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Designing Human and Kitchen Waste Based Biogas & Solar Plant for PabnaUniversity of Science & Technology (PUST)Campus and Cost Benefit Analysis after Renewable Energy Interconnection on PUST Campus's Grid Network

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ABSTRACT : *Bangladesh is facing serious energy crisis which is a great barrier for development and poverty alleviation. Shortage of electric power generation causes a significant amount of load shedding and which causes a great loss, discomfort and inconvenience in Domestic life. Students suffer most as it hampers their studies, examination and regular activities. Important University activities remain halted during load shedding, which have a severe effect in overall national development. Some of the Universities in Bangladesh use Gas or Diesel generators to alleviate this irritate situation and expense a lot of money, whereas most of the Universities all works come to a halt during load shedding hours. But there is a huge opportunity to backup load shedding using renewable energy sources (Solar energy, human and kitchen waste to generate biogas energy). This paper presents a design and analysis of solar plant and human and kitchen waste based biogas plant for load shedding backup at PabnaUniversity of Science and Technology (PUST), Bangladesh. And the cost analysis focus that the system is economically feasible for not only a University campus but also whole Country.*

KEYWORDS: *Renewable energy, Load shedding backup, Biogas plant, Cost analysis, Electricity Generation.*

I. INTRODUCTION

Electricity is the most convenient form of energy thatis needed for basic household appliances and cannotbe replaced by other forms of energy. In Bangladesh, only about 47%of the populations have access to electricity [1]. Thepresent installed electricity generation capacity isabout 6837.50 MW. The per capita electricityconsumption in Bangladesh is 182 kWh p.a. that isstill among the lowest in the world [1]. The solution is to use renewable energy.The Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat [2]. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services [3].About 16% of global final energy consumption presently comes from renewable resources, with 10% of all energy from traditional biomass, mainly used for heating [4]. New renewables (small hydro, modern biomass, wind, solar, geothermal, and bio-fuels) account for another 3% and are growing rapidly [5]. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20% of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond [6]. Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaics, solar thermal electricity, solar architecture and artificial photosynthesis [7][8].Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-derived materials which are specifically called lignocellulosic biomass [9].

As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of bio-fuel. Conversion of biomass to bio-fuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods. Energy demand in Bangladesh is more than generation. So shortage of electricity is meeting by load shedding. Load shedding creates a lot of problem where some important loads is present such as Medical Centre, Research Centre, School, colleges and Universities. In University, Load shedding hampers regular schedule lab works, research activities, and some other examination activities which is necessary to meet up in time. Students also cannot continue their studies due to load shedding. Some universities try to solve this irritate situation by taking some special steps such as taking high cost power line (i,e 11 kV/ 33 kV), special feeder with continuity of power supply. But they can think different with available resources. The aim of the study is to investigate availability, feasibility of biogas energy (human and kitchen waste) and solar energy in Pabna Science & Technology University. This study will also analyze cost benefits after renewable energy interconnection on university grid network and try to focus how introduced energy alleviates irritate situations which is occurred during load shedding.

OVERVIEW OF PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY (PUST)

The government passed the Act in 15 July 2001 to establish a science and technology university in Pabna. The university will be located in the district head quarter of Pabna. Pabna is a central district town in northern Bangladesh having long historical and cultural heritage. The academic curriculum of the Pabna University of Science and Technology was started on 15 July 2008. This university will play an innovative role in providing need-based higher education, training and research. The university offers education in science- and technology-based subjects for undergraduate and post graduate levels. This newly established university will occupies an area of about 30 acres, with a number of multi-storied buildings. Because of its location (position: 24.0100° N, 89.1800° E) is suitable for solar energy, it has also suitable weather Average maximum temperature 33.9°C, minimum 9.6°C for producing Biogas. It have several multistoried buildings i,e; Two Academic Building, One Administrative Building, Four Student Hall, Two Teachers and staff Dormitory , One VC Bungalow, One Mosque.

