EU-REI

Creating a Resource Efficient India

EU-REI
Creating a Resource Efficient India

Resource Efficiency and Circular Economy in the Indian Context

Module 4

Tools, standards and indicators for RE and CE:

Lifecycle Assessments

adelphi | CII Confederation of Indian Industry | CII-ITC Centre of Excellence for Sustainable Development | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH | teri

Course overview

Basic modules

1	Introductory session
2	Foundations of RE and CE in the international context
3	Towards RE and CE through sectoral strategies in India

Applied and advanced modules

4	Tools, standards and indicators for RE and CE	
	4a	Material Flow Analysis
	4b	Life Cycle Assessment
	4c	RE and CE Standards
	4d	RE and CE Indicators
	4e	Public Procurement
	4f	Circular Business Models
	4g	RE and CE Funding

Recap and evaluation

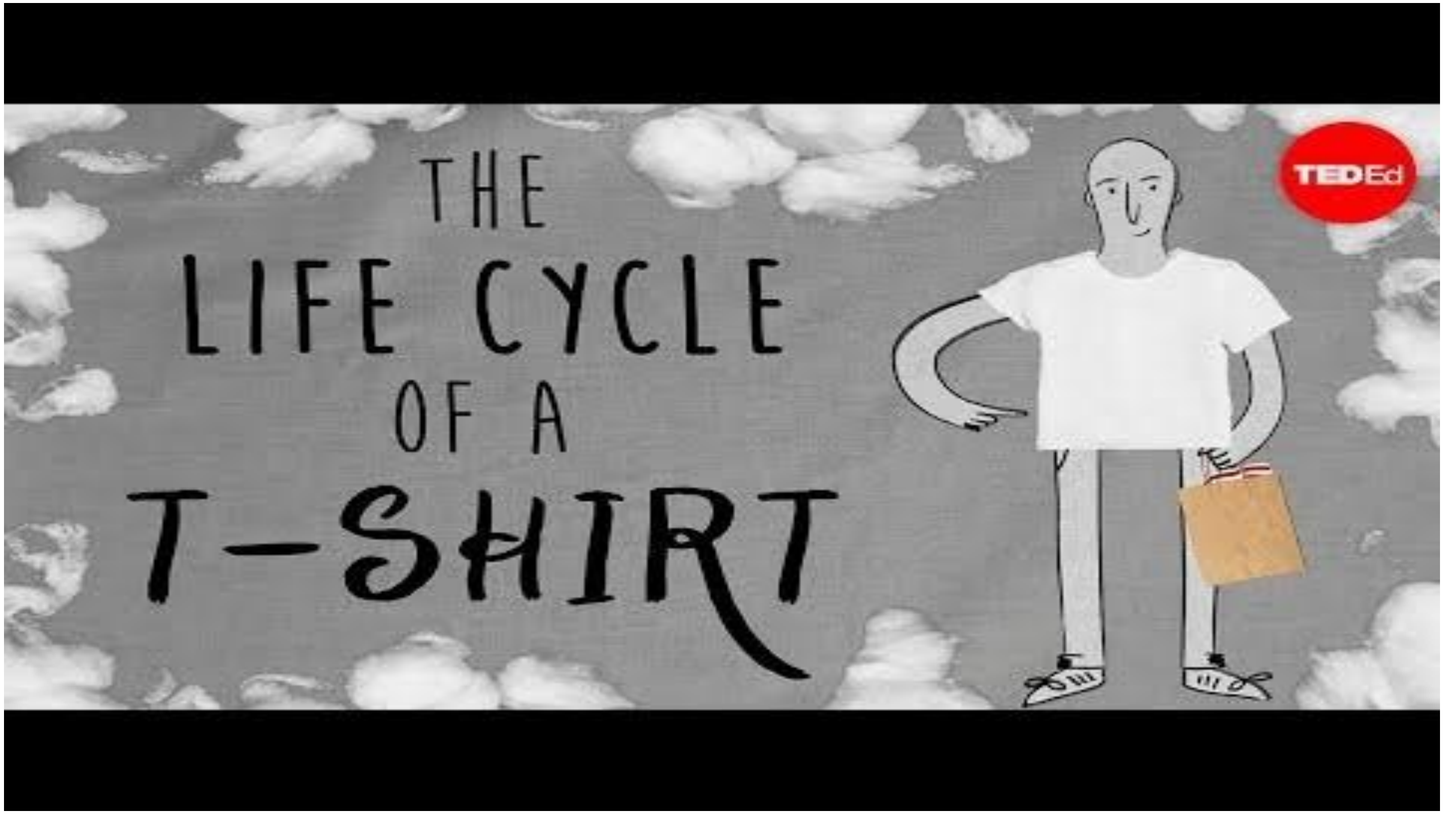
5	Summary, outlook and evaluation

Learning objectives: LCA

After completion of module 4b, participants will be able to

- relate to the concept and terminology of life cycle assessments (LCA)
- define the steps of a life cycle assessment
- interpret the results of life cycle assessments

