BIOGAS: A FIT OPTION FOR RURAL ENERGY

* Energy requirement in rural area.
* Biogas potential in India.
* Biogas: properties and applications.
* Biogas plant designs.
* Contribution to rural areas.
* Conclusion.

INTRODUCTION

- Biogas is clean environment friendly fuel that can be obtained by anaerobic digestion of animal residues and domestic and farm wastes, abundantly available in the countryside.

- Biogas is an important renewable energy resource for rural areas in India

- Biogas generally comprise of 55-65 % methane, 35-45 % carbon dioxide, 0.5-1.0 % hydrogen sulfide and traces of water vapor.

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

INTRODUCTION

- Biogas like Liquefied Petroleum Gas (LPG) cannot be liquefied under normal temperature and pressure.

- Critical temperature required for liquefaction of methane is -82.1^{o}C at 4.71MPa pressure, therefore use of biogas is limited nearby the biogas plant.

- 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.

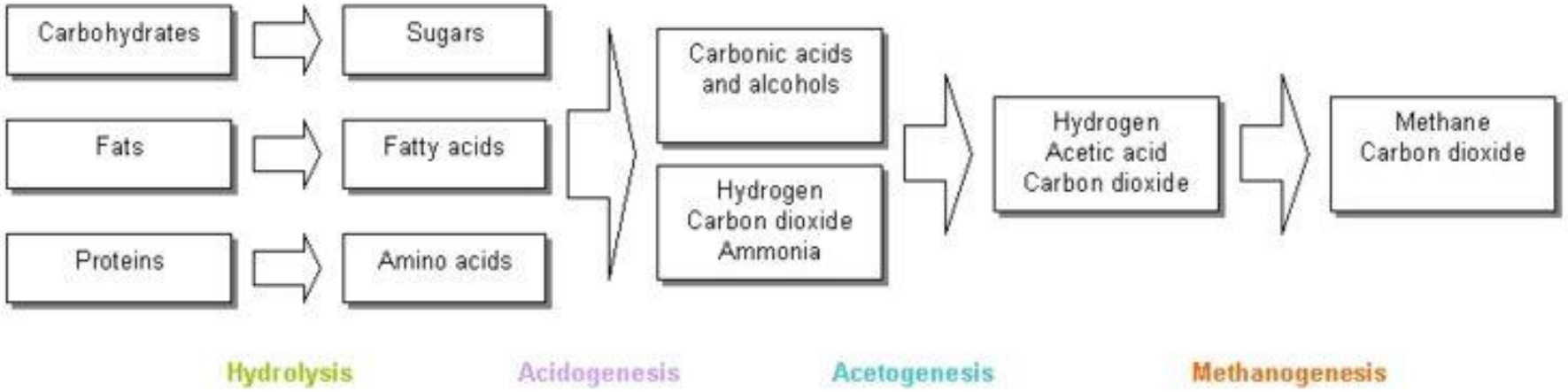
- The heat value of this gas amounts to 1.3 X 10^{12} MJ. In addition, 350 million tones of manure would also produce along with biogas.

POTENTIAL OF BIOGAS IN INDIA

* Cattle population : 300 million
* Farm families : 75 million
* Own 4 or more cattle : 43 million
* Potential of setting up family size BGP : 12 million
* Established : 4.75 million
* Dung collection (55% efficiency) : 1575 million kg/day
*Gas production : 39.85million cum gas/day
*Assuming 60% eff. equivalent to = 112695 million K.cal/day
= 12.37 million lit.of kerosene
= 14.54 million lit. of crude oil
= 16.26 million Kg.of coal
= 23.94 million lit. of fire wood
= 131.04 million kWh.of electricity

BIOGAS PRODUCTION PROCESS

Biogas production process (Anaerobic digestion) is a multiple-stage process in which some main stages are:



Chemical reactions involved in biogas production:

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

$$CO_2 + 4H_2 > CH_4 + 2H_2O$$

$$CH_3COOH > CH_4 + CO_2$$

THE QUANTITY, RATE AND COMPOSITION OF BIOGAS GENERATED DEPENDS ON

- The nature and concentration of the substrate,
- Feed rate,
- C/N Ratio,
- pH value,
- Bacterial population,
- Temperature, and
- Chemical inducers.

