Study on Technical Issues and Financial Viability of Net-Metering Mechanisms Perspective of Distribution Utilities

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Foreword

Net Energy Metering (NEM) is an enabling policy mechanism, which is designed to promote investment in Renewable Energy sector. Net-metered Photovoltaic (PV) Solar applications are becoming very popular amongst residential customers. NEM works through retail tariffs, thus allowing retail customers to offset their electricity bills via the utilization of their privately-owned generating system and selling their surplus generation (if any) to the Distribution Utility. NEM usually uses a single, bi-directional meter and can measure current flowing in both directions.

In the SAARC Region; Bangladesh, India, Pakistan, and Sri Lanka have already introduced and experienced NEM schemes; while Afghanistan, Maldives, and Nepal had announced NEM policies, which are now at the final stages of development. Therefore, it has become essential at this stage to determine the viability of NEM schemes for Distribution Utilities of the SAARC Member States.

In this context, the SAARC Energy Centre has conducted this study on "Technical Issues and Financial Viability of Net-Metering Mechanisms from Perspective of Distribution Utilities". The study assessed and analysed the performance of Distribution Utilities by applying quantitative assessment tools taking into account their input. The study also assessed the Distribution Utilities for the robustness of policies, business models, financing, incentives and implementation processes to support NEM. The study provided solutions to technical and financial challenges faced by the Distribution Utilities while implementing NEM mechanism.

The study finds that with the exception of few cases, the NEM results in savings for the Economy, the Customers and the Distribution Utility. Higher these savings, higher will be the momentum for NEM adoption in the Member States.

The recommendations are made to facilitate the Distribution Utilities for speedy adoption of NEM mechanisms. The study has proposed improvements in the NEM environment for reference Member States. The conditions necessary for growth transition are identified and accordingly utility-wide step wise strategies are listed.

Dr. Nawaz Ahmad
Director
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Study Limitations

Utility assessment approach: By design, the assessment of the NEM in SAARC region was based on secondary information assessment, supplement with utility inputs. No primary data collection exercise was carried out.

Utilities assessment scope: Guided by the scope of the study, detailed assessment of only nine utilities based in four Member States is carried out.

Technologies covered: A number of technologies qualify for NEM treatment (viz. solar (Photo voltaic (PV), thermal), wind, small hydro, biomass, biogas, geothermal, etc.). This study only covers solar PV option for currently other technologies are not yet considered for the NEM in the SAARC member states. Due to low LCOE, solar PV is the de-facto standard for NEM implementation.

Executive Summary

Background

Net-metering (NEM[1]) system allows consumers to generate electricity, use it for self-consumption, and export the surplus to the grid. The exported electricity accumulates as a credit in the customer's account. This credit can be used to import electricity from the grid when the consumption is more than the customer's generation. The net surplus left at the end of a crediting period is settled at a pre-agreed rate.

The 'prosumers' (producers and consumers) participating in NEM are expected to play a significant role in the emerging vision of utilities and grids.

A number of technologies qualify for NEM treatment across the globe viz. solar (Photovoltaic (PV), thermal), wind, small hydro, biomass, biogas, geothermal, etc. Except for solar, others depend on location specific resources and are therefore not widely used.

This study was commissioned by the SAARC Energy Centre to assess the potential for NEM implementation in SAARC Member States[2], understand challenges, assess key factors influencing growth and recommend improvements for realizing the goals for NEM.

Among SAARC Member States; Bangladesh, India, Pakistan, and Sri Lanka have announced NEM Policies in (2013-2016) and have begun implementation. Afghanistan, Maldives, and Nepal also announced NEM policies in 2015 and are at various stages of development.

In this study, the Member States were chosen such as Bangladesh, India, Pakistan, and Sri Lanka for deeper assessments. A total of 9 utilities were chosen – five from India, two from Pakistan, and one each from Bangladesh and Sri Lanka.

The primary information for assessments was gleaned from published literature, utility performance reports, consultant's past work with some of these utilities, discussions with industry experts and interviews with utility management.

Analytical approach

The study has used the following steps for analysis:

- **Study of global markets**. Five benchmark countries/ provinces were chosen where significant and diverse experience for NEM implementation exists. These were California and Hawaii (United States of America), Germany, Italy, Singapore, and Vietnam. Key learning from the study were identified in areas such as NEM policy, technical standards, business models, financing, incentives, and NEM implementation processes. A framework for evolution of NEM has been developed. Section 5 of the report covers this.
- **Study of the SAARC reference Member States and utilities**. Assessment of benefits of NEM for the economy, for consumers and for the utility was carried out. Also, NEM policies and regulations, implementation processes, technical standards, financing instruments and business models used were studied to assess areas where gaps exist, or where gaps may appear as NEM

[1] Acronym for Net-Energy-Metering

[2] The South Asian Association for Regional Cooperation (SAARC) is the regional intergovernmental organization, its Member States are Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka.

penetration of the grid increases. In this report, the author has termed this 'NEM Metering Assessment'. Section 6 of the report covers this.

- Using the NEM evolution framework, the study made an assessment of the stage of reference SAARC Member States and the utilities in their evolution journey. Using this assessment, the study forecasted likely grid penetration and NEM size. Section 7 of the report covers this.
- NEM Maturity Assessment highlights areas where improvements can be made, vis-à-vis successful practices in the benchmark States or the reference SAARC Member States. Recommended improvements cover policy, technical standards, business models, financing and implementation processes. Section 8 of the report covers this.

NEM has supported rapid rise of distributed solar on the basis of sizeable economic and financial savings.

Globally, distributed solar PV capacity will more than double between 2019 and 2024 to 530 GW, an increase equal to that of onshore wind or almost half of total solar PV. Commercial and industrial segments will contribute three-fourths of the growth and residential segment one-fourth (IEA, 2019).

Distributed generation offers significant saving vis-à-vis large fossil fuel-based power generation. It saves costs of generation, transmission and distribution losses, investment in expensive transmission and distribution network, peak hour energy procurement, environmental costs and land costs. Distributed generation enhances energy security by local production, and with right technical design can provide ancillary services for grid support. The integration of distributed generation with the grid happens under NEM.

Utilities have a negative perception of NEM which may not be fully justified.

Despite its obvious advantages, NEM has not been viewed positively by the utilities. NEM is perceived as resulting in 'loss of customers', 'adding costs' to manage infirm power generation and leaving utilities with 'committed fixed costs' to be allocated to non-NEM consumers. NEM Models such as 'All Buy All Sell' have been developed by utilities to treat distributed generation as simply a generation source. However, this is not attractive to many customers.

The analysis in the study shows that costs and problems attributed to NEM would not be there in utilities where energy demand is growing. The advantages of NEM are significant, and are increasing with time, as levelized cost of distributed generation falls. NEM offers benefits to all the stakeholders i.e., consumers, utility, and the economy.

Study of benchmark States reveals significant evolution of NEM over the last 30 years.

As experience with NEM grew, States relaxed capacity restrictions on NEM and transitioned the NEM policy to compete with the power delivered to the grid.

The initial high Feed in Tariff (FiT) paid on exported power, has given way to paying Average Pooled Purchase Cost (APPC) for the utility or price on the power exchange or auction prices.

Premiums are paid for NEM power to recognize its benefits in terms of saving of transmission and distribution losses, saving network investments and saving of environmental costs. Costs for integrating infirm nature of the NEM technologies to the grid (e.g., costs of reserves) are also recognized. Analytical frameworks such as Value of Distributed Energy Resources (VDER)[3] and Net Value of Distributed Energy Resources (NDER)[4], recognize the values and costs associated with NEM and reward the generators for the value delivered to the grid. These frameworks have been described in Section 5.4.

New modes for billing and paying for NEM have been evolved. Globally four modes are practiced i.e., the classic Net Metering, Net Billing, Time of Use (TOU) pricing and 'All Buy All Sell'.

As NEM penetration reaches high levels[5], technical standards have been developed to require control of 'active power' and 'reactive power' by the distributed generator in response to signals from the grid, and the 'fault ride through ability'. The systems now operate under a wider range of frequency and voltage. Wide area measurement of voltage and automated tap change of distribution transformer voltage is practiced. Artificial Intelligence (AI) capabilities are integrated in the grid so that forecasting of loads and generation is dynamic, and demand gaps are met through response from generators and grid resources. These capabilities become important as electric vehicles (EVs), energy storage and utility scale renewables get integrated into the grid.

Business models have also been developed. Added to the standard CAPEX model (consumer invests in the NEM facility) are Renewable Energy Supply Company (RESCO) models contracting for private PPA, leasing, shared savings and guaranteed savings. RESCOs bring in the benefits of scale in design, procurement, construction, financing and operation to deliver a superior value to the customers.

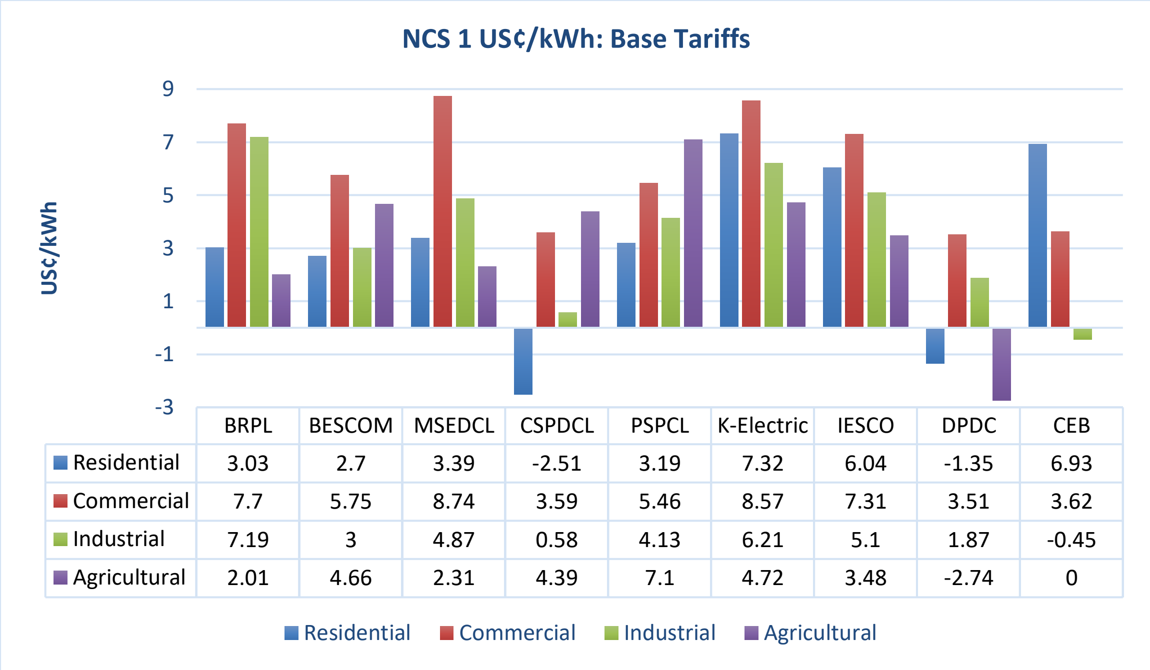
Utilities carry out Demand Aggregation, Engineering Procurement and Construction (EPC) Aggregation, On-Bill-Financing and Super RESCO roles. Such models help small customers in accessing vendors, lenders and independent RESCO services efficiently. Benefits of enhanced scale, reduced costs and improved risks are delivered. Previously inaccessible markets are made accessible.

Apart from simple bank loans, finance flows through RESCOs, leasing companies, utilities etc. Re-financing methods such as green bonds, asset-based securities are used. Insurance and risk guarantees provide risk protection for lenders.

NEM evolves in 3 phases i.e., Launch, Transition and Growth. The policies, technical standards, business models, financing etc. are different in different phases. The framework, summarized in Section 5.10, explains that when right conditions are met, a country or a utility transition from one phase to the next. However, if the conditions required are not met, the slower phase continues or even may revert back. In the growth phase, increase in NEM penetration of the grid is @2-4% annually.

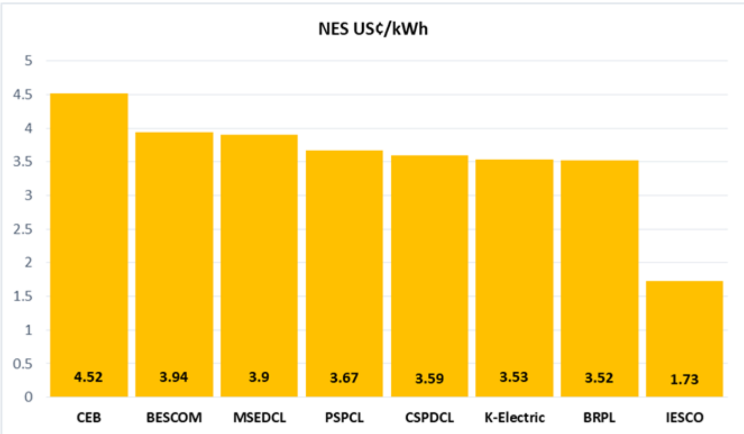
'Economic savings', 'customer savings' and 'utility savings' from NEM implementation are significant in SAARC Member States.

[3] VDER is being implemented in the utilities in USA
[4] A form of NDER is practiced in Singapore.
[5] In Germany, the NEM Solar PV capacity is 32 GW and system peak is 58 GW, indicating grid penetration of 55%



	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
Residential	3.03	2.7	3.39	-2.51	3.19	7.32	6.04	-1.35	6.93
Commercial	7.7	5.75	8.74	3.59	5.46	8.57	7.31	3.51	3.62
Industrial	7.19	3	4.87	0.58	4.13	6.21	5.1	1.87	-0.45
Agricultural	2.01	4.66	2.31	4.39	7.1	4.72	3.48	-2.74	0

Although NEM policies were announced earlier in many SAARC Member States, the real impetus for NEM implementation was seen around in year 2015-2016. This was the time when solar PV costs had dropped significantly and grid parity was breached.[6]



With low LCOE and easily available resources everywhere, solar PV has become the de-facto standard for NEM implementation.

Significant Net Economic Savings (NES)[7]

The author's estimates of economic savings for the reference utilities vary between 1.7 US¢/kWh to 4.5 US¢/kWh (detailed analysis and calculations in Annexure specific to each studied utility).

Only in the case of Dhaka Power Distribution Corporation (DPDC), the Utility in Dhaka, the savings are close to zero, due to higher solar Levelized Cost of Energy (LCOE) and lower cost of gas generation (the baseline energy source). High savings indicate clear rationale for governments to promote NEM.

[6] Solar LCOE for utility scale dropped from 30-35 US¢/kWh in 2010 to 4-5 US¢/kWh in 2016 in India.

[7] The method used in estimating Net Economic Saving (NES), Net Customer Savings (NCS1, NCS2) and Net Utility Saving (NUS) is explained in Section 6.4. Customer savings account for the effect of subsidies to customers and utilities in India. Customer subsidies are available only for small residential and agricultural sectors. In other Member States there are no subsidies.

Large Net Customer Savings

Customers also save with NEM implementation. They save when they substitute grid electricity (NCS1) because solar LCOE is less than the grid tariff and when surplus power is bought by the grid (NCS2) because solar LCOE is less than the price paid by the grid. The author has estimated these savings segment wise.

Four segments were studied i.e., Residential, Commercial, Industrial and Agricultural.

The savings (NCS1) are large in all utilities except for DPDC (Dhaka, Bangladesh) and CSPDCL (Chhattisgarh, India) where for a few segments the savings are low or negative.

The savings are significantly higher for high paying customers. Such customers also consume higher quantum of electricity and have the ability to invest in NEM facilities. They are prime target for NEM adoption.

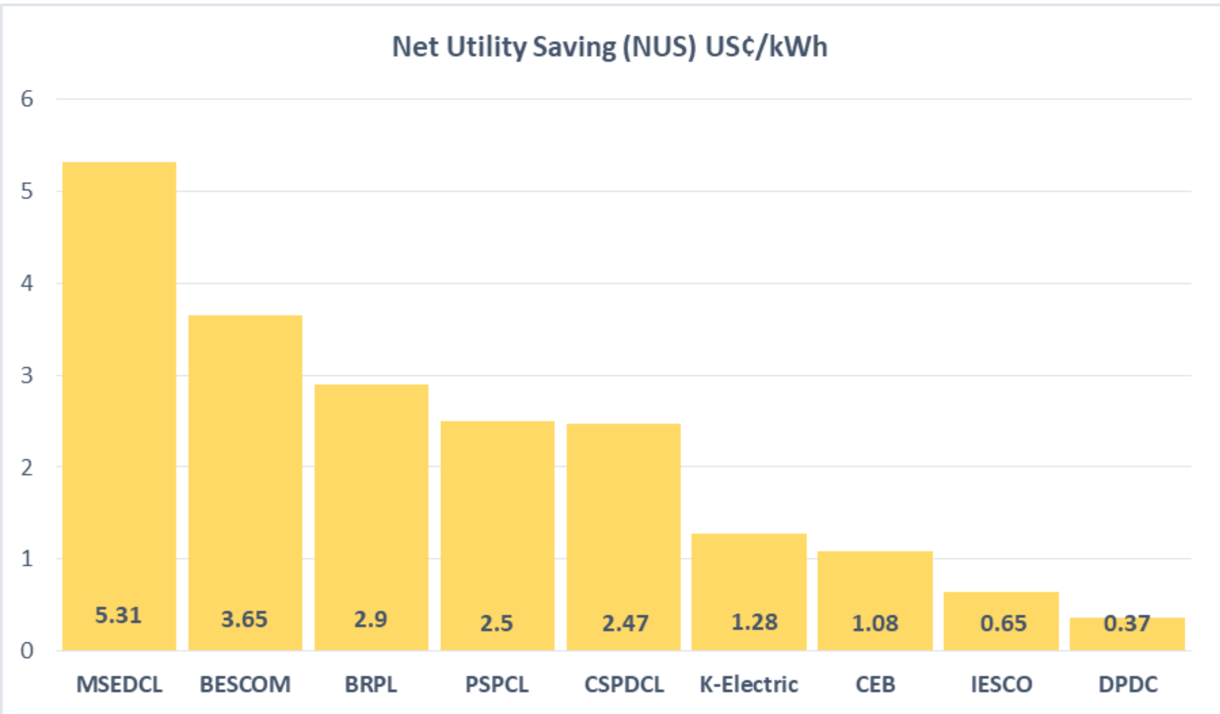
The 'customer saving for exports to grid' (NCS2) presents a mixed picture.

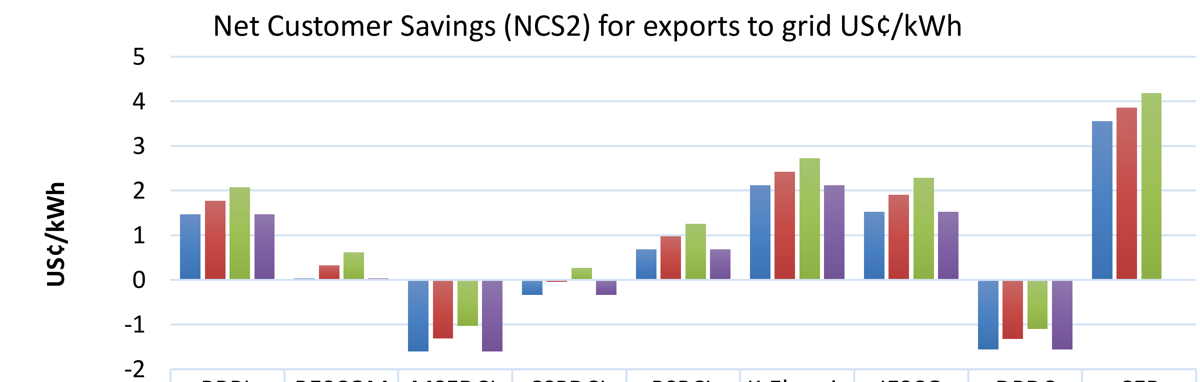
Many utilities in India have low or negative values for NCS2, because they price NEM exports at lower levels than their Average Pooled Procurement Cost (APPC), and sometimes lower than the price for utility scale solar.

