Barriers and Opportunities for Scaling Up Rooftop Solar PV Systems in Bangladesh

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Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
BDT	Bangladesh Taka
BERC	Bangladesh Energy Regulatory Commission
BOO	Build Own Operate
BOOT	Build Own Operate Transfer
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board (same as REB)
BSTI	Bangladesh Standards and Testing Institution
CAPEX	Capital Expenditure
CO2	Carbon Dioxide
DESCO	Dhaka Electric Supply Company Ltd
EPC	Engineering, Procurement and Construction
EZ	Economic Zone
EPZ	Export Processing Zone
EU	European Union
FIT	Feed-in-Tariff
GW	Giga Watt
IPP	Independent Power Producer
KII	Key Informant Interview
kV	Kilo Volt
kW	Kilo Watt
kWh	Kilo Watthour
kWp	Kilo Watt peak
LCOE	Levelized Cost of Electricity
MENA	Middle East North Aftica
MV	Mega Volt
MW	Mega Watt
NEM	Net Energy Metering
O&M	Operations & Maintenance
OPEX	Operational Expenditure
PPA	Power Purchase Agreement
PV	Photovoltaic
RCC	Reinforced Cement Concrete
RE	Renewable Energy
REB	Rural Electrification Board
RESCO	Renewable Energy Service Company
SREDA	Sustainable and Renewable Energy Development Authority
VAT	Value Added Tax
WZPDCL	West Zone Power Distribution Company

Executive summary

In July 2018, Bangladesh has issued the Net Metering (NEM) Guidelines in order to facilitate the grid integration of distributed renewable energy based electricity (Power Division, 2018). This policy aims to promote the expansion of primarily solar PV based renewable electricity in Bangladesh by encouraging prosumers (consumers and producers) to install solar PV systems on their premises or rooftops. The electricity generated through this can be used for self-consumption at a cost more affordable than the grid tariff rates, while any surplus electricity can be sold back to the Utility. Prosumers can include domestic or residential consumers, commercial consumers and industrial consumers.

In 2008, Bangladesh issued the renewable energy policy, which set a target of meeting 5% of the power demand by renewables by 2015 and 10% by renewables by 2020. However, by the end of 2023, Bangladesh had only 3% of its installed generation capacity from renewables, which is much lower than the targeted value. This was because the price of modern renewable electricity (solar and wind) was higher than that of fossil fuel-based electricity, and there was no grid parity. However, the technology has advanced, and economies of scale have brought down the cost of renewables, where now renewable electricity has achieved grid parity. The cost of renewable electricity is even lower than that of some types of fossil fuels in the current energy mix. This trend in the declining cost of renewables will continue into the future. There is an accompanying increase in investor interest in renewable energy. With this in consideration, Bangladesh has adopted the Mujib Climate Prosperity Plan in 2023. According to the Mujib Climate Prosperity Plan, 2022-2041 Bangladesh has set a target of 40% of energy from Renewable Sources by 2041 (Ministry of Environment, 2022) (BPDB, 2023). Solar rooftop systems can play a significant role in achieving this target.

To date Bangladesh has installed 2125 solar PV rooftop systems under the net metering scheme, which comprise 88.2 MW of generation capacity, whereas there are 232 large rooftop systems with a total of 76.36 MW of installed capacity outside the Net Metering scheme (SREDA, SREDA: National Database of Renewable Energy, 2024). The market for solar PV rooftop in Bangladesh remains largely untapped. This study looks into what are the reasons for these relatively low figures and how Rooftop Solar PV can be scaled up in Bangladesh.

Comparison with other countries:

The NEM policy in Bangladesh has terms that are meant to provide incentives for potential prosumers, and are flexible and inclusive, compared to many other countries. For example, any type of renewable energy technology can be eligible for the policy. The policy covers domestic, industrial and commercial consumers, but not agricultural consumers (while some other countries do include agricultural consumers). Bangladesh sets a capacity limit of upto 10 MW AC (Alternating Current) capacity, which is higher than that of most other Asian countries, and only Sri Lanka and Jordan have the same upper limit. Vietnam has no upper limit on installed capacity. Bangladesh states that the NEM capacity should not exceed 70% of the sanctioned load, while most countries do not impose this type of restriction. Bangladesh specifies that only three phase consumers (large consumers with sanctioned load greater than 7 kW) are eligible, but this limitation is not applicable in most other countries. In Bangladesh, the tariff structure is set at the bulk rate (only for the net exported amount), but can be subject to change over time (defined by BERC). Some other countries specify the tariff rate at a known fixed amount, either to remain fixed for the entire life of the system, or to vary according to the age of the system. In some cases, the tariff rate can vary according to the type of prosumer, whereas in other cases, the retail rate instead of the bulk rate is applied. In Bangladesh, one year is considered the settlement period, which can be upto two years in some other countries.

Reasons for low productivity of installed NEM systems:
In Bangladesh, the reasons identified for the low productivity of installed NEM systems have been identified to system failure, load shedding, shutdown of inverter due to technical problems in the power system, system maintenance, holiday shutdowns, and lack of cleaning and maintenance which reduces the conversion efficiency, the latest being the biggest cause. The next biggest cause is system failure, load scheduling. Deliberate shutdown happens in some systems and not others. System maintenance occurs once or twice a year. Holiday shutdown occurs five days during each Eid holiday.

Cost considerations:
A survey of existing NEM prosumers has revealed that the most important cost features were the cost of the PV system, the cost of financing, the payback period and the current rate of the grid electricity. The solar rooftop investors appear to have an overall very high satisfaction with the cost features of the industry (figure 22), including the cost of the systems itself, the cost and terms of financing, and the payback period. They are however much less satisfied with the cost of grid electricity, but the higher the dissatisfaction with grid electricity prices, the more the incentive to switch to solar PV rooftop. The investors would also like higher tariff rates for the NEM electricity sales. The most important support services, include the quality of grid connection, and time taken to complete the project. Expertise and professionalism of the Engineering, Procurement and Construction (EPC) contractors was considered crucial, including their information support. All firms were satisfied with the net metering policy for cost reduction.

Possible recommendations include:

- It is recommended to include single phase consumers to be eligible to apply for connection under net metering. For the single-phase consumer, a minimum capacity of 1 kW could be considered. In this way, the market for prosumers can be increased.
- It is recommended that the maximum AC capacity of the installed renewable energy system should be revised to be equal to the sanctioned load. In this way, the size of the system can be increased, and more capacity can be added under net metering.
- If space and other facilities permits then permission to increase installed capacity above sanctioned load should be encouraged, but in that case the prosumers needs to get approval from the utility to check the suitability of higher capacity RE system integration at the point of connection and dispatch capacity.
- It is recommended that the utility should be provided with a carbon credit facility in order to encourage them to accommodate NEM systems. At present the utilities do not have any incentive to promote net metering; rather it reduces their revenue due to self-consumption of prosumers. In the presence of carbon credit, the utilities can have a fiscal incentive to support NEM.
- It is recommended that import tax or duty waiver on the import of any NEM system should be provided for NEM system installer, the EPC contractor, or the OPEX operator. At present, Independent Power Producers (IPP) get import duty waiver for their power plant equipment, but NEM based prosumers do not. Giving them a waiver will create more incentives and reduce cost of installation.
- The NEM operator should have given the option to install renewable energy generation system in any part of the country and by providing a wheeling change to the grid operator or to the utility/utilities the prosumer should be able to use the energy produced by the

remote installed system. Many factories do not have enough rooftop area to install the solar PV system which is equal to their maximum allowable capacity under NEM, but the company may have other lands or building rooftops in other locations of the country (which may not be their point of consumption of electricity), which can be used for this purpose. This will utilize unused land or rooftops, reduce the land shortage problem, and increase self-sufficiency.

- It is recommended that the prosumer should be given the option to sell its excess energy to any other consumer or consumers within the Utility or any other part of the country by giving wheeling charge to the utility/utilities or to the grid operator. This will allow prosumers who want to use specifically renewable electricity from another prosumer.
- It is recommended that the EZ (Economic Zone) or EPZ (Export Processing Zone) authorities should support the NEM policy. At present, the economic zones buy electricity from utilities and sell to factories inside the zones. The industries in the zones are not direct consumers of the utilities. Industries inside the economic zones should be allowed to enjoy the benefits of the NEM policy.
- It is recommended that all consumers irrespective of voltage level should be allowed to avail NEM facilities. At present, only three phase low and medium voltage consumers are allowed to avail the NEM facilities.
- It is recommended to shorten the installation time in order to provide faster payback to the prosumers.
- It is recommended that there should be improvement of services from the utilities. Sometimes, there is a delay in getting an approval for the NEM system, which should be expedited.
- For OPEX operator it is recommended to have a tri-party agreement signed among the prosumer, utility and the RESCOs (for the OPEX model). The utilities then can enforce the industry to pay the bill to the RESCO thus reducing the OPEX model risk. For this an incentive in the form of wheeling charge can be provided to the utility.

Rooftop solar PV systems may be installed and operated under the Net Metering System of Bangladesh. The following sites are potentially suitable for solar rooftop systems:

- Roofs of government offices with large buildings.
- The tops of buildings and structures in all Export Processing Zones and Economic Zones.
- The rooftops of railway stations, platforms and adjacent land.
- Roof of metro rail stations
- Roofs of metro rail deport and workshops
- The rooftops of cold storages and storage silos
- Rooftops of garment factories, jute mills, paper mills and possibly roofs of all other industries.
- Roofs of rerolling mills and warehouses
- Rooftops of cyclone shelter centers.
- Rooftops of civil aviation centers and land available near the airports with sufficient glare protection.
- Rooftops of public educational institutions, especially schools, colleges and universities.
- The jetties of river and sea ports.
- Tops of stadiums, sports complexes.

1. Introduction

In July 2018, Bangladesh has issued the Net Metering Guidelines in order to facilitate the grid integration of distributed renewable energy based electricity (Power Division, 2018). This policy aims to promote the expansion of primarily solar PV based renewable electricity in Bangladesh by encouraging prosumers (consumers and producers) to install solar PV systems on their premises or rooftops. The electricity generated through this can be used for self-consumption at a rate more affordable than the grid tariff rates, while any surplus electricity can be sold back to the grid. Prosumers can include domestic or residential consumers, commercial consumers and industrial consumers.

To date Bangladesh has installed 1273 solar PV rooftop systems under the net metering scheme, which comprise 47.7 MW of generation capacity, whereas there are 203 rooftop systems of 58.74 MW of installed capacity which are outside the Net Metering scheme (SREDA, 2023).

1.1 Bangladesh Net Metering (NEM) Policy explained

The main idea behind the net metering policy is to enable consumers to become 'prosumers' (the consumer who also produces electricity) through the connection of their solar PV systems to the distribution grid through a bi-directional smart meter. The prosumer consumes the electricity produced from the rooftop system, and if there is any excess electricity, it will be fed into the grid through the net meter. The measured data can be stored in the meter or transferred to a centralized aggregator service. The customer's bill is calculated according to the net energy recorded on the meter; the aggregated energy drawn from the network minus the energy delivered to the network over the specified billing period. If the amount of electricity consumed from the grid is higher than the amount of electricity supplied to the grid from the rooftop solar PV system, the consumer has to pay the bill for net consumption. On the other hand, if the amount of electricity generated and exported from solar PV system or the renewable energy system to the grid is higher than the imported electricity, then the distribution utility allows all the credit (in terms of kWh) of the consumer to roll over to the next billing period. By the end of the specified rolling cycle or settlement period, the consumer is compensated for all kWh credits as a rate prescribed in this guideline by the distribution utility, and on the First of July of every year the credit account is set to zero. Figure 1 illustrates the architecture of a typical net metering arrangement using solar PV as an example of distributed renewable energy system.

The rate at which the customer is billed is determined considering various factors such as the consumer tariff class, type of renewable energy technology, installed capacity and export limitations. While installing such connections, the prosumer must also abide by the interconnection technical requirements and safety regulations set by the concerned authority.

The interconnection process, the mechanism by which net-metered distributed energy systems may be legally and safely connected to the electricity grid, is critical to the success of net metering programs. Interconnection standards are typically outlined separately from net metering policy parameters, but are fundamental to the development of the NEM policy.

For a Net metering connection, a consumer must meet some fundamental conditions. When filing a net metering application, he or she must be a valid client of the power distribution utility in the particular area with no outstanding electricity bills.

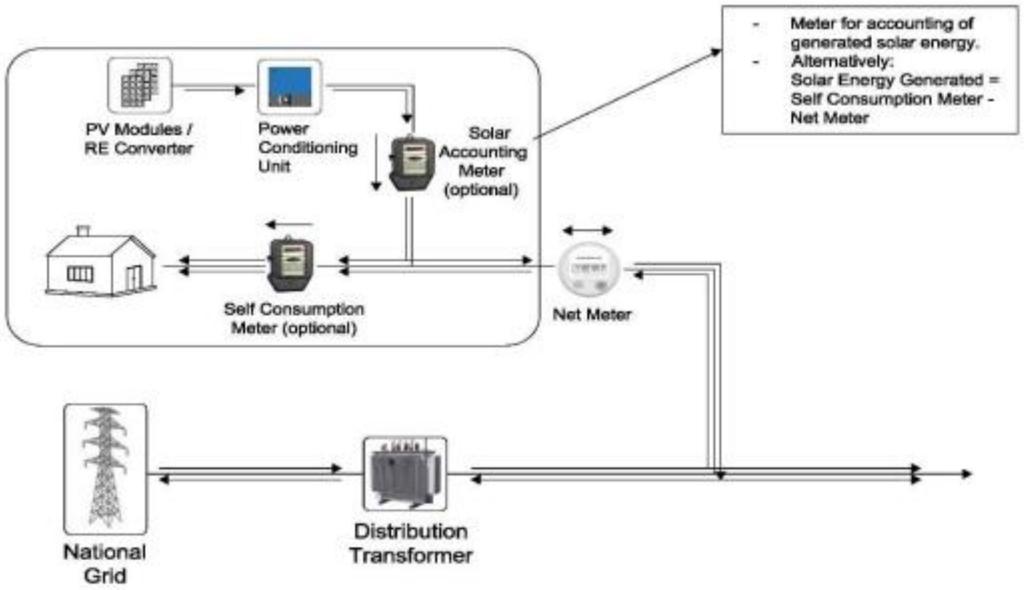


Figure 1: Architecture of a typical NEM system [Source: *(Power Division, 2018)*]

In Bangladesh, the net metering scheme has been launched on an experimental basis. To prevent the creation of a burden on the distribution utilities, the government has set a limit on the installed capacity of the rooftop system. Also, at present, only three phase consumers are made eligible to adopt the net metering scheme. The capacity and energy export limit of NEM system, according to revised *Net Metering Guideline (revised on November, 2019)* is as follows:

- Any three-phase consumer can be considered eligible for the net metering system;
- A consumer can install a solar PV system which has a AC capacity of up to 70% of the sanctioned load;
- The maximum output AC capacity of the installed RE system for NEM can be up to 10 MW; and
- For a medium voltage (MV) consumer, the installed capacity of the RE system can be a maximum of 70% of the rated capacity of the distribution transformers.

1.2 Challenges to solar PV rooftop expansion and role of the net metering policy

The progress of the expansion of rooftop systems has been impaired due to some limitations of the current net metering policy itself (Chowdhury & Khan, 2020). These include some restrictions imposed on potential prosumers. The policy excludes the largest market segment of grid-connected consumers, which are single-phase consumers (which have loads less than 7 kW), as the policy allows only three-phase electricity consumers to be connected. The output AC capacity of the renewable energy converter can be a maximum of 70 percent of the consumer's sanctioned load, which restricts the size of the system installed. Moreover, the maximum output AC capacity of the installed renewable energy system for NEM is 10 MW, again setting a cap on the system size. Grid upgrade costs must be borne by the prosumer if applicable. OPEX system owners cannot sell their electricity to anyone other than the utility, who consider the NEM prosumers to be competitors and a potential threat. These and other issues have impeded the faster growth of renewable electricity systems through the Net Metering scheme. Moreover, almost all solar rooftop systems (within and outside Net Metering) are self-financed by the prosumers, and there is little supportive financing for this (SREDA, 2023).

Net Metering policies have been widely and increasingly implemented across the world in order to promote the share and capacity installation of renewable electricity. The number of countries with NEM policies has increased from 9 in 2004 to 66 in 2019, with 2 in 2004 and 21 in 2019 in Asia alone (Rehman, et al., 2020). While Bangladesh has set a limit on the system size for Net Metering, Vietnam has no such cap. Vietnam, with the help of suitable incentives, had expanded its solar rooftop capacity by 8.5 GW in six months in 2020 (Broom, 2021).

Bangladesh has the potential to install solar PV rooftop systems in order to increase its share of renewable energy without placing much pressure on scarce land. Currently, solar rooftop PV generated electricity is cheaper than ground mounted solar PV in Bangladesh, where rooftop systems can produce electricity at the rate of 6 US cents per unit and the ground mounted systems have a tariff of 10 US cents. Moreover, the electricity rate from solar rooftop is much lower than the grid electricity for industrial or commercial consumers, which is approximately 10 US cents per unit. The weighted average electricity generation cost in 2022-23 was BDT 11.02 per unit (Electricity supply cost BDT 11.51 per unit), whereas the bulk sales tariff is BDT 5.94 per unit (BPDB, 2023). The generation cost of rooftop solar PV system now a days is less than BDT 5.00 per unit. Therefore, the generation cost for rooftop solar is lower than the average grid power generation cost of Bangladesh. The market for solar PV rooftop remains largely untapped.

1.3 Current state of solar rooftop PV systems under net metering in Bangladesh

Among the solar rooftop systems under net metering (figure 2), it can be seen that some of the systems are self-financed. These rooftop systems are usually small, in the range of a few to a few hundred kWp. At present, the limit for net metering rooftop projects is 10MW. However, this limit can be removed in case of large factories, where the potential is greater. In fact there is already a solar rooftop project in the Korean Export Processing Zone (EPZ) which is 16 MW, but they have a high degree of self-consumption, and so this condition could be extended to other companies.

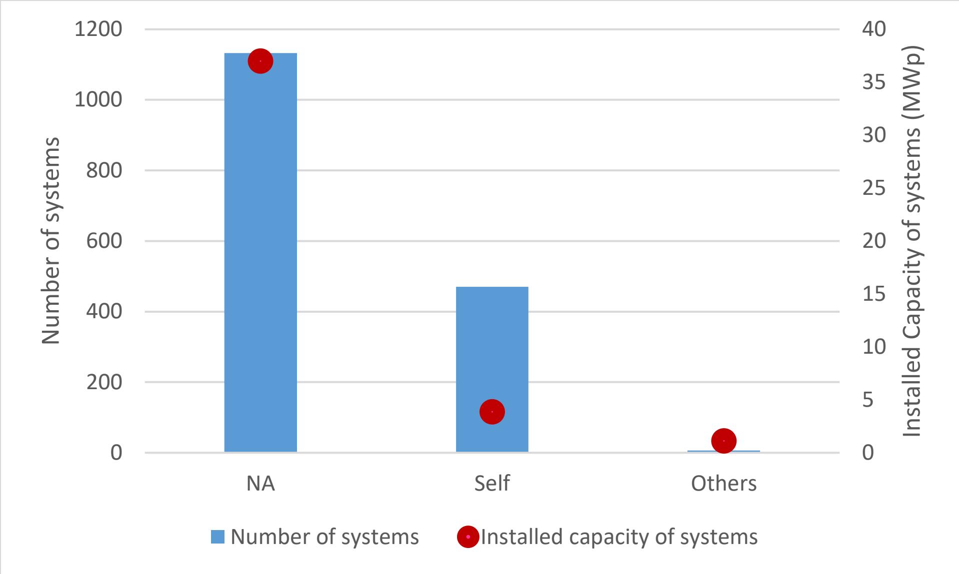


Figure 2: Financing sources of solar rooftop systems under net metering by number and installed capacities.

Among solar rooftop systems which are without net metering (figure 3), most of them are self-financed, whereas donors, the government and other sources contribute a minority of the funds. These small systems could also be encouraged to come under net metering. At present there is a lower limit for small systems, where a system lower than 7kW cannot be eligible for net metering connections. It could be considered to remove this lower limit can also be removed, as it will encourage smaller prosumers to install solar rooftop systems to benefit from self-consumption, as well as contribute small amounts to the grid. Many small prosumers could add up to a significant amount of installed capacity.

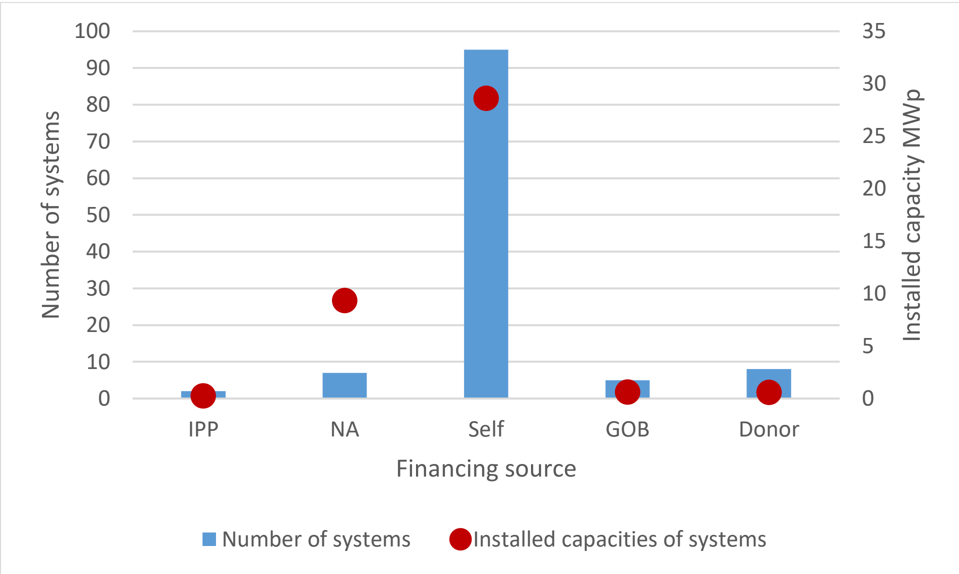


Figure 3: Financing sources of solar rooftop systems without net metering according to number and installed capacities.