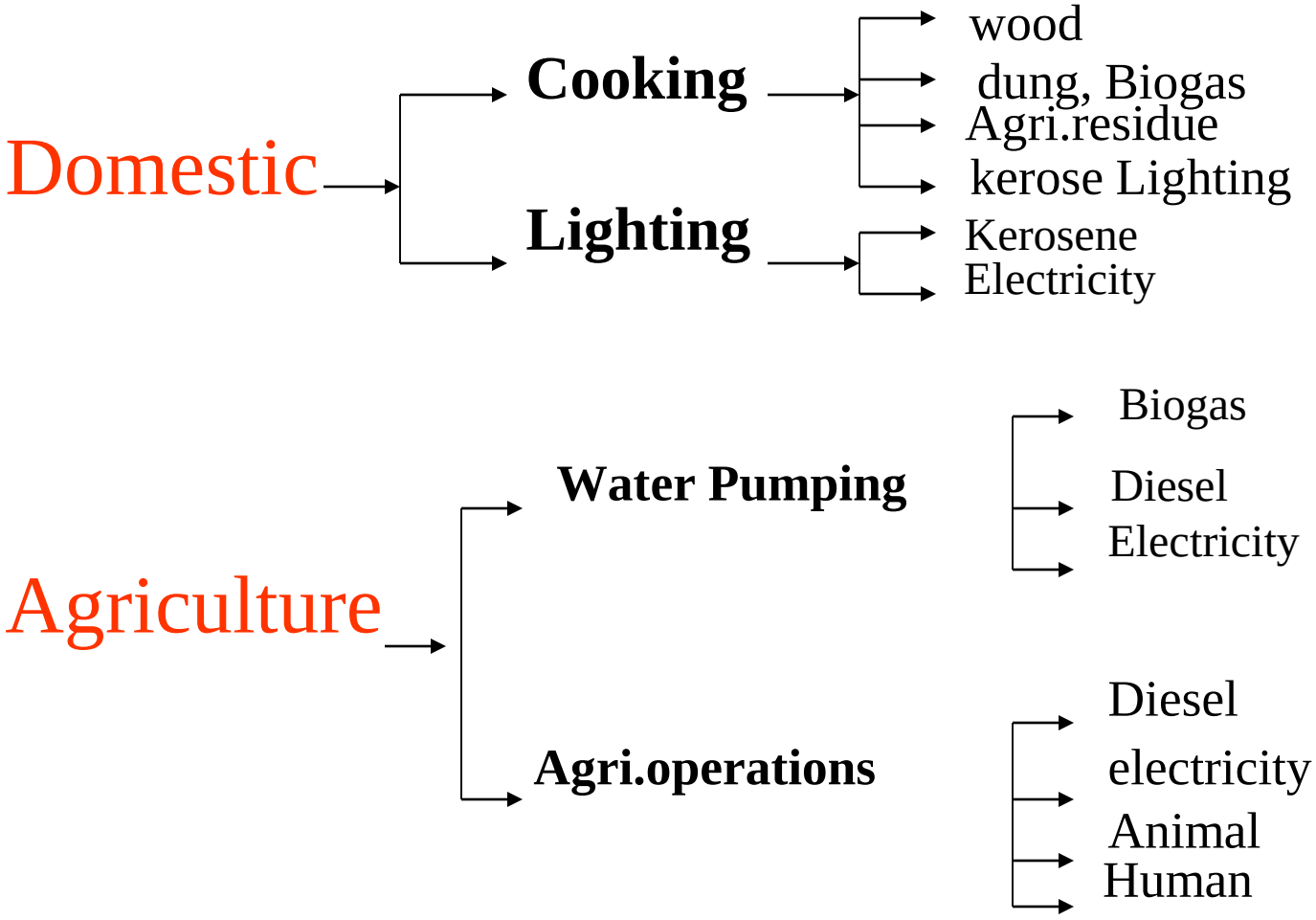
BIOGAS PRODUCTION POTENTIAL FROM DIFFERENT WASTES

Sl. No.	Raw Material	Biogas Production Litres/ kg	Methane content in Biogas (%)
1.	Cattle Dung	40	60.0
2.	Green leaves and twigs	100	65.0
3.	Food Waste	160	62.0
4.	Bamboo dust	53	71.5
5.	Fruit waste	91	49.2
6.	Bagasse	330	56.9
7.	Dry leaves	118	59.2
8.	Non-edible oil seed Cakes	242	67.5

UTILIZATION OF BIOGAS

- **Cooking:** Biogas can be used in a specially designed burner for cooking purpose. A biogas plant of 2 cubic metres capacity is sufficient for providing cooking fuel needs of a family of about five persons.
- **Lighting:** Biogas is used in silk mantle lamps for lighting purpose. The requirement of gas for powering a 100 candle lamp (60 W) is 0.13 cubic metre per hour.
- **Power Generation:** Biogas can be used to operate a dual fuel engine to replace up to 80 % of diesel-oil. Diesel engines have been modified to run 100 per cent on biogas. Petrol and CNG engines can also be modified easily to use biogas.
- **Transport Fuel:** After removal of CO_2, H_2S and water vapor, biogas can be converted to natural gas quality for use in vehicles.

ENERGYCONSUMPTION PATTERN IN RURAL AREAS



Transportation

- Vehicle → Diesel/ petrol
- Cart → Animal

Industries → Cottage Ind.

