Bamboo: Alternative Sustainable Feedstock for Fuels and Materials

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BAMBOO: ALTERNATIVE SUSTAINABLE FEEDSTOCK FOR FUELS AND MATERIALS

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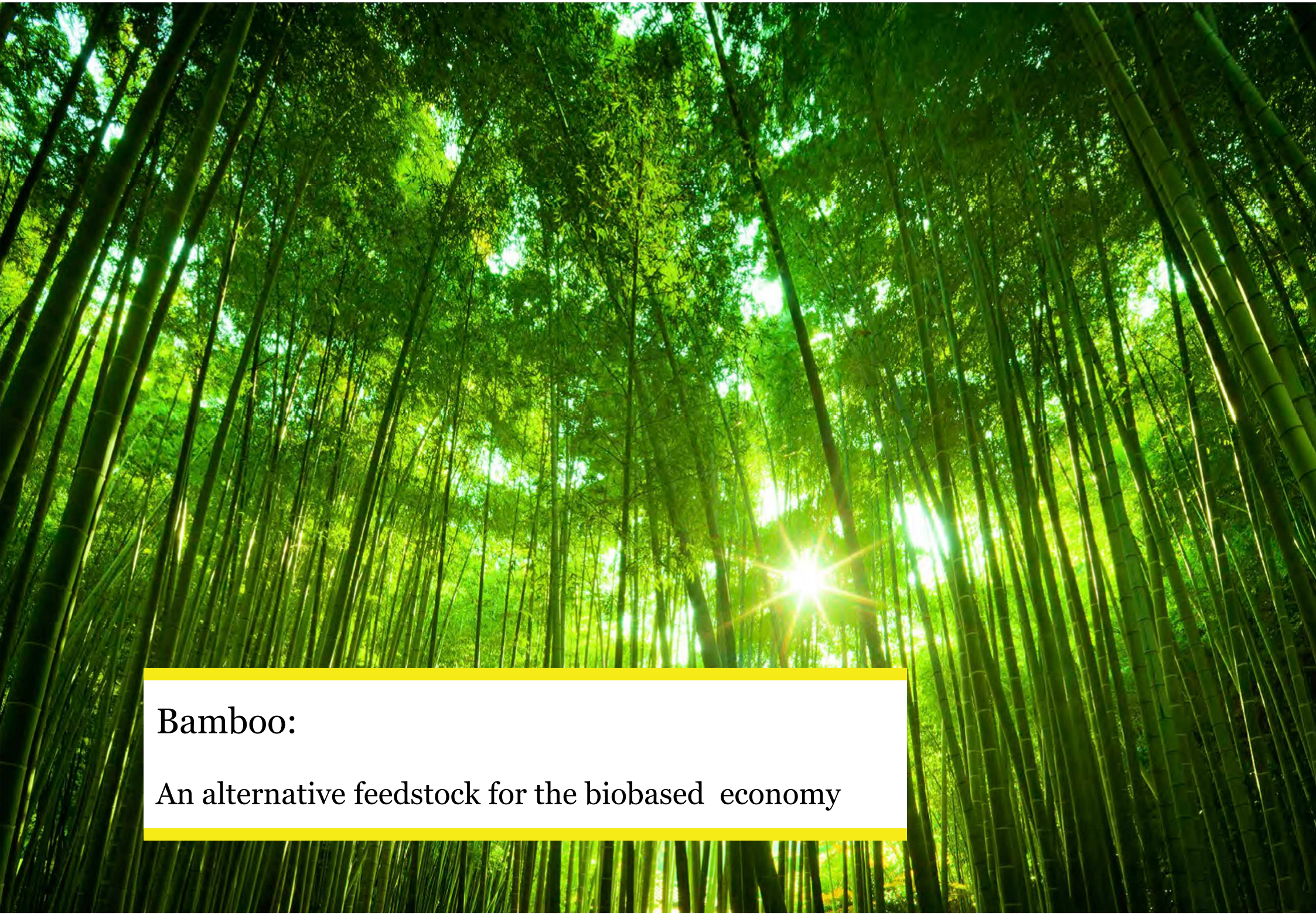
Energy research Centre of the Netherlands (ECN)

- What do we do:
  - ECN develops market driven technology and know-how to enable a transition to sustainable energy society
- Business units:
  - Biomass & energy efficiency
  - Solar energy
  - Wind energy
  - Policy studies
  - Environment & energy engineering

ECN

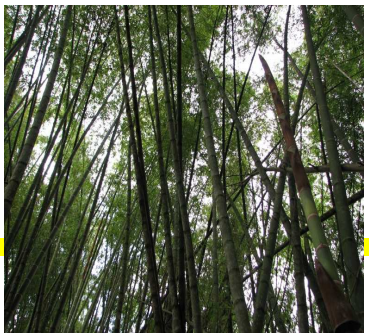
- Independent research institute
- ~600 employees
- Locations:
  - Petten (HQ)
  - Amsterdam
  - Eindhoven
  - Brussels
  - Beijing



