JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem	-	IV Year & VII Semester
Subject	-	Power Generation Sources [7EE6-60.2]
Unit	-	V (Bio Mass Energy)
Presented by	-	Lalit Kumar Sharma, Department of Mech. Engg.

VISSION AND MISSION OF INSTITUTE

Vision:

To become a renowned center of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission:

M1: Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.

M2: Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.

M3: Offer opportunities for interaction between academia and industry.

M4: Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISSION AND MISSION OF DEPARTMENT

Vision:

The Mechanical Engineering Department strives to be recognized globally for excellent technical knowledge and to produce quality human resource, which can manage the advance technologies and contribute to society through entrepreneurship and leadership.

Mission:

M1: To impart highest quality technical knowledge to the learners to make them globally competitive mechanical engineers.

M2: To provide the learners ethical guidelines along with excellent academic environment for a long productive career.

M3: To promote industry-institute linkage.

Introduction of Biomass Energy

•Biomass has always been an important energy source for the country considering the benefits it offers. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. Biomass is also capable of providing firm energy.

•About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. Ministry of New and Renewable Energy has realised the potential and role of biomass energy in the Indian context and hence has initiated a number of programmes for promotion of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits.

•For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration programme.

Potential of Biomass Energy

•The current availability of biomass in India is estimated at about 500 million metric tonnes per year.

•Studies sponsored by the Ministry has estimated surplus biomass availability at about 120-150 million metric tonnes per annum covering agricultural and forestry residues corresponding to a potential of about **18,000 MW**.

•This apart, about 7000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them

Technology

1.Combustion

The thermo chemical processes for conversion of biomass to useful products involve combustion, gasification or pyrolysis. The most commonly used route is combustion.

The advantage is that the technology used is similar to that of a thermal plant based on coal, except for the boiler. The cycle used is the conventional rankine cycle with biomass being burnt in high-pressure boiler to generate steam and operating a turbine with the generated steam.

The exhaust of the steam turbine can either be fully condensed to produce power, or used partly or fully for another useful heating activity. The latter mode is called cogeneration. In India, cogeneration route finds application mainly in industries.

Technology

2. Cogeneration In Sugar Mills

Sugar industry has been traditionally practicing cogeneration by using bagasse as a fuel. With the advancement in the technology for generation and utilization of steam at high temperature and pressure, sugar industry can produce electricity and steam for their own requirements.

It can also produce significant surplus electricity for sale to the grid using same quantity of bagasse. For example, if steam generation temperature/pressure is raised from $400^{o}C/33$ bar to $485^{o}C/66$ bar, more than 80 KWh of additional electricity can be produced for each ton of cane crushed.

The sale of surplus power generated through optimum cogeneration would help a sugar mill to improve its viability, apart from adding to the power generation capacity of the country.

Deployment of Biomass Energy

•The Ministry has been implementing biomass power/co-generation programme since mid-nineties.

•Over 500 biomass power and bagasse cogeneration projects aggregating to **9806 MW** capacity has been installed in the country for feeding power to the grid.

•States which have taken leadership position in implementation of bagasse cogeneration projects are Maharashtra, Karnataka, Uttar Pradesh, Tamil Nadu and Andhra Pradesh.

•The leading States for biomass power projects are Chhattisgarh, Madhya Pradesh, Gujarat, Rajasthan and Tamil Nadu.

Current Status

•A total capacity of 10145 MW has been installed in Biomass Power and Cogeneration Sector.

•Installed Capacity of Biomass IPP – 1826 MW

•Installed Capacity of Bagasse Cogeneration – 7547 MW

•Installed Capacity of Non-Bagasse Cogeneration - 772 MW

State-wise break up - 01

Name of State/UT	Biomass IPP (In MW)	Bagasse Cogeneration (In MW)	Non-Bagasse Cogeneration (In MW)	Cumulative Installed Capacity (as on 31.12.2019)
Andhra Pradesh	171	206.9	105.57	483.67
Bihar	12	100.5	12.2	124.7
Chhattisgarh	222	20	2.5	244.9
Gujarat	44.5	20.8	12	77.3
Haryana	19.4	102	89.26	210.66
Karnataka	137	1729.8	20.2	1887.3
Madhya Pradesh	92.5	0	14.847	107.347
Maharashtra	217	2351	16.4	2584.4
Punjab	139	161	173.95	473.45
Rajasthan	114	4.95	2	121.25

State-wise break up - 02

Name of State/UT	Biomass IPP (In MW)	Bagasse Cogeneration (In MW)	Non-Bagasse Cogeneration (In MW)	Cumulative Installed Capacity (as on 31.12.2019)
Tamilnadu	219	750.4	43.55	1012.65
Telangana	60.1	98	2	160.1
Uttrakhand	0.12	72.6	57.5	130.22
Uttar Pradesh	28	1929.5	159.76	2117.26
West Bengal	300	-	19.92	319.92
Odisha	50.4	-	8.82	59.22
Himachal Pradesh	-	-	9.2	9.2
Kerala	-	-	2.27	2.27
Meghalaya	-	-	13.8	13.8
Jharkhand	-	-	4.3	4.3

State-wise break up - 03

Name of State/UT	Biomass IPP (In MW)	Bagasse Cogeneration (In MW)	Non-Bagasse Cogeneration (In MW)	Cumulative Installed Capacity (as on 31.12.2019)
Assam	-	-	2	2
Manipur	-	-	-	0
Nagaland	-	-	-	0
Arunachal	-	-	-	0
Tripura	-	-	-	0
Sikkim	-	-	-	0
Mizoram	-	-	-	0
Goa	-	-	-	0
J & K	-	-	-	0
Total	**1826**	**7547.45**	**772.047**	**10145.917**

Brief Introduction of Biogas

•Biogas is produced when bio-degradable organic materials/wastes such as catle-dung, biomass from farms, gardens, kitchens, industry, poultry droppings, night soil and municipals wastes are subjected to a scientific process, called Anaerobic Digestion (A.D.) in a Biogas Plants.

•Biogas Plant designs depend upon several factors and the feed stock to be processed is of paramount importance. Biogas is the mixture of gases (primarily methane (CH_4) and Carbon di-oxide (CO_2) and traces of Hydrogen Sulfide (H_2S), Moisture) produced by the decomposition/breakdown of bio-degradable organic matter in the absence of oxygen from raw materials such as agricultural waste, cattle dung, poultry droppings, municipal waste, plant material, sewage, green waste or food/kitchen waste.

•Biogas has a calorific value of about 5000 kcal per m^3. The digested slurry produced from Biogas Plants as a by-product is a better source of nutrient enriched organic manure for use in Agriculture. It not only helps in improving the crop yield but also maintain soil health.

Biogas

•There is ample potential of setting up biogas plants considering the livestock population of 512.06 million, which includes about 300 million (299.98 million) total population of bovines (comprising of cattle, buffalo, mithun and yak). The livestock sector contributes about significantly to India’s GDP and will continue to increase. The dissemination of biogas technology is a boon for Indian farmers with its direct and collateral benefits.

•The Ministry of New and Renewable Energy promotes installation of biogas plants by implementing 2 Central Sector Schemes under Off-Grid/distributed and decentralized Renewable Power. The two on going schemes are:

[i] New National Biogas and Organic Manure Programme (NNBOMP), for Biogas Plant size ranging from 1 cu.m. to 25 cu.m. per day.