- Electricity
- Coal
- Diesel /Petrol
- Bio mass / Biogas

Factors Affecting Optimum Biogas Production

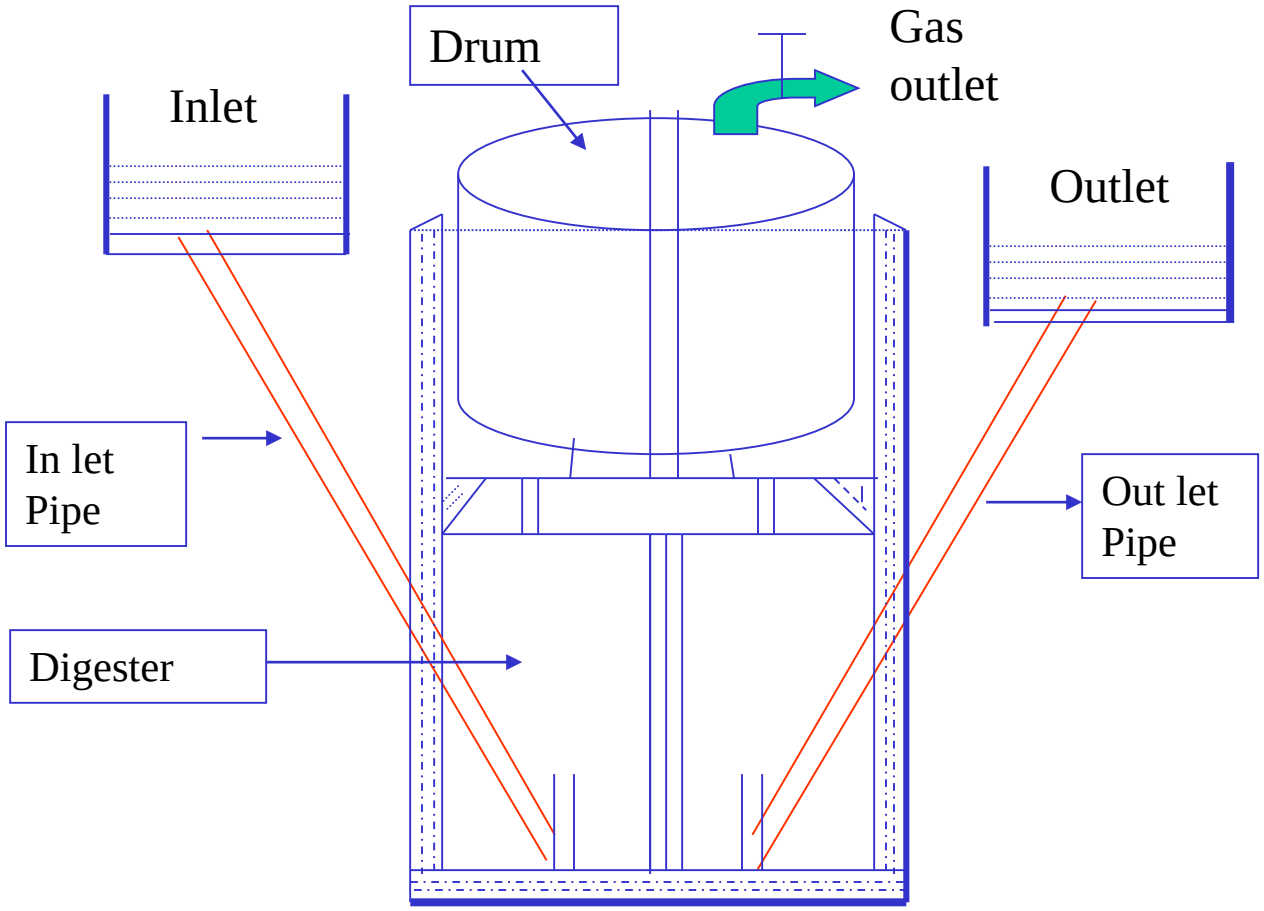
- **Temperature (35-37 C Mesophilic condition)**
- **C/N ratio (optimum between 25:1 to 30:1)**
- **pH (optimally pH between 6.8-7.2)**
- **Solid content (feed material should have approx. 10:1)**
- **Should not have toxic material/ harmful material to bacteria in digester**
- **HRT (Hydraulic Retention Time – 30, 40, 55 days)**
- **Loading rate**

Overview of commercially viable technologies

- Family size biogas plants (1 to 10 m^3) – KVIC, Deenbandhu, Janta, Pragati, Flexi etc.

- Large scale biogas plants (10 to 140 m^3) – KVIC

- Large scale plants above 1000 m^3 – UASB, Modified UASB, BIMA Digester (suitable for industrial effluents, MSW, fruit and vegetable waste etc.)

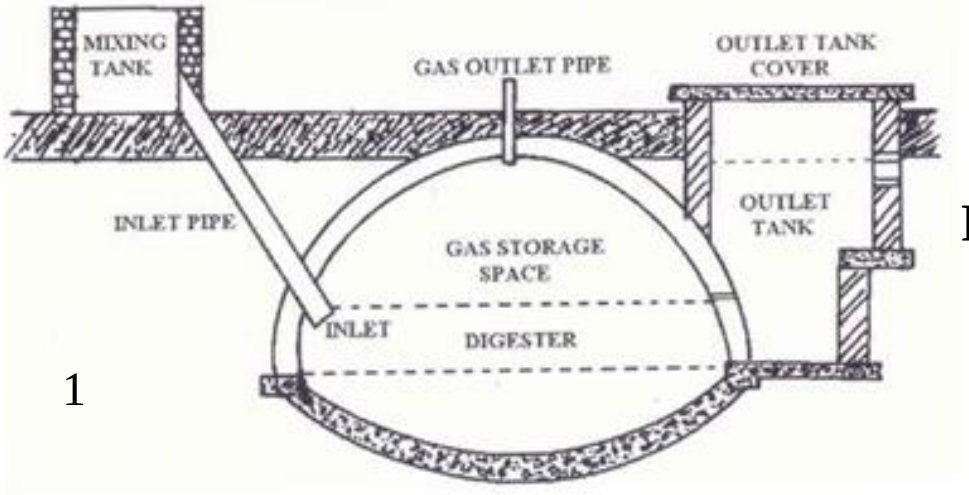


FLOATING DRUM TYPE BIOGAS PLANT

Biogas Plant

20 m^3/day Capacity Biogas Plant installed at IIT Delhi

Biogas Plant Designs



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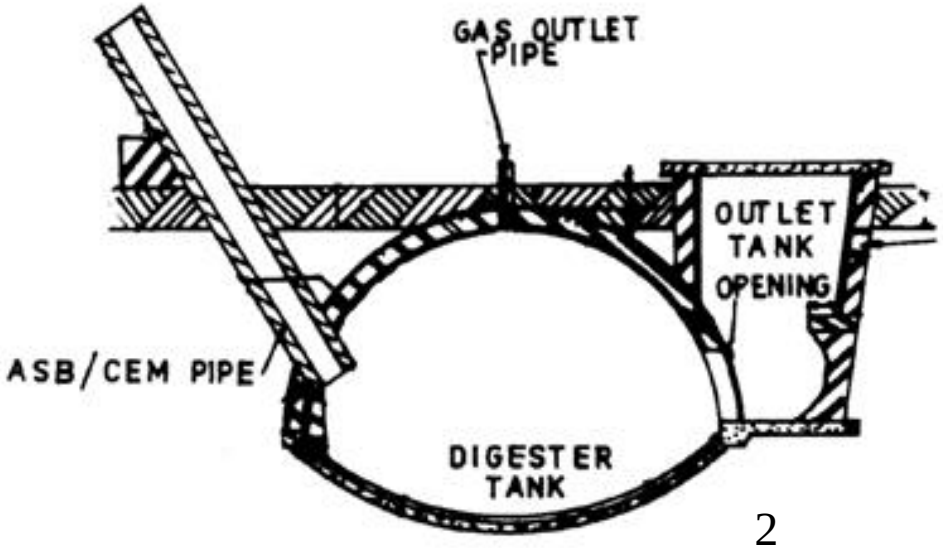