1.4 Scope for the expansion of solar rooftop systems in Bangladesh

Rooftop solar PV systems may be installed and operated under the Net Metering Scheme of Bangladesh. The following sites are potentially suitable for solar rooftop systems:

- Roofs of government offices with large buildings.
- The tops of buildings and structures in all Export Processing Zones and Economic Zones.
- The rooftops of railway stations, platforms and adjacent land.
- The rooftops of cold storages and storage silos.
- Rooftops of garment factories, jute mills, paper mills and possibly roofs of other industries.
- Rooftops of cyclone shelter centers.
- Rooftops of civil aviation centers and land available near the airports with sufficient glare protection.
- Rooftops of public educational institutions, especially schools, colleges and universities.
- The jetties of river and sea ports.
- Tops of stadiums.

2. Objectives and methodology of the study

This study aims to explore obstacles to the expansion of solar rooftop systems in Bangladesh and propose ways to promote the development of solar PV rooftop systems. The specific objectives can be stated as follows:

1. *Finding international best practices of NEM with examples of success stories (Chapter x – I think the two chapters now dealing with international practices should be merged)*

This section will cover a review of how different countries have expanded their solar PV rooftop capacities to a significant extent in a short time, and what policy instruments were employed to attain this. From this, some best practices will be identified, with potential lessons for Bangladesh.

2. *Survey of existing Net Metering rooftop systems in Bangladesh and the challenges faced (Chapter y)*

This section will include a survey of solar rooftop system prosumers in Bangladesh, in order to investigate their experience of the technology, and how the policy framework affects their investment and installation decisions. Large scale industrial and commercial consumers, with systems of different ages, will be surveyed. Based on the survey, recommendations will be proposed for the formulation of policy guidelines to support solar rooftop expansion.

3. *Review of the Net Metering Guidelines of Bangladesh and identification of scope for improvement (Chapter z)*

This section will cover a review of the features of the Net Metering Guidelines -2018 of Bangladesh, assessing how the terms and conditions support or limit the expansion of solar PV rooftops in the country under the current conditions of energy prices and technological progress. Based on this, some possible modifications and improvements will be proposed, so that the policy could be updated in line with with market and technological trends.

Literature review: The literature to be consulted included scholarly research obtained from peer reviewed journals, as well as analytical reports from government bodies and international or multilateral organizations like the World Bank, USAID, ADB, United Nations etc. In addition to these, we have also consulted all the available SREDA and BPDB reports in the relevant time frame.

Data sources and analysis: The report included both primary and secondary data. The secondary data includes panel data regarding the progress of solar rooftops in Bangladesh, presenting information about installed capacity, generation volume, performance, geographical distribution, financial parameters etc. These were retrieved from SREDA data banks.

Primary data included a survey of solar rooftop prosumers of large scale industrial systems, which were collected through structured and open ended questionnaires and verbal interviews. The experts discussed the description of their systems, their experience and satisfaction with the system and the net metering policy, and any suggestions for improvement. Another primary data collected was the generation pattern of the solar rooftop systems to date, and any sources of technical problems that can be addressed through the net metering policy.

Data collection instruments were prepared after the approval of the inception report. Updates of data collection instruments, and analytical frameworks was done after consultation of EU.

Next we discussed the proposed types of analysis needed to be conducted to produce the specific research outcomes of the project. For each research outcome, we discussed the type of data, the source of the data, and the analytical framework.

2.1 Finding international best practices of NEM with examples of success stories

Data to be presented: This section covered the types of net metering policies implemented across the world, the features of these policies, the strengths and weaknesses of these features. The success of solar rooftop systems in these countries, and lessons to be learned for Bangladesh.

Source of data: Relevant data were collected from academic journals, REN21 reports, industry reports, RISE databanks.

Analytical framework: Comparative analysis was conducted on the following dimensions of the policies:

- Technologies and resources covered in the policy.
- Sectors eligible to come under net metering policies.
- Capacity caps in the policies.
- Renewable energy targets overall and related to rooftop systems.
- Progress of rooftop under net metering policies and current state.
- Applicable tariffs for exporting into the grid.
- Cost of installing rooftop systems under net metering.
- Self-consumption rates.

2.2 Survey of existing Net Metering rooftop systems in Bangladesh and the challenges faced

Data to be presented: This objective was to explore the limitations and scope for improvement of the current net metering policy of Bangladesh, through a survey of the experience of current solar rooftop prosumers. It was also analyze the generation and profitability pattern of these systems through the generation data of these prosumers.

Source of data: Secondary literature, followed by key informant interviews of a sample of project developers.

Analytical framework: Qualitative and structured analysis of survey data from KIIs. Information collected in the surveys were included the following areas:

1. Investment and operating cost of the systems.
2. Time taken to obtain permission and install the systems.
3. Support from utilities and relevant agencies.
4. Availability of local expertise.
5. Knowledge about solar electricity.
6. Feasibility in the prosumers' premises.
7. Quality and reliability of materials and equipment.

2.3 Review of the NEM Guidelines of Bangladesh and identification of scope for Improvement

Data to be presented: This section was discuss the identified limitations of the current net metering policy based on the prosumer survey. It also identified the prosumer suggested scope for improvement and how viable these would be.

Source of data: This section used data collected from the previous sections.

Analytical framework: There is a quantitative analysis of the current policy based on comparison to prosumer responses and review of experience from other countries.

3. Net Energy Metering: International Applications and Best Practices.

Net metering is a regulatory model where an electricity producer can export its surplus electricity to the grid, and use the exported electricity to balance its own deficit. In this way, decentralized consumers can offset their metered consumption with actively generated electricity. This instrument works in the presence of grid parity, where the distributed consumers can produce their own electricity at a cost lower than the grid price. This system allows the use of low cost renewables resources, increases production capacity, frees up government grid capacity and stabilizes the grid. Utilities may lose customers and revenue in case of widespread implementation, however, and utilities must act as storage for the decentralized producers. (Energypedia, 2019)

3.1 Literature review of international success of Net Metering Systems

Net Metering Policies have had mixed levels of success in different countries, and often the success depends on the exact terms and conditions of payment and settlements specified in the policy. For example, in the case of Poland, Trela and Dubel (2021) have shown that a net metering policy, which allows the prosumers to use free of charge 80% of the energy supplied by their PV system into the grid, is more supportive of the investments in distributed PV installations than a potential net billing system, which would require prosumers to buy and sell electricity on a free competitive market.

In the EU, although net metering is a policy adopted in the different countries, there is no comprehensive law that applies uniform terms and conditions across the different countries. Iliopoulos, Fermeglia, & Vanheusden (2020) have shown a comparative analysis of net metering schemes in Belgium, Greece, Italy and Cyprus, demonstrating that the policies varied in terms of tenure, applicable technologies, grid charge, capacity limitations, and prosumer characteristics. They argue that a uniform net metering policy applied top down from the EU authorities will reduce uncertainty among investors and promote the expansion of the PV market.

Schelly, Louie, & Pearce (2017) have reviewed the net metering and interconnection policies of investor owned utilities in different states of the US. They have shown that there are inconsistencies in the policies among the utilities in the same state, and even within individual utilities, and this leads to lack of transparency among prosumers, but the utilizes are changing their policies in a rapidly changing environment, where there is increasing expansion of distributed renewable electricity.

The effect of tariff rates on investments in distributed solar PV capacity has been studies by Gautier & Jacqmin (2020), who have shown, taking a case study of different tariff zones in Wallonia, in Europe, that an increase by one euro cents per kWh in the tariff will result in an 8% increase in the investment in solar PV. (Gautier, Axel, Hoet, Jacqmin, & Driessche, 2019 (2019) have shown that the factors that encourage prosumers to self-consume in the presence of net metering include age and gender (older and female prosumers self-consume more), and environmental motivation. They show that tailoring the net metering policy by setting monetary incentives that synchronize production and consumption, promoting the use of smart devise and providing consumption and production information to the prosumers can motivate them to synchronize their use and displace loads optimally.

A simulation analysis done in the case of Pakistan showed that a net metering policy has the potential to make many improvements to the energy system, including improvement in voltage regulation, reduction in transmission and distribution losses, increase in power availability, less billing to consumers, and reduction of loading on utility grid (Zahid, et al., 2020).

The effect of PV system sizing on the profitability of solar PV systems under net metering has been studied by Ordóñez, Sánchez, Rozas, García, & Parra-Domínguez (2022) in the case of Spain and Ecuador. They have shown that small systems may not achieve grid parity, and systems above a certain threshold size become profitable, depending on the payment terms of the net metering policy.

The tariff rate in the net metering policy affects the profitability of the PV system. (Comello & Reichelstein (2017) have shown using the case of California, Hawaii and Nevada from the US that when the overage tariff of the net metering policy is equal to or above the Levelized cost of electricity (LCOE) of the system, the installation of the systems will continue, However, if the tariff is set below the LCOE, the system size and overall installation volume will sharply increase.

The level of energy consumption of the prosumer also has an effect on the profitability of installing a solar PV system in the presence of net metering. Mojonero, Villacorta, & Kuong (2018) have shown from cases in Peru that net metering provides strong incentives for prosumers to install PV systems when the prosumer has high levels of consumption and the region has high solar radiation, given a fixed tariff rate.

Applying different net metering methods to a prosumers electricity exchange also has an effect on cost and self-consumption. The different methods are dependent on whether netting is based on each individual phase or on the overall energy flow, and the netting interval used for settlement. It was shown that self-consumption increased when moving from instantaneous per phase netting to hourly summation netting (Ziras, Calearo, & Marinelli, 2021).

The time interval of recording energy transactions and the size of the system relative to the prosumers self-consumption also affect the success and profitability of distributed PV systems (Watts, Valdés, Jara, & Watson, 2015). In Pakistan at present, only three phase prosumers are eligible to use the net metering policy. A simulation analysis conducted by (Tahir, Siraj, Shah, & Arshad (2023) shoes that if single phase prosumers are allowed to use the policy, this can actually improve the voltage regulation, reduce line losses and network congestion, and supply additional power to eliminate or minimize load-shedding.

The following figure shows the solar PV potential across the globe, and the next figure shows the share of electricity from solar. The countries with the most resource do not have the highest solar electricity generation (Europe and Japan are areas where there is a high share of solar despite low resources). This implies that renewable energy policies are significantly responsible for promoting investments in the sector.

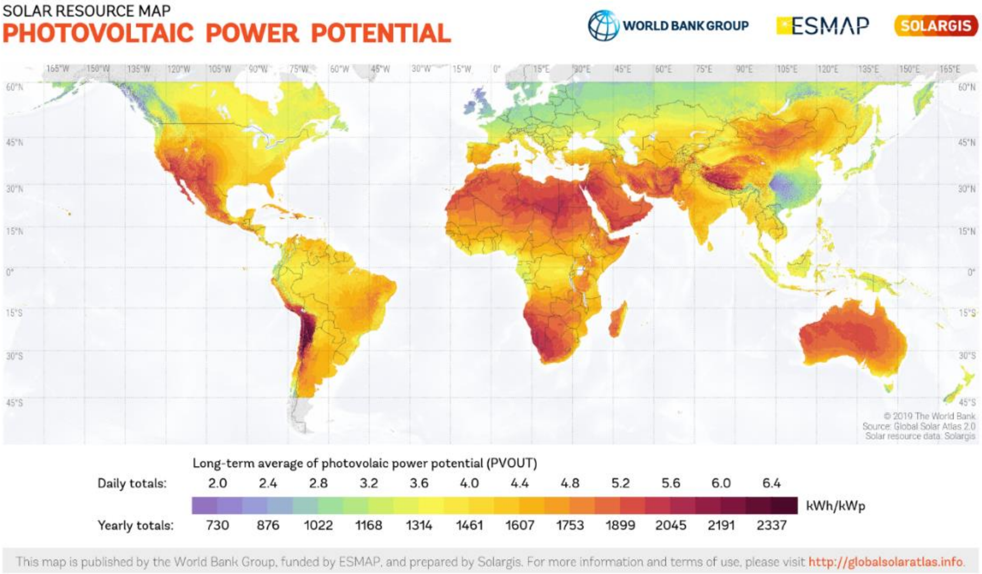


Figure 4: Global map of photovoltaic power potential.

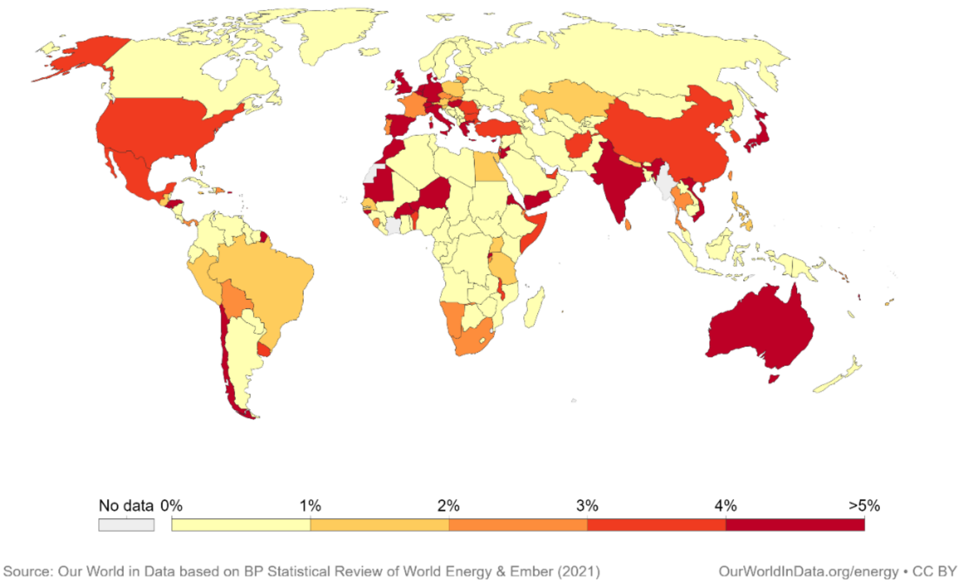


Figure 5: Share of electricity produced from solar energy.

In addition to the Net Metering Policy, other policy instruments like the Feed-in-tariffs, Renewable Portfolio Standards (RPS), subsidies, public investments and taxes have also been shown to have positive effects on solar PV investments across samples of countries. Carley, Davies, Spence and Zirogiannis (2018) have analyzed the design features of RPS policies in the US for a period of 25 years. They have found that the stringency of the RPS policy, defined in terms of the design features of the policy, increases the share of renewables in electricity generation, the total amount of generation, and the amount specifically from solar and wind. One of the latest econometric studies is by Bersalli, Menanteau and Al-Methini (2020), who find out the effects of the existence of different policy instruments on investments in renewable energy in 30 European countries and 20 Latin American countries. They define investments by the per capita increase in installed capacity of renewable energy in particular technologies, including wind, solar, geothermal and biomass. They test the effects of policy variables including feed-in tariffs, RPS, auctions and fiscal incentives, concluding that the policies have a positive impact, with the effectiveness varying across countries.

Jenner, Groba and Indvik (2013) measure the strength of FIT based on the return on investment it provides, and conclude that FIT policies producing higher returns increase solar PV capacity. Shrimali and Kniefel (2011) study the effects of RPS with different characteristics, on the capacity additions of total renewable energy, and on wind, biomass, geothermal and solar energy. They find that the RPS with a sales goal have a negative effect, whereas RPS with a sales requirement has a positive effect on wind, geothermal and solar,. RPS with capacity requirement has positive effects on biomass, geothermal and solar, but negative effects on others. Green power options and clean energy funds of the government have a positive effect. Li, Chang and Chang (2017) show the effects of policy instruments in primary electricity productions from wind and solar PV in European countries. They show that FIT, RPS, capital grants and preferential loans have a positive effect on wind and RD&D and tax incentives have a negative effect. FIT, RPS and preferential loans have a positive effect on solar PV, but capital grants, RD&D and tax incentives have a negative effect.

Bolkesjø, Eltvig and Nygaard (2014) explore the effects of FIT, RPS and tendering on total instaslled capacity of renewables in the five largest electricity consumers in Europe. They found that FIT and tendering had a positive effect on onshore wind, solar PV and biomass, whereas RPS had a positive effect. Alolo et al, (2020) have shown that the existence of feed-in system related subsides itself does not increase investment in renewables, especially solar and wind, in the EU. Policies which guarantee revenues for a particular period of time have a positive effect on wind, whereas neither the existence nor the features of feed in policies have an effect on solar investments.

3.2 Overview of the Net Metering Policy of Bangladesh, and Comparison with other Countries

The Net Metering Policy of Bangladesh has been updated in 2019, after having first been issued in 2018. In Bangladesh, the policy can be applicable to renewable energy from any type of renewable energy technology, unlike in some other countries, which specify that only some technologies are eligible to come under Net Metering. However, some countries allow multiple renewable sources to come under net metering, whereas other countries allow any type of renewable energy. Some countries allow only solar PV, or particularly rooftop solar PV to come under Net Metering (Tables 1, 2, 3, 4). This implies that the Net Metering policy is well suited to this technology.

The types of consumers who can become prosumers include domestic or residential consumers, commercial consumers and industrial consumers, but not agricultural consumers. A few countries in Asia allow agricultural consumers to be NEM prosumers, but most countries have the same consumer options as Bangladesh, while some countries do not have any criteria for this.

Bangladesh sets a capacity limit of upto 10 MW AC capacity, which is higher than that of other Asian countries except Sri Lanka and Jordan and Israel, and Vietnam has no upper limit on installed capacity. Although Bangladesh states that the NEM capacity should not exceed 70% of sanctioned load, most countries do not impose this type of restriction. Bangladesh specifies that only three phase consumers are eligible, but this limitation is not applicable in most other countries (except Pakistan).

In Bangladesh, the tariff structure is set at the bulk rate (only for the net exported amount), but can be subject to change with time. In comparison, some countries specify the tariff rate at a known fixed amount, either to remain fixed for the entire life of the system, or to vary according to the age of the system. In some cases, the tariff rate can vary according to the type of prosumer (Jordan), whereas in other cases, the retail rate instead of the bulk rate is applied (Rajsthan). In Bangladesh, one year is considered the settlement period, but in Israel and Malaysia, it is set upto two years. In Palestine, tariff rates can vary seasonally. Malaysia has some of the highest tariff rates for NEM, relative to the per kWp installation cost for solar PV, followed by Japan. In Bangladesh, the tariff rates are proportional to the per unit installation cost of solar PV.

3.2.1 Comparative analysis of Net Metering terms in different countries

The following tables 1 to 4 compare the terms and conditions of NEM policies in different Asian countries.

TABLE 1. **Net-metering development in South Asia.**

Country	Eligible RE Sources	Eligible Sectors	RE Capacity	RE Targets	Current RE Shares	Applicable Tariff Range for Surplus Energy Injection into Grid
Pakistan (announced on National level in 2015, expanded to entire country in 2017)	Solar PV and wind sources	All residential, commercial, industrial, and agricultural consumers having a three phase connection at 0.4-11 KV voltage	1kWp- 1MWp; DG capacity should not be more than consumer's sanctioned load (generation should not exceed the annual energy consumption of the eligible consumers)	20% and 30% of generation capacity by RE technologies by 2025 and 2030, respectively. Previously the RE target was set to be 5% share in total generation by 2030	Renewables make up-to 5.8% of the installed capacity by year-end 2018	Net-metering tariff: 1.2-9.4 US cent/kWh
Sri Lanka (announced on National level in 2009)	All RE sources	Residential, commercial, industrial	Up-to 10MWp	20%, 50%, and 100% of power generation by RE by year 2020,2030, and 2050, respectively.	10% RE shares (including mini hydro electric) by 2018~~~	Net-metering tariff (fixed rate tariff applies): 12 US cent/kWh for first 7 years, 8.3 US cent/ kWh for 8.20 years
Nepal (announced on National level in 2018)	Solar PV	Domestic, organizational and commercial	Up-to 1MWp	100% of generation by RE source by 2050	3% by generation sources	Net-metering tariff (fixed rate tariff applies): 6 US cent/kWh
Maldives (announced on National level in 2015)	No data available	Small scale domestic, business, government	No data available	100% of generation by RE source by year 2050 (to install at least 10MW of solar PV under net-metering by 2023)	RE makes 4% of total energy mix by year-end 2019 (as of 2019, ~1 MW net-metered installed capacity)	No data available
India (announced on sub-national level)	Varies on sub-national level (mostly solar rooftop sources)	Varies on sub-national level: all consumers are eligible in majority of states except for West Bengal where only institutional consumers like hospitals, colleges, government departments are allowed	Varies on the sub-national level: less than 500KWp for Uttarakhanand, Goa and union territories; less than 2MWp for Madhypa Pradesh: no cap for Delhi, Tamil Nadu, Uttar Pradesh, and West Bengal; 1 MWp of capacity cap for rest of Indian states	40% of power generation from RE sources by 2030	As per REN21 GSR-2019, 7.8% of power generation from RE sources by year-end 2017	Himachal Pradesh: 6-6.7 US cant/kWh (net metering). Karnataka: 9.6-13 US cent/kWh (both net metering and net-billing). Uttar Pradesh: 0.67 US cent/kWh (both net-metering and net-billing). Panjab: at retail supply tariff (net metering). Rajasthan, Goa and union territories: as per regulated solar tariff (net-metering)

TABLE 2. Net-metering development in West Asian region.