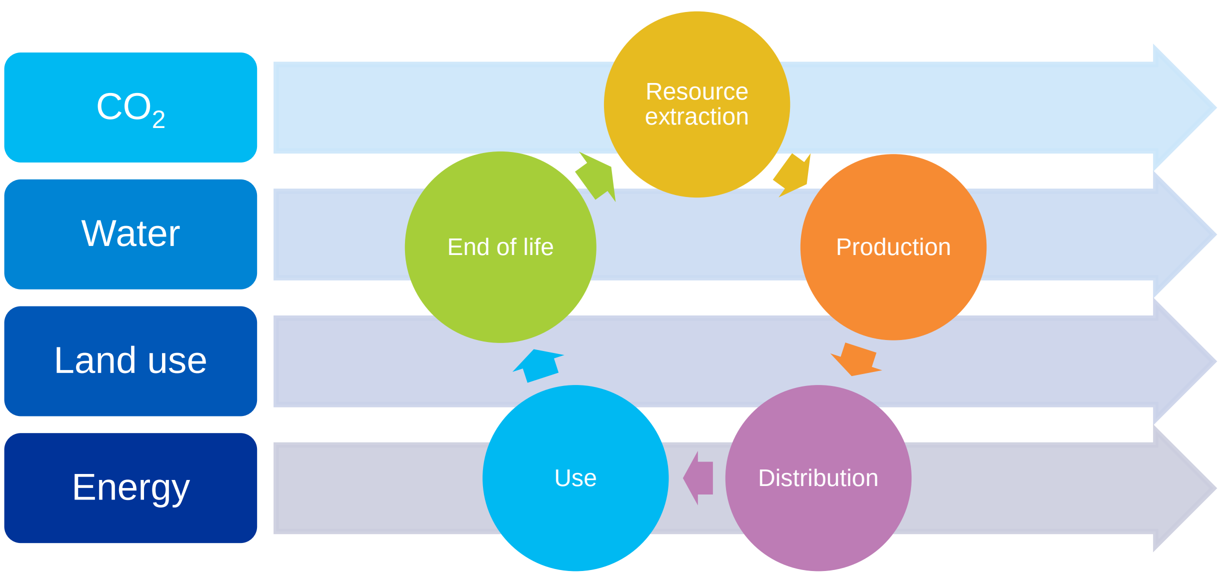
Lifecycle Assessments



Lifecycle Assessments

Lifecycle assessment (LCA) is a framework for assessing the environmental impacts of product systems and decisions from raw material acquisition through the end of life.

Impacts **Lifecycle stages**



Picture source: https://link.springer.com/chapter/10.1007/978-94-017-7610-3_2

Lifecycle Assessments

- The application of LCAs requires both tools (software) and datasets.
- Application guided by „ISO14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines“.

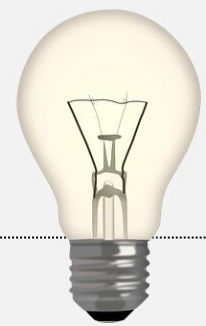
Software
- Umberto
- GaBi Software
- SimaPro
- openLCA *(freeware!)*

Datasets
- GaBi
- Ecoinvent
- ProBas
- ELCD

Lifecycle Assessments

Types of LCAs

Singular Analyzes the environmental impacts of a single product over all lifecycle stages	**Comparative** Compares the environmental impacts of different products across all stages
Attributional Describes the environmentally relevant physical flows to and from a lifecycle system embedded into a static background system	**Consequential** Describes how environmentally relevant physical flows will change in response to possible decisions in the analyzed life cycle



Lifecycle Assessments

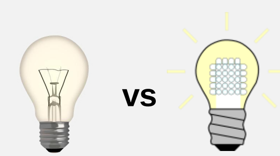
Examples

Singular

Analysis of (e.g.) greenhouse gas (GHG) emissions of an LED light bulb

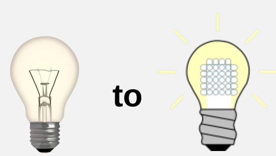
Comparative

Comparison between GHG emissions of an LED and incandescent light bulbs



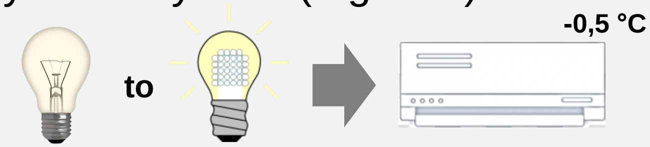
Attributional

How much GHG could be avoided by switching from incandescent to LED lightbulbs?



Consequential

How much GHG could be avoided by switching from incandescent to LED lightbulbs in context of a dynamic system (e.g. A/C)?



Lifecycle Assessments

EU-REI

LCA terminology

- ***Functional unit*** – normalizes the qualitative and quantitative aspects of the function(s) to allow for comparisons (e.g. drying hands on a daily basis for three years)
- ***System boundary*** – separates the analysed system from the background system
- ***Cradle, gate, grave*** – cradle = the birthplace of a product (e.g. raw material extraction); gate = production process (e.g. the factory gate); grave = end of life (e.g. landfill)

Lifecycle Assessments

Step 1: Goal definition and scoping

- Clarify purpose and context of assessment
- Define, describe product, process or activity including functional unit
- Identify boundaries and impact categories to be assessed

Step 2: Lifecycle inventory analysis

- Identify and quantify system flows
- Examples: energy, water and materials usage and emissions