This strategy forces customers to design smaller plants, minimizing exports. This paradoxically leads to lower savings for utilities and also for the economy.

The NCS2 savings are low for DPDC too.

NCS2 levels are the highest for the utilities in Pakistan and Sri Lanka (~1.5 - 4.2 US¢/kWh).



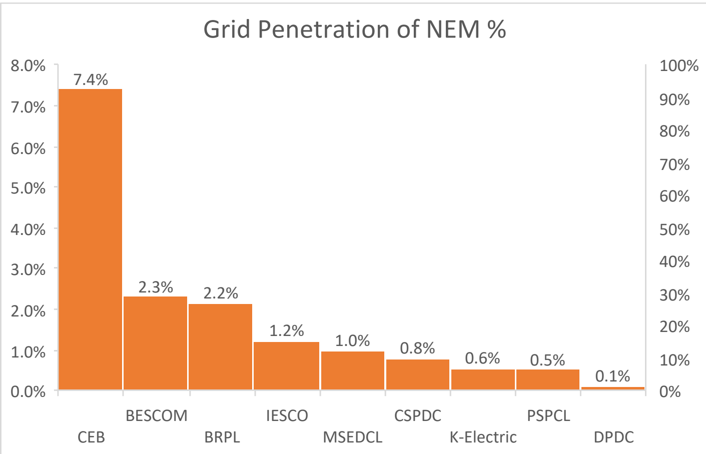


	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
Residential	1.47	0.03	-1.6	-0.33	0.68	2.12	1.52	-1.55	3.55
Commercial	1.77	0.32	-1.31	-0.04	0.97	2.42	1.9	-1.32	3.86
Industrial	2.07	0.61	-1.02	0.26	1.25	2.72	2.28	-1.09	4.18
Agricultural	1.47	0.03	-1.6	-0.33	0.68	2.12	1.52	-1.55	0

Net Utility Savings (NUS)

The estimates of Net Utility Savings (NUS) on exported power presents an inverted picture. The NUS levels are the highest for Indian utilities because they pay low prices for NEM power.

In summary, barring a few cases, the author assessed that that NEM results in savings for the Economy, the Customers and the Utility. Higher these savings, higher will be the momentum for NEM adoption.



The author assessed the reference utilities for the robustness of policies, business models, financing, incentives and implementation processes to support NEM. And the author correlated this with the grid penetration levels achieved, the time taken.

Sri Lanka has achieved good penetration levels (~7.4%), primarily in the last four years, after 2016 policy revision. Sri Lanka model displays the following features:

i. Excellent levels of savings for the economy, for the customers and for the utility. The primary reason is high cost of generation of fossil fired generators contributing to 50% of energy mix.

ii. High tariffs for NEM energy.

iii. Policy with very few restrictions on system capacity.

iv. Full bouquet of NEM models i.e., NEM, Net Accounting (Net Billing equivalent) and Net+ (All Buy and All Sell equivalent).

v. Low-cost financing and government commitment.

BSES Rajdhani Power Limited (BRPL, Delhi, India) has the second highest grid penetration levels. This utility too enjoys a very progressive net metering policy by Delhi Government (2016) which has innovative features such as virtual net metering and has few capacity restrictions. It provides a generation-based incentive for residential customers in addition to central government subsidy to small residential customers.

BRPL has a very positive understanding of benefits of NEM and is actively promoting NEM. It is also implementing a utility anchored demand aggregation model to support small customers.

The evaluation of utilities and the business environment around them was summarized in NEM Maturity Assessment. The parameters used included 'value for customers' (savings i.e., NCS1, NCS2, incentives), the utility (perspective for NEM, the organizational capability, and saving NUS), the government (policy maturity and saving NES), eco-system maturity, availability of cost-effective finance and maturity of business models. This is detailed in Section 7.8.

NEM Maturity Assessment was used to forecast NEM penetration (%) rates and NEM size.

CEB (Colombo, Sri Lanka) and BRPL (Delhi, India) are projected to cross 20% grid penetration levels by 2030. Others grow slower due to presence of various dampeners.

NEM Capacity size (MW)	BRPL	BESCOM	MSEDCL	CSPDC	PSPCL	K-Electric	IESCO	DPDC	CEB
Sept, 2020	69	137	216	28	67.8	19	18.45	1.82	260
2025	292	363	964	147	501	139	71	56	890
2030	1,025	944	2,987	473	1,699	467	211	207	1,421

By 2030 CEB achieves grid penetration levels of ~25% and achieves a size of 1.4 GW+. BRPL achieves a grid penetration level of ~19.7% and achieves a size of 1 GW too. MSEDCL, despite its slow growth in penetration achieves a size of ~3.0 GW due to its very large grid size.

A similar analysis was carried out for reference SAARC Member States and likely NEM capacity was forecasted. The results are summarized below:

Forecast NEM Capacity (MW)	India	Bangladesh	Pakistan	Sri Lanka
2020 (Actual)	5,440	15	94	267
2025 (Forecast)	18,110	594	1,077	916
2030 (Forecast)	58,746	1,735	3,411	1,462

India crosses 18 GW by 2025 and 58 GW by 2030. Pakistan reaches ~3.5 GW and Bangladesh, Sri Lanka reach ~1.5 GW sizes, by 2030.

The Member States will need to act on 'dampeners' and create the right power behind NEM Growth.

The author has proposed improvements in the NEM environment for reference Member States. These are outlined in Chapter 8. Key improvements suggested are

i. Removal and simplification of limits on capacity.

ii. Introduction of full bouquet of compensation models i.e., Net Metering, Net Buying and All Buy-All Sell.

iii. Acceptance of all Business Models i.e., RESCO, Utility Anchored and Community-scale.

iv. Judicious setting of compensation tariffs for exports- balancing the value for utilities as well as the customers.

v. Introduction and promotion of bundled loans, utility channelled finance, risk mitigation products such as partial risk guarantees, re-finance through green bonds and sustainable impact bonds.

vi. Fully automated NEM sanction process.

vii. In 2-3 years, adoption of new standards for 'fault ride through' and grid responsive control of active and reactive power by the distributed generation. IEEE 1547-2018 or equivalent.

These are the conditions that will support transition to the growth phase. First three changes relating to capacity, compensation models and business models can be adopted now in the Member States where NEM was recently launched. The rest can be introduced later when the NEM adoption matures and enters growth phase.

Acronyms

AB-AS	All Buy All Sell
ABS	Asset Based Securities
AC	Alternating Current
ADB	Asian Development Bank
AEDB	Alternative Energy Development Board, Pakistan
AFP	Costs of Regulation Reserves
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
APPC	Average Pooled Purchase Price
BDT	Bangladeshi Taka
BESCOM	Bengaluru Electricity Supply Corporation Limited
BOS	Balance of System
BPDB	Bangladesh Power Development Board
BRPL	BSES Rajdhani Power Limited, Delhi's Electric Utility
CAGR	Compounded Annual Growth Rate
CEB	Ceylon Electricity Board
CFA	Central financial assistance
CSPDCL	Chhattisgarh State Power Distribution Company Limited
CV	Capacity Value
CV	Community Value
DC	Direct Current
DERs	Distributed Energy Resources
DISCOM	Distribution Company
DML	Daily Minimum Load
DPDC	Dhaka Power Distribution Company
DRV	Distribution Resource Value
DT	Distribution Transformer
ECC	Energy Consumption Charge
EESL	Energy Efficiency Services Ltd, India
EM	Electric Mobility
EMC fee	Cost of Energy Management Company, Singapore
ENV	Environmental Value
EVN	Vietnam Electricity Corporation
EPC	Engineering, Procurement, Construction
EV	Energy Value
FiT	Feed in Tariffs
FOR	Forum of Regulators
GBI	Generation Based Incentive
GM	Ground Mounted
GSC	Grid Service Charge

GST	Goods and Service Tax, India
HEUC	Hourly Energy Uplift Charge
HT	High Tension
HV	High Voltage
ICAP	Installed Capacity
IGCEP-2047	Indicative Generation Capacity Expansion Plan, Pakistan
INR	Indian Rupee
IPP	Independent Power Producers
ISA	The International Solar Alliance
kW	Kilowatt (1000 W)
LCOE	Levelized Cost of Energy
LSRV	Location Specific Resource Value
LT	Low Tension
LV	Low Voltage
MRI	Meter Reading Instrument
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSSC	Market Support Service Charge
MV	Medium Voltage
NB	Net Billing
NBFCs	Non-Banking-Finance Companies
NCEF	National Clean Energy Fund, India
NDB	New Development Bank
NDER	Net Value of Distributed Energy Resources
NEM	Net energy metering or Net Metering
NEPRA	National Electric Power Regulatory Authority, Pakistan
NES	Net Economic Savings
NISE	The National Institute of Solar Energy, India
PKR	Pakistan rupee
PNB	Punjab National Bank
PPA	Power Purchase Agreement
PRGF	Partial Risk Guarantee Fund
Prosumers	producer-consumers
PSC	Public Service Commission
PSO	Power System Operator's Fee
PSPCL	Punjab State Power Corporation Limited
PSUs	Public Sector Units
RE	Renewable Energy
REC	Renewable Energy Credit
RESCOs	Renewable Energy Service Companies
RPO	Renewable Purchase Obligation
RT	Roof Top
SAARC	South Asian Association for Regional Cooperation

SBI	State Bank of India
SEBI	Securities and Exchange Board of India
SECI	Solar Energy Corporation
SLR	Sri-Lankan Rupee
SME	Small and Medium Enterprises
Solar PV	Solar Photovoltaic
SR	Costs of Spinning Reserve
SREDA	Sustainable and Renewable Energy Development Authority, Bangladesh
SRISTI	Sustainable Roof Top Implementation for Solar
T&D	Transmission and Distribution
UCC	Uncontracted Capacity Charge
UOS	Use of System Charge
USEP	Uniform Singapore Electricity Price
VDER	Value of Distributed Energy Resource
VNM	Virtual Net Metering

Conversion Factors

Country	Currency	Currency code	Member States currency to USD conversion (as on 1st Nov 2020)
Afghanistan	Afghan Afghani	AFN	76.834[8]
Bangladesh	Bangladesh Takas	BDT	84.874[9]
Bhutan	Ngultrum	Nu	74.646[10]
Indian	Indian National Rupee	INR	74.646[11]
Maldives	Maldivian Rufiyaa	MVR	15.412[12]
Nepal	Nepalese Rupee	NPR	119.28[13]
Pakistan	Pakistani Rupee	PKR	160.47[14]
Sri Lanka	Sri Lankan Rupee	LKR	184.32[15]

8 https://www.exchangerates.org.uk/data/currencies/live-usd-afn-exchange-rate
9 https://www.exchangerates.org.uk/USD-BDT-exchange-rate-history.html
10 https://www.exchangerates.org.uk/USD-INR-exchange-rate-history.html
11 https://www.exchangerates.org.uk/USD-INR-exchange-rate-history.html
12 https://www.exchangerates.org.uk/USD-MVR-01_11_2020-exchange-rate-history.html
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15 https://www.exchangerates.org.uk/USD-LKR-exchange-rate-history.html

1. Background

1.1. Global Net-metering Regulations and Development of Distributed Renewables

Net-metering originated in the United States of America (USA). The first two projects to use net-metering included an apartment complex and a solar test house in Massachusetts in 1979. Since then, all States in the USA have adopted NEM. Most States compensate generation at retail rate although some use 'whole-sale rates' and some are moving to 'Value of Distributed Energy Generation' (VDER)[16] to take care of true value and costs of Net Energy Metering (NEM) technology integration with the grid.

Australia, Canada, China, European Union, Japan and USA have strong policy support for growth of distributed generation of Solar Photovoltaic (PV) energy. Solar PV is the most commonly used technology for NEM. By 2017, NEM was adopted in 55 countries (IRENA, IEA and REN21, 2018). IEA forecasts (IEA, 2019) that:

i. Distributed Solar PV capacity will more than double to 530 GW by 2024 (from 2019), an increase equal to that of onshore Wind or almost half of total Solar PV. The distributed Solar capacity is driven by NEM policies.

ii. China, will account for half of global distributed PV growth, and overtake the European Union by 2021 as leader[17] even as distributed PV grows rapidly in the European Union through 2019-24. The primary driver for growth shall be increasing economic feasibility and improving policy environment. While Japan remains a strong market, India and Korea are emerging as leaders of capacity growth in Asia.

iii. The largest segments for solar PV roof top systems are commercial and industrial applications rather than residential. These segments represent almost three-quarters of new distributed PV installations through 2024 as their economic case is generally better than for residential systems. These segments require larger systems, resulting in lower investment costs per kilowatt (kW). As supply and demand are usually better aligned, this enables more self-consumption and larger electricity bill savings. These segments also present lower credit risk compared to residential segments, and are better suited for long term Power Purchase Agreement (PPAs) with Renewable Energy Service Companies (RESCOs).

iv. Residential segment is expected to account for one fourth of net capacity additions. The top five markets for residential PV installations per capita in 2024 are expected to be Australia, Belgium, California (in the USA), the Netherlands, and Austria. The total number of residential systems would expand to 100 million by year 2024.

v. In most countries, Levelized Cost of Energy[18] (LCOE) for commercial and industrial segment rooftop PV is already less than the grid tariffs. This will likely fall by ~35% (2019-2024), strengthening the business case further. Residential costs are also expected to fall by ~15%.

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[16] Various systems for NEM compensation mechanism are explained later. Refer to Section 5.4

[17] China mostly operates with Gross Metering or Auction regimes.

[18] LCOE – Levelized Cost of Energy is price of energy/kWh, paid for generated energy from a plant, over the operating life, covers operating and maintenance expenses and provides adequate returns on capital cost of investments.

1.2. Importance of Net Metering

NEM is a billing and metering mechanism which allows consumers to generate electricity and use it at a different time from when it is generated. This is achieved by a crediting mechanism which allows credit to accumulate to the customer for electricity fed to the grid, this credit is settled against grid-consumed electricity units of the customer.

Most NEM mechanisms compensate the generator for net-surplus exports to the grid, over a defined period of time.

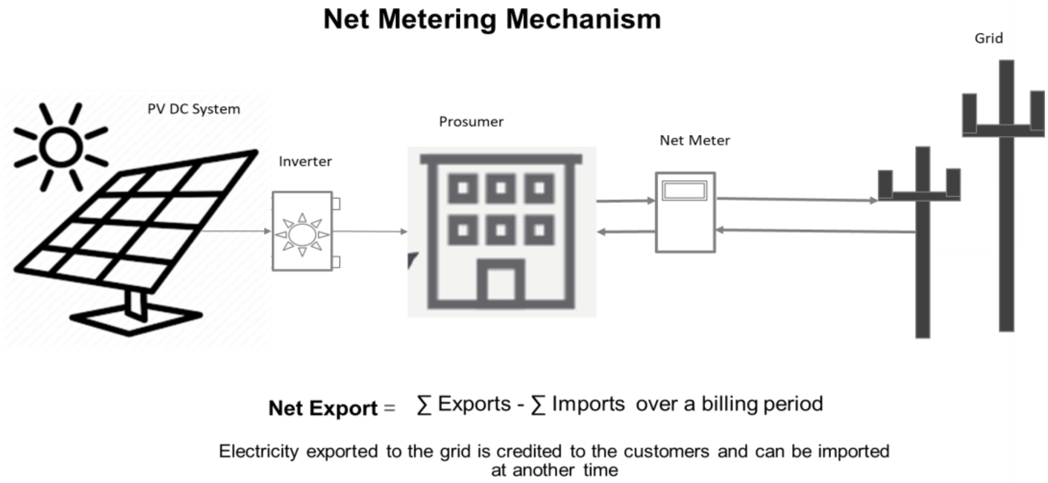

FIGURE 1: NET METERING MECHANISM

NEM is normally offered to renewable energy technologies (in many cases supported by energy storage) so as to promote green energy production in the grid. Solar PV is the most popular source under NEM because of its universal nature.

The benefits of NEM mechanisms are many:

i. It encourages distributed generation by consumers (called prosumers or producers + consumers), allows users to maximize generation based on ground or roof area owned by them.

ii. Since generation happens behind the meter, close to consumption loads, long term investments in Transmission and Distribution (T&D) networks are reduced. In addition, distributed generation reduces energy losses in T&D networks, when transmitting power from distant, large scale generation plants.

iii. If the renewable technology chosen for NEM generates energy during peak hours, it saves peak power procurement, and helps utilities reduce overall costs to serve.

iv. Because of the distributed nature of generation, the network becomes more diversified and can be operated with higher safety and security. The network does not need to be completely shut down, even in case of non-availability of central generating stations or faults in transmission networks, especially if energy storage is also available in the distribution network or with the prosumers.

v. With appropriate policies, coupled with energy storage, NEM can also be evolved to support efficient 'ancillary services for the grid' (voltage support, frequency support, black start, spinning reserve etc.).

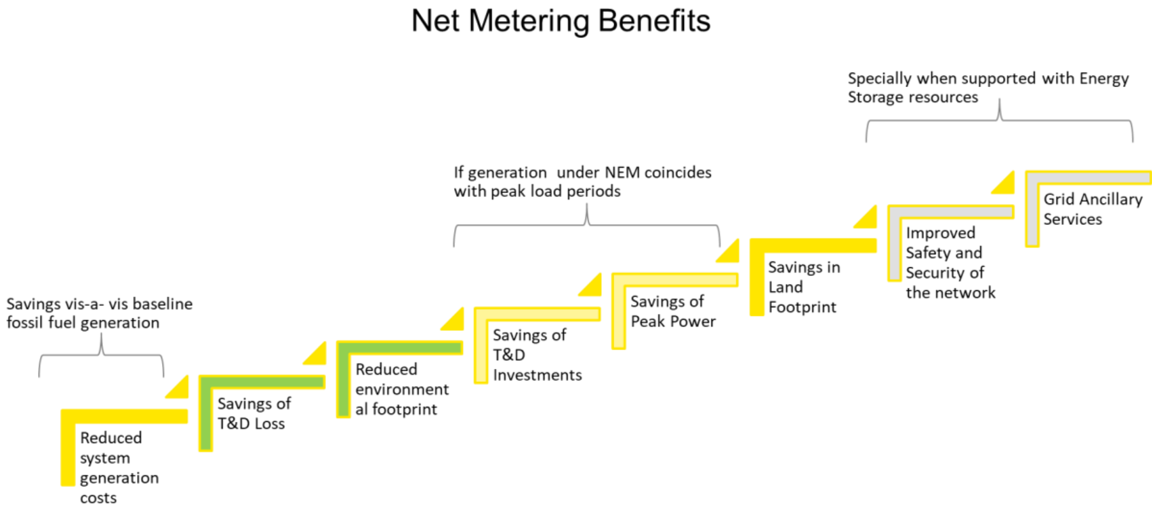

FIGURE 2: BENEFITS OF NET METERING

Just like all new technologies and solutions, NEM also has certain disadvantages:

i. NEM encourages consumers to start self-generating, this reduces demand on the grid, and most distribution utilities perceive this as 'Loss of Customers' or 'Revenue'. In the fast-growing developing economies, this loss may not often be a matter of perception as the energy demand is growing rapidly i.e., @5-7% annually and even with adoption of NEM, overall utility sales will continue to grow.

ii. NEM is particularly attractive to the Commercial and Industrial customers, being at the top of tariff structures, cross subsidizing residential and other segments for 'public good'. Hence, the sense of loss is perceived by the utility when commercial and industrial customers opt for NEM. However, in most cases such customers need round the clock power, and even after NEM they remain utility customers. In fact, they can even provide additional support services to the grid if energy storage is installed along with the NEM resource.

iii. Sometimes NEM compensation policies are not based on a detailed evaluation of 'costs and benefits' of distributed generation to the grid. The policies seem to favour prosumers at the cost of utilities. This eventually burdens those customers who do not use NEM[19].