Country	Eligible RE Sources	Eligible Sectors	RE Capacity Cap	RE Targets	Current RE Shares	Applicable Tariff Range for Surplus Energy Injection into Grid
Jordan (announced on national level in 2012)	All RE sources	Small renewable roof-top systems for commercial, industrial, residential, agricultural, consumers; Large scale solar generation for public institutions	Up-to 10 MWp for public institutions	15% of installed capacity by 2025	13.53% of installed capacity without hydro by year end 2017 (as of 2016, 35 MW net-metered projects have been implemented)	Net-metering tariff (variable rate tariff applies within each eligible sector): 11.58-16.95 US cent/kWh
United Arab Emirates (announced on Sub-national level under "Shams Dubai" net- metering scheme and Abu Dhabi net-metering program)	Solar PV	Residential, commercial, industrial	Less than consumer's approved total load	No national level targets. Abu Dhabi: 7% by 2020, Dubai: 7% by 2020, 15% by 2030, and 75% by 2050	2.03% of installed capacity by year-end 2018 (as of 2014, 12 MW net-metered projects have been implemented)	Net-metering tariff: 8-12 US cent/kWh
Bahrain (announced on national level in 2017)	Wind, solar PV, geothermal energy, and biogas	All RE producers	Sum of net metered RE generation capacity should be less than total approved load of the Consumption Account	5% by 2025, 10.3% by 2035. To achieve 255 MW of PV capacity by 2025 using net-metering	0.22% of installed capacity by year-end 2018	Net-metering tariff: 4.24-7.69 US cent/kWh (excess energy is credited at the upper tariff bracket applicable to the Consumption Account)
Saudi Arabia (announced on national level in 2017)	Solar PV	Commercial, governmental, industrial, agricultural	1kWp-1MWp; country-wide cap of 1.8 GW	30% by 2030. 9.5 GW and 54 GW power from RE by 2023 and 2040, respectively	0.18% of installed capacity by year-end 2018	Net-metering tariff: 4.8-8 US cent/kWh
Israel (announced on national level in 2012)	Solar roof-top and reservoir installations	No data available	Up-to 5 MWp; country-wide total capacity cap of 400 MWp	10% and 17% of power generation by 2020 and 2030, respectively	2% by power generation from RE sources by year-end 2017 (as of 2018, 170 MWp installed capacity has been net-metered)	Net-metering tariff: 0.78 US cent/kWh (consumers can transfer and accumulate credits up- to two years)

Lebanon (announced on national level in 2011)	Solar, wind, biomass, geothermal hydro-electric or other renewable generation source	Residential, commercial, industrial	10 kW nameplate rating	30% by 2030 100% by 2050	1.55% installed capacity without hydro-electric by year end 2017 (as of 2014, 2 MW net-metered projects have been implemented)	Net-metering tariff: 8.40-9.80 US cent/kWh
State of Palestine (announced on national level in 2012)	Mostly small-scale solar PV	Household, commercial, industrial	capacity cap is not specified (installed capacity less than 80% of the peak demand for PV projects in TDECO region)	10% by 2020 and 100% by 2050	As of year-end 2017, 5.5 MWp installed capacity has been net-metered	Net-metering tariff: 12-27 US cent/kWh (Time of use rate tariff varies seasonally: highest in summer and lowest in spring and fall)
Syria (announced on national level in 2010)	No data available	No data available	No data available	30% of installed capacity by 2030	0.07% of installed capacity without hydro-electric by year-end 2017	Net-metering tariff: 0.19-5.63 US cant/kWh

TABLE 3. Net-metering development in Central and East Asian Countries

Country	**Eligible RE Sources**	**Eligible Sectors**	**RE Capacity Cap**	**RE Targets**	**Current RE Shares**	**Applicable Tariff Range for Surplus Energy Injection into Grid**
Japan (announced on national level in 1990)	Mainly solar PV and wind	No data available	No data available	22-24% by electricity generation by 2030	14.8% including 7.5% from hydro in electricity production in 2016 (as of 2014, 94% of the PV systems installed in Japan are residentially grid-ties net-metering systems)	Net-metering tariff: 17-22 US cent/kWh
Republic of Korea (announced on national level in 2005)	Rooftop solar	Residential, commercial, industrial	< 1MWp	20% RE share by 2030	7% of total generation by year-end 2017	Net-metering tariff: 7.2-13.9 US cent/kWh

TABLE 4. Net-metering development in Southeast Asian Countries

Country	Eligible RE Sources	Eligible Sectors	RE Capacity Cap	RE Targets	Current RE Shares	Applicable Tariff Range for Surplus Energy Injection into Grid
Thailand (announced on national level in 2002)	Solar, biogas or biomass, wind, amd micro-hydro generators	Residential, commercial, industrial	Up-to 1 MWp	20% of power generation from RE by 2036, 30% of final energy consumption from RE by 2036	5% of electricity generation from RE by year-end 2017, 12% of final energy consumption from RE, as of 2014	Net-metering tariff: 9.3-11.6 US cent per kWh Net-billing tariff: 2.9-4.3 US cent per kWh
Philippines (announced on national level in 2013)	Wind, solar PV, Biogas and Biomass	Residential, commercial/ industrial, institutional	Up-to 100 kWp	100% by 2050 (20GW by 2040)	7% RE (solar PV, wind, and biomass) share in installed capacity by 2017 (total installed solar capacity of ~900MW by 2017, out of which, only ~8MW of solar PV deployed via net-metering scheme)	Net-metering tariff (fixed tariff applies): 11 US cent/kWh (excess energy injection is credited to next month's electricity bill)
Singapore (announced on national level in 2011-2012)	Solar PV	No data available	No data available	8% (no date specified), previously set target to attain 350MW solar installed capacity by 2020	<1% of electricity generation by solar PV	Net-metering tariff: 25-35 US cent/kWh
Indonesia (announced on national level in 2013, revised in 2018)	Rooftop solar PV	Residential, commercial, industrial	Generation from DG systems should not exceed the annual energy consumption of the eligible consumers	26% of installed capacity by 2025	8.4% by year-end 2019	Net-metering tariff: 12 US cent/kWh (net-metering is not on a 1:1 basis: the excess energy is injected into the grid at 65% of the applicable tariff)
Malaysia (announced in 2015, revised in 2018)	Rooftop solar PV	Residential, commercial, industrial, agriculture	Residential: 1- phase: 12kWp, 3-phase: 72 kWp. Commercial: up-to 1 MWp or 75% of their maximum demand (whichever is lesser) Industrial: 60% of the fuse rating	9% and 20% RE share by 2020 and 2030, respectively	2% RE share (mostly solar PV) by 2019	Net-metering tariff: 21.80-57.10 US cent/kWh (every injected energy unit into grid is offset by consumed unit from grid. Maximum roll over period is 24 months)
Vietnam (announced on national level in 2017, and revised in 2019)	Rooftop solar PV	Residential sector	No capacity limit is imposed	7%,10% and 100% of total electricity from RE sources by 2020, 2030, and 2050, respectively	Power generation from RE sources (wind and solar) is less than 6%	Net-metering tariff: 7.1-12.4 US cent/kWh

Two notable regions which have dynamic policies for expanding the solar PV rooftop market are the EU and India.

The European Union (EU)

The EU has taken a number of measures by the end of 2022 to rollout the expansion of solar PV rooftop in its Member States. It has raised the raise the target share of renewable energy in the **EU total energy consumption** from 32% to 42.5% by 2030, with an additional 2.5% indicative top-up that would allow to reach 45%. (. It has reduced permitting time to within three months. It has made it mandatory for the following types of buildings to install solar rooftop systems by the specified time:

- all new public and commercial buildings with useful floor area larger than 250 m2 by 2026;
- all existing public and commercial buildings with useful floor area larger than 250 m2 by 2027;
- all new residential buildings by 2029.

In addition, it has also made it mandatory that new buildings must be solar ready. It promotes collective self-consumption, and community based renewable energy, financial support, building integrated PV, and zero energy buildings (European Commission, 2022).

India

The Ministry of New and Renewable Energy (MNRE) of India, supported by the European Union, has developed and promoted the PV Rooftop Cell under the “Technical Cooperation for Energy and Environment in India”. The major activities of this include:

- Promotion of the PV Rooftop Programme at various platforms;
- Rooftop Solar data segregation and its analysis;
- Development of Model and Standard documents;
- Training and Webinars for various stakeholders;
- Representing MNRE at National Platforms, Workshops and Conferences;
- Market Analysis and Studies

3.2.2 Research on effectiveness of Net Metering policy

This section will cover a review of literature on renewable energy and environmental policy adoption covering policies of the electricity sector. Most cover limited geographic areas, like the different states of the US, or different European countries. Stadelmann and Castro (2014) have analyzed the factors leading to the adoption of four major policy instruments in developing countries- targets, feed-in-tariffs, financial incentives and framework policies. They have found that domestic energy consumption patterns, renewable resources, EU membership and historical linkages have led to the adoption of various policies. In the case of advanced industrialized economies, Schaffer and Bernauer (2014) find that Gross Domestic Product (GDP), electricity production from fossil fuels, carbon intensity of the economy, political systems and EU membership or candidacy serve to promote the adoption of feed in tariffs (FIT) and green certificate schemes. Berry, Laird and Stefes (2015) have shown that fossil fuel use, political leanings and economic conditions of American states influence their adoption and ambition of renewable portfolio standards. Alizada (2018) has shown that EU membership, common language and history, renewable resource, fossil fuel use patterns, per capita GDP and carbon dioxide (CO_2) emissions affect the adoption of FIT and renewable portfolio standards (RPS). Vachon and Menz (2006) have explored the drivers of adoption of four types of policies- RPS, net metering, public benefit funds, generation disclosure rules and proportion of renewable energy- using factor analysis, followed by binary logistic regression. They found that fossil fuel use positively affected the adoption of RPS, whereas sociopolitical factors, including income, education and voting patterns affected adoption of all the polity instruments. Huang, Alavalapati, Carter and Langholtz (2007) have explored factors that drive the adoption of RPS in US states. They found that the gross state product, population growth rate, and education promote the adoption of RPS, whereas expenditure on natural resources negatively affects it. Upton and Snyder (2015) have also explored the drivers of RPS adoption in the states of the US. They have found that in addition to wind and solar potential, the per capita GSP positively influences the adoption of state level RPS, whereas income from mining and manufacturing decrease chances of adoption. Information disclosure requirements, income and greenhouse gas emissions have been shown to promote the adoption of RPS in the states of the US (Bae & Yu, 2018).

Young and Sarzynski (2009) have found that the adoption of solar energy financial incentives in the states of the US are positively affected by solar potential, electricity prices, and green ideology, but negatively affected by population and income. Matisoff (2008) has shown that citizen ideology, air pollution and CO_2 intensity affect the adoption of climate change policies and RPS in US states. Zhou, Matisoff, Kingsley and Brown (2019) have found that EU membership promotes the adoption of research and development policies in Europe, whereas EU candidacy promotes the adoption of regulatory instruments. Carbon intensity negatively affects information and education policy, and energy dependence negatively affects the adoption of economic instruments. In a study on Spain, González-Limón, Pablo-Romero, and Sánchez-Braza (2012) have shown that population, shared residence, solar intensity, neighboring influence, income and debt positively affect the adoption of tax credits to promote solar thermal energy, whereas the number of agricultural companies and conservative ideology negatively affect it.

3.2.3 The progress of Net Metering policies in different regions

The following section traces the progress of the adoption of Net Metering policies and similar policies supporting renewable electricity across the world. Data is compiled from (REN21, 2000-2023)

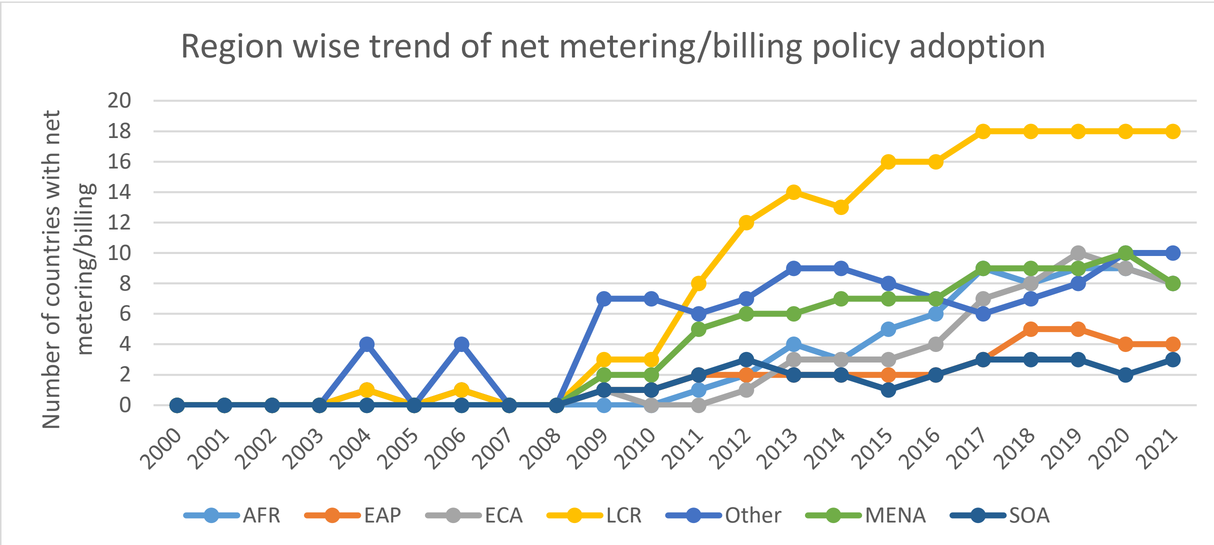


Figure 6: Region wise trend of net metering policy adoption

Net metering policies took off across different regions of the world from 2008, with the Latin American countries adopting the policy with the highest frequency.

In South Asia, Pakistan introduced the net metering policy first in 2009, followed by Sri Lanka in 2011 and India in 2012. This strategy was introduced by Bangladesh in 2018, and it is presently in place in India, Sri Lanka, and Pakistan. India has had net metering on a state level but not on a national level.

In MENA region, Jordan and Malta adopted the net metering policy first in 2009, followed by Lebanon and Syrian Arab in 2011 and Arab Republic in 2012. Currently, net metering policy is followed by Bahrain, Arab Republic, Jordan, Morocco, Malta, Lebanon, Saudi Arabia and Syrian Arab Republic in the MENA region.

Mexico was the first country in Latin America and the Caribbean region to implement the net metering regulation in 2004, followed by Costa Rica and Columbia in 2009. Following that, in 2011, this strategy was also adopted by Chile, the Dominican Republic, Guatemala, Haiti, and Uruguay. As of 2021, net metering is used in Argentina, Bolivia, Brazil, Barbados, Chile, Costa Rica, Dominican Republic, Grenada, Guatemala, Honduras, Jamaica, Saint Lucia, Mexico, Panama, Peru, Suriname, Uruguay, Saint Vincent and the Grenadines.

In the other region, Belgium, Denmark, Italy and Japan adopted the net metering policy first in 2004. After that in 2009, Canada and Germany also adopted this policy and currently in 2021, Austria, Belgium, Canada, Denmark, Greece, Israel, Italy, Netherlands, New Zealand and Singapore are following net metering policy.

In the region of Europe and Central Asia, net metering was first implemented in the Czech Republic in 2004, then in Cyprus in 2012, and finally in Latvia in 2013. America, Hungary, Lithuania, Latvia, Moldova, Slovenia, Turkey, and Ukraine are among the countries that implemented this approach in 2021.

Although net metering is a common policy in the Europe, it has recently been revised or superseded by more advanced policies. In 2022, Cyprus, Finland, Romania and Slovenia have revised their net metering policies, and Netherlands phased out the policy. Cyprus planned to expand the policy by EUR 40 million. Finland expanded the scope of their net metering policy to include more solar PV systems. The NEM policy in the Netherlands has been successful, resulting in rapid expansion of low quality solar rooftop systems, and surplus solar electricity production in the summer is so high that the storage capacity is not enough to contain it. A new policy in the Netherlands will phase out the previous NEM policy and incentivize the growth of storage, so as to accommodate the long term growth of solar PV. Poland is changing its policy from net metering to net billing (REN21, 2000-2023).

Thailand implemented the net metering policy first in the East Asia and Pacific area in 2004, followed by the Philippines in 2009 and the Republic of Korea in 2011. In 2021, the Philippines, Thailand, Vietnam, and the Federated States of Micronesia all adhere to this policy.

In the continent of Africa, Kenya adopted the net metering policy in 2015 after Lesotho did so in 2012 and Cabo Verde in 2011. Albania, Ghana, Kenya, Lesotho, Mauritius, Senegal, Seychelles, and Tanzania are now the only countries in 2021 that adhere to this strategy.

3.2.4 The progress of Feed-in-Tariffs in different regions

This section outlines the trends in adoption of Feed-in-Tariff (FIT) policies in different regions.

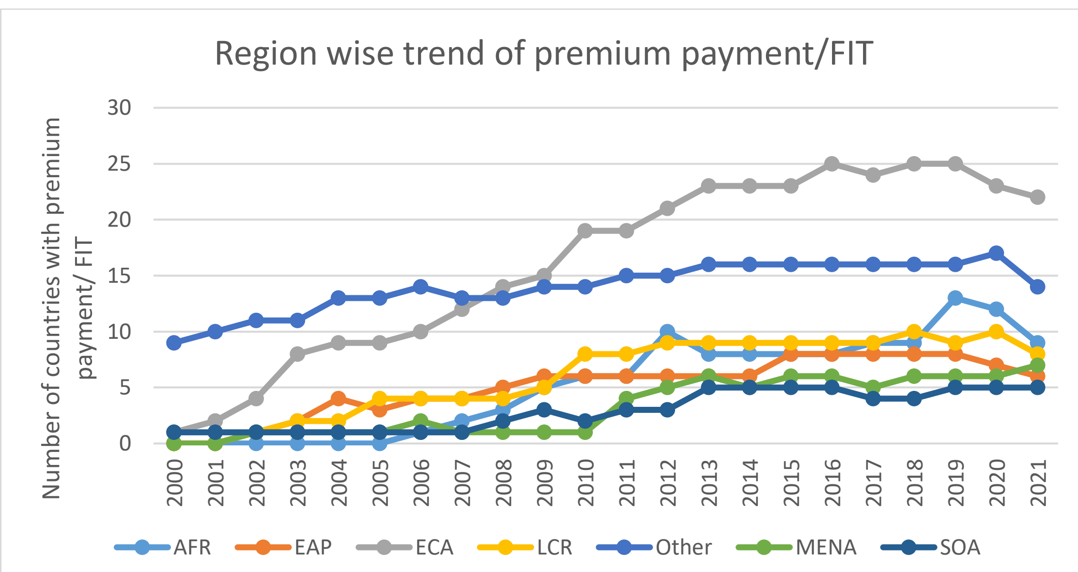


Figure 7: Region wise trend of Feed-in-tariff adoption

In South Asia, Sri Lanka adopted the feed-in tariff strategy first in 2000, followed by India in 2008. India, Sri Lanka, the Maldives, Nepal, and Pakistan are currently adhering to this strategy in 2021.

Switzerland, Germany, Denmark, Spain, Greece, Italy, Norway, Portugal, and Sweden have been implementing the feed-in tariff strategy since 2000 in the other region. This strategy was implemented in 2002 by Austria and Norway, and as of 2021, it is being followed by Andorra, American Samoa (U.S.), Canada, Switzerland, Germany, Denmark, United Kingdom, Greece, Ireland, Israel, Italy, Netherlands, and the United States.

In the MENA region, Malta adopted the feed-in tariff strategy in 2006 after Algeria did so in 2002. This policy was established in 2011 by the Syrian Arab Republic and the Islamic Republic of Iran. As of 2021, Bahrain, Algeria, the Arab Republic of Egypt, the Islamic Republic of Iran, Jordan, Malta, and other Arab Republics are also adhering to it.

Brazil introduced the feed-in tariff strategy to Latin America and the Caribbean in 2002, followed by Nicaragua in 2004, Argentina, and Ecuador in 2006. Argentina, Bolivia, Chile, Ecuador, Honduras, Nicaragua, Panama, and Peru are the countries that will implement this strategy in 2021.

In the region of Europe and Central Asia, Slovenia has been using a feed-in tariff policy since 2000. Latvia followed in 2001, the Czech Republic in 2002, and Lithuania in 2003. This strategy will be implemented in 2021 in the following countries: Armenia, Bulgaria, Bosnia and Herzegovina, Belarus, Cyprus, Czech Republic, Estonia, Croatia, Hungary, Kazakhstan, Lithuania, Latvia, Moldova, Russian Federation, Serbia, and Slovakia.

Indonesia introduced the feed-in tariff strategy in East Asia and the Pacific in 2002, followed by the Republic of Korea in 2003 and China in 2004. As of 2021, this strategy is being followed by China, Indonesia, Mongolia, Malaysia, Thailand, and Vanuatu.

The feed-in tariff strategy was first implemented in the African region by Uganda in 2006, then by Albania in 2007 and Kenya in 2008. This policy is being implemented in Angola, Albania, Ghana, Kenya, Rwanda, Senegal, Tanzania, Uganda, and Zambia in 2021.

3.2.5 The progress of Renewable Portfolio Standards in different regions

This section traces the trend of the adoption of RPS in different global regions.

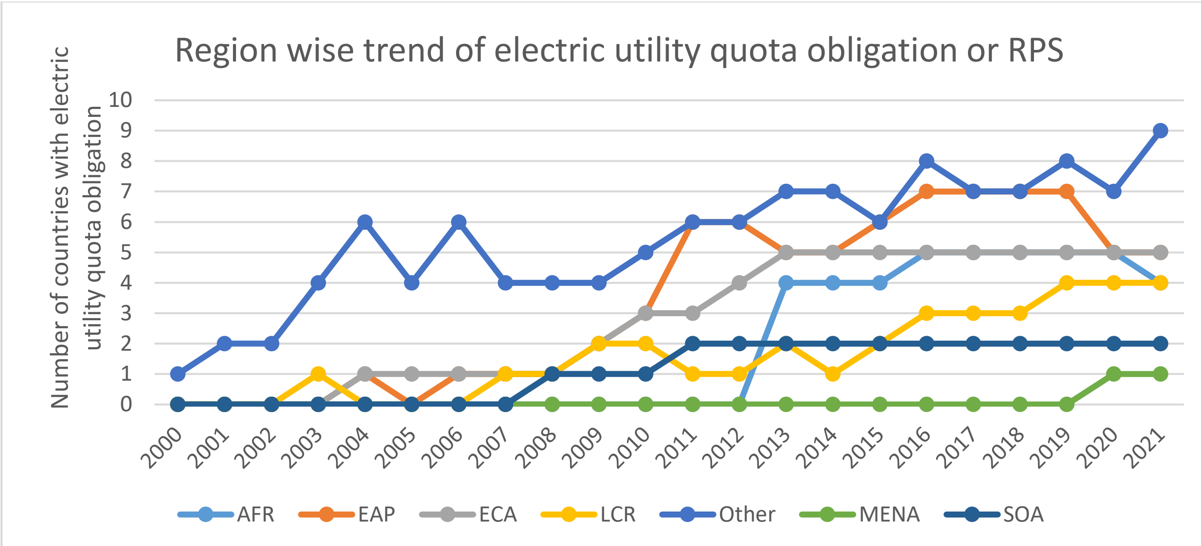


Figure 8: Region wise trend of RPS adoption.

