

# **Hemp lime construction and Carbon storage**

**Low energy, high biomass,  
Green building materials**



**Australian Hemp Masonry**  
[hempmasonry.com.au](http://hempmasonry.com.au)



## **Victorian Hemp Crop**

Industrial hemp fibre crop at 2 weeks



## **Ashford, Central Western NSW**

4 – 5m plants, minimal irrigation (1/3 water compared to lucerne), sustainably farmed (pigs free ranged the site prior to planting)



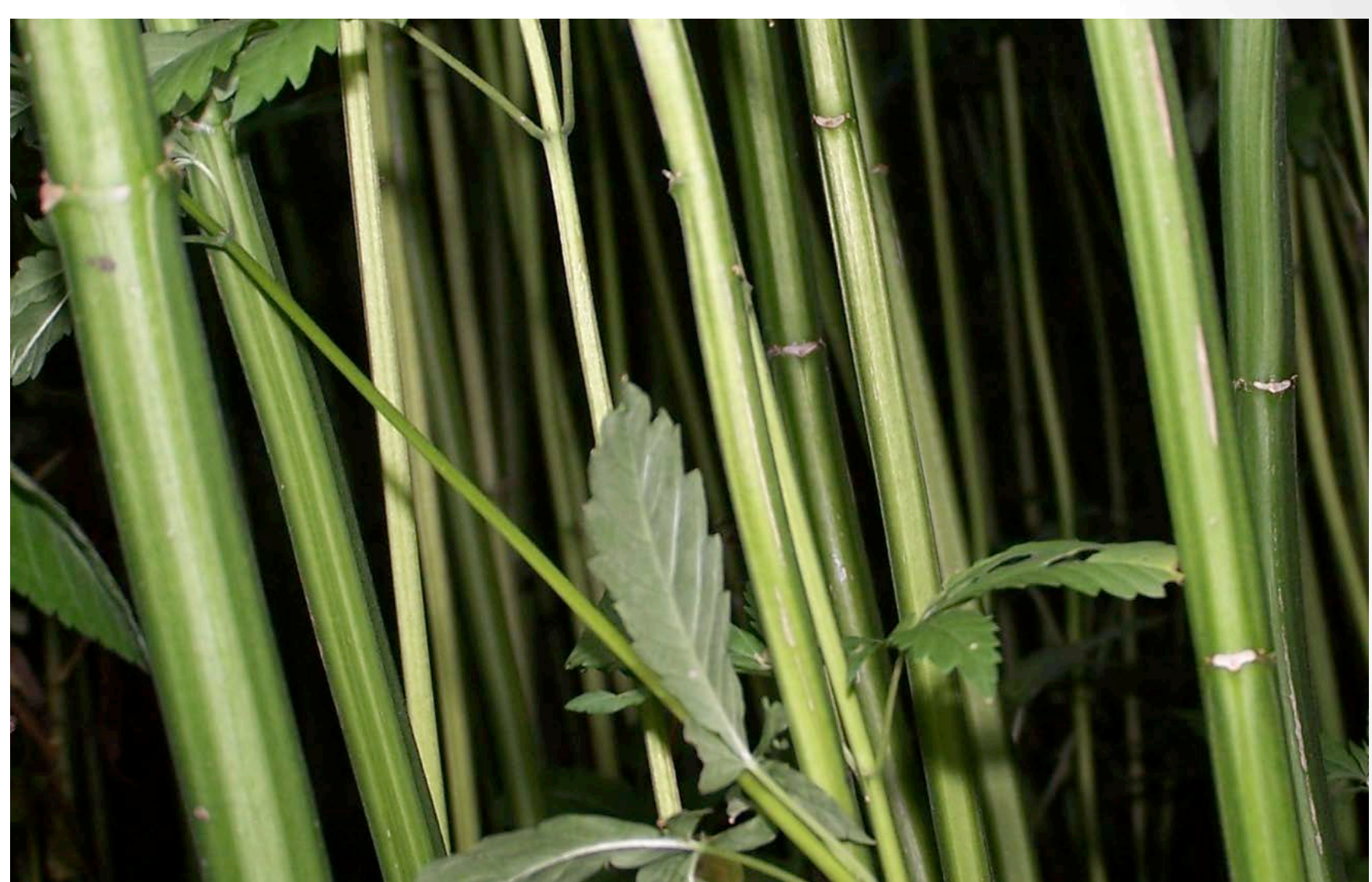
## **Dungog, NSW Hunter Valley**

Dungog Growers Group formed and Dungog Mill established 2015

