

Summerschool

“Between Protection and Production – advanced concepts
and solutions of a sustainable utilization of forest resources”

SUSTAINABLE DEVELOPMENT OF FOREST-BASED BIOENERGY PROJECTS IN THE MEDITERRANEAN REGION

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1. INTRODUCTION
2. SUSTAINABLE DEVELOPMENT OF THE FOREST-BASED BIOENERGY CHAIN UNDER MEDITERRANEAN CONDITIONS
3. FOREST-BASED BIOENERGY POTENTIAL IN THE COMMUNITY OF VALENCIA
4. INNOVATION CHALLENGES AND INTEGRAL BIOENERGY PROJECTS

1st RISK:

PROGRESSIVE RURAL EXODUS AND ABANDONMENT OF FORESTRY



INTRODUCTION

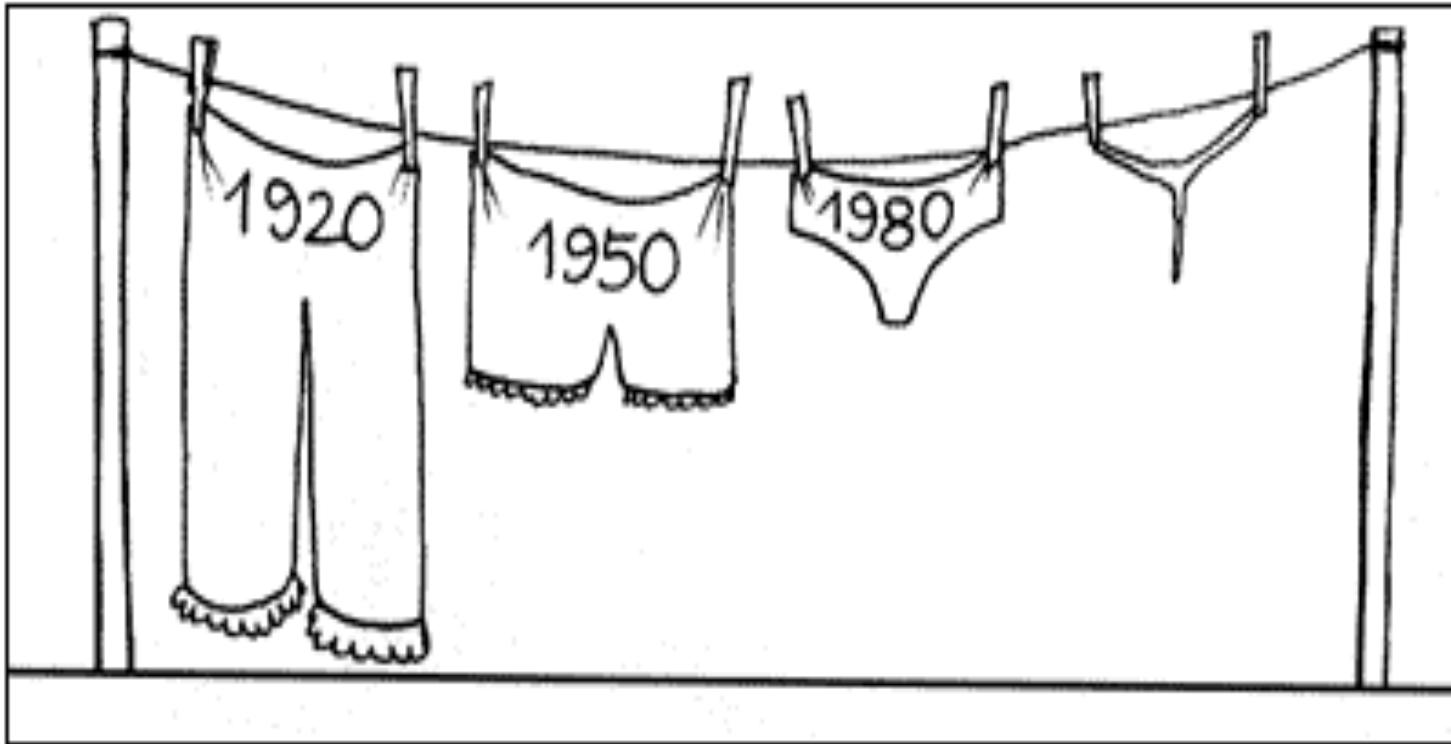
1st RISK:

PROGRESSIVE RURAL EXODUS AND ABANDONMENT OF FORESTRY



2nd RISK:

EFFECTS OF CLIMATE CHANGE: HOT SUMMERS AND DRY WINTERS



INTRODUCTION



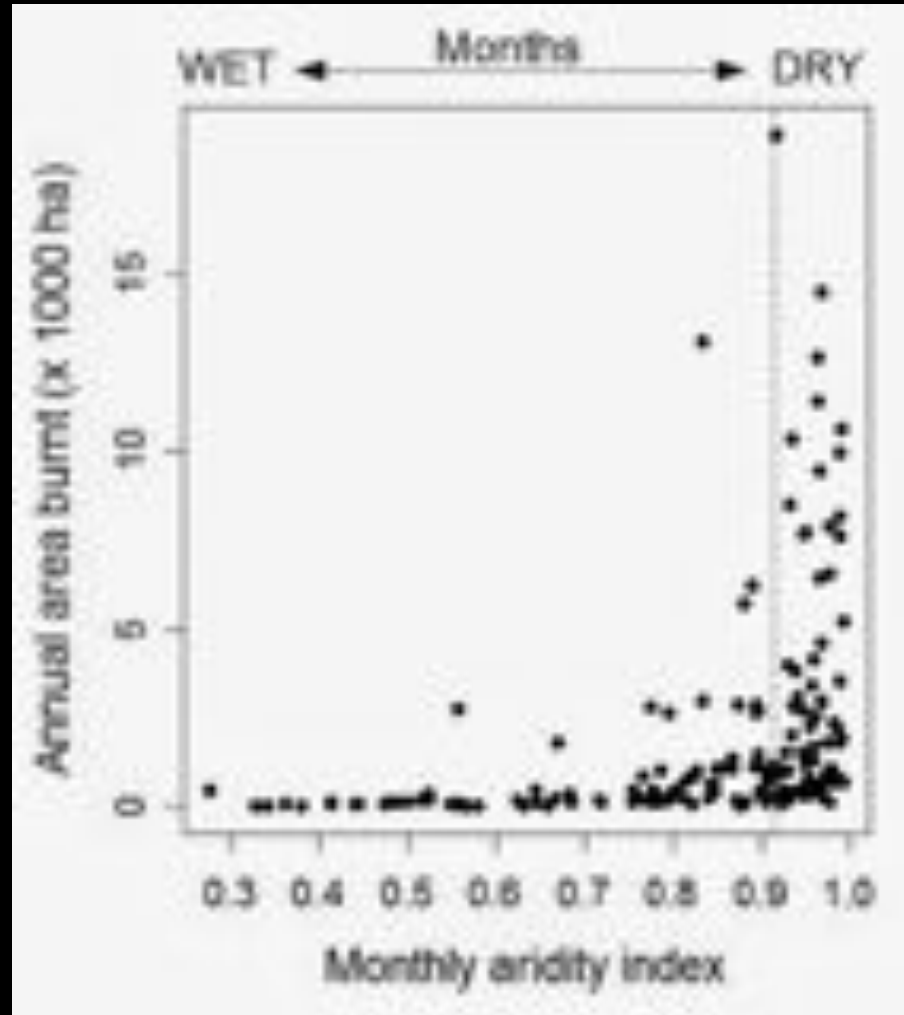


3rd RISK:

LARGE FOREST FIRES



INTRODUCTION



Forest fires in dependance on climate change
in the Western Mediterranean basin
(Pausas 2012)



