# WATER SCRUBBING BASED BIOGAS ENRICHMENT TECHNOLOGY BY IIT DELHI

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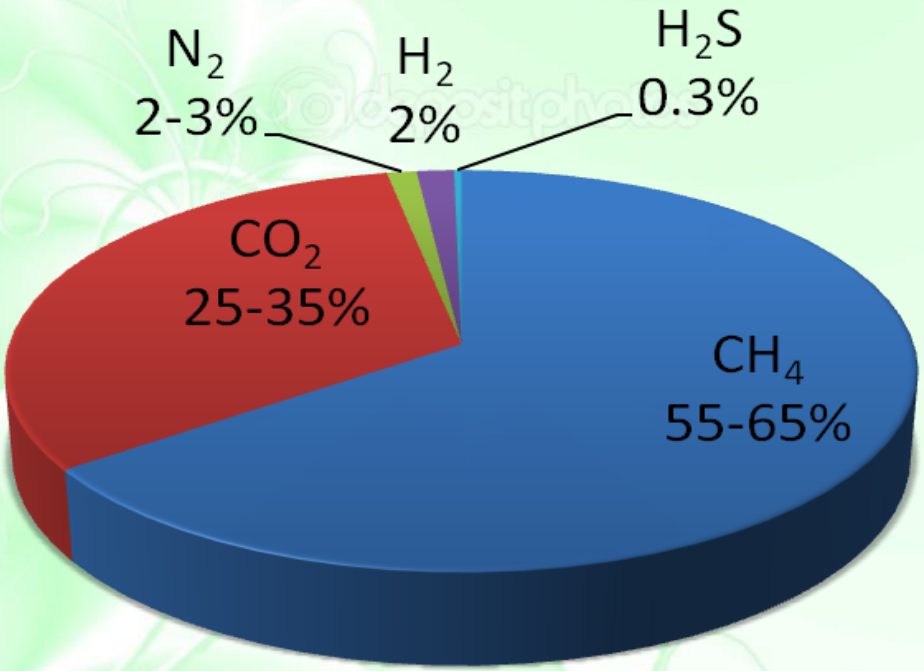
# BIOGAS - *Introduction*

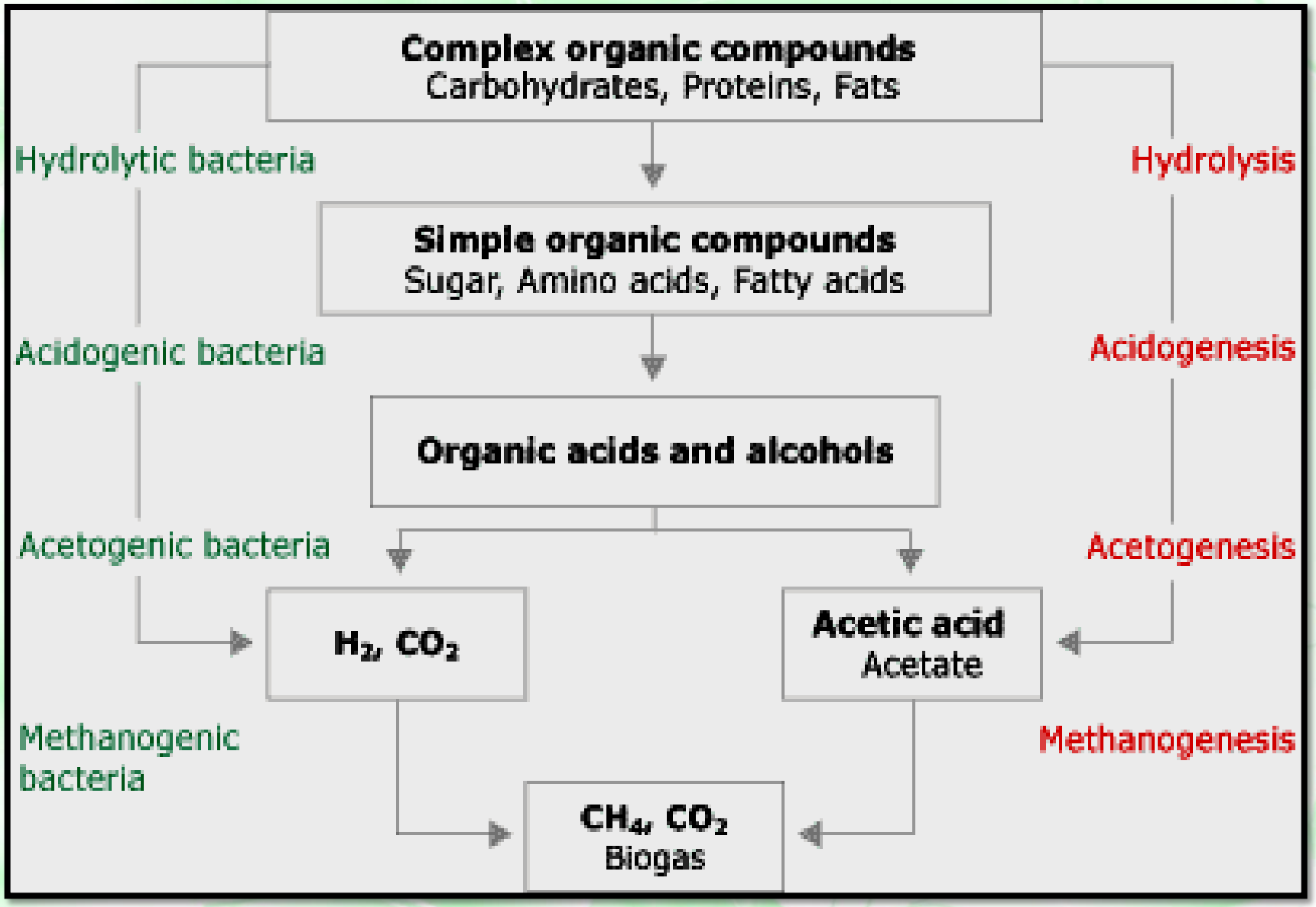
- Energy source produced from biodegradable /organic wastes.
- Green and cost effective replacement of wastes.
- Potential to meet the energy requirements in rural areas, and also counter the effects of reckless burning of biomass resources.
- Additional benefit of digested slurry - can be dried and sold as high quality compost.
- Wastes of variable qualities and quantities, such as animal dung, agricultural wastes and food and municipal solid waste, are available in rural and urban areas.
- This waste can be utilised for both centralised large-scale and decentralised small-scale biogas production/ enrichment and bottling.

# WHAT IS BIOGAS ?

Gas is produced by the anaerobic digestion/fermentation of biodegradable materials such as biomass, manure, food waste, sewage, municipal waste, green waste, agricultural/plant waste, and crops.



# BIOGAS PRODUCTION PROCESS




Source : http://www.schaumann-bioenergy.com/biogasproduktion/fermenterbio.php

# COMPOSITION OF BIOGAS DEPENDS ON

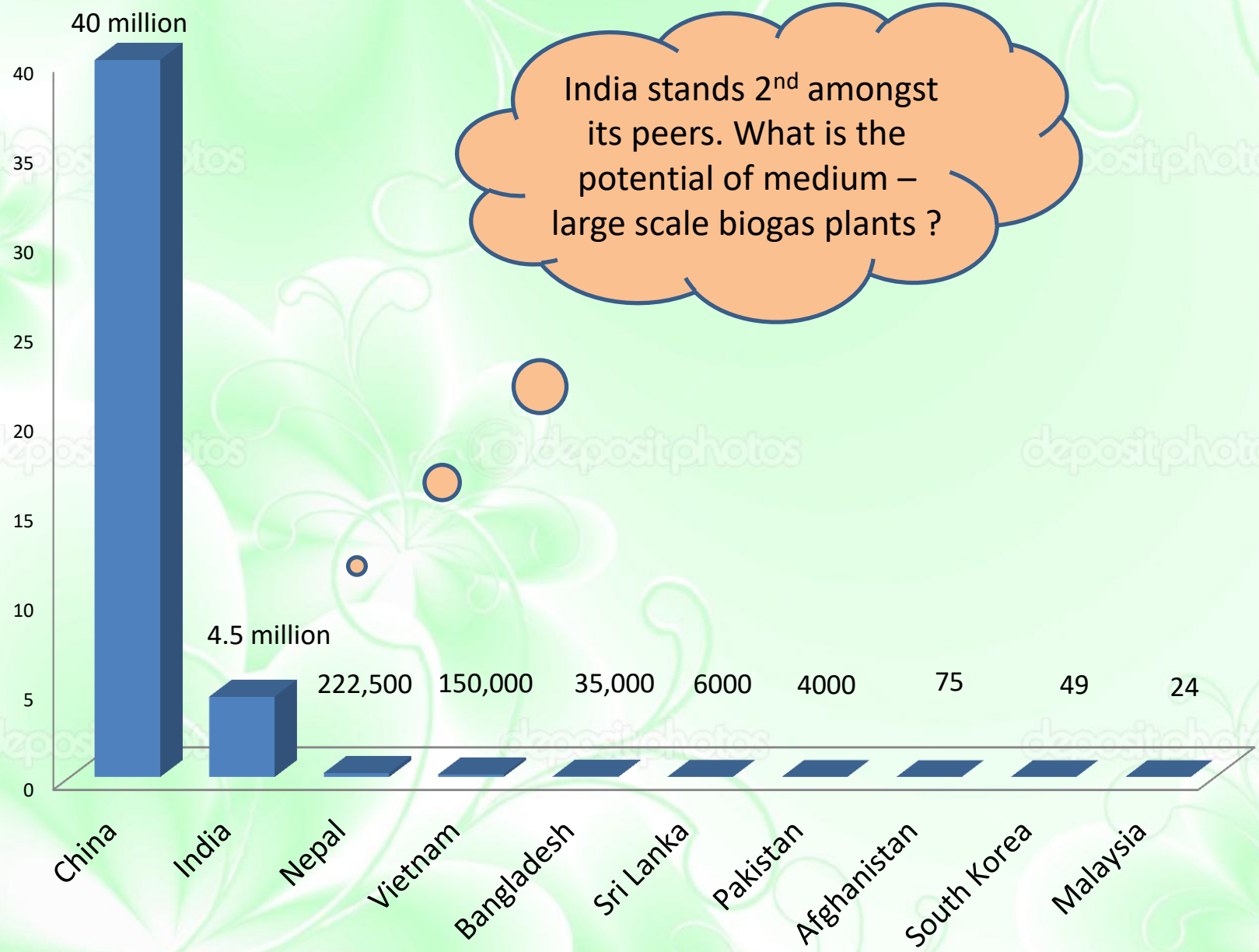
- The nature and concentration of the substrate
- Feed rate
- C:N ratio
- pH value
- Bacteria biomass
- HRT
- Designing of bioreactor
- Temperature

# BIOGAS PRODUCTION IN DEVELOPING COUNTRIES

- Biogas technology is a proven and established technology in many parts of the world, especially Asia where domestic size biogas plants are more popular.

