Sustainable Engineering Design Cheatsheet

Link to document for easiest access and best layout:
SED Cheatsheet

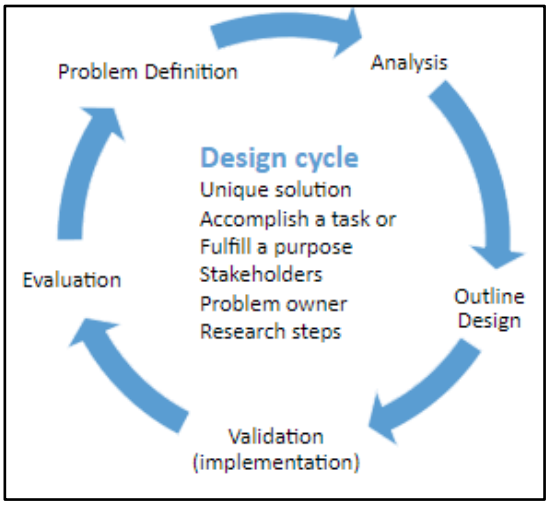
Lecture 1

BioFuels have both a short carbon dioxide cycle and are a replacement for fossil fuels.

Features that contribute to a sustainable design:

- Renewable energy
- Urban agriculture, efficient
- Compact, seemingly efficient used space

Sustainability has to be well defined, within boundaries that fits well in the design purpose.



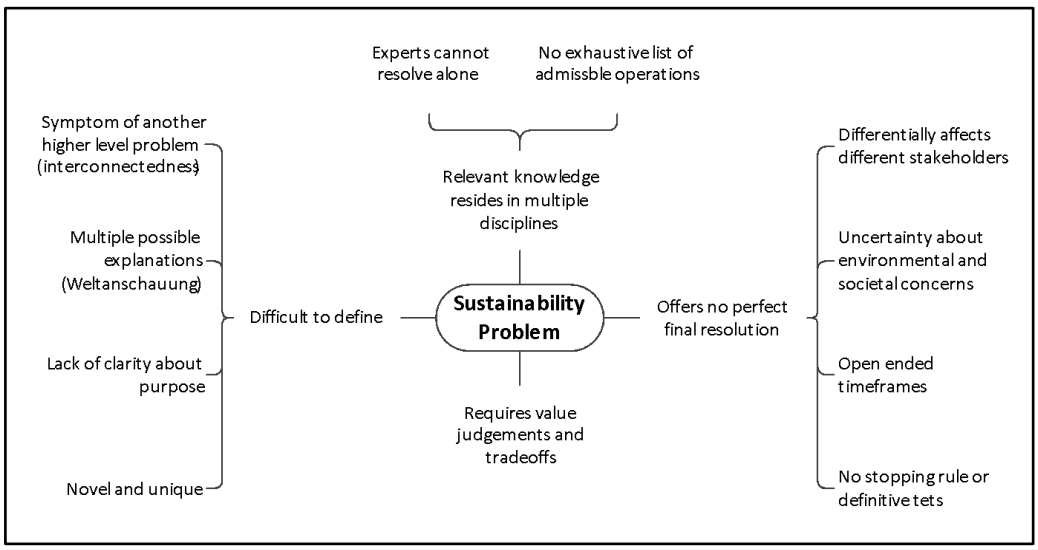
Engineering design

An engineering design fulfils a task or serves a purpose. The design cycle starts with the **problem definition**. The word problem is somewhat problematic, as the starting point of the design is not always defined as a problem, but as a vision or a challenge.
The **stakeholders** have a (foreseen) interaction with the design. They influence the design process and the outcome of the design will probably influence them.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
This includes two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given
- the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs.

In order to investigate sustainable design decisions, a set of analytical tools is used.

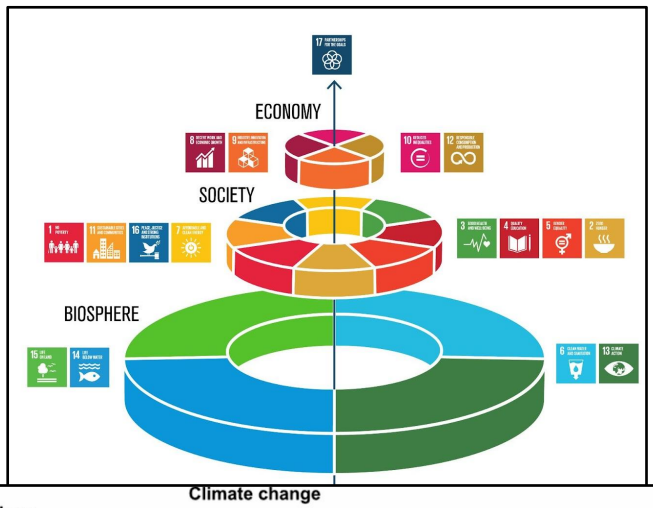


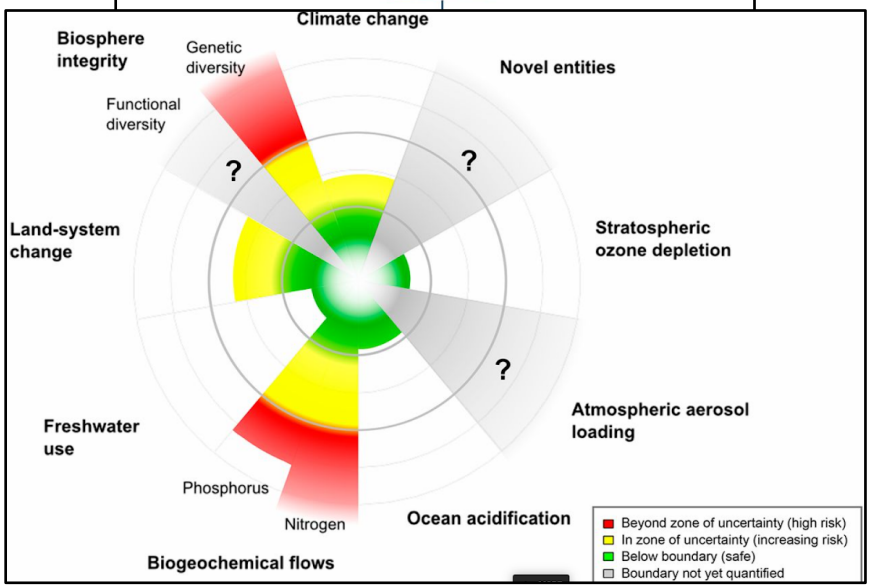
Triple P

Technology development always includes the Triple P assessment:

- People(socially acceptable)
- Planet(environmentally friendly)
- Prosperity(economically viable)

SDG's





Lecture 2

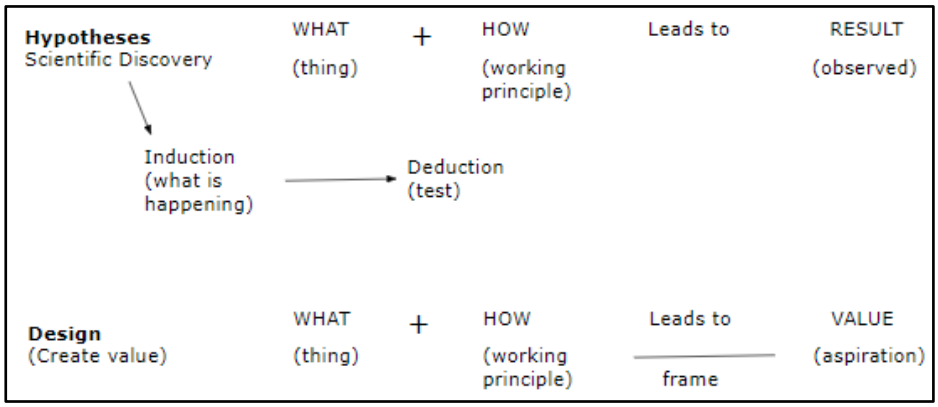
In constructing your design, it is important to determine what is the goal of the design, what you incorporate in your design and what is not included (the scope).

Design thinking

Design thinking is a different way of reasoning compared to research.
In **Deduction**, we know the 'what' (the 'players' in a situation we need to attend to), and we know 'how' they will operate together. This allows us to safely predict results.
Alternatively, in **Induction**, we know the 'what' in the situation, and we can observe results . But we do not know the 'how', the laws that govern these movements. The proposing of 'working principles' that could explain the observed behaviour (aka hypotheses) is a creative act.

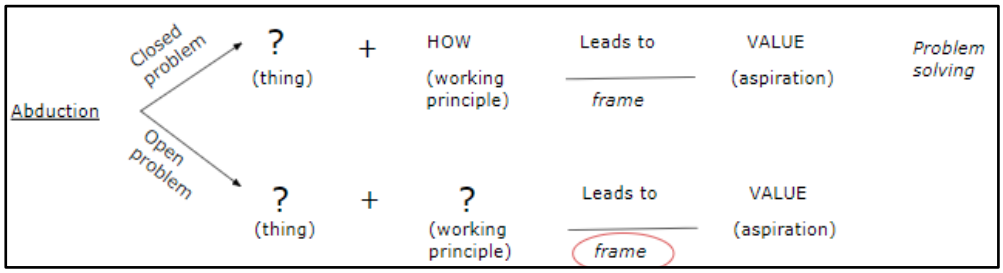
I = Induction II = Deduction	II.	WHAT (thing)	+	?	Leads to	RESULT (observed)

This form of reasoning is absolutely core to the 'context of discovery' in the sciences: this is the way hypotheses are formed. Within the sciences, these hypotheses are then subjected to critical experiments in an effort to falsify them. These rigorous tests are driven by deduction. Thus, in the sciences, inductive reasoning informs 'discovery', while deductive reasoning informs 'justification' However, this lacks creating value for others, as in design and other productive professions. To add value there, **abduction** is defined.



Abduction comes in two forms. The first form is often associated with conventional problem solving. The other form of productive reasoning is more complex because at the start of the problem solving process we ONLY know the end value we want to achieve. This 'open' form of reasoning is more closely associated with (conceptual) design.

In terms of our logical framework, a 'frame' is the general implication that by applying a certain working principle we will create a specific value. Framing is part of system thinking.



