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Net Energy Metering-An Optimistic Endeavour for Augmenting Renewable Power Generation in Bangladesh

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ABSTRACT
The vision of the government of Bangladesh is to produce 24,000 MW electricity for all by 2021, 40,000 MW for affordable, reliable, sustainable and modern energy for all according to SDG 7 by 2030 and 60,000 MW to be for developed nation by 2041. To get clean energy, renewable energy option is the first requirement to replace the fossil fuels as it causes greenhouse effect and environment pollution. Though around 55 million of solar home system is installed in the recent past, but very tiny amount of electricity is added to the grid. Net metering is a proper energy meter capable of recording both import and export of electricity from solar for self-consumption and excess amount is exported to the grid which results the reduction of electricity bills. This paper highlighted the requirement as well the benefits along with schematic diagram of net energy metering system in Bangladesh. Two pilot projects are being briefly narrated. Finally, a successful story of net metering system has been presented to encourage the investors and the customers that will curb the greenhouse Gas emission.

Keywords: Solar home system, Net energy metering, Greenhouse gas emission.

1. Introduction

Bangladesh is an over populated country with about 163.65 million people living in 147,570 square kilometers of land [1]. Our per capita power consumption is roughly 464 kilowatts [2]. Bangladesh aspires to achieve electricity for all by 2021 and aims to be middle income and higher income country status by 2021 and 2041 respectively. For this, there is a requirement to increase GDP growth to 7.5 to 8 percent per year. The economy of Bangladesh is at accelerated speed to reach the economic growth of 8% which will play an important role in migrating to the level of a middle-income country within 2021[3].

Bangladesh has also adopted Sustainable Development Goal (SDG) 7 which states that ensure access to affordable, reliable, sustainable and modern energy for all by 2030. For this, Bangladesh is in need of 40,000 MW of electricity by 2030 and 60,000 MW by 2041. Therefore, Government of Bangladesh (GoB) has undertaken short, medium and long term plans with the consideration of fuel diversification to achieve these goals [3]. Still now, our power generation is highly dependent on fossil fuels. In future days to come, renewable energy will play pivotal role in fulfilling the national requirement and keep this planet ecofriendly along with the conventional energy. Though Bangladesh is blessed with huge potentiality of solar energy, yet people are not being benefitted as grid-connected electricity consumers from the said energy. The GoB has fixed a renewable energy target to increase upto 10% by 2020 when likely generation of power will be 24,000 MW through a renewable energy policy 2008 [3].
The principal sources of renewable energy are solar, biogas, biomass, wind, hydro, geothermal, wave and tidal energy. Here Hydro has less potentiality for power generation due to unfavorable topology. Biogas and biomass has small potentiality in respect of power generation. Wind has limitations and expensive (5-6m/s at 100m ht.). Geothermal, wave and tidal energy are not tested for power generation in our country. Due to its geographical location, the solar has very good potential in Bangladesh (4.5-5.5 Kwh/m2/day). But, for 100 MW solar plant, it is required approximately 350 acres of land [4].
Therefore, it has been difficult to manage vast areas of land for constructing big solar power plants in this densely populated country. Considering the above, rooftop of residential, industrial and other commercial buildings have been targeted for potential area for installing grid tie solar system for generation of power. Mounting these solar systems on rooftops will not only enhance the contribution of generation of renewable energy but also the production of electricity.
The GoB has taken multiple initiatives to introduce net metering system including approval of the 'Net Energy Metering Guidelines-2018'. Net metering is a technique of recording both import from the grid and can sell surplus electricity to the power distribution by the consumers after self- consumption. As a result, the electricity expenditure will be reduced if he/she can export to the grid and exported electricity may be adjusted with the following month's bill. Until now over 50 countries including our neighbouring countries such as, India and Sri Lanka have the success story of adopting net metering scheme. Bangladesh is not far behind. A pilot project on the rooftop of Directorate General of Food at Bogura has been successful by connecting to the net metering system. This gives up a big boost for the consumers who are yet to install this net metering system [5]. It is important to identify the eligible renewable energy technologies and customer classes for net metering by the GoB.
As GoB has approved Net Metering Policy, the power distribution entities like Dhaka Electric Supply Company Limited (DESCO), Dhaka Power Distribution Company

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(DPDC), Bangladesh Rural Electrification Board (BREB) and Power Development Board (PDB) are bound to buy electricity from their own consumers, specially the rooftop solar users.

