A Sustainable Micro Gird Solution for Bangladesh: Photo Voltaic Powered Electric Cooking System

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***Abstract*—** Electric Stove (ES) is becoming popular in Bangladesh (BD). Although it has no direct impact on the environment, it consumes more power from the power grid. Photovoltaic based Electric Cooking System is an effective solution due to its clean, efficient and easy operation. The system includes energy storage, bidirectional inverter and smart exchanging control system with meter and a reflex charging method. This system is connected it to the grid for exchanging power with the grid for any accidental or uncertain occasions. It should decrease carbon dioxide emission rate up to 37% with saving 43% of natural gas with suppling 10 KWh to the grid from the each of 10 million sub-variant systems in a day. This system will help Government of the People's Republic of Bangladesh to fulfill some demands and targets.

***Keywords*—** electric stove, charging station, photovoltaic, energy storage, prepaid meter, reflex charging.

I. INTRODUCTION

Bangladesh is a developing country that situated between 20.30° - 26.38° north latitude and 88.04° - 92.44° east longitude with 164 million populations in density of 1, 115.62/Km2. This vast population use natural gas, coal, oil and wood for cooking. In a little country like Bangladesh, it causes both deforestation and running out of fuel sources. Over production of carbon dioxide can causes global warming and melting down the ice of two pole of the earth. Within last two decades the rate of melting rises up to 2000% in comparison of last 10000 years [1], [2]. Per year 32.33 ppm (parts per million) of CO2 has increased within the last 14 years [3]. The vast amount of fossil fuel needs thousands of years to produce naturally. Shortage of fuel, increasing of CO2 and malting of ice is an alarming sign for a country like Bangladesh. Electric stove (ES) can be a solution, it can easily prepare meal for 4-5 persons by consuming 2KWh of electric power without demising environment. But ES has a great impact on national grid. Bangladesh has some advantages as, 300+ clear sunny days with average of 10.5 solar hours which solar radiation varies between 4 and 6.5 kWhm-2 [4] to overcome the impact on grid. So, this paper is going to propose a solar based modern design of a micro grid power system for both rural and urban areas. This model will be very efficient for a developing country like Bangladesh [1], [5].

II. IMPORTANCE OF RENEWABLE ENERGY BASED COOKING METHOD IN BANGLADESH

In present scenario, the maximum production is 11,623 MW of electricity. Though maximum demand is reached in 12,400 MW. Bangladesh imports 1,160 MW power from India and demand for electricity in Bangladesh will reach 34,000 MW by 2030 [6], [7]. In order to produce this electricity, people are depending on fossil fuel-based power plants and finding new renewable generation places [19]. Adding Electric Stoves minimizing to burn more fossil than traditional cooking method which produce more carbon dioxide and harmful for our environment. The traditional cooking method is also less efficient. According to Table 1.

Table I: *Produced heat, efficiency and carbon emmission rate*

Fuel	Produced Heat (KJ/m3)	Efficiency (By using pressure cooker)	Rate of Carbon dioxide (Btu)
Natural Gas	42065.35	56.6%	117.0
LPG (Liquid Petroleum Gas)	46717.34	62.59%	139.0
Coal (Bituminous)	19409.78	43.34%	205.7
Oil (kerosene)	43100.56	52.75%	161.3
Wood (Dry)	16011.2	27.38%	196.6
Electric Stove (1500W)	19020.624	78.63%	0.00

Table I can explain that using electric stove is more efficient than other fuels.

III. SITE SELECTION

A. Free Space for PV:

Placing PV on the roof top in urban area and on the top of the pillar or any free space in rural area is the best option.

B. Sunlight:

In Bangladesh, sunlight hours minimum of 7.23 hours per day throughout the year [8],[18].

