Ultimate Cheat Sheet SED

- Containing main topics of all lectures prior to the individual exam
- Individual exam is **open book** (can bring any type of material)

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Sustainable Design

Engineering design focuses on task or purpose, addressing grand challenges such as education, health, transportation, etc.

Design cycle portraits the steps that are required to build the engineering design:

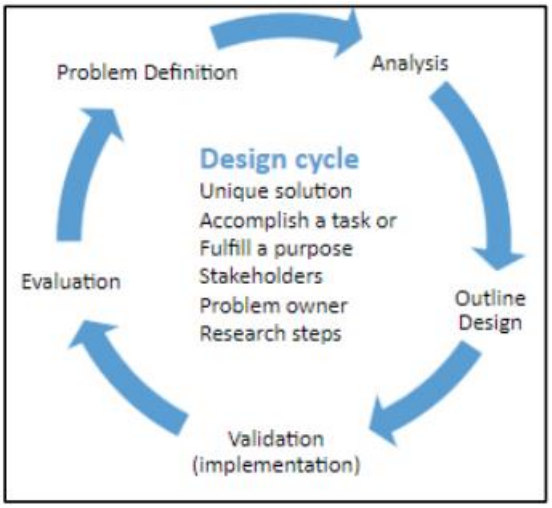

Figure 1: Design cycle

The goal of a design cycle is to design or optimize a product or process, solve a problem, or generally improve a situation for the sake of the three p's: **people, profit & planet**.

Complexities occur in every design cycle, and can be categorized:

- Technical complexity (Software integration, data interoperability, algorithm optimization)
- Social complexity (Stakeholder collaboration, user acceptance, cultural diversity)
- Normative complexity (Compliance with regulations, ethical considerations, industry standards)
- Institutional complexity (Organizational structure, decision-making processes, hierarchical dynamics)
- Business complexity (Market competition, financial constraints, strategic planning)

Sustainable Design Framework

To structurize complexities, **holism (systems thinking)** can be applied to create a Sustainable Design framework (SDf) (Figure 2).

Problem context needs to be explored (literature review, reports, surveys, etc.), identifying the problem owner, stakeholders and the research/design objective.

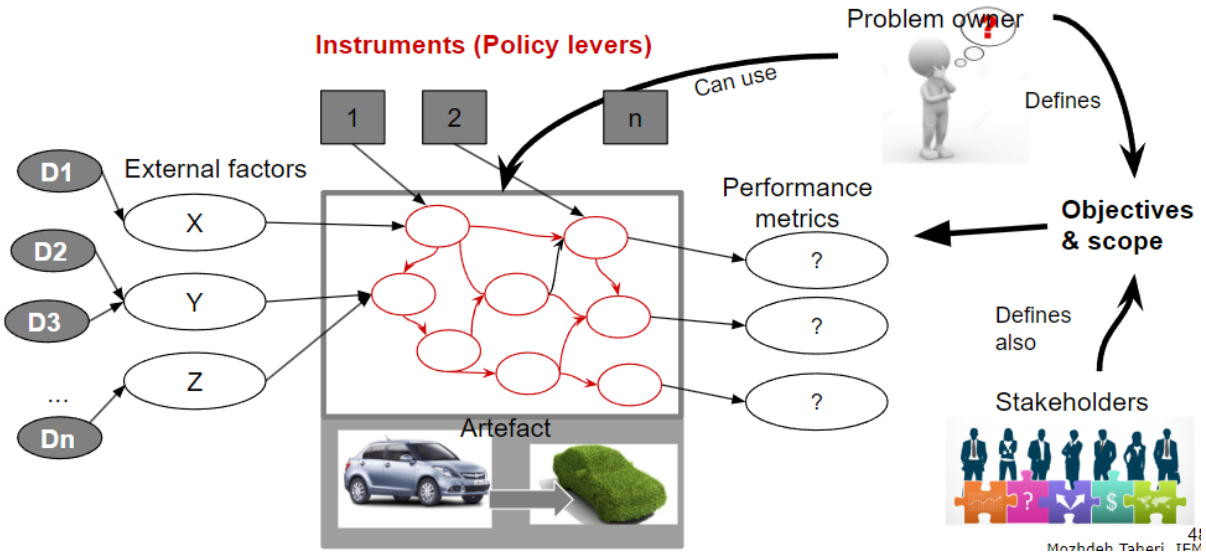

Figure 2: Sustainable Design framework (SDf)

Sustainable design framework is a clarification of the system that now contains 1) a demarcation of the boundaries and 2) a structure (i.e. elements and the relationships between them). Strongly dependent on the particular case selected.