Step 3: Lifecycle impact assessment

- Assess impacts of flows on humans and environment
- Examples: Global warming potential: 1 kg CO_2 = 1 kg CO_2-equivalent whereas 1kg CH_4 = 25 kg CO_2-equivalent

Step 4: Interpretation

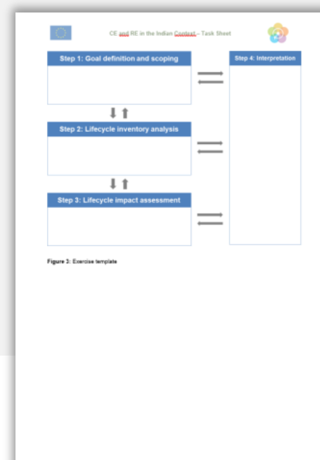
- Evaluate results of inventory analysis and impact assessment through sensitivity analysis, consistency checks
- Understand uncertainties and assumptions
- Select preferred products, processes and services

Exercise: Defining steps in LCA

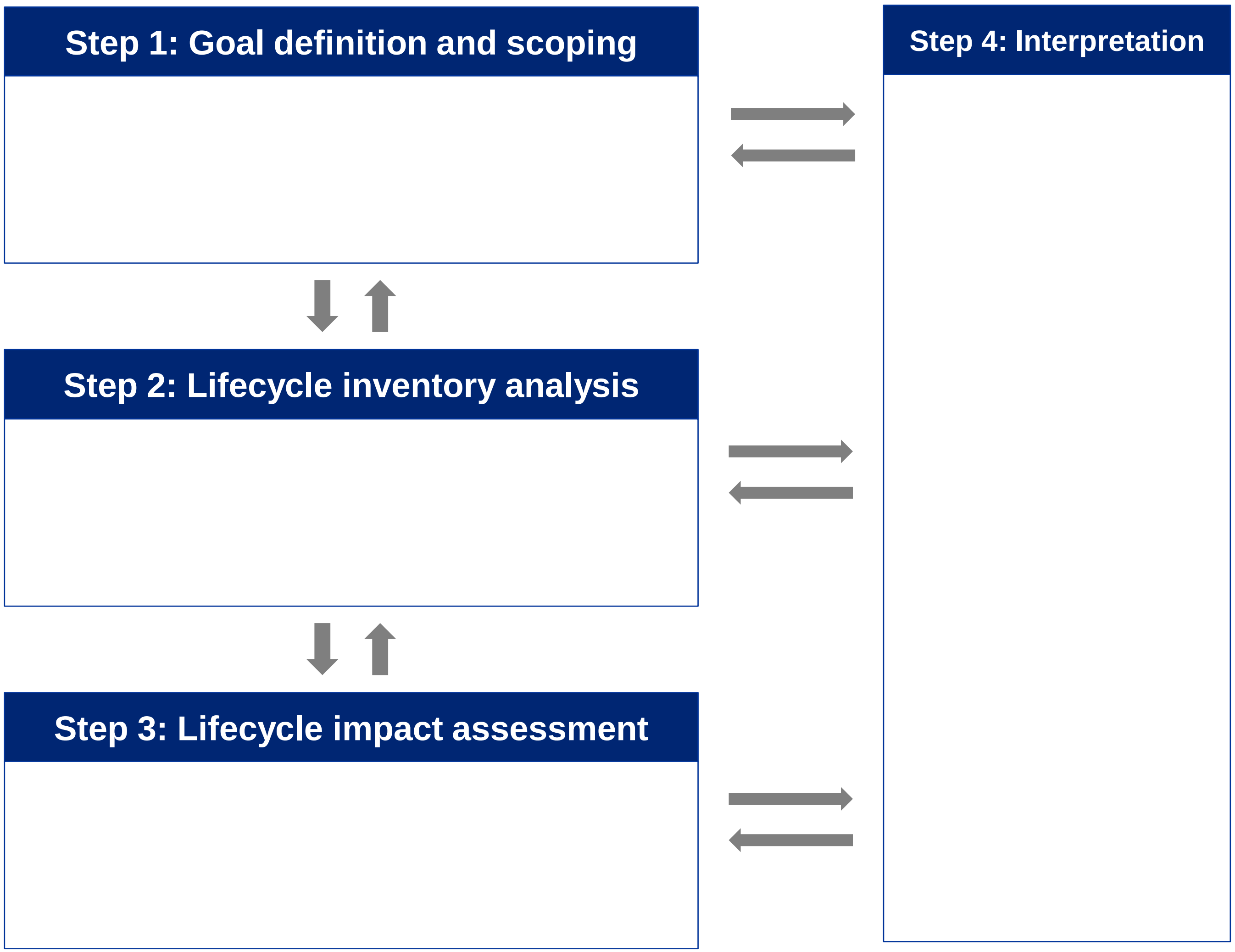
Exercise 4b.1: Defining steps in LCA

- Form groups of 2 - 3 persons
- Define steps 1-4 of a fictional LCA to compare two mobile phones
- Think of examples in each step and try to be as specific as possible