- Several countries in this region have embarked on large-scale programmes on domestic biogas, such as China, India and Nepal with millions of domestic biogas plants installations.

# Domestics Size Biogas Plants installed upto 2010 in some developing countries




***Sources: Based on various source as mentioned in references***

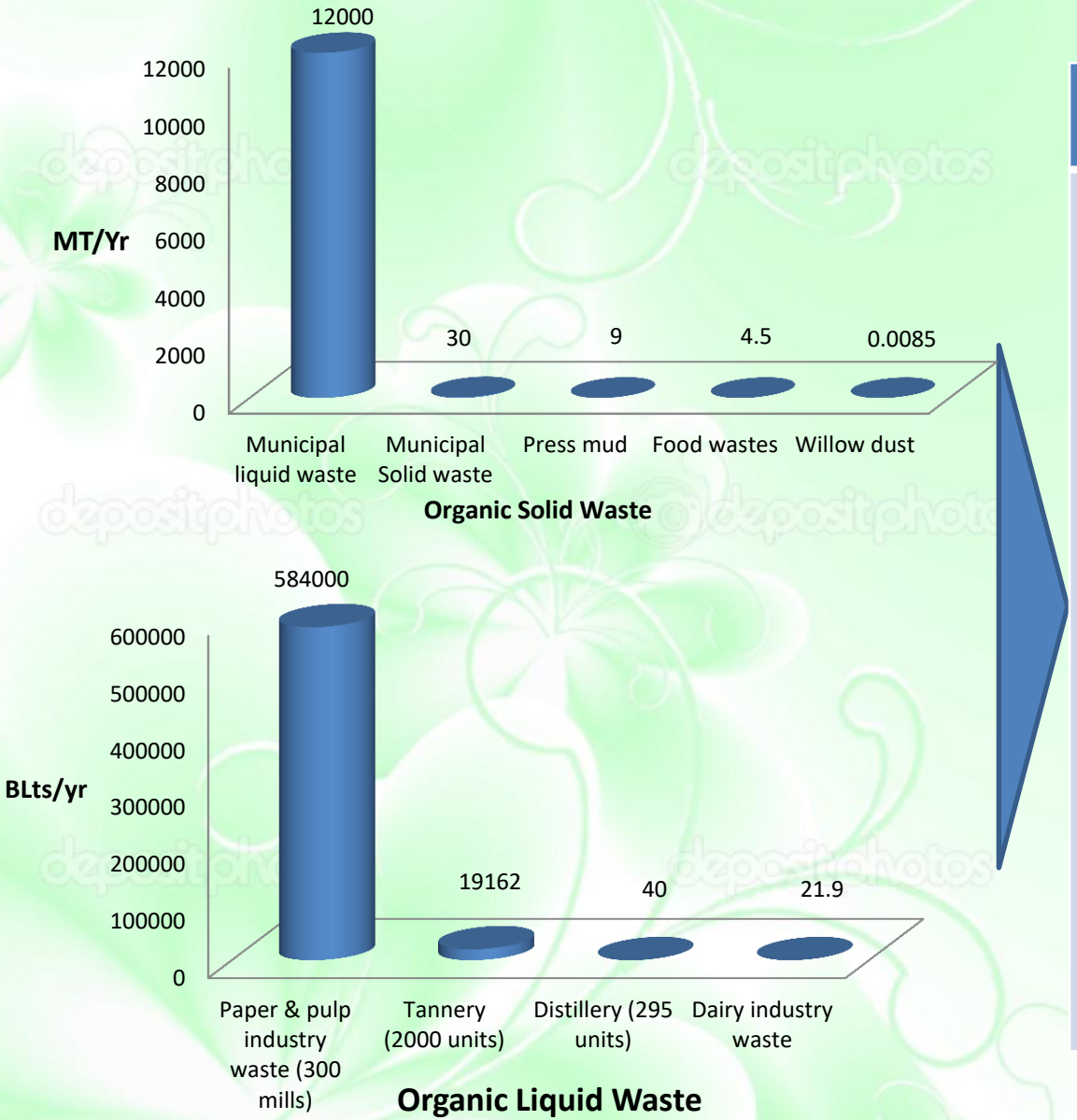
# Biogas in INDIA

- An estimate indicates that India has a potential of generating 6.38 X $10^{10}$ $m^3$ of biogas from 980 million tones of cattle dung produced annually.

- The heat value of this gas amounts to 1.3 X $10^{12}$ MJ. In addition, 350 million tones of manure would also produce along with biogas.

- Apart from the **4.5 million domestic biogas plants installed in India against the potential of 12 million**, there is a huge potential of installation of medium and large scale biogas plants installation in India in small scale industries, animal rearing farms, poultry farms, distilleries, tanneries, hotels, restaurants, military barracks etc.

# Biogas Production Potential From Organic Wastes in India




## Potential

There are around 300 distilleries throughout India which collectively have a potential of producing 1200 million $Nm^3$ biogas, and 2000 tannery units capable of producing 787,500 $Nm^3$ of biogas . The increasing number of poultry farms can also add to biogas productivity as with a current population of 649 million birds, another 2173 million $Nm^3$ of biogas can be generated.

*Source: MNES Report, Renewable Energy in India and business opportunities, MNES. Govt. of India, New Delhi*

# TYPES OF BIOGAS DIGESTERS AND PLANTS

Selection of Appropriate Design and Type of Digester depends upon

- Space
- Existing Structures
- Minimizing Cost
- Available Substrate

# BASIC BIOGAS PLANT DESIGNS

The basic designs of biogas plants that are being mostly promoted in the country are:

- **Floating gas holder:** Khadi and Village Industries Commission (KVIC) type design for family, community, institutional and industrial biogas plants.

- **Fixed dome design:** Janata and Deenbandhu designs for family size biogas plants.

- **Flexi model** bag digester design made of rubberized nylon fabric for family size plants and as a floating cover for sewage site biogas plants.

- **Upflow Anaerobic Sludge Blanket (UASB)** design and other designs for medium and large size plants for industrial, municipal and sewage waste based biogas plants.

**Different types of biogas plant recognised by MNES (Ministry of Non-Conventional Energy Sources)**

1.Floating-drum plant with a cylinder digester (KVIC model).

2.Fixed-dome plant with a brick reinforced, moulded dome (Janata model).

3.Floating-drum plant with a hemisphere digester (Pragati model).

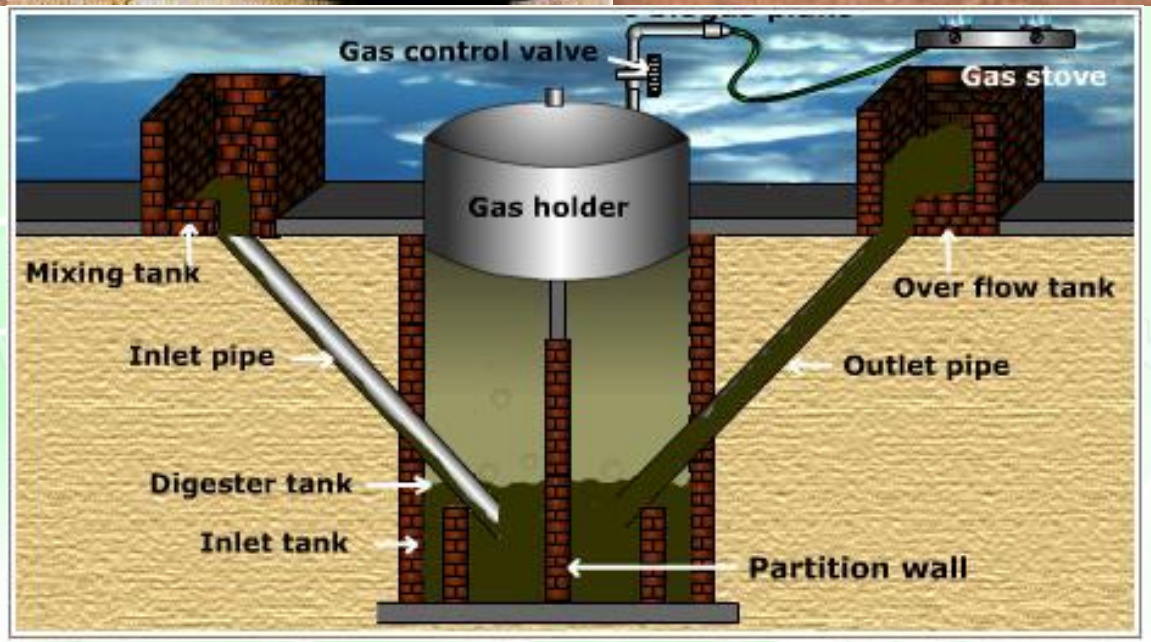
4.Fixed-dome plant with a hemisphere digester (Deenbandhu model).

5.Floating-drum plant made of angular steel and plastic foil (Ganesh model).

6.Floating-drum plant made of pre-fabricated reinforced concrete compound units.

7.Floating-drum plant made of fibreglass reinforced polyester.

