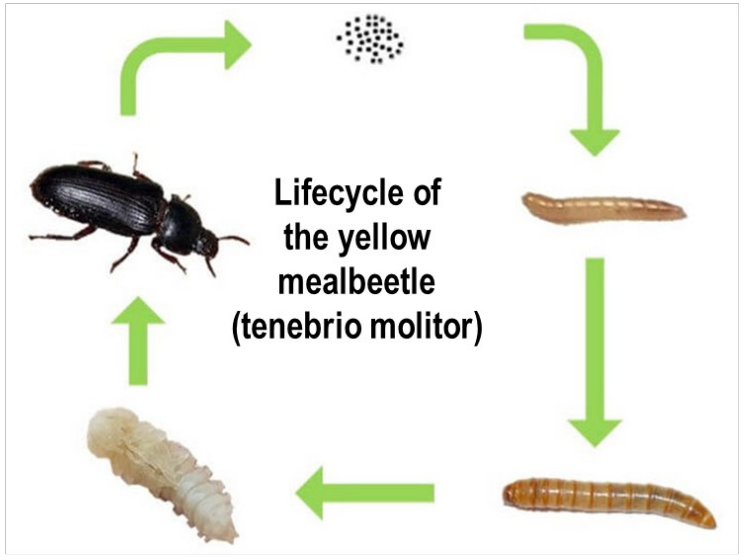
- Sensors and gateways for data collection and analysis
- Real-time monitoring and predictive data analytics



Smart (Precision) Farming (II)

--> Smart Insect Farming (SEE CASE STUDY)

Sorting insects by different stages of development (e.g., eggs, larvas, pupa and adult insects)



Optimizing culture conditions (e.g., humidity, temperature, feed composition)

Separating "waste materials"* (rotten feed, moulting skin, dead insects and dung)

Decision support (warning in case of diseases; optimal time and amount of harvest, ensuring a constant or growing culture)

https://mikrowuermer.jimdofree.com/mehlwuermer/

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Technology Assessment

- desired
- intended
- predictable

Technology impacts

- non-desired
- unintended
- unpredictable

- Dealing with technology impacts always means dealing with future
- and thus with uncertainty ("known unknowns") AND uncertainty ("unknown unknowns")
- Depending on the point of view technology impacts can be evaluated positively or negatively

For example:
Climate protection and the use of nuclear power

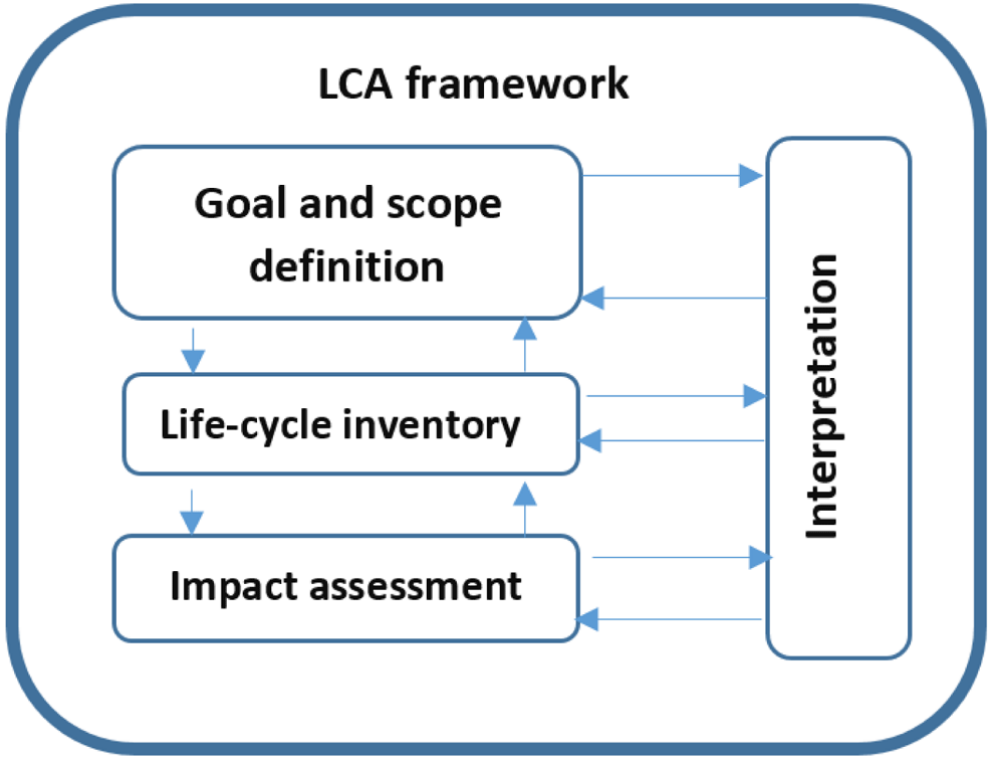
Life-Cycle-Assessment (LCA)

