Paludi-tiny house - a demonstrator for climate friendly building materials

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A tiny house built with paludi-materials

The Paludi-tiny house (Fig. 1) was built* in 2020 and incorporates insulation- and building material as well as furniture, made from reed, cattail, alder, and wet meadow grasses. The house demonstrates the use of existing and potential paludi-products "in practice".

Paludi-materials are incorporated within different components of the tiny house:

- **Reed** is used as thatching material on parts of the roof, as well as within insulation boards made of wire bound stems (Hiss Reet GmbH, Fig. 2).
- **Cattail** is used as wall insulation in the form of a cattail board based on *T. angustifolia* leaves being cut and processed into boards using a mineral glue (typha technik Naturbaustoffe GmbH). Further, chaff from *T. latifolia* (Hanffaser Uckermark eG) and pure seed wool (own processing) is used as blow-in insulation.
- **Grass** fibre soft insulation boards based on grass (mainly) from wet meadows (Gramitherm SA) is used as wall insulation.
- **Alder** wood based interior wall plywood panels and a kitchen work surface from solid alder wood (local timber retailer).
- An integrated wardrobe-staircase (Fig. 1) is constructed out of solid fibre boards made from wet **meadow grasses**, **reed** and hemp (in different compositions), with 100% fibre content and no adhesives (ZELFO Technology GmbH).

For more tiny house information see:
www.moor-and-more.de

Fig. 1: left: Paludi-tiny house with thatched canopy, based on steel trailer;
right: coloured furniture fibre boards made from wet meadow grass, reed and hemp.

Fig. 2: paludi-insulation materials in frame construction: reed (left), cattail boards (middle), grass fibres (right).

Tab. 1: Key figures of compared insulation material.

Insulation material	Heat conductance	Bulk density	Weight
	W/m K	kg/m³	kg / m²
Grass fibre soft board	0.035 – 0.04	35	2.54
Reed board	0.055	155	15.50
Cattail chaff	0.04	85	6.16
Wood fibre soft board	0.036 – 0.04	50	3.63
Stone wool	0.034 – 0.04	96	6.96
EPS rigid foam	0.032 – 0.04	20	1.45

*Designed and constructed by SOLE e.V., in collaboration with GMC, funded by German Council for Sustainable Development - Sustainability Culture Fund.

Photos: T. Galke

Carbon footprint of insulation materials and carbon storage

The building materials contribute to a reduced carbon concentration in the atmosphere through:

- reduced carbon emissions from **rewetted organic soils** used for raw material production (compared to drained peatland use)
- **carbon storage** within the building materials, and
- **substitution** of fossil oil based insulation materials.

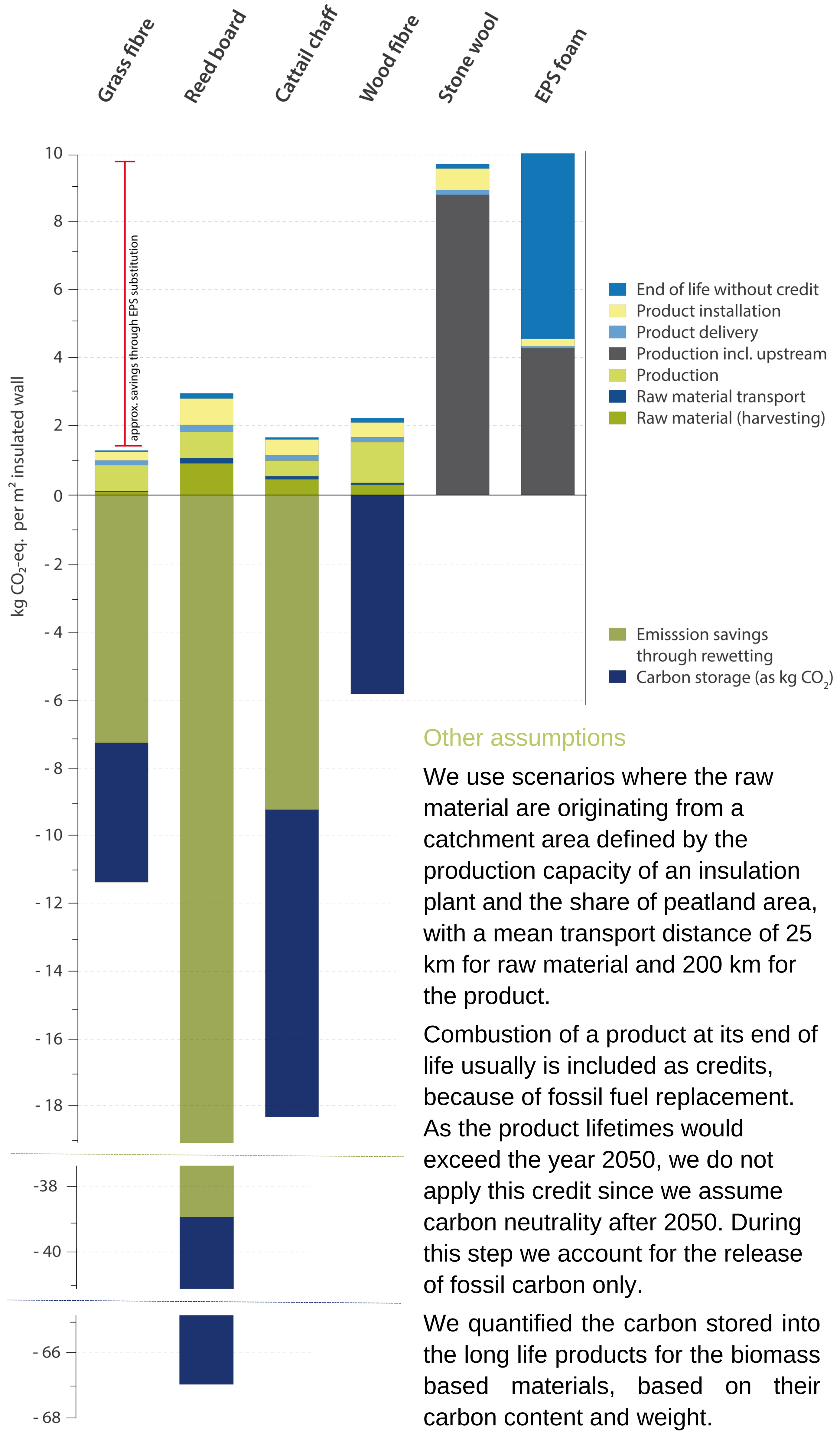
To demonstrate this, we exemplary quantified the carbon footprint of the different insulation material used in the tiny house and compare it to common non-renewable insulation products.