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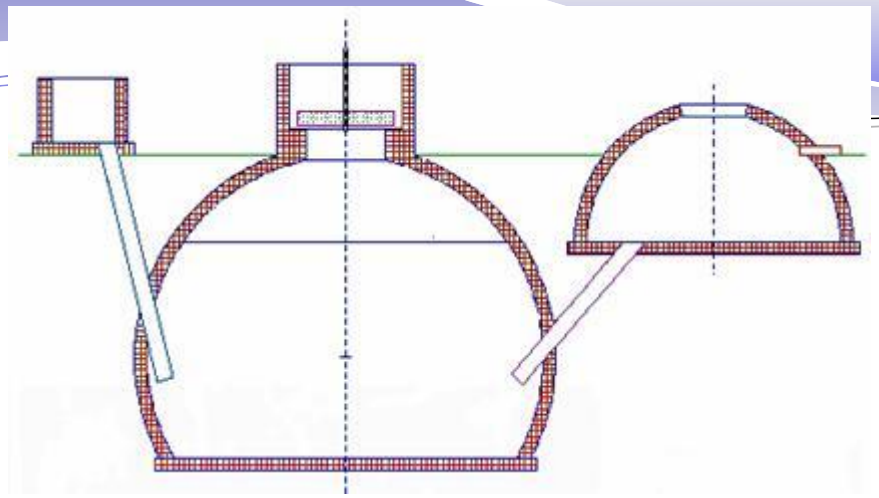
Fixed Dome type family size Biogas plant

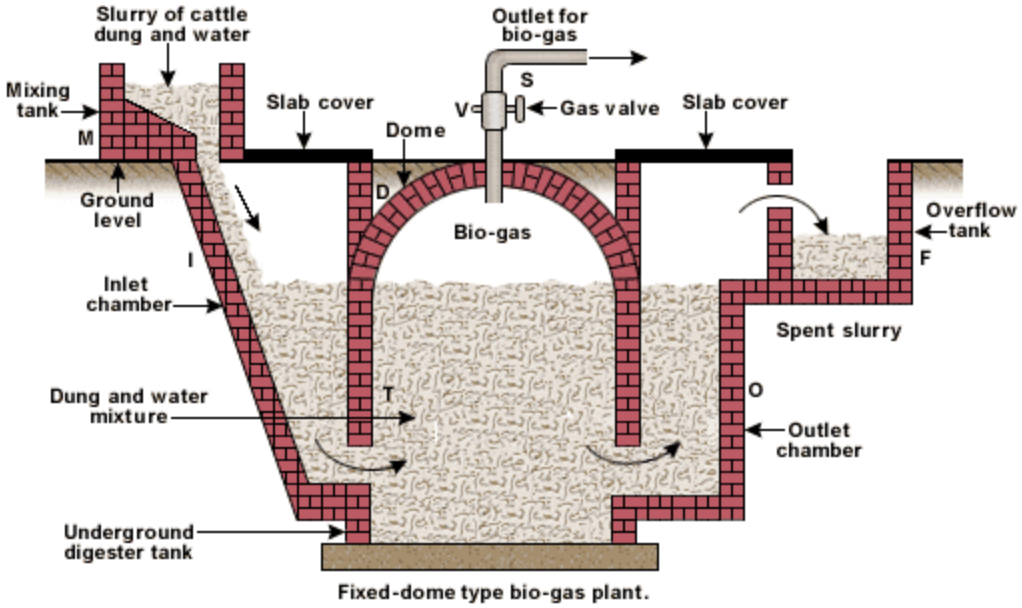
[1] Deenbandhu

[2] Modified for solid state

- **Water : (-) 3/4th**
- **Space : (-) 3/4th**
- **Gas : (+) 30%**
- **Operation easier**
- **Cost almost same**