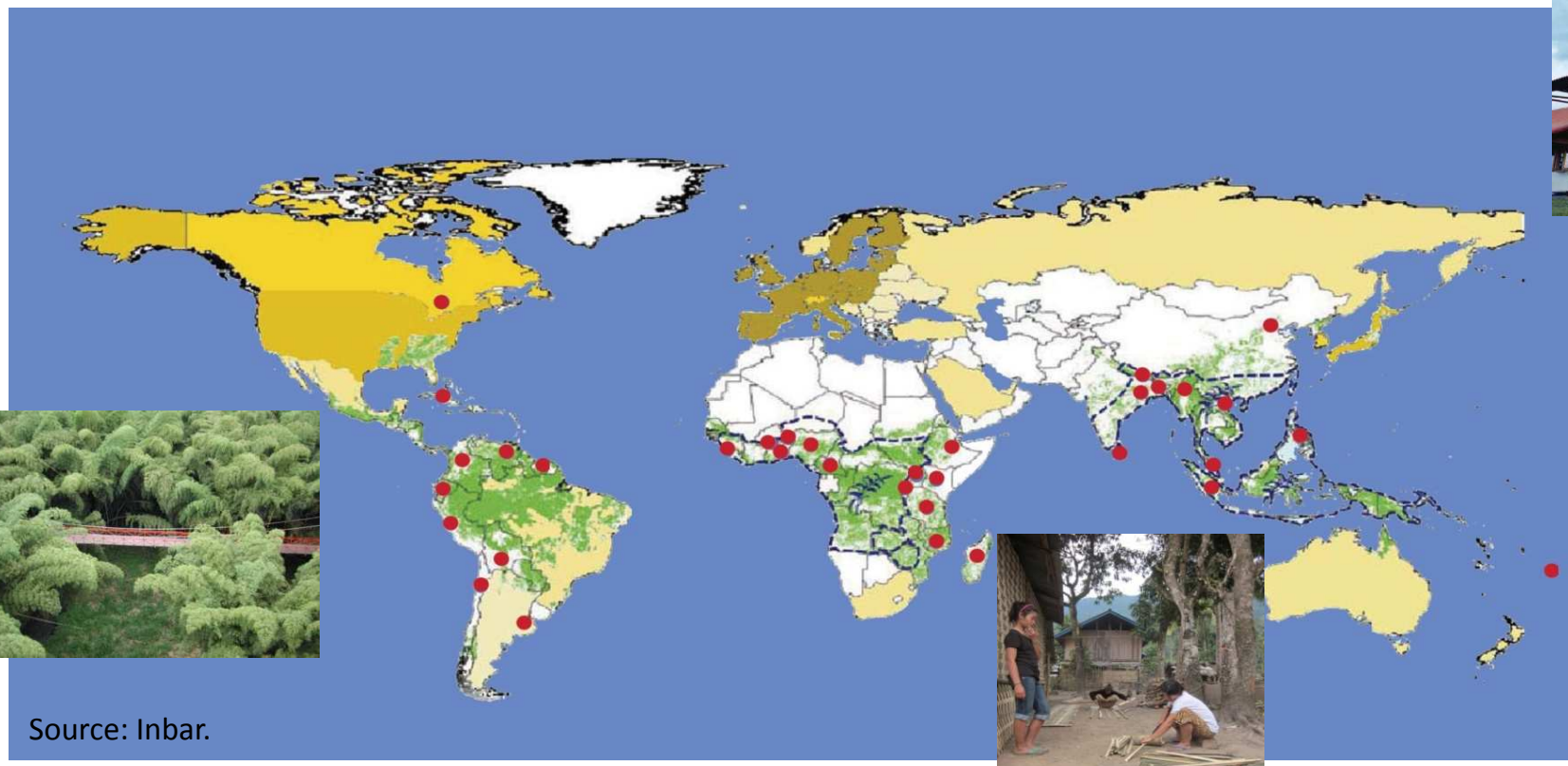
Bamboo:

An alternative feedstock for the biobased economy

Why bamboo?



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

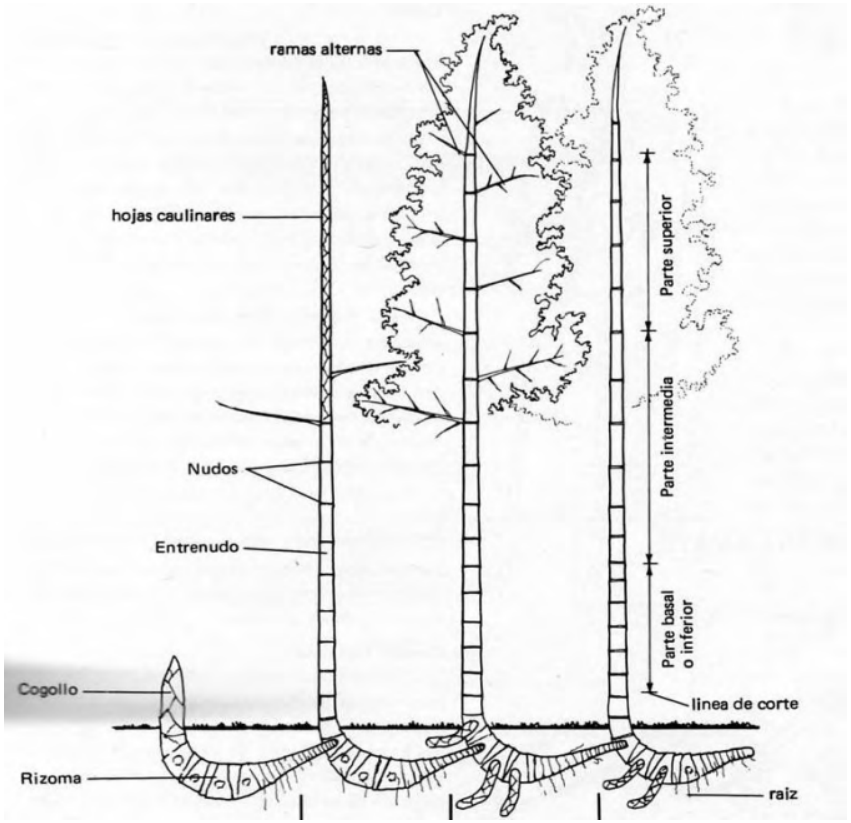


Source: Inbar.

Why bamboo?

