International Journal of Agriculture, Environment & Biotechnology
Citation: IJAEB: 6(2): 317-333 June 2013 .

Agricultural Engineering

Present Status of Renewable Energy Sources in Punjab

Sarbjeet Singh Sooch* **and Anand Gautam**

School of Energy Studies for Agriculture, Punjab Agricultural University, Ludhiana, Punjab, India

***Email:** sssooch@pau.edu

Paper No. 119 Received: November 13, 2012 Accepted: May 15, 2013 Published: June 1,2013

Abstract

The present energy generating systems in developing countries depend largely on local resources: wood, straw, dung for burning, hydraulic power for water wheels and electric power generation and whatever fossil fuel supplies are locally available. A country's energy requirements often are not fully met by these local resources and foreign-currency resources must be expended to import the needed fossil fuel. In most developing countries, the economic base and the majority of the population are still rural and machinery that requires energy (especially fossil fuel) is not heavily utilized. However, the lack of cheap and adequate energy often hampers rural development plans and retards improvement in the quality of rural life. As on March, 2007, the cumulative grid-interactive power-generating capacity from renewable energy sources was about 9372 MW (6315 MW – wind energy, 1905 MW – small hydro power, 1152 MW – bio power), contributing about 7% of the total installed power-generating capacity in the country. In addition to power generation, renewable energy is being used for a variety of other applications in the country such as cooking, heating domestic water, drying crops, heating in industrial process, and so on. Status of Renewable Energy Sources in Punjab as on March 31, 2012 was studied in details in the fields of biogas technology (1, 30,000 family size and 45 power generation plants), biomass power plants (42 projects of 375 MW capacity), 23 projects of solar energy (10 MW power generations and other applications of solar energy) and hydro power (56 projects of 72 MW capacity).

Highlights

- Status of Renewable Energy Sources in Punjab was studied in details in the fields of biogas technology, biomass power plants, solar energy and hydro power

Keywords: renewable energy, fossil fuel, power generation, local resources

Today the world is undergoing a transformational changes and adjustments because of simultaneous global warming and speculative crude oil prices, necessitating a paradigm shift towards sustainable growth. India's developmental needs require phenomenal growth of energy sector over the next decade. There is also an urgent requirement of energy security. Renewable energy sources and applications are, therefore, not only increasingly more relevant but also call upon us to attempt maximize and universalize their use as early as possible.

India is the only country in the world having an independent Union Ministry i.e. Ministry of New and Renewable Energy (MNRE) as well as Renewable Energy Nodal Agencies in each of states/ Union Territories and All India Coordinated Research Project on Renewable Energy Sources in Agriculture and Agro based Industries (AICRP on RES) for research and development operating in different State

Agricultural Universities, institutes/centres of Indian Council of Agricultural Research (ICAR) and other research institutes of India. For the development and promotion for renewable Energy, MNRE is the nodal Ministry of the Government of India for all matters relating to new and renewable energy.

Renewable Energy sources such as solar; wind, hydro and biomass are emerging as viable options for meeting energy requirements of various sectors in an environmentally benign manner. Municipal and industrial wastes are also useful sources of energy. During the last 30 years, adequate infrastructure for carrying out research and development, testing, demonstration and manufacture of renewable energy devices/ systems has been established in the country. MNRE is encouraging development and promotion of all renewable energy sources.

Advantages of Renewable Energy are:

- Perennial
- Available locally and does not need elaborate arrangements for transport
- Usually modular in nature, i.e. small-scale units and systems can be almost as economical as large- scale ones
- Environment-friendly
- Well suited for decentralized applications and use in remote areas.

Methods and materials

Brief information about important Renewable Energy Sources is as below:

I. Biogasplants

Biogas is produced from organic wastes. Biogas is a clean gaseous fuel produced through anaerobic digestion of cattle ding, human excreta and a variety of non-woody biomass wastes. Biogas is obtained by anaerobic digestion/ fermentation (fermentation in the absence of air) of cellulose containing organic materials like cattle dung, poultry droppings, pig excreta, human excreta and crop residues, perishable food products and kitchen wastes etc. (Grewal N. S. *et al.* 2000).

The decomposition of organic wastes results in the production of gases like methane (55 to 65%), carbon dioxide (30 to 40%), hydrogen (1 to 5%), nitrogen (1%) and hydrogen sulphide (0.1%) and water vapours (0.1%) at normal temperature and pressure. Calorific value of biogas is about 5000 kcal per m^3. Biogas can be utilised for cooking / lighting / running dual fuel engines / power generation / bottling etc. Apart from meeting cooking and other energy needs, installation of biogas plants are making valuable contribution in providing high quality organic fertilizer for sustaining soil fertility, organic farming and rural sanitation. The detail of the availability of animal excreta (organic waste) from different animals is given in Table 1 (Sooch S.S. 2010).

Selection of proper size of biogas plant

The size (capacity) of biogas plant means the quantity of biogas (in cubic metre or cubic foot), which we can get from it in 24 hours. From 25 kg of cattle dung about 1 m^3 of biogas is collected. On the basis of the above details, the requirement of the quantity of dung and number of animals for different size of biogas plants is shown in Table 2. (Sooch S. S. 2010).

Table 1: Different type of animal waste and their potential

S. No.	Type of fuel	Comparative potential (%) of biogas production	Average excreta Fresh wt. (kg/day)	Dry wt. (kg/day)
1	Cow dung	100	15.0	3.00
2	Buffalo dung	100	20.0	4.00
3	Goat droppings	308	1.0	0.35
4	Horse dung	258	10.0	3.5
5	Piggery waste	391	2.5	0.5
6	Poultry droppings	616	0.07	0.025

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

Table 2: Requirement of dung and number of animals for different size of biogas plants

S. No.	Capacity of biogas plant (m^3)	No. of animals required	Quantity of dung required (kg)	Cooking for number of persons
1.	2	3-4	50	4-5
2.	3	5-6	75	7-8
3.	4	7-8	100	10-11
4.	6	10-12	150	14-16

Table 3: Required quantity of biogas for different purposes

Sr. No.	Purpose	Use	Required quantity of biogas (m^3/hour)
1.	Cooking	per person/day	0.34-0.42
2.	Lighting	100 candle power lamp	0.13
3.	Diesel engine	1 H.P.	0.45-0.51

Biogas plant can also be operated with human excreta, poultry droppings etc. For 1m^3 capacity biogas plant, human excreta from 35 persons is required. Poultry droppings available from 250-300 birds are sufficient to operate 1m^3 capacity biogas plant, but the gas production from this plant will be up to 6 times than that of cattle dung.