Estimated time requirement: 10 min



Exercise: Defining steps in LCA



Exercise: Defining steps in LCA

Solutions

Step 1: Goal definition and scoping

- „targetting two new high-end smartphones by Sony (models Z3 and Z5) with accessories but without network usage“
- „funtctional unit is set to life time usage (3 years) for a representative usage scenario“
- „All life cycle stages and processes are included in […] except reconoditioning mobile phone for reuse“
- „the environemtal life cycle assessment indicators are chosen as presented in Table 1“

ELCIA indicators as recommended by ILCD	Unit
Global Warming Potential **(GWP)**	CO_2-eq.
Ozone Depletion Potential **(ODP)**	CFC-11-eq.
Human Toxicity Cancer potential effects (**HumToxCan**)	CTUh
Human Toxicity non-Cancer potential effects (**HumTox**)	CTUh
Particulate Matter (2.5 µm) (**PM**)	G
Photo-Oxidant Creation Potential (**POCP**)	NMVOC-eq.

Step 2: Lifecycle inventory analysis

Raw materials acquisition:

- Primary materials, packaging materials for parts and final delivery, virgin and recycled inputs

Production:

- Parts production, packaging and transportation, assembly, ICT manufacturer support abilities, distribution

Use:

- Smartphone energy consumption based on Sony Data, associated use of networks

End of life:

- Open to explore different scenarios in this section (e.g. 90 % recycled, 10% virgin materials, or 20% recycled materials and 80% virgin materials)

Based on another study: Liebmann, A., 2015 ICT Waste Handling: Regional and Global End-of-Life Treatment Scenarios for ICT Equipment

Exercise: Defining steps in LCA

Solutions

Step 3: Lifecycle impact assessment

Results of impact category „global warming potential (GWP)“:

- Total GWP of the device based on functional unit (3 years) for model Z5 is 57 kg CO_2-eq and for model Z3 is 50 kg CO_2-eq
- Production stage of dominates GWP
- End of life stage can be carbon-negative if contents are recycled or plastic is incinerated and substitutes fossil fuels

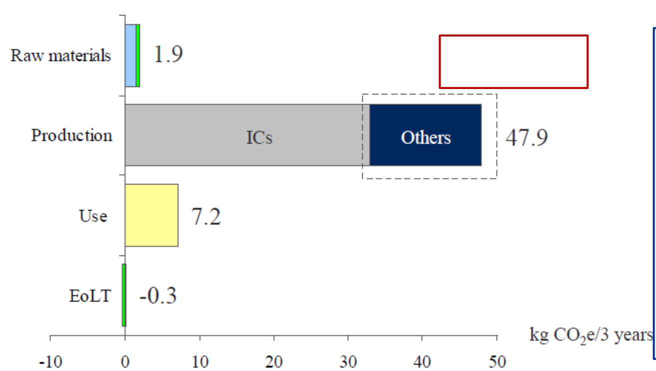
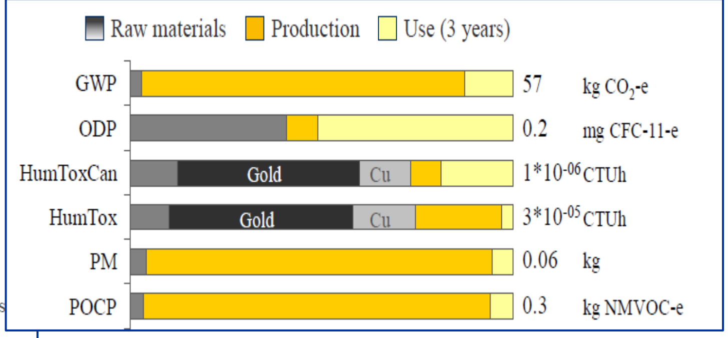


Fig.2 GWP for smartphone Z5 during its life time (3 years), including accessories but excluding network usage



Exercise: Defining steps in LCA

EU-REI

Solutions

Step 4: Interpretation

Interpretation and sensitivity analysis

- production and use impact influences outcomes to a high degree due to electricity consumption
- raw material toxicity impacts are dominated by gold and copper mining

Impacts from gold modelling depends on data base

- Ecoinvent assumes leakages of metals based on the conditions of one mine in South America for which mining tailings and dams are assumed to constantly leak or even break
- GaBi model represents a modern Northern Europe mine and smelter with no leakages whatsoever

GaBi Product Sustainability Performance

ecoinvent

Lifecycle Assessments

Advantages

- ✓ Provides a quantitative measurements of a product's potential impacts
- ✓ Allows for an easy identification of most impactful lifecycle stages
- ✓ Application can capture a wide range of different impacts (GWP, HumToxCan, ODP etc.)
- ✓ Standardized process in accordance with ISO 14044 creates maximum of transparency and reproducibility

Disadvantages

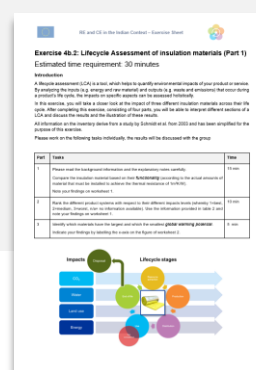
- × Resource and time consuming („heavy canon")
- × Definition of scope sustanstially impacts the quality of the LCA
- × LCA is dependent on consistent, high quality data (expensive!)
- × Fast changing innovation cycles (emergence of new technologies) can lead to outdated LCAs

