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Assessing the opportunity for producing hemp-based insulation in the Australian market

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Abstract

By-products (wastes or residues) of renewable materials have the potential to be manufactured into higher value fibre insulation products for the Australian market. Currently, such products have been imported for servicing the Australian market. This presents a potential opportunity to divert considerable quantities of waste from landfill and produce a high performance, locally made, low carbon, natural fibre insulation product for the Australian domestic and commercial building industry. This article assesses the hemp-based bulk insulations available in the Australian market.

Keywords

Australian market, Renewable material, Industrial hemp, Fibre, Thermal insulation

1. Background

1.1 Industrial Hemp Cultivation in Australia

Industrial hemp is a variety of the *Cannabis sativa* plant species that is grown only for industrial uses with very low levels of tetrahydrocannabinol. The entire plant has a variety of applications with fibres of the hemp plant used to make various high-value products including textiles, rope, paper clothing and insulation. Australia's emerging industrial hemp industry is particularly promising for its fibre applications and is well-suited to the country's diverse climatic conditions. Funded in part by Agri Futures Australia and regional agencies, specialized strains are being developed for optimal fibre yield in the Australian environment. Despite the suitable climate and strong existing agricultural industry in Australia, hemp cultivation is in its relative infancy with the total market Gross Value of Product (GVP) estimated to be around AU\$6 M in 2019 (Jefferies, 2022).

Hemp fibres, including the inner "hurd" and outer "bast" have a wide range of uses, from construction materials like hempcrete to textiles. The fibres are also internationally used in the production of sustainable insulation materials, offering a more sustainable and user-friendly alternative to traditional options.

1.2 Insulation Industry in Australia

The insulation industry in Australia offers significant contributions to energy efficiency, environmental sustainability, personal comfort, and health, as well as economic growth. The sector is crucial for advancing sustainable building practices across the country. The 2022 National Construction Code (NCC) revisions, requiring a minimum of 7 Stars in the National House Energy Rating Scheme (NatHERS) for residential dwellings, and are set to mandate sustained future demand for insulation between 2023 and 2025 with many new homes requiring up to 50% more insulation to meet the new requirements (Christopher, 2021). This increasing focus on energy conservation and sustainability underscores the value of insulation in the Australian context.

Australia's insulation industry comprises an array of products, including loose fill, insulation batts and rigid insulation panels as well as installation services and related equipment. According to industry reports, the market size for insulation in Australia is valued at approximately AU\$960M per year for both residential and commercial sectors (IBISWorld, 2023). This valuation considers new construction as well as retrofitting and upgrading existing insulation systems.

In the context of sustainable materials, Australia's hemp industry offers an environmentally friendly alternative to traditional insulation materials. Hemp fibres are a renewable resource, and their cultivation has less impact on the environment compared to other crops. Hemp fibre insulation not only supports waste reduction but also aligns well with green building initiatives.

Utilizing hemp fibres in insulation manufacturing opens the door to high-value, eco-friendly products for both domestic and commercial building projects in Australia. Unlike existing insulation waste, which presents several environmental and disposal challenges, hemp fibre is fully biodegradable and does not require harmful chemical treatments. By sourcing these fibres locally, the industry could produce sustainable,

Australian-made insulation materials. Currently, there is no natural fibre insulation panels production in Australia with hemp, jute and timber fibre insulation panels imported from Europe and North America.

This article assesses the opportunities associated with the manufacturing of hemp-based insulation products in Australia based on the existing insulation market focusing on residential construction.

2. Objectives

1. Investigate and summaries existing hemp fibre insulation products in the global marketplace,
2. Summarize the use of hemp fibre insulation applications in the Australian construction industry,
3. Investigate the potential for different Australian feedstock materials,
4. Assess the potential availability and cost of the shortlisted feedstock in Australia,
5. Assess the cost of production for hemp fibre insulation products in Australia and compare them with existing insulation products.

Processing and machinery requirements were beyond scope for this techno-economic assessment.

