

Anaerobic Digesters in India

V.V.N.Kishore¹ and D.C.Pant ²

¹TERI University

²The Energy and Resources Institute

Structure of presentation

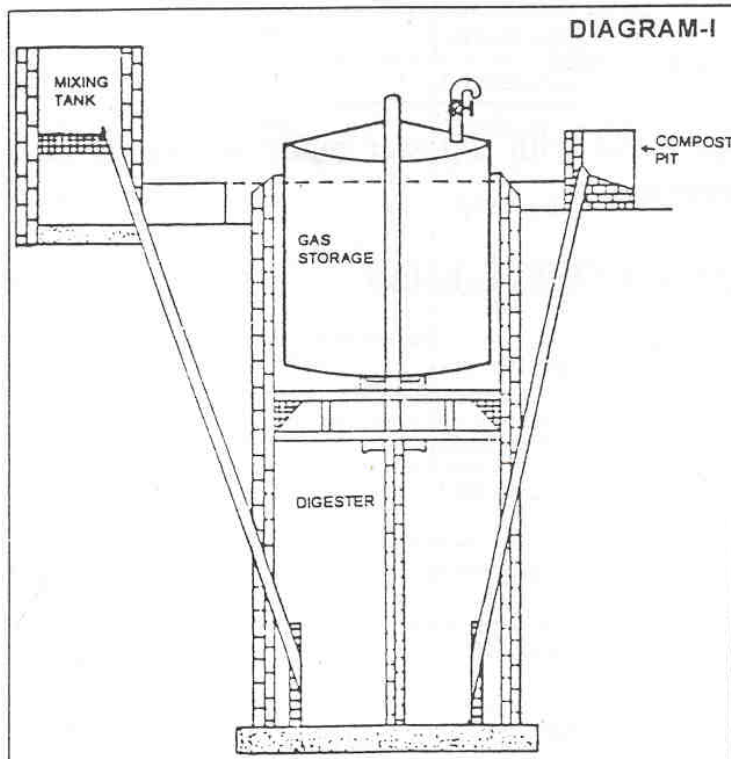
- Brief description of NPBD (National Program on Biogas Development)
- Recent non-NPBD projects
- Status of non-dung biomethanation

Potential and achievements of NPBD

- Potential: 289 million cattle, 12 million family size biogas plants
- Achievement: 4.17 million digesters
- Designs: KVIC model, Deenbandhu model etc.

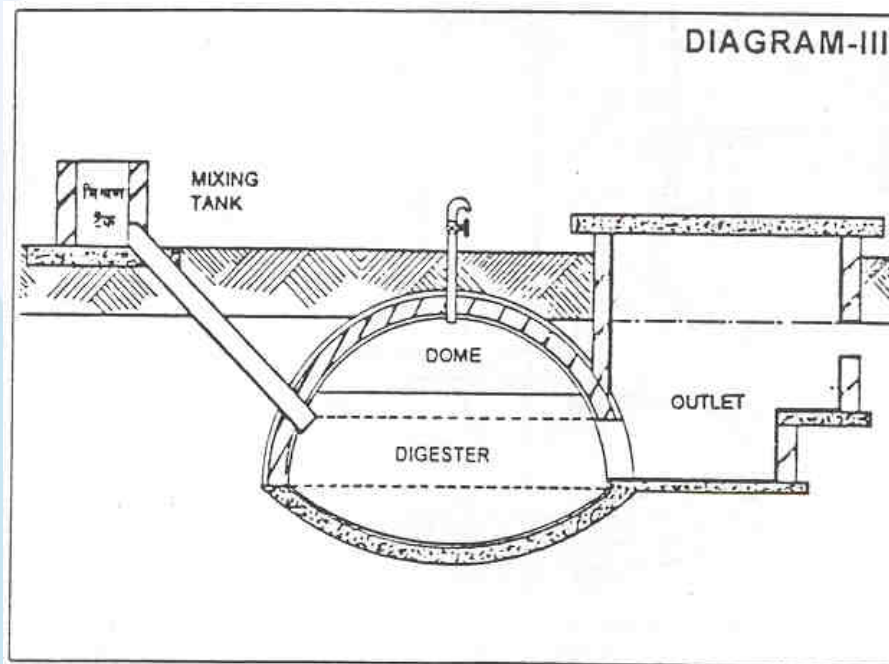
Floating gas holder type Biogas Plant (KVIC Model)

- KVIC model being disseminated since 1962
- Composite unit of a masonry digester and a metallic dome
- Maintenance of constant pressure by upward and downward movement



Deenbandhu Model

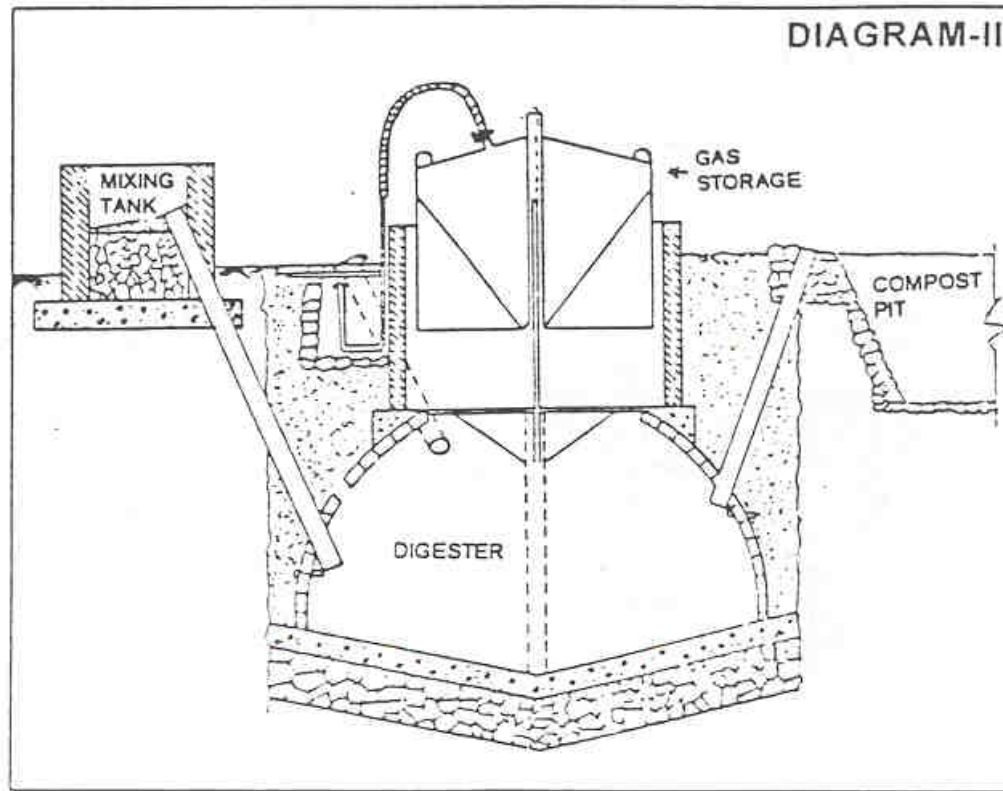
- Developed in early 80s
- Design consists of segments of two spheres of different diameters joined at their base
- Fluctuating gas pressure
- Lower cost compared to KVIC model



