Towards a model for circular renovation of the existing building stock: a preliminary study on the potential for CO$_2$ reduction of bio-based insulation materials

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Global fossil carbon emissions

Reduction of fossil emissions is not sufficient to achieve 2050 targets

Negative carbon technologies for CO$_2$ removal are urgently needed!

Source: IPCC Special Report on Global Warming of 1.5°C (2018)
2nd step: promote carbon removal technologies

CRITICAL ISSUES:
- Technologies are not ready
- Costs way too high (at the moment)
- Space limited (afforestation related issue)
Alternative: carbon storage in buildings

ADVANTAGES:

- Biobased technologies are already available in the market
- Costs are competitive compared to traditional systems (non biobased)
- We have a large demand of construction materials all over the world
Evolution of the Built Environment in the World

Building renovation is a Western problem!

Ex: 38.1 Bm²
New: + 18.8 Bm²

Ex: 29.8 Bm²
New: + 7.1 Bm²

Ex: 18.0 Bm²
New: + 38.0 Bm²

Ex: 19.3 Bm²
New: + 23.8 Bm²

Ex: 8.0 Bm²
New: + 10.0 Bm²

Ex: 15.8 Bm²
New: + 41.8 Bm²

Ex: 57.2 Bm²
New: + 27.4 Bm²

Ex: 9.8 Bm²
New: + 1.3 Bm²

Ex: 9.8 Bm²
New: + 5.1 Bm²

Ex: 19.3 Bm²
New: + 23.8 Bm²

Ex: 5.1 Bm²
New: + 13.0 Bm²

Ex: 2.1 Bm²
New: + 1.3 Bm²

Ex: 15.6 Bm²
New: + 16.7 Bm²
Building renovation in EU

Scie: Pittau et al. 2018
Carbon negative bio-based technologies for renovation

Standard ETICS system

Bio-based (fast-growing) systems
Bio-based technologies for renovation

OFF SITE PREASSEMBLED

- STR
  - I-joist frame with pressed straw

- HCB
  - Timber frame with injected hempcrete

- TIM
  - Timber frame with mineral insulation

ON SITE ASSEMBLED

- HCB
  - Hempcrete block external insulation

- EPS
  - Expanded polystyrene external insulation

SYN
  - BIO
Methodology: MFA + DLCA based model
System boundaries

1. Landfill (DS 1)
2. Energy recovery (DS 2)
3. Recycling (DS 3)
End of life and waste treatment scenarios


BENEFITS BEYOND THE SYSTEM BOUNDARY (module D)
Avoided products/processes
Critical issues of IPCC assessment method

• Biogenic carbon emissions are not taken into account in the GWP.

• Emissions are all considered as impulse at time 0 and GWP evaluated at time fixed time horizon (usually 100 years).

• Timing of emissions is not accounted for.

• Carbon storage in products and uptake are not included in the boundaries (no benefits).
Dynamic LCA principles

Steady-state assumptions

$X$ kg of GHG

Environmental modelling

Impact = $Y$

Positive emissions

Impact = $f(t)$

Negative emissions

$GWP$ $[kgCO_2-eq]$ $\rightarrow$ $\Delta F(t)$ $[W/m^2]$
Results – Cumulative GHG emissions
Sensitivity of the results

Renovation rate:

- 1%
- 2%
- 4%

RBSL:

- 60y
- 40y
- 30y
Final remarks and conclusions

→ **Building renovation** in EU-28 is urgently needed and impacts from material production - mainly insulation - **is not negligible** and can slow down the transition to zero carbon society.

→ **Bio-based materials** can contribute to **remove carbon** from the atmosphere and its large use in construction due to additional insulation required for existing facades is a valuable opportunity that **should not be wasted**.

→ **Fast-growing materials**, such as straw, hemp, etc., regrow fast in the crops and, contrarily to wood, are able to provide the **carbon sequestration** in a very short time.
Thank you very much for your attention!