Prospects & Developments of Small Scale Biogas Upgrading & Bottling in India

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BIOGAS

- Energy source produced from biodegradable /organic wastes by anaerobic digestion process
- Possible feedstock material: All good biodegradable organic materials

✓ Manure (liquid & solid)

✓ Organic waste (Household waste, restaurant waste, food industry waste, etc.)

✓ Energy crops (silage of maize, grass, corn, etc.)

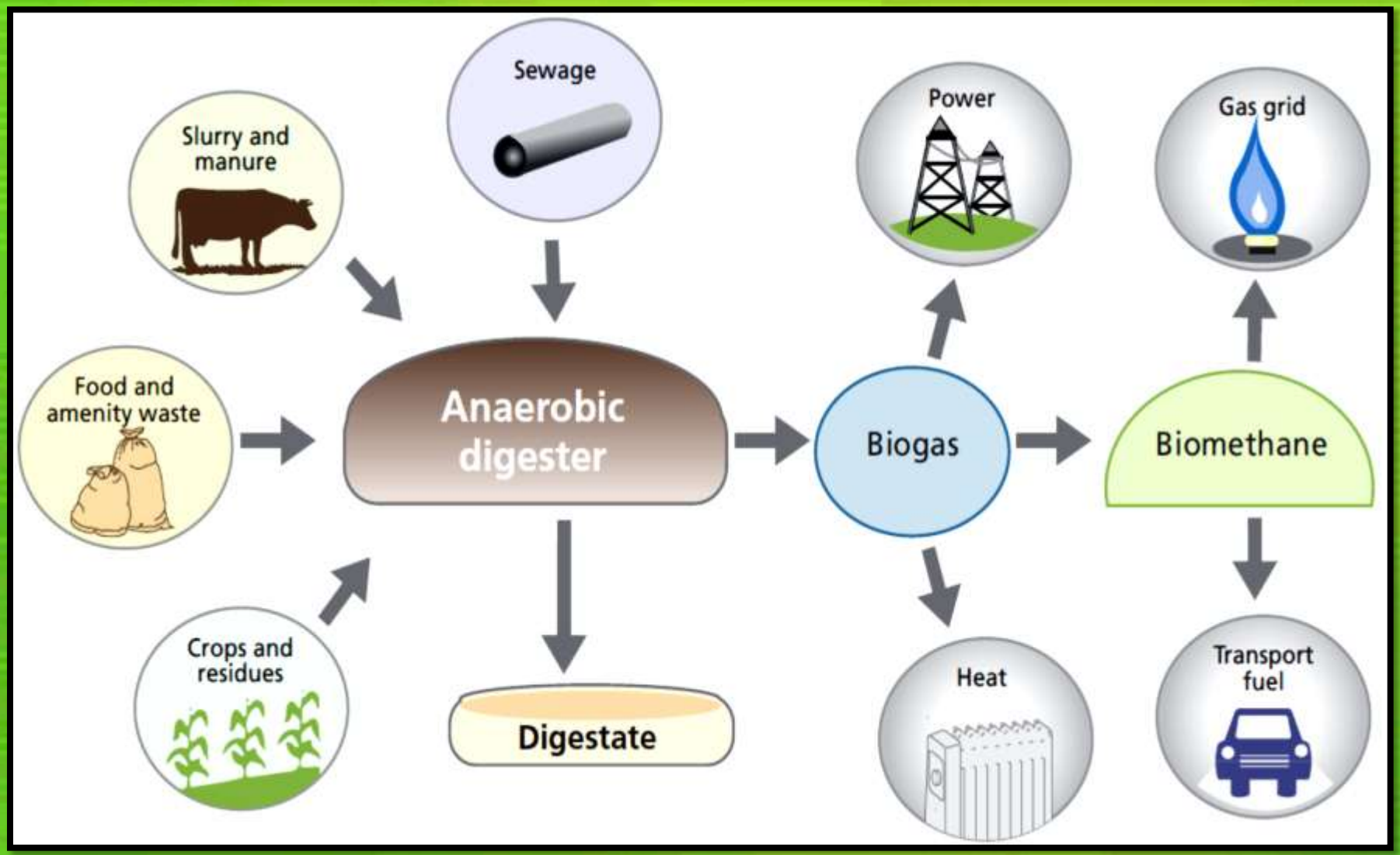
- Digested slurry - can be dried and sold as high quality compost.
- Biogas belongs to the same gas-family as natural gas
- After upgrading biogas, calorific value and density are almost similar to natural gas
- Biogas can be adapted to the quality of natural gas