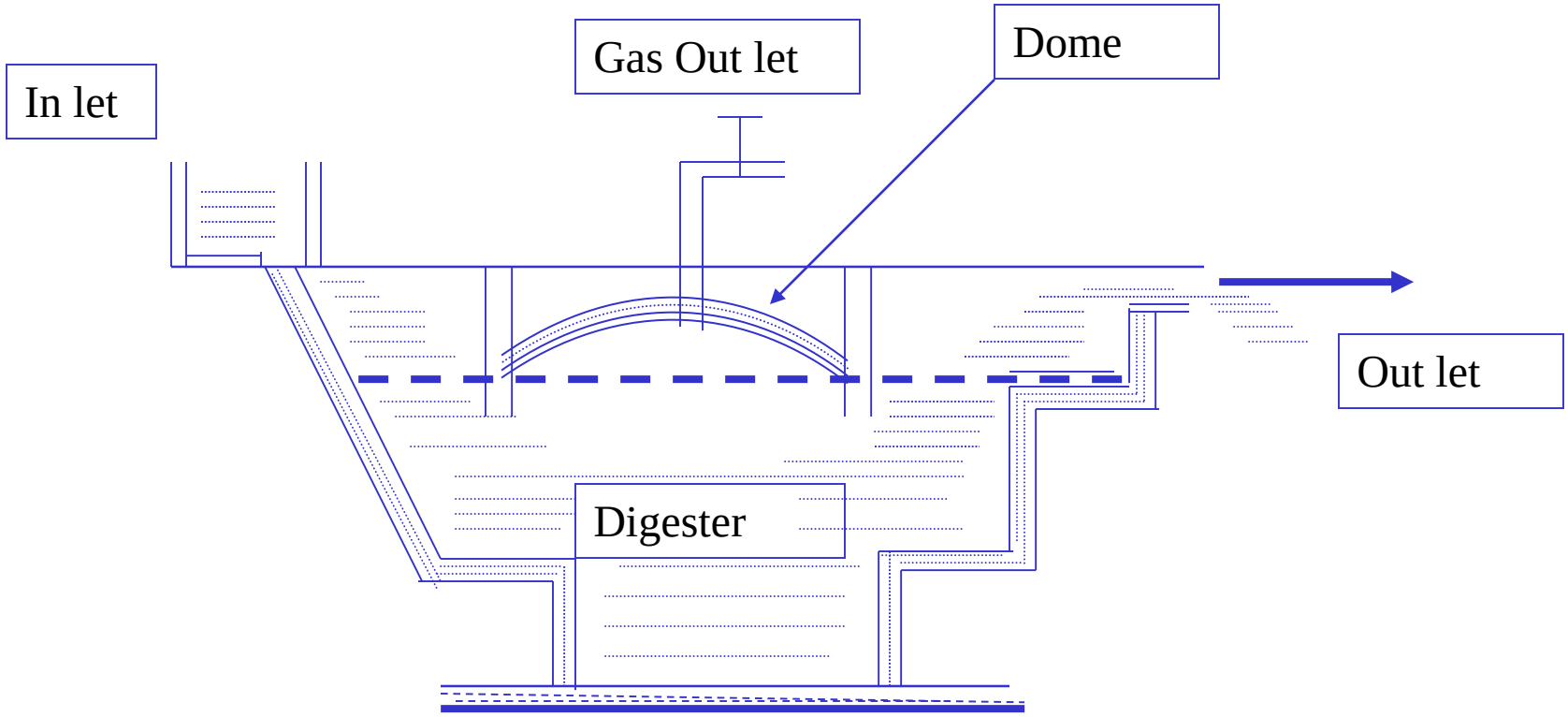


An outline of fixed dome biogas plant



Fixed-dome type bio-gas plant.

Detailed structural design of fixed dome biogas plant



FIXED DOME TYPE BIOGAS PLANT

CONTRIBUTION OF BIOGAS TECHNOLOGY TO RURAL AREAS

* Better and cheaper fuel for cooking, lighting and power generation.
* Produces good quality enriched manure to improve spoil fertility.
* Effective and convenient way for sanitary disposal of human excreata, improving the hygienic conditions.
* generate social benefits - reducing burden on forest, reduction in drudgery of women and children.
* As a smokeless domestic fuel it reduces the incidence of eye and lung diseases.

Possible Application of Biogas - Cooking. Lighting " Motive power Generation"

Table: **Quantities of Biogas consumed for different applications.**

Use	Specification	Quantities of Biogas consumed (M
Cooking	2" Burner	0.33
	4" Burner	0.47
	6" Burner	0.62
Per person Per day for cooking	→	0.24 m^3/day
Gas Lighting mantle lamp of	100 Candle Power	0.13 cum/hr
Dual fuel Engine	75-80% Replacement	0.50 m^3/ bhp /hour.
Electricity	1kwh	0.75