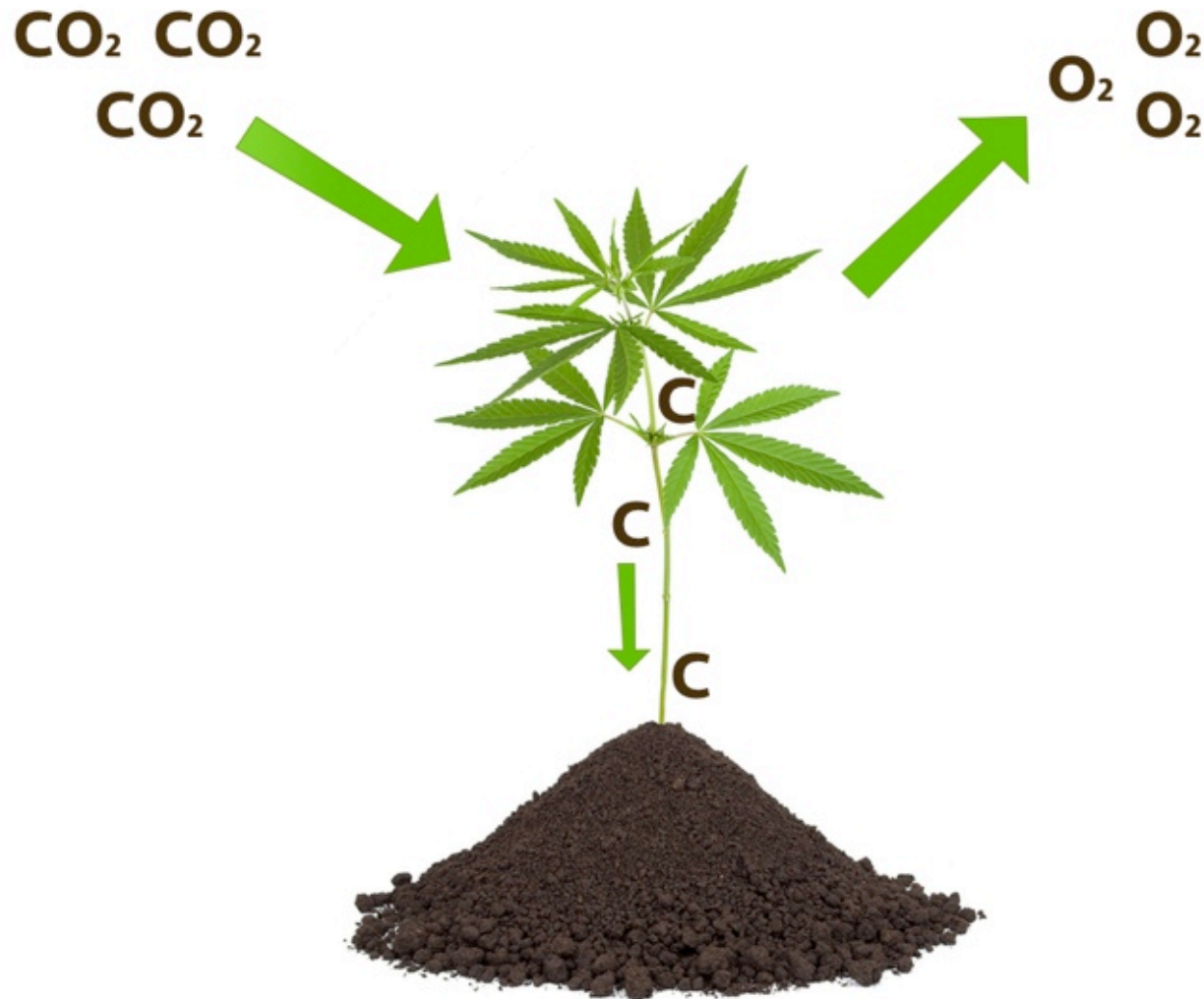


## **Dryland crop Tatham, Nth NSW**

Crop at 6 weeks planted in good subsoil moisture. Despite no further rain and 2 severe hailstorms which destroyed neighbouring soy crops, the crop produced 2 - 2.5 plants.

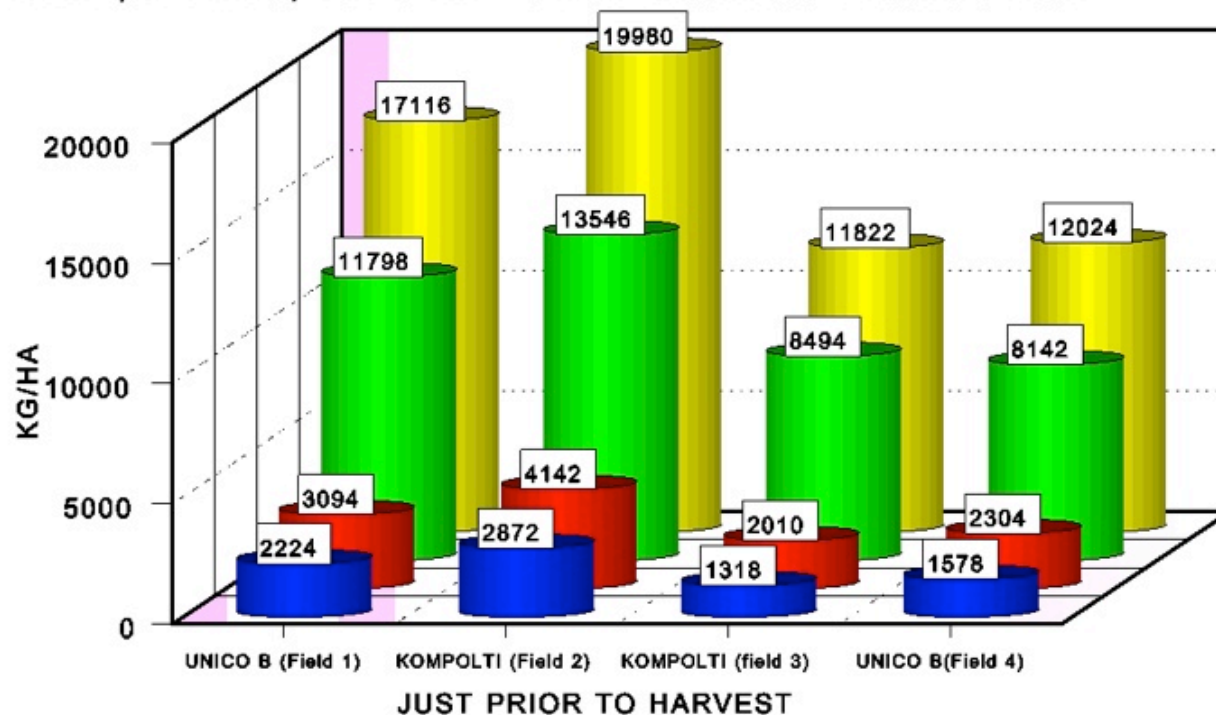


**Minimum planting rate for fibre is 40 Kg seed minimum per hectare to encourage growth of branchless woody stems rather than leaf**



- Hemp is one of the most effective carbon sequestering plants. Locking up more than 15000kg of  $\text{CO}_2$  per hectare in just 90 – 100 days

## HEMP, LEAVES, TOPS AND STEM BIOMASS PRODUCTION



Courtesy of Gordon Scheifele, M.Sc et. al  
1996 Hemp Trials Ontario, Canada

The stems, particularly the hurd store the bulk of the carbon. This can then be permanently locked up in building materials

# Existing research

Information based on data from the three major French producers

(LCDA, PDM industrie and Eurochanvre)

- Each tonne of hemp produces 60% shiv or hurd, 25-30% bast and 10%-15% fines and dust.