Customers find NEM attractive because of the following factors (see Figure 3 for depiction):

i. Savings in energy costs, as grid tariffs are often higher than costs of generation under NEM. When consumption is low, for example, when a resident prosumer goes out on a holiday, the system still generates returns by feeding electricity to the grid.

ii. Some consumers may reduce their demand charges in cases where peak loads are reduced through local generation.

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[19] Opposition has grown recently as NEM is taking-off. For example, In April 2020, the New England Rate-payers Association (NERA) filed a Petition to roll-back all 'solar net-metering' schemes in the US. They called NEM as 'Robinhood in reverse'. They claimed that NEMs tended to reward investors and RESCOs and put the burden of additional grid management costs on poor customers not able to afford NEM investments. This petition has however, been rejected on ground of not substantiating its claims.

iii. Renewable technologies have insignificant variable costs. Most of the generation costs are linked to capital investments which are fixed. Hence energy costs under NEM have a lock-in and are not inflationary. In comparison, grid tariffs increase as fossil fuel costs increase or as environmental costs are imposed on fossil fuels.

iv. It is possible to optimize local generation with energy efficiency measures. For example, with solar PV, many loads at home can be shifted to DC (e.g., fans, refrigerators, air-conditioners, pumps, TVs, computers, lights, etc.). This results in significant energy savings. Also, a roof-top solar PV system if properly designed, may reduce heat loads for air conditioners. This happens because when covered by solar panels, the roof may absorb less heat.

v. One's own generation of electricity, coupled with energy storage, offers relief when the distribution grid is down.

vi. Consumers get the satisfaction of using green energy. There is an evolving consumer class, which is targeting 'net-zero' grid use, as they move towards generating all their energy needs on their own, using renewable energy sources.

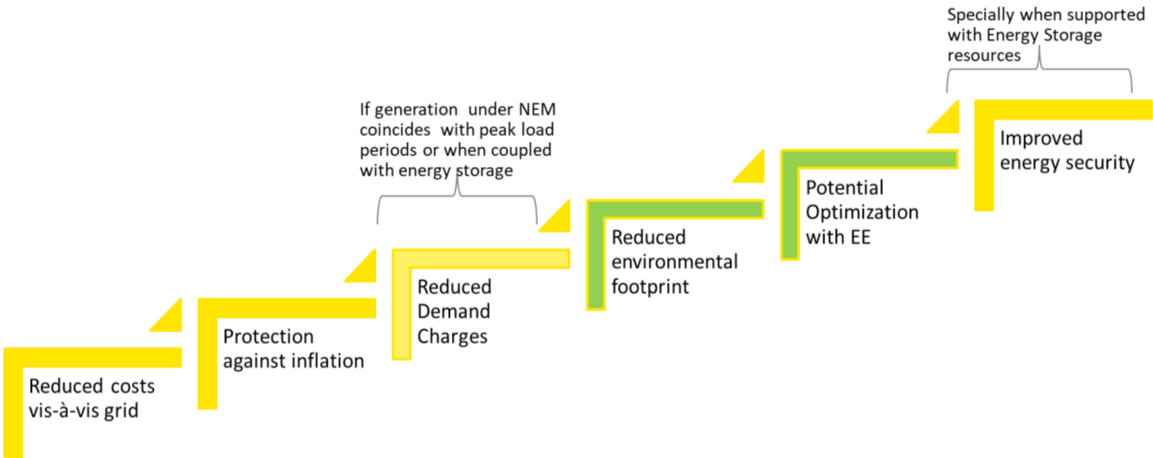

FIGURE 3: BENEFITS OF NET METERING TO CONSUMERS

2. Problem Statement

Despite the obvious benefits of NEM, the speed of its adoption is slow in many SAARC Member States. Bangladesh, India, Pakistan, and Sri Lanka have already introduced and experienced NEM schemes, while Afghanistan, Maldives, and Nepal also announced NEM policies and are now at the final stages of development.

TABLE 1: NEM SPECIFIC ISSUES FACED BY UTILITIES ACROSS SAARC MEMBER STATES

Country	Specific issues
Afghanistan	Afghanistan is in the nascent stages of its NEM policy framework but faces significant challenges due to poor investor confidence, limited business models, grid instability, no tariff incentive for NEM, etc.[20]
Bangladesh	Bangladesh has the issues of low awareness, high interest rates and no financing from commercial banks, no active participation of utilities, quality concerns of the installed systems (especially for the consumer), etc.[21]
Bhutan	Bhutan is yet to come out with its plans, policy and regulations for NEM.
India	India has robust policies and regulations, yet NEM market (which is solar rooftop) has been facing many hurdles. The issues vary across utilities, some of the concerns include - NEM not being applicable to certain customer segments (especially commercial and industrial (Saran, 2019)), preference to gross metering over NEM (Parikh, Andhra DISCOMs Want Net Metering Out and Gross Metering In for Rooftop Solar Systems, 2020), (Thomas, 2019), low Feed-in-Tariff and billing issues (Mishra, 2019), etc.
Maldives	The country has an active NEM policy, but challenges exist, including very limited financing options, no interest displayed by small business owners due to the requirement of collateral for loans, utility's hesitation to facilitate NEM agreements, etc.[22]
Nepal	Nepal has to deal with its long NEM application processing times, discontinuation of government support schemes, financing issues (access to collateral financing, high interest rates), lack of long-term targets and programs for the uptake of NEM, etc.[23]
Pakistan	Though one of the early movers to adopt NEM among the SAARC member states, Pakistan has faced multiple obstacles in the path of implementing net-metered RE (solar and wind) systems. The major barriers include discouragement by electric utility companies, technical capability at different organizational levels of the utilities, lack of awareness among stakeholders, inadequate access to tailored finance options, etc. (Qamar, Qamar, & Khan, 2016), (giz, 2016)
Sri Lanka	The utilities, though the most progressive of the lot, but do not have an entirely encouraging approach towards renewables (and also net-metering). Unavailability of grid, long application processing times, lack of awareness, financing issues, etc. are few of the issues faced.

[20] From SEC Webinar available at https://www.saarcenergy.org/wp-content/uploads/2020/09/Ghalib-Solar-Market-Prospect-Afghanistan.pdf

[21] Author's interaction with SREDA officials

[22] Presentation by Ministry of Environment & Villa College available at https://www.iges.or.jp/sites/default/files/inline-files/3_Maldives.pdf

[23] From SEC Webinar available at https://www.saarcenergy.org/wp-content/uploads/2020/09/Avishek-Malla-presentation.pdf

The purpose of this study is to identify important challenges for the utilities that may be reducing the speed of adoption of NEM in SAARC Member States, and suggest measures which could mitigate such challenges and rapidly increase penetration of NEM.

3. Objective

The overall objective of this study is to increase the deployment of the renewable energy technologies in SAARC Member States through the use of NEM mechanisms. The study will assess and provide solutions to all technical and financial challenges faced by the Distribution Utilities while implementing NEM technology. The aim is to facilitate the distribution utilities for speedy adoption of NEM mechanisms.

4. Methodology

The author has sought to address the Problem Statement and present the analysis and recommendation. The sub-steps are described in Figure 4.

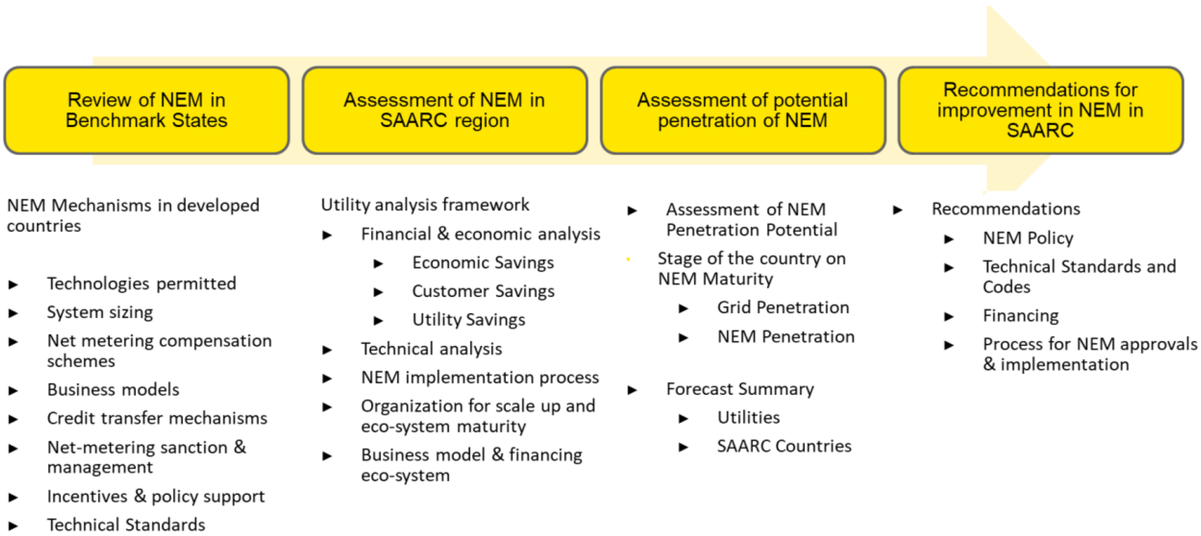

FIGURE 4: OUTLINE OF THE METHODOLOGY OF THIS STUDY

The description of the sub-steps:

i. Review of practices followed in the Benchmark States, which have made significant progress in NEM implementation.

ii. Assessment of NEM in SAARC Member States by analysing selected utilities.[24]

iii. Assessment of Potential Penetration of NEM in SAARC Member States based on NEM Maturity Assessments.

iv. Recommendations for improvement in NEM.

[24] The utilities selected for the study and reasoning behind selection is provided in Annexure 18. Afghanistan, Bhutan, Maldives and Nepal have not been included for detailed analysis due to nascent stage or no existence of NEM frameworks and markets as compared to Bangladesh, India, Pakistan, and Sri Lanka.

4.1. Selection of Benchmark States

In order to facilitate a comparison of best practices, the author selected some international NEM programs, where high penetration and integration of NEM has already taken place. These include NEM programs in Germany, Italy, California (USA), Hawaii (USA), Vietnam, and Singapore.

Germany and Hawaii have achieved high penetration of distributed solar in their grids, although the strategies adopted by them differ. Studying their evolution may provide interesting insights for NEM programs in SAARC Member States.

Germany has 33 GW of distributed Solar PV capacity (2018), of which 26 GW is under the commercial and industrial segment and 6.5 GW in the residential segment[25]. Renewable power share in Germany has reached 46.3% in 2019. Hawaii's HECO utility comprises 524 MW of customer-site solar output, equalling nearly 20% of its total grid capacity of 2626 MW (Cross-Call, Prince, & Bronski, 2020).

Germany has achieved success driven by attractive Feed in Tariffs (FITs), whereas Hawaii promoted access through NEM policies. Hawaii has very high grid tariffs because primary sources of electrical energy are very expensive, oil-based generating systems (Cross-Call, Prince, & Bronski, 2020).

Italy is amongst the top five residential solar PV markets in Europe. Italy has followed an interesting strategy of 'ranking NEM proposals' based on location and energy type. This focuses NEM investments in those areas, where NEM technology provides superior value in terms of saving of distribution resources and serving poorly served customer segments.

California has been a pioneer, introducing NEM policies in 1995. It has almost half of the residential solar PV market in the USA (IEA, 2019). California has developed specialized programs and incentives for different types of residences such as customers with 'no roof' (virtual net-metering), low-income residents, residential renewable energy tax credits etc.

Singapore offers an interesting example from Asia, where NEM is promoted using 'value-based pricing' for power fed to the grid. Another country from South-East Asia i.e., Vietnam has shown tremendous uptake of solar rooftop system installations despite moving from an NEM to an 'all-buy all-sell' regime.

The profiles of NEM policies in the benchmark countries are given in Annexure 1-6. Apart from these benchmark states, the author reviewed a few well-known global studies on distributed energy resources.

5. Review of Net Metering in the Benchmark States

5.1. Salient Features of NEM Policies

The salient features of Net Metering policies are structured below:

i. Technologies permitted

ii. System sizing

[25] Compared to a peak load of 56 GW in 2019, capacity of 32 GW translates to 55% grid penetration, which is amongst the highest globally.

iii. Net Metering Compensation Schemes

iv. Net Metering Business Models

v. Net Metering Credit Transfer Schemes

vi. Net Metering Sanction and Management Process

vii. Incentives and Policy Support

5.2. Technologies Permitted

Most states in Europe and the USA permit all renewable energy technologies to use NEM. These may include solar PV, wind, biomass, biogas, hydro, and solar (thermal). However, roof top Solar PV is the most popular technology for NEM. The policy in Germany also includes geo-thermal energy.

As penetration increases, the policies start to permit storage[26] and fuel cells[27] to optimize internal consumption as well as to control the timing of exports to maximize the value of power exported to the grid.

Conceptually all these technologies can be adopted in distributed generation architecture. However, they do not have the same level of development and competitiveness vis-a-vis the grid. The cost and benefit matrices also vary from country to country. Hence it may be useful to focus on those technologies which are most likely to be adopted in the beginning (e.g., solar PV, solar thermal) and gradually evolve the policies to include others.

5.3. System Sizing

The sizing of the system has many considerations:

i. Size of the system vis-à-vis the sanctioned or permitted load to the consumer.

ii. The cumulative size of NEM technologies vis-à-vis the distribution transformer capacity.

iii. The location of the NEM technology.

5.3.1 Minimum and Maximum Sizes

In the beginning, most countries have absolute minimum and maximum limits. Minimum system sizes could be kept at 1 kW and maximum at 500 kW, 1 MW, 10 MW, etc. These also vary depending on the customer segment.

However, as the economic attractiveness of renewable energy (RE) increases, ambitious targets are set, and processes of NEM management and grid controls improve, the minimum and maximum restrictions on the RE capacities are typically removed.

For example, Canada has removed the system size cap of 500 kW. In North Carolina state of USA, the system capacity limit was 20 kW for residential and 100 kW for commercial consumers. In 2007, this was raised to 1 MW. In California state, interconnection with the grid under net metering is permissible up to

[26] Refer to Annexure 2 on Hawaii NEM Profile- smart export program.
[27] Refer to Annexure 1 on California NEM Profile

10 MW, subject to customer category and technical feasibility of interconnection. The limit has been relaxed completely for government buildings. This has happened since, RE systems are increasingly becoming economically attractive.

5.3.2 Percentage of Sanctioned Customer Load

Another restriction imposed on the system size is based on the sanctioned consumer load. Normally 100% of the sanctioned load is permitted as permissible NEM capacity for on-site RE. This policy is designed on the premise that customers should be permitted to consume most of the generated energy within their premises and there should be no additional expense required to strengthen the grid.

5.3.3 Grid Capacity Linked Constraints

Most NEM policies begin with very limited permissions for RE capacities vis-à-vis the grid capacity. Normally the policies tend to limit cumulative RE capacity in a distribution feeder to 15% of feeder capacity or peak sanctioned load.

However, experience over the last decade as well as more detailed simulation models for various grids show that cumulative RE capacity can be easily increased to 100% of the peak capacity of the grid with very little investment in transformer load management systems (GIZ, 2017). It can also go beyond 100% of grid capacity, if peak generation of RE (e.g., solar) overlaps with peak loads in the grid[28], or if two RE technologies used under NEM have complementary generation patterns.

Germany, having ambitious RE targets, has given up all constraints on system sizing. The regulation in the country allows for extending the grid for any willing generator, and all upgradation costs are borne by the grid operator, which are socialized later.

Other states such as Italy, California, Singapore, etc. also do not have normative grid capacity constraints, however, they control power injection through support-costs charged (Singapore), or value-based compensation pricing for the exported electricity (e.g., California).

Vietnam, with its uneven transmission grid distribution, is finding it difficult to accommodate the new Solar projects onto the grid. This problem is more pertinent in two provinces i.e., Ninh Thuan and Binh Thuan, that have good solar and wind potential and the solar plants are located here with high density but the demand for electricity on-site is very low. As a result, the grid overload is unavoidable while the calculation, development and reinforcement of the grid to connect to these plants seem to be not simple and takes a large amount of time. Specifically, in Ninh Thuan, the total planned and installed capacity is currently so big with over 2500 MW, while the grid-connected capacity is still very low, less than 1000 MW. With such an overloaded situation, the power system would be very likely to encounter problems of power line and substation congestion, possibly causing system instability and dangerous situations for devices.

Most states are moving to Hosting Capacity Assessments and are permitting new capacities based on the hosting capacity of the grid. Hosting capacity is established using available information on grid resources

[28] Such load patterns occur as cities develop and begin to have very high penetration of air-conditioning, especially in tropical zones. Delhi has twin peak load periods (1400-1700 hrs and 2100-2400 hrs). Dhaka is also developing similar characteristics. During the first peak, solar PV can generate 30-40% of power.

(capacities of line, transformers, storage, controllers etc.), load profiles and generation profiles of RE, detailed feeder wise simulations using sample real time data. Simulation models help deduce acceptable RE capacities that can be hosted on the grid without breaching grid performance limits. This information is transparently shared with 'prosumers', who wish to set up RE capacities under NEM.

Hawaii experimented by capping cumulative solar PV capacities to percentage of Daily Minimum Load (DML), assessed after accounting for captive consumption by prosumers. Hawaii found that they could easily go up to 250% of DML without creating over voltage or grid instability issues.

5.3.4 Definition of the Capacity

Some NEM schemes tend to give permissions to only grid interactive roof-top Solar PV systems. They do not permit Solar PV capacities which are not grid interactive and the power produced is designed to be consumed only within the premises. Similarly, they do not permit solar PV installed on ground or facades within the customer premises.

Capacity can be defined in terms of maximum injection of AC power from a renewable energy system, assessed based on the technical design, and control and storage resources available for use in the system. As distributed RE capacities increase, the following challenges tend to occur:

i. In times of high RE generation, over-voltage situation may occur.

ii. In event of a grid fault (frequency, voltage) large distributed capacities may shut down and come online too quickly, creating instability.

iii. In the event of sudden variation in RE generation (e.g., due to cloud cover for a solar PV plant), the grid may face instability.

Improved inverters providing output control in response to signals from centralized control centers, fault ride through capabilities, delayed shut down and re-start features etc. can help the grid deal with such events. IEEE 1547-2018[29] has defined detailed technical requirements to enable this[30].

The right strategy to support high penetration of RE in the distribution grid would be to improve grid codes (compliance with IEEE 1547 or equivalent), and permit based on Hosting Capacity Assessments.

5.4. Compensation Schemes

Under NEM, the surplus energy generated by a prosumer, after captive consumption, is exported to the grid. Over the years distributed RE schemes have evolved a variety of compensation mechanisms for such surplus power, these include:

i. Net Metering

ii. Net Billing

iii. Time of Use (TOU) Pricing

iv. All Buy All Sell

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[29] IEEE 1547-2018 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

[30] See Annexure 7

A brief summary of such systems used globally is provided in Table 2. This section explains these mechanisms in detail.