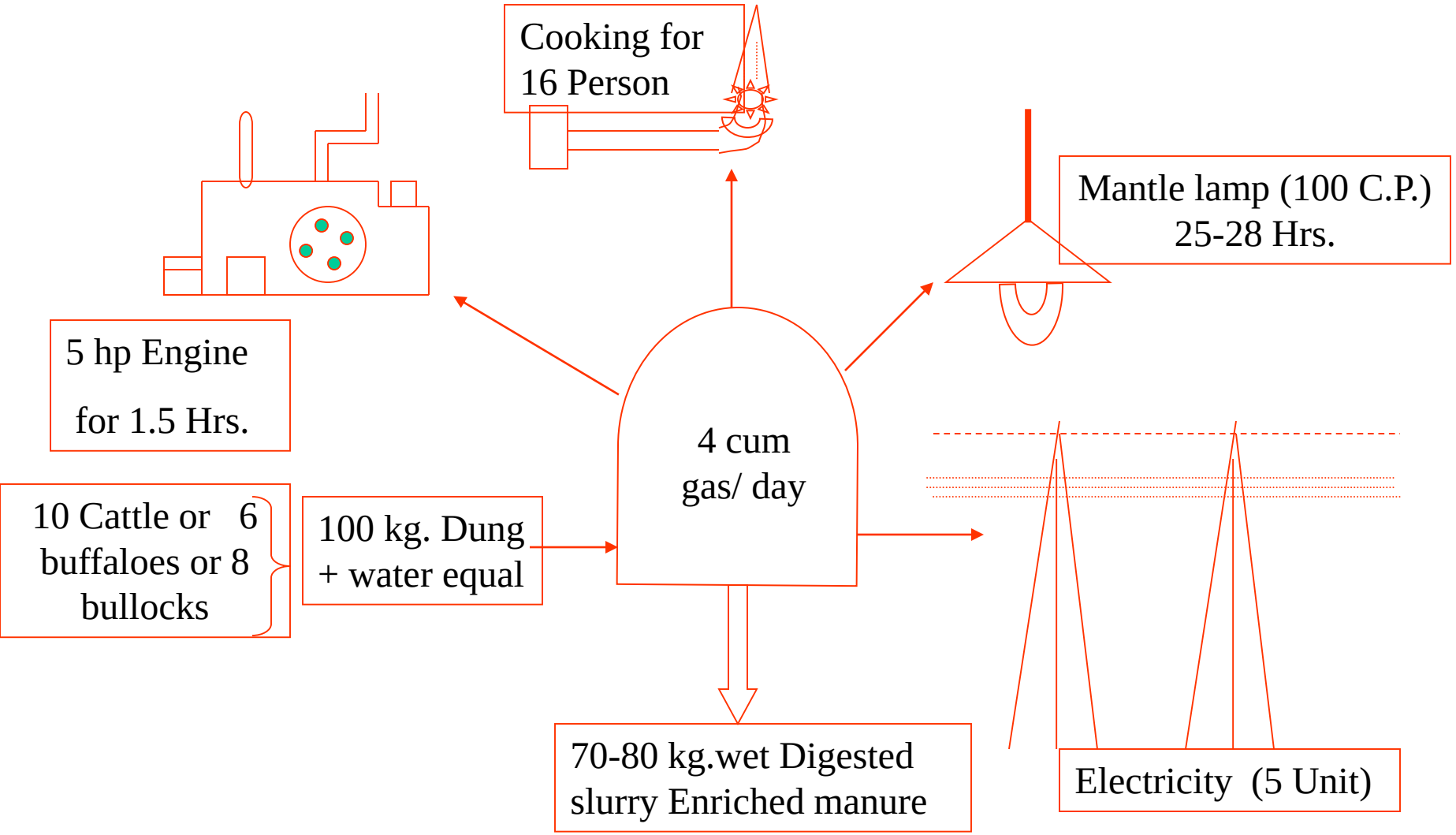
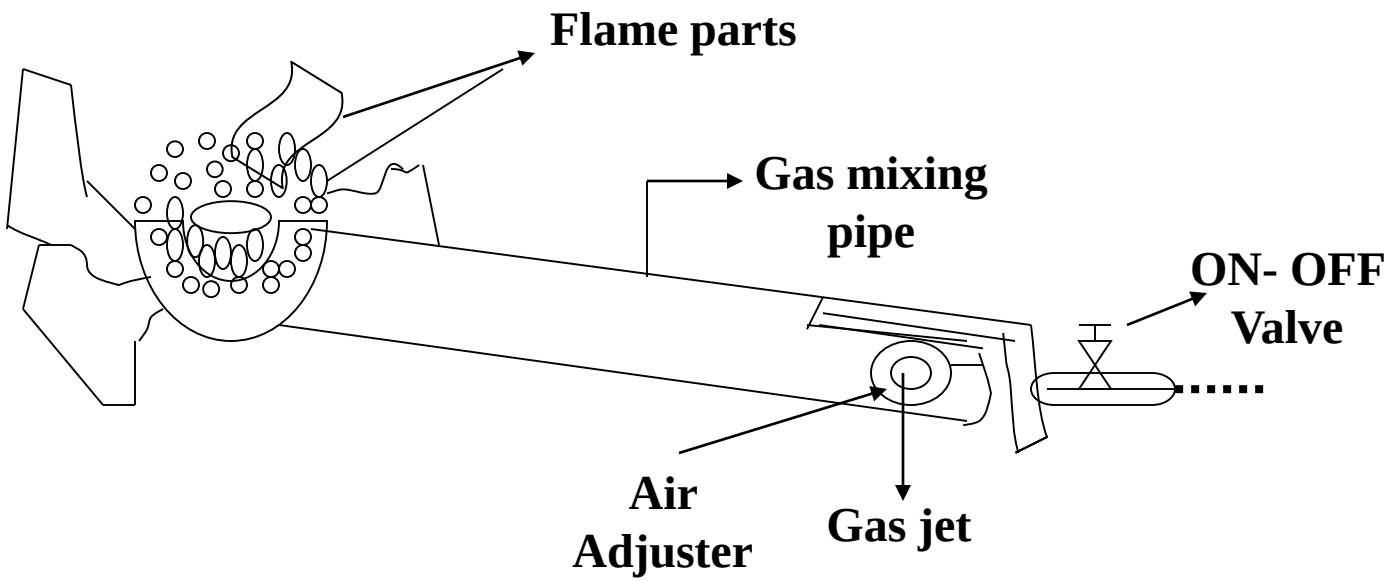