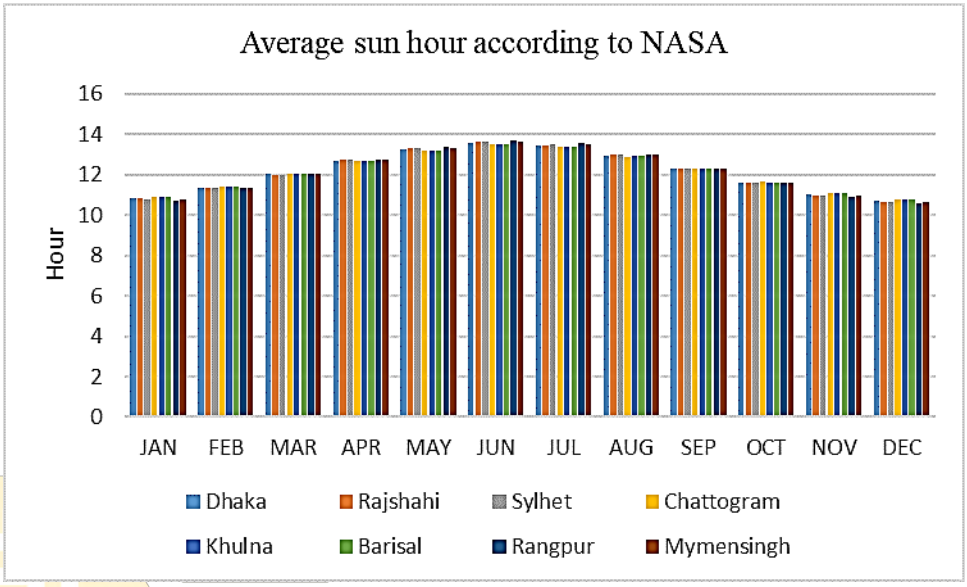

Figure 1: *Average sun hour per day throughout the year as per location*

C. Power Generation Probability:

As it is known that the cost of a complete PV system decreasing day by day and has a long-life cycle. It will be efficient to generate power in cheaper way.

IV. METHODOLOGY

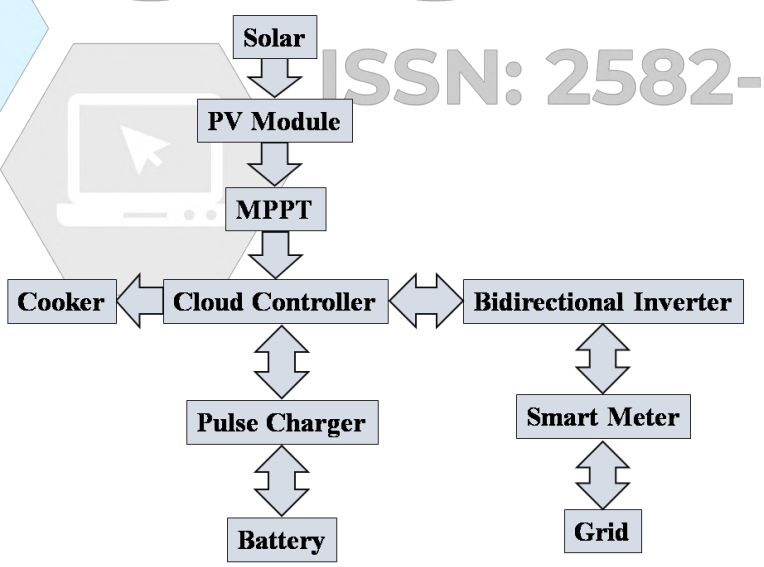

Figure 2: *Work flow of the system.*

In the model, a power system is implemented by choosing a home as a power generating unit. The hybrid system provides better energy sources than the conventional way of generating power [9]. PV solar panel is used as the source of energy during the day time Electric stoves stoves will be directly operated by using solar power and the storage system is being charged by using the same source. The storage system is integrated for operating the Electric Stoves during night time and helps to fulfill the household demand. After filling the storage, the system will supply extra power to the grid. During extreme weather or accidental moment, energy

is drawn from the power grid and it is not connected with the storage. A smart meter is connected with the system to calculate how much power is given to the grid and what amount is being taken from the grid and it will make payment method easier. As a result, the micro consumer can sell their extra power to the grid. Reflex charging method have been used to ensure safe battery charging. The whole system is controlled and supervised by a computerized energy management system. Fig-2 shows the block diagram of a solar-powered ES system.

