



Comparative Life Cycle Assessment of three insulation materials

Presented by

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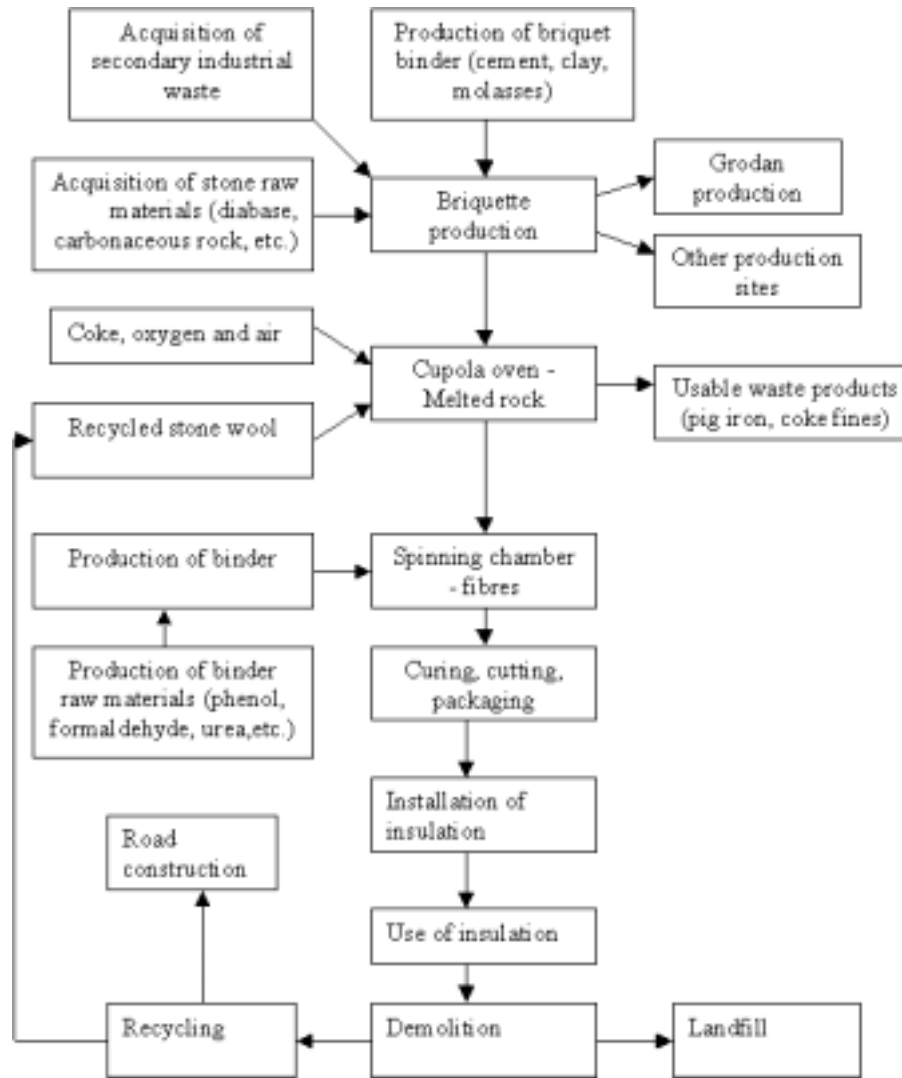
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Goal and scope