FIG : POSSIBLE APPLICATION OF BIOGAS

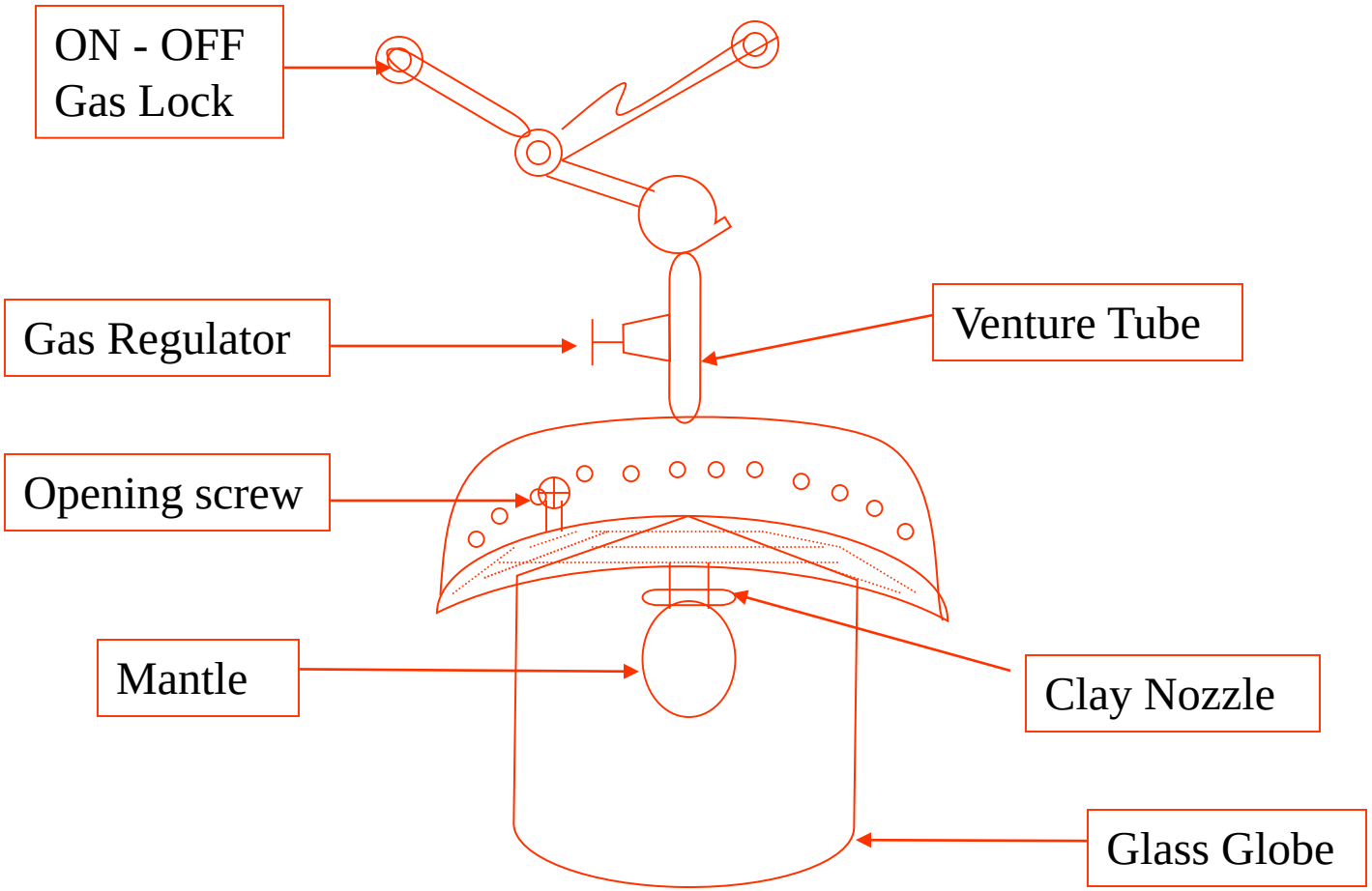
Cooking: **Typical0.45m^3 (16cubic feet) per hour stove, popular dimension are: jet size 2.25mm dia,area of jet - 3.98mm^2 Flame past size:6.0mm dia,No. of pasts :20, total area of posts =565mm^2**

ratio of jet area to flame post area = 1:142

Length & Dia of gas mixing pipe = 20mm



Biogas flame



INSIDE TYPE Lamp

Biogas Lamp for Lighting

Generation of power : Diesel / petrol saving

How ever, the power obtained is less as composed to liquid fuel alone, engine become hotter hence cooling has to be kept in good condition.

