Technical Evaluation of the Bamboo Species Guadua Angustifolia: Pretreated VS. Untreated Material

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  - *Policy studies*





Contents of presentation

- Overall project presentation
- Objective & scope of the technical evaluation
- Methodology, Results & Evaluation
- Conclusions

Overall Project description

Second Generation Torrefied Pellets for
Sustainable Biomass Export from Colombia

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

Imperial College London

NL Agency
Ministry of Economic Affairs

SOCIEDAD COLOMBIANA DEL BAMBU

Sustainable Biomass Import

The SBI scheme aims to promote the sustainable biomass import chains for **biobased energy and chemical applications (biofuels, chemicals)**

www.agentschapnl.nl/duurzamebiomassa-import

Specific task description: technical evaluation

Project: novel feedstock & pre-treatment options to introduce on large scale to energy power plants, incl. sustainability analysis, technical & economical evaluations, complete chain assessment.

Technical evaluation: lab-scale firing / co-firing of the bamboo species *Guadua Angustifolia*, non-pre-treated or torrefied, providing predictive data on its combustion and deposition behavior.

The testing includes:

(1) Deposition and heat exchange monitoring tests
(2) Ash sampling during the combustion process & analysis

Pre-treatment: Dry & Wet Torrefaction

Torrefaction

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

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

Combining torrefaction with a washing step in order to recover certain minerals from biomass for use as non-fossil fertilizer (Hydrothermal Torrefaction)

Proximate & ultimate (% mass, dry fuel)			
	Untreated	Wet torrefied	
ash @ 815°C	6,0	4,5	
Ash composition (mg/kg fuel, dry fuel)			
K	9902	510	-95%
Cl	1395	253	-80%

Selected Fuels & Properties

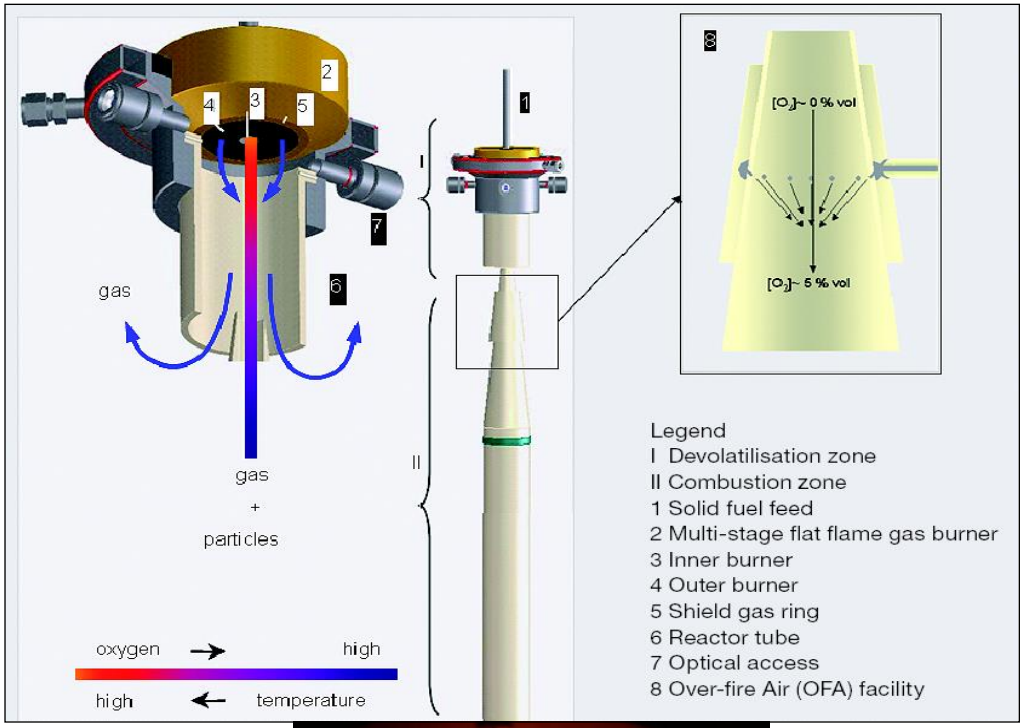
Fuel	El Cerrejon Coal	Guadua Angustifolia (5 years)	Dry torrefied Guadua (5 years) 270oC	Wet torrefied Guadua (5 years)	Average Herbaceous crop (Cynara)	Average Wood	Initiative Wood Pellets Buyers: Industrial wood pellets
Moisture %	4,5	12	0,3	0,06	11	7,1	< 10
Proximate analysis (% mass, dry fuel basis)							
Ash @ 815°C	10,5	5,1	7,6	4,5	5,1	1,44	1 – 3
Volatile matter	33,5	75	65	76	75	80	
HHV (KJ/kg)	26678	18811	20880	20286	19000	20093	>16500
Ultimate analysis (% mass, dry fuel basis)							
C	69	47	51	50	42	50,25	
H	4,55	5,9	5,5	5,8	5,5	6,13	
N	1,11	0,3	0,34	0,27	0,55	0,37	0.5 – 1.5
S	0,8021	0,084	0,068	0,026	0,015	0,026	0.15 – 0.4
O	12	43	35	44	43	44,2	
Ash composition (mg/kg, dry fuel basis)							
Na (± 7)	319	3	3,5	29,4	4100	191	
Mg (± 1)	916	218	169	15,9	1500	404	
Al (± 4)	9210	10	9,5	20,61	160	474	
Si (± 90)	25712	12731	25906	20121	650	1331	
P (± 15)	54	482	513	50,7	910	122	
K (± 20)	1588	9902	9271	510	12000	984	
Ca (± 20)	1695	252	242	396	12000	1919	
Ti (± 8)	470	0,5	0,5	0,75	8,6	96	
Mn (± 6)	42	2	2	2,1	17	66	
Fe (± 4)	5347	14	11,5	26,14	110	301	
Zn (± 1)	20	6,3	4	2,7	13	25	<200
Pb (± 20)	2	0	0	0,33	3,5	8	<20
Sr (± 5)	28	2,2	2,9	1,2	59	11	
Ba (± 5)	85	2,5	3,5	1,34	26	29	
Cl (± 20)	236	1395	949	253	2800	153	0.03 – 0.1%

