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# Feasibility Study of Offshore Solar Energy Near the Coastal Area of Bangladesh

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**Abstract:** The sustainable development of a country is very much dependent on access to electricity. The shortage of power is one of the major barriers to the economic development of Bangladesh. Bangladesh is lacking in its fossil fuel reservation. The abundance of renewable energy sources in the form of solar energy (4-6.5 kWh/m$^2$) provides opportunities for renewable energy systems in the offshore areas of Bangladesh. The offshore area of Bangladesh is mostly unused except for some natural gas exploration and fishing. The 200 nautical miles of Bangladesh from the coast is divided into several blocks and the number of shallow blocks is 11 which have areas from 4500-7700 square kilometers. The average depth of these blocks ranges from 20-200 meters deep. Bangladesh has a favorable geographical location to capture a good amount of solar energy. The proper utilization of this solar energy may reduce the country's energy demand to a great extent as the land is scarce and reduced by 1% each year. Therefore, Bangladesh cannot afford to lose more lands to solar-based power plants. Bangladesh's government has already made a master plan to utilize abundant solar energy in different ways. There are about 4.13 million solar-home systems (SHS) have been installed under the government program by the year 2019. However, the surplus power from these small discrete power generations cannot be brought into the main grid due to their remote location and fluctuation in production. There are rooftop solar and solar mini-grid projects that facilitated the capacity of 3.07 MW and 5 MW, respectively. A capacity of 40 MW could also be touched by solar irrigation projects with more than 1515 pumps for serving the country's rural people, and a solar-diesel hybrid solution program has been supporting the telecom operators. Bangladesh power development board (BPDB), and Infrastructure Development Company Limited (IDCOL) have been promoting numerous research-development solar projects to many governments and private universities to build a sustainable energy-equipped country. Here, SS-01 near the Hiron Point is considered where no grid power is available. The Hiron Point Public Base Station (HPPBS) is the gateway of Mongla Port. It's necessary to provide electricity to the station for smooth port operation. This article is a window to look into the effectiveness of an offshore solar power plant.

**Keywords:** Offshore, Solar Energy, Electricity, Bangladesh, Government, IDCOL, BPDP

## 1. Introduction

Bangladesh is a country in South Asia having a total land area of 148,460 sq. km. The country has a large population of 164 million with the shortages of many essential basic elements due to the shortages of natural resources. However, the economy o Bangladesh is still growing due to the Ready-Made Garments (RMG) sectors, manpower, and other exports. In the last ten years, the GDP growth rate of Bangladesh is about 6.5%. Moreover, Bangladesh possesses a 0.29% contribution of the world's GDP due to its worth GDP of 324.24 billion US dollars reported by the World Bank in Dec/2020 [1].

This impressive progress in the economy has happened for its increase of industries, especially export-based business, and opening new employments. The advancement of the country's economy, the growth of population, household and

industrial demand for power for export industries demanding more and more electricity pushed the Government of Bangladesh to establish some quick rental powerplants (IC Engine based) which are mostly operated by diesel and natural gas generators. At present, the energy consumption per capita of the country is 330 kWh/year. However, the energy consumption per capita in Bangladesh is still lower than that of other countries in South Asia [2] shown in Figure 1. Also, Bangladesh has lower electrical energy consumption per capita than any developed country like the USA (11,730 kWh) [2] and still suffering from power outages in the household and other industrial areas.