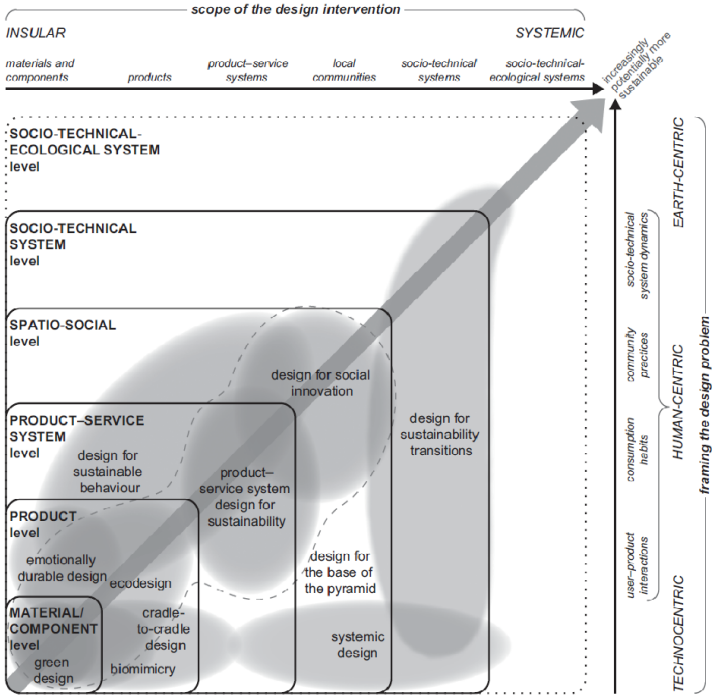
System thinking

With scientific discovery and hypotheses testing you analyse results, with the assumption of low interconnectivity and low interdependency. Design, forms of abduction, is synthesis and their relationships show high interconnectivity and high interdependency. System thinking is used to structure this complexity. Also, think of system dynamics.

The design innovation framework:

In the sustainability innovation framework, five innovation levels are distinguished.

- The material/ component innovation level. This includes design interventions aimed at incrementally improving products by developing new materials, replacing materials and (more generally) improving the individual qualities of a product.
- The product innovation level. Here the focus is on improving existing products or developing new products by considering the whole product life cycle, from material extraction to disposal.
- The product– service system innovation level. Here the focus goes beyond individual products towards integrated combinations of products, services, stakeholder value chains and business models.
- The spatio- social innovation level. Here the context of innovation is human settlements and the spatio- social conditions of their communities; this can be addressed on different scales, ranging from neighbourhoods to cities.
- The socio- technical system innovation level. This entails design interventions which focus on promoting radical changes in how societal needs (such as nutrition and mobility) are fulfilled and thus focus on supporting transitions to new socio- technical systems



The horizontal axis ranges from insular to systemic interventions and from materials to socio- technical systems. The vertical axis ranges from technocentric to human- centric framing.

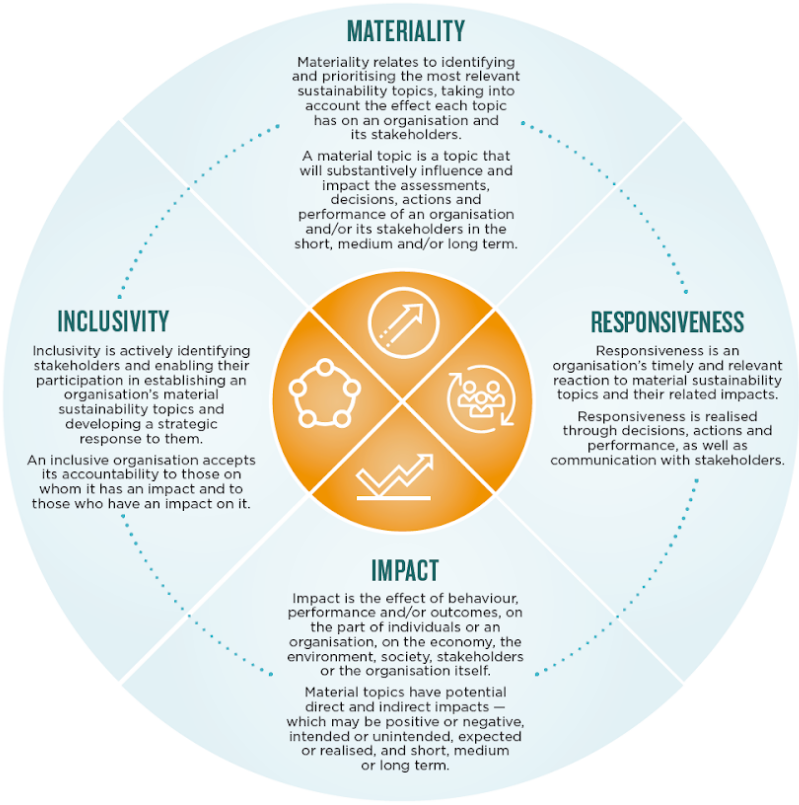
In the course unit we apply the framework to frame your objective and foreseen impact of your design: what is needed to accomplish intended sustainability related goals?

AA1000 principles

The second tool is the AA1000 principles, which originates from accountability. It is designed to advance responsive business practises and improve long term performance. The principles are:

- Inclusivity – People should have a say in the decisions that impact them.
- Materiality – Decision makers should identify and be clear about the sustainability topics that matter.
- Responsiveness – Organisations should act transparently on material sustainability topics and their related impacts.
- Impact – Organisations should monitor, measure and be accountable for how their actions affect their broader ecosystems.

Companies should align their goals to these principles in order to become fully sustainable.



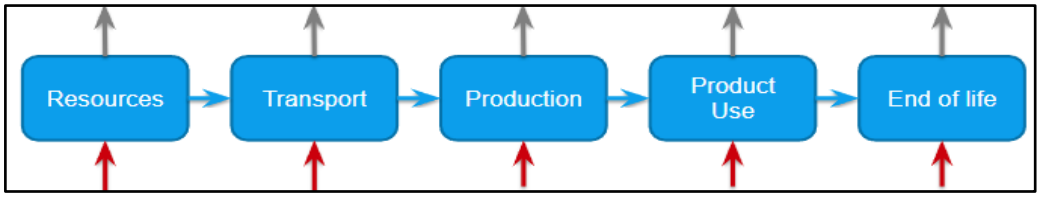
Lecture 3

Life Cycle Assessment

LCA adds quantitative information to support sustainable design decisions.

Sustainability as wicked or ill-defined problems focuses on the uncertainties which needs definition:

- Lack of clarity about purpose: a LCA requires a clear scope and goal
- Experts cannot resolve alone: typically LCA combines knowledge from different disciplines
- And with the uncertainty about environmental and societal concerns



LCA identifies the materials and energy needed for your process, service or product at hand with a specific focus about emissions to air, soil and water, therefore the environment. It talks about midpoints as the main sources of pollution. Furthermore, it includes all material and energy flows that matter in the system. Inputs of the LCA are in terms of resources, while outputs are in the form of emissions to air, soil and water.

Setting up an LCA takes the following five steps which require different fields of expertise:

- *Goal and Scope definition*: the area of Commissioners / Consumers / LCA Scientists
  Here, the reference state should be analysed and solutions compared to the reference state. For the scope, it should be considered which processes and flows are taken into account as well as the system boundaries.
  Furthermore, a ***Function unit*** should be constructed. This is a quantification of the identified function of the product or service to ensure that comparisons are made on a common basis. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related and this reference is necessary to ensure comparability of LCA results. It should, therefore, be measurable (kWh/year for example).
- *Life Cycle Inventory (LCI)*: Experts in System Analysis and Process technology
  This step includes data collection in the form of UN/World Bank/IEA reports.
- *Life Cycle Impact Assessment (LCIA)*: Experts in Environmental Sciences

This step recalls the midpoints and applies them.

- *Interpretation / Valuation*: Realm of Social Sciences (decision sciences) - Politics
  This part is used to analyse the reference state and identify the urge for improvement. Focus should be placed on flows of energy and material as they are: Substantially large, relatively harmful and valuable.
- *Improvement of your sustainable design solution*
  Finally, the solution should be compared to the reference state to reflect on the effectiveness of the applied policies on environmental impact.
  With the valuations, The new design should be better in some emissions and inputs and not worse on any of the other emissions and inputs.

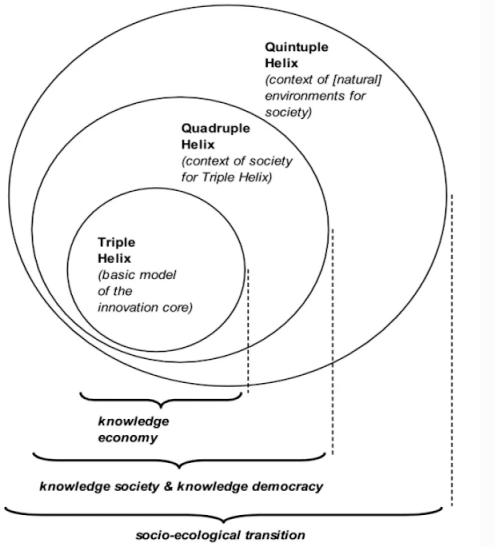
Typically a Life Cycle Assessment does not address economic or social elements, although interpretation may have many societal aspects.

Midpoints & Endpoints

Midpoints are:		Endpoints are:
-Acidification	-Photochemical Ozone Creation	-Human Health
-Ecological Toxicity	-Natural resources depletion	-Resource Depletion
-Eutrophication	-Ozone depletion	-Ecosystem Quality
-Global warming	-Human Toxicity	

Lecture 4

Sustainability anticipates future trends. Even so, no matter how much work is put into such a forecast, it will always turn out that the future will unfold more or less differently.
Trends analysis uses sourced computer data to predict the near future with help of combining related developments (Google, Microsoft, Facebook).
Regarding the European innovation process, the Quintuple Helix model forms an integral part of European innovation policy, which aims to create sustainable and inclusive growth in Europe. Current innovation processes increasingly include the context of society and (natural) environments for society respectively. Note the relationship between this model and the Design for Sustainability Framework, which both have higher levels of societal and environmental elements in the innovation process.



Scenario Analysis

Scenario planning is a tool which intends to handle the uncertainty of the future. With scenarios, we do not attempt to predict anything, but anticipate and become better prepared for the highly varying situations that are possible in the future.
Scenario analysis is suitable to explore the future of a multi-actor system. We start with a system model to write stories based on insights on how system environment might change over time.