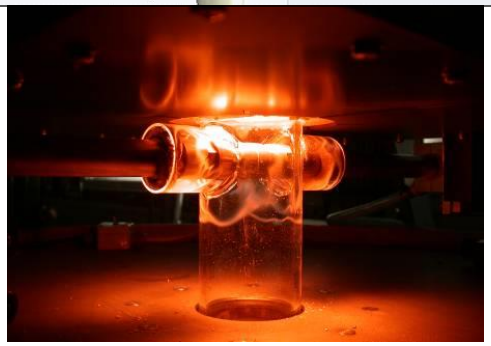
Test facility

- Combustion simulator
  - simulate pulverised-fuel combustion conditions
  - Slagging and fouling
  - Emissions

- Horizontal probe equipped with heat transfer sensors

- Vertical probe for near-burner deposition





Results & comments

Evaluation of the combustion behaviour of the fuels

The behavior of fuels can be evaluated based on various indicators, namely:

(a) **Deposition tendency** based on the ash captured on the probe, which is linked to the ash composition

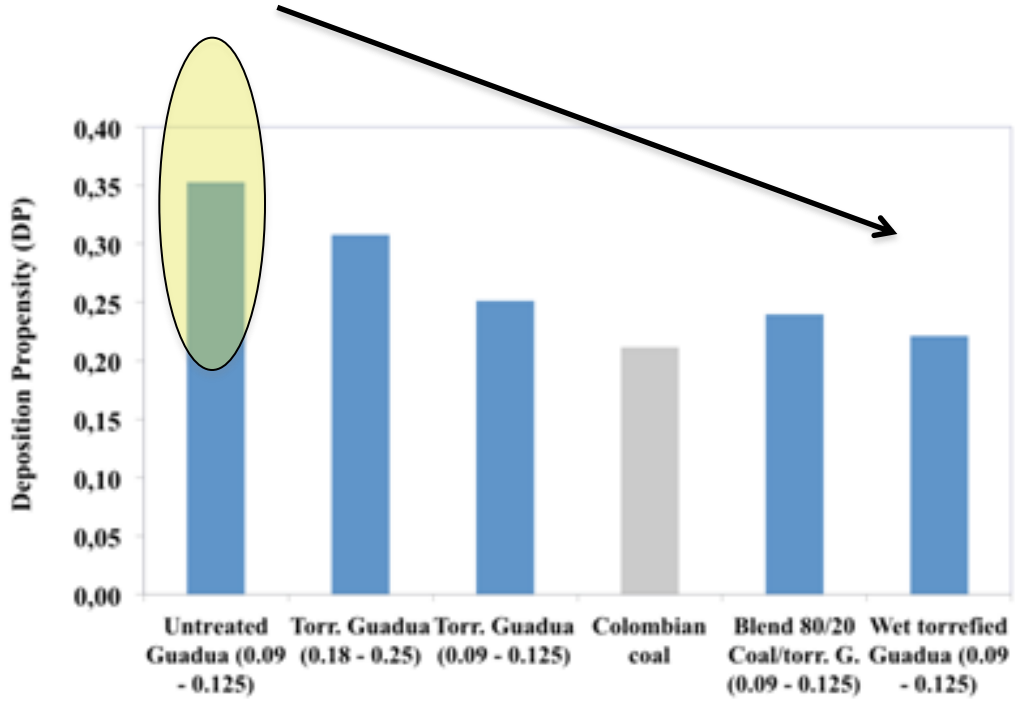
(b) **Fouling factor**, which is directly linked to the thermal conductivity of the deposit.