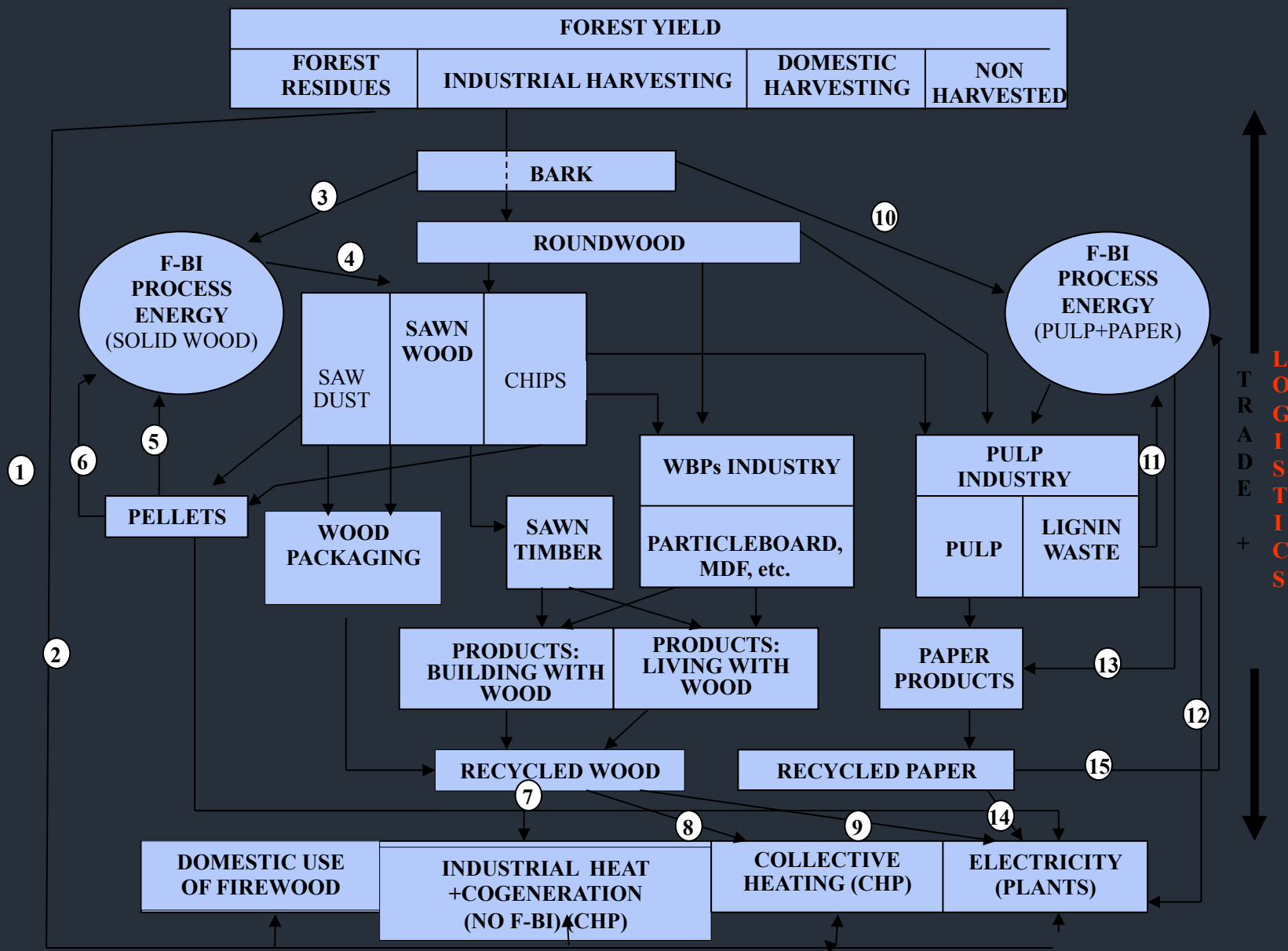


4th RISK/OPPORTUNITY: CASCADE USE OF WOOD



INTRODUCTION

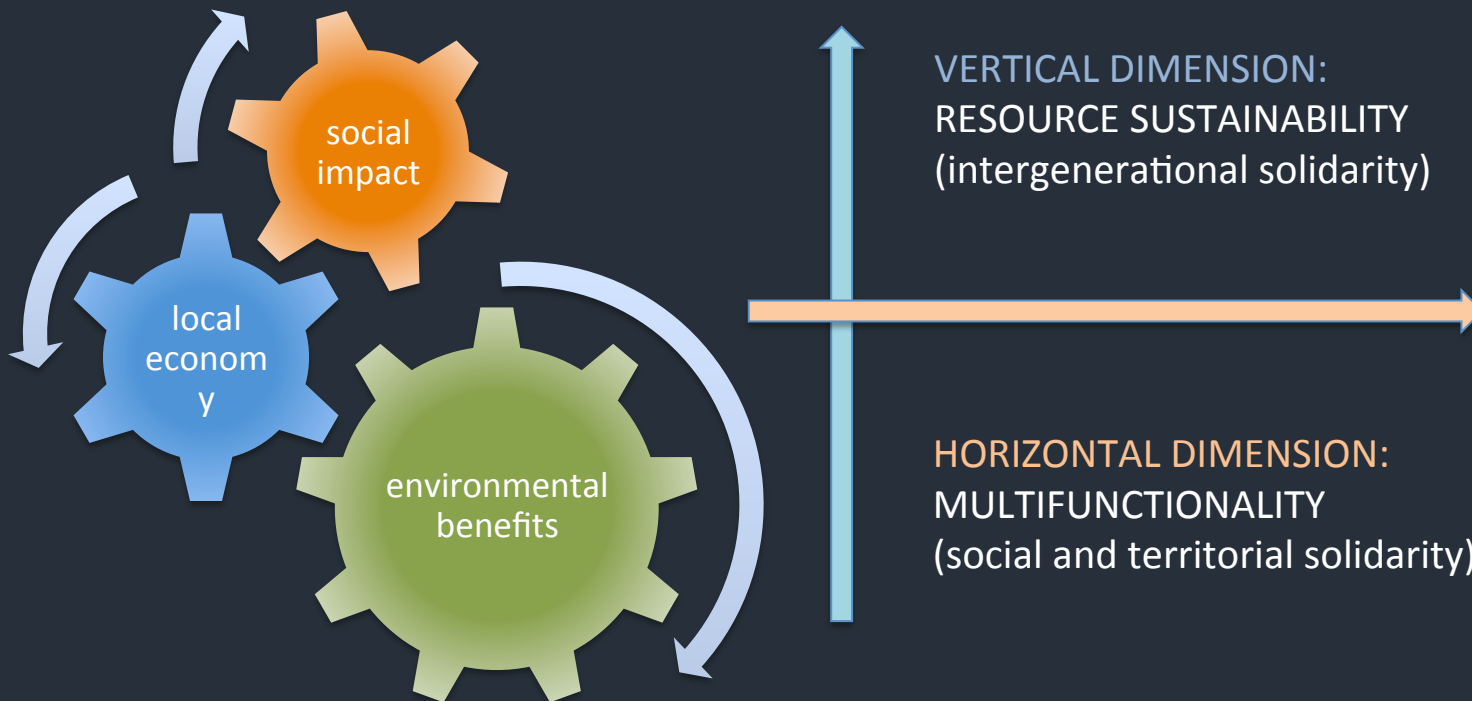
Static and dynamic carbon sequestration



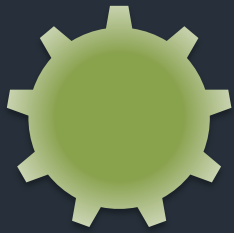
CONCLUSIONS:
KEY SUSTAINABILITY CHALLENGES FOR FOREST-BASED BIOENERGY
UNDER MEDITERRANEAN CONDITIONS AT LOCAL LEVEL

SUSTAINABILITY

AS BASIS FOR A LOW CARBON AND KNOWLEDGE-DRIVEN BIOECONOMY



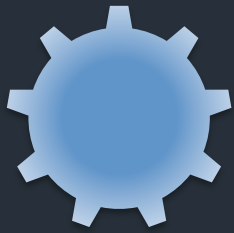
INTRODUCTION



ENVIRONMENTAL BENEFITS

- ☺ Extraction of forest residual biomass
- ☺ Active fire prevention silviculture: reduction of bushfire risk
- ☺ Improved forest ecosystems, soil protection, water regime and biodiversity
- ☺ Natural regeneration and increased CO₂ fixation
- ☺ Production and use of bioenergy at local level
- ☺ Substitution of fossil energy sources: reduction of CO₂ emissions
- ☺ Active mitigation of climate change

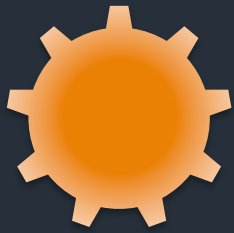
SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN



DEVELOPMENT OF LOCAL ECONOMIES

- 😊 Valorization of non-used forest residues: from waste to product
- 😊 Forest companies: forestry planning and management
- 😊 Harvesting companies: optimization and technological development of harvesting and logistics processes
- 😊 Local investors for bioenergy industrial projects at small and medium scale
- 😊 Local bioenergy distribution: thermal, electrical or biofuels
- 😊 SRCs as complementary energy crops at marginal agricultural land
- 😊 Integrated industrial projects across the entire bioenergy value chain in rural areas at local level