- Av production is 8-10 tonnes per ha

- Carbon dioxide or carbon uptake required to create one kilogram of dry material is equal to 1.7 kg of CO<sub>2</sub>.

Sylvie Pr'etot, Florence Collet, Charles Garnier, *Life cycle Assessment of Hemp Concrete Wall : Impact of Thickness and Coating*. Building and Environment, Elsevier, 2014, 72C, pp.223-231.

## *Australian variations*

- *Av production is 12-15 tonnes per ha*
- *Different cultivars are used for fibre production producing greater biomass*
- *Tertiary treated effluent irrigated crops have given yields of 22 tonnes per ha*
- *Dryland crops equal EU production rates*
- *Exceptionally hardy crop*

## Potential carbon sequestration of hemp biomass (based on 1.7 kgs carbon dioxide per kg of Hemp)

### Europe

- Yield 8 -10 tonnes per ha
- $1.7\text{kgs} \times 8,000 = 13,600$   
Kgs or 13.6 tonnes per ha
- $1.7\text{kgs} \times 10,000 = 17,000$   
kgs or 17 tonnes per ha

### *Australia*

- *Yield 12-15 tonnes per ha*
- $1.7\text{kgs} \times 12,000 = 20,400$   
*kgs or 20.4 tonnes per ha*
- $1.7\text{kgs} \times 15,000 = 25,500$   
*kgs or 25.5 tonnes*

# Soil carbon, remediation and soil improvement

- UK research 1 tonne carbon is added to the soil per hectare from:
  - a) continuous leaf drop
  - b) long taproot
  - c) stubble

Highly suited to organic agriculture, and significantly less “ecotoxic” across 26 criteria in comparison to many other major crops

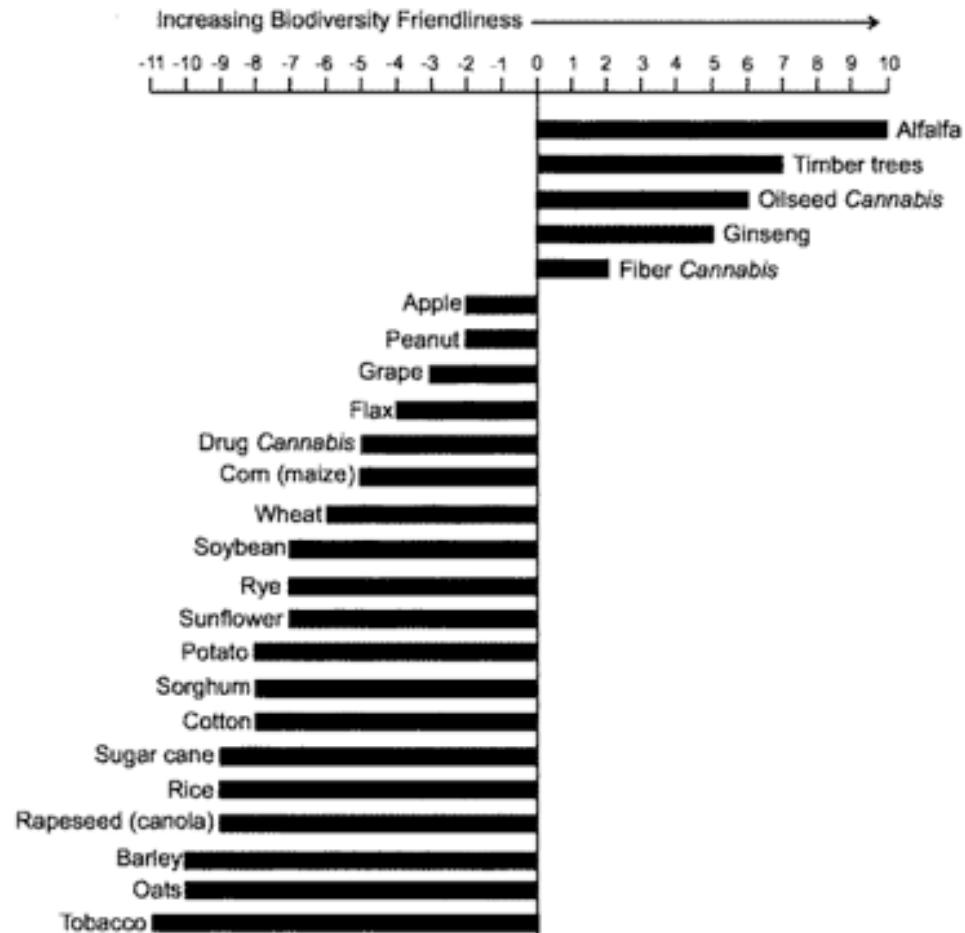
(<http://www.hort.purdue.edu/newcrop/ncnu02/v5-284.html>)