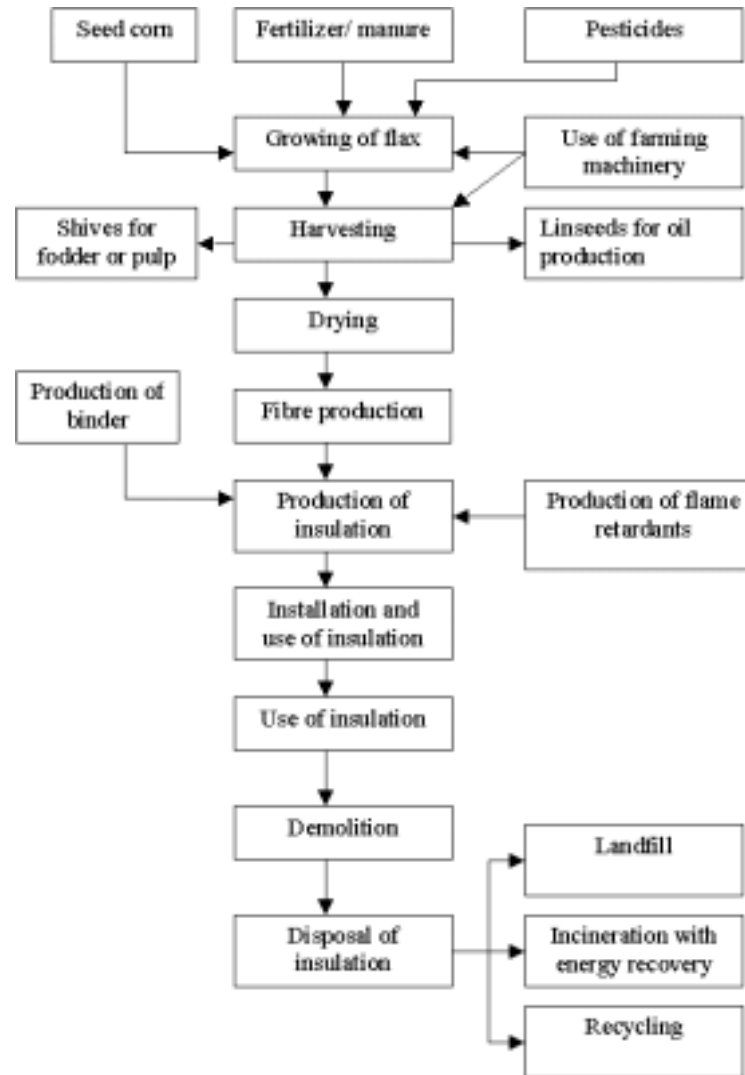


- **Goal:**
 - To produce a scientific paper, comparing three different insulation materials over their life cycle
 - To produce an up-to-date inventory for the Danish production of stone wool
- **Scope:**
 - Cradle-to-grave assessment
 - Global and regional emissions and environmental impact
 - Occupational Health
 - One application only (insulation of a roof)
 - No additional materials included
 - Three types of materials only
 - A number of popular insulation materials are excluded
- **Commissioner: Rockwool International**