India was the first country in South Asia to implement the electric utility quota obligation policy or the renewable portfolio standards (RPS) policy in 2008, and Sri Lanka did it in 2011. As of 2021, only Sri Lanka and India adhere to this strategy.

Since 2000, Italy has implemented a strategy requiring electric utility quotas in the other region. Following the United Kingdom in 2002, Australia adopted this policy in 2001. This policy is being implemented in 2021 in Belgium, Canada, the United Kingdom, Greece, Israel, Luxembourg, Norway, Portugal, and Sweden.

Only the United Arab Emirates is implementing the policy of an electric utility quota obligation in the MENA area. The policy was first implemented in this nation in 2020.

Chile was the first country in Latin America and the Caribbean to adopt the policy of electric utility quota obligations in 2003, and Uruguay did so in 2009. Peru implemented this strategy in 2013, and as of 2021, it is being followed by Argentina, Bolivia, Chile, and Peru.

Poland was the first country in Europe and Central Asia to establish a policy requiring electric utilities to meet quota obligations, followed by Romania in 2009 and the Kyrgyz Republic in 2010. In 2012, Lithuania adopted this stance. As of right now, in 2021, this policy is being implemented in Belarus, the Kyrgyz Republic, Lithuania, Poland, and Romania.

Thailand accepted the policy of electric utility quota obligation in the East Asia and Pacific region in 2004. China then implemented this strategy in 2006, and the Philippines did likewise in 2009. This stance was taken by the Republic of Korea in 2010. Following this approach in 2021 are Indonesia, Malaysia, Philippines, Palau, and Vietnam.

In the African continent, South Africa, Ghana, Senegal, and Albania all enacted quota obligations for electric utilities in 2013. Nigeria implemented this approach in 2016, and as of 2021, it is also being followed by Albania, Ghana, Senegal, and South Africa.

3.2.6 The progress of tax based policies in different regions

This section outlines the trend in adoption of policies covering sales tax , carbon tax, VAT or other taxes supporting renewables.

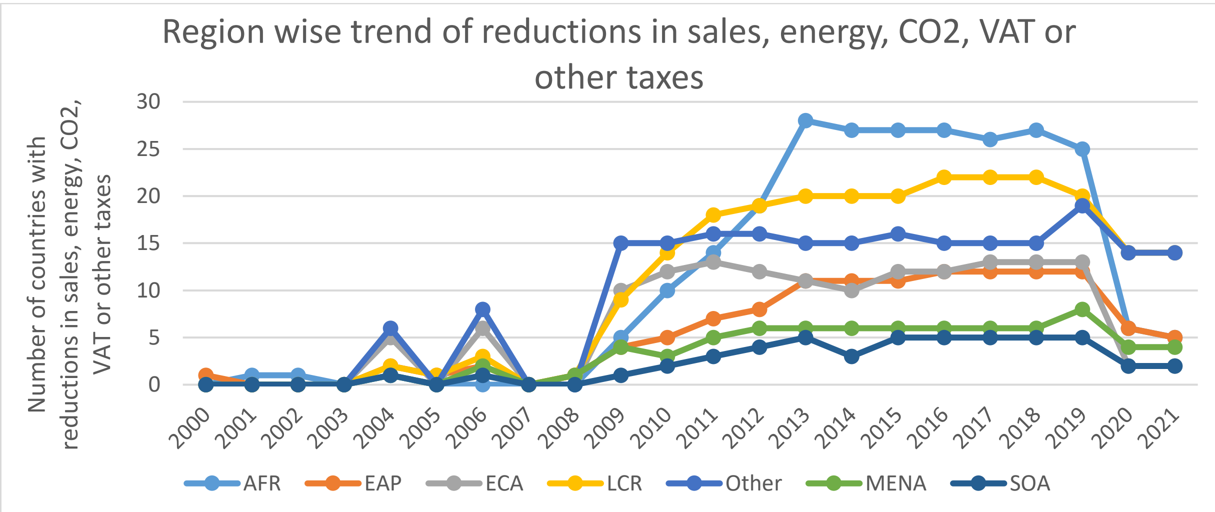


Figure 9: Region wise trend of tax based policy instruments.

India was the first country in the south Asian region to implement a policy of reduction in sales, energy, CO_2, VAT, and other taxes in 2004, followed by Nepal in 2010, Bangladesh, and Sri Lanka in 2011. Only India and Nepal are still adhering to this strategy as of 2021.

In other region, the reduction in sales, energy, CO_2, VAT, and other taxes was initially implemented in 2004 in Canada, Germany, France, and the United Kingdom. This policy was then implemented by Portugal and Sweden in 2006, and as of 2021, it is being followed by American Samoa (U.S.), Austria, Belgium, Canada, Germany, Denmark, Spain, France, the United Kingdom, Greece, Italy, the Netherlands, Sweden, and the United States of America.

Algeria implemented the policy of reduced sales, energy, CO_2, VAT, and other taxes first in the MENA area in 2004, followed by Morocco in 2006, and then Malta in 2004. This policy is being implemented in 2021 by the Arab Republic of Egypt, the Islamic Republic of Iran, Lebanon, and the Syrian Arab Republic.

Guatemala and Chile were the first countries in Latin America and the Caribbean to adopt the policy of reduction in sales, energy, CO_2, VAT, and other taxes in 2004. Honduras then enacted this strategy in 2005. As of 2021, this approach is being followed by Argentina, Brazil, Chile, Dominican Republic, Guatemala, Honduras, Jamaica, Saint Lucia, Mexico, Nicaragua, Panama, El Salvador, Trinidad & Tobago, and Uruguay.

Czech Republic, Estonia, Hungary, Poland, and Finland were the first countries in Europe and Central Asia to embrace the strategy of reducing sales, energy, CO2, VAT, and other taxes in 2004, followed by Romania in 2006. Although this strategy was adhered to in 2010 by Bulgaria, Belarus, the Czech Republic, Estonia, Hungary, Kyrgyz Republic, Latvia, Moldova, Poland, Romania, Slovenia, and Finland, only the Czech Republic and Slovenia are still doing so in 2021.

Since 2000, the Marshall Islands has pursued a policy in the East Asia and Pacific region that reduces sales, energy, CO2, VAT, and other taxes. Republic of Korea followed in 2004 and China in 2008, respectively. Following this approach in 2021 are Fiji, Indonesia, Republic of Korea, Philippines, and Vietnam.

Ethiopia was the first country in Africa in applying the policy of reduction in sales, energy, CO2, VAT, and other taxes in 2001. Following that, Ghana adopted this strategy in 2002, and as of 2021, Albania, Burkina Faso, Lesotho, Rwanda, and Seychelles have also done so.

3.2.7 The progress of tendering policies in different regions

This section covers the adoption of tendering or auctions policies in countries of different regions.

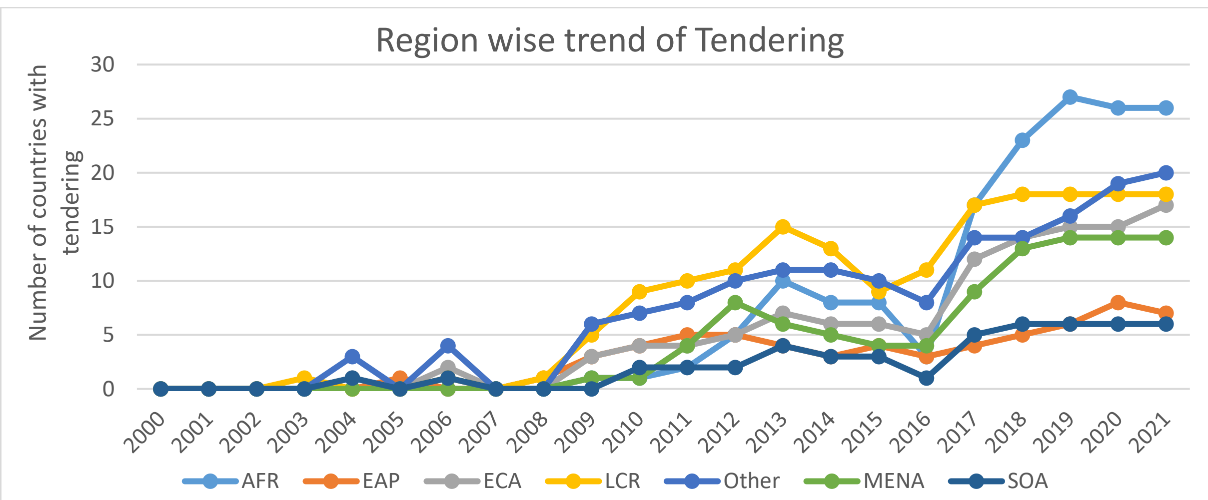


Figure 10: Region wise trend of the adoption of tendering.

India introduced the tendering strategy first in South Asia in 2004, followed by Nepal in 2010, and Bangladesh in 2014. As of 2021, this approach is being implemented in Afghanistan, Bangladesh, India, Sri Lanka, the Maldives, and Nepal.

In the other region, the policy of tendering was adopted by France, Ireland, and Norway in 2004, and then by Denmark in 2006. In 2009, Portugal, Israel, and Canada all followed this approach. As of 2021, this policy is being implemented in Andorra, American Samoa (U.S.), Belgium, Canada, Germany, Denmark, Spain, France, United Kingdom, Greece, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Singapore, and the United States of America.

Arab Republic of Egypt was the first country in the MENA region to adopt the tendering strategy in 2009, and Jordan, Morocco, and Syrian Arab Republic did so in 2011. This policy is being implemented in 2021 by the United Arab Emirates, Bahrain, Algeria, Arab Republic of Egypt, Iraq, Jordan, Kuwait, Lebanon, Morocco, Malta, Oman, Saudi Arabia, and Tunisia.

Chile was the first country in Latin America and the Caribbean to adopt the tendering strategy in 2003, and Argentina, Brazil, Mexico, Peru, and Uruguay did so in 2009. The following countries will implement this policy in 2021: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Panama, Peru, El Salvador, Suriname, and Uruguay.

Poland was the first country in the region of Europe and Central Asia to adopt the tendering policy in 2004, followed by Latvia in 2006 and Slovenia in 2009. Currently, in 2021, this policy is being implemented in Armenia, Bosnia and Herzegovina, Estonia, Croatia, Hungary, Kazakhstan, Lithuania, Latvia, Moldova, Montenegro, Poland, the Russian Federation, Slovakia, Slovenia, Turkey, Uzbekistan, and Finland.

Only China was the first country in East Asia and the Pacific to adopt the tendering strategy in 2005, followed by Mongolia and the Philippines in 2009. This rule was implemented in Indonesia in 2010. In 2021, this strategy is being implemented in Indonesia, Cambodia, Myanmar, Mongolia, Malaysia, the Philippines, and Vietnam.

Only South Africa was discovered to have implemented the tendering strategy initially in the African region in 2009, followed by Cabo Verde in 2011 and Burkina Faso, Côte d'Ivoire, and Lesotho in 2012. The following countries are now implementing this strategy in 2021: Albania, Burkina Faso, Botswana, Côte d'Ivoire, Ethiopia, Ghana, The Gambia, Kenya, Lesotho, Madagascar, Mali, Mozambique, Mauritius, Malawi, Niger, Nigeria, Rwanda, Senegal, Eswatini, Seychelles, Tanzania, Uganda, South Africa, Zambia, and Zimbabwe.

3.2.8 The progress of Public Investment policies in different regions

This section covers the adoption of public investments policies in countries of different regions.

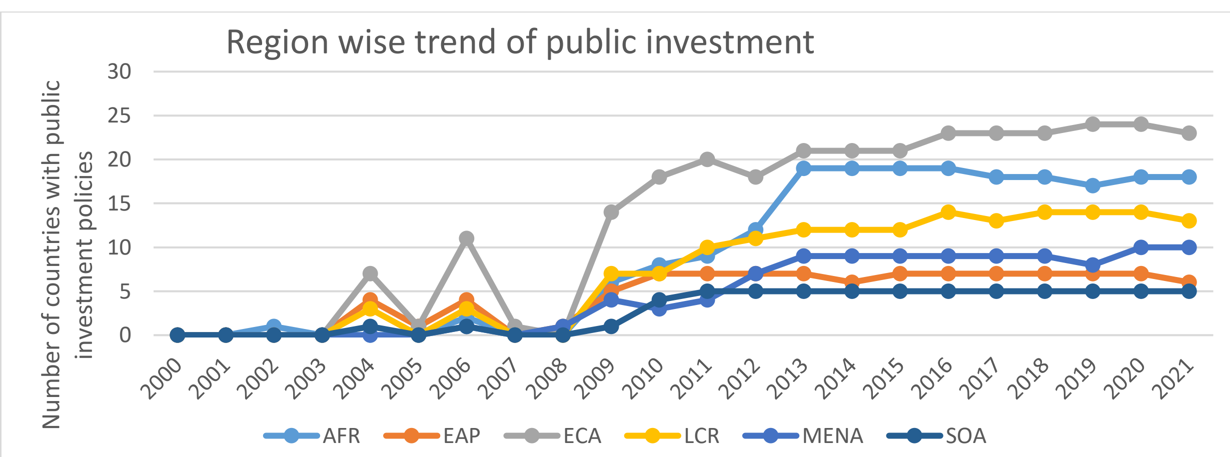


Figure 11: Region wise trend of the adoption of public investment.

India was the first country in South Asia to embrace public investment policies in 2004, and Bangladesh, Nepal, and Pakistan adopted them in 2010. As of 2021, this policy is being followed by Bangladesh, India, Sri Lanka, Nepal, and Pakistan.

Jordan, Morocco, and Malta all implemented public investment policies after Tunisia in the MENA region in 2009. United Arab Emirates, Bahrain, Algeria, Arab Republic of Egypt, Islamic Republic of Iran, Jordan, Lebanon, Morocco, Malta, and Tunisia are currently the only countries that adhere to this policy as of 2021.

Argentina, Brazil, and Chile were the first countries in Latin America and the Caribbean to implement public investment programs in 2004, followed by Mexico, the Dominican Republic, El Salvador, and Colombia in 2009. As of 2021, this approach is being implemented in Argentina, Bolivia, Brazil, Barbados, Chile, Dominican Republic, Haiti, Mexico, Nicaragua, Peru, El Salvador, and Uruguay.

First to implement the public investment program in the region of Europe and Central Asia were the Czech Republic, Hungary, Lithuania, Latvia, Poland, Turkey, and Finland in 2004, followed by the Russian Federation, Slovenia, and Slovakia in 2006. The countries that are currently implementing this policy are Armenia, Azerbaijan, Bulgaria, Belarus, Cyprus, Czech Republic, Estonia, Hungary, Kazakhstan, Kyrgyz Republic, Lithuania, Moldova, North Macedonia, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Tajikistan, Turkey, Ukraine, and Finland.

In East Asia and the Pacific, public investment policies were initially enacted in 2004 by Cambodia, Republic of Korea, Philippines, Thailand, China, and then Malaysia in 2009. In 2021, this policy is being implemented in Indonesia, Malaysia, the Philippines, the Republic of Korea, Thailand, and Vietnam.

Ghana was the first country in the African region to embrace public investment plans in 2002, and Uganda and South Africa followed in 2006. Angola, Albania, Botswana, Ghana, Kenya, Lesotho, Mali, Mauritius, Malawi, Namibia, Rwanda, Seychelles, Tanzania, Uganda, South Africa, Zambia, and Zimbabwe are now adhering to this policy, which was also adopted by Botswana, Ethiopia, Lesotho, Mozambique, Nigeria, Tanzania, and Zambia in 2021.

3.2.9 Carbon Credits

A carbon credit represents 1 tonne of CO2e that an organization is permitted to emit, and this is a policy instrument that can operate in a country where there is a cap and trade policy (Corporate Finance Institute, 2024). Carbon credits indirectly promote renewable energy, as generating emission free electricity can reduce the carbon footprint of an organization, and thereby limit or avoid penalty. Only few countries have national level carbon markets or carbon emission trading system, and some countries have this at the sub national level. Each country adopting this policy has set a price for carbon emissions, and in countries with sub-national policies, the prices can vary by province or state (Letourneau, 2023). There are forty seven countries with carbon prices in the world, and thirty six subnational entities. Carbon pricing can be implemented through carbon taxes or through the emission trading system or carbon market. Bangladesh has not yet implemented policies related to carbon taxes or emission trading systems.

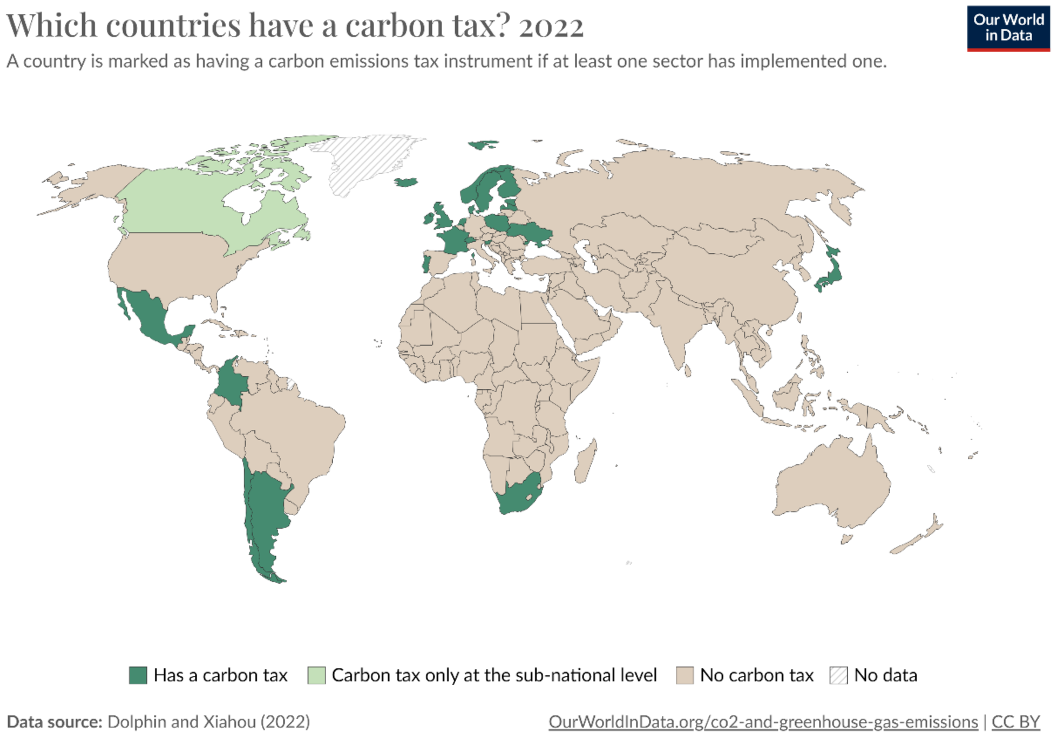


Figure 12: Countries with a carbon tax

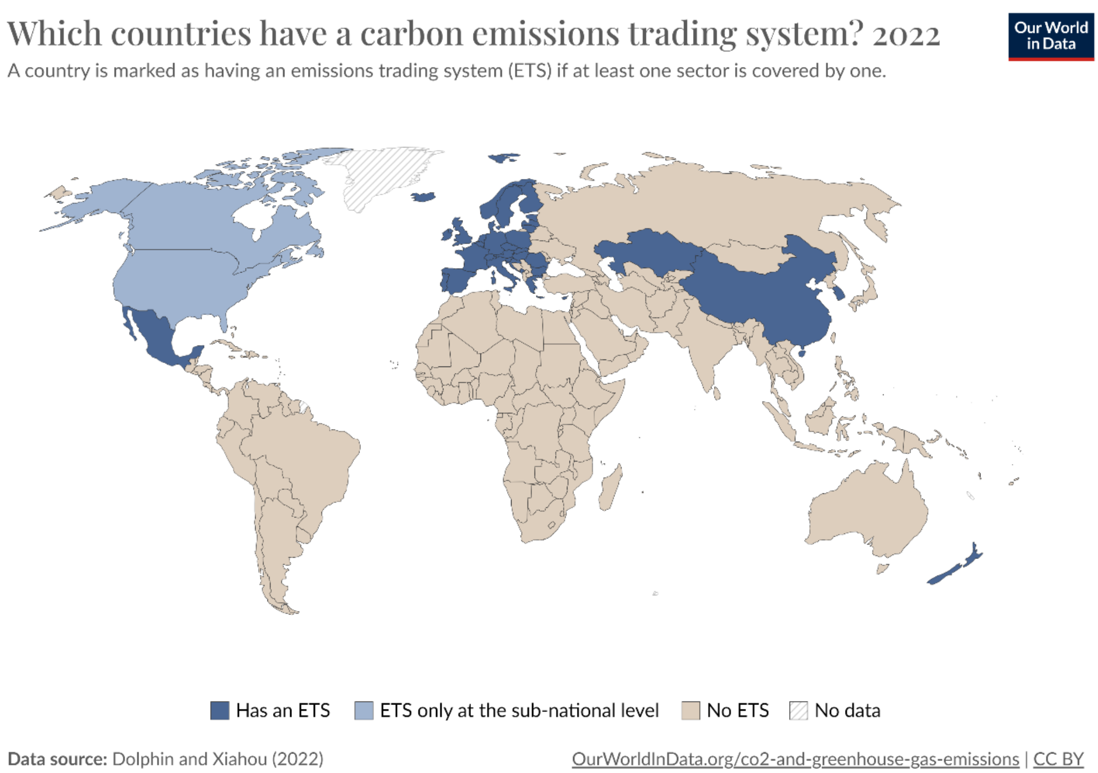


Figure 13: Countries with a carbon emission trading system.

The following section shows the progress of investment in solar energy capacity and electricity generation. Data is obtained from (IRENA, 2022)

3.2.10 The progress of Public Investment policies in different regions

This section shows the growth in the installed capacities and generations from renewables in different global regions.

