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The Implementation of Solar-Wind Cascading Power Station in Bangladesh

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ABSTRACT

Energy insufficiency is disturbing the improvement of Bangladesh. Since the sun light is not available always and the breeze does not blow constantly, solar and wind power alone are weaker power sources. Coupling solar as well as wind power sources along with storage batteries making up the full duration of time in the absence of wind or sun light supplies a pragmatic shape of power generation. In Bangladesh, breeze is not available most of the places. Only in the coastal areas, wind is sufficient to produce electricity. However, sunlight is available all over the year here. Although solar and wind alone power station has installed here but solar-wind cascading power station has not been installed yet.

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1. Introduction

The paper discusses a variety of options for the future power generation in the sector of solar-wind cascading power station in Bangladesh. Based on information collected and observed from the different sources, we will show a proper outline about the power situation in Bangladesh and how each of the hybrid power plants (solar, wind, solar-wind cascading) can play a vital role in improving power generation where load shedding is a common problem in Bangladesh. So we want to introduce a new power station Titled "Solar -wind cascading power station". First of all, a solar panel will be charged here. Then it will charge a dc battery. After charging, the battery there is a dc motor, which converts electrical power to mechanical power. It will rotate a fan and this fan will rotate the turbine. In our project, we want to make all of these in a small scale. Here we have made a small project lamp in corporate with solar and wind power.

1.1 Historical Background

Bangladesh, the South -Asian country, is located in between India and Myanmar. Bangladesh is an over populated country $(1015\ \mathrm{km}^{-2})$ (BBS, 2011). The whole area of the country is 1 lakh 47 thousand 570 square kilometers. Bangladesh has a humid as well as

misty summer. She has a torrid season in the cold months. January is known to be the coldest month and April is said to be the warmest month. Nearly all places get more than 1,525 mm of rain a year. Nearly maximum rains occur during the monsoon (June to September) and little in winter (November to February). Bangladesh has hot temperatures all over the year.

1.2 A Review on Solar Power as well as Wind Energy in Bangladesh

Bangladesh has a 724 km long coastline and many small islands in the Bay of Bengal, where stiff wind blow in the summer months and there is gentle wind breeze in winter months. By taking into consideration of the variation of wind velocities as well as convenient wind speed pattern, the existing power generation systems can be replaced by new system called 'solar-wind cascading power system'.

In future, solar energy or wind energy or solar-wind energy might be made use of many locations of Bangladesh. The topographical area of Bangladesh is perfect for utilizing solar power perfectly. In this research article, feasibility of the wind-solar cascading power method has been discussed. After an introductory survey carried out by calculated field data of wind velocities and solar radiation throughout Bangladesh, two particular sites Patenga as well as Thakurgaon have been pointed out.

1.3 Data

Energy Bangla has measured wind speeds at four locations in the coastal areas of Bangladesh. These locations are (1) Parky Saikat (2) Mognamaghat (3) Muhurim Dam and (4) Kuakata.

Table 1
Speed of wind in different places in Bangladesh

Month	Muhuri Dam H=50m, RCL=0	Mognamaghat H=50m, RCL=0	Parky Saikat Patenga H=50m, RCL=0	Kuakata H=50m, RCL=0
January	6.25	6.15	6.10	6.85
February	6.40	5.85	6.20	7.10
March	8.10	8.19	8.00	8.17
April	8.00	8.12	8.16	7.35
May	7.52	7.95	7.05	6.75
June	8.13	8.10	8.15	8.10
July	6.90	7.90	8.05	9.65
August	6.10	8.19	8.12	8.55
September	7.10	8.15	8.00	6.95
October	7.00	6.90	7.15	6.35
November	6.15	6.10	6.15	7.75
December	5.15	6.30	6.00	6.90
Annual Average Wind Speed (m/s)	7.50	7.8125	7.86	8.085

1.4 Theory

Basically, wind energy refers to the energy obtained from the force of energy. The power denoted by P(w) is proportional to the rotor swept area and to the cube of the wind speed. Therefore, we can write

$$P = (½) . r . A . V^3 . Cp \ (in \ Watts) \quad (1)$$

Where, A is called the area, V is called wind velocity (m/s). A maximum of 68.5% of power can be extracted, that is Cp (0.685). The maximum of 45% is achievable practically.

