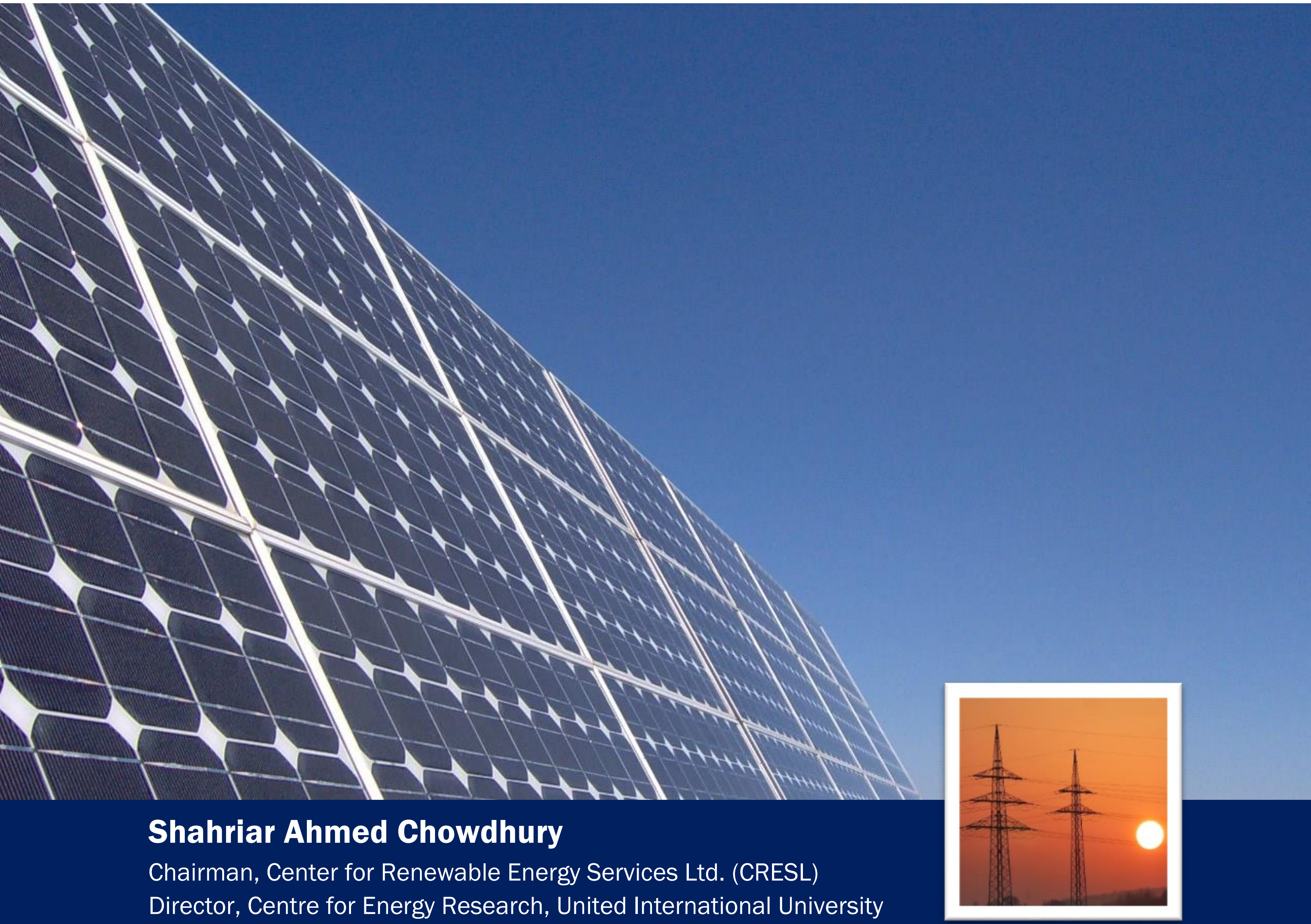
Final Report

Indicative Tariff for Utility-Scale Solar IPP in Bangladesh



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Abbreviations and acronyms

BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
CPSU	Central Public-Sector Unit
CPTU	Central Procurement Technical Unit
CTU	Central Transmission Utility
DPR	Detailed Project Report
GEF	Global Environment Facility
GOB	Government of Bangladesh
GOI	Government of India
GW	Giga-watts
IPP	Independent Power Producer
IRR	Internal Rate of Return
LCOE	Levelized Cost of Electricity
MNRE	Ministry of New and Renewable Energy (India)
MPEMR	Ministry of Power, Energy and Mineral Resources
MW	Mega-watts
NCEF	National Clean Energy Fund
NPV	Net Present Value
PGCB	Power Grid Company of Bangladesh Ltd.
PPA	Power Purchase Agreement
PV	Photovoltaic
SECI	Solar Energy Corporation of India
SPPD	Solar Power Park Developer
SREDA	Sustainable and Renewable Energy Development Authority
SREPGen	Development of Sustainable Renewable Energy Power Generation
STU	State Transmission Utility
UT	Union Territories
WACC	Weighted Average Cost of Capital

Preface

The Government of Bangladesh has been encouraging unsolicited proposals for large-scale solar photovoltaic power plants from Independent Power Producers (IPP) and mediating the tariff negotiation process for several such proposals. Understandably, the Ministry of Power, Energy and Mineral Resources (MPEMR)/SREDA intends to back such negotiations on realistic and informed knowledge base. The present study aims to assist MPEMR/SREDA by reviewing and analysis the practices of and latest trends of our neighboring countries, especially India, in the solar photovoltaic power sector. In more specific terms, the study investigates the latest government policies supporting the rapid development of solar PV sector on a massive scale and the resulting tariff trends in India. It also attempts to summarize the challenges of replicating similar level of tariff in Bangladesh. After focusing on the breakdown of typical tariff structure for utility-scale solar IPP projects to have a better understanding of the major components, the study finally suggests an indicative tariff for the same in Bangladesh. The indicative tariff is calculated based on the market price prevailing in the fourth quartile of 2017 and some reference values were taken from the last tendered projects.