3. Hemp Insulation overview

Hemp insulation is currently produced by a range of manufacturers predominantly based in Europe and North America with all hemp insulation products in Australia currently imported. This article will focus on existing hemp insulation products on the market with the assumption that comparable products could be produced with Australian grown and processed hemp.

These bast fibres from hemp are best suited for thermal insulation (Kymäläinen & Sjöberg, 2008). Hemp insulation is made by first harvesting the plants (after they have gone to seed) followed by a process called retting, whereby stalks break down to aid in separation of the fibres to the inner woody core. Decortication then processes the stalks to separate the bast fibres from the hurd which is subsequently cleaned, sorted, and shredded where necessary. Finally, the fibres are mixed with binders and fire retardants and formed into insulation batts which can be done using a variety of methods including compression moulding, wet laying, air laying and needle punching. The final products exhibit a range of thermal and mechanical characteristics, which vary based on the type of binders and additives used, as well as potential blending with other fibres like cotton, polyester flax, or jute.

3.1 Hemp Insulation Properties

Hemp based insulation typically has the following characteristics which can vary as proportions of other additives and fibres are blended (ThermoNatur, 2022):

- Non-carcinogenic and do not contain formaldehyde or isocyanate,
- Often bio-degradable,
- Recyclable,

- Normal flammability with a rating of B2, Class E in accordance with EN 13501-1:2007 making it appropriate for class 1 buildings (standalone dwellings) in Australia (excluding party walls).

Table 1 summarizes the key properties of different common blended hemp insulation products. Here, a variety of blends with both natural and synthetic fibres can achieve consistent thermal conductivity in the range of 0.038 to 0.043 W m⁻¹K⁻¹ which as discussed later in this paper is on par with traditional insulation products.

Table 1 Properties of common flexible insulation products (Latif et al., 2014)

No.	Density (kg m ⁻³)	Constituents	Thermal conductivity (W m ⁻¹ K ⁻¹)
1	55	30% Hemp fibre, 60% wood fibre, 10% polyester	0.038
2	50	85% Hemp fibre, 10–12% bi-component fibres and 3–5% soda	0.038
3	60	95% Hemp fibre and 5% combination recycled adhesive binder	0.043
4	39	95% Hemp fibre and 5% combination recycled adhesive binder	0.039
5	45	35% Hemp fibre, 35% recovered waste cotton fibre, 15% bi-component polyester fibre and 15% fire retardant	0.039

3.2 Comparison with Existing Insulation Products

Table 2 details how hemp-based insulation products compare to the most common other types of insulation in the Australian market. Hemp is similar with respect to thermal conductivity and has good vapour permeability aiding in its ability to maintain healthy, condensation free buildings. The fire resistance of hemp-based insulation is a key weakness, with additives required to reduce smoldering and fire risks (Kymäläinen & Sjöberg, 2008). This limits the applications of hemp-based insulation products to those that do not require non-combustibility, such as detached residential housing. Notably, there are no specific requirements for personal protective equipment (PPE) during installation, unlike fibreglass, rockwool and EPS insulations. One factor, however, that is not evident in most research articles is the necessity to cut the hemp-based insulation to size when installing. The strength of the fibres means that utility knives or

Table 2. Overall comparison for hemp vs. other insulation materials costs adjusted for the Australian Context (Altin & Yildirim, 2022; Kymäläinen & Sjöberg, 2008)

Insulation Materials	Hemp based	Sheep Wool	Fiberglass	Rock Wool	EPS	Wood Fiber
Heat Conductivity Factor (W m ⁻¹ K ⁻¹)	0.038-0.050	0.035-0.040	0.03-0.04	0.025-0.042	0.030-0.040	0.040-0.050
Water Vapor Diffusion Resistance Coefficient	2	1	3	2	100	1-5
Hygroscopicity % 100 RH	20	35	0	0	0	15-30
Fire Resistivity	Middle	Excellent	Good	Excellent	Low	Middle
Cost	High	High	Low	High	Low	High
Air Pollution Filter	Middle	Low	Middle	Middle	Very High	Middle
Measures to be Taken During Utilization	None	None	Mask, Gloves and Special Clothing	Mask, Gloves and Special Clothing	Mask, Gloves and Special Clothing	None
Raw Material	Natural	Natural	Natural	Natural	Synthetic	Natural
Costs of Transport	Middle	Middle	Low	Low	High	Middle
Sound Insulation	Middle	High	Middle	Middle	High	Middle
Moisture Resistance	High	Very High	Low	Middle	Very High	High
Recyclability	Yes	Yes	No	No	Challenging	Yes

shears are less effective, which adds time to an install where custom batt sizes are required.