Exercise: Lifecycle Assessment

Exercise 4b.2: Lifecycle Assessment of insulation materials (1/2)

- Work individually on the tasks on the provided exercise sheets
- Read the background information and compare the insulation material based on their functionality
- Rank the different product system with respect to their impact levels.
- Identify which material have the largest/ smallest global warming potential

Estimated time requirement: 30 min


RE and CE in the Indian Context – Exercise Sheet

Exercise 4b.2: Lifecycle Assessment of insulation materials (Part 1)

Estimated time requirement: 30 minutes

Introduction

A lifecycle assessment (LCA) is a tool, which helps to quantify environmental impacts of your product or service. By analyzing the inputs (e.g. energy and raw material) and outputs (e.g. waste and emissions) that occur during a product's life cycle, the impacts on specific aspects can be assessed holistically.

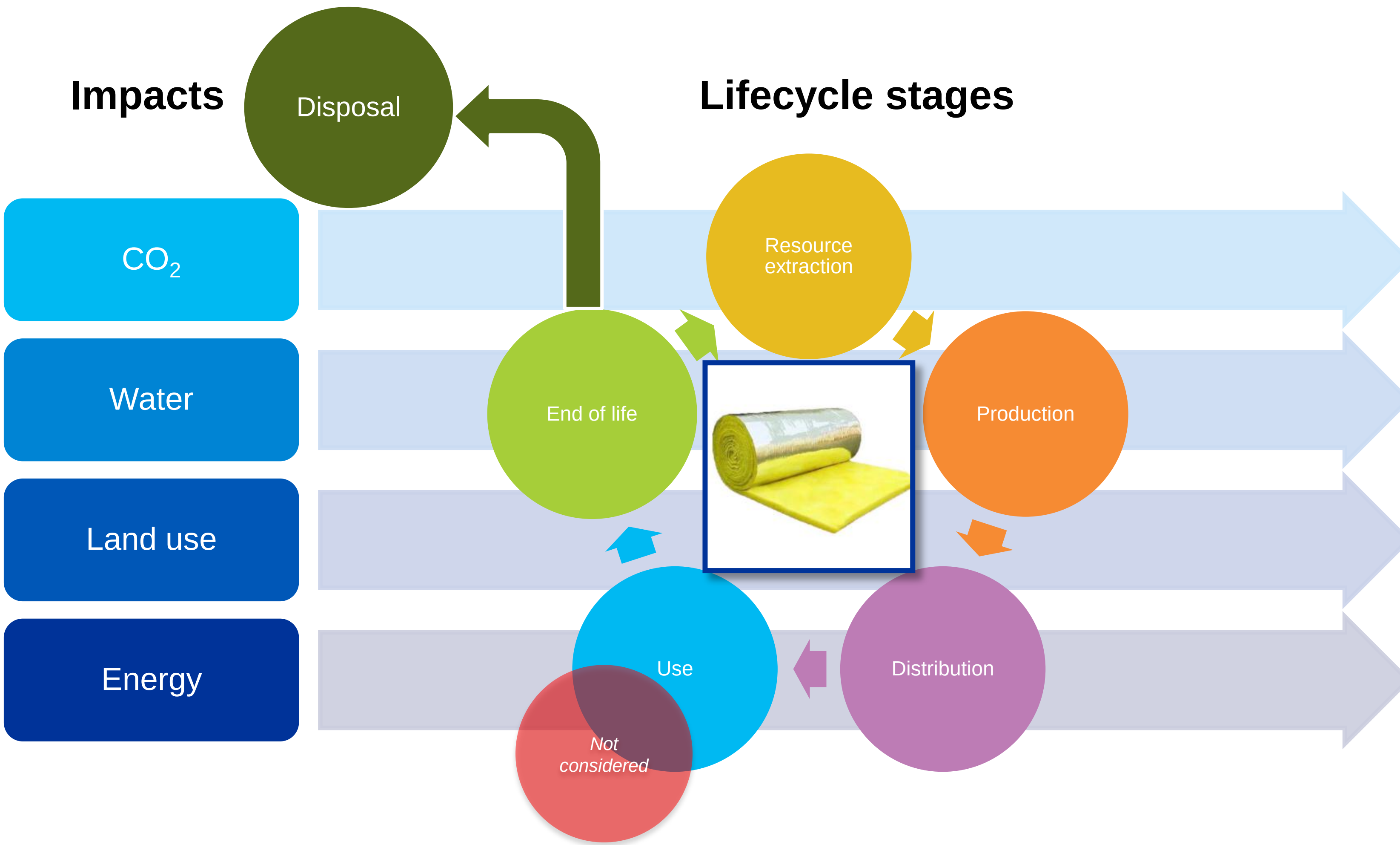
In this exercise, you will take a closer look at the impact of three different insulation materials across their life cycle. After completing this exercise, consisting of four parts, you will be able to interpret different sections of a LCA and discuss the results and the illustration of these results.

All information on the inventory derive from a study by Schmidt et al. from 2003 and has been simplified for the purpose of this exercise.