Biogas other than cooking food can also be used for running diesel engine and producing light. Table 3 shows the requirement of biogas for different purposes.(Sooch S. S.2010).

One cubic metre of biogas can help us to save 3.50 kg of wood, 12.30 kg of dung cakes, 1.6 kg of coal, 0.62 litre of kerosene oil, 0.43 kg of LPG and 0.52 litre of diesel etc. The slurry coming out of the biogas plant has various uses like organic manure, composting material, humus, pesticides, seed coating, weedicides, vermiculture, value added products and aquaculture etc.

Domestic Biogas Plants

The conventional models of biogas plants (KVIC, Janta, Deenbandhu and prefabricated models) available at present are very costly, because of ever increasing cost of building material. Therefore, it is absolutely necessary to dispense with the costly construction material altogether or to reduce the quantity to bring down the cost of the biogas plants. To meet this objective, PAU Ludhiana had developed PAU Janta model biogas plant (Figure 1) which brings down the cost to 25 to 40 % to that of conventional models. Here the digester was not lined with bricks but was an ordinary dug pit. To start with, some loss of water due to seepage from the pit is expected to occur, but in a week or so, the losses due to seepage will automatically stop due to clogging of the pores of the porous medium by the colloidal material available in cattle dung slurry because the micro-organisms present in the dung, form a layer when the dung slurry is constantly fed to any porous medium. The impervious layer acts like a mat which completely chokes the porous medium. This provides stability against side walls and earth pressure. Therefore, it is possible to completely or partially do away with the masonry lining around the pit and thereby reducing the cost of the plant. In an experiment to study the seepage of pollutants into the subsoil at PAU, it was found that the movement of ammonical nitrogen was very slow and it attained maximum value of 20 percent which never reached beyond 30 cm depth. Thus it can be safely concluded that an ordinary pit can be used as a biogas digester in all types of soils. There is no chance of ground water pollution from PAU model biogas plant Sooch S. S. (2010).

Conventional Models of Biogas Plants

Conventional models of biogas plants namely KVIC, Janta and Deenbandhu models are shown in Figures. 2, 3 and 4 respectively. However, the construction details are presented only for the Deenbandhu model which is the cheapest amongst the conventional models. (Sooch S. S. 2010).

