Evaluation of torrefied bamboo for sustainable bioenergy production

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ECN

Energy research Centre of the Netherlands

NL Agency
Ministry of Economic Affairs

Evaluation of torrefied bamboo for sustainable bioenergy production

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Presentation overview

- ECN – Energy research Centre of the Netherlands
- Sustainable bioenergy production from bamboo
  - Partners
  - Possible end-users
  - Possible pre-treatment
- Status
  - Pre-treatment
  - End-use
  - Sustainability
  - Issues
- Conclusions

Energy research Centre of the Netherlands (ECN)

- Dedicated to Sustainable Energy Innovation

  ECN develops and brings to market high-level knowledge and technology for a sustainable energy society

- Core activities
  - Sustainable energy technology development
  - R&D services to industry
  - Feasibility studies, system and technology assessments

ECN

- Largest Dutch energy R&D institute
- Independent
- 570 employees
- R&D units:
  - *Biomass*
  - *Solar energy*
  - *Wind energy*
  - *Efficiency & Infrastructure*
  - *Policy studies*





Sustainable energy production from bamboo

Partners beside ECN

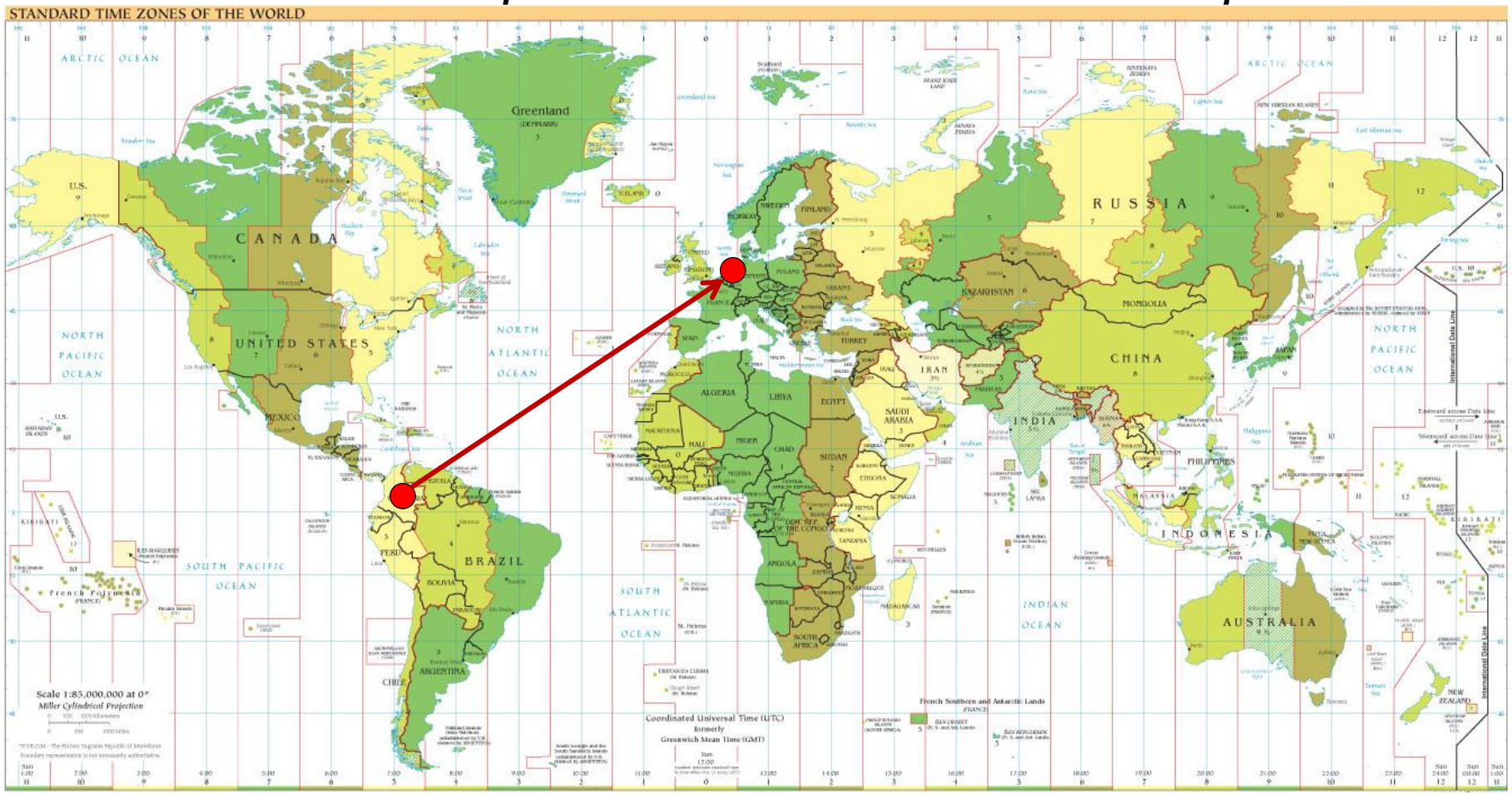
SOCIEDAD COLOMBIANA DEL BAMBU

Imperial College London

Ximena Londoño (SCB)
Rocio Diaz-Chavez (ICL)
Robin Zwart and Claudia Daza Montaño (ECN)
Juan Carlos Carmargo (UTP)

Sustainable energy production from bamboo