II. SYSTEM CONSTRUCTION

A. PV Power Generation System

PV cells are used to generate electricity and there are various types of PV panels based on solar cell types such as; thin-film solar panel, polycrystalline solar panel, and monocrystalline solar panel. Among all of the panels, monocrystalline is best for commercial use because of the long durability and high-efficiency rate. The output of a solar panel depends on its geographical location. As a result, maximum PV power is in April and minimum is in December. The cost of a PV power project is efficient in the long run.

B. Maximum Power Point Taking (MPPT) Controller

MPPT converter is being used to overcome the main disadvantage of a PV power supply system. MPPT converter supplies constant output voltage with the change of solar radiation and temperature. The algorithm makes use of power versus voltage curve and defines the point, where dP/dV=0, as the MPP. A positive impact can be obtained which enhances the efficiency of power utilization by using MPPT in the PV solar system. But an unstable voltage can be created by the MPPT controller at the same time. To perform a more sensitive approximation to MPPT a PI controller can be added [10], [11].

C. Real Time Site Controller:

It will control the system to run as an autonomous body and control the power exchanging system with grid.

D. Storage bank:

It is proposing the Lead-acid battery for the storage bank due to its long durability and capacity of 324KW. It has rating of current and voltage of 600ah and 540 volts individually [12].

E. Reflex Charging Method:

Reflex charging method is a new phenomenon of fast charging [13]. This is a concept of fast charging where a battery can be charge 0% to 80% within 15minutes. As a result, the system can be used in most efficient way [14].

III. MATHEMATICAL CALCULATION

Table I: *Efficiency and Losses Data*

Name of Equipment	Efficiency	Loss
PV module	24% (according to solar power)	-
MPPT & Bi-directional Inverter	80% (according to produced power by PV)	-
Electric stove (IR based)	80% (according to total ac power)	-
Transmission loss	-	3% (according to produced power by PV)
Internal Uses loss	-	2% (according to produced power by PV)

A. Generation target:

This view is proposed a micro unit for at least 6 person's standard meal in a day for three times. Almost 3.5KW power is needed to do it. As a result, at least 10.5KW power need from a micro generation system to make it economical.

A generation must provide = 10.5KW+5% losses (transmission + internal uses loss) + Bi-directional inverter loss + ES loss =10.5KW + 525W + 3150W + 3000W = 17.175KW + grid ≈ 22KW

B. Sun Hour Calculation:

Fig-1 get lowest peak sunlight hour is 7.23h

C. Panel Calculation:

Here is using mono crystalline silicon PV panel with efficiency of 24%. Single unit generates power of 22KW in a day where per panel power rating is 1500W. As a result, two panel is enough for load demand.

D. Measuring Area:

The solar power is in-between 4 to 6.5KW/m2 at Bangladesh. Let's assume that, the average solar power

is 5.25KW/m2. Therefore, with the efficiency of 24% to panels required area is 2.38 m2 or 25.62ft2 or (5.06×5.06) ft2.

E. Benefit of the system:

Assume that each family (as a unit) has 5 member and use 1kg of gas or 10.5 KW of electricity for cooking.