For this investigation, a typical hemp insulation branded “Thermo Hemp Premium” manufactured by KOSP made up of 85-90% hemp fibres (with the balance polymeric fibres and fire retardant) was selected. As shown in Fig. 1, prices for this insulation product in Australia are much higher than the current market leaders Glass wool and Earth wool. This is a function of a range of factors, firstly hemp-based insulation products in Australia are imported (typically from Europe) with distributors charging extra for both shipping and margins. Costs are further increased because hemp bast fibre is double the cost of mineral wool fibres in Europe (Kymäläinen & Sjöberg, 2008). When comparing to other natural fibre insulation products in Europe hemp insulation is also slightly more expensive, averaging 10-40% more than similar timber fibre insulation products.

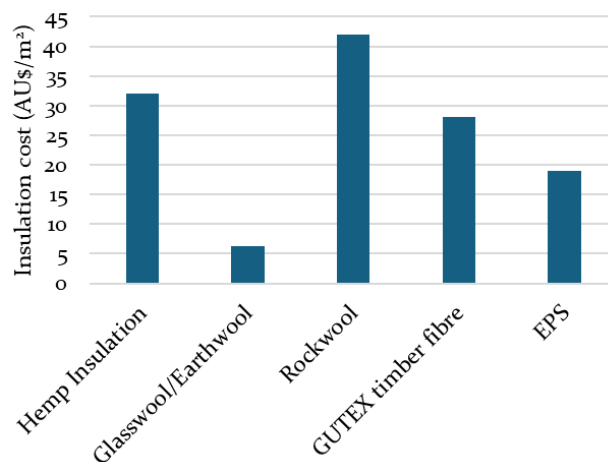


Fig. 1 Cost comparison for typical insulation relative prices adapted from Kymäläinen & Sjöberg (2008) and Pricewise Insulation (2022)

From an ecological perspective, there is very little data relating to the embodied energy or emissions associated with hemp insulation, most likely because of its relatively low market share. Hemp insulation products are likely to fair well relative to synthetic and mineral-based insulation products because of their storage of biogenic carbon, ability to be grown in a range of different climates (meaning less transportation distance) and relatively low temperatures for production.

4. Volume and Feedstock Assessment

Industrial hemp for fibre production has been found to yield approximately 1050 kg ha⁻¹ of hurd (Pasila, 2004). In Australia this it is estimated that in 2022 approximately 1000 ha of biomass area is planted (Gordon, 2023). As such this would yield approximately 1,050 t of hurd annually in Australia. Using typical hemp batt insulation densities as detailed in Table 1 this would equate to the production of 263,000 m² of R 2.0 m2K W-1 insulation batts (typical for external wall insulation) or 131,500 m² of R 4.0 m2K W-1 ceiling insulation batts. With typical insulation requirements this would insulate just over 500 new homes in Australia each year which is around 1% of new homes build Victoria each year (CSIRO, 2023).

When comparing to other natural fibre insulation feedstocks, such as timber fibre residues hemp makes up a mere 0.2% of the largest timber producer 's byproducts in Australia (Christopher et al., 2022). This significant volume disparity highlights the relatively early stages of the hemp fibre industry relative to other more established industries.