# Floating-Drum Plants

**KVIC Model Biogas Plant**

**Deenbandhu 2m$^3$ model Family size biogas plant**

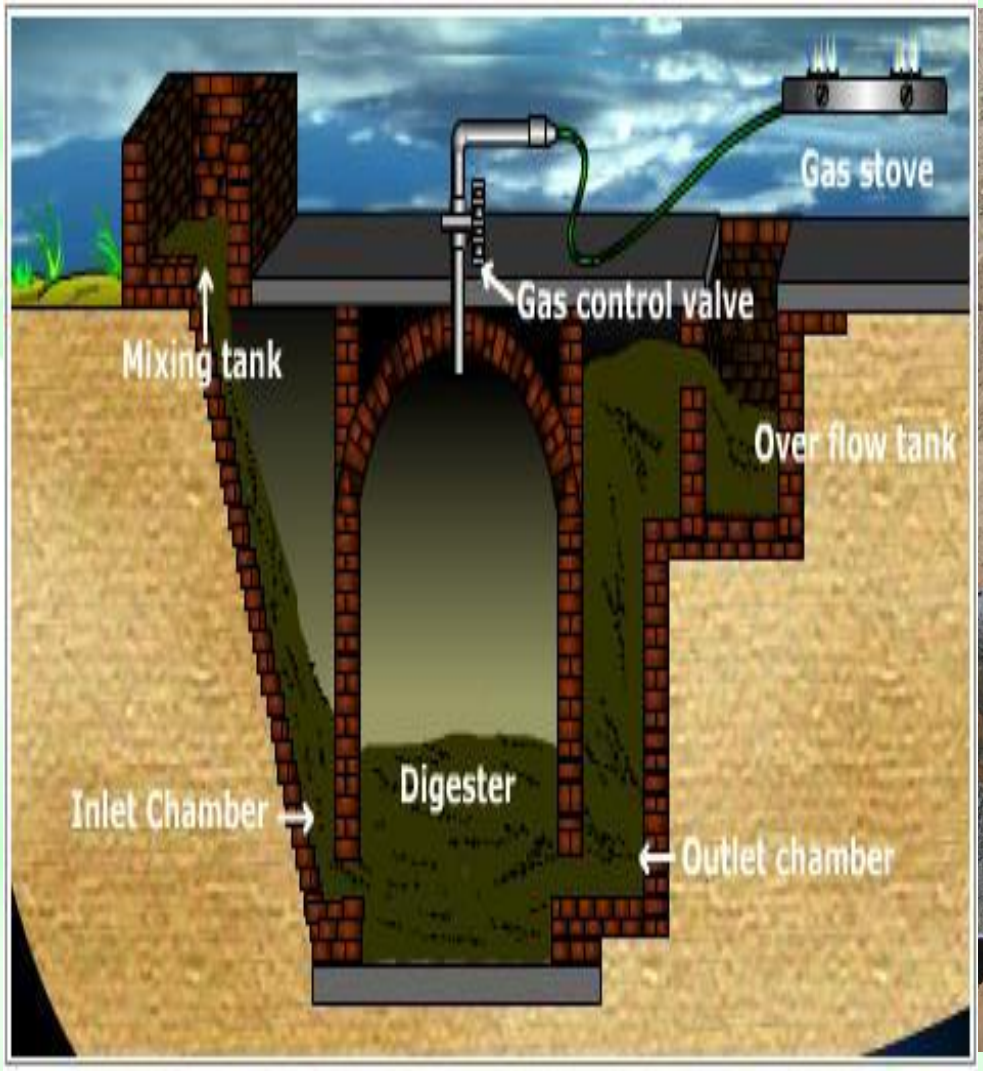
**A Pre-fabricated RCC based Krishna model fixed dome Biogas Plant**

**Sintex make Pre-fabricated HDPE material based 2m$^3$ Deenbandhu Model Biogas Plant**


BIO GAS SYSTEM

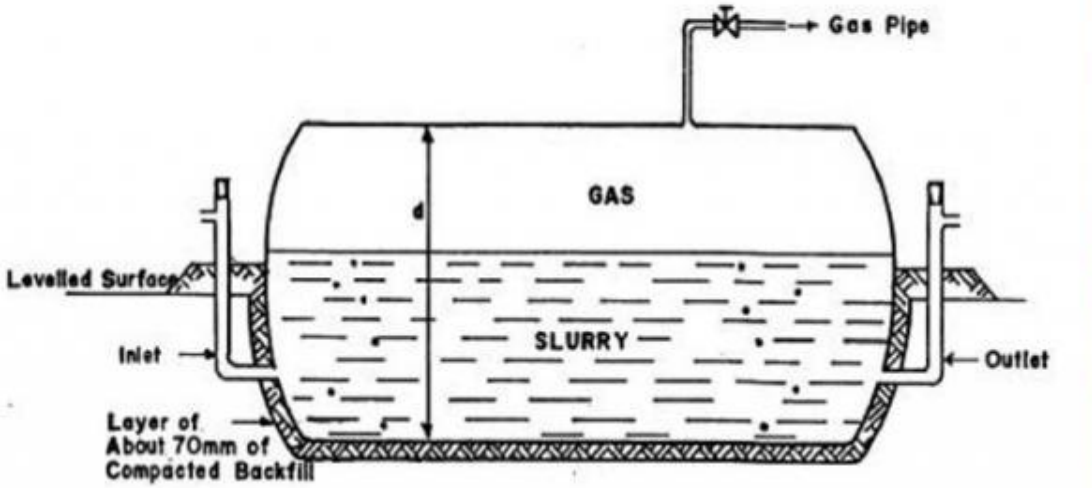
# Biogas plants at Ghaziabad Goshala

# Fixed-Dome Plants




Sources: http://www.tutorvista.com/content/science/science-ii/sources-energy/biogas-plants.php#, http://bio-gas-plant.blogspot.in/2011/08/biogas-plant-pakistan-photo-gallery.html

# Flexible - Balloon Biogas Plants




Sources: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/anaerobic-di, http://kochi.olx.in/biogas-balloon-plants-iid-233853697

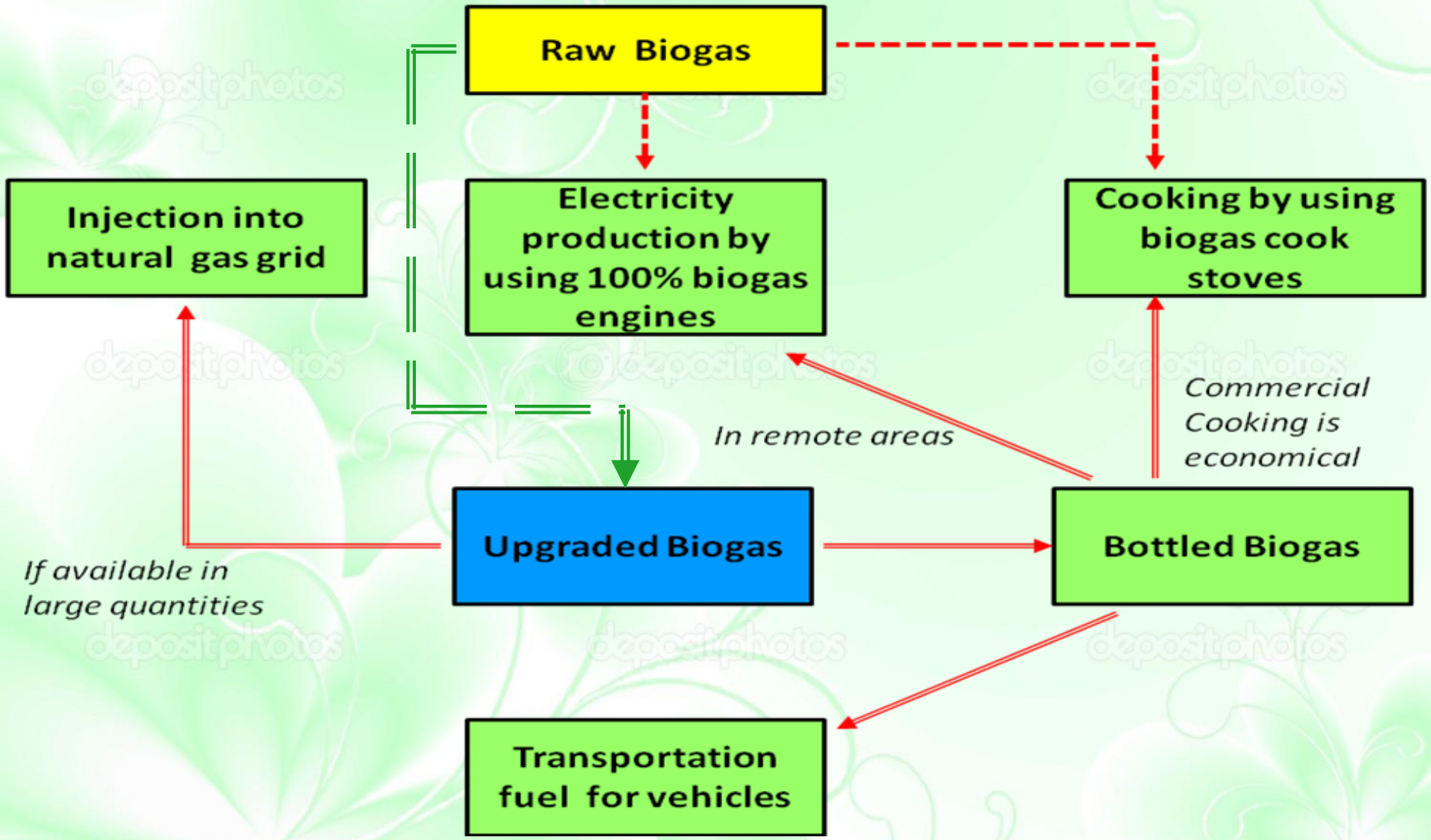
# The NEED……

## 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

# VERSATILITY OF BIOGAS USE




***Upgrading widens the scope of utilization***

# Utilization of Raw Biogas

Pipeline for raw biogas use as a cooking fuel


Raw biogas cookstove

Biogas lamp


Biogas Engine for electricity production

# 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

# The Solution……

……Low Cost biogas Upgrading

# *Biogas Enrichment*

*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.

# *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.

# Removal of $CO_2$ from Biogas

The feasible processes of biogas purification are:

- Absorption into liquid (Physical / Chemical)
- Adsorption on solid surface
- Membrane separation
- Cryogenic separation

*Selection of the appropriate process for a particular application depends on the scale of operation, composition of the gas to be treated, degree of purity required, capital cost and the need for $CO_2$ recovery.*