TABLE 2: DISTRIBUTED PV POLICY- GLOBAL EXAMPLES (IEA, 2019)

Country/ State/ Province	Buy-all, sell-all model	Net metering		Real time self-consumption	
		Energy accounting	Remuneration of grid exports beyond energy accounting	Energy accounting	Remuneration of grid exports
China	Y	N	NA	Y-real time	Value-based
New York (USA)	N	N	NA	Y-real time	Value-based
California (USA)	N	Y-annual	Value-based	N	NA
Germany		N	NA	Y-real time	Value-based
Japan	Y	N	NA	Y-real time	Value-based
Australia	N	N	NA	Y-real time	Value-based
France	Y	N	NA	Y-real time	Value-based
Spain	N	N	NA	Y-real time	Wholesale or value-based
Turkey	N	Y-monthly	Value-based	N	NA
Flanders (Belgium)		Y-annual	Value-based	Y	Zero- to wholesale price
Netherlands	N	Y-annual	Retail	N	NA
United Kingdom	N	N	NA	Y	Value-based
Maharashtra (India)	N	Y-annual	Value-based	N	NA
Telangana (India)	N	Y-biannual	Value-based	N	NA
Israel	Y	Y-monthly	Value-based	N	NA
Vietnam	Y	N	NA	N	NA
Chinese Taipei	Y	N	NA	N	NA
Sweden	N	N	NA	Y-real time	Value-based
Denmark	N	N	NA	Y-real time	Value-based
Italy	N	N	NA	Y	Value-based
Indonesia	N	N	NA	N	NA
Thailand	N	Y-annual	Value-based	N	NA
Philippines	N	Y-monthly	Wholesale	N	NA
Mexico	Y	Y-annual	Value-based	Y	Wholesale

5.4.1 Net Metering

In this mechanism, the exported electricity is credited to the prosumer's account and is allowed to be imported at any time within a defined credit period. The net electricity consumed in a billing cycle is billed at prevailing retail tariffs. If in a given month, accumulated credit is higher than the consumption, the variable electricity tariff in the bill is charged as zero and the net balance is carried forward.

Most countries begin with this basic NEM mechanism. A two-way meter is used to measure the imports and exports from a prosumer premise and credit and settlement is tracked and completed by the utilities.

Some states permit credits to be carried over without any time-limit. It is perceived that unlimited carryover may create undue burden on a utility, especially when grid tariffs are inflationary, and the credits are utilized at high prices of later years. Most schemes therefore limit it to a year.

The unutilized credit at the end of the credit period, is valued and credited in the prosumer bill based on a benchmark price. These pricing methods are similar to the ones described in further detail under Net-billing.

5.4.2 Net Billing

In this mechanism, rather than crediting and carry over, the exported electricity is valued at a fixed benchmark price. The benchmarks could be

i. Feed in Tariffs
ii. Retail tariffs or a fraction of retail tariff
iii. Prices discovered in an auction
iv. Average Pooled Purchase Price (APPC) for the utility or a fraction of it
v. Avoided Cost for the Utility
vi. Value of Distributed Energy Resource (VDER)
vii. Net Value of Distributed Energy Resources (NDER)

i. Feed in Tariffs

Feed in Tariffs (FiT), kept at attractive rates, promise an assured attractive return to prosumers and tend to be very effective in scaling up capacities under Net Billing systems. Most schemes start with this compensation mechanism and later migrate to APPC or VDER schemes. Germany uses FiTs for small systems (<100 kW) even now.

ii. Retail Tariffs

In 2011, Hawaii offered compensation at retail tariffs. Since the primary generation sources in Hawaii were oil fired generating stations, retail tariffs were very high (US$ 0.36-0.38/kWh). This made Hawaii very attractive for solar PV and almost 650 MW capacity came up between 2011-2018[31].

iii. Auction

Many European Utilities provide NEM compensation at tariffs discovered under auctions. This system can

[31] Hawaii Natural Energy Institute July 2020 PowerPoint presentation (available at https://www.hnei.hawaii.edu/)

be implemented in two forms:

i. Auctions for 'premium' over exchange traded power: The prosumer is compensated at a price determined by the average price discovered on a power exchange and an add-on premium, which is established, through auctions prior to approving the capacity. Thus, the prosumer carries a price-risk equivalent to price variation in exchange traded power. This system is used in Germany and Denmark.

ii. Auctions for 'price': The price does not change over the PPA/NEM contract period, which is normally 20 years. This system offers complete protection against price risk and can discover finer prices.

Italy uses a variant, it auctions for 'minimum guaranteed price' and the power is supplied to an exchange. If the exchange price is higher than the minimum guaranteed price, no additional price is payable. However, in case the exchange price falls below the guaranteed minimum, the shortfall is paid by the utility.

iv. Average Pooled Purchase Price

Utilities can also link the compensation to the average pooled purchase price (APPC) for power paid by the utility. This equates the distributed RE to large scale generating plants. Utilities perceive this system as fair, because they are not being asked to pay a higher price for distributed RE than what they are paying to other power sources. In some cases, a discount is applied to APPC, to compensate for costs incurred by utilities in dealing with infirm, variable nature of RE.

v. Avoided Cost

Some utilities in the USA have begun paying for exported energy at the 'avoided cost' for the utility. For example, since 2017, Arizona State is implementing an avoided cost rate, based on the 5-year running average price of utility-scale solar, including both power purchase agreements (PPAs) and utility self-built solar systems, adding an additional amount to represent avoided transmission and distribution (T&D) capacity and line-losses. Similarly, Indiana Act No. 309 of 2017 triggers a transition to a net billing arrangement to replace net metering, based on avoided cost. Indiana will begin to credit customers at 1.25 times the avoided cost rate. Avoided cost is defined as "the average marginal price of electricity paid by the electricity supplier during the most recent calendar year".

vi. Value of Distributed Energy Resource (VDER)

Many utilities in the USA are moving to some form of VDER. In essence, the system values RE power injected by a prosumer for a variety of effects. In the VDER structure being implemented in New York, the value is a sum of the following factors[32]:

i. Energy Value (EV), based on the energy commodity purchase requirements offset by each kilowatt-hour (kWh) injected

ii. Capacity Value (CAV), based on the Installed Capacity (ICAP) purchase requirements offset by (Distributed Energy Resource) DER injections

iii. Environmental Value (ENV), based on the Renewable Energy Credit (REC) compliance cost offset by

[32] Order regarding value stack compensation, State of New York, Public Service, Commission, April 2018

each kWh injected

iv. Distribution Resource Value (DRV), based on the distribution costs (including energy losses) offset by DER injections, averaged across the utility's service territory

v. Location Specific Resource Value (LSRV), available only in locations that the utility has identified as having needs that can be addressed by DERs, and based on the higher, specific distribution costs offset by injections in that area

vi. Community Value (CV), an adder if the project serves a target community of consumers or producers

vii. Most of these values are modelled for a utility, and are valid for the period, in which DERs are being set up. They provide a fixed remuneration to the investor in a DER. Factor value may be revised over time as the grid conditions change. However, for a given DER capacity, they are fixed for the NEM contract (20-25 years).

viii. This system scientifically values a DER and can be applied to a variety of NEM technologies, including energy storage and fuel cells.

ix. Variants of VDER are being evaluated across many utilities in the USA. 11 states have completed such assessments and 18 more are studying them (Stanton, 2019). VDER studies can be applied to some customer segments, and others may continue with old pricing methods. For example, New York is applying VDER prices to large distributed generators, and Minnesota is applying them to community solar participants.

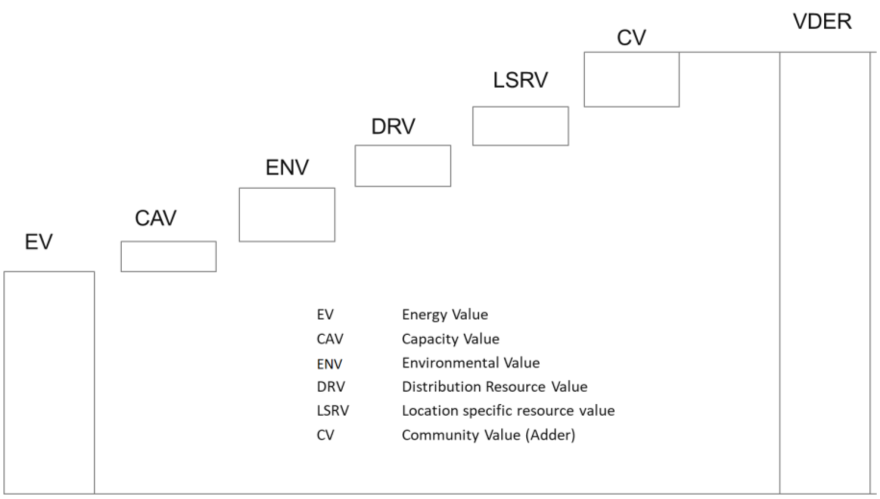

FIGURE 5: VALUE OF DISTRIBUTED ENERGY RESOURCE

vii. Net Value of Distributed Energy Resources (NDER)

Renewable DERs add costs to the grid, due to their variability and infirm nature and these costs are evaluated and charged to DERs. A generic NDER structure will begin with some VDER price for exported energy and impose additional charges on a prosumer as follows:

i. Use of systems for exported power

ii. Cost of reserves – spinning reserve and regulation reserves required to support variable nature of the RE resource.

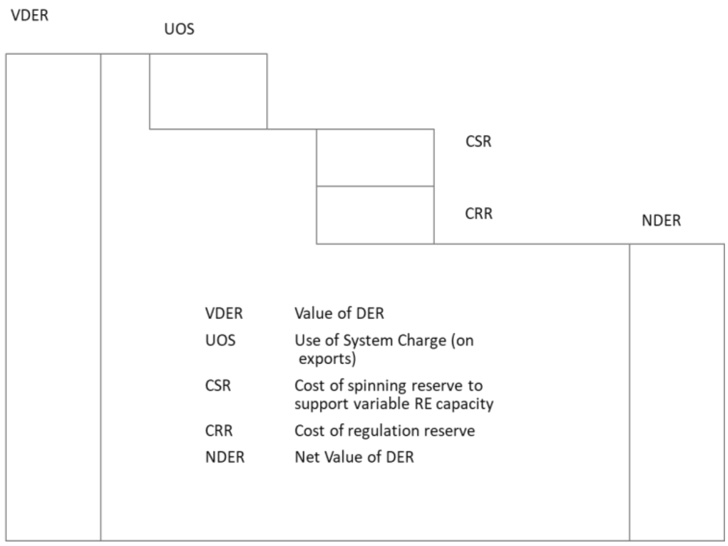

FIGURE 6: COST OF A DISTRIBUTED ENERGY RESOURCE (RE)

Singapore has adopted this approach. The costs are applied to large generators exporting surplus power to the grid.

The financial elements of the system are:

Inflows for the DER - Energy Value (EV) for exported energy paid based on a nodal price

Outflows:

i. Energy Consumption Charge (ECC) = Uniform Singapore Electricity Price (USEP) + Hourly Energy Uplift Charge (HEUC).
ii. Use of System Charge (UOS) – charges based on import channel for power.
iii. Uncontracted Capacity Charge (UCC) – to be charged for systems connected with high tension transmission system and linked to the type of back-up transmission resource required.
iv. Cost of Reserve Resources
    a. Costs of Spinning Reserve (SR) – applied to projects of > 10 MW capacity
    b. Costs of Regulation Reserves (AFP) – to be charged based on gross generation and gross consumption by a consumer
v. Non-Reserve Market Charges
    c. Cost of Energy Management Company (yearly EMC Fee)
    d. Power System Operator's Fee (PSO- based on daily net import or net export)
    e. Market Support Service Charge (MSSC, yearly charge based on net import only)

When a consumer opts for a DER, it will

$$\text{Save} = EV + \Delta ECC + \Delta MSSC$$

However, it may incur, depending on relative levels of import or export, the following costs

$$\text{Costs} = \Delta UOS + \Delta UCC + SR + AFP + \Delta EMC + \Delta PSO$$

Singapore has used carbon tax on fossil-fuel based generators to give the necessary price advantage to RE.

Arkansas is also looking at costs and benefits of surplus NEM power injected into the grid and valuing it accordingly. Arkansas Act 827 of 2015 directs the State's Public Service Commission (PSC) "to ensure net metering rates, terms, and conditions are appropriate to recover the full utility costs of serving net metering customers, net of any quantifiable benefits".

There are some US states which are planning to increase the Fixed Charge, or levy a Demand Charge linked to the capacity of DER to account for costs of standby transmission and distribution resources.

5.4.3 Time of Use (TOU) Pricing

Exports and/or imports are priced based on time of day and seasons. The pricing structure is assessed, communicated to prosumers, and revised from time to time, based on changes in market and grid conditions.

Alternatively, dynamic, real-time prices may be used based on exchange traded prices of energy, network resources, and management costs.

Exports and imports of power from a prosumer are valued in 15 minute/hourly time windows and the final energy bill is prepared over the billing period (normally monthly).

TOU pricing helps in incentivizing prosumers to export more during peak hours and consume more during off peak hours. This helps in balancing energy systems and reduces requirements for additional network capacity. A well-designed TOU pricing may support energy storage investments.

5.4.4 "All-Buy" and "All-Sell"

Under this system, all RE generation from a prosumer is assumed to be sold ("All Sell") to the grid and is paid based on benchmark rates. The entire consumption ("All Buy") of the consumer is priced based on existing grid tariffs.

The benchmarks for export tariffs could be any one of the following:

i. Feed in Tariffs

ii. Prices discovered in an auction

iii. Average Pooled Purchase Price (APPC) for the utility or a fraction of it

iv. Net Value of Distributed Energy Resources (NDER)

Utilities prefer this system because they can buy electricity generated under NEM, just like any other energy, and distribute this energy at a regulated price at their required return rates. Such system is perceived as not resulting in customer loss.

However, this system ignores consumer motivations for investing in DERs to reduce their energy bills along with reducing grid reliance. As DER costs fall vis-à-vis grid tariffs, the attractiveness of All Buy-All Sell system declines further.

Countries such as China, France, Israel, Japan, Vietnam, etc. use this system. It is interesting to note that Vietnam has made this shift to ABAS recently in 2019, prior to which an NEM mechanism was in place.

This is the trend among SAARC Member States, like India and Sri Lanka, with the power utilities opting for ABAS instead of NEM.

5.5. Business Models

Distributed Energy Investments can be made under a variety of business models. Different business models have evolved the world over depending on different stakeholders involved like the investor, roof owner or provider, plant builder and operator, electricity consumer, payer for the electricity consumed, etc. Different financing and payment mechanisms are also in place.

There are four primary anchors around which Business Models have been built:

i. Customer

ii. Renewable Energy Services Company (RESCO)

iii. Utility

iv. Community

5.5.1 Customer Anchored - CAPEX Model

The customer invests in the NEM system.

Customer roles include the following:

i. The customer owns the roof. Provides roof for a contractor to build the system.

ii. The customer invests in the NEM system

   a. Contracts with Engineering, Procurement, and Construction (EPC) contractors.

   b. Pays for the system at the end of installation.

   c. Takes a loan (if needed), from a bank.

iii. The customers can offer the system for an operations and maintenance contract to the contractor or may operate and maintain the system themselves.

iv. The customers receive the credit for the electricity generated and exported in their utility bills.

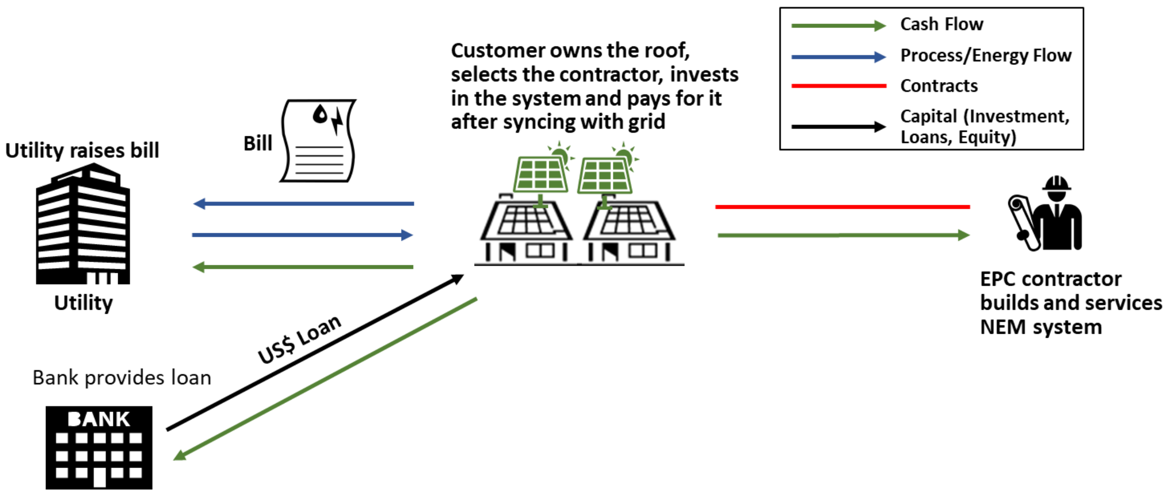

FIGURE 7: CONTOURS OF THE "CAPEX MODEL"

The customer takes care of all the risks:

i. The 'Technical Performance Risk' of the system.
   a. Design risk
   b. Construction risk
   c. Operational risk
ii. 'Financing risk' - the customer makes investments in the system, and obtains loans. There are risks involved in obtaining loans and servicing them over time.
iii. Commercial risks – the project may have risks relating to changes in grid tariffs i.e., if they go down, the savings from NEM will come down, posing a commercial risk to the NEM system.

This business model is popular only with customers with strong credit, and can severely limit adoption, if it is the only model permitted.

5.5.2 RESCO Anchored Business Models

RESCOs are third party specialized investor-operators of NEM systems who perform the following roles:

i. Design an optimized NEM system to maximize savings from the NEM system for the customer. This may include re-designing loads, adding energy storage devices and investing in high performance NEM system.
ii. Invest in NEM System
   a. Finance the system; organize loans
   b. Build the system
   c. Operate the system
   d. At the end of contract term, RESCOs usually transfer the system back to the customer.
iii. Depending on the RESCO contract terms, they may guarantee 'customer savings.

Thus, RESCO's may significantly reduce the 'Technical Performance', 'Financing' and 'Commercial' risks to the customer. RESCO systems are expected to be better designed, use higher quality materials, be better operated (using modern AI tools), and more likely to be efficiently financed. RESCOs however, may carry additional commercial risks arising from the 'Credit' quality of the customer and the ability to 'access' roofs/NEM system over the contract period. Often RESCO contracts are structured in such a way that apart from giving permissions to the RESCO, customer do not face any additional hassle and get access to savings from NEM.

