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Impacts of different End-of-Life process scenarios for bio-based insulation materials on carbon intensity and cost.

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Introduction

The end-of-life (EoL) scenario selected for biobased insulation materials significantly affects their cost and carbon footprint. While landfilling remains a common waste management practice for these materials [2], more information on the impacts of end-of-life options is limited. Yet, the study by Rabat et al. (2022) [2] provides valuable insights into different end-of-life scenarios for bio-based materials and the difficulties preventing applying them, indicating the need for more comprehensive research in this area.

Materials and methods

This work intends to find out how different EoL processing chain scenarios C2-C4 (excepting deconstruction), for 1 m^2 of bio-based insulations influence the impacts of the Financial and carbon cost and carbon intensity along 60 years. Through performing Life-cycle impacts (A-C), Global warming potential (incl. +A2) using the respective environmental declaration products (EPDs) Localised to Europe Energy Profile (Electricity, European Union - 27, IEA2020) for a comparable analysis.

Conclusion

The exploration of the different EoL processing chain scenarios for bio-based insulation emphasize the need for sustainable end-of-life management of landfilled, and recycled bio-based insulations to minimize the environmental footprint. Future research should be directed to explore the other indicators impacts and beyond the system (module D).

Results and discussion

The results indicate that the EoL process scenario can contributes significantly to the carbon density of the insulation as much as the production stage. Especially for hemp, cellulose, and prairie grass, where high percentages of about 80%, 90%, and 70% were reported, respectively (Fig.1). Most of the insulation, including Hemp fiber, Cork, Wood fiber, Wood wool, Prairie grass, and cotton are landfilled at the end of their life, as a common practice (more details in Table 1). Therefore, it contributed to the overall carbon intensity (Fig.2.) and leads to Methane emissions in the air. However, notably, even when recycled, cellulose insulation presents a high EoL impacts contribution, accounting for about 90% of its carbon intensity , consequently resulted in an expensive financial and carbon cost. This implies that although recycling helps reduce the overall footprint, the process itself or the method of recycling used may still have important contribution. In our previous work [2], where cellulose was set for the scenario: Landfilling for inert materials, recorded the lowest Carbon intensity, and moderate financial and carbon cost among the studied insulations. On the other hand, recycled straw offers a lower carbon footprint at the EoL stage than at the production stage.

