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A Comparative Analysis of Enabling Environment for Solar Rooftop OPEX Models in Bangladesh, China, India, and Vietnam

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List of Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
BDT	Bangladeshi Taka
BERC	Bangladesh Energy Regulatory Commission
BET	Birla Education Trust
BJMC	Bangladesh Jute Mills Corporation
BTM	Behind-the-Meter
C-PPA	Corporate Power Purchase Agreement
C&I	Commercial & Industrial
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CFA	Central Financial Assistance
COD	Commercial Operation Date
DISCOM	Distribution Companies
DoE	Department of Energy
DPDC	Dhaka Power Distribution Company
DPPA	Direct Power Purchase Agreement
EPC	Engineering, Procurement, and Construction
ESCO	Energy Service Company

EVN	Vietnam Electricity
EZ	Economic Zone
FDR	Fixed Deposit Receipt
FIT	Feed-in Tariffs
FOREX	Foreign Exchange
FPV	Floating Solar Photovoltaic
FY	Financial Year
GDP	Gross Domestic Production
GHG	Greenhouse Gas(es)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMPV	Ground Mounted Photovoltaic
GWM	Great Wall Motor
GWp	Gigawatt-peak
HVAC	Heating, Ventilation, and Air Conditioning
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IPG	International Partners Group
IPPs	Independent Power Projects
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
JETP	Just Energy Transition Partnership
JICA	Japan International Cooperation Agency

kWh	Kilowatt-hour
kWp	Kilowatt-peak
LC	Letter of Credit
LCOE	Levelized Cost of Electricity
LEED	Leadership in Energy and Environmental Design
MNRE	Ministry of New and Renewable Energy
MOIT	Ministry of Industry and Trade
MW	Megawatt
NBR	National Board of Revenue
NDCs	Nationally Determined Contributions
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEM	Net Metering
O&M	Operation & Maintenance
OA	Open Access
OPEX	Operating Expenditure
PBP	Payback Period
PDP	Project Development Programme
PE	Project Engineer
PGCB	Power Grid Company of Bangladesh
PPA	Power Purchase Agreement
PPP	Public Private Partnership

PV	Photovoltaic
QC	Quality Control
R&D	Research & Development
REB	Rural Electrification Board
RESCO	Renewable Energy Service Company
RMB	Chinese Currency- Renminbi
RMG	Ready-made Garments
ROI	Return on Investment
RTS	Rooftop Solar
SHS	Solar Home System
SREDA	Sustainable and Renewable Energy Development Authority
UPS	Uninterrupted Power Supply
USD	US Dollar
VAT	Value Added Tax
VND	Vietnamese Dong
WBS	Work Breakdown Structure

Executive Summary

The Government of Bangladesh embarked on advancing the Renewable Energy Sector through a phased strategy, marked by the enactment of the "Renewable Energy Policy of Bangladesh, 2008". This policy is designed to bolster the integration of renewable energy technologies. Bangladesh is guided by strategic imperatives, including ensuring energy security, enhancing the reliability and availability of modern electricity, championing environmental protection, fostering sustainable development, promoting social equity, addressing climate change, and tackling related challenges. Notably, renewables, particularly in solar PV and wind energy, have witnessed substantial growth worldwide over the past decade, characterized by increased deployment, technological advancements, and improved cost competitiveness. Bangladesh has installed 1.2 GW of renewable energy as of January 2024, out of which 1 GW comes from solar PV. This represents less than 5% of the country's installed capacity, against a goal of reaching 10% by 2021, 30% by 2030, and 40% by 2041.

Due to a postulated scarcity of available land for utility-scale solar installations, rooftop solar has emerged as a promising technology that can be scaled up rapidly to advance against the goals set. Most of the uptake to date is via a model where commerce and industry owners invest into the assets and the engineering, procurement and construction is handled by a dedicated rooftop solar provider, generally in South Asia referred to as CAPEX model. Less prevalent to date is the third-party or "OPEX" model, where the rooftop solar provider acts as an energy service company and invests itself into the assets against a power purchase agreement with the off-taker.

The report walks the reader through the steps of a typical OPEX project flow, runs a comparative assessment against the more prevalent CAPEX model and draws out challenges and potential mitigation steps. Key challenges include the ongoing USD crisis that prohibit any party without access to foreign currency to open a letter of credit and with that the ability to import the required resources, such as PV panels and inverters, a (perceived) high degree of off-taker risk combined with limited mitigation option given the weak rule of law in the country, concerns over roof integrity against a 20 year long power purchase agreement, and lastly a lack of regulatory freedom and/ or action to install rooftop solar in special economic zones or on public infrastructure.

The report also draws insights via international rooftop solar case studies. It infers that the Indian state of Gujarat clearly stands out here with its successful residential policy and the favorable stance of its DISCOMs towards rooftop solar. For developing rooftop solar, Bangladesh can look at Delhi for its policy design and emulate Gujarat for its effective implementation. To improve the

accessibility and reach of rooftop solar solutions, Bangladesh must actively promote innovative business models.

Reducing GHG emissions in supply chains is becoming a key factor in the sourcing strategies for global fashion brands. Here, increased levels of RTS installations are a key enabler for decarbonization, and therefore also for retaining the competitiveness of Bangladesh's vital RMG sector. However, even under a scenario of increased RTS installations on the premises of the supply factories, global fashion brands will not be able to make good on their global commitments in scope 3 emission reductions[1]. Therefore, Corporate Power Purchase Agreements would present a possible solution and deserve further investigation.

The report extracts further recommendations to promote and accelerate the growth of rooftop solar, in particular via the OPEX modality in Bangladesh, such as divisional/ district wise renewable energy targets along with a strict timeline in synch with the Mujib Prosperity Plan, to liaison with the National Board of Revenue to waive customs duty and vat for all RE equipment and machinery (not restricted to independent power producers holding a power purchasing agreement with the Government), to provide incentives for the use of storage in combination with RTS and in the EV sector for charging stations, to provide private developers with government PPAs for projects on public infrastructures, such as airports, metro stations, other larger public buildings, etc., to provide private developers with government PPAs for RTS installation on C&I factories, and create a national guarantee fund to give financial players more comfort and bring down the hurdle of bank guarantee requirements, among several others.

To fortify the monitoring and enhance the data-driven financial forecasting capabilities and quality assurance of solar rooftop implementations in Bangladesh, it is strongly recommended to establish a robust national data logging system. The recent advancements in the solar rooftop sector have laid the foundation for significant progress. However, to date, the sector operates largely on feasibility assessments and long-term yield projections based on theoretical values. Through technical assistance, SREDA should be empowered to encompass real-time project yield tracking and benchmarking, aggregate tracking of national renewable energy impact and emission savings, as well as smart features for stable grid operation. This should result in a dynamic national database that should be open to the public and be accessible to the key stakeholders, such as the C&I owners, EPC providers and financiers. dynamic national database.

[1] "Scope 3": Purchased goods and services. Many companies worldwide have set themselves emission reduction targets under the „sciencebased climate change targets" (SBTs).

This database will enable more detailed grid stability assessments, empowering grid operators to fine-tune dispatch strategies, issue curtailment orders, and optimize renewable energy utilization, thereby ensuring a highly reliable grid service. Such meticulous monitoring is essential for garnering public and private sector support, bolstering visibility, and fostering continued growth in the solar rooftop sector in Bangladesh.

1 Introduction

1.1 Background of the study

The Government of Bangladesh (GoB) launched the development of the Renewable Energy Sector through a progressive approach, enacting the "Renewable Energy Policy of Bangladesh, 2008." This policy aims to enhance the adoption of renewable energy (RE) technologies. The GoB is driven by strategic goals such as ensuring energy security, fostering reliability and availability of modern electricity, promoting environmental protection, supporting sustainable development, ensuring social equity, addressing climate change mitigation, and addressing other pertinent issues. Given the challenges of global warming and the dependence on fossil fuels, there is a concerted effort to gradually replace existing conventional power generation capacities with renewable alternatives. This shift is crucial for securing a stable and economically viable energy supply. Notably, renewables particularly solar PV and wind energy, have experienced significant growth worldwide over the last decade in terms of deployment, technological advancements, and cost competitiveness, and are also slowly picking up in Bangladesh.

The country has emerged as a promising player in the renewable energy sector hosting the world's largest solar home system program with over six million connections. However, since grid electrification has been reported to reach the entire country, these systems are no longer the people's primary energy supply option. Commercial & Residential (C&I) rooftop solar (RTS) has experienced increased growth, accelerated by the energy price shocks in the aftermath of the Russian invasion of the Ukraine. Most of the uptake to date is via a model where the C&I owner invests into the assets and the engineering, procurement and construction (EPC) is handled by a dedicated RTS provider, generally in South Asia referred to as CAPEX model. Less prevalent to date is the OPEX model, where the RTS provider acts as an energy service company (ESCO) and invests itself into the assets against designing of a power purchase agreement (PPA). A graphical comparison of the two models is depicted under Figure 1.

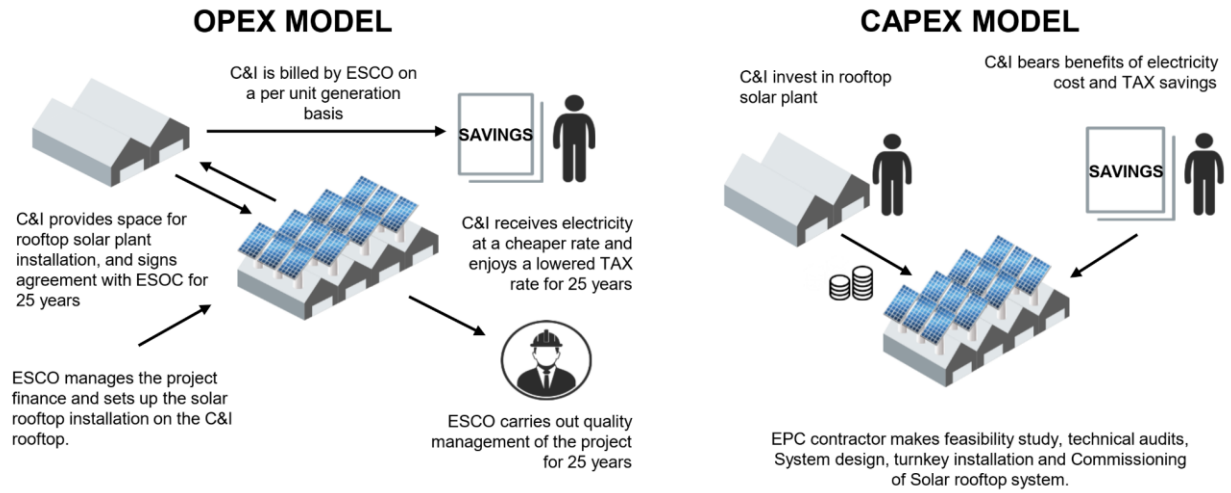

Figure 1: Financing Model Comparison for RTS (Source: Author's depiction)

When considering rooftop solar deployment, choosing between CAPEX and OPEX models involves a careful evaluation of risks and benefits. The OPEX model, relying on third-party providers, offers a more accessible entry point with reduced upfront costs. However, it comes with drawbacks such as limited control and flexibility, as the system is owned and operated by an external entity. Additionally, committing to a long-term financial agreement may pose risks, and concerns about performance and efficiency could arise. At present, Bangladesh does not offer tax incentives or subsidies for RTS. Nevertheless, implementing these kinds of incentives could greatly accelerate the development of RTS projects in the nation.

On the other hand, the CAPEX model demands an initial investment, providing greater control and ownership. Yet, uncertainties related to system performance and maintenance, as well as potential financial risks, accompany this model. Regulatory and policy changes can impact the returns for both CAPEX and OPEX models, introducing an element of unpredictability. Hence, careful consideration of these factors is essential for stakeholders navigating the dynamic landscape of rooftop solar investments. This report focuses on the OPEX modality.

Under these innovative OPEX-driven initiatives, the burden of upfront capital costs on the government is significantly alleviated, paving the way for a greener, more sustainable future. A As of January 2024, Bangladesh installed 1.2 GW worth of renewable energy, of which 1 GW is solar (SREDA, 2024) It is expected that the RTS sector could experience exponential growth with a much larger uptake of OPEX-based projects. However, there are still several bottlenecks that prevent a larger uptake to date, such as uncertainty of future cash flow streams, long-term

roof integrity, trust in the ability and willingness to pay off the off-taker, complex access to local debt and in combination with a foreign exchange crisis. These challenges are discussed in further detail in this report, mitigation measures are being presented.

Furthermore, the objective of this report is to analyse the regulatory and economic enabling environment of OPEX projects within the energy industry, focusing on Bangladesh and learning from neighboring countries such as India, Vietnam, and China. The report ends by providing select recommendations to public stakeholders, such as the Sustainable and Renewable Energy Development Authority (SREDA), development partners, financiers, such as IDCOL, among others.

1.2 What is rooftop solar (RTS)

RTS refers to the installation of solar photovoltaic (PV) panels on the rooftops of buildings or other structures to harness solar energy and convert it into electricity. RTS can be categorized into: i) residential small-scale solar systems (e.g., mini-grids, solar home systems), and ii) commercial and industrial (C&I) solar installations on distribution buildings, manufacturing plants, industrial estates, and retail stores. This report focuses on RTS for C&I purposes.