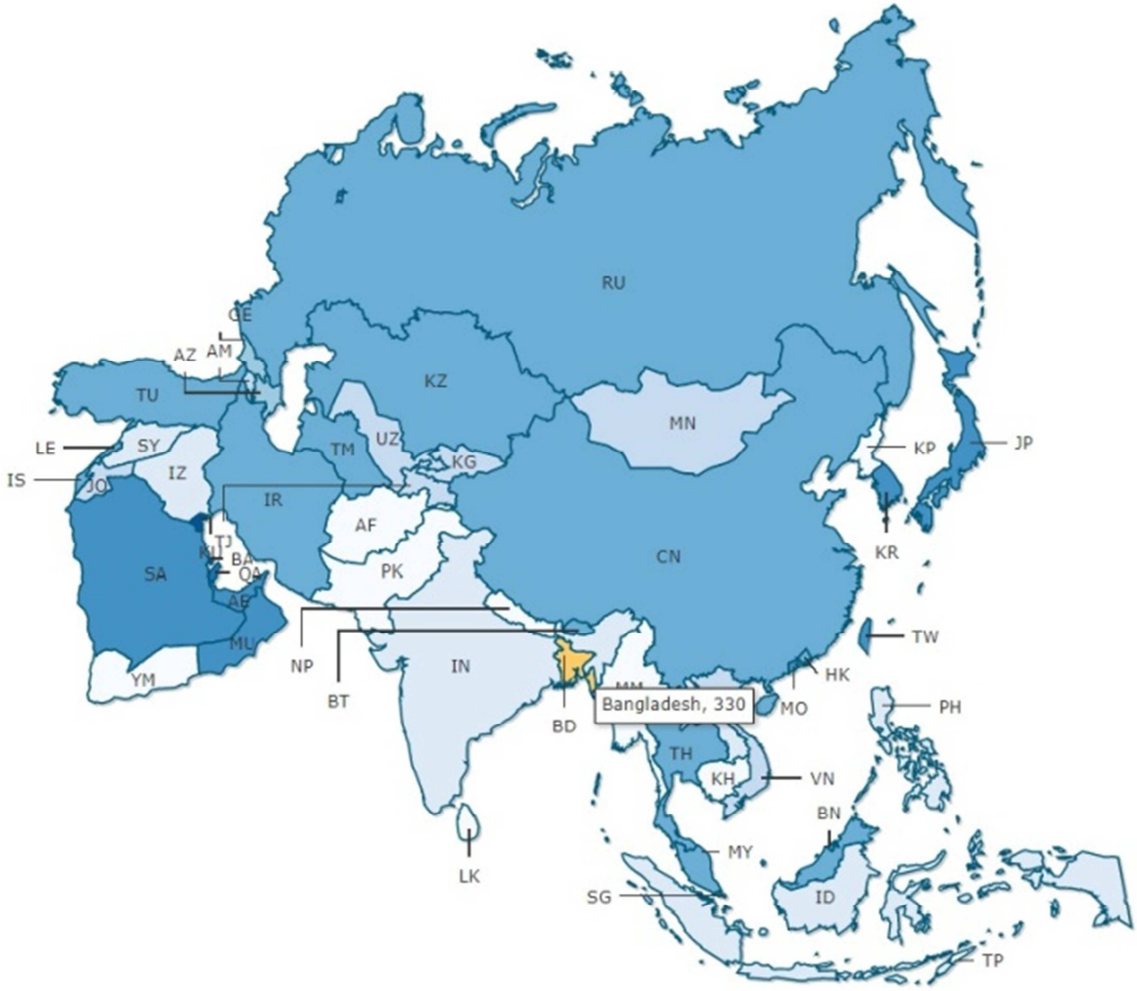


***Figure 1.*** *Per Capita Energy Consumption in Bangladesh.*

Although Government is ramping up many electricity projects with innovations, the electricity could not be well distributed due to the enormous development of industries as well as the increase of populations. Therefore, increasing the per capita power generation is very important to continue the development of Bangladesh but it produces its majority of power from natural gas burning. According to a report of the Bangladesh Power Development Board (BPDB), the country generates about 51.97% of its total electricity from natural gas as of November 2021 [3]. The country is also depending on other fossil fuels sources such as diesel, furnace oil, and coal. There are few renewable sources such as hydro, wind, and solar. The country produces only 0.59% electricity from renewable energy sources like solar. In another effort to supply the power, Bangladesh is importing power from its neighboring country India. Like other developed countries, Bangladesh is trying to reduce carbon emissions and putting more effort to produce power from renewable energy sources. Therefore, there is a possibility of establishing several offshore solar photovoltaic (PV) power plants as this kind of powerplant has a very small carbon footprint (production of PV cells and other construction materials). The vast unused offshore areas could be used for producing electricity and supplying them to the main grid for supplying in the coastal area. However, the sedimentation of silt and the seasonal storms should be considered during the designing and building of the offshore solar PV power plant.

## 2. Solar Energy

### *2.1. Source of Renewable Energy in Bangladesh*

Bangladesh is a densely populated country with a high density of solar power (4-6.5 kWh/m$^2$). The large population

in a small land makes it difficult to produce solar power. The solar power plant needs more land compared to others to produce a similar quantity of power. There are some land optimization studies so that the land for solar can be used for other purposes as well such as agriculture and fisheries. Besides, Bangladesh has only one hydroelectric power plant, and due to the deposition of silt in the water catchment area, the production of power from the hydropower plant is reduced over time [4]. The available sources of renewable energy of Bangladesh are mainly solar and hydro. There are some possibilities to produce electricity from the wastage burning but this cannot be considered as a renewable energy source but at least can reduce the wastage. The total production of power from renewable sources is only 776.36 MW [5] which is almost negligible (0.59%) to the power demand and offshore solar PV plants can be a solution.