Bamboo chain – from production in Colombia to end-use in Europe



Sustainable energy production from bamboo

The coffee area –

Energy crop

Construction residues

Sustainable energy production from bamboo

Why bamboo?

- Fast growing: 26-42 Ton/Ha-year
  - Superior than any other *“tree”*
  - 20-30 m in 6 months
- Low water consumption
- Excellent reforesting crop
- Regenerates itself after it has been responsibly cared for and harvested

Sustainable energy production from bamboo

Why Guadua Angustifolia?

- Native specie typical from the Andean region
- Some plantations of *"Guadua Angustifolia Kunth"* are FSC certified
- Non exploited yet as energy source
- Potential in Colombia: 1MTon/year

Sustainable energy production from bamboo

End-use in Europe

Pre-treatment

Co-firing in coal power plants

Sustainable energy production from bamboo

End-use in Europe

Location
Hemweg Power Station
Amsterdam

Fuel
Bituminous coal & biomass
Unit capacity
660 MW_e combustion plant

NUON

VATTENFALL

Location
Buggenum Power Station
Haelen

Fuel
Coal & biomass
Colombian coal & torrefied materials
Unit capacity
250 MW_e gasification plant

Sustainable energy production from bamboo

From coal to biomass

Woody biomass

Agricultural residues

Friable and less fibrous
19 - 22 MJ/kg (LHV, ar)
Hydrophobic
Preserved
Homogeneous

Superior fuel properties:

- Transport, handling, storage
- **Milling, feeding**
- **Gasification, combustion**
- Broad feedstock range
- Commodity fuel