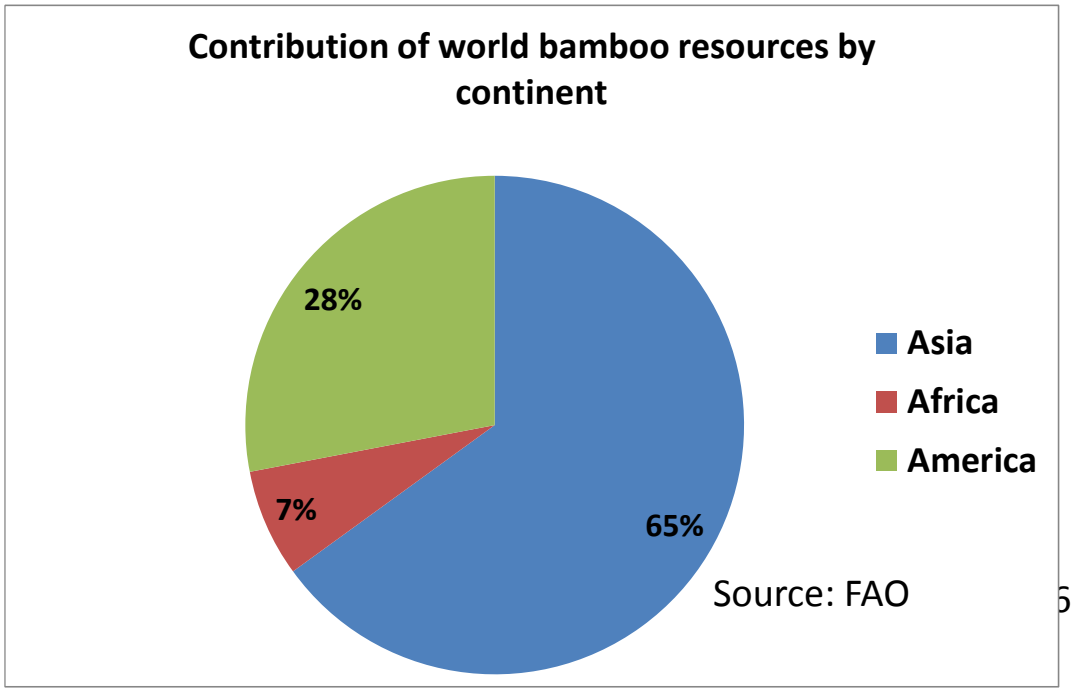
- Fast growing
  - 10-40 Ton/Ha-year
- Regenerates itself after it has been responsibly cared for and harvested➔ No replanting
- Excellent reforesting crop
  - Low consumption of fertilizers ➔(GHG)
  - Easy propagation➔no seeds
  - Water table preservation
  - Biodiversity preservation
- CO_2 sump
- 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



Source: FAO

BAMBUSA VULGARIS VAR. VULGARIS SCHRADER EX WENDLAND

ECN

SOCIEDAD COLOMBIANA DEL BAMBU

Lignocellulosic feedstock

Logistics Cost

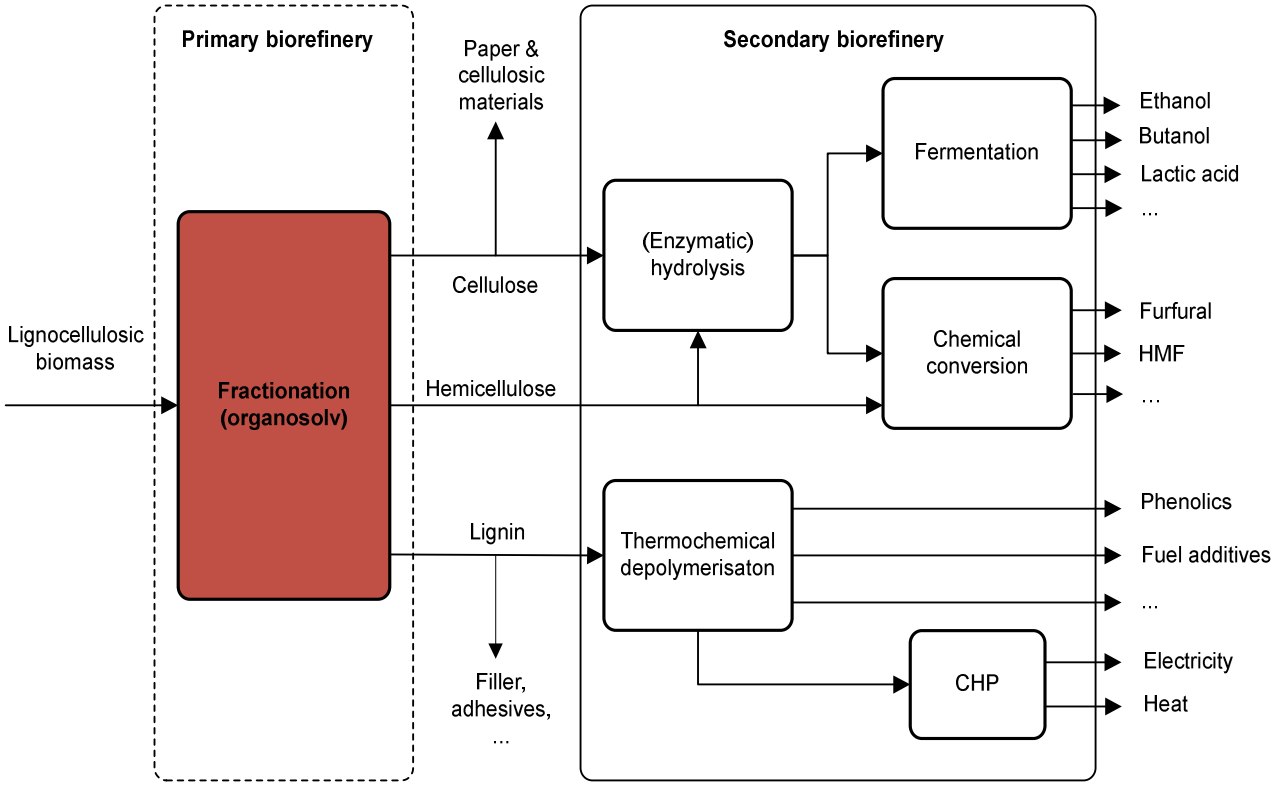
Feedstock		Bamboo culm	Cane Bagasse	Wheat straw	Wood
HHV (dry)	MJ/kg	17-20	18-20	16-19	17-20
Density	kg/m^3	**500-700**	150-200	160-300	200-500
Yield	Ton/Ha-year	**20-40**	7-10	6-12	10-20
Overall composition (dwt %)					
Cellulose		40-60	35	38	50
Hemicellulose		20-30	25	36	23
Lignin		20-40	20	16	22
Others**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