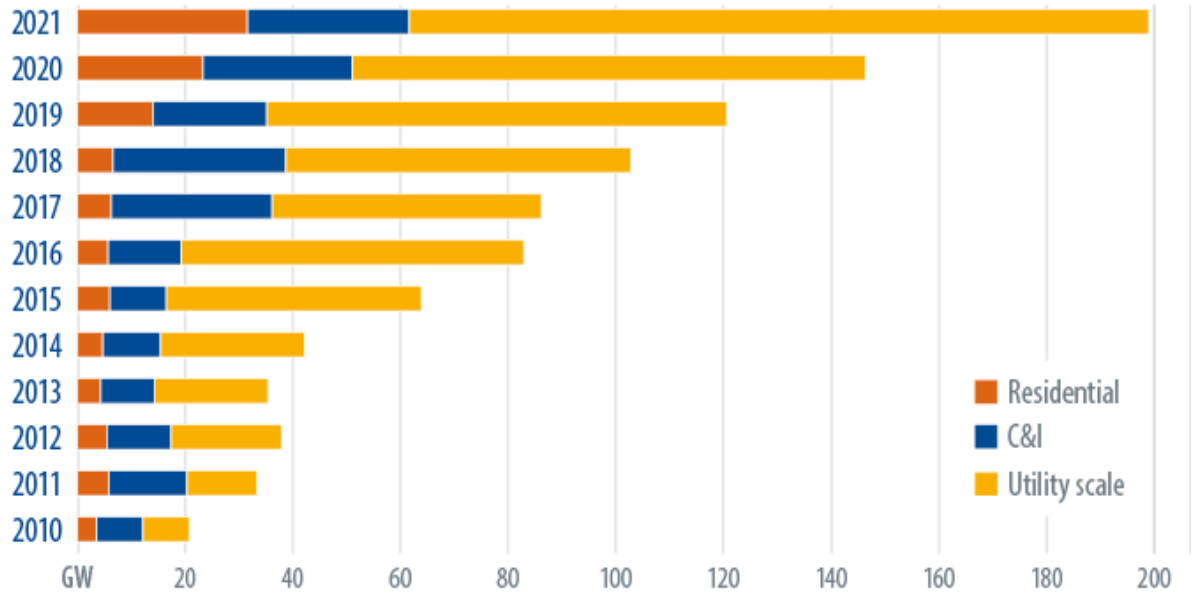

Figure 2: Annual global solar installations by system type (Source: PV Magazine, 2022)

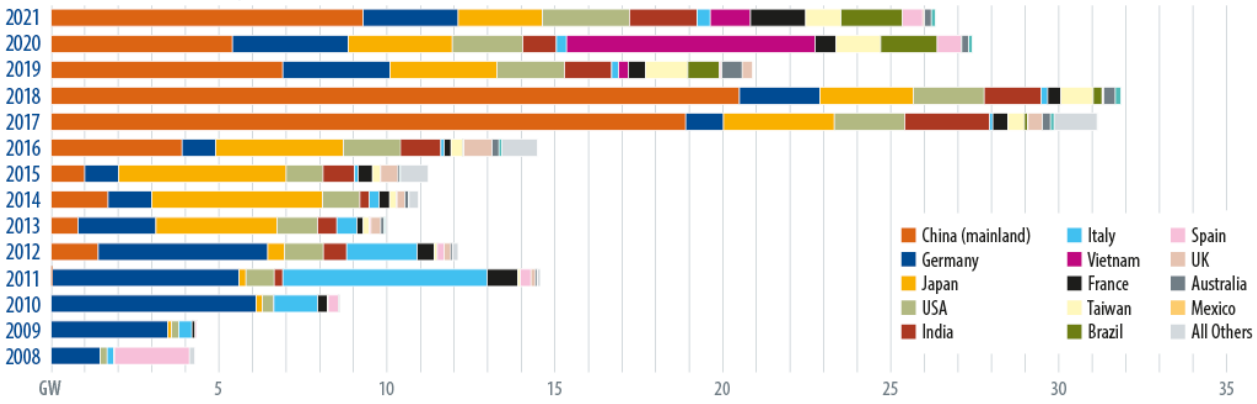

Figure 3: C&I solar installations per continent (Source: PV Magazine, 2022)

In the past decade (see Figure 2), RTS grew remarkably globally, driven by a combination of environmental awareness, favorable government policies, and advancements in technology. The International Energy Agency (IEA) predicts a substantial increase in the global installed capacity of rooftop solar, reaching 1,900 GWp by 2040, with China, the United States, and Europe leading this expansion (IEA, 2020). This decentralized approach to energy generation has increased its market penetration for its:

- **environmental sustainability:** By generating electricity from a renewable source, rooftop solar helps reduce dependence on fossil fuels, mitigating greenhouse gas emissions and combating climate change. According to the International Renewable Energy Agency (IRENA), solar PV systems could avoid up to 4.6 gigatons of CO_2 emissions globally by 2050 (IRENA, 2019). The ready-made garment (RMG) sector in Bangladesh represents by far the strongest industry player, being responsible for more than 80% of the country's exports (Uddin, 2022). With over 200,000 industrial factories nationwide, including 7,000 Ready-Made Garment (RMG) factories, of which only 150 are LEED-certified, and a vast untapped potential of 5,000MWp solar power achievable from industrial rooftops, along with 42 million sq. ft of available solar rooftop space in the textile industry alone (GIZ-PEP, 2023). The RMG sector is strongly influenced by its buyers, majorly from Europe and the US, who in turn have strong binding commitments for their net-zero strategies. The pressure from the brands on the supply factories has recently been significantly increasing to bring down their CO_2 footprint as much as possible. This solution can potentially provide greater self-sufficiency for C&I consumers. However, to meet global commitments, global

brands need to be able to avail corporate PPAs (C-PPAs) which are so far not considered under the present rules and regulations (with a few exceptions).

- **potential cost savings:** RTS offers long-term cost savings. The decreasing cost of solar panels and various government incentives have made solar energy more accessible to homeowners and businesses. The U.S. Department of Energy (DOE) notes that the cost of solar photovoltaic systems has dropped by about 70% over the past decade (Feldman et al., 2023). The economics favouring solar uptake are based on the retail electricity price versus the LCOE of RTS and the government incentives to incentivize renewables.
- **flexible power supply:** RTS energy storage has many benefits for businesses of different sectors and sizes. The main ones are:
    - Peak shaving: C&I energy storage can reduce the peak demand charges that businesses pay to the grid operator by discharging stored energy during periods of high electricity consumption. This can lower the electricity bills and improve the profitability of the business.
    - Energy arbitrage: C&I energy storage can take advantage of variable electricity tariffs by charging the battery when electricity prices are low and discharging it when prices are high. This can generate additional revenue for the business and optimize its energy management.
    - Renewable energy integration: C&I energy storage can increase the self-consumption of renewable energy generated on-site, such as solar photovoltaic (PV), by storing excess energy during periods of high generation and using it during periods of low generation or high demand. This can reduce the reliance on grid electricity, lower the carbon footprint and enhance the sustainability of the business.
    - Backup power: C&I energy storage can provide uninterrupted power supply (UPS) to critical loads in case of grid outages or power quality issues. This can ensure the continuity of operations, protect sensitive equipment and avoid losses due to downtime.
    - Grid services: C&I energy storage can provide various services to the grid operator or utility, such as frequency regulation, voltage support, demand response and congestion relief. This can improve the stability and reliability of the grid, facilitate the integration of more renewable energy sources and create new revenue streams for the business.

1.3 RTS characteristics based on type of energy off-taker and type of business model

1.3.1 Off-taker of energy

Governmental segment

Government organisations, whether directly or indirectly owned, exhibit a willingness to incorporate renewable energy, particularly in newly established buildings with high electricity consumption. These are prospective locations for Operational Expenditure (OPEX) projects due to their usage of power-intensive appliances and systems. Initiatives by entities like the Power Grid Company of Bangladesh (PGCB) and the Bangladesh Jute Mills Corporation (BJMC) underscore the potential of utilizing rooftop spaces for solar parks, contributing over 90 MWp to the national grid (Islam, 2023).

The Infrastructure Development Company Limited (IDCOL) plays a crucial role in financing renewable infrastructure, having refinanced a large majority of the existing RTS installations. IDCOL covers 80% of rooftop solar costs at a low interest rate of 5% - 5.5%. While the government has revised policies to encourage increased stakes in domestic Independent Power Producers (IPPs) for renewable projects, the focus extends to educational institutions. Despite recognizing the solar potential in over 175,000 primary and secondary schools, real initiatives are yet to materialize. Public-private partnerships with Energy Service Companies (ESCOs) are considered suitable for government organizations, offering technical expertise and meeting project feasibility requirements for OPEX. However, administrative complexities pose challenges to ESCO entities in reaching the installation phase, impacting project timelines (Ayan & Pritha, 2021; TFE Consulting GmbH, 2017).

Industrial segment

These are the biggest consumer facilities in the nation (primarily manufacturing facilities with sufficient space up to 4,800 square meters and peak loads between 2 and 5 MWp, along with the highest power per unit rate). The majority operate for 12 hours per day, six days per week. Additionally, manufacturing companies that focus on exports frequently have regulatory obligations for integrating renewable energy, making them ideal OPEX clients.

The Ready-Made Garment (RMG) industry is one of the largest industries and the largest exporter for Bangladesh (80%), with over 4,000 factories operating across the country to produce world-class apparel. RMG and textile factories have a combined roof space potential of over 5,000 MWp

of solar electricity (GIZ-PEP, 2023). Bangladesh Garment Manufacturers and Exporters Association (BGMEA), the trade association responsible for representing the garment industry, has recently entered a deal to outfit the enlisted garment factories of Bangladesh with over 2 GWp of solar rooftop systems, under both OPEX and CAPEX models. Under this initiative, the RMG factories will have an annual generation of 2,600 GWh of solar electricity (The Business Standard, 2022).

Commercial segment

Many businesses are eager to use renewable energy and strive to run green or sustainable operations. With moderate-to-heavy machinery and electrical systems like elevators, HVACs, and servers (air conditioning is needed more when solar regeneration is higher), their operating times are comparable to those of industrial systems. Additionally, tariffs are higher than for typical homes.

Commercial buildings are mostly co-owned, and roof spaces are not as spacious, making the OPEX installation process difficult. Billings are unsecured, and shifting tenants can drastically reduce revenues. Also, for singular-user commercial buildings, CAPEX models might be more feasible.

Economic Zones (EZs)

With 88 EZs currently and a government initiative to reach 100 EZs, the cumulative rooftop space is projected to be around 650 square kilometers, presenting an extensive opportunity for solar installations. EZs are expected to outpace other segments in energy usage, theoretically offering a technical potential of up to 10 GWp of rooftop solar PV. The strategic advantage lies in the high consumption rate of EZs, leading to a balanced consumption-to-export ratio. This equilibrium opens the door for the implementation of long-term (20–25 year) rooftop solar projects. Notably, the largest economic zone, Bangabandhu Sheikh Mujib Shilpa Nagar, covering over 33,000 acres, plans to integrate various solar technologies, including floating solar on lakes, PV on rooftops, and solar parks. The government's proactive measures to harness the 328 MWp solar generation capacity of this economic zone further signify the commitment to sustainable energy practices. Till date, a marginal aggregate of only 454 kW of solar panels has been installed in different EZs run by BEPZA (BEPZA, 2023).

For these EZs, BEZA and BEPZA are the main responsible government authorities in charge. These authorities also provide the electric power to the industries in these zones, effectively becoming the DISCOMs for those zones. It is therefore important to consider BEZA, BEPZA and other similar authorities in the same way as the DISCOMs for the solar rooftop rollout process,

e.g. through having them participate relevant stakeholder meetings and events and through assigning them governmental targets of solar rooftop installations in the same way as official targets for solar rooftop are in place for DISCOMs.

Although the potential for these EZs is high, the interest of BEZA and BEPZA in solar power so far seems to depend on the initiative of individual officers at those authorities, as no official targets or frameworks are in place here. Furthermore, BEZA and BEPZA are allowed to charge an additional 15% on their electricity sales to their industry customers inside the EZs (compared to normal tariffs in Bangladesh) so they can cover their costs for supplying electricity in these areas; so with this guaranteed cashflow, they don't have much of an incentive to explore other options for power supply. Consequently, they also seem to so far have restricted the installation of NEM in their zones (partly also based on concerns like land lease contracts). In order to bring these authorities on board for solar rooftop, the above discussed "OPEX model" seems to be the easiest option where they themselves to invest into solar and be part of the business. This option should be discussed and implemented with BEPZA and the other authorities.

Another reason for the EZs being slow in implementing solar power is the unfavourable economic situation worldwide since early 2022; the development in the EZs has been slow in general and developed areas are lying idle.

<u>Options for BEZA/BEPZA to implement solar rooftop in their EZs:</u>

1. Grid export: The authority can install PV on its areas (including rooftops), invest itself and sell to the grid through a negotiated tariff. This allows the authority to have a cashflow and create revenue – however, it first has to negotiate a tariff with the respective DISCOM which supposes time and the resulting tariff might be relatively low.
2. Individual solar: The authority can allow/encourage its local industry clients to go for solar rooftop themselves – however, thereby losing its own revenues on electricity sales.
3. OPEX model: The authority can install PV on its areas (including rooftops) and sell the electricity to its industry clients as part of its (already existing) electricity supply, allowing for additional cashflow without relying on the DISCOMs and grid export. As the LCOE of solar power is below the grid tariff, it can earn an additional margin (part of which would be passed on to the client). The authority needs to ensure the investment (e.g. through IDCOL) once for large quantities (MW) of solar power. It could also enter a PPP with a private investor in order to reduce its own equity requirements and share or outsource the technical responsibility and maintenance of the solar plants.

The OPEX model would therefore be an attractive option for BEZA/BEPZA to scale up solar power in their Ezs.

Residential Housing

Regardless of holidays, energy is utilized continuously in this area throughout the day. However, residential rooftops are mostly used by their tenants, and given that most residential buildings have multiple tenants, there will be confusion in terms of the division of savings. Thus, a scarcity of usable rooftop space areas coupled with issues of shadowed areas make solar energy prospects challenging for residential housing.