Mixed waste

Torrefaction and pulverisation

Fuel powder

Pelletisation

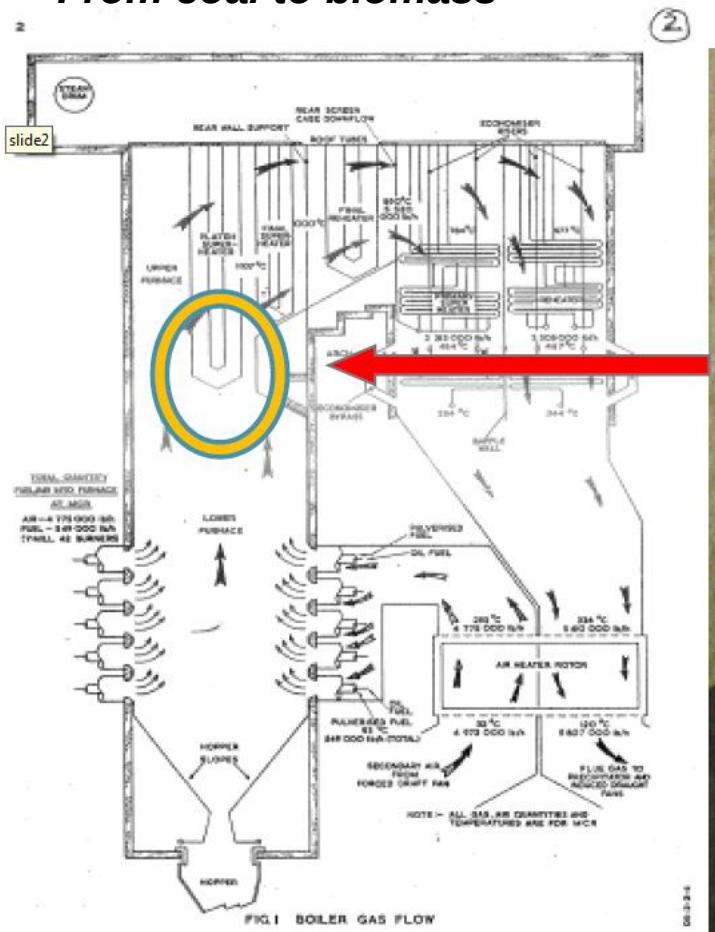
Fuel pellets

Tenacious and fibrous
10 - 17 MJ/kg (LHV, ar)
Hydrophilic
Vulnerable to biodegradation
Heterogeneous