[ii] Biogas Power Generation (Off-grid) and Thermal energy application Programme (BPGTP), for setting up biogas plants in the size range of 30 m^3 to 2500 m^3 per day, for corresponding power generation capacity range of 3 kW to 250 kW from biogas or raw biogas for thermal energy /cooling applications.

Biogas

•Biogas contains about 55-65 % of methane, 35- 44 % of carbon dioxide and traces of other gases, such as Hydrogen Sulphide, Nitrogen and Ammonia. Biogas, in its raw form, that is without any purification, can be used as clean cooking fuel like LPG, lighting, motive power and generation of electricity.

•It can be used in diesel engines to substitute diesel up to 80% and up to 100% replacement of diesel by using 100% Biogas Engines.

•Further, Biogas can be purified and upgraded up to 98% purity of methane content to make it suitable to be used as a green and clean fuel for transportation or filling in cylinders at high pressure of 250 bar or so and called as Compressed Bio-Gas (CBG).

State/UT-wise estimated potential and cumulative achievements for biogas plants

State/ Union Territories	Estimated Potential (Nos. of Biogas Plants)	Cumulative achievement up to 2018-19* (31/03/2019) (Nos. of Biogas Plants)
Andhra Pradesh	1065000	555294
Arunachal Pradesh	7500	3591
Assam	307000	138423
Bihar	733000	129905
Chhattisgarh	400000	58908
Goa	8000	4226
Gujarat	554000	434995
Haryana	300000	62825
Himachal Pradesh	125000	47680
Jammu & Kashmir	128000	3195
Jharkhand	100000	7823
Karnataka	680000	503935
Kerala	150000	152019

State/UT-wise estimated potential and cumulative achievements for biogas plants

State/ Union Territories	Estimated Potential (Nos. of Biogas Plants)	Cumulative achievement up to 2018-19* (31/03/2019) (Nos. of Biogas Plants)
Madhya Pradesh	1491000	373037
Maharashtra	897000	918201
Manipur	38000	2128
Meghalaya	24000	10659
Mizoram	5000	5838
Nagaland	6700	7953
Odisha	605000	271656
Punjab	411000	183835
Rajasthan	915000	72132
Sikkim	7300	9044
Tamil Nadu	615000	223618
Telangana	-	19694
Tripura	28000	3688

State/UT-wise estimated potential and cumulative achievements for biogas plants

State/ Union Territories	Estimated Potential (Nos. of Biogas Plants)	Cumulative achievement up to 2018-19* (31/03/2019) (Nos. of Biogas Plants)
Uttar Pradesh	1938000	440385
Uttarakhand	83000	363615
West Bengal	695000	972
A&N Islands	2200	97
Chandigarh	1400	169
Dadra & Nagar Haveli	2000	681
Daman & Diu	-	0
Lakshdweep	-	0
Delhi/ New Delhi	12900	578
Puducherry	4300	17541
KVIC Mumbai	-	0
TOTAL :	**12339300**	**50,28,340***

State wise cumulative achievements under biogas power (off-grid) programme up to 2018-19 (finalized as on 31.03.2019)

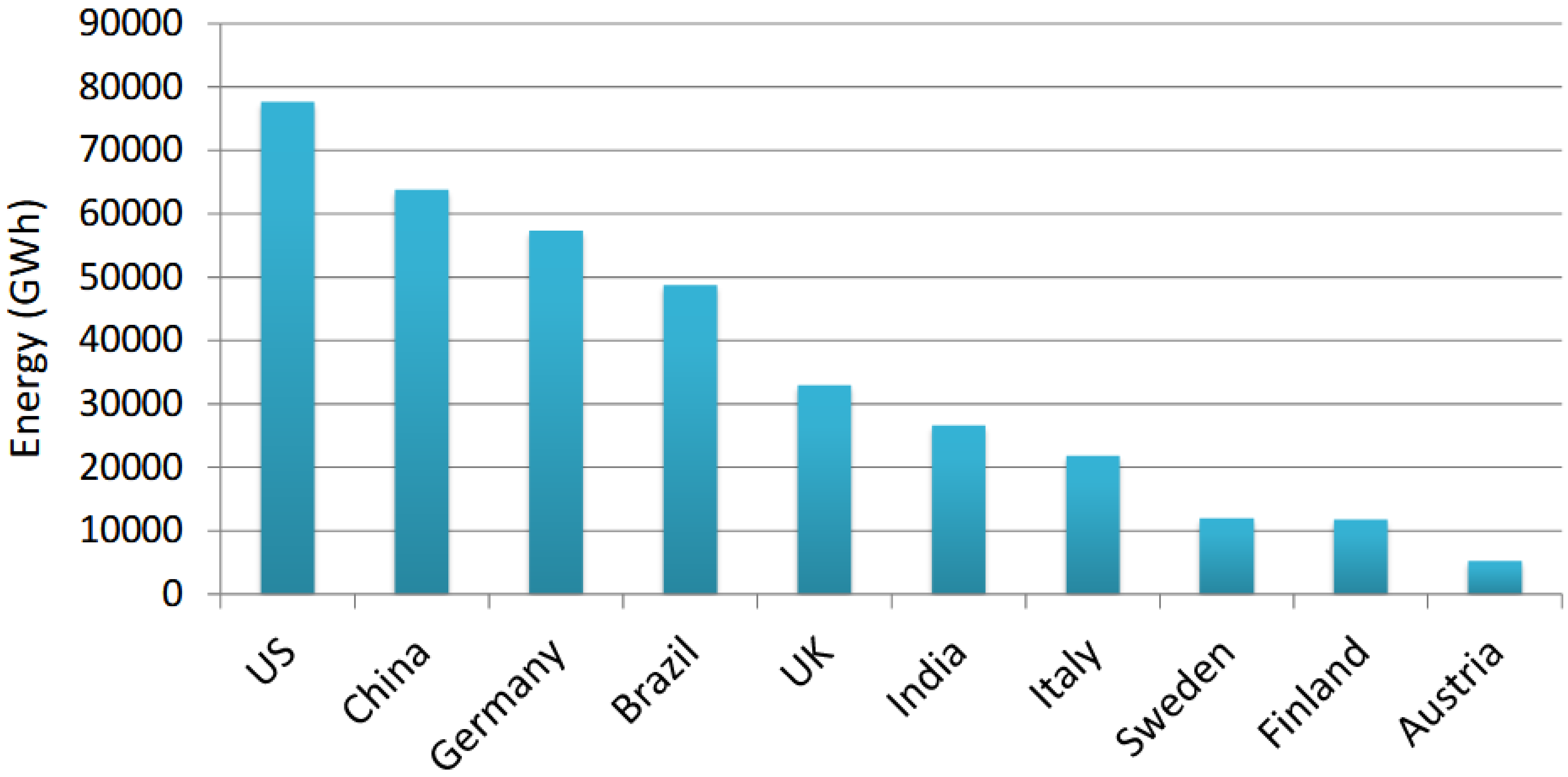
S.No	Name of the state	Installed		
		Nos	M^3	kW
1	Andhra Pradesh	34	4320	481
2	Gujrat	2	285	30
3	Haryana	3	2540	155
4	Karnataka	70	15670	1581.5
5	Maharashtra	68	11690	1257.5
6	Punjab	41	9980	1035
7	Rajasthan	2	120	15
8	Tamil Nadu	52	30360	2853.5
9	Uttarakhand	17	1070	124
10	Uttar Pradesh	30	4400	591
11	Madhya Pradesh	6	735	70
12	Kerala	36	1010	118
13	West Bengal	1	340	60
14	Odisha	2	60	10
15	Telangana	25	5410	574
		389	**87990**	**8951.5**