MA Scenarios (EXAMPLE):

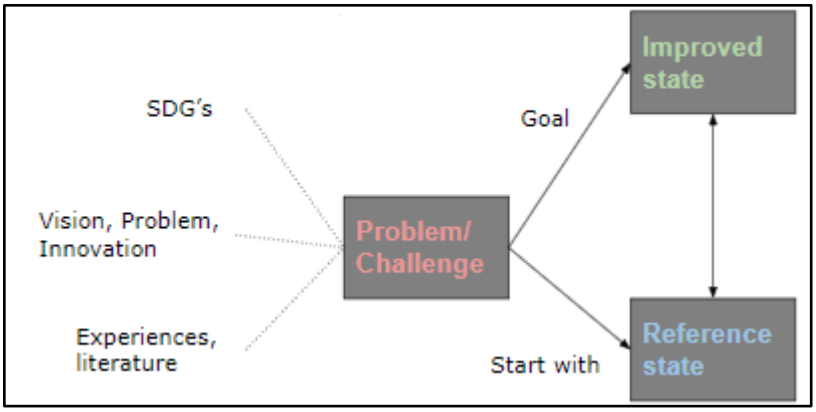
- The Order from Strength scenario examines the outcomes of a world in which protection through boundaries becomes paramount.
- The TechnoGarden scenario explores the potential role of technology in providing or improving the provision of ecosystem services.

As a worker in sustainability you may prefer Technogarden, however, as stated before, the likelihood of a scenario is not important, ideally each should have an equal opportunity to come into existence. Other two scenarios are:

- The Global Orchestration scenario explores the possibilities of a world in which global economic and social policies are the primary approach to sustainability.
- The Adapting Mosaic scenario explores the benefits and risks of local and regional management as the primary approach to sustainability.

SMART Goals.

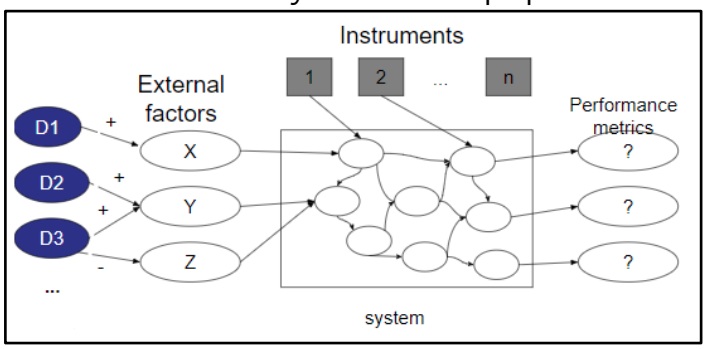
Goals of a sustainable project should be aligned to the SMART indicators, which are: Specific, Measurable, Achievable, Realistic and Timely. Making the metrics as measurable as possible, helps in creating a clear system. Possibilities for this are: Numbers originating from SDGs, Midpoints related to LCA, Economic related indicators as market share, or Number of votes for green parties.

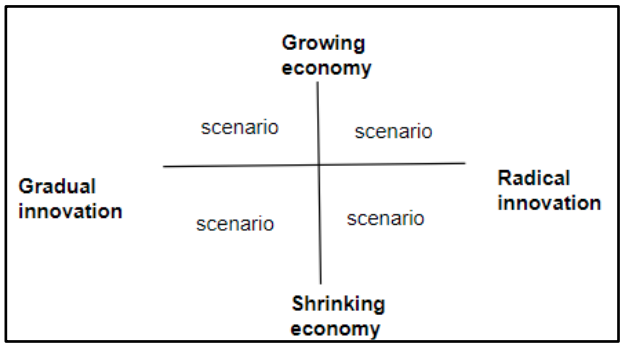


Scenario Planning Method

In scenario planning, key research, external factors and driving forces should be identified.
Driving forces are uncertain as trends may change and impact is unknown.
The steps are:

1. *Framing the challenge*
   - The goal usually already is determined in the system definition
   - Probably refined to the purpose of the scenarios





Classification:
Classify driving forces based on level of *uncertainty* and *impact*.

2. *Gathering information (use as much reliable resources)*
3. *Identifying driving forces (such as with PE(E)ST)*
4. *Defining the future's critical Either/Or uncertainties*
   In this step, quadrants of the matrix should be set up, in which the scenarios can be placed.
5. *Generating the scenarios*
   - Combining driving forces to scenario axis
   - Provide helpful titles
   Each quadrant is a scenario, also often referred to as a world view. They describe, based on the drivers, what the world looks like in the time span stated
6. *Fleshing them out and create storylines*
   - Here we usually recommend to test if the technology is expected to be robust to future trends and improve if necessary
   It is helpful to go back to step one and try to answer the research question accordingly. Also impacts of scenarios are investigated on effectiveness of instruments (policies) and on system performance. The scenarios should be independent of the solution! Aspects on the instruments can now be adapted and the system performance should be evaluated. The design solution may be adapted to improve robustness.

Articles

Week 1

1)The book from Jonker, engineering for sustainability provides insights in: The role a 'sustainable ' engineer should have: based on

- System thinking
- Industrial ecology
- Triple p

This book is mostly aligned with the first case deliverable in which you had to propose and explain your case.

Definition sustainability: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*
It contains with it two key concepts:
• The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
• The idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future trends

Triple P
After the more theoretical consideration of sustainability, system thinking, and the role of Industrial Ecology, the concept of Triple P provides a very practical application of sustainability. The financial and business world adopted the concept sustainability, but defined it further by introducing three essential dimensions of Sustainable Developmentnamely: Social, Ecological and Economic dimensions [26,27]. This in turn was transferred into the Triple P bottom line: People, Planet, and Profit, by Elkington [28]. Soon after, a number of companies started using it (e.g., Shell [29]). According to the triple bottom line concept, equal weight should be given in corporate activities to:
• "People", the social consequences of its actions
• "Planet", the ecological consequences
• "Profit", the economic profitability of companies (being the source of "Prosperity")

Think about the video where there is no equal weight.

OVERVIEW OF MAKING A SUSTAINABLE DESIGN

Setting up a Design Assignment

OUTLINE

General rules about group work, brainstorming and guidelines to write a report are central.

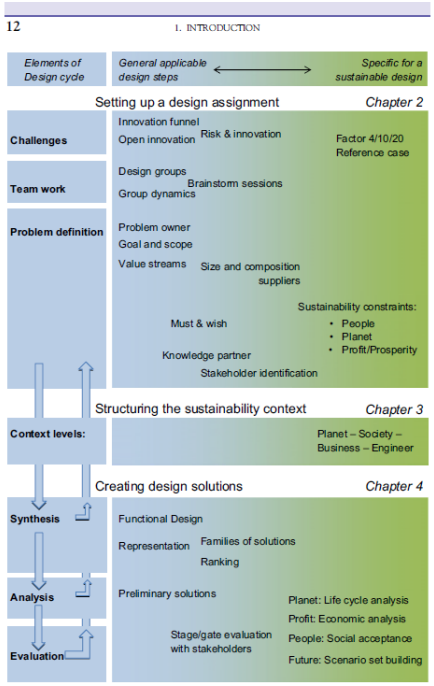


FIGURE 1.2 Sustainable design cycle as a leading guide for Chapters 2, 3, and 4.

Safe Operating Space for Humanity

The effect of mankind on the global environment was negligible in the period of the Holocene, starting 10 000 years ago until the Industrial Revolution in the eighteenth century. However, since the Industrial Revolution, human actions have become the main driver of global environmental change. Many subsystems of the Earth are behaving non-linearly: If thresholds are crossed, the subsystem may become unstable and could shift to another state, often potentially threatening human living conditions [60]. The main subsystems are summarized in Fig. 3.2 [60]: the

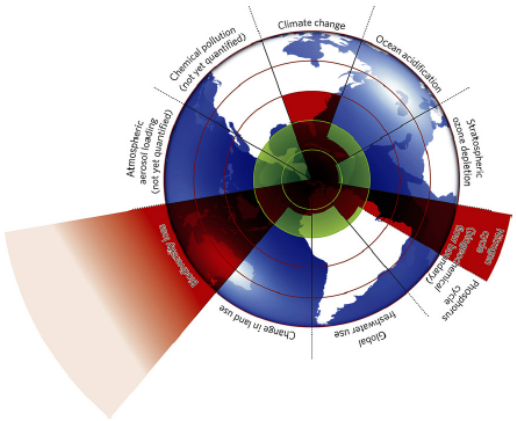


FIGURE 3.2 Safe operating space for humanity. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position of each variable. The boundaries in three systems have already been exceeded, see the main text. Reprinted by permission from Macmillan Publishers Ltd: *Nature*, copyright 2009 [60].

BOX 3.2

UNITED NATIONS MILLENNIUM GOALS

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria, and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

Chapter 3, about the basic needs and current problems in the world.

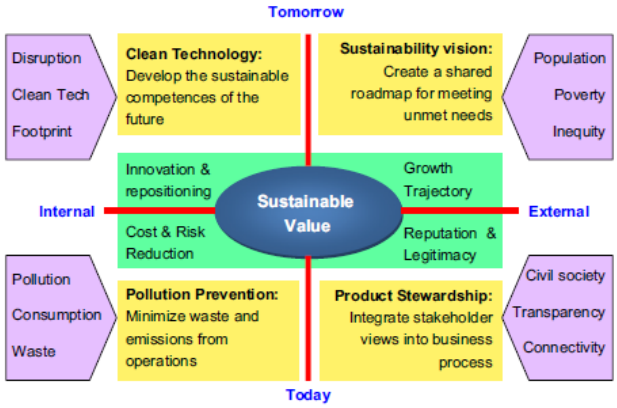


FIGURE 3.11 Sustainability value framework [2,27]. Matrix inner box: Corporate payoff; matrix outer boxes: Strategy. Left and right arrow type of boxes: drivers.

BOX 3.9

CLOSING THE CYCLE

On a more fundamental scale, the principle of green chemistry provides a means of a fundamental reduction of waste streams, e.g. by performing addition reaction instead of substitution reaction [133]. The cradle-to-cradle principle advocates to even abandon waste (waste equals food), which is a challenge for chemists to establish a true recycle flow (instead of downcycling) [7].

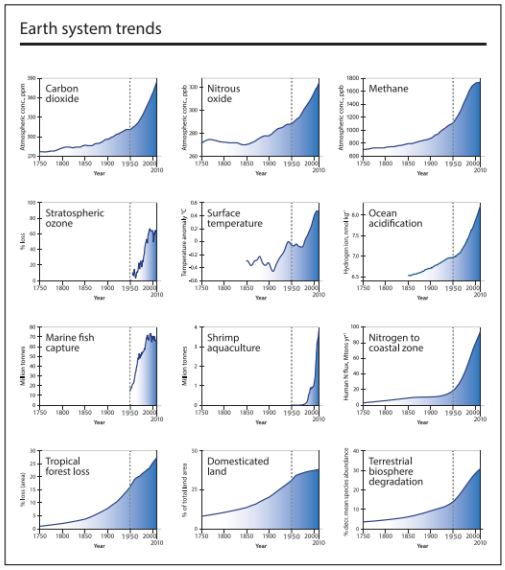
Chapter 1,2,3 are mostly there as a basis for chapter 4 which is the most important. Chapter 4 is about the construction of a quick scan LCA which is in week 3.