Bulk density 650-750 kg/m^3
Bulk energy density 13-17 GJ/m^3

Sustainable energy production from bamboo

From coal to biomass



Sustainable energy production from bamboo

From coal to biomass

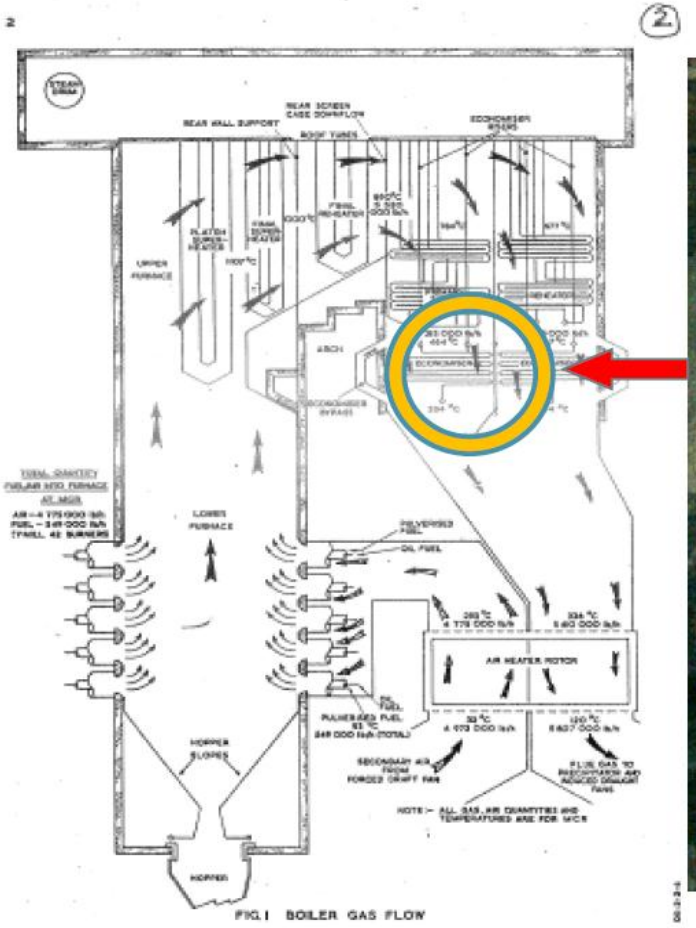
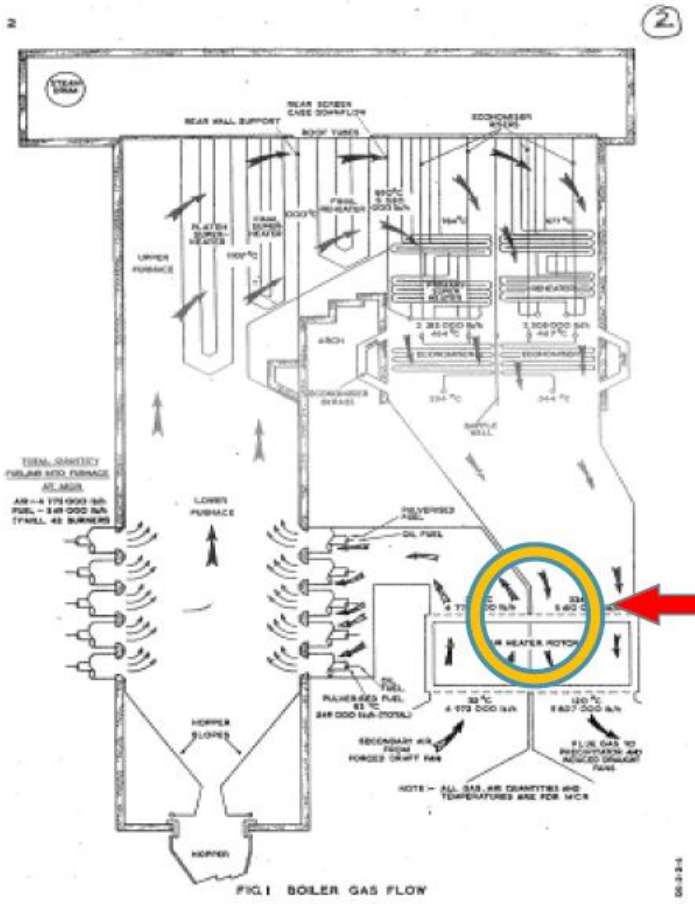
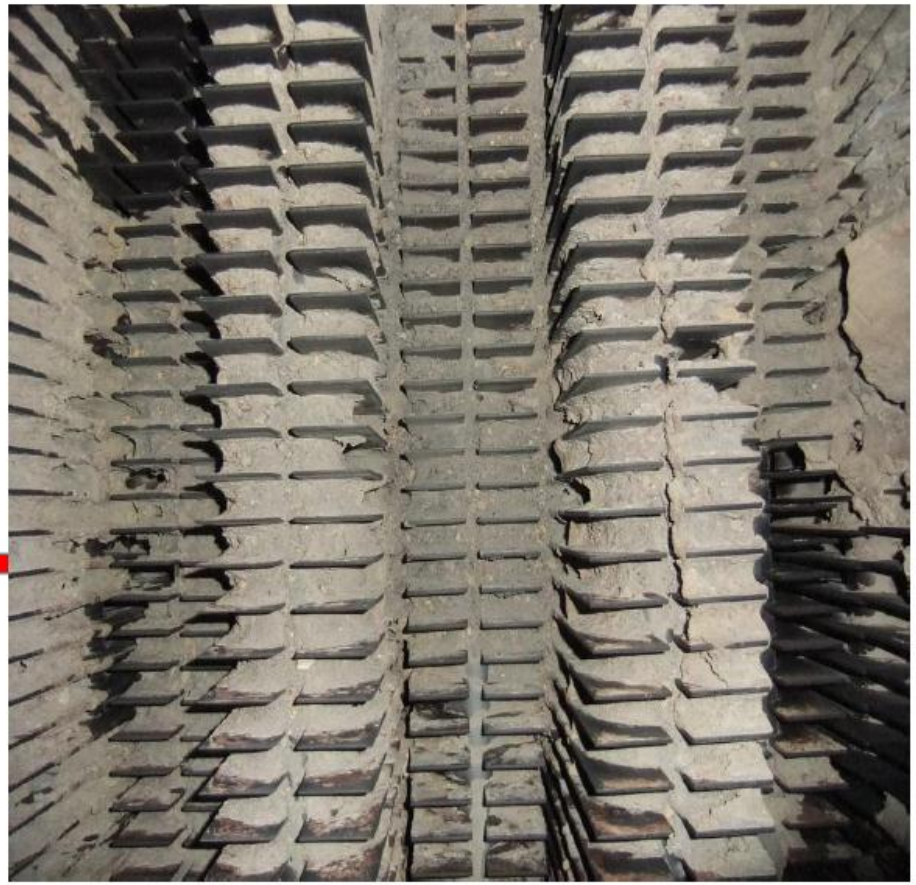