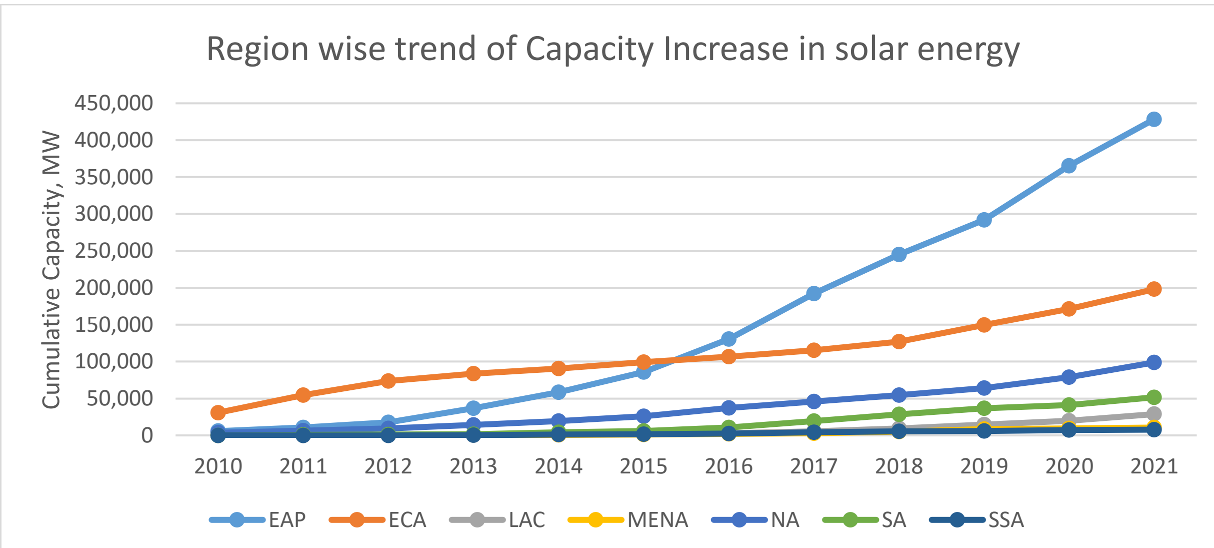


Figure 14: Region wise trend of increase in solar energy capacity.

South Africa, with a capacity of 6221.095 MW, has the highest growth rate among all the Sub-Saharan African nations as of 2021, and it also has the highest capacity. Congo, Rep, on the other side, will have the lowest capacity in 2021 with 0.72 MW.

India has the biggest capacity in the South Asian region in 2016, and its growth rate has also been shown to be the highest. Afghanistan and the Maldives were found to have the lowest capacities. Additionally, Bangladesh's capacity growth rate has been determined to be modest.

The United States has the largest capacity (95208.513 MW) and growth rate in the North American region as of 2021. Canada's capacity growth rate has also been shown to be favorable.

United Arab Emirates has the highest capacity and growth rate among all the nations in the MENA region. Qatar, on the other hand, has the lowest capacity (5.1 MW) and has weak growth.

Chile has the biggest capacity (4468.277 MW) and the highest growth rate in the region of Latin America and the Caribbean. Paraguay, on the other hand, has the lowest capacity (0.057 MW) and the weakest growth rate as of 2021. Additionally, Haiti's capacity has been discovered to be inadequate.

Italy has the largest capacity (22698.11 MW) and Azerbaijan has the lowest capacity (40.1 MWh) in the region of Europe and Central Asia in 2021. However, Kazakhstan and the United Kingdom both have adequate capacity growth rates.

China has the largest capacity found in 2021, and it is 306,972.8 MW, in the East Asia and Pacific area. Malaysia was found to have the highest rate of capacity expansion. But out of all the nations in this region, Papua New Guinea has the smallest capacity.

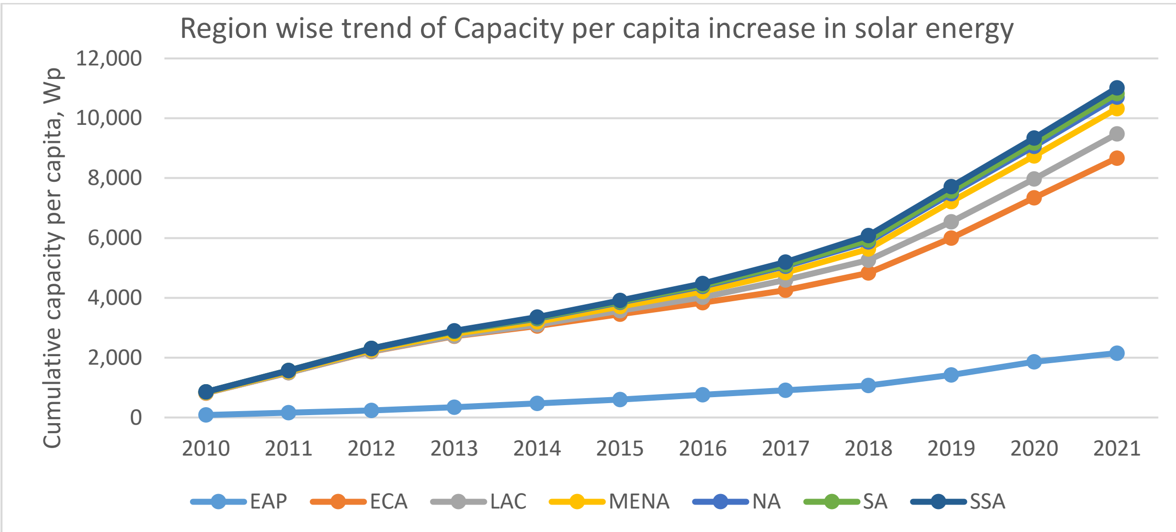


Figure 15: Region wise trend of increase in solar energy capacity per capita.

The maximum capacity per capita in Sub-Saharan Africa was found to be 104.74 Wp in South Africa in 2021, and its growth rate was also found to be the highest. The lowest capacity per capita increase was observed in Chad in 2021, on the other hand. Mauritania's capacity per capita growth rate is also respectable.

Maldives has the highest capacity per person identified in the South Asian region in 2021, and it is 59.07 Wp. Afghanistan has the slowest growth rate while India has the fastest.

The United States has the highest capacity per capita (282.52 Wp) and highest growth rate in the North American region. Canada has the lowest capacity in 2021.

In MENA region, Israel has the highest capacity per capita (287.11 Wp) and its growth rate is also good. United Arab Emirates has the second highest capacity per capita increase (275.24 Wp) and its growth rate has been found to be the highest. On the other hand, Qatar has the lowest capacity per capita.

Chile has the largest capacity per capita in Latin America and the Caribbean, at 229.22 Wp, and it also has the highest growth rate. However, with only 0.228 Wp, Haiti has the lowest capacity per capita among the nations in this region.

The Netherlands has the largest capacity per capita in Europe and Central Asia, with a capacity of 814.15 Wp, and a strong growth rate. Germany has the second-highest capacity per capita but the lowest growth rate.

Australia has the largest capacity per capita in East Asia and the Pacific, at 882.29 Wp, although its growth rate is modest. Out of all the nations in this region, Vietnam has the fastest pace of growth.

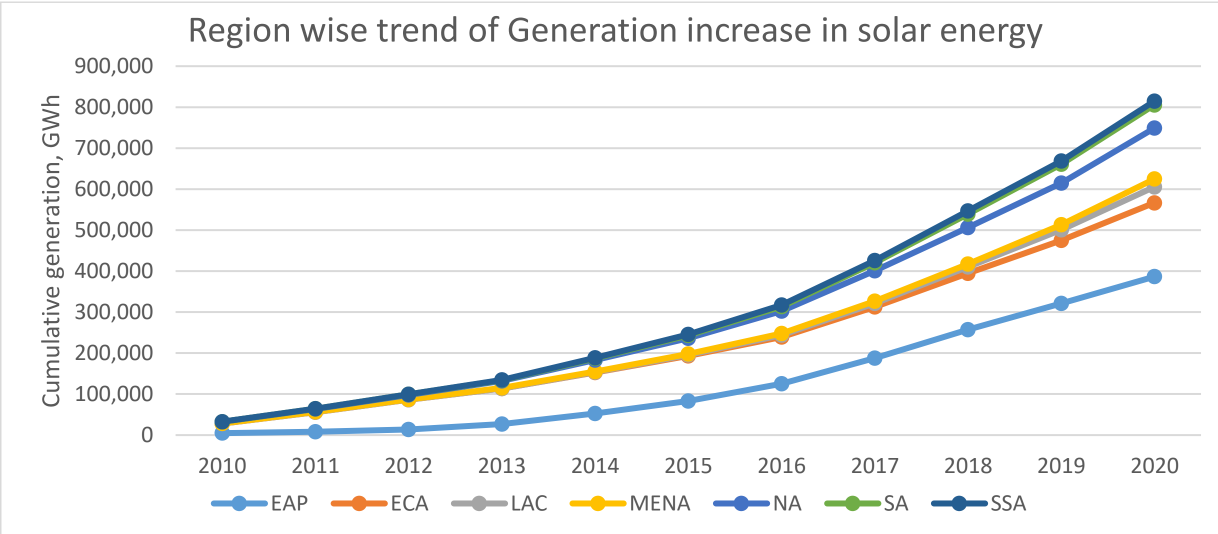


Figure 16: Region wise trend of increase in solar energy generation.

South Africa has the greatest generation in the Sub-Saharan African region, estimated to be 7587.43 GWh in 2020, as well as the highest growth rate. Chad, however, has the least amount of generation (0.38 GWh). Senegal also has a healthy rate of generational growth.

India has the greatest generation in the South Asian region as of 2020, with 54666.197 GWh, and its growth rate is also considered to be acceptable. Bangladesh has the lowest generational growth rate of any nation in this region.

In comparison to the other countries in the North American region, the United States has the greatest generation, with a projected output of 119,329 GWh in 2020. The generational growth rate is lowest in Canada, on the other side.

In MENA region, United Arab Emirates has the highest generation and it is 5484.693 GWh in 2020, growth rate is also high. But, Algeria has the highest growth rate in generation among the countries in this region. Qatar has the lowest growth.

Mexico has the highest generation in Latin America and the Caribbean, with a 2020 output of 13527.61 GWh. The lowest generation and growth rates are found in Paraguay. Brazil has been shown to have the highest growth rate of any nation in this region.

In Europe and Central Asian region, Italy has the highest generation found in 2020 and it is 24953.979 GWh but the growth rate has been found to be low. Growth rate of Romania and France are good enough and Uzbekistan has the lowest generation.

China has the highest generation in East Asia and the Pacific in 2020, at 261659.011 GWh, with an inadequate growth rate. However, Vietnam has the second-highest generation and a rapid rate of economic expansion.

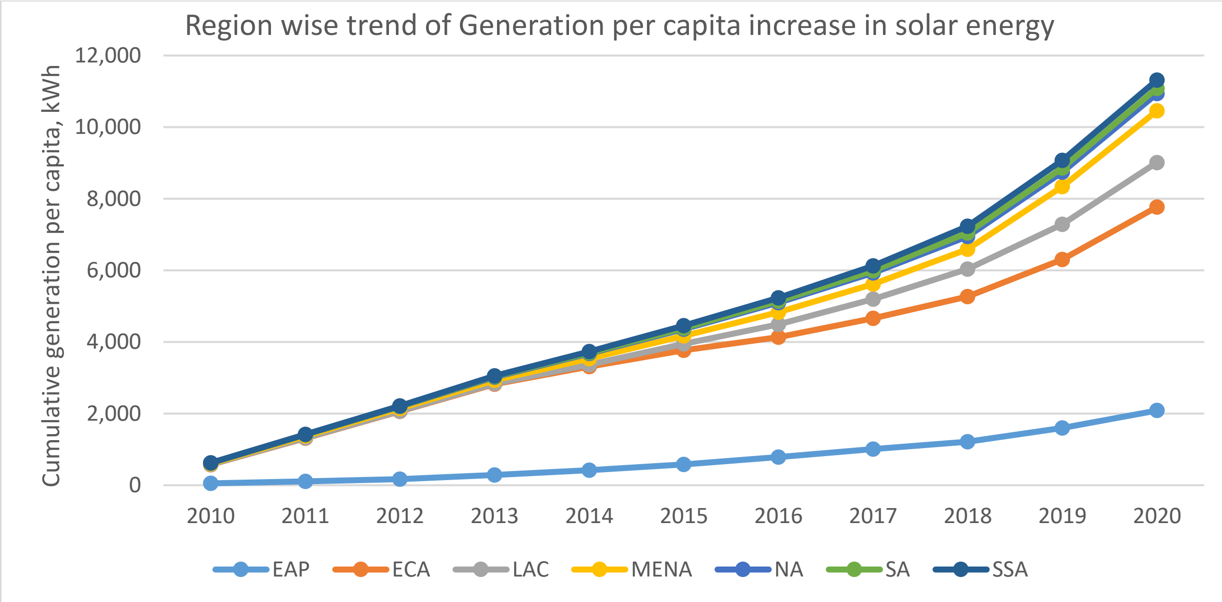


Figure 17: Region wise trend of increase in solar energy generation per capita.

In the Sub-Saharan African area, South Africa's generation per capita was found to be the greatest in 2020, at 129.03 kWh, and its growth rate was also the highest. However, of all the nations in this region, Chad has the lowest generation per capita.

In South Asian region, Maldives has the highest generation per capita found in 2020 and it is 77.86 kWh, its growth rate is also found be highest. But, Afghanistan has the lowest generation per capita and its growth rate has been found to be lowest too.

The United States has the largest generation per capita in the North American region in 2020, at 355.20 kWh, and it is also seeing the most growth. Canada has the lowest generation per capita, on the other hand.

United Arab Emirates, with a generation per capita of 590.56 kWh in 2020, has the highest generation in the MENA area. Its growth rate is also the greatest. Qatar, on the other hand, has the lowest growth rate and the lowest generation per capita.

In Latin America & Caribbean region, El Salvador has the highest generation per capita in 2020 and it is 144.37 kWh and its growth rate has been found to be highest too. On the other hand, Haiti has the lowest generation per capita found among all the countries in this region.

In Europe and Central Asian region, Germany has the highest generation per capita found in 2020 and it is 583.72 kWh, but it has a low growth rate. On the other hand, Serbia has the lowest growth and lowest generation per capita.

Australia has the highest generation in the East Asia and Pacific region as of 2020, at 819.36 kWh, with a good growth rate. However, it has been discovered that China has the fastest growth rate in this area. The lowest generation per capita is in Indonesia, where it is only 0.65 kWh.

3.2.11 Summary

The analysis of policy adoption and renewable electricity installed capacity and generation has shown that all regions have been steadily adopting renewable energy supporting policies, and have also seen a growth in the installation and generation from renewable energy. However, it can be seen that the adoption of different policies reaches a saturation point in almost all regions and for all policies. This indicates that the different policies have reached a mature stage. On the other hand, the increase in installed capacity or generation from renewables has not reached a saturation point, or does not seem to be declining. Instead, it can be seen that the growth rate has taken an exponential turn, especially in the last five years. Therefore, it can be surmised that most countries now support renewables through policies, but other factors also play a role in the growth of the industry. These can include the improvement in the renewable energy technology in terms of increased efficiency and cost reduction, and the improvements in the electricity infrastructure of countries. It can also be due to increasing costs of fossil fuels.

4. Analysis of Policy and Progress of Implementation in Bangladesh

According to data from SREDA (SREDA, 2023), Net metering policy was implemented and took effect from 2018 onwards. The rooftop system can be installed in two models- the OPEX (operational expenditure) model and the CAPEX (capital expenditure) model. The CAPEX model is managed by the owner who installs the system on their own property. The OPEX model system is operated by a third party on the rooftop of the consumer who buys the electricity from the third party, at a lower rate, under a bilateral contract. The amount of installation is not equal in every year, with high levels of overall installations in 2019 and 2022, when the greatest amounts came from net metering. Moreover, there is not an increasing trend of either net metering based solar rooftop installation nor of solar rooftop overall (figure 18).

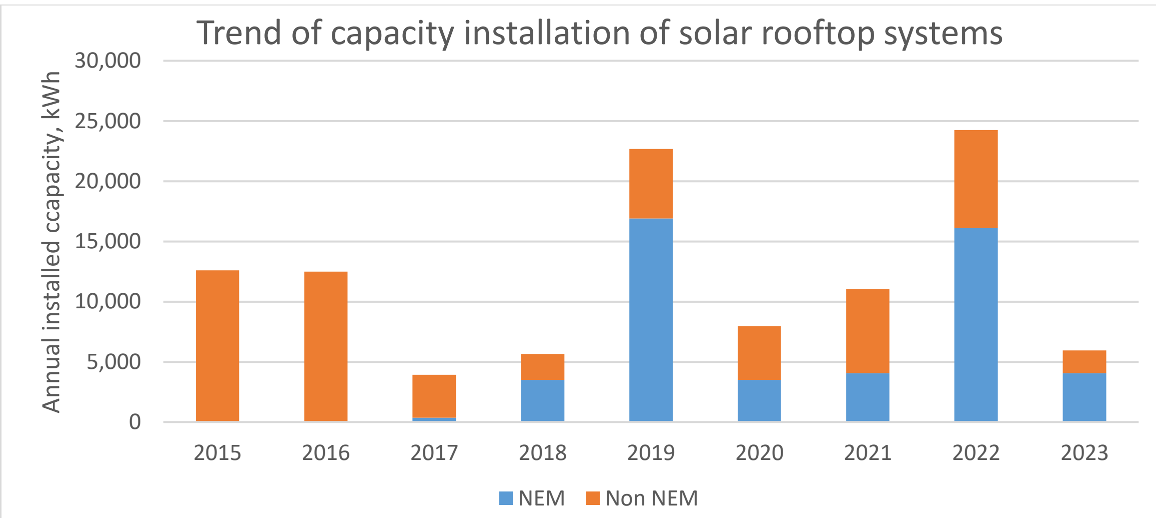


Figure 18: Annual installation capacity of solar rooftop systems in Bangladesh.

The amount of cumulative generation matches the levels of capacity installation, but the amount of generation is greater from the net metering based solar rooftop than the other ones. From the year 2018, it is seen that the amount of net metering PV capacity installed is proportionately less than the amount of electricity generated from PV systems (figure 19). This shows that if a PV based rooftop system is installed to the grid through net metering, there is overall more electricity generated from that system, compared to a system, which is not connected by net metering. In keeping with the electricity generation, the amount of carbon abatement is also greater from net metering systems than from systems, which hare not connected through that policy (figure 20). Therefore, it can be concluded that the net metering policy plays a significant role in promoting climate goals by reducing CO2 emissions.

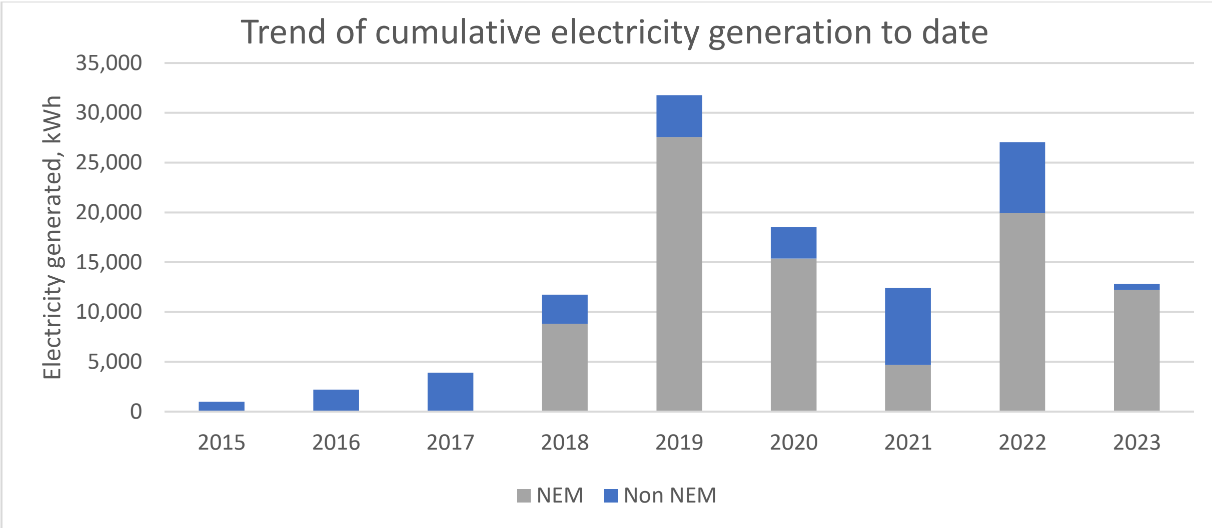


Figure 19: Annual cumulative electricity generation of solar rooftop systems in Bangladesh.

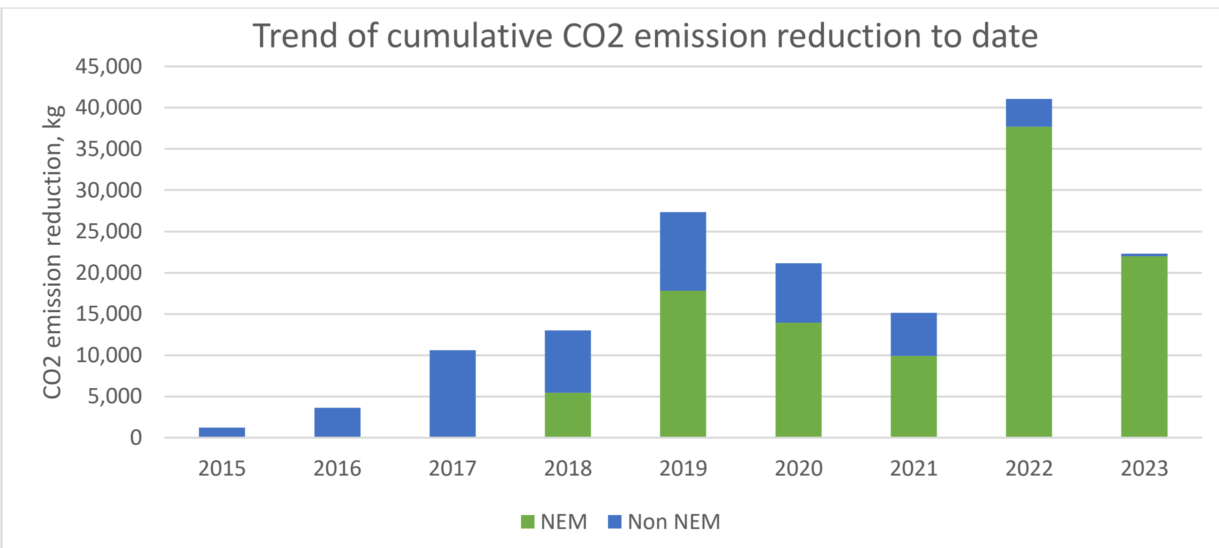
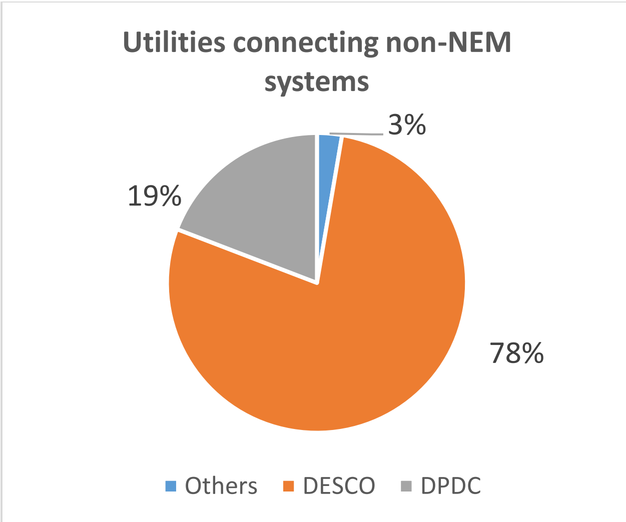


Figure 20: Annual CO2 emission reduction from solar rooftop systems in Bangladesh.