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN



SOCIAL IMPACTS

- ☺ Direct employment: forest management, harvesting and logistic operations, energy conversion processes, energy distribution etc.
- ☺ Indirect employment in rural areas: services (2x1)
- ☺ Education and training in a future-oriented sector: specialised skills and knowledge transfer
- ☺ Active contribution to a KBBE in Mediterranean rural areas

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN

CONCLUSIONS:
KEY SUSTAINABILITY CHALLENGES FOR FOREST-BASED BIOENERGY
UNDER MEDITERRANEAN CONDITIONS AT LOCAL LEVEL

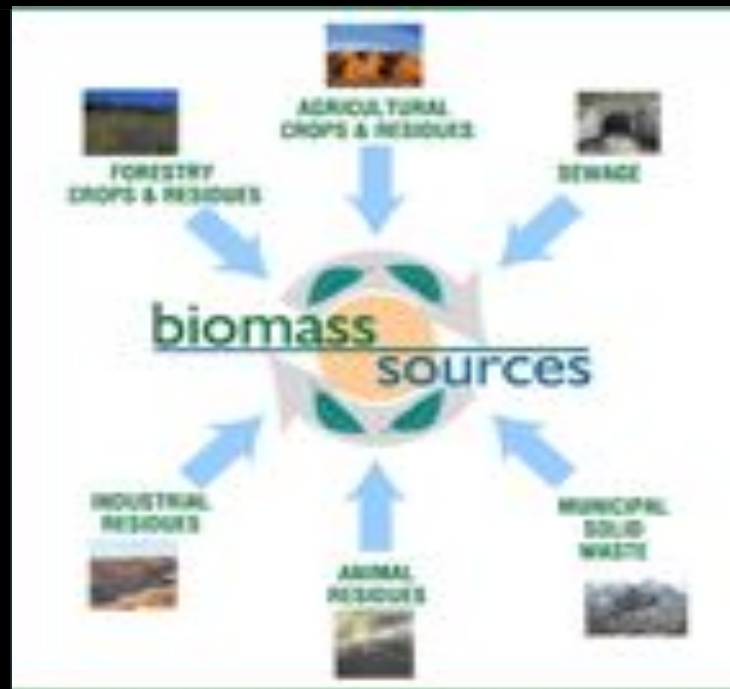
1. RATIONALE USE OF FOREST RESSOURCES:
from waste to product (market)
2. ENERGY RECOVERY OF LIGNOCELLULOSIC WASTE:
optimisation of contribution to mitigation of climate change
3. INTEGRAL VALORISATION PROJECTS AT LOCAL/SUBREGIONAL SCALE:
carbon emmisions minimisation, economic optimisation and
rural development

BIOENERGY
development in CV based on
huge potential of
BIOMASS SOURCES
in rural areas

FOREST-BASED BIOENERGY

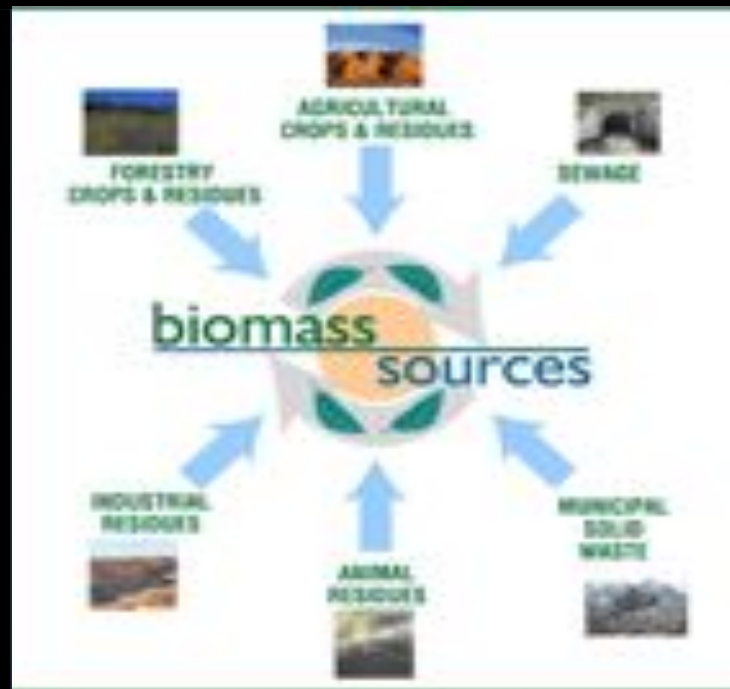
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in rural areas



→ FOREST-BASED BIOMASS

- >50% forest land

FOREST-BASED BIOENERGY



BIOENERGY
development in CV based on
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in rural areas



→ FOREST-BASED BIOMASS

- >50% forest land
- increasing forest area and stocking volume in large unmanaged forests

FOREST-BASED BIOENERGY

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→ FOREST-BASED BIOMASS

- >50% forest land
- increasing forest area and stocking volume in large unmanaged forests
- fire prevention silviculture

FOREST-BASED BIOENERGY



BIOENERGY development in CV based on

huge potential of
BIOMASS SOURCES
in rural areas



→ FOREST-BASED BIOMASS

- >50% forest land
- increasing forest area and stocking volume in large unmanaged forests
- fire prevention silviculture
- high calorific power