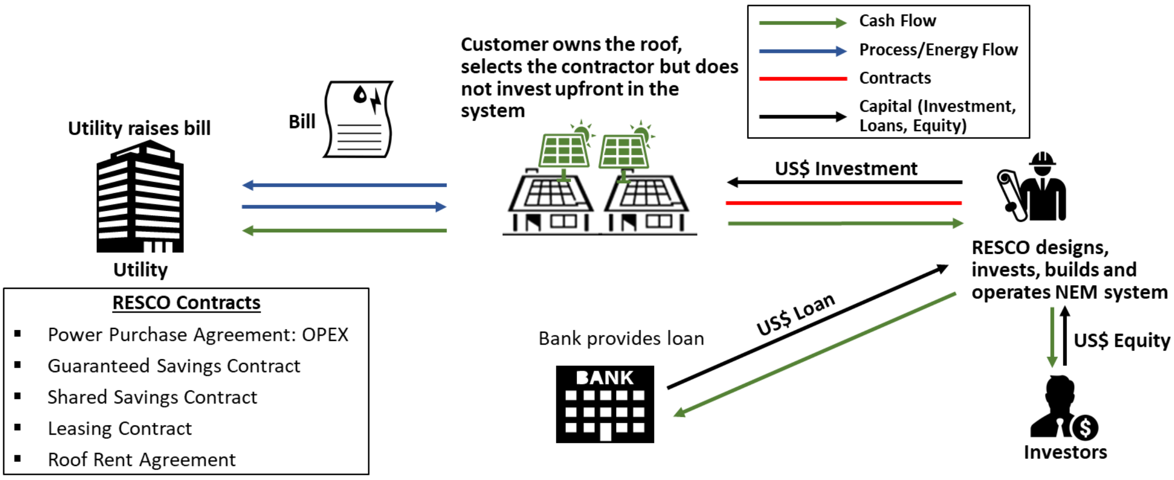

FIGURE 8: RESCO MODELS

RESCOs can contract with customers under different Business Models:

i. Power Purchase Agreement (PPA)

ii. Guaranteed Savings Contract

iii. Shared Savings Contract

iv. Leasing Contract

v. Roof Rent Agreement

i. RESCO Power Purchase Agreement

Based on the optimized technical design, RESCOs offer installation of the NEM system at a per unit price for electricity generated to be paid by the customer based on actual generation. Normally all receipts/savings, including substitution of energy within the premises and sale of surplus electricity to the utility, exchanges or other markets are managed by the customer.

i. PPAs may be for 10, 15 or 20 (project life) years.

ii. PPAs may have a built-in inflation or may be locked in tariff (same tariff throughout the life of the project).

Under PPA, the RESCO carries the following risks:

i. Technical Performance Risk

ii. Financing risk

However, the commercial risks arising from grid tariff cost changes, and changes in NEM compensation rates, are borne by the customer. PPA models are also commonly referred to as 'OPEX (Operational Expenditure) Models'.

ii. Guaranteed Savings Contract

i. Under such contracts the RESCO offers a protected savings, either absolute (US$) or in terms of per unit of energy (US$/kWh). Such contracts require baselining of energy consumption by the customer.

ii. In effect, the customer transfers the risk of changes in 'grid tariff' and 'NEM compensation' mechanism to the RESCO along-side energy 'generation risks' (due to changes in weather, technical performance or operational effectiveness of the asset).

iii. Such contracts, however, reward high performance design of the NEM systems, and designs which benefit from higher TOU tariffs.

iv. Just as in PPAs, receipts and savings are all managed by the customer.

iii. Shared Savings Contract

i. Shared Savings Contracts pay a defined share (%) of savings from NEM to the RESCO in exchange for RESCO designing, investing, building, and operating the system. Such contracts are very useful when the NEM system has complex configuration i.e., combination of energy efficiency, management of loads across time of day, performance of grid services, and generation of renewable energy and sale of energy to the most valuable markets at the most optimal times.

ii. Such contracts are difficult to operate due to complexities of setting baselines and accurate measures of savings vis-à-vis the baselines.

iii. In such contracts both the operation of NEM system and commercial aspects of maximizing savings and receipts are managed by the RESCO.

iv. Leasing Contracts

i. Under leasing contracts RESCO charges a fixed monthly rental to the consumer, for an agreed time period, in exchange for designing, investing, building and operating the NEM system. After the lease period is over, the system is transferred to the consumer. For protection against technical performance, RESCO may provide minimum performance guarantees.

ii. Just as in PPAs, receipts and savings are all managed by the customer.

v. Roof Rent Agreements

Under Roof Rent Agreements, the customer agrees to let a RESCO use its roofs or space and set up an NEM system. RESCO designs, invests, builds, operates and realizes all revenues and cash-flows from the operation of the system.

The customer gets a fixed rental for use of the roof and/or some share of the electricity generated.

This is useful for customers who have large vacant spaces within their premises but have very little consumption. These would include, large warehouse owners, or owners of large condominium complexes where residents do not own roofs. Such agreements also help the customers meet government mandates for NEM implementation.

Relative Popularity of Different RESCO Models

i. PPAs, Guaranteed Savings Contracts and Shared Savings Contracts are attractive to Commercial and Industrial (C&I) Customers. PPAs have been used by C&I Customers in Germany, Austria, UK, Belgium, etc. (Dunlop & Roesch, 2016). PPAs are also the most common model used in the USA.

ii. Leasing and Roof Rent Agreements are normally used by residential, government and not for profit segments.

iii. The famous Solar City, operating in USA has very popular offerings under PPA and Lease models. Other well-known US RESCO operators include Sunnova, Sun Power, SunRun, Vivint, Mosaic, One Roof Energy, Solar Universe, etc.

iv. Octopus Investments, Enerparc AG, Encavis, Foresight Group, NextEnergy are top 5 players in Europe.

Summary Analysis of Value of RESCO Models

Benefits of RESCOs:

i. RESCOs bring in significant benefits of high-performance designs, better materials, efficiency in procurement and financing (due to scale), better operations (using modern AI tools and better operational practices).

ii. RESCOs minimize customer risks and help adoption rates.

iii. RESCOs also make the NEM market accessible for large scale investors.

Challenges of RESCOs:

v. RESCOs carry additions risks such as credit risk of customers, and ability to access assets when needed (due to defaults from customers).

vi. Additionally, RESCO contracts require long term commitment from customers to not use their roofs or space in the premises for other alternative purposes, including modifications in the building, which is difficult for many customers.

vii. RESCO models are difficult to implement when roofs are shared (e.g., in multi-family residential complexes) or when owners of a building and users (tenants) are different.

- In case the user (tenant) moves, will the next user (new tenant) pay? If a new tenant is not found quickly, who will pay during vacancy?
- In case, the contracting party (the owner or the manager of multi-family complex) and the beneficiary (the resident) is different, there is no incentive for the owners or managers to contract because they do not derive any value from the reduced costs of NEM or larger savings of NEM. Tenants cannot contract because they do not own the roof.

5.5.3 Utility Anchored Business Models

Utilities can help reduce risks, improve system cost-performance, and make NEM technologies scalable. Utility anchored business models may work in conjunction with RESCO or customer anchored models.

Utility Anchored Models can be defined based on the primary roles played by Utility:

i. Demand Aggregation

ii. Aggregated EPC

iii. Super RESCO

iv. On-Bill Financing

v. Payment Assurance

i. Demand Aggregation

Utility promotes the concept of NEM and registers customers who wish to implement NEM technologies within their premises.

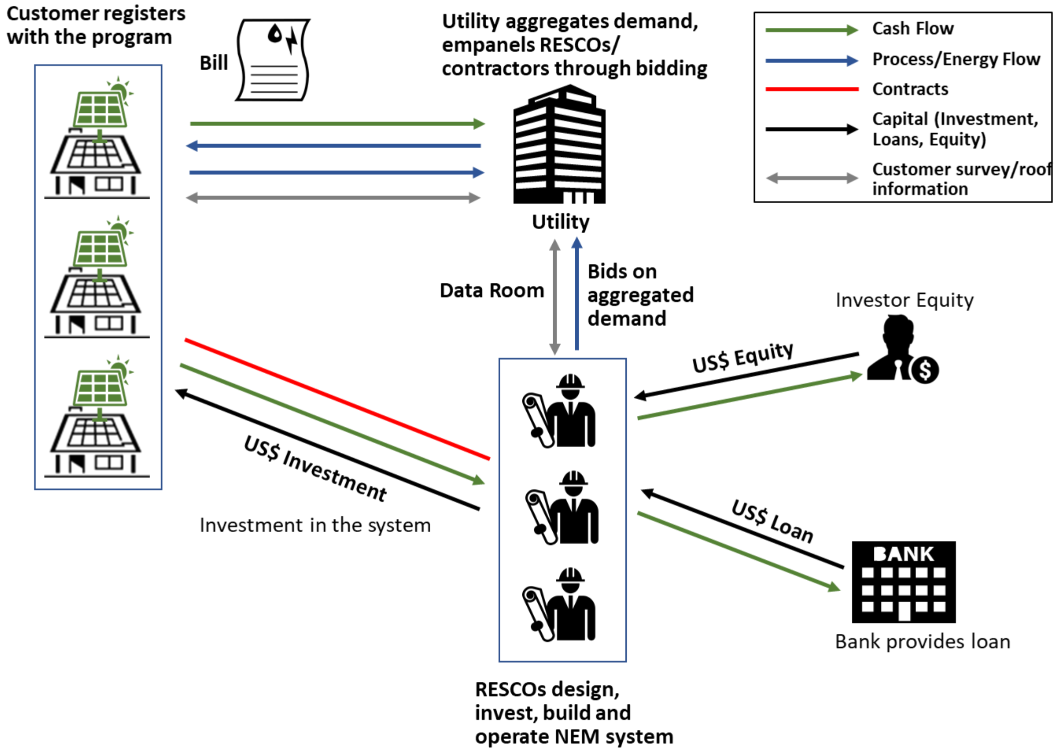

FIGURE 9: UTILITY ANCHORED DEMAND AGGREGATION

Utility then plays the following roles:

i. Organises technical 'survey' of customer premises, and estimates capacity and basic 'design' of the NEM system.

ii. Empanels vendors / RESCOs, screened on defined technical and financial criteria.

iii. Aggregates 'survey and 'design' information into a data room and makes the information available to vendors.

iv. Develops minimum technical performance criteria and standard contract documents.

v. Invites vendors to bid based on information in a data room.

vi. Makes the information on winning bidders available to customers through an online platform. Enables contracting between customers and bidders through some organized interface or portal.

vii. Ensures contracts are honoured.

Through aggregations, the utility increases demand access for vendors and this 'scale- up' allows better pricing and performance guarantee terms for smaller consumers. Utilities may offer this service for a defined 'Fee'.

Customers derive significant benefits by overcoming information asymmetries, improving access to qualified vendors, higher protection against contract risks, improved cost-performance of the system etc.

Vendors derive benefits of 'scale 'and faster 'sales-cycle'.

ii. Aggregated EPC

Under this model the utility acts as a 'Contractor'. It enters into EPC Contracts with the customers and gets the system built through back-to-back contracts with independent contractors.

The utility may be able to optimize cost-performance due to:

i. Scale of aggregated demand.

ii. Procurement efficiency- by entering into supply contracts directly with important material suppliers (e.g., suppliers of modules and inverters).

iii. The cost of EPC, Material supply and Balance of System (BOS) supply may be efficiently and transparently set using bidding.

However, this model increases the risk of contractual performance on the utility.

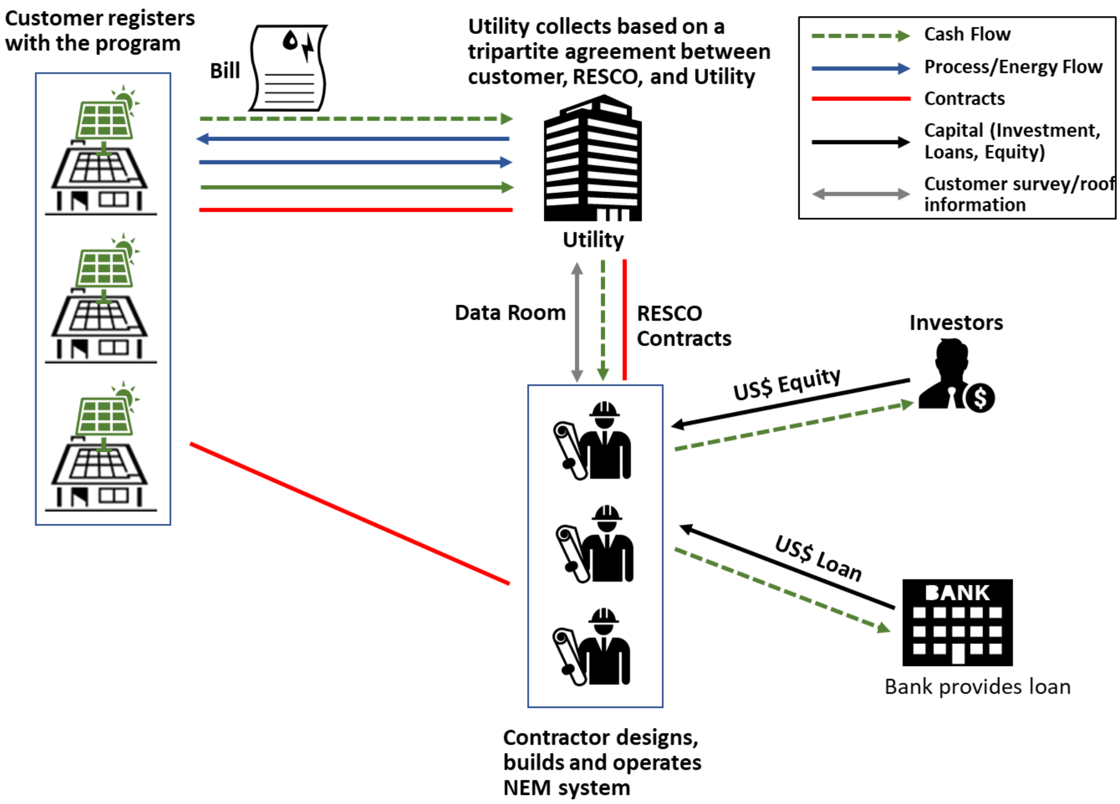

FIGURE 10: EPC AGGREGATION OR SUPER RESCO MODELS FOR UTILITIES

iii. Super RESCO

The utility offers RESCO contracts (PPAs, Leases, Shared/Guaranteed Savings, Roof Rent Agreements, etc.) to customers and has back-to-back agreements with contractors/ RESCO operators. This is similar to EPC aggregation except that a RESCO type contract is used. In an alternative model of Super RESCO, the utility enters into a RESCO contract with the customers, invests in the system, and gets the system built by EPC contractors. In this model the financing is organized by the utility. The additional advantage of a super RESCO model could be the added efficiency of low-cost financing by a utility.

A utility may have access to low-cost funds from government or development financial institutions.

A utility has lesser collection risk as compared to a RESCO because it collects money from customers regularly and already has established protocols and processes for collection.

The model has higher risks for Utilities (technical performance, financing, etc.).

iv. On Bill Financing

On Bill Financing is a financing mechanism for customers, which is aggregated and organized by a utility. The Utility collects repayments and interest, as part of the billing process. The utility may also facilitate the customers by EPC Aggregation and have efficient plants built at improved costs.

The advantages of on-bill financing approach are:

i. Cheaper and faster loans to customers.

ii. Improved cost performance when EPC aggregation is coupled.

iii. Lower collection risks due to collection by the Utility.

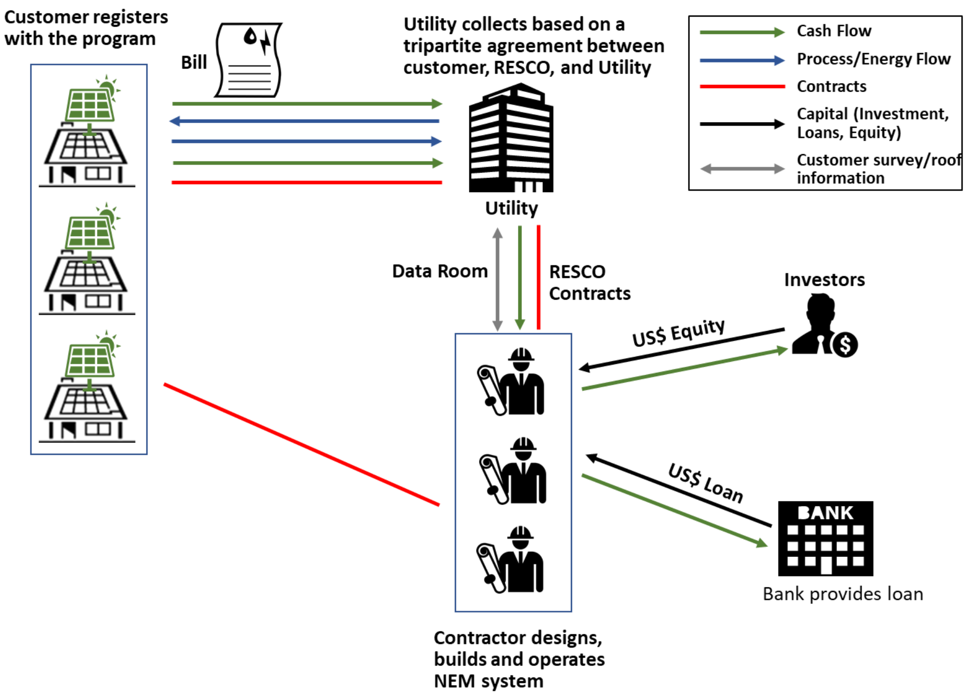

FIGURE 11: ON BILL FINANCING APPROACH

This is a better system than customers individually getting loans from financing institutions.

This system can have very good potential for implementation in SAARC Member States, especially for small consumers.

v. Payment Assurance Models

In normal RESCO models, collection risk is a big risk for RESCOs, as customers are diverse, and distributed. The consequences of this risk are:

i. The cost of financing of NEM capacity portfolios is higher.

ii. Not all customers are offered RESCO contracts. Hence scale-up speed is reduced.

Utilities can efficiently manage and reduce this collection risk, due to already existing processes and special powers to collect and control on electricity supply of defaulting customers etc.

If regulators permit utilities to collect money on behalf of RESCOs, through existing bills or separate bills, this would facilitate RESCO led growth. Utilities may charge a small fee for such collections.

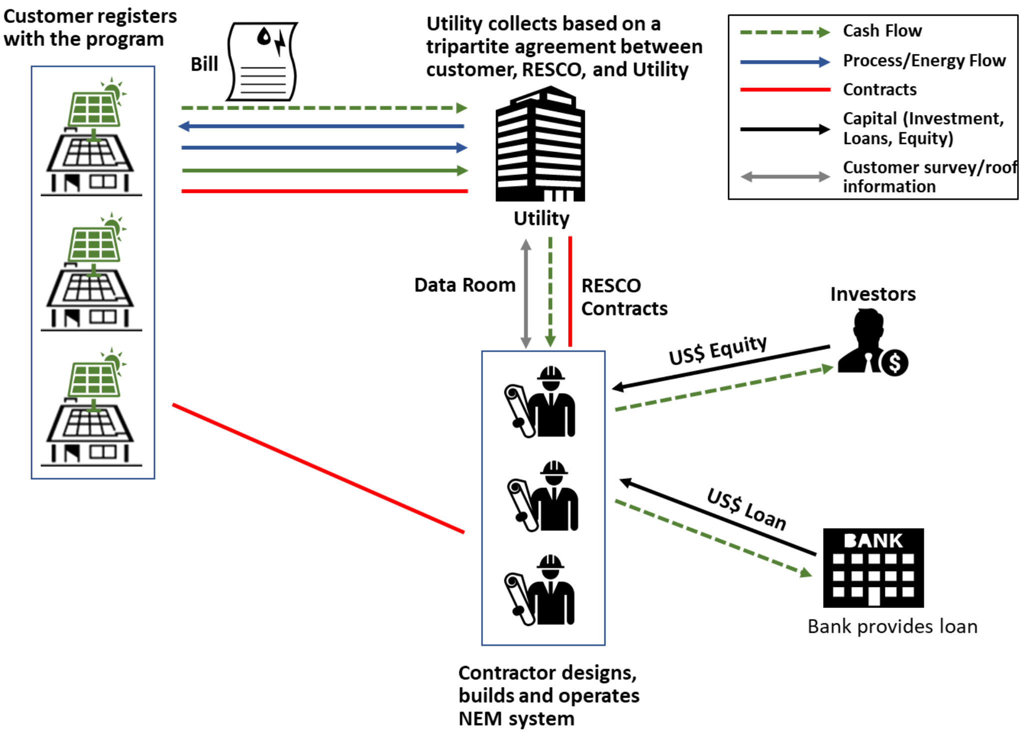

FIGURE 12: PAYMENT ASSURANCE MODELS

Implementation Experience of Utility Anchored NEM Models

With obvious advantages of aggregation and risk reduction, utility anchored models are being piloted, especially in USA (Stanton, 2019).

i. Tucson Electric Power's Residential Solar Program reached its target of 600 projects and a total of 3.5 megawatts.

ii. Arizona Public Service's (APS) Solar Partner program consists of 1,600 residential solar customers with a total of 10 megawatts.

iii. APS Solar Communities program is an additional program for limited-income and moderate-income customers in the residential segment and adds non-residential and multi-family residential customers, schools, non-profits serving limited-income groups and rural governments and municipalities. Single-family customers receive the same US$ 30 monthly bill credit from APS, while other customers will receive a bill credit relative to the size of the rooftop or parking lot canopy solar array.

iv. CPS Energy in San Antonio, TX, launched SolarHostSA, by buying electricity from independent solar developer, PowerFin. Under the agreement, CPS agreed to purchase electricity from the 5 megawatts of capacity installed by PowerFin on 600 residential and commercial rooftops. Customers received 3 US¢/per kilowatt-hour produced by the panels hosted on their rooftop for twenty years.

v. Reliant's 'Make It Solar' program is a solar program (Reliant is a subsidiary of NRG - an Investor-Owned Utility) that lets consumers buy or sell solar power and has some features of utility anchored business models.