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
- economical feasibility

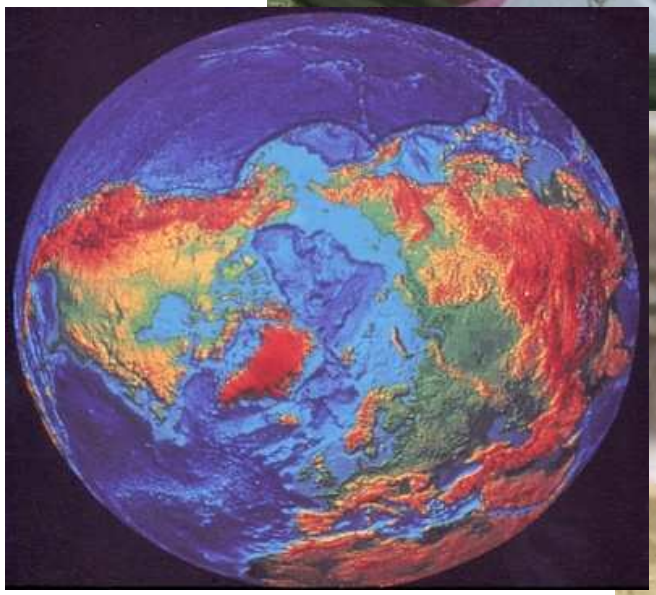
for:

- Co-firing torrefied Colombian bamboo pellets in NL

NL Agency
Ministry of Economic Affairs

The SBI 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**

Sustainable Biomass



Sustainability Themes

- Greenhouse gas emissions
- Competition with food and local applications
- Biodiversity
- Environment
- Prosperity
- Social well-being.

Looking for certification

The Dutch technical agreement (NTA8080) describes the requirements for **sustainably produced** biomass for energy applications (power, heat & cold and transportation fuels).

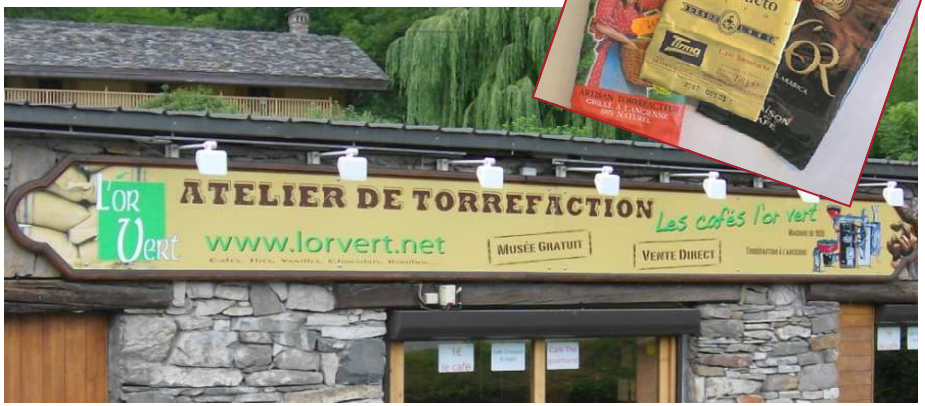
Biomass includes solid as well as liquid and gaseous biofuels. The NTA 8080 is intended to be applied at organizations that wish to sustainably:

- **Produce,**
- **Convert,**
- **Trade; or**
- **Use biomass for energy generation or as transporting fuel.**