- Belgian Nuclear Research Centre findings: Hemp and flax recommended for remediation of irradiated soils

(<http://www.sciencedirect.com/science/article/pii/S0265931X05000160>)

- Polish Agricultural University, Poznan: Removal of heavy metals from anaerobic sewage sludge

(<http://www.pjoes.com/pdf/12.6/779-784.pdf>)

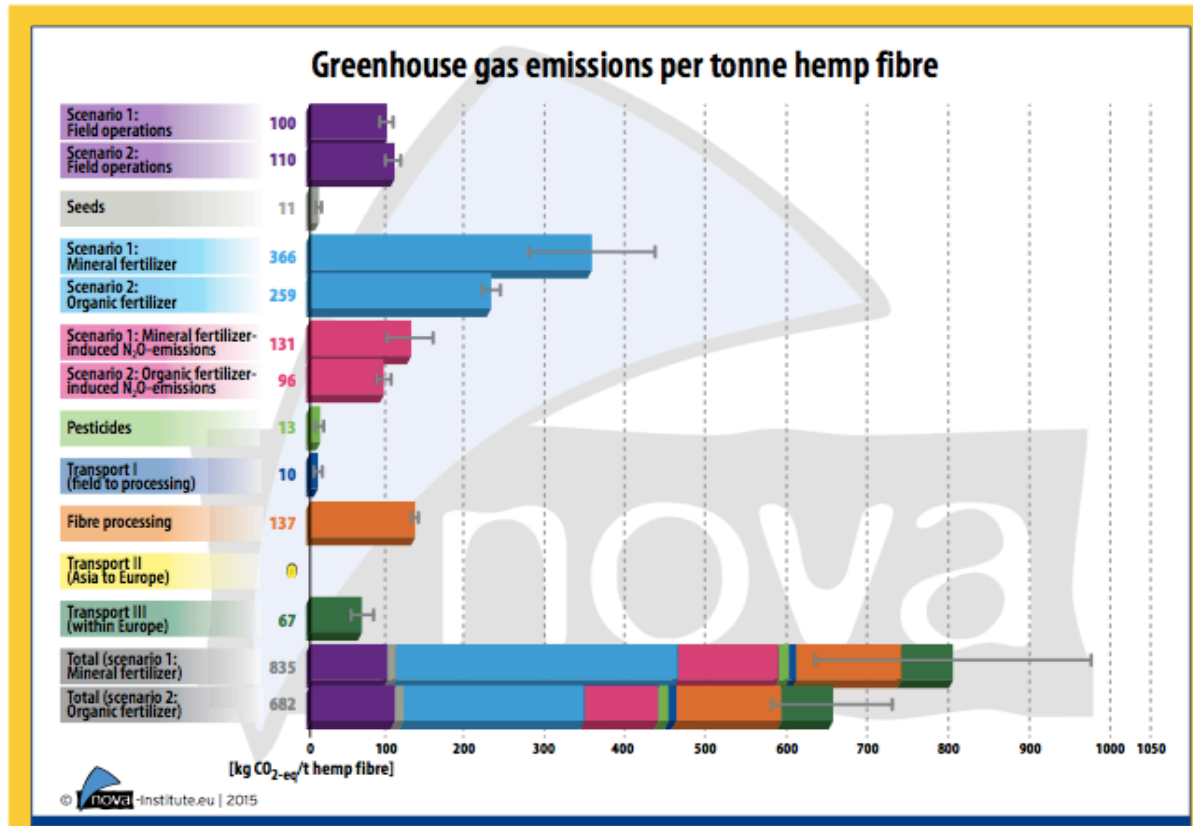


Small, E. and D. Marcus. 2002. Hemp : A new crop with new uses for North America. p. 284–326. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