Internal factor is a property of the system that informs how instruments propagate through the system. The internal factors are established through causal relations between the elements of the system.

External factor is a property that lies outside of the system and that cannot be controlled by the problem owner. External factors play an important role in scenario planning.

Objectives are a set of items that represent the desired situation. Objectives are established for a particular system/situation, based on the problem owner's interests. Stakeholders opinion might be considered in setting the objectives. Objectives could be linked with the purpose of project in DFS framework (Lecture 3)

Performance metrics (SPIs) are a set of *measurable* items that track the progression toward the objectives with respect to the three p's (Figure 3).

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Indicators (Woldring, Larsen, Jonker)

Internal? External?Global?
How to measure it?

Economic
- Net Profit
- Total Revenue
- Total Sales
- Return on Investment (ROI)
- Research and Development (R&D) investment
- Investment in Employee training
- Environmental Fines
- Expenditures on EHS compliance
- Community investment
- Production Cost
- Utility Costs
- Labor Cost
- Maintenance Cost
- Total Taxes
- Raw Material Cost
- Packaging Material Cost
- Operating Cost
- Total Operating Profit (EBIT)
- EBITDA
- Customer Satisfaction
- Local Suppliers
- Certified Suppliers
- Cost associated with Defective Products
- Turnover
- Overhead Cost
- Return of Capital employed
- Market Share

Environmental
- Water Consumption
- Water Pollution
- Water Recycled
- Waste Produced
- Hazardous Waste Produced
- Waste Recycled/Reused
- Energy Consumption
- Renewable Energy Consumption
- Efficiency of Energy Consumed
- Hazardous Material Consumption
- Toxic Emission
- Material Consumption
- Renewable Material Consumption
- Recycled Material Consumption
- Fuel Consumption
- Renewable Fuel Consumption
- Greenhouse Gas (GHG) Emission
- Sulfur Dioxide (SOx) emission
- Nitrogen Oxide (NOx) emission
- Volatile Organic Compounds (VOC)
- Ozone Depleting Substance (ODS)
- Land Use
- Land Pollution
- Environmental Accidents
- Environmental Fines
- Environmental Certification

Social
- Employee Turnover Rate
- Employee Satisfaction
- Employee Training and Development
- Wage level
- Employee Safety and Safe Working Environment
- Absenteeism
- Customer Satisfaction
- Customer Complaints
- Health and Safety Customers
- Employment involvement (in decision making)
- Community involvement (in decision making)
- Community Complaints
- Community Projects and Donations
- Jobs Created and Local Employment
- Number of Employees
- Disabled Employees
- Gender Discrimination
- Child Labour
- Efforts against Corruption
- Freedom of association and Collective Bargaining
- Environmental Protection
- Health insurance
- Level of Growth and Opportunity

Figure 3: Set list of Sustainable Performance Indicators (SPIs)

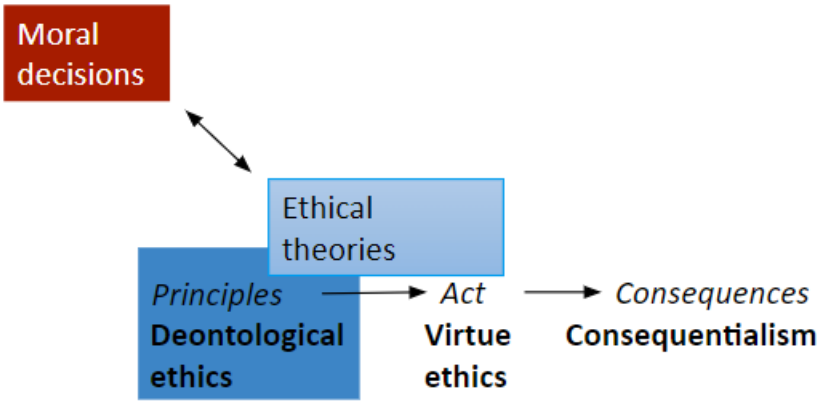
Sustainable Performance Indicators can linked to **United Nation Sustainable Development Goals (UN-SDGs)** to ensure that organizational goals align with globally recognized and comprehensive sustainability objectives (Figure 4).

