Renewable Gas / CBG

Deploying PRAJ RenGas Technology to boost Circular Bioeconomy

3rd EU – India Conference on Advanced Biofuels
3rd & 4th March 2020, New Delhi

Nitin Shete – PRAJ Industries Limited
Praj through its Bio-Mobility™ solutions is at the fore-front of ESG

Bio-Mobility facilitates decarbonization through circular bio-economy

ESG

1G

Marine Biofuels

2G

SAF

CBG

BioDiesel

*SAFs - Sustainable Aviation Fuels

NATURAL RESOURCES

WASTE MANAGEMENT

CLIMATE STABILITY

INNOVATION

HUMAN CAPITAL MANAGEMENT

DIVERSITY

VALUE CHAIN

CORPORATE GOVERNANCE

RISK MANAGEMENT

TRANSPARENCY

ANTI BRIBERY CORRUPTION

ENVIRONMENT

SOCIAL

SOCIETY

G

S

E

ENVIROMENT

DIVERSITY

INNOVATION

HUMAN CAPITAL MANAGEMENT

VALUE CHAIN

CORPORATE GOVERNANCE

RISK MANAGEMENT

TRANSPARENCY

ANTI BRIBERY CORRUPTION

ENVIROMENT

SOCIAL

SOCIETY
CBG – Need of the Hour

Challenges

- Growing Emission – Vehicles & Burning Agriwaste
- Industrialization impact on Ecology balance
- Climate change affecting monsoon
- Rural unemployment
- Traders gaining at the expense of farmers
- Farmers in dire states - drought, untimely rains
- Extreme dependency on imported crude oil
- Heavy forex payout
- Insecurity of availability & pricing

Solutions

- Renewable fuels & Gas Economy
- Captive feed stocks - Cleaner renewable fuels
- Fulfill COP 21 Paris Summit obligations
- Agri-residue as alternate revenue stream
- Creating rural Agri-employment
- Helping farmers improve farm income
- Circular Bio-economy
- Change to Renewable Gas – within Country
- Blend Ethanol in Petrol
- Use indigenous renewable waste feeds
- Secure Indigenous Fuels Reduces forex bills
CBG: Potential Opportunity (India)

Ministry of Petroleum, India has announced SATAT (Sustainable Alternative for Affordable Transportation) scheme to buy CBG from producers, for transport application.

**SATAT SCHEME**
- **GOAL**: 15 MMT
- **CBG Plants**: 5000
- **CAPEX**: 1.5 Lakh Cr

**Non SATAT**
- **Potential**: 1 MMT
- **CBG Plants**: 300
- **CAPEX**: 9000 Cr

**Organized Feedstock**
- Surplus Agri-residues
  - Rice & Wheat straw,
  - Corn cobs / Stover
  - 300 MMT / Yr
- Can give 20 MMT of CBG/Yr

- Sugar mill waste
  - Pressmud / Spent wash
  - 100 MMT / Yr
- Can give 5 MMT of CBG/Yr
India – Need Best Fit CBG Technology – Circular Farm Bioeconomy

- Preferably from Farms waste & Organizable supply
- Rice & Wheat Straws, Corn Stover / cobs, Bagasse
  - Agro-based Sugar mill waste- Pressmud / Spent wash

- Minimize emissions - CBG based transport
- Stop Stubble burning
- Zero budget farming - Organic manure as co-product
- Replace as much Urea Import

- Replace CNG Import (15 MMT/Yr)
- For Clean Transport
- Replace UREA - By Organic Manures - Zero Budget Farming
- Substitute CNG in Industrial Power & Heat (Non-SATAT)
- Replace Static / local diesel consumption in Farm sector

- USD 5 to 7 Billion saving Opportunity
- Re-inject in Farm economy - Improve Farming income
- Local Jobs Creation
- CBG Agro-based industry - distributed
- Local production & consumption

Say No to Fossils
Rengas Plant designs are the Key: Viability Bench marks

- CBG feedstocks in Sugar Industry: Pressmud and Bagasse
- Technology must deliver highest performance for viable returns

Minimum 350 Days / Yr Operation

- **PM >130 M3 / MT**
- **Bagasse >375 M3 / MT**
- **InR 2000 / MT**
- **InR 18 / Kg CBG**
- **Bagasse InR 22 / Kg CBG**
- **PM 150-300 TPD / 6.75 – 13.5 TPD CBG**
- **Bagasse 100-200 TPD / 15 - 30 TPD CBG**
- **Gas Yield**
- **Manure Price**
- **Variable Cost / Kg CBG**
- **Plant Capacity**
## The RENGAS Technology Focus