1.3.2 Business models

There are a variety of business models that enable city governments, local businesses, households, and large corporations to deploy rooftop solar. These business models have emerged in response to a mix of factors, including price reductions in solar PV modules, supportive incentives and policies, new digital technologies, and changes in consumer awareness towards climate change. These models can be categorized as provided below:

Table 1: RTS business models

Business Model	Description	Remarks
CAPEX	• The entire investment for procurement, construction and commissioning of the rooftop solar plant is borne upfront by the power consumer • The consumer hires a solar EPC company, which provides turnkey installation of the entire solar power system. In addition, the EPC player may also carry out annual operation and maintenance (O&M) of the plant on mutually agreed commercial terms	• Low transaction costs, lower payment risks and sole ownership of the rooftop plant • However, requirement of upfront capital, high interest rates on the money borrowed, are few of the challenges in implementing this model.
OPEX (or RESCO)	• An investor or project developer (also called Renewable Energy Service Company – RESCO) invests the upfront capital expenditure for setting up the rooftop plant and sells energy to the consumer at a per unit price under a PPA. • The terms and conditions (such as tenure, tariff) of the power purchase are governed by a power purchase agreement signed between RESCO	• The technological risk is mitigated by choosing a qualified RESCO, capable of ensuring performance guarantee of the rooftop solar plant • Prevents customers from locking up significant capital in terms of upfront investments. • A major disadvantage of this model is payment risks because the long-term PPAs signed between RESCO and

Business Model	Description	Remarks
	and the consumer.	consumers generally lack provision of termination compensation. Due to this, consumer is not legally bound to remain in the contract
Lease model	• In this model, the customer leases the system from a developer and pays a rental amount over time. The model of lease may be either a financial lease or an operating lease. • At the end of the lease tenure, the asset is fully transferred to the customer.	• Prevents customers from locking up significant capital in terms of upfront investments and will help in meeting their short-term financial demands • The lease model is not popular in India because of limited tax benefits available to lessors and thus reduced returns to equity. • Other risks involved in this business model are payment default issues and ownership issues
Aggregator model	• Under this model, the third party/ RESCO, aggregates the demand of various consumers and installs rooftop solar captive power plants up to the total capacity of the cumulative contracted load of the selected group of customers connected with the same distribution transformer. • This model is now picking up pace in India and has been tried by various DISCOMs and banks.	• Helps the aggregator to gain scale and offer resulting in low transaction cost. Financial institutions save considerable time and resources. • To gain a complete line of credit for rooftop financing, developers aggregate the portfolio of projects so that the project financing cost can be significantly reduced. Hence, the end consumer is offered competitive tariffs. • This model assists in better risk management due to lower risk of project failure arising from any one individual buyer.

2 RTS OPEX models

2.1 Characteristics of the OPEX model

Globally, RTS energy businesses have followed two broad routes for development. The first route has been focused on consumers, who develop small decentralized distributed solar projects, mostly on their rooftops. Such small projects range from a few kilowatts to megawatts in case of industry and commercial (C&I) consumers, and are developed under facilitating policy and regulatory framework, with the role of utility being limited to granting permissions and facilitating interconnection with the grid. Facilitative policies, incentives, tax rebates, capital subsidies, feed-in tariffs and net metering have been key drivers of such business models. Customer-focused

routes — or business models — can also involve a third-party, rooftop developer, known as a RESCO (Rooftop Energy Service Company). RESCOs often facilitate financing for the systems they install, service and maintain on behalf of the consumers, against payment for energy generation.

A second route for decentralized solar energy involves direct involvement by the utility, which plays an active role in developing rooftop solar projects, including investment, facilitation, or development with third-party developers. Utilities have an inherent advantage because they act as the interface between the customer and the grid. Declining cost of solar and simultaneous increase in the costs of conventional power has resulted in an increased interest in decentralized distributed solar models from utilities. Table 2 summarizes both customer-centric and utility-centric business models.

Table 2: Customer-centric and utility-centric business models (Source: PACE-D, 2023)

Utility-focused solar business models	Customer-focused solar business models
Utility-owned, on customer or utility premises	Consumer (rooftop owner)-owned (CAPEX)
Community-owned and utility-facilitated	RESCO (third-party)-owned (OPEX)
Utility-financed	

The operating costs model, often known as the OPEX model, is a scheme in which the developer owns the solar project, and the consumer just pays for the energy produced. The OPEX model requires users to commit to a long-term, legally enforceable agreement for the roof on which the solar system is installed. In addition, they must sign a long-term Power Purchase Agreement (PPA) for the supply of power. The PPAs can last for a period of up to 25 years, with the consumer agreeing to pay a predetermined rate over that time. Any extra electricity produced can be fed into the grid. In this arrangement, the developer is responsible for all capital costs and risks. The developer owns the system for the rest of its life and is responsible for its operation and maintenance throughout its lifetime. A major advantage of the OPEX approach is that it allows the consumer to go solar without a huge upfront expenditure (Mercom, 2020).

The OPEX model is appropriate for individual consumers who are skeptical about making long-term capital investments in technology they have less understanding about. After a five-year trial period, they can choose to exercise the buy-back provision on their PPAs. It is also ideal for

smaller companies aiming to meet their green goals as they expand. Depending on the tariffs set by their various state distribution firms (DISCOMs), they can save roughly 30-40% on their electricity bills (ISR, 2021).

However, not all installers may be willing to offer rooftop installations in the 5 kWp range using the OPEX model. To make it profitable, they'll need a minimum capacity of 500 kWp or more. As a result, the commercial and industrial (C&I) sector is the key consumer for developers. Ownership of the rooftop project will be transferred to the consumer once the PPA expires. Companies, on the other hand, incorporate a clause that allows them to acquire back the project before the PPA expires. This permits the consumer to return the product to the creator at a predetermined rate after five years.

2.2 Step by Step Process Diagram of an OPEX model

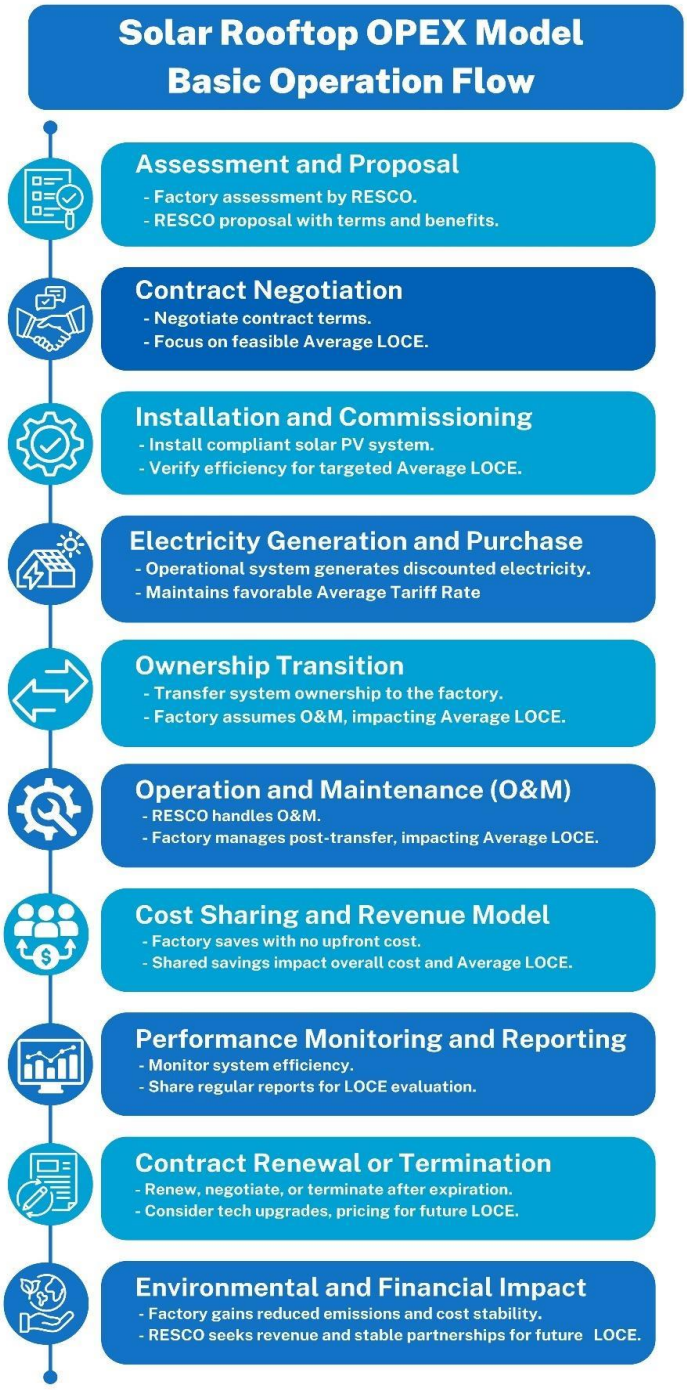

Figure 4: Step by step process diagram of an OPEX model

2.3 RTS in Bangladesh: Current market and trends

In recent years, Bangladesh has witnessed a significant surge in the adoption of RTS energy solutions, driven by a combination of factors such as increasing energy demand, cost of energy, environmental concerns, and load shedding which causes frequent power outages. This shift towards solar energy is particularly prominent in the C&I sector, where businesses are recognizing the economic and environmental benefits of rooftop solar installations. The solar energy market in Bangladesh is expected to grow from 0.4 GWp in 2023 to 2.05 GWp by 2028, at a CAGR of 38.60% during the forecast period (2023-2028) as shown in Figure 5 (Mordor Intelligence, 2023):

Figure 5: Expected growth of the solar energy market in Bangladesh (Source: Mordor Intelligence, 2023)

The market experienced adverse effects from the COVID-19 outbreak, characterized by regional lockdowns and disruptions in ongoing and upcoming projects. However, it has recovered to levels comparable to those before the pandemic. Bangladesh has set an ambitious target to install over 4,100 MW of electricity from renewable sources by 2030 (Hasan & Rahman, 2021). About half of this power is expected to come from solar energy, presenting a substantial opportunity for the country's solar energy market. According to the International Renewable Energy Agency, Bangladesh's solar PV capacity reached approximately 537 MWp in 2022, marking an increase from 480 MWp in 2021 (IRENA, 2023; Mordor Intelligence, 2023). And in 2023, Bangladesh

approved over 1.5 GW of solar installation projects (PV Magazine, 2023). This growth was driven by significant deployments of solar PV installations in the country, especially in utility projects. The Ministry of Energy and Power in Bangladesh aims to further increase the installed capacity of solar PV by 2023.

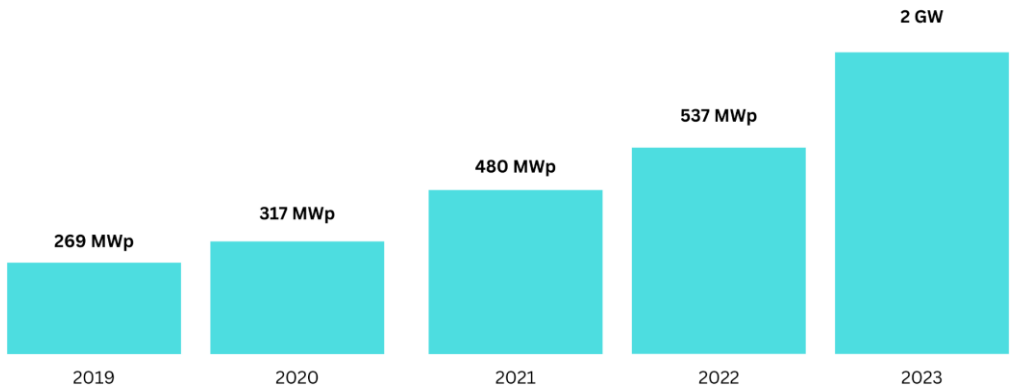

Figure 6: Growth of PV installations in Bangladesh

Both governmental authorities and public sector utilities acknowledge the significance of RTS in the country's energy mix. Solar energy is gaining attention as the country shifts its energy mix away from natural gas, given shortages. Despite discussions surrounding the implementation of a policy for RTS, there is currently a lack of it. While the Bangladesh Energy Regulatory Commission (BERC) has shown interest in RTS by releasing a draft policy guideline in March 2017 titled 'Terms and Conditions for Determination of RE Tariff,' it primarily focuses on a net metering framework (TFE Consulting GmbH, 2017). The draft outlines details such as capacity limits, system types, and associated costs but does not include a tariff for excess energy injected into the grid (see Table 3). Instead, it establishes a methodology and parameters for determining a potential tariff in the future. Consequently, the draft does not offer clear guidance to market participants on the direction of net metering support and lacks any indication of potential power evacuation compensation, which could serve as an additional revenue stream for C&I customers.

Table 3: Regulation parameters for PV systems

Parameter	Applicable Regulation	Implications / Comments
Capacity Limits	Applicable to rooftop and land-based systems of less than 1 MW (AC) classified into two categories: 1. Less than 10kW 2. Between 10kW and 1 MW	Different capacity limits are required since rooftop solar system costs are extremely sensitive to scale.
Capacity Utilization Factor	18%	Indicates the quantum of energy generated by the system.
Approved System Price	BDT 130,000 per kWp (less than 10 kWp) BDT 120,000 per kWp (Between 10 kWp and 1 MWp)	Actual system prices can be much lesser than these indicative prices. On ground discussions indicate that prices are closer to BDT 70,000 per kWp
Normative Operation and Maintenance Expenses	1.4% of capital cost (annually)	This number is highly specific. Remote sites tend to have higher service costs compared to urban locations.

Net Metering is a billing arrangement/ policy that gained popularity in 2018 following the introduction of the Net Metering Guidelines in July of that year (Net Metering Guidelines, 2018). This also boosted the installation of industrial rooftop solar systems on a large scale. This technology enables prosumers to earn credits in the form of energy or money by connecting their renewable energy sources to distribution grids. CAPEX and OPEX are the two financing models that are currently being offered in Bangladesh. The government of Bangladesh faced challenges in increasing the share of renewable energy for limited space for large-scale renewable energy power facilities. However, net metering emerged as a pivotal measure to alleviate this challenge.

Technology Name	Units	Capacity (MW)
Solar Home Systems	6037641	263.471
Solar Irrigation Systems	2816	53.268
Roof Top Solar Systems (except Net metering)	191	56.596
Net Metering Rooftop Solar	1684	46.327
Solar Mini-Grids	28	5.805
Solar Parks	47	2295.92
Solar Charging Stations	14	0.282
Solar Drinking Water Systems	116	0.126
Solar Mini Grid	28	5.805
Solar Nano Grid	2	0.001
Solar Street Light	296861	17.065

Figure 7: Bangladesh Solar System overview

In 2021, the chairman of SREDA announced 500 MWp of rooftop solar projects for industrial and commercial establishments powered by the net metering system and solar parks with over 1,000 MWp capacity to be in operation soon (The Daily Star, 2022).