Next there will be a review of the characteristics of net metering (NEM) and non-net metering (non-NEM) systems.

Next graph (figure 21) presents the pattern of grid connection according to utilities. It can be seen that most of the non-NEM systems are connected to the grid by DESCO, followed by DPDC. This indicates that most of the grid connected systems are located in the capital region, and not to even other urbanized or economically active areas. There should be an effort to extend the installment of grid connected rooftop systems to other regions of the country. Among NEM systems, almost all are connected to the grid through BREB. This is because majority of the industries are out of city area and thus the consumer of BREB.



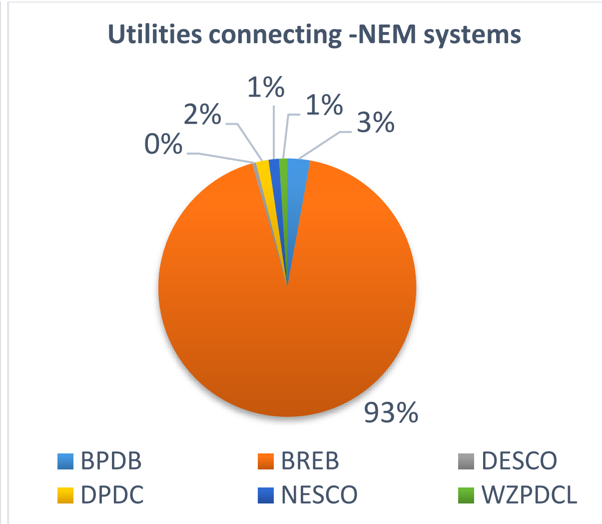


Figure 21: utilities connecting non-NEM and NEM systems.

Next, there is a review of the sources of financing of non-NEM systems (figure 22). It can be seen that most of the non-NEM systems are self-financed, with a small number being financed by IPPs or the government. This indicates that providing financing can promote the proliferation of solar rooftop systems. In the case of NEM systems, most are self-financed. This reveals that this policy of net metering is not directly financed by the usual financial institutions.

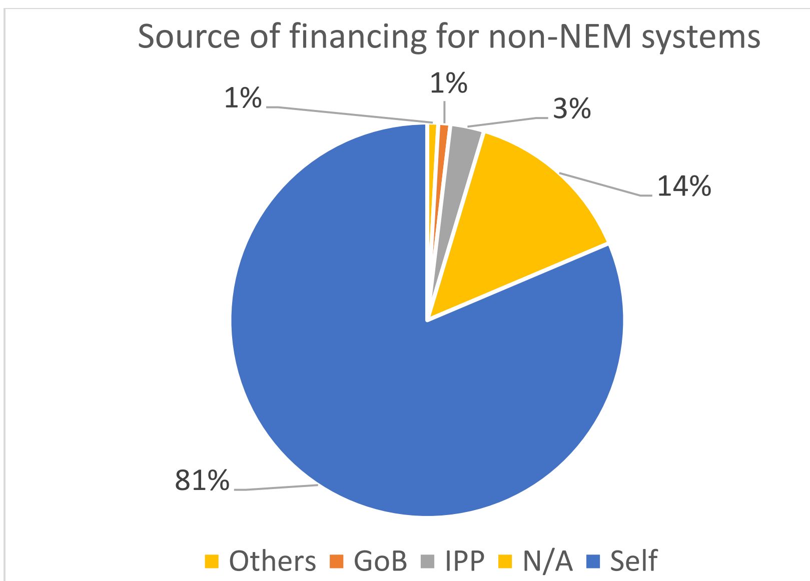


Figure 22: Financing sources of non-NEM.

5. Analysis of the performance of a sample of solar PV rooftop systems

This section will cover the performance of a sample of solar rooftop plants in Bangladesh, and how the electricity production varies with the insolation in those areas. For the purpose of confidentiality, the actual names of the rooftop systems have not been disclosed. Systems of different sizes are taken, ranging from small system of less than 1 MWp, to a large system of more than 8MWp. In each system, there are data loggers which record the insolation in that spot, and the power output of that system in 30 minute slots. The systems have different ages, and so for some new systems, six months of data is available, and for older systems, one and half years of data is available. Table 5 shows the performance features of the six systems. The average daily generation in the studied time period is calculated, and the standard deviation of this value. The number of low performance days is also calculated, as the number of days that the electricity generation is around one and a half standard deviations below average generation. The aim of this is to calculate the share of days that the system had very low productivity. Next, there was inquiry into how many

TABLE 5. Descriptive statistics of six solar PV rooftop systems analyzed for performance. [Time Frame]

System	Capacity (MWp)	Average daily generation (MWh)	Standard deviation of daily generation (MWh)	Standard deviation as % of average generation	Share of lost days (%)
S-1	3.556	8.08	4.22	52%	12.25
S-2	8.44	30.39	9.53	31%	2.33
S-3	0.682	1.97	0.68	35%	3.28
S-4	2.517	7.25	2.72	38%	6
S-5	2.66	8.75	2.9	33%	7.5
S-6	3.23	7.64	3.32	43%	6
Average	**3.51**	**10.68**	**3.895**	**36%**	**6.23**

In order to analyze the performance, first the power has been divided by capacity to find the power output per capacity, according to the following formula:

Power output per capacity = (Total power output/capacity)……………………………….(1)

This is done so that all the systems can be comparable. The irradiation is measured in W/m², and the total power output of a system is proportional to the insolation and the size of the system. However, as the system sizes are different, the power output is standardized by capacity to make them comparable. Next, the standardized power output is plotted side by side with the irradiation, in order to see where the power output is low despite a high level of irradiation.

We will examine the System 6 (s-6), as an example. The graph of standardized power output and irradiation is given in the following figure 23, showing the values day wise, for several days.

In the graph, the yellow represents the solar irradiation, and the purple represents the power generation. In each day, the irradiation and related power output first increases and then falls throughout the day. It can be seen in the graph that in some days, the peak has a larger yellow portion, indicating that the power generation has been lower compared to the insolation (labelled “A” in the graph). In other cases, where the purple color reaches close to the irradiation, it shows that power generation is high, in keeping with the radiation (point “B”). In some days, there is adequate irradiation, but there is no power generation (point “C”). This may be because of load shedding or closure of the system for maintenance or closure of the entire plant during a public holiday. Finally, in some days, there is low irradiation as well as low power generation (point”D”).

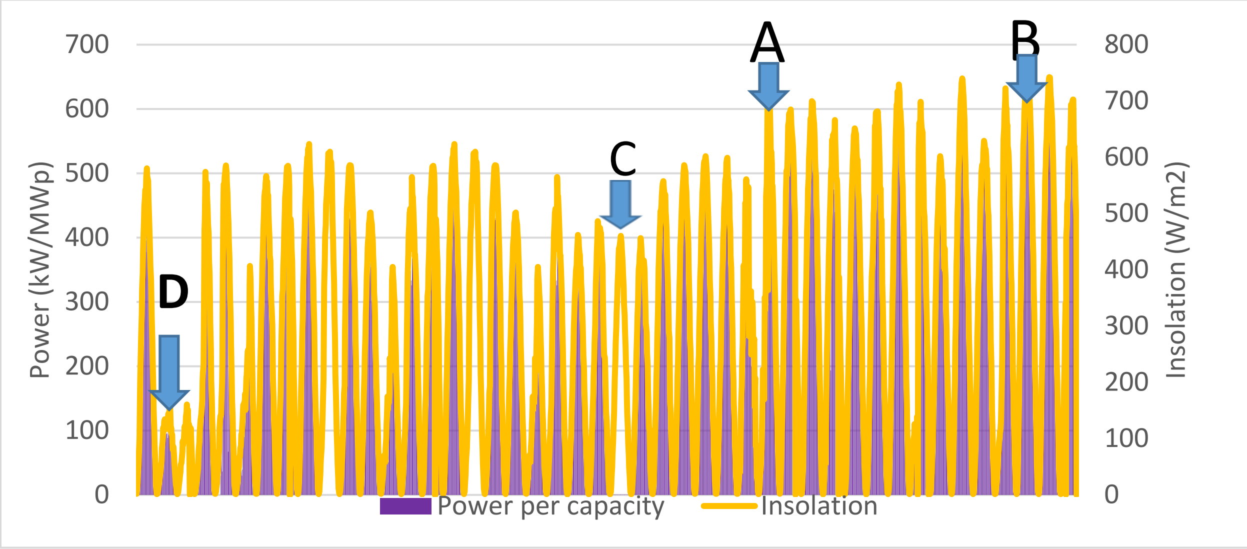


Figure 23: Comparison of power generation and solar irradiation in a sample rooftop system.

Reasons for low productivity despite high radiation are as follows:

1. System failure: Hybrid controller communication failure, if there is damage in the control cable.
2. Load scheduling: Where there is an interruption in the grid connection by the utility.
3. Deliberate shutdown of inverter: This is due to technical problems with the power system.
4. System maintenance: The system is deliberately shut down for maintenance.
5. Holiday shutdown: During holidays, there is a switching off of the system during long holidays when the office is completely closed.
6. Lack of cleaning and maintenance: Dust accumulates on top of the solar panels, resulting in lower generation.

In general, the biggest cause is lack of cleaning and maintenance. Next is system failure, load scheduling. Deliberate shutdown happens in some systems and not others. System maintenance occurs once or twice a year. Holiday shutdown occurs five days during each Eid holiday.

6. Survey among Rooftop Investors

This section covers an in-depth interview-based survey of twenty-one solar PV rooftop investors whose systems are under net metering. The rooftop systems are chosen from different locations of the country, and from industrial firms in different sectors, with different types of core businesses, including agribusiness, textiles, technology, heavy industry etc. The sizes of the systems range from 0.15 MW to 8.4 MW. The ages of the systems range from 4 months to more than three years. All of them are connected to the grid by BREB, except one, which is connected by WZPDCL. Four are funded by IDCOL, four are on rental basis or funded by the EPC, and the rest are self-financed. The CAPEX model systems are financed by the EPC. Only one has a hybrid business model of CAPEX and OPEX, and the others all operate on OPEX or CAPEX model. One firm has a build, own operate and transfer model (BOOT). All the systems are placed on the factory shed. The survey questionnaire is given in appendix 2.

When asked about the motives for installing the rooftop system, most reported that the motive is to reduce cost, self-consumption, reduce emissions, and few firm reported multiple motives including compliance with business standards, self-consumption and selling to the grid and reducing cost and emissions. One firm reported that the motive was compliance only. All the systems have installed capacities which are lower than the sanctioned load of the firm. All except one firm had an installed capacity which was around 70% of the sanctioned load, and only one firm had a system which was 33% of the sanctioned load. However, almost all the firms reported that they would like to increase the size of the system to as big as possible, as the premises allow. Most have also not faced any grid upgrade costs when installing the systems. All the firms reported to have a high knowledge about solar PV systems. Only one firm has upgrade cost of BDT six hundred thousand, and another an upgrade cost of BDT fifty million.

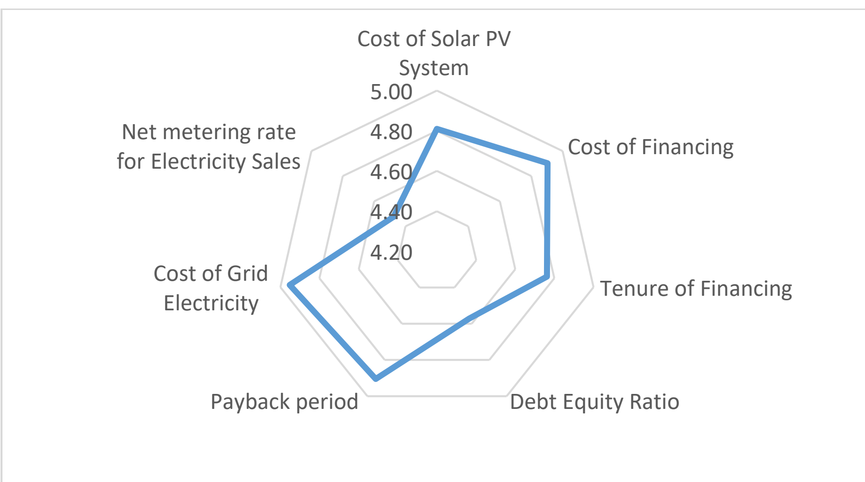


Figure 24: Importance of solar rooftop cost features.

When looking at the importance of the cost features of the solar rooftop systems (figure 24), it was found that the most important cost features were the cost of the PV system, the cost of financing, the payback period and the current rate of grid electricity. This concurs with the stated motive for installing the rooftop system, which was to reduce electricity cost. In contrast, the net metering rate was not considered very important, nor was the debt equity ratio required or the tenure of the financing.

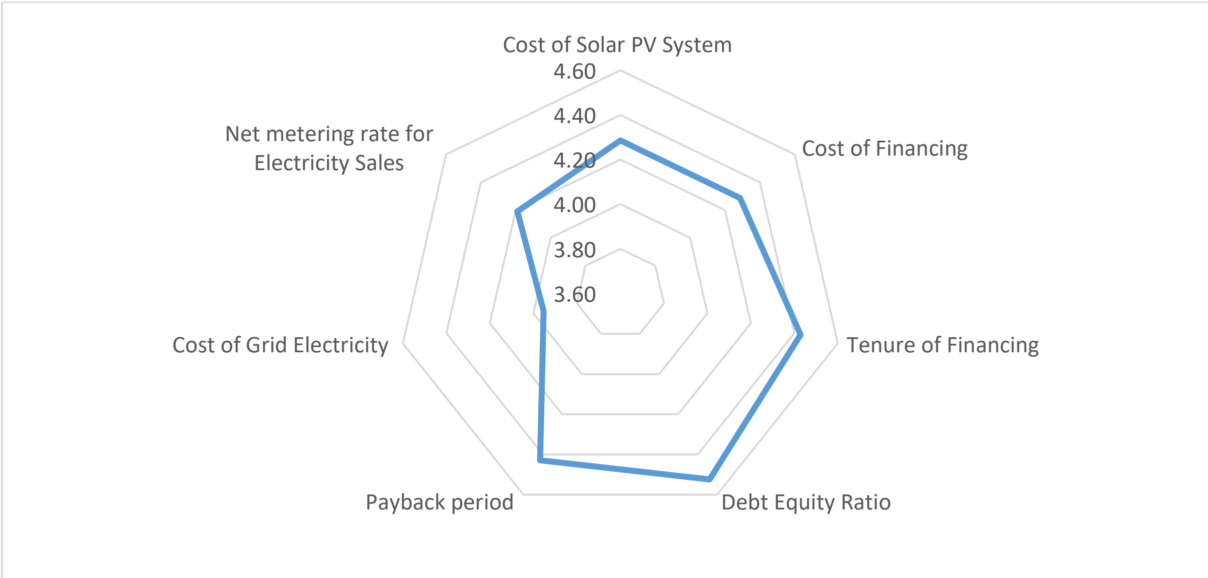


Figure 25: Investor satisfaction with solar rooftop cost features in Bangladesh.

The solar rooftop investors appear to have an overall very high satisfaction with the cost features of the industry (figure 25), including the cost of the systems itself, the cost and terms of financing, and the payback period. They are however much less satisfied with the cost of grid electricity, but the higher the dissatisfaction with grid electricity prices, the more will be the incentive to switch to solar PV rooftop. The investors would also like higher tariff rates for the NEM electricity sales.

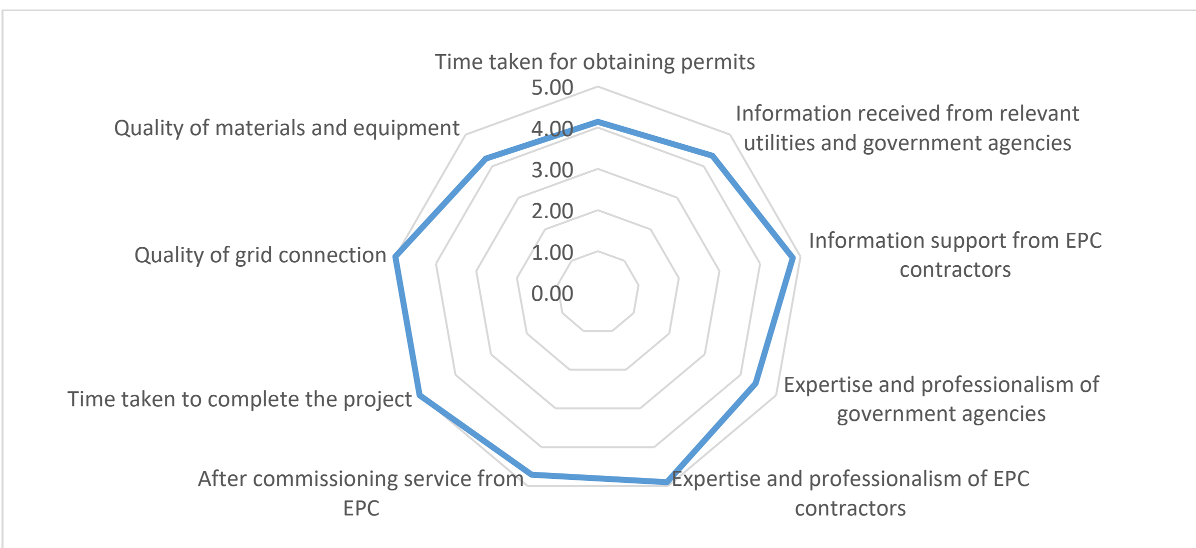


Figure 26: Importance of support services to solar rooftop investors.

With respect to the support services, the rooftop investors have considered some to be more important more than others (figure 26). The most important include quality of grid connection, and time taken to complete the project. Expertise and professionalism of the EPC contractors was considered highly important, and the information support from EPC contractors was considered very important.

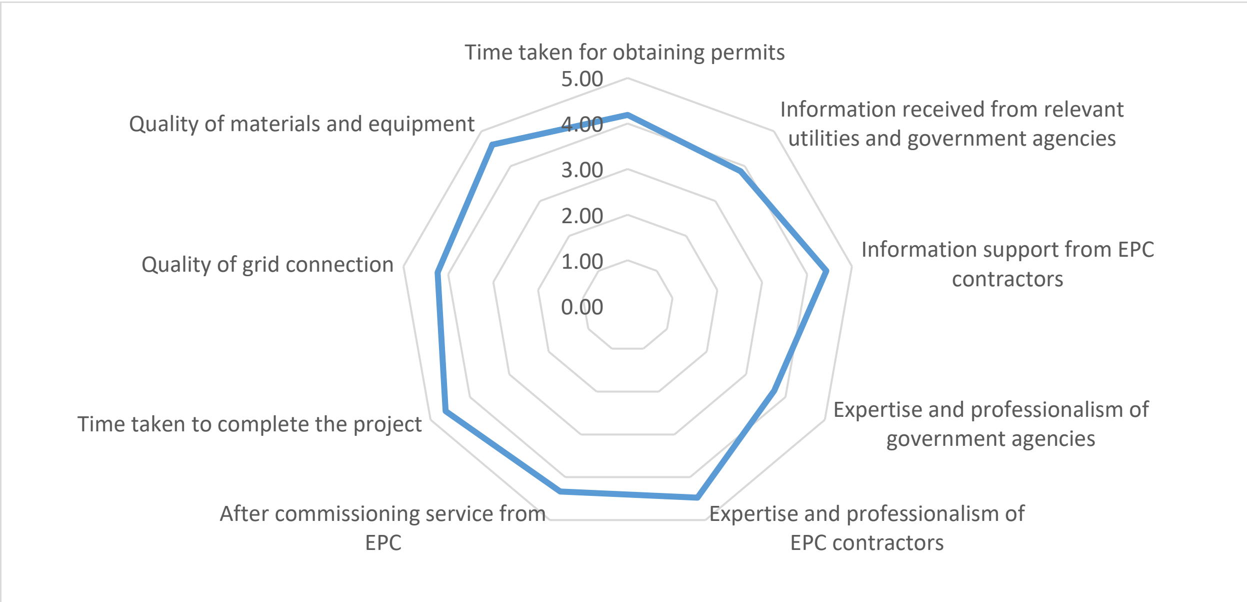


Figure 27: Satisfaction with support services to solar rooftop investors.

In comparison with the importance of these features, investors of rooftop systems appear to be satisfied with the conditions of the support systems available in Bangladesh (figure 27).

All the firms have satisfaction with the net metering scheme because it reduces cost. However, one reported that the service of the utilities is not so good, as people of the utility agencies are not cooperative. One firm said that solar systems reduce electricity cost, selling excess electricity to grid. In addition, they can reduce their factory shed internal temperature by fitting solar panel on roof top.