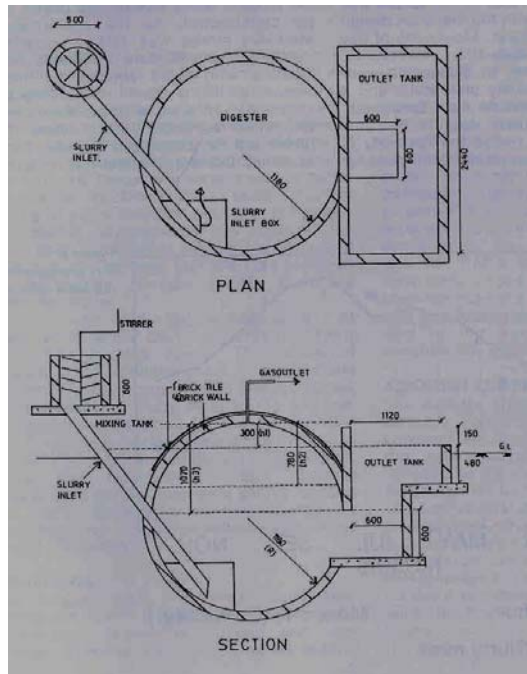
A Deenbandhu Biogas Plant at Deoli Village, Himachal Pradesh.

Pragati Model

- Combination of Deenbandhu and KVIC designs
- Lower part of the digester is semi spherical with conical bottom
- Floating drum acts as a gas storage



TERI's Mark-4 System



A view of the TERI's Mark – 4 biogas plant model

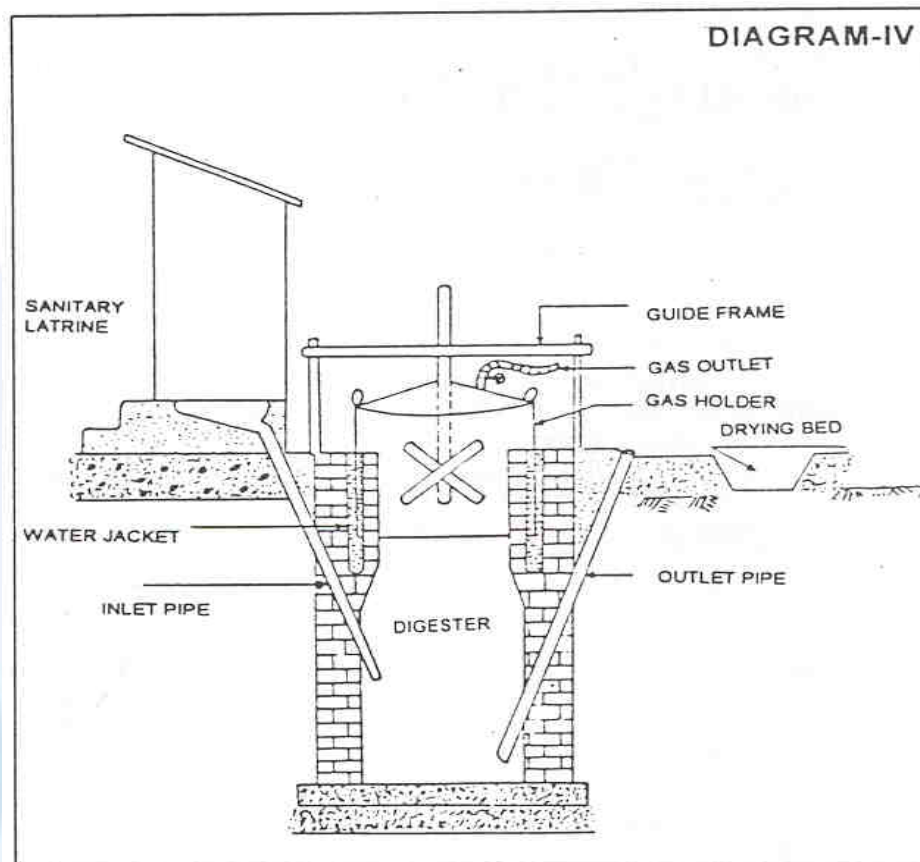
A schematic diagram of the TERI's Mark-4 Bio-gas plant

Features

- Completely Spherical in shape
- Reinforced dome with layers of Ferro-cement and tile bricks
- Slurry Inlet box to avoid short circuits
- Stirrer to have a homogenous mixture of slurry.
- 60% gas storage

Sanitary latrine with biogas plant

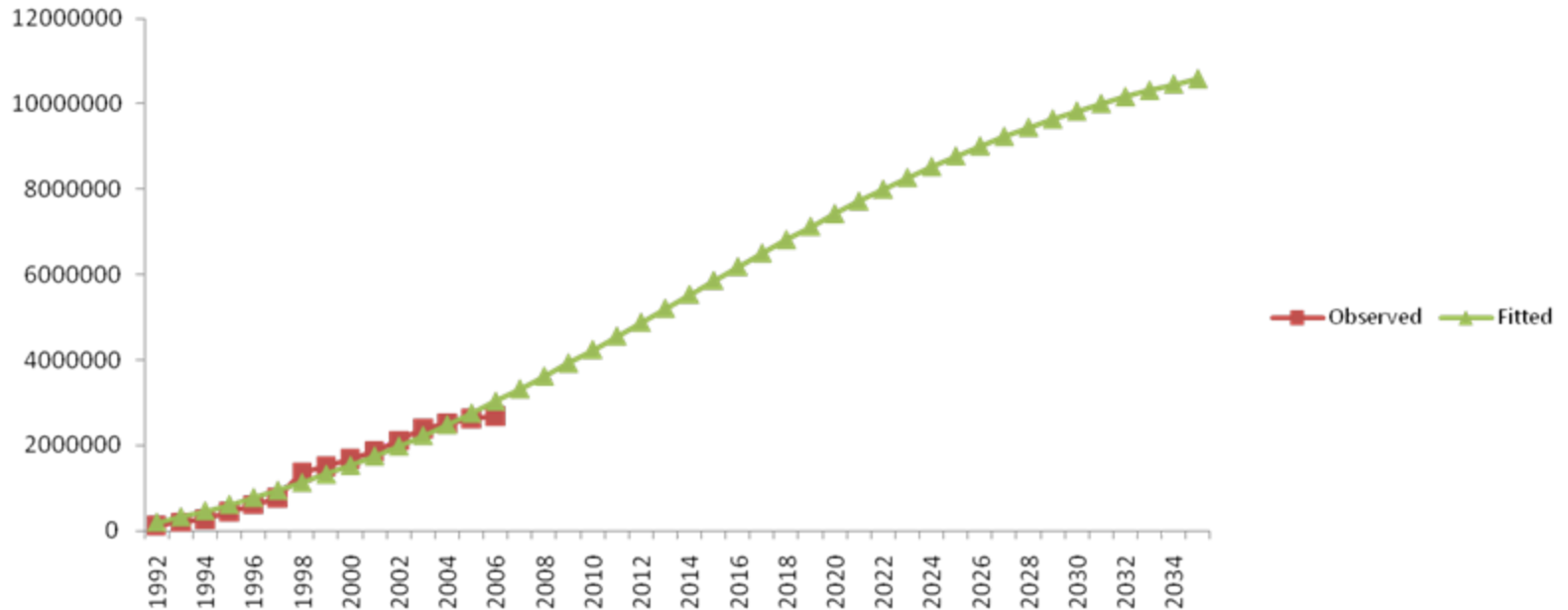
- Toilet linked biogas plants for conversion of night soil into biogas
- Popular in rural areas of some western districts
- Serves the purpose of sanitation and conversion of night soil into manure