In October 2023, the Bangladesh government mandated the installation of net-metered solar systems in newly constructed residential, educational, medical, industrial, and commercial buildings as a prerequisite for new grid connections. This move is expected to increase rooftop PV generation in the country (Islam, 2023). There is also a growing interest among industry owners, small to large scales, of installing solar projects on the rooftops of their factories, especially garments, textiles, and jute mills considering their cost-effectiveness (Khan, 2023).

With a focus on the C&I sector consumer segment, the RTS market in Bangladesh can be categorized into three types of consumers: government, industrial, and commercial (TFE Consulting GmbH, 2017).

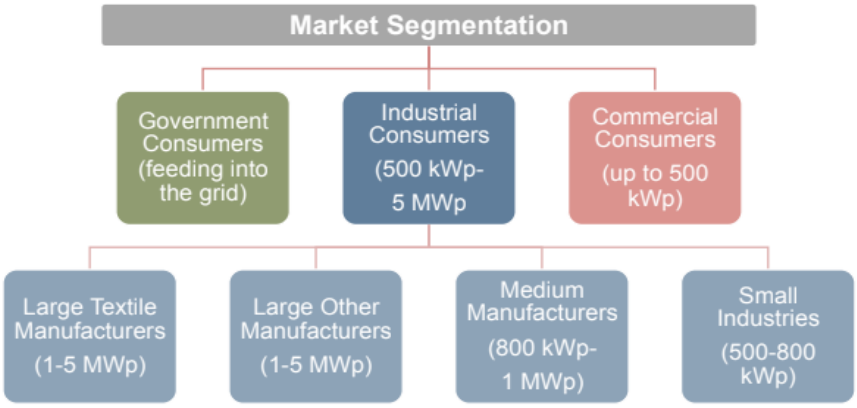

Figure 8: Market segmentation Bangladesh

Government

The government plays a pivotal role as a substantial demand source in the current early stage of the market. The government's interest in implementing rooftop solar on various structures, including electrical substations, university rooftops, and offices. The primary motivation behind these initiatives was to contribute to the country's objective of achieving 10% of electricity generation from renewable sources by 2021 (Nabi, 2019). Additionally, the government aims to enhance the familiarity of government officials and public utilities with solar PV and catalyze the development of a rooftop solar Engineering, Procurement, and Construction (EPC) and financing ecosystem.In evaluating this segment, the load factor is not a significant consideration. This is attributed to the fact that, for government projects, a utility entity typically procures the energy for

integration into its electricity system. The government building itself does not directly consume the generated power, and consequently, is not billed for it. This operational model mandates that all government projects be situated in proximity to a high-voltage power evacuation line owned by a utility such as DPDC. As the DPDC procures the electricity, the entirety of the energy generated by rooftop systems installed on government buildings can be fully utilized. Therefore, in this specific segment, load considerations do not impact the sizing of the systems.

Industrial

Industrial consumers, particularly manufacturing industries, are pivotal to Bangladesh's economy, contributing nearly 20% to the GDP (The World Bank, 2023). This sector, with its demand for cost-effective and uninterrupted electricity, currently propels the rooftop solar market in the country. Noteworthy industrial segments include large textile manufacturers, other large manufacturers (such as glass and ceramics), medium manufacturers (including ready-made garments and battery manufacturing), and small industries (e.g., poultry and agro-processing companies). The diversity of economic activity (length of operations, load profile) in this segment influences the total capacity installed, rooftop layouts, and system design.

Commercial

This category typically comprises offices, malls, and shopping areas, with electricity loads often exceeding 1 MWh. In developing countries like India, RTS for the same type of consumers range between 100-200 kWh. However, market insights indicate that the level of commercial development in Bangladesh is comparatively lower than in India. Consequently, only a limited number of commercial buildings are suitable for rooftop solar installation.

Moreover, due to the high population density and limited land availability, commercial buildings in Bangladesh tend to have smaller areas, resulting in roof spaces more suitable for solar systems ranging from 10-20 kWp. According to feedback from EPC companies, this makes the commercial segment less attractive to them, leading to a lack of noteworthy market activity in this area.

2.4 Stakeholders and Regulatory Setup

2.4.1 Stakeholders

The key stakeholders for rooftop solar in Bangladesh include:

Industrial Consumers

These are the driving force behind the exploration of rooftop solar systems, particularly in the size range of 100-1,000 kWp. Described as 'early adopters,' industrial players aim to maximize roof

space to mitigate the impact of power cuts and rising grid electricity costs. Their interest lies in reducing energy expenses and enhancing supply security.

EPC Companies

A small but emerging EPC ecosystem is playing a crucial role in implementing rooftop solar installations in Bangladesh. These companies are technically competent, have executed high-quality installations, and present financially attractive proposals to potential customers. They are instrumental in advancing the adoption of rooftop solar.

Infrastructure Development Company Limited (IDCOL)

IDCOL plays a key role in facilitating the rooftop solar market by bringing together installers and customers. Despite not being explicitly mandated for such activities, IDCOL representatives assist companies with quick pre-feasibility checks and promote their financial lending terms to potential customers.

Government Stakeholders

The Power Division, Ministry of Power, Bangladesh, Sustainable and Renewable Energy Development Authority (SREDA), and Dhaka Power Distribution Company Limited (DPDC), Bangladesh Rural Electrificaiton Board (BREB), Dhaka Electric Supply Company (DESCO), Bangladesh Power Devcelopment Board (BPDB), West Zone Power Development Company (WZPDCL) are government entities involved. Despite government support, the process of finalizing rooftop solar policies is slow due to concerns about the relatively high cost of solar PV electricity compared to current utility power procurement rates.

These stakeholders, including industrial consumers, EPC companies, and IDCOL, and Government Stakeholders express confidence in the growth potential of rooftop solar in Bangladesh. They emphasize the necessity of policy support to expedite adoption and fully realize the market's potential.

Development Partners

Development partners like the Asian Development Bank (ADB), World Bank, GIZ (German Agency for International Cooperation), and JICA (Japan International Cooperation Agency) are playing a pivotal role in advancing rooftop solar initiatives in Bangladesh to expedite infrastructure development projects. Recognizing the importance of sustainable and clean energy sources, these organizations are collaborating with the Bangladeshi government and local stakeholders to promote the widespread adoption of rooftop solar technology. Their support includes financial assistance, technical expertise, and capacity building programs aimed at enhancing the country's

ability to implement and manage solar projects. One notable example is the G310 Project Development Programme (PDP) by GIZ, which is part of the German Energy Solutions Initiative. The PDP specifically aims to promote the use of rooftop solar in Bangladesh by providing technical support to humanitarian agencies for renewable energy exploration, including feasibility studies and project development. Moreover, the PDP actively participates in the selection of suitable contractors to ensure the effective implementation of rooftop solar projects, contributing significantly to Bangladesh's sustainable and resilient future.

2.4.2 Regulatory Setup

The regulatory setup for the Rooftop Solar sector in Bangladesh faces significant challenges. Policies primarily originate from top-level authorities, but there is a noticeable gap between policymakers and industry stakeholders, including professionals, producers, consumers, and engineers. Limited citizen involvement in rural areas, coupled with a lack of consideration for diverse viewpoints during policy formulation, contributes to the existing constraints. Policymakers often perceive renewable energy, particularly solar, as intermittent and not a significant alternative.

The 2018 introduction of a net metering policy aimed to encourage energy contribution to the grid, but the lack of specific guidelines for different projects has impeded widespread adoption. Despite a 2010 mandate for solar panels on all buildings, the initiative faced challenges like low awareness, leading to the installation of low-quality panels. The current grid setup is not conducive to various renewable energy solutions, and outdated infrastructure hampers the integration of variable renewable energy. Many remote areas lack grid access, excluding captive power plants from net metering benefits.

Although Bangladesh aspires to achieve 40% of its electricity from renewables by 2041, it has already been falling short of this 10% target by 2020, scratching only the 3% mark (The Daily Star, 2023). Land scarcity and with that a limited potential for utility-scale solar is often made the main culprit. The current shift toward rooftop solar in the C&I sector is a promising development, coupled with a very promising Renewable Energy Policy 2023 draft, as issued by SREDA on Nov 20, 2023.If/ once implemented, this could/ will be a key enabler for a larger uptake of renewables in Bangladesh in general.

Foreign companies express interest, but they encounter obstacles due to evolving regulations and the need for clear guidelines. The government provides incentives such as waived import duties and VAT exemptions for solar-related goods, especially for registered Solar Panel

Manufacturing Plants. Bangladesh Bank supports solar projects through refinancing schemes and a fund for technological development.

Challenges persist, including the high initial investment, limited information, and public awareness, technical knowledge gaps, and regulatory uncertainties. The use of low-quality panel modules further impacts the durability and efficiency of installed solar panels. Addressing these challenges is crucial for enhancing the effectiveness of solar panel systems in Bangladesh.

3. Challenges of the OPEX Model and Potential Risk Mitigation

3.1 Challenges of the OPEX model

Uncertainty in Revenue Streams

The revenue streams from renewable energy projects can be uncertain, at least in a nascent market with little to no historical data, as they are dependent on factors such as the weather and the price of electricity. This can make it difficult for developers to predict their future cash flows and make informed investment decisions. Moreover, the usual PPA (Power Purchase Agreement) term is 20 years which exposes the ESCO company to several risks such as payment risk, bankruptcy risk, etc. as cash flow management is extremely critical.

Foreign Exchange Risk

Many of the components used in renewable energy projects in Bangladesh are imported from foreign countries, which exposes developers to foreign exchange risk. This can increase the cost of projects and make it more difficult to predict their profitability. Additionally, the current inflation rates coupled with the rapid currency devaluation trends in the domestic economy pose a threat to commissioning solar OPEX projects by destabilizing project budgets. Moreover, financing through foreign loans is not a feasible option given the return on investment (ROI) for the service provider comes in Bangladeshi Taka (BDT) which has historically devalued considerably against the USD.

Lack of access to finance: Bangladesh's renewable energy developers face challenges in obtaining financing from conventional lenders. This is caused by several things, such as the unpredictability of revenue streams, and the lack of collateral. Moreover, the weak Taka makes borrowing in FOREX extremely risky. As the Bangladesh Bank is providing the Taka an artificial floor price, and faces increasing pressure to stabilize the Taka, significant devaluation can be expected in 2024. Since PPAs are not available in US$, the only option for debt financing is in local currency.

Access to Local Debt

Private organizations such as ESCOs and EPCs find it difficult to satisfy the financial institutions' requirements when it comes to domestic funding choices. One of the main lenders of solar installations, for example, is IDCOL, which offers financing facilities that cover 80% of the installation costs. But to meet IDCOL's lending requirements, borrowers must secure the loan amount by giving IDCOL collateral in the form of a bank guarantee, land mortgage, or lien on FDR. The bulk of private companies in the energy sector, however, lack land that may be mortgaged to IDCOL, whilst bank guarantees, often at 100% margin, come with costs because the guarantor banks need to pay quarterly margin fees. For most commercial service providers, it is not practical to supply such collateral for every project during the quick rollout of OPEX projects. Also, the process of obtaining a loan can easily take nine months, which means that the project financing often has to be upfronted, and then the IDCOL loan might be rolled over for consecutive projects.

The Bangladesh Bank's refinancing initiatives, which offer refinancing for financial institutions to provide loans for green projects at comparatively lower interest rates than the commercial banks, are another important domestic financing option for solar OPEX in Bangladesh. After that, ESCOs receive funding from financial institutions to start eco-friendly projects. The refinancing plan presents a hurdle because it necessitates Bangladesh Bank's approval of the borrower's project. Therefore, a borrower runs the risk of the project's failure to materialize if they obtain funding from a financial institution under the program but their project is rejected. Also, comparing the refinancing plan to standard finance, however, various bureaucratic problems, such as the channeling through commercial banks that prefer to finance larger and simpler energy efficiency projects, have led to almost no deployment.

High Tax, VAT & Customs Duty

Solar OPEX providers have to import the items at a high tax rate which makes it difficult to manage capital expenditures. Unlike the IPPs who benefit from exemption as their business relationship is through a governmental PPA, rooftop solar projects do not have access to or incentives of capital benefits, customs exemption, or tax holidays spanning up to 15 years, thus rendering it expensive and its prospects less lucrative.

US Dollar Crisis and L/C Opening Issues

The persisting dollar crisis on one hand influences the possibility of securing foreign loans and on the other exerts an impact on the initiation of Letters of Credit (L/C), consequently impeding the process of importing essential equipment and components for renewable energy projects,

notwithstanding the availability of sufficient funds in the local currency. Effectively, at present an EPC needs to bring one USD into the country before being able to open an LC worth one USD.

Roof Integrity Concerns

One of the significant challenges associated with the OPEX model of rooftop solar in Bangladesh revolves around uncertainties regarding roof integrity. Assessing whether a roof will remain structurally sound and unchanged for the typical lifespan of a solar installation, which often spans 20 years or more, poses a considerable hurdle. In the event that a roof does require replacement or repair within this timeframe, additional deinstallation and reinstallation costs become a pressing concern. Moreover, even with legal indemnification clauses in place, the potential for leaks or damages to the roof can lead to disputes between solar service providers and property owners. These disputes not only entail financial implications but also raise questions about the practicality and effectiveness of long-term solar leasing agreements, necessitating careful consideration and risk mitigation strategies for both parties involved in the OPEX model.