Please work on the following tasks individually, the results will be discussed with the group

Part	Tasks	Time
1	Please read the background information and the explanatory notes carefully. Compare the insulation material based on their **functionality** (according to the actual amounts of material that must be installed to achieve the thermal resistance of 1m²K/W). Note your findings on worksheet 1.	15 min
2	Rank the different product systems with respect to their different impacts levels (whereby 1=best, 2=medium, 3=worst, n/a= no information available). Use the information provided in table 2 and note your findings on worksheet 1.	10 min
3	Identify which materials have the largest and which the smallest **global warming potential**. Indicate your findings by labelling the x-axis on the figure of worksheet 2.	5 min

Exercise: Lifecycle Assessment



Picture source:
https://p.globalsources.com/IMAGES/PDT/B1165797122/Waterproof-insulation-material-glass-wool-refrigerator-insulation-blanket-roof-insulation.jpg

Exercise: Lifecycle Assessment

Solutions

Task 1: Compare the insulation material based on their ***functionality*** (according to the actual amounts of material that must be installed to achieve the thermal resistance of $1 m^2K/W$).

Best functionality: **Stone wool**
Medium functionality: **Flax**
Lowest functionality: **Paper wool**

Only very small differences - all materials perform well with respect to their insulation properties!

Material	Functional Unit (kg)	Corresponding insulation thickness (mm)
Rock wool	1.184	37
Paper wool	1.280	40
Flax	1.260	42

Exercise: Lifecycle Assessment

Solutions

Task 2: Rank the different product systems with respect to their different impacts levels.

Impact category	Unit	Stone wool	Flax	Paper wool
Global warming potential	g CO_2-equivalent	**2**	**3**	**1**
Acidification	g SO_2-equivalent	**2**	**3**	**1**
Nutrient enrichment	g NO_3^-equivalent	**2**	**3**	**1**
Generation of solid waste	g non-hazardous waste	**2**	**3**	**1**
Generation of hazardous waste	g hazardous waste	**2**	**1**	**3**

Exercise: Lifecycle Assessment

Solutions

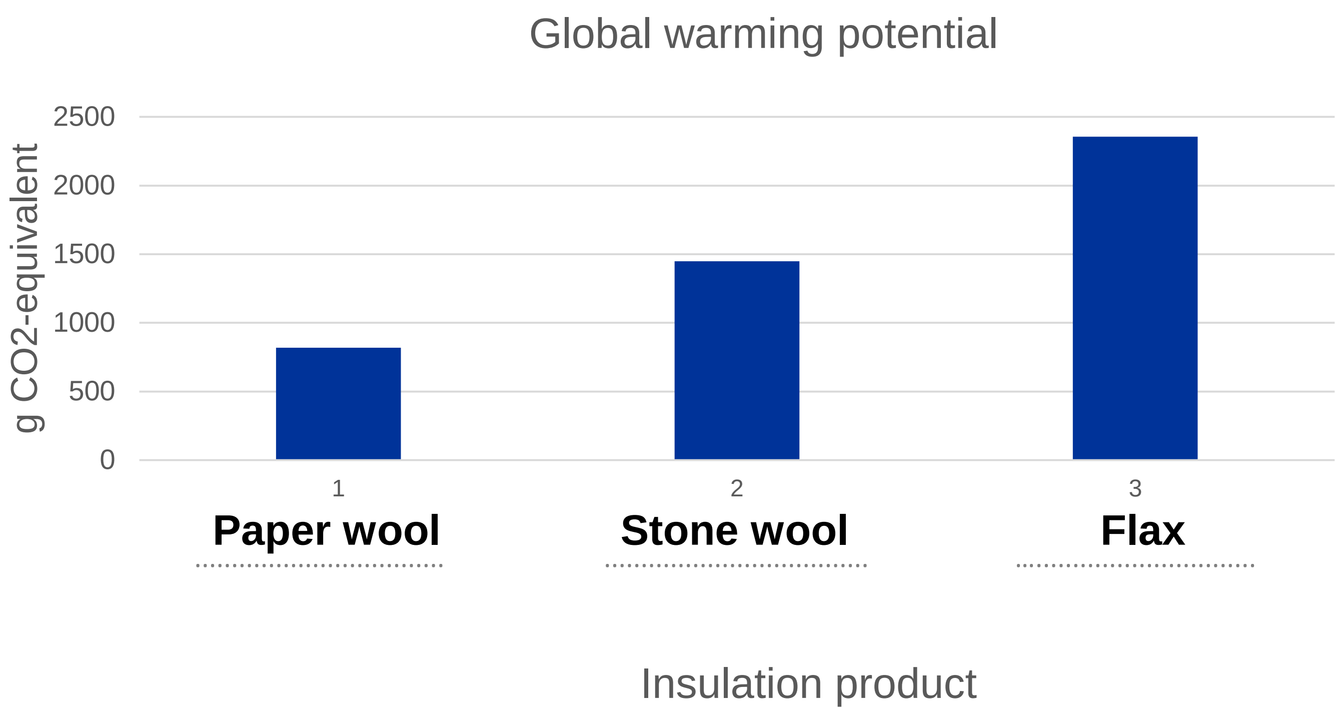
Task 2: Rank the different product systems with respect to their different impacts levels.