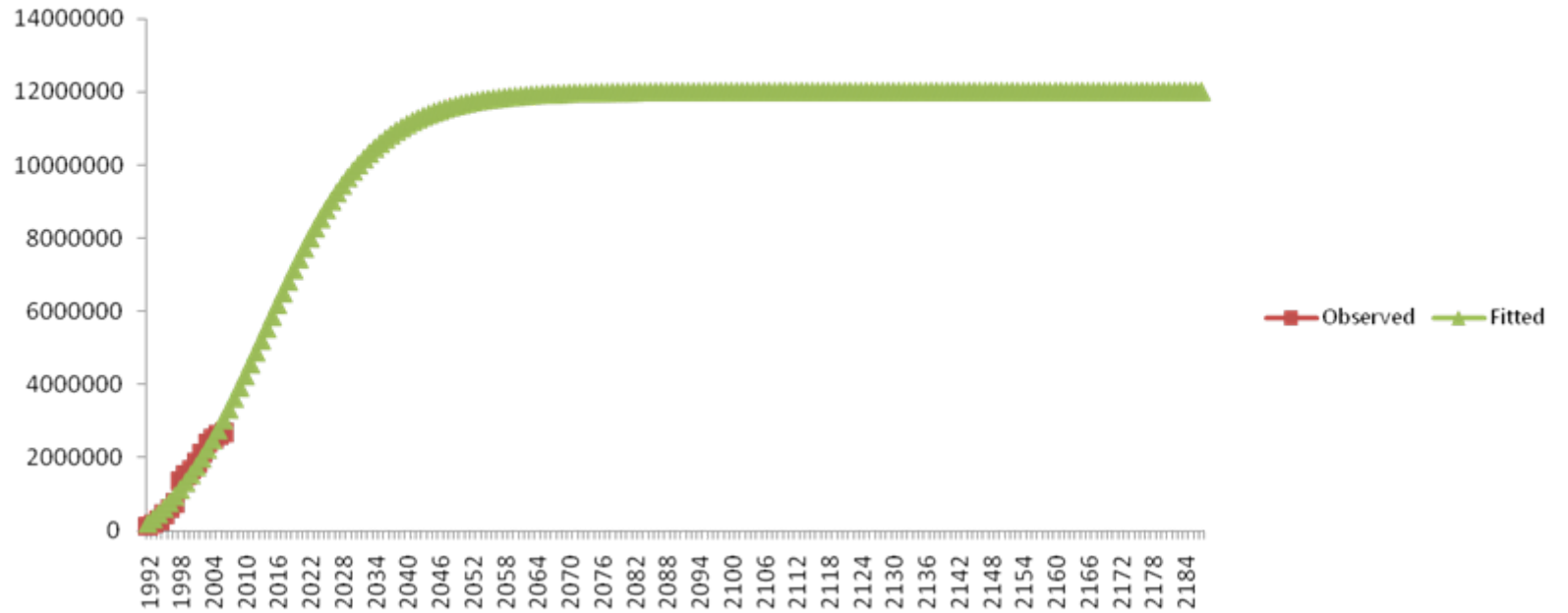
Diffusion rate of subsidy based programs is very slow

$$dN(t)/dt = [p + (q/m) N(t)] \times [m - N(t)]$$

Cumulative Biogas Plants Installations in India (in Nos.) Best Fit for $p=0.009$, $q=0.09$, $m=12000000$



Cumulative Biogas Plants Installations in India (in Nos.) Best Fit for $p=0.009$, $q=0.09$, $m=12000000$



Dairy farms

- Smaller farms with 10-100 cattle heads with traditional milking facility
- Location of dairy farms close to several modern milking parlor set – ups housing 1500 or 2000 cattle.
- The size and concentration of cattle in small and large ones has major environmental issues due to manure handling and disposal.



1.0 MW power project based on cattle dung at Haebowal Dairy Complex Ludhiana, Punjab



Potential of non-dung biomethanation

- Poultry wastes: ~3000 million cu.m biogas/yr
- MSW: 3670 MW
- Sewage: 390 MW
- Distillery effluents: 503 MW
- Milk processing: 70 MW
- Food processing
- Leather processing
- Rubber processing
- Slaughterhouse wastes
- Pulp and paper industry wastes
- Vegetable markets, kitchen and canteen wastes

Poultry in India

Total Poultry in India*						
States/UTs	Population (In ' 000)					
	Total Cocks	Total Hen	Total Chickens	Total Fowls	Total Duck etc	Total Poultry
India	58995	132225	206034	397254	31676	428929
Major contributors						
Andhra Pradesh	6319	34964	60702	101985	293	102278
West Bengal	7514	17618	18568	43700	16955	60656
Tamil Nadu*	3992	7322	24478	35792	719	36511
Maharashtra*	4834	13509	16321	34663	74	34737
Karnataka	2411	10050	13114	25576	17	25593
Orissa	2361	4757	9767	16886	724	17610
Kerala	1951	6143	5178	13272	1788	15059
Jharkhand	2540	3954	6717	13211	962	14173
Haryana	531	6330	6748	13610	9	13619
Uttar Pradesh*	3042	4017	4472	11531	438	11969
Madhya Pradesh	1997	3757	5924	11677	28	11705
Punjab	638	2719	7415	10773	6	10779

