International Ecology & Sustainable Design

1st TETHYS webinar - Day 3

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Funded by
the European Union

University of Cyprus

UNIVERSITÀ DEGLI STUDI FIRENZE

NEEST
NEW ENERGY & ENVIRONMENTAL SOLUTIONS AND TECHNOLOGIES

AARHUS BSS

Who AM I?

EngTech

Conducts research within technology and engineering.

CET

Focuses on the development of new and innovative energy systems for businesses and consumers.

- Wind Projects Development Coordinator at **Iberdrola Renewables**
- Wind Project Developer at **Vector Hellenic Windfarms S.A.**
- Researcher in the Center for Electric Power and Energy, at the **Technical University of Denmark**
- As a freelancer, had the chance to work with: the **Green Fund, GSF Capital, Volkswind GmbH**, and other institutes and SMEs

Since Nov. 2019, also a Lecturer at **Johns Hopkins University** at Energy Policy and Climate program teaching 425.624 Wind Energy: Science, Technology and Policy.
Since Jan. 2024, also an Assoc. Professor at the dept. of Mechanical Engineering, University of Peloponnese

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Industrial Ecology and Sustainable Design

Principles of industrial ecology

Design for sustainability and life cycle assessment

Cradle-to-cradle approach in renewable energy systems

WHAT IS ENVIRONMENAL SUSTAINABILITY?

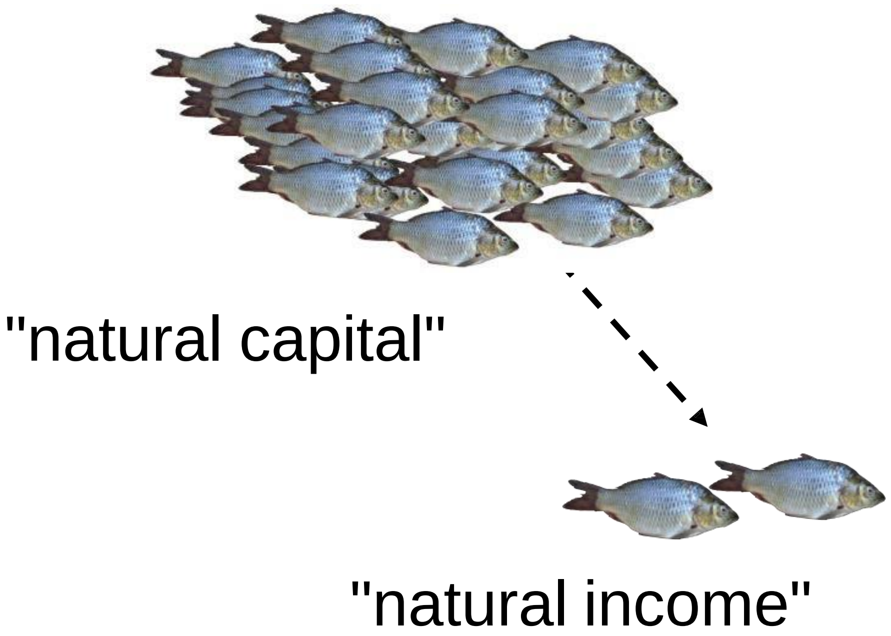
The term environmental sustainability refers to systemic conditions where neither on a planetary nor on a regional level do **human activities** disturb the natural cycles more than **planetary resilience** allows, and at the same time do not impoverish the **natural capital** that has to be shared with future generations.

NATURAL CAPITAL

Two broad types of natural capital:

1. **Renewable or active natural capital (RNC)**
   - Renewable natural capital is active and self-maintaining using solar energy. Ecosystems are renewable natural capital.

Wikimedia Commons



Costanza, R., & Daly, H. E. (1992). Natural capital and sustainable development. *Conservation biology*, *6*(1), 37-46.

NATURAL CAPITAL

Two broad types of natural capital:

2. **Non-renewable or inactive natural capital (NNC)**
    - For example, fossil fuel and mineral deposits. They generally yield no services until extracted.

https://etimg.etb2bimg.com/photo/66445714.cms

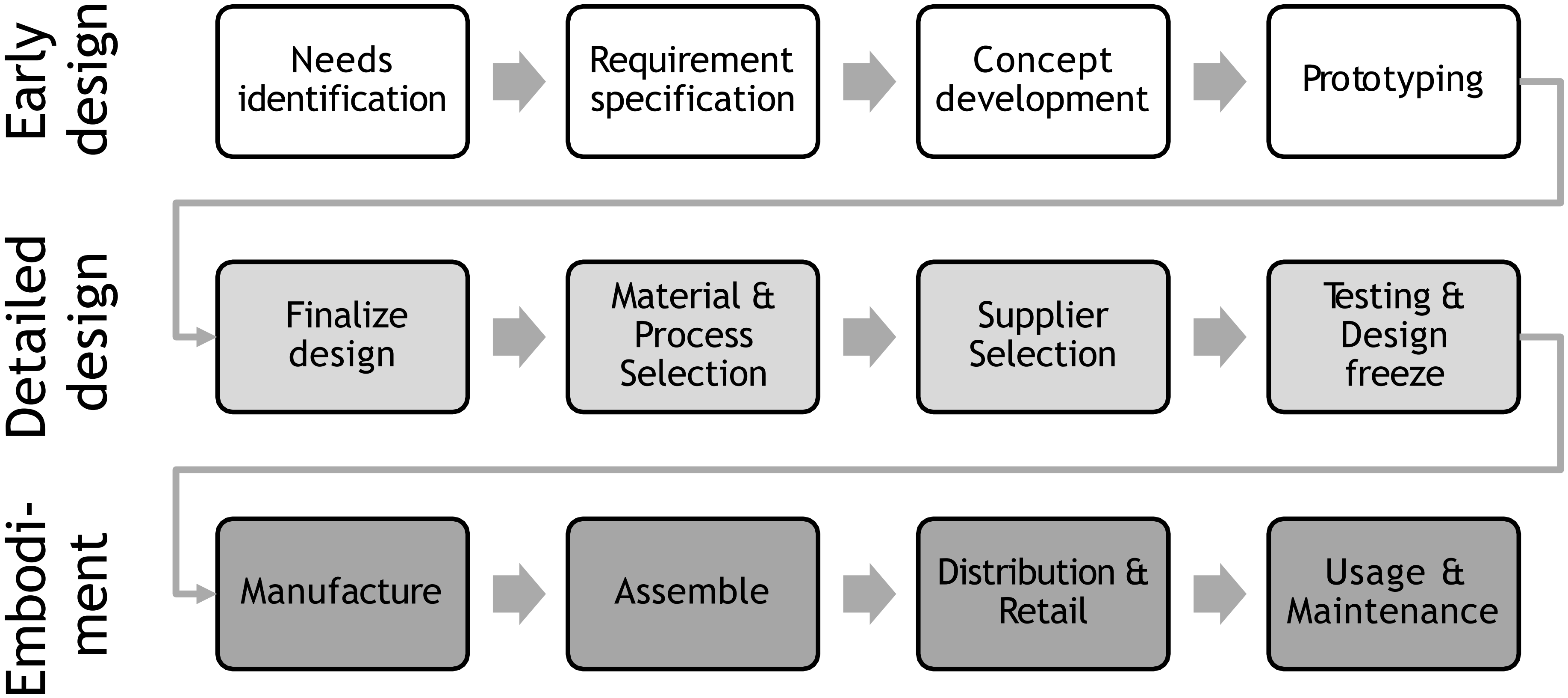
NATURAL CAPITAL

- NNC runs down (depletes) with use.
- However, a logical way to maintain constant income is to maintain the total natural capital constant

TNC = RNC + NNC

Constancy of total natural capital (TNC) is the key idea in sustainability of development.

