Torrefied Bamboo: an alternative for sustainable biomass export

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March 2014
ECN-L--14-014

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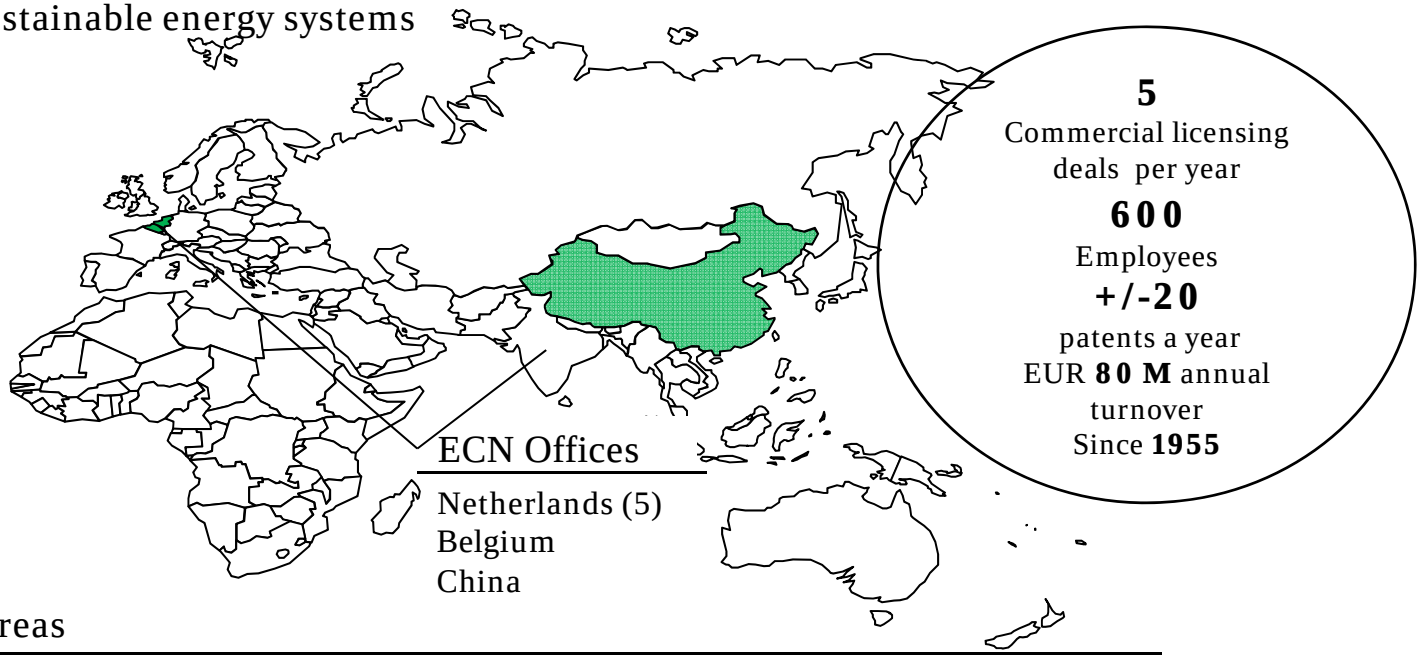
Claudia Daza Montaño

Sustainable Biomass Production in Latin America
Bogotá - Colombia
29 January 2014

ECN at a glance

Mission

To develop knowledge and technologies that enable a transition to more sustainable energy systems



5
Commercial licensing deals per year
600
Employees
+/-20
patents a year
EUR **80 M** annual turnover
Since **1955**

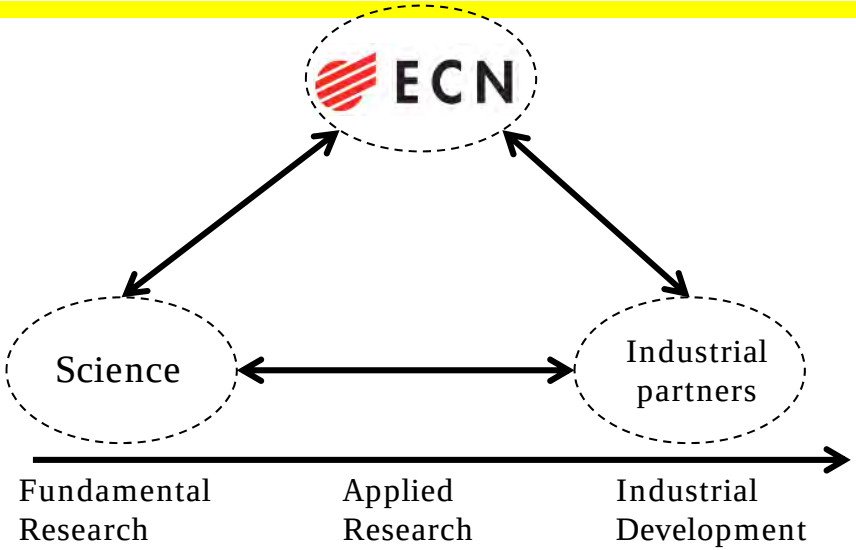
ECN Offices

Netherlands (5)
Belgium
China

ECN Focus Areas

- Solar energy
- Biomass
- Policy studies
- Energy efficiency
- Wind energy
- Environment & energy engineering

ECN acts as a bridge between science and corporate innovation



What we do

Problem solving
Using our knowledge, technology, and facilities to solve our clients' issues

Technology development
Developing technology into prototypes and industrial applications

Studies & Policy support
Creating insights in energy technology and policy

How we can work with you

Consultancy & Services
Serving your short-term business and R&D needs

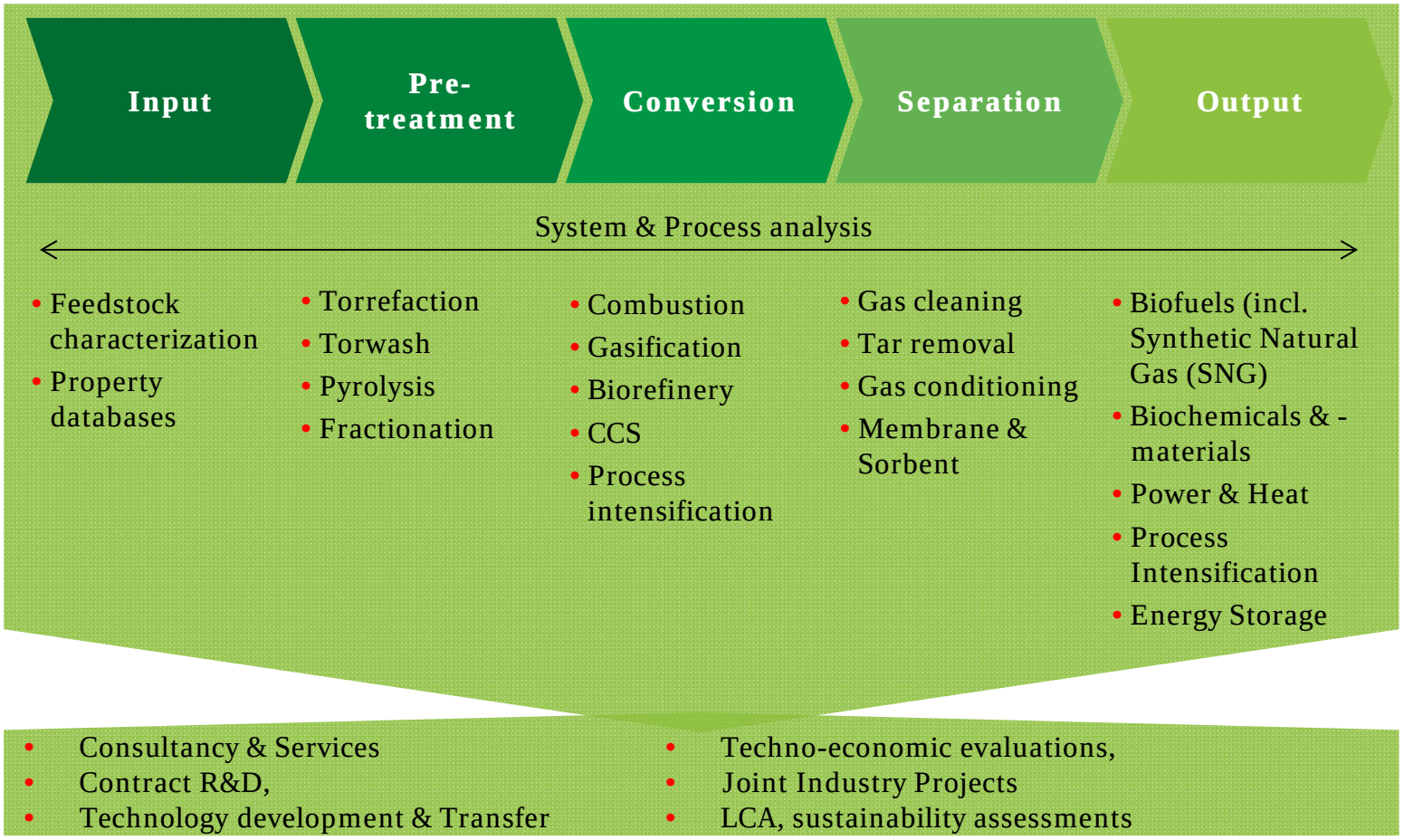
Contract R&D
Support your R&D with our knowledge, technology and (test) facilities

