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Develop a Green Village Dependent on Renewable Resources for fuel and Electricity

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***Abstract*: -**Development of an village with electricity is a dream and need of rural India .We know that urban areas are always rich in the development and supply of energy but rural areas like villages are always lacking behind .So in this paper we are making an effort to make a village totally dependent on green power available in the nature. The power requirement in the village can be fulfilled by green energy such as solar energy, biogas energy, water energy and wind energy etc. Solar energy can be used through plants, solar cell, solar heater, solar pond, and solar pump whereas biogas is produced by waste material or garbage available in the household. We have calculated power requirement of the different types of families living in the village and making an effort to meet the power requirement through solar energy and biogas energy. The uses of agricultural waste, human wastes, and waste of aquatic plants in the village will be helpful for generation of power and for cooking purpose in village.

Keywords: *Solar Energy, Biogas Energy, Water Energy, Wind Energy*

I. INTRODUCTION

The demand of energy is increasing due to industrialization and population growth and the convectional sources of energy such as coal; oil etc. is depleting and are insufficient to meet the demand. Non-renewable sources are limited and bound to finish one day. These sources cause pollution whereas renewable energy sources are environment friendly. India has vast supply of energy resources even though energy crisis has become a great bottleneck in our sophisticated life. The total demand of electricity expected to cross 2550,000 MW by 2030 .The electrical sector have an install capacity of 195.5 GW as of April 2015. The per capita KWh electrical energy consumption was 684.11 in 2015 according to the World Bank. The thermal plant constitutes 65%, hydroelectricity has 25% and the rest is the combination of wind and solar power. In January 2012 our 700 million citizens had no access to electricity and many people get electricity intermittently. Electrical consumption as per 2015 was 130 KWh in rural areas and 300KWh in urban areas. India is currently suffering from major shortage for electricity. India should become one of the leading power producers in the world, but the current technology is towards the green power in rural areas .N on Convectional energy sources are called renewable sources, that are continuously replenished by natural process. For example, solar energy, bio-energy, hydropower, tidal energy, wind energy, geothermal energy, MHD etc. A renewable energy system converts the energy found in sunlight, wind, falling water, sea –wave, geothermal heat, or biomass into heat or electricity. Our government wish to achieve 20,000 MW solar power plants in five stages. P.M Narendra Modi requested China, Japan, Germany and US to invest Rs 100 crore Arab dollars in India in solar energy in the next seven years in the world. Year wise installed capacity of Renewable energy resource is shown in figure 1