Composition of Raw Biogas

Compound	%
Methane CH_4	55–65
Carbon dioxide CO_2	35–45
Nitrogen N_2	0–10
Hydrogen H_2	0–1
Hydrogen Sulfide H_2S	0–3
Moisture	Saturated

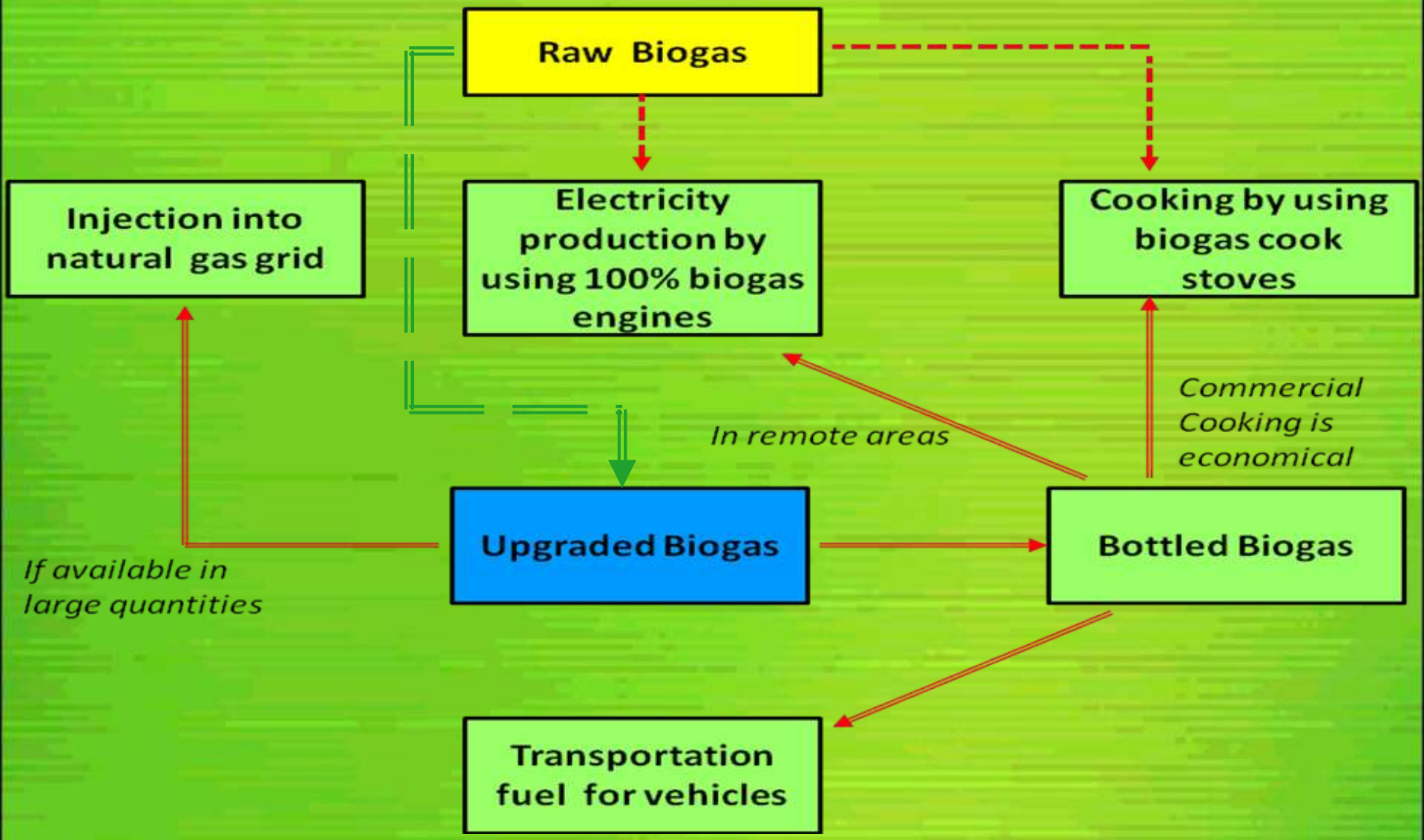
Average calorific value of biogas is 20 MJ/m^3 (4713 $kcal/m^3$)

BIOGAS PRODUCTION AND UTILIZATION



(Source: OFGEM, 2011)

VERSATILITY OF BIOGAS USE



Upgrading widens the scope of utilization

Resource Availability for Small Scale Biogas Upgrading in India

- Medium and small size biogas plants can be built due to the availability of widespread organic waste

- Animal / agro waste, human waste, wastes from agro-based industries (paper and pulp production, sugarcane processing, distilleries, and other food and food-processing industries

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Medium size biogas plants	biogas plants in urban localities
Dairies, cattle sheds, poultry farms, piggery farms and animal rearing farms, fruit and vegetable market waste, water borne biomass such as water hyacinth, algae and variety of such agro wastes.	Biogas Plants intended to recycle the biodegradable MSW, sewage waste water, food waste etc of communities and centralised human habitats as hostels, restaurants, military barracks, hotels, community toilets, etc.