Calculation of gas for a day:

- Gas production in BD = 193798450 kg
- Gas use for cooking = 23255814 kg
- Probable gas save = 10000000 kg (1kg×10 million unit)
- Percentage of save = (10000000×100)/23255814 = 43%

Calculation of Electricity for a day:

- Total production by the system = 22 KW×10 million = 220000000 KW
- Use for cooking (6 persons) = 10.5 KW
- For (6 person) ×10 million = 105000000 KW
- Loss + grid + other factors = 115000000 KW
- Feed to grid (115000000×93%) = 106950 MW

Emission of Carbon dioxide:

- Carbon dioxide from 1kg gas = 1.665 kg
- Total emission of CO2 = 45000000 kg
- Reduce of co2 (1.665×10000000) = 16650000 kg
- % of reduction = (16650000×45000000) ×100 =37%

F. Efficiency of the system:

- Residential demand per unit = 10.5KW
- Feed to grid from per unit = 106950MW ÷ 10 million = 10.695 KW
- Electrical efficiency = ((10.5+10.695) ÷ 22) × 100% = 96.341%
- Plant efficiency = (24×96.341) ÷ 100 =23.122%

IV. COST SHEET

Table II: *Cost Sheet for a Unit*

Item	Quantity	Rating	Unit cost (BDT)	Total cost (BDT)
PV Panel	2	1.5 KW	65 per Watt	195,000
Solar Storage Battery	2	3.24 KW	100,000	200,000
Reflex Charger	1	-	18,000	18,000
Bidirectional Inverter	1	-	15,000	15,000
MPPT with PI	1	-	7,000	7,000
Maintenance	50 Times	-	2,000	100,000
Electric Stove	2 Burner	2KW	12,000	12,000
Total				547,000

The total system has life time of 25 years.

- In comparison with LPG 1050×2×12×25=630,000 BDT is needed in 25 years [15].
- In case of this system with 300 sunny days/year it can harness 112500 or (75,000+37,500) KWh in 25 years by costing only 4.86 BDT/KWh.
- This electricity can be sold to the grid at cost of 7.29 BDT/KWh.

Here,

- Yearly revenue = 300×7.29×10 = 21,870 BDT
- And total revenue = 25×21870 = 546,750 BDT
- It will save = 630,000 BDT, as well as 19×25×12= 5700 litter of LPG.

If install unit is 10 million in the country, this will provide 100 million KW or 100 GW per day to the grid [16].

V. PROJECTED MODEL AND SUSTAINABLE DEVELOPMENT GOALS

The study has proposed this model due to find out an efficient and sustainable solution for the next era of Bangladesh. This model can fulfill 1, 2, 3, 6, 7, 8, 11, 13, 14 and 15 no. goals of SDG (Sustainable Development Goals) which is given by UNDP. It will

save the environment from emission of carbon dioxide. As a result, affordable and clean energy as well as another SDG's can be obtained. If UNDP funding BD government 65% of total cost then it will help Bangladesh to obtain the SDG agenda 2030 [17].

VI. CONCUSION

It is a critical time; people are giving their maximum effort to make the world greener again. By implanting that system Bangladesh surely will go one step forward to the green world concept. Bangladesh has a very low amount of land to use. So, Bangladesh has to focus on appropriate using. Roads, roofs, build everything should under the over-using term. In recent years, solar panels are one of the most interesting over-use terms. By adding to the grid, generation pressure can be reduced. This system will help both the government and civilians.

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REFERENCES

[1] World Population Prospects, "Bangladesh Population 2019," 28-Aug-2019. [Online]. Available: http://worldpopulationreview.com/countries/bangladesh-population/ . [Accessed: 10-Sep-2019].

[2] Dahr Jamail, "Earth's ice loss, is a nuclear explosion of geologic change," 9- Oct-2018 ; Available: http://www.dahrjamail.net/2018/10/10/earths-ice-loss-is-a-nuclear-explosion-of-geologic-change/

[3] https://truthout.org/articles/earths-ice-loss-is-a-nuclear-explosion-ofgeologic-change /.[Accessed: 10-Sep-2019].

[4] "Carbon dioxide, direct measurements: 2005-present," 2019 Available: https://climate.nasa.gov/vital-signs/carbondioxide/ . [Accessed: 10-Sep-2019].

[5] Md. Maruf Hasan, Md. Fayyaz Khan, "A comparative study on installation of solar PV system for grid and non grid rural areas of Bangladesh," 2nd International Conference on the Developments in Renewable Energy Technology (ICDRET), 5-7 Jan. 2012, Dhaka, Bangladesh.