PRODUCT DEVELOPMENT PROCESS



LIFECYCLE THINKING

Products/Systems may have (very different) environmental effects across all stages of the lifecycle

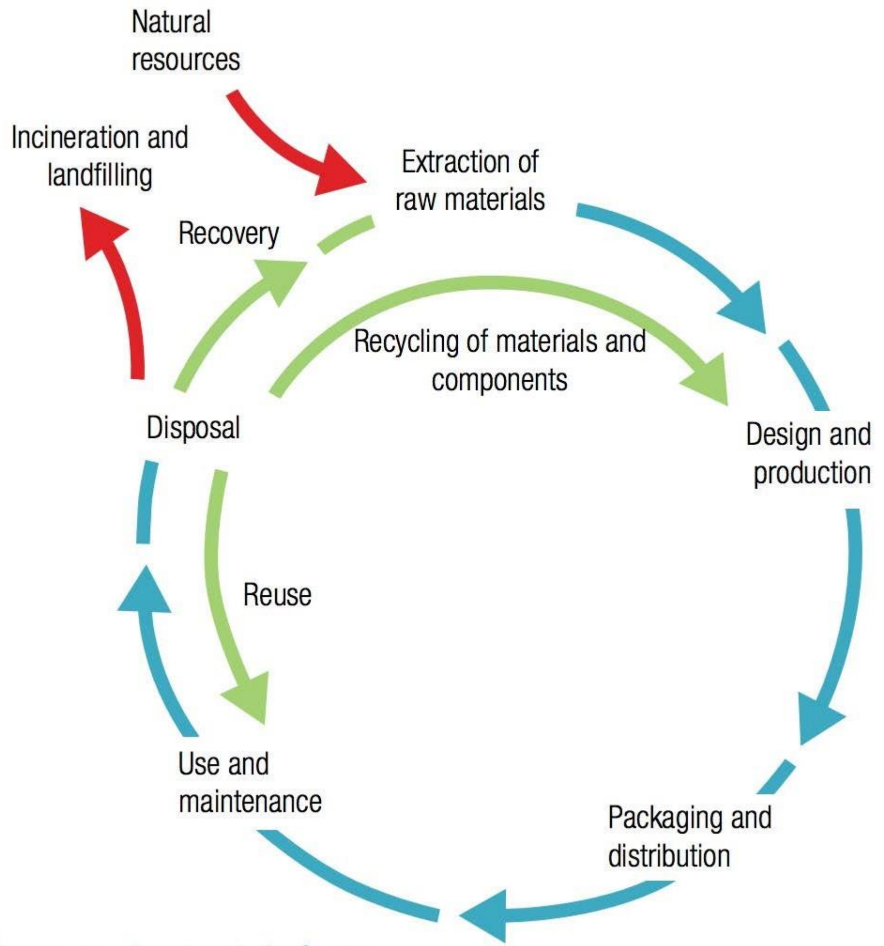


Figure 1 – Product Life Cycle

Source: UNEP/SETAC. Life Cycle Management: A Business Guide to Sustainability. Paris, 2007.

lca-center.dk

INTRODUCTION TO LCA

The steps in performing environmental LCAs include,

1. compiling an inventory of relevant energy and material inputs and environmental releases;
2. evaluating the potential environmental impacts associated with identified inputs and releases;
3. interpreting the results to help you make a more informed decision.

(US EPA)

BENEFITS OF LCA

- Select the product or process that results in the least impact to the environment.

- LCA data identifies the transfer of environmental impacts from one media to another (e.g., eliminating air emissions by creating a wastewater effluent instead) and/or from one life cycle stage to another (e.g., from use and reuse of the product to the raw material acquisition phase).

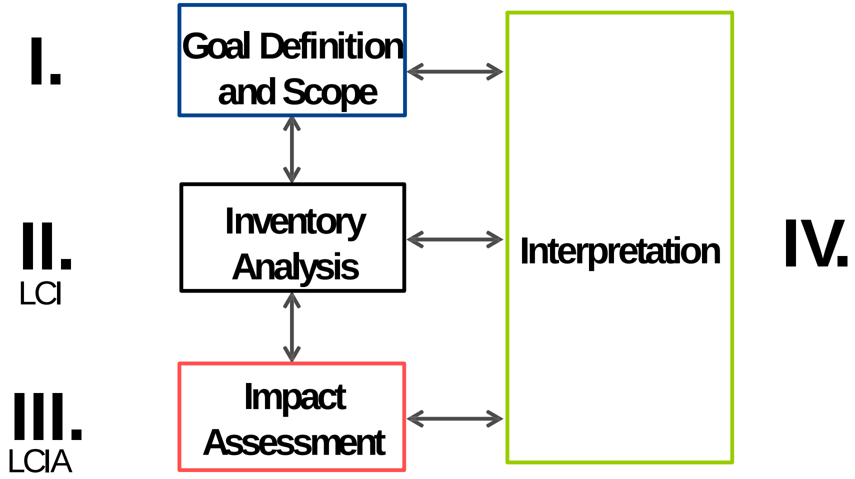
STEPS IN LCA

Step 1: Defining the goal and scope of the study.

Step 2: Making a model of the product life cycle with all the environmental inputs and outputs. This data collection effort is usually referred to as life cycle inventory (LCI).

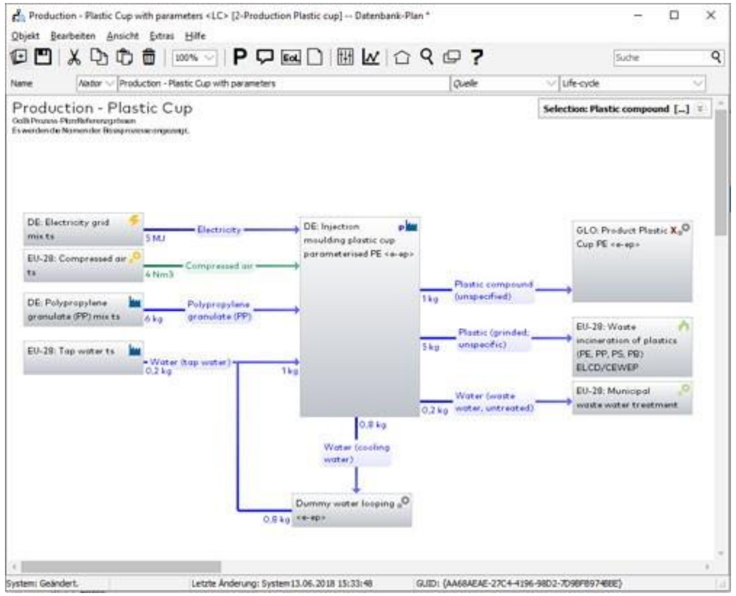
Step 3: Understanding the environmental relevance of all the inputs and outputs. This is referred to as life cycle impact assessment (LCIA).

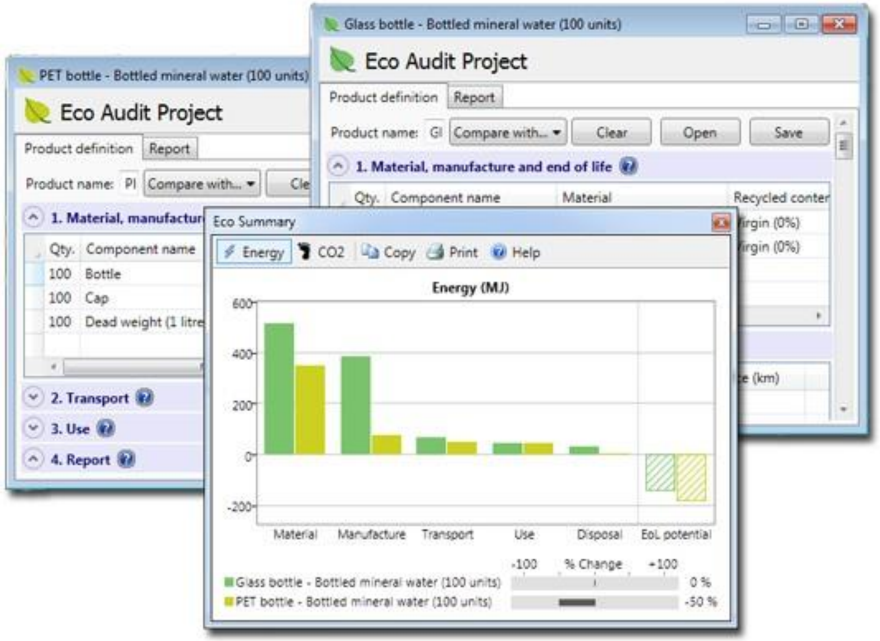
Step 4: The interpretation of the study.