Technology development & Transfer
Implement our technology in products & processes

Joint Industry Projects
Developing tomorrow's technology together

Our Biomass & Energy Efficiency (BEE) unit focuses on multiple areas in the Biomass and Energy value chain

ECN focus in Biomass & Energy Efficiency



Bamboo Project: Jan 2011-April 2013

Torrefied Pellets for
Sustainable Biomass Export from Colombia

Assessing the whole chain of bamboo cultivation & collection via torrefaction upgrading to application as biofuel

NL Agency
Ministry of Economic Affairs

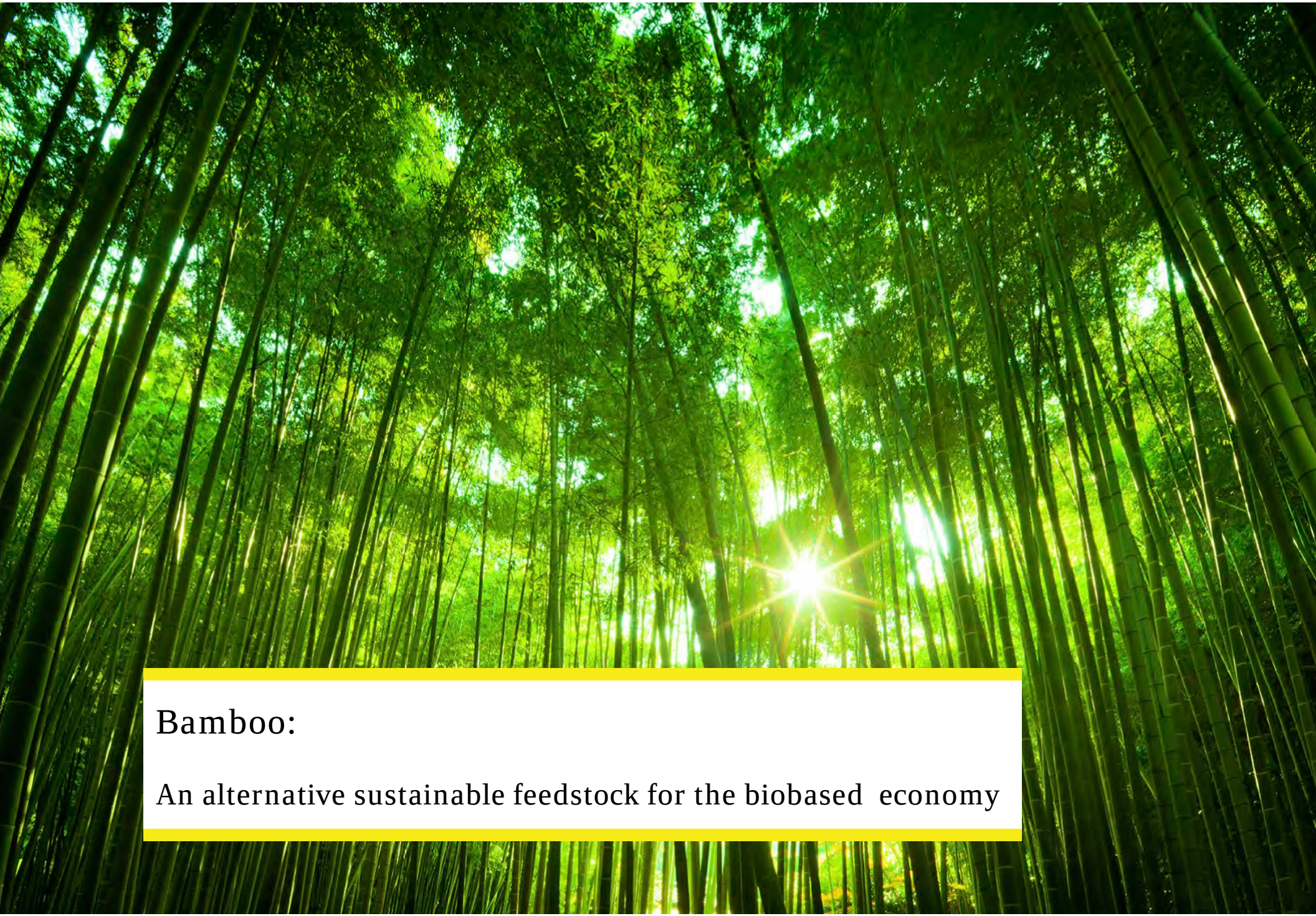
Bamboo as a biomass import chain

Assessment of:
- technical suitability
- sustainability
- economic feasibility

for:
- Co-firing torrefied Colombian bamboo pellets in NL

NL Agency
Ministry of Economic Affairs

The DBI scheme aims to give an impulse to the promotion of the sustainability of the biomass import chains for **biobased energy and chemical applications/transport/electricity/heating and chemicals/materials**



Bamboo:

An alternative sustainable feedstock for the biobased economy

Partners

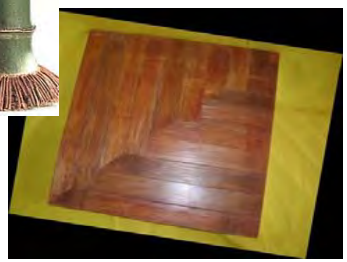
SOCIEDAD COLOMBIANA DEL BAMBU

- Experts on bamboo
- Local data
- Link to local stakeholders
- Material supply

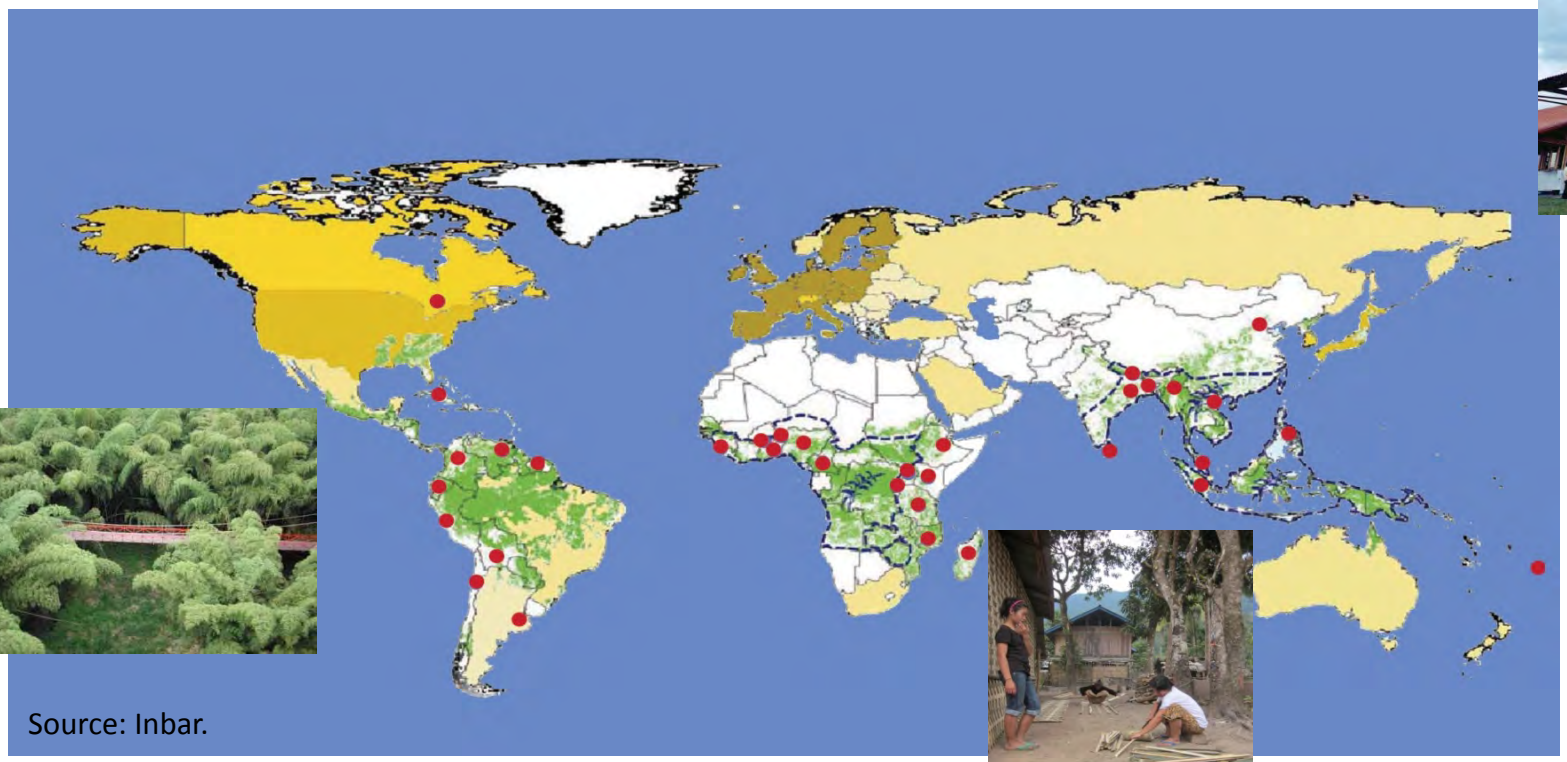
Partners

- Sustainability Assessment
- Technology Assessment
- Techno- economic evaluation
- Results dissemination

Why bamboo?



- ±36 Million Hectares (FAO)
- Millions of tons could be harvested sustainably each year
- Opportunities for sustainable development



Source: Inbar.

Why bamboo?

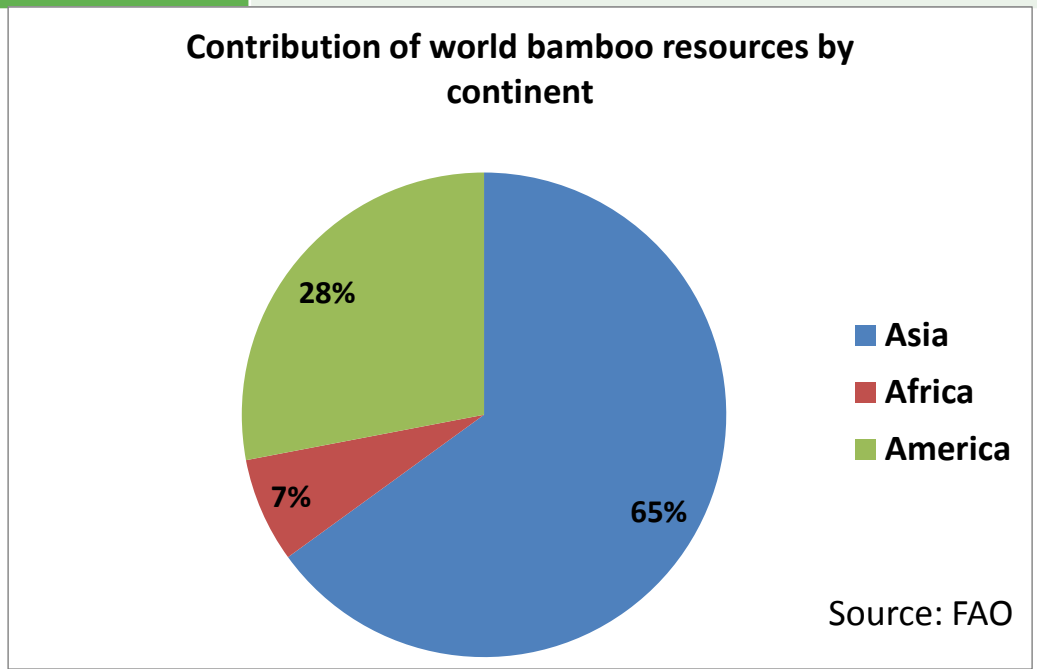
- Fast growing
  - 10-40 Ton/Ha-year
- **Regenerates itself** after it has been responsibly cared for and harvested➔ **No replanting**

- Excellent reforesting crop
  - Low (or none) consumption of fertilizers ➔(GHG)
  - Easy propagation➔**no seeds**
  - Water table preservation
  - Biodiversity preservation
  - Counteracts soil erosion
- CO_2 sump➔ Climate change
- Opportunities for rural development
  - Product diversification

Current Uses

Major global supplier of products: China

Plant section	Current use
Culm	Finished products: housing, **flooring,** furniture, paper, charcoal.
Leaves	Left in the field as fertilizer, and/or collected for animal feed.
Branches	Low value applications, low market (chopsticks)
Roots	Food



Lignocellulosic feedstock

Logistics Cost

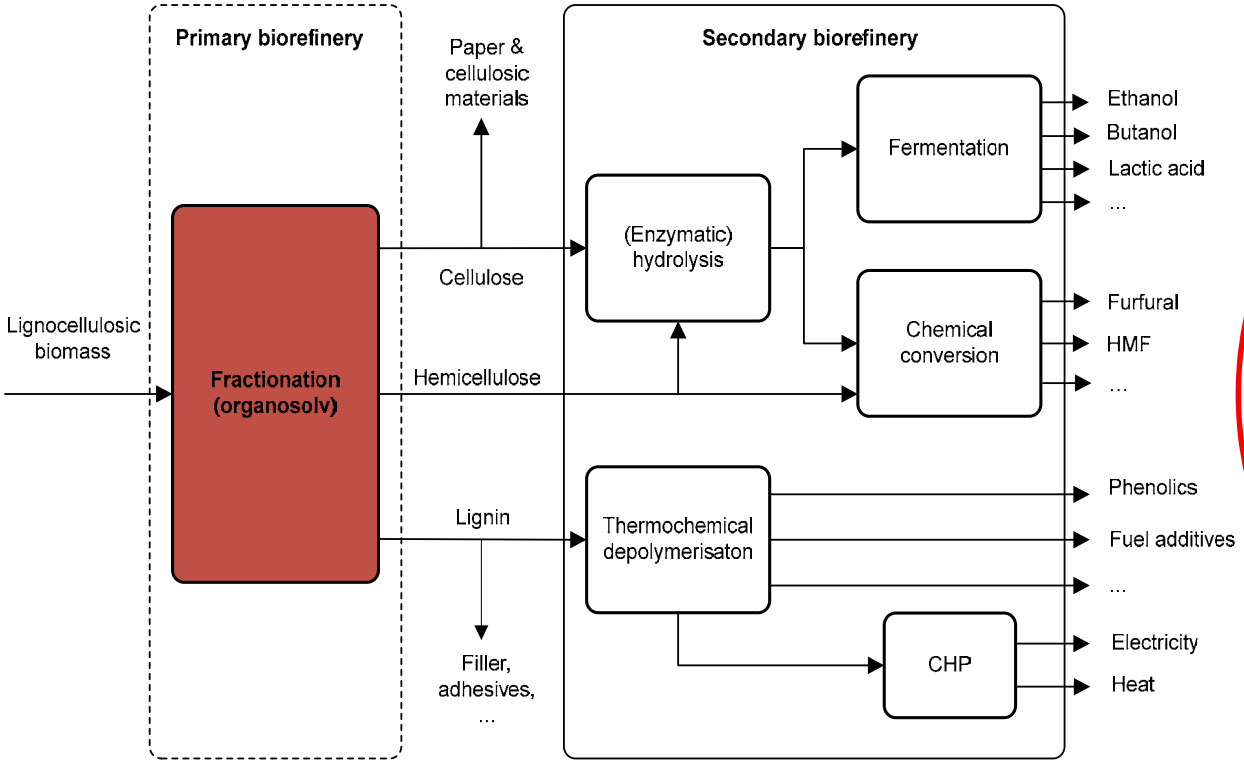
Feedstock		Bamboo culm	Cane Bagasse	Wheat straw	Wood
HHV (dry)	MJ/kg	17-20	18-20	16-19	17-20
Density	kg/m^3	**500-700**	150-200	160-300	200-500
Yield	Ton/Ha-year	**10-40**	7-10	6-12	10-20
Overall composition (dwt %)					
Cellulose		40-60	35	38	50
Hemicellulose		20-30	25	36	23
Lignin		20-40	20	16	22
Others**		2-10	20	10	5