II. METHODOLOGY

This paper will investigate available renewable energy resources; calculate Potential of Energy (watt) based on experts opinion, Design energy plant according to used model and analysis its feasibility for Pabna University of Science and Technology University (PUST) Campus. This paper also analysis energy cost savings after renewable energy interconnection on University campus grid network.

III. POTENTIAL OF SOLAR ENERGY AT PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY (PUST)

Photovoltaic is a system which is convert energy from the sun directly into electricity. The combination of photovoltaic cells that generate a small current when sunlight strikes them. Building integrated photovoltaic systems are rapidly incorporated into new university and other buildings as a principal or catalog source of electrical power. Photovoltaic arrays are often associated with buildings either integrated into them, mounted or, them or mounted nearby on the ground. From used data of 100 watt solar panel, It is measured that panel have length, l = 3.36 ft , Width, w= 2.20 ft , Area = Length × Width = 3.36×2.20 = 7.392 square ft.

Assuming a small portion of total roof space of some Buildings: Administrative Building 01 = 4000 sq. ft. So, Calculation of watt from available area can be measured:

7.392 square ft. equal to = 100 Watt

1 square ft. equal to = (100 / 7.392) Watt

4000 square ft. equal to = (100 × 4000) / 7.392 Watt

= 54.11 Kilo-Watt = 54 KW (Approximately)

So, Total panel required in every hostel = 540 pieces (Because of each of the panel wattage is 100 Watt). So, by assuming available multistoried buildings, we can calculate total solar output power. Potential of Solar Energy in Pabna University of Science and Technology –

Building Name	Assume sq.m	Potential of Energy (kW)
ADMINISTRATIVE BUILDING 01	4000	54
ACCADEMIC BUILDING 01	4000	54
ACCADEMIC BUILDING 02	4000	54
STUDENT HALL 01	7000	94
STUDENT HALL 02	10000	135
STUDENT HALL 03	7000	94
STUDENT HALL 04	10000	135

Total Potential of Energy (kW) from solar energy is 620 kW.

IV. POTENTIAL OF BIOGAS ENERGY

Every university has sufficient renewable energy which can act as rising part to reduce the load shedding problem of that university. By considering these, we are presenting a biogas plant with respect to human waste and kitchen waste of hostel 1,2,3,4 dormitory building of a campus where these wastes are used as raw materials.

For Human waste:

Building Name	Capacity of Population
STUDENT HALL 01	500
STUDENT HALL 02	1000
STUDENT HALL 03	500
STUDENT HALL 04	1000
Teachers and Staff Dormitory	300

STUDENT HALL 01: Total capacity of Populations is 500 people.
On an average each person's human waste is = 0.5Kg.

So, Total Human waste = (0.5×500) = 250 Kg.

An ordinary temperature (30° C) biogas obtained from human waste = 0.365 m^3 / Kg TS (estimated).

Again TS value of human = 20%.

So, the total biogas from 500 peoples = (0.5×500×0.2×0.365) = 18.25 m^3 .

Each cubic meter (m3) of biogas contains the equivalent of 6 kWh of calorific energy. However, when we convert biogas to electricity, in a biogas powered electric generator, we get about 2 kWh of useable electricity, and the rest turns into heat which can also be used for heating applications.

So, Electricity from biogas in kW = 18.25 × 2 kWh = 36.5 kWh

According to above calculation, it can be calculate from all Buildings:

Building Name	Capacity of Population	Resources of Biogas	Potential of Energy (kWh)
STUDENT HALL 01	500	Human waste	36.5
STUDENT HALL 02	1000	Human waste	73
STUDENT HALL 03	500	Human waste	36.5
STUDENT HALL 04	1000	Human waste	73
Teachers and Staff Dormitory	300	Human waste	21.9
Total Population of university campus	3300	Kitchen Waste	325

Total Potential of Energy from Biogas Energy is 565.9 kWh.

