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

Estimated time requirement: 30 minutes

Introduction

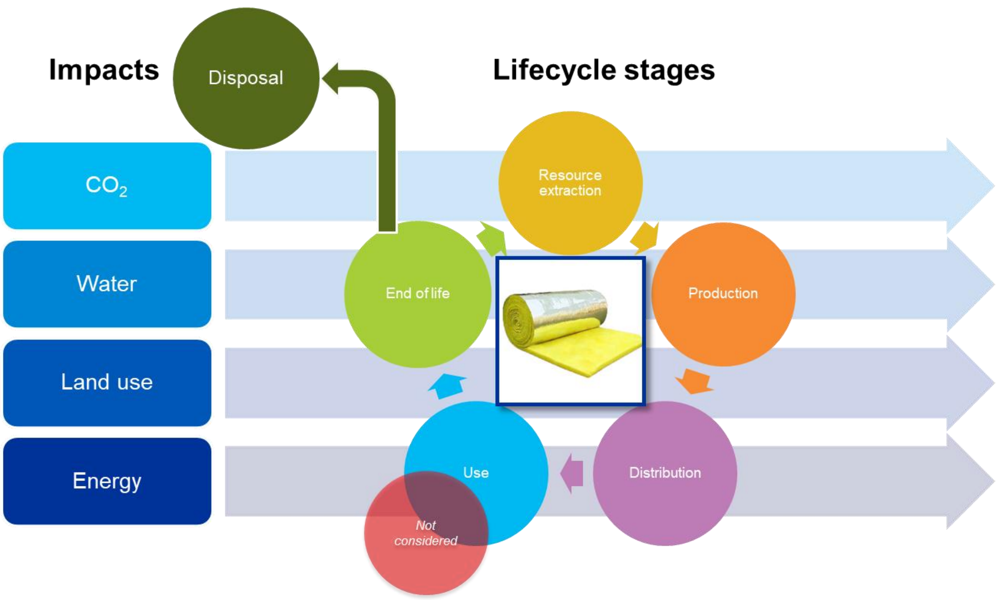
A lifecycle assessment (LCA) is a tool, which helps to quantify environmental impacts of your product or service. By analyzing the inputs (e.g. energy and raw material) and outputs (e.g. waste and emissions) that occur during a product's life cycle, the impacts on specific aspects can be assessed holistically.

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



Background information

Proper insulation of buildings can save significant amounts of energy and resources and therefore can contribute to a lower demand for energy resources and a reduction in pollution emissions.

Three different insulation materials for attics were assessed according to their impact during their life cycle to compare the global and regional emissions and environmental impact, as well as potential health effects:

Stone wool insulation

- Briquettes produced from natural rocks (low energy requirements)
- Mixed with industrial waste (e.g. recycled material from cement and steel production)
- Binder and impregnation oil are added in small amounts to achieve desired technical properties
- Product is cured in a polymerization chamber and finally cut into the desired dimensions.
- Medium energy requirements of production process
- Finished insulation material: widely homogenic
- Used in construction sector: frequently

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

Paper wool insulation

- Based on shredded newsprint
- Additives like Aluminium hydroxide, borax and boric acid needed to achieve the requested and desired technical properties.
- Newsprint industry and the paper wool industry draws from the same pool of resources: every kilo of old newsprint leaving the system must be replaced by a corresponding amount of virgin fibers
- Final production under medium energy demands
- Finished insulation: small differences in the recipes, larger differences for production of newsprint, paper recycling schemes may differ significantly
- Used in construction sector: most sold product based on "grown" biomaterial

Explanatory notes

Table 1: Explanatory notes

<table>
<tr><td>Lifespan</td><td>Expected to be 50 years.
By the end of life of the material a basic scenario of low-grade recycling (e.g. incineration or composting) was assumed due to uncertainties regarding future disposal technologies.</td></tr>
<tr><td>Functional Unit</td><td>Described by the ISO 14040 is the "the quantified performance of a product system for use as a reference unit in a life cycle assessment study".
In this case: the amount of insulation required for an additional thermal resistance of $1\ \frac{m^2K}{W}$ over the lifespan of the materials. The functional unit values for each material are as follows:
<table>
<tr><th>Material</th><th>Functional Unit (kg)</th><th>Corresponding insulation thickness (mm)</th></tr>
<tr><td>Rock wool</td><td>1.184</td><td>37</td></tr>
<tr><td>Paper wool</td><td>1.280</td><td>40</td></tr>
<tr><td>Flax</td><td>1.260</td><td>42</td></tr>
</table></td></tr>
</table>

Environmental impact categories	• **Global warming potential**
	  ○ As g CO_2- equivalent
	  ○ Also accounts for emissions of other greenhouse gases, as methane (CH_4) and nitrous oxide (N_20)
	• **Acidification**
	• **Nutrient enrichment**
	• **Waste generation**
	  ○ Generation of solid waste
	  ○ Generation of hazardous waste
	    ➢ Both aspects included only to a limited extend due to a high level of uncertainty during data acquisition
	• **Energy consumption**
	  ○ Fossil fuels (incl. feedstock)
	    ➢ Includes consumption of mineral resources during the production phase!
	  ○ Renewable fuels
	  ○ Electricity
	  ○ Total energy consumption
	• **Water consumption**
	    ➢ Included only to a limited extend due to a high level of uncertainty during data acquisition
	• **Health aspects**
	  ○ Carcinogenicity (tested with animals)
	  ○ Lung disease