  - **Currently being revised and extended to bio-based products**

Torrefaction for upgrading biomass

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



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

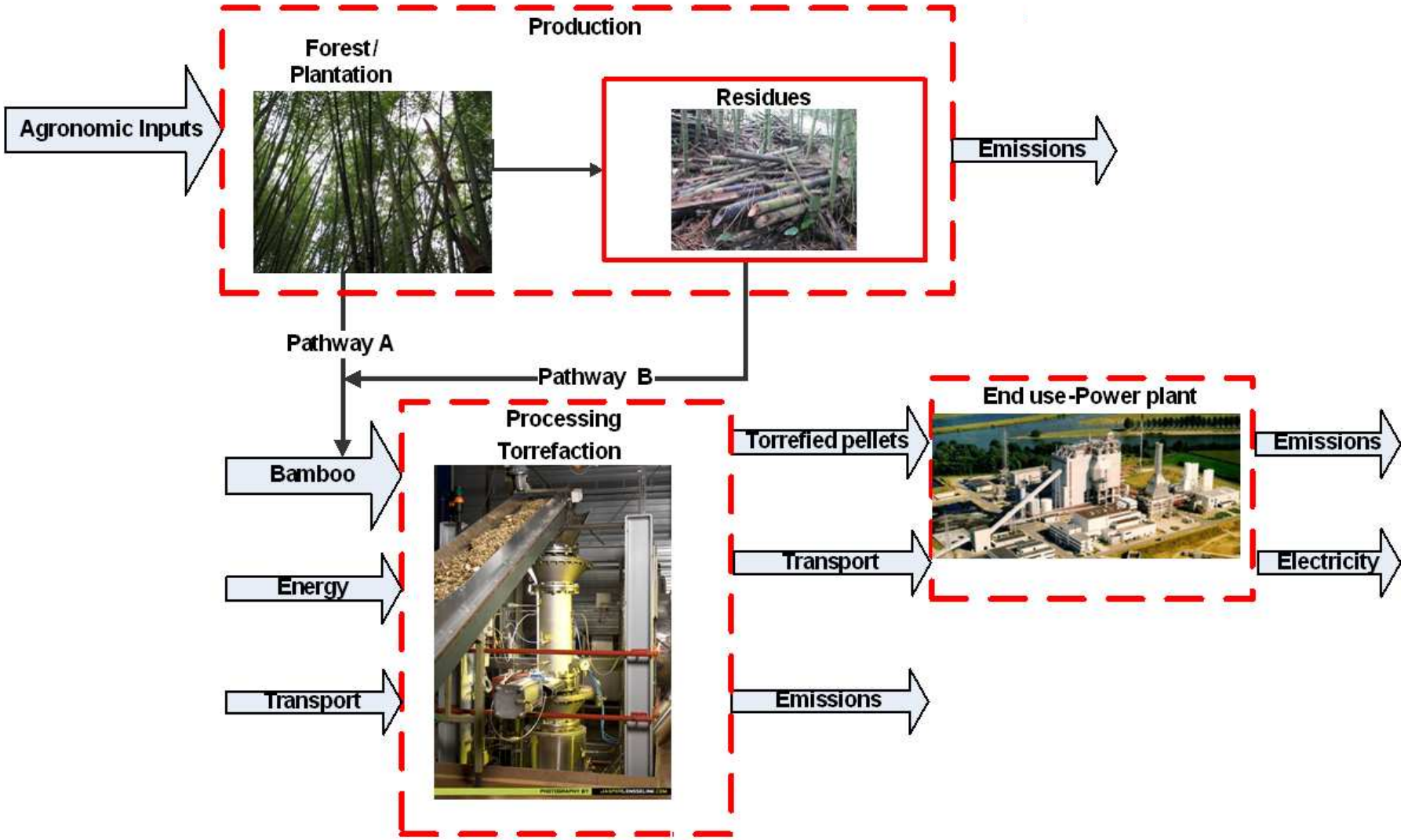
Torrefaction

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

Biomass chain assessment

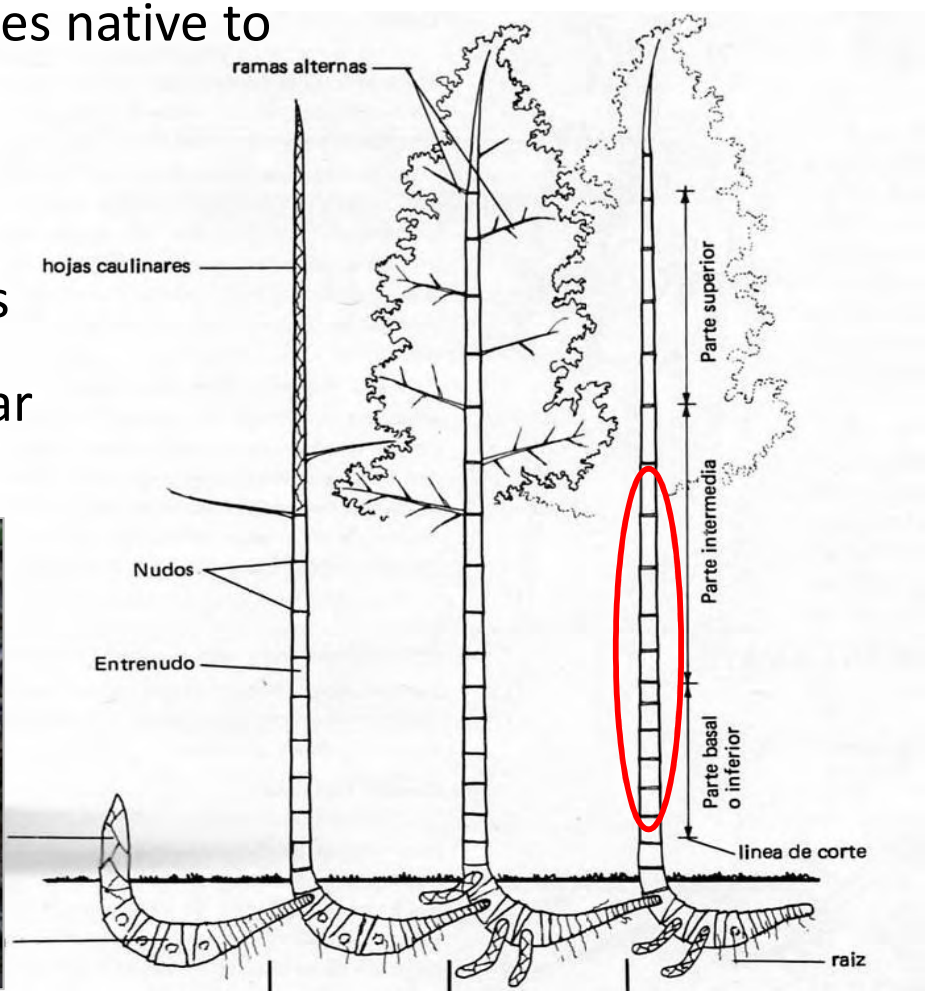


Case study: Guadua *angustifolia*

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

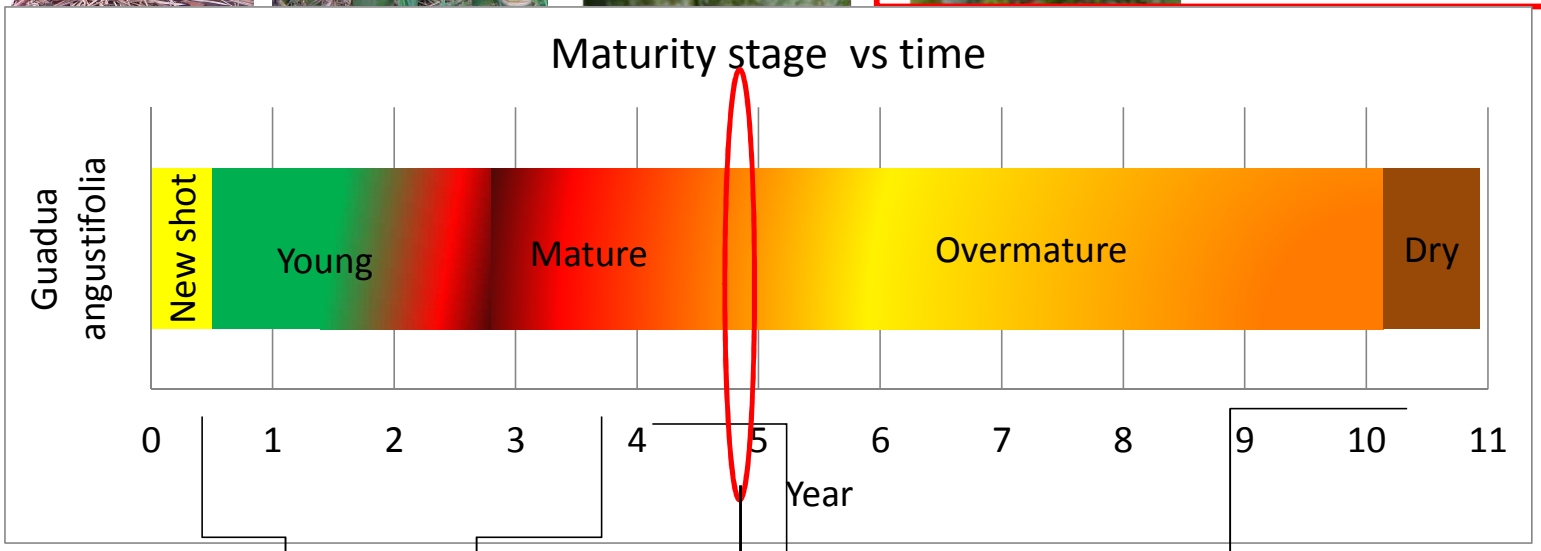
  30 m in 6 months

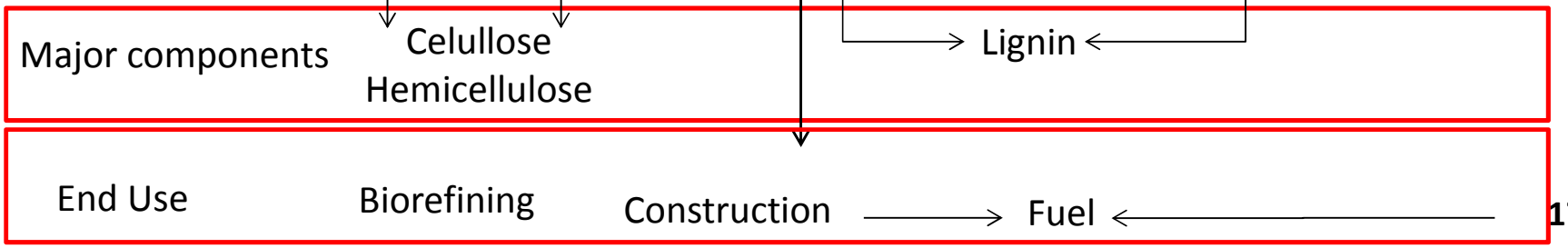
  20-40 Ton/ha-year