TOTAL GENERATION CAPACITY FROM HUMAN WASTE, KITCHEN WASTE AND SOLAR ENERGY

The total generation capacity from human waste, kitchen waste and solar energy that is calculated is given below in the following table:

Building Name	Assume sq.m	Energy Type	Potential of Energy (kW)
ADMINISTRATIVE BUILDING 01	4000	Solar	54
ACCADEMIC BUILDING 01	4000	Solar	54
ACCADEMIC BUILDING 02	4000	Solar	54
STUDENT HALL 01	7000	Solar	94
STUDENT HALL 02	10000	Solar	135
STUDENT HALL 03	7000	Solar	94
STUDENT HALL 04	10000	Solar	135
		Total DC Energy	620
Building Name	Capacity of Population	Resources of Biogas	Potential of Energy (kWh)
STUDENT HALL 01	500	Human waste	36.5
STUDENT HALL 02	1000	Human waste	73
STUDENT HALL 03	500	Human waste	36.5
STUDENT HALL 04	1000	Human waste	73
Teachers and Staff Dormitory	300	Human waste	21.9
Total Population of university campus	3300	Kitchen Waste	325
		Total AC Energy	565.9

V. IMPORTANT LOADS

According to the demand of power we have separated the total generation on the basis of renewable energy. The demand of electricity is varying with respect to time. When we required a huge amount of power then connects the required energy with respect to some units (Renewable energy). We are maintaining the total generation and BPDB supply by using control unit and substation. With respect to renewable energy source and BPDB we can fulfill the total demand of university campus.

Identifying Important Loads Which Needs Continuous Supply:

Building Name	Load (kW)	Quantity of Light	Rating per light (Watt)	Quantity of Fan	Rating of Fan (Watt)
ADMINISTRATIVE BUILDING 01	6	80	40	40	70
ACCADEMIC BUILDING 01	3.35	40	40	25	70
ACCADEMIC BUILDING 02	3.35	40	40	25	70
STUDENT HALL 01	8.35	200	40	5	70
STUDENT HALL 02	18.70	450	40	10	70
STUDENT HALL 03	8.35	200	40	5	70
STUDENT HALL 04	18.70	450	40	10	70
Some other important loads (Servers, security system, Research Lab)	30				
Teachers and Staff Dormitory	6.8	100	40	40	70
Vice-chancellor Bungalow	1.5	20	40	10	70
Central Mosque	1.85	20	40	15	70
Total	106.95				

VI. AVAILABLE RENEWABLE ENERGY DISTRIBUTION

Here load can be grouped based on load characteristics with respect to time so that load management will be easier. Load groups also indicate when those loads have higher priority.

Load Group	Total Load (kW)	Building Name	Load	Quantity	Rating	Quantity	Rating
A	6	ADMINISTRATIVE BUILDING 01	6	80	40	40	70
B	6.7	ACCADEMIC BUILDING 01	3.35	40	40	25	70
		ACCADEMIC BUILDING 02	3.35	40	40	25	70
C	54.1	STUDENT HALL 01	8.35	200	40	5	70
		STUDENT HALL 02	18.7	450	40	10	70
		STUDENT HALL 03	8.35	200	40	5	70
		STUDENT HALL 04	18.7	450	40	10	70
D	30	Some other important loads (Servers,	30				
E	6.8	Teachers and Staff Dormitory	6.8	100	40	40	70
F	1.5	Vice-chancellor Bungalow	1.5	20	40	10	70
G	1.85	Central Mosque	1.85	20	40	15	70

Important Load Duration Table based on regular load Characteristics:

Time of day	00:00 – 05:00	05:00 – 08:00	08:00 – 14:00	14:00 – 17:00	17:00 – 19:00	19:00 – 24:00
Running Load			Load A			
			Load B	Load B		
	Load C					Load C
	Load D	Load D	Load D	Load D	Load D	Load D
	Load E	Load E			Load E	Load E
	Load F	Load F	Load F	Load F	Load F	Load F
		Load G		Load G	Load G	
Total Load (KW)	92.4	40.15	44.2	40.05	40.15	92.4