Lifecycle stages	• For this comparison the following lifecycle stages were included:
	  ○ Production,
	  ○ packaging and transportation,
	  ○ installation and,
	  ○ dismantling and disposal phase.
	• 50-year use phase was excluded as it was assumed that no interventions would be necessary during that time.
	• All three material perform about equally well in terms of the insulation properties.
	• Despite their environmental performance during all the lifecycle stages each of the material has overall a positive environmental performance as the energy savings through insulation overweigh.

Table 2: Life cycle impacts for the three material to fulfill the same functional unit

Impact category	Unit	Stone wool	Flax	Paper wool
Global warming potential	g CO_2-equivalent	1449	2357	819
Acidification	g SO_2-equivalent	12.3	17	5.5
Nutrient enrichment	g NO_3^-equivalent	12.0	12.6	5.5
Generation of solid waste	g non-hazardous waste	53	122	30
Generation of hazardous waste	g hazardous waste	0.5	0.4	1.7
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ	14.61	27.84	6.75
Renewable fuels (incl. Feedstock)	MJ	1.07	15.31	15.35
Electricity	MJ	3.07	6.58	4.14
Total energy consumption	MJ	20.75	49.73	26.24
Water consumption	g water	3907	5771	822
Health aspects				
Carcinogenicity	Animal evidence	Yes	Not tested	Yes
Lung disease (non-malignant)	Human evidence	No	Yes	Not tested

Worksheet 1

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 1m²K/W).

1. Best functionality: ……………………………………… **(Stone wool)**
2. Medium functionality: ……………………………………… **(Flax)**
3. Lowest functionality: ……………………………………… **(Paper wool)**

Note: only very small differences. All materials perform well with respect to their insulation properties.

Task 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 in the table below:

Table 3: Ranking of the three insulation materials with respect to different impacts

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**
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**

Advantages of ranking system:

- **provides good overview**
- **easy to read**
- **no professional knowledge needed**

Disadvantages aspects of ranking system:

- **provides only general picture**
- **differences between materials might be marginal and therefore insignificant**
- **impact categories might be of varying relevance depending on your intention and the scope of your study/product**

Worksheet 2

Task 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 below:

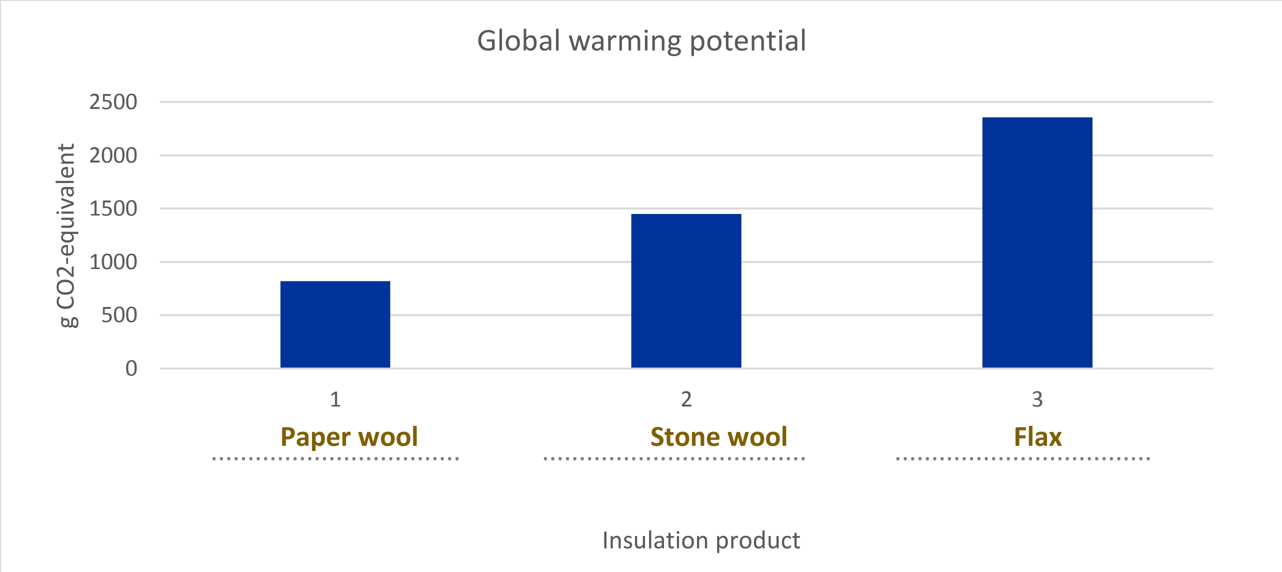


Figure 1: Global warming potential of the individual insulation products