2. Bangladesh Renewable Scenario

As Bangladesh is located in tropical country, Bangladesh has abundant of renewable resources namely solar, biogas, biomass, wind, hydro etc. Yet the progress in production of electricity from renewable energy sources has not satisfactory. The GoB has taken numerous steps to promote renewable energy sources and has approved Renewable Energy policy-2008, Power System Master Plan-2016, Private Sector Power Generation Policy 2004, Solar Energy Development Program 2013 and NDC to promote the investors.

2.1 Renewable energy contribution in power mix

The electricity generation mix is shown in table 1. Though Bangladesh is bless with plenty of renewable resources, yet the generation of electricity is not very encouraging. Only 2.92% of contribution in total generation whereas the natural gas has still the overwhelming dominance in producing electricity.

Table 1 Electricity generation mix as on 07 October 2020 [6].

Fuel	Installed Capacity (MW)	Share in Percentage
Coal	524	2.26%
Gas	10678	48.07%
Heavy Fuel Oil	5208	23.44%
High Speed Diesel	1795	8.08%
Imported	1160	5.22%
Renewable	649.38	2.92%
Captive	2200	9.9%
Total	22214.38	100%

2.2 Renewable energy status from SREDA database

According to SREDA website, renewable energy share in generating electricity is shown in table 2. Among renewable energy sources, solar contributes the maximum (63.98%), followed by hydro which share 35.42% in electricity generation.

Table 2 Renewable energy contribution in generating electricity as on 07 October 2020 [6]

Technology	Off-Grid (MW)	On-Grid (MW)	Total (MW)	Percentage of Share
Solar PV	327.39	88.06	415.45	63.98%
Wind	2	0.9	2.9	0.45%
Hydro	-	230	230	35.42%
Biogas to Electricity	0.63	-	0.63	0.09%
Biomass to Electricity	0.4	-	0.4	0.06%
Total	330.42	318.96	649.38	100%

Renewable Energy Share = 2.92%

2.3 Rooftop solar : Government initiatives

The GoB initiatives regarding the net metering is given below:

a. Cabinet issued directives to gradually meet lighting and cooling load (Fan) of public offices by installing solar panels on 24 August 2009.

b. Power Division instructed distribution utilities to request new applicants for residential connection to meet 3% of their demand by installing solar panels if sanctioned load exceeds 2 kW 07 November 2010.

c. Industrial & commercial customers with load up to 50kW are required to meet 7% of lighting & fan load from solar and when load exceeds 50 kW it is 10%.

d. Garments industry should meet 5% of lighting and fan load from solar.

2.4 Challenges of rooftop program

a. Lack of supervision by distribution utilities.

b. Lack of awareness of the clients.

c. Lack of incentive for consumers.

d. Misguide on compulsory installation of storage battery.

e. Absence of comprehensive guidelines.

3. Net Energy Metering Concept

Net energy metering (NEM) refers to an electricity policy mechanism that allows the utility customers to connect their self-produced electricity from renewable energy systems to the grid. The customers can export excess generated electricity to the grid after their use and import the same amount of electricity from grid or may sell at retail price the exported amount of electricity to grid and get the financial benefit at the end of the specific period as per the NEM guidelines. Fig. 1 presents the schematic diagram of a typical net metering arrangement where solar PV is used as renewable energy system [7].

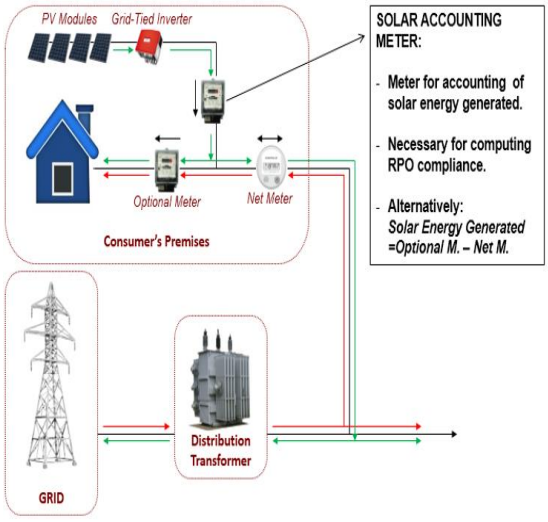

Fig. 1 Schematic diagram of NEM system

Under the process of net metering electricity can flow in both directions via a bidirectional meter. Meter is able