Feedstock Availability and potential of medium – community scale biogas plants in *Rural Areas*

DECENTRALSED Biogas Production

- **Cattle Waste** - From about 304 million cattle till 2012 - an estimated potential of about 18,240 M m3 of biogas annually.

- **Poultry Waste** - There are large number of poultry farms and about 10 major poultry processing plants and can generate 2173 M m3 biogas annually with 649 million numbers of birds

- **Crop/ agricultural residue** – Some is used as fodder to feed animals or fire wood. The remaining biomass may be available for bioenergy generation and is estimated as 278.71 million tonnes annually. The biogas potential for the crop residue and agricultural waste is estimated as 45.8 million cubic meter of biogas generation annually.

Feedstock Availability and potential of medium – community scale biogas plants in Urban Areas

- *Vegetable Market Waste* (Mandi waste)
- *Food waste/ Canteen Waste*
- *Human Waste/ Community Toilets*
- *Municipal Waste (Housing Societies)*

Potential for Small-Scale Upgraded Biogas Storage, Bottling & Distribution in Developing Economies

Type of Biogas Plants	Range of Biogas Plant Capacity/Size (Assumption)	Viability of Biogas Upgrading and Bottling
Medium size biogas plants	85 - 600 Nm^3 day^{-1} for dairies, vegetable markets, poultry farms etc.	• On-site small-scale biogas upgrading and bottling and hence captive utilisation of biogas as vehicle fuel. • Collection and transportation in pressurised tankers to centralised upgrading and bottling station. • Distribution of bottled gas to far off places or filling stations for vehicle fuel applications.
Community size biogas plants	85 - 600 Nm^3 day^{-1} Hostels, restaurants, military barracks, hotels, community toilets.	• On-site small-scale biogas upgrading and bottling and hence captive utilisation of biogas as vehicle fuel. • Commercial selling of bottle biogas for cooking or transport. • Collection and transportation in pressurised tankers to centralised upgrading and bottling station. • Distribution of bottled gas to far off places or filling stations for vehicle fuel applications.

Raw Biogas ⟶ Upgraded Biogas

- **A low Grade fuel** (CH_4 55-65 % & CO_2 35-45 %) with lower percentage of methane.
- **Mode of utilisation**
  - On site or nearby
  - Cooking and for electricity production.
  - **The presence of CO_2 besides being non combustible, restrains its compressibility there by making biogas difficult to be stored in containers.**
  - For utilisation at far off places it must be stored in biogas balloons and taken to the site of utilisation or it can be transported by pipelines.

- **A high grade fuel** (CH4 > 90 % and < 10 % other gases) with high percentage of methane.
- **Mode of utilisation**
  - Remote applications
  - Methane burns faster hence yields a higher specific output and thermal efficiency compared to raw biogas when used as engine fuel.
  - Upgrading , compression and bottling facilitates easy storage and transportation as
    - As a vehicle fuel
    - As a cooking fuel
    - For electricity production

Utilization of Raw Biogas

Pipeline for raw biogas use as a cooking fuel

Raw biogas cookstove

Biogas lamp

Biogas Engine for electricity production

Prospects of Biogas Bottling in India

- Commercial Cooking as a replacement of LPG
- Electricity / Power production-in remote areas through biogas engines
- Upgraded –Bottled Biogas for vehicular use - BioCNG

Utilization of Upgraded Biogas

Upgraded and bottled biogas for use as a cooking fuel

Cascades of Upgraded biogas being transported

Biogas Motorcycle in Thailand

Biogas car in Sweden

Biogas Train in Sweden

Biogas Car in India

Characteristic Comparison of Natural gas, Upgraded Biogas and Raw Biogas

Properties	Compressed Natural Gas	Upgraded Biogas	Raw Biogas
Composition % (v/v)	CH_4 – 89.14% CO_2 – 4.38% H_2 – .01% N_2 – .11% C_2H_6 – 4.05% C_3H_8 – 0.83% Iso-C_4H_{10} – 0.28% Neo-C_4H_{10} – 0.66% Iso-C_5H_{12} – 0.09% Neo-C_5H_{12} – 0.28% C_6H_{14} -0.17%	CH_4 – 93% CO_2 – 4% H_2 – .06% N_2 – 2.94 % H_2S – 20 ppm	CH_4 – 55- 65% CO_2 – 35-45% H_2 – .02% N_2 – 1.98% H_2S – 500 ppm
Lower Heating Value	44.39 MJ/kg	42.62 MJ/kg	20.5 MJ/kg
Relative Density	0.765	0.714	1.014
Flame speed (cm/sec)	34	–	25
Stoichiometric A/F (kg of Air/ kg of Fuel)	17.03	17.16	17.16
Auto-ignition Temperature (^{0}C)	540	–	650