1 Background

Bangladesh aims at achieving universal access to electricity and joining the ranks of middle-income countries by 2021. To achieve this target, the country needs to increase its power generation capacity. The Government has targeted an increase in its power generation capacity to 24 GW by 2021. Electricity generation now largely relies on fossil fuels, the stock and supply of which is limited in Bangladesh. In view of the challenge of primary fuel sourcing and supply, the Government of Bangladesh has recently developed the power generation strategy based on fuel diversification to enhance energy security. Alongside the conventional energy sources, renewable energy will play a significant role in meeting the future demand of electricity as well as fulfilling environmental obligations. Keeping pace with the global trend, Bangladesh adopted the Renewable Energy Policy in 2008, which mandates the sourcing of 10% of electricity from renewable sources by 2020. Recently, the Government of Bangladesh has approved more than 1 GW of solar PV power projects. However, the realizations of these projects are delayed due to a variety of reasons.

Sustainable and Renewable Energy Development Authority (SREDA) aims to support the Ministry of Power, Energy and Mineral Resources (MPEMR) to identify the challenges of establishing large-scale grid connected solar PV projects and establish a suitable tariff structure for such projects by Independent Power Producers (IPP) in Bangladesh. It is only reasonable to assert that the first step taken towards devising a suitable tariff is to identify the barriers that lie in the path of successful large-scale solar PV independent power producer (IPP) project implementation. The resulting analysis shall subsequently lead to the identification of the factors that contribute to the Levelized Cost of Electricity (LCOE) and thus ultimately affect the tariff structure. A brief review and comparative study of policy incentives and tariff structure from one of the neighboring countries (India) can be expected to strengthen the understanding even further.

The present report aims to assist SREDA in achieving the above-mentioned aim and it is prepared as a part of the GEF funded “Development of Sustainable Renewable Energy Power Generation (SREPGen)” project, which is implemented by the Power Division operating under the Ministry of Power, Energy and Mineral Resources of Bangladesh Government.

2 Objectives

The broader aim of the SREPGen project is to reduce the annual growth rate of greenhouse (GHG) emissions from fossil fuel-based electricity generation system by utilizing Bangladesh's renewable energy resources for electricity. Through this project, support will be provided to the Sustainable and Renewable Energy Development Authority (SREDA) to achieve a considerable portion of renewable energy in the country's energy mix by promoting widespread use of it. In doing so, this report is prepared with the specific objective of assisting MPEMR to develop a suitable tariff structure for unsolicited private sector IPPs attempting to develop large-scale solar PV projects in Bangladesh.

3 Scope of work

The scope of this report comprises the following:

1. Identify challenges for large-scale grid connected solar IPP project development in Bangladesh;
2. Identify the factors that affect the tariff of grid connected solar IPP;
3. Identify incentives that neighboring countries (India) provides for grid connected solar PV project development;
4. Identify reasons for lower tariff, if applicable, in the neighboring country India;
5. Suggest suitable tariff considering the local climate, geographic location, grid connection and other applicable reasons; and
6. Compare the advantages and disadvantages between solar IPP project development in Bangladesh and India.

4 Challenges for large-scale grid-connected solar IPP projects

Challenges for the large-scale grid-connected solar IPP project development in Bangladesh are linked with (a) the lack of available land, (b) weather and climatic conditions, (c) gaps in logistics and supply chain, (d) the lack of well-established technical standards and codes, (e) lack of experience and (f) the lack of robust financial and business models. To ease the purpose of analysis, the challenges are tabulated in a few major categorizes as presented in Table 1.

Table 1. Summary of challenges for large-scale grid-connected solar IPP projects.

Category	Components in detail
a) Land related barriers	• **Scarcity of suitable lands**: Large-scale solar PV power plants require vast stretches of land. Being an agriculture dominated economy; the Government of Bangladesh understandably preserves agricultural lands from being used for solar PV project development. As a result, there are very little non-agricultural lands that lie mostly in the north-western part of the country, in the river banks and islands, sand bars and in coastal regions. Again, these areas are far away from the national grid facilities or are limited by the grid capacity. • **Ownership of land**: The population density is very high in Bangladesh and very often it is found that the ownership of suitable lands for large-scale solar PV project is distributed among several hundred individuals. The legal acquisition of land from several hundred owners requires a considerable amount of time. Moreover, it has also been found very often that the transfer of lands through deeds was not properly conducted in the past, which also delays the project implementation period and thus incurs cost. Until the ownerships of the lands are not clear the project financial closure cannot be achieved. • **Land development**: Having a flat terrain, Bangladesh is prone to flooding and majority of the suitable land for solar PV project development are on the banks of rivers. Most of the land available for solar PV projects, therefore, needs to be backfilled, which adds an additional cost to the project. • **Erosion protection**: Some of the mighty rivers flow through Bangladesh. Suitable lands on the banks of these rivers need an

