Les matériaux biosourcés sur la voie de la bioéconomie :

Valorisation des écorces d'eucalyptus, retour d'expérience "Du laboratoire à l'industrie"

César SEGOVIA
Research manager
Co-director
CETELOR – Université de Lorraine

UNIVERSITÉ DE LORRAINE

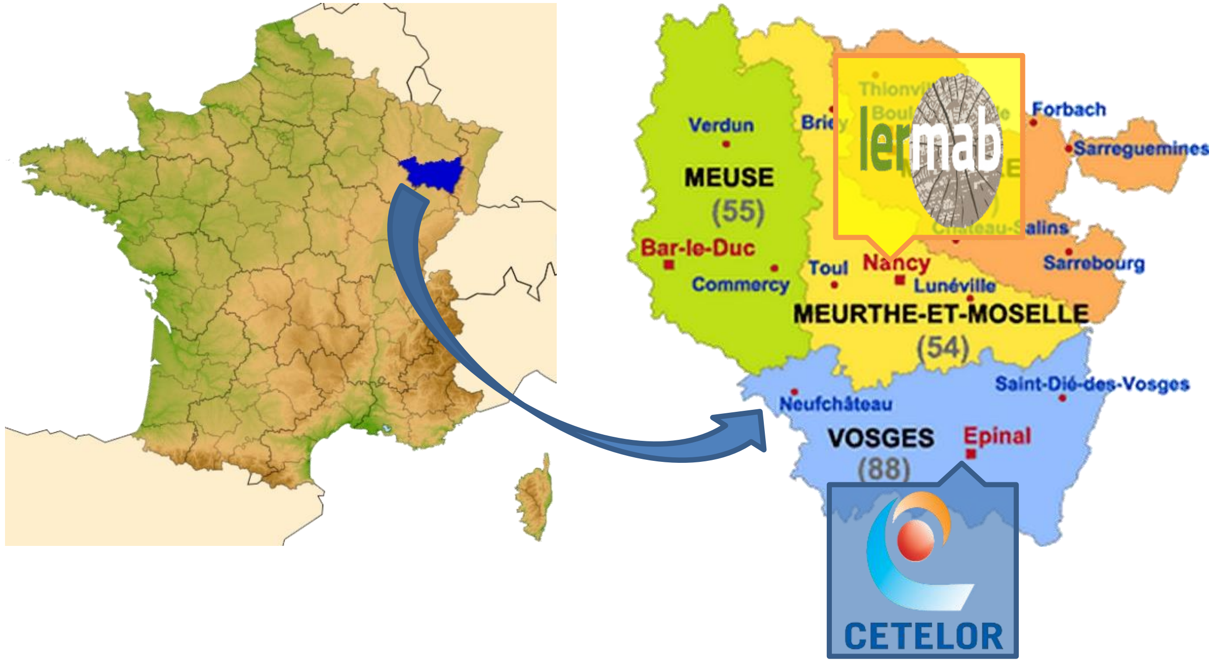
CETELOR

Universidad de Concepción

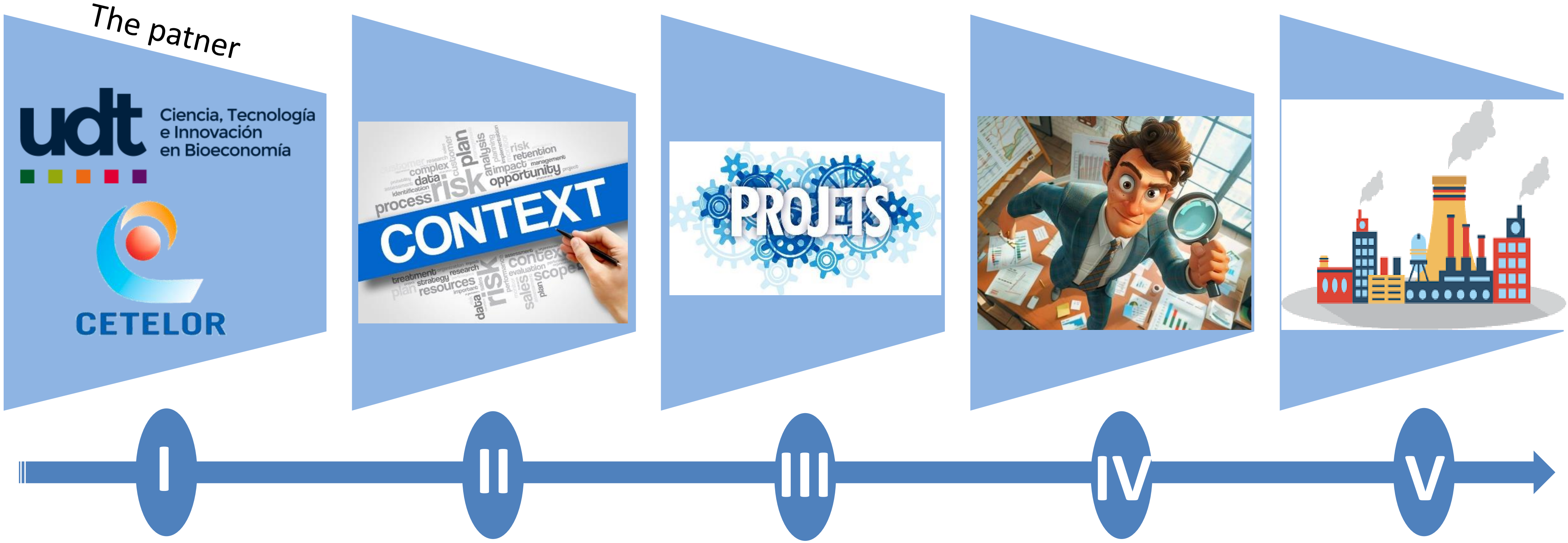
udt Ciencia, Tecnología e Innovación en Bioeconomía

CETELOR

UNIVERSITÉ DE LORRAINE



Valorisation des écorces d’eucalyptus, retour d’expérience "Du laboratoire à l’industrie"