(ISO14040, 2006)

SOFTWARE





Detailed:
GaBi
Simapro
Umberto
OpenLCA

Streamlined:
Ecoaudit – EduPack
One Click LCA – Autodesk Revit
Sustainability Xpress - Solidworks

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DEPARTMENT OF BUSINESS DEVELOPMENT AND TECHNOLOGY
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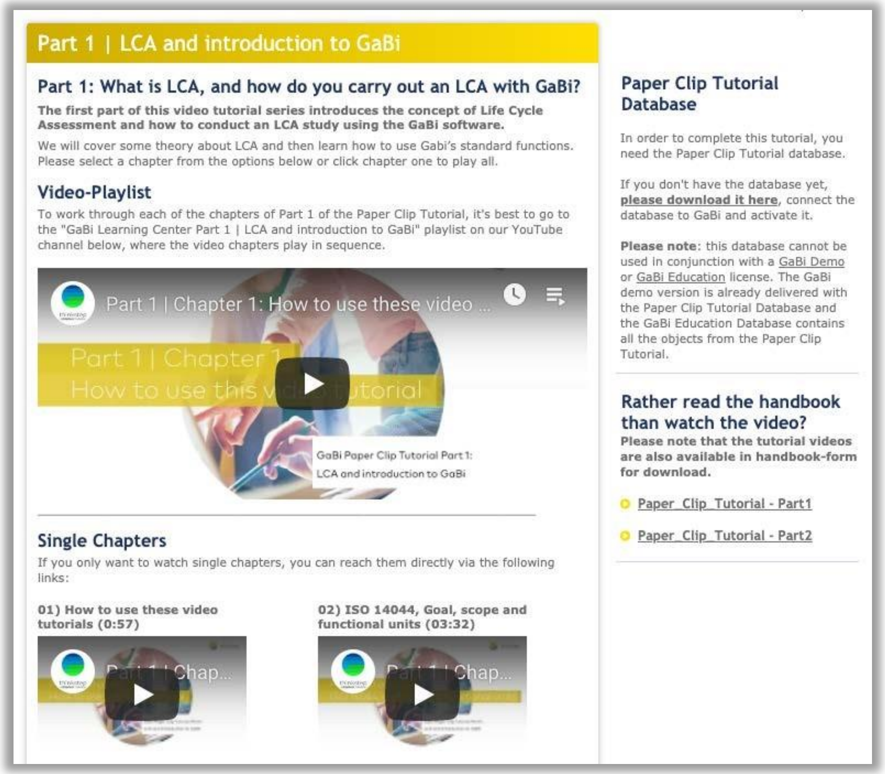
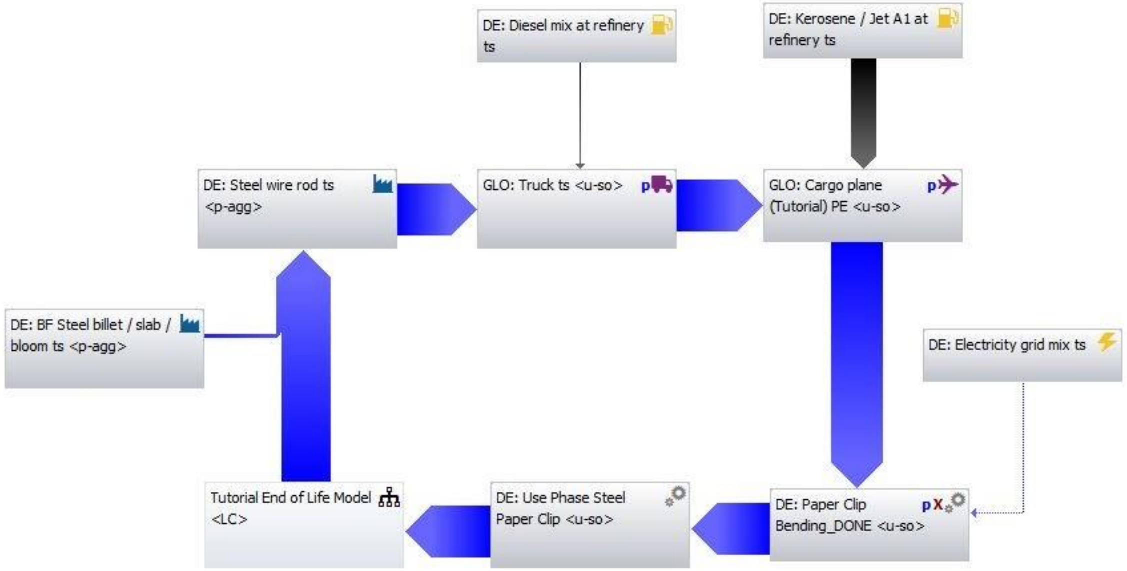
GABI LCA DEMO (PAPERCLIP)