### Feedstock Pretreatment

**Sugar Mill Pressmud**
- 5 to 6 months production
- Highly Perishable
- Needs Stabilization of VS for 350 days CBG production

**PM STAB Technology for Pressmud Preservation (> 350 days operation)**

### Biomethanation

- High Degradation efficiency very high yields
- Very High Mixing at low energy – mass transfer
- Avoid VS loss - Bypassing
- Two stage design - Acidogenic & Methanogenic
- Low maintenance & shut downs (350 Days operation)
- Handling of solid waste
- **PRAJ-DVO Duel Plug Flow reactor plants**

### Gas Purification

- Simple cost effective & robust
- Should operate in remote areas
- High quality of CBG
- Efficient H2S & CO2 removal
- **PRAJ -DVO Duel Plug Flow reactor plants**

### High Value Organic Manure

- High quality balanced Organic manure co-product
- **NOCA certification for both Pressmud and Biomass CBG plants**

### Agri-residues

- Ligno-cellulosic VS needs critical hydrolysis
- Minimum Hydrolysis Costs

**BM Solve Technology for Biomass hydrolysis**
PRAJ RENGAS USPs

PRAJ RENGAS CBG PLANTS - USPs

Sugar Mill Pressmud based
- PM STAB Technology for Pressmud Preservation (> 350 days operation)
- High Biogas Yield above 130 M3/MT (Low Opex)
- Feasible Project IRR > 20%

Proprietary Rumen Culture

Proprietary Plug Flow Design Reactor

Round the Year Operation

NOCA Certified Organic Manure

Agri-residue Biomass based
- BM Solve Technology for Biomass Hydrolysis (Low cost Microbial hydrolysis)
- High Biogas Yield above 400 M3/MT
- Feasible Project IRR > 15%
### Biomethanation

<table>
<thead>
<tr>
<th>Continuous Stirred Tank reactors</th>
<th>DVO Mixed Duel Plug Flow reactor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reaction mechanism</strong></td>
<td>Inefficient - Prone to bypassing of substrate</td>
</tr>
<tr>
<td><strong>Reaction</strong></td>
<td>Single phase – No separation of acidogenic &amp; methanogenic stages</td>
</tr>
<tr>
<td><strong>Robustness</strong></td>
<td>Sensitive to feed and parametric variations</td>
</tr>
<tr>
<td><strong>Conversion efficiency</strong></td>
<td>Low (&lt; 60 %)</td>
</tr>
<tr>
<td><strong>Gas yields</strong></td>
<td>Low due to low degradation</td>
</tr>
<tr>
<td><strong>Retention time</strong></td>
<td>Very high - Makes plant bigger &amp; expensive</td>
</tr>
<tr>
<td><strong>Mixing efficiency</strong></td>
<td>Low due to agitators</td>
</tr>
<tr>
<td><strong>Flexibility &amp; expansion</strong></td>
<td>Low - Multiple reactors difficult to synchronize</td>
</tr>
<tr>
<td><strong>Electricity consumption</strong></td>
<td>High due to large multiple mechanical agitators</td>
</tr>
<tr>
<td><strong>Start-up and restart time</strong></td>
<td>High due to slow reaction</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>Frequent and High cost - due to mechanical agitators and membrane domes</td>
</tr>
<tr>
<td><strong>Maintenance Shut downs</strong></td>
<td>Complete shutdown – Every alternate year - Loss of production for 2 months</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td>Complex to automate - High manpower</td>
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</tbody>
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### CSTR limitation

- **Retention times**

### DVO advantage

- **Plug Flow concept**
A typical PRAJ DVO dairy installation.
PRESSMUD is organic waste generated by cleaning of cane juice in a mill

- Typically 10000 TCD mill gives 400 MT/day pressmud (4% by weight)
- Contains 30% solids & 70% moisture - Solids Comprise Soil, Organic solids and sugars
- Mill runs 150 days/year – 60000 MT annual pressmud generation
- However, Round the year CBG plant is designed @ 200 TMT/day Pressmud input.
- This means pressmud needs at least 6 months storage without yield loss

Pressmud is very perishable and degenerates naturally reducing organic matter & Gas yield

- PRAJ has developed
- Unique patented PM Stab Microbial technology to preserve
- Pressmud without losing gas yield
Press Mud Deterioration with ageing & Loss of Gas Yield