Traditional ecological LCA (ISO 14040):

„Eco balance“, only focusing on environmental impacts (climate warmig potential, acidification, biodiversity etc.)

(Integrated) Social-LCA (UNEP):

- Focusing (additionally) on social and economic impacts (life-cycle costs, working conditions, etc.)
- Integrating the perspective and assessment of different stakeholder groups (workers, users etc.)

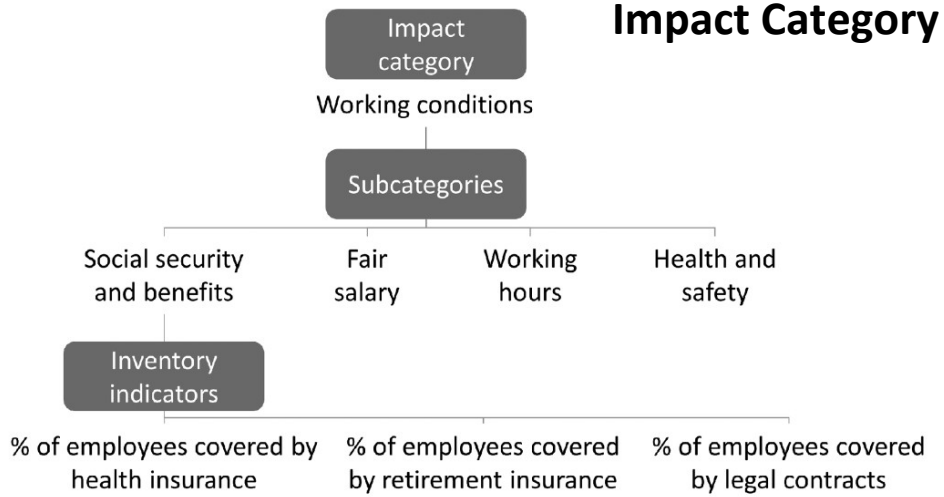


https://open-research-europe.ec.europa.eu/articles/2-14

S-LCA of a T-shirt

System Boundaries

Impact Category



Indicators

UNEP 2009

Digitalization: Sustainability Deficits

- **Ecology**
  Power Consumption through ICT, Internet and Data Centres
  Smart phones: Consumption and use
  E -Waste
- **Economy**
  Recycling
  Smart phones: Manufacturers, Suppliers and Working conditions
  Planned obsolescence (shortened service life)
  Digitalisation of the World of Work
- **Politics**
  Network Expansion
  Preservation of Democracy; Education
- **Society**
  Social problem situations through Extraction of raw material
  Psychological obsolescence; Rebound effects
  Consumption opportunities; E-Commerce; Freight transport

Three Main Risks of ICT referring to the Environmental Dimension of Sustainability

- The implications of the increased energy consumption of ICT, data centers and the internet – which leads to a significant carbon footprint of these technologies.
- The repercussions of the steadily increasing amount of E-Waste – which is characterized by particular hazardousness as some components of ICT are usually and corrosive materials.
- The rising demand of raw materials of those technologies – their extraction is associated with high risks for the workers and it sometimes takes place in the context of forced labor and generates a high level of pollution.