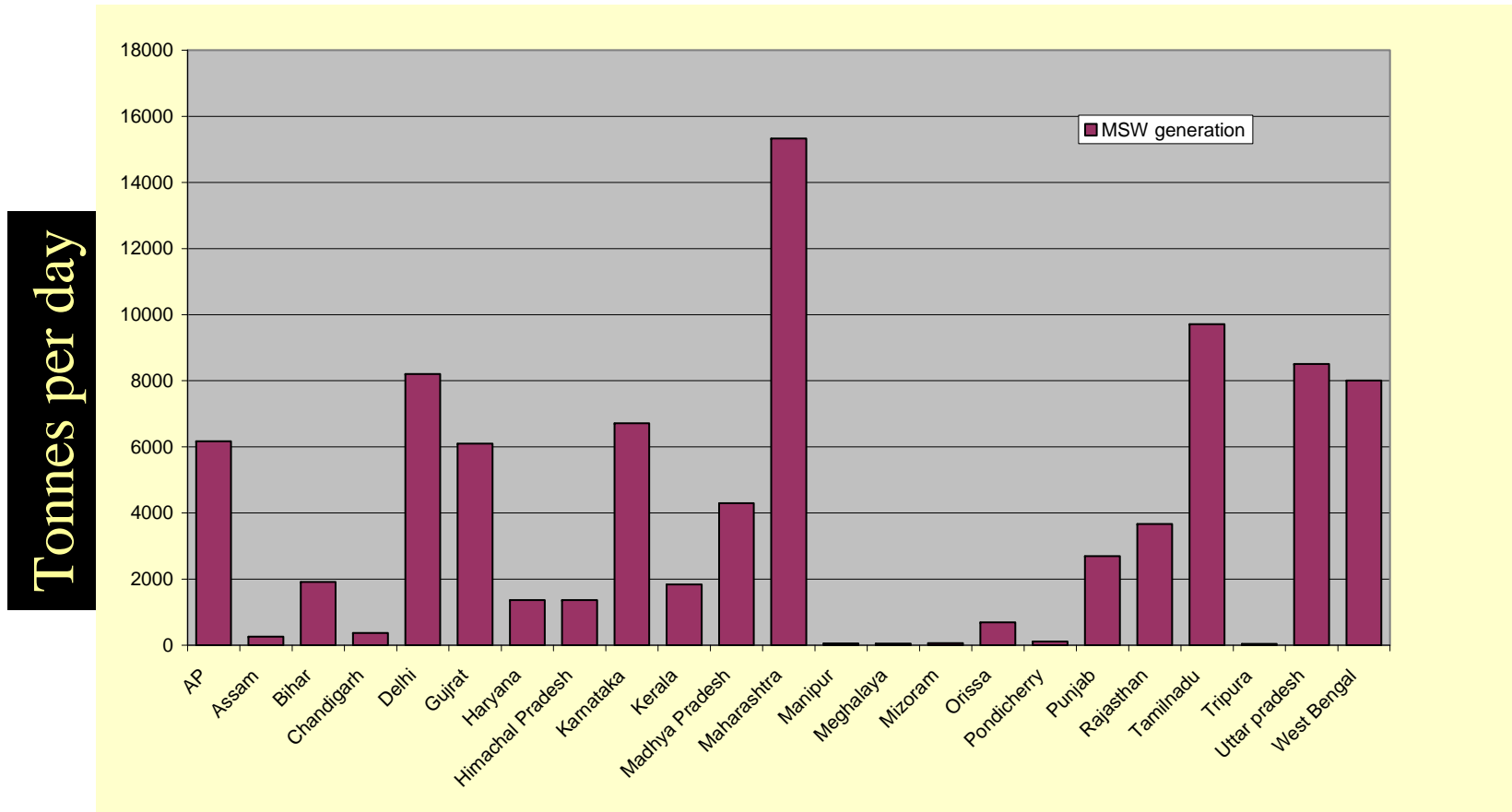
Poultry litter based biogas plants

- 1.55 and 2.5 MW project based on poultry litter at Namakkal District in Tamilnadu (registered as CDM project, not fully functional)
- DPR prepared for a 6 MW project in Panchkula, Haryana