Category	Components in detail
	erosion protection scheme, which increases the project cost and thus the tariff.
b) **Challenges of weather & climatic conditions**	• **Weather conditions:** Very often, Bangladesh experiences cyclones in the southern region due to its geographical location. This creates the need for special precaution in the form of mounting structure design and also the assembly, thus increasing the project cost. • **Low irradiance**: Solar irradiation is moderate in Bangladesh, whereas the suitable land for solar PV project development in India is has higher irradiance (Rajasthan, Gujarat etc.). In some parts of India the annual average GHI (Global Horizontal Insolation) is over 6 kWh/m^2/day, whereas in Bangladesh it is about 4.5 kWh/m^2/day. • **Dust**: Dust accumulation on the solar panels is much higher in Bangladesh compared to other countries, which results in higher O&M cost for the plants. Therefore, higher maintenance cost needs to be allocated in the project O&M budget, which also increases the cost of electricity from solar PV projects. • **Longer implementation period**: During the monsoon, most of the country's land is inundated and it is difficult to work in the rainy season, which also delays project implementation time thus increasing the cost.
c) **Challenges arising from gaps in supply chain**	• **Insufficient local human resources:** There is a lack of human resources with sufficient knowledge of large-scale solar PV project development in Bangladesh. So far, the country has only one grid-connected solar PV project (3.28 MWp at Sharishabari, Jamalpur). The system design and EPC contractor need to hire experts from outside / foreign countries. The construction environment for them is rather new as the country is yet to have sufficient number of solar PV projects to gain the experience. • **Economies of scale:** So far, the implemented utility scale grid tied solar PV projects are relatively small (in size) and Bangladesh is yet to fully grasp the real challenges of implementing large-scale projects. Unless the market increases, the cost comparison with the neighboring countries may not be reasonable. • **Limited information on available services:** Lack of information on relevant services, such as supply chain companies, finance,

Category	Components in detail
	developers, and relevant standards affects and delays important design related decisions. • **Long downtime:** Unless there is a stable market, component failure or damage can lead to long periods of system downtime due to the lack of local expertise and/or access to replacement parts.
d) Existing power infrastructure & technical standards related challenges	• **Weak grid**: Renewable power is intermittent in nature. Bangladesh's national grid is still not robust and reliable enough to absorb intermittent power beyond a certain capacity. This necessitates a rigorous and effective grid integration study. Again, at present the country does not have the local capacity to conduct thorough study on the impact of intermittent power injection into the national grid. So, if the investors see some risks, they have to conduct such studies on their own. • **The right of way for transmission network**: Generally, the selected solar PV power plants are far away from the grid substation. Getting right of way for the evacuation line construction and transmission tower installation is also a challenging work, as the concerned land owners generally do not want to provide permission to erect transmission towers on their land. Obtaining the right of way for transmission lines is time consuming and sometimes exceeds the estimated cost considering the population density of the country. • **Insufficient transmission infrastructure:** The capacity of the power transmission network also hinders the development of large-scale solar projects. According to government policies and estimates, most of the suitable lands for solar project developments are in the north-western part of Bangladesh, but the transmission line capacity limits the progress of solar project development in those areas. Also, for the other regions, the transmission line capacity is one of the main obstacles for large-scale solar PV project development. • **Lack of technical standards:** There is a lack of nationally recognized technical standards and codes for large solar PV projects. Unless these codes and standards are developed, the works and studies need to be done by the developers. Moreover, significant assumptions are made in the absence of data, compelling the developers to take risks, which results in risk premiums.

Category	Components in detail
e) Policy and regulations	• **No regulated tariff/incentive:** There is an absence of regulated tariff structure/incentive for large solar PV IPP projects in Bangladesh. • **Considerable administrative overheads:** To develop an IPP project, the developer needs to organize more than 30 permits and acquiring such permits is quite a challenging task in Bangladesh. Therefore, such challenges and obstacles need to be converted into transparent and quantifiable cost components.
f) Financing and business models	• **Absence of capacity payment**: Unlike the conventional IPP projects, capacity payment is absent in the solar IPP project. So, the financial model needs to be adjusted to cover the risks. Solar plants usually operate at 17–19% plant factor. So, without capacity payments, all O&M, returns and debt services needs to be covered from the sale of electricity from solar PV Power. • **Risk investment:** The credit rating of Bangladesh is BB- (where as in India credit rating is BBB-) (Standard & Poor's), which can be perceived as discouraging for foreign investors. If the return is not high enough, the foreign investors are not encouraged to invest. The lack of project realization related information, knowledge and also guidance relating to policy and regulatory compliance obligations for solar PV projects forces the developers to take risk.

5 Factors affecting tariff structure

Tariffs are the amount of money paid by the off taker to the project developer for per unit of electricity sent to the grid, as per Power Purchase Agreement (PPA). The cost of electricity produced can be expressed by a function as explained in equation 1.

Cost of the electricity produced

= f {Cost of the machineries and equipment, Cost of balance of systems, Cost of construction and installation, Cost of fund (debt-interest and other fees), Available resources (irradiance etc.), Cost of operation and maintenance, Cost of land and land development, Cost of evacuation line and substation construction, Cost of organizing permits, Cost of insurance, Return on equity or margin of IPP, Depreciation}

There are other factors that affect the suitable tariff for the project developers like, the maturity of market, among others. Each of the above components can be further broken down into numerous sub-components, each of which again is influenced by a number of intertwined factors. However, the major influencing factors can be nested under the following broad categories.

- **Natural resource and weather conditions**: The available solar irradiation and number of clear days at the project location directly affects the annual electricity generation and thus greatly influences the tariff.
- **Land**: Insufficient availability of land leads to increased price and the lengthy acquisition procedure increases the overall administrative cost of the project. Geographical conditions such as uneven terrain, flood prone areas, risks of soil erosion lead to increased cost of land development.
- **Equipment market**: The absence of local quality equipment market extends the length of logistics chain and downtime. These in turn increases the capital cost as well as the operation and maintenance (O&M) cost, which is then reflected in the LCOE.
- **Excessive cost burden on the developer**: In Bangladesh, the IPPs are burdened with the cost of grid impact study, line root survey, construction of transmission line and evacuation sub-station, and the cost of acquiring right of way for transmission network. These costs are eventually reflected in the higher cost of electricity production.
- **Finance market**: Factors related to project financing play a significant role in determining the tariff. Debt equity ratio, interest rate, and loan tenure affect the LCOE.