Impact of biogas power plants

•Based on the data reported and evaluation done through third party study, the overall impact of the programme implementation was observed to be encouraging. As revealed from the table given below, for a case study of 45 Biogas plants and extrapolated for 163 projects,

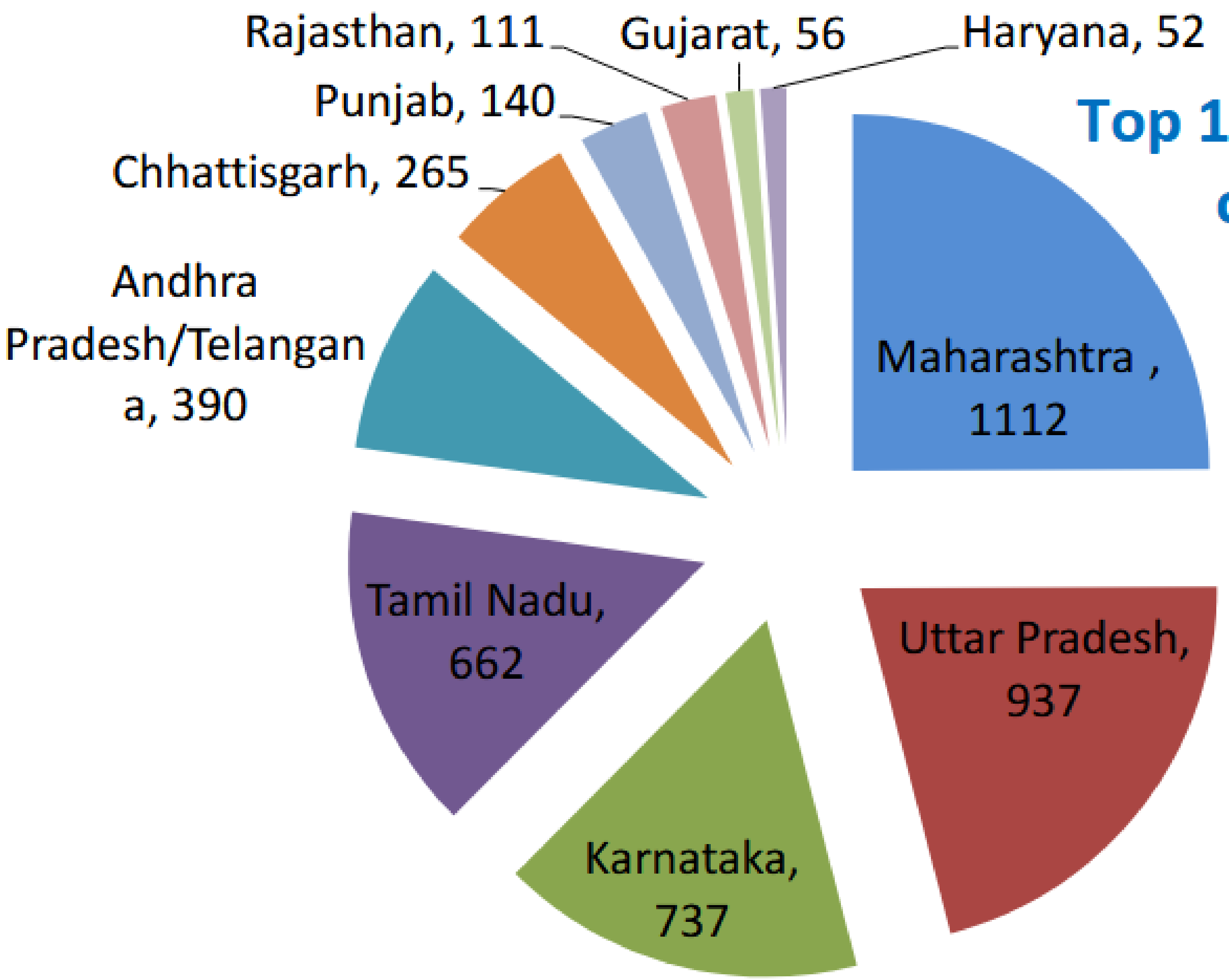
Total No. of Plants	163
Annual Energy Cost Savings (In Rs. Lakhs)	787
Annual CO_2 Savings (In Tons)	9587
Annual Bio-manure Production (In Tons)	32582
Direct Employment (Man-days)	63438
In-Direct Employment (Man-days)	56894

Top 10 nations in Biomass Electricity (GWh)



Source: https://en.wikipedia.org/wiki/List_of_countries_by_electricity_production_from_renewable_source

Top 10 nations in Biomass Electricity (GWh)



Top 10 states in Biomass capacity (MW) in India

Source: Ministry for New and Renewable Energy (MNRE)

Biomass Energy

- In the past few years, there have been significant improvements in renewable energy technologies along with declines in cost.
- The growing concern for the environment and sustainable development, have led to worldwide interest in renewable energies and bio-energy in particular.
- Biomass can be converted into modern energy forms such as liquid and gaseous fuels, electricity, and process heat to provide energy services needed by rural and urban populations and also by industry.

Biomass Energy-1

- This paper explains the different ways of extracting energy from biomass and a comparison is made among them.
- This paper also explains about the potentiality of biomass energy in India.
- Analyses current situation compares bio-energy and other options for promoting development.
- Brings out the advantages over the other renewables putting forth the drawbacks to be overcome to make it still more successful.
- This paper analyses current situation compares bio-energy and other options for promoting development, explore the potential for bio-energy.

Biomass Energy-3

Introduction

- In past 10 years or so, considerable practical experience has accumulated in India as well as in other developing and industrialized countries, on biomass energy production and conversion.
- India is pioneer among developing countries, with significant indigenous efforts in promoting renewable energy technologies.
- The importance of bio-energy as a modern fuel has been recognized. India has about 70,000 villages yet to be connected to the electricity grid.

Biomass Energy-4

- The supply of grid power to rural areas is characterized by
  - a) Low loads.
  - b) Power shortages.
  - c) Low reliability.
  - d) Low and fluctuating voltages.
  - e) High transmission and distribution costs and power losses.
- Decentralized power generation based on renewables is an attractive option to meet the energy needs.
- The availability of biomass such as wood, cow-dung, leaf litter in rural areas is more.
- Hence a choice of biomass energy especially in rural areas is more reasonable but at the same time the technology is being developed to meet the large-scale requirements using biomass.

Biomass Energy-5

- Biomass energy has played a key role in the time of Second World War when there was a fuel deficiency.
- Many vehicles, tractors and trucks used wood gasifies, which generate producer’s gas, running an internal combustion Engine.
- One of the major advantages of biomass energy is that it can be used in different forms.
- For e.g., Gas generated from the biomass can be directly used for cooking or it can be used for running an internal combustion Engine for developing stationary shaft power or otherwise coupled to generator for generating electric power.