Not included in this week but helpful:

BOX 4.3

QUICK SCAN LCA

1. Goal definition and scoping
   - Define functional unit.
   - Define system boundaries.
2. Inventory
   - Define all life cycle steps.
   - Draw all input and output streams (air, water, and soil).
   - Determine key components in each stream.
   - Quantify key components of streams.
3. Impact assessment
   - Determine types of pollution.
   - Determine sizes of pollution.
4. Valuation
   - Normative criterion for valuation: The new design should be better in some emission and input types and not worse on any of the other emission and input types.
5. Improvement
   - Identify major contributions to pollutions.
   - Reduce pollution by re-design relevant step.



2) Anthropocene area (Steffen 2015)
Article about all the growth in the world, not really interesting for the exam in my opinion. It is there to provide background information.

3) Sustainable development goals for people and planet (Griggs 2013)
Planetary stability must be integrated with United Nations targets to fight poverty and secure human well-being, argue David Griggs and colleagues.
• Goal 1: Thriving lives and livelihoods. End poverty and improve well-being through access to education, employment and information, better health and housing, and reduced inequality while moving towards sustainable consumption and production.
• Goal 2: Sustainable food security. End hunger and achieve long-term food security — including better nutrition — through sustainable systems of production, distribution and consumption.
• Goal 3: Sustainable water security. Achieve universal access to clean water and basic sanitation, and ensure efficient allocation through integrated water-resource management.
• Goal 4: Universal clean energy. Improve universal, affordable access to clean energy that minimises local pollution and health impacts and mitigates global warming.
• Goal 5: Healthy and productive ecosystems. Sustain biodiversity and ecosystem services through better management, valuation, measurement, conservation and restoration.
• Goal 6: Governance for sustainable societies. Transform governance and institutions at all levels to address the other five sustainable development goals.

4)Planetary Boundaries (Nature paper of Steffen 2015)The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth System. Here, we revise and update the planetary boundaries framework, with a focus on the underpinning biophysical science, based on targeted input from expert research communities and on more general scientific advances over the past 5 years. Several of the boundaries now have a two-tier approach, reflecting the importance of cross-scale interactions and the regional-level heterogeneity of the processes that underpin the boundaries. Two core boundaries—climate change and biosphere integrity—have been identified, each of which has the potential on its own to drive the Earth System into a new state should they be substantially and persistently transgressed.

5)State shift (Barnosky 2012) Localised ecological systems are known to shift abruptly and irreversibly from one state to another when they are forced across critical thresholds. Here we review evidence that the global ecosystem as a whole can react in the same way and is approaching a planetary-scale critical transition as a result of human influence. The plausibility of a planetary-scale 'tipping point' highlights the need to improve biological forecasting by detecting early warning signs of critical transitions on global as well as local scales, and by detecting feedbacks that promote such transitions. It is also necessary to address root causes of how humans are forcing biological changes.

6) Nidumolu paper Why sustainability is now the key driver of innovation
When companies pursue **sustainability**, it's usually to demonstrate that they are socially responsible. They expect that the endeavor will add to their costs, deliver no immediate financial benefits, and quite possibly erode their competitiveness. Meanwhile, policy makers and activists argue that it will take tougher regulations and educated, organized consumers to force businesses to adopt sustainable practices. But, say the authors, the quest for **sustainability** can unearth a mother lode of organizational and technological **innovations** that yield both top-line and bottom-line returns. That quest has already begun to transform the competitive landscape, as companies redesign products, technologies, processes, and **business** models. By equating **sustainability** with **innovation** today, enterprises can lay the groundwork that will put them in the lead when the recession ends. Nidumolu, Prahalad, and Rangaswami have found that companies on the journey to **sustainability** go through five distinct stages of change:

(1) viewing compliance as opportunity;
(2) making value chains sustainable;
(3) designing sustainable products and services;
(4) developing new **business** models; and
(5) creating next-practice platforms.

The authors outline the challenges that each stage entails and the capabilities needed to tackle them

Lastly, i have cited the most important parts of the SED reader:

Learning Goals

1. Set-up and test appropriate design goals and constraints and planning related to sustainable development in terms of economical, societal, and environmental contexts.
2. Systematically develop innovative solutions for a sustainable design and show an academic analytical attitude.
3. Applying analytical methods as building sets of scenarios and performing quick scan life cycle analyses for evaluating the implications of the design.
4. Develop adequate communication skills on normative values, such as to write a normative reflection on a design

Currently, technology development almost always includes elements of Triple P assessment: People (socially acceptable), Planet (environmentally friendly) and Prosperity (economically viable). This added complexity requires a specific palette of knowledge and methods, such as key issues in sustainable development, thorough long-term view, life cycle assessment and a balanced professional personal assessment.

System thinking is the starting point in the course unit. Systems are defined by humans to serve a certain purpose: a system has a goal, is surrounded by a border (scope) and contains elements and relationships. Dynamic systems are processing input (data) to generate an output. Systems thinking is a holistic approach that is used for examining the complexity of systems. One of the complex problems that humanity faces is the sustainability challenge. System thinking is the starting point for structuring the complex and ill-defined problem context, see chapter 1 and as described in the first chapter of the work of Ceschin and Gaziolusoy (2020). In the initial stage of the design process, the diagnosis phase, the problem/challenge and business context provides increasing insight in the goal and purpose of the design. In this respect sustainability may have a coercive character: instead of only complying to regulations, it could be a choice of the design team to deliberately facilitate a change, e.g. to stay ahead of competitors (business) or force a next step in societal behavior (government). The Design for Sustainability Framework (Ceschin and Gaziolusoy (2020)) is a system approach to define the purpose of the design. Specific framework comprises guidelines to define an accompanying impact of the sustainable design, with best practices and key stakeholders involved. As with complex problems, the sustainability challenge can be addressed by Design Thinking.

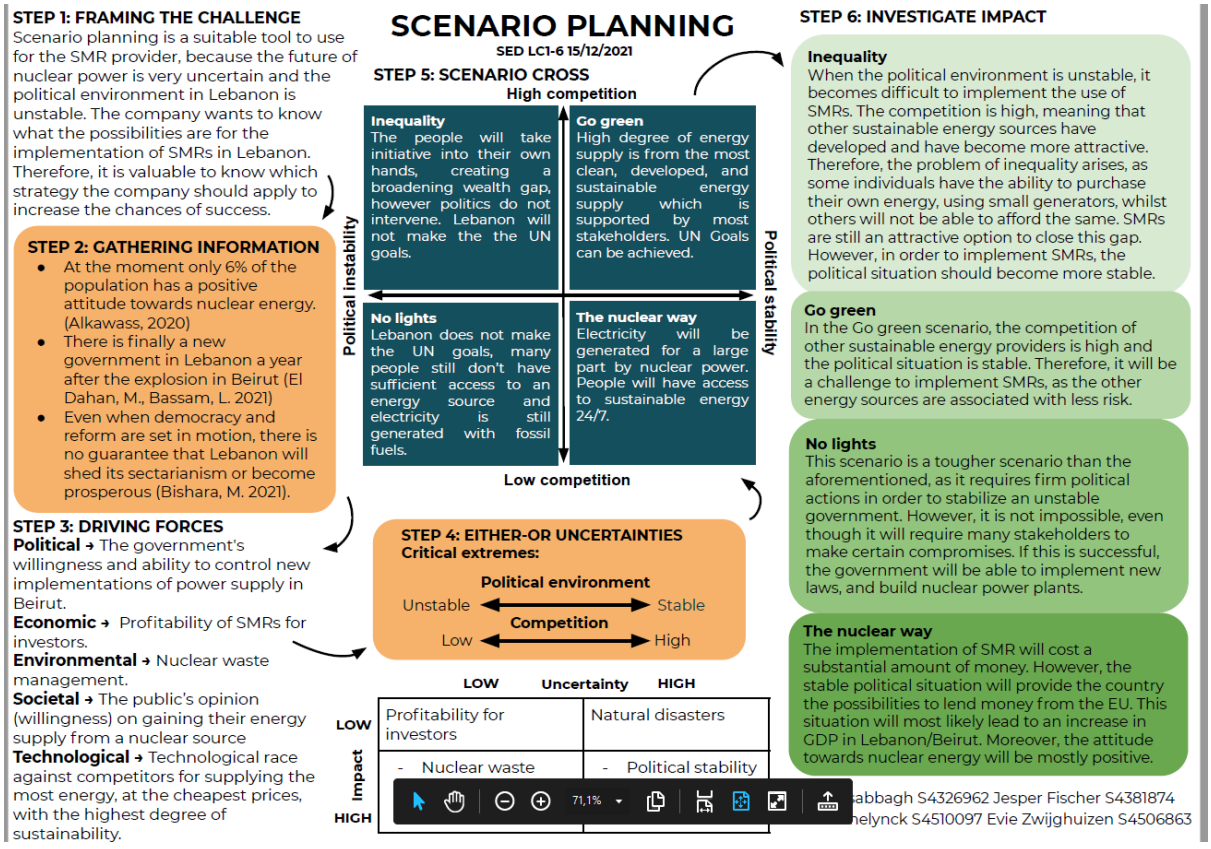
The book they mention here is design for sustainability: chapter 1 4 12 -> print chapter 12
Stakeholders within the scope can have two roles, either they affect the implementation of the sustainable design or they are affected by the implementation of the sustainable design. The Harvard Business Review article on stakeholder identification can provide a solid basis for assessing the stakeholder and its interrelations with the problem owner and the other stakeholders, within the scope of a sustainable design project. In addition, thinking about who is responsible for the (in)actions regarding the sustainability challenge in a design project is essential.

1. Does the stakeholder have a fundamental impact on your organisation's performance? (Required response: yes.)
2. Can you clearly identify what you want from the stakeholder? (Required response: yes.)
3. Is the relationship dynamic — that is, do you want it to grow? (Required response: yes.)
4. Can you exist without or easily replace the stakeholder? (Required response: no.)
5. Has the stakeholder already been identified through another relationship? (Required response: no.)

Chapter 4 book jonker -> print (about quick scan LCA)
In the book "Scenario Planning : A Field Guide to the Future" by Woody Wade, you are presented with 6 main steps that guide you in constructing your scenarios, followed by 4 additional steps meant to help you reevaluate what you've come up with. We urge you to carefully consult the second chapter of the book for a detailed description of each step, but here is a breakdown of the main points within them:

Chapter 2 ^ -> print (6 scenario steps)
STEP 1. FRAMING THE CHALLENGE
STEP 2. INFORMATION GATHERING
STEP 3. IDENTIFYING DRIVING FORCES
STEP 4. DEFINING THE FUTURE'S CRITICAL "EITHER/OR" UNCERTAINTIES
STEP 5. GENERATING THE SCENARIOS
STEP 6. FLESHING THEM OUT AND CREATING STORY LINES

I include a screenshot of our poster to have a better understanding.