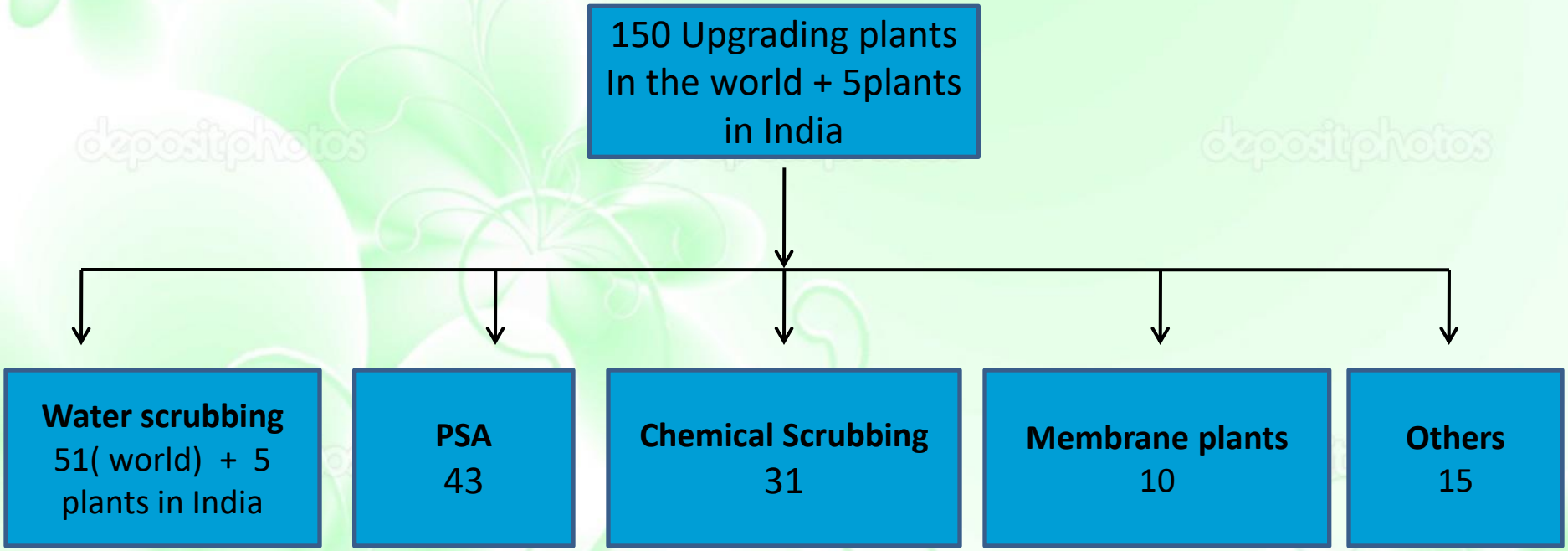
# Comparison between selected parameters for common upgrading processes

| 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 % | 1-2 % | 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 |

•The most widely used technologies for biogas upgrading are water scrubbing, PSA, membrane and chemical scrubbing. Out of these technologies, water scrubbing and PSA are most appropriate at a small scale due to low cost and easy maintenance.

•Till 2011, the number of biogas upgrading plants in the world were 150.

•In India there are 5 biogas upgrading plants till 2011.




Source: http://www.iea-biogas.net/_download/publi-task37/upgrading_rz_low_final.pdf

# DESIGN OF WATER SCRUBBING SYSTEM

# 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.

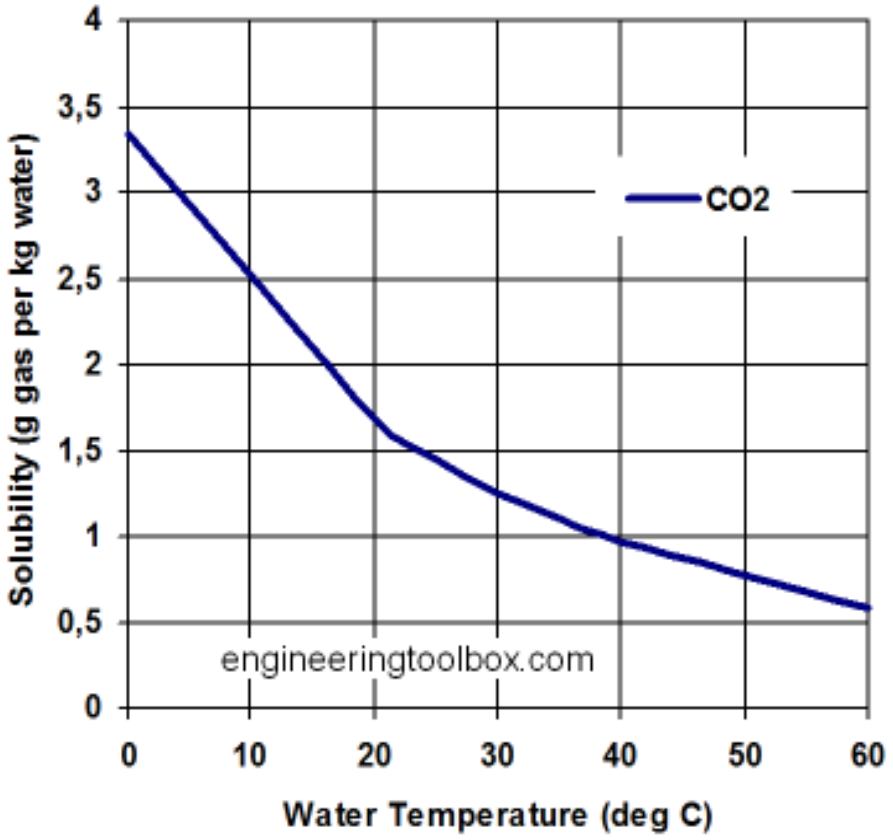
# Absorption of $CO_2$ in water

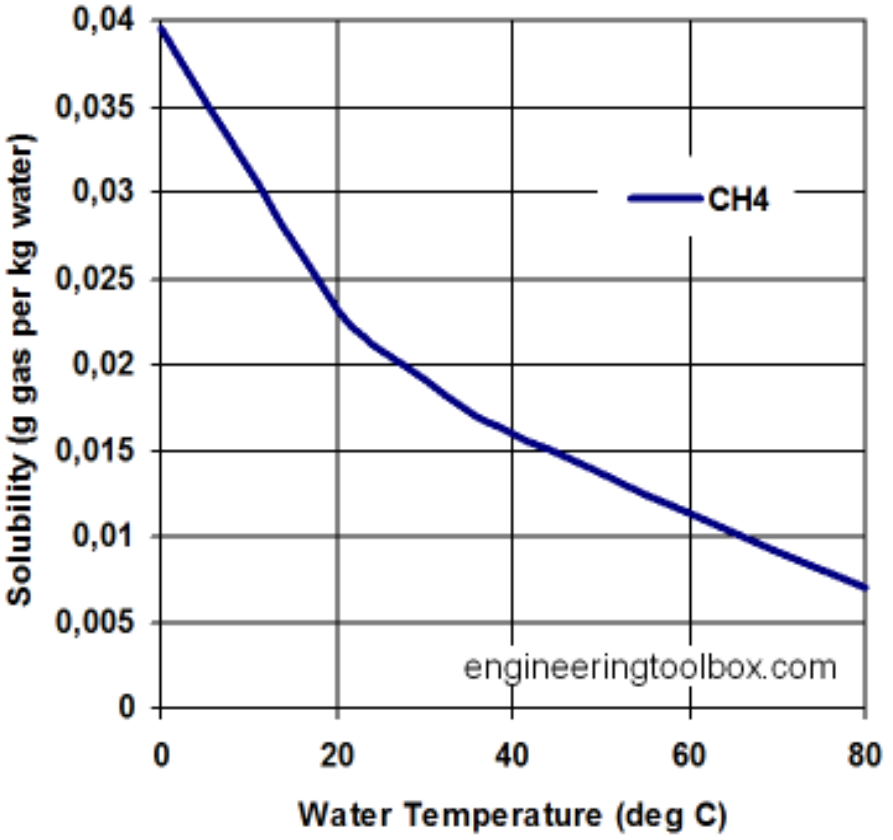
The amount of $CO_2$ being dissolved in water is determined by:

1) **The time of contact between biogas and with water** - To increase the contact time of the gas with water, counter current mechanism is followed by making water to flow from the top to bottom and raw biogas from bottom to top.

2) **the pressure** of the raw biogas and water.

# Solubility of $CO_2$ and $CH_4$ in Water



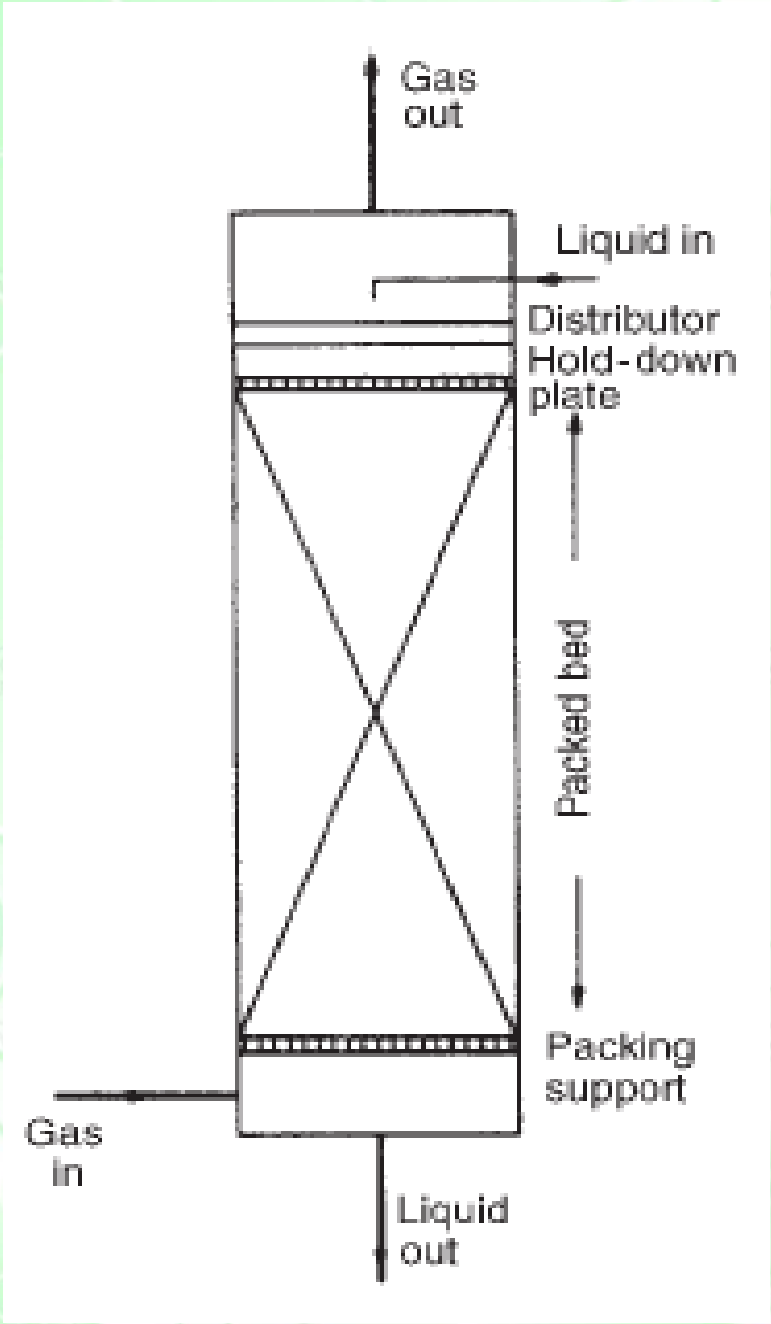
# Approximate Solubility of $CO_2$ in Water

| **Pressure (atm)** | **Solubility, in kg of $CO_2$ per kg of water at different temperatures.** | | | |
|---|---|---|---|---|
| | 0° C | 10° C | 20° C | 30° C |
| 1 | 0.40 | 0.25 | 0.15 | 0.10 |
| 20 | 3.15 | 2.15 | 1.30 | 0.90 |
| 50 | 7.70 | 6.95 | 6.00 | 4.80 |

# Packed Bed Scrubber

- Packed bed scrubbers are used for distillation and gas absorption.
- Consists of
  - a cylindrical column, equipped with a gas inlet and distributing space at bottom,
  - a liquid inlet and distributor at top,
  - liquid and gas outlets at bottom and top respectively and
  - a supported mass of inert solid shapes.
- The solid shapes are called column packing or filling.
- The packing provides a larger area of contact between the liquid and gas and encourages intimate contact between the phases.

