Benefits and challenges of anaerobic digestion of organic waste for energy production in India: A review of established business models

L. Breitenmoser\textsuperscript{a}, T. Gross\textsuperscript{a}, H. Dhar\textsuperscript{b}, S. Kumar\textsuperscript{b}, C. Hugi\textsuperscript{a}, T. Wintgens\textsuperscript{a}

\textsuperscript{a} Institute for Ecopreneurship, University of Applied Sciences and Arts Northwestern Switzerland (FHNW)

\textsuperscript{b} CSIR-NEERI, India
Introduction and background
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(Organic) waste management in India

- 143,000 tons of municipal solid waste (MSW) generated per day

- > 70% of solid waste collected and disposed off untreated on open dumps

- Mixed with industrial and hospital waste, agricultural waste

- Significant hazards for health and environment

- Challenges for urban local bodies (ULBs): Lacking financial resources for infrastructure and management (CPCB, 2015)
Introduction and background
2016: New legal and policy framework

Swachh Bharat ‘Clean India’ Mission 2014 → Aim: 100% door-to-door collection, transportation, treatment and disposal of MSW in over 4'000 Indian towns by 2019 (MoUD, 2014; Gosh 2016)

Revised MSWM Rules 2016
- Solid waste management duty of municipalities (urban local bodies)
- Urban MSW composition in India: > 50% - 75% organic (biodegradable) (Kumar et al., 2009)

Technology push → increase in anaerobic digestion systems expected
Introduction and background

Anaerobic digestion (AD) for energy production

A multi-purpose technology between **MSW treatment, energy and agriculture** (closing nutrient cycles)

Advantages of AD:
- Volume reduction of municipal solid waste (organic load)
- Purification of MSW (pollution load) – public health
- Smaller land area required compared to landfilling
- Odour control
- Energy recovery plus high-grade fertilizer
- Mature technology, applicable from small to large scale

Sources: Minde GP, Magdum SS, Kalyanaraman V (2013); Kalyani KA, Pandey KK (2014)
Introduction and background

Objectives

- **AD well established in rural, agriculture-based areas** running with manure and agricultural waste. 4.9 million biogas units installed in rural households for cooking purposes; few larger community plants (MNRE, 2016).

- **BUT: Diffusion in urban context is challenging.** Only 600 community biogas plants set up; several examples of failures of large urban biogas plants with solid organic waste (CPCB, 2015)

- **What are enabling factors and challenges for biogas plants in the urban Indian context?**

  - Analysis of business models and sustainability aspects of established biogas systems


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Business model CANVAS

“A business model describes the rationale of how an organization creates, delivers, and captures value, in economic, social, cultural or other contexts.”

Urban local body perspective

Key Partners
- Who are our Key Partners?
- Who are our Key Data Suppliers?
- Which Key Resources are we acquiring from partners?
- Which Key Activities do partners perform?
- Motivations for Partnerships: Optimization and Economy, Reduction of risk and uncertainty, Acquisition of particular resources and activities

Key Resources
- What Key Resources do our Value Propositions require?
- Our Distribution Channels?
- Customer Relationships?
- Revenue Streams?
- Categories: Production, Product Making, Partners/Network

Key Activities
- What Key Activities do our Value Propositions require?
- Or Distribution Channels?
- Customer Relationships?
- Revenue streams?
- Categories: Production, Product Making, Partners/Network

Value Propositions
- What value do we deliver to the customer?
- Which one of our customer’s problems are we helping to solve?
- What bundles of products and services are we offering to each Customer Segment?
- Which customer needs are we satisfying?

Customer Relations
- What type of relationship does each of our Customer Segments expect us to establish and maintain with them?
- Which ones have we established?
- How costly are they?
- Examples: Personal assistance, Dedicated Personal Assistance, Self-Service, Automated Services, Community, Co-Creation

Customer Segments
- For whom are we creating value?
- Which colleagues, departments and subsidiaries, partners and customers are demanding, who?
- Who are our most important customers?
- Mass Market, Niche Market, Segments, Unsatified

Channels
- Through which Channels do our Customer Relations?
- Which channels are most efficient?
- Examples: Mass Awareness, Evaluation, Partners, Deliveries, Interactions

End users

Infrastructure management

Product

Financial viability

Cost Structure
- What are the most important costs inherent in our business model?
- Which Key Resources are most expensive?
- Which Key Activities are most expensive?
- Is our Business more Cost Driven (lowest cost structure, low price, value proposition, maximum automation) or more Value Driven (focused on value creation, premium value proposition)

Revenue Streams
- For what value are our customers really willing to pay?
- For what do they currently pay?
- How are they currently paying?
- How would they prefer to pay?
- How much does each Revenue Stream contribute to overall revenues?