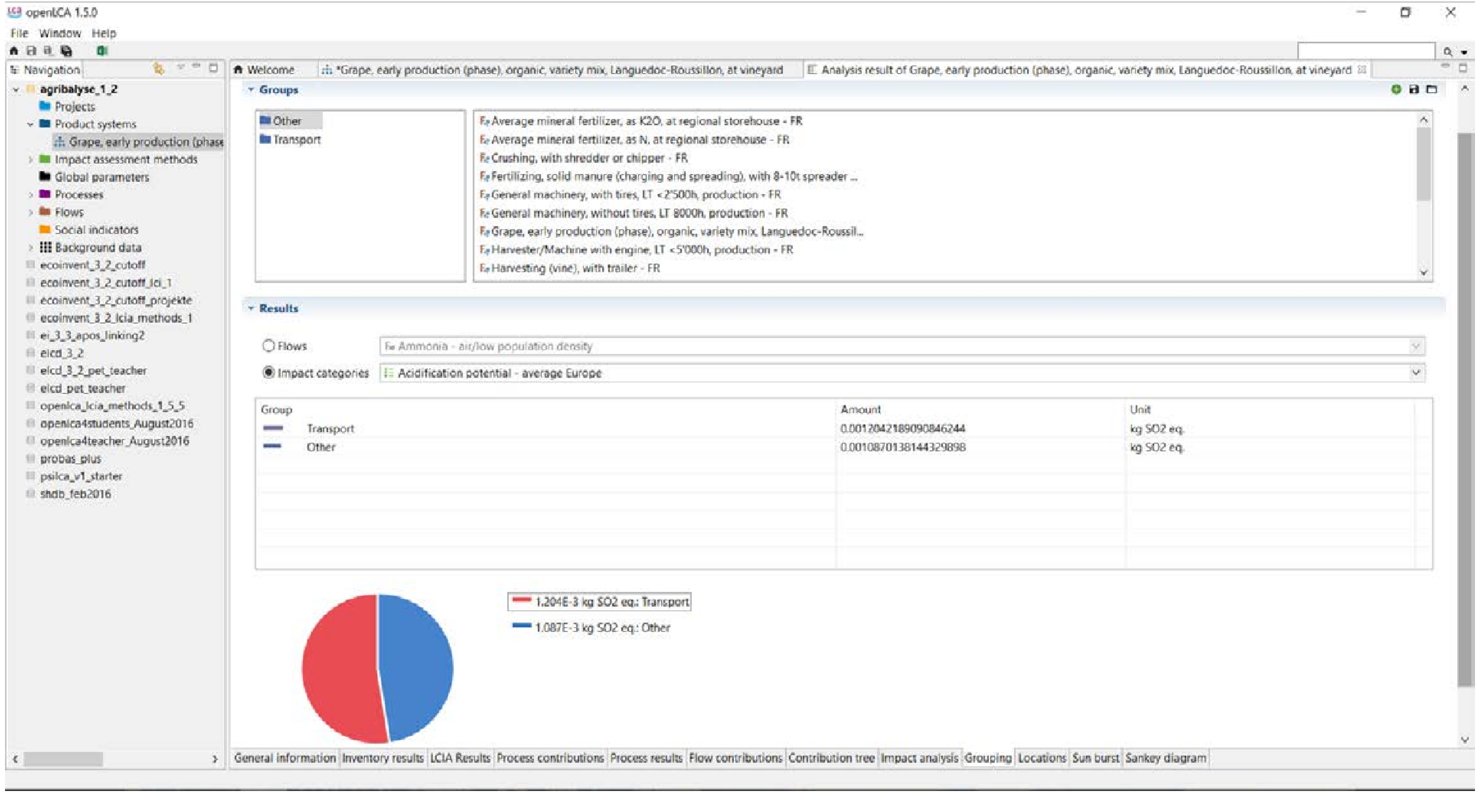




http://www.gabi-software.com/support/gabi-learning-center/gabi-learning-center/

OPENLCA

https://www.openlca.org/openlca/



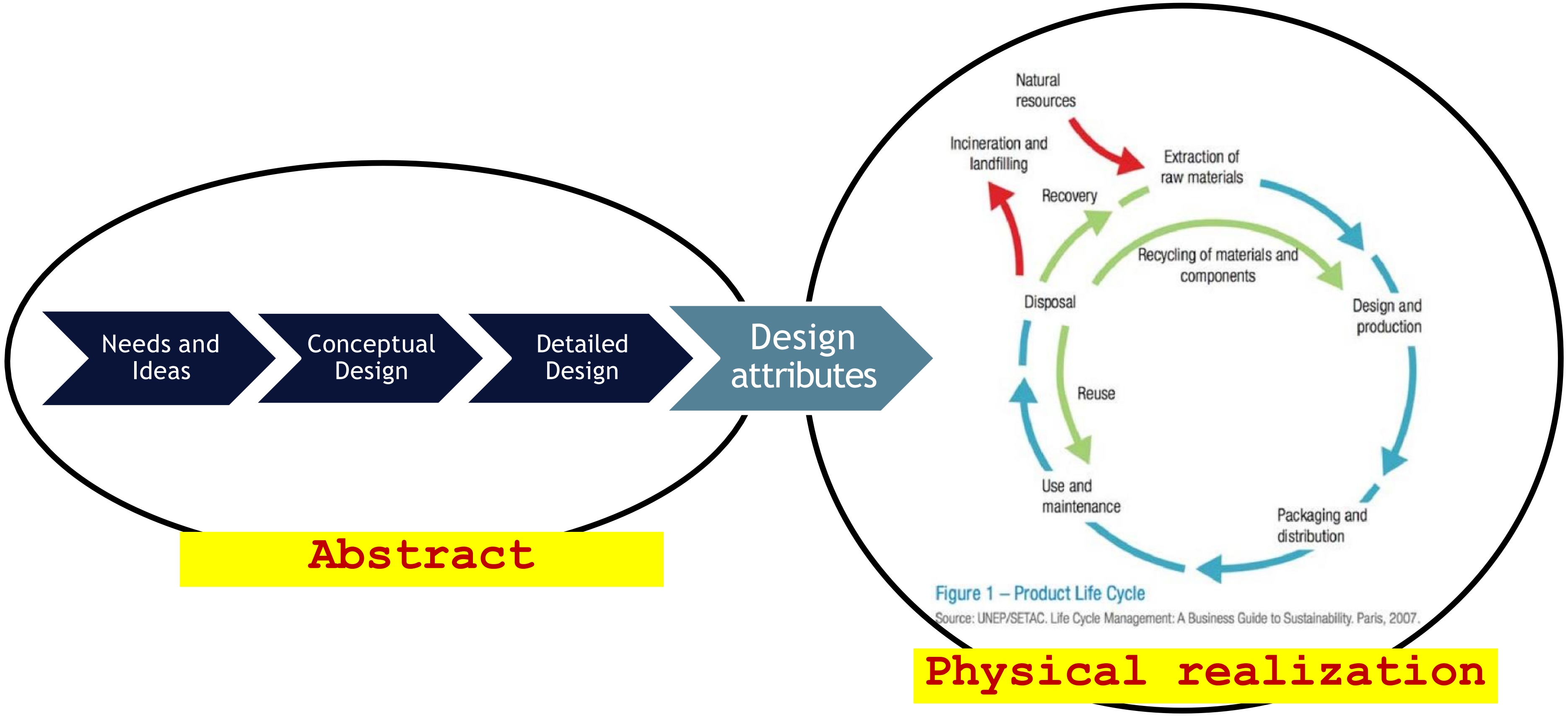
SUSTAINABLE DESIGN WHEN TO INTERVENE?

3BL Media

Proactive

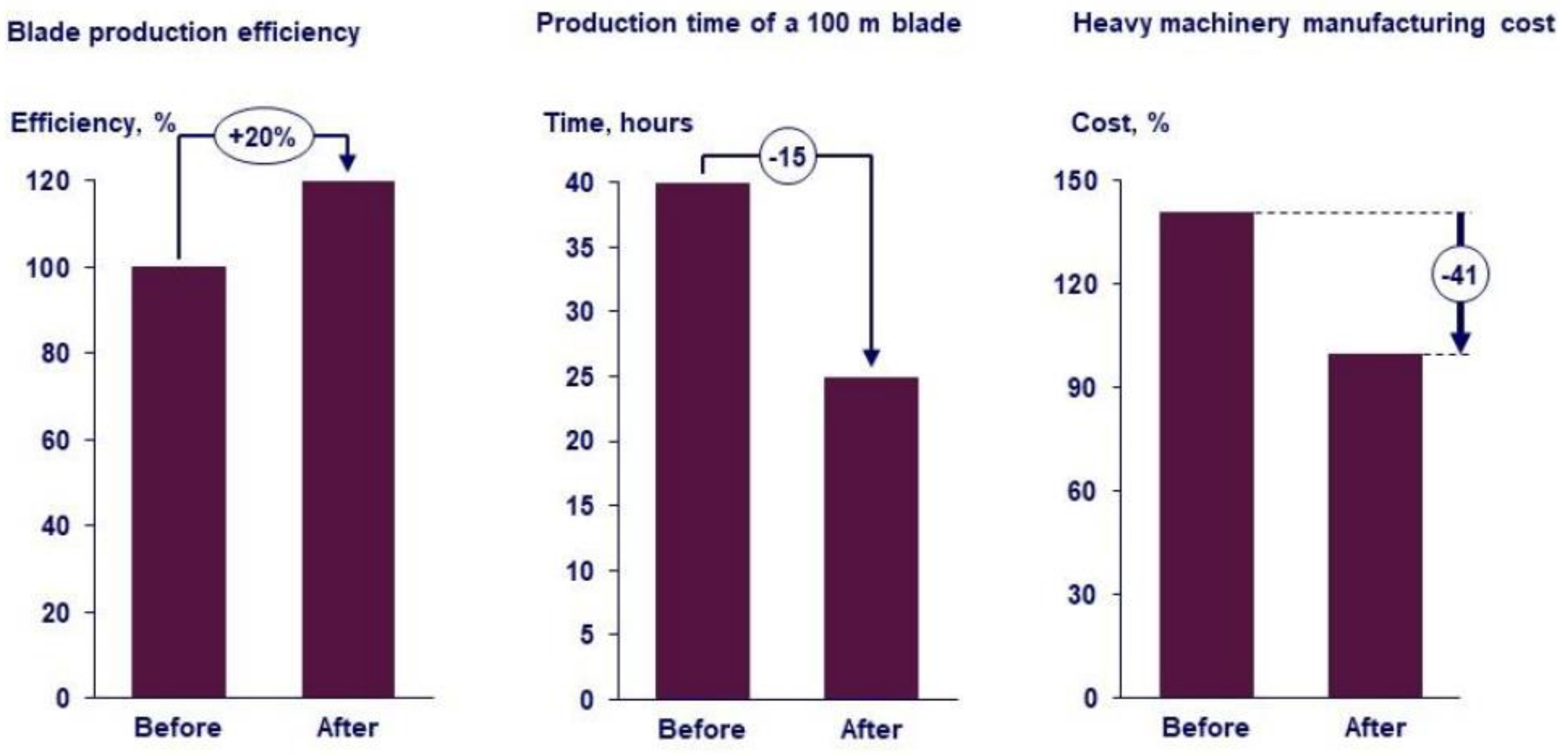
Institute of environmental engineering, Kaunas University of Technology

SUSTAINABLE DESIGNWHEN TO INTERVENE?