- Policy and regulations: Reduced /no import duties on imported plant equipment, tax holidays and other similar favorable policy incentives and regulation have a positive influence on reducing the LCOE.

6 India's policy incentives for large-scale solar IPP projects

Bangladesh's neighboring country India has recently been very active in promoting the utilization of renewable energy sources, especially solar energy, to: (a) meet its ever increasing energy demand, (b) ensure universal access to energy, and (c) mitigate the impacts of climate change. Even though the history of India's RE utilization dates back to the 1970s', 42% of the total capacity was supplied by large-scale hydro plants only [1]. The utilization of grid-tied solar energy emerged later. An overview of historical developments of India's on-grid solar power sector is presented in the article by Moallemi et al. [1].

As part of their National Action Plan for tackling climate change, India has launched an ambitious and elaborate initiative titled Jawaharlal Nehru National Solar Mission (JNNSM) on 11 January 2010 [2]. The initial target was to generate 20 GW power from grid-tied solar plants including rooftop systems, 2 GW of power from off-grid solar applications and installing 20 million square feet of solar collector across the country by 2022 [3]. Despite the initiative appearing to be ambitious, both the central and state governments have been very active in realizing the goals of JNNSM.

Following up on JNNSM, the current Government has revised and expanded the targets in 2015. According to the updated resolution, the initial target of generating 20 GW electricity from grid-tied solar plants has been increased to 100 GW [4]. To facilitate the large-scale deployment, various sub-components have been devised. Around 60 GW has been set for ground-mounted medium– and large–scale grid–connected solar power projects, while the remaining 40 GW is planned to be generated from grid–connected rooftop solar PV systems. Various favorable policies and regulations have also been adopted, and solar project schemes have been launched to encourage private investments. Notable policy initiatives by the Government of India (GOI) are summarized as follows [5].

- Ministry of New and Renewable Energy (MNRE) has proposed the development of 7.5 GW of solar power by 2022 using locally produced components during the 2nd phase of Central Public Sector Unit (CPSU) program.
- The guidelines for the disbursement of the National Clean Energy Fund (NCEF) has been amended by the MNRE for the development of inter-state transmission systems under the Green Energy Corridor Project in several states.
- MNRE has also issued an advisory note to state governments requiring the utilization of unused spaces available near sub-stations/transmission systems by giving priority to solar projects.
- Waiver period for inter-state transmission charges and losses for solar projects has been extended by the Ministry of Power.

- Ministry of Power has issued final guidelines for tariff-based competitive bidding process for large-scale solar projects.
- MNRE is in the process of formulating an INR 50,000 crore scheme titled 'Kishan Urja Surakshaevam Utthaan Mahabhiyan (KUSUM)' for harnessing solar power in rural India [6].

As a result, the current share of renewable energy in India's energy mix has reached approximately 18%, with solar accounting for nearly 4.5% of the total. Until August 2017, the cumulative solar technology installation surpassed 15 GW [5]. There are around 13.3 GW of utility-scale solar projects currently at different stages of construction with another 5.8 GW of tenders to be auctioned in the recent future. The lowest bid for tariff reached down as low as INR 2.5 per kWh in the second quarter of 2017, making electricity generated from solar energy cheaper than thermal power in some cases. Therefore, an in-depth review of the on-going scenario in India in the domain has the potential to offer useful insights for determining a tariff structure in Bangladesh.

Apart from the above-mentioned policy updates, the GOI has launched a special scheme for incentivizing large-scale solar projects across India, the main features of which are discussed in the next section.

6.1 Incentives for India's large-scale solar PV project developers

In March 2017, the MNRE has sanctioned the "Scheme for the Development of Solar Park and Ultra Mega Solar Power Projects". Under the framework, the MNRE aims to set up at least 50 solar parks with 500 MW capacity each that are defined as "concentrated zone of development of solar power generation projects and provides developers an area that is well characterized, with proper infrastructure and access to amenities and where risk of the projects can be minimized" [7]. Around 34 solar parks have already been approved by MNRE in 21 states with a total capacity of 20 GW.

The scheme identifies the Solar Energy Corporation of India (SECI) as the nodal agency to administer the scheme and regulate MNRE funds, and terms Solar Power Park Developers (SPPD) as development agencies. The SPPDs are entrusted with activities that will not only speed up the establishment of the solar parks but will also ensure significant and wide-ranging incentives for the investors. The noteworthy features of the scheme are as follows.

- Site selection and land acquisition: The SPPD with or without the support from the State or Union Territories (UT) governments will select the site, acquire and develop the land for setting up the solar parks. For private entrepreneurs, there are provisions for long-term lease and the State/UT government is again responsible for ensuring dispute free acquisition of land in such cases. The scheme recommends the selection of sites with higher solar irradiation, water availability and at locations that have easy access to spare transmission capacities from either Central Transmission Utility (CTU) or State Transmission Utility (STU).