Motivation

- There are several renewable and non-renewable energy options for power generation at the decentralized level.
- It is necessary to understand why biomass-based energy options should receive priority over other options and to discuss the advantages to local and global communities as well as the environment.
- Biomass is renewable fuel used in nearly every corner of the developing countries as a source of heat, particularly in the domestic sector.
- Biomass energy includes energy from all plant matter (tree, shrub, and crop) and animal dung.
- Biomass, unlike other renewables, is a versatile source of energy, which can be converted to modern forms such as liquid and gaseous fuels, electricity, and process heat.

Motivation-1

- For example, small-scale (5-100 KW), medium-scale (110MW), and large scale (about 50 MW).

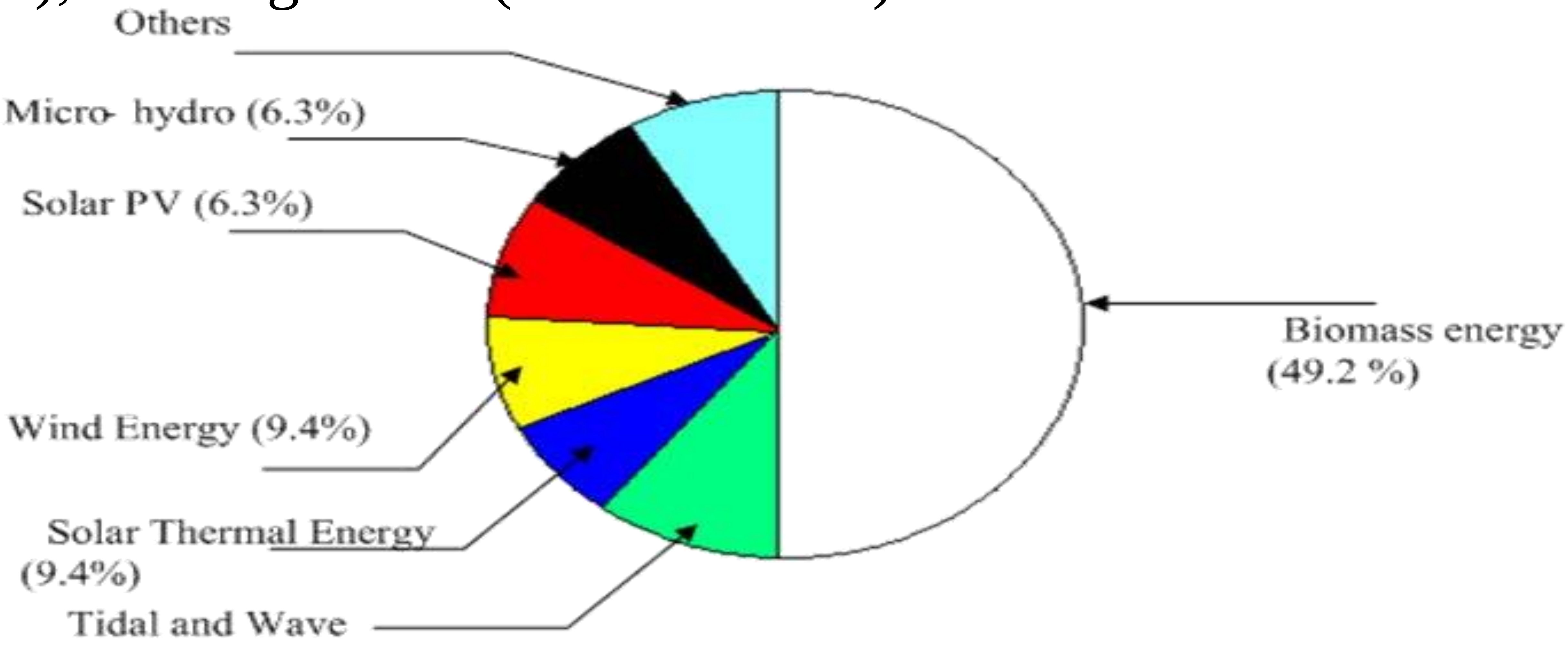


Fig 1: Expenditure on different renewable energy programmes for 1992-1997 indicating the share of bioenergy technologies for renewables in India

Motivation-2

- Advantages of biomass gasify energy over other renewable energy options:
  a) Suitable in most locations.
  b) Varying capacity can be installed; any capacity can be operated, even at lower loads; no seasonality.
  c) Need for storage of energy is not required.
- Advantages and drawbacks of biogas energy over other renewable energy options:
  a) It can be used directly for cooking, or heating water from the abundantly available dung and dried plant leaves in rural areas.
  b) Capacity determined by availability of dung. Not suitable for varying loads.
  c) Not feasible to locate at all the locations.

Different Ways of extracting energy from biomass

- The different methods of biomass extraction can be broadly be classified as:
  a) Anaerobic Digestion.
  b) Gasification.
  c) Liquefaction.
- **Solid fuel combustion**
  a) The simplest and most common way of extracting energy from biomass is by direct combustion of solid matter.
  b) Majority of the developing countries especially in rural areas obtain the majority of their energy needs from the burning of wood, animal dung and other biomass. But burning can be inefficient.
  c) An open fireplace may let large amounts of heat escape, while a significant proportion of the fuel may not even get burnt.

Different Ways of extracting energy from biomass-01

Gasification

- Gasification is a process that exposes a solid fuel to high temperatures and limited oxygen, to produce a gaseous fuel.
- This is a mix of gases such as carbon monoxide, carbon dioxide, nitrogen, hydrogen and methane.
- Gasification has several advantages over burning solid fuel.
- One is convenience – one of the resultant gases, methane, can be treated in a similar way as natural gas, and used for the same purposes.
- Another advantage of gasification is that it produces a fuel that has had many impurities removed and will therefore cause fewer pollution problems when burnt.

Different Ways of extracting energy from biomass-02

- under suitable circumstances, it can produce synthesis gas, a mixture of carbon monoxide and hydrogen.
- This can be used to make almost any hydrocarbon (e.g., methane and methanol), which can then be substituted for fossil fuels. But hydrogen itself is a potential fuel of the future.

Paralysis :

- Paralysis is an old technology with a new lease of life.
- In its simplest form it involves heating the biomass to drive off the volatile matter, leaving behind the black residue we know as charcoal.
- This has double the energy density of the original material.

Different Ways of extracting energy from biomass-03

- This means that charcoal, which is half the weight of the original biomass, contains the same amount of energy making the fuel more transportable.
- The charcoal also burns at a much higher temperature than the original biomass, making it more useful for manufacturing processes.
- More sophisticated Paralysis techniques have been developed recently to collect the volatiles that are otherwise lost to the system.
- The collected volatiles produce a gas rich in hydrogen (a potential fuel) and carbon monoxide.
- These compounds, if desired, can be synthesized into methane, methanol and other hydrocarbons. 'Flash' Paralysis can be used to produce bio-crude – a combustible fuel.

Different Ways of extracting energy from biomass-04

Digestion

- Biomass digestion works by the action of anaerobic bacteria.
- These microorganisms usually live at the bottom of swamps or in other places where there is no air, consuming dead organic matter to produce, among other things, methane and hydrogen.
- We can put these bacteria to work for us.
- By feeding organic matter such as animal dung or human sewage into tanks – called digesters - and adding bacteria, we can collect the emitted gas to use as an energy source.