to rotate forward & backward and record energy flow. When the consumer is consuming power from the grid, the meter rotate forward and when electricity is export to the grid, meter rotate backward. Thus the consumer gets to adjust the amount of electricity consumed from grid and any excess electricity after self-consumption that is produced by rooftop solar system or any other renewable energy sources, given that all the conditions stated in this guideline are met. The customer gets the bill only for the net consumption of electricity at the end of the month. NEM is designed for only for grid connected systems.

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 shall allow 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 1 July of every year credit account is set to zero. The GoB has approved the guideline for NEM to enhance all types of consumers so that they install solar panels on their respective roofs for grid-connected electricity production from solar energy. The guideline not only highlights to fulfil the own demand from the self-generated electricity from renewable sources, but also allows to sell the excess electricity to the grid.

4. Net Metering Components

The net metering components are described briefly in the following paragraph [8]:

4.1 Bi-Directional meter

It is an important component for net metering. This meter is able count or record the flow of energy in both directions. When the power is consumed by the clients then meter move in one direction and when power is exported then meter moves in other direction. Therefore, this meter is able to display the net amount of electricity either consumed or exported by the customers in kWh by arithmetic means.

4.2 Grid-Tie inverter

This is considered as a power inverter. It is used to convert Direct Current (DC) electricity into Alternating Current (AC) electricity with an ability to harmonize to interface with a utility line. The DC sources like solar panels, small wind turbines or other renewable sources are converted into AC for connecting with the national grid. Electricity transmitted to the grid can be compensated in several ways. The owners will receive compensation from the utility for the net quantity outflow of electricity determined by bi-direction meter. For example, if prosumers produce 500 kWh of electricity and he/she consumes 200 kWh. Rest are exported to the grid, so he/she will receive compensation of 300 kWh.

4.3 Cables and other accessories

All cables required for utilizing in NEM system should be of IEC 60227/ IS 694 & IEC 60502/IS 1554. The voltage rating is supposed to be 1,100V AC, 1,500V DC. For the AC cabling, PVC or XLPE insulated and PVC sheathed single formulate-core flexible copper cables is required to be used. Outdoor AC cables are advised to have a UV-stabilized outer sheath. Total voltage drop on the cable segments should not exceed 2.0%. DC cables from the SPV module array should follow through a UV stabilized PVC pipe which have adequate diameter with a minimum 1.5mm wall thickness. Cables and wires which are used for the interconnection shall be provided with solar PV connectors (MC4) and couplers. All cables and PVC pipes shall be fixed at intervals not exceeding 50 cm to the rooftop, walls and ceilings with thermoplastic clamps. The minimum AC and DC cable size should be 4.0 mm² copper.

5. Net Metering Benefits

The net metering has both financial and environmental benefits. It establishes mechanism to integrate distributed renewable energy to grid. Prosumers (Electricity consumer and producer) can connect their renewable energy system to grid. Consumer can produce their own electricity. It can reduce electricity bills by lowering dependency on the grid and also reduce greenhouse emission by promoting power generation from renewables. Further, by popularize renewable energy based electricity generation, it can lessen dependency on expensive imported fossil fuels. It reduces not only day peak load demand but also reduces the transmission and distribution loss as power is consumed at the point of generation. Our Solar House System, MiniGrid for the off-Grid area is very much popular & well reputed throughout the world. NEM Guideline has been introduced to popularize the solar system in the on-Grid areas of the country.

6. Statistics of Net Metering and its Cost

6.1 Statistics of net metering system in Bangladesh

As per the SREDA website, the total installed capacity in Bangladesh as on 07 October 2020 is given in Table 3[6].