Social Dimension: Crowd- and Clickwork (I)

https://www.mturk.com/

"Amazon Mechanical Turk (MTurk) is a crowdsourcing marketplace that makes it easier for individuals and businesses **to outsource their processes and jobs to a distributed workforce who can perform these tasks virtually.**

Traditionally, tasks like this have been accomplished by hiring a large temporary workforce, which is time consuming, expensive and difficult to scale…"

Your Virtual Workforce – On Demand – Worldwide

With more than 3.6 million freelancers, known as Clickworkers, in Europe, America and Asia, clickworker is one of the leading providers of paid crowdsourcing.

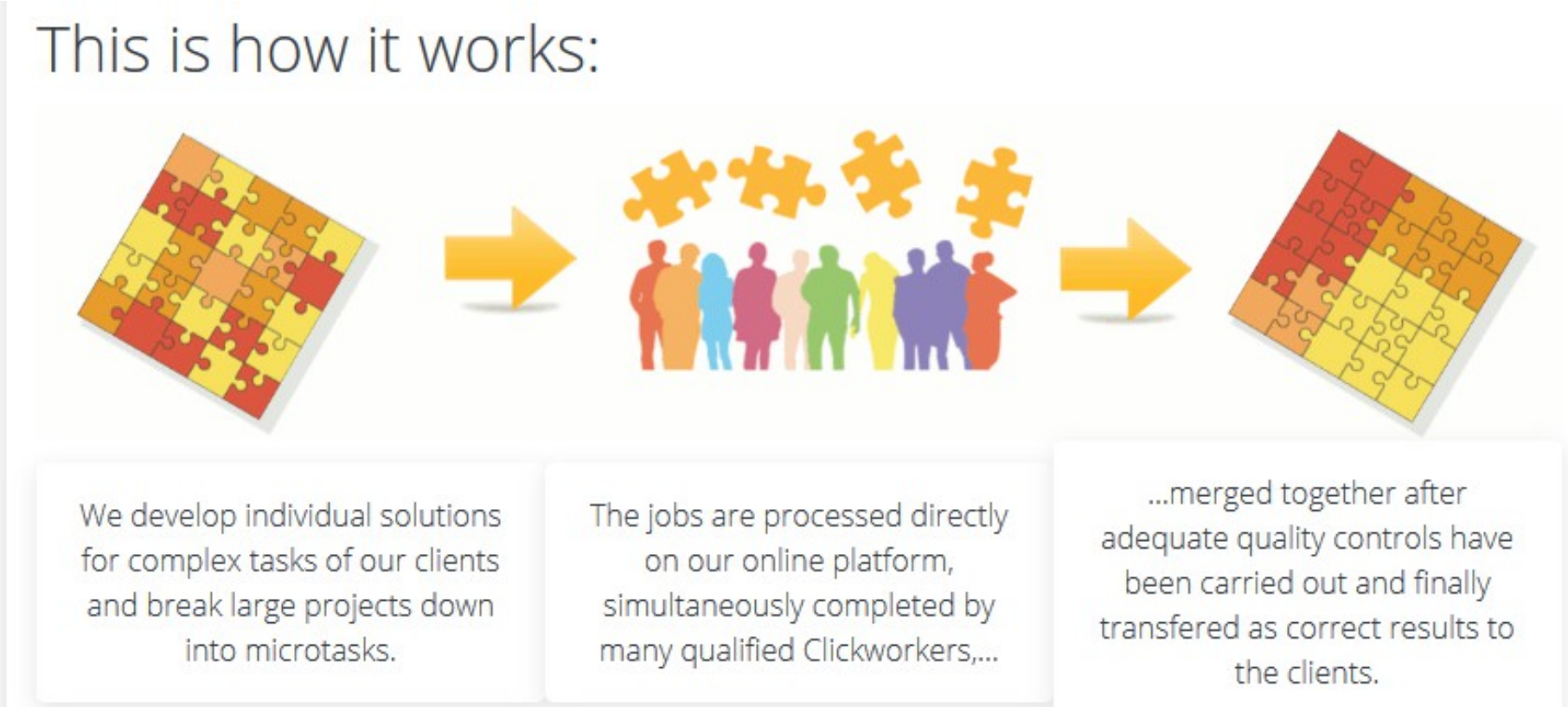
www.clickworker.com

Social Dimension: Crowd- and Clickwork (II)