## A Typical Packed Bed Tower



**Main parameters calculated for the packed bed for a particular capacity are—**

- Working Pressure
- Tower Packing
- Diameter of Packed Bed
- Height of Packed Bed

# Working Pressure of the Packed Bed Tower

- The solubility of $CO_2$ & $CH_4$ in water is directly proportional to pressure. As the pressure increases, requirement of water and volume of packed column decreases for a fixed flow rate of biogas.

- Higher working pressure poses the problem of difficult fabrication of tower, difficulty in finding control equipments (sensor, valves etc.) and higher electricity consumption for compression of gas.

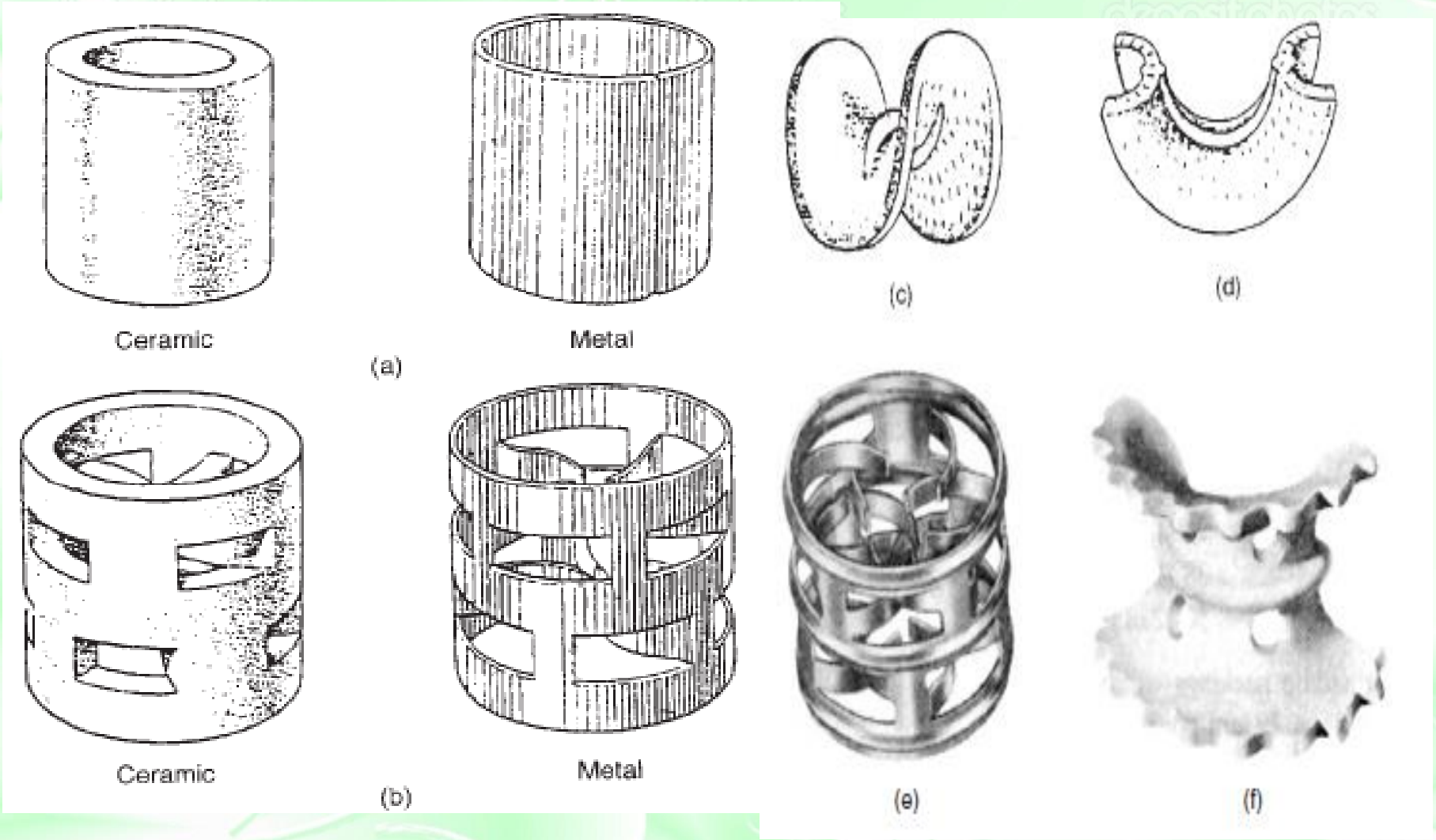
- Very low pressure results in excess water requirement and much bigger size of columns.

- Therefore, an intermediate value working pressure of 10 bar (absolute) is chosen in IIT Delhi WS system case.

## Tower Packing

- Packing provides the large interface area for the contact of liquid and gas phase inside the packed tower.
- Has an open structure: low resistance to gas flow.
- Promote uniform liquid distribution on the packing surface.
- Promote uniform vapor gas flow across the column cross-section.

Types of packing (*a*) Raschig rings (*b*) Pall rings (*c*) Berl saddle ceramic (*d*) Intalox saddle ceramic (*e*) Metal Hypac ( *f* ) Ceramic, super Intalox



## Determination of Diameter (D) and Height (H) of the Packed Bed Column

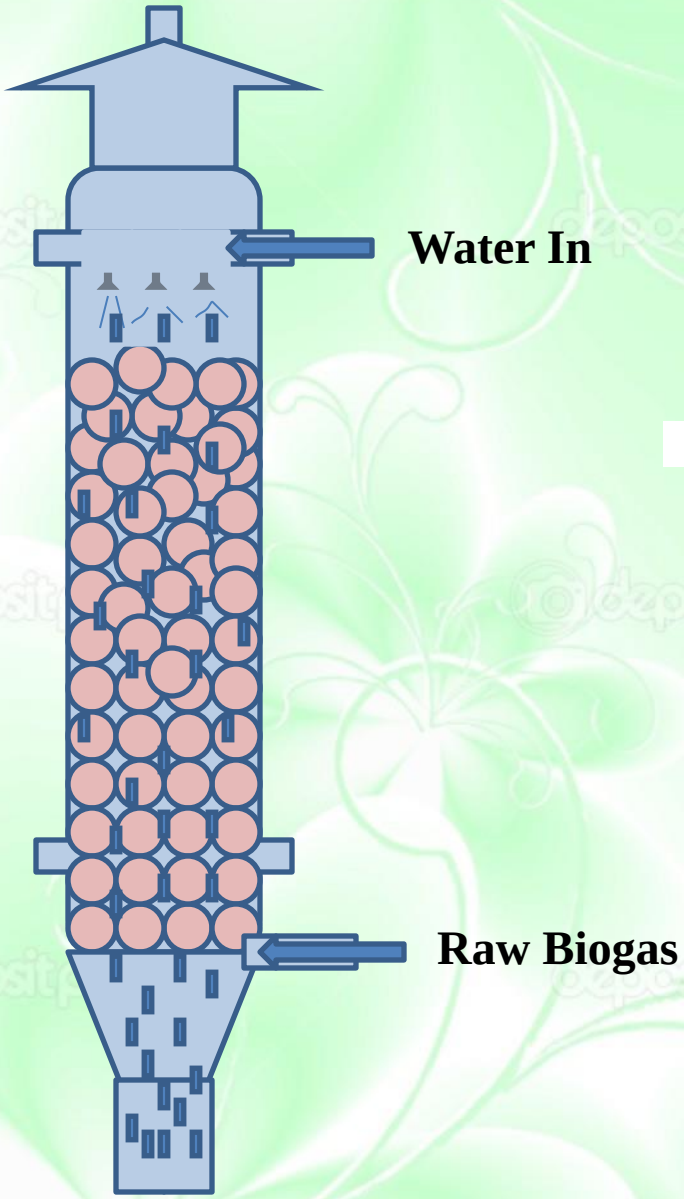
- The capacity of a packed bed absorption column is depended on its cross-sectional area.
- The column will be designed to operate at the highest economical pressure drop, to ensure good liquid and gas distribution.
- There is no entirely satisfactory method for predicting the height of a transfer unit.
- In practice the value for a particular packing will depend not only on the physical properties and flow-rates of the gas and liquid, but also on the uniformity of the liquid distribution throughout the column, which is dependent on the column height and diameter.