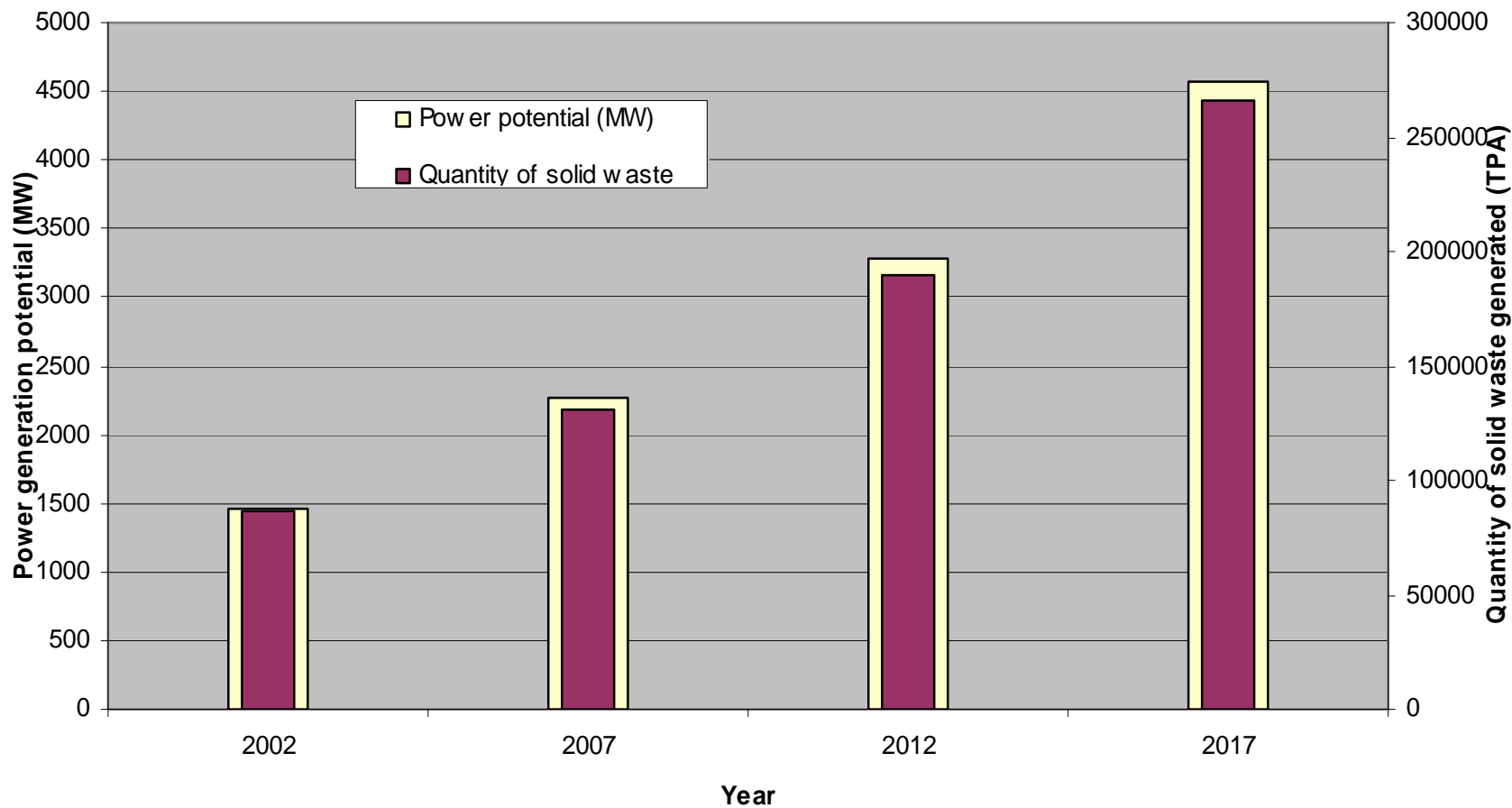
Municipal Solid Waste

- Significant potential for methane recovery
- Large scale projects feasible for power generation with CDM benefits

Daily waste generation



Projected power generation potential



Projects Installed for Energy from Urban Wastes

- 6.6 MW project based on MSW at Hyderabad
- 6 MW project based on MSW at Vijayawada
- 5 MW project based on MSW at Lucknow

Biomethanation plant in Lucknow using BIMA technology,
5 MW design capacity, 500 TPD MSW



Distillery effluents

- About 150 biomethanation units using biogas generated from distillery effluents for heat and power applications
- Mostly UASB technology used for biomethanation

Other biomethane projects in India

- Palm oil industry waste (3 MW)
- Vegetable market waste (0.3 MW)
- Slaughterhouse wastes (0.5 MW)
- Tannery fleshings and sludge (0.03 MW)
- Miscellaneous wastes

**State-wise list of completed
Industrial Waste-to-Energy
Projects up to 31.03.2009**

Andhra Pradesh

1	Industrial waste based power generation project at Gowthami Oil Solvents Ltd., Tanuku, A.P.	2.75 MW	1996-97
2	Biogas plant based on Starch Industry Wastes at Vensa Biotek, Samalkot, A.P.	0.70 MWeq	1999-2000
3	Biogas generation project based on liquid abattoir waste at M/s Alkabeer Exports Ltd., Medak, A.P.	0.25 MWeq	1997-98
4	Biogas generation project based on slaughter house solid waste at Al-kabeer Exports, Medak, A.P.	0.25 MW eq	2001-2002
5	Power generation from Starch industry solid waste at M/s Vensa Biotek Ltd., E.G. District, Samalkot, A.P.	4.00 MW	2003-2004
6	Palm oil industry waste based power generation project by Sai Renewables (P) Ltd. at Kamavarakupota, West Godavari District. A.P.	3.00 MW	2004-05
7	Biogas based power generation project by M/s Sri Sarvaraya Sugars Ltd. at Chelluru Village, East Godavari Distt., A.P.	1.00 MW	2006-07
8	Biogas based power generation project by M/s Jeypore Sugar Company Ltd., Chagallu Village, West Godavari Distt., A.P.	1.00 MW	2006-07
9	Biogas based power generation project by M/s Tern Distilleries (P) Ltd., Tallapalam Village, Visakhapatnam, A.P.	0.75 MW	2006-07
10	Oil Extraction Industry waste based power generation project by M/s Food Fats and Fertilizer Ltd. Tadepalligudem, Vest Godavari Dist. A.P.	6.00 MW	2006-07
11	Poultry litter based power generation project by M/s SLT Power & Infrastructure Projects Pvt. Ltd., PochamPally Village & Mandal, Nalgonda Distt., A. P.	3.50 MW	2007-08
12	Poultry litter based power generation project by M/s Raus Power Ltd., Dupalapudi, East Godavari Distt., A. P.	3.66 MW	2008-09

Gujarat			
	Biogas based power project at Kanoria Chemicals & Industries Ltd., Ankleshwar, Gujarat	2.00 MW	1998-99
	Biomethanation plant based on starch industry waste at Anil Starch, Ahmedabad, Gujarat.	0.45 MWeq (4800 m ³ biogas/day)	2001-2002
	Starch industry waste based biomethanation project by M/s Riddhi Siddhi Gluco Biols, Ltd., Riddhi Siddhi Nagar, Village – Juna Paddaar, Becharjee Road, Virmgam, Distt. Ahmedabad, Gujarat	0.458 MWeq. (5500 m ³ biogas/day)	2007-08
	Starch industry waste based biogas to power (through 100% biogas engine) project by M/s Sayaji Industry Ltd., Ahmedabad, Gujarat	1.00 MW	2008-09
Karnataka			
	Biogas based power project at Ugar Sugar Works, Belgaum, Karnataka	1.00 MW	1999-2000
	Starch industry waste based biomethanation project by M/s Riddhi Siddhi Gluco Boils Pvt. Ltd., Gokak, Karnataka	2.00 MWeq. (24000m ³ biogas/day)	2007-08
	Starch industry waste based biomethanation project by M/s Riddhi Siddhi Gluco Boils Pvt. Ltd., Gokak, Karnataka	1.00 MWeq. (12000m ³ biogas/day)	2008-09

Madhya Pradesh		
Biogas based power project at Som Distilleries Ltd., Raisen, M.P.	2.7 MW	1999-2000
Biogas generation project for leather solid waste (chrome shavings) at Tata International Ltd., Dewas, MP.	0.025 MWeq (300 m ³ biogas/day)	2002-2003
Tannery liquid waste based biomethanation project by M/s Bhopal Gelatines Pvt. Ltd., Jinsi, Bhopal	0.08 MWeq (988 m ³ biogas/day)	2008-09
Maharashtra		
Biogas based Power Generation Project at Brihan Sugar Syndicate Ltd., Sheerpur, Dist. Solapur, Maharashtra	1.00 MW	2000-2001
Biogas generation project at Universal Starch-Chem Ltd., Dhule, Maharashtra	0.90 MWeq. (10,000 cum biogas per day)	2001-2002
Seafood industry waste based biomethanation project by M/s Gadre Marine Export Pvt. Ltd., Ratnagiri, Maharashtra	0.86 MWeq. (10000 m ³ biogas/day)	2006-07
Food Processing Industry Liquid waste based biomethanation project by M/s Saf Yeast Co. Pvt. Ltd., Ratnagiri, Maharashtra,	0.36 MWeq. (4410 m ³ biogas/day)	2008-09
Biogas based power project with 100% biogas engine by M/s Tilak Nagar Distilleries, Ahmednagar	0.694 MW	2008-09