Adaptability Scenario of Bottled Biogas in Natural Gas Infrastructure & Network in India

Availability of

- Natural Gas Vehicles
- Natural Gas Grid Availability in some urban areas
- CNG conversion kits availability
- Interchangeability/ use of Technologies/ equipments available for CNG
  - *Upgrading Units*
  - *High Pressure Compressors*
  - *Gas Storage and Distribution Units(CNG Cylinders/Dispensing Units etc)*

Feasible Scenarios for the Adoption of Bottled Biogas in India

Captive/ In-house Use

- *Biogas upgrading and bottling in rural areas (Cattle sheds)*
- *Biogas upgrading and bottling in communities like hostels, fruit and vegetable market, marriage halls, community toilets.*
- *Biogas upgrading and bottling in urban areas serving housing societies/ housing clusters (WWTP, Sewage Treatment Plants, medium scale biogas production)*

Selling of Bottled Biogas as a Fuel

- *Biogas upgrading and bottling at far off location from the site of production of waste (collection of waste from different locations and transportation to a centralised site of biogas production and upgrading)*
- *Mobile upgrading and bottling system*
- *In urban areas – in housing societies, clusters of households*

Centralised Waste Collection, Biogas Production, Upgrading & Bottling

Waste as Feedstock

Community Biogas Plants

Raw Biogas

Water scrubbing

or

PSA

Purified Biogas

Biogas engine

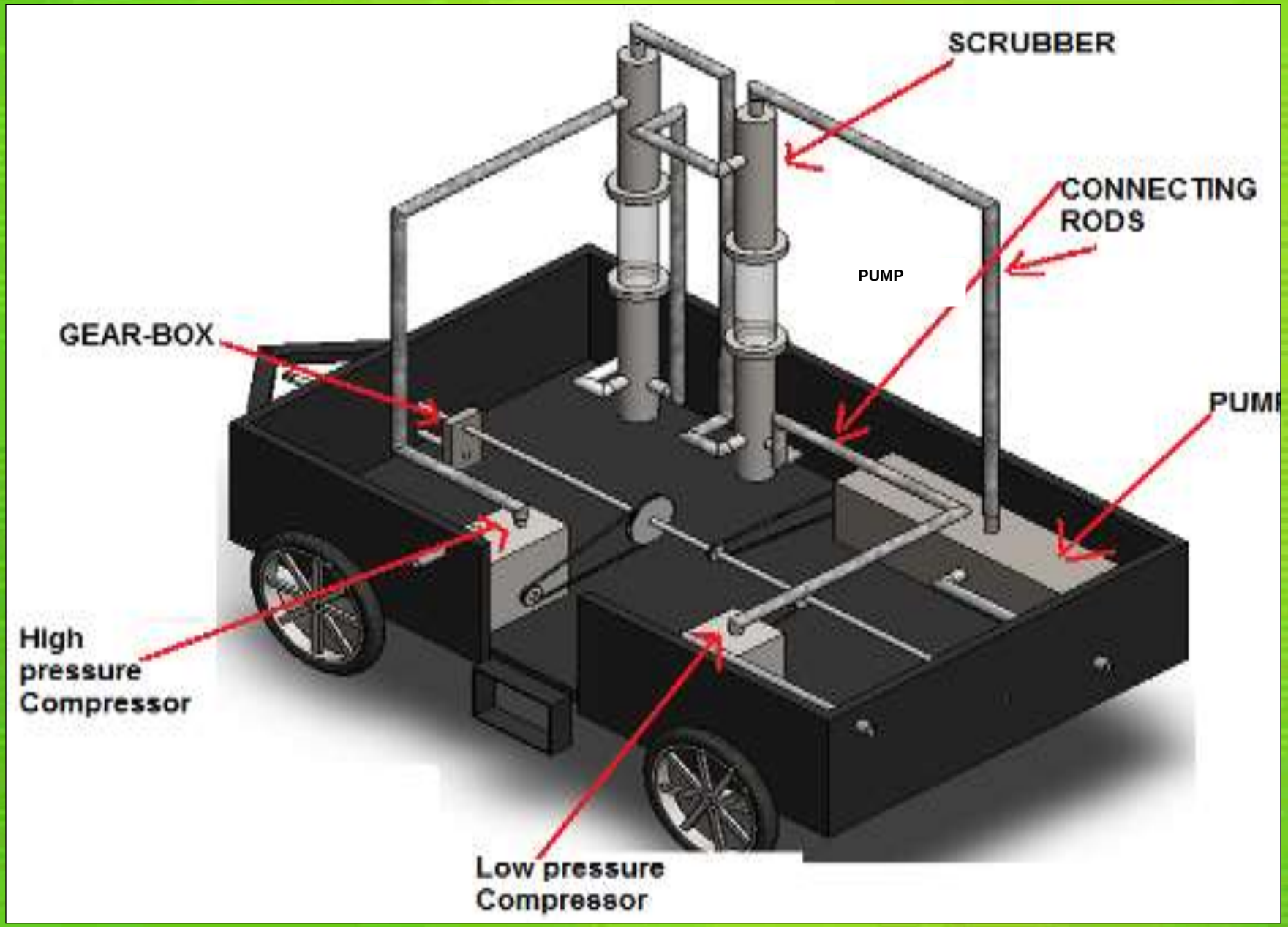
Purified Cylinder Cascade

Electricity Production

Cooking Fuel

Transport Fuel

Mobile Biogas upgrading and bottling system



Biogas Upgrading

The use of a biogas upgrading or purification process in which the raw biogas stream like CO_2, H_2S and moisture are absorbed or scrubbed off, leaving above 90% methane per unit volume of gas.