- **Facilities to be provided**: SPPD will ensure specialized services throughout the solar park in a "central, one-stop-shop, single window format". Such facilities include:
    1. Approved land with necessary permissions;
    2. Proper road connectivity (both approach roads and smaller access roads leading to each individual plots);
    3. Dedicated water reservoir with demineralization plant within the premise, boundary fences and security service;
    4. Flood mitigation measures such as flood discharge and internal drainage systems;
    5. Telecommunication facilities and centralized weather monitoring station;
    6. Transmission facilities including pooling stations with suitable voltage levels; and
    7. Parking, warehouses and housing facilities for basic manpower wherever possible.
- **Financial models**: The SPPD will be responsible for estimating the total cost of the project and then formulating a recovery model to ensure the sustainability of the solar parks. SPPDs will also be allowed to put in its own equity, raise loans, create small corpus for working capital and invest in the operation and maintenance of the parks, activities related to marketing and publicity. The SPPDs will also be responsible for organizing the registration process for prospective project developers. Apart from the one-time registration fee, the investors are to pay in four installments at different stages of the project development.
- **Grant support from MNRE**: MNRE will provide grants of up to INR 25 lakhs to the approved SPPD in order to conduct necessary surveys and to prepare Detailed Project Report (DPR). Based on the DPR of the solar park, Central Grant will be channeled in installments to the SPPDs for development of the solar park (INR 12 lakhs per MW or 30% of the cost, whichever is lower) and to CTU/STU for the construction of external transmission systems (INR 8 lakhs per MW or 30% of the cost, whichever is lower).
- **Transmission and power evacuation systems and relevant funds**: The cost of constructing transmission and power evacuation infrastructure is a significant component of the total project cost. While the CTU/STU is held responsible for

setting up sub-stations close to the solar parks and the SPPDs are to set up pooling stations inside the parks, the project developers will have to only interconnect each project plot with the pooling station via underground, over-ground or overhead cables. The scheme mentions that such infrastructures should be designed as per the highest possible standards and a list of latest technologies be provided. Also, there are provisions for applying for MNRE grants to build the power evacuation infrastructure.

- **Obligatory power purchase by state governments**: The scheme partially creates a secure investment arena by obliging the state governments to purchase at least 20% of the generated electricity through its utility companies. However, the scheme doesn't guarantee the PPA or the tariff.
- **Extended deadline for project implementation:** The MNRE of India has very recently extended the project implementation deadline up to 2 years for solar IPP projects with capacity over 250 MW. Previously, the implementation deadline was 15 months [8]. The rationale is that this will allow the project developers more time to procure equipment and thus reduce the cost even further.

It is apparent from the above discussion that the policy incentives provided for prospective project investors of large-scale solar PV projects are manifold. These incentives have triggered India's recent global record of one of the lowest tariffs.

6.2 Reasons for lower tariff in India

As mentioned in previous sections of this report, there has been a noticeable decline in tariff trends in India over the past few years. Figure 1 illustrates that following a trend of 52% drop in 12 months, solar tariff has reached INR 2.44 /kWh in 2018. There are some identifiable factors that have contributed to India's record lower tariff in the recent years. The reasons are briefly discussed as follows.

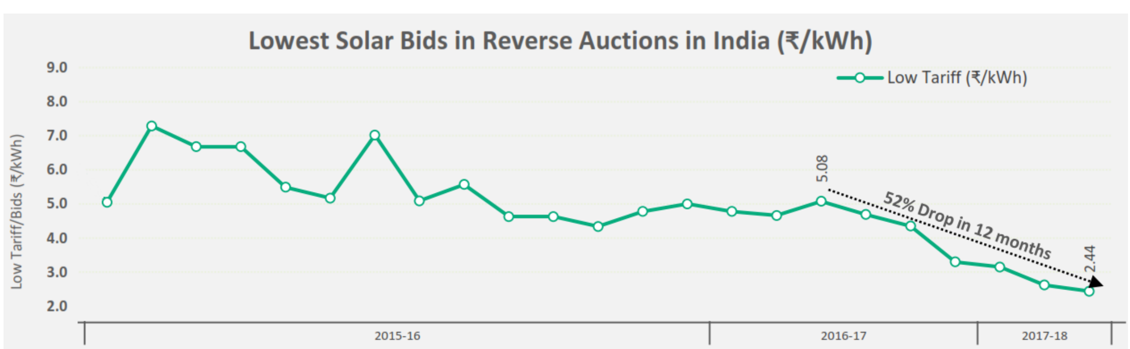

Figure 1. Declining trend of tariff bidding in India (Source: Mercom India Research).

- **Declining cost:** The cost of solar technology has declined and fast–moving financial markets across the country and the globe have an influence on the reduction of LCOE, bid price and finally the tariff.
- **Economy of scale**: Various schemes that are already launched or are in the process of being devised benefit from the economy of scale. With mega-scale solar park projects, the variable component of LCOE is reduced by a significant margin.
- **Favorable policy framework**: Both the Central and State Governments of India are actively working towards creating significantly favorable policy incentives for interested project developers. As discussed in the previous section, wide ranging incentives directly reduce the cost burden on the project developers, such as assured availability of already developed land, transmission and power evacuation systems, reduced administrative overheads, tax benefits, and assistance in securing loans and obligatory power purchase by state governed utilities. Such measures not only attract prospective investors but also secure a safer environment for investment.
- **Transparency**: Ensuring an open, transparent and fair bidding process contributes to a competitive ground for private project developers.

7 Recommended tariff structure for solar IPP projects in Bangladesh

The indicative tariff for IPP solar PV project is calculated based on a 50 MW (AC) or 65 MWp solar project. The technical and financial assumptions that were considered for calculating levelized tariff for electricity from Solar PV power plant are mentioned in the following sections.