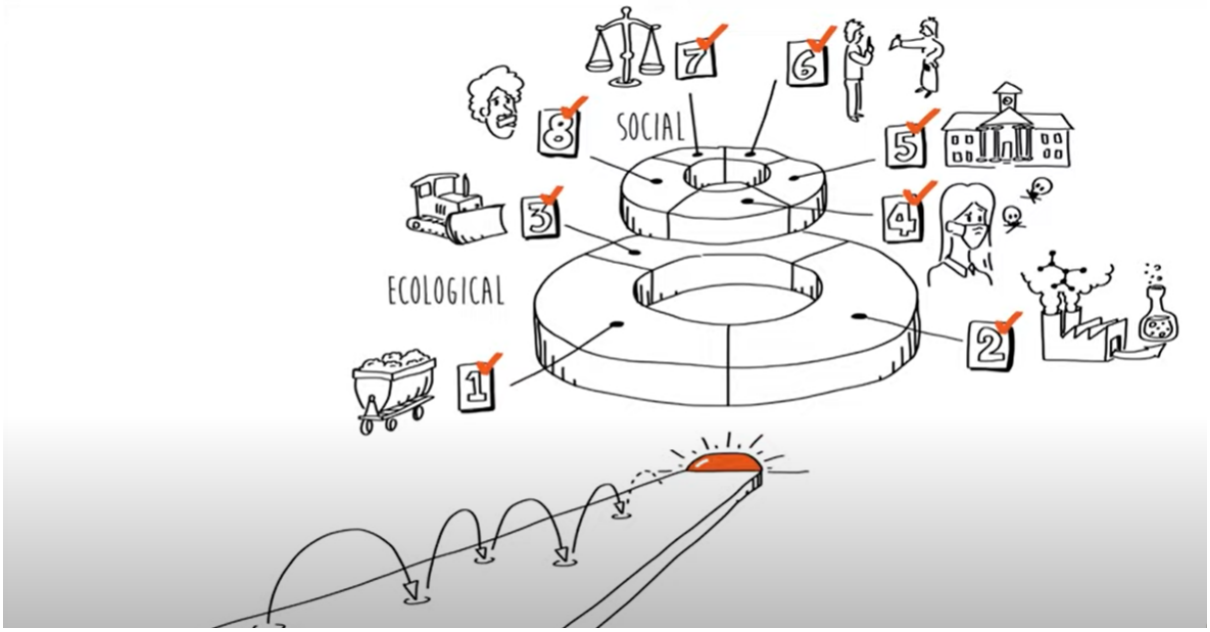
Week 2

1. There are two main lines of reasoning: analysis and synthesis. Analysis is based on the premise of reductionism: everything is broken down into parts which are then in turn analysed. Properties in isolation are investigated. By doing this, when recomposing these components or parts into the whole system again, behaviour can be described in terms of properties of its subparts. Reductionism is the leading line of reasoning in the scientific world, think of atoms etc. limitations are: relationships between components are often not considered as components are investigated individually. With a high level of interconnectivity, synthesis is a better line of reasoning (systems thinking). Synthesis = the combination of components or elements to form a connected whole. It defines an entity through the context of its relationships within the whole system that it is a part of. (also called holism (holistic))
2. From the conclusion: This paper has concentrated on frame creation as a core practice that is particular to the designing disciplines, and explored how that design practice could interface with an organisation. We have seen that design practises can relate to the practice of an organisation on at least five different levels: as the design practises that address problems within an existing frame (Abduction-1); as design practises that involve framing (Abduction-2), where the frame originates from the existing company practice; as the adoption of a new frame that has been brought or developed by an outsider; and as the creation of a new frame through the investigation of themes, in a deeper transformation of the organisations' own practises. This last level is where design based practises and organisational innovation are most intimately linked. This is where design practises and the knowledge that has been built up over almost 50 years of design research can directly relate to processes that have been described in terms of 'entrepreneuring' (Steyaert, 2007) and 'effectuation' (Sarasvathy, 2008) in management literature.
3. The development model should be changed radically in order to adapt to sustainability as a goal. The change should be from a society that measures economic health and well-being by growth to a society that lives better, consuming far less. We have to urgently move towards socio-technical systems that are capable of operating within the planet's limits while ensuring that this move follows pathways that are ethical and just. Sustainability started being a systematic concern around the 1980s, and has transitioned to the current concern, which is design for sustainability transitions.
   Design for sustainable behaviour:
   This design approach deals with triggering shifts in the everyday behaviour of people in order to support the adoption of sustainable innovations, attitudes and behaviours. The scope of intervention includes products and, more broadly, systems of products and services, digital artefacts, the built environment and even policies. A key benefit of this approach is that it can effectively enable societal change by shaping or instilling new behaviours and habits. In this sense, it can complement other designs for sustainability approaches and address some of their limitations. Despite its potential, this approach presents some important challenges and limitations, for example the ethical implications of driving user behaviour and, from a more operational perspective, the lack of metrics with which to measure the effect of design for behaviour change strategies.
   Design for sustainability approaches are categorised into five innovation levels: material/component, product, product–service system, spatio-social and socio-technical system. The chapter puts forward an innovation framework capable of coherently integrating the different designs for sustainability approaches. The framework provides an understanding of the overall evolution of design for sustainability, showing how it has progressively expanded from a narrow technical and product-centric focus towards a focus on large-scale system-level changes. The framework provides a synthesis of the design for sustainability field and illustrates how the various approaches contribute to particular

sustainability aspects. It also visualises linkages, overlaps and complementarities between the different approaches. The chapter discusses how the framework can be used in different ways by design researchers, educators and practitioners. It also reflects on the knowledge and know-how that are required by designers to apply the various design for sustainability approaches, and concludes by outlining the potential future evolution of the field.

4. SDG wedding cake and other interesting ways to use sustainable goals to check whether business is sustainable.

17 goals seems like a lot: they are the result of many public consultations and provide a shared language for all countries to report on. The goals are interconnected rather than individual. Essentially, sustainability is about meeting human needs within ecological constraints, and the economy is a strategy to make money while achieving sustainability. This shows that goals are interconnected: you can't have economic growth or zero hunger without taking care of life below water first. However, doing good on these goals, targets and indicators does not necessarily mean a country is good in sustainability: the countries rated highest are also some of the countries that have the highest ecological footprint. Looking at the aggregate core of a country can therefore be misleading. Road to a sustainable country:

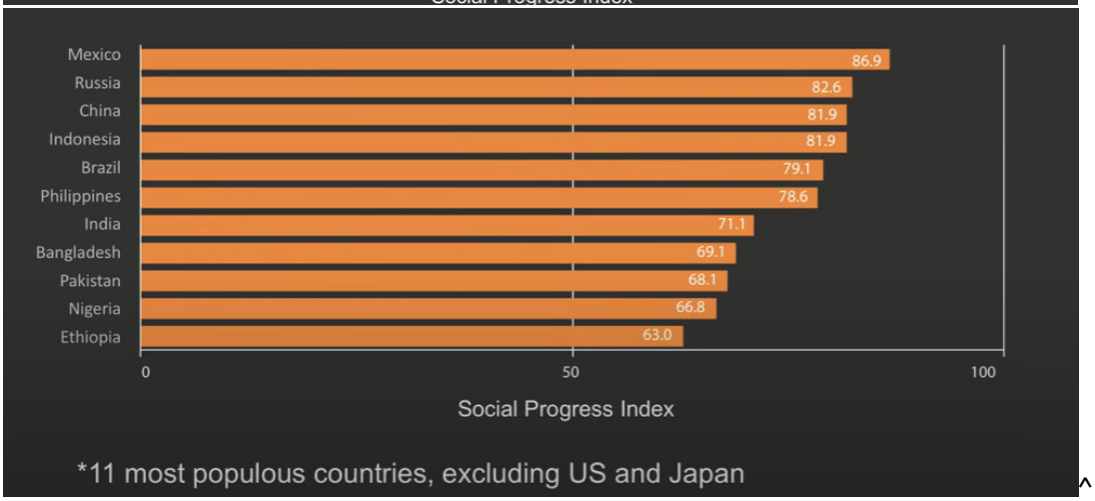


For companies, futurefit business is recommended (it provides action guides) organises as following:

- Environmental goals
- Employee Goals
- Community Goals

5. What goals were made progress on?

100 is what is to be reached at 2030



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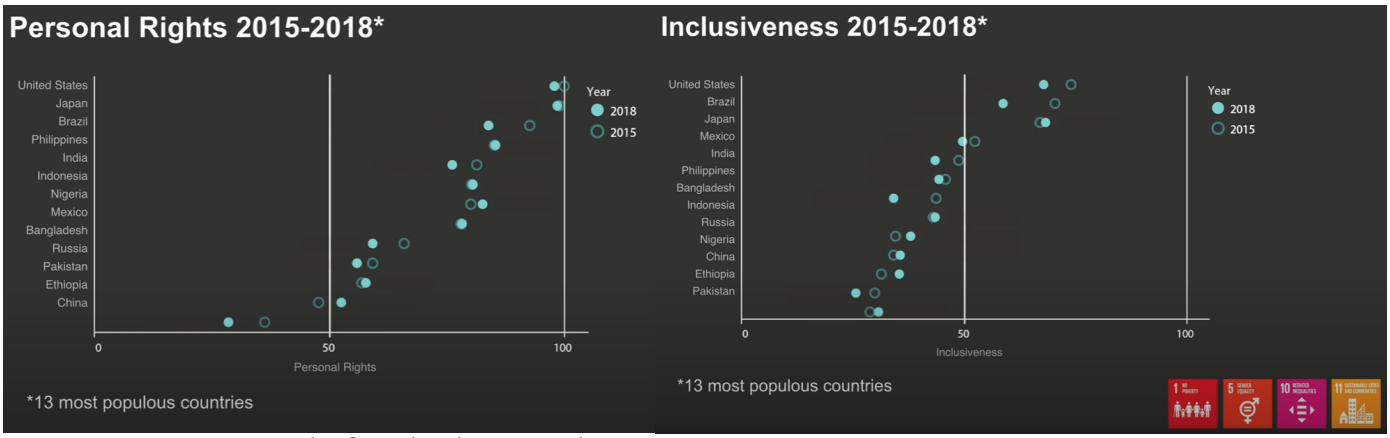
This is forecast for 2030

According to this, we won't achieve our 2030 targets until 2094
Lots of progress on targets 2 and 3, less on target 6. However, many problems are already solved, they just need to be scaled (water pollution for example is already reached by many countries, this just needs to be scaled globally)
Some targets are worsening:



However, the fact that human rights
are included in the SDGs is a positive: when choosing to just pick the easiest to solve, the entire goal of these SDGs will be missed.