(c) Indices based only on fuel composition and not tests, e.g. **fouling index**

(a) Deposition propensity

Percentage of the ash collected on the deposit probe, m_{dep}, divided by the total ash content in the fuel fed, m_{ash}, as given by the proximate analysis of the fuel

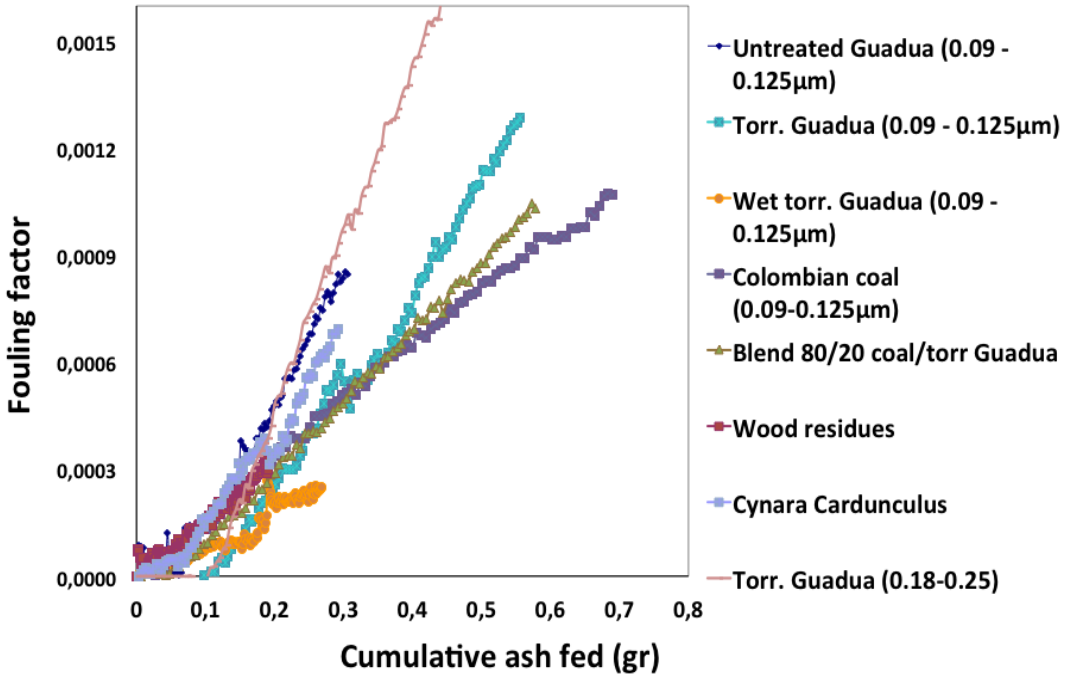
$$DP = \frac{m_{dep}}{m_{ash}}(\%)$$



(b) Fouling factors

Based on the heat flux data measured on-line by the sensor probes, the so called fouling factor *Rf* of the tested fuels can be estimated, which corresponds to the heat transfer resistance of each tested fuel

$$R_f = \left(\frac{1}{U_1} - \frac{1}{U_0}\right) = \frac{T_g - T_c^1}{HF_1} - \frac{T_g - T_c^0}{HF_0}$$



R_f – fouling factor, (K·m²)/W (heat transfer resistance)
U_1 – ash deposits heat transfer coefficient after time t=t_1, W/(K·m²)
U_0 – initial heat transfer coefficient after t=t0=0, W/(K·m²)
T_g – flue gas temperature, K,
T_c – coolant medium temperature in the deposition probe, K,
HF_1 – heat flux to the sensor after time t=t_1, W/m²,
HF_0 – initial heat flux to the sensor t=t_0=0, W/m².

(c) Fouling Index

Based on the fuel composition

	$R_{B/A}$	S
G. angustifolia	0.46	0.4
Dry torrefied *Guadua*	0.21	0.145
Coal El Cerrejon	0.191	0.153
Blend Coal/ Dry Torr. *Guadua* 80/20	0.20	0.15
Wet torrefied *Guadua*	0.029	0.0077
G. amplexifolia	1.56	0.29
B. vulgaris	0.55	0.027
B. strictus	0.17	0.03
Chusquea subulata	0.25	0.085

$$R_{B/A} = \frac{Fe_2O + CaO + MgO + Na_2O + K_2O}{SiO_2 + Al_2O_3 + TiO_2}$$

$$Sf = R_{B/A} \times Sulphur\ in\ coal\ (d\%)$$

The fouling index $R_{B/A}$ describes well the deposition (fouling) behaviour of the tested fuels, as it takes its highest value for the untreated *Guadua*, is lower for the torrefied *Guadua*, and the lowest for the wet torrefied *Guadua*.

None of the fuels shows severe slagging (near burner ash melting).

Conclusions & recommendations

Conclusions

- The deposition tendency of treated *Guadua Angustifolia* is lower than for untreated biomass: variations in S, Cl and K.

- Wet torrefied *Guadua* shows fouling behavior comparable to clean wood.

- Due to the low concentrations of S, Cl and alkalis and heavy metals in the ash, no problems are expected in view of further ash utilization options (cement industry or landfilling). Flue gas cleaning though may be necessary.

- Increased biomass co-firing percentage pending.

- Further development of (wet)torrefaction technology necessary.

- Alternative bamboo species possibly more suitable for thermal power plant applications

Thank you for your attention.

Questions?

For more information, please contact:

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