Life Cycle Assessment of the use of natural materials as thermal insulation in buildings. The case of cork boards

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Introduction / *Environment and buildings*

The European building sector is incorporating the sustainability through the total life cycle energy of buildings to improve its environmental performance.

It is the area with the greatest potential for intervention, as improving the sustainability of buildings is crucial to the energy transformation of the European Union

Thermal insulation materials will play an important role in this challenge because of their influence on the energy required to maintain desired interior temperatures and on the environmental impact and embodied energy of the building.

Introduction / *Environment and buildings*

The European market of insulation materials is still dominated by two groups of products:

· Mineral or inorganic fibrous materials: glass wool (GW) and stone wool (SW)

· Organic foamy materials: expanded polystyrene (EPS), extruded polystyrene (XPS) and the polyurethane (PU).

The rest of the market is composed for other alternative materials, including renewable materials, among them: kenaf-fibres, cotton, jute, flax, hemp and cork.

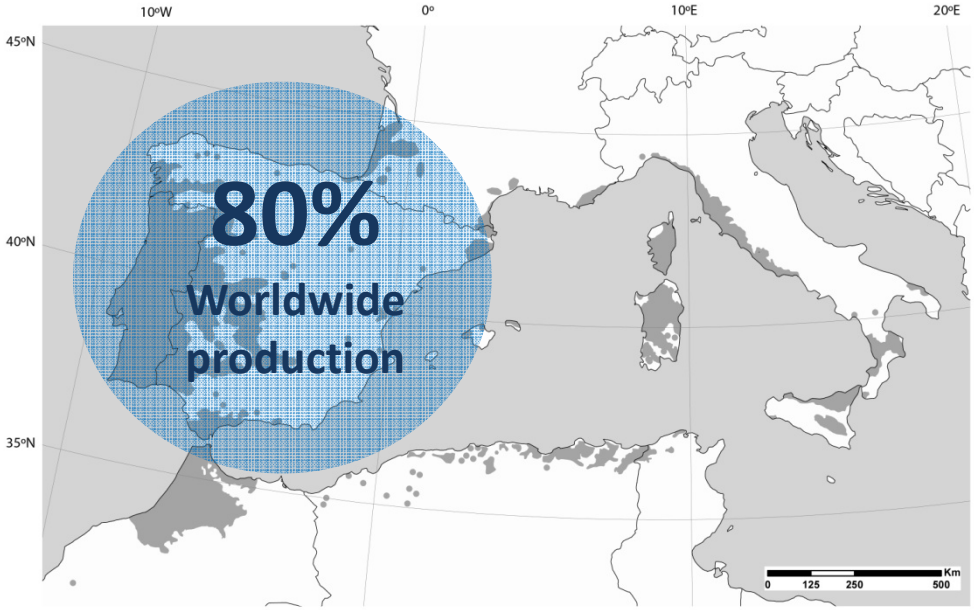
Introduction / *The cork material*

Cork oak (Quercus suber) forests are one of the best examples of balanced conservation and development in the world. They play a key role in ecological processes such as water retention, soil conservation, and carbon storage [4].

Introduction / *The cork material*

The cork oak tree is a long-life species (250- 350 years) with an outer bark, the cork; whose extraction occurs every 9-14 years.

The cork oak forests are distributed along the coastal regions of the western Mediterranean basin.



Properties of the cork material

- very light (0.16 g/m^3)
- impermeable to liquids and gases
- elastic and compressible
- an excellent thermal and acoustic insulator
- fire retardant
- highly abrasion resistant

Objectives

The aim of this cradle-to-gate LCA is to assess in detail the sustainability of cork as an insulation material, quantifying the environmental impact of producing boards of white agglomerated and expanded cork.

The specific objectives are:

· Provide a detailed environmental impact assessment that determines which stages and operations in the production process are the most influential.