Impact category	Unit	Stone wool	Flax	Paper wool
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ	**2**	**3**	**1**
Renewable fuels (incl. Feedstock)	MJ	**1**	**2**	**3**
Electricity	MJ	**1**	**3**	**2**
Total energy consumption	MJ	**1**	**3**	**2**
Water consumption	g water	**2**	**3**	**1**
Health aspects				
Carcinogenicity	Animal evidence	**1**	**n/a**	**3**
Lung fibrosis (inhalation)	Animal evidence	**1**	**3**	**3**
Lung disease (non-malignant)	Human evidence	**1**	**3**	**n/a**
Cancer (IARC)	Human evidence	**3**	**n/a**	**n/a**

Exercise: Lifecycle Assessment

Solutions

Task 3: Identify which materials have the largest and which the smallest ***global warming potential***.



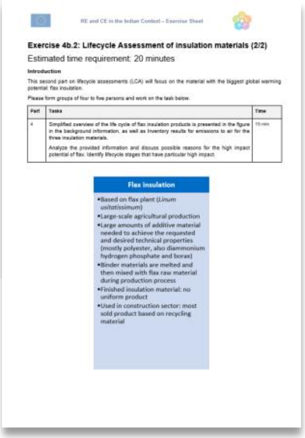
Paper wool **Stone wool** **Flax**

Exercise: Lifecycle Assessment

Exercise 4b.2: Lifecycle Assessment of insulation materials (2/2)

- Form groups of 4-5 people.
- Analyse the lifecycle of flax insulation and the inventory results for emissions.
- Discuss possible reasons for the high impact potential of flax. Also identify lifecycle stages that have particular high impact.

Estimated time requirement: 20 min


RE and CE in the Indian Context – Exercise Sheet

Exercise 4b.2: Lifecycle Assessment of insulation materials (2/2)

Estimated time requirement: 20 minutes

Introduction

This second part on lifecycle assessments (LCA) will focus on the material with the biggest global warming potential: flax insulation.

Please form groups of four to five persons and work on the task below.

Part	Tasks	Time
4	Simplified overview of the life cycle of flax insulation products is presented in the figure in the background information, as well as Inventory results for emissions to air for the three insulation materials. Analyze the provided information and discuss possible reasons for the high impact potential of flax. Identify lifecycle stages that have particular high impact.	15 min

Flax insulation

- Based on flax plant (*Linum usitatissimum*)
- Large-scale agricultural production
- Large amounts of additive material needed to achieve the requested and desired technical properties (mostly polyester, also diammonium hydrogen phosphate and borax)
- Binder materials are melted and then mixed with flax raw material during production process
- Finished insulation material: no uniform product
- Used in construction sector: most sold product based on recycling material

Exercise: Lifecycle Assessment

Background information

Flax insulation

- Based on flax plant (*Linum usitatissimum*)
- Large-scale agricultural production
- Large amounts of additive material needed to achieve the requested and desired technical properties (mostly polyester, also diammonium hydrogen phosphate and borax)
- Binder materials are melted and then mixed with flax raw material during production process
- Finished insulation material: no uniform product
- Used in construction sector: most sold product based on recycling material

Picture source: https://images-na.ssl-images-amazon.com/images/I/6126gym-5OL._AC_SX466_.jpg

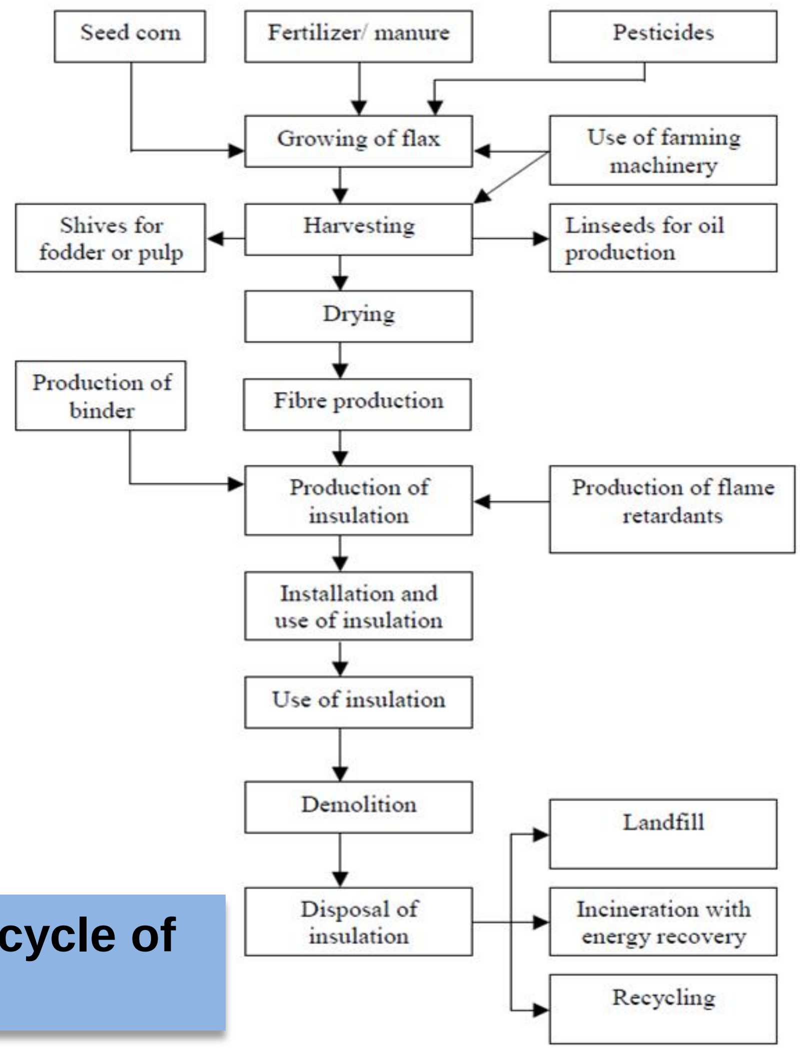
Exercise: Lifecycle Assessment
Background information