** Ash, resins, etc.

Yields and composition depend on: specie and age of the plant, plant section, cultivation site and harvesting season.

Biobased: Chemicals+ Materials+ Energy

Lignocellulosic Biorefinery

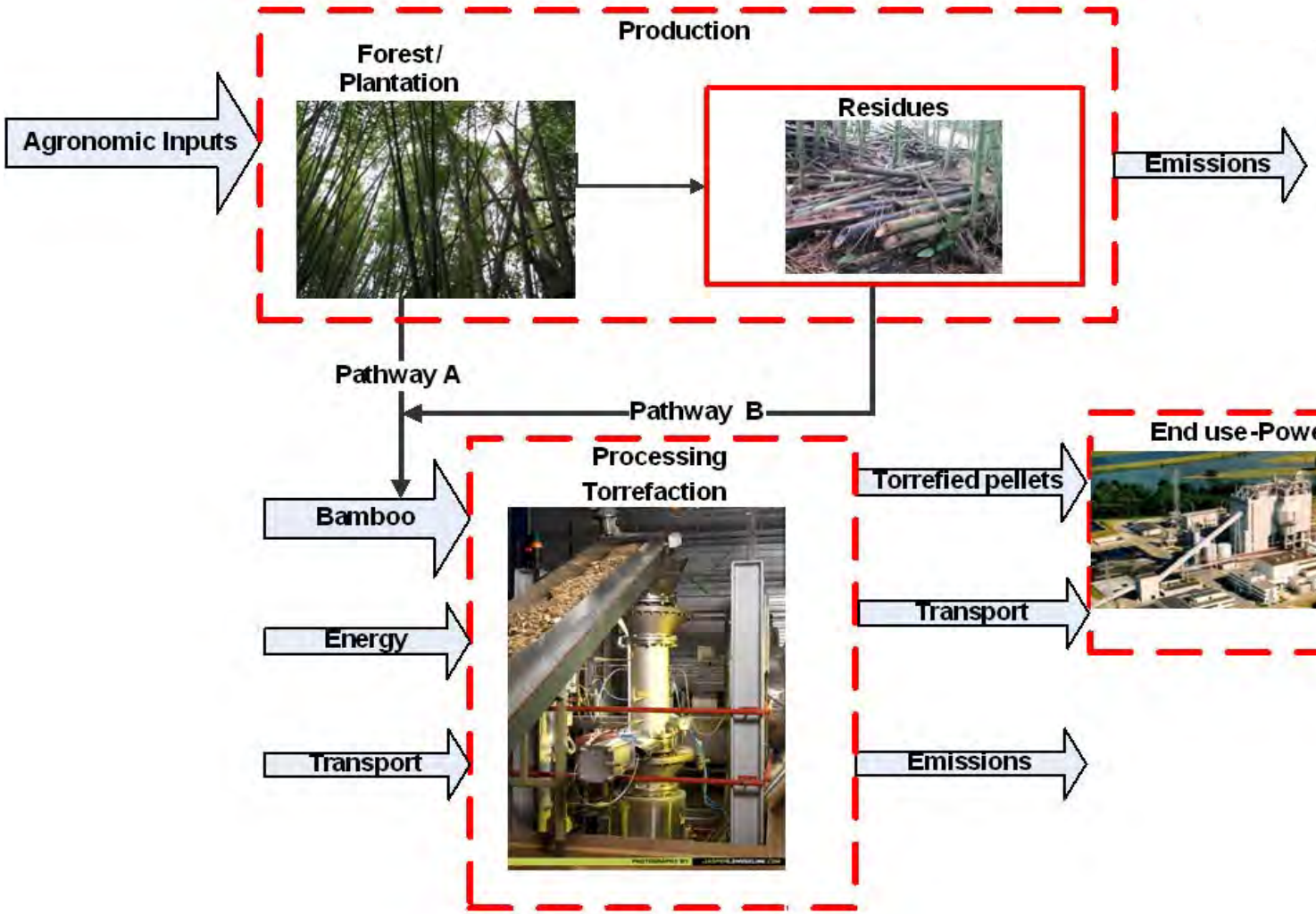


Fibers
Fertilizer
Biochar

Solid Fuel in Power Plants

Coal & biomass

Biomass chain assessment



Technical specifications
Security of supply
Sustainability

REPORT n°1
Initiative Wood Pellets Buyers (IWPB)
Work Group on Sustainability
Sustainability Principles

Torrefaction for upgrading biomass

- Process parameters
  - Temperature: 200-300 °C
  - Absence of oxygen

Tenacious and fibrous
LHV = 9 - 12 MJ/kg
Hydrophilic
Biodegradable
Heterogeneous

Torrefaction

Friable and less fibrous
LHV = 18 - 24 MJ/kg
Hydrophobic
Preserved
Homogeneous

Pelletisation

Bulk density = 650-800 kg/m^3
Bulk energy density = 12 - 19 GJ/m^3

Logistic and operational cost

From Coal to Biomass

← Shipment

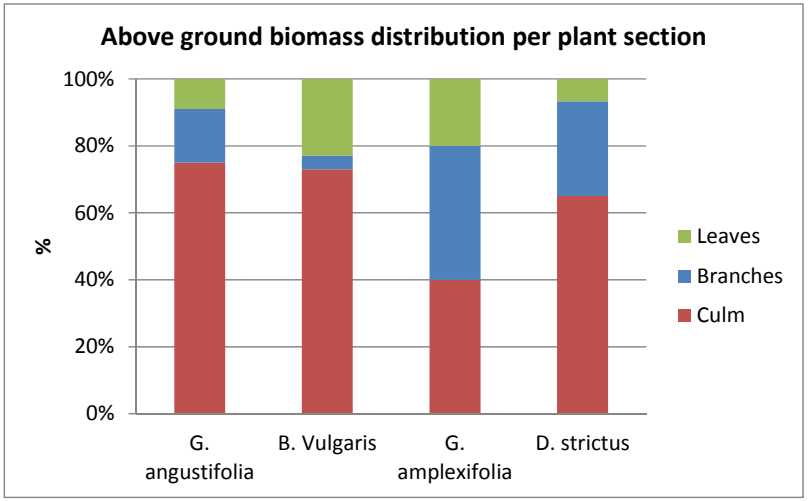
Grinding & Feeding →

← Storage & handling →

Bamboo in Colombia

Native and exotic species

Bamboo species	Native (N) Exotic (E)	Altitude Amsl
Guadua angustifolia Kunth	N	900-1600
Guadua amplexifolia Presl.	N	0-1000
Chusquea subulata L.G. Clark	N	2200-2800
Bambusa vulgaris var. vulgaris	E	0-1500
Dendrocalamus strictus	E	0-800