### *2.2. Prospect of Solar Energy in Bangladesh*

The most plentiful energy source on earth is solar energy. This energy can be utilized in two different methods: 1) Solar Thermal; 2) Photovoltaic (PV). In the thermal process, the heat exhausted from solar energy is mainly stored for heating purposes, purifying water, generating power, and other purposes. The PV cell converts light energy into DC (Direct Current) power. The DC power can be converted into AC power to run AC machines. Both AC and DC power can be used for mechanical and electric equipment for various purposes.

In 2020 the amount of generated PV-based electric power was 821 TW (global) and PV-based electricity generation is required to obtain 6970 TW (terawatt) by 2030 [6]. The country absorbs average solar radiation of 4.0 to 6.5 kWh/$m^2$ per day, which is capable of producing $1018\times10^{18}$ J of energy [7]. Therefore, solar radiation to generate electricity is in Bangladesh to reduce the power demand is highly promising and the offshore solar PV plant can contribute to it.

### *2.3. Components for Solar Power Plant*

#### *2.3.1. Solar Cell*

The solar panels are the main component of the PV plant which converts the incident energy of the sun into electricity. The solar panel has several solar cells in an array form to increase the power. There are different kinds of solar panels such as monocrystalline, polycrystalline, die sensitized solar panel, PERC (Passivated Emitter and Rear Cell/Contact) solar cell, thin-film solar cell, and so on. However, silicon-based monocrystalline or polycrystalline PV cells are used for PV power plants. The price of silicon-based solar cells has reduced in the last decades drastically due to the increasing market demand and people's choice of moving from fossil fuel to more sustainable solutions like renewable energy. The emerging electric vehicles will increase the power demand in the next couple of decades and Tesla car manufacturers also provide total off-grid solutions with an electric car and solar tiles for producing the electricity. The only drawback of solar PV cells is the nighttime when the solar cell does not produce any electricity. The battery-based power storage system is still very expensive and holds the solar power plant's rapid growth. The monocrystalline solar cell is more expensive than the polycrystalline solar cell. However, PERC solar cell does not differ much from the conventional solar cell but increases the efficiency without increasing the cost. The thin-film solar cell is also used in many places but the efficiency of the thin-film solar cell is much less than the silicon-based solar cell.

The solar cell does not produce electricity efficiently if they are fixed at an angle. Solar tracking is now used so that the solar panel always moving to receive the maximum solar radiation from the sun. In an offshore solar PV plant, it is not possible to track the sun, and hence the distance of the solar plant should be far enough to get the light from the very morning to the end of the day. Therefore, the offshore PV power plant should be far enough from the land to produce maximum power. In the offshore PV power plant of Bangladesh, the tides and seasonal storms can be a threat to the solar panels. Therefore, the thin-film solar cell could be a good option to reduce the damage of the solar cell. In terms of efficiency, the thin-film solar has reached the efficiency level of 22.9% [8] whereas the silicon-based solar cell has almost 29% [8] efficiency.

#### *2.3.2. Solar Power Management*

As the solar PV panel does not produce electricity during night time, therefore, the power produced during the daytime should be stored. There are different ways to storage methods such as lead-acid battery storage, Lithium-ion battery-based storage, thermochemical storage, pumped hydro, and so on. The battery energy storage system (BESS) is used in many ways to manage power [9]. The offshore solar PV plant near Hiron Point of Bangladesh is a very remote area and it will be very difficult but not impossible to connect the power to the main grid of Bangladesh. As the power will be used to run the Mongla port and Hiron Point Public Base Station, therefore, it is possible to connect the power to the main grid. The storage system could be a lead acid-type battery if the BEES system is established near the Mongla port. The lithium-ion battery has a fire hazard, and Bangladesh does not have a lithium-ion battery recycling plant. Therefore, the lithium-ion battery will produce environmental waste.

The thermochemical storage method is not commercialized yet and therefore will be difficult to implement. On the other hand, the proposed area for offshore solar PV power plants does not have any hills/mountains to establish a hydroelectric power plant. Therefore, pumping the water to the catchment area of the hydroelectric pump would not be possible. Therefore, the lead-acid battery-based BEES could be a good solution for Bangladesh. The UPS (Uninterruptible Power Supply) system can be installed for a smooth power supply.

## 3. Off-Grid Solar Power Plant Design

### *3.1. Site Assessment*

The solar PV Module needs lots of sunlight to produce

electricity. The site SS1-01 is considered in the Bay of Bengal shown in Figure 2. The depth varies from 20-200 m and the area of the block varies from 4500-7700 square kilometers. It requires 6 acres (0.0243 sq. km) of land to produce 1 MW of power from the thin filmed solar cell. Therefore, the 4500 offshore area will produce 185 GW of power.