In the initial programs, very limited savings were offered to the customers by the utilities. This resulted in tepid customer response. Utilities must be very efficient in passing on aggregation benefits to customers and model their pricing accordingly.

Outside the US, India has taken up demand aggregation models for country wide implementation. Customer segments, where aggregation has been used on priority are public buildings, schools, hospitals, religious places, low-cost housing, etc. The World Bank funded SUPRABHA Technical Assistance Program is one such example that funded the demand aggregation programs in 17 Indian states (Suprabha, 2020).

Summary Analysis: Value of Utility Anchored NEM

Benefits of utility anchored business models:

i. Improved cost performance metrics of implemented systems.

ii. Accessing those customers, who are ignored by RESCOs normally, due to credit risks or small sizes.

iii. Reduced risks for customers, RESCO operators, contractors, lenders, etc.

iv. Faster scale-up- cycle time of contracting, project implementation, financing, etc. is reduced significantly.

Challenges of utility anchored business models:

i. The biggest challenge is creating a deal structure that protects customers, without utilities cornering a large portion of the economic value. Appropriate regulatory approaches should be put in place for enhancing public good.

ii. The capacity of utilities to undertake such business models is often limited. This needs to be enhanced for launching utility anchored programs.

5.5.4 Community Anchored Business Models

Community anchored business models can meet requirements of excluded stakeholders in scaling up NEM technologies. Such stakeholders are:

i. Energy consumers with 'no/limited/shared roof or space' within their premises. Such customers include renters. These customers want the benefit of consuming power under NEM but cannot set up NEM capacities.

ii. A second set of stakeholders are those customers who have large roof space but limited or no loads of their own. These include building managers who manage large residential and commercial spaces.

iii. Third set of stakeholders are those who may or may not have roof or space, but who wish to invest in NEM technologies for the superior and stable returns offered by such systems.

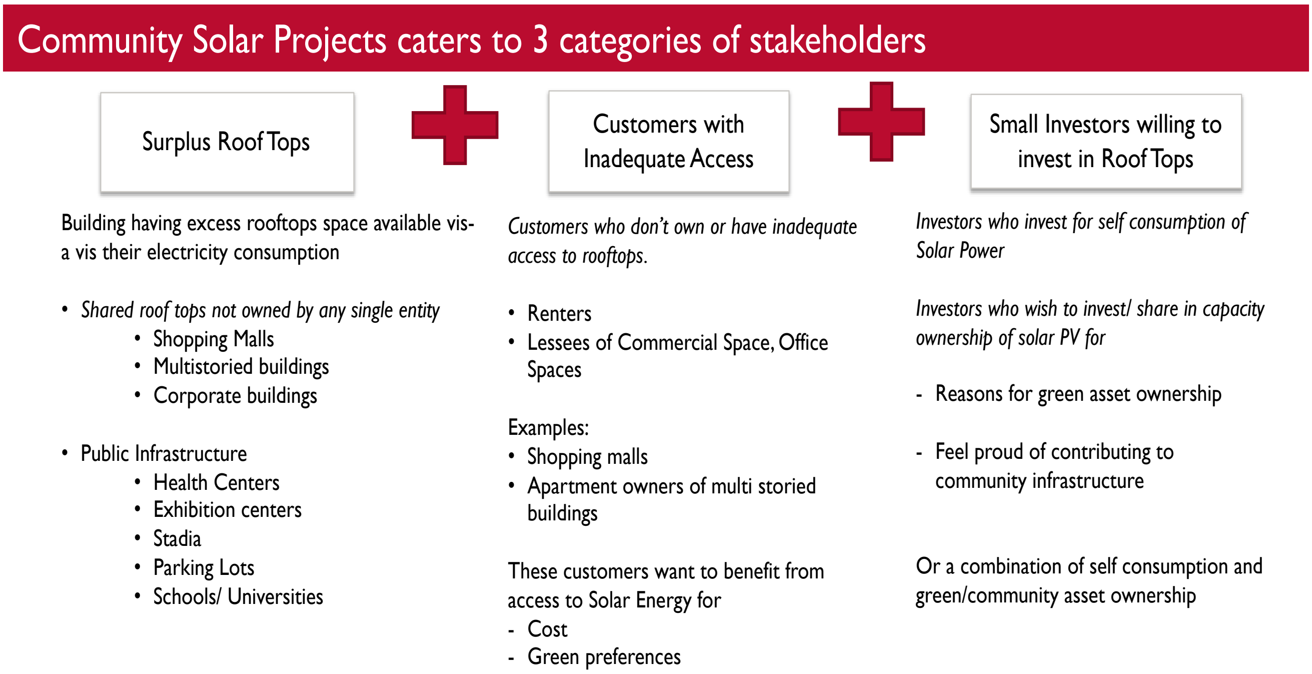

Figure 13: Community Solar NEM Programs

In large crowded mega cities of today, more than 50% customers will face such challenges. Community Solar Programs will need support from appropriate Credit Transfer Mechanisms such as Virtual Net Metering (VNM) which have been described in the section 5.6.

In a typical Community NEM Solar program the following activities happen:

i. A program administrator registers customers, roof top owners, investors and/or RESCOs to participate in the program.

   a. RESCOs design, build and operate NEM facilities on multiple roofs and spaces owned by the group of buildings and roof owners.

   b. The electricity produced is credited to users, using 'virtual net metering' or 'group net-metering' provisions in NEM policy.

   c. The transfer of electricity to users is done at a pre-agreed price providing adequate return to investors/RESCO.

ii. In some structures consumers pool funds and get electricity credits in proportion to their investments, after accounting for the share that needs to be provided to roof and space providers.

iii. The program administrator keeps account for investments made, operation and maintenance of community plants, electricity credits transferred to various stakeholders, billing and sale of surplus electricity to the utility, enrolment and exit of participants (consumers, roof top owners, investors).

iv. The utility bills the consumers based on electricity credits allocated.

v. The program administrator may typically be played by the Utility, Third Party/ RESCO and Consumer Groups.

vi. Examples of Utility Administered programs

   a. Tucson Electric Power's (IOU-Arizona) - Bright Tucson Community Solar Program,

b. Colorado Springs Utility model for leasing community solar garden from projects developers, Xcel Solar.

vii. Example of Third Party/ RESCO administered Program - Clean Energy Collective partners with several Utilities and Community Groups to develop Community Solar Projects.

viii. Examples of consumer administered program- Vermont's Group Billing: For consumers in the same utility's service territory.

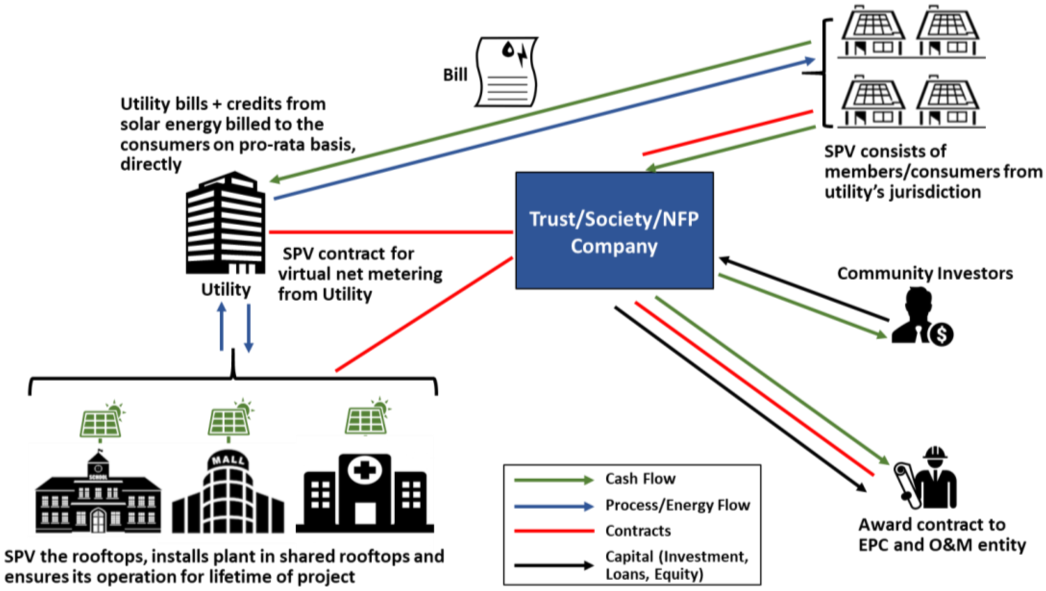

FIGURE 14: COMMUNITY SOLAR PROJECTS[33]

California has implemented NEM-V scheme, which allows qualified customers to benefit from a single Eligible Generating Facility (typically, but not exclusively, a solar PV system) installed on a site, in which energy credits produced (kWh) are allocated, by a predetermined percentage, to the participating tenants and/or accounts, referred to as the Benefitting Accounts. This scheme is applied to multi-tenant, multi meter properties being served from a single delivery point.

Other states practicing community solar under NEM include Colorado, Connecticut, Delaware, Massachusetts, District of Columbia, Maine, Maryland, Minnesota, New Hampshire, New York and Vermont. In Europe, Germany and Denmark have listed community owned RE projects as an area of priority.

5.6. Credit Transfer Mechanisms

When NEM technologies scale up, there is a need to permit transfer of NEM credit from one customer or generating station to multiple customers, meters. Such transfers are allowed under two distinct policy provisions:

i. Group Net Metering (GNM) – NEM Credit transferred from identified generating stations to many meters, owned by one customer, within a distribution utility. For example, a large corporate like Microsoft may own many buildings within a utility's distribution area. It should be allowed to

[33] SPV- Special Purpose Vehicle

transfer electricity credits from its contracted generating stations to its multiple electricity meters.

ii. Virtual Net Metering (VNM) – Credit from identified generating stations is transferred to many customers who are part of a virtual net-metering program. The credits are allocated in accordance with agreed share across customers, which will be defined in a Virtual Net Metering Agreement between customers.

Many US utilities are developing and implementing such mechanisms. In India, Delhi is implementing such credit transfers. The Delhi Electricity Regulatory Commission has come out with regulations in 2019 for GNM and VNM[34]. Such official guidelines leveraged the uptake of solar under GNM and VNM in Delhi especially in residential communities where the NEM credits are being shared to multiple customers. Another Indian state, Goa, has also released its regulations for NEM in 2019 and included VNM and GNM in its notification[35].

5.7. Net-metering Sanction and Management

A very important aspect of NEM implementation are the processes for creating awareness, helping consumers make decision, invitation of NEM applications, evaluation and grant of sanctions, permissions for grid synchronization, monitoring and control of NEM facilities during operation.

If the processes are simple, customer friendly, transparent, visual and online, they can accelerate adoption of NEM.

Based on the study of benchmark utilities, features of a good Net Metering Management process are presented.

TABLE 3: FEATURES OF A GOOD NET METERING MANAGEMENT PROCESS

NEM Management Process			
SN	Step	Customer	Utility
1	Create Consumer Awareness		
2	Empanel Qualified Vendors		
3	Submit NEM Application		
4	Grant Stage-1 Approval		
5	Submit System Details		
6	Grant Permission to construct		
7	Grant Permission for Grid Synchronization		
8	Monitor and Control NEM system		

[34] Delhi Electricity Regulatory Commission (Group Net Metering and Virtual Net Metering for Renewable Energy) Guidelines, 2019 available at http://www.derc.gov.in/sites/default/files/DERC%28Group%20Net%20Metering%20and%20Virtual%20Net%20Metering%20for%20Renewable%20Energy%29%20Guidelines%2C%202019.pdf

[35] Gazette notification at http://jercuts.gov.in/writereaddata/UploadFile/solar%20pv%20grid%20regulation_1355.pdf

5.7.1 Create Consumer Awareness

NEM programs thrive with serious efforts towards increasing consumer awareness. The areas where consumers need information include:

i. Key features of the NEM Policy.

ii. Benefits of NEM adoption – for the consumer, for the country, for the environment.

iii. Subsidies and incentives available to support NEM. Regulatory requirements (e.g. Building Codes, Mandates etc.).

iv. Key aspects of the NEM technology – how the system works, generates electricity, pattern of generation etc.

v. Tools and calculators to estimate system size, financial benefits etc.

vi. The application process, information needed to apply

Typically,

i. Web portals are used, not only to help customers understand NEM, but also to manage the application process online.

ii. Help centres are set up to respond to customer queries.

iii. Customer meetings, social messaging applications, digital media campaigns are extensively used.

5.7.2 Empanel Qualified Vendors

Customers need to have access to a list of qualified, screened, reliable vendors who can be contracted for setting up solar systems of right quality.

Singapore has a process for qualifying vendors. Vendors need to be Licensed Electrical Workers (LEW). India has established a process of screening and empanelling vendors in the distribution area of each utility. Sri Lanka and Bangladesh have started work on such qualifications.

A list of such vendors with some record of their past performance/ rating[36] could be used to facilitate a customer's decision on whom to hire. Vietnam's EVN has made available the list of qualified solar EPC contractors/installers on its EVN Solar Platform[37].

Indian utilities have empanelled vendors, through a formal screening process as they are implementing Demand Aggregation Models (ref 5.5.3) for solar roof top implementation. They invite screened vendors to bid for aggregated roof top system demand.

5.7.3 Submit NEM Application

Most SAARC utilities, as well as utilities in benchmark countries now use online application process for NEM. Extent of automation varies.

Hawaii is an interesting example, they use their web-portal, to fetch and store system details and the first

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[36] New digital service platforms for doctors, lawyers, technicians, physical trainers etc. use system of user ratings. Similar rating system could be used with some standard profile information of various vendors.

[37] https://solar.evn.com.vn/

approval (Stage-1) is done completely on-line.

The customer sees a visual map of Hosting Capacity in the distribution system at his or her location and can assess whether the proposed system size can be accepted in the grid. The Hosting Capacity is dynamically updated as customer applications are granted. The application process takes the meter number along with location zip-code and uses all the customer information available in the utility systems to support filling up of the application.

India uses a web portal to process applications in a similar manner. The process also simultaneously registers the customer with the Ministry of New and Renewable Energy (MNRE) for capital subsidy[38]. The solar rooftop systems up to 3 kW will qualify for the MNRE subsidy of 40% and above 3 kW and up to 10 kW will get a subsidy of 40% for the first 3 kW and 20% for the remaining capacity. Above 10 kW, it is 40% for the first 3 kW and 20% for the remaining 7 kW and there is no subsidy for the capacity beyond 10 kW. For group housing societies, the financial assistance will be limited to 20% for common facilities up to 500 kWp (@10 kWp per house)[39].

The key feature of a good application process is that the NEM application is made online, customers get analytical support while filling the applications, relevant information is pulled from/sent to related databases, and the first level of approval is granted online. Customers can use the hired vendors to fill in the technical information.

5.7.4 Grant Stage-1 Approval

The application is checked for primary qualification criteria (e.g., minimum, maximum capacity, distribution system hosting capacity, the mode of operation of the system etc.), in line with the published NEM policy and the first stage approval is granted. The process time is quick and depends on decision rules set up in the computing systems of the utility.

The permission is granted with a time limit for the next stage submission so that the applicants do not hoard grid capacity without real intent to invest in the NEM system.

5.7.5 Submit System Details

This approval allows the applicant or his vendor to fill in details of the technical system proposed, the vendor information, the make of critical equipment (e.g., modules, inverters, and meters), basis of system size etc. At this stage the requirements of grid connection for the system are studied.

5.7.6 Grant Permission to Construct

For larger systems, the technical interconnection assessment can be supported by a physical site visit. The decision criteria for approval can be simplified for smaller systems, or systems with less complex business models (e.g., 100% self-consumption model with no exports) and can be done without physical site visit.

Issues such as line capacity, distribution transformer capacity, potential reverse power flow and the ability of the grid to handle NEM requirements, the grid type (radial v/s ring network) are pre-studied.

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[38] Capital subsidy is available for residential segment.
[39] PSPCL commercial circular at https://docs.pspcl.in/docs/cecommercial1520200122164058585.pdf

Most developed countries use the services of qualified third-party engineers to make such visits, they then submit their reports for consideration by the utility.

Based on design data and site-visit report (if needed), the second stage of permission is granted to start construction activities.

5.7.7 Grant Permission for Grid Synchronization

Once construction is completed, customer informs the utility requesting permission to interconnect. At this stage the utility checks quality of constructed facility for conformance with grid code, submitted design, safety and security provisions and then grants interconnection permission. Large systems' requests might require third-party engineers' assessments and grid-impact studies, for which the fee can be levied on the system owners. For smaller systems, approvals may be granted based on self-declaration of the customer and the vendor.[40]

On satisfactory assessments, the permission is granted for grid synchronization.

5.7.8 Monitor and Control NEM System

For smaller systems, many utilities use manually operated MRIs (Meter Reading Instruments) for meter reading. The same system is used for utility billing process.

However, for NEM, it is recommended to use AMI (Advanced Metering Infrastructure), which is capable of automatic transmission of information on energy flow, as well as integrated with billing and system controls of the utility.

For large penetration of NEM, when several generators are consuming or injecting power into the grid, appropriate automated responses of NEM systems to control signals from the grid may be set up. This may be crucial for resolving over-voltage, rapid frequency changes, grid faults etc. Inverters must have centralized control capability and must be compliant with IEEE 1547. The utility control centers should have necessary software and AI tools to ensure optimal response by NEM systems to active grid conditions.

Utilities may provide customers access to an information sharing system for tracking NEM system performance. This will help customers assess their system's performance relative to other live systems, identify underperformance and initiate rectification requests with the vendor.

5.8. Incentives and Policy Support

In the launch phase, the LCOE of NEM technologies can be high due to higher costs or lower efficiency of available technologies, small scale of implementation, and low levels of industry know-how. Grid tariffs in such cases may be lower than LCOE of the NEM technologies.

In many developing countries, including SAARC Member States, economic cost of generation of electricity using conventional fuels is much higher than LCOE of NEM technologies. There is an economic gain to the country, as NEM technologies substitute such generation[41]. However, due to existing electricity subsidies,

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[40] Such approvals based on self-declaration are granted in Singapore

[41] Refer to Economic analysis of SAARC Member States for Solar PV roof tops provided in Section 6.5.

certain segments such as 'residential' and 'agricultural' have low grid tariffs compared to the initial LCOE of NEM technologies, and thus these seem unattractive to customers.