[6] Daft Logic, "List of the Power Consumption of Typical Household Appliances," 2019. [Online]. Available: https://www.daftlogic.com/information-appliance-power-consumption.html . [Accessed: 10-Sep-2019].

[7] "Power Generation Units," BPDB, 19-Aug-2019. [Online]. Available: http://www.bpdb.gov.bd/bpdb_new/index.php/site/power_generation _unit/ . [Accessed: 10-Sep-2019].

[8] UNB, "PM: Target set to generate 24,000 MW by 2021," Dhaka Tribune, 07-Dec-2016. [Online]. Available: https://www.dhakatribune.com/bangladesh/2016/12/07/pm-target-setgenerate-24000-mw-2021/ . [Accessed: 10-Sep-2019].

[9] "Renewable energy data collection 2019," 2019 [Online]. Available: https://power.larc.nasa.gov/data-access-viewer/ . [Accessed: 10-Sep-2019].

[10] Muhammad Nizam, F. X. Rian Wicaksono, "Design and Optimization of Solar, Wind, and Distributed Energy Resource (DER) Hybrid Power Plant for Electric Vehicle (EV) Charging Station in Rural Area," 5th International Conference on Electric Vehicular Technology (ICEVT), 30-31 Oct. 2018, Surakarta, Indonesia.

[11] Taha N. Gucın, Kayhan Ince, FilizKaraosmanoğlu, "Design and Power Management of a Grid-Connected Dc Charging Station for Electric Vehicles Using Solar and Wind Power," 3rd International Istanbul Smart Grid Congress and Fair (ICSG), 29-30 Apr. 2015, Istanbul, Turkey.

[12] AinurRofiqNansur, AlfisSyahLailiHermawan, Farid DwiMurdianto, "Constant Voltage Control Using Fuzzy Logic Controller (FLC) to Overcome The Unstable Output Voltage of MPPT in DC Microgrid System," 2018 International Electronics Symposium on Engineering Technology and Applications (IES-ETA), 29-30 Oct. 2018, Bali, Indonesia.

[13] EAI, "Cost of Li-ion Batteries – Cost Trends 2018-2030 – $/kWh with Break Ups," 22-Dec-2018. [Online]. Available: http://www.eai.in/blog/2018/12/cost-of-batteries.html. [Accessed: 10-Sep-2019].

[14] Huang-Jen Chiu, Li-Wei Lin, Ping-Lung Pan, Ming-Hsiang Tseng, "A novel rapid charger for lead-acid batteries with energy recovery," IEEE Transactions on Power Electronics, vol. 21, no. 3, p. 640 - 647, May 2006.

[15] "Pulse Chargers and Battery life maximisers," Amazonaws, 19-Mar2017. [Online]. Available: http://dnp.s3.amazonaws.com/b/b5/Battery%20pulse%20charger/ . [Accessed: 10-Sep-2019].

[16] Bangladesh Energy Regulatory Commission, "Bangladesh Power Issue 2019," 28-Aug-2019. [Online]. Available: http://www.berc.org.bd/ . [Accessed: 10-Sep-2019].

[17] UNDP, "SUSTAINABLE DEVELOPMENT GOALS," 2015. [Online]. Available: https://sustainabledevelopment.un.org/?meanu=1300. [Accessed: 10-Sep-2019].

[18] Mridul, M. K., Al Mahbub, A., Alam, M. T., & Ali, M. (2020, June). Designing Solar Charging Station for Electric Car at Dhaka-Chattogram National Highway in Bangladesh. In 2020 IEEE Region 10 Symposium (TENSYMP) (pp. 66-69). IEEE.

[19] M. Ali, M. K. Mridul and A. A. Mahbub, "Comparative Wind Power Assessment by Weibull Distribution Function in Faridpur," 2020 11th International Conference on Electrical and Computer Engineering (ICECE), 2020, pp. 13-16, doi: 10.1109/ICECE51571.2020.9393088.