Assessment of Carbon Mitigation Potential of Biogas Technology in India

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Context

- Energy use and climate change
- Increasing energy needs – alternatives
- Renewable energy systems offer GHG mitigation while serving the purpose of energy needs
- Bioenergy is the traditional source of energy – cooking, lighting and transportation
India’s Total Primary Energy Supply Mix

(Source: British Petroleum, 2013)
India’s GHG Emission Profile (2007)

(Emissions (2012): 1823 Mt CO2 equivalents (Global share of 5.3 %)

(Source: MoEF, 2008)
GHG Abatement Cost Curve for India

(Carbon Mitigation Potential (CMP) is the amount of carbon emission that can be avoided or reduced)

(Source: McKinsey, 2009)
Objectives

• To understand the current status of biogas technology in India
• To assess carbon mitigation potential of biogas technology in India by multi-attribute evaluation for different end-use applications
  – Residential cooking
  – Residential lighting
  – Transportation (Bio-CNG)
Households by type of fuel used for cooking

(Number of households in million)

- **Urban**
  - Biogas: 16
  - LPG/PNG: 51
  - Kerosene: 19
  - Coal, Lignite, Charcoal: 18.252466
  - Crop residue: 0
  - Fire-wood: 0

- **Rural**
  - Biogas: 0
  - LPG/PNG: 21
  - Kerosene: 0
  - Coal, Lignite, Charcoal: 0
  - Crop residue: 105
  - Fire-wood: 0

(Source: Household level survey, Census of India, 2011)
Households by main source of lighting

(Source: Household level survey, Census of India, 2011)
State wise family type biogas plants in India (2011)

Typical size: 1-4 m$^3$

Achievement: 4.7 million

(Source: MNRE, 2014)
<table>
<thead>
<tr>
<th>Biogas plant type</th>
<th>Models recognized by MNRE</th>
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<tbody>
<tr>
<td>Fixed dome biogas plant</td>
<td>- Deenbandhu fixed dome model with brick masonry construction</td>
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<tr>
<td></td>
<td>- Deenbandhu ferro-cement model with in-situ technique</td>
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<td>- Prefabricated RCC fixed dome model</td>
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<tr>
<td>Floating dome biogas plant</td>
<td>- KVIC floating steel metal dome with brick masonry digester</td>
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<td></td>
<td>- KVIC floating type plant with ferro-cement digester and FRP gas holder</td>
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<td>- Pragati model biogas plant</td>
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<tr>
<td>Pre-fabricated biogas plant</td>
<td>- Prefabricated reinforced cement concrete (RCC) digester with KVIC floating drum</td>
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<td>Bag type biogas plant (Flexi model)</td>
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Technology Attributes

- Digester design (fixed dome Vs. floating drum)
- Hydraulic Retention Time (HRT)
- Operating Temp. (mesophilic Vs. thermophilic)
- Recirculation of the slurry (with or without)
- Type of digestion (wet Vs. dry)
- No. of phases (monophasic Vs. biphasic)
- No. of stages (single Vs. multiple)
Scope of the Work

- **Kitchen & Food Waste / Cattle Dung**
- **Anaerobic Digestion**
- **Biomethane / Biogas**
  - **Design type** (Fixed Vs. Floating)
  - **HRT**
  - **Presence of Recirculation**
  - **Size of the digester**

- **Replacing Grid Electricity**
- **Replacing subsidized LPG**
- **Replacing CNG**

- **Cooking**
- **Lighting**
- **Transportation**
Alternatives Considered

Design

Deenbandhu (Fixed Dome)

HRT

40 Days

55 Days

Scale

1 – 4 m³

1 – 4 m³

Mixing

With Recirculation

Without Recirculation

With Recirculation

Without Recirculation
Alternatives Considered

**Design**
- KVIC (Floating dome)

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<td>40 Days</td>
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<td>1 – 4 m³</td>
<td>Without Recirculation</td>
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With Recirculation
Without Recirculation
Screening criteria for alternatives

- Compliance with current regulations
- Minimum no. of installations
- Minimum no. of existing installations for a specific end-use or application reliably operating since last 5 years
- Unacceptable risk or nuisance, such as noise or odour
- Technological maturity in terms of commercial availability and post-installation service
Evaluation Methodology

Performance & Economic model

Nuisance & Risk

Technological Maturity

User Acceptance

MAC

LCOE

N & R

TM

UA

Multi-attribute Evaluation
Modeling Framework

- Multiple performance attributes describing digester and feedstock
- Economic attributes
  - Economic attributes
  - Baseline
  - Marginal abatement cost & Abatement Potential

Spread sheet based model is built for the purpose and the data related to attributes was collected through field visits and secondary sources.
Methodology

Marginal Abatement Cost (MAC) = \( \frac{C_M - C_B}{E_B - E_M} \)

Where,
- MAC = marginal abatement cost in Rs. / kg CO2eq avoided
- \( C_M \) = Cost of the mitigation option in Rs.
- \( C_B \) = Cost of the baseline scenario in Rs.
- \( E_B \) = Emissions in the baseline scenario in kg CO2eq
- \( E_M \) = Emissions in the mitigation scenario in kg CO2eq

MAC = \( \frac{\sum \text{NPV\_Costs}}{\sum \text{Emission reductions}} \)

(Source: Halsnaes et al., 1999)
Key Findings

Abatement Cost Curve for Biogas End-use Applications

- Residential Cooking: -3
- Electricity: 0.25
- Transportation: 7

Abatement Potential in million tonnes of CO2eq
Abatement cost curve for different biogas technology alternatives for electricity (Without recirculation)
Discussion

• Abatement cost for biogas technology ranges from Rs. -2.84 to 6.5 for different end-use applications (with an abatement potential ranging from 25- 70 million tonnes of CO$_{2}$eq)

• Using Biogas for cooking energy needs may offer co-benefits such as avoided deforestation while mitigation emissions

• Biogas for electricity and transportation seems to be associated with costs.

• Deenbandhu type biogas technology with 40 days HRT found to be effective in mitigating emissions.
Thank You