5.8.1 Economic Measures

To make NEM technology attractive, grid tariffs can be effectively increased and LCOE of the NEM technology can be lowered, through incentives, subsidies and taxes. Alternatively, realizable price benefit from NEM can be raised compared to the cost of conventional power procurement.

Examples of policy measures to increase grid tariff:

i. Carbon Tax on fossil fuel-based generators.

ii. Public Benefit Surcharge applied on all fossil fuels.

iii. Higher feed in tariffs for NEM technology than average cost of generation from conventional sources.

Examples of policy measures to lower LCOE of NEM technology:

i. Capital subsidies (paid as % of investments made).

ii. Investment Tax Credits (reducing payable tax by giving tax credits as % of investment made). Higher depreciation rates, resulting in lower tax outgo.

iii. Lower custom duties, sales tax or VAT on NEM equipment.

iv. Tradable renewable energy credits (RECs, valued in US$/kWh).

Examples of policy measures to improve realizable price for exported power under NEM, vis-a-vis the price paid for conventional power:

i. Generation based incentives (GBI)

ii. Higher Feed in Tariffs (FITs)

Carbon tax has been used by Singapore. US uses Investment Tax Credits or RECs. Vietnam, Germany and Japan employ higher FITs. Denmark waives off PSO (Public Service Obligation) on NEM technologies. PSO is a tax levied on supply of conventional energy. India has used FITs, GBI, Capital Subsidies, and RECs.

Most countries use lower taxes on NEM technology equipment.

5.8.2 Financial Measures

Since NEM technologies are capital intensive, their scale up would require availability of easy, low-cost long-term finance. To reduce risks and cost of lending, experts have proposed use of 'partial risk guarantee funds' and 'additional insurance mechanisms. To separate development and operational phase risks, 'warehousing' facilities have also been proposed.[42]

Most common form of support to NEM technologies is low-cost loans. Germany had popularized 'one-minute loans' to NEM investments operating under FITs. FITs lowered the pricing risks. These loans were granted, using information in NEM applications submitted to utilities, as soon as a customer entered a

[42] Such a facility has been proposed by the IFC

bank branch.

India has used low-cost credit lines from multilateral banks such as the World Bank and ADB to support solar roof top projects in commercial, industrial and government segments. Bangladesh and Sri Lanka are also using low-cost loans as primary financing structures. A recent Sri Lankan loan facility (US$ 100 M) has been created by India to support installation of solar rooftops on low-income housing and government buildings.[43]

UK and USA have successfully issued Asset Based Securities (ABS) against cashflows from solar roof-top portfolios.[44] ABS tend to reduce effective cost of loans. Once development risks are over, ABS bring in long term investors to the NEM market. ABS releases capital for further project development.

5.8.3 Mandates, Codes and Priorities

Most European states use merit order priority for dispatch of renewables. Germany has very strict rules for it. Any request from a grid operator to back-down an NEM capacity has to be explained. If revenue loss in a year due to grid system bottleneck exceeds 1% of revenues of that year, the operators affected by such curtailment are compensated at 100 per cent loss protection from that point onward[45].

Germany also has a forward-looking policy on interconnection. Any capacity being set up under NEM can ask for grid interconnection. The cost of upgradation or grid extension, if needed for such inter-connection, is borne by the utility.

Building solar roof tops is mandated in many states in the USA. The state of California and cities of Orlando, Florida, and Tucson, Arizona, along with others, have building codes requiring commercial or residential buildings to be solar-ready. SolSmart, a program run by The Solar Foundation, distinguishes cities and counties that are "open for solar business" and this encourages states and cities to adopt solar-ready building codes. New York also adopted a solar mandate for new buildings and existing buildings undergoing certain significant roof renovations in 2019.

Many states in India (e.g., Haryana, Delhi, Tamil Nadu) have also adopted similar codes. Tamil Nadu Energy Conservation Building Code (ECBC) 2018[46] specifies the minimum solar zone in a building (for commercial ones like star hotels, resort, universities, etc.) and Delhi's building bylaws have been recently made flexible regarding the maximum height allowed for mounting solar panels (Singh, 2020). Haryana mandated solar plants in new buildings (residential, government, hospitals, etc.) through its 2016 circular[47].

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[43] http://solarassociation.org.in/india-x-cleantech-july-2020/

[44] Example: SunRun a residential solar company has issued ABS in 2019. Tesla started such transactions in US with US$ 53 million notes.

[45] Section 15, Hardship Clause of Germany's Renewable Energy Sources Act (EEG 2017) available at https://www.bmwi.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf%3F__blob%3DpublicationFile%26v%3D3

[46] https://www.tnei.tn.gov.in/pages/down/27

[47] Sales circular by Indian utility Dakshin Haryana Bijli Vitran Nigam (DHBVN), available at: https://www.dhbvn.org.in/staticContent/saleregulation/salecircular/circular2016/SC.2016-42.pdf

5.9. Technical Standards

Technical standards for DERs have been developed in benchmark states. Key features of these standards are:

i. Reduce frequent tripping, especially in situations when the grid needs power injection. A large volume of DER power getting shut down due to low frequency or voltage, resulting from overload, will exacerbate grid stability issues.

ii. Introduce management of active power injected by DERs, by remote control of the utilities in response to grid conditions. A similar provision exists for reactive power management.

iii. Active interchange of data between DER operators and the grid managers, including grid conditions and DER operations. Once DER penetration increases, the utilities move to integrated planning, forecasting, and automated operational control signals which respond to connected DER systems in the grid. Such capabilities would need new analytical and AI capabilities.

USA has adopted IEEE 1547-2018 standards to establish responsive DERs to keep the grid stable.[48]

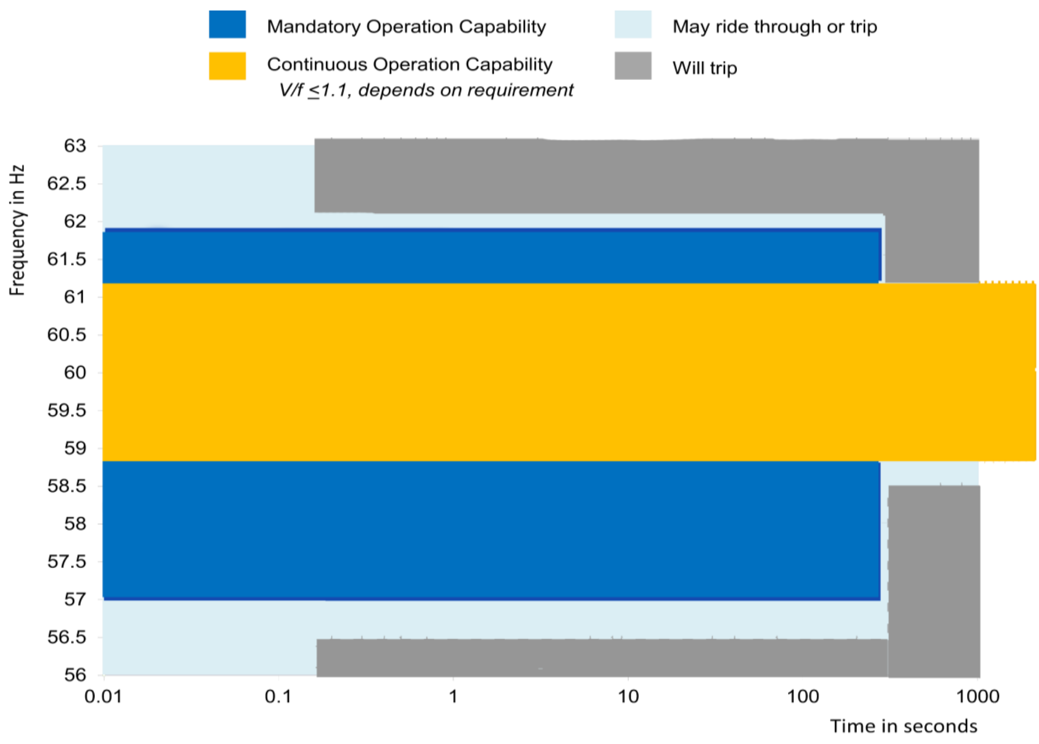


FIGURE 15: FREQUENCY RESPONSE REQUIRED UNDER IEEE 1547-2018 (NAGARAJAN, 2018)

It prepares against large scale tripping due to transmission faults, which can depress distribution voltage over very large areas, or central-station generator trips that can depress system frequency.

IEEE 1547-2018 mandates both 'Tripping' and 'Ride-through' requirements.

[48] IEEE 1547-2018 defines grid support functions that shall be capable of actively regulating voltage, shall be capable of frequency response, shall ride-through abnormal voltage/frequency, may provide inertial response

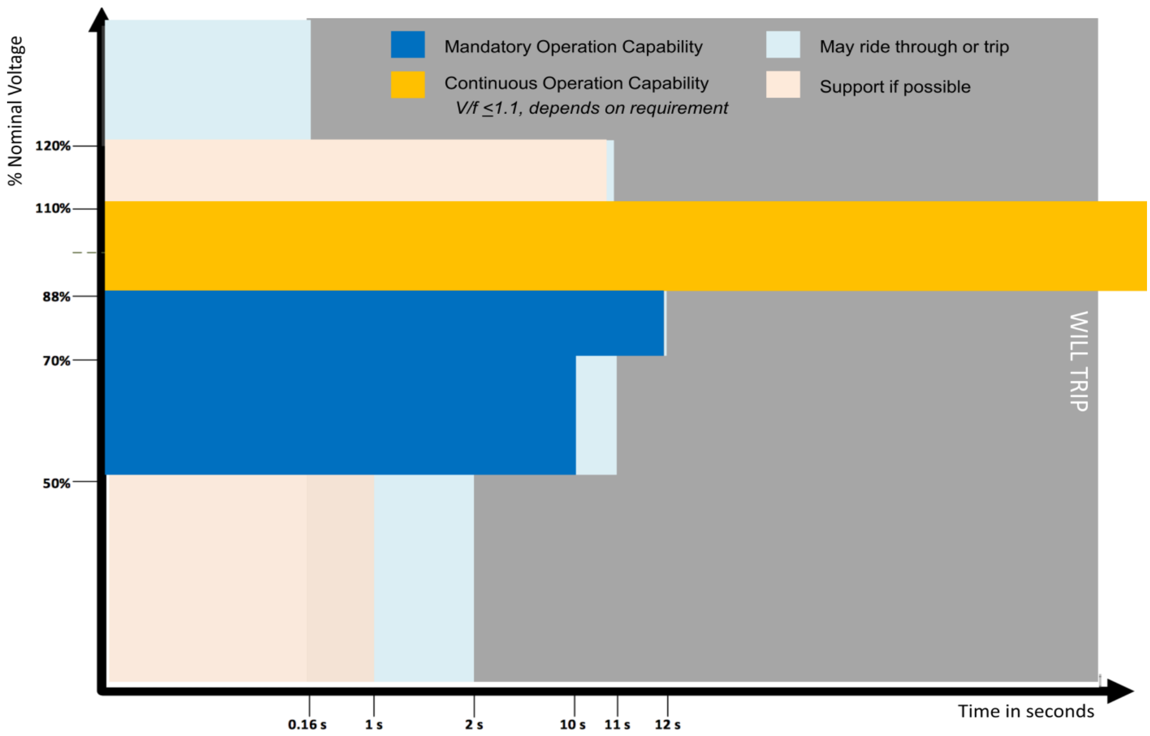


FIGURE 16: VOLTAGE SUPPORT RESPONSE REQUIRED UNDER IEEE 1547-2018 (NAGARAJAN, 2018)

The wide operating range under mandatory operation capability is noticeable for both frequency and voltage.

The other features of IEEE 1547 are:

i. Anti-islanding (unintentional) protection and response to short-circuit fault and open-phase conditions are part of the core requirements

ii. Requirements for DER output power quality are quantifiable and include limits on

   a. Harmonics causing distortion,

   b. Voltage fluctuations, including contributions to overvoltage at the point of common coupling,

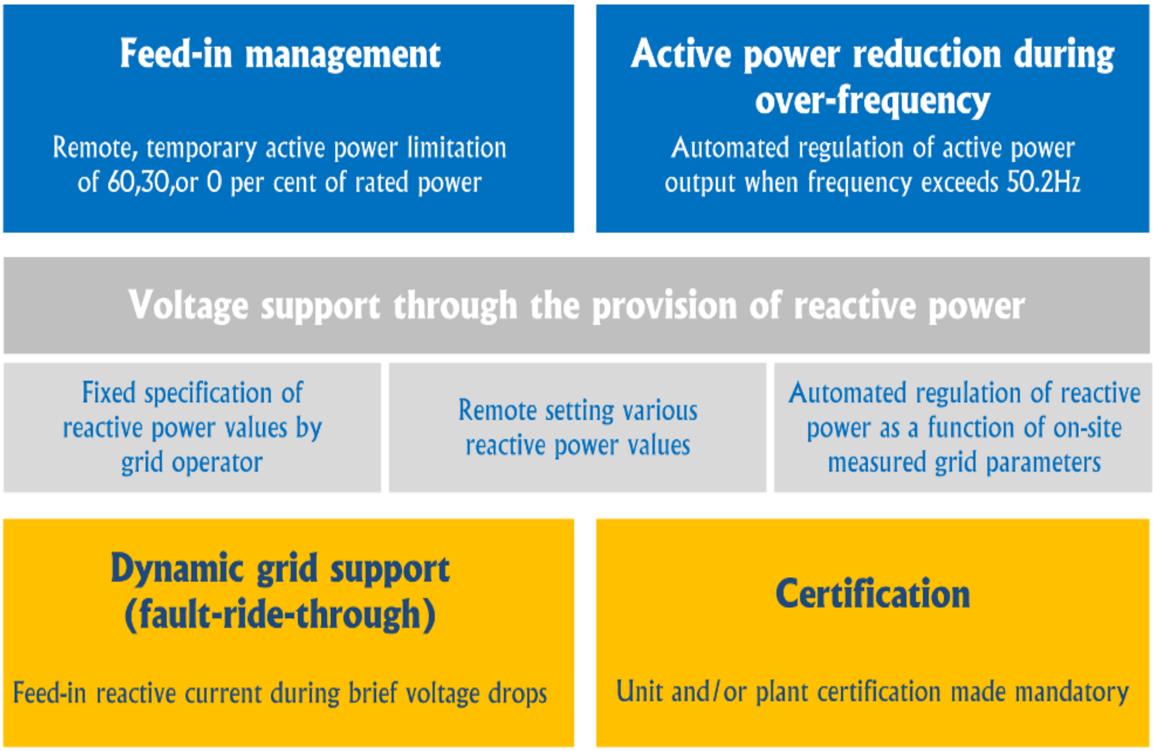
   c. New synchronization tolerances

Germany Grid Codes: BDEW for MV (6-30 KV) grid and VDE 4105 for LV (230-400 V) grid provide for management of Active Power and Reactive Power based on signals from the Utility. These features are important as the penetration of DERs grow and may be in addition to the features required under IEEE-1547.

These standards require:

i. Temporary remote control over power injection limiting output to 60%, 30% or 0%. Automatic reduction of power output, once frequency goes past a limit (+0.4%/ 50.2 Hz).

ii. Remote setting of reactive power values to provide grid support, in response to grid conditions. Inverters capable of such response are available in the market. Most global brands have these features and therefore they would be possible to adopt when countries require such capabilities.



Adopted from "grid code essentials &streamlining process for interconnections," Michael Ingram, P.E.FIEEE, under support from USAID & NREL, July 2020

FIGURE 17: GRID CODE FEATURES (NAGARAJAN, 2018)

5.10. Evolutionary Phases of Net Metering

The evolution of NEM over last 30 years presents an interesting pattern, which may be of use in states which have recently launched NEM programs.

The evolution framework presented in Table 4 is indicative and presents the natural evolution of NEM, as customers and utilities enhance their understanding of NEM, and NEM technologies become competitive. The evolution may accelerate or slow down based on the specific context of a country or program.

Support of utilities is critical for making the transition. With experience, and appropriate technical analysis support, utilities can see that NEM technologies can be integrated well with the grid and can alleviate grid capacity constraints, apart from providing the utilities, a cheap source of power. When compensation of NEM energy exported to the grid is transitioned to a 'VDER or avoided cost' system, the sense of financial loss is also corrected.

The economic rationale arising from the difference in the economic cost of generation from existing energy options vis-à-vis LCOE of NEM technologies and the savings in grids, is the key driver for accelerating NEM adoption. This has been the experience of Hawaii where solar PV has achieved a penetration of ~20% in a mere 7 years.

Utilities with growing demand tend to tolerate loss of demand better, because their revenues increase despite NEM implementation. This holds true in most developing countries.

TABLE 4 : NEM EVOLUTION STAGES FOR UTILITY PROGRAMS

Parameter	Launch - Policy Support Phase	Transition Phase	Market Competitive- Growth Phase
1. Customer Attractiveness	Grid Tariff ~<LCOE (NEM)	LCOE (NEM) drops below Grid Tariffs in some segments	LCOE(NEM) < Grid Tariffs
2. Policy Instruments	Lower LCOE ▸ Capital subsidies ▸ Investment Tax Credits (ITC) ▸ Accelerated depreciation ▸ Tax waivers ▸ Effective increase of Grid Tariff ▸ Carbon Tax ▸ Accessible and attractive Finance ▸ Low-cost loans	Enforce NEM ▸ Mandates, codes and priorities ▸ RECs, Renewable Portfolio Obligations (RPOs) Green Procurement ▸ Aggregated NEM programs in Public Buildings, Schools, Warehouses, and Municipal Infrastructure etc. Accessible and attractive Finance ▸ Low-cost loans ▸ Long tenor loans ▸ Risk guarantees ▸ Specialized sectoral loans (e.g., for low-income houses, schools, agricultural sector etc.) Utility subsidies may be used, linked to MW_p NEM capacities inducted in the grid. This is to encourage utilities to support NEMs	▸ No direct financial and economic support ▸ Utility performance parameters may include NEM penetration as an important measure
3. Level of NEM penetration (NEM capacity as % of grid capacity)	1-2% ▸ First 3- 4 years	~2-5% ▸ 4- 8 years	5%+ (can increase to 50%+)[49] ▸ 4 years+

[49]In Germany DERs have a capacity ~55% of Peak Load. In crowded cities like Delhi, a level of 20-25% grid penetration can be achieved by NEM solar.

Parameter	Launch - Policy Support Phase	Transition Phase	Market Competitive- Growth Phase
4. Utility Perspective	Utilities perceive NEM as resulting in revenue loss. They do not support NEMs, in the initial phases. However, begins implementation due to government targets, guidelines etc.	▸ Utilities begin to realize NEM benefits (in terms of grid support). ▸ However, they also face challenges in terms of grid stability, especially in dense populations.	▸ In this phase NEM technologies are competitively priced, and also support the grid in achieving its performance goals. ▸ Integration of NEM technologies happens, with better equipment, grid codes and utility controls. ▸ NEM technologies begin to be viewed as positive.
5. NEM Compensation rules (for exported energy)	▶ Retail Tariffs ▶ Feed in Tariffs (FITs) ▶ Generation Based Incentives (GBIs) ▶ Primary mechanism is NEM with carry-over of credits allowed for 1 year or more.	▶ Average Purchase Cost of Power ▶ Primary mechanism is NEM with carry- over of credits allowed for 1 year or more	Compensation begins to become market competitive when following mechanisms are used: ▶ Auctions ▶ Auction tariffs ▶ Premiums ▶ Minimum guarantees ▶ Value of Distributed Energy Resources (VDER); Net Value of Distributed Energy Resources (NDER). ▶ Grid support charges for providing support to NEM Technologies. ▶ 'Avoided Cost' based compensation NEM with credit carry over is stopped and is replaced with: ▶ Net Billing ▶ TOU credits ▶ All Buy All Sell mechanisms
6. NEM Capacity constraints	▶ Minimum (normally >= 1 kW), maximum (~up to 1 MW) limits. ▶ Peak capacity sanctioned in a distribution system limited to < 30-50%.	▶ Minimum and maximum limits continue. ▶ Peak capacity limits liberalized. ▶ Peak NEM capacity up to 100% of distribution system capacity. ▶ Energy storage normally not permitted.	▶ Peak NEM capacity in a Distribution system is assessed based on Hosting Capacity assessments. ▶ Upper caps are removed. ▶ Focus is more on evaluating what is being injected into the grid rather than the installed NEM capacity. Injections may be limited based on grid capacity constraints.