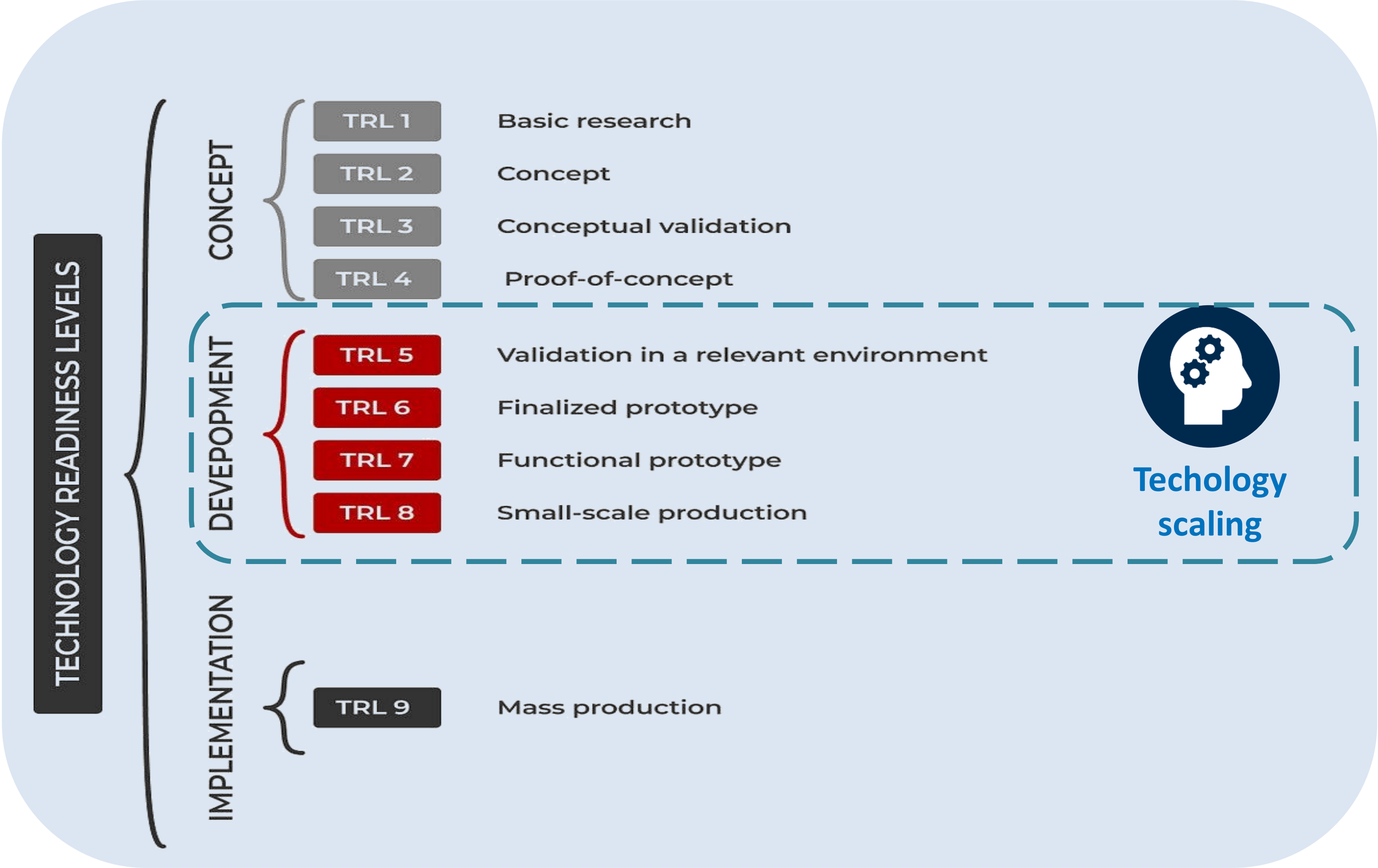
Universidad de Concepción

udt Ciencia, Tecnología e Innovación en Bioeconomía

Universidad de Concepción

udt Ciencia, Tecnología e Innovación en Bioeconomía

Technological Development Unity
University of Concepción - Chile



- 27 years of activity
- Close relationship with companies
- Applied science and innovation
- Self-financing
- Technology scaling

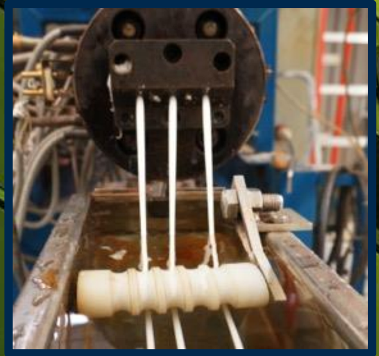
Research lines

Ciencia, Tecnología e Innovación en Bioeconomía

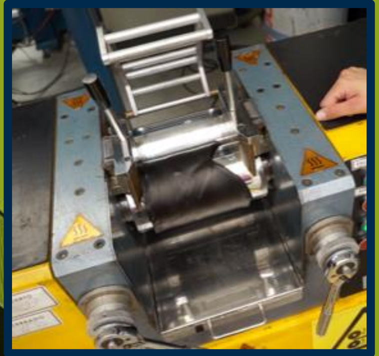
Bioeconomy

Lignocellulosic materials

Packaging



Plastic

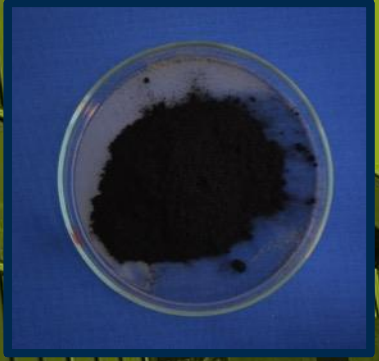


Elastomeric materials

Pyrolisis

Bioenergy

Thermal storage materials



carbonaceous materials

udt Ciencia, Tecnología e Innovación en Bioeconomía

WORK TEAM

4	35	24	9	67
Directors	Professionals	Technicians	Administrative	Total employees

12 specialized laboratories for testing and analysis of different materials

udt Ciencia, Tecnología e Innovación en Bioeconomía

4 processes rooms, where its pilot plants are located, which allow scaling up processes from a laboratory scale to a demonstration production level and from there, to an industrial level.

PROCESOS QUÍMICOS

- Plantas piloto de extracción sólido-líquido
- Plantas piloto de evaporación
- Plantas piloto de secado
- Columna de destilación continua
- Prensa de extrusión
- Equipo de filtración por membranas
- Homogenizador
- Reactores
- Planta piloto extracción líquido-líquido
- Planta piloto para la impregnación de madera

PROCESOS TERMOQUÍMICOS

- Pirolizadores flash
- Planta piloto de torrefacción
- Planta piloto de combustión de carbón
- Planta de gasificación laboratorio
- Planta de pirólisis de plástico
- Planta productiva semi-móvil de peletización
- Planta piloto para tratamiento térmico de madera
- Planta piloto de pirólisis intermedia de biomasa
- Planta piloto Fotorreactores Solares para tratamiento de aguas

CONVERSIÓN DE BIOMATERIALES

- Planta piloto para la producción de tableros reconstituidos de madera
- Planta piloto para la producción de fibras MDF o TMP
- Plantas piloto para la producción de materiales plásticos compuestos
- Planta piloto para la extrusión de plásticos
- Planta piloto para la inyección de plásticos
- Plantas piloto para la producción de películas termoplásticas
- Planta piloto de producción de Microfibrilas de Celulosa

PREPARACIÓN DE MATERIAS PRIMAS

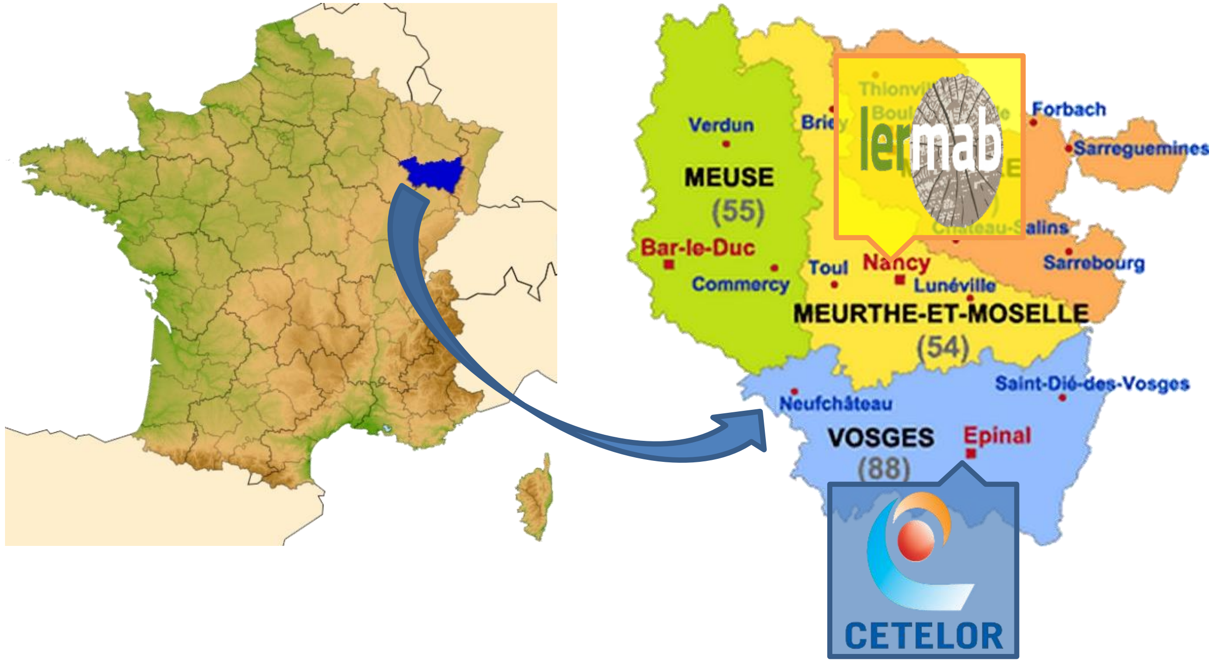
- Molinos
- Tolvas de alimentación con piso oleohidráulico
- Cintas transportadoras
- Refinador
- Triturador
- Criba rotatoria
- Harnero