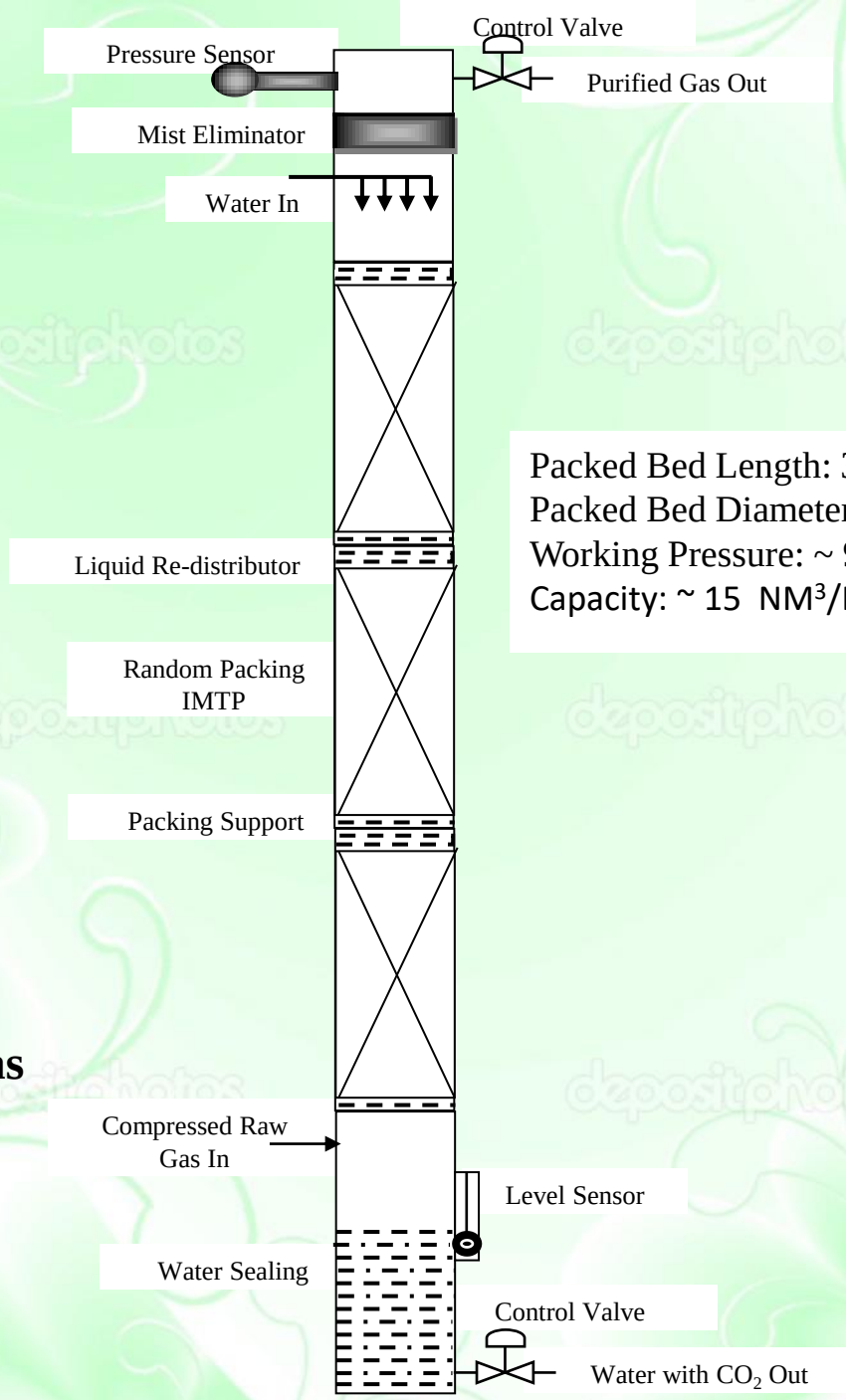
Hence based upon the above calculations and selections the following input parameters are decided

**Biogas Enrichment Plant Parameters**

| | |
|---|---|
| **Raw Biogas Flow Rate** | **20Nm3/Hr** |
| **Vapour phase** | **Biogas (63% CH4, 34% CO2)** |
| **Liquid Phase** | **Water** |
| **Working Pressure** | **~10 Bar** |
| **Working Temperature** | **Ambient** |
| **Packing Material** | **IMTP** |
| **Diameter of Packed Bed** | **15cm** |
| **Height of Packed Bed** | **3.0 m** |
| **Water flow rate** | **4 Nm3/hr** |

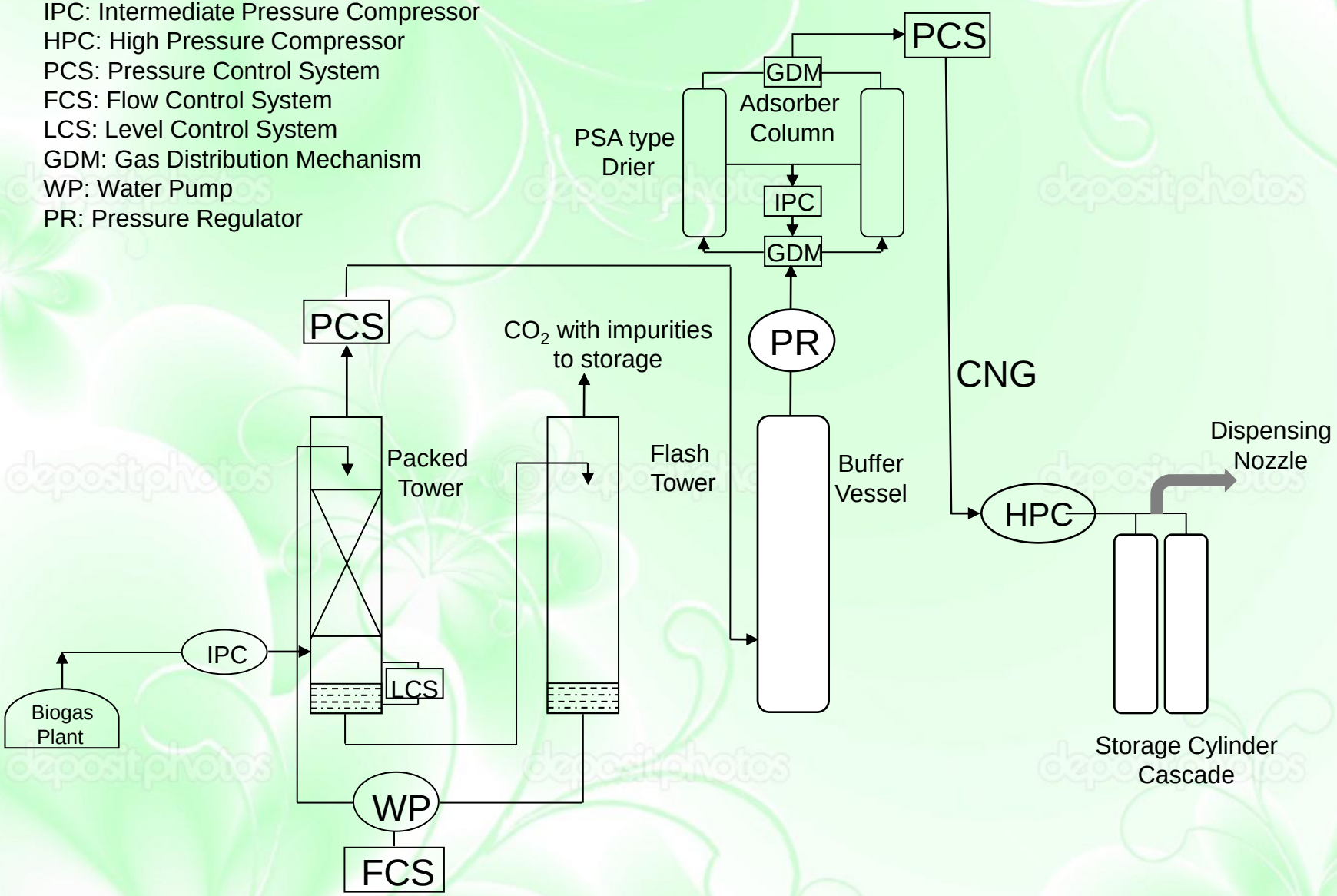
# Water Scrubbing System for Biogas Enrichment at IIT Delhi




Packed Bed Length: 3M
Packed Bed Diameter: 15 cm
Working Pressure: ~ 9 Bar
Capacity: ~ 15 $NM^3/Hr$

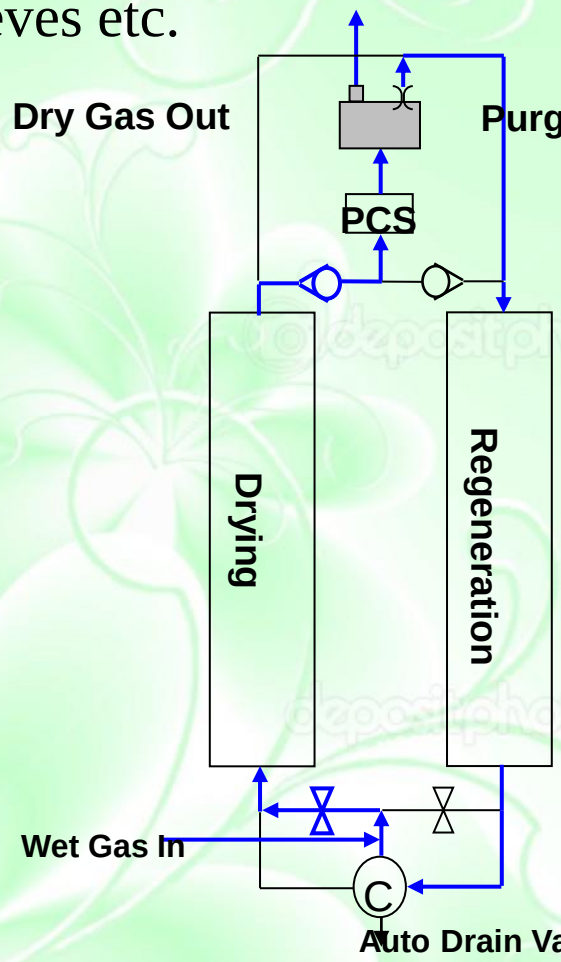
IPC: Intermediate Pressure Compressor
HPC: High Pressure Compressor
PCS: Pressure Control System
FCS: Flow Control System
LCS: Level Control System
GDM: Gas Distribution Mechanism
WP: Water Pump
PR: Pressure Regulator




**Block Diagram of Biogas Purification & Bottling Plant**

# Moisture Removal Setup

PSA type drier is employed for the removal of moisture. Based on the concept of selective adsorption of moisture at the outer surface of adsorbents such as Silica Gel, Activated Alumina, Zeolite Molecular Sieves etc.