Guadua *a.* development stages

Residues





Biomass production: FSC Certification

- **FSC standard for Guadua**
  - **Colombian national interpretation for guadua bamboo forest**
  - **1st in the world➔ Now used in Asia**
- **Some forest of "Guadua *angustifolia* Kunth" are FSC certified ➔ Small holders**
- **Access to international market.**

Sustainability certification

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

➔**50-70% reduction**

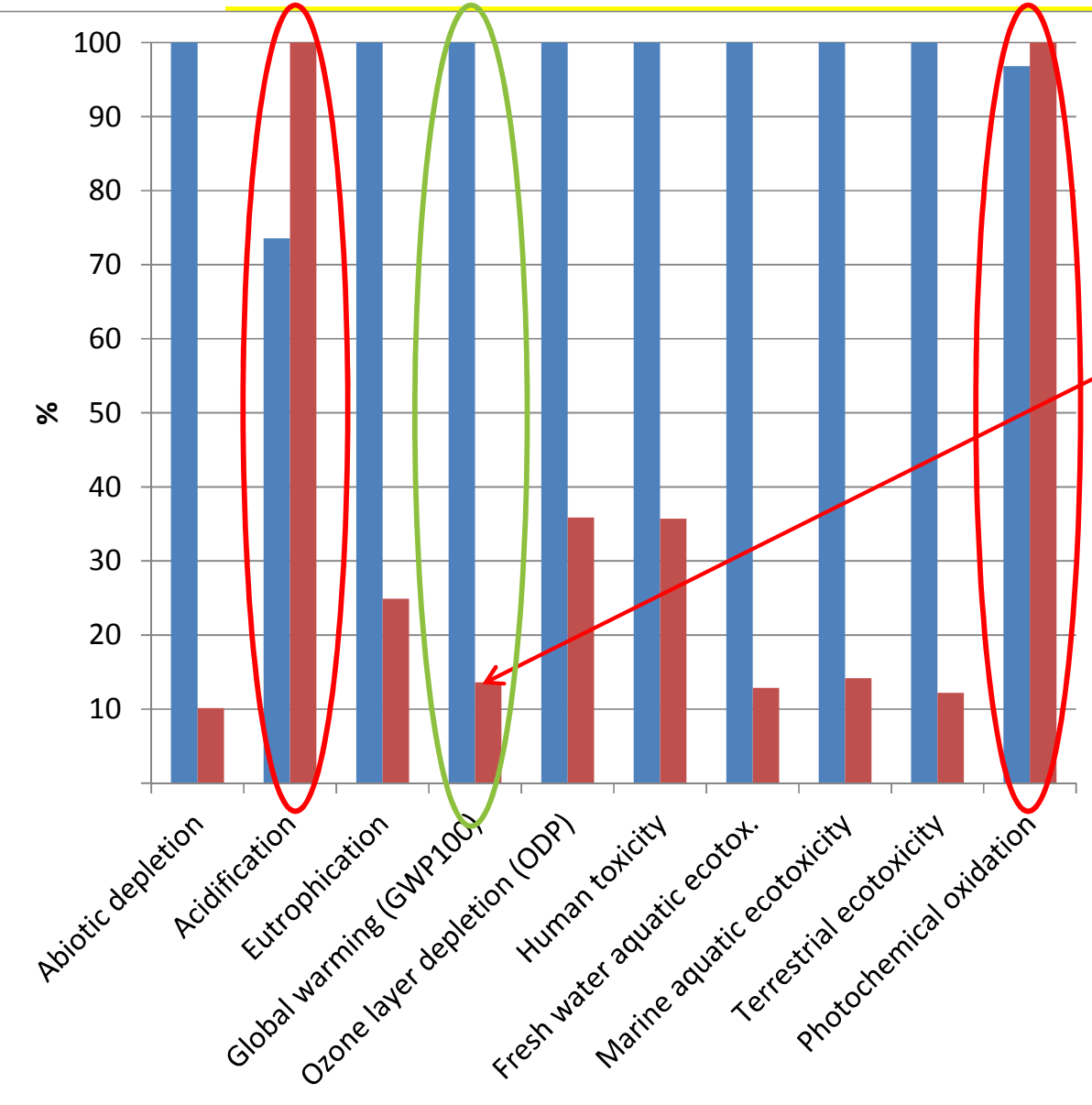
Life Cycle Assessment

SimaPro Software + CML method (Centrum voor Milieukunde Leiden (CML)