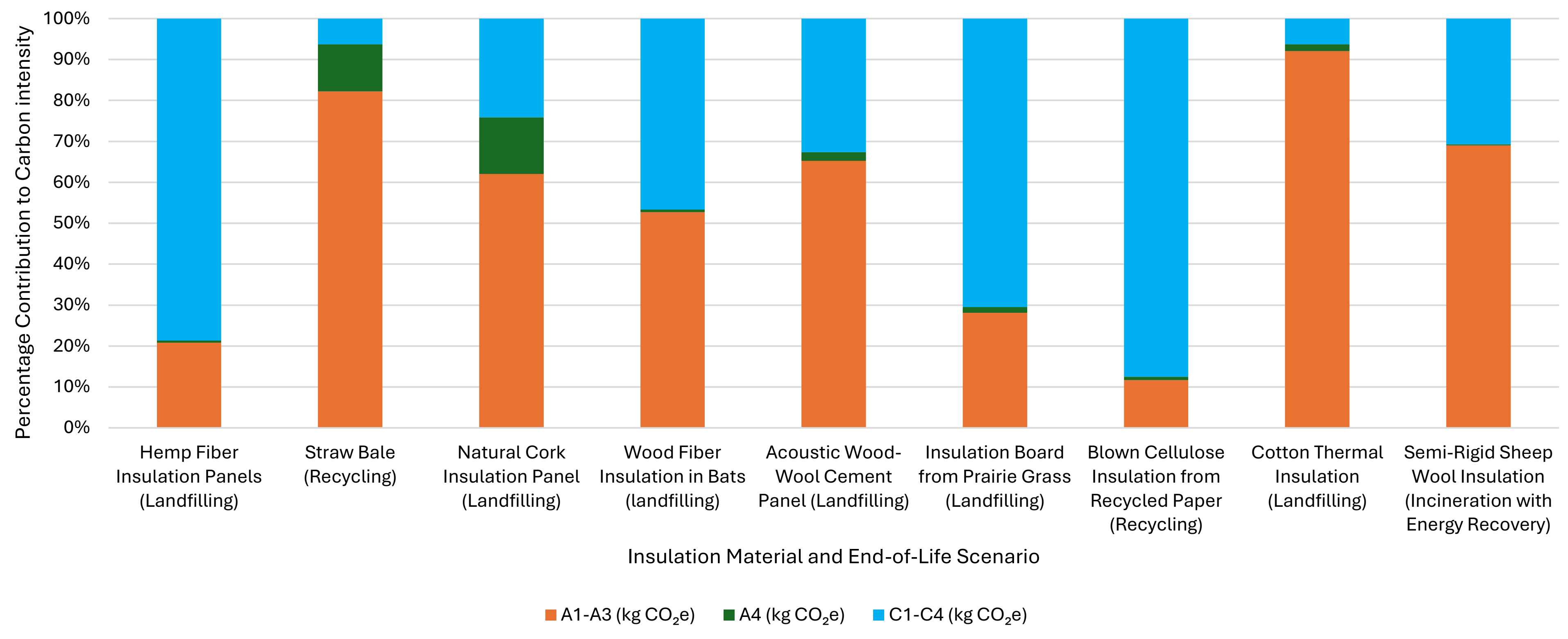

Fig.1. The Percentage contribution of life-cycle stages to the carbon intensity of different bio-based insulation materials