Inventory results for emissions to air for the three insulation materials

Emission to air	Unit	Stone wool	Flax	Paper wool
CO_2 (fossil)	g	1421	2142	805
CO	g	105	2.0	1.0
SO_x	g	6.08	11.57	2.88
No_x	g	2.47	7.44	3.74
N_2O	g	0.02	0.41	0.01
CH_4	g	1.04	4.19	0.57
HCl	g	0.06	0.04	0
H_2S	g	0.03	0	0
Ammonia	g	2.37	0.02	0
Hydrocarbons (except CH_4)	g	0.21	2.2	1.22
VOC	g	0.7	0.85	0.39
Particulates	g	1.19	1.54	5.08

Exercise: Lifecycle Assessment

Background information



Simplified overview of the life cycle of flax insulation products

Picture source: https://www.researchgate.net/publication/247152335_Comparative_life_cycle_assessment_of_three_insulation_materials_stone_wool_flax_and_paper_wool

Exercise: Lifecycle Assessment

Solutions

Contribution to global warming potential of **paper wool:**

- Although the raw material for paper wool, old newsprint, primarily is based on renewable resources, its production still demands an input of fossil fuels
- This causes emissions of carbon dioxide, which is the main contributor (more than 55%) in this system.
- Other significant sources: production of aluminum hydroxide and the final production, each contributing with 10-15%.

Contribution to global warming potential of **stone wool:**

- Production process: fossil fuels as energy source
- Binder materials are only used in very small amounts
- Besides emissions from energy consumption there are no other known emissions that contribute to global warming in significant amounts.

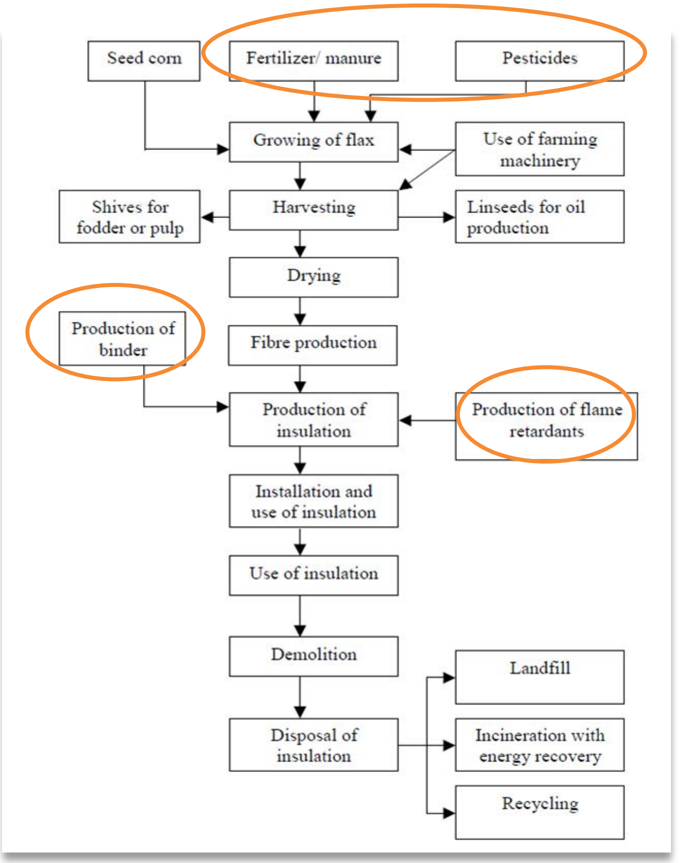
Production of stone raw materials is not very demanding in terms of energy consumption and there are no other emissions during their production that have a global warming potential.

Exercise: Lifecycle Assessment

Solutions

Contribution to global warming potential of **flax insulation:**

- Large-scale agricultural production of flax:
    - requires artificial fertilizer: high energy production, high emissions of carbon dioxide and dinitrogen oxide
    - Evaporation of N2O of the fields
- Binder and flame retarding materials added use relatively large amounts of fossil fuels for their production
- High energy consumption of production process itself (melting of binder materials with the flax raw material)



Picture source: https://www.researchgate.net/publication/247152335_Comparative_life_cycle_assessment_of_three_insulation_materials_stone_wool_flax_and_paper_wool

Summary

Take-home messages

- LCAs are useful tools for modelling impacts/material flows across products and systems, but require large amounts of data
- LCAs are useful tools when analysing specific cases with regards to RE and CE
- Lifecycle stages and impact categories are to be analysed individually and in comparision to each other to get the full pictures of a products impact

EU-REI

Creating a Resource Efficient India