SOCIEDAD COLOMBIANA DEL BAMBU

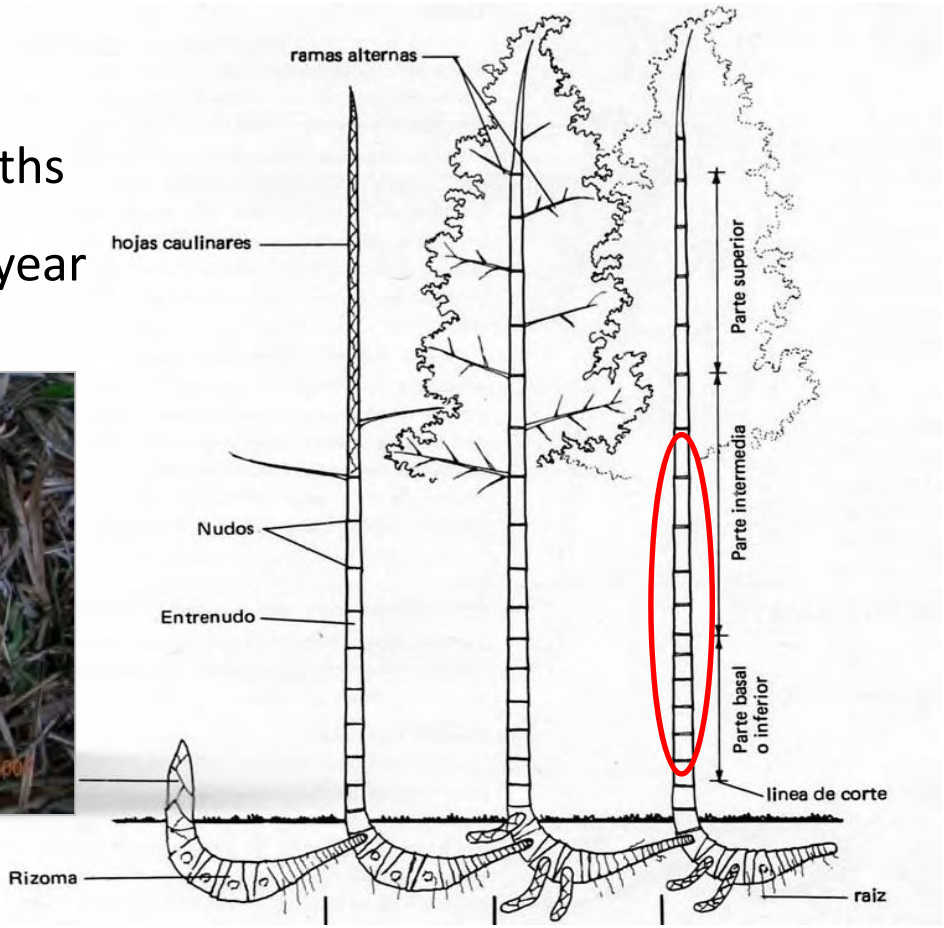
Universidad del Tolima

Case study: Guadua *angustifolia*

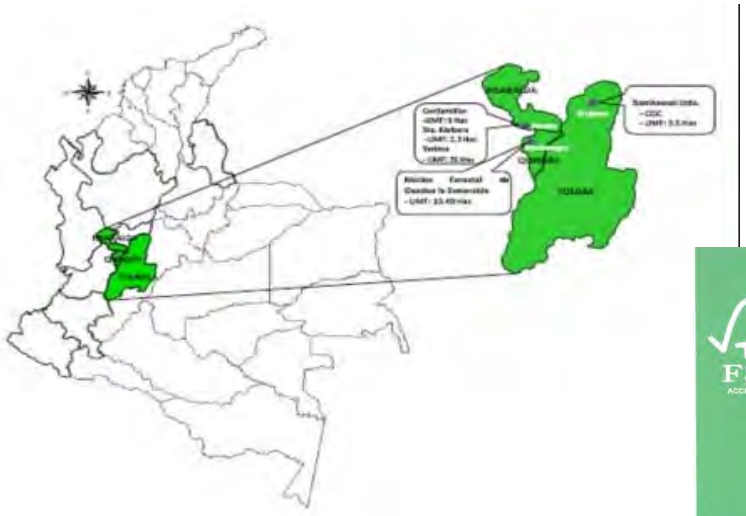
- Woody bamboo species native to Latin America.
- Fast growing:

  30 m in 6 months

  20-40 Ton/ha-year



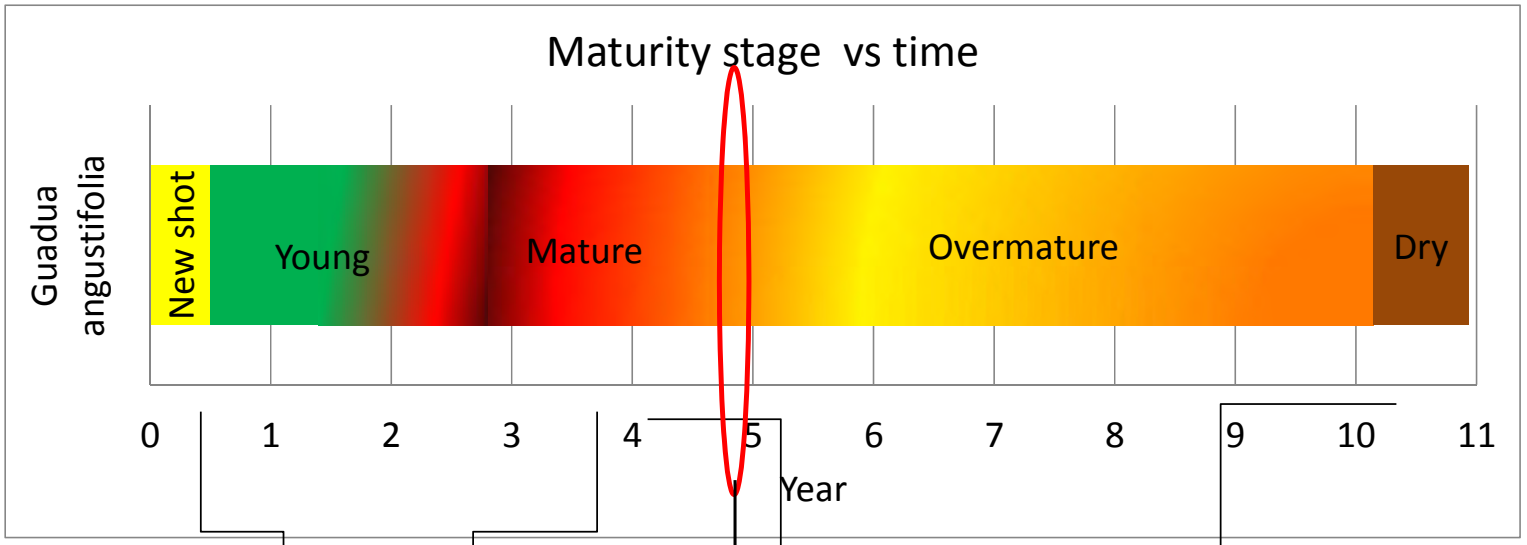
Producers case study: Corguadua



- The Corporative for the sustainable management of guadua CORGUADUA
- 5 members (or units) ➔ 96 ha FSC Certified
- Barriers and opportunities with FSC certification
- Experience and knowledge➔ could be reproduced in other regions

Guadua *a.* development stages

Residues



Major components	Celullose Hemicellulose	Lignin
End Use	Biorefining	Construction → Fuel