6. AA1000 principles

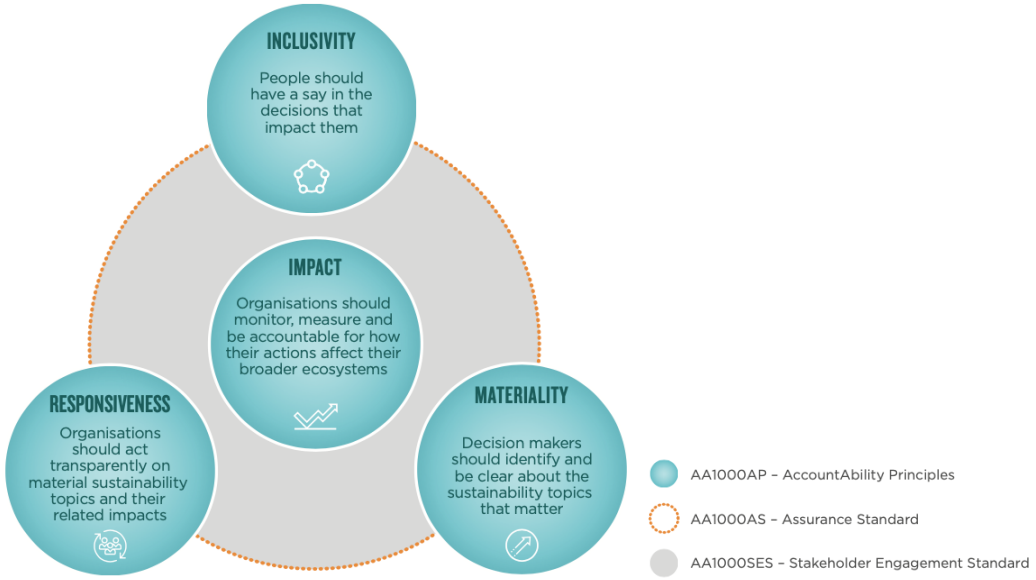
The AA1000AP (2018) provides guidance on how organisations can become and remain accountable for their results and broader ecosystem impacts.

Accountability is the state of acknowledging, assuming responsibility for and being transparent about the impacts of an organisation's policies, decisions, actions, products, services and associated performance.

When an organisation holds itself fully accountable, it seeks to involve stakeholders in identifying, understanding and responding to material sustainability topics and concerns, and to communicate with and be responsive to stakeholders regarding one's decisions, actions and performance.

Accountability comprises the way in which an organisation sets strategy, governs and manages performance.

The accountability principles are depicted in the following picture.



Inclusivity:

Inclusivity is actively identifying stakeholders and enabling their participation in establishing an organisation's material sustainability topics and developing a strategic response to them.

An inclusive organisation accepts its accountability to those on whom it has an impact and to those who have an impact on it.

Required adherence criteria:

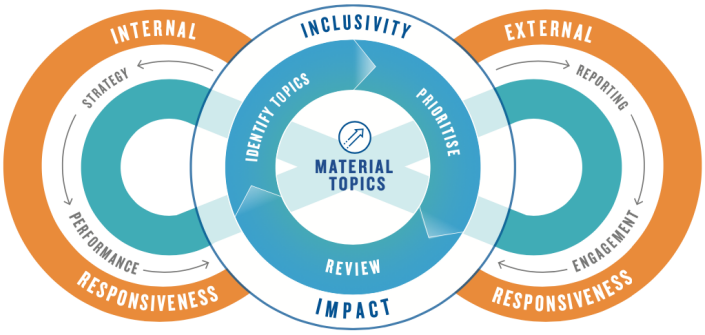
The following action items are designed to guide organisations in both applying the Principle of Inclusivity and monitoring their own progress in its application. Fulfilment of the criteria leads to adherence with the Principle. These criteria are also used by assurance providers to assess an organisation's enactment of the Principle.

COMMITMENT, INTEGRATION & CAPACITY BUILDING
1. Formalise a commitment from the highest governing body of the organisation to be accountable to stakeholders.
2. Integrate stakeholder engagement processes into governance, strategy and relevant decision-making processes across the full organisation, seeking senior management, cross-functional and cross-geographical involvement as appropriate.
3. Establish the scope and objectives of stakeholder participation.
4. Integrate stakeholder engagement and responses into relevant policies, operational procedures and systems, for example by performing risk analyses, materiality assessments, and setting and monitoring meaningful objectives.
5. Ensure that the necessary competencies and resources are allocated and available for stakeholder engagement.

ENGAGEMENT STRATEGY & PROCESS DEVELOPMENT
6. Identify and understand stakeholders, including their capacity to engage and their views and expectations, and address potential stakeholder and engagement risks.
7. Develop formal strategies for ongoing engagement and communication with stakeholders.

PERFORMANCE MEASUREMENT & STAKEHOLDER COMMUNICATIONS
8. Set relevant metrics to measure engagement effectiveness, outcomes and impact.
9. Use outputs of engagement to facilitate understanding, learning and improvement of the organisation.
10. Communicate with stakeholders in an appropriate, transparent and timely manner, as per the organisation's established boundaries of disclosure.

<u>Materiality:</u>
Materiality relates to identifying and prioritising the most relevant sustainability topics, taking into account the effect each topic has on an organisation and its stakeholders.
A material topic is a topic that will substantially influence and impact the assessments, decisions, actions and performance of an organisation and/or its stakeholders in the short, medium and/or long term.

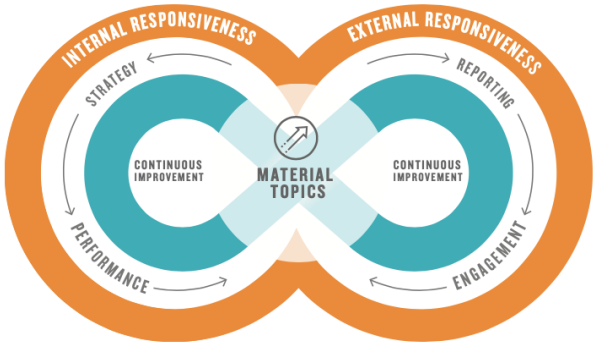


Required adherence criteria:
COMMITMENT, INTEGRATION & CAPACITY BUILDING
1. Establish an organisation-wide, robust, systematic and ongoing materiality determination process under the governance of senior management, including key cross-functional involvement.
2. Ensure integration of the assessment process across the organisation, including through relevant processes, such as risk management and compliance with laws, regulations, and internal policies and procedures.
3. Provide the necessary competencies and resources to apply the results of the materiality assessment process.

MATERIALITY DETERMINATION
4. Set consistent and clear boundaries, as well as a purpose, time period and scope, for the materiality assessment, with underlying assumptions appropriately documented.
5. Identify and fairly represent topics from a wide range of sources.
6. Evaluate the relevance of identified material sustainability topics based on suitable and explicit criteria*.
7. Determine the significance, likelihood, and present and expected future impact of identified material sustainability topics, using appropriate criteria and thresholds*.
8. Take into account the evolving sustainability, macroeconomic, geopolitical and regulatory contexts and maturity of topics and concerns, allowing for industry- related, geographical, cultural and operational-level differences.
9. Include a means of addressing conflicts or dilemmas arising from diverging or conflicting expectations regarding material topics.

COMMUNICATION
10. Create and disclose a comprehensive and balanced understanding and prioritisation of material sustainability topics for the organisation and its stakeholders.
* Criteria and/or thresholds that are credible, clear and understandable as well as replicable, defensible and can be subject to external assurance.

<u>Responsiveness:</u>
Responsiveness is an organisation's timely and relevant reaction to material sustainability topics and their related impacts.
Responsiveness is realised through decisions, actions and performance, as well as communication with stakeholders.



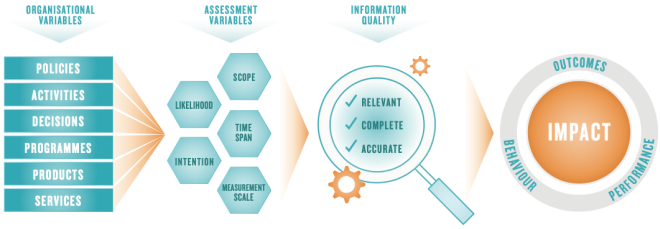
Required adherence criteria:
COMMITMENT, INTEGRATION & CAPACITY BUILDING
1. Under the governance of senior management, including key cross-functional involvement, implement a process for developing responses related to material topics and communicating them to stakeholders that is applied across the organisation.

2. Integrate this process into the organisation, including through relevant organisational processes, such as risk management, compliance and strategy development.
3. Provide the necessary competencies and resources to respond appropriately to material topics, using a range of response types.

RESPONSE STRATEGY DEVELOPMENT
4. Implement a process for developing responses and communicating with stakeholders that is continuous and ongoing.
5. Consider the relationship between the maturity, impact and prioritisation of a topic and the appropriateness of the response.
6. Validate proposed responses with internal and, when appropriate, external stakeholders, and assure feasibility to deliver reasonable and viable responses.

RESPONSE IMPLEMENTATION & ONGOING COMMUNICATION
7. Respond in a way that addresses the needs, concerns and expectations of stakeholders.
8. Report to stakeholders in a comprehensive, accurate, timely, accessible and balanced way, using suitable reporting principles, frameworks and guidelines that support comparability of information.

Impact:
Impact is the effect of behaviour, performance and/or outcomes, on the part of individuals or an organisation, on the economy, the environment, society, stakeholders or the organisation itself. Material topics have potential direct and indirect impacts — which may be positive or negative, intended or unintended, expected or realised, and short, medium or long term.



Required adherence criteria:
COMMITMENT, INTEGRATION & CAPACITY BUILDING
1. Perform robust processes to understand, measure, evaluate and manage the organisation's impacts that are applied across the organisation under the governance of senior management, including key cross-functional involvement.
2. Ensure these processes are documented and integrated into the organisation, including through relevant organisational processes such as risk management, compliance, strategy development and performance management.
3. Provide the necessary competencies and resources to understand, measure, evaluate and manage the organisation's impacts.
4. Integrate identified impacts into key management processes, for example, the materiality assessment process and organisational strategy, governance, goal-setting and operations.