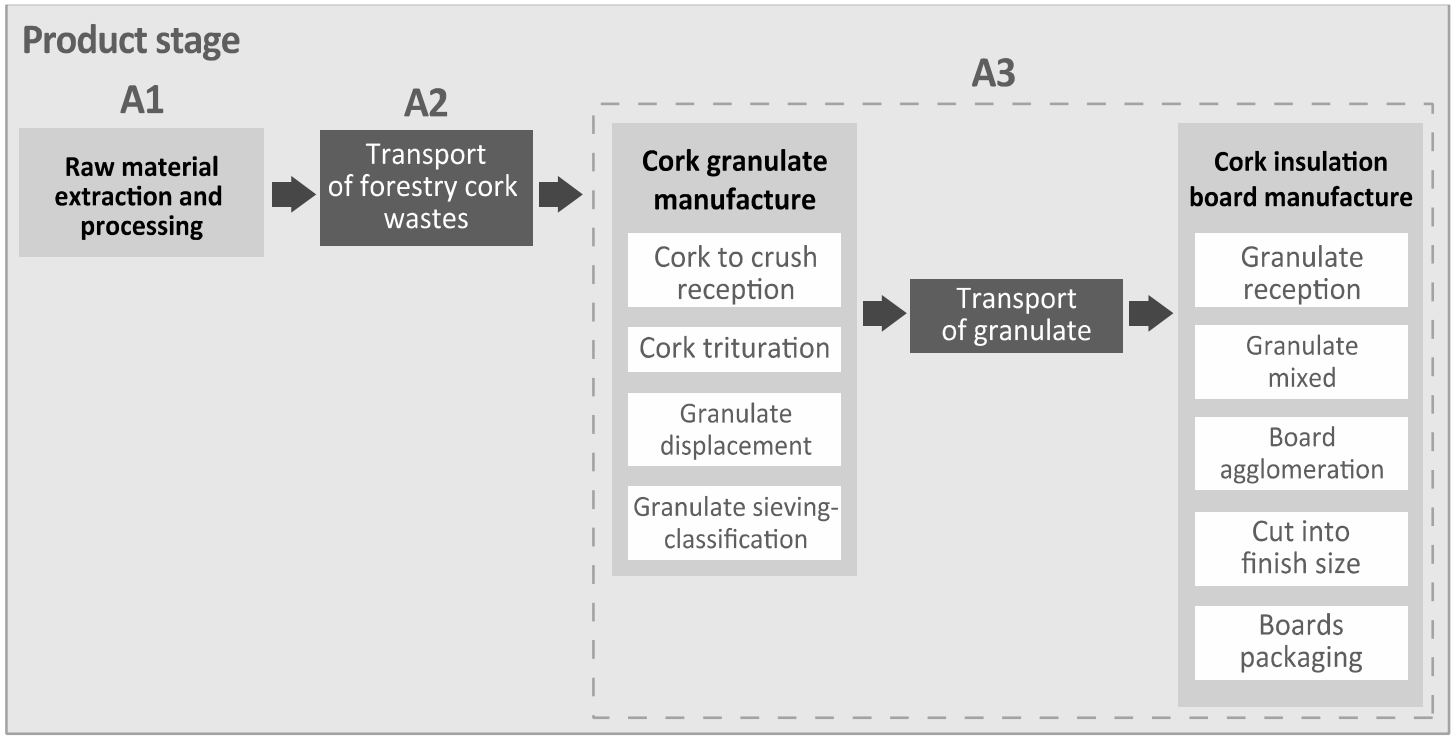
· Assess the influence of the biogenic carbon stored in the cork boards and with respect other insulation materials.

Methodology / *Life cycle assessment*

The LCA methodology is used in this study, from a cradle to gate approach.

The software Simapro 7.3 has been used and environmental database is Ecoinvent. Inventory data from previous projects and LCADB.sudoe (http://lcadb.sudoe.ecotech.cat/)

System boundaries



Methodology / *Types of cork boards*

The most common insulation products made of cork are assessed in this study.