Limited Scope-3 Emission Reduction Potential

Reducing greenhouse gas (GHG) emissions within supply chains is increasingly pivotal in the sourcing strategies of global fashion brands. The proliferation of renewable energy technologies, especially (RTS), plays a crucial role in decarbonization efforts, thereby bolstering the competitiveness of Bangladesh's essential Ready-Made Garments (RMG) sector. Yet, even with a surge in RTS installations at supply factories, these brands may struggle to fulfill their global commitments for reducing scope 3 emissions. Corporate Power Purchase Agreements (C-PPAs) emerge as a potential solution: C-PPAs involve an agreement between a business and a renewable energy generator, wherein the business commits to purchasing a designated amount of electricity at a fixed price over a set period – however, contrary to establishing a PPA project on the off-taker’s premises, the energy is generated at another location and routed to the off-taker via the existing grid (“wheeling”). This arrangement offers businesses a reliable energy supply while concurrently diminishing their carbon footprint and advancing the nation's sustainable development objectives, while eliminating the space limitation on the off-taker’s site premises. Regrettably, the current net metering policy overlooks the possibility of incorporating C-PPAs and wheeling, while in principle part of the original Renewable Energy Policy, has not yet been implemented, mostly due to the concerns of the DISCOMs.

Data availability

Currently, technical data availability on solar rooftop is very low in Bangladesh. There is a list of all approved rooftop plants on the SREDA website, but there is no performance data or even an

updated registry of plants still in operation. Local solar irradiation measurement data to estimate the output of a plant in a certain location is not available; the only available datasets are satellite data. For the electric grids, granular and real-time data, such as grid outages, grid voltage, grid frequency, and reactive power injection are not available or hard to achieve from DISCOMs. All of this hampers a standardized, informed decision-making from an investor's point of view or makes it impossible to benchmark projects between different suppliers.

3.2 Risk Mitigation

Uncertainty in Revenue Streams

Revenue streams should be diversified through the use of Power Purchase Agreements (PPAs) with fixed tariffs. Hedging strategies concerning foreign currency should be implemented to minimize the impact of market volatility. Furthermore, it is recommended that bank guarantees, spanning 12 months of electricity bills, be demanded to mitigate this risk concerning off-takers. When it comes to OPEX projects, government entities, as off-takers, can easily comply with the National Net Metering Regulations like the Tripartite Power Purchase Agreement (PPA). A Tripartite PPA involves three parties—the power producer, the power purchaser, and a government entity or regulatory body—providing a framework for renewable energy projects with added assurances and support mechanisms. However, the case is different for private off-takers. For private off-takers, the practice of these tripartite agreements and selling bulk electricity to the REB upon failure of payment is not as effective as it is for the government off-takers. This creates a compliance risk for the private entities with OPEX projects on the ground. Therefore, a specified and clarified set of directions needs to be set in this regard, tailored for private off-takers.

Access to Local Debt

It might be necessary to finance first projects with 100% equity to create a track-record and in parallel pursue local debt which can then be used to finance consecutive projects. This approach requires careful cash flow management.

Foreign Exchange Risk

Diversification of equipment and component suppliers is necessary to reduce reliance on a single currency if possible. Foreign currency hedging options should be explored to mitigate exchange rate risk. A foreign currency reserve should be maintained to cover short-term currency fluctuations.

Tax Exemption

Engaging in discussions with relevant authorities like SREDA, NBR, etc. to explore potential tax exemption for renewable energy projects is crucial. Tax considerations should be included in financial modeling to accurately assess project costs.

US Dollar Crisis and L/C Opening Issues

Diversification of sources for equipment and components to reduce reliance on a single currency is advisable. This can be achieved by establishing partnerships with multiple suppliers across diverse regions, mitigating the impact of currency fluctuations on procurement costs. Exploration of alternative trade financing options, such as trade credit insurance and export financing, is necessary. Companies can actively seek out partnerships with financial institutions specializing in renewable energy projects to secure favorable trade credit insurance terms. Additionally, engaging in discussions with both financial institutions and regulators to address concerns related to Letter of Credit (L/C) availability is essential. Proactive measures, such as negotiating flexible L/C terms or exploring digital and blockchain-based financing solutions, can streamline transaction processes. By implementing these practical and targeted risk mitigation strategies, the renewable energy sector in Bangladesh can navigate the intricate financial landscape with greater agility, enhancing the resilience of projects and ensuring their long-term success and sustainability.

Data availability

To fortify the monitoring and enhance the data-driven financial forecasting capabilities and quality assurance of solar rooftop implementations in Bangladesh, it is imperative to establish a robust system. The recent advancements in the solar rooftop sector have laid the foundation for significant progress. This solution encompasses real-time project yield tracking and benchmarking, aggregate tracking of national renewable energy impact and emission savings, as well as smart features for stable grid operation. Currently operational in a testing environment across the country, the implementation is closely monitored by the Sustainable and Renewable Energy Development Authority (SREDA), which acts as the central regulatory entity holding project owners accountable for data availability. The initial data collection focuses on daily yield and hourly average generation power. The expansion of the program to include more granular and real-time data, such as grid voltage, grid frequency, and reactive power injection, will contribute to a dynamic national database. This comprehensive dataset enables more detailed grid stability assessments, empowering grid operators to fine-tune dispatch strategies, issue curtailment orders, and optimize renewable energy utilization, thereby ensuring a highly reliable

grid service. Such meticulous monitoring is essential for garnering public and private sector support, bolstering visibility, and fostering continued growth in the solar rooftop sector in Bangladesh.

4 RTS environment in selected countries

4.1 RTS market and trends

4.1.1 India

RTS is an important market segment of India’s solar sector. It comprises on-site solar installations connected in a behind-the-meter (BTM) configuration on the consumer’s premises. It provides buyers a viable option to green their electricity consumption by procuring on-site cheaper and cleaner renewable energy. According to the Ministry of New and Renewable Energy (MNRE), as of July 2023, the cumulative installed capacity of rooftop solar in India was 10.9 gigawatts (GWp). This represents a share of around 15% of the total solar installations in India. Until fiscal year (FY) 2019, RTS in India was only 1.8 GWp. Since then, the RTS market has consistently grown by around 1.9-2.2 GWp annually. According to industry estimates, FY2024 will see the largest installations to date of about 4 GWp. Out of this, 2 GWp has already been installed between April and July 2023. States like Gujarat, Andhra Pradesh, Telangana, and the union territory of Delhi, have the most favorable ecosystems for setting up rooftop solar projects. Conducive net metering policies, ease of regulatory approvals, and potential monetary savings that a C&I consumer can realize by adopting rooftop solar influence a state's attractiveness. States like Tamil Nadu and Uttar Pradesh continue to discourage their high-paying C&I consumers from shifting to rooftop solar-based solutions.

In terms of consumer segments, commercial and industrial (C&I) consumers added the bulk (~66%) of rooftop solar capacity in India. The other 34% of rooftop solar installations are in residential and government buildings. The lack of consumer awareness, the dearth of suitable financing options, and regulatory issues around net metering have hindered the uptake of rooftop solar in the residential segment. Regarding the split by different business models, the capital expenditure (CAPEX) model is more prevalent, with around 70% additions. The primary reasons for the smaller operating expenditure (OPEX) share are the substantial contractual and payment risks that project developers encounter because of a lack of creditworthy C&I consumers.

As part of India’s overarching National Solar Mission, the government envisioned the installation of 100 GWp of solar capacity by 2022. Out of this, 40 GWp was assigned to rooftop solar. To

achieve the 40 GWp target, the central government launched two phases (in 2015 and 2019) of the Grid-Connected Rooftop and Small Solar Power Plants Programme. The program provided incentives through central financial assistance (CFA) to install rooftop solar plants. Despite the government's efforts, by the end of 2022, only 8.1 GWp had been installed, according to data from the MNRE. The prevailing practices of RTS implementation is observed to be complex, repetitive, tedious, and time-consuming for potential consumers and there is a lack of coordination among implementing agencies. Therefore, even with vast potential, supportive measures, dedicated policies, and regulations the penetration of RTS systems is far below their respective potential. This massive shortfall (around 80%) in the target forced the MNRE to extend the timeline of Phase-ll of the program by more than three years to March 2026.

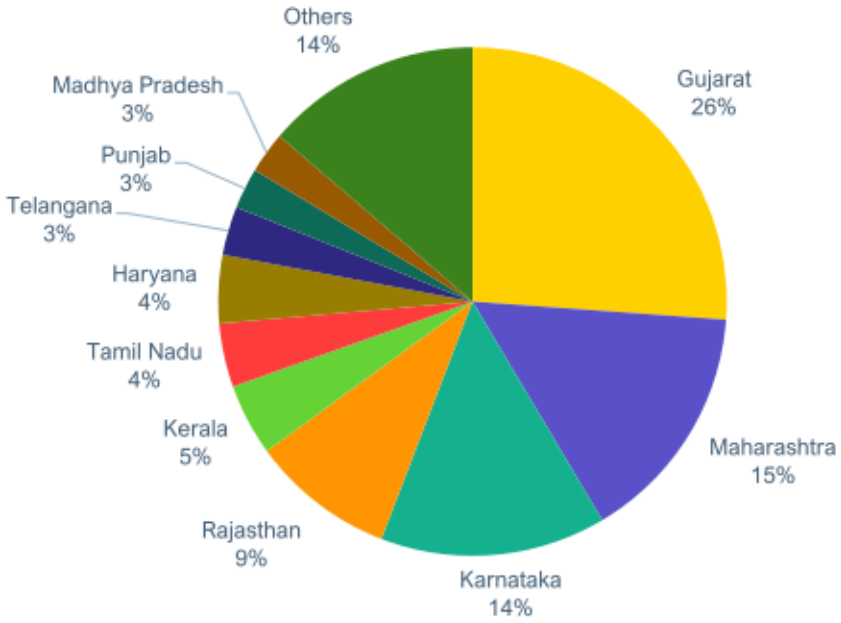

Figure 9: State-wise share rooftop solar installations (as of July 2023) (Source: Gulia et al., 2023)

4.1.2 Vietnam

By the end of 2022, around 19.38 GWp of solar generation capacity has been installed in Vietnam. RTS has been the rising star which has seen a skyrocketing increase of installations in 2020 before a deadline for the FITs scheme, with a total capacity of 9.73 GWp installed by the end of December 2020. RTS installations grew by more than 25 times, rising from the capacity of 378 MWp at the end of 2019 and spread across almost 105,000 RTS systems throughout 2020.

In terms of average capacity size of RTS systems by sector, the industrial sector has the biggest size of 482 KWp/system, 4.6 times bigger than the commercial size (105 KWp/system), 3.5 times bigger than the administrative sector (137 KWp/system) and 30 times bigger than the household sector (16 KWp/system). The administrative sector includes Hospital, Nursery, Kindergartens, Schools, Public buildings, and public lighting and has an average capacity of 137 KWp/system. There is no specific data on the number of systems and total capacity for schools.

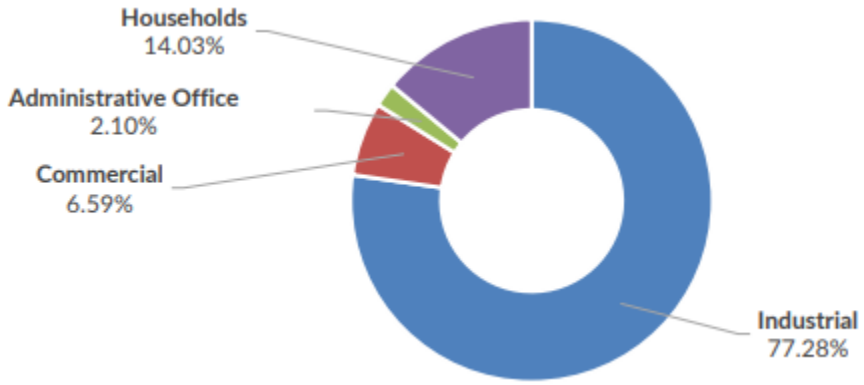

Figure 10: RTS capacity by customer segment until Dec 2020 (Source: UNICEF, 2022)

The exploding growth of the solar power sector, including the rooftop solar segment, has put significant strain on the national distribution network because the existing network cannot absorb such a sharp increase in electricity generated by solar energy. As a result, there has been forced electricity output cut due to an overloaded transmission system. For example, the solar output of some major solar plants in the central and southern regions was cut by up to 50% during the long Tet holiday, otherwise known as the Vietnamese New Year holiday, causing a loss of VND200-250 million per day. In the same way, many rooftops solar owners were forced to cut output by as much as 80%, which was a drastic cut. Other than the overheating development of solar power that outpaces the limited transmission capacity, the solar power sector is also faced with other obstacles including uncertainty of legal framework, non-bankability of the Power Purchase Agreement due to EVN's monopoly, lengthy and complicated investment procedure, and limited access to project financing.

On May 15, 2023, the Prime Minister of Vietnam finally approved the National Power Development Plan VIII (PDP 8) for the period of 2021–2030, with a vision to 2050. Solar capacity targets until 2030 account for a total of 12.84 GW and until 2050 to 189.3 GW. All RE targets are subject to funding provision under the Just Energy Transition Partnership (JETP) agreement with the International Partners Group (IPG) entered on December 14, 2022. The PDP 8 further

includes a 50% target by 2030 for rooftop solar self-consumption for residential and office buildings.

4.1.3 China

In 2022, China's newly installed PV capacity exceeded 87.4 GWp, an increase of 59.3% year-on-year. New solar installations reached a new record high, becoming the largest and fastest-growing power source in terms of new installations. From the amount of installed capacity, it is evident that the rate of new PV installations in China continues to accelerate. By the end of 2022, the cumulative PV capacity reached 392.6 GWp, close to the 400 GWp milestone, becoming the third largest installed power source. In 2022, PV annual power generation reached 425 TWh, exceeding 400 TWh for the first time, and added about 100 TWh of new power generation. This accounted for 30% of all new power generation (REGlobal, 2023). In April 2023, the National Energy Administration issued the "Guidance on Energy Work in 2023", guiding the deployment of energy work in addition to development targets. The document highlights a 160 GW target for the annual installed capacity of solar and wind for 2023, with the share of electricity generated by solar and wind power reaching 15.3% of the country's total electricity consumption.

In 2022, centralized PV installed capacity reached 36.3 GWp, accounting for 41.5% of all installations. The distributed PV annual installed capacity hit 51.1 GW, providing the remaining 58.5% share. Distributed PV has, thus, become the main driver behind the country's newly installed PV capacity. The residential segment installed 25.3 GWp, accounting for 49.4% of installations, while the C&I segment added 25.9 GWp, accounting for 50.6% of installations. Residential installations grew by 17.3% from 2021.