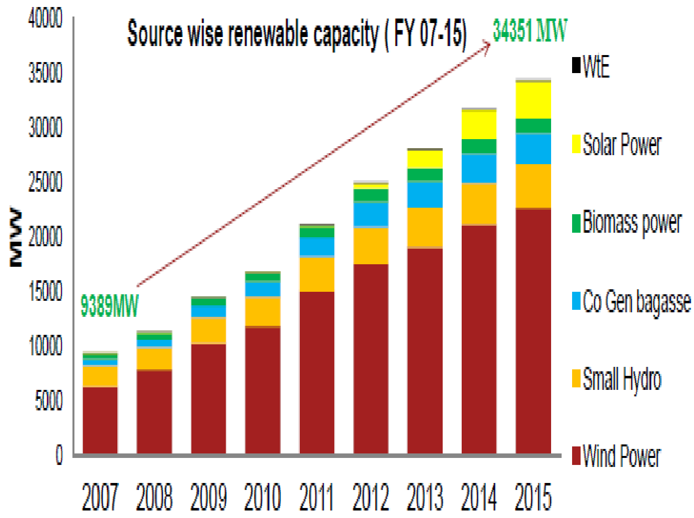

Figure1: Year wise installed capacity of Renewable energy resources

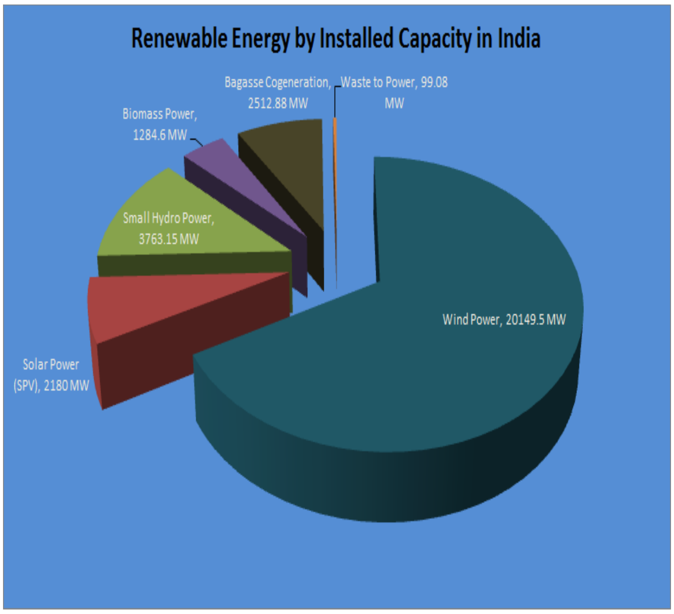

Figure2: Contribution of renewable power

A. Solar Energy

The sun is a large sphere of very hot gases, the heating being generated by various kinds of fusion reaction. Its diameter is 1.39*106 Km while of earth is 1.27*104 Km. The solar power where the sun hits atmosphere is 10^17 watts, whereas solar power on earth's surface is 10^16 watts. The total worldwide power demand of all needs of civilization is 10^13 watts. Therefore the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require. However on account of large space required, power generation. India receives solar energy in the region of 5 to 7 kWh/m^2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plants per square kilometre land area which is shown in figure 3.

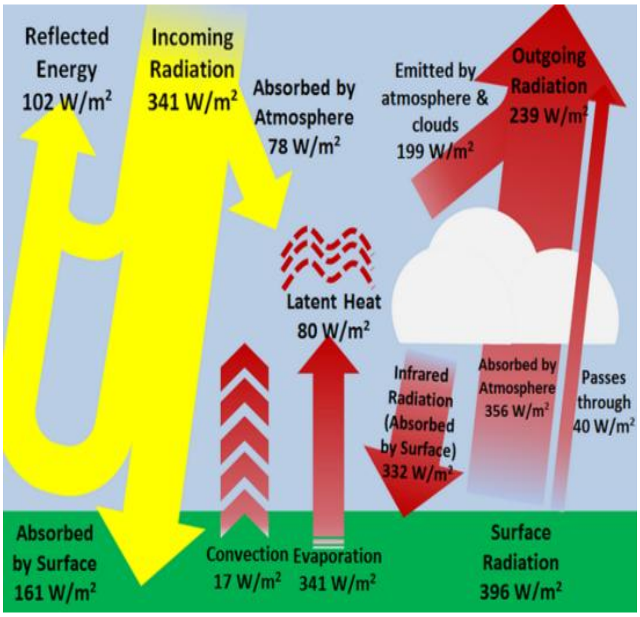

Figure 3: Earth energy Budget

Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials, etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and light.

APPLICATION OF SOLAR ENERGY IN THE VILLAGE

- Solar pump
- Solar cooker
- Solar street light
- Solar electric generation by solar pond