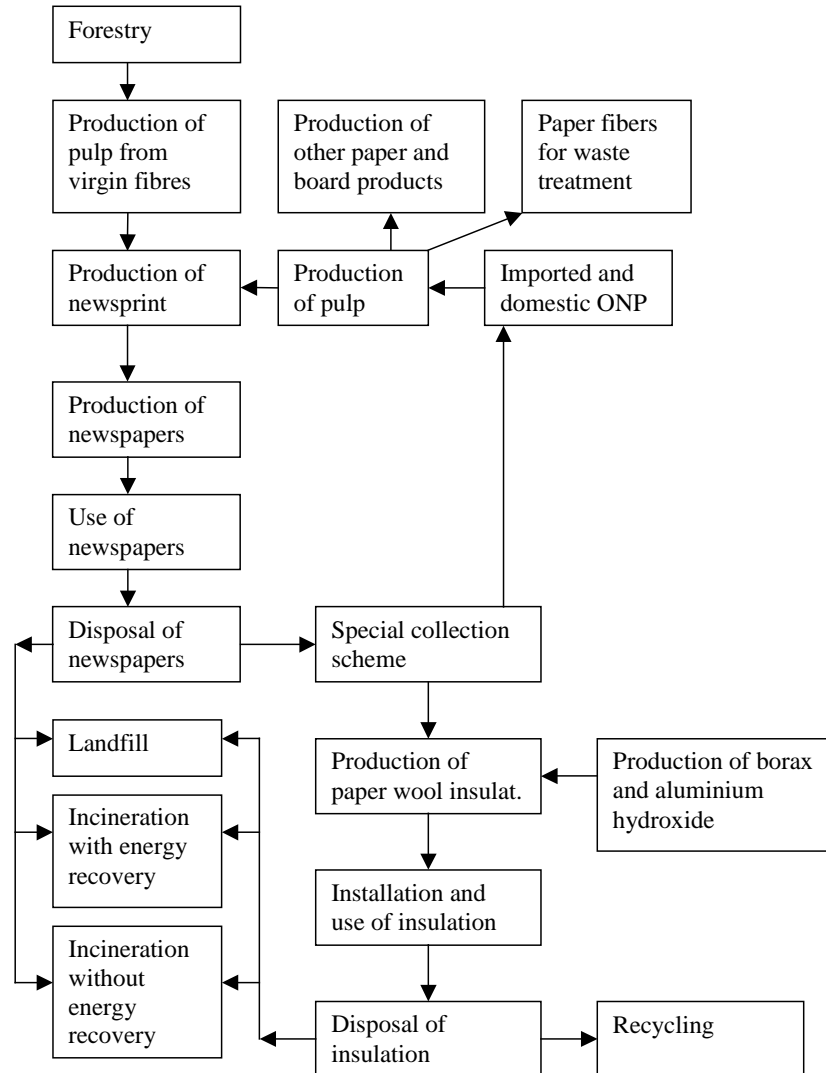
Flow diagram - Stone wool



Flow diagram - Flax



Flow diagram – Paper wool



General assumptions



- **All three materials are suited for the examined application, insulation of attics**
 - A detailed description of the technical requirements regarding fitness for use can be found in the report
- **All three products are assumed to be representative on the European level**
 - Stone wool: Only small differences between manufacturing plants
 - Flax: Not a uniform product at the European level. The recipe from the largest producer has been used in the basic scenario; a new Danish product is examined in the sensitivity analysis
 - Paper wool: Small differences between paper wool recipes; Larger differences for production of newsprint; Paper recycling schemes may differ significantly between countries and regions

General assumptions (2)



- **European average is used for electricity production and consumption**
 - Except for materials and substances for which specific scenarios as in the original inventories were used, e.g. APME and KCL data
- **Management of insulation waste 50 years from now?**
 - High uncertainty with respect to future disposal, but only little influence on the results
 - Recycling in low-grade applications is the basic scenario
 - Incineration, composting and landfilling is examined in the sensitivity analysis, thus also pointing to the "best" disposal method
- **European averages are used for packaging waste**
- **Fair estimates for transportation distances**

Allocation procedures



- **System expansion is used where possible, e.g.**
 - Use of old newsprint for insulation causes production of newsprint from virgin fibers (there is a high demand for paper fibers for recycling).
 - Production of newspapers is excluded from the calculations
 - Fiber flax also gives a yield of seeds (for oil production) and shives (e.g. for cattle fodder). The replaced products are taken into account in the calculations of the basic scenario
- **Economic allocation is used in a sensitivity analysis for flax**
- **Mass allocation is used for co-products at the stone wool factory, producing Grodan (for plant nurseries) and briquettes for other facilities**

Impact assessment



- **Global and regional impacts are calculated according to EDIP and CML methodology:**
 - Global warming
 - Acidification
 - Photo-chemical ozone formation
 - Eutrophication
- **Energy consumption is inventoried in weight and MJ:**
 - Renewable fuels
 - Fossil fuels (coal, fuel oil, natural gas)
 - Electricity
- **Water consumption and waste generation are included, but with a relatively high uncertainty**

Impact assessment (2)