Figure 4: United Nation Sustainable Development Goals

Ethical Consideration

Moral evaluation of an act can be categorized into three points in time:

- Intention of the act (Deontology)
- The act itself (Virtue ethics)
- Consequences of the act (Consequentialism)



Deontology is the evaluation of acts with certain principles irrespectively of the consequences

- Respect for the individual
- Justice
- Autonomy
- Privacy

Example: *You go to a friend to borrow the money and tell this friend that you will pay him back. You know you won't be able to pay your friend back, but you promise him nonetheless.*

You are making a false promise. Is this permissible?

To test, we first look at the maxim underlying the action, something like, "If I need something, I'll make a false promise in order to get what I need."

What would happen if everyone were to make false promises every time they needed something? Since the maxim can't be universalized, we shouldn't follow it, and thus we derive the duty to not make false promises.

Virtue ethics is doing the right thing, at the right time, in the right way, in the right amount, toward the right people.
→Translating to the state or condition of 'good spirit'

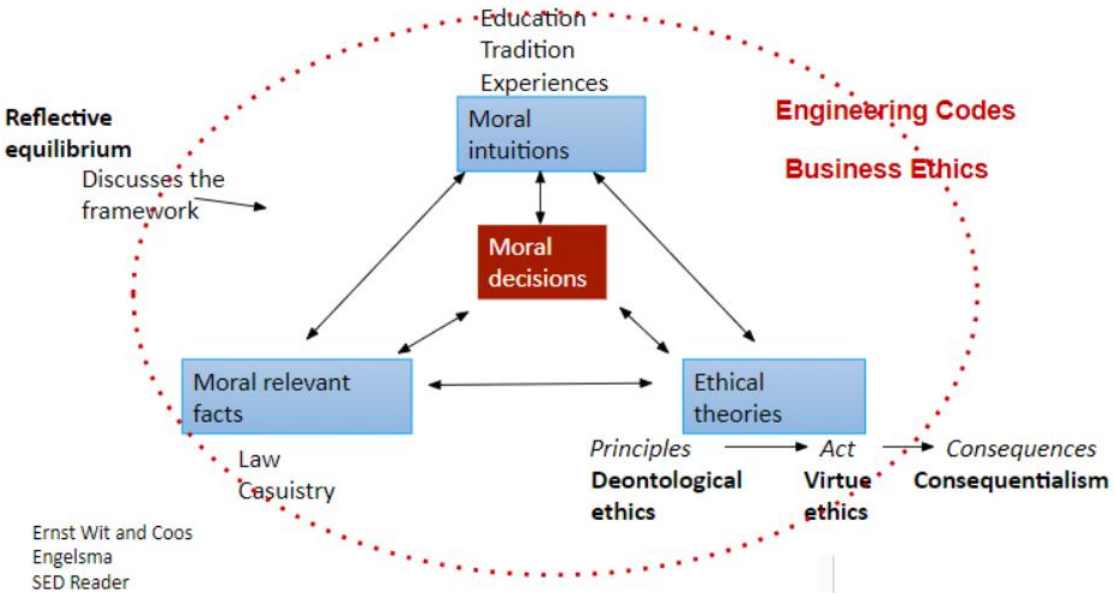
Consequentialism is the weighing of the aggregated sum of pleasure and pain of all involved sentient beings.
Σ, the sum of

- Human health & welfare
- Animal suffering
- Economy

Principle of utility = We should always act so as to produce the greatest good for the greatest number of people.

Reflective equilibrium is the combination of strengths of previous approaches and avoid their pitfalls

Changing the perspective from an **exclusively profit-generating attitude** towards **one in line with a consequentialist morality accounting for sustainability.**



Engineering code (How to behave as an engineer)

1. **Integrity** (Exercise good judgment, Adherence to ethical principles).
2. **Honesty** (Truthfulness, Fairness, Sincerity).
3. **Self-Discipline** (Acting with reasonable restraint, Not indulging in excessive behavior).
4. **Fidelity** (Faithfulness to clients, Allegiance to the public trust, Loyalty to employer, firm, or agency, Loyalty to the profession).
5. **Charity** (Kindness, Caring, Goodwill, Tolerance, Compassion/Mercy, Adherence to the Golden Rule).
6. **Responsibility** (Reliability/Dependability, Accountability, Trustworthiness).