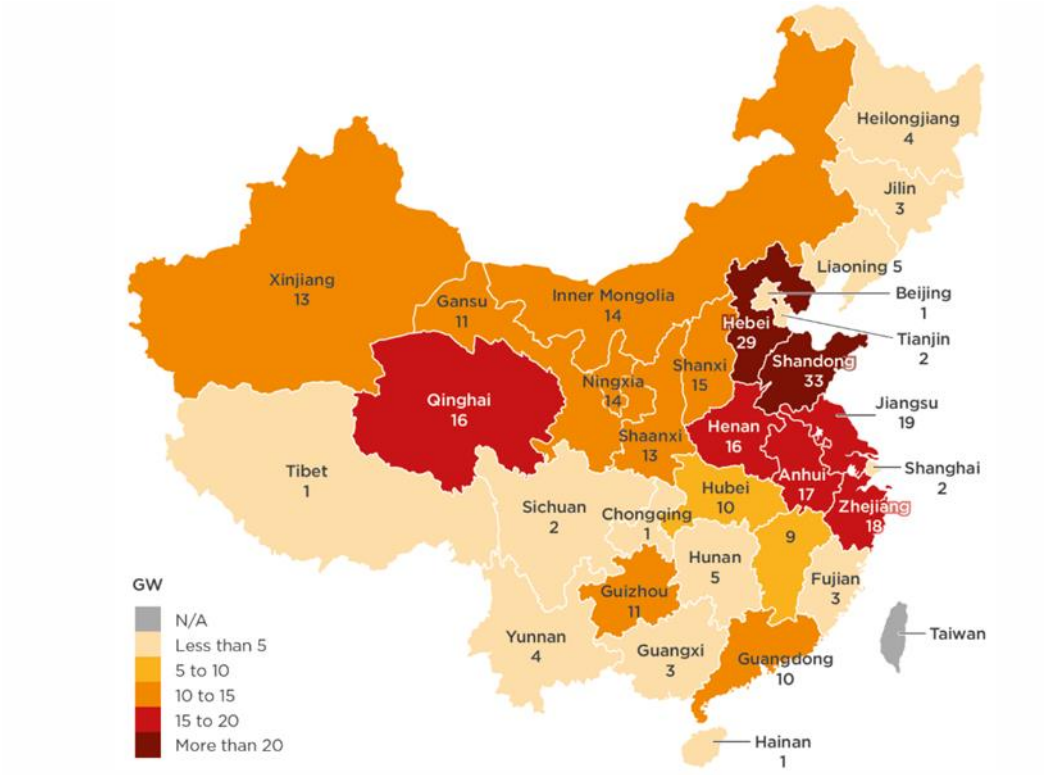

Figure 11: Cumulative solar PV installed capacity by Province (GW) 2021 (GIZ, 2022)

China's 2022 PV market was well-balanced, and each market segment – centralized, C&I, and residential – accounted for about one-third of the total market.

2022 marked the installation of the world's largest commercial & industrial rooftop solar PV plant in China. The newly completed rooftop solar project stretches across 43 rooftops with a total capacity of 120 MWp, generating as much as 110 GWh per year – powering the industrial park itself but also feeding excess electricity into the grid.

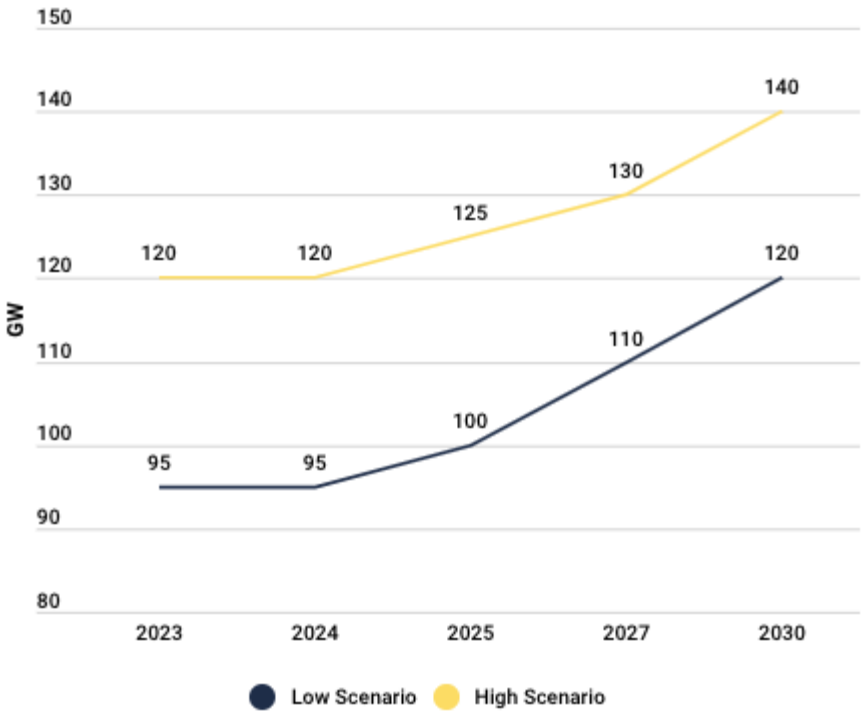

Figure 12: China PV market scenarios 2023 – 2030 (Source: CPIA, 2023)

Figure 13: World's largest C&I installation, Jining, Shandong, China (Source: Hill, 2021)

4.2 Stakeholders and regulatory environment

4.2.1 India

In India, the RTS regulations and factors vary widely across states. There are few states where the attractiveness across influencing parameters is favourable for rooftop solar market growth.

- Gujarat, Delhi, Andhra Pradesh and Telangana have the most favourable ecosystems for setting up C&I rooftop solar projects. In Maharashtra, due to its high grid tariffs for C&I consumers, cost savings will be highest by adopting rooftop solar. However, its unfavorable regulations when it comes to approvals and net metering restrictions negate some of the favourable parameters.
- Some states do not provide compensation for excess injection of solar electricity into the grid, while in others, the surplus injection compensation is not attractive enough. Compensation is very low compared to the current corporate power purchase agreement (PPA) rates of around US¢6/kWh.
- Even the implementation of net metering has been slow, and some states set arbitrary constraints and limits. For example, some states do not allow net metering for high voltage power consumers, i.e., large off-takers of power.
- In most states, there is a cap on the size of the solar plant linked to the distribution transformer's capacity or connected load capacity under net metering.
- Karnataka has revised its period of compensation for surplus electricity from annual to monthly, even though most other major states currently have an annual compensation period for surplus injections of electricity.

A study conducted in 2023 by the Institute for Energy Economics and Financial Analysis and JMK Research on the RTS market in India concluded in the following overview the attractiveness of RTS installations:

Table 4: RTS attractiveness by state, India

SN	State	Net metering for C&I	% Savings for C&I customers	Ease of approvals for net metering	Surplus compensation payable	Other remarks
1	Chhattisgarh	Allowed with restrictions	30 - 35%	Moderate	Rs 5.51/kWh (US¢ 4.2/kWh)	
2	Odisha	Allowed	10 - 15%	Moderate	Excess generation lapsed	

3	Punjab	Net metering and net billing allowed	25 - 30%	Moderate	Excess generation lapsed	
4	Bihar	Allowed	40-45%	Low	Excess generation lapsed	
5	Gujarat	Allowed	10-15%	High	Rs. 1.75/kWh (US c2.1/kWh)	
6	Rajasthan	Net metering and net billing allowed with restrictions	30-35%	Moderate	Excess generation lapsed	Levied grid charges
7	Haryana	Allowed with restrictions	40-45%	Moderate	Excess generation lapsed	Net metering connectivity is denied to consumers availing open access
8	Uttar Pradesh	Net metering not allowed	40-45%	Low	Not applicable	
9	Delhi	Allowed	35 - 40%	High	Rs. 4.51/kWh (US c. 5.5/kWh)	
10	Telangana	Allowed	30-35%	Moderate	Rs. 4.36/kWh (US¢ 5.3/kWh)	
11	Andra Pradesh	Allowed	30 - 35%	High	Rs. 4.32/kWh (US c. 5.2/kWh)	
12	Karnataka	Allowed with restrictions	45 - 50%	Moderate	Rs. 2.84/kWh (US c. 3.4/kWh)	[2]
13	Tamil Nadu	Net billing allowed	30-35%	Low	Based on preferential tariff	Network charges are levied on all types of consumers
14	Maharashtra	Allowed with restrictions	50 - 55%	Moderate	Rs. 3.05/kWh (US c.3.7/kWh)	[3]
15	Madhya Pradesh	Allowed with restrictions	30-35%	Moderate	Rs. 3.63/kWh (US c. 4.4/kWh)	

4.2.2 Vietnam

While the New National Development Plan (PDP 8) lays out more ambitious long-term goals for RE, including solar energy, the implementation remains rather slow, with the Direct Power Purchase Agreement (DPPA) program regulations still pending, solar (and wind) projects receiving tariffs making project profitability challenging, and further negatively perceived adjustments of the PPA template. While the bidding law has been updated, specific prospects for

[2] Net metering connectivity is denied to consumers availing open access; restricts net metering availability to CAPEX - based systems

[3] Same.

utility-scale solar remain vague, also due to the ongoing required national grid updates. The C&I market continues to be one of the steadier growing segments in the solar energy market.

- Direct PPA (DPPA) program: The new PDP 8 emphasizes the need for regulations for the pending DPPA program. In August 2023, the Ministry of Industry and Trade (MOIT) submitted a report to the Prime Minister with two options for the DPPA program, the first option without going through Vietnam Electricity's (EVN) grid. In this case, which the ministry recommended for implementation, the sales of electricity would be conducted via privately invested transmission lines, hence mitigating capacity, voltage level, and electricity use restrictions. Applicable tariff would be the electricity retail prices for large users regulated under Decision No. 1062, dated May 4, 2023, with an average price at 1,920.37 VND/kWh (around 0.081 USD/kWh). The second option would be going through EVN's grid, requiring a minimum capacity of 10 MW, and selling at voltage levels > 22 kV. The tariff for the second option would be governed by the Prime Minister's Decision No 24/2017 about the average electricity retail prices and Decision No 28/2014 about the electricity price bracket until the Law on Price would come into effect, which would base tariff on production costs plus service fee.

- Transitional solar (and wind) project mechanism: On October 3, 2022 the MOIT issued Circular 15/2022/TT-BCT describing the method for formulating tariff ranges for transitional solar (and wind) power plants. On January 19 2023, the MOIT issued Circular No. 01/2023/TT-BCT which annulled certain provisions regarding the implementation and development of solar (and wind) projects, including annulment of FIT references, USD indexation, 20-year PPA tenure, and rooftop solar capacity limits. On January 7, 2023, the MOIT issued Decision No. 21/QD-BCT setting ceiling prices (EVN to negotiate tariffs per project) tariff for transitional solar (and wind) power plants, with ground-mounted solar at 1,184.9 VND/kWh (around 0.049 USD/kWh) and floating solar at 1,508.27 VND/kWh (around 0.063 USD/kWh). On the 24/25th of May 2023 the MOIT issued documents to EVN regarding the urgency to negotiate temporary tariffs for operational projects and submit to MOIT for approval and issue PPAs for projects with MOIT-approved tariffs. Meanwhile most affected projects have entered PPAs with temporary tariffs equal to 50% of ceiling price under Decision No 21/QD-BCT with EVN.

- Updated bidding law: On July 23, 2023 a new bidding law was passed by the National Assembly, coming into effect on January 1, 2024, which also is applicable to power generation and transmission projects. The new bidding law clarifies when bidding for investor selection is applicable and adds five new inclusions – a new approach to the scope of application of international bidding, new criteria to assess bids and select winning investors, new detailed regulations on the list of key provisions of project contracts, new requirements regarding contract performance security, and new conditions for project transfers.
- Commercial & industrial (C&I): The C&I segment shows steady growth and given the prioritization of rooftop solar in Vietnam's PDP 8, is expected to be a major market segment with a broad mix of international and local players developing projects.

4.2.3 China

The Renewable Energy Law is a framework policy that lays out the general conditions for renewable energy to become a more important energy source in the People's Republic of China. It covers all modern forms of renewable energy, i.e., wind, solar, water, biomass, geothermal and ocean energy, but not low-efficiency burning of straw, firewood and dejecta. Renewable energy becomes the preferential area for energy development under this law. Furthermore, research and development and the industrial development of renewable energy are listed as the preferential area for hi-tech industrial development in the national program. According to the renewable energy law, the State Council is responsible for the overall implementation, management, development, and utilization of renewable energy at the national level. It sets middle- and long-term targets for the total volume of renewable energy development, and, on the basis of this, will prepare national plans for the implementation of these targets. In drawing up these targets and plans, it will cooperate with the regional and local peoples' governments to reflect regional differences in the final plans. Renewable power generation projects will have to obtain an administrative permit to proceed with project development; should there be more than one application for the same project license, an open tendering process will be held. Project developers that have obtained an administrative permit will be guaranteed a connection to the power and gas grid. All output can be sold at guaranteed prices to the grid company, where prices will be determined by the price authorities of the State Council. Grid operators will be able to recover extra costs associated with this regime through their own selling prices. Energy authorities of local peoples' governments shall prepare renewable energy development plans specifically for rural areas with specific financial support. Standards for renewable energy technologies will be

set by the standardization authorities of the State Council. In case of breaches of the law by government entities, or grid, gas pipeline or fuel companies, penalties can be imposed by the relevant superior government authority.

China's National Energy Administration (NEA) has attempted to move the dial on small scale PV in the nation by asking its provincial offices to nominate counties where a trial program to push blanket rooftop solar can be carried out. The state entity wants selected counties to have at least 20% of all residential rooftops equipped with solar, as well as at least 30% of commercial and industrial structures; 40% of non-government public buildings, such as hospitals and schools; and half of the roofs on the government estate.