Table 3 Share of installed net metering system

Electricity Distribution Utilities	Number of Net Metering	Installed Capacity (MW)
BPDB	217	1.118
BREB	204	10.094
DPDC	214	1.94
DESCO	265	1.9
West Zone Power Distribution Company Ltd (WZPDCO)	148	0.785
North East South	22	0.638

Company Ltd (NESCO)		
Total	1070	16.485

6.2 Net metering cost

The tentative cost of net metering system is given in Table 4. From the table it is evident that the Solar PV is consuming the maximum (55% of total cost) price followed by grid tied inverter which is 20% of the total cost [9].

Table 4 Tentative net metering cost

Components	Price (Tk)	Percentage
Solar Module/Panel	13,86,000	55%
Grid Tied Inverter	5,04,000	20%
Mounting Structure	3,78,000	15%
Energy Meter, Cable, Protection Device and Installation etc.	2,52,000	10%
Total	25,20,000	100%

7. **NEM in Bangladesh**

To encourage homeowners to use their rooftops for solar energy production, the government has introduced a net metering system. As such BREB is procuring 9.623 MW of unconsumed solar electricity from 191 consumers, DPDC 1.752 MW of electricity from 200 consumers, BPDB 1.083MW of solar power from 207 consumers and DESCO 1.384 MW from 223 consumers. Meanwhile NESCO is procuring 0.638MW from 22 consumers and WZPDC 0.74 MW from 133 consumers [10].

7.1 First concept of NEM in Bangladesh

With the help of JICA, an endeavor has been taken by Department of Food, Bogura to install a Grid Tied Solar PV System on the roof of its multi-storied warehouse, SILO at Santahar, Bogura. Parameters of the initiative are highlighted below:

a. Utility: BPDB/NESCO.
b. Installed Capacity: 360 kWp
c. Sanctioned Load: 710 kW and Tariff: F, Peak-Off peak
d. 11 kV consumer
e. PT ratio is 11000/110 and CT Ratio is 50/5
f. Commissioned: February, 2017.
g. Generated Electricity: 150,000 kWh (150 MWh).
h. Bill saved: BDT 10 lakh/year.

7.2 Piloting of NEM

SREDA obtained an E-Cluster Solar System from ADB and those are installed at two sites of Khulna Division. Later on those are being used as pilot of NEM system with the help of GIZ. Piloting project is at Shrimp Research Station, BFRI, Bagerhat and Fish Seed Production Farm, Khulna.

7.3 Objectives of the piloting

The objectivesof piloting is highlighted below:

a. Develop demonstration sites based on net metering guideline.
b. Access feasibility for grid connectivity based on local grid condition.
c. Utilize the scope of cooperation from utility.
d. Develop utility workforce through learning while implementing.
e. Verify financial model for solar rooftop integration to grid.
f. Monitor site data for net production, export loss and net export.
g. Share learning and findings with stakeholders.

7.4 E-cluster system

All System components have been installed in a container which is described below:

a. Solar PV modules for the System : 15.3 kWp
b. Solar Charge Controllers : 5 units, 3 kW each
c. Total Capacity of Solar Batteries : 18 kWh
d. AC water pump; 2.2kW (3 HP), 2 units.
e. Solar PV modules for pumps : 2 sets, 5.1 kWp each
f. DC/AC off-grid inverter (1-phase) : 3 kW (1 unit)
g. Solar power Controller for water pumps: 2 units, 4 kW each.

7.5 Layout & orientation of e-cluster sites at Bagerhat & Khulna

Fig. 2 shows the layout of e-cluster sites at Bagerhat and Khulna. Here the office rooftop is being used for generation of electricity. Total components of net metering and the load are shown in the figure. The red line is the proposed lines whereas the blue is the existing one.

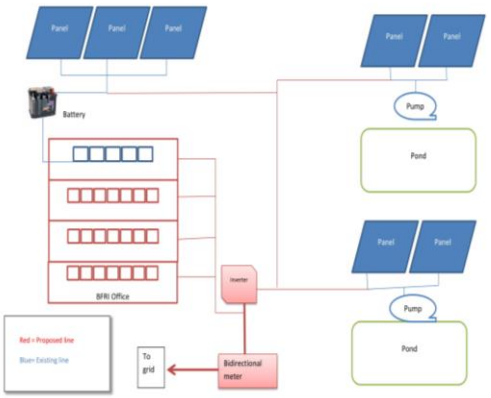

Fig. 2 Layout of e-cluster sites at Bagerhat and Khulna

7.6 Single line diagram of e-Cluster sites with NEM

Fig. 3 represents the single line diagram of e-cluster sites with NEM. The net metering piolot project 25 kW at Bargerhat is presented in the figure. Here the soalr panel is conneted to inverter through fuse. Bidirectional meter is connected to main substation and main load distribution box. Again, main load distribution box is connected to energy meters. One

energy meter is conneted to load and other energy meter is connected to inverter through circuit breaker.