Case study 1: Residues

Forest/plantations residues

Processing residues

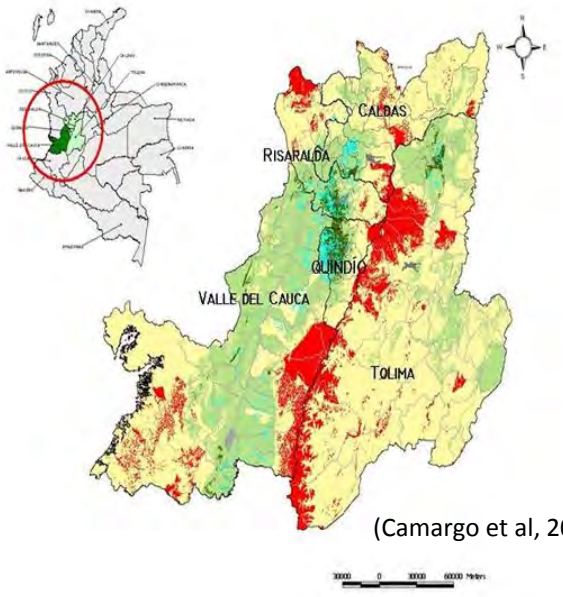
Potential/Forest residues

Forest Residues Potential

Natural forest	Ha	kton/year	MWth
National (Carder, 2000)	51000	765	530
Coffee axis (Camargo, 2007)	28000	420	290

Less than 10% of Guadua forest are under proper management

Case study 2: Plantations/Bioenergy Crop



(Camargo et al, 2007)

Suitable area	Hectares	kton/year
Coffee axis (Camargo 2007)	125,000	1,800
Other regions	?	-
2% of Degraded land	400,000	6,000

*15 Ton/ha-year

Technical Assessment

ECN 50 kg/h torrefaction pilot plant
(Since February 2008)

Torrefaction tests at ECN

feeding

torrefaction

pelletization

1-10 tons of test batches

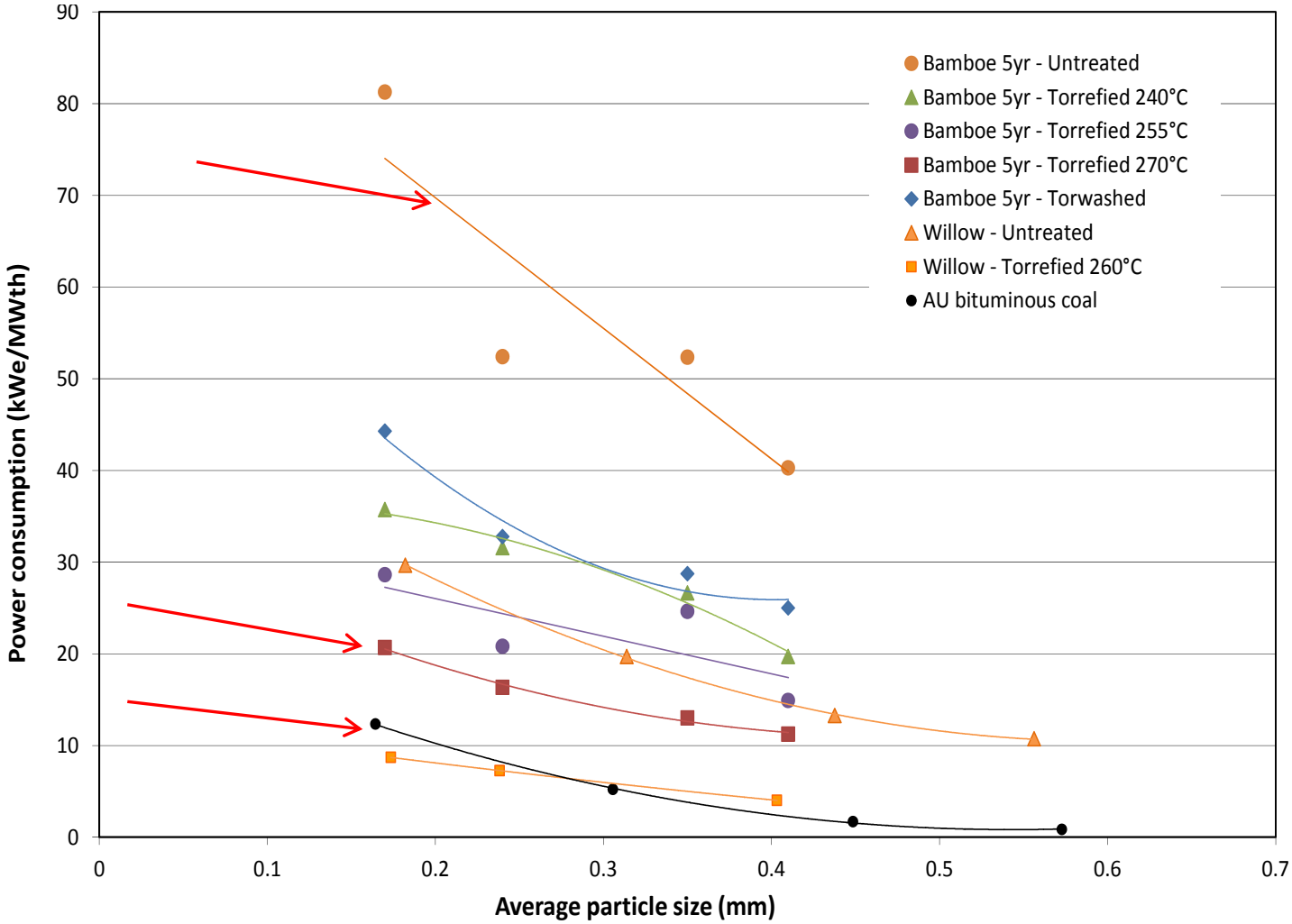
untreated bamboo

bamboo treated @ 245°C

bamboo treated @ 255°C

bamboo treated @ 265°C

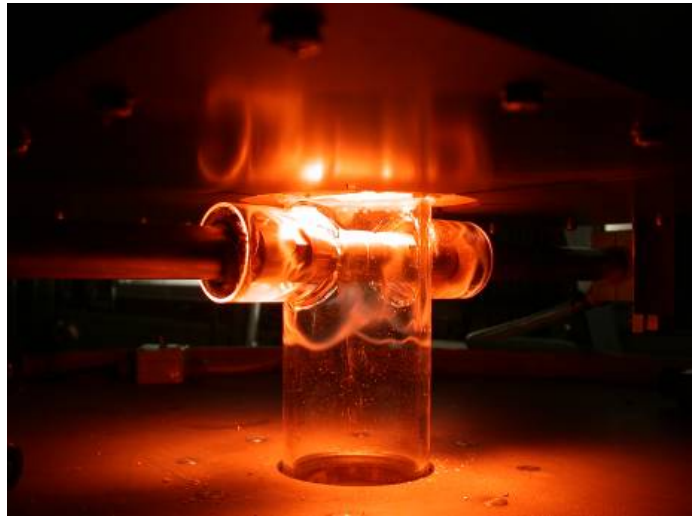
Grindability



Janssen, A.