FOREST-BASED BIOENERGY

Tipo de biomasa	Procedencia	Humedad (base húmeda) en el momento de la corta.	Poder Calorífico Superior Humedad=0% MJ/kg (valores medios)	Poder Calorífico Inferior (PCI) Kcal / kg (valores medios)
<i>P. pinaster</i> (ramas)	Varías	35-50 (42.5)	21.1	2465.2597
<i>P. pinaster</i> (madera)	Varías	40-50 (45)	20.7	2280.1338
<i>P. pinaster</i> (corteza)	Varías	25-40 (32.5)	21.0	2979.6299
<i>P. halepensis</i> (ramas)	Zaragoza	30-45 (37.5)	20.8	2685.7503
<i>P. halepensis</i> (madera)	Zaragoza	38-48 (43)	20.4	2343.5090
<i>P. halepensis</i> (corteza)	Zaragoza	25-40 (32.5)	20.0	2818.5320
<i>P. sylvestris</i> (ramas corta)	Varías	35-50 (42.5)	21.1	2465.2597
<i>P. pinea</i> (árbol entero, claras)	Ciudad Real	40-48 (44)	20.2	2265.4013
<i>P. nigra</i> (ramas corta)	Varías	35-50 (42.5)	20.6	2396.6439
<i>P. radiata</i> (ramas corta)	País Vasco	38-50 (44)	20.5	2305.4968
<i>E. globulus</i> (ramas)	Asturias	50-55 (52.5)	20.2	1832.7511
<i>E. globulus</i> (madera)	Asturias	55-65 (60)	19.5	1384.1752
<i>E. globulus</i> (corteza)	Asturias	45-55 (50)	15.9	1446.8747
<i>F. silvatica</i> (madera)	Varías	40	19.2	2325.804
<i>Castanea sativa</i> (madera)	Varías	40	19.8	2411.722
<i>Populus sp.</i> (ramas corta)	Varías	40-50 (45)	19.4	2109.4894
<i>Q. pyrenaica</i> (ramas sin hojas)	Soria	35-45 (40)	19.2	2325.804
<i>Q. pyrenaica</i> (rollo cc)	Soria	38-50 (44)	19.1	2118.3843
<i>Q. petraea</i> (madera)	Varías	40	19.3	2340.123
<i>Q. ilex</i> (hojas)	Varías	40	19.3	2340.123
<i>Q. ilex</i> (ramillas)	Varías	40	18.5	2225.565
<i>Q. ilex</i> (madera)	Varías	40	18.2	2182.605
<i>Q. ilex</i> (desbroce)	Varías	40	19.2	2325.803

development of forest-based
bioenergy value chain at local level in
Mediterranean rural areas based on
REGIONAL CO-OPERATION

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN



development of forest-based
bioenergy value chain at local level in
Mediterranean rural areas based on
REGIONAL CO-OPERATION

UNIVERSITIES

RESEARCH CENTRES

FOREST OWNERS

SMEs

NGOs

PUBLIC ADMINISTRATIONS

etc.

SUSTAINABLE DEVELOPMENT OF THE
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FOREST SECTOR

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN



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FOREST SECTOR

WG BIOENERGY

**SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN**



development of forest-based
bioenergy value chain at local level in
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EU CO-OPERATION

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN



development of forest-based bioenergy value chain at local level in Mediterranean rural areas based on EU CO-OPERATION



Cost E9 "LCA of forestry and forests products" 2000-2005



Cost E31 "Management of Recovered Wood" 2004-2008



INTERREG III C PERSPECTIVE 2005-2008



LIFE+ BEST4VARIOUSE 2009-2012



LIFE+ FIRE PREVENTION & BIOENERGY 2010-2013



MED PROFORBIOMED 2011-2014



+ ERASMUS + LEONARDO

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN

development of forest-based
bioenergy value chain at local level in
Mediterranean rural areas based on
SUSTAINABILITY

SUSTAINABLE DEVELOPMENT OF THE
FOREST-BASED BIOENERGY CHAIN

FOREST-BASED BIOENERGY POTENTIAL

PATFOR (Oliver et al. 2013):

Forest (and agricultural) biomass potential: 1,2 Mt/y = 260.000 toe

5% of regional energy demand

750.000 CO₂ t/y reduction of emissions

Additional potential of lignocellulosic energy crops (SRC)

Direct+indirect employment in rural areas

FOREST-BASED BIOENERGY POTENTIAL
IN THE COMMUNITY OF VALENCIA



FOREST-BASED BIOENERGY POTENTIAL IN THE COMMUNITY OF VALENCIA

INDUSTRIAL/VALORIZATION PROJECTS

8-10 industrial CHP plants at small scale (2 MW, 20.000 t/y)

10 x 15 M Kweh/y = 150 Mio Kweh/y x 0,14€/KWeh = 21 Mio €/y

10 x 40 M KWth/y = 400 Mio KWth/y x 0,03€/KWth = 12 Mio €/y

10-15 district heatings (1 MW, 10.000 t/y)

10 x 40 M KWth/y = 400 Mio KWth/y x 0,03€/KWth = 12 Mio €/y

8-10 pellet plants (10.000 t/y)

10 x 10.000t/y pellets x 200 €/t = 20 Mio €/y

FOREST-BASED BIOENERGY POTENTIAL
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INDUSTRIAL/VALORIZATION PROJECTS

8-10 industrial CHP plants at small scale (2 MW, 20.000 t/y)

$10 \times 15 \text{ M Kweh/y} = 150 \text{ Mio Kweh/y} \times 0,14\text{€/KWeh} = 21 \text{ Mio €/y}$

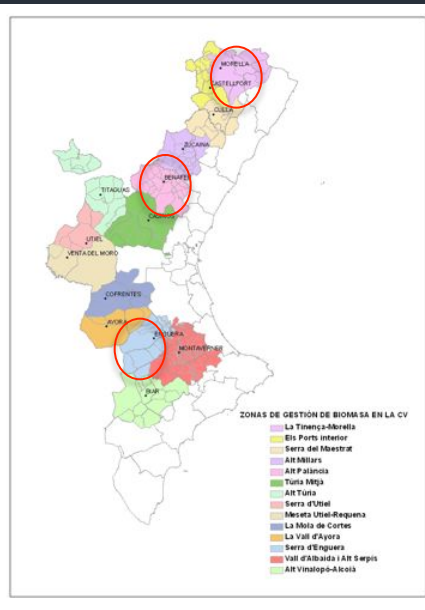
$10 \times 40 \text{ M KWth/y} = 400 \text{ Mio KWth/y} \times 0,03\text{€/KWth} = 12 \text{ Mio €/y}$