IMPACT IDENTIFICATION & METRICS DEVELOPMENT
5. Set consistent and clear boundaries, as well as a purpose, time period and scope, for impact assessment, with underlying assumptions appropriately documented.
6. Establish processes to understand, measure, evaluate and manage impacts that are credible, clear and understandable as well as replicable, defensible and can be subject to external assurance.
7. Include a means of capturing and measuring actual as well as potential impacts, such as direct and indirect, intended and unintended, and positive and negative impacts.
8. Identify and fairly represent impacts from a wide range of sources, such as activities, policies, programmes, decisions, and products and services, as well as any related performance. Furthermore, the sustainability context of each impact should be clearly understood.
9. Present impacts as a qualitative, quantitative or monetised measurement.

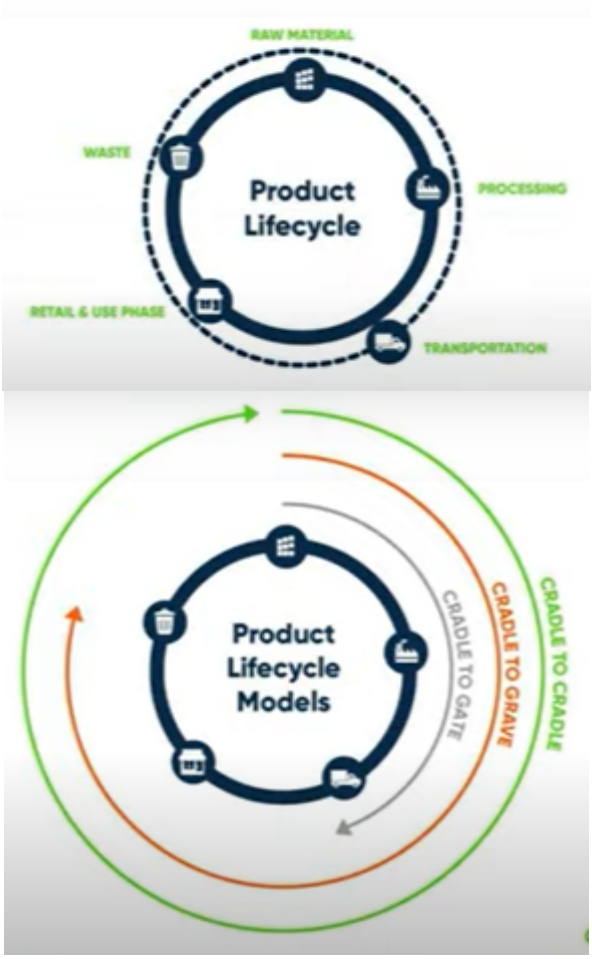
IMPACT ASSESSMENT & DISCLOSURE
10. Create and disclose a comprehensive and balanced understanding of the measurement and evaluation of the organisation's impacts on stakeholders and on the organisation itself.

Designing socio-technical systems

Week 3

1. How Does LCA Work

LCA measures environmental impacts of products, services etc. How is it produced? How is it transported? How is it heated? Etc. Part 1: Define the scope. Why do you conduct the LCA?
Usually 3 reasons for companies:
1. Comply with governmental regulations
2. Customer demand (usually customers want to know about the ecological footprint of what they are purchasing)
3. Purpose (lead by example)
In the goal and scope you define: Functional unit, the system in which you work and the limits of the analysis.
Two LCA's are not always comparable: often LCAs have different goals so they do not align.
Frameworks are created to overcome this: product category rules (PCR) does this for example.
Part 2: Life Cycle Inventory: Environmental in/outputs are considered by collecting data for the analysis. The goal is to quantify the environmental in/outputs of the product/service we are assessing. Usually the most time-demanding phase. If no data is available, we might need to rely on industry averages. You end up with a flowchart that shows all in/outputs in all phases of the life cycle.
Part 3: Next, these data are unified into impact categories (like CO2eq)
Part 4: Interpretation of the data. (sanity check, sensitivity assessment) where does the assessment have limitations?
Part 5: conclusions where lies the biggest impact?



2. Ch.4 from book Jonker & Harmsen (2012) → Quick Scan Life Cycle Assessment

This source is somewhat the same as the first, but a little more detailed.

3. Ch.1-7 from LCA: A practical guide for students

90 pages = too much

4. Towards a Life cycle sustainability assessment

Life Cycle Sustainability Assessment (LCSA)
In order to achieve reliable and robust sustainability assessment results, it is inevitable that the principles of comprehensiveness and life cycle perspectives are applied. The life cycle perspective considers all life cycle stages for products, and for organisations the complete supply or value chains. Through such a systematic overview and perspective, the unintentional shifting of environmental burdens, economic benefits and social well-being between life cycle stages or individual processes can be identified and possibly avoided.
LCSA = (environmental) LCA + S-LCA + LCC
(environmental) LCA = lca concerning environmental effects
S-LCA = social lca

LCC = economical lca
By combining these, more relevant results are provided in the context of sustainability
There are some areas that still need refining in terms of the (environmental) LCA:
methods for assessing impacts on ecosystem services from land use and impacts from water use, valuation methods, uncertainty assessment methods and consistency, quality assurance of (environmental) LCA databases, the field of consequential LCA, hybrid approaches combining input-output (IO) and LCA, etc.
(environmental) LCA usually consists of4 independent phases:
1. Goal and scope
2. Inventory of resource uses and emissions
3. Impact assessment
4. Interpretation
Phase 1: context for assessment, to whom, how communicated, functional unit, system boundaries, assumptions, limitations, impact categories and methods
Phase 2: All emissions released into the environment and resources extracted from the environment along the whole life cycle of a product are grouped in an inventory. Results are quantified.
Phase 3: results or indicators of environmental interventions are translated, with the help of an impact assessment method, into environmental impacts.
Phase 4: This interpretation phase should generate a set of conclusions and recommendations. It should also (according to ISO 14040) raise significant environmental issues, including an evaluation of the study considering completeness, sensitivity and consistency checks; and limitations.

To comply with ISO 14040 (2006) and ISO 14044 (2006) standards, a critical review (CR) is mandatory for (environmental) LCAs where results are made available to the public. A CR panel for reviewing an LCA study should be composed of at least three experts (independent consultants or members of external independent bodies)
In cases of non-comparative (environmental) LCA studies or assertions based on such studies, the CR is voluntary and can be performed in principle by one or two independent experts
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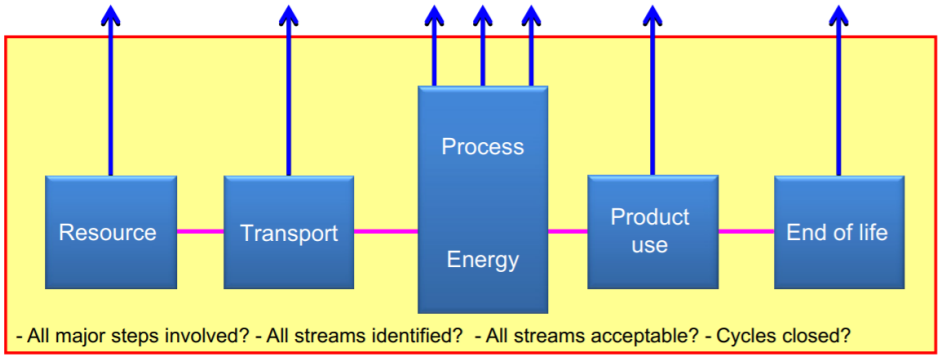
What is a Life Cycle Assessment (LCA)?
A Life Cycle Assessment (LCA) is an analysis of the impact one object has on the world around it.

Who benefits from LCA

- R&D
    - Comply w regulations & develop sustainable product
- Supply chain management & procurement
    - Find better suppliers
- Marketing & sales
    - Act on customer demand for sustainability
- Executive level & strategic management
    - Incorporate sustainability in the entire business.

Rapid Life Cycle Analysis



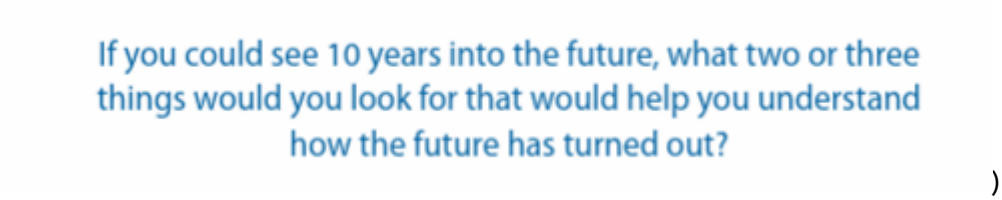
Week 4

1. Scenario planning : a field guide to the future
1.1 Chapter 1
In order to plan, scenarios are created. With the use of these, forecasts are irrelevant; different scenarios are anticipated and considered. With the use of scenario planning, designs can be more robust as you prepare it for multiple possible outcomes. It should be said that scenarios are NOT predictions, however they are just considerable possibilities of outcomes. scenario planning aims to illuminate and explore different ways the future might realistically develop.

1.2 Chapter 2
The process of scenario planning consists of the following six steps:
1. Framing the challenge
2. Gathering information
3. Identifying driving forces
4. Defining the future's critical "either/or" uncertainties
5. Making the scenarios
6. Fleshing them out and creating story lines.