1.5 Results

A program named 'Hybrid Power C' is developed in programming language (C++) to measure power. The coastal site of Patenga and the two districts of Thakurgaon and Jessore have the largest wind power densities of 255.15wm^{-2}, 175.7 Wm^{-2} as well as 75.95 Wm^{-2} respectively.

2. Literature Review

There is possibility of natural calamity like cyclone in every 10 years. So adequate control strategies might be given in order to control the turbine in high-speed wind during cyclone. Hybrid power generation is definitely worthy. Finally, government of Bangladesh has declared its vision to provide electricity for all by the year 2025.

Figure 1: The Wind Power Plants in Kutubdia

Figure 2: A Wind Pump at Patenga, Chittagong

To be honest, Kutubdia is the separated island in which current is produced by diesel generator in this long distance place. It is very expensive and time consuming to transport diesel to this island and have been replaced directly diesel with the energy produced by the wind battery hybrid power system.

2.1 Limitations of Wind Power Plant

1. Wind power should challenge with other low-cost energy origins.

2. Ideal wind location is always in far-off locations.
3. Turbines generate noise.
4. Local wildlife can be affected by wind plants.

2.2 Solar Power

Most of the generated power in Bangladesh comes from coal, diesel and gas driven power stations (Khan, Rahman, & Hossain, 2012). Solar power operates converting energy from the sunray into power**.** There are two manifestations of energy generated from the sun for our use, which are electricity and heat. In Bangladesh, maximum amount of radiation is available on the month of March-April and minimum on December-January. Bagerhat is now Bangladesh's largest solar photovoltaic (PV) plant.

2.3 The Solar Energy Transformation Method

We have many types of solar energy methods. A layout (Block) representing 3 of the most fundamental techniques sorts is shown as Figure 3. In the first figure, the solar resource has been trapped and then turned into heat that is then provided to a demand for heat energy /load such as house heating. This type of system usually incorporate an auxiliary source of energy.

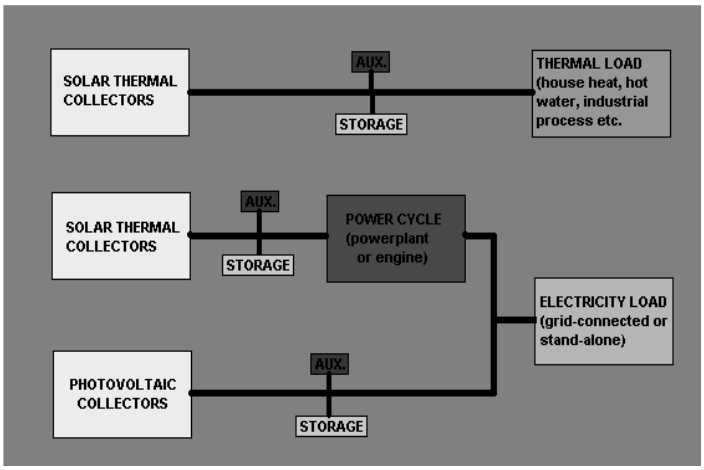

Figure 3: Solar Energy Transformation Method

We have two methods of turning solar energy into electricity. One system is to collect solar energy as heat and convert it into electricity by means of a particular power plant. In addition, another method is to use PV cells to transform solar energy directly into electricity. Both methods are shown systematically in Figure 3.

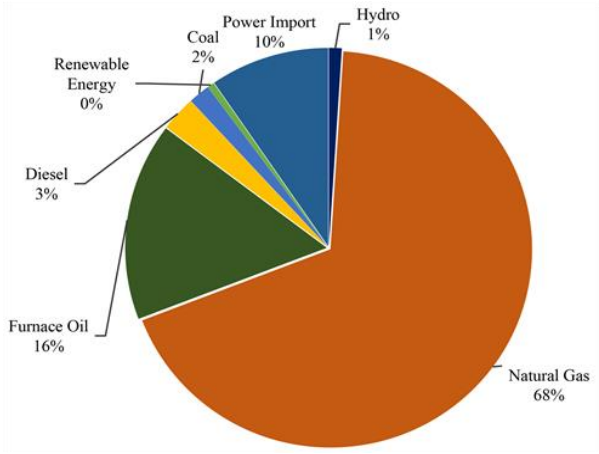

Figure 4: Solar Energy prospectus in Bangladesh

2.4 A Layout for Solar PV Home Systems in Bangladesh

A survey of the features related to the sketch of a solar PV home system has been shown. Besides, the solar home systems are getting popularity in the village areas of Bangladesh. It is very important to sketch the systems properly to keep the price low and the performance satisfactory. Performance of a solar PV system varies with a number of factors like geographical location, climatic condition etc (Khan et al., 2012). Availability of relevant data for detailed performance analysis of SHS in Bangladesh is quite limited. So, realistic values were chosen, based on the available data, for the cases where data was not available. These are:

1. The solar panels are fixed with no sun tracking facility or solar concentrator.
2. The charge controllers are simple ON/OFF type with no maximum power tracking facility.
3. The system must have 3 days autonomy.

2.5 Performance of the Solar PV Module

Solar panel ratings usually refer to the Standard Testing Conditions (STC). The peak power of the incident light on the panel is 1000Wm^{-2} and a cell temperature of 25°C during testing.

Depending upon the geographical location and the climatic condition, the maximum sunlight that reaches a site can be different than 1000 Wm^{-2}. Hence, a factor termed as insulation factor is introduced here.

It has been reported that the maximum insulation on a clear sunny day, as measured in Dhaka, is around 900 Wm^{-2}. As Bangladesh is a small country with climatic conditions similar throughout, this value is taken to be the average maximum insulation in Bangladesh. Hence, the insulation factor is hi = 0.9. Another important factor influencing the performance of the solar panel is the ambient temperature. The efficiency of a solar panel falls by about 0.4% per degree centigrade increase in cell temperature. The average cell temperature in Bangladesh can be taken to be 40°C, which requires a correction factor of 0.94 for the output power of the panel. Hence the net correction factor for the solar panel in Bangladesh,

$Hp = 0.94x\ hi = 0.846$

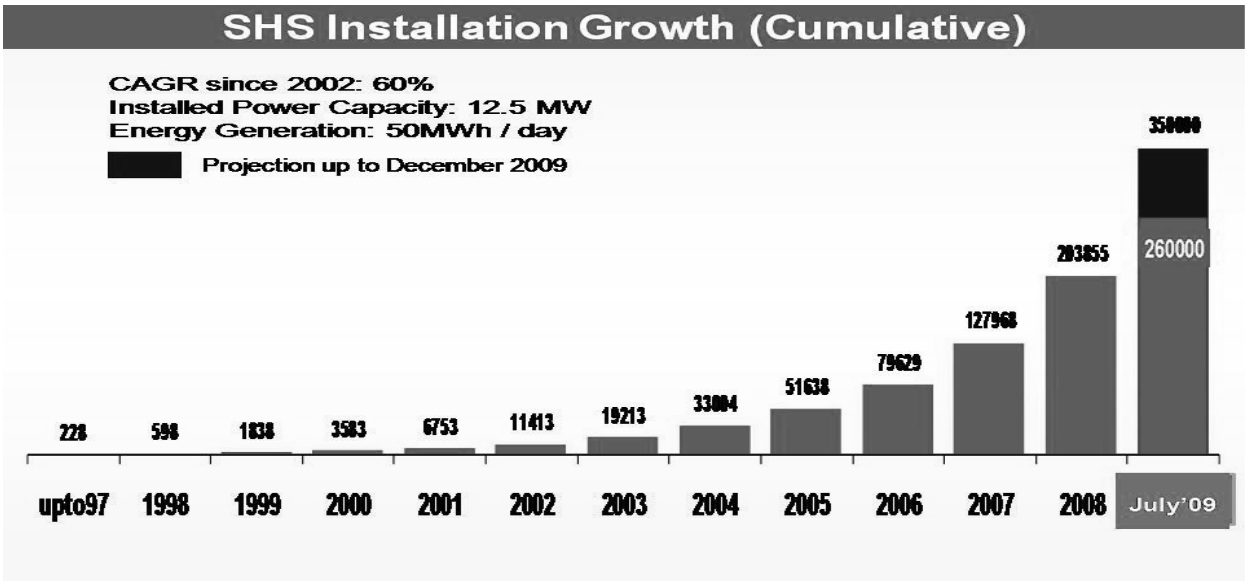

Figure 5: SHS Installation Growth

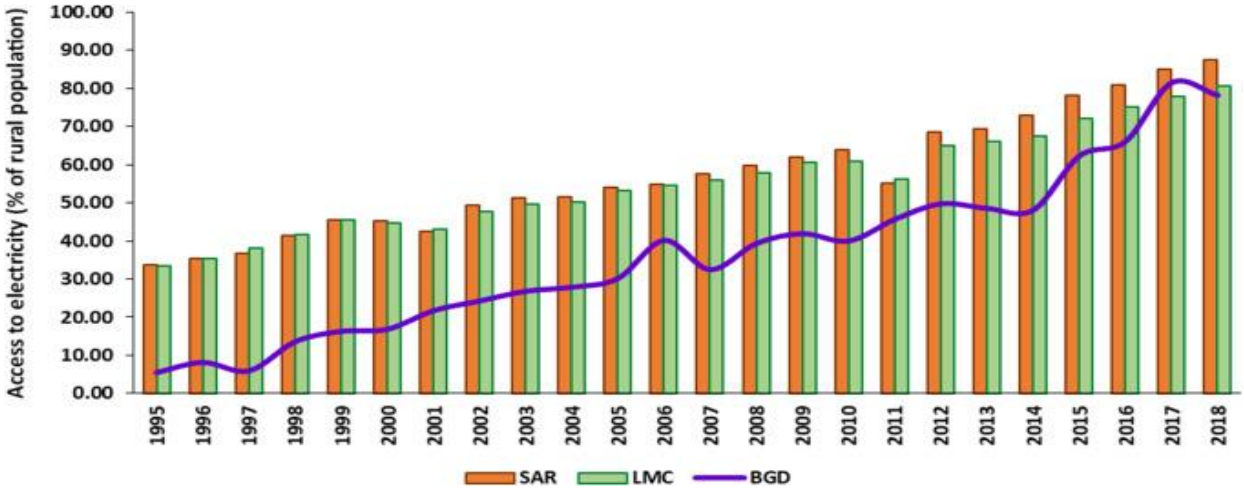

Figure 6: Solar Energy Sustainability in Bangladesh

2.6 Existing Solar Power

Figure 7: Solar Plants in Bangladesh

Women gain particular benefits from possessing a solar home system. Solar home systems have also led to raise production in fishing, rice processing, poultry farming and handicraft. In fact grameen shakti first introduced low cost solar systems to the rural people in 1996 (Barua, 2007) and in 1997. Brac launched Solar Energy Program for sustainable development (Biswas, 2002; Islam, Bakshi, & Momotaz, 2002).

Figure 8: Bangladesh Largest Solar Power Plant Connected to National Grid

2.7 Limitations of Solar power in Bangladesh

In fact, the establishment of solar power stations needs intense infrastructure and equipment. These need a huge amount of fund. Besides, Bangladesh doesn't own the compulsory technologies in order to construct the photovoltaic cells (PV), reflectors and other equipment's. To be honest, a solar power plant must entail huge area cleared for its construction. Therefore, it must have unfavorable effects on the atmosphere.

3. Research Methodology

Although a solar-wind, cascading system needs a higher initials investments but the hybrid solution is the best option for getting significant improvement in terms of efficiency and output.