UNIVERSITÉ DE LORRAINE

CETELOR

CETELOR

UNIVERSITÉ DE LORRAINE



Wood Campus


TRANSBATIBOIS
CENTRE DE DOCUMENTATION
AIENSTIB
CROUS
RESTAURANT UNIVERSITAIRE
1
2
4
5
6
7
enstib
INTERFACE INDUSTRIELLE
ctp
fibres
INTERFACE INDUSTRIELLE
CETELOR
INTERFACE INDUSTRIELLE
Crittbois
RECHERCHE & DÉVELOPPEMENT
lermab
CRAN

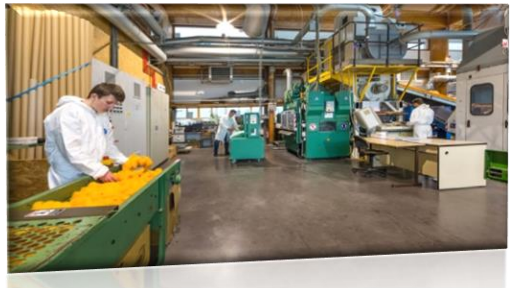
UNIVERSITÉ DE LORRAINE

CETELOR
Three areas of activities

CETELOR

R&D Technical Center

Project Engineering Unit



Textile Metrology

cofrac
ESSAIS
ACCREDITATION N° 1-2401
PORTEE DISPONIBLE SUR
WWW.COFRAC.FR

R&D Technical Center

Technical means of industrial type at disposal

Production of bio-sourced materials based on vegetable and technical fibers:

- Non-woven insulation for the building industry
- Reinforcement of composite
- Non-woven geotextile type
- Treatment and / or complexing of materials

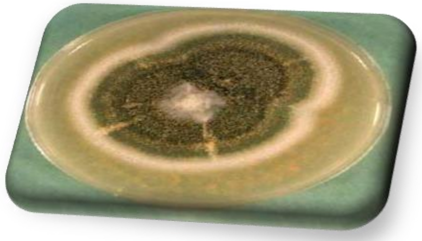
Development on the recycling and revalorization of materials

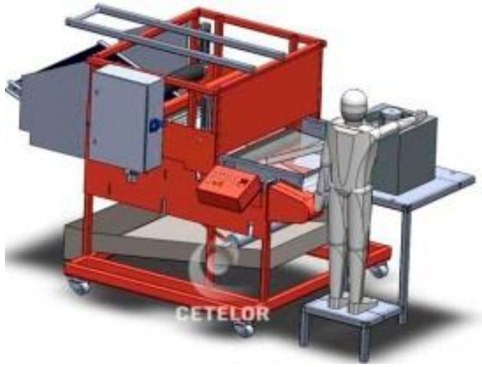
Characterization of the plant fiber

- Morphological, chemical, mechanical

Characterization of materials:

- Chemical and Mechanical
- Thermal conductivity
- Resistance to mould growth in materials (bio-composite, building insulation, textile)
- Resistance to degradation and accelerated aging



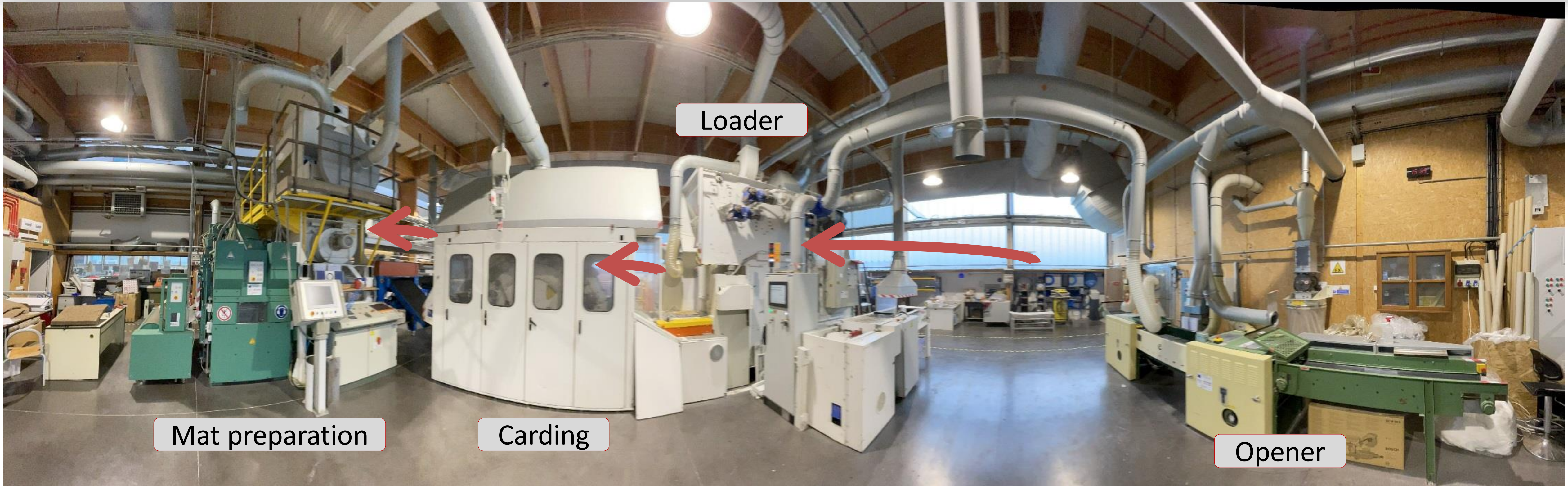


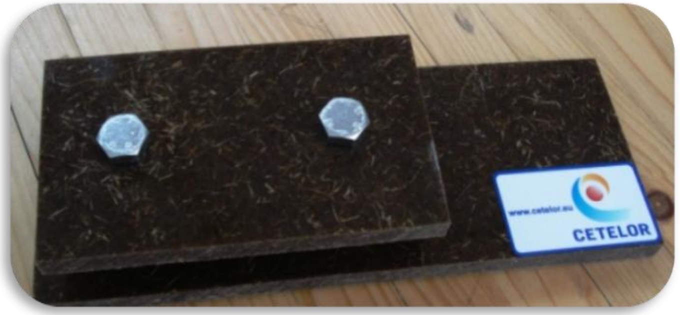
Development of technical means for specific research needs or for companies

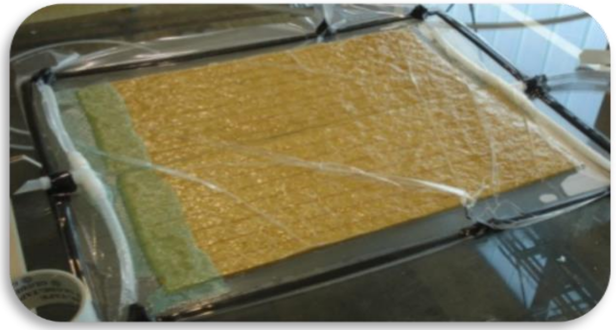
Two pilot production line !