- Presence of CO_2 in biogas poses following problems:
  - It lowers the power output from the engine;
  - It takes up space when biogas is compressed and stored in cylinder;
  - It can cause freezing problems at valves and metering points where the compressed gas undergoes expansion during engine running.

- The traces of H_2S produces H_2SO_4 which corrode the internals of pipes, fittings etc.

- Moisture causes corrosion and decreases heating value of the fuel.

Technologies for Conversion of Raw to Upgraded Biogas

- Water scrubbing
- Chemical absorption
- Pressure swing absorption
- Membrane
- Cryogenic

Comparison between selected parameters for common upgrading processes

Methods / Parameters	High pressure water scrubbing	Chemical absorption	Pressure swing absorption	Membrane separation	Cryogenic
Gas Pre Cleaning Requirement	No	Yes	Yes	Yes	Yes
Working Pressure	9-10 Bar	1 Bar	4 – 7 bar	4-7 bar	40 bar
Methane Loss	1– 2 %	1-2 %	1-9 %	10 - 15 %	1-2%
% purity attained of upgraded Biogas	95-98 %	Upto 99 %	95 - 99 %	Upto 90 %	Upto 99 %
Heat requirement	-	Required	-	-	-
Operating Cost	Low	Moderate	Moderate	Low	High
Initial Cost	Low	Moderate	Moderate	Moderate	High
Process Handling	Easy	Complex	Easy	Easy	Complex

Compression of Biogas

- The energy density of upgraded biogas is comparatively low at ambient pressure and as a result it must be compressed at high pressures (e.g. 200-250 bar) to allow its sufficient storage in bottles/cylinders.

- Compressing biogas
  - reduces storage space requirements,
  - concentrates energy content and
  - increases pressure to the level needed to overcome resistance to gas flow.

- Compression can eliminate the mismatch of pressures and guarantee the efficient operation of the equipment.