Business code is a global compact on environment, anti-corruption, labor laws and human rights

AA1000 Principles

AA1000 (AccountAbility 1000) principles are a set of internationally recognized standards and guidelines for assessing, managing, and reporting an organization's sustainability performance founded on four principles (Figure 5).

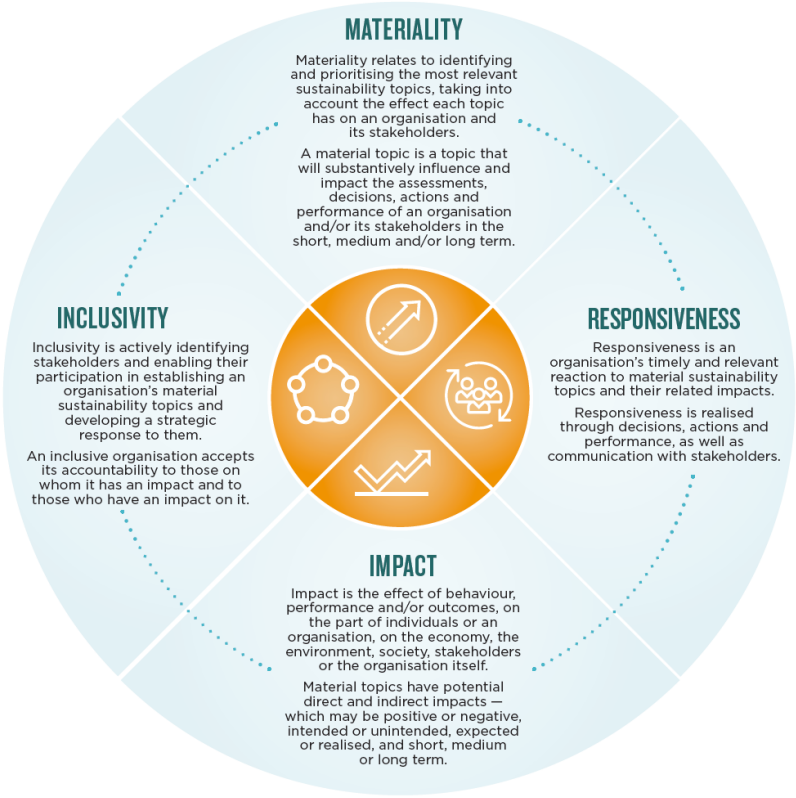


Figure 5: The four AA1000 principles

Design for Sustainable Innovation Framework

The **Design for Sustainability Innovation Framework** (**DfSF)** distinguishes five innovation levels, showing the different scales on which a design intervention can focus.

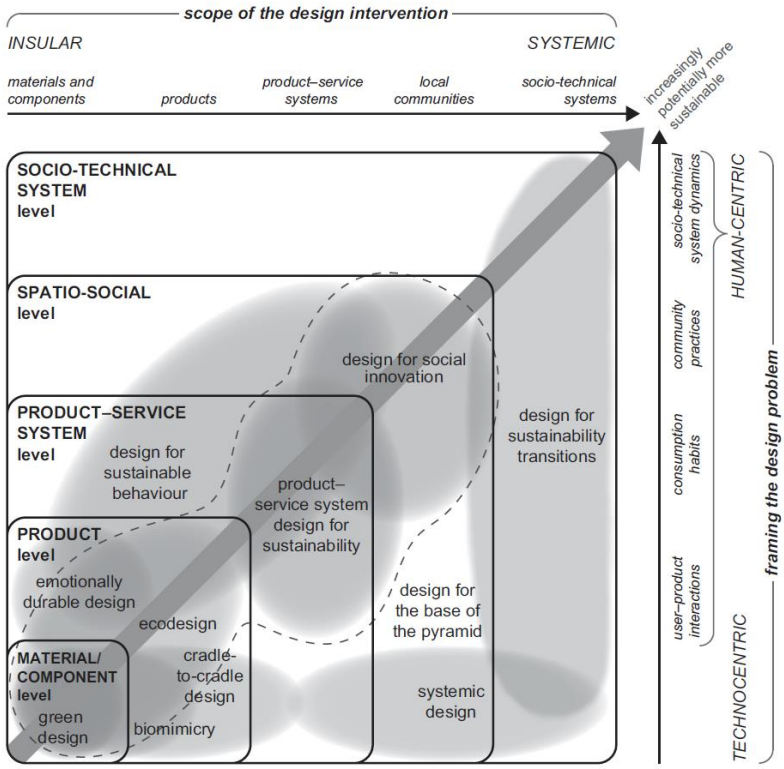


Figure 6: Design for Sustainability Innovation Framework

In the early 1990s: focus on a redesign approach, reduce environmental impacts, increase the efficiency of individual products (**green design**). In the second half of the 1990s: focus on the entire life cycle of a product (**ecodesign**).