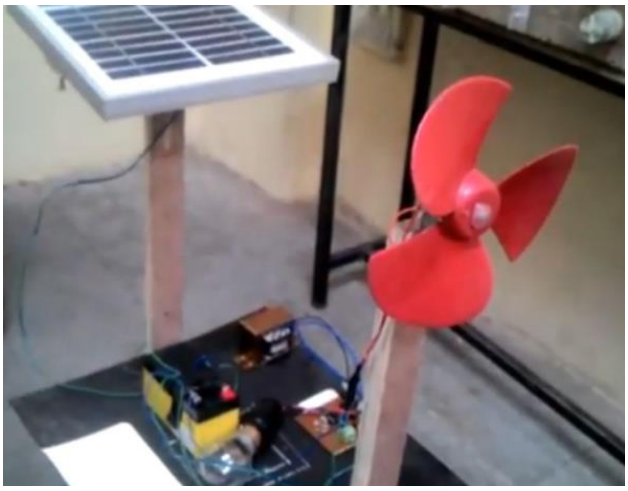

Figure 9: A Model of Solar-Wind Cascading Hybrid System

3.1 Internal Design of Proposed Solar-Wind Circuit

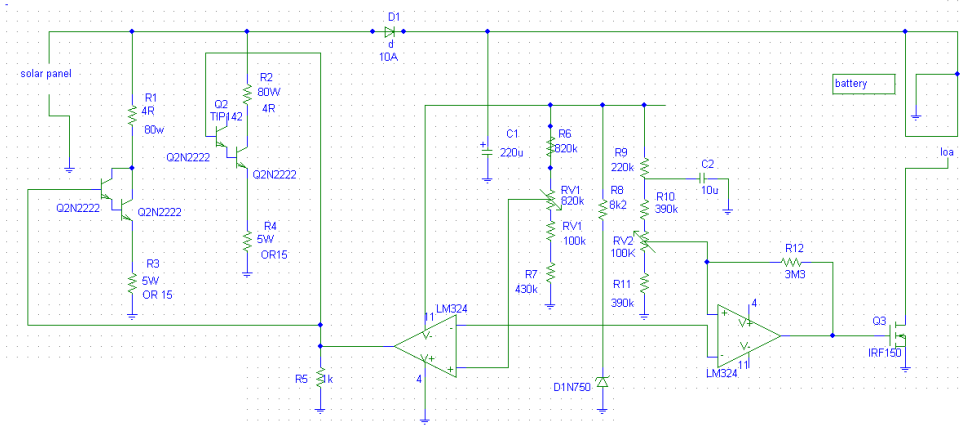

Figure 10: Solar-Wind Circuit

In this system, we have discussed about the solar & wind power for power consumption. In this portion we have used duel transistor, micro resistor, solar panel, fuse able transistor, Opamp, carbon resistors, variable resistance, Zener diode, Mosfet, battery, dc motor, stepper motor. Solar panel is using for charge the battery. Micro resistor is used to pass the high amount of current, fusable resistor is used to transistor protection. Carbon resistor is used to pass a less amount of current, variable resistance for voltage control. Zener diode is used for certain amount of negative voltage control, Opamp is used for switching (transistor & mosfet), Mosfet is used for passing negative voltage, battery is used

to store charge. DC motor is use to convert electrical power to mechanical power. Stepper motor works like generator.

3.2 Input Portion

The input comes from light to solar panel passes through a forward bias diode & stores the charge into battery. A portion of charge generated from battery move to capacitor C1& carbon resistors (R6, R7, R9, and R10). Variable resistors control the voltages and works as the input of Opamps (U1A, U1B). Opamp (U1B) works as to switch the MOSFET, which passes negative voltage to load. Load displays voltage through light & rotating the fan.

3.3 Internal Design of the Wind-Solar Circuit Components

3.3.1 Necessary Apparatus

R1 - 4R 80W
R2 - 4R 80W
R3 - 0.15R 80W
R4 - 0.15R 80W
R5 - 1K 1/2W
R6 - 820K 1/2W
R7 - 430K 1/2W
R8 - 8.2K 1/2W
R9 - 220K 1/2W
R10 - 390K 1/2W
R11- 390K 1/2W
R12 - 3.3M 1/2W
RV1-100K
RV2 -100K
C1 - 220U
C2-10U
Q1 - TIP142
Q2 - TIP142
Q3 - RFP70N06
U1A - LM358
U1B - LM35B
U2 - LM336Z - 5.0
D1 -10A
Battery - Load-acid deep cycle low self-discharge 12V, 100to 300Ah
Panel: 17V, (10-7) A
DC motor
Stepper motor

3.3.2 Equipment Purpose

R1: It is micro resistance, which supplies voltage from panel for transistor biasing.
R2: It is micro resistance, which supplies voltage from panel for transistor biasing.
Micro resistance drops voltage, works as transistor biasing, causes short circuit and is used to pass high amount of current.
R4: Fuse able resistance. It is used for voltage short.

3.3.3 Fuse able Resistance

It works as protection, fuse and it drops voltage.
R5: It is a carbon resistor, which causes negative voltage drop.
R6: It is a carbon resistor, which causes positive voltage drop.
R7: It is a carbon resistor, which causes negative voltage drop.
R8: It is a carbon resistor, which causes controlling voltage of zener diode.

R9: It is a carbon resistor, which causes positive voltage drop.
R10: It is a carbon resistor, which causes positive voltage drop.
R11: It is a carbon resistor, which causes negative voltage drop.