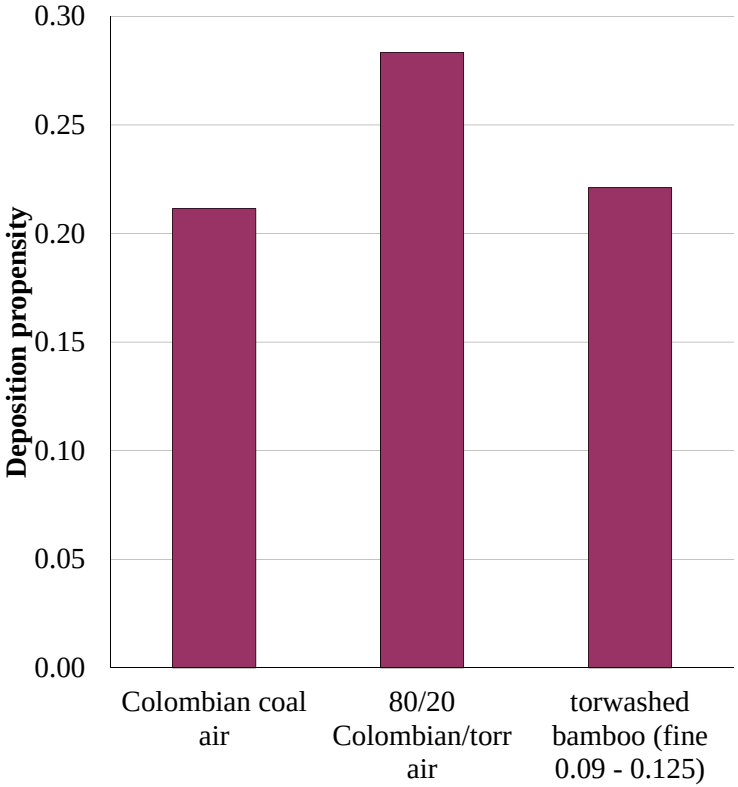
Combustion and gasification

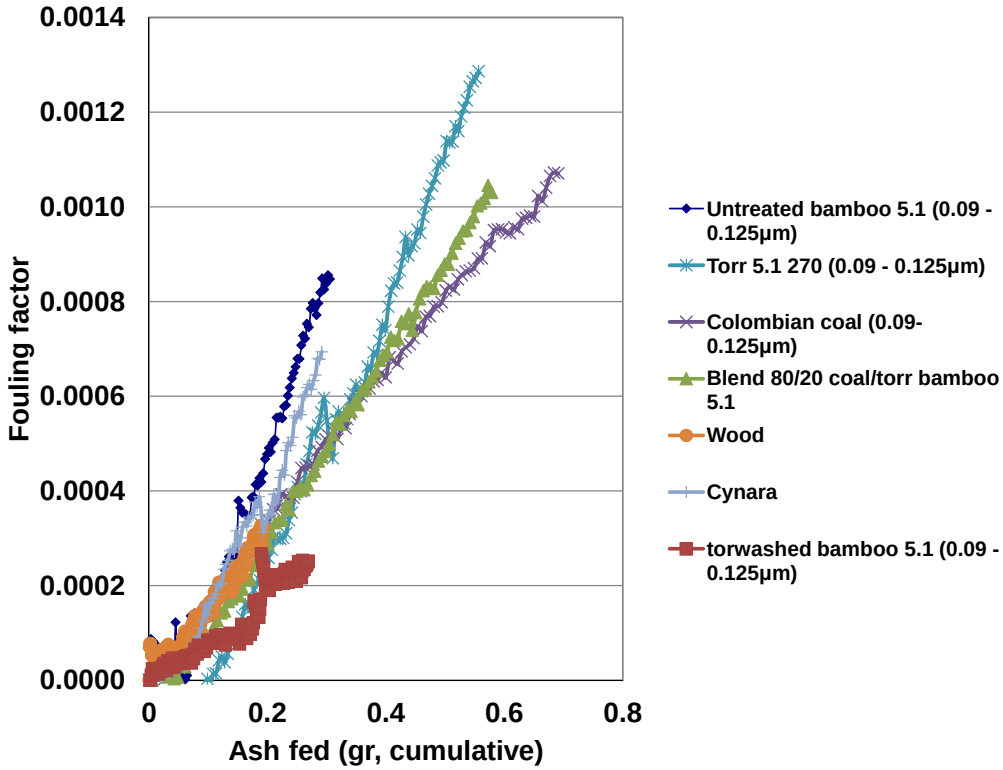
- Combustion simulator
  - Combustion characteristics
  - Slagging and fouling
  - Emissions (NOx, SOx, Dioxins)
- On-site measurements
  - Slagging and fouling
  - Gas sampling
- Fuel and Ash characterisation
- Phyllis database of biomass properties



Combustion tests

- **Life time and maintenance of equipment**
- **Efficiency of the installation**