<http://www.hort.purdue.edu/newcrop/ncnu02/v5-284.html>

## · Life Cycle Analysis and hemp building materials: What needs to be considered?

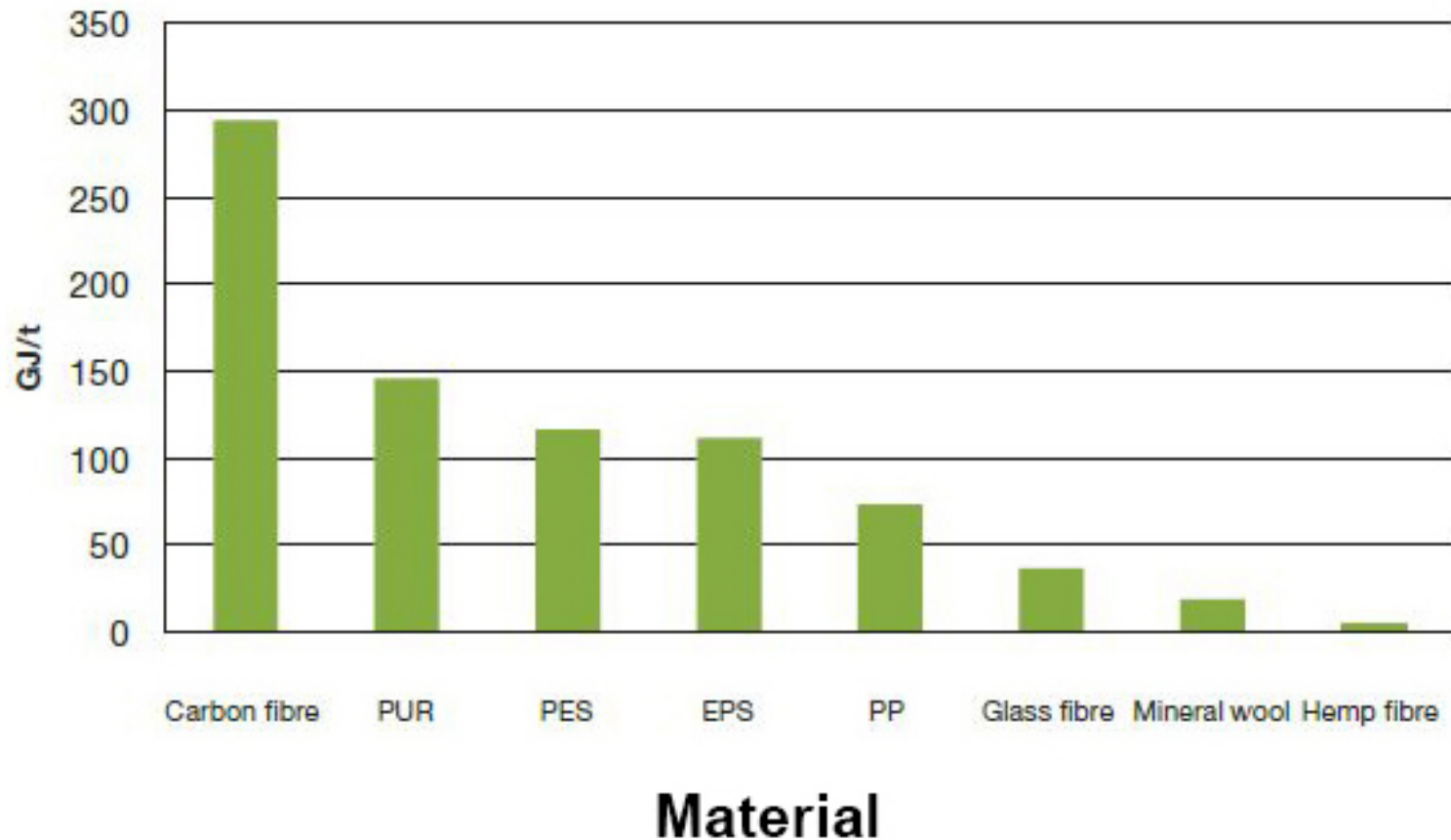
- Farming including soil preparation, fertiliser use, harvesting and processing
- Freight
- Quantity and binder materials
- Creation/production of building material
- Waste
- Durability
- End of life or recyclability
- Performance – energy efficiency
- Performance – air quality and health
- Comparison with impacts of other materials