FIG.1 BOILER GAS FLOW

Sustainable energy production from bamboo

From coal to biomass





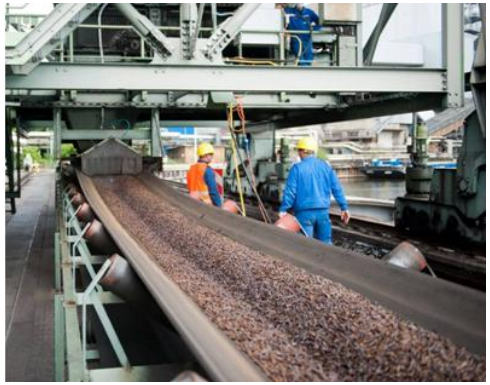
Sustainable energy production from bamboo

From coal to biomass

← Shipment

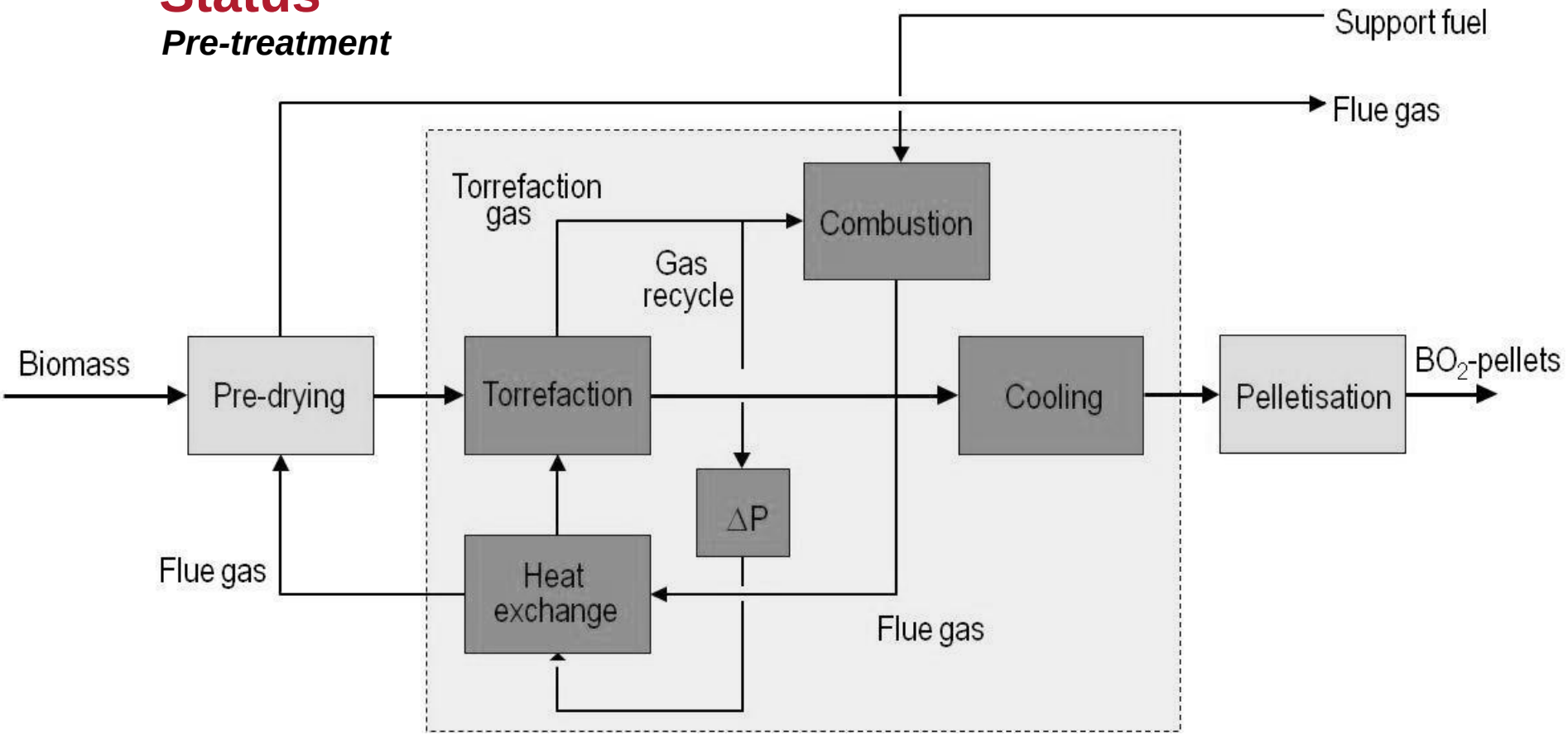
Grinding & Feeding →

← Storage & handling →



Status

Pre-treatment

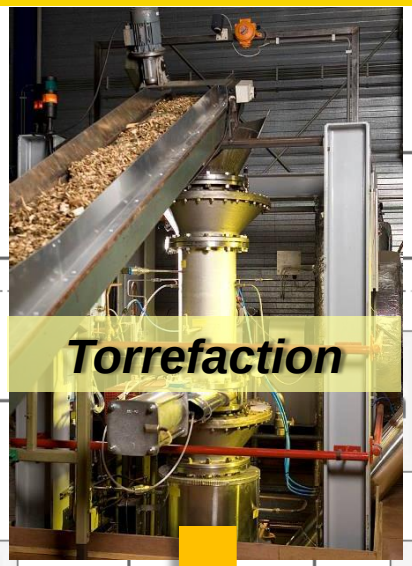


Status

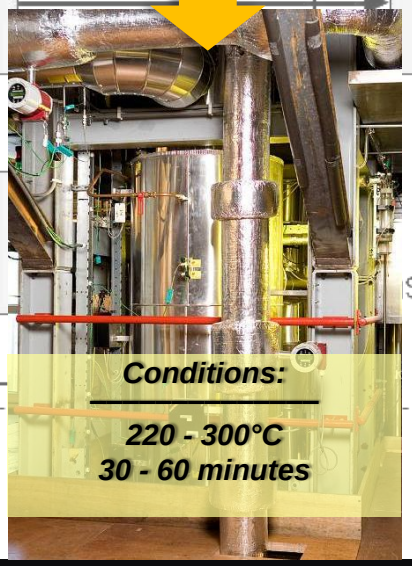
Pre-treatment

50 - 100 $^{kg}/_{hr}$ feeding

Pre-drying



Torrefaction



Conditions:

220 - 300°C
30 - 60 minutes

1 - 10 tonne test batches

Pelletisation

Cooling and storage

Torrefaction gas

Torrefaction

Heat exchange

Cooling

Fl gas

Status

Pre-treatment

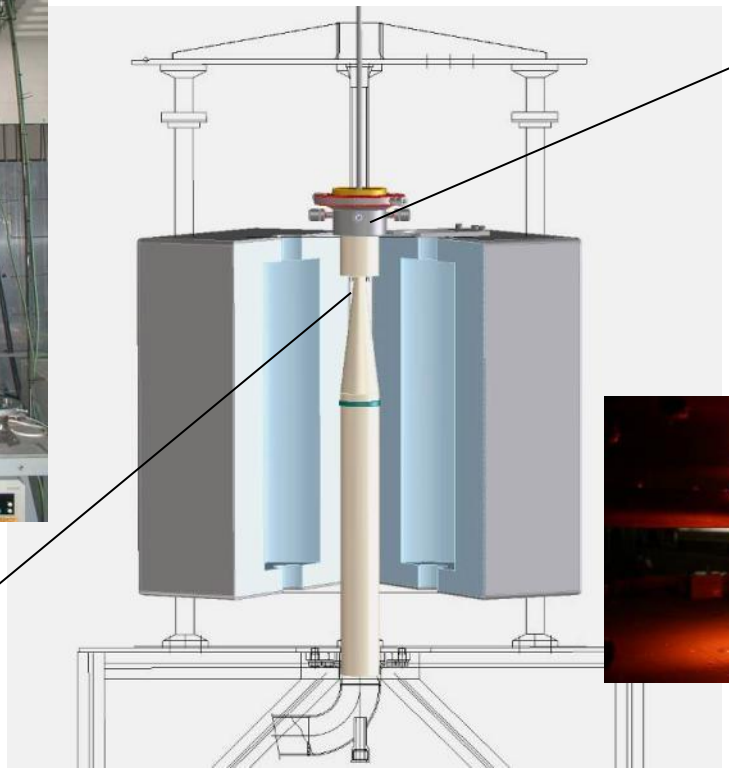
Presented by Electrabel at Biopower generation / 13-15 March 2012 / Rotterdam

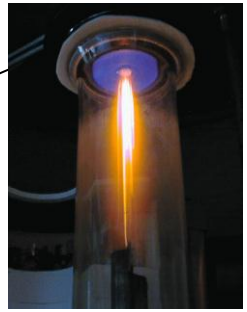
Status

End-use

Status

End-use





Staged gas burner: high heating rate + proper gas atmosphere

Fouling probe

Particle sampling probe

Special reactor design:
1-2 s residence times with limited total reactor length

Status

Sustainability

Main sustainability themes

- Green house gas emissions
- Competition with food and local applications
- Biodiversity
- Environment
- Prosperity
- Social well-being
- Certification

Status

People

Well being

The production of biomass must contribute towards the social well-being of the employees and the local community

Environment

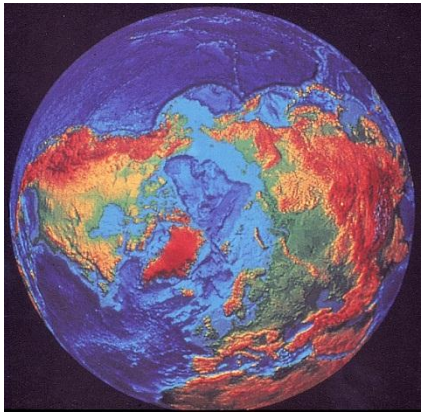
In the production and processing of biomass, quality of soil, surface & ground water and air needs to be preserved, if not improved.

Status

Planet

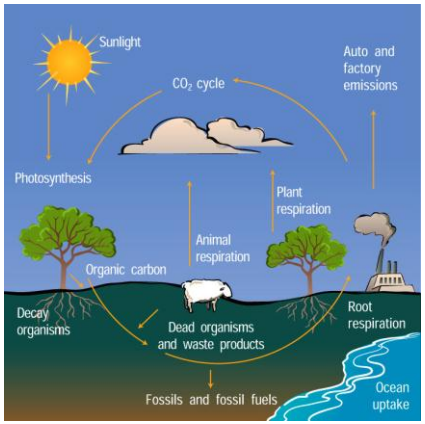
Biodiversity

Biomass production may never harm protected or vulnerable biodiversity but- wherever possible- needs to strengthen the biodiversity



Greenhouse gases

Considered over the entire chain, the use of biomass needs to result in a sharp reduction in GHG emissions compared to fossil fuels



Status

Profit

Prosperity

The production of biomass needs to contribute to the local economy

Competition

The production of biomass for energy purposes may not endanger the food supply or other local applications