From available renewable energy resources of Pabna University of Science and Technology campus, It is observe that 620 kW Power can be obtained from Solar Energy. Solar Energy in the form of DC. So, it is necessary to convert this energy to AC and supplied to grid. To get continuous power from solar energy, it is necessary to use storage device. Power can also be obtainable directly during day time. Here it is assume that a few amount of power (55 kW) can be get from storage device and 400 kW power can be obtainable directly. According to these assumptions, Power from Solar Energy is distribute among all day. Total Biogas energy 567 kWh is in the form of AC and it can be directly obtainable from different size of Gas-generator. 40 kWh power can be obtainable by load management with 12 hour. By assuming these criteria, Renewable Energy can be distributing among all day as shown:

Time of day	**00:00 – 05:00**	**05:00 – 08:00**	**08:00 – 14:00**	**14:00 – 17:00**	**17:00 – 19:00**	**19:00 – 24:00**
Solar Energy supplied to PUST Campus grid Network (kW)	**55**	**55**	**400**	**400**	**100**	**55**
Bio-gas Energy supplied to PUST Campus grid Network (kW)	**40**	**0**	**0**	**0**	**40**	**40**
Total renewable Energy supplied to PUST Campus (kW) power grid	**95**	**55**	**400**	**400**	**140**	**95**
Important Loads of PUST Campus (kW)	**92.4**	**40.15**	**44.2**	**40.05**	**40.15**	**92.4**

From this table, It is also observed that important loads can be easily run by using renewable energy.

VII. COST BENEFIT ANALYSIS AFTER RENEWABLE ENERGY INTERCONNECTED ON UNIVERSITY GRID

Pabna University of Science and Technology can consider renewable energy sources as alternative sources of energy. Though it is necessary to take Electricity supply from national grid, It is also necessary to consider renewable energy as a backup source of power in order to maintain continue of Electricity. Self producing energy can play as cost saving way to maintain academic development of university. Both national grid supply and renewable energy supply play a vital role in order to maintain continuity of energy supply and energy cost savings.

Time of day	00:00 – 05:00	05:00 – 08:00	08:00 – 14:00	14:00 – 17:00	17:00 – 19:00	19:00 – 24:00
Solar Energy supplied to PUST Campus grid Network (kW)	55	55	400	400	100	55
Bio-gas Energy supplied to PUST Campus grid Network (kW)	40	0	0	0	40	40
Total renewable Energy supplied to PUST Campus (kW) power grid	95	55	400	400	140	95
Renewable Energy (kWh)	475	165	2400	1200	280	475

Total Renewable Energy supplied to PUST power grid Network is 4995 kWh.

If Energy cost is 5 Tk per kWh, Then Total Energy cost is Tk 24975 per day.

Pabna University of Science and Technology can save Tk 749250 per month for energy cost.

VIII. CONCLUSION

Bangladesh has a great opportunity to generate biogas and solar with the help of human waste, kitchen waste and sun shine. This renewable energy sources can be used for generating electricity and removing load shedding problems in Bangladesh. As the load shedding problems may not be removed in near future, this is the best alternative source to generate electricity. Our thesis paper represents the back-up source during load shedding at a University Campus according to biogas and solar based where human waste, kitchen waste and sun-shine is used as new materials. Complete design including system specification has been worked out. To remove load shedding problem, our represented thesis paper can be used as an ideal model for every University Campus in Bangladesh.

IX. FURUTE WORK

We will investigate about more detail regarding interconnected grid system, reliability and system failure and management of load. We will try to implement for this new concepts to our university not only to save cost but also reliable electric supply. So our thesis objectives not only focus for one campus but also community based power generation as well as development of our country through green energy.

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