Punjab

Biogas generation project for Paper Mill black liquor at Satia Paper Mills, Muktsar, Punjab	0.75 MWeq (10000 cum. Biogas/ day)	1997-98
Paper industry liquid waste based biomethanation project by M/s Shreyans Industry Ltd., Sangrur, Punjab	0.375 MWeq. (4500 m ³ biogas/day)	2006-07
Starch industry waste based biomethanation project by M/s Sukhjit Starch & Chemicals Ltd., Phagwara, Punjab	0.458 MWeq (5500 m ³ biogas/ day)	2006-07
Biogas waste based power project by M/s Chandigarh Distillers and Bottlers Ltd., Banur, Dist. Patiala, Punjab	8.25 MW	2007-08

Tamil Nadu			
	Power generation project based on biogas from Sago Industry Waste at Varalakshmi Starch Industry Ltd., Salem, Tamilnadu	0.20 MW	2001-2002
	Biogas generation project using tannery fleshings and sludge at Melvisaram, Tamilnadu	0.03 MWeq (300 m ³ biogas/day)	1999-2000
	Biogas generation project for tapioca processing industry waste water at Varalaxmi Starch Industry Ltd, Salem, TN.	0.50 MWeq (6000 m ³ biogas/day)	2002-2003
	Biogas generation project for paper mill effluents at Tamil Nadu Newsprints and Papers Ltd., Karur, TN	1.25 MWeq (15000 m ³ biogas/day)	2002-2003
	Power generation from poultry droppings by M/s G.K. Bio-energy Pvt. Ltd., Namakkal, T.N.	1.50 MW	2005-06
	Poultry litter based power generation project by M/s Subhashri Bio-energies Pvt. Ltd. Namakkal, T.N.	2.50 MW	2006-07
	Starch industry waste based biomethanation project by M/s Varalakshmi Starch Industries Pvt. Ltd., Salem, T.N.	1.00 MWeq. (12000 biogas m ³ / day)	2006-07
	Biogas based power project with 100% biogas engine by M/s Trichi Distillers & Chemicals Ltd., Senthannipuram, Tiruchirapalli	1.40 MW	2008-09
	Starch Industry Liquid waste based biomethanation project by M/s Varalakshmi Co., Mallur, Salem, Distt. Namakkal	0.75 MWeq (9,000 m ³ biogas /day)	2008-09
	Tapioca Starch Industry Liquid waste based biomethanation project by M/s Spac Tapioca Products (India) Ltd., Poonachi Bhavani TK , Erode, Tamilnadu	1.00 MWeq (12,000 m ³ biogas /day)	2008-09

Uttar Pradesh		
Biogas based power project at K.M. Sugar Mills at Faizabad, U.P.	1.00 MW	1997-98
Biogas based power generation project at Saraya Distilleries, Gorakhpur, U.P.	2.00 MW	2002-2003
Biogas based power generation project by M/s Pilkhani Distillery & Chemical Works, Pilkhani, Saharanpur Distt., U.P.	1.00 MW	2006-07
Biogas based power generation project by M/s Shamli Distillery & Chemical Works, Shamli, Muzaffarnagar Distt., U.P.	1.00 MW	2006-07
Food industry waste based biomethanation project by M/s Saf Yeast Co. Pvt. Ltd., 101, UPSIDC, Industrial Area, Sandila, Distt. Hardoi, U.P.	0.73 MWeq. (8820 m ³ biogas/day)	2006-07
Uttarakhand		
Starch industry liuquid waste based biomethanation project by M/s Riddhi Siddhi Gluco Biols, Udham Singh Nagar, Uttarakhand	1.52 MWeq (18,300 m ³ biogas/day)	2007-08
Starch Industry Liquid waste based biomethanation project by M/s Gujarat Ambuja Exports Ltd., Udham Singh Nagar	1.08 MWeq (12,960 m ³ biogas /day)	2008-09

150 kW Power Project Utilizing Vegetable Market and slaughterhouse Wastes at Vijayawada, A.P.



3000 cum biomethanation project for solid waste at Slaughterhouse in Andhra Pradesh



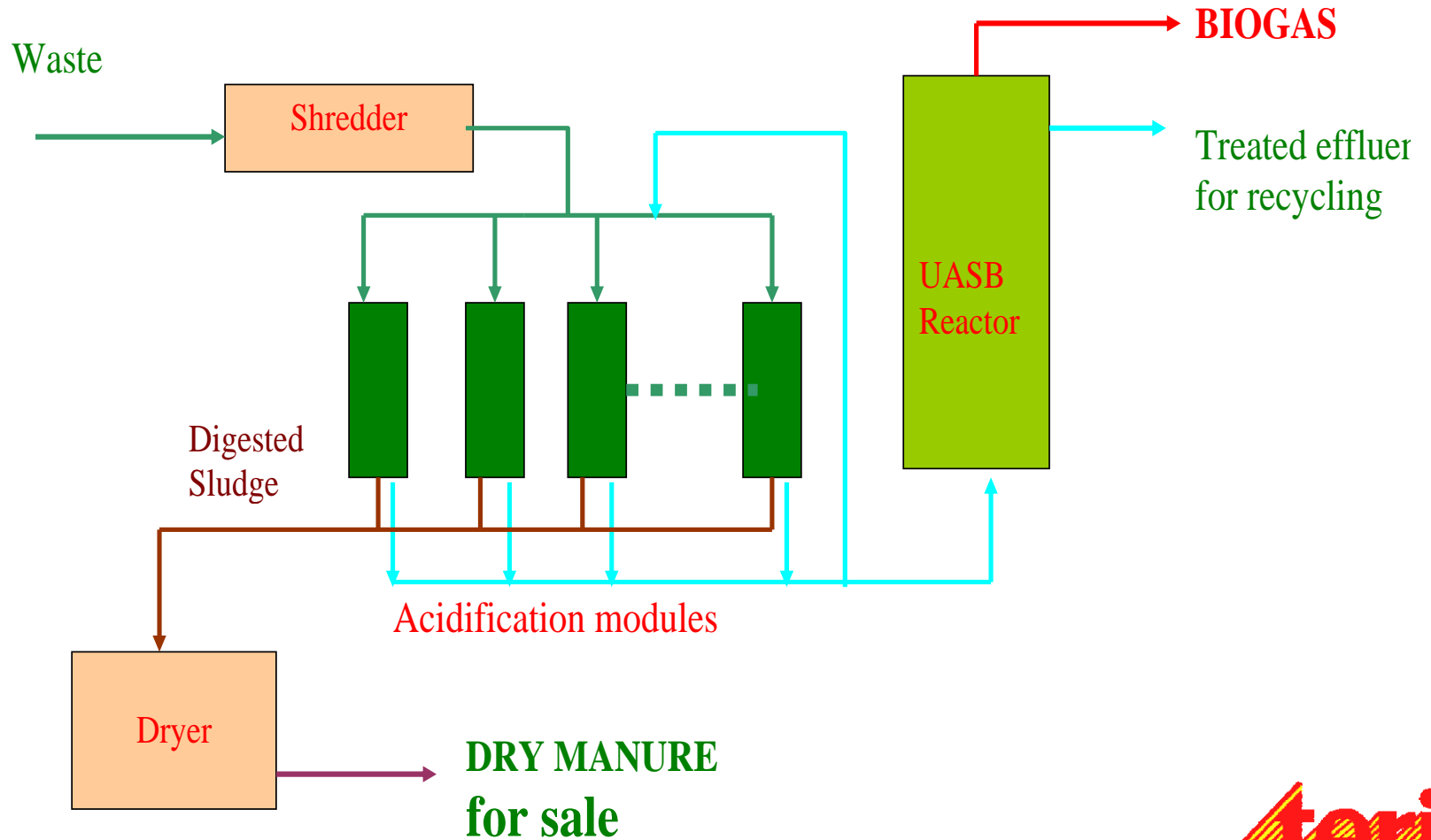
TERI's Enhanced Acidification & Methanation (TEAM) Process