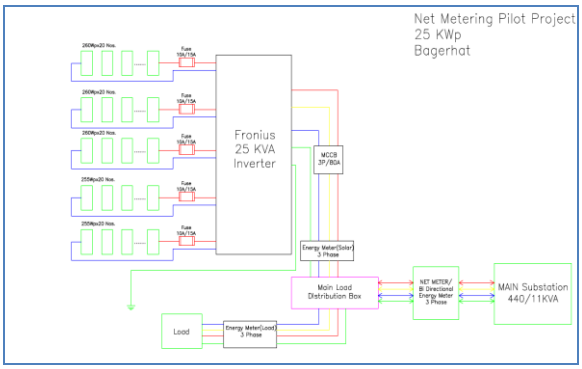

Fig. 3 Single line diagram of e-cluster sites with NEM

8 Results and Discussion

8.1 Daily generation

Fig.4 shows the daily generation. From the figure, it is seen that total 118.72 kWh is generated on 10 August 2018 where at 1200 hours the generation is maximum. However, a single day generation is not likely to be same as it completely depends on nature.

Fig. 4 Daily generation

8.2 Generation of 10 days

Fig. 5 shows the daily generation for 10 days. From 10 days, total 1,145.34 kWh of electricity is generated and the generation is not uniform. Becasuse it completely depend on the avaialblity of solar radiation.

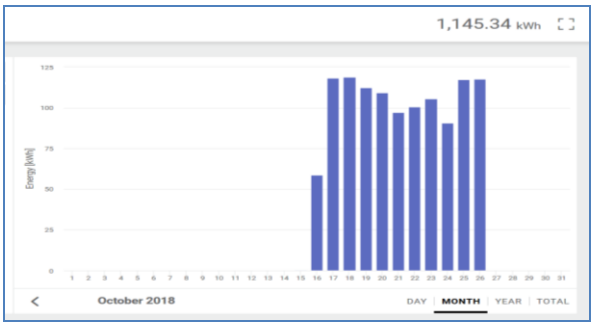

Fig. 5 Daily generation for 10 days

8.4 Generation of 24 days

Generation of elctricity in October and november18 are shown in Fig. 6. Total generation of electricity in 24 days is 1457.26+735.10=2192 kWh.

Fig. 6 Generation of elctricity in October and November 18

Therefore, the summary of 24 days is appended below:

a. Total electricity generated=25 kW x15%X24 hrx24 days=2160 kWh)
b. Electricity saved=2160 kWh x3.50 Tk=7560 Tk
c. CO_2 saving- 1162 kg

The generation rate of electricity from solar will not be same round the year because solar energy heavily depended on nature. However, all sunny days can be utilized for generation which will help for self-use as well as additional electricity can be exported to grid after use.

8.4 Load pattern of 3 days

Load pattern is shown in Fig. 7. The minimum load is observed at around 0700 and 1300 hours. From 0800 in tendes to rise and become maximum at 1000 hours and then it comes to minimum at 1300 hours. From 1400 hours the load keep on rising and become maximum at 1800 hours. Then onword, the load is desending and become minimum at around 0700 hours.