Status

Issues

Fuel	Russian Coal	Lignite	Wood	Olive kernel	Cynara cardunculus	Shea meal	Guadua angustifolia
Moisture	10.4	48	7.1	5.78	11	11.13	16.4
Proximate analysis (% mass, dry fuel basis)							
Ash @ 815°C	8	27	1.44	6.29	5.1	5.41	6.3
Volatile matter	32	45	80	72	75	61.9	70
HHV (KJ/kg)	27800	15000	20093	20000	19000		18750
Ultimate analysis (% mass, dry fuel basis)							
C	68	41	50.25	48	42	49.4	47.1
H	4	2.4	6.13	5.75	5.5	5.35	6.05
N	0.87	1.1	0.37	1.1	0.55	2.61	1
S	0.35	0.67	0.026	-	0.15	-	0.125
O by diff.	11.6	31	44.2	38	43	40.05	44
Ash composition (mg/kg fuel, dry basis)							
Na (± 7)	405	775	191	1300	4100	179	111
Mg (± 1)	1277	6850	404	1800	1500	1937	405
Al (± 4)	16583	9000	474	1200	160	772	339
Si (± 90)	34841	20000	1331	6200	650	1861	12143
P (± 15)	386	250	122	620	910	1684	770
K (± 20)	2390	1600	984	8900	12000	20789	23029
Ca (± 20)	2750	110000	1919	13000	12000	2145	344
Ti (± 8)	622	395	96	76	8,6	47	12.5
Mn (± 6)	89	130	66	35	17	24	6.5
Fe (± 4)	6077	9700	301	1800	110	1095	140
Zn (± 1)	21	9.3	25	12	13	3.6	10.7
Pb (± 20)	10	~5	8	25	3,5	1.9	0
Sr (± 5)	183	170	11	15	59	18.3	6.9
Ba (± 5)	260	78	29	11	26	22.4	8
S	3500	6700	260	860	1500	2704	1284
Cl (± 20)	100	76	253	2000	2800	797	568

Status

Issues

Fuel	Russian Coal	Wood	Guadua angustifolia
Moisture	10.4	7.1	16.4
Proximate analysis (% mass, dry fuel basis)			
Ash @ 815°C	8	1.44	6.3
Volatile matter	32	80	70
HHV (KJ/kg)	27800	20093	18750
Ultimate analysis (% mass, dry fuel basis)			
C	68	50.25	47.1
H	4	6.13	6.05
N	0.87	0.37	1
S	0.35	0.026	0.125
O by diff.	11.6	44.2	44

Status

Issues

Fuel	Russian Coal	Wood	Guadua angustifolia
Moisture	10.4	7.1	16.4
Ash composition (mg/kg fuel, dry basis)			
Na (± 7)	405	191	111
Al (± 4)	16583	474	339
Si (± 90)	34841	1331	12143
K (± 20)	2390	984	23029
Ca (± 20)	2750	1919	344
Fe (± 4)	6077	301	140
S	3500	260	1284
Cl (± 20)	100	253	568

Status

Issues

TORWASH

Combining torrefaction with a washing step in order to recover certain minerals from biomass in order to use it as a non-fossil fertiliser.

Proximate &ultimate (% mass, dry fuel)		
	Raw	Torwashed (wet torrefaction)
ash @ 815°C	6,3	4,5
Ash composition (mg/kg fuel, dry fuel)		
K	23029	510
Cl	568	120

Conclusions

- Guadua angustifolia is a potential solid fuel due to its elemental composition and high heating capacity.
- Properties are similar to those of clean wood rather than other herbaceous feedstocks, except for alkali content.
- Initial implementation most likely via initially utilization of residues rather than dedicated energy crops production.
- With wet torrefaction it is possible to eliminate the alkali characteristics that may prevent bamboo from being co-fired.

Thank you for your attention!

For more information,
please contact:

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Production of tonne-scale test batches at ECN for industrial trials