B. Solar Pond

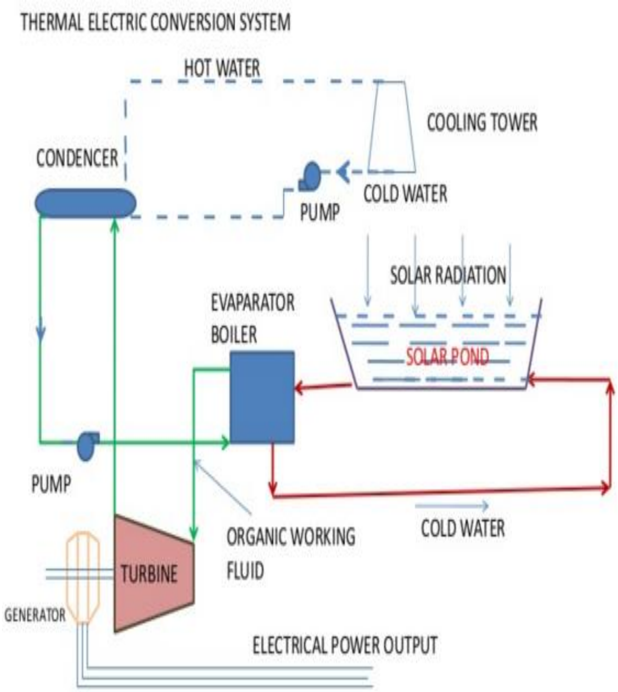

Figure 4: Figure of solar pond

Solar pond is defined as an artificially constructed pond for collecting and absorbing solar radiation energy and storing it as heat. A solar pond combines solar energy collection and sensiblr heat storage. Solar pond is very shallow about 5 to 10cm deep, with radiation absorbing ie black plastic at bottom.A bed of insulating material under the pond minimizes loss of heat to the ground.

A curved cover made of transparent fibre glass , over the ponds permits entry of solar radiation but reduces losses by radiation and convection. A solar pond can store solar heat much more efficiently than a body of water of the same size because the salinity gradient prevents convection currents. Solar radiation entering the pond penetrates through to the lower layer, which contains concentrated salt solution. The temperature in this layer rises since the heat it absorbs from the sunlight is unable to move upward to surface by convention

C. Biogas Plant

Biogas is a mixture containing 55-65 percent methane, 30-40 % carbon dioxide and rest being impurities (H2, H2S, and N2) can be produced from decomposition of animal, plant, and human waste. It is clear but slow burning gas and have calorific value between 5000 to 5500 Kcal/Kg .It can be used directly in cooking, reducing the demand of fire wood. Biogas is produced by digestion; hydrolysis or hydro gasification .Digestion is biological process that occurs in the absence of oxygen and in the presence of anaerobic organism at ambient pressure and temperature of 35-70 degree Celsius.

Stage 1: First of all the original organic matter containing complex compounds e.g., carbohydrate, proteins, fats etc. is broken through the influence of water (know as hydrolysis) to simple water soluble compounds. The polymers (large molecule) are reduced to monomer (basic molecules). The process takes about a day at 25*C in an active digester.

Stage 2 : The microorganisms of anaerobic and facultative (that can live and grow with or without oxygen) groups , together know as acid formers produce mainly acetic acid and prop ionic acids. This stage also takes about a day at 25*C. much of carbon dioxide is released in this stage.

Stage 3: Anaerobic bacteria also called methane former slowly digest the product available from second stage to produce methane, carbon dioxide, small amount of hydrogen and other gasses. The process takes about two weeks time to complete at 25 degree.

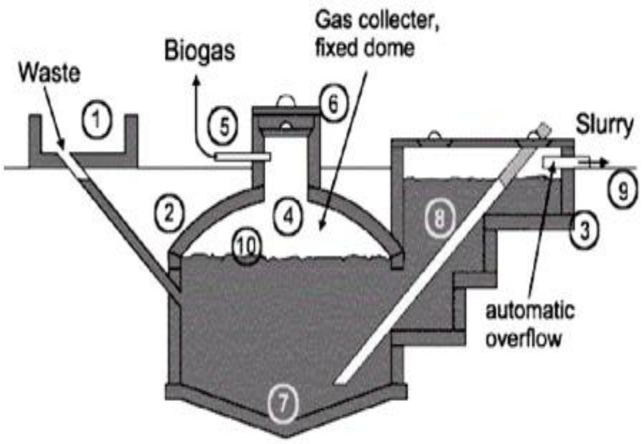

Figure 5: Fixed Dome digester plant

II. CASE STUDY

A village of Punjab consisting of 100 families expanded in 200 acres of area. A village is divided in three categories i.e. 30 richer, 40 middle class and 30 poor families.