Next, these scenarios are used:
7. Validating the scenarios and identifying further research needed
8. Assessing their implications and defining possible responses
9. Identifying signposts
10. Monitoring and updating the scenarios as time goes on

Step 1: Framing the challenge: In this step, you could state a mission, a specific goal or project or even a crisis situation. Don't be afraid to use a negative sentence in framing the challenge, as this might catch the attention of the stakeholders sooner.
Step 2: Gathering information: Scenarios can not be guessed of course, so research has to be done: You want to know as much as possible before drawing up scenarios. Any (in)direct linkages, cause-and-effect relationships et cetera should be investigated as the scenarios have impact on them. Opinionated, knowledgeable people - preferably stakeholders- should be identified and asked clever questions in order to contain the extent of the research (think of questions like:



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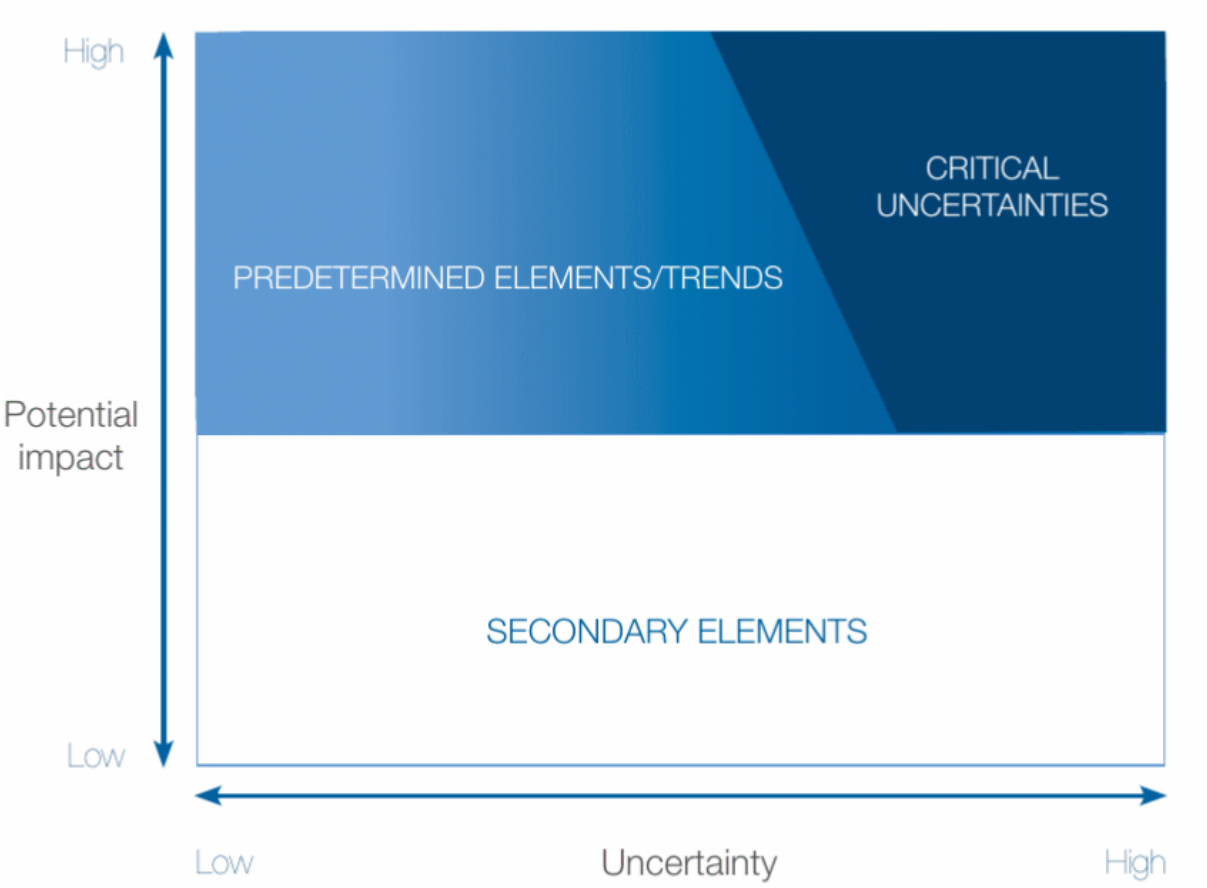
Step 3: identifying driving forces: Key attributes that affect the future should be considered.

What exactly is a driving force ? In a nutshell, a driving force is something with the potential to bring about significant change in the future. It may be a trend, already clearly defined and understood—for example, the falling fertility rate in Italy, which will have a fairly predictable impact on the number of Italians who will be 20 years old two decades from now.

Consider STEEP:
Social, Technological, Environmental, Economical, Political

These are the five main categories in which driving forces can fall, however it should be noted that infinite amounts of driving forces can be considered (the more the merrier) however, these are the most important (and easiest to remember)

Step 4: Defining the future's critical "either/or" uncertainties: next, the driving forces should be considered which make the biggest difference in the future. Driving forces should be placed into a matrix of high/low uncertainties and high/low impacts.



Scenario planning focuses on the critical uncertainties, as these bring on the largest differences between realities. In the end, the goal is to consider the two most critical uncertainties, i.e., the two driving forces, trends, or developments that combine the greatest degree of uncertainty with the greatest potential impact on the future success of the organisation or the outcome of the project. Over time, the range between the polarities of outcomes becomes greater, as uncertainties are large, thus they may have greater chance to have an impact. Next, the two critical uncertainties are placed opposite to each other in a cross diagram (as used in the poster and tutorial), and with this, four quadrants (or scenarios) are created.
Step 5: Making the scenarios: scenarios are written with the knowledge acquired at the second step, about what could happen in the scenarios for the aforementioned extremes. Large differences between these different futures can be observed, as uncertainties are extreme. Optional is to give the scenario names: giving fun names motivates the group (apparently) and makes scenarios easier to remember and explain.
Step 6: Fleshing them out and creating storylines: Try to consider what might happen in the case of these scenarios: who will it affect? How will it affect them? What does it mean financially? How is adaptation necessary? Et cetera. Quantification up to a certain extent can be considered.
As a result of this, it might come forward that the two uncertainties look too much alike; the 'either' is too much like the 'or'. In this case, a new pair of extreme uncertainties has to be defined, as otherwise scenarios are too close to each other, not preparing a design for a wide range of outcomes. Uncertainties need to be **independent** of each other.

Additional:
Step 7: Validating the scenarios and identifying further research needed: Are scenarios plausible? Clear? Relevant? Consistent? Complete? Experts should be consulted.
Step 8: ASSESSING THEIR IMPLICATIONS AND DEFINING POSSIBLE RESPONSES: design strategies to work with these scenarios
Step 9: Identifying signposts: At what point will you know you have to consider a certain scenario? How? What signs should be considered? How to identify the scenarios?
Step 10: Monitoring and updating the scenarios: Over time, things change, uncertainties become certain, et cetera. That's why a scenario planning group should meet on a regular basis, consider what signposts have been passed, and adapt the scenarios to these changes.

Rubric requirements.

1. Set-up and test appropriate design goals and constraints and planning related to sustainable development in terms of economical, societal, and environmental contexts;

Importantly, the design goal and constraints of the case reflect a proper understanding of the complexity of sustainable design in the technical and social context. Refer to the first row of the Table to learn more about what differentiates Satisfactory, Good and Excellent. Elements contributing to this learning objective are:

- The application of a (sustainable) design cycle approach, specified in problem definition and planning for analysis, synthesis and evaluation;
- An application of system analysis to determine the purpose and outreach of the sustainable design goal, taking into account the restrictions as set by your boundaries or scope;
- A holistic approach to sustainable development, as indicated by Triple P constraints (economical, societal and environmental constraints), which includes the considerations of internal and external stakeholders;
- Incorporation of main aspects of the current state of sustainable development indicated by the Sustainable Development Goals and further information on typical sustainability topics such as climate change, equity, and general trends in business strategy;

Learning on sustainable design starts by knowing these concepts, summarized as (sustainable) design cycle, Triple P constraints, current state of sustainable developments and context levels. Materials on Nestor provide basic knowledge.

2. Systematically develop innovative solutions for a sustainable design and show an academic analytical attitude;

In the course unit and therefore also in group case work, the focus is on sustainable innovation, rather than incremental type of improvement. Innovation is expected to become apparent in:

- Evaluation of the solutions of the group case work on (radical) improvement;
- Develop metrics to determine and benchmark achievements in sustainable development;
- Apply an engineering approach, such as to aim for a feasible concept solution; i.e. a concept solution that can be developed into a solution that will be implemented.

Industrial sustainable innovation paths are introduced in a presentation, preferably by a representative of an industrial sector. Additional reading materials on innovation provide more information. During case work, groups should be aware to apply a radical though realistic solution. The final report discusses innovative features of the solution and is expected to incorporate a short feasibility study.

3. Applying analytical methods as building sets of scenarios and performing quick scan life cycle analyses for evaluating implications of the design;

Highlighted is an adequate usage of both analytical tools in analyzing a sustainable design, specified as:

- A useful and relevant definition of the reference state for the sustainable design;
- Analysis of material and energy flows of their case;

- Set up a life cycle analysis and show the ability of a quick scan, that is focusing on bottlenecks and most relevant flow of materials and energy;
- Building sets of scenarios to support design decisions.

A sustainable design implies relative improvement compared to a reference state. The analytical methods applied are related to material and energy usage (life cycle analysis) and a test on robustness for future developments (building sets of scenarios).

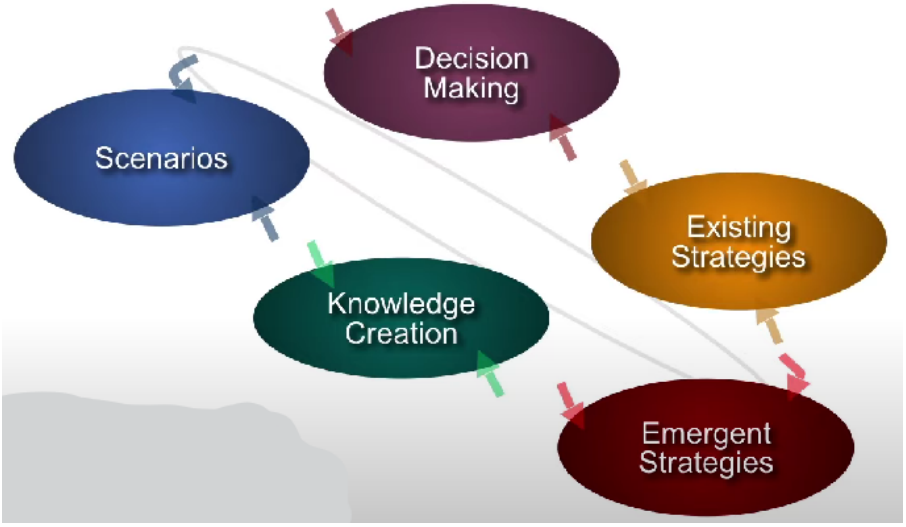
4. Develop adequate communication skills and usage of tools to support (sustainable) design decisions, including normative considerations.

Importantly, in group work and individual contributions, it is expected to be able to present, defend and reflect on the work on sustainable design and development, which includes values, normative and ethical considerations:

- What are underlying normative aspects of design decisions related to sustainable development and (technical and economical) feasibility of the design outcome
- Show understanding of the basics of ethical considerations.

2. Scenario Planning for the Long-term — Peter Schwartz at The Interval

At the moment, there are no real studies into long term institutions planning. People make decisions as a result of their mental maps of the position they are in. It is hard to break out of these mental maps. Diversity is the single most important factor for forecasting the future. Scenario planning requires imagination and analytic realism.



3. Scenario planning - the future of work and place | Oliver Baxter | TEDxALC

6 years is a good time to plan scenarios into the future as more time into the future will not be reliable. This talk is more or less also about the importance of diversity of scenario planning.
There are three scenarios:
Data sphere, New normal and Polarised world. Scenario planning should follow trends and should encompass concepts and ideas that already exist.
'Chance favours the prepared mind'