Packed Bed Length: 1.5 M
Packed Bed Diameter: 25 mm
Working Pressure: ~7 Bar
Working temperature: Ambient
Capacity: 6 $NM^3/Hr$

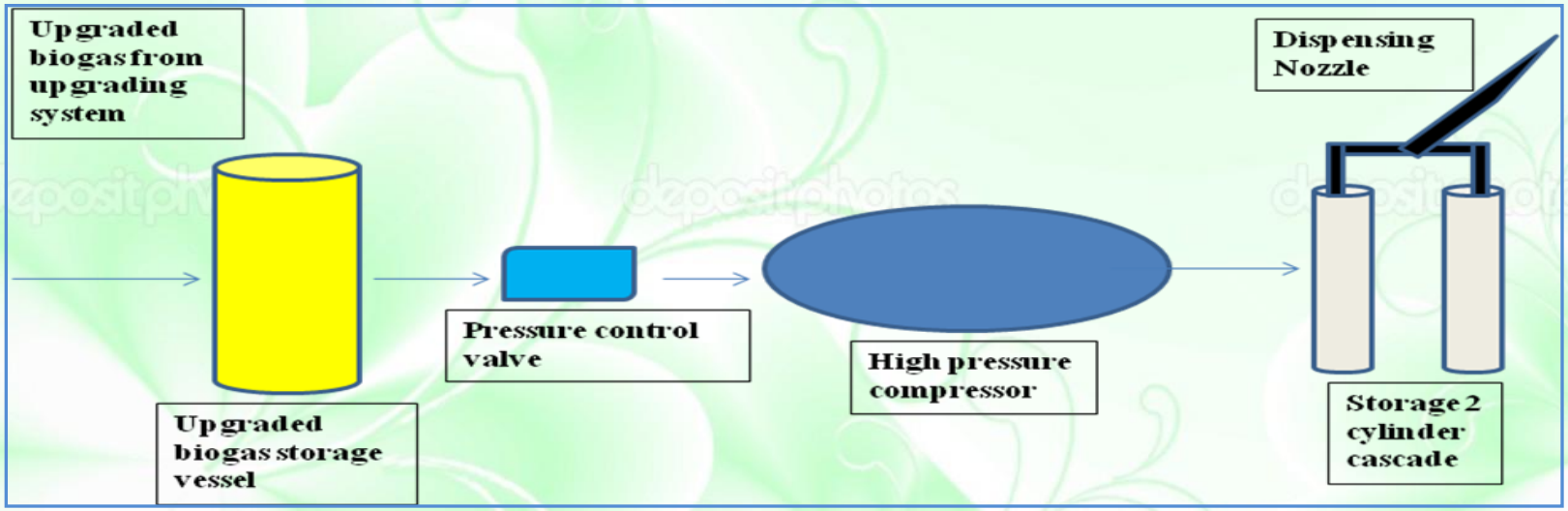
**PSA type Drier for Moisture Removal**

# 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.



# Control System

Is used for maintaining the desired working parameters in the plant. There are mainly three control systems in the plant:

- Water flow rate control
- Gas pressure Control
- Water level control

## Power Consumption in the Upgrading Plant:

- For a 20 $Nm^3$/hr capacity plant, the power requirement in upgrading is —
- Raw Biogas Compressor: 3 KW
- Water Pump: 2 KW
- Control Valves & Sensors etc.: 0.25KW
- Total: 5.25 KW
- 0.26 kWhr/Nm3 of raw biogas.

## Power Consumption in the Bottling System :

- Energy Required for Compression And Bottling:3 kW
- Total energy required for upgrading and bottling of 20m3/hr of raw biogas=2 + 3+ 3+0.25 = 8.25 kW
- Power requirement per Nm3 raw biogas=0.4125 kWh
- System energy requirement as a percentage of raw biogas= 6.88 % of raw biogas energy


Biogas Plant at IIT Delhi

New Modified Water Scrubbing Tower at IIT Delhi

Liquid Redistribution unit in the new modified water scrubbing tower at IIT Delhi

Water pump

Rotameter


Intermediate Gas Compressor


High Pressure Compressor


Raw and upgraded biogas storage vessels


Two cylinder cascade for bottling of upgraded biogas

# Upgraded Biogas Dispensing System at IIT Delhi

# Dispensing upgraded biogas in vehicle

# Enriched Biogas Operated Three Wheeler Luggage Carrier



Biogas Dispenser


BIOGAS OPERATED VEHICLE
Demonstration and Performance Evaluation
IIT Delhi
Sponsored by
PCRA


Biogas
vehicle


BioGas


Biogas
vehicle
MNRE
Govt. of India

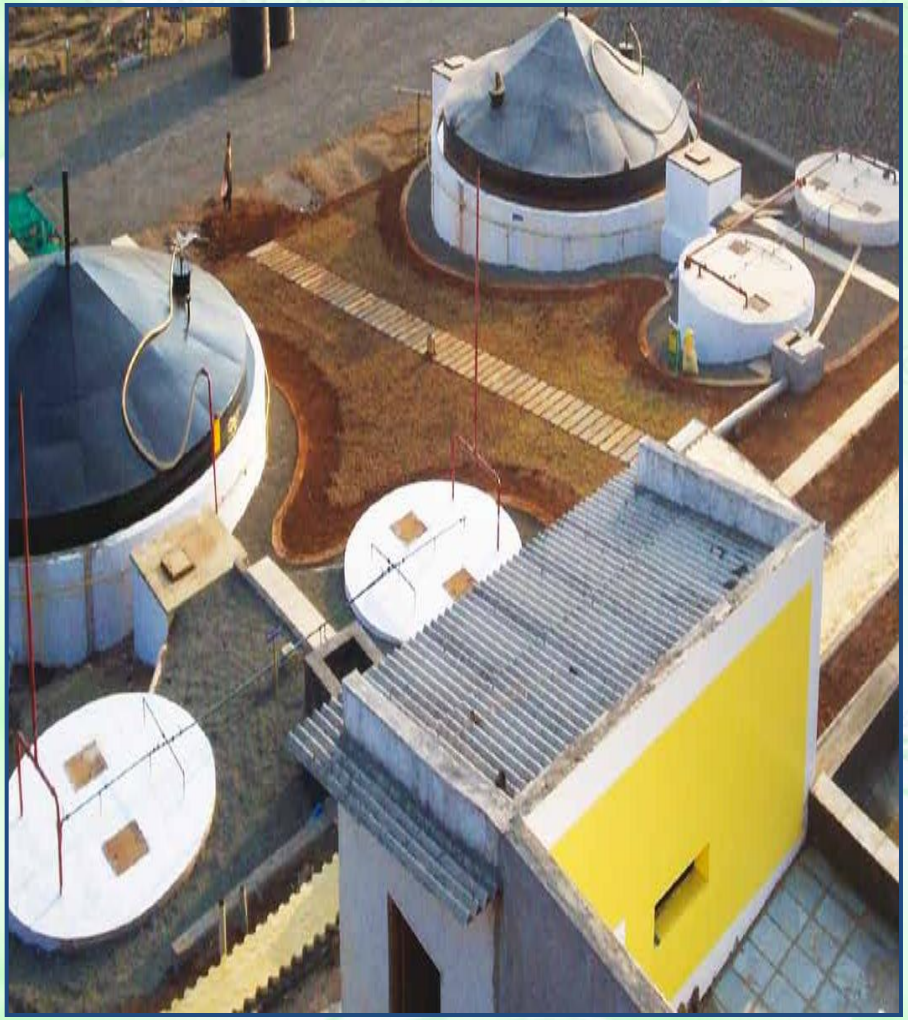
# Results

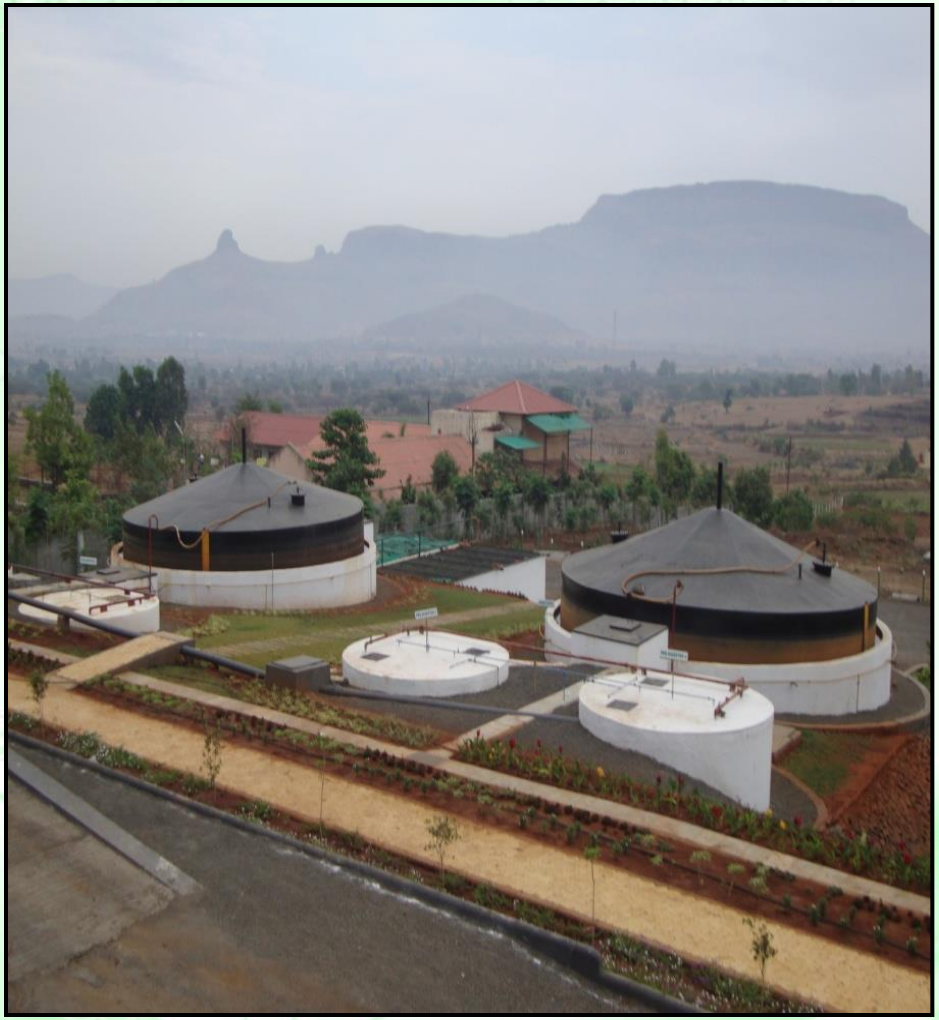
- A fully automatic plant of 20 $Nm^3$/Hr capacity has been developed successfully at IIT Delhi.
- Desired composition of purified gas ($CH_4$: 95% (min), $H_2S$: 20 ppm (max), Moisture: 20 ppm (max) is achieved with a consistent gas quality.
- Our system is automatically controlled with consistent quality of enriched gas and a methane loss of about 2%.