As for recommendations for improvement, it was reported that in the net metering scheme, SREDA should clearly describe the equipment enlistment regulations and also all the equipment should be enlisted and certified from BSTI before materials are release from port. It was also recommended that installation time should be reduced and annual settlement policy should be implemented. All firms reported they would recommend it to others, for reasons of low cost, sustainable energy and reduced emissions. Moreover, installation was recommended it the available area would enable self-consumption. One company recommended battery backup for smooth power supply. Most companies recommended reducing the installation and administrative time. One firm recommended permission be given to increase the limit above 10MW, and open access to single phase consumers.

7. Overview of a cost benefit analysis of solar rooftop systems under the Net Metering Policy

The cost of electricity from rooftop solar PV systems is much cheaper than the conventional grid electricity. Considering the present cost trends of solar equipment and concessionary financial facilities available in Bangladesh, the cost of electricity generated from rooftop solar PV systems can be 20~30% less when compared to the commercial tariff rates of utility electricity. This has the potential not only to reduce the average energy cost of the industry, but also bring down the overall consumption from the conventional sources of energy. Solar PV systems generally do not require heavy maintenance as they have no moving parts. Only regular cleaning of solar PV panels is necessary. The warranty periods of the major system components are quite long, e.g., the solar panel manufacturers give 25 years of output warranty, and the warranty for gird-tied solar inverters is 5~10 years. After covering the initial installation cost of the system, no major investment is required for maintenance and repair of the solar PV systems. Solar rooftop systems can be installed in two financial modes- CAPEX and OPEX. The cost benefit aspects of these two models to the solar rooftop investors are given as follows.

7.1 OPEX model

The solar OPEX model is increasingly becoming popular as an operating model globally. In this model, a third-party investor, technology provider or OPEX operator (often called an energy service company (ESCO) or renewable energy service company (RESCO)) makes the capital investment for the Solar PV system installation on the factory roof. A Power Purchase Agreement (PPA) is signed between the technology provider and consumer under which the consumer agrees to purchase the generated output from the solar PV system at a certain pre-agreed tariff during the PPA tenure, and also agrees to give site access rights to the investor for operation and maintenance of the plant. Under OPEX, there is the BOOT (Built-Own-Operate-Transfer) and the BOO (Built-Own-Operate) model

In the BOOT model, the OPEX operator is responsible for design, installation, finance, operation and maintenance of the solar plant for a certain agreed period (the PPA tenure). The consumer usually purchases the entire generated electricity from the rooftop solar PV system during such a period at a pre-agreed tariff. Afterwards, the OPEX operator transfers the fully operational plant to the consumer (free of cost or at a certain pre-agreed price), who continues enjoying solar energy almost free of cost for the rest of system's life (only needs to bear the O&M cost and some replacement cost). The OPEX operator can be engaged for O&M of the plant under a long-term service agreement or the consumer can develop his own O&M team. Tariff charged by the OPEX operator in this model is usually less than the grid electricity tariff. From the consumer's perspective, it is important to ensure that the plant uses proven equipment so that it runs efficiently during its entire operational life.

The major difference between the BOOT and BOO models is that there is no transfer of ownership from the OPEX operator to the consumer and the operator continues owning and operating the plant throughout the plant's life. However, there can be early exit clauses in the PPA which gives the consumer the option to take over the plant at any time during the PPA tenure by paying a certain compensation amount to the operator.

For the BOO model, it is beneficial for the consumer to enter into a long term PPA (usually 20 years or for the entire operational life of the plant) to get the lowest possible tariff. Also, it is less important to worry about the quality of equipment or the services or the operation and maintenance requirement, as the consumer will only pay per kWh of electricity consumption.

In both the BOOT and BOO models, tariff rates can widely vary based on a number of parameters i.e. PPA tenure, transfer price options, available financing terms from lenders, etc. In its simplest form, the tariff can be fixed for the entire PPA tenure. It can also have a fixed escalation provision (annually or after some other predefined interval). Sometimes the tariff is also linked with the utility tariff (usually a certain percentage lower than the utility tariff).

7.1.1 Project cost of OPEX system (considering 1 MWp system)

There are many variable factors that determine the project cost. The cost of module mounting structure varies depending on the installation area (ground mounted or rooftop system). The cost of the mounting structure also varies depending on the type of roof (RCC or Metal Industrial Shade). The efficiency of the solar PV module, the load profile of the consumer, captive generation, project capacity, equipment brand and country of origin/manufacturing etc. are also important factors that play a vital role in the project cost.

The area requirement for installing one Megawatt (peak) of solar PV panels is approximately 6,000 square meters. It may vary according to the pattern of the roof (roof tilt, roof orientation etc.). The unit panel size is in general 2.2 meters by 1 meter and the capacity of each panel varies according to the efficiency of the solar PV cells. At present, 600Wp to 700 Wp panels are available in the market. An approximate cost estimation of a 1 MWp grid tied rooftop solar PV system with standard equipment is given below in table 6 [The project cost reference has been taken from recently approved rooftop solar PV projects of similar size in Bangladesh]:

TABLE 6. Cost assumptions for a 1MWp grid tied rooftop PV OPEX system with standard equipment.

Project cost components	***Price (BDT)***	***% of project cost***	***Unit Cost***
Solar PV Module (1 MWp), Product and output warranty: 25 years	*14,000,000*	*34.15%*	*BDT 41/ Wp*
Module Mounting Structures	*8,200,000*	*20.00%*	
Solar Grid connected Inverter	*6,000,000*	*14.63%*	
Hybrid/Fuel Save controller for PV-Generator-Grid	*800,000*	*1.95%*	
Monitoring & Communication System	*500,000*	*1.22%*	
Energy Meter	*100,000*	*0.24%*	
Cleaning system and cable trays	*1,200,000*	*2.93%*	
Combiner Box	*600,000*	*1.46%*	
Earthing/Lightning protection, with High voltage, 500KV cable and maintenance free chemical earthing	*1,000,000*	*2.44%*	

Cables and Connectors (UV protected)	*4,500,000*	*10.98%*	
Spares	*500,000*	*1.22%*	
Service walkways	*600,000*	*1.46%*	
Safety Equipment for O&M	*500,000*	*1.22%*	
Transportation, Installation & Interconnection, Commissioning	*1,000,000*	*2.44%*	
Design & Consultancy	*800,000*	*1.95%*	
Legal & Other costs	*400,000*	*0.98%*	
Environmental Consultancy	*300,000*	*0.73%*	
Total Project Cost	***41,000,000***	***100%***	

7.1.2 Annual Savings from adaption of OPEX Model (for 1 MWp solar PV system)

The table has been prepared considering the following assumptions:

- BOOT OPEX Model: Fixed tariff (8.00 taka) for solar PV electricity for 12 years. After that the full operational system will be transferred to the consumer at no cost and from then on the consumer will enjoy almost free electricity for rest of the project life.
- Grid tariff: BDT 9.75 [Small Industrial, Offpeak Tariff (50kW<Load<5MW),]
- Utility tariff escalation: 5% per year
- Project life: 20 years
- Specific energy yield: 1200 kWh/kWp/Year

Generation from solar PV system depends mainly on the following five parameters (but not limited to):

- **Location of the system**: Solar irradiance varies according to the geographic location. For example, in Bangladesh higher solar energy insolation is in the Chittagong and Rajshahi regions and lower solar insolation are in Panchagarh and Sylhet regions.
- **Quality of equipment:** Quality of equipment plays a vital role in energy yield of a solar PV project. Systems with good quality products has higher efficiency and lower ageing effect (performance degradation with time). On the other hand, Good quality products have higher prices. Very often the project developers ignore the quality of products and they go for cheaper products. Using of low quality products results in lower yield than the expected yield.
- **Orientation of the roof (Azimuth):** South facing roofs receive the highest solar irradiance whereas east, west and north facing roofs receive relatively lower solar irradiance.
- **Roof angl**e **(Tilt angle):** If the roof is not concrete roof (flat roof), then generally the solar PV panels are installed at an angle equal to the angle of the roof. The amount of solar irradiance depends on the angle of the roof (i.e. the angle of solar PV modules). With a tilt angle of local latitude (For Bangladesh it is between 21^{o} to 26^{o}) facing towards south receives the highest solar irradiance.
- **Availability of grid:** Almost all the rooftop solar PV systems are grid tied systems. The solar system can generate electricity only when there is solar radiation and the grid is present. During the load shedding hours or the outage hours for grid maintenance, the solar PV system cannot generate electricity.
- **Dusts on the solar panels:** Solar PV panels are keep in the open roof to get solar insolation. So, dusts accumulates on it. The panels needs to be cleaned on a regular basis. If dusts

accumulates on panels, it reduces the solar energy fall onto the solar cells and thus the output energy.

- **In optimum conditions:** south facing panels with tilt angle equal to local latitudes and no load shedding or grid outage and with premium quality products the annual energy yield can be as high as 1500 kWh/kWp/year. Here we have considered annual generation of electricity of the installed PV system 16.67% less than optimum conditions (as an example)]
- **Performance degradation of the PV system:** First year degradation 1%, after that 0.5% linear degradation each year. This value is guaranteed by the panel manufacturers.
- **Yearly maintenance cost**: It is considered to be 1% of the initial investment cost. Maintenance cost escalates at a rate of 5% per year. The maintenance cost is an approximate value from the market reference.

The savings from the system over the lifetime is elaborated in the following table 7.

TABLE 7. Net savings from a 1MW solar PV rooftop OPEX system over its lifetime.

Year	***Energy produced from PV systems (kWh/year)***	***Utility Energy Tariff (5% increase per year)***	***OPEX Rate***	***Gross savings from Utility bills (per unit)***	***Maintenance Cost (1% of project cost)***	***Net savings***
Y 1	*1,200,000*	*9.75*	*8*	*1.75*	*-*	*2,100,000*
Y 2	*1,188,000*	*10.24*	*8*	*2.24*	*-*	*2,658,150*
Y 3	*1,182,000*	*10.73*	*8*	*2.73*	*-*	*3,220,950*
Y 4	*1,176,000*	*11.21*	*8*	*3.21*	*-*	*3,777,900*
Y 5	*1,170,000*	*11.70*	*8*	*3.70*	*-*	*4,329,000*
Y 6	*1,164,000*	*12.19*	*8*	*4.19*	*-*	*4,874,250*
Y 7	*1,158,000*	*12.68*	*8*	*4.68*	*-*	*5,413,650*
Y 8	*1,152,000*	*13.16*	*8*	*5.16*	*-*	*5,947,200*
Y 9	*1,146,000*	*13.65*	*8*	*5.65*	*-*	*6,474,900*
Y 10	*1,140,000*	*14.14*	*8*	*6.14*	*-*	*6,996,750*
Y 11	*1,134,000*	*14.63*	*8*	*6.63*	*-*	*7,512,750*
Y 12	*1,128,000*	*15.11*	*8*	*7.11*	*-*	*8,022,900*
Y 13	*1,122,000*	*15.60*	*0*	*15.60*	*736,301*	*16,766,899*
Y 14	*1,116,000*	*16.09*	*0*	*16.09*	*773,116*	*17,180,534*
Y 15	*1,110,000*	*16.58*	*0*	*16.58*	*811,772*	*17,586,478*
Y 16	*1,104,000*	*17.06*	*0*	*17.06*	*852,361*	*17,984,639*
Y 17	*1,098,000*	*17.55*	*0*	*17.55*	*894,979*	*18,374,921*
Y 18	*1,092,000*	*18.04*	*0*	*18.04*	*939,728*	*18,757,222*
Y 19	*1,086,000*	*18.53*	*0*	*18.53*	*986,714*	*19,131,436*
Y 20	*1,080,000*	*19.01*	*0*	*19.01*	*1,036,050*	*19,497,450*
Total	**22,746,000**				**7,031,019**	**206,607,981**

According to the analysis, accumulated (cumulative) net savings in electricity bills in the project life (in 20 years) for OPEX (BOOT) model is BDT 206,607,981.

7.2 CAPEX model

7.2.1 Project cost of OPEX system (considering 1 MWp system)

There are many variable factors that determine the project cost. The cost of module mounting structure varies depending on the installation area (ground mounted or rooftop system). The cost of mounting structure also varies depending on the type of roof (RCC or Metal Industrial Shade). The efficiency of the solar PV module, the load profile of the consumer, captive generation, project capacity, equipment brand and country of origin/manufacturing etc. are also important factors that play a vital role in the project cost. The area requirement for installing one Megawatt (peak) of solar PV panels is approximately 6,000 square meters. It may vary according to the pattern of the roof (roof tilt, roof orientation etc.). The unit panel size is in general 2.2 meters by 1 meter and the capacity of each panel varies according to the efficiency of the solar PV panels. At present, 600Wp to 700 Wp panels are available in the market. An approximate cost estimation of a 1 MWp grid tied rooftop solar PV system with standard equipment is given below in table 8. [The project cost reference has been taken from recently approved rooftop solar PV projects of similar size in Bangladesh]:

TABLE 8. Cost assumptions for a 1MWp grid tied rooftop PV CAPEX system with standard equipment.

Project cost components	***Price (BDT)***	***% of project cost***	***Unit Cost***
Solar PV Module (1 MWp), Product and output warranty: 25 years	*14,000,000*	*34.15%*	*BDT 41/ Wp*
Module Mounting Structures	*8,200,000*	*20.00%*	
Solar Grid connected Inverter	*6,000,000*	*14.63%*	
Hybrid/Fuel Save controller for PV-Generator-Grid	*800,000*	*1.95%*	
Monitoring & Communication System	*500,000*	*1.22%*	
Energy Meter	*100,000*	*0.24%*	
Cleaning system and cable trays	*1,200,000*	*2.93%*	
Combiner Box	*600,000*	*1.46%*	
Earthing/Lightning protection, with High voltage, 500KV cable and maintenance free chemical earthing	*1,000,000*	*2.44%*	
Cables and Connectors (UV protected)	*4,500,000*	*10.98%*	
Spares	*500,000*	*1.22%*	
Service walkways	*600,000*	*1.46%*	
Safety Equipment for O&M	*500,000*	*1.22%*	
Transportation, Installation & Interconnection, Commissioning	*1,000,000*	*2.44%*	
Design & Consultancy	*800,000*	*1.95%*	
Legal & Other costs	*400,000*	*0.98%*	
Environmental Consultancy	*300,000*	*0.73%*	
Total Project Cost	***41,000,000***	***100%***	

7.2.2 Annual Savings from the Investment:

The project cash flow table below has been prepared considering the following assumptions (Current market prices of similar types of rooftop solar PV projects):

- Financial assumptions: Loan equity ratio 80:20. Interest rate 6%, Loan tenure 10 years with a grace period of 1 year. No return on equity is considered rather net savings of the investor has been shown.
- Tariff of electricity: BDT 9.75 [Small Industrial, Offpeak Tariff (50kW<Load<5MW)].
- Tariff Escalation: 5% per year [considering the previous year's tariff trend of the country]
- Project life: 20 years
- Specific energy yield: 1200 kWh/kWp/Year

Generation from solar PV system depends mainly on the following five parameters (but not limited to):

- **Location of the system:** Solar irradiance varies according to the geographic location. For example, in Bangladesh higher solar energy insolation is in the Chittagong and Rajshahi regions and lower solar insolation are in Panchagarh and Sylhet regions.
- **Quality of equipment:** Quality of equipment plays a vital role in energy yield of a solar PV project. Systems with good quality products has higher efficiency and lower ageing effect (performance degradation with time). On the other hand, good quality products have higher prices. Very often the project developers ignore the quality of products and they go for cheaper products. Using of low-quality products results in lower yield than the expected yield.
- **Orientation of the roof (Azimuth)**: South facing roofs receive the highest solar irradiance whereas east, west and north facing roofs receive relatively lower solar irradiance.
- **Roof angle (Tilt angle)**: If the roof is not concrete roof (flat roof), then generally the solar PV panels are installed at an angle equal to the angle of the roof. The amount of solar irradiance depends on the angle of the roof (i.e. the angle of solar PV modules). With a tilt angle of local latitude (For Bangladesh it is between 21^o to 26^o) facing towards south receives the highest solar irradiance.
- **Availability of grid:** Almost all the rooftop solar PV systems are grid tied systems. The solar system can generate electricity only when there is solar radiation and the grid is present. During the load shedding hours or the outage hours for grid maintenance, the solar PV system cannot generate electricity.
- **Dusts on the solar panels:** Solar PV panels are kept in the open roof to get solar insolation. So, dust accumulates on it. The panels need to be cleaned on a regular basis. If dust accumulates on panels, it reduces the solar energy fall onto the solar cells and thus the output energy.
- **In optimum conditions:** South facing panels with tilt angle equal to local latitudes and no load shedding or grid outage and with premium quality products the annual energy yield can be as high as 1500 kWh/kWp/year.

Here we have considered annual generation of electricity of the installed PV system 16.67% less than optimum conditions (as an example)]

- Performance degradation of the solar PV system: First year degradation is 1%; after that there is 0.5% linear degradation each year. This value is guaranteed by the panel manufacturers.

- Yearly maintenance cost is considered to be 1% of the initial investment cost. Maintenance cost escalates at a rate of 5% per year. The maintenance cost is an approximate value from the market reference.

The savings from the system over the lifetime is elaborated in the following table 9.

TABLE 9. Net savings from a 1MW solar PV rooftop CAPEX system over its lifetime.

Year	***Energy produced from PV systems (kWh/year)***	***Grid electricity tariff (5% increase per year)***	***Gross savings from Utility bills***	***Debt Service***	***Maintenance cost (1% of project cost)***	***Insurance (0.5% of PC)***	***Net savings***
Y 1	*1,200,000*	*9.75*	*11,700,000*	*1,968,000*	*410,000*	*205,000*	*9,117,000*
Y 2	*1,188,000*	*10.24*	*12,162,150*	*4,822,329*	*430,500*	*205,000*	*6,704,321*
Y 3	*1,182,000*	*10.73*	*12,676,950*	*4,822,329*	*452,025*	*205,000*	*7,197,596*
Y 4	*1,176,000*	*11.21*	*13,185,900*	*4,822,329*	*474,626*	*205,000*	*7,683,944*
Y 5	*1,170,000*	*11.70*	*13,689,000*	*4,822,329*	*498,358*	*205,000*	*8,163,313*
Y 6	*1,164,000*	*12.19*	*14,186,250*	*4,822,329*	*523,275*	*205,000*	*8,635,645*
Y 7	*1,158,000*	*12.68*	*14,677,650*	*4,822,329*	*549,439*	*205,000*	*9,100,881*
Y 8	*1,152,000*	*13.16*	*15,163,200*	*4,822,329*	*576,911*	*205,000*	*9,558,960*
Y 9	*1,146,000*	*13.65*	*15,642,900*	*4,822,329*	*605,757*	*205,000*	*10,009,814*
Y 10	*1,140,000*	*14.14*	*16,116,750*	*4,822,329*	*636,045*	*205,000*	*10,453,376*
Y 11	*1,134,000*	*14.63*	*16,584,750*		*667,847*	*205,000*	*15,711,903*
Y 12	*1,128,000*	*15.11*	*17,046,900*		*701,239*	*205,000*	*16,140,661*
Y 13	*1,122,000*	*15.60*	*17,503,200*		*736,301*	*205,000*	*16,561,899*
Y 14	*1,116,000*	*16.09*	*17,953,650*		*773,116*	*205,000*	*16,975,534*
Y 15	*1,110,000*	*16.58*	*18,398,250*		*811,772*	*205,000*	*17,381,478*
Y 16	*1,104,000*	*17.06*	*18,837,000*		*852,361*	*205,000*	*17,779,639*
Y 17	*1,098,000*	*17.55*	*19,269,900*		*894,979*	*205,000*	*18,169,921*
Y 18	*1,092,000*	*18.04*	*19,696,950*		*939,728*	*205,000*	*18,552,222*
Y 19	*1,086,000*	*18.53*	*20,118,150*		*986,714*	*205,000*	*18,926,436*
Y 20	*1,080,000*	*19.01*	*20,533,500*		*1,036,050*	*205,000*	*19,292,450*
Total	*22,746,000*		*325,143,000*	*45,368,964*	*13,557,041*	*4,100,000*	*262,116,995*

The accumulated (cumulative) net savings in electricity bill in the project life (in 20 years) in CAPEX model is BDT 262,116,995. The Net Savings in project life is Savings in electricity bill minus Equity= BDT 221,116,995.

8. Conclusions and Recommendations

In July 2018, Bangladesh has issued the Net Metering Guidelines in order to facilitate the grid integration of distributed renewable energy based electricity. This policy aims to promote the expansion of primarily solar PV based renewable electricity in Bangladesh by encouraging prosumers (consumers and producers) to install solar PV systems on their premises or rooftops. The electricity generated through this can be used for self-consumption at a rate more affordable than the grid tariff rates, while any surplus electricity can be sold back to the grid. Prosumers can include domestic or residential consumers, commercial consumers and industrial consumers.

To date Bangladesh has installed 1273 solar PV rooftop systems under the Net Metering Scheme, which comprise 47.7 MW of generation capacity, whereas there are 203 rooftop systems of 58.74 MW of installed capacity which are outside the Net Metering scheme (Chapter 4).

Rooftop solar PV systems may be installed and operated under the Net Metering Scheme of Bangladesh. The following sites are potentially suitable for solar rooftop systems:

- Roofs of government offices with large buildings.
- The tops of buildings and structures in all Export Processing Zones and Economic Zones.
- The rooftops of railway stations, platforms and adjacent land.
- The rooftops of cold storages and storage silos.
- Rooftops of garment factories, jute mills, paper mills and possibly roofs of other industries.
- Rooftops of cyclone shelter centers.
- Rooftops of civil aviation centers and land available near the airports with sufficient glare protection.
- Rooftops of public educational institutions, especially schools, colleges and universities.
- The jetties of river and sea ports.
- Tops of stadiums.

Many of these sites are however currently not used and the market for solar PV rooftop in Bangladesh remains largely untapped. The Net Metering Scheme of Bangladesh offers advantageous terms in comparison to most other countries in Asia, but in order to take full advantage of the local market potential, some significant improvements could be proposed. These improvements can be from the perspectives of eligibility criteria, technological upgrades, infrastructure support, financial support and awareness raising interventions.

