M.A.D in India

Source: Google Images

Source: Chandler, 2010

Todd Newman
DePaul University
School of Public Service
4/21/2012

Source: Chandler, 2010

Contents

Population and Ecological Constraints

- Increased population growth and persistent poverty in developing countries continue to influence ecological degradation.
  - 70% of India's population inhabit rural areas(Ravindranath & Balachandra, 2009).
  - 80% of the total energy consumed in rural areas comes from biomass fuels such as firewood, crops and live stock dung(Ravindranath & Balachandra, 2009).

Energy Constraints

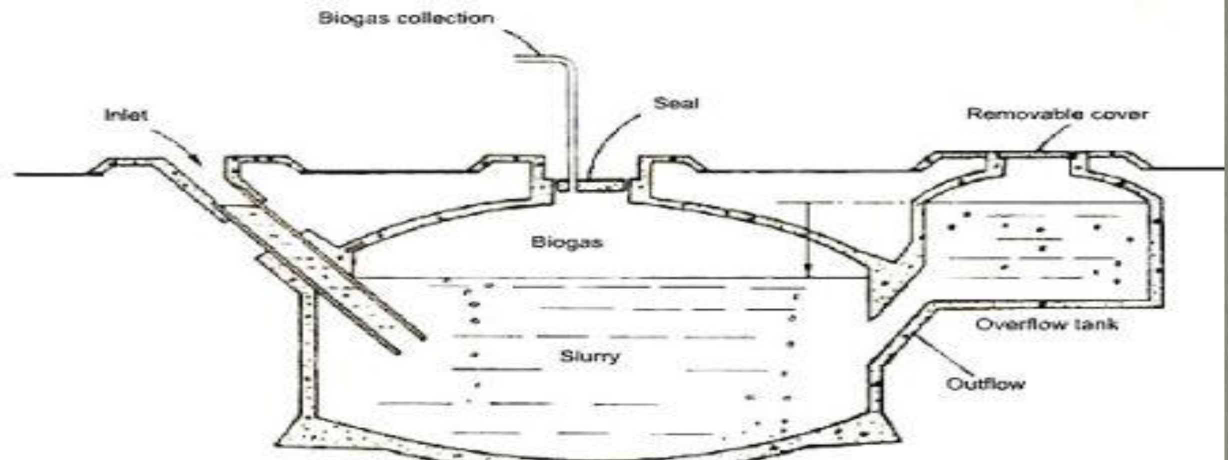
- Economic prosperity and quality of life closely linked to energy consumption:
- Inadequate, poor, and unreliable energy services.
  - In 2005, 75% of villages were electrified, but only 55% had access to electricity (Ravindranath & Balachandra, 2009).
  - Only 9% had access to LPG (liquefied petroleum gas) and <3% have kerosene for cooking(Ravindranath & Balachandra, 2009).
  - Current energy demand is expected to increase three to four times the current level in another 25 years (Ravindranath & Balachandra, 2009).
- Urgent need to provide adequate energy in a sustainable manner to the large populations in the rural regions of India.

Micro-Anaerobic Digestion: What is it?

- What is Anaerobic Digestion?
  - A natural process where biomass is consumed in the absence of oxygen.
    - Biomass: Organic matter derived from trees, plants, crops or human, animal, municipal and industrial wastes.
    - Process:
      - Biomass→ Acids (acidogensis)
      - Acids→Gas (methanogenesis)
        - Methanogens
- In 2006, 3.8 million digesters in rural India with a potential for 17 million (Agoramoorthy & Hsu, 2008; Ravindranath & Balachandra, 2009).

Micro-Anaerobic Digestion: Design

- Four Components: Slurry mixing tank ,digester, gas holder, and outlet tank.



Source: Google Images

- Biogas: 50-60% methane, 30-40% carbon dioxide, 1-5% hydrogen and traces of nitrogen, hydrogen sulphide, oxygen, water vapors.
  - Effluent as fertilizer

Micro Anaerobic Digester: Quantity and Size

- Quantity and Size
  - 4-6 member household requires 2m³ plant, which provides biogas for 4hrs daily.
  - Amount of water proportional to quantity of waste (dung).
- Hydraulic Retention Time (HRT): 40 days
- 1kg dung=0.04m³ of biogas

Table 1

Number of persons that may be served by and animals required for different capacity biogas plants