WHEN TO INTERVENE?

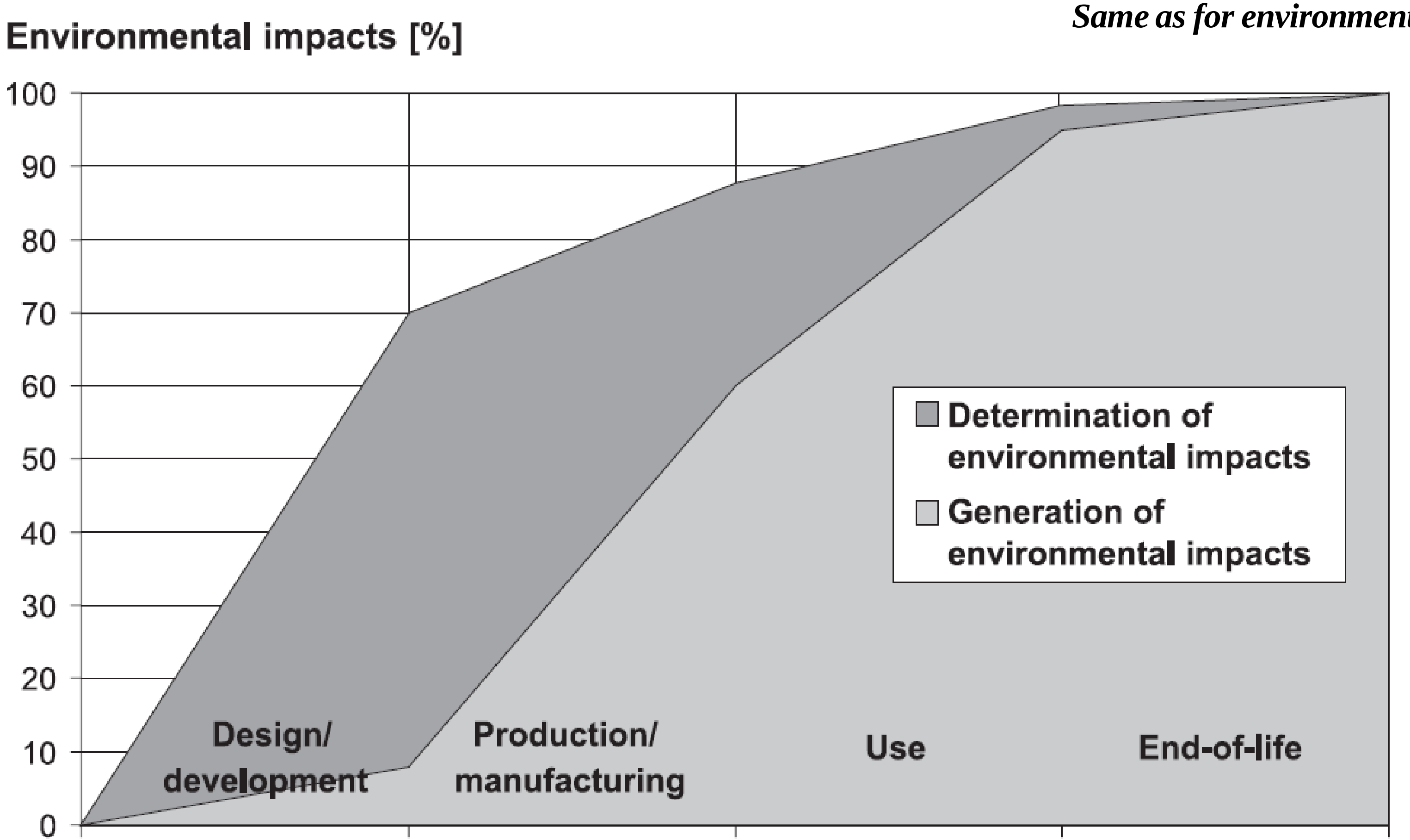
Figure 7: SANY Group's claimed benefits: advanced manufacturing integrates digitalisation, automation and lean manufacturing



Source: Wood Mackenzie, SANY Renewable Energy Co.

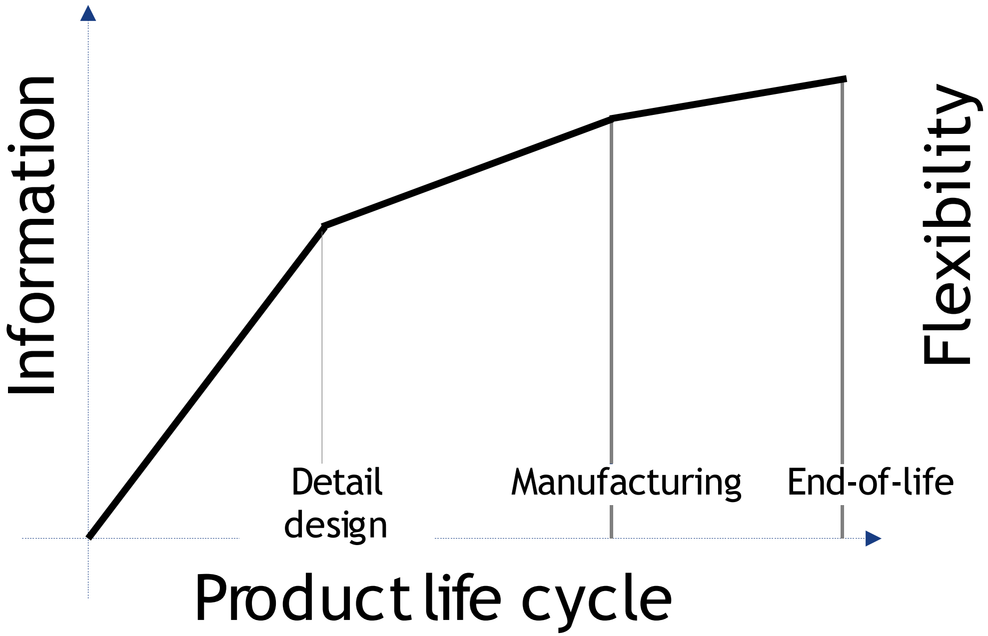
WHEN TO INTERVENE?

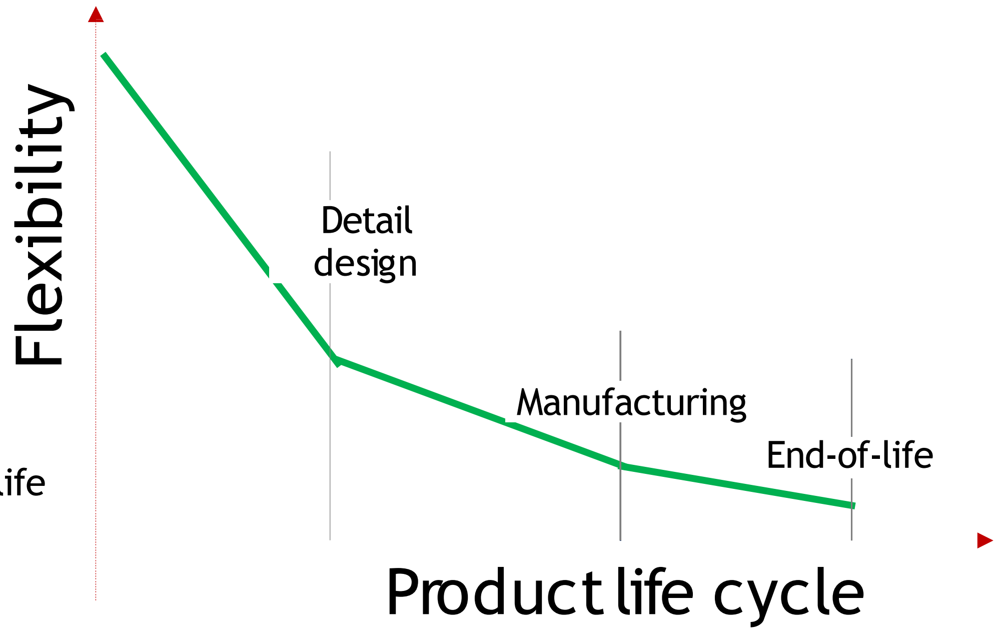
Same as for environmental impacts…



Rebitzer, G., Ekvall, T., Frishkencht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W. P., Suh, S., Weidema, B. P., Pennington, D. W., "Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications," Environment International, 30(5), pp. 701-720.