White agglomerated cork

Produced in Catalonia, Spain. White agglomerate cork boards are made of forestry cork wastes with the addition of synthetic materials (Polyurethane) to the granules in the manufacturing process.

Expanded cork

Produced in Portugal. Expanded cork boards are made of forestry cork wastes, which are agglomerated for the expansion of cork granulates and the heating of their natural resins.

Methodology / *Functional unit*

It has been established a Declared Unit (DU) according to the environmental product declaration (EDP) for construction products EN 15804:2014.

The functional unit (FU) used in this LCA study is defined as the mass (kg) of insulation board with an area (A) of 1 m^2 that provides a thermal resistance R-value of 1 m^2 K/W

	White agglomerated cork board	Expanded cork board
Raw cork (kg)	32.25	16
Board weight (kg)	7.2	4.4
Density (kg/m^3)	171	110
Volume (m^3)	0.04	0.04
Thermal conductivity (λ) (W/m K)	0.04	0.042

Results / *Global environmental impacts*

The comparison of the results for the total life cycle shows that the white agglomerated has higher environmental impacts than expanded cork board for all the categories.

Impact category	Unit	White agglomerated cork board	Expanded cork board
Abiotic depletion	kg Sb eq	3.8E-05	8.0E-07
Abiotic depletion (fossil fuels)	MJ	1.8E+02	1.7E+01
Global warming (GWP100a)	kg CO_2 eq	1.2E+01	1.2E+00
Ozone layer depletion	kg CFC-11 eq	1.9E-06	1.4E-07
Photochemical oxidation	kg C_2H_4 eq	2.5E-03	3.8E-01
Acidification	kg SO_2 eq	5.3E-02	4.6E-02
Eutrophication	kg PO_4--- eq	1.5E-02	4.3E+02
Embodied energy	MJ	2.0E+02	2.5E+01

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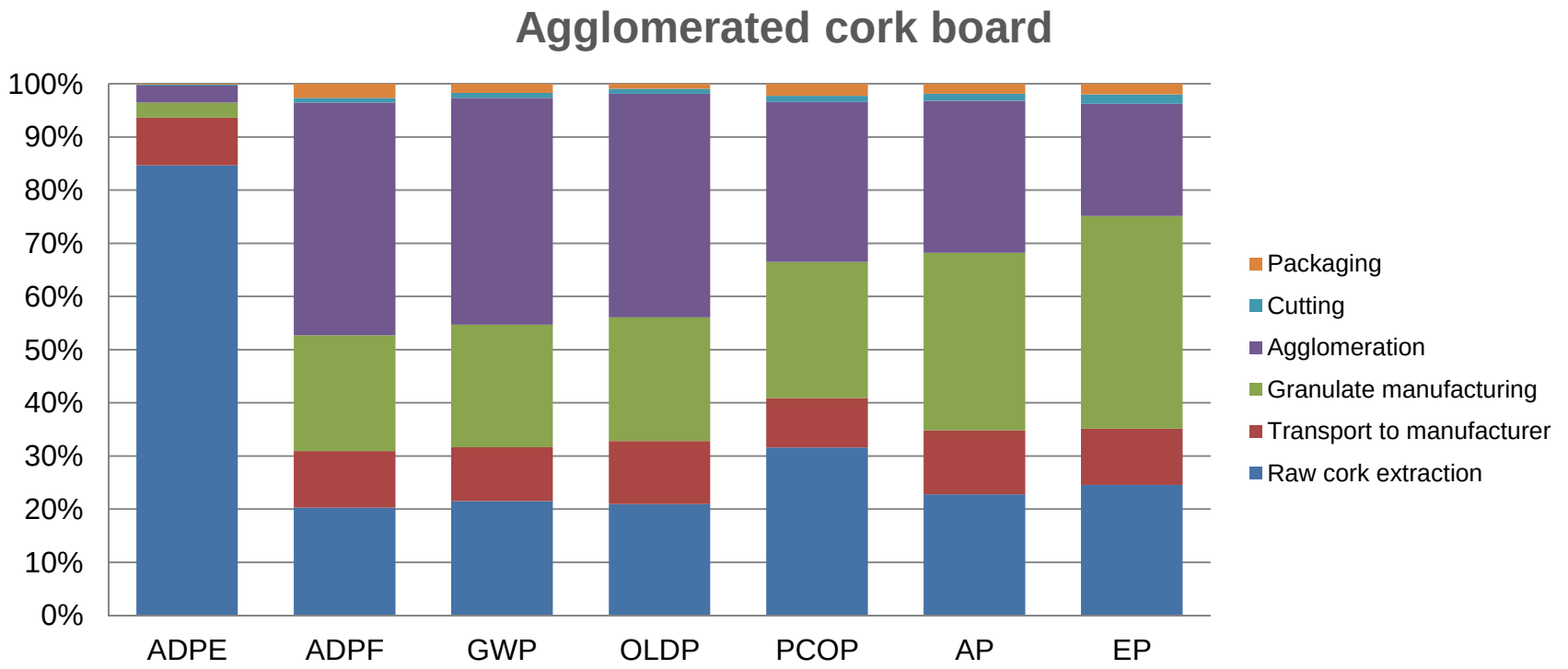
Acidification	kg SO_2 eq	5.3E-02	4.6E-02
Eutrophication	kg PO_4--- eq	1.5E-02	4.3E+02
Embodied energy	MJ	2.0E+02	2.5E+01