Assessment of 1 tonne of hemp fibre cultivated in Europe and moved 300km to the factory gate to a non-woven producer in Germany demonstrated that in the production of hemp, the highest footprint in the cradle to cradle analysis is from mineral fertiliser use (835 co<sub>2</sub>-equiv Kg/tonne) compared to use of organic fertilisers (682 co<sub>2</sub>-equiv Kg/tonne).

**Carbon Footprint and Sustainability of Different Natural Fibres for Biocomposites and Insulation Material (Nova Institut, 2015)** [www.bio-based.eu](http://www.bio-based.eu)

# Energy Required to Process



Comparative assessment of hemp processing for insulation matting and biocomposites with other currently used materials.



## **What the fibre farmer is producing**

Partially processed industrial hemp fibre  
Bast fibre (outer) and hemp hurd (woody core)



**Processed hemp hurd used for construction of walls and for insulation**

Material needs to be dust free, dry and bast should be removed.

## Hemp lime and the Binders

- Globally the majority of available binders for hemcrete are lime based.
- Depending on the country of origin the lime is hydraulic or hydrated.
- Most are produced in the England, Ireland and France.
- AHMC produces a lime-based Binder in Sydney.  
R&D UNSW
- *Hydraulic lime, available in Europe is sourced from the edge of lime fields and contains other minerals in varying quantities. Dependent on the materials in the lime it is heated to temperatures between 900C and 1400C.*
- *Hydrated lime is available on all the major continents in the world and on some islands. It is heated to 900C.*



## **Hemp lime building materials**

High volumes of carbon lightly coated with a lime Binder.  
A low embodied energy masonry material.

# Performance characteristics of Hemp lime materials

- High volume use of a readily renewable resource
- Low embodied energy
- Excellent thermal performance
- Mitigates humidity well
- Excellent acoustic performance
- Breathable walls
- Does not encourage mould growth
- High flexural strength
- Zero waste
- Non combustible
- Lighter than most masonry materials
- Airtight construction
- Can be retrofitted –combines well with other materials
- Used in historic buildings to manage problems with moisture in walls
- Recyclable and reusable
- Performs as an effective carbon sink
- Easy building skill to transfer – socially beneficial

# Hemp's uses in varying forms as insulation in roofing, flooring and walls

- Most common current use – external walling. Minimum 200 – 250mm which is generally rendered externally.
- Internal walling minimum 150mm thick
- Architects vary wall thickness dependent to the climate zone
- Walling R2.85 – 200mm, R3.55 250mm, R4.25 300mm
- Insulation R2 – 100mm, R3 – 150mm, R4 – 200mm



# Two-storey studio, Kyneton, Victoria

1 sq m 'truth' window

Lime rendered hemp lime walls





300 year old hemp building, Miasa Mura Japanese National Trust.