APPROACHES TO ENVIRONMENTALLY SUSTAINABLE DESIGN





DESIGN FOR ENVIRONMENT

Steps in Product Design

Product Definition Concept

Generation Concept

Selection Materials

Management Detailed

Product Design

Product-Process Interactions

Interactions with Suppliers

Marketing Interactions

Not an once through process, iterate as needed...

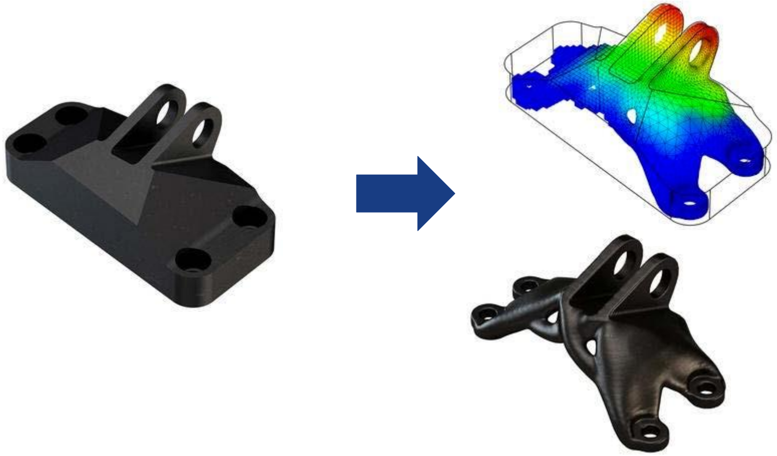
Environment as a new dimension?

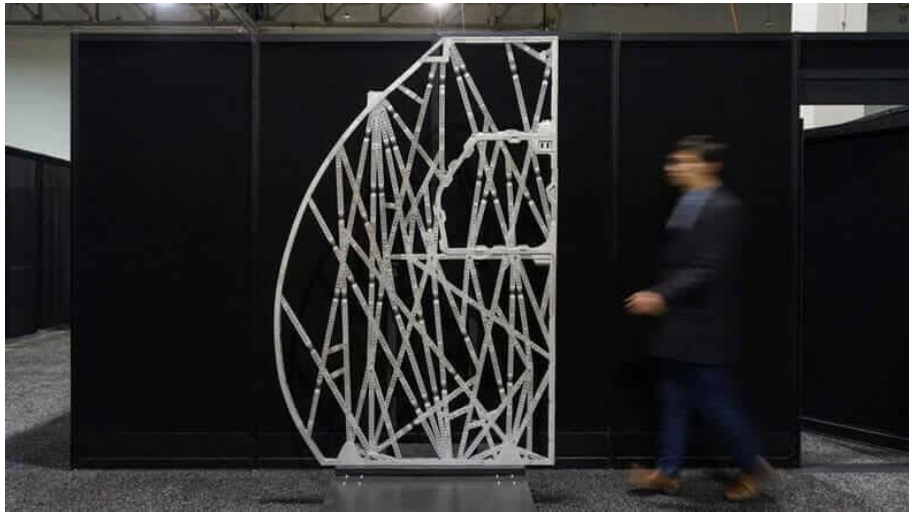
DESIGN FOR ENVIRONMENT

Design for Environment is a ***systematic*** consideration of performance with respect to environmental, health, and safety objectives over the full product and process ***life cycle***.

REAL EXAMPLES

GE engine bracket
Topology optimization





Airbus bionic design

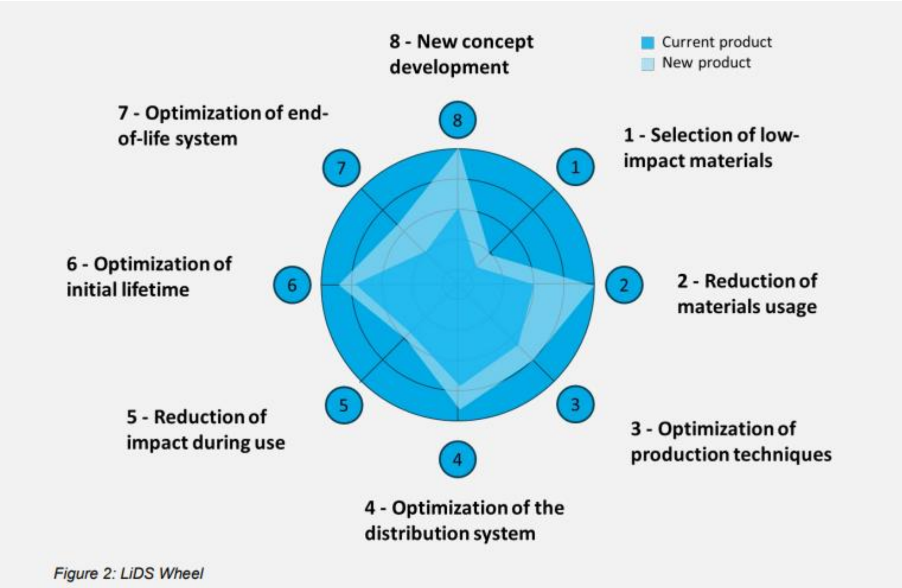
EXAMPLE #4: ECO-DISTRIBUTION

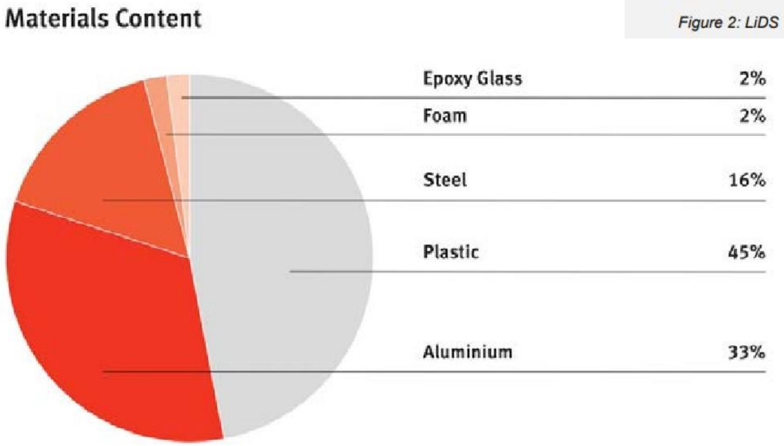
- **Use Less, Cleaner, and Reusable Packaging**
  - Avoid using packaging to make up for cosmetic design defects
  - Consider a deposit system to encourage return and reuse of packaging
  - Use appropriate materials; e.g., do not use non-returnable packaging

- **Use an Energy-Efficient Transportation Mode**
  - Sea is better than air; avoid urgency
  - Transport by container ship or train vs. truck

- **Develop Energy-Efficient Logistics**
  - Use standardized containers and pallets
  - Work with suppliers to minimize transport distances
  - Transport more goods simultaneously