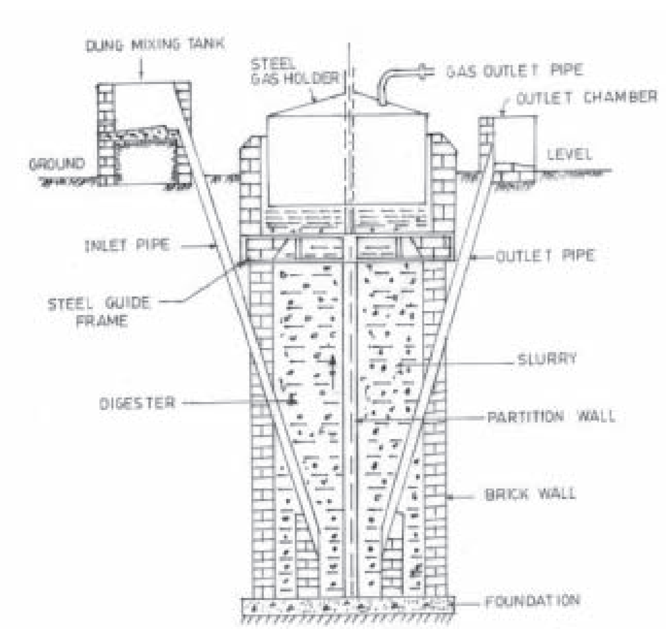

Figure 1: PAU Janta Model Biogas Plant

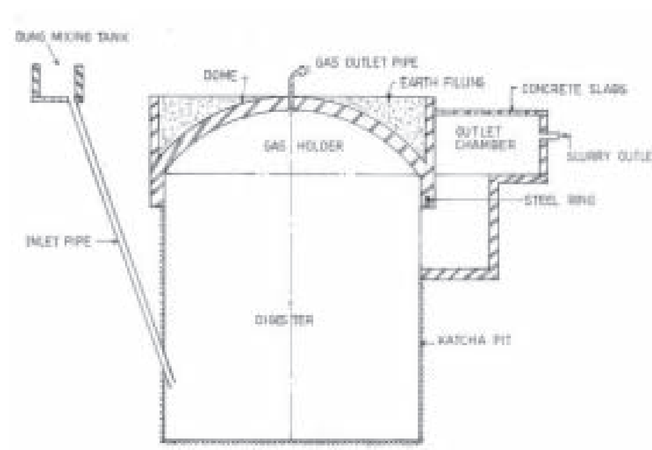

Figure 2: KVIC Model Biogas Plant

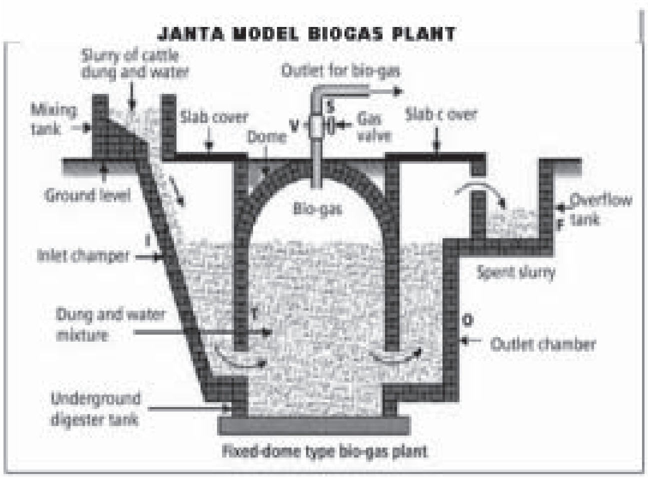

Figure 3: Janta Model Biogas Plant

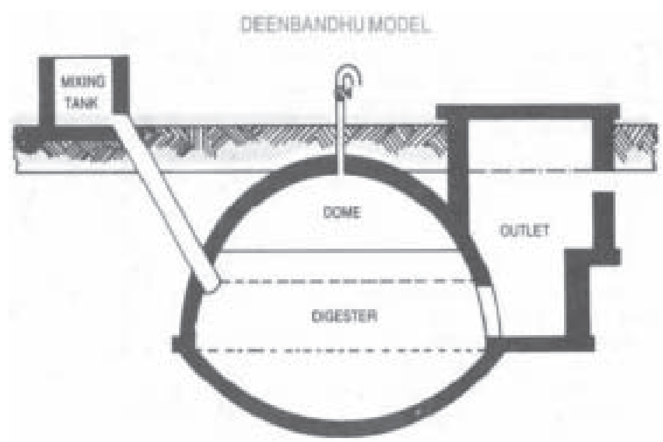

Figure 4: Deenbandhu Biogas Plant

Table 4: Comparison of the Cost for the Installation of Different Type of Biogas Plants (All values in Rupees during March, 2012)

S. No.	Model	Plant Capacity			
		2 m^3	3 m^3	4 m^3	6 m^3
1	PAU Janta	12,000	13,000	15,000	17,000
2	Deenbandhu	18,000	20,000	23,000	27,000
3	Janta	22,000	25,000	30,000	35,000
4	K.V.I.C	28,000	32,000	40,000	50,000

Source: Punjab Agricultural University, Ludhiana

The comparative cost of different types of biogas plants is given in Table 4. (Sooch S. S. 2010).

Financial Assistance for Installation of Family Size Biogas Plants

Some financial assistance for installation of these biogas plants is provided by Ministry of New and Renewable Energy (MNRE), Govt. of India through State Nodal Agency as per the following details:

S. No.	Financial assistance	Family type biogas plants		Contact Agency
		1 m^3	**2-4 m^3**	Punjab Energy Development Agency (PEDA)Plot No.: 1 – 2, Sector – 33-D, ChandigarhorDistrict level officials of PEDA
1.	Family size biogas plant (in Rs. per plant)	4,000	8,000	
2.	Additional CFA for toilet linked biogas plants (in Rs. per plant)	1,000		
3.	Incentive for saving diesel and other conventional fuels by using biogas in engines /gensets and/or biogas refrigerators (in Rs. per plant)	5,000		

Source: Ministry of New and Renewable Energy, New Delhi

Large Capacity Biogas Plants

The Punjab Agricultural University, Ludhiana developed a large capacity fixed dome type biogas plant (New Modified PAU Janta Model Biogas Plant – Figure 5) to cater the needs of dairy farmers, poultry farmers, gaushalas, industries, educational/religious institutes, NGOs etc. The construction of this plant is easy and is not very difficult and different from the method for the construction of Dennbandhu Biogas Plant.(Sooch S. S. 2010 ; Sooch S. S. *et al.,*2012).

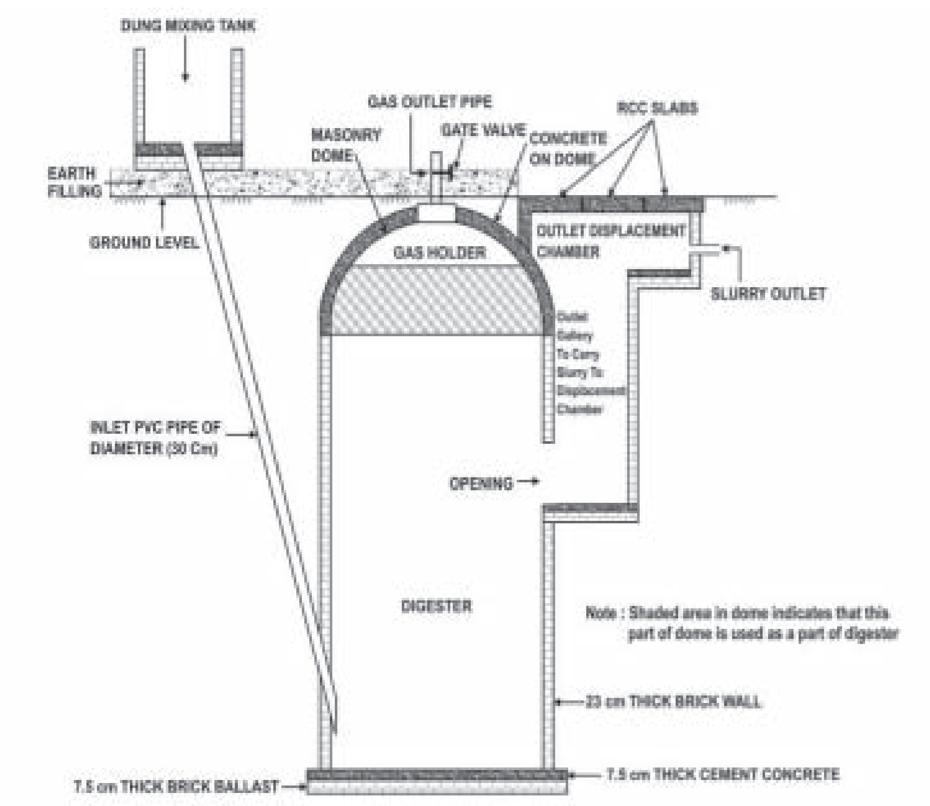

Figure 5: New Modified PAU Janta Model Biogas Plant

Details for Space Required for Construction of Biogas Plants

The details for space required for construction of different size biogas plants (shown in Fig. 6) are given in Table 5