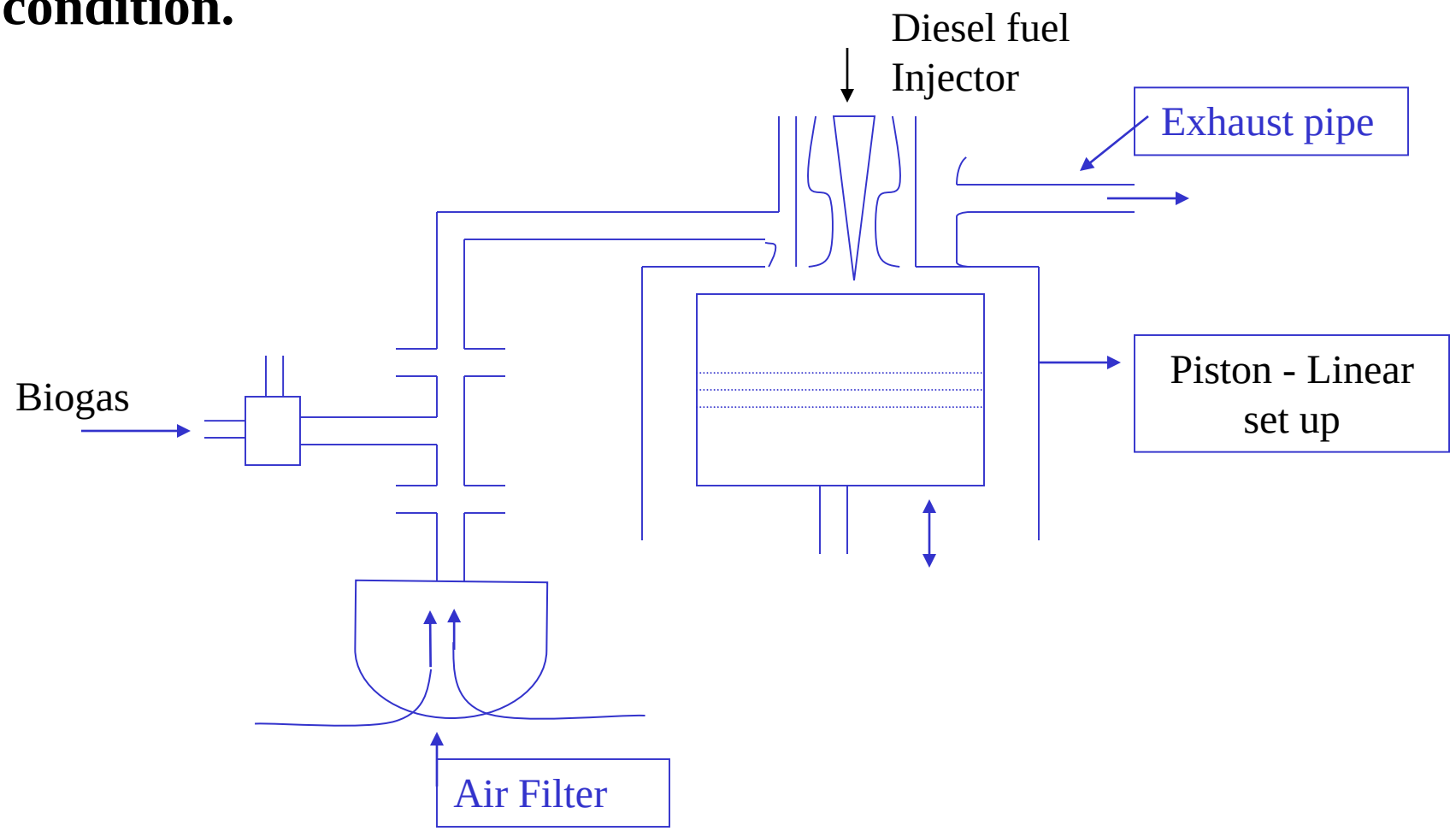


Table - Quantity of Diesel oil saved by running a 5 hp dual fuel engine on biogas.

Size of biogas	5 hp engine is run twice a day	Quantity of dies Diesel oil (lit./day)
8	4 hour	3.6
15	6.5 hour	5.8
25	12 hour	10.8

UTILIZATION OF BIOGAS FOR FUEL, LIGHT, MANURE AND MOTIVE POWER GENERATION

BIOGAS :- Main constituent Methane (CH_4) = 55-70 %, Carbon dioxide (Co_2) =30-45%, other gases like Nitrogen, Hydrogen, Co, Oxygen, and H_2S in small quantities. Almost 20% lighter than air and has an gumption temperature of 650-750^oC. It's calorific value 4700 kcal/cum.

Table :- Potential gas production From different feed stocks.

Type of feed stock	Gas yield (m^3/kg)	Normal manure availability per animal per day (kg)	Gas yield per day (m^2)
Dung : cattle	**0. 036**	**10**	**0. 36**
Buffalo	**0. 036**	**15**	**0. 54**
Pig	**0. 078**	**2.25**	**0. 18**
Chicken	**0. 062**	**0. 18**	**0. 011**
Human excreta	**0. 070**	**0.4**	**0. 028**

TABLE :- Comparison of various Fuels.

Name of Fuel	Calorific value (k cal/kg)	Thermal Efficiency (%)	To replace ($1m^3$) Biogas	Useful heat (k cal/kg)
Gobar gas (m^3)	4713	60	1	2770
Kerosene (lit.)	9600	50	0. 62 lit.	4800
Fire wood (kg)	4700	10	3. 474 kg	470
Cow dung cake (kg)	2090	10	12. 29 kg	209
Char coal (kg)	6930	28	1. 458 kg	2079
Soft cake(kg)	6292	28	1. 605 kg	1887
Indane (kg)	10882	60	0. 433 kg	6529
Furnace oil (lit)	9041	75	0. 417	6780
Coal gas (m^3)	4004	60	1.177	2400
Electricity	860	70	4. 698	602

Special features of Biogas engine.

(1) **Saving in diesel :-** can replace 80% diesel.

Example: 5 hp engine running daily 8 hour on biogas & normal specific fuel consumption 175 gms/bhp- our for 25 days pr month operation.

Then omly42 lit. diesel will be required and about 168 lit.of diesel per month will be saved.

(2) The engine cost can be recovered in one year.

Monthly saving - 168 lit. @ 5.00 Rs/lit. = Rs. 840.00 or Rs 10080.00 per year. Hence cost recovered.

(3) Exhaust smoke density - is less when run on biogas .

(4) Exhaust gas temperature- remains almost the same.

(5) Engine deposits - general cleanliness of engine with biogas is better then the diesel operation.

Compression of gas :- It liquefies at a pressure of about 47.4kg/cm^2 at a critical temp of - 82.1^{0}C.

Not economics on account of cost of cleaning the gas, compressing it, purchasing a special high pressure storage bottle and transporting these heavy bottles. 3.5 Balloon are available 3.5cum size.

Manure for agriculture and aquaculture-

Table :- comparison of NPK contents -

Plant Nutrient	DS (%)	FYM (%)
NITOGEN (N)	1.5-2.0	0.5-1.0
PHOSPHOROUS	1.0	0.5-0.8
POTASH	1.0	0.5-0.8

About 70-75% of original wt. of dung is conserved on BG plant while in compost 50% is lost .

Slurry as manure improves soil fertility & increases crop yield by 10-20%

Recommended dosage – 10 tonnes /ha in irrigated & 5tonnes / ha in unirrigated use full for raising fish common crop fry & fingerlings fed on a mixture of 1:3 (rice bran & slurry) on equal nitrogen basis showed faster growth in farmer. Recommended feed for SINGI fish is equal quality of mustered oil cake bran & digested slurry.

Integrated energy system -

Defined as a concept that encompasses -

-…….All the facets on the rural energy problem - an integrated approach which is expected to result in optimum matching of the needs with energy availability the emphasis is on renewable sources which can result in local, decentralized option which are ecologically sound.

Schematic Diagram for Biogas Fertilizer Plant
(For Rural Entrepreneurs/ Women Self Help Groups)