A. Rich Class

Table 1: Power demand of richer family

Name of Equipment	No.	Rating (W)	Power(W)
Bulb	10	40	400
Fans	5	75	375
T.V	1	60	60
Cooler	1	250	250
Freeze	1	500	500
pump(i-phase)	1	1492	1492
Pump (3 phase)	1	2238	2238
Total	20		5315

Total demand for 30 rich families is 159450 W

Table2: Waste generated by richer family

Animal	No	Waste generated kg/day	Total waste generated kg/day
Cows	5	10	50
Goats	5	5	25
Buffaloes	5	15	75
Oxen	2	10	20
Total	17		170

B. Middle Class

Table 3: Power demand of middle class family

Name of equipment	No.	Rating (W)	Power (W)
Bulbs	8	40	320
Fans	4	75	300
T.V	1	60	60
Pump(1-phase)	1	1492	1492
Pump(3-phase)	1	2238	2238
Refrigerators	1	500	500
Total	17		4910

Total demand for 40 middle class is 196400 W

Table 4: Waste generated by middle class

Animals	No.	Waste generated Kg/day	Total waste generated/day
Cows	4	10	40
Goats	4	5	20
Buffalo	3	15	45
Oxen	1	12	12
Total	12		117

C. Poor Class

Table 5: Power demand for poor family

Name of equipment	No	Rating (W)	Power(W)
Bulbs	4	40	160
Fans	2	75	150
TV	1	60	60
Total	7		370

Total power demand for30 poor family is 11100 W

Table 6: Waste generated by Poor family

Animal	No.	Waste generated Kg/Day	Total Waste generated kg/day
Cows	1	10	10
Goats	5	5	25
Total	6		35

Government Facility

One Solar Cooker (advance type) to each poor family

One Solar lantern to each of poor family and middle class

Loan facility to villagers to purchase animals like cows, buffaloes etc. and also for agriculture purchase

GOVERNMENT PROPERTIES

Government have agriculture area in 15 acess and pond in 0.5 acres area .There is also community centre, primary and secondary school in 20 acres area

2 pump of 2 hp (running 3 hours)=2*2*735*3= 2940 Wh

50 bulbs 20 W each (8 hrs)=50*20*8 hrs=8000Wh

25 fans 100 W each (8hrs) = 25*100 *8= 20000Wh

1 BPL shop

2 bulbs 20 W (8hrs) = 2*20*8= 320 Wh

1 fan 100 W (8hrs) = 1*100*8=800Wh

STREET LIGHT

50 bulbs 100 W each (10 hrs)= 50*100*10=5000Wh

DAIRY FARM

20 bulbs 20 watt (8 hrs) = 20*20*8= 3200Wh

10 fans 100W (8 hrs) =10*100*8=8000 Wh

Waste generated per day

10 cows 10* 10kg/day=100 Kg/day

10 buffaloes 10*15 kg/day= 150 kg/day

5 oxes = 5*12 kg/day=60 kg/day

10 goat = 10* 5kg/day=50 kg/day

Total = 360kg/day

TOTAL ENERGY REQIUREMENT = 233860 Wh

CALCULATION FOR RICHER FAMILY

Specification and performance of a typically module under standard condition

Module size	119cm * 53.3 cm
Module weight	7.5 kg
Cell size	12.5 cm * 12.5 cm
No of cells	36
Nominal output	80W
Nominal voltage	12 V
Maximum voltage	17 V
Open circuit voltage	21.2 V
Short circuit current	4.9 A

SOLAR PHOTO VOLTAIC POWER GENERATION

Let us consider N modules having efficiency 20 %

Batteries 12V, 120Ah=80%

Module area= 1.191* .533 m each =90% (depth of discharge 0.7)

Incident flux on arrays=650W/m2

Conversion efficiency =12.5%

Cell temperature= 35 degree

Module conversion 20 %

Power output from PV array= 650*6*N*(1.191*.533)*.2 = 495.14N

Multiplying this output by the battery charging and discharging = 495.14*.9*.9*.8=320 WH

Power to be meet by photo voltaic generation=5315 W

Therefore no of modules required for one richer family= 5315/320=17

17 modules of solar cells are required for one richer family to meet their energy requirement