Although research suggests that incentive policies such as solar subsidies and investment tax credits are crucial in driving RTS penetration, the Chinese government has been reducing state-level solar subsidies year by year, while the growth rate of RTS has significantly accelerated (Xu et al., 2023). Over these years, the subsidy for RTS power generation has been reduced several times from USD 0.059 per kWh (tax included) in 2013 to USD 0.0042 per kWh in 2021, and 2021 is the last year of this national-level financial subsidy (NDRC, 2021). Interestingly, the adoption of RTS did not slow down even with the withdrawal of subsidies. In fact, the growth of RTS reached its highest point in 2021. Notably, this was the same year when subsidies were scheduled for elimination. FITs and subsidies were greatly reduced and capacity caps and budget controls became stricter—not only for centralized (utility-scale) solar PV as before but also for distributed PV projects, which were capped at no more than 10 GW for the first time. In 2019, capacity caps and subsidy budget control became stricter still. The total budget for PV projects was RMB 3 billion, including RMB 0.75 billion for household distributed PV (about 3.5 GWp) and RMB 2.25 billion for large-scale PV projects and wholesale distributed PV projects.

Types \ Year		2013–2015	2016	2017	2018		2019	2020
					Before May 31	After June 1		
FIT for large-scale PV	I Zone	0.90	0.80	0.65	0.55	0.5	0.40	0.35
	II Zone	0.95	0.88	0.75	0.65	0.6	0.45	0.40
	III Zone	1.00	0.98	0.85	0.75	0.7	0.55	0.49
Subsidy for distributed PV	Industrial and commercial (wholesale)	0.42	0.42	0.42	Same as large-scale PV			
	Industrial and commercial (self-consumption and sale to grid)				0.37	0.32	0.10	0.05
	Household						0.18	0.08

Figure 14: China's Feed-in Tariff and Subsidy for PV projects, 2013 - 2020 (RMB/kWh, including tax) (Source: Martinot et al., 2020)

The existing forms of policy support are ending, including both the feed-in tariff policy and production subsidies. As this happens, distributed energy is gravitating toward market-oriented and competitive models. At the same time, new policies are emerging that will indirectly support distributed energy, remove barriers, and provide a favorable environment for distributed energy to continue to grow. For example, new policies encourage that additional energy demand in cities be met, in full or mostly, by distributed energy generation. The small residential subsidy may still prove effective because the residential retail tariff is low. A possible new policy and market mechanism will allow “peer-to-peer” sales and exchanges of distributed power on a local distributed system, with distribution wheeling fees to be paid to the grid utility. And Chinese cities are faced with reducing and stabilizing carbon emissions by 2030 and will be enacting a wide range of urban planning strategies and investments to meet those goals, including distributed energy.

4.2.4 Bangladesh

Bangladesh’s RTS sector is in a way similar to Vietnam’s, in terms of regulatory predictability and share of responsibility among public stakeholders. Numerous regulations relating to the RTS projects are still too general and incomprehensive, leading to difference and inconsistency in interpreting and applying the laws amongst competent authorities. This, in turns, creates difficulties to the developers/investors to carry out their generation of electricity. In Vietnam, the current laws provide that the rooftop solar power developers can sell the remaining electricity,

after generated for onsite consumption, to EVN or another off taker. However, due to the lack of specific guidance on connection of such excess electricity to the grid at the moment, the excess electricity may not be conveyed back to the national grid for selling to EVN or another off taker. China represents an outlier when it comes to RTS due to its manufacturing force and economies of scale, so much so that subsidies for solar PV panels have been eliminated. After the Renewable Energy Law took effect in 2006, PV penetration was accelerated. Capital subsidies and feed-in tariffs, which were still in a trial stage, public bidding and the cooperation among relevant Ministries played important roles. A series of public R&D projects provided elemental technologies and meanwhile the preferential tax policies encouraged PV R&D nationwide. From the China RTS experience, Bangladesh can establish a clearer framework for capital subsidies, create an enabling environment for R&D projects, and encourage local manufacturing. Local manufacturing would not be a novelty in Bangladesh, as proven during the IDCOL SHS program, where local supply chains for batteries and PV panels had been created.

India might represent Bangladesh's peer in terms of RTS journey. India's early experience with its RTS market has revealed two significant barriers to market growth, which can be seen today in Bangladesh, and that are directly linked to (i) equity and political economy factors and (ii) institutional factors in the electricity distribution sector. The electricity distribution tariffs in Indian states are used as an income redistribution tool. The political economy of this aspect is very sensitive, and the central government's role is limited since the electricity distribution sector is controlled by the elected governments in each of the 28 states. Furthermore, distribution companies (DISCOMS) are bundled meaning that in addition to owning and operating distribution grids, they are retailers responsible for customer service delivery and payment collection. As the growth of grid-connected solar rooftops could affect the financial viability of these companies, they have a tendency to resist or slow down penetration of RTS PV, unless incentives are provided, enabling DISCOMS also to benefit from the deployment of these resources.

5 Case Studies

5.1 India

Birla Education Trust - GSE Renewables (EPC)

One of the oldest education trusts in the country, running five schools and the country's first science and technology museum under their roof. BET campus primarily consists of historic buildings with old electric system arrangements and a lack of stairway access to roofs. There was

one transformer present for a widespread system, and cable routing was a major challenge. Also, because Rajasthan is an area with high wind speeds, higher structural stability was needed. Non availability of a proper ladder to the roof was also one of the challenges. To ensure the safety of the long cable routing, after every inverter, one breaker was installed. A stronger structure was installed to withstand heavy wind loads. The client is saving on electricity costs by 30%.

Table 5: Project information India

Key Information	
Type of Project	OPEX – Boot
Generation Capacity (kWp)	237
Site	Plani, Rajasthan
Carbon Emission Saved	194 metric tons
Client Savings (in INR)	26 Lakhs
Date of Commissioning	January 2019
Trees Saved	7584 (115 annually)
Type of Project	Rooftop RCC behind the meter

5.2 Vietnam

Nhon Trach Industrial Zone - Dien Xanh 365 (EPC) (GoodWe, 2021)

Dong Nai is considered a province of great development potential in rooftop solar energy. The province is rich in solar resources with an average yearly irradiation reaching 1850 kWh / m2 and average total sunshine hours at approximately 2500 hours / year. Dong Nai presents many advantages for solar energy projects, especially in industrial zones and industrial clusters. The project owner chose Dien Xanh 365, an outstanding EPC provider in Vietnam, for the installation. To maximize cost efficiency, Dien Xanh 365 proposed 410Wp JA solar panels to be paired with Good We GW120K-HT and form a 5MWp solar system which is expected to earn over 565k USD per year and minimize O&M costs.

Table 6: Project information Vietnam

Key Information	
Type of Project	OPEX
System Capacity	5 MWp
Technology	JA Solar 410W * 12,300 units - solar PV GW120K-HT * 37 units - inverter
Electricity generation	7 GWh/year
Site	Nhon Trach, Dong Nai
Carbon Emission Saved	5,667 tons
Client Savings	565,000 USD per year
Date of Commissioning	November 2020
Type of Project	Rooftop RCC behind the meter

5.3 China

Great Wall Motor - Trina Solar (EPC)

GWM is one of the largest automobile manufacturers in China, with over 4% of the market share within China and supply operations across the Eurasian region. The combined annual savings in CO_2 and other gasses is equivalent to planting 962,600 trees each year, helping enterprises achieve the ambitious goal of “becoming the first zero-carbon factory in 2023". Design and Layout: The grid uses Trina Solar's 210 Vertex 670W series ultra-high-power modules.

Table 7: Project information China

Key Information	
Type of Project	CAPEX
Generation Capacity (in MW)	18
Annual average power generation capacity (kWh)	20,825,500
Annual saving of coal	6,350 tons
Average annual saving of carbon dioxide	17,326 tons
Annual saving sulfur dioxide	3.332 tons
Annual saving of Nitrogen oxides	3.728 tons

5.4 Bangladesh

Greener Garments Initiative – Project 1

The RMG Company I , a pivotal location in Kabirpur, Savar exemplifies a commitment to cutting-edge practices with its deployment of a special model designed to mitigate moral hazard and adverse selection under Operational Expenditure (OPEX) parameters. This distinctive approach not only enhances operational efficiency but also highlights the organization's dedication to fostering a risk-conscious environment.

Moreover, the RMG Company I project, seamlessly integrated into the Bangladesh Rural Electrification Board (BREB) grid connection, operates with a phase 3 connection type, aligning perfectly with the national Net Energy Metering (NEM) guidelines. The utilization of phase 3 connection is particularly noteworthy, as it is considered ideal for rooftop solar installations, showcasing the company's strategic alignment with sustainable energy practices.

Table 8: Project information Bangladesh Project 1

Key Information	
Type of Project	OPEX
Per panel Capacity (Wp)	660
Total no. of Panels Used	809
Total No of building/shed used	2
Capacity (kWp)	534
Project Cost in BDT	3,25,26,595.93
Energy Generation	635,247 kWh/year
CO2 saved in kg/ per year	437,855
Electricity Bill Savings in BDT	1,100,000
Commission Date	17th January, 2024
Operation period	20 years

Greener Garments Initiative – Project 2

The RMG Company II), located in Sreepur, Gazipur, sets a benchmark for innovative practices with its implementation of a specialized model aimed at addressing moral hazard and adverse selection within Operational Expenditure (OPEX) parameters.

The RMG Company II project also integrates into the BREB grid connection, utilizing a phase-3 connection type that aligns with the NEM guidelines and is optiomal for rooftop solar installations.

Table 9: Project information Bangladesh Project 2

Key Information	
Type of Project	OPEX
Per panel Capacity (Wp)	660
Total no. of Panels Used	792
Total No of building/shed used	2
Capacity (kWp)	523
Project Cost in BDT	24,942,517.69
Energy Generation (kWh)	642,694
CO_2 Saved in kg/ Per Year	294,273
Electricity Bill Savings in BDT	659,538
Commission Date	28th November, 2023
Operation Period	20 years

Greener Garments Initiative – Project 3

The RMG Company III) located in Jamgora, Ashulia, serves as a prime example within Operational Expenditure (OPEX) parameters. Despite its relatively smaller capacities compared to previous OPEX models, The RMG Comapny III seamlessly integrates into the Bangladesh Rural Electrification Board (BREB) grid connection. Operating with a phase 3 connection type, it aligns perfectly with national Net Energy Metering (NEM) guidelines. This choice of phase 3 connection is particularly noteworthy, as it is deemed optimal for rooftop solar installations, showcasing the company's strategic commitment to sustainable energy practices.

The company of the author has effectively installed three OPEX projects, yielding valuable insights. From this experience, it has become evident that the implementation of EPC must adhere to a rigorous process. Effective communication between the off-taker is also paramount for successful execution. Otherwise, the project remains prone to delays and additional (often unforeseen) cost. To ensure a seamless implementation, we propose the following process flow Figure 15).

Table 10: Project information Bangladesh Project 3

Key Information	
Type of Project	OPEX
Per panel Capacity (Wp)	660
Total no. of Panels Used	432
Total No of building/shed used	2 buildings, 1 shed
Capacity (kWp)	285.12
Project Cost in BDT	13,905,656
Energy Generation (kWh)	360,185
CO2 Saved in kg/ Per Year	165,647
Electricity Bill Savings in BDT	316,769
Commission Date	3rd December, 2023
Operation Period	20 years

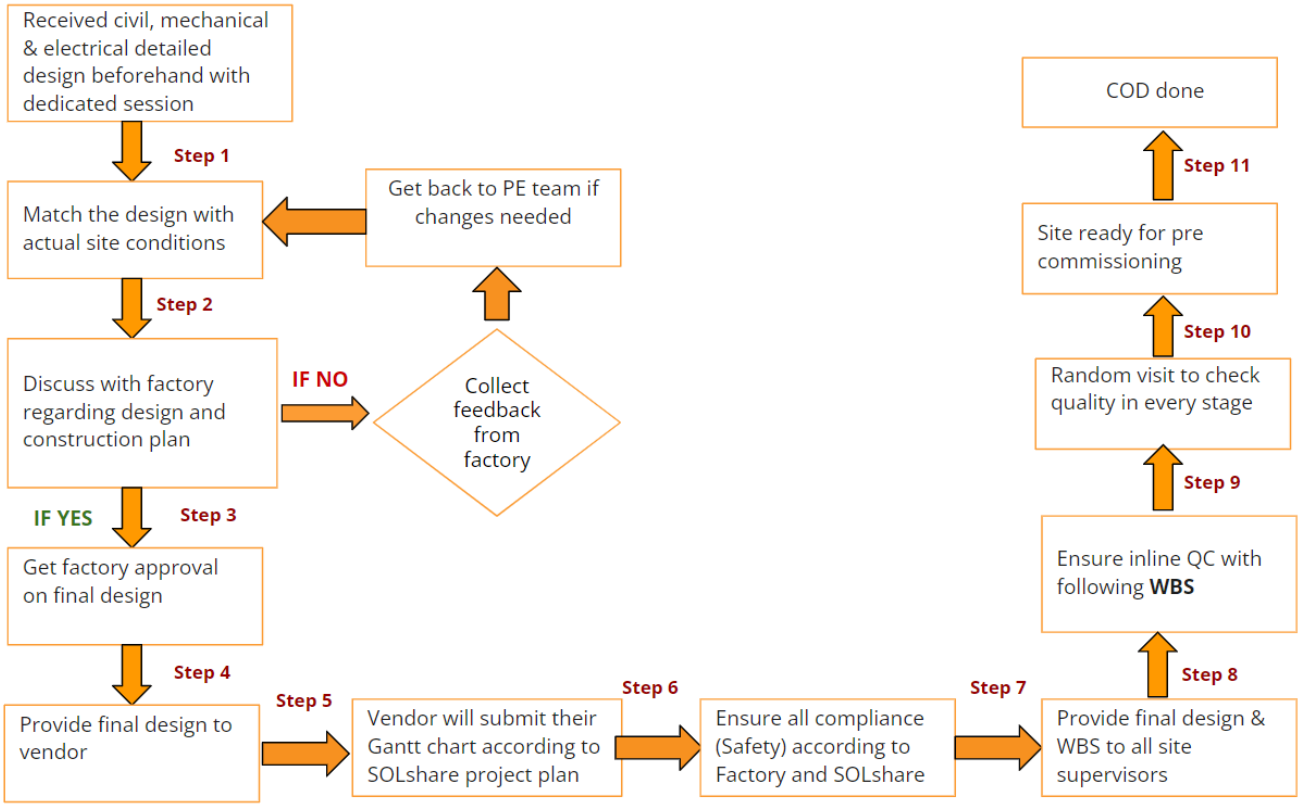

Figure 15: Project implementation process

Transformative Potential of Bangladesh's Tea Estates under net-metering & public PPAs

There is a transformative potential for Bangladesh's Tea Estates through the adoption of renewable energy solutions. Beyond operational enhancements and core business outcomes, this shift embodies a dedication to environmental stewardship, economic efficiency, and a leading role in fostering sustainable practices within the broader agricultural landscape. Tea estates represent another promising sector for distributed solar, serving as a logical progression following the RMG sector. With a vast total land area dedicated to tea cultivation in Bangladesh amounting to 280,000 acres, of which approximately 50% (140,000 acres) is actively used for tea farming, tea estates hold significant potential for solar integration. The remaining land, characterized by low-lying terrain, flooding, and poor soil conditions, presents opportunities for sustainable solar projects.