- Bi-phasic reactor
 - Acidification
 - The organics from solid waste are extracted in the form of leachate (liquid form) by the action of hydrolytic and acidogenic microbes
 - Digested slurry is rich in available nutrients which is dried and used as manure
 - Methanation
 - The extracted organics (leachate) are treated in a high rate upflow anaerobic sludge blanket reactor to form biogas (composed of methane and carbon dioxide) by the action of acetogens and methanogens

Features of TEAM

- Elimination of Scum formation - a feature in small size plants.
- Proven performance of pilot plant since Jan. 1999.
- Low capital cost compared to imported design
- Energy and enriched manure
- Suitability for small and decentralized application
- Very low water requirement due to recycling
- Low maintenance cost
- Ease in material handling
- Process suitable for adaptation by small entrepreneurs and hence market potential is high

Schematic diagram of TEAM



Salient features of TEAM process

Acidification

- 6 reactors for extraction of organics
- Volatile fatty acids
- HRT of 6 days
- Digested waste is a very good manure

Methanation

- High rate methanation reactor- UASB
- HRT-16 h and COD reduction- 90%
- Treatment of high strength leachate to produce biogas (70-75%)
- Granules of 5 mm and SVI of 5 ml/g

TEAM Process (acidification)

Startup of acidification process



Drying of digested sludge for manure production

TEAM process (methanation)



