Well To Wheel-A case study of usage of Beema bamboo as a sustainable energy source

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The paper attempts to use a fuel species with focus on the **Well to Wheel** to connect fuel production to power generation. Bamboo is a member of the grass family Graminae and one of the fastest growing woody plant on the earth. Beema Bamboo a perennial non-flowering species ensures average sustained biomass yields 40 tons / acre/year from third year, for over a 50 year period cycle with 2000 mm irrigated condition with adequate nutrients.

The paper also addresses the use of the fuel for power generation. Results from the tests carried at Indian Institute of Science for power generation using biomass gasification. With a gasification efficiency of 75 % at 250 kWth capacity gasification system, about 8 % char is extracted with the surface area in the range of 950 m^2/g is obtained. The reason for this high surface area is also addressed. The gas quality to address engine application is evaluated and the performance of a gas engine is reported.

Background

Biomass is an important source of energy in tropical countries. Properly managed biomass energy plantations can be sustainable, environmentally advantageous, economically sound and generates substantial local employment. Biomass as a resources is potentially the world's largest renewable source. *It is important to cite that fuel linkage is an important aspect for the success of bioenergy technologies.*

Fuel linkage

Apart from a potential of about 16000 MW from agro residues using 120 to 150 Million tonnes of residues, there are wasteland area that might be available is about 45 million hectares. Agro-forestry can also be promoted through contract farming whereby corporate bodies can organize groups of farmers to produce the required biomass under contract through development of wastelands. **Except paper and sugar where structured plantation is addressed, the power sector has never addressed this.**

Methodology adopted

Bamboo as a plantation crop is addressed as a part of fuel linkage and the plantation data is extensively obtained.

Issues related to use of bamboo for gasification are addressed

- Presence of silica and potassium in the ash and its impact on design addressed
- Tests carried at IISc for power generation using biomass gasification indicate efficiency of 75 % at 250 kWth.
- With an overall char extracted at 8 % char an important aspect related to activated carbon established
- Surface area in the range of 950 m^2/g is obtained.
- The gas quality to address engine application is evaluated and the performance of a gas engine is addressed.

The Plantation

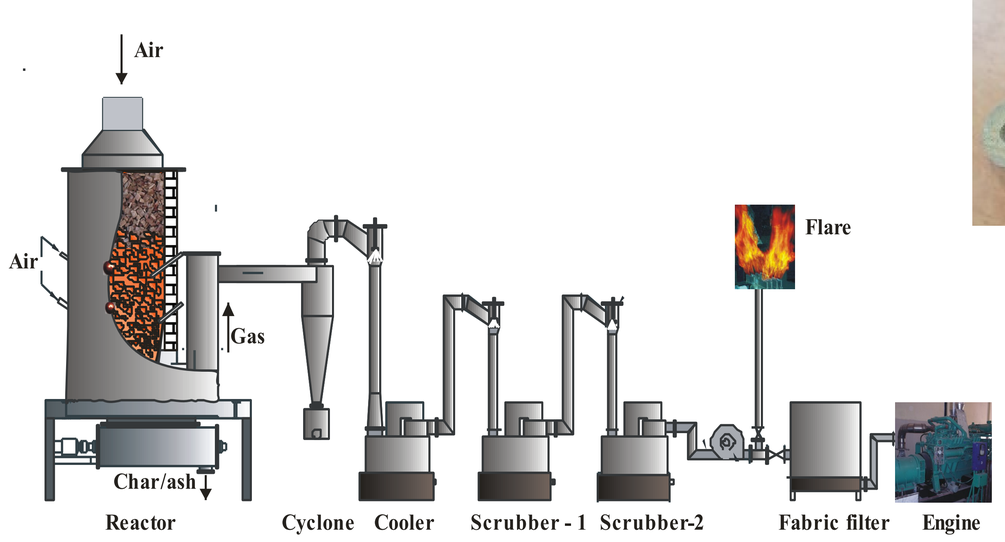
- Beema bamboo can grow in all types of soil. Preferred soil is light soil, loamy soil, red soil and sandy loam soil. Needs about 600 mm of soil depth with an ideal pH between 5 to 6.5.
- Can be made to grow up to 8 pH by correction for the soil.
- The water requirement for Beema bamboo is similar to sugarcane which is 2000 mm/annum.
- Beema bamboo harvest starts after 2 – 2 ½ years, grown to a size of 3 inches in diameter in the bottom and 1 ½" in the top with a height of 15 ft to 20 ft, each culm weighing 6 to 10 kgs.
- In one years time, the second harvest is undertaken. Average yield of 40 tons / acre is achieved and the harvest is repeated every year and yield of 40 to 50 tons of bamboo biomass is harvested.

Naturally grown in forest
0.5 tons per acre

Cultivated
4 to 8 tons per acre

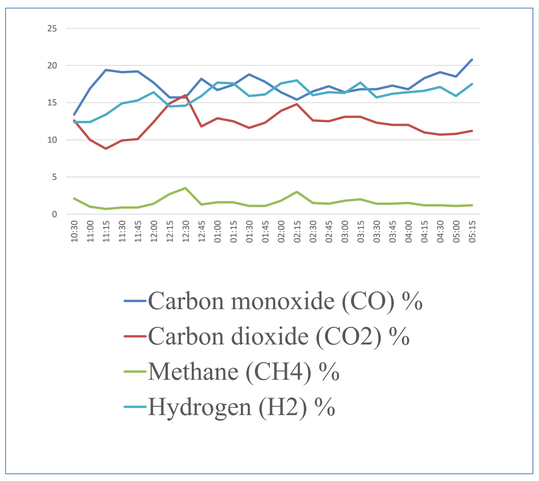
Farming Beema Bamboo
35 to 40 tons per acre

Gasification



Material	Beema Bamboo
Processed size	50 x 50 x 40
Moisture as received (wet basis)	38%
Moisture after sun drying	13.55%
Ash on dry basis	3.5%
Bulk density as received basis	538 kg/m3
Bulk density after sun drying	388 kg/m3

Ash analysis	% DM
SiO2	0.045%
Al203	0.004%
Fe203	0.02%
TiO2	0.000%
CaO	0.15%
MgO	0.021%
Na2O	0.003%
K2O	0.415%
P205	0.130%
SO3	0.028%



- Bulk density 100±10 kg/m3
- carbon > 90 %.
- Surface area 900 ±75 m2/g.
- SFC 1.25 ± 0.1 kg/kWh

Conclusions

- Apart from easy to harvest and further preparation as a fuel for gasification in a fixed bed being simple the poly-generation aspect with the major focus on activated char as a by product.
- About 1 MW power generation suppored by 100 hectares
- By product value is about 1 USD per kg
- Overall techno-ecnomics very attractive