Business Model Canvas (Osterwalder, 2004)
- Holistic analytical tool and framework for business models

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‘Value propositions’ as starting point

A business model describes the rationale of how a community creates, delivers, and captures value, in economic, social, cultural or other contexts.”
Methods and materials
‘Sustainability questions’

Anaerobic digestion (environmental technology)

P1 – Value proposition

Waste management  Renewable energy  Fertilizer

End user: Who are the end users? Who pays for the biogas related products?
Services: Which additional services/assistance is needed on the end user site?
Delivery: How is the product delivered to the end users?
Methods and materials
‘Sustainability questions’

Anaerobic digestion (environmental technology)

P1 – Value proposition

Waste management Renewable energy Fertilizer

End user: Who are the end users? Who pays for the biogas related products?

Services: Which additional services/assistance is needed on the end user site?

Delivery: How is the product delivered to the end users?

Cost structure: What are investment (CAPEX) and operating costs (OPEX)?

Revenue streams: Are adequate revenues from the end user generated?

Environment

Economy

Society

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‘Sustainability questions’

Anaerobic digestion (environmental technology)

P1 – Value proposition

Waste management
Renewable energy
Fertilizer

Resources: Which substrate type, quality and quantity is required? What is the year-round availability?

Partners: Who are key partners, key suppliers?

Cost structure: What are investment (CAPEX) and operating costs (OPEX)?

Revenue streams: Are adequate revenues from the end user generated?

Activities: Which installation, O&M works are related to the biogas technology and value proposition?

End user: Who are the end users? Who pays for the biogas related products?

Services: Which additional services/assistance is needed on the end user site?

Delivery: How is the product delivered to the end users?

• Literature review
• Key informant interviews

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Results and discussion
### Results and discussion

**Energy aspect dominating**

<table>
<thead>
<tr>
<th>Business-Model:</th>
<th>MNRE programme (I1)</th>
<th>Biogas use (P1):</th>
<th>Capacity installed:</th>
<th>Resources (organic waste) (I3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Family:</strong></td>
<td>National Biogas and Manure Management Programme (NBMMMP) 1981</td>
<td>Cooking</td>
<td>4.9 million units (potential 12 million units)</td>
<td></td>
</tr>
<tr>
<td><strong>2. Community decentralized:</strong></td>
<td>Off-grid Biogas Power Generation Programme (BPGP) 2006</td>
<td>Power (cooking, streetlights)</td>
<td>250 units installed /4.07 MW</td>
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<td><strong>4. Industrial:</strong></td>
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## Results and discussion

### Value proposition, End users, revenue generation

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|             | Waste management              | Rural and peri-urban households (on-site use) | Economic incentives: replacement of liquid petroleum gas (LPG) for cooking; of conventional fertilizer | E3 –services: Technical expertise lacking & poor assistance  
I2 – activities: no performance evaluation (methane leaks, fertilizer quality?)  
I3 - resources: substrate & water availability |
|             | ☑ Renewable energy             |                       |                       |                                                                                |
|             | ☑ Fertilizer                  |                       |                       |                                                                                |
# Results and Discussion

## Value Proposition, End Users, Revenue Generation

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<td>Rural, peri-urban and urban communities, institutions (on-site use)</td>
<td>Proper waste management as community-based initiatives – organic waste disposal and treatment fee</td>
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<td>Peri-urban, community members, households, farmers</td>
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<td>I2 – activities: technical expertise lacking; no performance evaluation (methane leaks, fertilizer quality?)</td>
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<td>Corrected</td>
<td>Fertilizer</td>
<td>No willingness to pay for waste management (E1) Renewable energy tariffs too low to compete (I1) No market for digestate (I1)</td>
<td>I3 – resources: Substrate quality and quantity</td>
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<td>E1 – end user (individual): Lack of awareness of importance of waste management E1 – end users (municipalities): Lack of planning capacities</td>
<td>E2 – delivery: Cost for energy upgradation and delivery too high</td>
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Conclusions and recommendations
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MSWM Rules 2016; Swachh Bharat 2014: Technology push → increase in AD systems expected → time to establish good practice

Decentralized AD systems - Success factors:
✓ promising waste management option of source-segregated waste streams (e.g. market waste, restaurant waste)
✓ waste management fee paid by end user (private, commercial)
✓ private operators of AD systems

Centralized AD systems - Requirements:
– source-segregation needed (quality)
– awareness programmes and interaction with community members to introduce waste management fee (e.g. involvement of informal sector)
– Public-private partnerships (PPP) to ensure technical assistance and servicing; or training and awareness regarding correct O&M
Conclusions and recommendations

MSWM Rules 2016; Swachh Bharat 2014: Technology push $\rightarrow$ increase in AD systems expected $\rightarrow$ time to establish good practice

Both models - Requirements
- Proper **planning tools** to assess **substrate quantity and quality**
- **Quality and performance control** of value propositions along the waste value chain:
  - Waste management: volume reduction, public health and environmental impact reduction
  - *Fertilizer*: Improvement of digestate quality to facilitate market uptake
  - *Renewable energy*: Optimisation of biogas quality and delivery
Thank you for your attention
Dhanyavaad!

Contact details:

Lena Breitenmoser
Institute for Ecopreneuship
School of Life Sciences, FHNW
Muttenz, Switzerland

lena.breitenmoser@fhnw.ch

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