- **No legal framework** established: missing social protection, sometimes pseudo self-employment of “crowd-workers” (Leimeister et al. 2015)
- **Micro-tasks** leading to poor remuneration and monotonous work

  ….“without limit”
- **Payments** are not always sure
- **FCFS-rule** or competitive selection

Social Dimension: Crowd- and Clickwork (III)



https://www.clickworker.com/how-it-works/

→ "Digital Taylorism" and Hyperspecialization (Malone et al. 2011)?

Social Dimension: Transparent Citizen

How do we live, following mostly figures?

- We start our heater or air condition, we measure our data using our data when biking, jogging, swimming, watering strawberry fields etc.
  Everything we are doing: we measure…
- Amount of data 2018 = 33 zettabyte, 2025 about 175 zettabyte
- **Consequence:** we are producing data which are evaluated by companies and governments
- **But:** for what purpose? Who benefits? **And:** what does that do to us – Individually, in Economy, to the Climate and Environment?
- **Consequence:** Total individual transparency - pros and cons
- What's about our individual lack of transparency?

Digitalization ↔ Sustainability

Digitalization has not only to satisfy the **“dreams of engineers”** but also to **take into account**

- the needs of the **society** in general
- the needs of the **individuals**
- the limitedness of **natural resources**
- the problematic **planetary boundaries**

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EXERCISE

Profile of “Future Engineers“

Guiding question (Group 1 and 2)

- Which SDGs are of most relevance for “future engineers”?
  - Please select 3-4 relevant SDGs and explain your choice.

- Which concrete solutions/contributions can be developed?
  - Provide a concrete example and think about the technology impacts.

Working time: about 25 min

Guiding question (Group 3 and 4)

- Which skills does a “future engineer“ need?
  - Please provide at least 5 skills/competencies and explain your selection.

- Additionally, how would you describe the responsibility of a “future engineer“?
  - Provide concrete examples along, referring to sustainability.

Working time: about 25 min

Discussion

The Engineer of the 21st century - Problem Solver to safeguard our future?

Basic requirements for the engineer of today

- Innovation
- Technical skills and engineer know how
- Special management skills
- Social and personnel skills such as
  - high ethic standards
  - leadership characteristics
  - dynamic, agility and flexibility to adjust coming prblems
  - readiness for lifelong learning

Sustainable Digitalization Guidelines for a Digitalization we need for the Future we want

End poverty in all its forms everywhere and reduce inequality within and among countries (1 & 10)

End hunger, achieve food security and improved nutrition and promote sustainable agriculture (2)

Ensure healthy lives and promote well-being for all at all ages (3)

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (4)

Achieve gender equality and empower all women and girls (5)

Ensure availability and sustainable management of water and sanitation for all (6)

Sustainable Digitalization Guidelines for a Digitalization we need for the Future we want

Ensure access to affordable, reliable, sustainable and modern energy for all and Take urgent action to combat climate change and its impacts (7 & 13)

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (8)

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (9)

Make cities and human settlements inclusive, safe, resilient and sustainable (11)