~20% Degradation in 1\textsuperscript{st} Month & up to 50% Degradation by 4\textsuperscript{th} Month

- Only PRAJ has the knowhow of preserving pressmud round the year
- With PM Stab and Proprietary Biomethanation the yield is increased >130 CuM gas / MT
Pressmud 200 MT / Day

PM Stab Treatment

Pressmud 200 MT / Day

Slurry preparation: 30 MT / Hr

Duel Plug Flow Reactor system
HRT: < 20 Days

Biogas 1080 CuM / Hr

Gas Cleaning – H2S removal < 5 PPM

Gas Cleaning – CO2 Removal < 3%

Compression and cascades
10,200 KG / Day CBG

Solid Liquid Separation

Digestate

Solids Drying

High Quality Organic manure
35 to 40 MT / Day

Liquid Recycle

Solid Liquid Separation

Surplus Liquid

Ferti-irrigation to Farms (130 CuM / Day)
PRAJ Biomass to CBG Technology & Plants

- **PRAJ CBG Plants** produce CBG from Agri-residues: Rice Straw, Wheat Straw, Corn Stover & cobs

  - **PRAJ BM Solve Technology** uses special microbe to hydrolyze the Ligno-cellulose and convert into Volatile solids
  - High efficiency conversion / **No** Chemicals, Enzymes or Steam is required
  - Hydrolyzed biomass is directly biomethanated to Biogas in **one step**
  - Very high gas yields **400 to 500 CuM** (Depending on type of feedstock)

Highest Yield in the Industry
PRAJ Biomass to CBG plants configuration

Rice Straw: 100 MT / Day

Milling / Bioextrusion
4 to 6 MT / hr

Slurry preparation:
55 MT / Hr

Continuous Microbial Pretreatment
HRT 2 days

Duel Plug Flow Reactor system
HRT: 25 - 28 Days

Biogas 1625 CuM / Hr

Gas Cleaning – H2S removal
< 5 PPM

Co2 Removal < 3%

CBG 15500 Kg / Day

High Quality Organic manure
35 to 40 MT / Day

Liquid Recycle

Solid Liquid Separation

Solids Drying

Surplus Liquid

Ferti-irrigation to Farms (250 CuM / Day)
Reaction-I
\[ 2 \text{Fe}^{3+} + S^{2-} \rightarrow 2 \text{Fe}^{2+} + S \]

Reaction-II
\[ 4\text{Fe}^{2+} + 4 \text{H}^+ + \text{O}_2 \rightarrow 4 \text{Fe}^{3+} + 2 \text{H}_2\text{O} \]

- IS 16087 (2016)
- Clean methane
- CH4: >95%
- H2S :< 5 PPM
- CO2 :< 3%

PRAJ Rengas - CBG purification technology
PRAJ RENGAS - Organic Manure technology

Optional Technology for Recovering Manure with Value
- Ammonium Sulfate recovery System
- Phosphorous Recovery System
- Add-Back balancing for the Manure

High Performance Bio-manure
- Complete TVS degradation ensures Bio-manure with high minerals
- Stable characteristics with low degradation

NOCA Certification for all feedstocks
- National Organic Certification Agency approval for Bio-manure from various grades and feedstocks
Praj’s Pressmud & Biomass to CBG - Demo Plant near Pune

Location: Shreenath Mhaskoba Sugar Karkhana
Year: Plant in operation since 2017
PRAJ RENGAS Technology Advantage

• **End to End Solution with Performance Guarantees**

• **Flexible Technology:**
  - Rice straw & other Agri-residues
  - Pressmud
  - Distillery Spent wash
  - Farm waste
  - Modular capacity expansion

• **Under one Roof**
  - Technology License
  - Turn Key Plant supply
  - Basic & Detailed Engg
  - Equipment supply
  - Piping & Instrumentation
  - Electrical Automation
  - Civil & Structural
  - EPC Contracts

• **Partnership:**
  - Pre-feasibility studies & permitting assistance
  - Plant Supply
  - Operation training and commissioning
  - After sales support services such as trouble shooting, maintenance and expansion

• **High Gas & Biopower yields with low Opex**

• **High Co-product credit from Bio-fertilizer**

• **Multiple applications: CBG / Biopower / Industrial gas / Heat**

• **Round the Year Operation – High Quality & Yields**
Praj presence across the globe with 750+ references in more than 75 countries.

CPES references across the globe with >1500 equipment and >300 Skids in 20 countries.