Calculation of cooking gas produced

Gas produced from 1 kg of goober in winter = 42 litre

Gas produced from 1kg of goober in summer= 55 litres

Calorific value of the biogas/m3=4713 Kcal

Density if slurry=1090kg/m3

Total gas produced in winter= 42*170=7140l/day=7.140m3/day

In summer= 55*170=9350l/day=9.350m3/day

Taking minimum gas produced=7.140m3/day

Cooking gas required per family=.28*5=1.4m3

Extra gas produced= 7.140-1.4=5.74

Gas required for 100 C.P for 8 hours lightning=8*.126=1.008m3

Total no of such lights will glow=5.74/1.008=5.6 ~6

6 bulbs can be lighten up after fulfilling fuel requirement

Calculation of power generated from Solar Pond:-

Annual area -2acres = 2*1046 = 2092m^2

Annual mean temperature t_1 =35˚C

Annual average daily radiation of the village = 19600kj/m^2 -day

Annual average ambient temperature = 26.3 ˚C

Depth of the pond at the bottom of the non-convective zone is 0.95m

For horizontal surface, β= 0

Angle of incidence

$$cos\theta = sin\varphi sin\delta + cos\varphi cos\delta cos\omega$$

On equinox day δ =0 at 1400h (LTA)

$$\therefore cos\theta = cos\varphi cos\omega$$

Where, Φ =21.1(latitude angle)

Ω = -30 (hour angle)

$$\therefore cos\theta = cos 21.1 \cos(-30) = 0.8080$$

$$\theta = 36.1$$

Angle of refraction $\theta = \sin^{-1}\left(\sin\frac{36.10}{1.33}\right)$

= 26.30

$$\cos\theta = 0.8965$$

Hence $K_j' = Kj/0.8965$

Annual average daily global radiation

Hg = 19600KJ/m^2 day

$= \frac{196*1000}{3600*24} = 226.9W/m^2$

Now, we have

$$T_{111} - T_a = \frac{\tau Hg}{k}\sum_{j=1}^{4}\frac{Ai}{Kj}(1 - e^{-Kjl}) - \frac{l}{K}q\frac{load}{Ap}$$

Where, T_a = annual average ambient temperature = 26.3˚C g = annual average global radiation = 19600KJ/m^2 day

Kj = (Kj/cosθ_2), where θ_2 is the angle of refraction corresponding to an effective angle of incidence .this is taken to be the angle of incidence on the equinox day at 1400h (LAT)at the location under consideration.

L_2 = depth of the pond at the bottom of the non-convective zone = 0.95m

Qload = annual average heat extraction rate

τ = transitivity = 0.976 for angle of incidence 36.10

K = thermal conductivity = 0.648W/m-k

Corresponding to mean temperature of 50˚C of the whole pond

K_j&A_j= A1 = 0.237 $K_1 = 0.32\ m^{-1}$ for $0.2<\lambda<0.6$ µm

$A_2 = 0.193$ $K_2 = 0.45 m^{-1}$ for $0.6<\lambda<0.75$µm

$A_3 = 0.167$ $K_3 = 3\ m^{-1}$ for $0.75<\lambda<0.9$ µm

$A_4 = 0.179$ $K_3 = 35\ m^{-1}$ for $0.9<\lambda< 1.2$ µm

A_p = area of plant

$$\therefore (35 - 26.3) = \frac{0.976}{0.648} * 226.9 \sum_{j=1}^{4} \frac{0.8965\ Aj}{Kj}\left(1 - e^{-\frac{0.95 Kj}{0.8965}}\right) - \frac{0.95}{0.648} \times \frac{q\text{load}}{2092}$$

$$\Rightarrow (35\text{-}26.3) = 141.85 - 0.0007 q_{load}$$

Qload=190214.28571W

Hence the power generation from the 200 acres of area of pond is 190.214 KW.

CONCLUSION

We have calculated the power demand of the richer family and its generation from solar photovoltaic cell and also we have calculated the total waste generated by richer family and gas produced from biogas , the extra gas aegis left by fulfilling cooking purpose will be used to glow 6 bulbs after fulfilling the requirement of cooking gas and 17 modules of solar cells are required for generation through solar energy Similarly the power generation and gas produced for the middle class and poor family can be calculated. And hence the village will be dependent on renewable energy resources and called as green village.

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