The total power capacity of the power plant cannot be this large as the maintenance will be complicated and seasonal storms can damage the plant severely. However, if the produced power is integrated with the main grid then the plant cannot be less than 20 MW as the smaller solar PV plant introduces more fluctuation to the grid [8]. The 20MW power plant will take only 0.486 sq. km of the area; therefore, it will be better to establish a 1.25 sq. km area which will produce an approximately 50MW power plant. Another reason for the 1.25 sq. km area is that the power plant will not be in the deep water which will reduce the cost for power plant structure building. However, the power plant could be as large as a 200MW capacity [10].

Any major natural land-based disaster will be needed some kind of power backup that can be provided by the offshore power plant. There are 11 blocks like SS-01 in the Bay of Bengal and all of them (SS-01 to SS-11) could be used such power plant and can be used to produce such power plant and would produce 550MW to 2200MW of power.

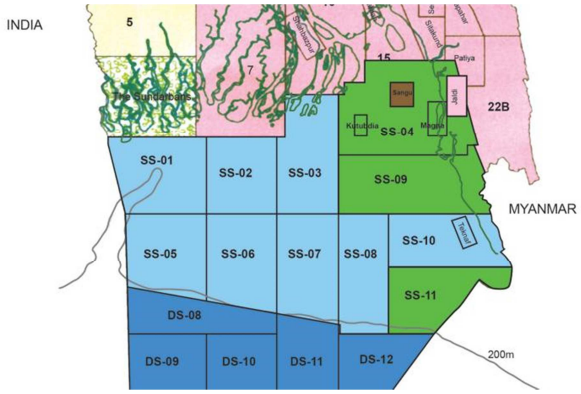


***Figure 2.*** *Different offshore blocks in the Bay of Bengal (Courtesy: Energy & Power Report, February 2018).*

If the power is added to the main grid then the capacity of the Karnafuli hydroelectric power plant can be increased by pumping the water to the dam during the daytime when there is excess power and can reduce or eliminate the BEES system cost.

The ocean is a complex ecosystem and responds very slowly to any change. The sunlight plays an important role in the ocean's ecosystem. The shallow water power plant will reduce the solar light penetration to zero where the solar PV plant will be built. The adverse effect of such a power plant requires a study to investigate to find the affected marine life. However, a small fraction of (1.25 sq. km of 4500 sq. km) in every 11 offshore blocks will be used. Therefore, marine life may not be affected. The solar power plant does not produce any visible waste to harm marine life and therefore, the offshore PV power plant could have almost no effect on the marine ecosystem.

### *3.2. Solar PV Panel*

The solar PV plant could be floating type so that the tidal wave cannot damage the solar cells. Global warming will increase the sea levels in the future and seasonal storm also brings extra water. Therefore, the floating-type PV panel will reduce the water damage to the plant. The seawater is salty and corrosive therefore, high-strength heavy-duty plastic material could be used for constructing the floating type PV panel. To reduce the effect on the PV panel, the floating barrier can be built around the plant.

The panel could be mounted to withstand 250 km/h wind speed so that the panel does not get damaged. During the monsoon, it rains heavily in Bangladesh, therefore, the solar panel mounting could be slightly slanted, or transparent hydrophobic coating could be used so that rainwater does not stay on the PV panel.

The seawater is salty, therefore, any splashed (due to the wave [11]) water on the PV panel will deposit some salts as it evaporates. This will reduce the power production from the solar panel and needs continuous monitoring of such to run the solar PV plant run on full capacity.

### *3.3. Inverter, Module, Storage, and Charge Controller Sizing*

The DC power produced by the solar PV plant will be converted into AC power to run the AC machines or to integrate into the main power grid. Therefore, the inverter capacity needs to be calculated and Equation 1 can be used to calculate the inverter capacity.

$$Inverter\ Capacity = \frac{Total\ kW\ Load\ X\ Safety\ Factor}{Power\ Factor\ X\ Inverter\ Efficiency} \quad (1)$$

The solar panel also needs sizing and this depends on the average sunshine per day and the number of modules can be calculated from Equation 2.

$$Total\ No\ of\ PV\ Panel = \frac{\text{Daily Load in kWh}}{\text{Avg.Sun}\frac{\text{Shine}}{\text{hour}}\text{X Bat.Efficiency X Inv.Efficiency X Chg.Contlr.Efficiency}} \quad (2)$$

The BEES capacity is also needed to calculate in case no other storage method is available. The capacity of Battery storage can be calculated from equation 3.

$$The\ Capacity\ of\ Battery\ Storage = \frac{\text{Daily Load in Wh X Days of Autonomoy}}{\text{Battery Efficiency X DOD X Nominal Battery Voltage}} \quad (3)$$

The Maximum Power Point Tracking (MPPT) charge controller can be selected based on the voltage and current produced by the solar panel string. A 100 ampere and 48-volt solar charge controller for each panel string can be changed depending on the requirements. Besides, the power plant will also need a substation, distribution line, accommodation for maintenance people and operators.