R&D Technical Center

Technical Hall

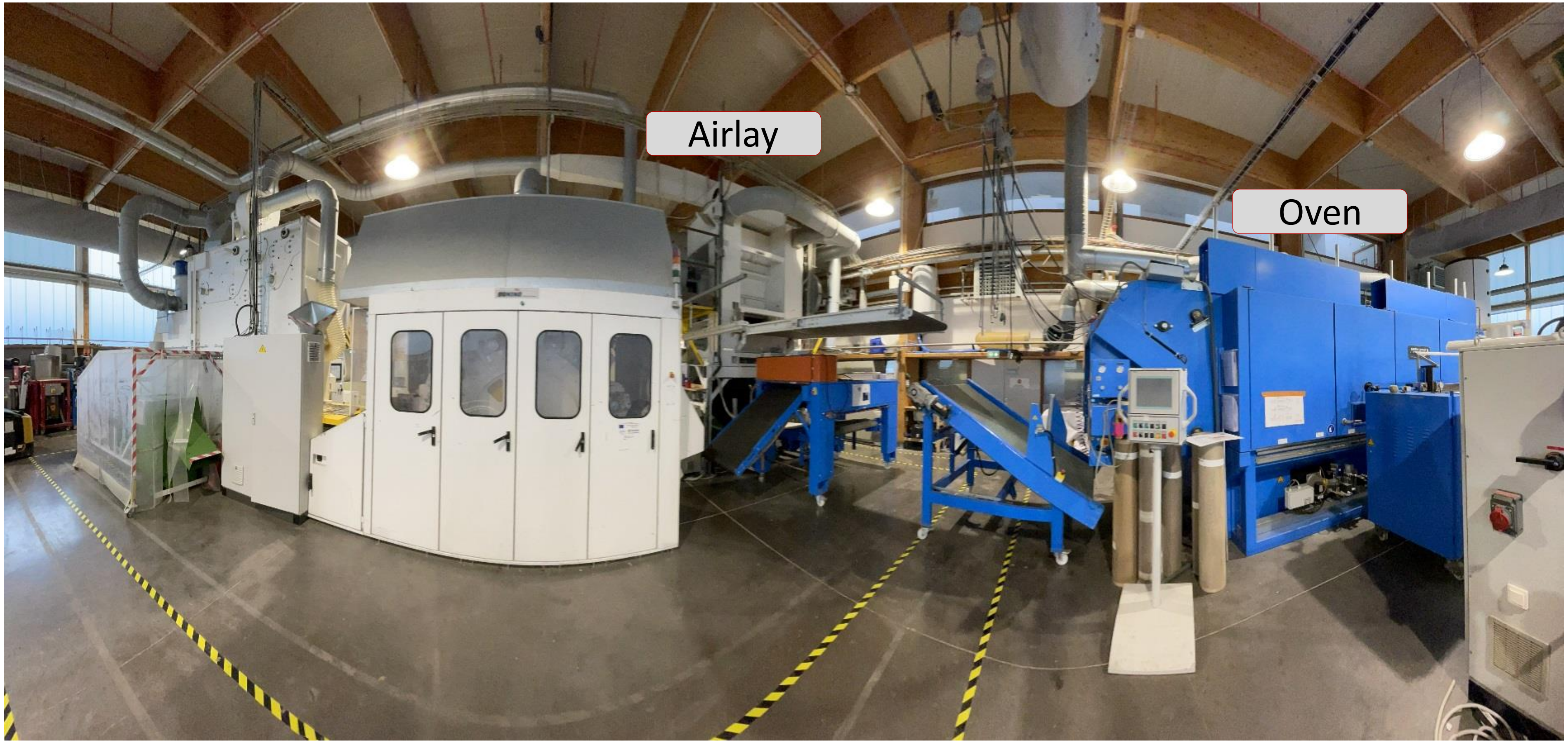






R&D Technical Center
Technical Hall

Non-woven insulation for the building industry



- Thermal conductivity
- Resistance to mould growth in materials (bio-composite, building insulation, textile)
- Resistance to degradation and accelerated aging

R&D Technical Center

Technical Hall – Microspinning line

R&D Technical Center
Technical Hall – Stem Explosion

STEAM EXPLOSION
pilot machine

lermab

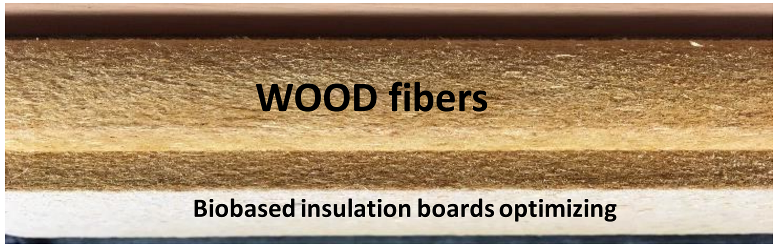
CETELOR

steam generator

Project Engineering Unit

Setting up and monitoring of research projects

National Projects

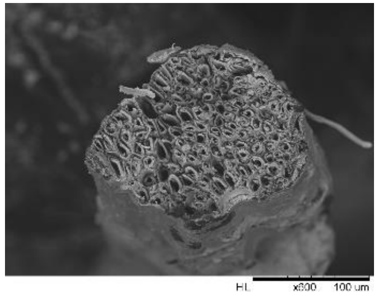


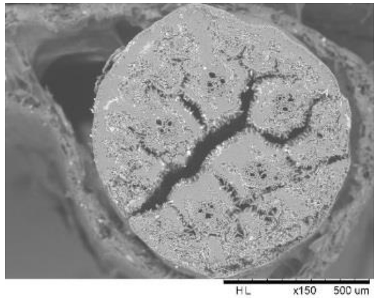
Flax
Hemp
Nettle
Hop

International Projects

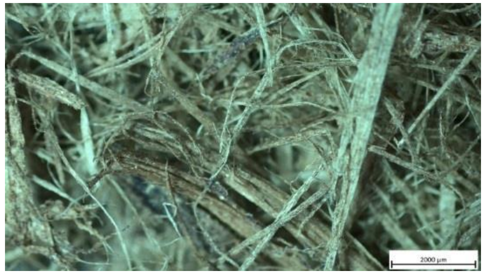
Project **PHC Utique & Project EcoSUD**

Alfa
Posidonia





Eucalyptus bark fibers



Triumfeta Cordifolia

Another fibers : Jute, kenaf, Palm, Rodofolia etc

Valorisation des écorces d'eucalyptus, retour d'expérience "Du laboratoire à l'industrie"