- **Occupational health aspects are addressed by a (qualitative) risk assessment approach:**
 - Potential exposure to fibres (Occupational Exposure Limits exceeded?)
 - Potential effects of fibres
 - Animal evidence
 - Carcinogenicity (inhalation/injection)
 - Lung fibrosis (inhalation)
 - Biopersistence
 - Human evidence
 - Cancer
 - Non-malignant lung disease
- **Impacts on local ecosystems and the general population not examined**

Results



Most important result is

- **It pays to insulate – also in environmental terms**
 - The life cycle impacts are counterbalanced with more than 100 times the "investment" over 50 years

Most important recommendation is

- **Use as much insulation as practically possible to save energy!**
 - In cold climates, an energy consumption as low as 15 kWh/m²/y can be achieved ("passive house")
 - In hot climates, energy consumption for air conditioning can be reduced by more than one third

Results (2)



- **Detailed inventory tables can be found in the report for**
 - Stone wool
 - Briquette production (1 kg)
 - Binder production (1 kg)
 - Stone wool (1 kg + functional unit (1.184 kg))
 - Flax
 - Yields, impacts of machinery (production and use)
 - Production of fertilizers and pesticides
 - Production of final product
 - Flax insulation (1 kg + functional unit (1.260 kg))
 - Paper wool
 - Paper wool insulation (1 kg + functional unit (1.280 kg))
 - Production of newsprint is "confidential"

Impact assessment results



Impact category	Unit	Stone wool	Flax	Paper wool
Global warming	g CO ₂ -equivalents	1449	2357	819
Acidification	g SO ₂ -equivalents	12.3	17	5.5
Nutrient enrichment				
CML-method	g PO ₄ ³⁻ -equivalents	1.2	1.2	0.7
EDIP-method	g NO ₃ ⁻ -equivalents	12.0	12.6	5.5
Photochemical ozone creation	g C ₂ H ₄ -equivalents	4.6	0.5	0.2
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	16.6	27.8	6.8
Renewable fuels (incl. feedstock)	MJ	1.1	15.3	15.3
Electricity	MJ	3.1	6.6	4.1
Total energy consumption	MJ	20.7	49.7	26.2
Water consumption	g water	3907	5771	822

Health impacts - results



Fiber dust	Animal evidence			Human evidence		Exposure	
	Carcinogenicity		Lung fibrosis by inhalation	Biopersistent	Non-malignant lung disease	Cancer (IARC)	OEL exceeded (Breum et al. 2002)
Inhalation	Injection						
Traditional stone wool	No	Yes	Yes	(No)	No	No	No
HT stone wool	No	No	No	No	No	No	No
Paper wool (Cellulose fibers)	Not tested	Yes	Yes	Yes	Not tested	Not tested	Yes
Flax (Cellulose fibers)	Not tested	Not tested	Not tested	(Yes)	Yes	Not tested	(Yes)

Conclusions



- **The results are comparable, despite the very different nature of the three materials**
 - LCA of agricultural products has inherited difficulties
- **Paper wool has in general the smallest impacts in global and regional impact categories**
- **Stone wool consumes the smallest amount of energy**
- **Flax insulation seemingly performs worst of the three materials**
- **Stone wool is assessed as having the least potential for impacts on occupational health compared to flax and paper wool**

Overall conclusions



- With respect to potential environmental impacts, stone wool and paper wool are seen as the most preferable materials. Flax insulation has the largest impacts of the three materials in most of the impact categories examined in the study.
- HT stone wool seems to be the most tested, well-known and safest choice of the three as regards potential health hazards. Absence of serious potential impacts on human health is seen as an integral part of product quality, and for that adequate documentation is missing for paper wool and flax.
- All three products provide a large benefit to the environment in the life cycle perspective. The quality of the products (their fitness for use throughout their life time) may in the end prove to be the determining factor.

Thanks



- **to the co-authors of the report:**
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