Different Ways of extracting energy from biomass-05

- This can be a very efficient means of extracting usable energy from such biomass – up to two-thirds of the fuel energy of the animal dung is recovered
- A large proportion of household biomass waste, such as kitchen scraps, lawn clippings and pruning, ends up at the local tip.
- Over a period of several decades, anaerobic bacteria are at work at the bottom of such tips, steadily decomposing the organic matter and emitting methane.
- The gas can be extracted and used by 'capping' a landfill site with an impervious layer of clay and then inserting perforated pipes that collect the gas and bring it to the surface.

Different Ways of extracting energy from biomass-06

Fermentation

- Like many of the other processes described here, fermentation isn't a new idea.
- For centuries, people have used yeasts and other microorganisms to ferment the sugar of various plants into ethanol.
- Producing fuel from biomass by fermentation is just an extension of this old process, although a wider range of plant material can now be used, from sugar cane to wood fiber.
- For instance, the waste from a wheat mill in New South Wales has been used to produce ethanol through fermentation.
- This is then mixed with diesel to produce 'dishelm', a product used by some trucks and buses in Sydney and Canberra.

Different Ways of extracting energy from biomass-07

Anaerobic Digestion

- *Anaerobic Digestion* is a biochemical degradation process that converts complex organic material, such as animal manure, into methane and other byproducts.

What is Anaerobic Digester?

- Anaerobic digester (commonly referred to as an AD) is a device that promotes the decomposition of manure or “digestion” of the organics in manure to simple organics and gaseous biogas products.
- Biogas is formed by the activity of anaerobic bacteria. Microbial growth and biogas production are very slow at ambient temperatures.

Different Ways of extracting energy from biomass-08

- These bacteria occur naturally in organic environments where oxygen is limited.
- *Biogas is comprised of about 60% methane, 40% carbon dioxide, and 0.2 to 0.4% of hydrogen sulfide.*
- Manure is regularly put into the digester after which the microbes break down the manure into biogas and a digested solid.
- The digested manure is then deposited into a storage structure.
- The biogas can be used in an engine generator or burned in a hot water heater. AD systems are simple biological systems and must be kept at an operating temperature of 100 degrees F in order to function properly..

Different Ways of extracting energy from biomass-09

- The first methane digester plant was built at a leper colony in Bombay, India.
- Biogas is very corrosive to equipment and requires frequent oil changes in an engine generator set to prevent mechanical failure.
- The heating value of biogas is about 60% of natural gas and about 1/4 of propane.
- Because of the low energy content and its corrosive nature of biogas, storage of biogas is not practical.
- There are two major types of biogas designs promoted in India

  a) Floating Drum

  b) Fixed Dome

Different Ways of extracting energy from biomass-10

- The floating drum is an old design with a mild-steel, Ferro-cement or fiberglass drum.
- which floats along a central guide frame and acts as a storage reservoir for the biogas produced.
- The fixed dome design is of Chinese origin and has dome structure made of cement and bricks.
- It is a low-cost alternative to the floating drum, but requires high masonry skills and is prone to cracks and gas leakages.
- Family biogas plants come in different size depending on the availability of dung and the quantity of biogas required for cooking.
- The average size of the family is 5-6 persons, and thus biogas plant of capacity 2-4 m^3 is adequate. The biomass requirement is estimated to be 1200 liters for a family.

Different Ways of extracting energy from biomass-11

Comparison between two designs:

Fixed dome	Floating Drum
Digester and gas holder, masonry or concrete structure	Digester, masonry, Gas holder, mild steel or fiberglass
Requires high masonry skills	Low masonry or fabricating skills
Low reliability due to high construction failure	High reliability, gas holder prefabricated
Variable gas pressure	Constant gas pressure
Digester could be inside the ground	Requires space above ground for three tanks; inlet, digester, outlet
Low Cost (2 m^3 = Rs.5000)	Low Cost (2 m^3 = Rs.8000)

Different Ways of extracting energy from biomass-12

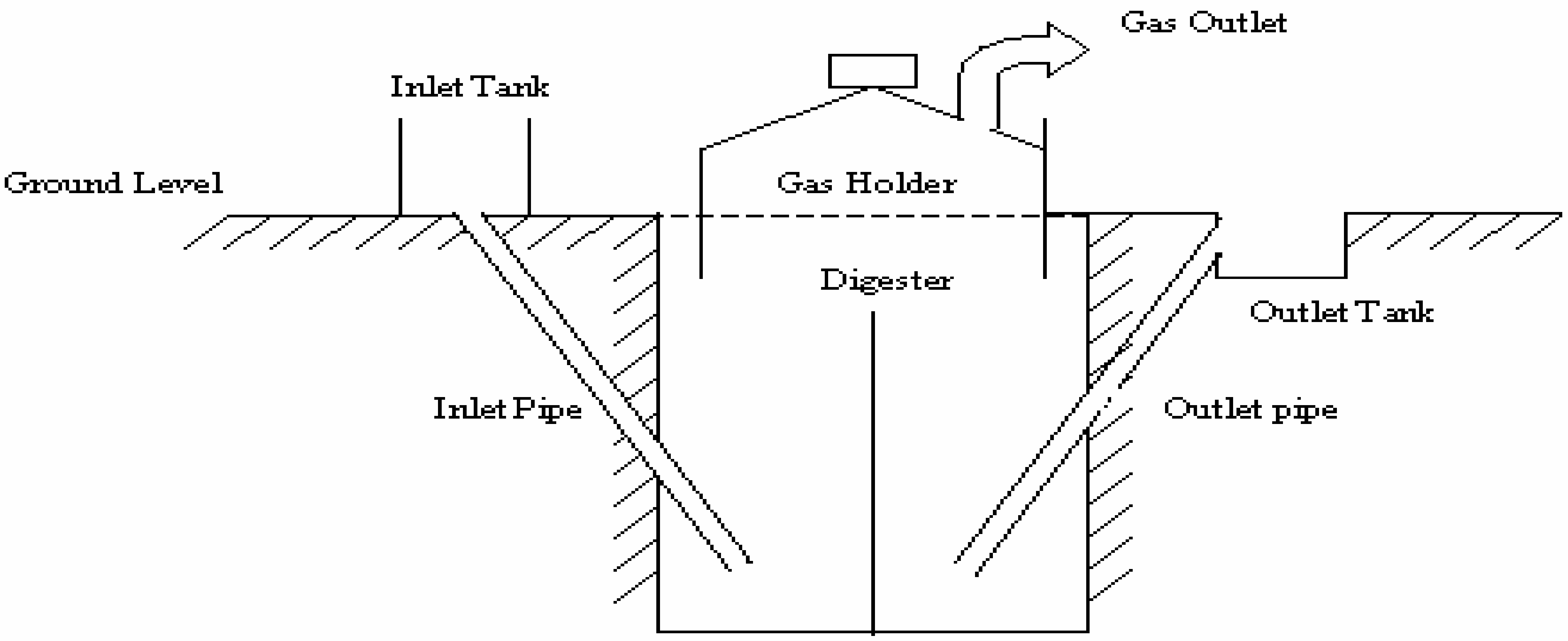


Figure 2: Floating Gasholder drum design (a conventional Indian design)