Universidad de Concepción

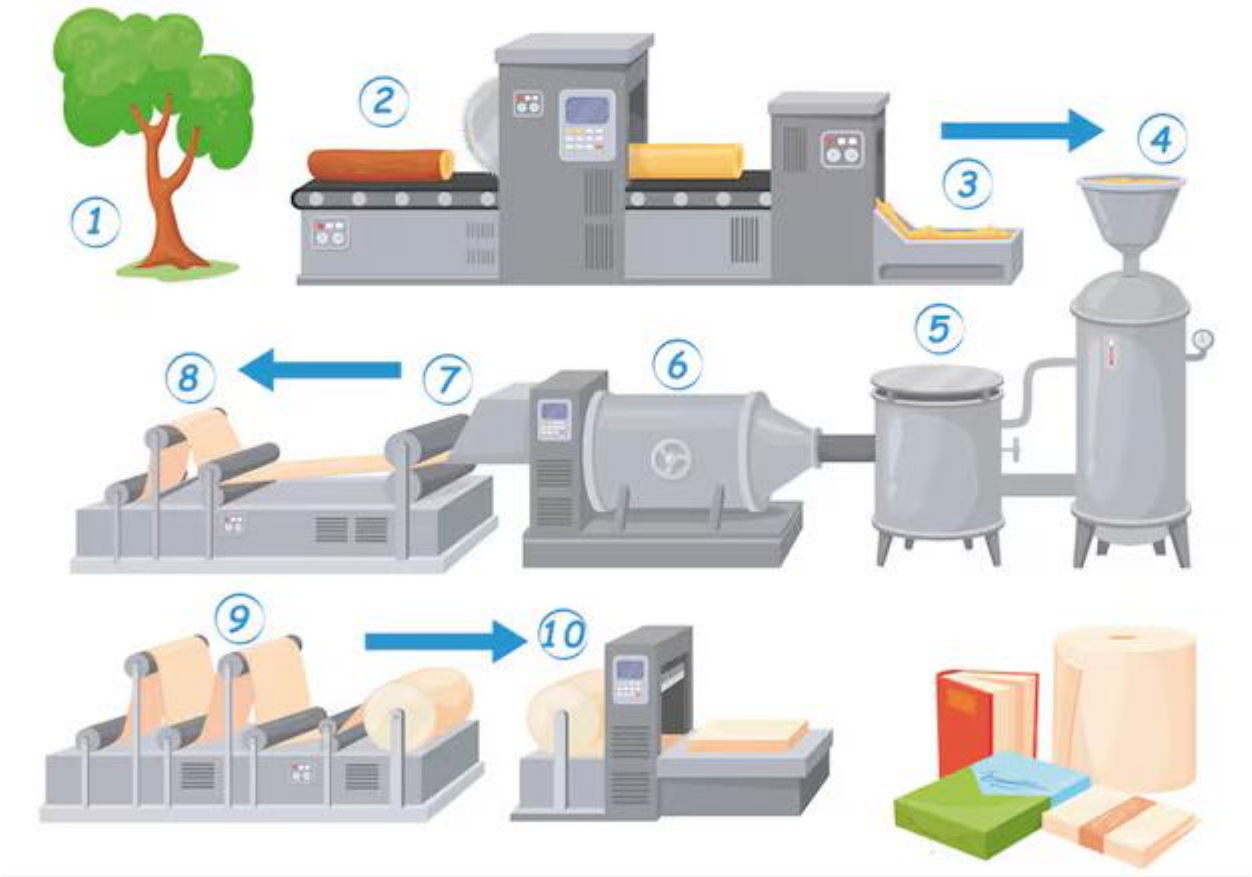
udt Ciencia, Tecnología e Innovación en Bioeconomía

CETELOR

UNIVERSITÉ DE LORRAINE

ECOS Sud

PRODUCTION CELULOSA



According to the FAO, **193 million m3** of paper pulp are produced worldwide every year, mainly to make cardboard and paper.

Forestal Collicura

DEBARKING

(DECORTICATION)

24 millions m^3 par year in Chile
Then 80% eucalyptus

6000 m^3 /months

- **20 million hectares** of *Eucalyptus sp*. worldwide
- **0,85 million hectares** of *Eucalyptus sp*. in Chile
- Chile, 2023, roundwood consumption: **14 MM m³**
- **Huge quantity** of bark is generated yearly
- In Chile, more than **1 MM/ton year**
- Bark is used as a fuel
- Low calorific value and complex material
- E. bark is a real waste management problem

- **Particular morphology** can be used as an advantage
- New source of natural fiber
- Adding value (current selling price is 50 USD/ton)

- Increased biobased products
- Decreased petroleum dependency
- Decreased pollution

Eucalyptus bark fibers

Bioproducts development

Limitations
- Raw materials availability
- Technological development

Oportunity
High availability of Eucalyptus bark

Eucalyptus bark

Standardized fibers

Biobased Thermal insulation panel

- **Technologies** to produce fiber from wood are known
- **Refining process** requires high investment and advanced expertise, also high energy consumption
- The refiner machine **is not suitable** for bark (high heterogeneity and morphology)

Eucalyptus bark fibers

Eucalyptus bark (high heterogenety)

Cleaning

Screening

Mill type selection

Opening/carding machine

Mechanical process: Bark to fiber

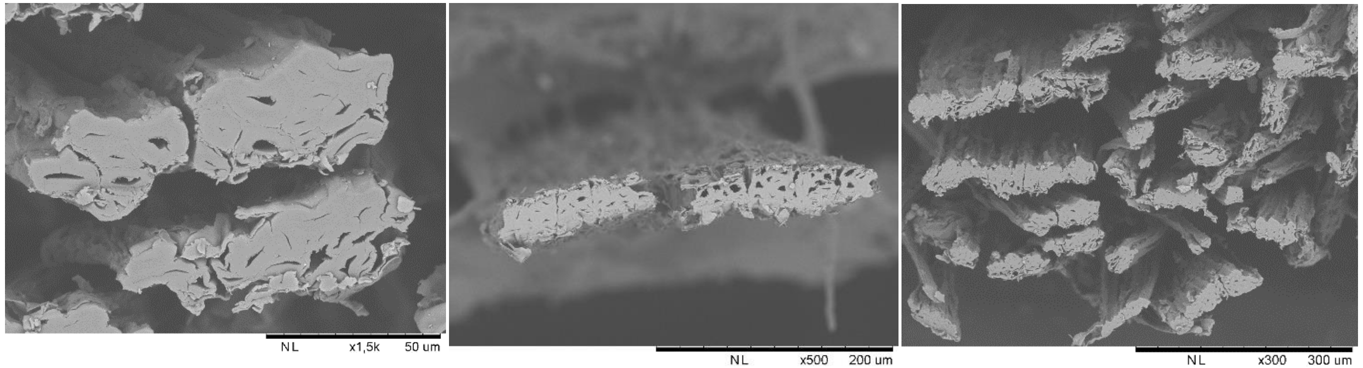
Moisture content: 12- 27% o.d.b

Quality of the E. bark

Yield: 50% - 70%

Ciencia, Tecnología e Innovación en Bioeconomía

Technical *Eucalyptus* fiber



Morphological properties

Length (mm)	Diameter (mm)
20-80 mm	50-500 µm

Mechanical properties

Air (µm2)	Maximum strength (N)	Tensile stress (MPa)	Elasticity modulus (GPa)	Elongation at Break (%)
7911	1,65 ± 0,75	224 ± 109	2,29 ± 1,52	1,25

Chemical components (%, dry solid basis)

Cellulose	Hémicelluloses	Klason lignine	Ethanol/water extractives	Ash
49,91 ± 2,56	18,12 ± 4,16	17,60 ± 0,49	7,43 ± 0,03	7,62 ± 0,32

- High length variability
- Diameters in the range of hemp and flax
- Compose of several elementary fibers

- Low mechanical resistance compared to flax and hemp
- In airlay technology the strength requirement over the fiber is low

- Higher content of cellulose/hemicellulose and lower lignin than other tree barks