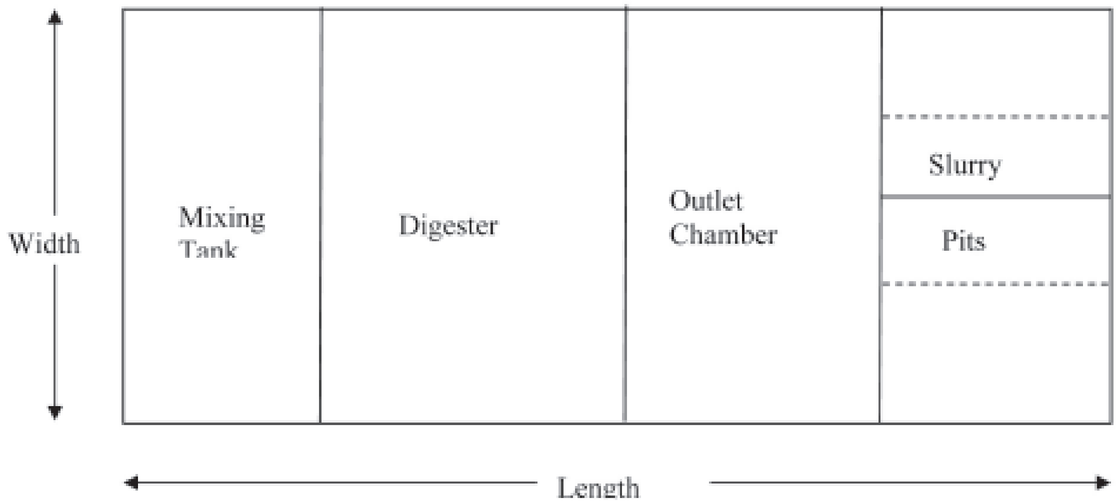

Figure 6: Space Required for Construction of Biogas Plant

Table 5: Details of space required for construction of biogas plants

Sr. No.	Capacity of Biogas Plant (m^3)	Space Required for Biogas Plant: Length(ft.)	Width(ft.)	Area: Sq. ft.	Marla
1.	25	65	20	1300	6.00
2.	50	70	25	1750	8.25
3.	75	75	30	2250	10.50
4.	100	80	35	2800	13.00
5.	125	85	37	3145	14.50
6.	150	90	40	3600	16.75
7.	175	95	42	3990	18.50
8.	200	100	45	4500	21.00
9.	225	105	47	4935	23.00
10.	250	110	50	5500	25.50
11.	275	115	52	5980	27.75
12.	300	120	55	6600	30.75
13.	325	125	57	7125	33.00
14.	350	130	60	7800	36.25
15.	375	135	62	8370	39.00
16.	400	140	65	9100	42.25
17.	425	145	67	9715	45.25
18.	450	150	70	10,500	48.75
19.	475	155	72	11,600	52.00
20.	500	160	75	12,000	55.00

Project Cost of Large Capacity Fixed Dome Biogas Plant Projects for Power Generation

The cost of Large Capacity Fixed Dome Biogas Plant Projects of different capacities for Power Generation as per March, 2012 Market rates is mentioned in Table 6. (Sooch S. S. 2010; Sooch S. S. *et al.* 2012).

Table 6: Project Cost of Large Capacity Fixed Dome Biogas Plants for Power Generation as per March, 2012 Market rates

Available No. of Cattle	Size of Biogas Plant	Capacity of Gen-set(kW)	Constructioncost of BiogasPlan (Rs. in lac)	Gen-set cost (Rs. in lac)	Gen- set shed cost (Rs in lac)	Slurry handling system cost (Rsin lac)	Total Project cost (Rs in lac)
50-60	25	3	2.50	1.50	1.00	1.00	6.00
80-90	50	6	4.00	2.00	1.00	1.00	8.00
120-130	75	9	5.00	2.50	1.00	1.00	9.50
150-170	100	12	6.00	3.50	1.50	1.50	12.50
200-220	125	15	8.00	4.00	1.50	1.50	15.00
250-270	150	18	10.00	4.50	1.50	1.50	17.50
280-300	175	21	11.50	4.50	1.50	1.50	19.00
330-350	200	24	13.00	5.00	2.00	1.50	21.00
380-400	225	27	14.50	5.50	2.00	2.00	23.50
430-450	250	30	16.00	5.50	2.00	2.00	25.50
470-490	275	33	17.50	6.00	2.00	2.00	27.50
500-520	300	36	19.00	6.50	2.00	2.00	29.50
530-550	325	39	21.00	7.00	2.00	2.00	32.00
560-580	350	42	23.00	8.00	2.00	2.50	35.50
590-610	375	45	25.00	8.50	2.00	2.50	38.00
620-630	400	48	27.00	9.00	2.00	2.50	40.50
640-660	425	51	29.00	9.50	2.00	3.00	43.50
670-700	450	54	31.00	10.00	2.00	3.00	46.00
710-740	475	57	33.00	10.50	2.00	3.00	49.00
750-800	500	60	34.00	11.00	2.00	3.00	50.00

Source: Punjab Agricultural University, Ludhiana
NOTE:
(i) Cattle dung available from one cattle = 15 kg.
(ii) 1 Kg of cattle dung will produce 0.04 m^3 of biogas
(iii) Cattle dung required for production of $1m^3$ of biogas = 25 kg
$25m^3$ of biogas will generate approximately 3kW of Power

Financial Assistance for Installation of Large Capacity Biogas Plants

Some financial assistance for installation of these biogas plants is provided by Ministry of New and Renewable Energy (MNRE), Govt. of India through State Nodal Agency/PAU as per the following details.(Sooch S. S. 2010;Sooch S. S. *et al.* 2012):

S. No.	Power generating capacity	Maximum support for preparation of DPR	CFA/subsidy limited to the following ceiling or 40% of the cost of the system whichever is less	Contact Agency
1.	3 – 20 kW	No DPR required	Rs. 40,000 per kW	School of Energy Studies for Agriculture /Department of Civil EngineeringPunjab Agricultural University, LudhianaOrPunjab Energy Development Agency, Chandigarh
2.	> 20 kW to 100 kW	Rs. 20,000 per plant	Rs. 35,000 per kW	
3.	>100 kW to 250 kW	Rs. 1,00,000 per plant above 100 kW	Rs. 30,000 per kW	

Source: Ministry of New and Renewable Energy, New Delhi

II. *Solar energy*

Sooch S. S. *et al.* (2012) solar energy - experienced by us as heat and light can be used through two routes:

1. The thermal route uses the heat for water heating, cooking, drying, water purification, power generation and such other applications.
2. The photovoltaic route converts the light in solar energy into electricity which can then be used for a number of purposes such as lighting, pumping, communication and power generation.