We compare the carbon footprint of grass fibre soft boards, reed boards, cattail chaff, wood fibre soft board insulation (Steicoflex of STEICO SE), stone wool (DEUTSCHE ROCK-WOOL GmbH & Co. KG) and EPS rigid foam for wall and roof insulation (Styropor®). GHG Emission data for the latter three are derived from environmental product declarations.

The comparison is based on **1 m² insulated wall** (Tab. 1). We assume that the same wall structure is used for all insulation materials, thus the carbon footprint is estimated for the insulation materials only.

For the paludi-materials we use emission factors for rewetting organic soils and estimate direct emissions from harvesting, transport, processing, installation and end of life treatment. Establishment of paludi-crops, site maintenance and application of fertilizer were excluded. We also quantify the carbon stored in the biomass based insulation material.

The comparison is based on a rough first estimation with asymmetric system borders. This approach has to be improved in future, but this does not hamper the basic conclusions drawn from the calculations.



Other assumptions

We use scenarios where the raw material are originating from a catchment area defined by the production capacity of an insulation plant and the share of peatland area, with a mean transport distance of 25 km for raw material and 200 km for the product.

Combustion of a product at its end of life usually is included as credits, because of fossil fuel replacement. As the product lifetimes would exceed the year 2050, we do not apply this credit since we assume carbon neutrality after 2050. During this step we account for the release of fossil carbon only.

We quantified the carbon stored into the long life products for the biomass based materials, based on their carbon content and weight.

Results

This first rough estimation depicts the potential for climate friendly insulation materials based on biomass from wet peatlands.

Substituting stone wool or EPS foam by the assessed biomass based insulation materials leads to significant GHG savings (up to ~8.5 kg CO_2 per m² insulated wall). The renewable materials cause far less emissions in almost all life cycle steps.

The carbon storage within the biomass based products is related to the amount of biomass used, and is in the same order of magnitude as the GHG savings through substitution (4 to 9 kg CO_2 per m² insulated wall). For the reed board, it is an order of magnitude higher (28 kg CO_2 per m² wall), because of high biomass input. In total the Paludi-tiny house stores approx. 4,5 t CO_2 in its building materials from renewable resources (paludi-biomass and timber materials).

GHG emission savings through rewetting are dependent on the amount of biomass within the product, and site productivity. The paludi insulations render between 7 and almost 39 kg CO_2 emission reduction per m² insulated wall.

Conclusion

The amount of CO_2 stored in long-life paludi-products is nearly as high as the amount of soil-borne CO_2 emissions reduced through rewetting. Rewetting PLUS processing of paludi-biomass into long-life products results in higher CO_2 reduction. Paludiculture therefore has a stronger climate positive effect, compared to rewetting without further land use.

The reed and cattail insulation considered are made of 100% or near 100% biomass and entail low processing intensity, resulting in low emissions and limited investment needs for processing plants. Thus they seem suitable for local processing with short transport distances for raw materials.

If consumers are willing to pay a 10% price premium for environ-mental benefits of paludi-insulation material, this would result in about 500 to 2.000 € per ha revenue, and could remunerate land user for high water tables.

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