CETELOR

Laboratory prototype

Binder selection and dosification

Resins/synthetic fibers

Consolidation process

Pressing process
Air convection oven

Characteristic parameters

Density
Thickness selection

Bark-synthetic fiber

Mixture system Bark-synthetic fiber

Conformación colchón

Método 1: Consolidación por inyección a vapor

Método 2: Consolidación en horno

Thermal conductivity

50 kg/m³
50 mm
0,04 W/mK

Ciencia, Tecnología e Innovación en Bioeconomía

Pilot plant demostrative process

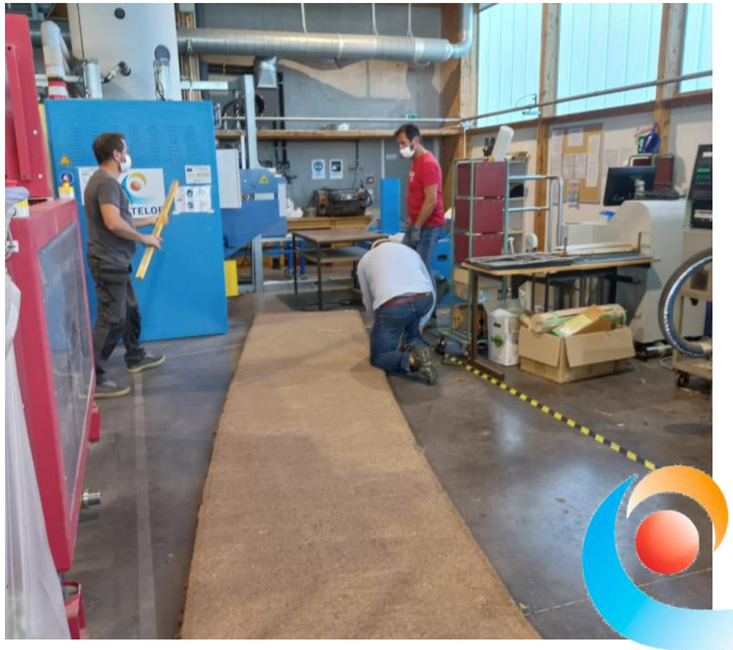
Collaborative network

Airlaid technology

Demostrative test

Density, yield, synthetic fiber (kind, dosification and lengh).

Characterization



CETELOR

Characterization

Thermal insulation material	Density (kg/m^3)	Thermal conductivity (λ) (W/mK)	Reference
Panel 1	83.1 ± 6.5	0.0391 ± 0.00052	
Panel 2	97.8 ± 3.3	0.0379 ± 0.00024	
Kenaf	30-180	0.034-0.043	Asdrubali, 2015
Jute	26.1	0.0458	Korjenic, 2011
Flax	32.1	0.0429	
Hemp	79.6	0.0475	
Hemp	40.2	0.0393	
Rock wool	40-200	0.0330-0.0040	Asdrubali, 2015
Expanded polystyrene (EPS)	15-35	0.0310-0.0380	
Polyurethane	24	0.0240	Ardente, 2006

Demostrative industrial scaling process

Contact with technological supplier

Demostrative test

Yield, density, synthetic fiber (kind, dosification and lengh).

Characterization

Demonstrative industrial scaling process

Demonstrative industrial scaling process

The feasibility of production of the insulating panel on an industrial scale is demonstrated.

TRL8
Validated technology

- **Biobased**
- **Good technical characteristics**
- **Competitive price**

Characterisation

- Fire behaviour
- Thermal Conductivity
- Permeability
- Fungi resistance

Centro UC de Innovación en Madera

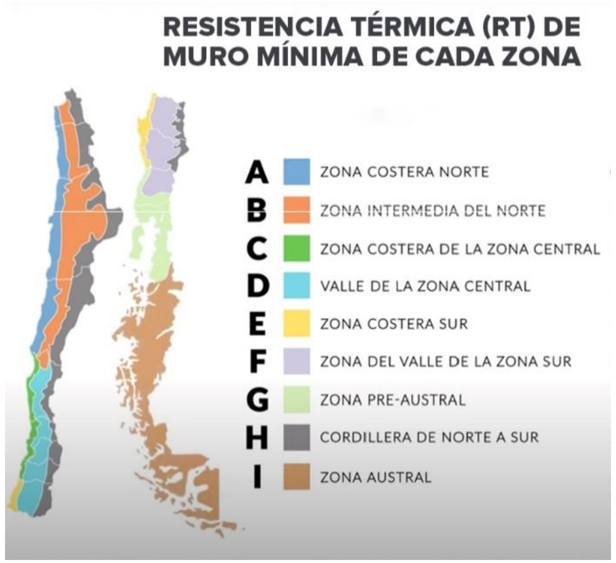
Centro UC de Innovación en Madera
Informe N° 202317
ORIGINAL

CASO BASE				
Descripción de la sección de análisis de la solución constructiva: Sección puente térmico (pie derecho) Muro madera estructura 2x4" y distanciadores 2x3", con aislante fibras naturales aislacor 150 [mm]				
	Puntos de análisis			HR Cond.
HR interior, φi:	65%	75%	80%	42%
Condensación superficial:	No	No	No	No
Res. Térmica caso base	1.784	1.784	1.784	1.784
Res. Térmica total min, $R_{T,min}$	0.375	0.557	0.715	0.191
Condensación intersticial:	Sí	Sí	Sí	Sí
Detalle de interfases con condensación:				
Superficie exterior				
Interfase 1	X	X	X	X
Interfase 2				
Superficie interior				
N° Interfaces condensación:	1	1	1	1
Total:	3 interfases			

CASO PROYECTADO				
Descripción de la sección de análisis de la solución constructiva: Sección puente térmico (pie derecho) con barreras Muro madera estructura 2x4" y distanciadores 2x3", con aislante fibras naturales aislacor 150 [mm]				
	Puntos de análisis			HR Cond.
HR interior, φi:	65%	75%	80%	86%
Condensación superficial:	No	No	No	No
Res. Térmica caso proyectado	1.786	1.786	1.786	1.786
Res. Térmica total min, $R_{T,min}$	0.375	0.557	0.715	1.053
Condensación intersticial:	No	No	No	Sí
Detalle de interfases con condensación:				
Superficie exterior				
Interfase 1				
Interfase 2				X
Interfase 3				
Interfase 4				
Superficie interior				
N° Interfaces condensación:	0	0	0	1
Total:	0 interfases			

Para eliminar el riesgo de condensación superficial y reducir el riesgo de condensación intersticial, en los escenarios de porcentaje de humedad relativa interior antes mencionados, para la sección del material aislante se especifican las siguientes barreras:

- Barrera de vapor:
  - Instalada entre el entramado de madera (pies derechos) y la placa de revestimiento interior (yeso-cartón)
  - Polietileno:
    - Marca: Genérico
    - Espesor: 0,00025 [mm]
    - Factor de resistencia al vapor de agua (μ): 151.800
  - Se analizó como alternativa la barrera tipo VolcanWrap, obteniendo los mismos resultados.
- Barrera de humedad:
  - Instalada sobre la cara exterior de la placa OSB
  - Traspir 95
    - Marca: Rothoblaas
    - Espesor: 0,0004 [mm]
    - Factor de resistencia al vapor de agua (μ): 50
  - Se analizaron como alternativas las barreras tipo Typar y Tyvek HouseWrap, obteniendo resultados similares.



Minimum thermal resistance R100 of the thermal insulating material in roof complexes, perimeter walls and ventilated floor.

ZONA TÉRMICA	COMPLEJO DE TECHUMBRE	COMPLEJO DE MUROS PERIMETRALES	COMPLEJO DE PISO VENTILADO
	R100(*) [(m²K)/W]x100	R100(*) [(m²K)/W]x100	R100(*) [(m²K)/W]x100
A	119	48	28
B	213	125	143
C	213	125	115
D	263	125	167
E	303	167	167
F	357	222	200
G	357	250	256
H	400	333	313
I	400	286	313

(*) Según la norma NCh 2251: R100 = valor equivalente a la Resistencia Térmica (m²K/W) x 100.

Fire behavior test

Constructive solution F15 according with MINVU

Sample	Section (mm x mm)	Thickness (mm)	Total mass (Kg)	Side exposed to fire	Side non-exposed to fire	Insulation panel	Structure
1	700 x 700	90	13,5	GYPSUM PLASTERBOARD, 10 mm	OSB 9,5 mm	Natural fibers Thickness, 50 mm, Density= 50 kg/m3	Wood=Pinus radiata, 45 x 70 (mm) and moisture 15%.
2	700 x 700	90	14,0	GYPSUM PLASTERBOARD, 10 mm	OSB 9,5 mm	Glass wool, Thickness, 50 mm, Density= 50 kg/m3	Wood=Pinus radiata, 45 x 70 (mm) and moisture 15%.