S. No.	Capacity of biogas plant (m^3)	No. of persons that may be served	Quantity of dung required (kg)	No. of animals thus required
1	1	2–3	25	2–3
2	2	4–6	50	4–5
3	3	7–9	75	6–7
4	4	9–12	100	8–9
5	5	12–15	125	9–10
6	6	14–17	150	10–12

Source: Singh & Sooch, 2004

Types of M.A.D Models

- Fixed Dome:
  - Janta Model
  - Deenbandhu Model
- Floating Drum:
  - KVIC Model
  - Pragati Model
  - Ganesh Model

Source: Google Images

Source: Google Images

Fixed Dome Construction

Source: Chandler, 2010

Source: Chandler, 2010

Agoramoorthy, G.& Hsu J. M. (2008). Biogas plants ease stress in India's remote villages. *Human Ecology*, *26*, 435-441.

- Impact of M.A.D on local ecology and community
- Built between 2001-2005.
- Data recorded in 2007.
- NGO: Sadguru
- Methods:
  - 125 sites in three states:
    - Dahod (Gujart State)
    - Jhabua(Madhya Pradesh)
    - Jhalawar and Banswara (Rajasthan State)
- Selection:
  - Average Household: 4-8 members
  - Cattle/Buffalo
    - 25 to 50 kg (55lbs to 110lbs) of dung daily
  - Water
    - 50 l (13 gal.) of freshwater daily
  - Access to land near kitchen
- Financing
  - Family had to pay 20% (½ before and ½ after) of construction ($250).
  - Must be used by families for minimum of 10 years. If not, must return 80% of funds to the agency.

Impacts

- Reduced Health Hazards
  - Average of 6 visits per year/ family to 2 visits per year/family
    - 400,000 deaths annually related to indoor air pollution in rural areas (WHO 2005)
- Reduced Fertilizer Use
  - 51% reduction of chemical fertilizer
    - 427 kg (940 lbs.) per year/ total households to 235 kg (518 lbs.) per year/total households.
- Reduce Firewood
  - 80 T (160,000 lbs.) of forest saved annually by 125 households annually.
    - Use of firewood dropped 1048 kg(2,310 lbs.)→410 (903 lbs.) kg annually/household
- Increase in social capital
  - 2.5 hours per day saved

Singh, H. K., & Sooch, S. S.(2004). Comparative study of economics of different models of family biogas plants for state of Punjab, India. *Energy Conversion and Management*, 45, 1329-1341.

- Economic comparison of KVIC, Janta, and Deenbandhu Models.
- Family size (1-6m^3)
- Market prices based in Punjab, India
  - Installation: Bricks, Cement, Sand, Pipe, etc.
  - Labor
- Subsidy: Rs. 1800 (2004)
- Ministry of New and Renewable Energy:
  - National Biogas and Manure Management programme (NBMMP) (2012): Rs. 8000 – 10,000 for 2-4 cm^3 plant.

Model Comparison

Table 10
Calculation of economics of KVIC model of biogas plant

Name of component	For biogas plant of capacity					
	1 m^3	2 m^3	3 m^3	4 m^3	5 m^3	6 m^3
1. Installation cost (Rs.) (Table 2)	10,558	13,135	15,722	17,935	19,798	21,653
2. Actual income (Rs.) (Table 9)	2506	5010	7515	10020	12525	15030
3. Annual operational cost (Table 6)	2110	3557	5008	6432	7814	9202
4. Annual profit (Rs.) (2–3)	396	1453	2507	3588	4711	5828
5. Payback period (years) (1÷4)	26.66	9.03	6.27	5.85	4.20	3.71

Source: Singh & Sooch, 2004

KVIC Model:
-Installation Cost: $260
-Income (Gas/Effluent): $100
-Operational Cost: $67
-Profit: $30

Table 11
Calculation of economics of Janta model of biogas plant

Name of component	For biogas plant of capacity					
	1 m^3	2 m^3	3 m^3	4 m^3	5 m^3	6 m^3
1. Installation cost (Rs.) (Table 3)	8132	11,050	14,136	17,296	18,858	20,270
2. Annual income (Rs.) (Table 9)	2506	5010	7515	10,020	12,525	15,030
3. Annual operational cost (Rs.) (Table 7)	1787	3205	4635	6069	7406	8735
4. Annual profit (Rs.) (2–3)	719	1805	2880	3951	5119	6295
5. Payback period (years) (1÷4)	11.31	6.12	4.90	4.37	3.68	3.22