# Carbon storage and Hemp lime construction

- 48 sq m cabin (walls only)  
approx 1 - 2 tonnes hurd (7  
pallets 2m high), 1.5 – 2.5  
tonnes Binder.
- 
- Larger home 4 – 6 tonnes hurd
- Marks and Spencer (world's first  
carbon neutral retailer) 210,000ft<sup>2</sup>  
building saving 360 tonnes of  
emissions
- *Carbonation – a slow curing  
process achieved through the  
drawing in of carbon on an  
ongoing basis from the  
atmosphere.*
- *Full carbonation process  
thought to be approx 50 years*



## **Adnam's Brewery and Distribution Centre**

2400 sqm Hemp lime building with sebum roof. 500mm thick walls. Requires no refrigeration. Temperature constant at 12 to 13 degrees C



## Social Housing – The Triangle, Swindon UK

43 Hemp lime homes with community gardens



## **Award winning large objects store for London Science Museum**

Hemp was installed to mitigate humidity that detrimentally affects metal objects and archival materials



## **CDL Green Gallery and Heritage Museum**

UNESCO World heritage listed Singapore Botanic Gardens  
Australian Hemp lime materials and living walls

# Singapore's first zero energy building

## Modular steel construction



The hemp wall is supported on an L beam and tied into the steel with purlins





## **Owner built cottage**

Bateman's Bay, NSW



## **Hemp home, Hazelbrook, NSW Blue Mtns**

Rendered external walls and partially rendered walls sealed with a clear breathable sealant

# Retrofit - Deep Ecology Centre, Maclean NSW

Internal walls are unrendered other than around windows and doors





## **Retrofit Canberra**

40mm thick uninsulated gyprock walls replaced with 120mm hemp lime for acoustic and thermal insulation.

## UK Renewable House Monitoring Project, April 2015

- 2009 -10, UK Government's Low Carbon Investment Fund (LCIF) invested £6.3m to support the construction of 283 low carbon affordable homes built with a range of innovative, highly insulating, renewable materials. The findings from a subsequently funded 2 year monitoring project reported:

*“the insulating properties of hemcrete mean that **heating plant can be reduced in size, reducing corresponding energy consumption and carbon emissions, which could be in the range between 50% and 80%** lower than in buildings with conventional brick and block construction insulated to the same U-value as the hemcrete construction.*

*The **lower energy demand in-use, combined with the negative embodied carbon footprint (carbon sequestration potential) of the hemcrete structure at -4.3 tonnes CO2 (compared with +10.7 tonnes CO2 for brick- block house of same dimensions)**”*

# Proceedings of the 1st International Conference on Zero Carbon Buildings Today and in the Future,

**Birmingham City University, 11-12 September 2014.**

*“We believe that hemcrete has considerable potential for transforming the UK construction industry. The stable internal temperature and relative humidity lead to reduced reliance on mechanical systems, and to their lower installation and running costs. The stability of internal conditions has a considerable positive influence on thermal comfort.*

*The negative embodied carbon facilitates substantial long-term carbon emissions savings and goes a long way towards achieving the future UK carbon emissions targets.*

*Overall, we need more projects like this... ”*

## Hemp lime Construction in Australia

- 22 homes (approx 35 in total)
- 8 retrofits
- Homes in most states
- Shepherds Ground Ecovillage, Hunter Valley (commencing February 2016)
- AHMC currently averaging 2 – 3 homes per month
- To date AHMC has fibre industry partnerships in NSW, Victoria, WA. Our hope is to work with farmers to support the development of regional fibre industries in each state and with them, to have a major positive impact on carbon management.

Thank you for your interest!

Klara Marosszeky