Tea cultivation is a substantial contributor to Bangladesh's economy, employing four million individuals and standing as the second-largest cash crop in the country. This sector's entry into distributed solar initiatives could further diversify and strengthen the renewable energy landscape, contributing to both economic and environmental sustainability. The following short case consolidates findings and recommendations based on an extensive analysis of present energy consumption patterns at a representative Tea Estate introducing three potential components under the OPEX modality: Rooftop Solar (RTS) on existing sheds mechanically suitable for PV panel installations, Floating Solar PV (FPV) on the tea estates' own lake, and Ground Mounted PV (GMPV) for areas not suitable to grow tea on. Detailed energy consumption analysis, followed by a practical design of a 127 kWp RTS system, indicates a required investment of BDT8.12M with a 7-year Payback Period (PBP) and a 16.5% Return on Investment (ROI). This is in combination with a high-level estimation of an FPV Plant with a capacity of 4.2MWp on the lake of the Tea Estate requires an approximate investment of $4.93M, with a projected tariff of $0.16 per kWh under a public PPA. This investment yields an attractive Internal Rate of Return (IRR) of 28.77% over a 20-year PPA tenure (SOLshare, 2023). Similarly, a high-level estimation of a GMPV plant with a capacity of 1 MWp on the land area adjacent to the lake of the Tea Estate requires an approximate investment of $0.436M, with a projected tariff of $0.12 per kWh. This investment results in an attractive IRR of 19.91% over a 20-year PPA tenure.

5.5 Comparison of Bangladesh RTS OPEX market to India, Vietnam, and China

Table 11: RTS OPEX comparison between countries

Topic	Bangladesh	China	India	Vietnam
Operationalization				
Net metering for C&I	Allowed, but lacks power evacuation compensation	Allowed, with power evacuation compensation	Allowed, with certain restrictions based on state	FiT and Solar Policies expired in 2020
Ease of approvals for net metering	Easy	Easy	Moderate	Low due to absent regulations
% Savings for Customers (C&I)	10-17.5%	10% - 30%	10% - 55%	10% - 20%(McKinsey, 2023)
Financing				
Access to financing instruments and institutions	Limited to IDCOL & Bangladesh Bank Green financing (re-financing)	Green loans and non-recourse project financing	Limited	Low; recent international financing agreements (ADB loan)
Market appetite	High due to consecutive energy tariff hikes	High due to national solar targets and governmental incentives	Market reached saturation for C&I	High during the 3 year FiT
Investment trends	Foreign investments are slow due to effective risk mitigation protection measures	High, increased appetite due to decarbonization targets and low cost of technology	Flows towards open access and utility-scale market	Early-stage market entry of international banks
Regulatory setup				
Overall regulatory perception	The government is encouraging. Requires installations of approved components	Supportive and comprehensive	Restrictive net metering provisions, stringent conditions on the maximum solar size system	Lack of incentive policies
Intricacies of stakeholders' constellation/setup	Clear set up in the private sector. However, it is unclear how the structure and policies are defined for government entities.	Clear setup	Clear setup, state by state basis	Unclear responsibilities between national and municipal authorities
Predictability of regulations	Low	Predictable and consistent	Consistent	Low

Governmental incentives				
Tax exemptions	No exemptions in general. An exemption exists for IPPs which are selling power to the government utility	A three-year exemption and three-year 50% reduction in corporate income taxes. Additional fiscal and taxation support.	Exempt from paying income tax on all project earnings for the first ten years of their existence and operation, and accelerated depreciation (AD) allows solar energy producers to recover 40% of their costs in the first year.	Draft proposal from MOIT on tax exemption for solar components
Subsidies	No Subsidy	Declining due to reduced CAPEX costs (market pull)	Capital subsidies + Subsidies for the residential sector of 40% up to 3 kW, 20% for capacity between 3 and 10 kW.	Draft proposal from MOIT on reduced lending rates via State Bank of Vietnam
Public financing	Limited to IDCOL	For RTS for public institutions predominant.	Renewable Energy Certificates (RECs)	Draft regulation on exemption from power operation licenses and electricity business registration certificates

Legend:

Lack of incentives and supporting policies, unpredictable setup
Moderately enabling setup
Enabling and clear setup for RTS, easiness of doing business, transparent and predictable

6 Conclusion

6.1 General remarks

Rooftop Solar (RTS) stands as an example of sustainable energy, providing environmental, economic, and social benefits. As the world continues to grapple with the challenges of climate change and the transition to renewable energy, RTS could become a pivotal player in shaping a greener and more sustainable future. With further increasing utility prices and increased awareness, rooftop solar will play an increasingly important role in **Bangladesh's** energy mix. The **C&I RTS** segment has its challenges, such as system ownership, maintenance responsibilities and distribution of benefits between building owners and tenants, but as Bangladesh aims to achieve its Nationally Determined Contributions (NDCs), the country will strive to make the economics stack up for this energy-hungry sector.

6.2 Learnings from other countries

In **India**, the RTS market is yet to truly pick up. Regulatory uncertainties and lack of support from local DISCOMs have forced prominent developers to either shift their focus to other segments or exit the market by selling their rooftop solar business vertical. Several states are moving away from net metering to less beneficial gross metering and net billing arrangements. The realized revenue and associated benefits for consumers under gross metering and net billing are significantly less than under net metering, leading to C&I consumers shifting focus to other greening options, such as Open Access (OA). Delhi has the best RTS policy framework, with clear official policy directives on innovative business models, such as group net metering, virtual net metering, P2P trading, etc. Gujarat has long been leading the way in RTS installations, mainly due to its successful residential policy and the favourable stance of its DISCOMs towards rooftop solar (The Print, 2022). For developing RTS, Bangladesh can look at Delhi for its policy design and emulate Gujarat for its effective implementation. To improve the accessibility and reach of RTS solutions, Bangladesh must actively promote innovative business models.

Despite the evolution of the policy framework with attractive incentives and explosion of RTS in the last years in **Vietnam**, RTS does not seem to develop evenly across sectors. There exists potential policy barriers and lack of initiatives to promote development of RTS, taking into account differences in infrastructure of buildings, technology awareness and availability of capital resources. Attractive Feed-in tariffs and financial incentives over time for promotion of solar power project development can be key drivers towards this achievement.

According to Bloomberg 2023, one in five solar panels installed worldwide last year were mounted on a Chinese rooftop, putting **China** at the forefront of the energy transition efforts (Bloomberg News, 2023). Most of that rooftop solar has been added in the past two years, as China offered support for local governments to boost installations, and raised power rates to businesses, making generating their own electricity more attractive. The resulting renewables boom saw China build more small-scale solar last year than the total new clean power capacity in any other country. Ambitious in terms of local deployment in the years and decades to come, China plans to ensure that its carbon commitments will be met in the future. Approved multiple GW-large project pipelines, a strong focus on distributed generated power, industry specific carbon reduction plans, an upgrading/transforming of former major coal bases, and a massive enlargement of its national grid infrastructure among other measures, will drive demand for RTS to new heights (Haugwitz, 2022).

6.3 Hurdles in Bangladesh

In Bangladesh, the net metering regulations are not as flexible in comparison to other countries. Consumers are only allowed to install solar capacity up to 70% of their sanctioned load, meaning they still have to pay the utility for the remaining electricity consumption. Any production that exceeds consumption is only paid at the significantly lower bulk tariff which is close to at par with the LCOE of an RTS. There is also no similar facility of gross metering available in Bangladesh's solar energy market. Additionally, Indian state regulations for the PPA are relatively more comprehensive as well as specific in nature and they are well implemented through state-mandated maintenance and control mechanisms even long after the project is completed, ensuring stability for the OPEX projects. The Bangladeshi reality is far more troublesome, as PPAs are not often practically implemented and often risk the project's stability and future prospects. Indian regulations provide for an inflation-adjusted rate for the solar electricity buy-back pricings, whereas the rates are fixed in the Bangladeshi market. Bangladesh, on the other hand, has strict market regulations requiring EPCs and ESCOs to source a set percentage of the components locally when commissioning a project, in addition to lacking any particular financial incentives for the solar or renewable energy sector. Additionally, there is the burden of high tax and import duties on the foreign-sourced components.

Reducing GHG emissions in supply chains is becoming a key factor in the sourcing strategies for global fashion brands. Here, increased levels of RTS installations are a key enabler for decarbonization, and therefore also for retaining the competitiveness of Bangladesh's vital RMG sector. However, even under a scenario of increased RTS installations on the premises of the

supply factories, global fashion brands will not be able to make good on their global commitments in scope 3 emission reductions. Therefore, **Corporate Power Purchase Agreements (C-PPAs),** allowing the generation or RE on another premise through wheeling, would present a possible solution (see chapter 3). This enables businesses to secure a stable and predictable energy supply while reducing their carbon footprint and contributing to the country's sustainable development goals and could strongly increase the number and size of C&I PV projects. However, to date there is no consideration of a C-PPA under the net metering policy.

6.4 Specific Recommendations for Bangladesh

To promote and accelerate the **growth of RTS, and particularly OPEX RTS in Bangladesh**, based on the comparative analysis between Bangladesh, India, China, and Vietnam, along with the collective knowledge and work of the consultant's team of experts, the following recommendations are proposed:

For the public actors and the development sector, especially SREDA in collaboration with the Ministry of Power, Energy and Mineral Resource:

- **Establish a framework for C-PPAs and wheeling**: allowing for C-PPAs could enable the quick and efficient development of areas which are suitable for PV installations (ground-mounted or roof spaces) by RESCOs and would allow companies, e.g. from the RMG sector, to meet their RE targets. A fair wheeling charge would ensure that DISCOMs don't suffer losses from increased wheeling.
- **Promote a simplified grid-connection process for RTS**: the smoother the official processes for connecting an RTS plant, the quicker the sector can develop.
- **Establish a framework to provide private developers with governmental PPAs for projects on public infrastructures**, such as airports, metro stations, other larger public buildings, etc. There are large quantities of spaces that could be utilized for this purpose (e.g. on multiple metro stations currently under construction in Dhaka), however, the absence of an overall framework which urges the responsible government agencies to tender these spaces out for solar power leads to these spaces being unutilized on a large scale.

  A similar construct would work for C&I buildings where the owner is (for whatever reason) not interested to set up a solar plant for his own consumption or the ownership structure is such that the on-site consumer is not the same as the building owner (e.g. for the EPZs where many buildings are leased by e.g. BEPZA out to the individual companies): Here,

the GoB could offer to purchase that power through a PPAs if the project developer is able to come up with an agreement with the site owner to lease the necessary rooftop space.

- **Create a national guarantee fund to give financial players more comfort** and bring down the hurdle of bank guarantee requirements: For India, for example, such an option was proposed in the study "Credit Support Pathways for Rooftop Solar Projects in India" by the Climate Policy Initiative (October 2018). The study states that "*We find that under Credit Guarantee Mechanism, one million dollars of donor grant capital invested in the facility enables US$14 million of capital mobilization, and a capacity installation of 18 MW in the rooftop solar sector.*" The MW number would be even higher with today's decreased PV prices.[4]
- Fund or subsidize the piloting of new business and finance models that are not widely adopted but show great potential for scale-up;
- **Implement systematic data collection** to enable data-driven financial forecasting and benchmarking between suppliers (see chapter 3.2) through SREDA
- **Provide incentives for foreign direct investments and ease the repatriation of funds processes**. This would make it easier for local developers to attract foreign investment which is crucial for these kinds of projects, especially as most of the components for PV plants are imported.
- **Fund local market studies** that allow public decision-makers to measure market maturity, business outlooks, potential sites and development opportunities. Such studies could be implemented via the Solar Help Desk at SREDA, for example. The focus of a study could e.g. be the public buildings that fall under the ownership of a specific national ministry and assess the potential roofs and PV sizes that could be installed on those premises; these could then be tendered out together under the OPEX model, allowing the government to save on electricity costs without investing. Another example could be solar thermal collectors for thermal processes in RMG factories which are currently powered by gas; example cases of these have been implemented in China and, to a pilot stage, in Vietnam.

For the industry and the financiers, especially IDCOL:

- **Reducing the administrative effort and timeline** from the currently approximately 9 months of average processing time to get a loan. Such long lead time makes it almost

[4] In the Net Metering Gap Report (GIZ, 2023), it has also been proposed that the Bangladesh Bank could give such payment guarantees to RESCOs or, alternatively, that the DISCOMs could guarantee the off-take of electricity from stranded projects at the national bulk purchase rate to ensure some safe cashflow for these cases.

impossible to sustain on a market where a customer wants a project implemented as quickly as possible.

- **Reduce the bank guarantee requirement, ranging currently between 50% and 100%**: Requiring the same (or half) the amount of the loan itself as a guarantee renders the whole idea of the loan leverage impossible, as the loanee needs to provide the same (or half) the amount as guarantee from its assets. IDCOL could also help to develop other, new forms of third-party risk-sharing.
- **IDCOL could also identify and finance new business models** and share the results and metrics with the industry to develop the market.

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