Sample 1, Side non exposed to fire

Sample 2, Side non exposed to fire

Sample 1, Side non exposed to fire. Test finished

Sample 2, Side non exposed to fire. Test finished

Criterios de resistencia al fuego		NCh935/1 Of.97	Tiempo de falla Probeta N°1	Tiempo de falla Probeta N°2
i) Capacidad de soporte de carga		9.2.1	No evaluado	No evaluado
ii) Aislamiento	Temperatura media cara no expuesta **(153°C máx.)**	ítem 9.2.2.1 a)	85 [min] [2]	55 [min] [3]
	Temperatura máxima cara no expuesta **(193°C máx.)**	ítem 9.2.2.1 b)	89 [min] [4]	54 [min] [5]
iii) Estanquidad	Grietas y fisuras	ítem 9.2.3.1	N.O.	N.O.
	Falta de estanquidad	ítem 9.2.3.2	N.O.	N.O.
iv) Emisión de gases inflamables		ítem 9.2.4	N.O.	51 [min]

N.O.: No observado hasta el término del ensayo.

Journal of Cleaner Production 249 (2020) 119356

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Life cycle assessment of innovative insulation panels based on eucalyptus bark fibers

Yannay Casas-Ledón [a,*], Karen Daza Salgado [a], Juan Cea [b], Luis E. Arteaga-Pérez [c], Cecilia Fuentealba [b,**]

[a] Environmental Engineering Department, Faculty of Environmental Sciences-EULA Center, University of Concepción, Chile
[b] Technological Development Unit (UDT), University of Concepción, Chile
[c] Laboratory of Thermal and Catalytic Processes (LPTC), Department of Wood Engineering, University of Bio-Bio, Chile

ARTICLE INFO

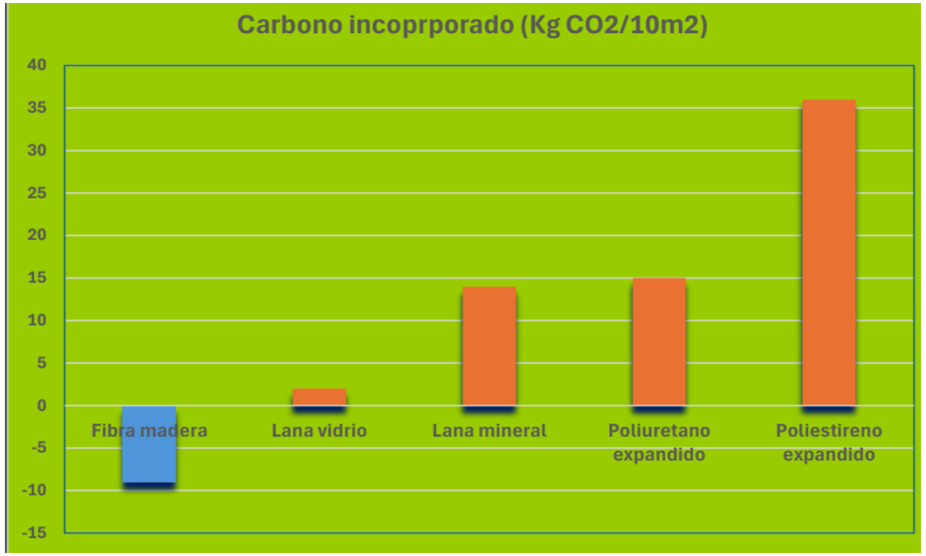
Article history:
Received 1 July 2019
Received in revised form
15 November 2019
Accepted 16 November 2019
Available online 19 November 2019

Handling editor: Mingzhou Jin

Keywords:
Insulation materials
Eucalyptus bark fibers
Life cycle assessment

ABSTRACT

This paper reports on the environmental issues associated with the manufacturing of a new insulation material (panel) produced with fibers from Eucalyptus bark. The analyses consider four types of eucalyptus bark panels with different bulk densities (25, 50, 75 and 100 kg/m^3). For each type of panel, the environmental impact assessment is performed using Life Cycle Assessment (LCA) methodology and considering system boundaries from cradle to gate. Major environmental impacts were associated to the panel with a density of 100 kg/m^3, due to the higher mass required for the same functional unit (R = 1 m^{2}K/W). The panel manufacturing, forest management and biomass transport were the stages with the highest significance, mainly due to: the contribution of the synthetic fiber used for binding the bark-derived fibers, intensive use of agrochemicals in forest management and long traveled distances for biomass transportation. Furthermore, the eucalyptus bark panels with densities of 25 and 50 kg/m^3 shown the lower embodied energy and carbon emissions than traditional insulation materials (expanded polyurethane, polystyrene, glass fibers and glass wool). Therefore, it could be an attractive insulation material for a more sustainable building sector.



forests

Article

Efficient Bio-Based Insulation Panels Produced from Eucalyptus Bark Waste

Cecilia Fuentealba [1,2,*], César Segovia [3], Mauricio Pradena-Miquel [4] and Andrés G. César [5]

1 Unidad de Desarrollo Tecnológico, Universidad de Concepción, Concepción 4070374, Chile
2 Centro Nacional de Excelencia para la Industria de la Madera (CENAMAD), Pontificia Universidad Católica de Chile, Av. Vicuña Mackena, 4860, Santiago 7820436, Chile
3 Centre d'Essais Textile Lorrain, CETELOR—Université de Lorraine, 27 rue Philippe Seguin, 88051 Epinal, France; cesar.segovia@univ-lorraine.fr
4 Facultad de Ingeniería, Arquitectura y Diseño, Universidad San Sebastián, Lientur 1457, Concepción 4080871, Chile; mauricio.pradena@uss.cl
5 Escola Politécnica, Departamento de Engenharia de Transportes, Universidade de São Paulo, Cidade Universitária, São Paulo 05508-010, Brazil; andresgcesar@usp.br
* Correspondence: c.fuentealba@udt.cl

Abstract: Traditional thermal insulation panels consume large amounts of energy during production and emits pollutants into the environment. To mitigate this impact, the development of bio-based materials is an attractive alternative. In this context, the characteristics of the Eucalyptus fiber bark (EGFB) make it a candidate for insulation applications. However, more knowledge about the manufacturing process and in-service performance is needed. The present study characterized the properties that determine the in-service behavior of the EGFB insulation panel. The assessment involved two different manufacturing processes. The results indicated that the hot plates and the saturated steam injection manufacturing system can produce panels with similar target and bulk density. The thermal conductivity fluctuated between 0.064 and 0.077 W/m·K, which indicated good insulation, and the values obtained for thermal diffusivity (0.10–0.37 m mm^2/s) and water vapor permeability (0.032–0.055 m kg/GN s) are comparable with other commercially available panels. To guarantee a good in-service performance, the panels need to be treated with flame retardant and antifungal additive. The good performance of the panel is relevant because bio-based Eucalyptus bark panels generate less CO_2 eq and require less energy consumption compared to traditional alternatives, contributing to the sustainability of the forestry and the construction industry.