Different Ways of extracting energy from biomass-13

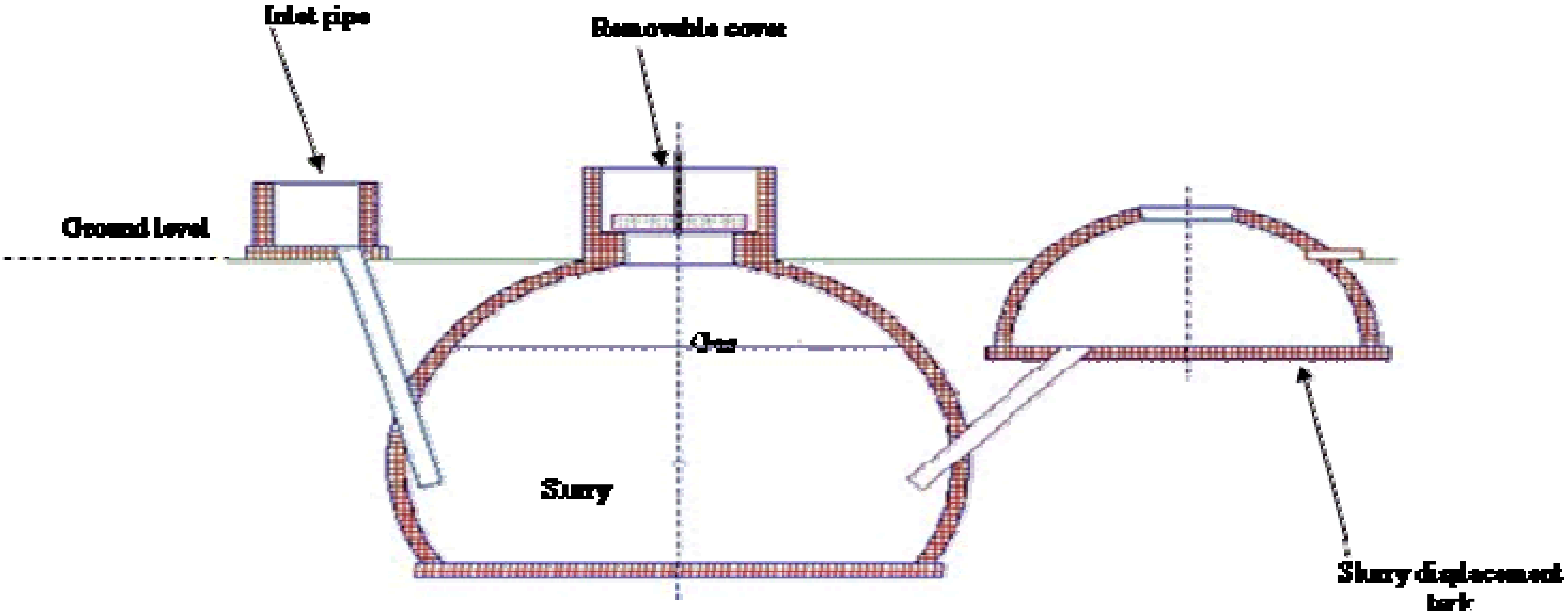


Figure 3: Spherical shaped fixed - dome plant

Uses of Biogas

- Biogas can be directly used for cooking by supplying the gas though pipes to households from the plant.
- Biogas has been effectively used as a fuel in industrial high compression spark ignition engines.
- To generate electricity an induction generator can be used and is the simplest to interface to the electrical grid.
- Induction generators derive their voltage, phase, and frequency from the utility and cannot be used for stand-by power.
- If a power outage occurs generator will cease to operate.
- Synchronous generator can also be used to connect to the grid. However, they require expensive and sophisticated equipment to match the phase, frequency and voltage of the utility grid.
- Biogas can also be used as fuel in a hot water heater if hydrogen sulfide is removed from the gas supply.

Case Study of Community Biogas programmes in India

Biogas Electricity in Pure Village:

- In India, Biogas option is considered largely as a cooking fuel.
- The need for considering decentralized electricity options and the potential of biogas is analyzed.
- A field-demonstration programme was implemented in pure village in South India to use cattle dung in a community biogas plant to generated electricity for services such as pumping drinking water and home lighting.

Case Study of Community Biogas programmes in India

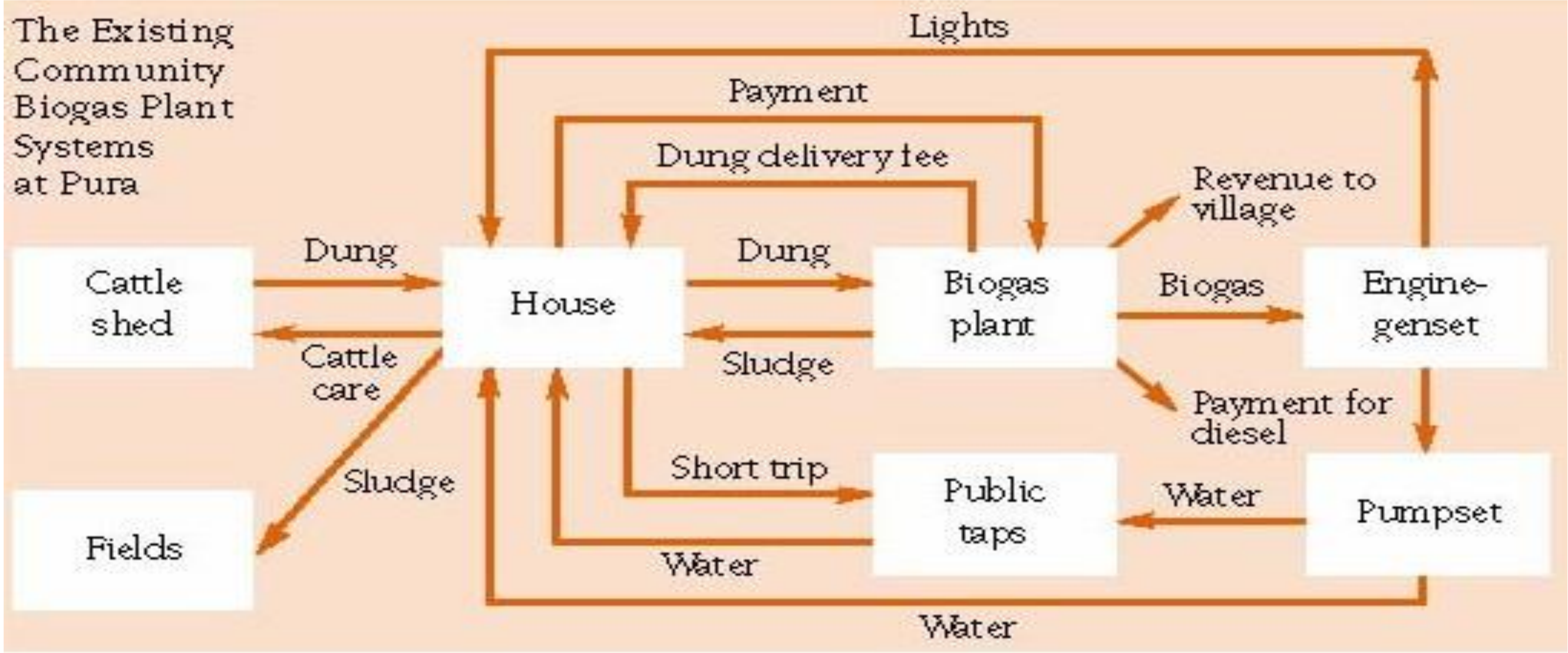


Fig 4: Community Biogas Plant in Pura Village

Technology

- The Indian floating-drum design shown in fig.1 with modified dimensions for cost reductions was used.
- The Pure biogas plants have a capacity to digest up to 1.2 t cattle dung/day and produce 42.5-m3 biogas/day.
- Sand bed filters were installed to remove excess water and convert the sludge to dung-like consistency for subsequent use as a fertilizer.
- The filtrate, which contains the required anaerobic microorganisms, is mixed with the input dung.
- A 5 kW diesel engine is connected to a 5kVA, 440 V three- phase generator of electricity generation.