Estimates put the 2022-23 value of processed Hurd at around AU\$1500 per ton (Gordon, 2023). Using typical the density of hemp insulation this equates to approximately AU\$6.00 per m² for R 2.0 m2K W-1 insulation batts or AU\$12.00 for R 4.0 m2K W-1 insulation batts in raw feedstock costs. These figures do not include any of the subsequent processes, addition of other fibres or additives required to produce insulating batts. This is a significant cost per when compared to other insulation products on the market, as shown in Fig. 1 where earth wool is currently just over AU\$6 per m² of R 2.0 m2K W-1 for a final retail product. The figure of AU\$1500 per tonne would likely reduce as processes scaled with typical prices, where in the US costs have been typically closer to AU\$1000 per tonne (United States Department of Agriculture, 2022). If this figure is to be compared to the timber industry byproducts such as pine chips, then there is still a significant discrepancy with the wholesale value of timber products in the AU\$40-\$50 per tonne range. Consequently, despite hemp hurd requiring less processing than timber residues, its feedstock value is nearly 20 times greater as shown in Fig. 2.

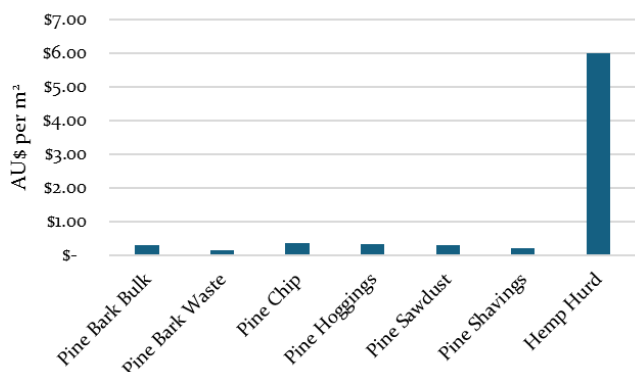


Fig. 2 Feedstock value in final insulation product (Christopher et al., 2022)

This analysis clearly indicates that hemp hurd based insulation has a significantly larger feedstock cost than comparable natural fibres such as timber fibres, however it is important to contextualize this relative to the cost of a new home. The Australian Bureau of Statistics estimates the average size of a new home in Australia in 2019 to be 230 m² (Australian Bureau of Statistics, 2020). A typical home of this size, founded on a concrete slab, would require approximately 210 m² of R 4.0 m2K W-1 ceiling batts and 170 m² of R 2.0 m2K W-1 wall insulation batts. Using the previously cited hurd costs and insulation density, this would equal about AU\$3,900 in hurd feedstock costs for insulating each new home, compared to a mere AU\$130 if the home were to be insulated using timber fibre insulation. This additional cost represents approximately 1.2% of the total average home construction cost of AU\$320,200 in 2019. Customers will ultimately need to decide if the benefits of selecting hemp insulation outweigh the significant additional expense.

5. Conclusions

The Australian hemp industry is in an emerging phase, well-suited for the diverse climatic conditions of the country. With properties like biodegradability, recyclability and user-friendly installation experience, hemp fibres offer an eco-friendly alternative to traditional insulation materials, aligning well with Australia's focus on sustainability and green building initiatives.

Given the revisions in Australia's National Construction Code (NCC) in 2022, which requires enhanced insulation standards, it is expected that there will be a sustained future demand for insulation products. This opens doors for high-value, eco-friendly hemp insulation products in the residential construction sector.

Hemp insulation competes well with traditional insulation materials in terms of thermal conductivity and offers added benefits, such as vapor permeability and absence of harmful chemicals. However, it falls short in terms of fire resistance, which limits its applicability to specific types of detached residential structures.

Australia is currently import dependent for all hemp-based insulation products from Europe and North America. This presents an opportunity for local manufacturing using Australian-grown hemp, which could offset the higher costs associated with importing. However, the cost of hemp-based fibres far exceeds comparative natural fibres such as timber, highlighting the challenges with building a business case to produce hemp-based insulation products. This coupled with a very low production capacity of slightly over 1000 t of biomass in Australia highlights the relative immaturity of the hemp industry and subsequent insulation opportunities.

While this report covers a range of important facets, it does not delve into processing and machinery requirements to produce hemp-based insulation. A further study could provide a comprehensive techno-economic analysis to ascertain the viability of producing hemp insulation domestically at a small scale.

Overall, hemp insulation presents an exciting, albeit challenging, opportunity for Australia's construction industry. Careful attention to aspects like cost, fire resistance, and local manufacturing could make it a viable and sustainable option for the future.

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