8.1 Eligibility criteria

1. At present in Bangladesh, potential prosumers have a sanctioned load (maximum amount of electricity a consumer is authorized to draw from the grid), and they are not allowed to install a solar rooftop system which has a capacity greater than 70% of this sanctioned load. The study recommends to give permission for an installed capacity equal to or above the sanctioned load, even if it cannot be accommodated in the premises of the factory. This is because solar PV rooftop

systems do not always produce electricity at the full theoretical potential. If the system size is increase, the total output will still be within the stipulated limits and increasing the system size can increase overall production of renewable electricity without overwhelming the grid infrastructure. For example, some firms may obtain additional space in other locations in order to install the systems. Moreover, as these firms have self-financed systems in most cases, it is a convenient way to privatize the expansion of solar PV systems under net metering (chapter 1, Figures 2 and 3, financing sources of solar rooftop systems with and without net metering).

2. In Bangladesh, there is the single-phase category of consumers (small consumers with sanctioned load less than 7 kW), who have small loads, and three phase consumers (large consumers with sanctioned load greater than 7 kW), who have higher loads and voltages. At present only three phase consumers are eligible to apply for NEM connection (Appendix 1, Net metering scheme of Bangladesh, Capacity and energy export limits). This leaves out a significant number of smaller potential prosumers who can also install small or medium sized systems. It is therefore recommended that single phase consumers should also be allowed to apply for connection under net metering. For the single-phase consumer, a minimum capacity of 1 kW could be considered.

4. At present, only the consumers of Low Voltage (Low T, 0.4 kV), Medium voltage (Medium T, 11 kV) and High voltage (High T, 33 kV) are allowed to use NEM facilities. Large consumers who are connected by very high voltage lines (132kV and 230 kV), are thus currently not permitted to obtain NEM connection. The study recommends that all consumers, irrespective of the voltage level, should be allowed to avail NEM facilities (Appendix 1, Net metering policy of Bangladesh, Capacity and energy export limits).

8.2 Financial support

1. The survey of prosumers indicated that some prosumers are not satisfied with the timeliness of settlement at the end of the period (chapter 6, Survey among rooftop investors). It is therefore recommended to ensure timely payment of net exporting prosumers, at the end of the annual settlement period.

2. Under the current conditions, utilities have no financial incentive to connect prosumers according to the NEM system. Furthermore, as prosumers can produce and sell electricity into the grid, the utilities can see prosumers as potential competitors. One way to overcome this is to initiate a carbon credit system. This is a mechanism which enables a firm to obtain financial benefits or avoid financial penalties by avoiding emissions. It could thus be explored whether and how utilities could be provided with a carbon credit system in order to encourage them to accommodate NEM systems. This would create a financial incentive for utilities to support NEM, as they would face loss of revenue from self-consumption of renewable electricity prosumers (chapter 3, section 3.2.9, countries having carbon prices and carbon credit systems).

3. In Bangladesh, the IPP (Independent Power Producers) who sell power to the national grid, are allowed to import power plant equipment and spare parts with a tax waiver. However, NEM prosumers do not enjoy this incentive. It is suggested that this tax waiver incentive could also be provided to the NEM EPC contractors and the NEM OPEX operators (authors’ observations).

8.3 Infrastructure support

1. Many prosumers have commented that the installation time for the rooftop systems is lengthy (chapter 6, Figure 24: Satisfaction with support services to solar rooftop investors). This can delay the return on investment, or it can hamper the regular activities at the factory. It is advised to expedite the installation time in order to improve the return on investment and payback period of the NEM prosumers. In order to do this, the EPC contractors could devise a more efficient or streamlined project management system, to shorten the completion time.

2. In the OPEX model of solar rooftop projects, renewable energy service companies (RESCOs) are responsible for installing the solar rooftop system on the consumer's premises, and the consumer has a power purchase agreement (PPA) with the service company to buy all the electricity generated from the solar rooftop system installed in the consumer's premises by the RESCO (chapter 7, section 7.1, description of OPEX model). In order to better secure the financial investment of the RESCO, a tri-party agreement could be signed between the prosumer, utility and the RESCOs for the OPEX model. The utilities could then enforce the industry to pay the bill to the RESCO thus reducing the OPEX model risk. In this way, the responsibility of the utilities will not end anymore at the grid connection. For this an incentive in the form of wheeling charge can be provided to the utility.

3. In some cases, a prosumer has rooftop space with a potential to generate more solar electricity than is necessary for its own consumption. It is recommend to allow the NEM consumer to use his excess electricity to any place within the country by providing wheeling charge to the utility/s or the grid operator. This will make use of any available land or rooftop area, irrespective of location (authors' observations).

4. To the contrary, owners of a solar rooftop system, for example on a factory, may not have enough space to meet the factory's electricity needs. However, this prosumer may own other lands or properties in other locations of the country, where additional solar panels could be installed. In order to make use of this space, the NEM operator could be given the option to install renewable energy generation system in any part of the country (if it does not have sufficient space to install rooftop systems in its metering place), and to use the energy produced by the remotely installed system by providing a wheeling charge to the grid operator or to the utility/utilities (authors' observations).

5. Sometimes, an electricity consumer may wish to use renewable electricity exclusively in order to meet a compliance standard, but may not have the rooftop space. The prosumer could be given the option to sell its excess energy to any other consumer or consumers within the Utility or any other part of the country by giving wheeling charge to the utility/utilities or to the grid operator (authors' observations).

6. NEM is not supported in Economic Zones (EZs) or Export Processing Zones (EPZs). In these zones, the zone authority purchases power from the utility and sells it to industries inside the EZ or EPZs. The zone authorities do not welcome the Net Metering Scheme inside the economic zones. Many large-scale industrial rooftops are available for solar PV systems installation there, but due to the lack of support for NEM, the industry owners are discouraged from installing such systems. The EZ or EPZ authorities should support the NEM policy (authors' observations).

It should be noted that one major project of solar PV rooftop has been completed in the Korean EPZ in Chittagong, in 2021. This system is 16 MW, and is expected to be extended to 40 MW (The Financial Express, 2021). This is the country's largest rooftop solar power project, and its size indicates the great potential for solar rooftop projects in other EPZs of the country.

8.4 Technological upgrades for operation and maintenance monitoring and safety

Some equipment manufacturers were also consulted in the course of this study. They have the following recommendations regarding technological and operational issues:

1. In order for proper quality monitoring, it is recommended by equipment suppliers that an I-V Curve diagnosis for 100% PV strings and quarterly diagnosis report for the PV plant are provided. This way, the supplier shall have online I-V Curves diagnosis reference if the system is more than 1MWp. The software or function should be certified by renowned testing laboratory, and the test report should be provided.
2. Some improved safety requirements could be recommended, as follows:
    a. The PV system should have an Arc-fault circuit interrupter (AFCI) function. Inverters should comply with the IEC 63027 requirements.
    b. TUV or Bureau Veritas or Inter Tek or similar certification for AFCI function should be provided with NEM application.
    c. The PV system should have Rapid Shutdown function, which can save the system from any fault at the DC side within 30 seconds of rapid shutdown initiation. This can protect the installed PV system from accidental fire hazards.

8.5 Awareness raising

It is recommended to also work on increased awareness on the NEM policy among potential prosumers. It could be considered to have promotional campaigns, targeting the general public and targeting specifically industrial prosumers with large premises. It would be recommended for the utilities to have a prosumer service department or officer, to support the incorporation of the NEM into new and existing systems (authors' observations).

8.6 Scope for further studies

Based on the findings of this study, a number of further research studies could be pursued. These studies will further shed light on the potential for renewable electricity projects in Bangladesh. Some proposed studies are as follows:

1. The demand for renewable electricity in the RMG (ready-made garments) sector, in order to meet compliance standards as a condition for exports.
2. The potential demand for renewable electricity in other export-oriented industries in Bangladesh, for meeting compliance standards as a condition for exports.
3. The potential demand for renewable electricity in office or commercial buildings, in order to make them green buildings as a part of corporate environmental sustainability measures.

9. Recommendations with Responsible Stakeholders and Timelines:

SN	Recommendation	Responsible Stakeholder	Time line
1	Single phase consumers should be made eligible for Net Metering Scheme	MPEMR	Short
2	The maximum AC capacity of the installed renewable energy system should be equal of the sanctioned load.	MPEMR	Short
3	If space and other facilities permits then permission to increase installed capacity above sanctioned load should be encouraged.	MPEMR	Mid
4	A tri-party agreement should be singed between the prosumer, utility and the RESCOs for the OPEX model. The utilities then can enforce the industry to pay the bill to the RESCO thus reducing the OPEX model risk. For this an incentive in the form of wheeling charge can be provided to the utility.	MPEMR & Utilities	Mid
5	For the single-phase consumer, with a minimum capacity of 1 kW should be considered as Prosumers	MPEMR	Short
6	The utility should be provided with a carbon credit facility, so that it works as a incentive to the Utilities.	MPEMR, Utility & Facilitators	Mid
7	The NEM EPC contractor and the NEM OPEX operator should get import tax or duty waiver on the import of any NEM equipment and also the spares.	MPEMR	Mid
8	The NEM consumer should be able to use his excess electricity to any place within the country by providing wheeling charge to the utility/s or the grid operator.	MPEMR	Mid
9	Annual settlement policy should be executed	Utility	Short
10	Faster installation time should be ensured	EPC & Financiers	Short
11	The NEM operator should have given the option to install renewable energy generation system in any part of the country and by providing a wheeling change to the grid operator or to the utility/utilities the prosumer should be able to use the energy produced by the remote installed system.	MPEMR	Mid
12	The prosumer should give the option to sell its excess energy to any other consumer or consumers within the Utility or any other part of the country by giving wheeling charge to the utility/utilities or to the grid operator.	MPEMR	Mid

13	NEM is not supported in Economic Zones (EZs) or Export Processing Zones (EPZs). In these zones, the zone authority purchases power from the utility and sells it to industries inside the EZ or EPZs. The zone authorities do not welcome the Net Metering Scheme inside the economic zones. Many large-scale industrial rooftops are available for solar PV systems installation there, but due to the lack of support for NEM, the industry owners are discouraged from installing such systems. The EZ or EPZ authorities should support the NEM policy for the industries inside the EZs/EPZs.	MPEMR	Mid
14	At present, only the consumers of Low Voltage (LT, 0.4 kV), Medium voltage (MT, 11 kV) and High voltage (HT, 33 kV) are allowed to avail NEM facilities. There are some consumers who are consumers of very high voltage (132kV and 230 kV), who are not permitted to obtain NEM connection. All consumers irrespective of voltage level should be allowed to avail the NEM facilities.	MPEMR	Short

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Appendix 1: Net Metering Policy of Bangladesh

Eligibility Criteria

A consumer shall be considered eligible when the following clauses are complied with:

i. The prosumer should be a current customer of the Utility that is responsible for the supply of electricity in the area;
ii. The applicant should not have any outstanding arrears prior to making the application;
iii. Electricity produced ONLY from renewable energy sources are eligible;
iv. The applicant must either be the legal owner or have the legal permission from the owner(s) or their legal representative(s) for installing the proposed renewable energy system in the premise;
v. Any empty space on the roof or facades of buildings, car parking, garages, factory or industrial buildings or sheds or similar buildings or at land within own premise of the consumer or any other suitable area accepted by Utility where Utility meter exists;
vi. The prosumer shall consume the electricity at the point of RE electricity generation, and only export the excess amount to the grid;
vii. Interconnection standards shall comply with the interconnection rules and standards set by the Utility or other relevant governing authority;
viii. Determination of the renewable energy system capacity shall comply with Section 3.3 of this regulation.

Note: The consumer can be allowed to distribute electricity to another point of use given that s/he is not doing so with the help of the existing distribution network. In other words, the overhead cost associated with such distribution network shall be borne by the consumer. But if the other consumer is customer of any other distribution utility, s/he must secure permission from them.

Consumer Categories

Eligible consumers (as described in Sec. 3.1) under the framework of this net metering regulation can be broadly classified into three categories.

i. Domestic or residential consumers
ii. Commercial consumers
iii. Industrial consumers

Capacity and Energy Export Limits

The size of the system and maximum allowable electricity export correspond with consumer type and usage patterns. To reduce the technical challenges, initially following conditions are applied for defining RE system capacity and export of energy. In the future based on the experience of installation of NEM systems Ministry of Power, Energy and Mineral Resources can re-define the system capacity.

i. Any three phase consumer will be considered eligible for the net metering system.
ii. The output AC capacity of the renewable energy converter can be a maximum of 70% with respect to the consumer’s sanctioned load. In other word 70% on the customer’s sanctioned load is specified as the maximum permissible generator size (installed output AC capacity).
iii. The maximum output AC capacity of the installed RE system for NEM cannot be more than 3 MW.
iv. In case of a medium-voltage (MV) consumer, the installed capacity of the renewable energy system cannot be more than 70% of the rated capacity of the distribution transformer or, cumulative capacity of the distribution transformers. The MV consumer needs to fulfill the first three clauses.

Energy Accounting and Settlement

The specifics of the energy accounting and settlement are described below:

i. The concerned distribution Utility shall prepare and send the electricity bill to the consumer for each billing period. After adjusting on the basis of the net export or net import (kilowatthour) as per section 3.5 of this guideline, any credited electricity units will be carried over to the next billing period, or the prosumer has to pay for the net consumption. If at the end of the settlement period (in June which is the last month of a fiscal year), any kilowatthour credit is accumulated by the prosumer, the Utility will pay as per this guideline.
ii. For each billing period, the Utility shall prepare an energy statement, which shall separately mention:
    a) The amount of electricity imported by the consumer from the Utility grid;
    b) The amount of electricity exported to the grid by the installed renewable energy systems; and
    c) Net amount of electricity billed to be paid by the prosumer or net credited kWh to roll over to the next billing period.
iii. If the amount of electricity units imported by the eligible prosumer during any billing period exceeds the amount exported, the prosumer will be considered net importer. In that case, utility shall prepare a bill for the net electricity consumption by the prosumer after adjusting the carry over units (if any) from the previous billing cycle of the same settlement period.
iv. If the amount of electricity units exported by the eligible prosumer during a billing period exceeds the amount imported, the prosumer will be consider net exporter. In that case, after adjusting with the carry over units (if any) from the previous billing cycle of the same settlement period, either accumulated kilowatthours will be carried over to the next billing cycle, or utility shall prepare a bill for net peak consumption (if any). In either cases, the prosumer should pay for the demand, service charge and all other fixed charges.
v. The energy accounting shall be according to the tariff structure as specified in §3.5 of this guideline.

vi. The unadjusted kWh credit shall be allowed to roll over for a maximum period of 12 months, which is otherwise known as the 'settlement period'. The settlement period will be the end of each fiscal year and all the credits should be adjusted or compensated in the last month (June) of the settlement period.

vii. At the end of settlement period, if the prosumer is net exporter of electricity then the Utility shall pay for the net exported amount of electricity to the prosumer at bulk purchase rate (tariff) for the Utility set by BERC.

Tariff Structure

The tariff structure, according to which the utility will prepare the bill, settle accounts either via proper adjustment of by collecting dues at the end of every billing period and at the end of the settlement period, are described in this section:

i. For each billing period, the Utility conducts the energy accounting and appropriate adjustment based on the tariff order issued by the Bangladesh Energy Regulatory Commission (BERC).

ii. The electricity bill for prosumers will be calculated based on any of the three possibilities described below:

    a) If the amount of imported and exported electricity is equal, then the prosumer shall pay only the demand charge and other fixed charges.

    b) After adjusting with any carryover credit from the previous billing period (if any), if the prosumer remains a net exporter, then the excess kilowatthours will be carried over to the next billing period. For the current billing period, the prosumer shall pay only the demand charge and other fixed charges.

    c) After adjusting with any carry over credit from the previous billing period (if any), the prosumer becomes a net importer, then prosumer shall pay for the additional consumption along with the demand charges and other fixed charges.

iii. At the end of the settlement period (in June), the Utility shall pay all consumers classes (residential, commercial and industrial) for any accumulated kilowatthour unit of electricity at the bulk rate. In such cases, the bulk tariff rate for 33kV lines determined by the BERC shall be applicable.

iv. For prosumers whose electricity consumption during peak and off-peak hours are separately recorded, the off-peak units will be adjusted first and then the peak hour consumption will be adjust later.

v. The tariff rates are subjected to change according to the tariff structure determined by BERC. If the tariff is changed within a settlement period, then the changed tariff will be considered for energy accounting for the remaining billing cycles.

vi. Examples of energy accounting and sample electricity bills for single billing period and at the end of settlement period for three possible cases as mentioned in the sub-section 3.5 ii, are provided in Annex V of this guideline.

Metering Arrangement

The metering arrangement shall be done according to the following conditions.

i. A single three phase bidirectional smart meter (capable of recording import, export and net energy consumption) shall be installed at the point of interconnection by the Utility. If by reprogramming, the existing meter can fulfill the requirements, then reprogramming is sufficient and no new meter needs to be installed.
ii. The net meter shall conform to the specifications as mentioned in Annex II of this guideline or approved by relevant authority (Utility or SREDA).
iii. In case of eligible consumers, who fall under the different tariff metering scheme, smart meter capable of recording electricity consumption and generation during peak and off-peak hours separately shall be installed.
iv. The Utility shall be responsible for procuring, testing, installing (and replacing the existing meters), maintaining and reading the net meters. The prosumer can also procure and install the meter but in that case the brand and model should be approved by the Utility or relevant authority (i.e. SREDA)
v. The price of the meters and other relevant costs shall be borne by the consumer.
vi. The reading from the net meters shall be the primary basis of energy accounting and commercial settlement.
vii. In case of the consumer is a prepaid meter consumer, then the prepaid meter should be capable of calculating export, import and net usage of electricity. It should also able (or programmed) to satisfy the above mentioned classes.

Application Procedure

The eligible consumers, who intend to install and/or connect their renewable energy generation systems with the grid and benefit from net metering shall follow the procedure mentioned in this section.

i. The eligible consumer shall apply in writing for a net metering agreement to the Utility.
ii. The eligible consumer shall use the application template as provided in Annex I of this guideline. Only completed applications with the necessary supporting documents shall be considered acceptable by the Utility.
iii. Upon receiving the completed application package (and proof of payment, if any), the Utility shall officially acknowledge the receipt of the application.

iv. The applicant together with the Utility shall agree on the detailed work plan, which shall include the physical installation of the system (for new installations), the establishment of interconnection, checking and verification, approval and signing of the NEM contract.

v. Upon successful completion of all the necessary steps by the NEM applicant as mentioned above in clause iv, the Utility shall issue the NEM approval. Otherwise the Utility shall notify the applicant of the proper reason and next steps to follow.

vi. After completing all the necessary steps mentioned above, the Utility shall issue the NEM approval as mentioned in clause v within 10 (ten) working days, starting from the submission date of the application as mentioned in clause i.

vii. Within the specified time span, the consumer, with the support of Utility shall carry out the necessary steps to install the renewable energy system (required for new installation) and/or establish the necessary interconnections.

viii. The applicant shall fill the NEM system checklist (Annex III) with assistance from the Utility for the renewable energy system.

ix. The NEM consumer shall complete all the tasks installing the renewable energy system including the NEM system within 08 (eight) months of receiving the NEM approval. The NEM consumer shall submit the filled up NEM checklist to the associated distribution utility requesting verification of the standards set by this guideline and the relevant authority.

x. The Utility shall check and verify the system to ensure that the system components and interconnection parameters comply with the rules and standards of this guideline and Utility. If the standards are found to be in compliance, the Utility shall communicate a contract signing date with the consumer.

xi. The NEM Agreement shall be prepared according to the template provided as specified in Annex IV.

xii. Within a maximum of 15 (fifteen) days of submission of application by the consumer as mentioned in clause ix, the Utility shall settle all necessary formalities and sign the contact as mentioned in clause xi. If the required standards are not met, the Utility shall inform the consumer the proper reasons and steps to follow within this time period.

xiii. If the distribution Utility's system has to undergo any modification in order to install the consumer's the renewable energy system, the NEM applicant shall bear all incurred costs.

Appendix 2: Survey questionnaire

EU Study: Survey of Net Metering rooftop systems in Bangladesh and the challenges faced

Survey questionnaire

Name of prosumer organization:	
Designation of respondent:	
Address:	
Latitude and longitude:	
Contact:	
Size of system:	
Date of installation:	
Duration of operation:	
Agency:	
Source of financing:	

Note: The purpose of this survey is to obtain information about the challenges facing the expansion of solar rooftop in Bangladesh through the net metering policy. Answer all questions.

1. What type of premises has been used for installing the rooftop system (flat building rooftop/factory shed/ground/others)?____

2. What is the main motive for installing the rooftop system? (self consumption/reduce electricity cost/selling to the grid/ compliance with business standards/ others)

3. What is the business volume of the organization in terms of annual revenue?

4. How would you rate your own knowledge about solar PV systems?

Very little	☐	☐	☐	☐	☐	Very high

5. What was the cost of the following components of the system?
   a. Solar panels____

b. Inverters____
c. Other equipment____
d. Installation charge____
e. Financing charge____
f. Others____

6. How important are the following investment considerations in your decision for installing a solar rooftop? What is your level of satisfaction in these areas according to your experience
   a. Cost of the rooftop system

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   b. Cost of financing

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   c. Tenure of financing

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   d. Debt equity ratio

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   e. Payback period

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   f. Cost of grid electricity

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

   g. Net metering rate for electricity sales to the grid

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

7. What is the importance of the following support mechanisms for installing solar rooftop? What is your satisfaction level with the service you received?

a. Time taken for obtaining permits

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

b. Information received from relevant utilities and government agencies

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

c. Information support from EPC contractors

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

d. Expertise and professionalism of government agencies

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

e. Expertise and professionalism of EPC contractors

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

f. After commissioning service from EPC

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

g. Time taken to complete the project

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

h. Quality of grid connection

Not at all important	☐	☐	☐	☐	☐	Very important
Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

i. Quality of materials and equipment

Not at all important	☐	☐	☐	☐	☐	Very important

Highly dissatisfied	☐	☐	☐	☐	☐	Highly satisfied

8. What is the full potential size of rooftop system that you can install in the given area of your premises? ____

9. What is your sanctioned load?____

10. If given the choice, would you have installed a larger solar PV rooftop system? If yes, what would be the capacity?____
11. Did you incur any grid upgrade cost? If so, how much? ____
12. What type of system is it (OPEX/CAPEX/other(explain))? ____
13. How is your experience with net metering arrangement?

14. Would you recommend other organizations to install such a system? ______________________

15. What are some recommendations for improvement?

Barriers and Opportunities for Scaling Up Rooftop Solar PV Systems in Bangladesh

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