10-15 district heatings (1 MW, 10.000 t/y)

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8-10 pellet plants (10.000 t/y)

$10 \times 10.000\text{t/y pellets} \times 200 \text{ €/t} = 20 \text{ Mio €/y}$



FOREST-BASED BIOENERGY POTENTIAL
IN THE COMMUNITY OF VALENCIA

INTEGRAL FOREST-BASED BIOMASS MODEL



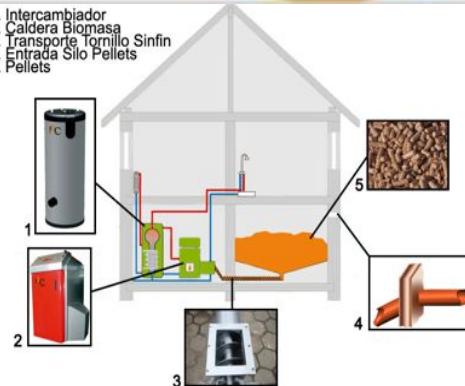
L o g i s t i c s



L o g i s t i c s



1. Intercambiador
2. Caldera Biomasa
3. Transporte Tornillo Sinfin
4. Entrada Silo Pellets
5. Pellets



FBiomass

private
municipal
public

ABiomass

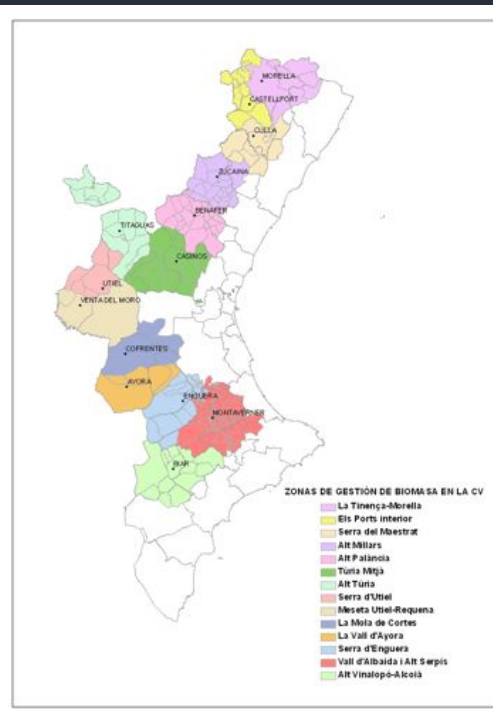
private

Energy crops

Private

Urban and industrial waste biomass

municipal
private



Direct employment (ex. integral project in ENGUERA)

17.000 ha public forests (Canal de Navarrés)
12.000 ha municipal forests (Municipality of Enguera)
9.000 ha municipal forests (Municipality of Moixent)
13.000 ha private forests
15.000 ha private agricultural land (olive and almond crops)
500 ha SRCs as energy crops
Approx. 30.000 t/y

Forest planning (inventory and management plans, harvesting annual plans)	2
Harvesting operations and in-situ chipping	16
Transport and logistics	6
CHP plant (2MW) + district heating	11
Pellet plant	9
TOTAL	44

+ INDIRECT EMPLOYMENT (x1,8)

SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS

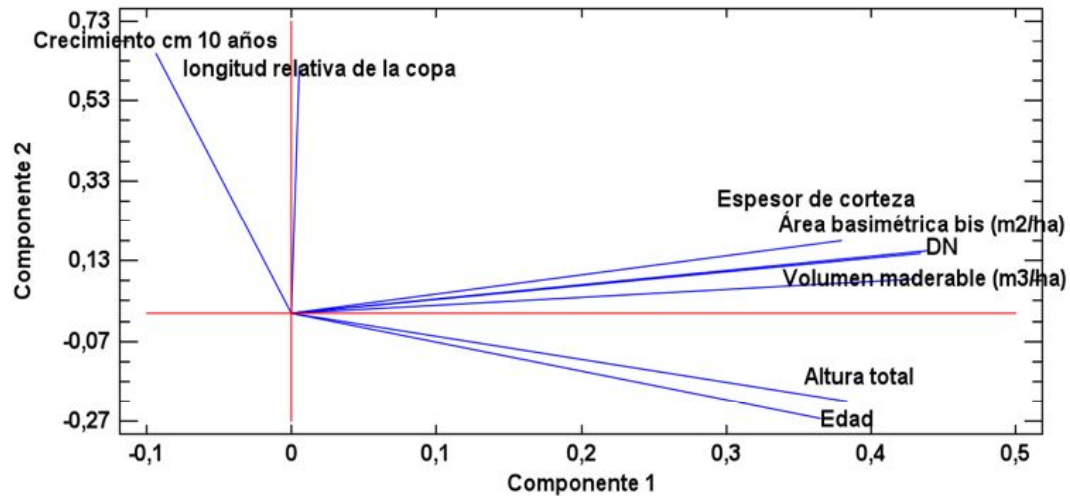
INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

1. Biomass oriented forest management plans for sustained raw material supply



SUSTAINABLE DEVELOPMENT OF
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INDUSTRIAL PROJECTS

Gráfica de Pesos del Componente



Bioenergy oriented approach for harvesting plans in pure stands of *Pinus halepensis*
(LIFE BIOENERGY AND FIRE PREVENTION 2013)

INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

1. Biomass oriented forest management plans for sustained raw material supply
2. Optimisation of harvesting and logistic costs



SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS



LOGGING
RESIDUES

15 - 20 %



TREES
AND
TREE SECT'S

35 - 40 %



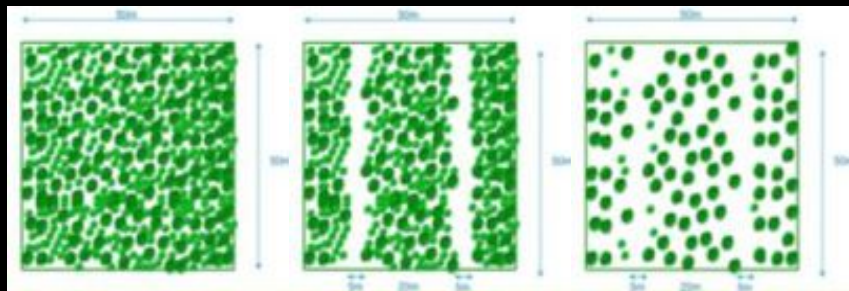
CHIPS

~ 40 %



PULP-
WOOD

60 - 70 %



HARVESTING SYSTEM	WORKING OPERATIONS	HOURLY COST (€/h)	EFFECTIVE WORKING TIME (h/t)	PRODUCTIVITY (t/h)	UNIT COST (€/t)
FULL-TREE HARVESTING	FELLING with chainsaw STIHL 045ii	15,00 €/h	0,732 h/t	1,366 t/h	10,98 €/t
	SKIDDING with forwarder VAL-MET 860	29,50 €/h	0,752 h/t	1,330 t/h	22,18 €/t
	CHIPPING with mobile chipper STARK SH4585	95,00 €/h	0,050 h/t	20 t/h	4,75 €/t
	TRANSPORT with multi-lift truck 25t (25 Km)				5,00 €/t
	TOTAL				42,91 €/t
INTEGRATED HARVESTING	FELLING with chainsaw STIHL 045ii	15,00 €/h	1,124 h/t	0,890 t/h	16,85 €/t
	DEBRANCHING with chainsaw STIHL 045ii	15,00 €/h	1,040 h/t	0,960 t/h	15,60 €/t
	SKIDDING with forwarder VAL-MET 860	29,50 €/h	0,976 h/t	1,025 t/h	28,79 €/t
	CHIPPING of crown material remained at forest	45,00 €/h	0,170 h/t	4,170 t/h	-
	CHIPPING with mobile chipper STARK SH4585	95,00 €/h	0,050 h/t	20 t/h	4,75 €/t
	TRANSPORT with multi-lift truck 25t (25 Km)				5,00 €/t
	TOTAL				70,99 €/t



Current tests with harvester for medium-aged reforested stands and
with multitree harvester for young natural regenerated stands

INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

1. Biomass oriented forest management plans for sustained raw material supply
2. Optimisation of harvesting and logistic costs
3. Appropriated CHP technologies for Mediterranean biomass (combustion, gasification)



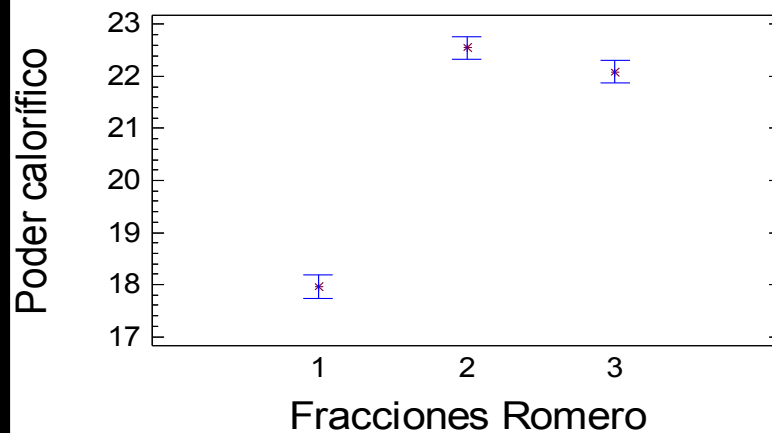
SUSTAINABLE DEVELOPMENT OF
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INDUSTRIAL PROJECTS



Fluid bed experimental gasifier (UPV – IIE)



Medias y 95,0 Porcentajes Intervalos LSD



Net calorific value of *Rosmarinus officinalis* in combustion tests (MJ/Kg)

INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

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4. High qualitative biofuels (pellets, HTC, 2nd generation biofuels)



SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS

Propiedades del análisis	Unid.	Parámetros Técnicos	Cumplimiento de normas				
			Naranja	Olivo	Almendro	Paulonia	Encina
Propiedades físicas							
Humedad	(%)	≤10	-	-	-	-	-
Densidad	Kg/m³	≥600 ¹	✓	✓	✓	✗	✓
Propiedades energéticas							
Cenizas	(%)	≤1,5 ¹	✗	✗	✓	✓	✗
PC	MJ/kg	16,3≥Q≤19 ⁵¹	✗	✓	✓	✓	✓
Elementos químicos							
Nitrógeno (N)	%	≤0,5 ¹	✗	✓	✓	✓	✓
Azufre (S)	%	<0,03 ¹	✗	✓	✓	✓	✓
Arsénico (As)	mg/Kg	≤1,0 ¹	✓	✓	✓	✓	✓
Cromo (Cr)	mg/Kg	≤10,0 ¹	✓	✓	✓	✓	✓
Plomo (Pl)	mg/Kg	≤10,0 ¹	✓	✓	✓	✓	✓
Mercurio (Hg)	mg/Kg	≤0,1 ¹	✓	✓	✓	✓	✓
Níquel (Ni)	mg/Kg	≤10,0 ¹	✓	✓	✓	✓	✓
Zinc (Zn)	mg/Kg	≤10,0 ¹	✓	✓	✓	✓	✓