India has large capacity for production of solar cells modules and solar energy systems.

Recent initiative of MNRE to upgrade Solar Energy: Jawaharlal Nehru National Solar Mission

The objective of the Jawaharlal Nehru National Solar Mission (JNNSM) is to setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. With the launch of JNNSM, policy initiatives have been focused on to encourage setting up commercial projects by providing generation based incentives for the power fed to the grid and at the same time pursuing research and development efforts to develop indigenous technologies and capacity and capabilities in this sector.

The brief description of different solar gadgets has been explained as under:

(1) Solar Water Heating System

One of the popular devices that harness the solar energy is solar water heating system (SWHS). Broadly, the solar water heating systems are of two categories i.e. closed loop system and open loop system In the first one, heat exchangers are installed to protect the system from hard water. In open loop system the water directly flows through the collector pipes/ tubes and collects in the hot water tank.

The deployment across the application Segment is envisaged as follows under JNNSM

S. No.	Application Segment	Target		
		Phase-I(2010-13)	Phase-II(2013-17)	Phase-III(2017-22)
1.	Solar thermal collectors	7 million m^2	15 million m^2	20 million m^2
2.	Off grid solar applications	200 MW	1,000 MW	2,000 MW
3.	Grid power, including roof top and small plants	1,100 MW	4,000-10,000 MW	20,000 MW

Source: Ministry of New and Renewable Energy, New Delhi

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

The thermosyphon systems are simple and relatively in-expensive. These are suitable for domestic and small institutions. The forced circulation system employs electrical pump(s) to circulate the water through collector and storage tank(s). Solar water heating systems work efficiently during clear sunny days. For foggy and cloudy days electrical backup system is provided in the system. Solar water heating systems can be installed at any shadow free area, near to the point of usage. The collectors are installed with inclination of 45^o facing due south.

Solar Water Heating Systems can also be categorized as Flat Plate Collector System, Evacuated Tube Collector System and Parabolic (Dish Type) System. Flat Plate Collector System and Evacuated Tube Collector System can heat water up to 80 ^{o}C of temperature on a clear Sunny Day. These systems are used in domestic, institutional, commercial and industrial Sectors where hot water requirement is up to 80 ^{o}C.

(i) Flat Plate Collector (FPC) based solar water heating system

The solar radiation is absorbed by Flat Plate Collector which consists of an insulated outer metallic box, covered on the top with glass sheet. Inside there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry water. The absorber absorbs the solar radiation and transfers the heat to the flowing water. Flat Plate Collector (FPC) based solar water heating system is shown in the following Figure 7.

Figure 7: Flat Plate Collector (FPC) System

(ii) Evacuated Tube Collector (ETC) based solar water heating system:

Evacuated Tube Collector is made of double layer borosilicate glass tubes, evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tubes. Evacuated Tube Collector (ETC) based solar water heating system is shown in Fig. 8.

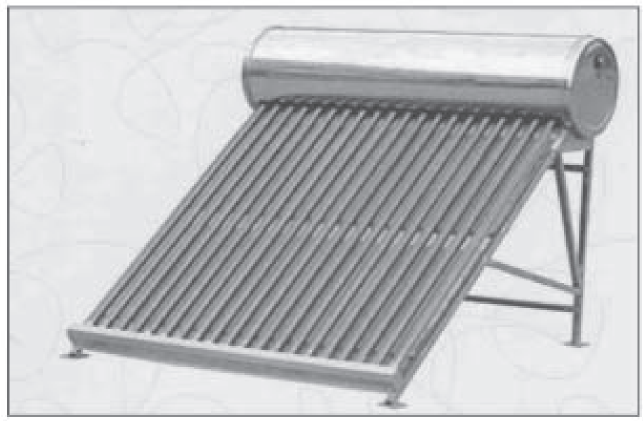

Figure 8: Evacuated Tube Collector (ETC) Systems

(iii) Parabolic (Dish Type) solar water heating system

This type of solar water heating system consists of a metallic parabola on which high quality mirrors are fitted which reflect and concentrate the solar radiation on a receiver through which cold water flows, resulting in the heating of water at higher temperature. Mainly this type of system is used to produce steam in industries and cooking of food in institutions.

Life Cycle Expectancy of Solar Water Heating System

The life of a Solar Water Heating System depends on the quality of the material used, workman- ship and the quality of water. Generally, the life of FPC system is considered as 15-20 years, ETC system10-15 years and that of parabolic system 20-25 years.

Cost and Subsidy

MNRE is providing 30% subsidy on all types of solar water heating systems subject to maximum as under:

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

S. No.	Type of System	Approximate Cost	MNRE Subsidy
1.	Flat Plate Collector System	Rs.25000 / 100 LPD	Rs.6600 / 100 LPD
2.	Evacuated Tube Collector System	Rs.18000 / 100 LPD	Rs.4500 / 100 LPD
3.	Parabolic System	Rs.300 / LPD	Rs.5400 / m^2 of dish areas

Source: Ministry of New and Renewable Energy, New Delhi

Economics of Solar Water Heating System

The return of investment on SWHS is very attractive. The payback period of a SWHS is 1.7- 3 years depending upon its type and usage. Payback period of 1000 LPD capacity system at 60ºC temperature with solar insolation of 5.5 kWh /m^2/ day at ambient temperature of 20ºC is calculated using standard formula:

(Quantity of heat is equal to the product of mass of liquid, specific heat and differential temperature

(Quantity of heat is equal to the product of mass of liquid, specific heat and differential temperature

Total energy required to heat 1000litre	= 40,000 Kcal
Water (60^0-20^0 C)	= 40ºC
Calories of 1 kWh of electricity	= 860 Kcal
No. of units (kWh) required to heat 1000 LPD	= 40000/860
Water up to 60ºC	= 46 kWh = 46Units
Rate of l kWh (1Unit)	= Appx. Rs.5.80
Cost of Electricity used	= Rs.269/day
Cost of electricity for 300days(Assuming 300 sunny days in a year)	= Rs.80,700
Cost of 1000 LPD system	= Rs.200000 (FPC system)
Govt. Subsidy 30%	= Rs.60000
Beneficiary share	= Rs.140000
Payback period of the system	= 140000/80700= 1.7years

Source: Ministry of New and Renewable Energy, New Delhi
Note:
- The payback period is less in case of ETC Systems.
- A system of 1000 LPD saves about 1700 litres of furnace oil and 13800 units of electricity per year.
- Environment Benefits: 1000 LPD system prevents emission of 15 tonnes of carbon dioxide in to the atmosphere per year.