Ecodesign (ED)

Suppose you advice a company which maintains a car fleet for their employees.

The wish of the company's board of directors is to set a statement on sustainability, primarily targeted, to internally raise awareness regarding sustainability. The company's car fleet should set an example.

A possibility could be to perform a relatively simple step, e.g. *substitute the current fossil fuel cars for electric cars*. That approach is within *ecodesign*, transferring the product to a more 'green' edition.

In this example, ecodesign implies a limited ambition on sustainability.

Emotionally durable design aims to enhance the emotional tie between the user and the product in order to delay or avoid product replacement.

Design for sustainable behaviour aims to address use-related impacts by implementing strategies that target influencing user behaviour so that it tends towards pro- environmental modes.

Product-service system (PSS) is a mix of tangible products and intangible services designed and combined to fulfill final customer needs. PSS implies that the value proposition or function of your product changes from selling heating systems to providing thermal comfort services, or from selling cars to offering mobility services.

In this example, a PSS Design for Sustainability explicitly includes the

- Thorough evaluation of the service the cars represent, e.g. internal traffic on sites, visiting clients, marketing (visibility of logo)
- The intended performance on sustainability, in terms of carbon footprint, effectiveness (time) and minimal total costs (€/y) of internal company traffic, employee satisfaction, customer intimacy, sustainability induced decisions
- Choice of instruments, depending on Board of directors could include public transport, electric scooters, excellent video call services, etc.

PSS introduces an increased ambition and complexity, compared to Ecodesign

Life Cycle Analysis (LCA)

Life Cycle Analysis (LCA) evaluates the environmental impact of a product (or service), over its entire life cycle (Figure 7&8).

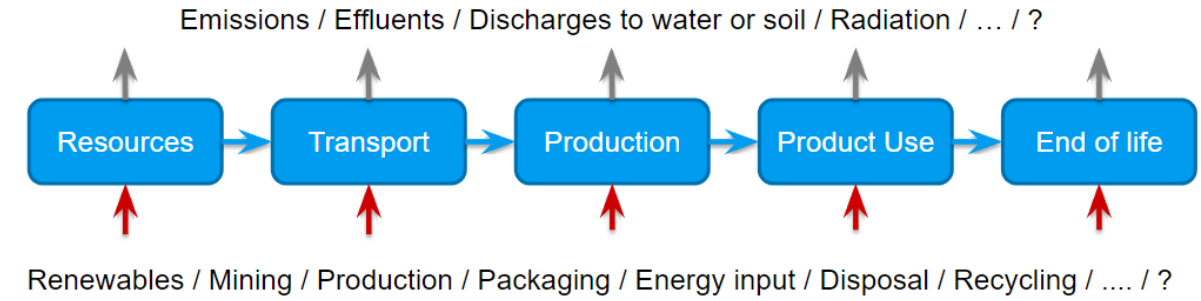


Figure 7: Life Cycle Analysis

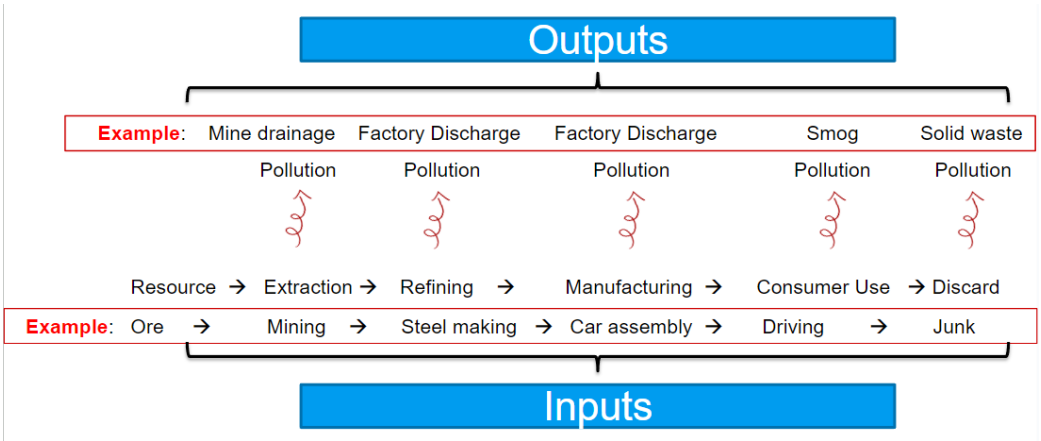


Figure 8: Example of an LCA

LCA is created through a stepwise process:

1. **Goal and Scope definition**
2. **Life Cycle Inventory (LCI)**
3. **Life Cycle Impact Assessment (LCIA)**
   Commissioners / Consumers / LCA Scientists
4. **Interpretation / Valuation**
   Experts in System Analysis and Process technology
5. **Improvement**
   Experts in Environmental Sciences
   Realm of Social Sciences (decision sciences) - Politics

Goal and scope of definition

- **Product system:** which process and flows are to be taken into account? (Figure 9)
- **System boundaries:** cradle to grave or cradle to cradle?
- Model of reality.

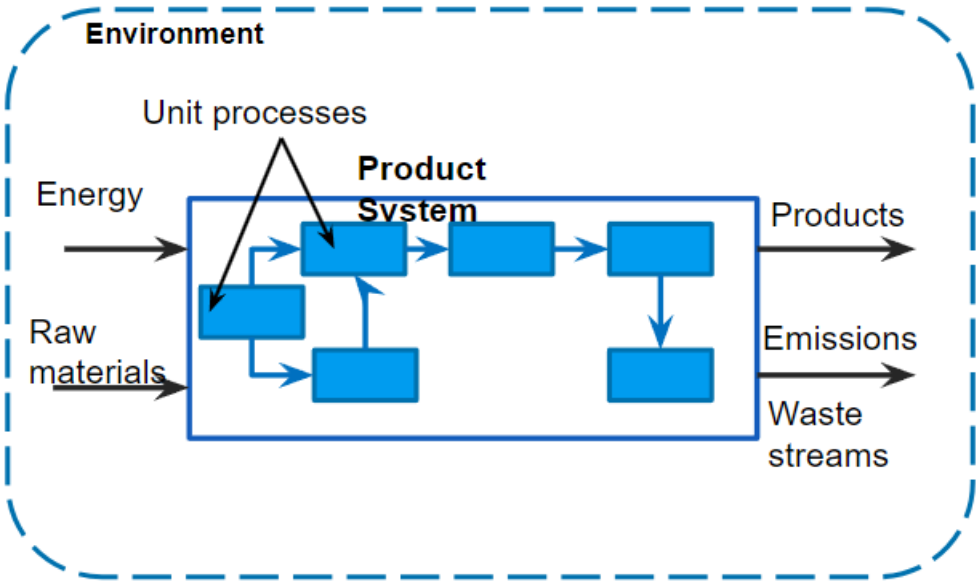


Figure 9: Product system

Funtional Unit (FU) is the quantification of the identified function of the product or service to ensure that comparisons are made on a common basis.

Power generation systems → kWh of electricity per year

Comparing cars in CO2 emissions → 20.000 km per year

Light bulbs → Lighting 20m² office space with x lux per year

Life Cycle Inventory (LCI)

Life Cycle Inventory (LCI) is the act of data collection and calculation procedures to quantify relevant inputs and outputs of a product system (allocation of flows and releases to processes)

Life Cycle Impact Analysis (LCIA)

Midpoints (at least 2!) provide a more detailed and specific understanding of the environmental factors contributing to different impact categories during the life cycle stages.