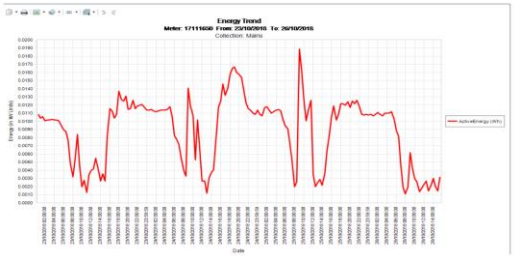

Fig. 7 Load pattern

9. Successful experience of project implementation

9.1 Project brief

a. Name: 1.1 MWP Rooftop Solar project of Far East Spinning Industries Ltd
b. Project Cost: BDT 8.9 crore
c. Factory Location: Uttar Surma, Madhabpur, Habiganj
d. Sponsor: Far East Spinning Industries Ltd. (FESIL)
e. Equipment Supplier and Turnkey Contractor (EPC): PSL-RIMSO Consortium
f. Utility: Habiganj PBS, BREB
g. Project Timeline

i. Financial Closure: 28 Jan 18
ii. Civil Construction: Apr-June 18
iii. Installation Period: Aug-Oct 18
iv. Commercial Operation Date: 31 Oct 18

8.2 1.1 MW Rooftop Plant Overview (100sqft:1KWp)

Table 5 shows the overview of 1.1 MW Rooftop Plant

Table 5 Overview of 1.1 MW rooftop plant

Location of PV Module Installation	Utilized Space (Sqft)	Installed Capacity (kWp)
Ground	96040	890
Utility Bay Rooftop	17670	182
Substation Rooftop	2914	28

8.3 Project performance during 01-25 Nov'18

a. Total generation : 96,556 kWh
b. Average Daily Generation: 3862 kWh
c. Electricity Cost Saving: 7.82 Lac (Tk)

8.4 Electricity generation of 7 Days

Fig. 8 represents the Electricuty Generation during 19-25 November 18. Production of electricity was maximum on 25 November 18 amonting 4,692 kWh.

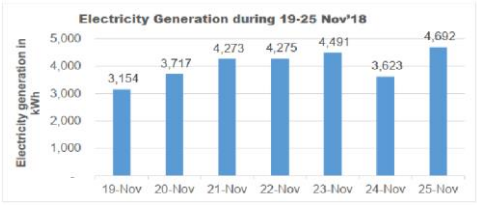

Fig. 8 Electricuty generation during 19-25 November 18 [7]

8.5 1.1 MW system scenario

The 1.1 MW system scenarios are described below:

a. Project Cost: BDT 8.9 Crore (Tk.80k/kW)
b. IDCOL Financing (Debt-Equity: 80%: 20%)
c. Installation Period: 3 months (Aug'18-Oct'18)
d. Source of Grid electricity: 33 kV REB Grid
e. Average daily demand: 14,000 kWh
f. Average daily supply from solar: 3,828 kWh (Nov'18)
g. Percentage Consumption from Solar: 27%
h. Project Electricity Cost Savings: Tk 16 lac/month, 2cr/yr, and 38cr/20 yrs [7].

8.6 Levelized cost & project performance

Levelized cost of Electricity (LCOE) is given below:

a. Levelized Solar Electricity Cost: BDT 7.45 per kWhr
b. Current Grid Electricity tariff: BDT 8.56 per kWhr
c. Project Performance during 1-25 November 2018
d. Total Generation: 96,556 kWhr
e. Average Daily Generation: 3,862 kWhr
f. Electricity Cost Savings: BDT 7.82 lakh [7]

8.7. IDCOL financing activities on NEM

7(Seven) projects of rooftop NEM systems having capacity of 4.3MWp are approved for commissioning and 2(two) of them having capacity 1.8MWp are already in operation and nearly 43 projects of 28.7MWp are in pipeline. Few features are as below:

a. Target: 300 MWp by 2021
b. Levelized Energy Cost: BDT 7.70/kWh
c. Financial Structure: Loan-80%, Equity-20%
d. Interest rate; 6%, Tenure: 10years, Grace: 1year [7].

9. Conclusion

The GoB has endeavor various initiatives to promote production of electricity from renewable sources to keep CO_2 emissions at a low level. Under the present condition, if any new consumer wants to take electricity connection, he has to mandatorily install rooftop solar panel to generate a certain small portion of power from the rooftop plant. But due to absence of any Net Metering policy, many of the consumers allegedly install fake solar panels only to get connections. Formulation of net metering guideline will help the business entrepreneurs as well as it will focus on green factory to reduce carbon emission. It is seen that there are few successful projects on net metering which is giving not only financial divided after self-use but also it promote the green energy and save the environment.

10. Acknowledgement

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