(1) Solar Lantern (12 V / 10 W)

This is an emergency light charged with sunlight and works for 3 to 4 hours. Its approximate cost is Rs. 3500/- . (See Fig. 9).

(2) Solar Home Lighting System

This system consists of one 37 W capacity solar panel, one 40 Ah capacity battery, one charge controller and two lights (9 W each). These work for 4 to 6 hours. Its approximate cost is Rs. 12,000/- (See Figure 10).

(3) Solar Street Light

This system consists of one 40 W capacity solar panel, one 12V/26 Ah battery and one LED light of 18 W. It automatically works from sunset to sunrise. Its approximate cost is Rs. 22000/- (See Figure 11).

(4) Solar Water Pump

This system consists of 1800 W D.C. motor which operates during the day time with 1800 W solar panels. It pumps about 1, 20,000 to 1, 40,000 litres of water daily and works satisfactory up to 10 m water level. Its approximate cost is Rs.2.80 lac. The Punjab Government provides 70% (Rs.1.96 lac.) subsidy to the farmers having orchard of minimum 2 acre area, for installation of this pump for horticulture purpose through drip irrigation system (See Figure 12).

(5) Solar Inverter

It consists of two 150 Wp capacity solar panels, one 150 Ah battery and one 600 VA inverter which can operate two fans and two electric tubes for 5 to 6 hours. Its approximate cost is Rs. 45000/- (See Figure 13).

Figure 9: Solar lantern

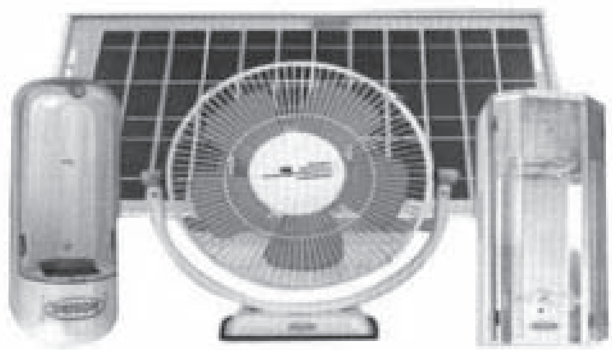

Figure 10: Solar home lighting system

Figure 11: Solar Street light

Figure 12: Solar Water Pump

(6) Solar Cooker

It cooks four vegetables in a period of 2-3 hours. Its approximate cost is Rs. 3500/-. (See Figure 14).

(7) Solar Dryer

It is used for drying of agricultural product.

(i) Domestic Solar Dryer

It is a natural circulation solar dryer of 0.36 m^2 aperture area. It dries 2-3 kg of product in 3-4 days. Its approximate cost is Rs. 3500/-. (See Figure15).

(ii) Farm Solar Dryer

It is a natural circulation solar dryer for use at farm. It has aperture area of 3.34 m^2. It dries 20-30 kg of product in 4-5 days. It can be disassembled when not in use. Its approximate cost is Rs. 20000/-. (See Figure 16).

III Bo,ass Energy

Sooch S. S. *et al.* (2012) Biomass is generated from forestry, agricultural and agro industrial operations. Biomass has been one of the main energy sources for rural area as well as providing viable solution in the off grid mode to meet the electricity needs of rural area on sustainable basis. Punjab Agricultural University, Ludhiana