7.1 Technical assumptions

Date and Timing Assumptions

	Days from PED	Comment
Signing of all Project Agreements (Project Effective Date – PED)	0	
Financial Closing Date	90	3 Months from PED
Required COD	547	18 Months from PED
Financing Period Ends	456	15 Months from Financial Closing Date

Project Economic Life	20	Years
Concession Period	20	Years from COD

Operating Cost Assumptions

Replacement Particulars	Cycle	Replacement Amount
Solar Inverter Change- Phase-1	9 th Year	15%
Solar Inverter Change- Phase-2	10 th Year	15%
Solar Inverter Change- Phase-3	11 th Year	15%
Solar Inverter Change- Phase-4	12 th Year	15%
Captive Lighting	4 Year Cycle	40%
Evacuation Switchyard	5 Year Cycle	2.5%
DC/AC Cable	5 Year Cycle	10%
SCADA System	5 Year Cycle	20%
Water Supply System	7 Year Cycle	20%
Radiation Measurement Sys.	10 Year Cycle	100%
Data Logging System	10 Year Cycle	100%

Economic Assumptions

Current Exchange Rate at	2-July-2018	83.75
US Inflation		2.20%
Bangladesh Inflation		5.70%
Base US CPI as at	2-July-2018	100
Base Bangladesh CPI at	2-July-2018	100

Depreciation and Tax Assumption

Plant equipment and civil construction life	20	Years
Depreciation Type	Linear (straight line)	
Income Tax Rate (1st 15 years)	0%	
Income Tax Rate (After 15 years)	37.5%	

PPA Assumptions

Specific Energy Yield	1450	kWh/kWp
Installed Capacity	65	MWp
Annual Energy Yield assumption	94,250,000	kWh/Yr
Performance Ratio	77.07%	
Availability Loss	1.00%	From EPC Guaranteed Yield
Distribution Loss	0.00%	Substation and other loss
Grid Maintenance Loss	2.50%	Due to 10 days maintenance right of BPDB
First Yr. degradation	2.00%	
Guaranteed degradation/year	0.70%	/Year

Energy Generation & Degradation

Particulars	Ct. Yr. 1	Ct. Yr. 2	Ct. Yr. 3	Ct. Yr. 4	Ct. Yr. 5
Annual Energy Yield kWh/Year	93,307,500	92,035,125	91,375,375	90,715,625	90,055,875
Net Electricity Generation (kWh/Year)	90,041,738	88,813,896	88,177,237	87,540,578	86,903,919
Particulars	**Ct. Yr. 6**	**Ct. Yr. 7**	**Ct. Yr. 8**	**Ct. Yr. 9**	**Ct. Yr. 10**
Annual Energy Yield kWh/Year	89,396,125	88,736,375	88,076,625	87,416,875	86,757,125
Net Electricity Generation (kWh/Year)	86,267,261	85,630,602	84,993,943	84,357,284	83,720,626
Particulars	**Ct. Yr. 11**	**Ct. Yr. 12**	**Ct. Yr. 13**	**Ct. Yr. 14**	**Ct. Yr. 15**
Annual Energy Yield kWh/Year	86,097,375	85,437,625	84,777,875	84,118,125	83,458,375
Net Electricity Generation (kWh/Year)	83,083,967	82,447,308	81,810,649	81,173,991	80,537,332
Particulars	**Ct. Yr. 16**	**Ct. Yr. 17**	**Ct. Yr. 18**	**Ct. Yr. 19**	**Ct. Yr. 20**
Annual Energy Yield kWh/Year	82,798,625	82,138,875	81,479,125	80,819,375	80,159,625
Net Electricity Generation (kWh/Year)	79,900,673	79,264,014	78,627,356	77,990,697	77,354,038

7.2 Financial assumptions

Financing Assumptions

Minimum Equity Return	17%	
Equity Contribution (%)	30%	of project cost
Debt Financing (%)	70%	of project cost
Equity Amount	20,117,864	USD
Debt Amount	46,941,682	USD
USD Loan	100%	of Debt Financing
BDT Loan	0%	of Debt Financing

USD Loan

Amount (USD)	46,941,682	
Tenor (from Financial Close)	12 Years	
Grace Period	1.50 Years	
Tenor (from Payment Date)	10.5 Years	
Number of Repayments (Per Year)	4	
Total Number of Repayments	42	Quarter
Interest Rate Spread	4.5%	p.a.
Financing Fees	2.0%	one time
Arrangement Fee	0.0%	one time
Commitment Fee	0.0%	one time
Swap Rate	2.5%	
Interest Rate (Fixed)	7%	

BDT Loan

BDT Loan Amount	-	BDT
Interest Rate	10.0%	
Tenor (from Financial Close)	12 Years	
Grace Period	1.5 Years	
Tenor (from Payment Date)	10.50 Years	
Number of Repayments (Per Year)	4.00	
Total Number of Repayments	42	
Financing Fees	2.0%	
Commitment Fee	0.0%	
Arrangement Fee	0.0%	

Discount Rate	12.0%	per year

O&M Assumptions

Fixed O&M Expenses	7,000	USD/MW per Year

Salary & Allowances:

Position	Number of Employees	Monthly salary	Monthly Salary	Annual Salary
			BDT	
Plant Manager	1	120,000	120,000	1,680,000
Asst Plant Managers (Engineers, Accounts, Admin)	4	50,000	200,000	2,800,000
Driver	2	25,000	50,000	700,000
Technician	4	25,000	100,000	1,400,000
Cleaner cum maintenance assistance	12	20,000	240,000	3,360,000
Security Service	15	20,000	300,000	4,200,000
Total	38		1,010,000	14,140,000

Insurance (on Civil Construction & Machinery)	0.40%	per annum on net asset

Other General & Administrative Expenses:

Admin Expense	2,400,000	BDT/year
Factory & Office Maintenance	1,200,000	BDT/year
Fuel & Vehicle Maintenance	1,800,000	BDT/year
Utilities Expenses	1,200,000	BDT/year
Total Gen. & Admin Exp.	6,600,000	BDT/year