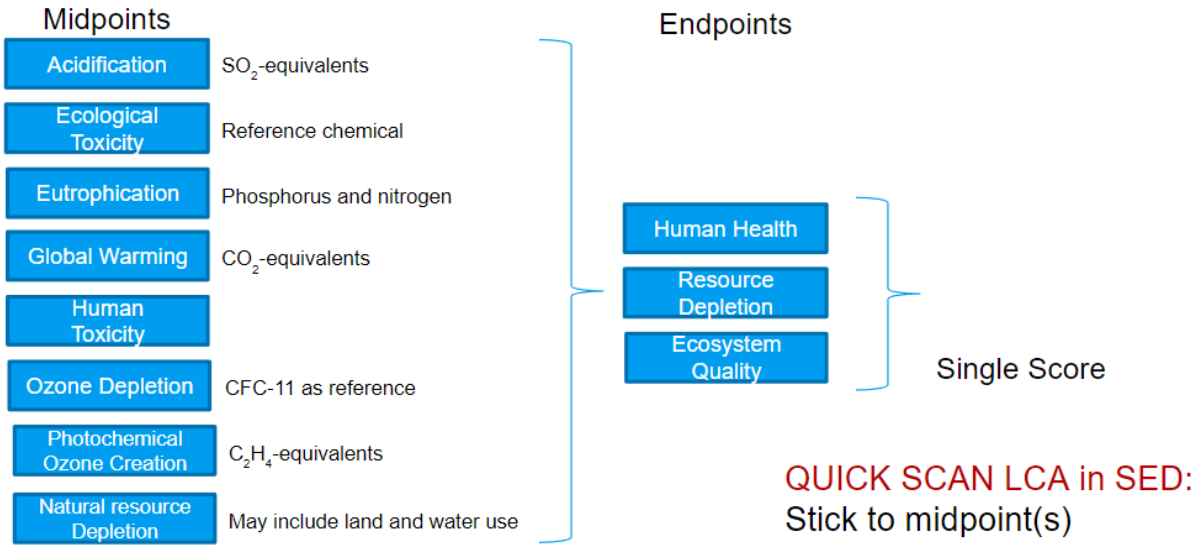


Figure 10: Set list of measurable midpoints

Interpretation

Goal of **Interpretation** is to analyze your reference state.

Results that are consistent with defined goal and scope.
Reach conclusions, explain limitations and provide recommendations.
Interpretation should reflect the fact that LCA results are based on a relative approach.

Improvement

Analyze both **reference state and improved state** and compare to show the improvement with respect to environmental impact

Scenario Analysis

Scenario analysis (scenario planning) is a suitable method to explore the *future* of multi-actor systems both qualitatively and quantitatively.

→Adds robustness to your design plan (improved resilience to future trends)

1. Framing the analysis (complexity)
   In scenario analysis we need to identify:
   - key research/design question
   - External factors
   - Driving forces

   Driving forces are uncertain:
   - Trend may change (uncertain)
   - Impact is unknown (high vs. low)

   Examples:
   - D1: Innovation in wind energy storage (radical/gradual)
   - D2: power of EU legislation (high/low)
   - D3: NL economy (growing/shrinking)

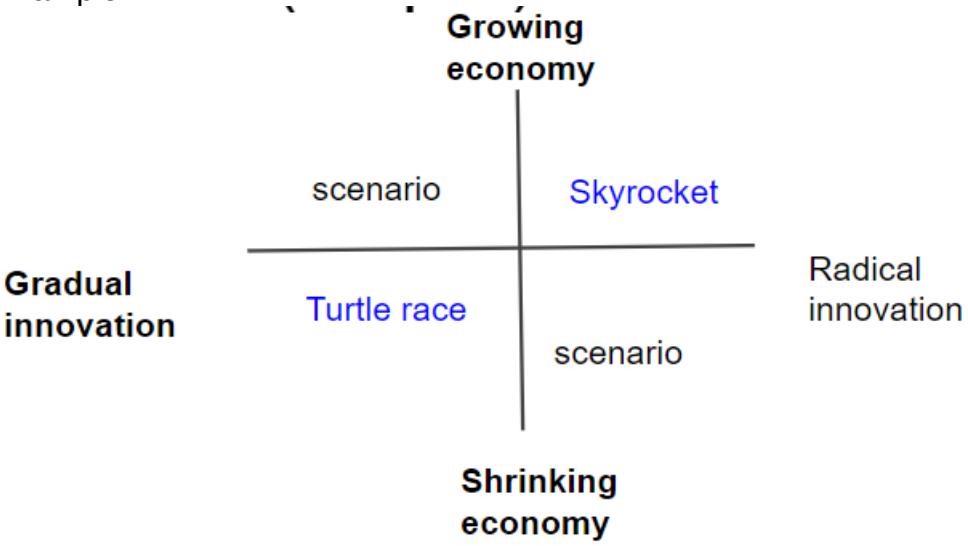
2. Gathering information (use as much reliable resources)
3. Classifying driving forces
   Based on:
   - Impact
   - Uncertainty

		Uncertainty	
		Low	**High**
Impact	**Low**	D6	D4
	High	D7	D1 , D3

   Driving forces with **high impact** and **high uncertainty** are critical driving forces
4. Defining the future's critical Either/Or uncertainties
   Critical driving forces are used to develop scenarios, for example:
   - D1: innovation in wind energy storage
   - D3: NL economy
5. Generating the scenarios

a. Combining driving forces to scenario axis
   b. Provide helpful titles

Example:



Skyrocket…
-In 2030, The NL will experience a booming economy…
-Radical innovation revolutionize storage of wind energy and it would be implemented in large scale.
-This result in decreasing prices of non-fossil energy and ...