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

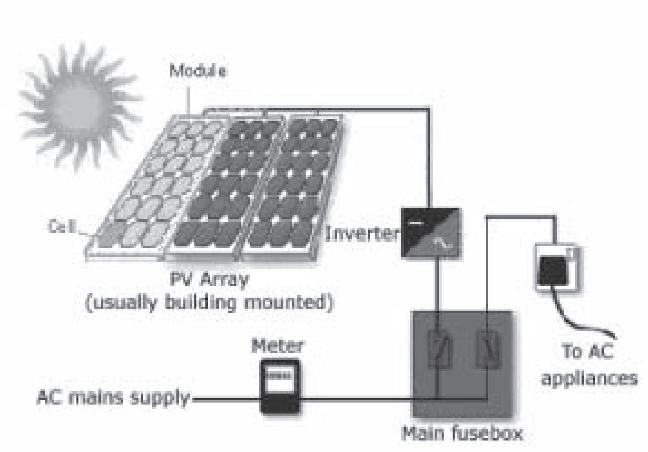

Figure 13: Solar Inverter

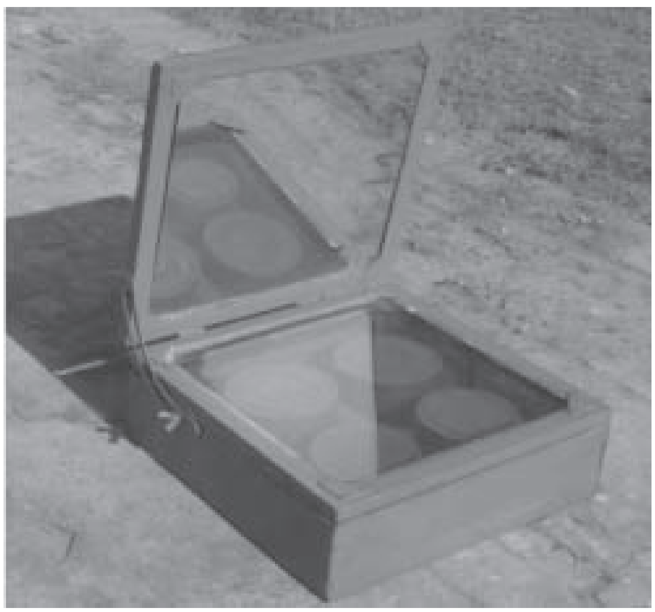

Figure 14: Solar Cooker

Figure 15: Domestic Solar Dryer

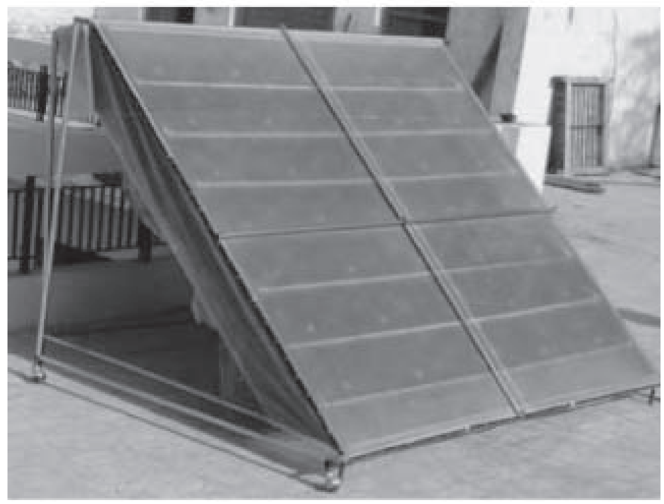

Figure 16: Farm Solar Dryer

promotes biomass Power/ cogeneration as well as gasification technology for grid connected and off grid applications. Rice husk based gasifiers have been found economically viable option for captive power for rice mills**.**

Combustion of Biomass

Gasification is an advanced thermo-chemical process. In this process, the fuel is ignited by partial supply of oxidant (30-40 % of the stoichiometric requirement). Different processes and operations occurring in the gasifier reactor are mainly in four reaction zones (i.e., oxidation, reduction, pyrolysis and drying). The sequence of reaction zones in a gasifier depends on the type of gasifier and direction of flow of fuel and air or gas. When air is used as an oxidant, the product is referred to as producer gas. It consists of CO (20-22%), H_2 (10-12%), CH_4 (1-2%), N_2 (50-55%), CO_2 (10%). Char and Tar also produced in gasification.

Mainly fixed bed gasifiers are used for small scale applications. The commonly used fixed bed gasifiers are of two types viz. downdraft and updraft type gasifiers. In Updraft gasifiers the flow of oxidant is in upward direction while in downdraft gasifiers the flow is in downward direction.

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

These gasifiers can convert various types of agricultural residues and wood based material into producer gas. The producer gas can be used in burners for thermal applications and engines for producing mechanical energy or for further conversion to electricity.

Some examples of the type of gasifiers in use are shown in the Figures. 17-19.

Figure 17: Commercial Rice Husk Based open throat downdraft Gasifier (Cost Rs 7 Lacs)

Figure 18: Imbert type downdraft gasifier of 50,000 kCal/h Capacity developed at PAU
(Cost Rs 2.00 lacs)

(iv) Energy recovery from waste

About 60 million tons of municipal solid waste and about 4400 million cubic meters of liquid waste are generated every year in the country. Most waste that are generated find their way into land and water bodies without proper treatment causing severe water pollution. They also emit green house gases like methane and carbon-di-oxide and add to air pollution. The problems caused by solid and liquid waste can be significantly mitigated through the adoption of environmentally waste to energy technologies such as biomethnation, combustion, pyrolysis etc. A

Figure 19: Rice husk gasifier of 10 kW capacities for engine applications (Cost Rs 1.00 lacs)

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

number of wastes to energy projects have been set up at distilleries, paper-mills, sugar and starch factories etc.

(v) Wind energy

Wind energy has been utilized by mankind for centuries. It is environmentally benign and does not emit green gases. Generation of electricity has emerged as the most important application of wind energy worldwide. The concept is simple: flowing wind rotates the blade of a turbine and causes electricity to be produced in generator unit. The blades and generators are mounted on the top of the tower. Wind-solar hybrid systems have been successfully used in off-grid mode. Water pumping is also an important application of wind energy for irrigation and community use.

(VI) Small hydro power

Hydro power is the largest renewable energy resource being used for the generation of the electricity. Hydropower is generated from the potential and kinetic energy of water flowing from a height. The energy contained in the water is converted into electricity by using a turbine coupled to a generator. A number of small hydro projects are being set up in the country both on rivers and canals.

(VII) Hydrogen energy

Hydro energy is a clean gas with highest energy content. It is abundantly available in water, biomass and hydrocarbons. Hydrogen can be used for power generation and also for, transport application. Hydrogen is also used in fuel cells. Hydrogen power Motor Cycles, Auto Rickshaws have been developed and demonstrated in India.

(VIII) Biodiesel

Sooch S. S. *et al.* (2012) Biodiesel is a clean fuel made from natural, renewable sources, such as new and used vegetable oils and animal fats, for use in a diesel engine for diesel fuel replacement. The type of process that needs to be done to produce biodiesel is called transesterification. The transesterification of refined or waste cooking oil and animal fats can be carried out with short-chain alcohols, in the presence of acid or base catalyst, by means of single step batch transesterification process in order to obtain biodiesel fuel. Biodiesel has physical properties very similar to petroleum-derived diesel fuel, but its emission properties are superior. Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. Diesel blends containing up to 20% biodiesel called B20 can be used in nearly all diesels powered equipment, and higher-level blends and pure biodiesel, B100 can be used in many engines with little or no modification. Lower-level blends are compatible with most storage and distribution equipment, but special handling is required for higher level blends.

The cost of producing biodiesel at laboratory scale comes out be near Rs.77/- per litre. At current production levels, biodiesel requires a subsidy to compete directly with petroleum-based fuels. However, central and state governments should provide incentives that would encourage the rapid growth of the biodiesel industry.

The different plant oil biodiesel have been shown in the Figure 20.