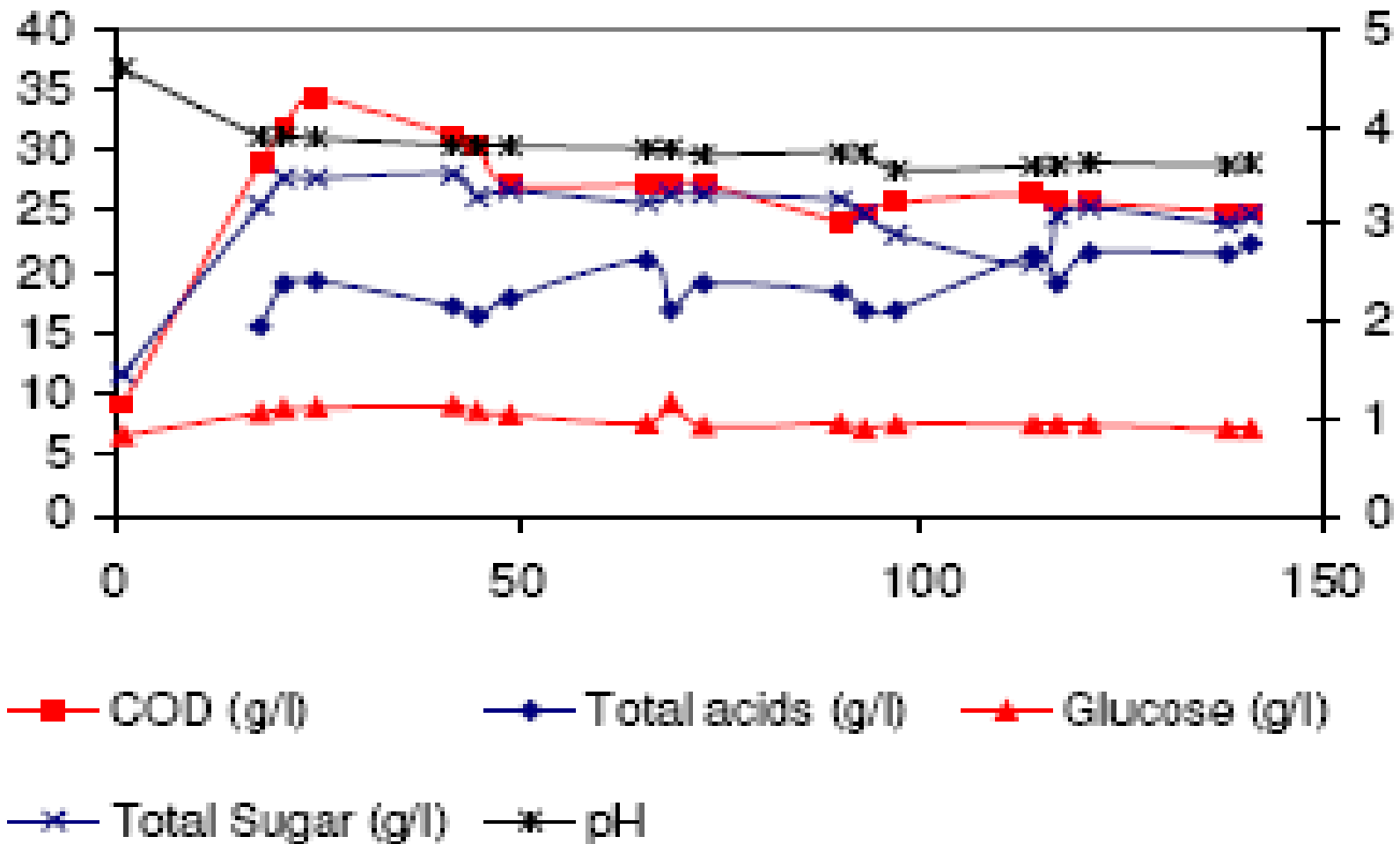
Granules



Microscopic view

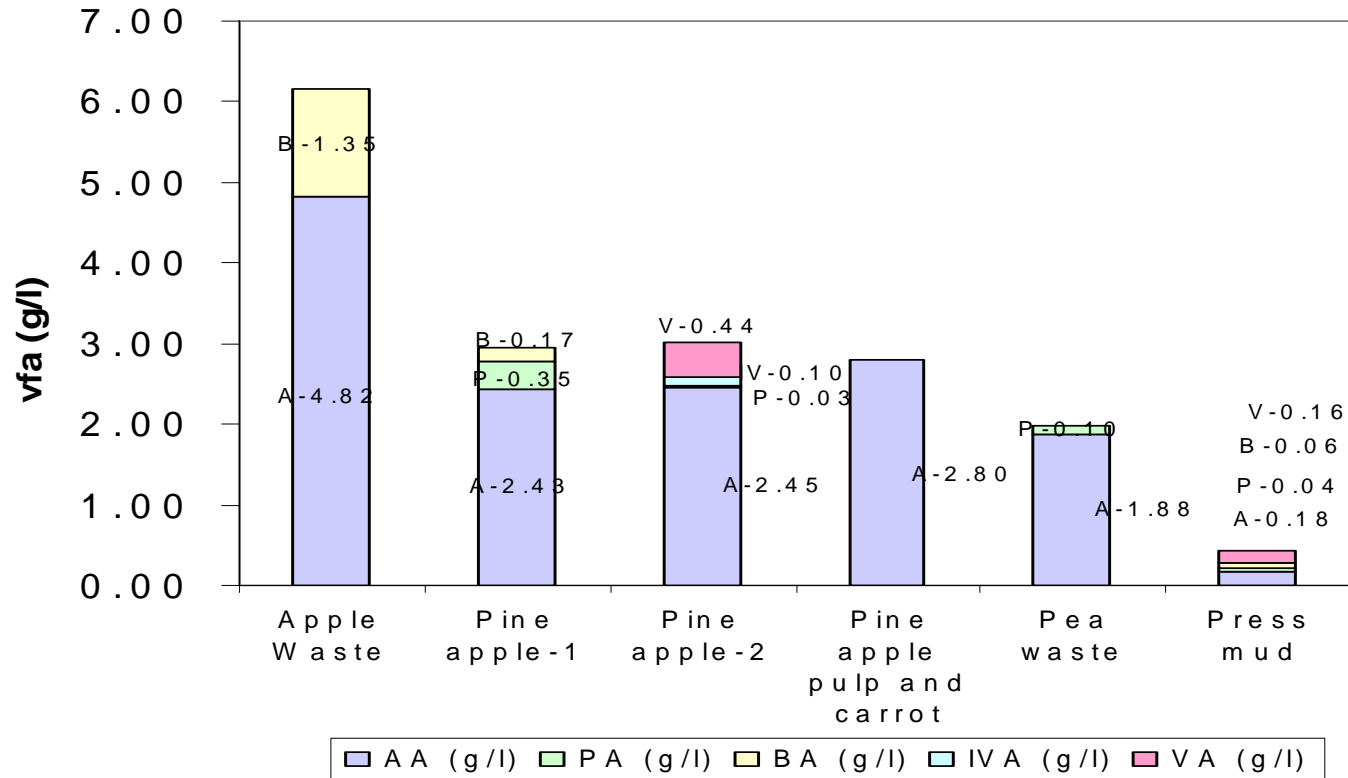


Acidification of Mixed waste



Acids production during digestion

Food waste; COD.....45 gm/l. Total VFA concentration...12 gm/l



Product potential

Type of waste	Biogas (m ³ /t)	Manure value		
		N	P	K
Apple waste	32.4	0.9	0.04	0.43
Pineapple	13.77	0.33	0.06	0.51
Pressmud	8.9	0.61	0.60	0.37
Vegetable waste	20	2.1	1.6	2.4
Mixed waste	20.25	1.2	0.07	0.63
Coffee pulp	10	1.8	0.1	3
Food waste	54	0.5	0.1	0.3
Tapioca	6.1	2.3	0.02	0.34

Plant at Sona Steering Ltd., Gurgaon



Biomethanation plant at NTPC township



Modified digester for rural applications

- Non-suitability of high rate biomethanation system for rural areas
- Application of the system to mix of biomass residues and cow dung
- Integration of the hydrolysis and acidification reactors with conventional biogas digester (KVIC)
- 20 m³ plant in two villages



Modified hybrid biodigester

- 4 modules of 5 m³ capacity
- Feed is high strength liquid extract from acidification phase
- Plastic filter media with high surface area enhances the digestion efficiency



Support for AD in India

Financial and fiscal support available, e.g., subsidy

- (capital / interest), tax and duty exemptions, CDM etc

Financial support from MNRE

- **Small biogas plant (1 cum to 6 cum)**
 - Rs 2100 to Rs 11,700 per plant depending on geographical location
- **Toilet linked biogas plant**
 - Additional amount of Rs 500 per plant to above cost.
- **Sewage treatment plant**
 - 40% of project cost subject to max of Rs 2,00,00,000
- **Large plant (Biomethanation of urban wastes)**
 - For thermal use: Rs 1,00,00,000 per MWeq (i.e. for 12000 cum of biogas).
 - For power generation: 50% of project cost subject to max of Rs 3,00,00,000
- **Biogas bottling plant**
 - 50% subsidy on project cost (gas enrichment equipment and compresor)
- **Power generation based on high rate biomethanation technology**
 - Rs 2,00,00,000/MW
- **Preparation of DPR**
 - Rs 1,00,000
- **Training program**

Loan facility:

NABARD

- IREDA
- KVIC

Other initiatives

- Financial incentives
 - Ministry of non-conventional energy sources
 - Capital subsidy
 - Interest subsidy
 - Indian Renewable Energy Development Agency and state nodal agencies
- Legislations
 - Ministry of Environment and Forests (Solid wastes management and handling rules), 2000
 - Biodegradable wastes for generation of useful resources
 - Landfill sites for inert wastes
- Public private partnerships
 - Municipal corporations (Delhi, Surat, Ahmedabad)
 - Schemes initiated for collection and segregation of biodegradable and non biodegradable waste at source involving cooperation of the residents and private institutions

THANK YOU