6. Investigate impacts of scenarios on
    - Effectiveness of instruments (policy levers)
    - Evaluate system performance

Mock Exam Answers

Question (5 points): Explain what is meant by ED.

EcoDesign (ED) involves integrating environmental considerations into the design process, aiming to minimize the environmental impact of products throughout their lifecycle.

Question (10 points): Briefly discuss consequences of this approach for the implementation of RtR.

- Reduces resource consumption and waste by optimizing design for longevity and ease of repair.
- Supports the principles of the Design for Sustainable Innovation Framework, especially the focus on improving individual products (green design).
- Potential conflicts with traditional design practices and product aesthetics.
- Requires collaboration with manufacturers to implement design changes.

Question (5 points): Explain what is meant by PSSDS.

- PSSDS integrates tangible products and intangible services, focusing on sustainable outcomes throughout the product's life cycle.

Question (15 points): Discuss how goal and scope in the implementation of RtR between ED and PSSDS varies.

- **Goal and Scope in EcoDesign:**
    - Primarily emphasizes the environmental impact reduction through design improvements.
    - Focuses on the product itself, aiming to enhance its environmental performance.
- **Goal and Scope in PSSDS:**
    - Expands beyond the product, considering the entire product-service system.
    - Involves the creation of sustainable services alongside durable and repairable products.

Life Cycle Analysis (LCA)

Question (5 points): For either the case of Ecodesign or PSSDS, set-up an LCA for a television in which you investigate the effect to extend its duration, by adding repair possibilities.

- **Reference State:**
    - Television with traditional design and limited repair options.

Question (5 points): Discuss an adequate Functional Unit (FU).

- Hours of television viewing over its entire lifetime.

Question (10 points): Draw an LCA flow sheet in which you indicate the position of the FU.

- **LCA Flow Sheet:**
    - Start with raw material extraction, manufacturing, product use, and end-of-life phases.
    - Clearly indicate inputs and outputs at each stage.

Question (10 points): Discuss of two (or more) probably relevant midpoints.

- **Midpoints:**
    - Global warming
    - Natural resource depletion

Stakeholders and Moral Considerations

Question (10 points): Set-up relevant triple P objectives that G4RtR can apply to support the usage of the repairability scoring matrix; you may relate to your LCA (question 2, 10 points).

- **People:**
  Ensure the repairability scoring matrix enhances user experience and product satisfaction.
- **Profit:**
  Collaborate with manufacturers to integrate repair-friendly design without compromising profitability.
- **Planet:**
  Align repairability goals with environmental benefits, reducing electronic waste.

Question (10 points): Discuss how these triple P objectives can be best implemented in the AA1000 principles to govern the relationship between G4RtR and the stakeholders (10 points, 100-200 words).

- *Implementation in AA1000 Principles:*
    - **Inclusivity:**
        - Engage stakeholders in the development of repairability standards.
    - **Materiality:**
        - Prioritize repairability metrics based on their significance to stakeholders.
    - **Responsiveness:**
        - Address stakeholder concerns and feedback in the repairability scoring matrix.

Question (15 points): Discuss the possible dilemma Should the European Union interfere in the technology market and with OEMs practices? Is protecting customers interfering with the principles of the free market? Choose either a Consequentialism or a Deontology point of view (15 points, 200-300 words).

- *Dilemma: EU Interference in the Technology Market:*
    - **Consequentialism View (Focus on outcomes):**
        - Focus on positive outcomes, such as reduced electronic waste and increased consumer protection.
        - Evaluate the overall consequences on environmental sustainability and consumer well-being.

OR

- **Deontology View (Focus on intentions):**
    - Uphold principles of consumer rights and environmental responsibility.
    - Consider the moral duty to protect consumers from premature obsolescence and promote sustainable practices.