## 4. Conclusion

Bangladesh is a developing country having significant offshore and coastal areas. Moreover, countries' overall production of electricity is insufficient compared to the total population but the prospect for solar energy is enormous [12, 13, 14]. Power is one of the ingredients for bringing Bangladesh out of poverty. The shortages of power will hamper the country's dream to join the 4$^{th}$ industrial revolution. The export industries are heavily dependent on power. Therefore, increasing power production is a must. By offshore PV power plant, Bangladesh can increase the power production up to 2200 MW. The offshore power plants will provide power to the coastal belt of Bangladesh in the southern region and the main grid.

Bangladesh is a densely populated country and any big structure will be required to move people and destroy cultivable lands. This causes chaos in society as people lose their livelihood. Therefore, the offshore power plant will be a winning situation for Bangladesh for power production.

The offshore power plant also has a very small carbon footprint compared to thermal power plants. Reducing carbon emissions by establishing renewable energy power plants will help the battle against climate change which is also vital for Bangladesh. The proposed offshore power plant can play a very important role in that case.

## 5. Future Work

The offshore power plant project should contribute to the national grid of Bangladesh. However, a pilot project should be established to investigate the project implementation cost, project, productivity, assessing design challenges, effect on the marine life, the impact of different seasonal storms, and many others. The outcome of the pilot project should give the authority the proper knowledge required to approach a large-scale project. The high land requirement for the solar power plant [15].

## References

[1] World Bank national accounts data, and OECD National Accounts data files (2020).

[2] Electricity Consumption Per Capita by Country—South Asia. (2020). Index Mundi.

[3] Bangladesh Power Development Board, Power Generation Unit Report. (2022).

[4] Fakir, S., Tahmidur., R., Abdullah, M., Omar, M., Altaf, A. (2021). An approach to increase the power output of Karnafuli Hydroelectric Power Station: A step to sustainable development in Bangladesh's energy sector. PLOS ONE, 16 (10).

[5] Sustainable and Renewable Energy Development Authority (SREDA), National Database of Renewable Energy Report, (2022).

[6] IEA (2021), Solar PV, IEA, Paris.

[7] Lucio., A, Angelo., B, Piotr., K, Marco., L, Lisa, R. (2019). Silicon Solar Cells: Toward the Efficiency Limits.

[8] Vinod Kumara, R. L. Shrivastavab, S. P. Untawalec. (2015). Solar Energy: Review of Potential Green & Clean Energy for Coastal and Offshore Applications. International Conference on Water Resources, Coastal and Ocean Engineering (ICWRCOE 2015).

[9] Cody, H., Matthew, C., Dongmei, C., Juan, G., Mack, G. (2012). Battery Energy Storage for Enabling Integration of Distributed Solar Power Generation. IEEE Transactions On Smart Grid, 3 (2).

[10] Kim, T, Dean, M. (2013). Proposing offshore photovoltaic (PV) technology to the energy mix of the Maltese islands. Energy Conversion and Management 67, 18–26.

[11] Hugh, B. (2014). Bangladesh's dynamic coastal regions and sea-level rise. Climate Risk Management, 1, 51-62.

[12] Halder., K, Paul., N, Joardder., M, Sarker., M. (2015). Energy Scarcity and Potential of Renewable Energy in Bangladesh. Renewable and Sustainable Energy Reviews, 51.

[13] Sazzad, H., Maksudur, Rahman. (2021). Solar Energy Prospects in Bangladesh: Target and Current Status, Energy and Power Engineering, 13, 322-332.

[14] Abdullah, B., Mustafizur, R., Sadrul, I., (2017). Development of renewable energy sector in Bangladesh: Current status and future potentials, Renewable and Sustainable Energy Reviews, 73, 1184-1197.

[15] Sean, O., Clinton, C., Paul, D., Robert, M., Garvin, H. (2013). Land-Use Requirements for Solar Power Plants in the United States, Technical Report, NREL/TP-6A20-56290.