Source: Singh & Sooch, 2004

Janta Model:
-Installation Cost: $221
-Income (Gas/Effluent): $100
-Operational Cost: $65
-Profit: $36

Table 12
Calculation of economics of Deenbandhu model of biogas plant

Name of component	For biogas plant of capacity					
	1 m^3	2 m^3	3 m^3	4 m^3	5 m^3	6 m^3
1. Installation cost (Rs.) (Table 4)	4367	5704	7302	8394	9888	11067
2. Actual income (Rs.) (Table 9)	2506	5010	7515	10,020	12,525	15,030
3. Annual operational cost (Rs.) (Table 8)	1577	2904	4245	5571	6905	8223
4. Annual profit (Rs.) (2–3)	929	2106	3270	4449	5620	6807
5. Payback period (years) (1÷4)	4.70	2.70	2.23	1.88	1.75	1.62

Source: Singh & Sooch, 2004

Deenbandhu Model:
-Installation: $114
-Income (Gas/Effluent):$100
-Operational Cost: $58
-Profit: $42

Barriers

- Chandrasekar, B., & Kandpal C. T. (2007). An opinion survey based assessment of renewable energy technology development in India. *Renewable & Sustainable Energy Reviews*, 11, 688-701.

Table 4a
Assessment of barriers affecting the promotion of some renewable energy technologies: biogas plants (family size)

Barriers	Responses in %				
	Extremely important	Very important	Important	Less important	Not important
Resource availability	58.0	20.4	13.0	7.2	1.4
Appropriateness of the technology	38.8	40.3	17.9	3.0	0.0
Financial and economic viability	17.4	13.0	52.2	10.2	7.2
Energetic feasibility	32.8	13.1	36.1	13.1	4.9
Socio-cultural acceptability	32.8	44.8	10.4	6.0	6.0
Environmental sustainability	50.8	27.7	12.3	7.7	1.5
Institutional preparedness	18.2	16.7	54.5	9.1	1.5
Awareness and user's training	35.3	38.2	23.5	1.5	1.5
Availability of after sales and services	42.6	26.5	14.7	14.7	1.5

Source: Chandrasekar & Kandpal, 2007

Method:
-Electronic Survey
-400 professionals
-25% response rate

- Ravindranath, H. N., & Balachandra P. (2009). Sustainable bioenergy for India: Technical, economic and policy analysis. *Energy*, 34, 1003-1013.
  - Limited capacity to assess, adopt, adapt and absorb technology options.
    - Lack of motivation and incentives
  - Access to Financing
    - Manufacturers and users
  - Difficulty in mainstreaming environment into development plans

Recommendations

- Multi-Stakeholder involvement
  - Cross-sector: Government, Nonprofit and Private sectors.
    - Ministry of New and Renewable Energy (NBMMP Program), Sadguru, KVIC, ARTI (Urban M.A.D), Biotech, Sintex, etc.
      - Increased private sector participation
- Participatory approaches to identify technology priorities
  - "Bottom-up"
    - Technology needs assessment: GHG mitigation, economic development, improved living standards, and access to quality energy.
    - Technology evaluation: diffusion potential, acceptability by the users, ability to meet development goals, commercialization possibilities, etc.
- Structured training programs
- Effective monitoring and evaluating systems
- Developing widespread information packages

Ravindranath, H. N., & Balachandra P. (2009). Sustainable bioenergy for India: Technical, economic and policy analysis. *Energy*, *34*, 1003-1013.

Thank You

Sources

- 1). Agoramoorthy, G.& Hsu J. M. (2008). Biogas plants ease stress in India's remote villages. *Human Ecology*, 26, 435-441.
- 2). Chandler, C. (2010). "One goes mad in India: a micro-adventure."
- 3). Chandrasekar, B., & Kandpal C. T. (2007). An opinion survery based assessment of renewable energy technology development in India. *Renewable & Sustainable Energy Reviews*, 11, 688-701.
- 4). Ravindranath, H. N., & Balachandra P. (2009). Sustainable bioenergy for India: Technical, economic and policy analysis. *Energy*, 34, 1003-1013.
- 5). Singth, H. K., & Sooch, S. S.(2004). Comparative study of economics of different models of family biogas plants for state of Punjab, India. *Energy Conversion and Management*, 45, 1329-1341.
- 6). WHO (2005). The world health report 2005: Make every mother and child count. WHO, Geneva.