Keywords: bio-based material; eucalyptus bark; thermal insulation; forestry waste; natural fibers

Citation: Fuentealba, C.; Segovia, C.; Pradena-Miquel, M.; César, A.G. Efficient Bio-Based Insulation Panels Produced from Eucalyptus Bark

Thermal insulation panel

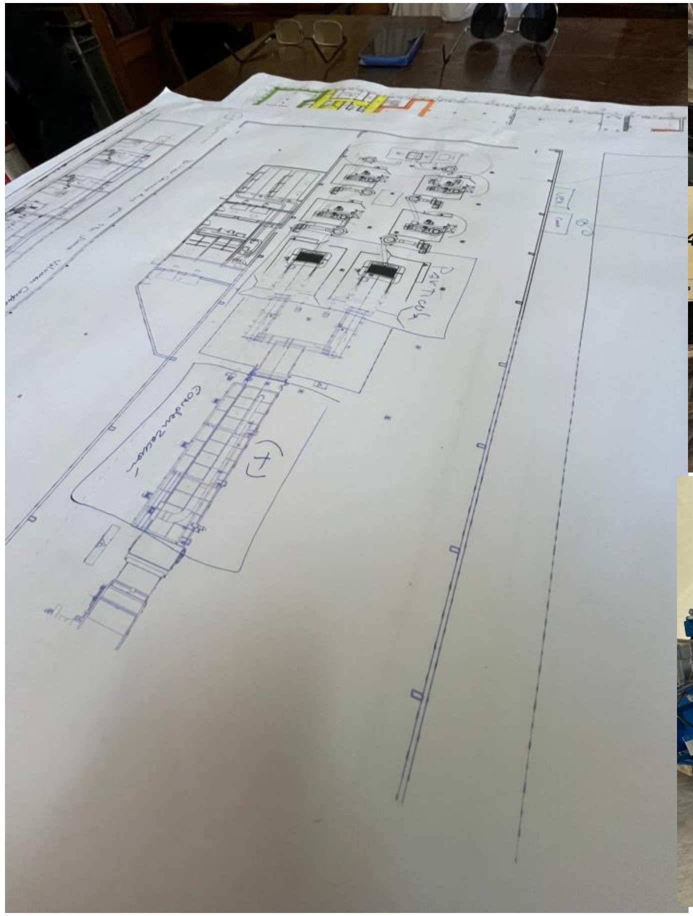
AISLACOR
AISLANTE NATURAL

Propiedad	Unidad de medida	Norma	Valor	Validación
Densidad	kg/m3	NCh850.Of.2008	50	DICTUC-N°1607325
Espesor	mm	NCh850.Of.2008	50	DICTUC-N°1607325
Conductividad térmica, λ	W/m.K	NCh850.Of.2008	0,036	DICTUC-N°1607325
Calor específico	J/kg.K	EN 12667	2253	Laboratorio ASA
Resistencia térmica, R100	m2.K/W	NCh 2251	1,389	DICTUC-N°1607325
Permeancia al vapor de agua, W	Kg/m2 s Pa	ISO 11654:1997	1,14x10-9	DICTUC-N°1607325
Resistencia a difusión vapor agua, Zp	m2 s Pa/Kg	NCh850.Of.2008	8,74x10-8	DICTUC-N°1607325
Permeabilidad de vapor de agua	Kg/m s Pa	NCh2457-2014	5,91x10-11	DICTUC-N°1607325
Factor resistencia al vapor de agua	-	NCh2457-2014	3,7	DICTUC-N°1607325
Aislación acústica (Cpia)	-	ISO 11654-1997	Aw=0,7;NCR=0,75	CPIA N° 331
Material Inflamable	-	US-EPA, CFR part 261	No	UDT-2022 RT-007
Resistencia a mohos	-	AWPA E24-16	100%	UDT-2022 RT-007

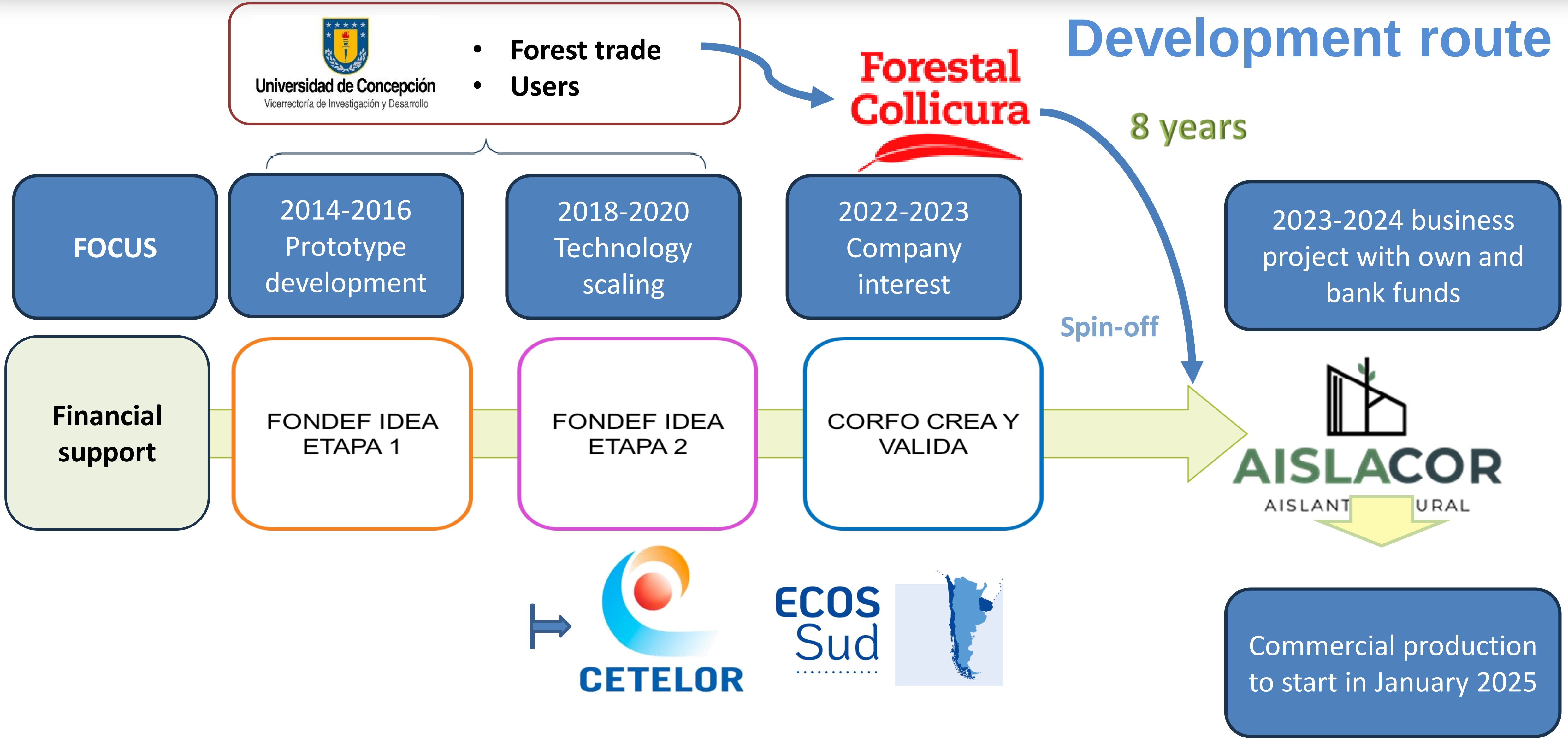
- New competitive, environmentally friendly and commercially viable product.
- Full characterization in accordance with Chilean regulations (MINVU).
- Natural alternative as replace of glass wool and EPS
- Licenced to **Aislacor SpA** en 2023
- Productive plant in 2025, 1-2MM m^2/año

Thermal insulation panel

AISLACOR
AISLANTE NATURAL



Development route



UNIVERSITÉ DE LORRAINE

CONCLUSION

CETELOR

DIAMOND HEMP
POSITIVE IMPACT FARMING

udt Ciencia, Tecnología e Innovación en Bioeconomía

CETELOR

AISLACOR
AISLANTE NATURAL

Thank you for your attention !