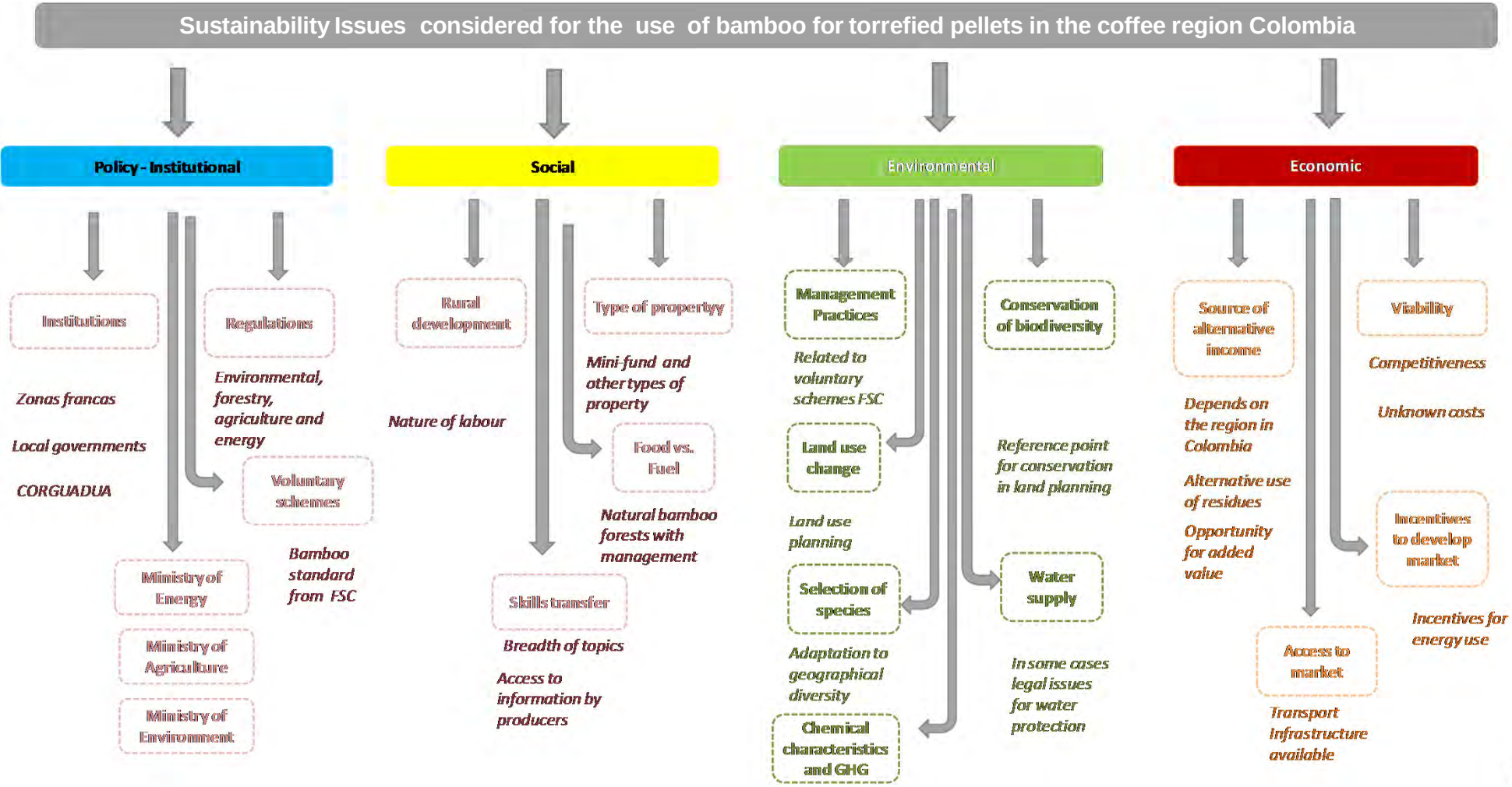


Fryda et al, 2013

- **Similar to wood**

Sustainability assessment

Sustainability issues

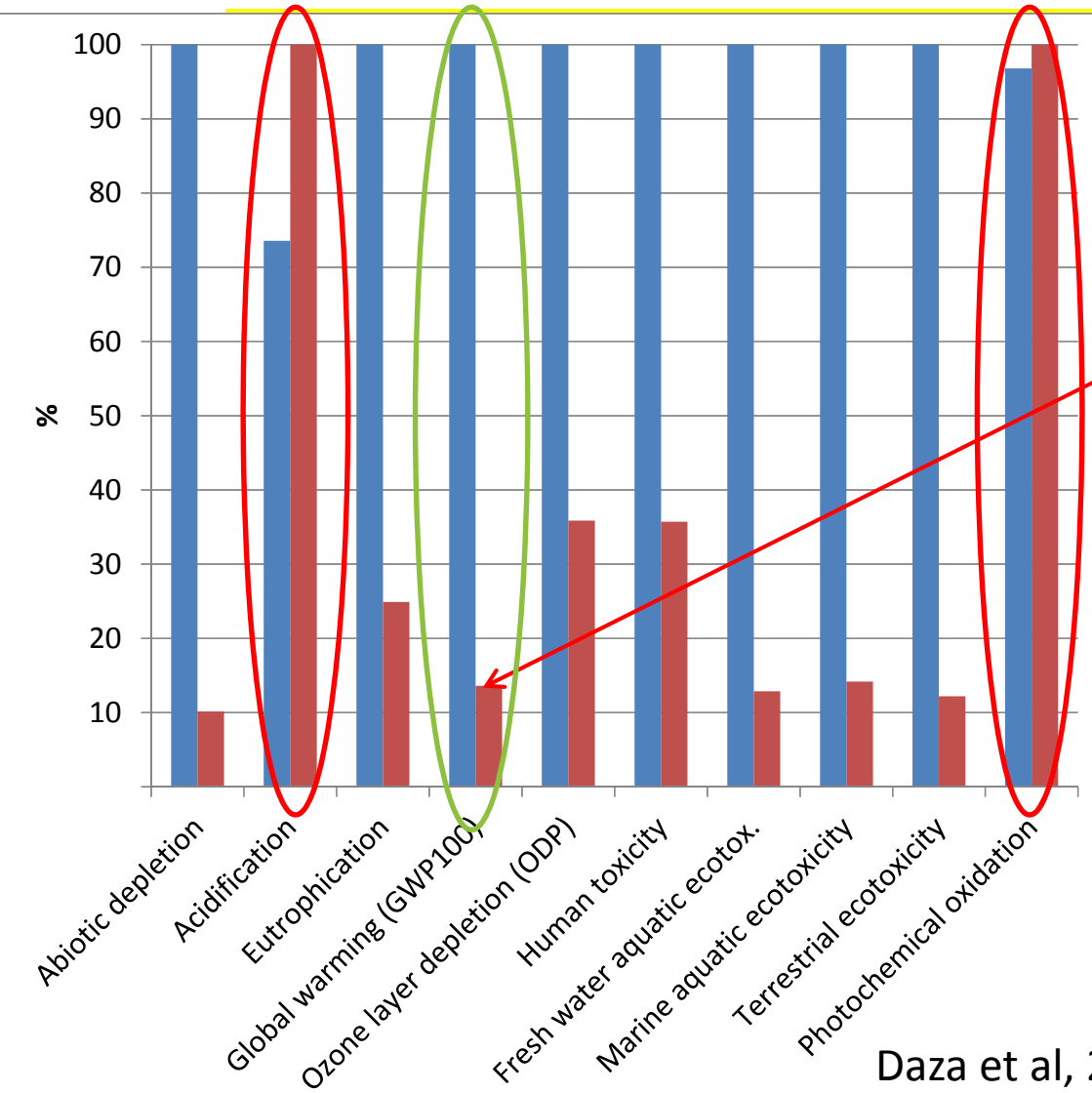


(Diaz-Chavez et al, 2012)

Sustainability certification

Sustainability criteria included	FSC	NTA8O8O
Biodiversity	Yes	Yes
GHG	No	Yes
Environment	Yes	Yes
Social	Yes	Yes

LCA: 1 MJ of Electricity from Coal vs. Bamboo



88 % GHG emission reduction

NTA8080 = 70%

Accounting methodology follows:

EC recommendations for solid biomass

Default values/processes/references

Carbon stock is not included

Daza et al, 2013

When carbon stock is included: CO2 storage

Living stands
Below ground biomass: (soil organic carbon, roots)

Estimated GHG emissions

Reduction: 300 % vs. 88%

Bamboo is not included as a default biomass chain (EC, NTA) ➔
Performance needs to be proven

Harmonize methodologies
Measure, monitor and demonstrate

Residues vs. Bioenergy crop

Parameter	Residues from forest	Residues from plantations	Bioenergy crop/plantations	Comments
Yield per ha	+	++	+++	Forest exploitation is controlled and needs permit in Colombia
Current potential	++	+	--	Existing area covered/ Species
Future Potential	++	++	+++	Suitable area
Cost	++	++	+	Main production/management cost are allocated to main product.
Small holders	++	+	+	Forestry Management Units FMU
GHG emissions reduction	+	+	+++	Use of residues account for emissions from the collection point➔Does not include carbon stock

Conclusions and lessons learned

- Bamboo has the potential to be a highly sustainable biomass source for the biobased economy ➔ species, location and practices dependent (Residues and biomass crop).
  - Solid Fuel
    - Superior to agricultural residues and herbaceous biomass
    - Torrefaction improves properties
  - Chemicals and materials (lignocellulosic biorefineries)
  - Traditional use➔ **Product diversification**
- Sustainability certification is possible
  - Potential to be superior to other solid biomass
  - GHG emission reduction➔ Measure and monitoring activities are required to demonstrate the superior performance (Bamboo is not a default biomass chain)
- Costs
  - First estimate: equivalent cost over the entire chain when compared to conventional wood pellets

Recommendations

- Development of technology
  - Broader analysis of bamboo species ➔ Different regions
  - Feedstock adaptation/pretreatment/conversion➔ Depends on end use, scale and location

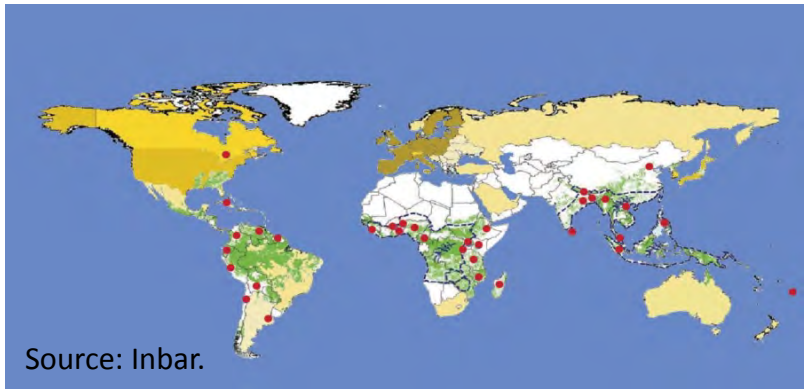
- Development of the market chain
  - Financial support
  - **Public and Private sector** involvement
  - Design of the supply chain➔ Pilot projects
    ➔ Combined with other biomass sources
  - End users requirements
    - Security of supply
    - Technical specifications
    - Sustainability
  - Opportunity to include small/medium scale producers

Recommendations

- The recognition of bamboo as a biomass source for different applications in the **local** and international market.

- Public institutions➔ Regulatory framework where bamboo is clearly defined as an agricultural resource, a forestry resource or an agro-forestry resource.

- A multidisciplinary expertise on bamboo production, pre-treatment, conversion techniques, and system assessments (local and international) are of key importance in the successful integration of bamboo in the bio-based economy.


Source: Inbar.


J.C. Camargo

Thank you for your attention
Gracias por su atención

This work forms part of the project: “Torrefied bamboo pellets for sustainable biomass import from Colombia”. Financial support by NL Agency under the subsidy scheme Sustainable Biomass Import. Partners in the project were: Technological University of Pereira (Co), Colombian Bamboo Society (Co) and Imperial College of London (UK).

NL Agency
Ministry of Economic Affairs

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