Project cost assumptions

Solar Plant EPC	46,916,185	USD	EPC cost = 0.722 /Wp
Land & Land Development	7,038,627	USD	Considering 2 meters land filling
Non-EPC Related Civil Works and Fixtures, Vehicles	632,239	USD	
Evacuation & Transmission	3,550,000	USD	Considering 10 km transmission lines
Pre-Operating Expense	925,765	USD	
Misc. Charges for Import & Transportation	1,175,131	USD	
IDCP, DSRA & Other Financing Costs	5,506,706	USD	
Contingency	1,314,893	USD	
Total Project Cost	**67,059,546**	USD	
Cost per MWp	**1,031,685**	USD/MWp	

7.3 Tariff Calculation

Year	Debt Service (USD)	Return on Equity (USD) from Power Generation only	Fixed O&M (USD)	Net Electricity Generation kWh/Year
1	7,639,200	3,574,750	984,840	90,041,738
2	7,326,255	3,574,750	987,489	88,813,896
3	7,013,311	3,574,750	1,030,491	88,177,237
4	6,700,366	3,574,750	1,208,853	87,540,578
5	6,387,422	3,574,750	997,633	86,903,919
6	6,074,477	3,574,750	1,044,728	86,267,261
7	5,761,533	3,574,750	1,046,238	85,630,602
8	5,448,588	3,574,750	1,399,628	84,993,943
9	5,135,644	3,574,750	1,643,972	84,357,284
10	4,822,699	3,574,750	1,410,677	83,720,626
11	2,293,995	3,574,750	1,456,802	83,083,967
12	-	3,574,750	1,034,857	82,447,308
13		3,574,750	1,084,893	81,810,649
14		3,574,750	1,264,353	81,173,991
15		3,574,750	1,097,256	80,537,332
16		4,915,282	1,065,629	79,900,673
17		4,915,282	1,074,542	79,264,014
18		4,915,282	1,083,885	78,627,356
19		4,915,282	1,372,728	77,990,697
20		4,915,282	1,187,069	77,354,038

Year	Debt Service (USD)	ROE	Fixed O&M (USD)	Total Tariff USD/kWh/Year
1	0.0848	0.0397	0.0109	0.1355
2	0.0825	0.0402	0.0111	0.1339
3	0.0795	0.0405	0.0117	0.1318
4	0.0765	0.0408	0.0138	0.1312
5	0.0735	0.0411	0.0115	0.1261
6	0.0704	0.0414	0.0121	0.1240
7	0.0673	0.0417	0.0122	0.1212
8	0.0641	0.0421	0.0165	0.1226
9	0.0609	0.0424	0.0195	0.1227
10	0.0576	0.0427	0.0168	0.1172
11	0.0276	0.0430	0.0175	0.0882
12	0.0000	0.0434	0.0126	0.0559
13	0.0000	0.0437	0.0133	0.0570
14	0.0000	0.0440	0.0156	0.0596
15	0.0000	0.0444	0.0136	0.0580
16	0.0000	0.0615	0.0133	0.0749
17	0.0000	0.0620	0.0136	0.0756
18	0.0000	0.0625	0.0138	0.0763
19	0.0000	0.0630	0.0176	0.0806
20	0.0000	0.0635	0.0153	0.0789

Levelized Tariff	**0.1140**	USD/kWh
Levelized Tariff	**9.55**	BDT/kWh
WACC	10%	
NPV	$4,554,980	
Project IRR	11.06%	

8 Comparative advantages and disadvantages of solar IPP projects development in Bangladesh and India

This section of the report aims to present a brief comparison of solar IPP project development landscape in Bangladesh and India. The differences arise mainly from the variation in available natural resources and also the investment friendly policy environment. A summary of differences between these two neighboring countries is presented in Table 1.

Table 2: Comparison between largescale solar IPP project development landscape in India and Bangladesh.

Factors	Details of comparison
Availability of solar resource	It has been mentioned earlier in this report that some parts of India benefit from higher GHI compared to Bangladesh. For example, annual average GHI in Ahmedabad, Gujarat and Jodhpur, Rajasthan is 5.76 and 5.78 kWh/m^2 per day respectively [9, 10]. In Bangladesh, it is about 4.5 kWh/m^2 per day. Moreover, Bangladesh's annual climate cycle is heavily influenced by long monsoon period that results in low and irregular solar insolation for several months in a row. So, annual energy yield is higher for solar IPP projects in India.
Availability of land	Solar sector development landscape in India also benefits from the availability of vast land, whereas in Bangladesh there is serious competition over land use. Under the Solar Park scheme launched by the MNRE (India), selection of location, acquisition and development of the land is carried out by the implementing agency, while in Bangladesh the project developer has to do all these by themselves. This not only reduces the cost, but also makes the process more efficient and convenient.
Civil and electrical construction cost	Under India's solar park scheme, the implementing agency will construct not only the required roads and transportation systems, but also the transmission line and substation. These are significant cost components for a large-scale solar plant. In Bangladesh, the project developers have to build such infrastructure on their own and also have to get the necessary permits for this. Bangladesh is also comparatively prone to frequent natural calamities, such as seasonal storms, floods, tornado and cyclones. This requires that special care is taken in designs and construction

	of mounting structures for the solar panels, leading ultimately to increases cost of construction.
Benefit of economy of scale	India is advancing in the path of extracting benefits from economy of scale by planning, incentivizing and implementing large-scale solar projects. But for Bangladesh, it will be very difficult to adopt similar measures due to numerous practical issues.
Public grant support	In India, public grant support is made available on comparatively easy terms either from the state or the central government. In Bangladesh, the project developer has to apply and secure the grant from IDCOL, which is a non-bank public finance organization.
Low tariff	All the above mentioned factors have led to global record of low tariff for solar IPP projects in India. The tariff is also determined in a transparent and open process. This indicates that large-scale solar energy is much cheaper in India compared to Bangladesh.
Obligatory power purchase by state utility	The GOI also guarantees that the state owned utility will buy electricity from the solar PV plant for a certain period of time, whereas in Bangladesh such clear and binding provisions or policies are still absent.