· Agglomerated board uses double quantity of raw cork than expanded board to produce the same FU, so the use of energy and resources is much more.

The source of energy is the main difference between two products. Agglomerated cork use a diesel boiler, meanwhile expanded cork uses biomass boiler using cork dust as combustible.

Results/ *Environmental impacts per stages*

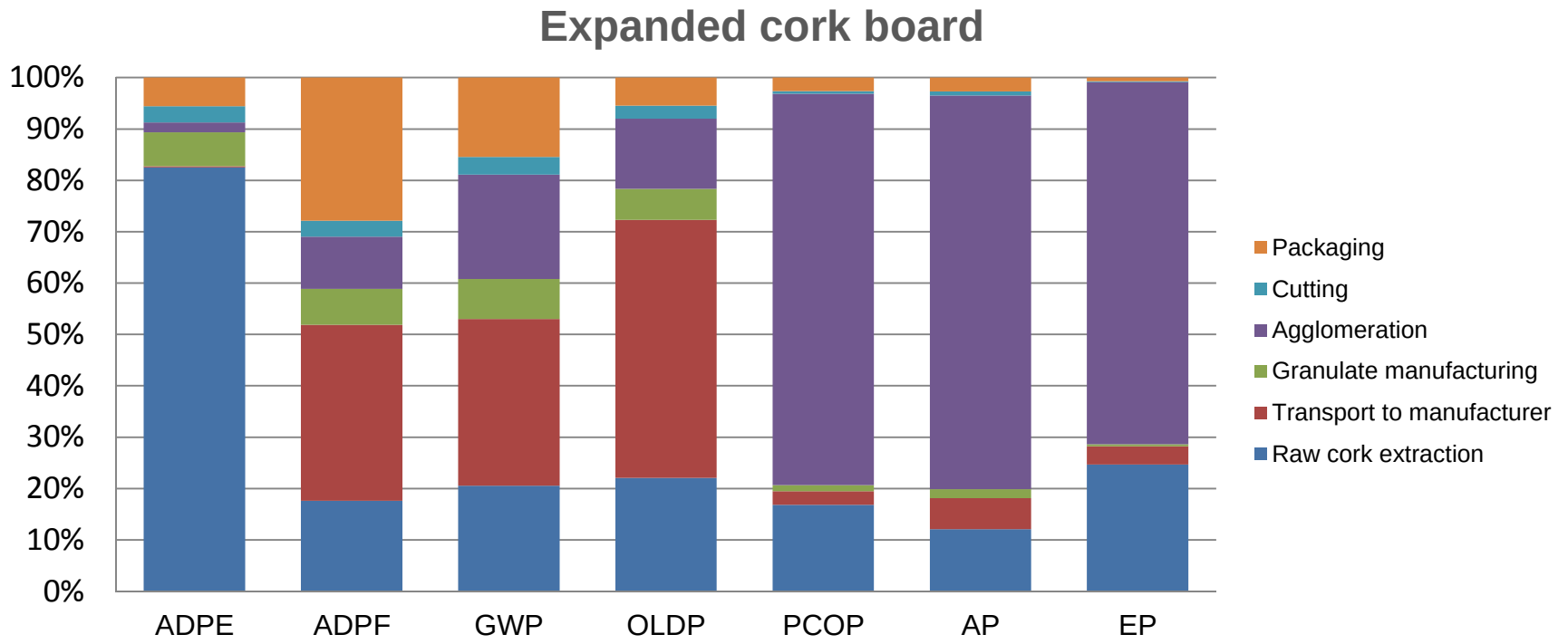
Granulate manufacturing and agglomeration represent more than 50% of global impacts in the majority of the categories, unless for ADPE.