Biogas upgrading using water scrubbing method at IIT Delhi

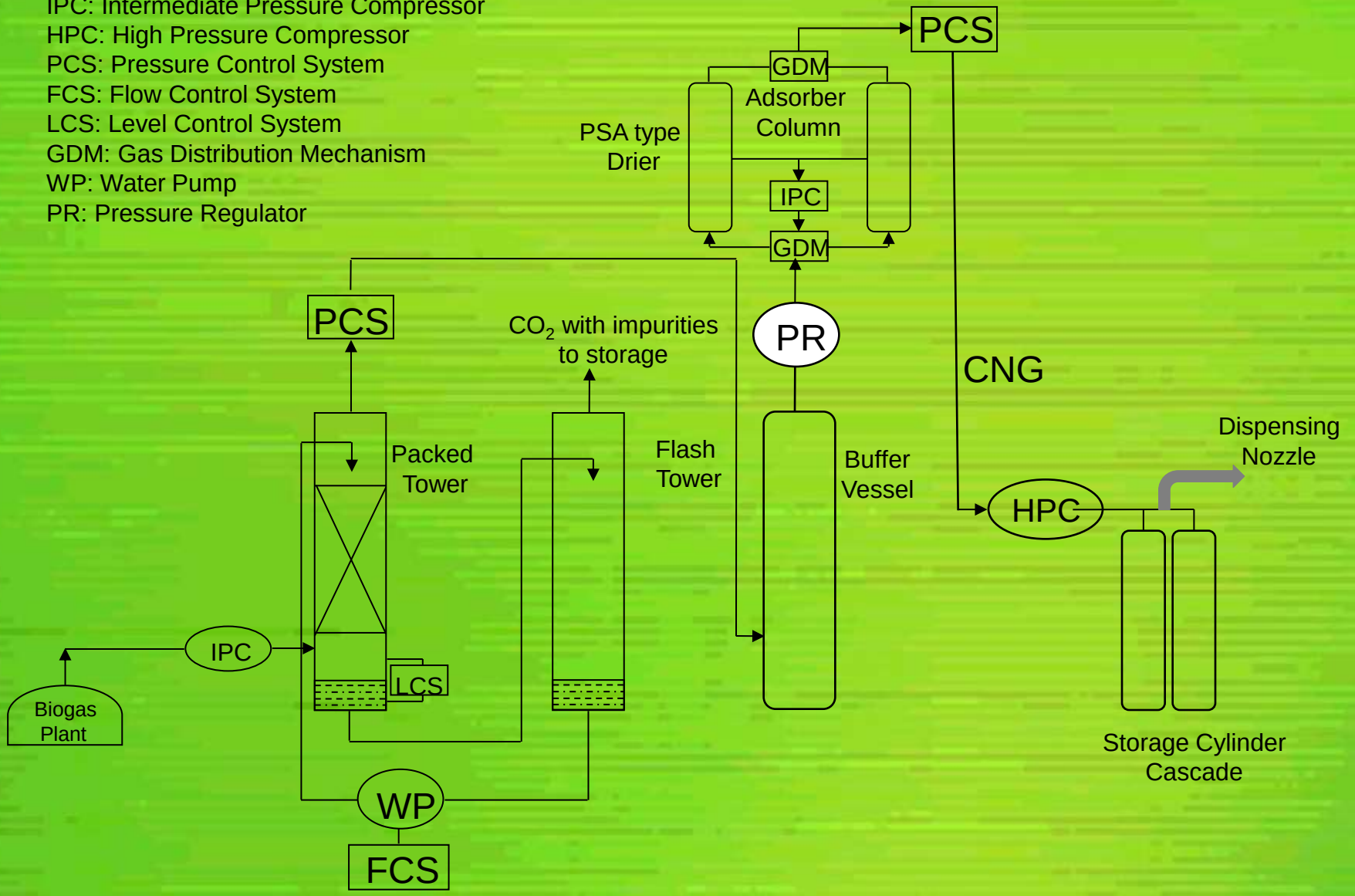
Water Scrubbing Method

- Involves the physical absorption of CO_2 and H_2S in water at high pressures and regeneration by a release in pressure with very little change in temperature.

- Easiest and cheapest method involving use of pressurized water as an absorbent.

- The absorption process is, thus a counter-current one. The dissolved CO_2 and H_2S in water are collected at the bottom of the tower.

IPC: Intermediate Pressure Compressor
HPC: High Pressure Compressor
PCS: Pressure Control System
FCS: Flow Control System
LCS: Level Control System
GDM: Gas Distribution Mechanism
WP: Water Pump
PR: Pressure Regulator



Block Diagram of Biogas Purification & Bottling Plant

Bhilwara goshala (common cowshed)