9 Conclusion

The tariff calculation is based on the assumptions mentioned in Section 7 of this report. The tariff of a solar PV power plant depends on various parameters that varies from location to location. For example, in Bangladesh, the irradiation varies from district to district. The cost of the equipment is not fixed and the cost of solar PV technology is declining in the international markets. Organizing land for large-scale solar PV projects is very challenging, since the Government does not allow agricultural lands to be used for solar PV project development. The cost of land development also varies from location to location depending on the filling materials and the distance from where the filling material is being transported. Sometimes the erosion protection scheme influences the project cost significantly. The power evacuation infrastructure is also an important parameter. Distance to the grid line and infrastructure and their capacity are also important.

The tariff calculated in this report is an indicative one for negotiation. Land requirement for per MWp of solar PV project is considered to be 3 acres. Here it is assumed that the land is purchased by the project developers. In Bangladesh, the cost of per acre of land is considered to be BDT 10 lacs, which is low compared to that of agricultural land (since agricultural land is simply not available). Also, it has been assumed in this analysis that the developers are to construct 10 km transmission line. Therefore, the tariff will also vary if the distance of evacuation substation varies.

Considering this tariff as a reference, tariff for other solar PV projects can be estimated by taking into account the varying solar irradiation level and other cost factors that are dependent on the selected site of the solar PV power plant.

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11 Short Biography of the Consultant

Education & Employment

Shahriar Ahmed Chowdhury obtained his B.Sc. in Electrical and Electronic Engineering from Bangladesh University of Engineering and Technology (BUET) in 1997 and M.Sc. in Renewable Energy from University of Oldenburg, Germany in 2006 with the highest marks in the graduating class. He has the working experience in Bangladesh power sector for a decade. He worked in system control & grid circle (DESA) and planning & design (BPDB). Currently he is working as the Director of Centre for Energy Research at United International University. He has designed and initiated a course in Renewable Energy for the first time in Bangladesh for the undergraduate students of EEE department in 2007.

Research Achievements and Awards

Shahriar has invented a novel dry fabrication process (alternate buffer layer) for CIGS thin film solar cell with highest efficiency at the time (2006) in Centre for Solar Energy and Hydrogen Research at Stuttgart, Germany. In 2016 one of his research project "Peer-to-Peer Smart Village Grid" funded by IDCOL / WB won the "UN Momentum for Change" award in UNFCCC CoP 22 in Marrakesh, Morroco and "Intersolar Award" in Munich, Germany. His Research projects "Smart Solar Irrigation System" and "Demand Response Enabled Smart Grid" won the "Inter University Innovation Award" at Power and Energy Week 2016 & 2018 respectively, organized by the Ministry of Power, Energy and Mineral Resources. Mr. Chowdhury was the supervisor of the finalist student project for the IEEE International Future Energy Challenge, 2009 in Illinois Institute of Technology, Chicago, USA. In June, 2018 he received the "Education Leadership Award" from "World Education Congress, 2018" in Mumbai, India for his contribution in Education, Research, Leadership and Teaching in the Renewable Energy sector.

Works and Affiliations

As a team leader he has performed the first two technical auditing of the SHSs installed all over Bangladesh under IDCOL program. He is extensively involved in developments of grid connected and off grid solar PV systems. He is the designer of the first ever utility scale grid connected solar PV project of Bangladesh (Engreen Sharishabari 3.28 MWp, came into operation in August, 2017). He is involved in designing Kaptai 7.4 MW (BPDB) and Sirajganj 7.6 MWp (NWPGCL) solar PV projects. He is also supporting RPCL for the development of their 250 MWp grid tied solar PV project at Mollahat, Bagerhat. So far he has designed more than 25 solar diesel hybrid minigrids for rural electrification (Out of 17 operational solar minidgrids for rural electrification under IDCOL financing, he has designed 16). He has also designed several rooftop solar PV systems ranging from 25 kWp to 3 MWp. He has drafted the Net Metering Guidelines for Bangladesh. The Guideline has been approved in July, 2018 by the Ministry of Power, Energy and Mineral Resources of Bangladesh.

As a power & energy sector expert he was involved in projects like Bangladesh Delta Plan 2100, Bangladesh Energy and Emission Modeling 2050, Supporting implementation of Bangladesh Climate Change Strategy and Action Plan (BCCSAP), Bangladesh off grid energy sector assessment, etc. He has working experience in projects funded by GoB, IDCOL, World Bank, UNDP, ADB, DFID, EPSRC, DECC, GIZ, kfW, JICA etc. He has developed a solar PV minigrid laboratory at his University by the grant support from IDCOL and the World Bank. Mr. Chowdhury has jointly initiated a bi-yearly International Conference on Renewable Energy (ICDRET), this is first conference of its' kind in Bangladesh [So far successfully organized 5 events]. He is the author of more than 45 book articles, journal papers and conference proceedings. He has working and project experience in Bangladesh, Germany, UK, Kenya and Nigeria. He is the Member of Expert Panel of International Electrotechnical Commission (IEC) for Systems Evaluation Group (SEG 4) on "Low Voltage Direct Current Applications".