Lighting

- Out of 87 house holds in the village 39 already had grid electricity.
- there are 103 fluorescent tube lights of 20 W capacity connected biogas generated electricity.
- Forty-seven houses opted for one tube light and 25 houses have two tube lights.
- Lighting is provided in the evening for 2.5 hours/day.
- Even homes connected to the grid had lighting connections from the biogas system.

Water supply

- A submersible pump is connected to a tube well and water is pumped to storage tanks for 1 hour and 40 minutes/day.
- The majority of the households have opted for private taps at their doorsteps.

Basic Statistics on Pura Village

	July, 1987	1991	1994
Population	430	463	485
Cattle population	241	248	254
Human/cattle ratio	1.78	1.87	1.91
No. of Households	80	87	88
Households with grid electricity			
(number)	34	39	52
(percent)	(43%)	(45%)	(59%)
Households with grid + biogas electricity			
(number)		24	34
(percent)		(28%)	(39%)
Households with only biogas electricity			
(number)		48	36

Fig 5: Table showing the statistics on Pura village

Biomass Gasifies

- Biomass, or more particularly wood, can be converted to a high-energy combustible gas for use in internal combustion engines for mechanical or electrical applications.
- This process is known as gasification and the technology has been known for decades, but its application to power generation is of recent origin.
- A biomass gasified consists of a reactor where, under controlled temperature and air supply, solid biomass is combusted to obtain a combustible gas called *Producers gas* (consisting of H_2 and CH_4) .
- This gas passes through a cooling and cleaning system before it is fed into a compression ignition engine for generation of mechanical or electricity (by coupling to a generator).

Biomass Gasifies-1

- An assessment of its potential concluded that India presents a unique opportunity for large-scale commercial exploitation of biomass gasification technology to meet a variety of energy needs, particularly in the agricultural and rural sectors.
- The large potential of biomass gasification for water pumping and power generation for rural electrification was recognized.