Impact category	Definition	Unit
Abiotic depletion	Depletion of non-living natural resources, including energy resources	kg Sb[1] eq.
Global warming	**Contribution of a substance to the greenhouse effect**	**kg CO_2 eq.**
Ozone layer depletion	Thinning of the stratospheric ozone layer as a result of anthropogenic emissions	kg CFC[2]-11 eq.
Human toxicity	Impacts of toxic substances present in the environment on human health	kg 1,4-DCB[3] eq.
Fresh water aquatic ecotoxicity	Impacts of toxic substances on freshwater aquatic ecosystems	kg 1,4-DCB eq.
Marine aquatic ecotoxicity	Impacts of toxic substances on marine aquatic ecosystems	kg 1,4-DCB eq.
Terrestrial ecotoxicity	Impacts of toxic substances on terrestrial ecosystems	kg 1,4-DCB eq.
Photochemical oxidation	Capacity of volatile organic compounds and carbon monoxide to produce photo-oxidants such as ozone	kg C_2H_4 eq.
Acidification	Impacts of acidifying pollutants (mainly SO_2, NO_x and NH_x), through emissions to the air, on the natural and man-made environment, human health and natural resources	kg SO_2 eq.
Eutrophication	Impacts of eutrofying substances (nutrients), through emissions to air, water and soil, on the natural and man-made environment, and natural resources	kg PO_4^{3-} eq.

[1] Sb = antimony [2] CFC = Chlorofluorocarbons [3] DCB=Dichlorobenzene

1 MJ of Electricity: Coal vs. Bamboo



88 % GHG emission reduction

NTA8080 = 70%

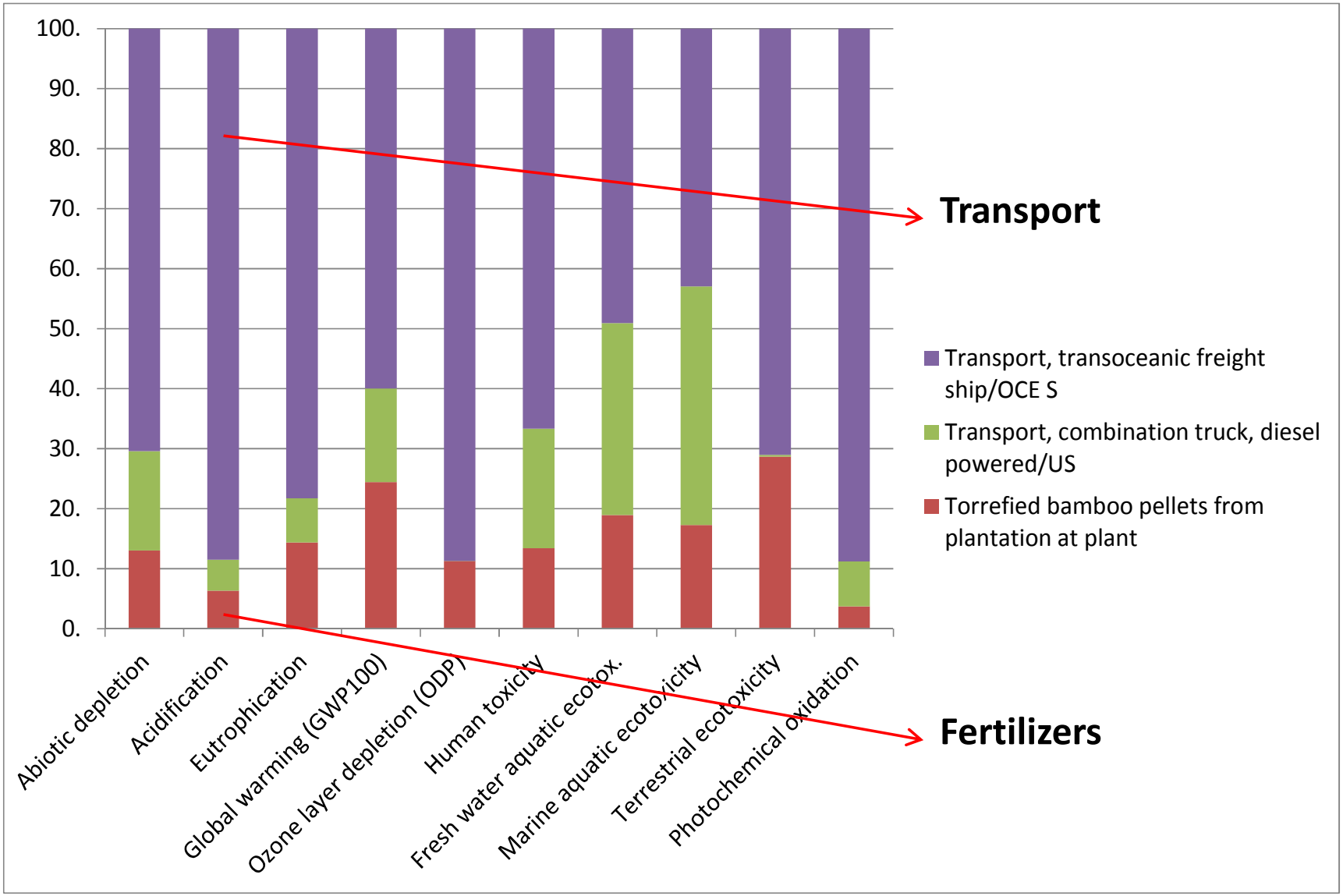
Accounting methodology follows:

EC recommendations for solid biomass

Default values/processes/references

Carbon stock is not included

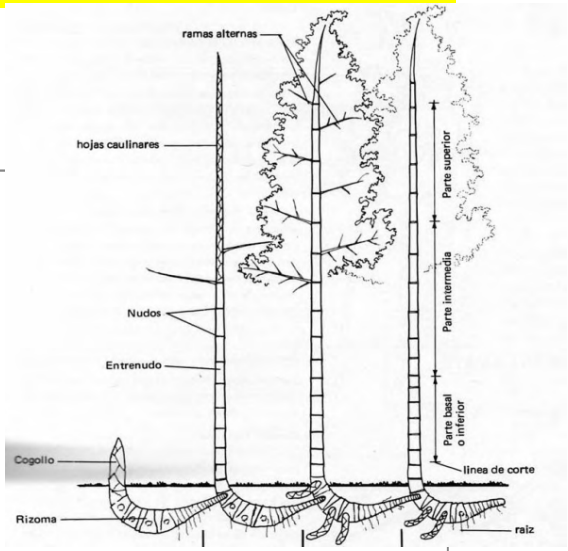
Impact distribution

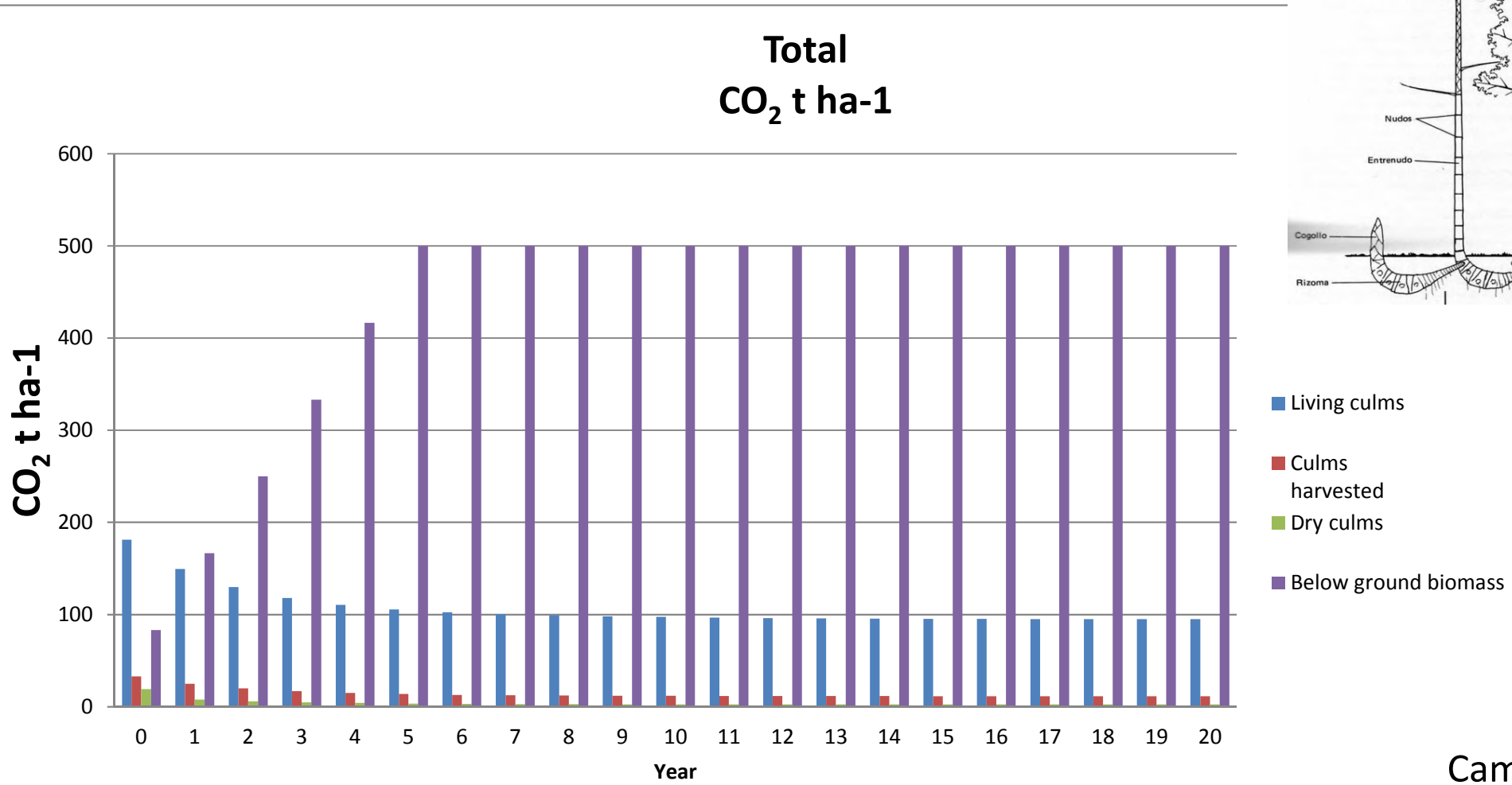


When carbon stock is included: GHG

Living stands

Below ground biomas: (soil organic carbon, roots)





Camargo

When carbon stock is included: GHG

Estimated:

-320 gr CO_2 eq/MJ vs. 26 gr CO_2 eq/MJ

Reduction: 300 % vs. 88%

Harmonize methodologies

Measure, monitor and demonstrate

Conclusions

- Bamboo has the potential to be a highly sustainable biomass source for the biobased economy➔ species, location and practices dependent.
- Sustainability certification: FSC + GHG ➔ NTA 8080
- LCA: Bamboo-based electricity superior than coal-based
- Monitoring activities
  - GHG emission reduction over the entire chain
    - Needs to be demonstrated
  - European harmonization of methodologies
- Research and Development

Thank you for your attention

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

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