LIDS WHEEL FOR REDESIGN BRAINSTORMING





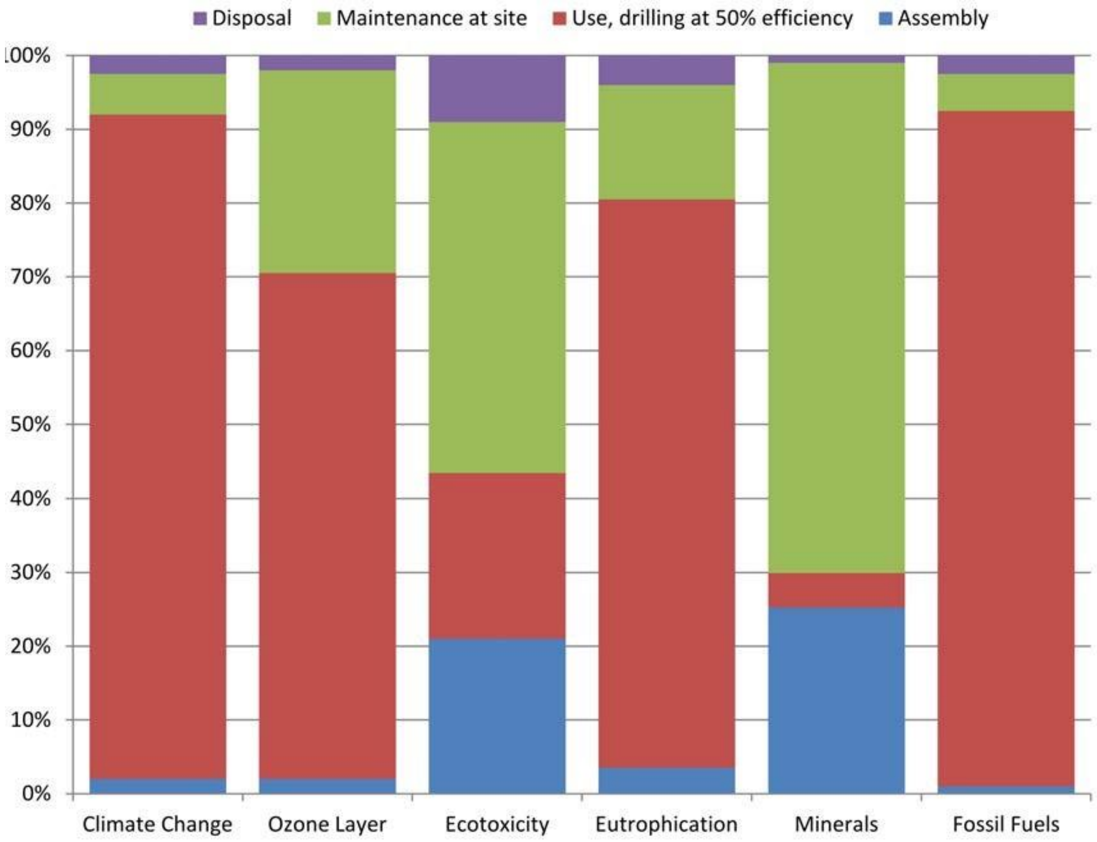
Brainstorm ideas for reducing the environmental impact of the Aeron chair using the LiDS wheel

REAL PROBLEMS ARE COMPLEX!

LEGO "sustainable" brick

LEGO® botanical elements such as leaves, bushes and trees will be made from plant-based plastic sourced from **sugarcane** in the future and will appear in LEGO boxes.

LCA EXAMPLE

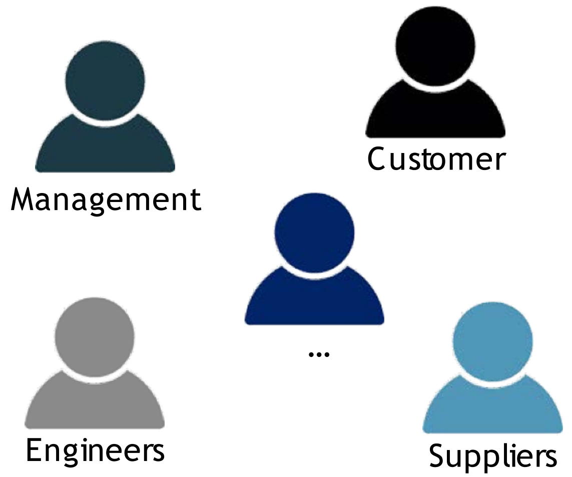

Disposal
Maintenance at site
Use, drilling at 50% efficiency
Assembly
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Climate Change
Ozone Layer
Ecotoxicity
Eutrophication
Minerals
Fossil Fuels

OBSERVATIONS FROM LCA RESULTS

- The most significant life cycle phase from an environmental perspective is **maintenance and use**. Close to **95% of the life cycle impact** due to **high diesel fuel consumption and resulting emissions**
- **Oil consumption** along with maintenance of **change rods and crowns** also contribute toward significant use phase impacts
- There is a strong potential for reducing end-of-life environmental impacts by pursuing strategies related to **substitution with recyclable materials** and **elimination of toxic materials**. Planning for **disassembly** is a key criterion for enabling better management of the end of life
- Design for durability can greatly aid in reducing use phase impact by **reducing the frequency of oil and part changes**
- **Reducing material flow and waste at the assembly plant** could lead to significant savings

RECOMMENDATIONS BASED ON LCA RESULTS

1. Reduce use phase oil consumption
2. Reduce the percentage of Nickel and Chromium in the steel mixture
3. Increase part reliability to minimize the number of part replacements over the lifetime of the product
4. Incorporate a recycling program for minimizing the end-of-life impacts of the product
5. Reduce consumption of drilling consumables
6. Reduce part count of the product one through design for manufacturing strategies
7. Reduce assembly phase consumables in the plant, including electricity and water
8. Reduce use phase noise pollution.



Acceptable (or optimal) product and process changes

CASE STUDY


INNOVATIVE FLOATING WIND TURBINES DESIGN
Exploring the integration of floating wind turbines and hydrogen production through sustainable design principles, addressing environmental and economic challenges.

CASE STUDY

01 DEFINITION OF SUSTAINABLE DESIGN

It encompasses designing objects and environments that prioritize sustainability.

02 PHILOSOPHY OF SUSTAINABLE DESIGN

Focuses on social, economic, and ecological sustainability principles.

03 APPLICATION IN FLOATING WIND TURBINES

Utilizes sustainable design to enhance efficiency and reduce environmental impact.

04 HYDROGEN PRODUCTION SYSTEMS

Incorporates sustainable practices to create cleaner energy alternatives.

05 'DESIGN FOR THE ENVIRONMENT' MINDSET

Encourages designs that minimize harm to the environment throughout their lifecycle.

CORE PRINCIPLES OF DESIGN FOR ENVIRONMENT

Understanding critical aspects of sustainable design

1. RESOURCE EFFICIENCY

Utilize sustainable materials and optimize manufacturing processes to reduce overall resource consumption.

2. MINIMIZING WASTE

Focus on designs that promote recyclability and aim to minimize material waste throughout construction.

3. ENERGY EFFICIENCY

Design systems that maximize energy output while reducing carbon footprints and enhancing sustainability.

4. LIFE CYCLE THINKING

Adopt a holistic view by considering all environmental impacts from material extraction to disposal.

5. ECOSYSTEM INTEGRATION

Create designs that support local ecosystems and promote biodiversity through thoughtful integration.

EXPLORING THE CONCEPT OF FLOATING WIND TURBINES

An Overview of Innovative Offshore Energy Solutions

DEFINITION OF FLOATING WIND TURBINES

01

Floating wind turbines are offshore turbines positioned in deeper waters, enhancing wind resource access.

ANCHORING AND DEPLOYMENT CONFIGURATIONS

02

These turbines are anchored with mooring lines, allowing flexible deployment to optimize energy capture.

ENVIRONMENTAL CONSIDERATIONS

03

Designs must account for marine ecosystems and navigational routes to minimize ecological impact.