Water Redistributors

Water Pump

Pneumatic Valve

PID Controllers

Compressor

High Pressure Compressor

Gas Storage Vessel

Biogas Cylinders

PSA

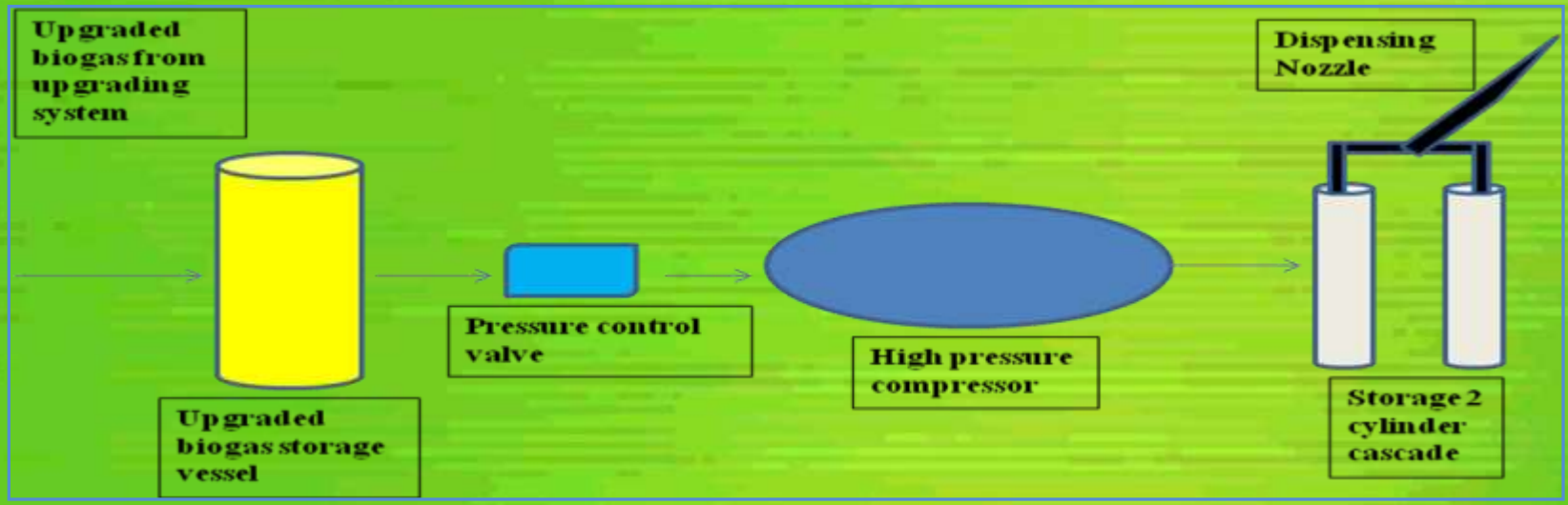
Biogas Vehicle

A Biogas Bottling plant

Consists of

- High Pressure compressor,
- Cascade of storage cylinders and
- A dispensing nozzle for filling the compressed purified gas in the vehicles.

Dried and purified gas goes into the suction of High Pressure Compressor, where it compress the gas to desired working pressure (~200 Bar) and fill into the storage cylinder cascade. A CNG dispensing cable along with nozzle is used for filling of gas in the vehicles.



Upgraded Biogas Dispensing System at IIT Delhi

High Pressure Compressor

Two cylinder cascade for bottling of upgraded biogas

Dispensing Nozzle - NZ type


BioGas


Biogas
vehicle

Video


BIOGAS ENRICHMENT AND
BOTTLING PLANT - IIT
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Biogas Programmes for Upgrading and Bottling

New Initiative for Technology Demonstration:

- **Demonstration of Integrated Technology Package on Biogas-Fertilizer Plants (BGFP) for Generation, Purification/ Enrichment, Bottling and Piped Distribution of Biogas.**

- **Establishment of Business Model for Demonstration of an Integrated Technology Package for creation of smokeless villages using biogas/ bio-energy systems and meeting 'Life-line Energy' envisaged in 'Integrated Energy Policy'**

Main Components of Biogas-Fertilizer Plants (BGFPs)

- Slurry/ Feed-stock preparation systems.
- BGFP Digester.
- Biogas Purification/ Enrichment and Safety Systems.
- Biogas bottling and piped distribution for various applications.
- CO_2 bottling and utilization.
- Slurry processing/ for recycling of water.
- Vermi-composting and slurry management system.
- Bio-fertilizer upgradation and packaging.
- Marketing and supply management of Bio-fertilizers.

Financial Support for BGFP Projects

Proposed financial support:

Organization	Percentage of Project Cost
• MNRE support:	50%
• IREDA/ Bank Loan:	30%
• Promoter/ user agency contribution:	20%