Figure 20 : Different plant oil biodiesel

Results and discussion

Indicative costs of few common system and devices are given as below Sooch S. S. *et al.* (2012):

S. No.	Renewable Energy System / Device	Indicative Capital Cost (Rs.)	Govt. Subsidy, if any (Rs.)
1.	Biogas Plant (4 m^3- 6 m^3)	23,000 to 27,000	8,000
2.	Domestic Solar Water (100 ltr/day)·		
	ETC system·	15,000 to 25,000	4,500
	FPC system	22,000 to 25,000	6,600
3.	Box type Solar Cooker	3,000 to 4,500	1,500
4.	Dish Type Solar Cooker	60,000 to 70,000	-
5.	Solar Steam Generating System (300 l)	14,000 to 18,000 per m^2 of collector area.	5,400
6.	Solar Lantern (12V/10 kW)	3,500	1,330
7.	Solar Home Lighting Systems·		
	Model I- One 9W CFL·	5,500 to 6,500	5,000
	Model II- Two 9W CFL	12,000 to 13,000	5,000
8.	Stand alone Solar Street Lighting System	19,000 to 25,000	5,250
9.	Solar Inverter	45,000	-
10.	Solar Photovoltaic Pumping Systems·		
	DC surface pump of 900 W·	2,30,000	-
	DC surface pump of 1800 W·	4,30,000	-
	AC submersible pump 1800 W	5,50,000	-
11.	SPV Power Project (per MW)	11 crore to 12 crore	30 % of the project cost
12.	Wind power Plant (per MW)	5.50 crore to 6 crore	-
13.	Water Pumping Wind Mill	45,000 to 1,50,000	-
14.	Wind-Solar Hybrid System (per kW)	2.00 lac to 2.50 lac	-
15.	Small Hydro Power (per MW)	5 crore to 7 crore	-
16.	Biomass Power Plant (per MW)	4 crore to 5 crore	20 lac to 1 crore
17.	Bagasse based cogeneration plant	4 crore to 5 crore	-
18.	Waste-to-Energy (per MW)	5 crore to 12 crore	-

Source: Ministry of New and Renewable Energy, New Delhi and Pujab Energy Development Agency, Chandigarh

India is implementing one of the world's largest programmes in renewable energy. The country ranks second in biogas utilization, fourth in wind power, fifth in small hydro and seventh in photovoltaic production in the world. Renewable sources already contribute to about 10% of the total power generating capacity in the country.

Achievement under different programmes of Renewable Energy in India and Punjab has been mentioned as below Table 12.

Achievement under Different Programmes of Renewable energy in India and Punjab

S. No.	Programmes/Systems	Cumulative achievement in India (as on 31.03.2012)	Cumulative achievement in Punjab (as on 31.03.2012)	No. of projects installed in Punjab	Detail in Annexure
I	**Power from Renewable**				
A	**Grid-interactive Renewable Power**				
1.	Biomass power (Agro Residues & Plantations)	1209.60 MW	46.50 MW	05	I
2.	Wind Power	17967.15 MW	-	-	-
3.	Small Hydro Power (up to 25 MW)	3434.07 MW	Completed-39.6524 MWUnder installation-31.85 MW	-	32
4.	Bagasse Cogeneration	2109.73 MW	326.34	37	II
5.	Waste to Power (Urban & Industrial)	93.68 MW	-	-	-
6.	Solar Power (SPV)	1044.16 MW	6.00	05	III
B	**Off-Grid / Distributed Renewable Power** including Capacity/ CHP plants				
1.	Large capacity for cooking/operating diesel engines/decentralized power generation	-	Conventional design (IBP/NBP)PAU Design	53140	IV
2.	High rate Biomethantion Grid Power Geneartion Project based on Cattle Dung	-	1 MW	01	V
3.	Biogas enrichment and bottling of biogas plants	-	6600 m^3	03	V
4.	Energy Recovery from Waste	106.34 MW	-	-	-
5.	Biomass (non-bagasse) cogeneration	398.40 MW	326.34 MW	37	II
6.	Biomass gasifier	153.89 MW	-	03	-
7.	Aero – Generators / Hybrid systems	1.74 MW	-	-	-
8.	SPV systems (> 1 kW)	96.61 MW	771 kW	18	VI
9.	Watermills/ Microhydel	2121 (nos)	-	-	
II	**Decentralized / Other Renewable Energy Systems**				
1.	Family type Biogas Plant (nos)	45.45 Lakh	Conventional Models PAU Models	1,25,000 5,000	- -
2.	Solar Photovoltaic System				
	i. Street Lighting System (nos)	1,82,000	-	5354	-
	ii. Home Lighting System (nos)	7,33,245	-	8620	-
	iii. Home Lanterns (nos)	8,31,604	-	14995	-
3.	Solar Photo voltaic Water Pumping Systems (capacity 2 HP each)	-	-	1850	-
4.	Solar water Heating Systems	5.83 Million m^2 Collector area	13.145 lac LPD	-	-
5.	Solar cookers	-	-	16600	-
6.	Solar dryers:	Domestic	200	-	-
-					
1.	Farm	40	-	-	-
7.	Solar air heaters	-	120 m^2 Collected Area	2	-

Source: Ministry of New and Renewable Energy, New Delhi and Punjab Energy Development Agency, Chandigarh

Conclusion

The present energy generating systems in developing countries depend largely on local resources: Wood, straw, dung for burning, hydraulic power for water wheels and electric power generation and whatever fossil fuel supplies are locally available. A country's energy requirements often are not fully met by these local resources and foreign-currency resources must be expended to import the needed fossil fuel. In most

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

developing countries, the economic base and the majority of the population are still rural and machinery that requires energy (especially fossil fuel) is not heavily utilized. However, the lack of cheap and adequate energy often hampers rural development plans and retards improvement in the quality of rural life.

References

Grewal N. S., Sooch S. S., Ahluwalia S and Brar G. S. 2000. *Hand Book Biogas Tech*, PAU, Ludhiana.

Sooch S.S. 2010. Biogas Plants for Rural Masses. School of Energy Studies for Agriculture, PAU, Ludhiana.

Akshyay Urja 2012. Energing the re way, Ministry of Renewable Energy Government of India, **5** (6). www.mnre.gov.in.

Sooch S. S., Soni R., Singh S., Saimbhi V. S and Gautam A. 2012. Renewable Energy In Punjab: Status and Future Prospects, School of Energy Studies for Agriculture, PAU, Ludhiana.

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X