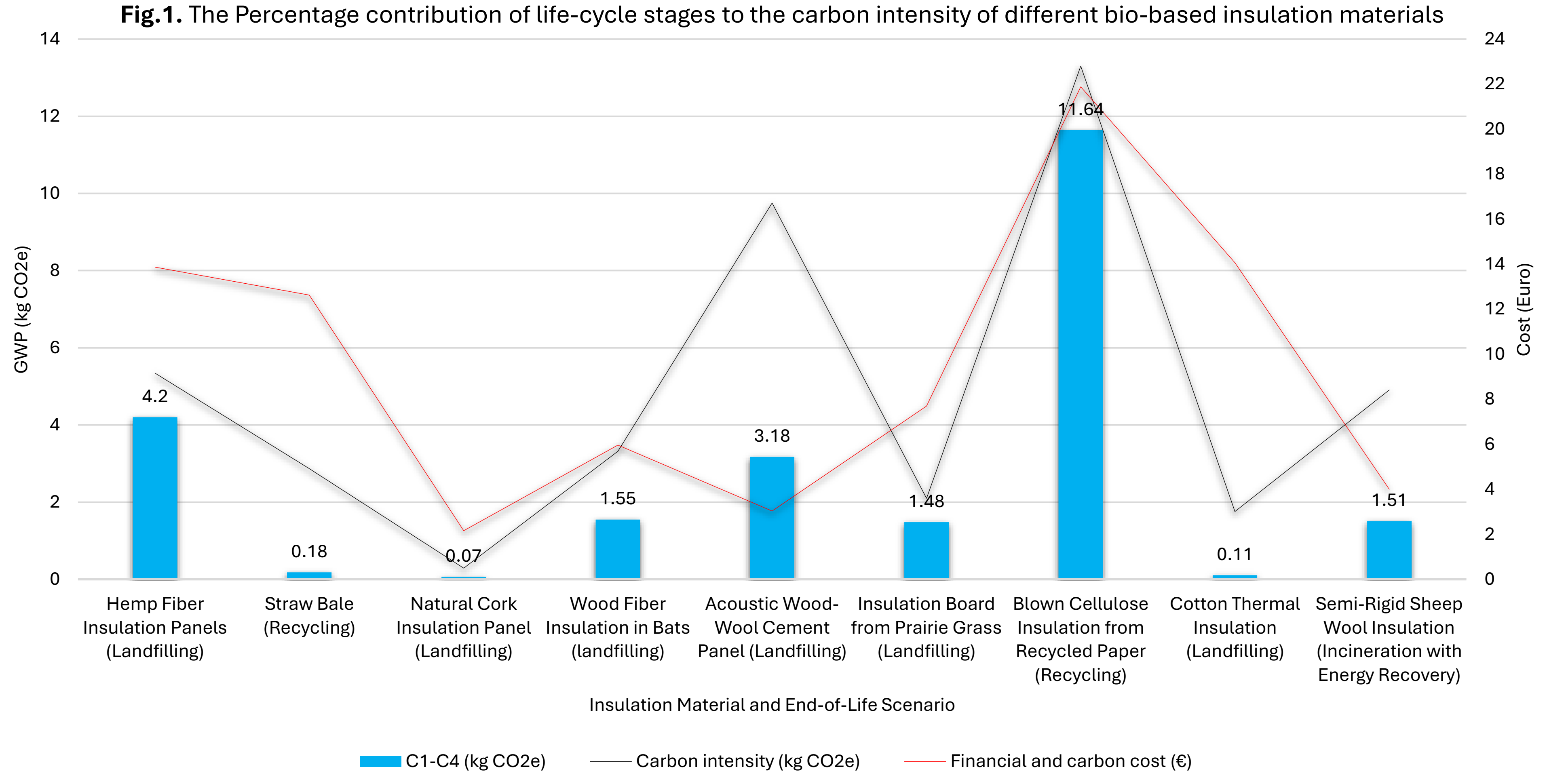

Fig.2. The Percentage contribution of life-cycle stages to the carbon intensity of different bio-based insulation materials

Insulation	EoL process	Details	EPD Number
Hemp Fiber	Landfilling	Manual removal, Transport 30 Km to waste processing site, not specified for reuse or recycling, Complete landfilling	INIES_IYMJ20220822_153947, 30755
Straw	Recycling	In the deconstruction phase (C1), electricity is provided for deconstruction using an electric saw. During the transport phase (C2), the straw is transported to an agricultural valorization site for use as mulch or bedding, while the polypropylene twine is transported to a recycling center or landfill. In the treatment phase (C3), no additional processes are required for the reuse of straw as mulch or bedding; however, electricity is provided for shredding polypropylene for recycling. Finally, in the disposal phase (C4), a portion of the polypropylene twine is stored in a non-hazardous waste storage center.	INIES_ILPN20230414_092401, 33929
Cork	Landfilling	Manual demolition, Transport modeled for 50 km distance, No recovery of the material, Landfilling	S-P-02315
Wood Fiber	Landfilling	Part of complete building demolition, Transport 50 km to disposal site, entirely landfilled without reuse, recycling or recovery, amounting to 1.6 kg. Degradation rate of landfilled wood fibers: 15%.	INIES_IFMH20211126_093805, 32513
Wood-Wool	Landfilling	Waste destined for entire landfilling (100%): 13.1 kg. 6,82 kg of biogenic CO_2 remain in the product.	EPD-KNA-20200028-IBA1-EN
Prairie Grass	Landfilling	Manual deconstruction, transport to the landfill site at 50 km, the insulation is entirely landfilled. Non-hazardous waste is disposed of 100%.	INIES_IPGN20210903_100307, 28874
Cellulose	Recycling	Manual removal (7.97kg collected with mixed construction waste), Transport to recycling facility 100 km. 100 % recycled as the product is equipped with a granulation line where part of the recovered cellulose can be reprocessed.	INIES_IOUA20200127_133857, 29452
Cotton	Landfilling	Part of complete building demolition (2.50 kg (100% of cotton wool) collected for landfilling), Transport to disposal site modeled for 50 km, No reuse, recycling or recovery, Complete landfilling of cotton wool waste. It is assumed that 90% of the biogenic carbon remains non-degraded. The remaining 10% of the biogenic carbon is converted into CO_2 and CH_4 and released into the atmosphere.	INIES_IIMV20231114_172840, 35681
Sheep Wool	Incineration with Energy Recovery	Manual dismanteling, Demolition debris, which includes the sheep wool insulation, is transported to a designated recovery center. The transport process encompasses two distinct journeys: a shorter route covering 50 km to a recycling center and a longer 100 km journey to an incineration facility. 95% of the product is directed towards incineration where energy recovery is implemented. The remaining 5% of the product is landfilled.	23.0173.001-01.00.01

Table 01. Details of the Insulations EoL process scenarios as defined in their respective EPDs

References

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2. S. Zerari, R. Franchino, and N. Pisacane, "Cost and Carbon Intensity Analysis of Different Bio-based Insulation Materials across European Countries," E3S Web Conf. (to be published)