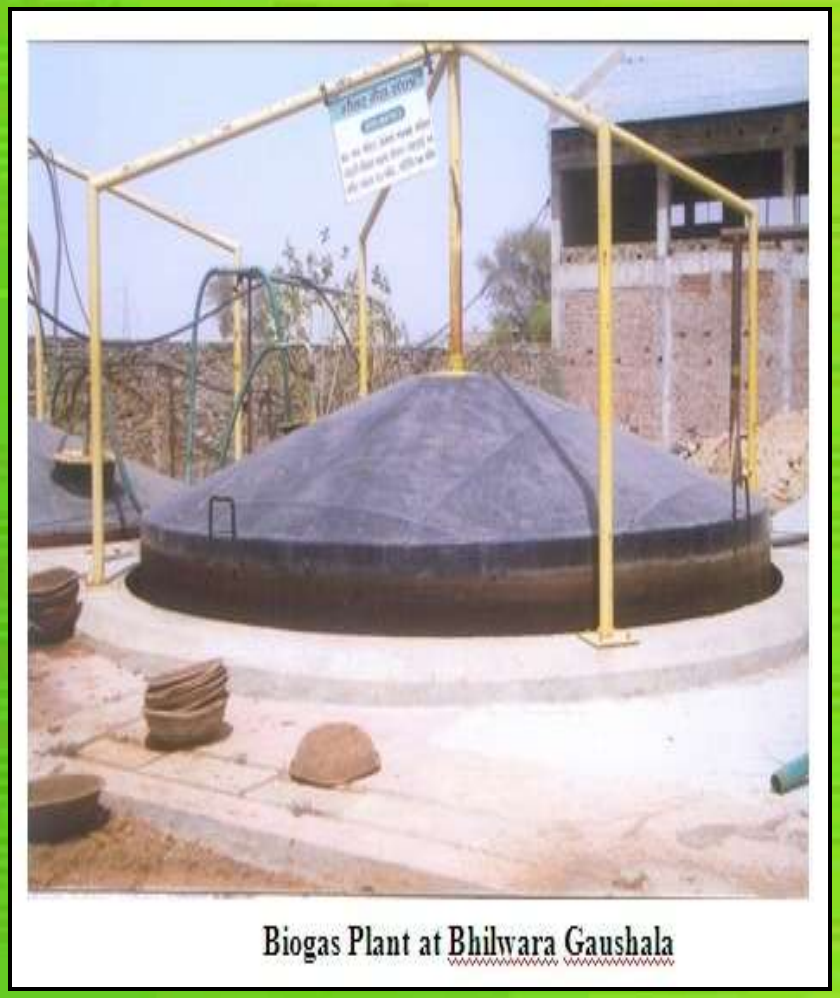
Indian Standard on Biogas (Biomethane)- specification IS 16087 : 2013

Sl. No	Characteristic	Requirements	Method of Test, Ref to.
1	CH_4, Percent, *Min*	90	IS 15130(Part 3): 2002
2	Moisture, mg/m^3 *Max*	16	IS15641 (Part 2): 2006
3	H_2S, mg/m^3 *Max*	30.3	ISO 6326-3: 1989
4	$CO_2+N_2+O_2$, Percent, *Max (v/v)*	10	IS15130 (Part 3): 2002
5	CO_2, Percent, *Max (v/v),* (*When intended for filling in cylinders)*	4	IS15130 (Part 3): 2002
6	O_2, Percent, *Max (v/v)*	0.5	IS15130 (Part 3): 2002

Pilot Scale Technology Demonstration and Biogas Upgrading Plants in India

1.Rajasthan Go Seva Sangh Plant, Jaipur (1st pilot model)

2. MGVAS Bhilwara Plant (2nd pilot Plant)



Biogas Plant at Bhilwara Gaushala

Biogas Enrichment Plant

3. Biogas upgradation and bottling plant at Nasik, Maharashtra - BGFP

Water Scrubbing and PSA system at Nasik

Cylinder Cascade for bottled biogas

High Pressure Compressor at Nasik plant

4.Biogas Upgrading and Bottling Plant at Abhohar, Mukatsar, Punjab 1st Technology demonstration plant BGFP project

Biogas Based Entrepreneurial Avenue Options in India

In rural areas of developing economies many entrepreneurial avenues in the biogas sector are available in :

1)Goshalas (common cow –shed),
2) Poultry Farms
3) Dairy farms
4) Cluster of biogas plants in villages
5) Mobile Biogas Upgrading & Bottling Units

Is It The Future

Suggestions for the successful development of the small scale biogas bottling industry

- Appropriate grants should be made available to support the initiation of this industry.
- Special allowances and incentives for the promotion of biogas bottling projects should be made.
- Bank loans and central subsidies should be provided for the promotion of biogas upgrading and bottling plants
- By 2017, in India will have a natural gas pipeline grid of 30,000-km. Currently, country wide network of 12,000 km of gas pipeline and another 12,000 km of pipelines are under construction. Hence, financial support, standards and allowance for the use of natural gas infrastructure should be provided for upgraded biogas.

- Central Financial Support (CFA) should be provided to support biogas bottling.
- Training, workshops and dissemination activities for users, manufacturers and entrepreneurs.
- It has also been suggested that norms for small-scale biogas bottling systems should be eased for small-scale biogas bottling systems,
- Subsidies should be provided for application of biogas bottling systems in rural areas.
- Development of a system for manure management.
- Government should make biogas projects eligible for funding for efficient rural development.
- Introduction of green certificates should be encouraged for the producers of bottled biogas. The project developers should receive a certificate for converting waste to energy efficient fuel called bioCNG / biomethane

OR IS THIS THE FUTURE

THANK YOU