Bamboo gasification

- Gasification? Combustion vs. Gasification
- Why gasification when there is combustion?
- What biomass properties matter in gasification?
- The process.
- The performance.
- Applications.

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Gasification vs Combustion

- Gasification converts the solid fuel to gaseous fuel.
- Combustion converts solid fuel-to-product gases at high temperature. The heat is delivered right at the place where the fuel is fed.
- The gaseous fuel from gasification can be cooled and cleaned for transportation over 10 to 100 m distance (could even be longer but for economics limits it).
- Gasification should be done “carefully” avoiding “tar” to enable simpler cleaning approach.
- There is a “confusion” about biogas, biomass gas, producer gas and syngas – biogas is from biomethanation; others are from thermo-chemical conversion, Biomass gas and producer gas are the same – from air gasification – for thermal and electrical power; syngas is from oxygen-steam mixture used for liquid fuel generation

Why gasn when there is combustion?

- Combustion – steam route is good for large scale power – 3 MWe and above – economical (6 - 7 crore/MWe)
- Power from combustion – steam route becomes much less economical at lower power levels (8 – 10 crore/MWe)
- Gasification + reciprocating engine allows low cost power generation as well as better performance (6 – 8 crore/MWe)
- Also the fuel/kWh is much lower via gasification route compared to combustion route at low power levels.
- Gasification and subsequent combustion in engines can be understood as multi-stage combustion process; this will turn out to be low emission route

What biomass properties matter in gasification?

- Only three properties matter – Ash content, shape and size and moisture.
- We cannot help the first one. But we can affect two others and we should do that.
- Ash content of most biomass fuels varies between 1 – 20 %. Bamboo ash content itself varies between 3 to 6 %.
- Shape and size can easily be dealt with by cutting along and across to desired shapes.
- Moisture of green bamboo is 55 %. It should be brought down to 10 % (sun-dry condition).

Broad performance details

Technology	Fuel/ capacity	SFC kg/kWh
Steam	Biomass, fossil fuel • < 100 kW • 100 - 500 kW • 500 - 2000 kW • ~ 4000 kW	 ~ 6 -8 kg/kWh ~ 4 - 6 kg/kWh ~ 2 - 3 kg/kWh ~1.5 – 2 kg/kWh
Gasification •Dual fuel and gas alone operation •Gas turbine with recuperater	Agro residues • < 100 kW • < 100 - 500 kW • ~ 1000 kW	 ~ 1.2 – 1.5 kg/kWh ~ 1.0 – 1.3 kg/kWh ~ 0.8 - 1.0 kg/kWh
Stirling engines	Can be agro residues • < 100 kW	< 1.5 kg/kWh
IGCC	Agro residues > 2000 KW	 ~ 0.7 – 0.8 kg/kWh

The process… the system

The 2 kg/h system that can deliver 0.75 kWe. In Assam

A 50 kg/h system connected to a 45 kWe gas engine- alternator system

…in Switzerland

A 50 kg/h system to deliver 50 kWe in dual-fuel mode at 85 % diesel replacement

A 600 kg/h system to generate 500 kWe power from Cummins gas engines

…the 25 kg/h system
for pump sets
Up to 20 hp

Applications that can be serviced

- Electricity generation
  - Village electrification
  - Captive power generation
  - Grid linked power generation
  - Energy Service Company - ESCO
- Thermal application
  - Low temperature (drying, etc.,)
  - High temperature (furnaces, kilns, etc.,)

Distributed Power generation system

- Various outputs
  - Electricity
  - Activated charcoal
  - Using waste heat recovery
    - Cold storage
    - Steam generation

Energy demand in a typical rural set up

- Major activities that take place on a farm/rural community
  - Irrigation
    - Electricity for Water pumping
  - Agro processing
    - Electricity for processing
    - Heating and cooling needs
  - Human settlements
    - Domestic energy needs; lighting, cooking, etc
  - Some industrial activities
    - Electricity and heat
  - Rural transport

Energy utilization

- Major energy consuming activity is irrigation
  - It is also this activity that provides livelihood and secure the labor for adequate man-days
  - Agro produce also provides opportunities for various other sub activities within the village boundary for economic transactions
- Even though domestic lighting is important, it is not the priority as far as economic sustenance is concerned
  - Currently, this energy is met through the State grid and is suppressed due to decisions of free electricity.
  - Being managed through subsidies, which continues year by year and is not sustainable

Challenges for distributed power generation system

- Ensuring ownership of the equipment amongst the community
- Ensuring sustained biomass supply
- Equitable sharing of services
- Recovering the service charges

This approach ensures a sustainable replication possibility

Sustained biomass supply

Even though the biomass is available it is distributed.

- Fuel linkage
  - Pre-processing is a must
  - Fuel properties crucial
  - Cost - a very important criterion
- Issues
  - Processing is a sequence of events
  - No universal processing for range of biomass
  - Low density – high transportation costs
- Possible solutions
  - Identify various biomass around the area
  - Setting of **biomass banks** – processed biomass
  - Ensuring usage of biomass to electricity in short distances

Power plant packaging - System design

- Ensure multi-fuel option
- Capability to operate in islanded and grid connected mode
- Agro residue gasification
  - Ability of the gasifier to handle different biomass
  - Simpler route is to use homogenizing and compaction – to bring to standard form by Briquetting / pelletizing
- The process involves - Briquetting / pelletizing
  - Additional input required towards
    - Maintenance and
    - Engineering

Other issues

1. The loads in villages generally are related to quality–of–life, at least to start with.
2. These are lighting, fans, refrigerator (in some cases).
3. Some public/private services like drinking water supply, flour mills, primary health care center, street lighting and others.
4. Electricity for irrigation is a major and important demand.
5. Private electricity based industries will come in only after watching and ensuring sustained supply of power beyond promises.

These imply that load will build with time; it is useful to factor this into the design of the power plant capacity. Investment pattern may also need tuning appropriately.

Issues - contd

1. The diurnal variation of load is also to be accounted for.
2. Normally, the domestic load is the highest between 5.30 pm till 11.00 pm. The loads are the lowest between 11.00 pm and 5.30 am. Other times, the load would be in-between the two.
3. The peak to low of the load is about 4. This has a direct impact on the design plant capacity. Doing it to meet the peak implies it runs at a very capacity for substantial periods of time.

These imply that the plant capacity factor (PLF) – the ratio of the energy produced to energy that could be actually produced will be low. Typically, it will be 0.25 to 0.3.

Strategies…

1. Any rural energy supply package must take note of the impact of the revenue collection on water supply for irrigation.
2. It would be advantageous to both the supplier and the receiver to talk about water supply rather than electric supply.
3. Risks on electricity supply and infrastructure for water supply can be borne by the supplier and the receiver pays for the water supplied. All hidden costs can be covered in this approach.

Strategies…

1. It is noted that the objective is rural energy supply rather than just commercial energy generation.
2. Grid supply must be made use of for generating revenue, either from the State or a private entrepreneur.
3. The quality-of-life electricity must be made a small fraction of the total generation to ensure that this segment does not affect the economics of operation.
4. The much needed irrigation water could be a profitable venture requiring the engineering of suitable arrangements outside the "State" for a foreseeable future.
5. Bamboo with its high rate of growth can be a fuel of the future.

Thanks ………Any questions?