Pellet quality requirements (EN+) of different lignocellulosic raw materials



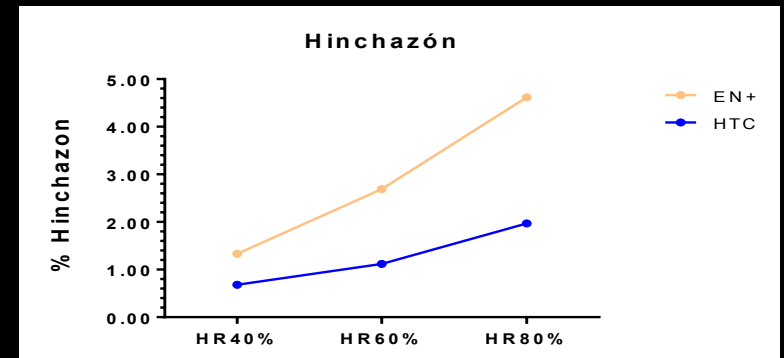
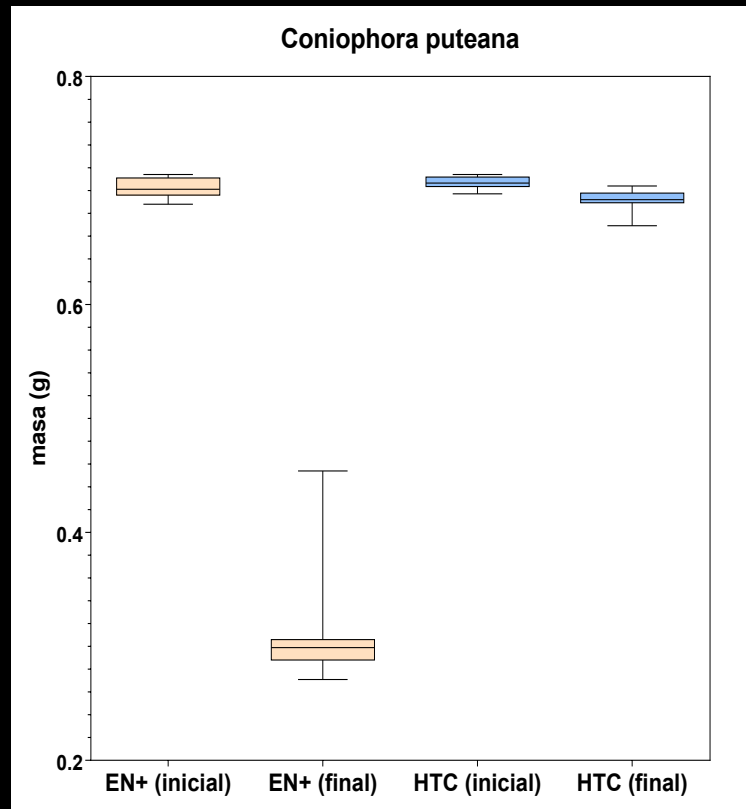
HTC tests with several forest waste material in INGELIA S.L (Náquera)



$$ICP = \frac{K1 * PCS + K2 * D + K3 * (1 - M)}{Hh * FR}$$

ICP	EN+	HTC
	0,289	0,545

Calorific Quality Index of HTC pellets



Durability of HTC pellets

INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

1. Biomass oriented forest management plans for sustained raw material supply
2. Optimisation of harvesting and logistic costs
3. Appropriated CHP technologies for Mediterranean biomass (combustion, gasification)
4. High qualitative biofuels (pellets, HTC, 2nd generation biofuels)
5. Energy contracting at local scale



SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS

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6. Optimisation of energy distribution channels (thermal energy in district or industrial heating systems)



SUSTAINABLE DEVELOPMENT OF
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INDUSTRIAL PROJECTS



Small scale district heating Enguera
(0,8 MW)



INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

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7. Adequate lignocellulosic energy crops in SRC



SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS



Experimental plots of *Paulownia* SRC
in several areas of the Community of Valencia

Zona Geográfica	Ecuación (MJ/árbol)	Ecuación (GJ/ha)
zona interior	$= 4,8648 \text{ DAC}^2 - 15,5676 \text{ DAC} + 8,7568$	$= 9,1966 \text{ DAC}^2 - 29,429 \text{ DAC} + 16,5538$
zona costera 1	$= 20,919 \text{ DAP}^2 - 410,11 \text{ DAP} + 2.171,2$	$= 20,722 \text{ DAP}^2 - 406,253 \text{ DAP} + 2.150,8$
zona costera 2	$= 3,8919 \text{ DAP}^2 - 25,2973 \text{ DAP} + 54,9729$	$= 3,8553 \text{ DAP}^2 - 25,0595 \text{ DAP} + 54,4562$

Zona Geográfica	Pot. energético (MJ/árbol)	Pot. energético (GJ/ha)
zona interior	39,4	55,6
zona costera 1	191,2	189,4
zona costera 2	247,6	245,3

INNOVATION CHALLENGES AND BUSINESS OPPORTUNITIES

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4. High qualitative biofuels (pellets, HTC, 2nd generation biofuels)
5. Energy contracting at local scale
6. Optimisation of energy distribution channels (thermal energy in district or industrial heating systems)
7. Adequate lignocellulosic energy crops in SRC
8. INVESTMENT



SUSTAINABLE DEVELOPMENT OF
INTEGRAL FOREST-BASED BIOENERGY
INDUSTRIAL PROJECTS



Thank you!