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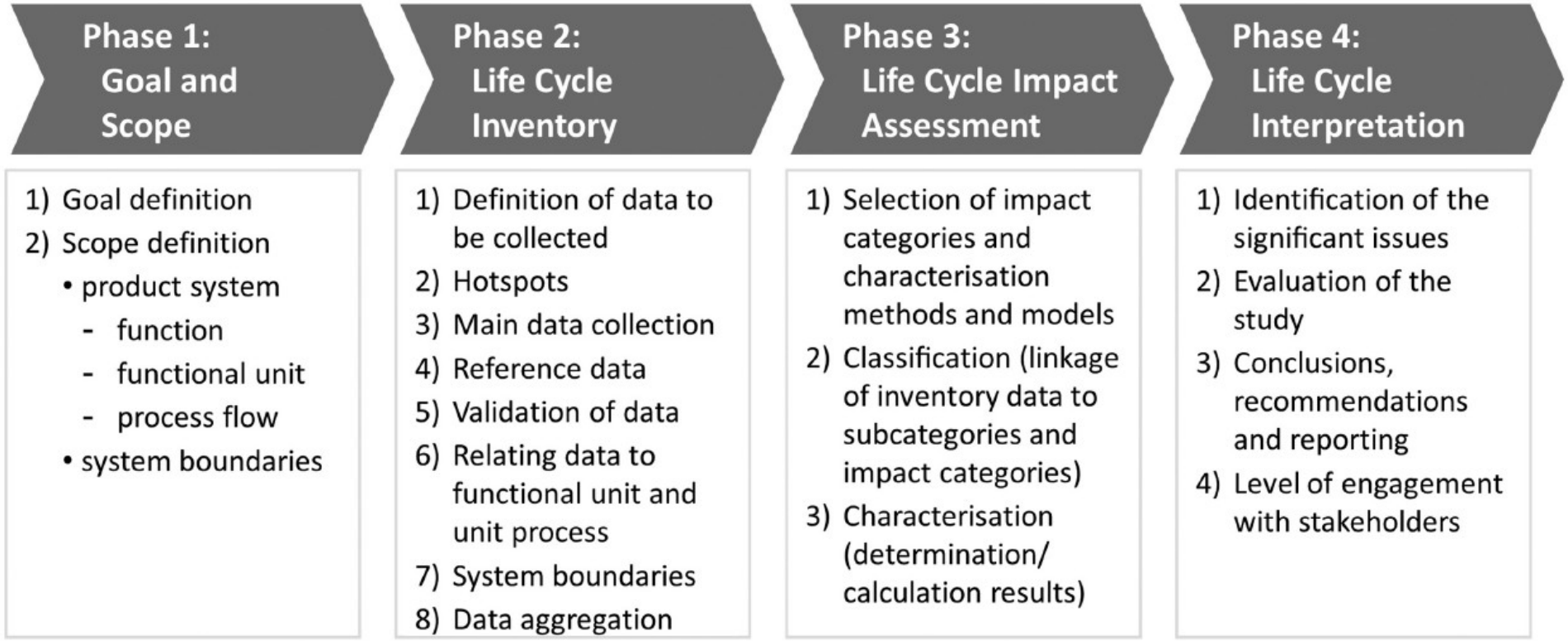
BACKUP

S-LCA Phases (UNEP)



Jentsch (2019)

Rebound Effect

- Rebound effects describe the increasing demand of an economy which is caused or enabled by an increasing productivity. Originally intended savings can be partially cancelled by the rebound effect.
- Increasing digitalization makes electricity bills grow. The more we digitalize the more electricity we consume.
- Example 1: The growing transition from traditional bikes to e-bikes leads to increasing power consumption
- Example 2: Home Office, Distance Learning, Video Conferences lead to more power consumption but attracts less green gas emissions because of less traveling activities

Digitalization and Power Consumption

- Power consumption is exploding due to growing digitalization
- Digitalization is a power guzzler (2020 3% of global CO 2 emissions are due to internet activities, estimated 2030 up to 13%)
- Only in Germany (2019): 33 million tons of CO 2 for internet and internet-enabled devices p.a. = CO 2 emissions for the aviation traffic
- Scientific numbers for global CO 2 consumption are not available yet
- Trend of digital over consumption (e.g. screaming, you tube) does influence climate situation (so called rebound effect)
- Does digitalization make our world more sustainable? What do we have to pay attention to?