Results/ *Environmental impacts per stages*

Agglomeration concentrates the majority of impacts in PCOP, AP and EP.

The transport to manufacturer stage represents between 30-50% of the global impacts in ADFP, GWP and OLDP.



Results / *Comparison with other materials*

The comparison with other insulation materials shows than agglomerated cork represents more environmental impacts in its manufacturing. Expanded cork boards represents the insulation material with the best environmental performance.

To promote the use of natural insulation materials, it has to increase the efficiency of the manufacturing process.

Insulation material	Ref.	GWP	Embodied energy
		kg CO_2 eq	MJ
Agglomerated cork	3	1.22E+01	2.11E+02
Expanded cork	3	1.2E+00	2.5E+01
EPS	1	8.25E+00	1.18E+02
	2	3.25E+00	7.44E+01
XPS	2	5.21E+00	9.81E+01
PU	1	6.51E+00	9.90E+01
	2	3.33E+00	8.59E+01
SW	1	3.60E+00	6.33E+01

(1) (Zabalza Bribián et al., 2011)
(2) (Pargana et al., 2014)
(3) Present study

Results / *Comparison with other materials*

If the biogenic carbon contained in the cork boards is taken into account, the use of cork as insulation material can help to mitigate the GWP of buildings.

Improving the energy efficiency of the cork boards manufacturing, especially agglomerated cork, could increase the contain of biogenic carbon.

Insulation material	Ref.	GWP	GWP (biogenic carbon)	Embodied energy
		kg CO_2 eq	kg CO_2 eq	MJ
Agglomerated cork	3	1.22E+01	-2.86E+00	2.11E+02
Expanded cork	3	1.2E+00	-9.1E+00	2.5E+01
EPS	1	8.25E+00	8.25E+00	1.18E+02
	2	3.25E+00	3.25E+00	7.44E+01
XPS	2	5.21E+00	5.21E+00	9.81E+01
PU	1	6.51E+00	6.51E+00	9.90E+01
	2	3.33E+00	3.33E+00	8.59E+01
SW	1	3.60E+00	3.60E+00	6.33E+01

(1) (Zabalza Bribián et al., 2011)

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(3) Present study

Conclusions

- The use of renewable materials does not necessarily represent an overall environmental improvement.
- The use of cork as insulation material represents a sustainable alternative in the decarbonisation of buildings if the biogenic carbon contained in cork is taken into account.
- The manufacturing process of the cork insulation boards is not designed in a sustainable approach, and it is necessary to introduce measures to optimize the use of resources and energy.

References

- Pargana, N., Pinheiro, M.D., Silvestre, J.D., de Brito, J., 2014. Comparative environmental life cycle assessment of thermal insulation materials of buildings. Energy Build. 82, 466–481. doi:10.1016/j.enbuild.2014.05.057

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