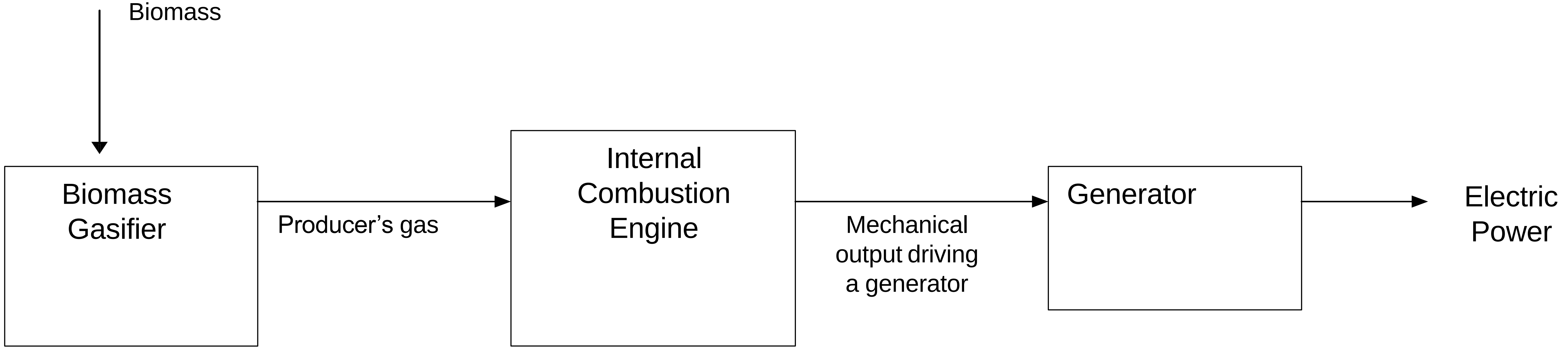


Figure 6: Block diagram of a producers gas electricity system

Biomass Gasifies-2

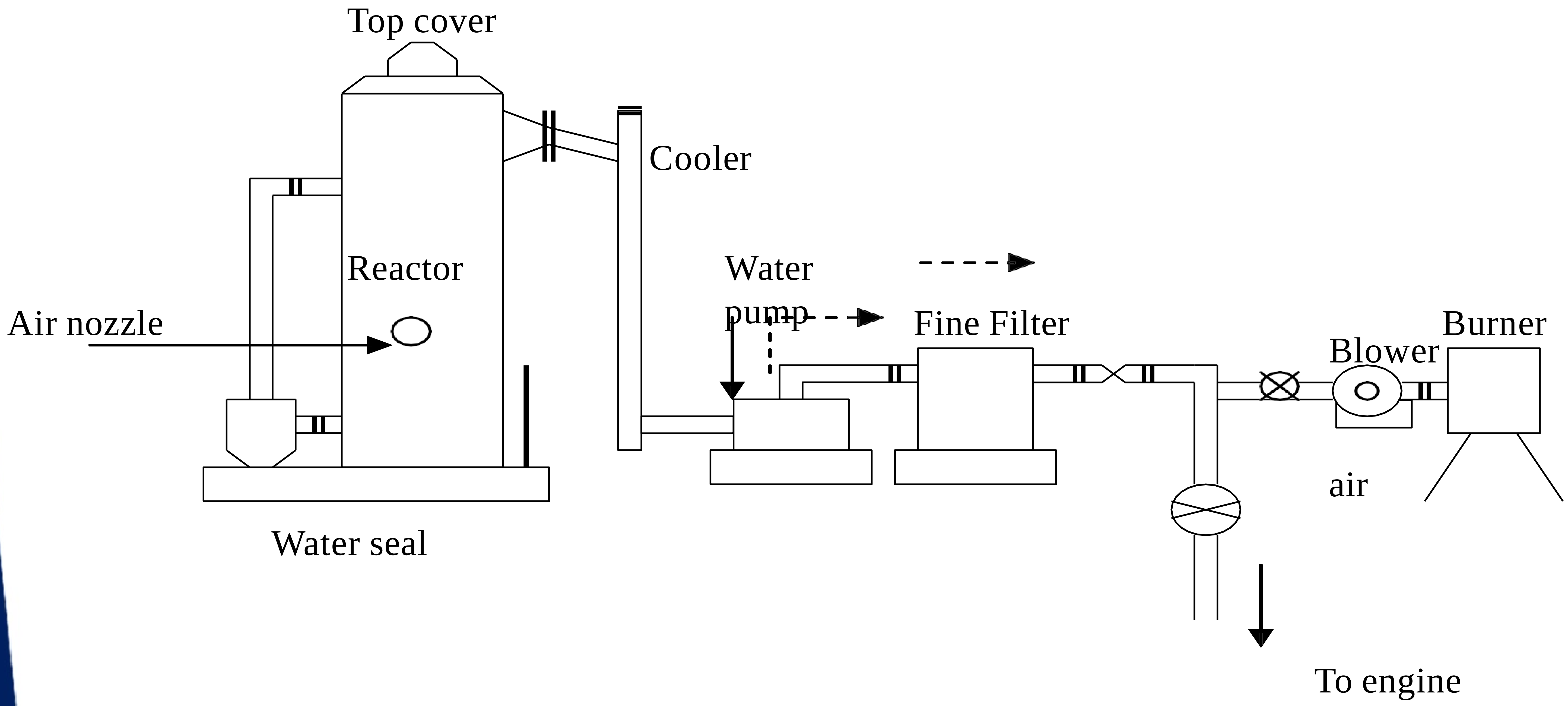


Figure 7: A 20 kW gasifier with cooling and cleaning system

Feed Stocks for producer-gas systems

- A range of crop residues and woody biomass from trees could be used as feedstocks for producer-gas systems.
- Currently, wood-based systems are available, and designs using other low-density biomass are under development and should soon be available in India.
- Crop residues with fuel potential are limited, since nearly all cereal and most pulse residues are used as fodder or manure and thus are not available as fuel.
- It is important to note that currently crop residues are used and have an opportunity cost.
- Rice husks are used in the cement industry, in rice mills and in the manufacture of bricks.

Feed Stocks for producer-gas systems-1

- Coconut leaves are used as thatch and the husk as fiber and sugarcane biogases is used in sugar mills.
- In Punjab, for rice-husk-based power generation systems, the price of residues such as rice husk could increase once new uses and demands are developed.
- Crop residues may continue to be used as fuel in domestic sector assuming that cooking-energy requirements are going to be met from bio-energy options.
- Constant supply of crop residues as feedstock cannot be assured over a long period on continuous basis and the transportation of low-density residues is not feasible.

Case Studies of Producer's gas electricity

Electrification of Hosahalli, a south Indian village

- A small-capacity one-top wood gasified has been developed and implemented a field demonstration program in the non- electrified South Indian village of Hosahalli.
- The village has a population of 250 and was unelectrified.
- A 20 kW one-top wood gasified was setup to meet the demand for electricity.
- The plant is providing electricity to the people, who in turn have improved the overall economy and living conditions of the villagers.
- The loads being served by the power plant include domestic lights, streetlights, drinking water and irrigation tube wells, and a flourmill. The villagers themselves are managing the power plant.

Services provided with Producer-gas electricity

- The electricity produced was used for three services: lighting, pumping domestic water, and flour milling.

Lighting

- All the 42 houses were provided with a 40 W fluorescent tube and a 15 W incandescent bulb, along with eight streetlights.
- Connected load is 2.68 kW. Hours of operation: 6 p.m. to 10 p.m.

Water Supply

- A submersible pump of 3 hp capacity was connected to a deep tube well.
- Water is pumped to storage tanks to provide 2-3 hours of water supply per day.

Services provided with Producer-gas electricity

Flour milling

- A 7.5 hp flourmill was connected to the producer gas diesel- engine generator.
- The flourmill, which operated for 2 hours/day, was operated for a few months in 1992; its operation was suspended, as the rate of milling was lower than the desired rate by the village community due to limitations of the 5-kVA system.

Services provided with Producer-gas electricity

Installation: HOSAHALLI, Karnataka

Application: Village Electrification – Illumination, drinking water and irrigation

Rating: 20 kW

Year of Installation: Version I – 1988 (3.75 kWe)
Version II – 1999 (20 kWe)

Biomass Used: Forest wood

Hours of Operation: 7000 hours

Fig 8: Biomass Gasifier Installed in Hosahalli, Karnataka.

Electrification of Chhotomollakhali, a village in West Bengal

- Chhottomollakhali Island in Sunderbans situated in the district of South 24 Parganas, is about 130 km. away from Kolkata.
- It has a population of about 28,000. The main occupation of the people is fishing and agriculture.
- It is difficult to extend grid electricity to Chhottomollakhali Island due to prohibitive cost involved in crossing of various rivers and creeks.
- In the absence of electricity, the economic activities of the Island were suffering.
- The switching on of the 4x125 kW Biomass Gasifier based Power Plant on 29th June 2001 has changed the life the inhabitants of this remote Island.

Electrification of Chhotomollakhali, a village in West Bengal

- The plant is catering to electricity needs of domestic, commercial and industrial user's drinking water, hospital, ice factory, etc.
- Four villages of Chhottomollakhali Island will be benefited with electricity from the power plant.

Plant capacity: 4 x 125 kW No. Of

consumers: 800

Total Project Cost:Rs.1, 46, 70,390/- Hours

of operation: 5 PM to 11 PM

Electrification of Chhotomollakhali, a village in West Bengal

- Tariff Structure:
  a) 4.00 / unit Domestic
  b) 4.50 / unit Commercial
  c) 5.00 / unit Industrial
- Energy Plantation Area:40 hectares Fuel

  Consumption pattern under full:

  Load condition

  (a) Biomass:70%

  (b) Diesel :30%

  - Generation cost (per unit) under full load condition: Rs.2.75

Biomass availability issues

- Before assessing the country's bioenergy production potential, it is important to:

i. Estimate the land availability for biomass production.

ii. Identify and evaluate the biomass production options—yield/ha and financial viability.

iii. Estimate sustainable biomass production potential for energy.

iv. Estimate the energy potential of biomass production.

v. Assess the investment required and barriers to producing biomass sustainably for energy.

Biomass availability issues-1

Different options for wood supply

- Conservation potential of wood used in cooking.
- Producing wood on community, government, or degraded forest land.
- Producing wood on degraded private or farm land.
- Sustainable harvest from existing forest.
- Logging waste.
- Consideration of options 2 and 3 involves a range of related issues, such as land availability, land quality, competitive uses of land, and sustainability of wood production.

Biomass availability issues-2

- Some proportion of wood currently burnt, as cooking fuel would become available for the producer-gas electricity option.
- Tree plantations, farm trees, homestead gardens, and degraded lands are the various sources of fuel wood used for cooking.
- Among these sources, only wood from tree plantations could be considered as easily available as feedstock for power generation.
- Woody biomass would be the dominant source of feedstock for gasification.

Biomass availability issues-3

- The availability of woody biomass and production potentials are discussed in the following section. *Estimates of degraded land availability in India (Mha):*

SPWD; degraded (waste) land quoted in PC	Degraded forest, Degraded non-forest, Total degraded land	Total degraded land 130 Mha
Chambers; land available for tree planting	Cultivated lands, Strips and boundaries, Uncultivated degraded land, Degraded forest land, Land for tree planting	Total Land for tree planting 84 Mha
Kapoor; land available for tree plantation	Agricultural land, Forest land, Pasture land, Fallow, Urban	Total land for tree planting 106 Mha
Ministry of Agriculture	Forest land with < 10% tree crown cover, Grazing land, Tree groves, Culturable waste, Old fallow.	Total degraded land 66 Mha

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Thank you!