# Some pilot plants for biogas upgradation

- Rajasthan Go Sewa Sangh Jaipur since 2007
- Madhav Govigyan Sansthan Bhilwara 2008
- Muni Sewa Asharam near Vadodra since 2008
- Community level Biogas plant for piped distribution of gas near Valsad ( Guj) sine 2008
- Shri Krishna Goshala , Ghaziabad since 2009

# Biogas upgradation and bottling plant at Nasik, Maharashtra





Water Scrubbing and PSA system at Nasik

Cylinder Cascade for bottled biogas

High Pressure Compressor at Nasik plant

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

**In developing economies many entrepreneurial avenues in the biogas sector are available in :**

1) Goshalas
2) Poultry Farms
3) Dairy farms
4) Cluster of households in villages

## In the developing countries the following biogas enterprenurial options are possible

**Consider :** Cluster of households in villages

***Centralized waste collection system***

**Rural people put all their wastes- animal dung and human waste, agricultural wastes in a centralized collection place.**

***The waste is mixed and shredded then put in the biogas digesters***

***Raw biogas is then purified-***

**Bottled and filled in cascade of cylinders for transportation in rural areas.**

**Can be used for cooking or filling in the vehicle cylinders for transport,**

**Can be used for generating power using 100 % biogas engines**

# GOBAR BANK


# Community Biogas Plant (CBP)

Agricultural Waste

Cow Dung

Waste as Feedstock

Community Biogas Plants

Raw Biogas

Food Waste



Centralized Waste Collection

Water scrubbing

or

PSA

Purified Biogas

Biogas engine

Purified Cylinder Cascade

Electricity Production

Cooking Fuel

Transport Fuel

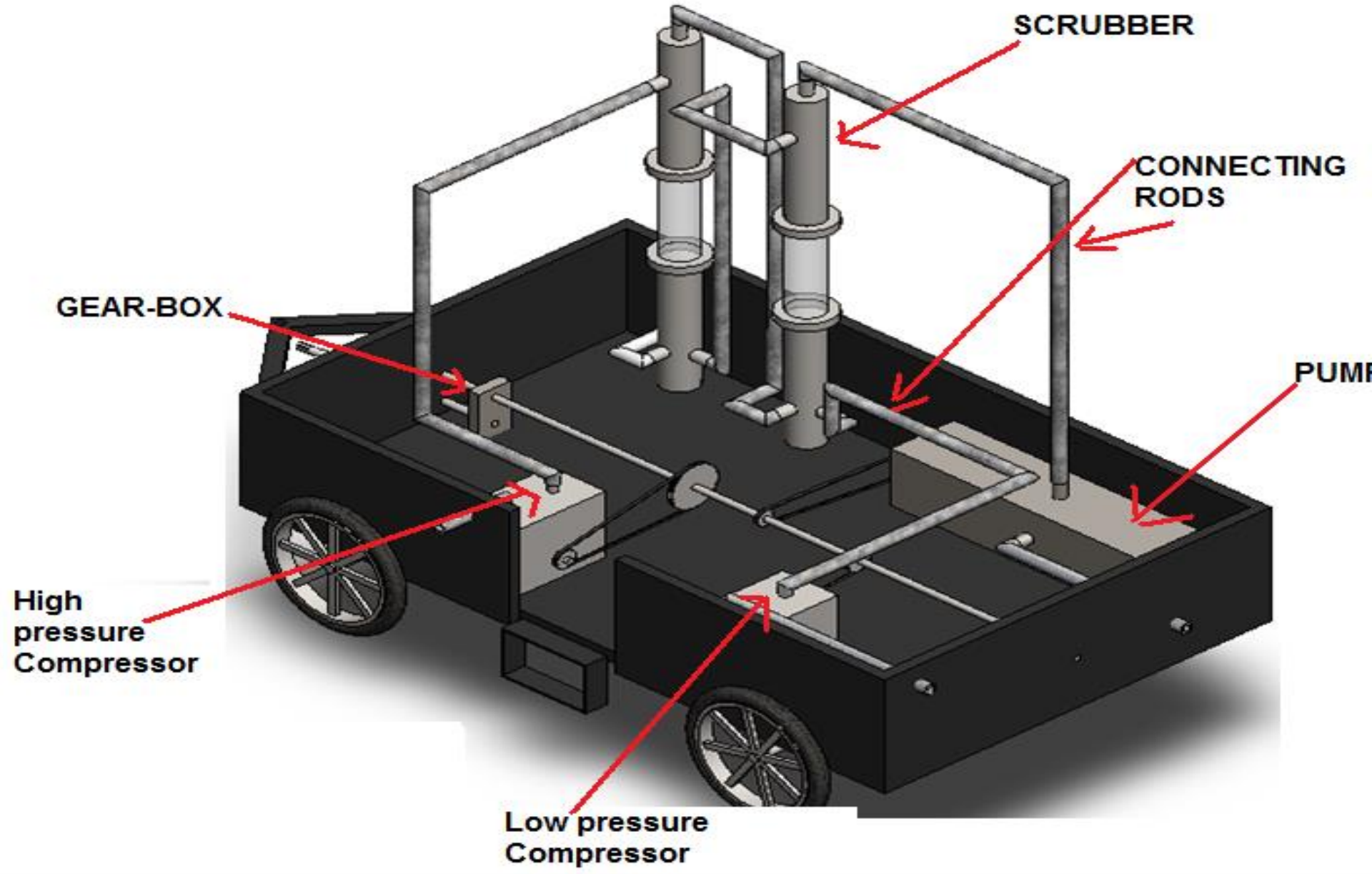
# Mobile biogas upgrading unit

- Upgradation unit is attached to a vehicle mounted on a trolley. This unit can cater to more than one biogas plants in a cluster.

- The trolley mounted machine with the help of a vehicle can be transported to the digesters located at different locations and raw biogas is filled up in the storage vessel.

- The raw biogas can be upgraded by these mobile units and can fill up CNG cylinders for storage at high pressure and transported to the required place with ease, causing an uninterrupted supply of upgraded biogas

# Mobile biogas upgrading unit



# Economic viability of 200 $m^3$ $day^{-1}$ biogas production and 20 $m^3$ $hour^{-1}$ upgrading plant

| | | |
|---|---|---|
| **Biogas Plant:** | | |
| | **Biogas Production** | **200 $Nm^3$ $day^{-1}$** |
| **A.** | **Cost:** | **Rs. 2 million (~ €30,000)** |
| **Biogas Upgrading and Bottling System (20 $m^3$ $hour^{-1}$)** | | |
| | **Purified Gas Quantity** | **~ 80 kg $day^{-1}$** |
| | **Purified Gas Composition** | **$CH_4$: 95 %, $CO_2$: 3, $H_2S$: < 20 ppm, Moisture: < 20 ppm** |
| | **Cost of biogas upgrading system** | **Rs. 4.5 million** |
| | **Cost of biogas bottling system** | **Rs. 0.5 million (including high pressure compressor system, cylinders for gas storage and gas dispensing system)** |
| **B.** | **Total cost of biogas upgrading and bottling system** | **Rs. 3.5 million (~ € 75,000)** |
| **Slurry Management System** | | |
| | **Slurry Production** | **~ 1.5 tonnes (50 % solid)** |
| **C.** | **Cost:** | **Rs. 1million (~ € 15,000)** |
| **D.** | **Other Costs : Land preparation, Civil work, High pressure gas storage cylinders taxes, Logistic etc.** | **Rs. 1million (~ € 15,000)** |
| | **Total Initial Cost of Project (A+ B+ C+D)** | **Rs.9 million (~ € 1,35,000)** |

| | | |
|---|---|---|
| **Revenue: if upgraded biogas is sold as a vehicle fuel** | | |
| | **Purified Gas: as vehicle fuel** | **(Rs. 35 kg) * (80 kg) = Rs. 2800 day$^{-1}$** |
| | **Slurry:** | **(Rs. 3 kg$^{-1}$) * (1500 kg) = Rs. 4500 day$^{-1}$** |
| | **Total Revenue** | **Rs. 7300 day$^{-1}$** |
| **E.** | **Annual Revenue:** | **(Rs. 7300 day$^{-1}$) * (350 day) = Rs. 2.6 million (~ € 39,000)** |
| | **Cost of Dung** | **(Rs. 250 tonne$^{-1}$) * (5 tonnes day$^{-1}$) = Rs. 1250 day$^{-1}$** |
| | **Annual cost of dung** | **(Rs. 1250 day$^{-1}$) * (365) = Rs. 0.45 million** |
| | **Annual cost of water and electricity** | **Rs. 0.15 million (Annual)** |
| | **Annual cost of manpower** | **Rs. 0.2 million (Annual)** |
| | **Annual Maintenance cost** | **Rs. 0.15 million** |
| **F.** | **Total Recurring cost** | **Rs. 0.95 million (~ € 14,200)** |
| | **Annual Profit:** | **Rs. 1.65 million (~ € 25,000)** |
| | **Subsidy (Power Equivalent)** | **Rs. 1.6 million** |
| | **Beneficiary Expenditure** | **Rs. 7.4 million (~ € 1,10,000)** |
| | **Payback Period** | **4.625 years** |
| **Revenue: if upgraded biogas is sold as a cooking fuel** | | |
| | **Purified Gas as cooking fuel**<br>**Commercial gas cost @ 72 kg** | **(Rs. 70 kg$^{-1}$) * (80 kg) = Rs. 5600 day$^{-1}$** |
| | **Slurry:** | **(Rs. 3 kg$^{-1}$) * (1500 kg) = Rs. 4500 day$^{-1}$** |
| | **Total Revenue** | **Rs. 10,100 day$^{-1}$** |
| **G.** | **Annual Revenue:** | **(Rs. 10,100 day$^{-1}$) * (350 day) = Rs. 3.56 million (~ € 52,000)** |
| | **Total Recurring cost** | **Rs. 0.95 million (~ € 14,200)** |
| | **Annual Profit:** | **Rs. 2.61 million (~ € 39,000)** |
| | **Subsidy (Power Equivalent)** | **Rs. 1.6 million** |
| | **Beneficiary Expenditure** | **Rs. 7.4 million (~ € 1,10,000)** |
| | **Payback Period** | **2.84 years** |

- An automatic plant of 20 $Nm^3$/Hr capacity has been developed successfully at IIT Delhi.

- Desired composition of purified gas ($CH_4$: 95% (min), $H_2S$: 20 ppm (max) has been achieved with a consistent gas quality.

- The system gives consistent quality of enriched gas as per the Indian Standards for Upgraded Biogas.

# Standards for Upgraded Biogas in India (BIS)

Upgraded biogas delivered to any vehicle, stationary engine or piped network shall comply to the following standards……

| No. | Biogas Component | Percentage |
|---|---|---|
| 1 | Methane ($CH_4$) | ≥ 90 % |
| 2 | Carbon Dioxide ($CO_2$) | ≤ 4 % |
| 3 | Hydrogen Sulphide ($H_2S$) | ≤ 20 ppm |
| 4 | Moisture | ≤ 0.02 g $m^{-3}$ |

# Conclusions

- Out of several methods of biogas enrichment, water scrubbing is found to be a simple, easy and suitable method for enrichment of biogas.

- An indigenous technology is developed by IIT Delhi for small sale biogas enrichment and bottling.

- The designed and fabricated biogas water scrubber is able to enrich biogas with above 95% methane .

- To make biogas suitable for automobile application, the enriched biogas is compressed up to 200 bar and filled in special high pressure cylinders (as used in CNG filling).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# THANK YOU