ENVIRONMENTAL IMPACTS OF FLOATING WIND TURBINES

Key Considerations for Sustainability

IMPACT ON MARINE ENVIRONMENTS

Floating wind turbines, while a renewable energy source, can disrupt marine ecosystems and habitats.

EFFECT ON BIRD POPULATIONS

The installation of turbines may pose risks to local bird species, leading to potential declines in their populations.

IMPACT ON LOCAL FISHING INDUSTRIES

Fishing industries could be affected due to changes in marine biodiversity and turbine placements in key fishing areas.

IMPORTANCE OF SUSTAINABLE PRACTICES

Implementing sustainable practices can mitigate negative impacts, fostering community support and regulatory compliance.

LONG-TERM SUSTAINABILITY

Understanding environmental impacts is essential for ensuring long-term sustainability and health of ecosystems.

SYNERGY BETWEEN WIND AND HYDROGEN

A Sustainable Energy Solution

SUSTAINABLE ENERGY SOLUTION

Hydrogen production via electrolysis from wind energy offers a viable sustainable energy option.

FLOATING WIND TURBINES

Utilizing floating wind turbines to supply power directly for hydrogen production enhances efficiency.

INTEGRATED RENEWABLE SYSTEM

Creating a cohesive system where wind energy and hydrogen production work together can optimize resource use.

CLEAN FUEL ALTERNATIVE

This strategy significantly boosts hydrogen's potential as a clean alternative fuel, particularly in isolated areas.

CASE OFFSHORE WIND ELECTRICITY GRID GREEN HYDROGEN +8

Energy island – the Baltic sea's nodal point for intelligent energy

11. OCTOBER 2022

Solution provider

ENERGINET

Energinet is an independent public enterprise owned by the Danish Ministry of Climate, Energy and Utilities. We own, operate and develop the transmission systems for electricity and natural gas in Denmark.

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REQUEST VISIT

Denmark's $34BN Energy Islands Could Solve Europe's Power Problem

The Brussels Times

Denmark delays construction of North Sea energy island by three years

Denmark delays construction of North Sea energy island by three years ... Denmark has postponed its North Sea energy island project by at least...

Aug 24, 2024

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ENERGY POLICY OR ENERGY POLITICS?

energynews.pro

Swedish Defense Blocks Offshore Wind Farms in the Baltic Sea

Offshore wind farm projects in the Baltic Sea are deemed incompatible with Sweden's national defense due to the disruptions they would cause to critical...

Nov 28, 2024

Review Energy

Sweden halts 13 offshore wind farms in the Baltic Sea due to national security concerns

OffshoreWIND.biz

Denmark Unveils Plan for Up to 3.8 GW Bornholm Energy Island

The Danish Energy Agency (DEA) has revealed its Plan for Program Bornholm Energy Island, outlining the framework for the future energy...

May 14, 2024

BLOG

Top 7 Upcoming Floating Offshore Wind Projects In the World

Last Updated on 31st December 2024

Project Name	Country	Project Owner	Stage	Project Value (in USD Million) (e)	Capacity (MW)
Arven Floating Offshore Wind Power Plant	United Kingdom	Ocean Winds and Mainstream Renewable Power	Permitting	3500	2300
Kultje Floating Offshore Wind Power Plant	Sweden	Aker Offshore Wind Holding and Hexicon AB	Announced	3225	2150
Linosa Floating Offshore Power Plant	Italy	Acciona Energia	Planning	3093	1020
Bellrock Floating Offshore Wind Power Plant	United Kingdom	BlueFloat Energy and Renantis UK	Planning	1800	1200
Ayre Floating Offshore Wind Power Plant	United Kingdom	Thistle Wind Partners (TWP)	Planning	1500	1008
Broadshore Floating Offshore Wind Power Plant	United Kingdom	BlueFloat Energy and Renantis UK	Planning	1350	900
Nao Victoria Floating Offshore Wind Power Plant	Spain	IberBlue Wind	Planning	1287	990

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LIFE CYCLE ASSESSMENT OF WIND TURBINES

Assessing Environmental Impact of Wind Turbines

UNDERSTANDING LCA

A life cycle assessment evaluates the environmental impacts at each stage of a product's life.

MATERIAL EXTRACTION

Assessing the ecological footprint of raw materials used in floating wind turbines.

MANUFACTURING IMPACT

Evaluating the energy usage and waste generation during the manufacturing phase.

INSTALLATION AND OPERATION

Measuring emissions and energy efficiency during the installation and operational phases.

DECOMMISSIONING PROCESS

Understanding disposal and recycling processes at the end of the turbine's life cycle.

OPPORTUNITIES FOR IMPROVEMENT

LCA identifies potential improvements in design and operational efficiency.

STRATEGIES TO MITIGATE ENVIRONMENTAL IMPACT

Effective methods to reduce environmental harm

TURBINE DESIGN INNOVATIONS

Innovative designs enhance turbine efficiency and minimize material usage.

ADVANCED MOORING SYSTEMS

Mooring advancements significantly reduce seabed impact while ensuring stability.

PREDICTIVE MAINTENANCE TECHNOLOGIES

Using predictive analytics to extend the lifespan and operational efficiency of turbines.

ENERGY STORAGE SOLUTIONS

Enhanced storage methods support hydrogen production and distribution effectively.

CONDUCT ENVIRONMENTAL IMPACT ASSESSMENTS

Thorough EIAs should be performed before initiating any project to identify potential environmental effects.

IMPLEMENT MONITORING SYSTEMS

Effective monitoring systems are essential for tracking environmental changes during the project's operation.

UTILIZE ADVANCED TECHNOLOGIES

Advanced technologies can help minimize noise pollution and reduce disruptions to marine life.

COLLABORATE WITH ENVIRONMENTAL ORGANIZATIONS

Partnerships with environmental organizations ensure compliance with conservation efforts and regulations.

LAST BIT?

ENGAGING COMMUNITIES FOR SUSTAINABLE DEVELOPMENT

The Role of Stakeholders in Wind Project Success

01

UNDERSTANDING THE REGULATORY LANDSCAPE

A comprehensive grasp of regulations is essential for successful deployment.

- **FOSTERING LOCAL SUPPORT**
  Involving local communities from the start nurtures trust and support for floating wind projects.
- **EDUCATIONAL OUTREACH**
  Providing education on benefits and impacts ensures informed community participation.
- **TRANSPARENT COMMUNICATION**
  Open discussions and information sharing help mitigate concerns and build relationships.
- **ECONOMIC BENEFITS**
  Supporting local economies through job creation enhances project acceptance and social responsibility.
- **SOCIAL RESPONSIBILITY INITIATIVES**
  Implementing initiatives that prioritize local needs strengthens community ties and project viability.

ECONOMIC VIABILITY OF FLOATING WIND AND HYDROGEN SYSTEMS

Evaluating cost, funding, and sustainability in energy projects

COST STRUCTURE ANALYSIS

Examine the cost structures of floating wind and hydrogen to ensure market competitiveness.

FUNDING OPPORTUNITIES EXPLORATION

Identify government incentives and private investments to support project development.

FEASIBILITY STUDIES CONDUCTED

Evaluate return on investment and operational costs for long-term sustainability.

CONCLUSION AND KEY TAKEAWAYS ON SUSTAINABILITY

Key insights on floating wind turbines and hydrogen systems

01

IMPORTANCE OF ENVIRONMENTAL DESIGN

'Design for the Environment' is crucial for enhancing floating wind turbines and hydrogen production systems.

02

BENEFITS OF SUSTAINABLE PRACTICES

Sustainable practices bolster environmental stewardship and improve both project viability and community backing.

03

COLLABORATION AMONG STAKEHOLDERS

Ongoing collaboration among stakeholders is essential for advancing sustainable energy solutions.

04

ROLE OF TECHNOLOGICAL INNOVATIONS

Technological innovations play a pivotal role in the evolution and success of sustainable energy projects.

05

ADHERENCE TO BEST PRACTICES

Following best practices ensures the effective implementation of sustainable energy solutions.

THANK YOU

QUESTIONS?