3.3.4 Carbon Resistor

It is used to pass less amount of current.
R12: It is using for increasing the gain.
RV1: Controlling the input voltage of opamp (U1A).
RV2:.Contrling the input voltage of opamp (U1B).
C1: It is using for increasing the capacity.
C2: It is using for increasing the capacity.
Q1: Duel npn transistor for voltage supply.
Q2: Duel npn transistor for voltage supply.
Q3: Mosfet (RFP70N06) passes negative voltage to load.
Load: Displays voltage through bulb & rotating fan.
Diode: Forward bias voltage is passing to charge the battery from panel.
Zener diode: It is used for certain amount of negative voltage control.
Opamp (U1A): It is used for transistor switching.
Opamp (U1B): It is used for mosfet switching. After getting gate pulse both drain & source remains short & passes negative voltage to load.
DC motor: It converts electrical power to mechanical power to rotate the fan.
Steeper motor: It works as a generator.

3.4 Circuit Operation of Wind-Solar Circuit

Solar panel gets charge from sunrise passing through a forward bias voltage and stores the charge in the battery. The voltage doesn't reverse. A portion of the charge generated from battery will move to capacitor C1 and be stored there. Rest of it is transferred to R6, R8, and R9 resistor. In R6, there is a positive voltage drop and In R7 there is a negative voltage drop. These voltages are controlled by variable resistance (RV1) which is the input of Opamp (V1A). R8, which is used for controlling the voltage of zener diode. Zener diode is used for certain amount (5.1V) of negative control. When excess amount of voltage passes through this node R8 reduces the excessive voltage and transfers to zener diode. R9 is a high resistance, which causes a high amount of positive voltage drop and stores it into C2. R10 & R11 are causing positive & negative voltage drop respectively. These voltages are controlled by the variable resistance (RV2) which is the input of opamp (U1B). R12 increases the voltage gain of the opamp (U1B). R6, R7, R9, R10, R11, R12, R5 are carbon resisters which flows less current (1/2W).

Opamp (V1B) is used for switching Mosfet. After giving gate pulse, the drain & source become shorted and passes negative voltage to load. Load displays voltage through an energy saving bulb & a dc motor which converts electrical power to mechanical power to rotate the fan. Here stepper motor works as a generator. Opamp (V1A) is used to transistor switching. Here duel transistor is being used because if one transistor is used, transistor would be on in low voltage and the solar panel would have been shorted and the battery wouldn't have been charged sufficiently. Duel transistor is used. Here R1 & R2 is called micron resistors which is used to pass a high amount of current, voltage supply from panel, for transistor biasing, for voltage drop & cerate short circuit. Here another resistor R3 & R4 are fuse able resistance which is used for transistor protection, works as a fuse, for voltage drop. R5 resistance is used for negative voltage drop. If the transistor gets a slight amount of voltage then it opens & charge coming from solar panel again charges the battery. Again, when the voltage is higher than it is closed and shorts the circuit and no charge can pass through the forward bias diode.

3.5 Potential Benefits

1. Improvement of the air quality in the area due to less diesel use: Environment is polluted by diesel. There is no chance of environmental pollution by using solar wind power station.
2. Increased capacity building & enhanced facilitation of electric power: Bangladesh has more moderate and tropical areas for building power plants. To reduce the cost of building solar as well as wind power plant separately, combining them into a single plant will help increase the power capacity.
3. Sufficient electricity: In the offshore area of Bangladesh, the average wind speed is high enough to produce electricity. Besides, the usage of fossil fuels creates serious environmental problem. Wind energy is considered to be especially suitable for such inaccessible offshore areas that can meet the electricity demands of those deprived people.
4. Low cost: If we use solar- wind power station then our yearly gross profit will be almost 2.08 million tk & it is more effective than other power plant

4. Conclusion

In conclusion, we have tried to give a clear picture of how solar, wind and solar-wind cascading power plants can improve the power situation in Bangladesh. In Bangladesh, the wind power is not available all the day. However, there is ample amount of sunlight all the day. Therefore, if we implement solar-wind cascading power station it will be more efficient. Therefore, the existing plan for future power generation can create a large supply of power to many coastal districts and many villages and towns of Bangladesh. After all, it is important that the implementation of the solar-wind cascading power system may actually increase the power production very efficiently in particular to our country.

Authors Contribution
Saddamul Isalm: study design, literature search, data collection, analysis, drafting
Mohammad Tarique: critical revision and incorporation of intellectual content

Conflict of Interests/Disclosures
The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

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