Parameter	Launch - Policy Support Phase	Transition Phase	Market Competitive- Growth Phase
	► Energy Storage normally not permitted.		► Energy storage is permitted to allow maximum realization of value of NEM energy exported to the grid, and to overcome grid capacity constraints.
7. Business Models	**Predominant models** ► CAPEX Model. ► RESCO Models (A few) begin to be popular.	**Predominant models:** ► CAPEX Model. ► RESCO Models (different varieties of RESCO Models such as PPA, Lease, Roof Lease, etc.). RESCO models take off based on private capital. ► Start of Utility Anchored Business Models to support scale. ► Different types of business models formally accepted in NEM regulation.	**All types of Business Models operate and are incorporated in NEM regulation:** ► CAPEX Model ► RESCO Models ► Utility Anchored Business Models ► Community Models The objective is to maximize the usage of roofs/spaces available for NEM.
8. Credit Transfer Mechanisms	► No credit transfers generally permitted.	► No credit transfers generally permitted.	► Credit Transfers using Virtual Net Metering and Group Net Metering mechanisms permitted. ► This credit for electricity generated under NEM is transferred to users even if they do not have roofs/space for NEM.
9. Monitoring and Control of NEM systems	► No or very limited monitoring and control.	► Utilities establish a central monitoring station, where they integrate energy generation data from DERs.	► Apart from universal monitoring, NEM systems are made to respond to control signals from Utility's Central Control room based on power demand-supply patterns. ► Utilities can provide alerts to consumers in case of drop in performance of the NEM system.

6. Review of Net Metering in SAARC Member States

6.1. Potential of Net-metering in SAARC Member States

SAARC Member States have a great potential for adoption of NEM. In many Member States such as Bangladesh, Maldives, Nepal and Sri Lanka, the land resources are scarce and large-scale renewable plants or even fossil fuel fired generation plants may be difficult to set up. Hence, local generation on roof-top or on-ground within the consumer premises is a great alternative for conserving scarce resources and adding energy capacity. Afghanistan (50%), Bangladesh (98%), India (62%), Maldives (99%), Pakistan (66%), and Sri Lanka (50%) have significant dependence on electrical energy produced from fossil fuels which are very costly. The cost of generation from renewables technologies (e.g., Solar PV or on-shore Wind) is falling rapidly and is very competitive vis-à-vis business-as-usual (BAU) baseline technologies (oil, gas, coal). Pakistan and Afghanistan also face significant transmission and distribution capacity constraints, which can be partly alleviated by NEM mechanism. NEM supports generation near the point of consumption, not requiring expensive transmission and distribution network.

TABLE 5 : BASELINE FEATURES OF POWER SECTOR IN SAARC MEMBER STATES[50]

Country name	Land issue (scarcity)	Baseline electricity from fossil fuel	Transmission and distribution constraints	Power access concerns and outages
Afghanistan		50%	√	√
Bangladesh	√	98%		√
Bhutan				
India		62%		√
Maldives	√	98%		
Nepal				√
Pakistan		66%	√	√
Sri Lanka	√	50%		

Most of SAARC Member States need significant additional generation capacities in the next decade (2020-2030). Afghanistan, Bangladesh, Pakistan, Sri Lanka have a real choice to adopt NEM, expand the renewable capacities, and avoid costly and environmentally destructive fossil fuel-based generation. IEEFA's Bangladesh Power Review (Nicholas & Ahmed, Bangladesh Power Review, 2020), conducted in May 2020, highlights that the country should urgently slash planned coal and gas fired generation capacities, expand renewable energy footprint and increase NEM implementation. Tourism is a big industry for the Maldives, being an island and sharing much of the same constraints of land and oil imports as other SAARC Member States. It should emulate the

[50] Compiled from multiple sources and information from interviews conducted by the author.

example of Hawaii. Hawaii has set itself a goal of using 100% renewable energy by 2045. Distributed renewables in Hawaii have already reached 20% share of its grid capacity in 2019, in about 7-8 years from the launch of the program. Hawaii is investing in a mix of renewables including bio-mass and is incorporating energy storage in a big way. Sri Lanka has very aggressive plans to expand renewables and reach a 74% share of GWh consumed by 2030. This would require a significant expansion of utility scale wind and solar, as well as roof top solar. They have a strong case for such a shift as their existing sources of oil, or gas generation are very expensive. They can also emulate the Hawaii example. SAARC Member States with significant levels of power cuts and/or power access issues will benefit greatly by incorporating energy storage as part of NEM policy.

TABLE 6: THE ENERGY MIX OF SAARC MEMBER STATES

Country	Energy Production	Fuel / Resource						
		Coal	Oil	Gas	Nuclear	RE	Hydro	Total
Afghanistan	MW in 2016 (IMCE, 2016)	-	312	-	-	55	255.5	623
	% (MW) in 2016		50			9	41	100
	GWh in 2016	-	100		900	1,000		
	MW in 2025		312	650		596	1,408	2,966
	GWh in 2025 (ME&E, 2017)		1,640	3,416	0	954	4960	10,970
	CAGR (GWh) %/a up to 2030						21	21
Bangladesh	MW in 2019 (Nicholas & Ahmed, 2020)	524	6,140	10,877	-	30	230	17,801
	% (MW) in 2019	3	34	61	-	0	1	100
	GWh in 2019	1,230	13,448	48,306	-	39	725	70,534
	MW in 2030	18,057	311	28,160	2,232	2,458[51]	230	51,448
	GWh* in 2030[2]	42,386	681	125,062	15,269	3195	725	187,318
	CAGR GWh %/a up to 2030	17	-13	4	-	44	0	5
Bhutan	MW in 2018 (IRENA, 2020)	-	18	-	-	1	1,614	1,633
	% (MW) in 2018		1			0	99	100
	GWh in 2017 (IRENA 2017)					2	7,728	7,730
	MW in 2030 (IRENA, 2019)					79.7	4,544 (JICA, 2019)	4,624

[51] To be achieved by 2021. Bangladesh targets RE capacity of 3,864 MW by 2041 as outlined in Transforming the Power Sector in Bangladesh (PwC, 2018)

Country	Energy Production	Fuel / Resource						
		Coal	Oil	Gas	Nuclear	RE	Hydro	Total
	GWh in 2030					160	21757	21,917
	CAGR(GWh) %/a up to 2030					44	9	9
India	MW in 2020 (CEA, 2020)	205,955	510	24,992	6,780	88,042	45,699	371,978
	% (MW) in 2020	55	0	7	2	24	12	100
	GWh in 2020 (CEA 2020)	99,4197	108	48,443	46,381	127,018	155,970	1,372,117
	MW in 2030 (MoP, 2020)	266,911	0	25,080	18,980	435,155	71,128	817,254
	GWh* in 2030 (CEA, 2020)	1,402,884	0	131,820	129,839	627,796	242,759	2,535,099
Maldives	MW in 2018 (IRENA, 2020)	-	222	-	-	11	-	233
	% (MW) in 2018%		95			5		
	GWh in 2017		642			17		658
	MW in 2030 (CRISIL, 2020)		930			150		1,080
	GWh in 2030		2,689			232		2,921
	CAGR (GWh) %/a up to 2030		13			24		14
Nepal	MW in 2020 (NEA, 2020)	-	53	-	-	1	1,274*4	1,328
	% (MW) in 2020	-	4	-	-	0	96	100
	GWh* in 2030 (MoEWRI, 2017)							19,151
	CAGR (GWh) %/a up to 2030							17
Pakistan	MW in 2019 (NEPRA, 18-19)	22,848*2				1,999	9,732	34,579
	% (MW) in 2019	66				6	28	100
	GWh in 2020 (Profit, 2020)	25,553	4,178	15,064	9,924	3,527	38,000	96,246
	MW (2040) (NEPRA, 2019)	30,099	919	7,965	4,278	16040	38790	98,091
	GWh* in 2040[2]	134,307	21,960	41,864	29,980	28301	151461	407,872
	CAGR(GWh) %/a up to 2030	8	8	5	5	10	6	7
Sri Lanka	MW in 2018 (CEB, 2018)	900	1,137	-	-	611	1,399	4,046
	% (MW) in 2018	22	28	-	-	15	35	100

Country	Energy Production	Fuel / Resource						
		Coal	Oil	Gas	Nuclear	RE	Hydro	Total
	GWh in 2018	4,764	3,629	-	-	1,832	5,149	15,374
	GWh in 2030 (Ralapanawa, Jayasinghe, & Withanage, January)	8,000*[1]			-	15,000	7,000	30,000
	CAGR (GWh) %/a up to 2030	-0.4			-	19	3	6

*[1]Data available in GWh (coal+oil+gas) for Sri Lanka plans for 2030
*[2]Data available as thermal (assumed thermal includes coal, oil, gas, nuclear)
*[3]includes coal, gas, oil generation in India
*[4]Includes grid-connected small-hydro and large hydro

6.2. Net Metering Regulations in SAARC Member States

All the SAARC Member States except Bhutan, formulated or in the process of formulating their respective country-wide NEM policies and regulations. Solar PV is the most accepted NEM Technology. India has a widescale government program incentivising solar pumps[52], in a bid to solarise especially the diesel-based pump sets. One of the components of this scheme allow farmers to sell excess solar power generated to the grid through NEM. Bangladesh too is coming out soon with a policy that makes solar pumps eligible for NEM.

Table 7: Introduction of Net Metering Regulations in SAARC Member States

SAARC Member State	Introduction Year	Approved Technologies
Afghanistan	2015	Solar PV
Bangladesh	2018	Solar PV, solar pumps to be included soon (Islam, 2019)
Bhutan	-	-
India	2013	Solar PV and solar pumps
Maldives	2015	Solar PV (Waheed, 2018)
Nepal	2018	Solar PV, wind, biogas
Pakistan	2015	Solar PV and wind
Sri Lanka	2010	Earlier all RE was permitted. Now, solar PV is the primary NEM focus.

Few Member States like Bangladesh, Nepal, Pakistan and Sri Lanka have provisions in their NEM regulations for allowing other renewable energy technologies like wind, biogas, small hydro, etc. But

[52] MNRE Memorandum available at https://mnre.gov.in/img/documents/uploads/8065c8f7b9614c5ab2e8a7e30dfc29d5.pdf

the scale of deployment of these technologies, other than solar PV, under NEM has almost been nil as per the information received from the country specific local utilities/nodal agencies. SAARC Member States, blessed with immense renewable energy sources, can use distributed generation systems coupled with NEM for increasing energy security and moving towards a low carbon energy system.

6.3. Utilities Selected for Analysis

The author has analysed NEM implementation in 9 chosen utilities.

Five utilities were chosen from India, as India has the most aggressive plans for implementation of NEM with plans for 40 GW+ of solar roof tops and large-scale solar pump installation using NEM. Different state utilities have designed different programs for NEM keeping in mind their specific requirements, conditions, and challenges. The increased scale of adoption resulted in drastic reduction of costs, all the while ensuring the quality of components used. The central and state government subsidies targeted towards solar rooftop and the government targets like Renewable Purchase Obligations for electric utilities and other entities like industries have resulted in uptake of solar rooftop and also utilities actively engaging and campaigning for solar rooftop, especially to the residential segment. Funds from organisations like the World Bank, GIZ, ADB, etc., in partnership with major Indian banks like the State Bank of India (SBI), Punjab National Bank (PNB), etc. have helped regulators and utilities leverage the solar rooftop activities like campaigning, empanelling qualified vendors, opting for different business models like RESCO, streamlining the application process, training the manpower, etc. The chosen Indian utilities for this study are:

i. Bangalore Electricity Supply Company Ltd (BESCOM)
ii. BSES Rajdhani Pvt Ltd (BRPL, the largest utility in Delhi)
iii. Chhattisgarh State Power Distribution Company Ltd (CSPDCL)
iv. Maharashtra State Electricity Distribution Company Ltd (MSEDCL)
v. Punjab State Power Corporation Limited (PSPCL)

The rationale for the choice of these utilities was ‘size’ and ‘the diversity factor’, to ensure diversity of climate, grid conditions and different outlook towards the adoption of NEM.

Four utilities from other SAARC Member States were chosen, based on the potential size of NEM programs and maturity of NEM Policies. These utilities are:

i. Ceylon Electricity Board (CEB), Sri Lanka
ii. Dhaka Power Distribution Company Ltd (DPDC), Bangladesh
iii. Islamabad Electric Supply Company (IESCO), Pakistan
iv. K-Electric (formerly Karachi Electric Supply Company (KESC)), Pakistan

The lessons learnt from these utilities may be applied to SAARC utilities in general. The analysis of these utilities is based on published reports, annual revenue filings of the utilities, and interviews with senior management from the utilities or related nodal agencies. The gathered information is summarized in Utility Profiles.

6.4. Utility Analysis Framework

Financial and Economic Analysis

NEM succeeds when the right financial and economic rationale drives it. This is brought out by the analysis of the benchmark states.

Economic Rationale

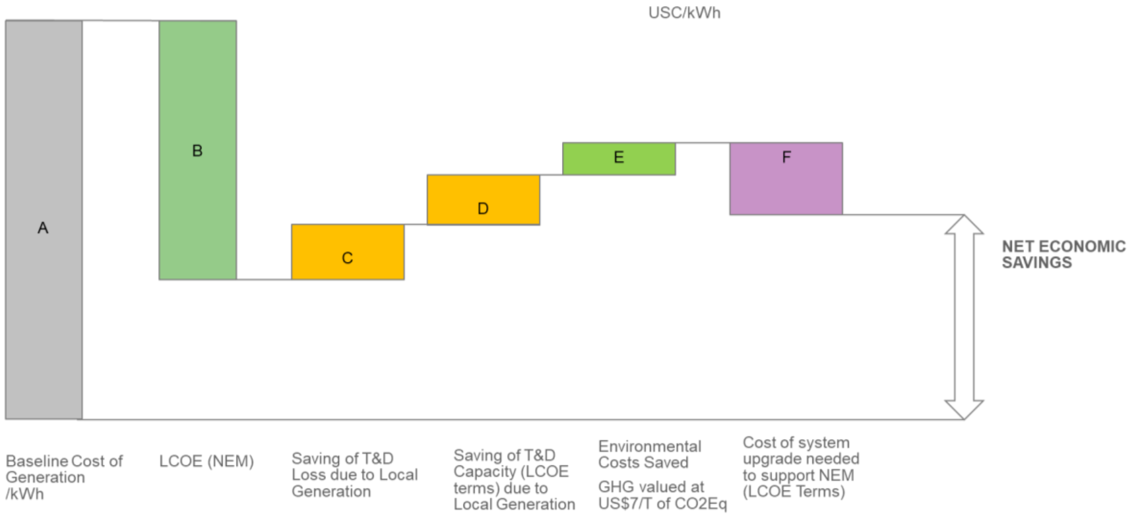


Figure 18 Net Economic Savings From NEM

The economic rationale for a country to adopt NEM is when it results in economic savings (/kWh of electricity), for the economy. An analytical framework to assess this is presented in Figure 18.

The economic analysis is carried out without taxes. The effect of subsidies is also removed by pricing all inputs at the market (domestic or international) prices.

Net Economic Savings (NES) = A - B + C + D + E - F

- A = Baseline cost of generation of electrical power
- B = LCOE of NEM technology
- C = T&D losses saved, because of local NEM generation
- D = Investments in T&D capacity saved (converted to eq. LCOE) by local generation
- E = Savings in environmental costs[53]
- F = Cost of T&D system upgrade (eq. LCOE) required to integrate NEM technology

The baseline technology of generation is identified by looking at the costliest technology (on the margin)

[53] Environmental savings are approximated to the costs of GHG Emissions Saved valued at a moderate price of US$7/T of CO_2e. Chris Bataille et el in their paper "why carbon prices should and will be different across countries" (2018), a world bank supported assessment, give a price range of US$40–80/T CO_2e by 2020 and US$ 50–100/T CO_2e by 2030 to be consistent with 2ºC temperature increase scenario. This is a very high level and will make NEM investments very attractive. The author has used a lower price of US$ 7/T CO_2e based on Author's experience with variety of corporates who are making investment decisions.

or the most prevalent technology (due to resource mix for the country) that would be substituted or would not be set up due to NEM.

The value of savings in T&D losses can be assessed as follows:

C = (% energy loss of distribution system + % energy loss of transmission system) X A

The value of savings of T&D capacity (eq. LCOE) because of NEM can be estimated as follows:

D = Average cost of T&D investments/kWh x average cost of capital x % of NEM energy that is supplied during peak period.[54]

The remaining two factors can be estimated as follows

E = Grid emission factor (T of CO_2e / MWh) x cost of emissions (US$/T of CO_2e)/1000

F = Cost of system upgrade needed to support NEM (US$/MW)/Yield of NEM (MWh/MW) x cost of capital

F has been ignored in this analysis because NEM is at a nascent stage and the grid can absorb NEM technology, such as solar PV, without a significant upgrade. F can be assessed in more mature stages of growth of NEM.

When NES is positive, it means every unit of electrical energy substituted by NEM generation results in savings for the country. Hence, the government can look at supporting utilities or customers through appropriate subsidies and incentives to encourage such substitution.

It should be noted that most NEM technologies go through a learning effect[55] and as the installed capacity grows, costs fall. Hence even if NES is estimated to be negative in the initial stages, the cost differentials that can be achieved in the future and encourage the new NEM technologies should be considered.

Financial Rationale

The financial rationale can be looked from the following perspectives:

i. Customer's financial savings due to NEM
ii. Utility's Financial Savings due to NEM.

Net Customer Savings (NCS1) = A1 - B1 + C1 + D1 + E1 - F1 (for energy consumed by the customer)

A1 = Net variable tariff (including electricity duty, fuel pass-through charges, surcharges, etc.) paid by the customer for grid electricity.

B1 = LCOE of NEM Technology. It is assumed that NEM, since it is serving captive consumption, will not have to bear taxes, electricity duties etc., otherwise applied on grid supplied electricity. It is also assumed that fixed or demand charges paid by the consumers will not change when NEM is employed,

[54] % of NEM energy supplied during peak period can be assessed by analyzing the generation pattern. RETSCREEN and PVwatt (NREL) models have been used to estimate this factor for Solar PV. Average cost of T&D investments/kWh has been taken at US$ 0.7M/MW, international norms for such investments and 65% average capacity utilization.

[55] LCOE of solar PV declines by 20-22% as installed capacity doubles.

because sanctioned load size remains the same[56].

C1 = Effect of capital subsidies (LCOE is lower because investment in NEM is reduced)

D1 = Generation linked incentives – paid on generated electricity

E1 = Value of REC or Carbon Credits (if the customer qualifies)

F1 = Cost of system support charged by the utility to support NEM

E1[57] and F1[58] have been ignored in the analysis.

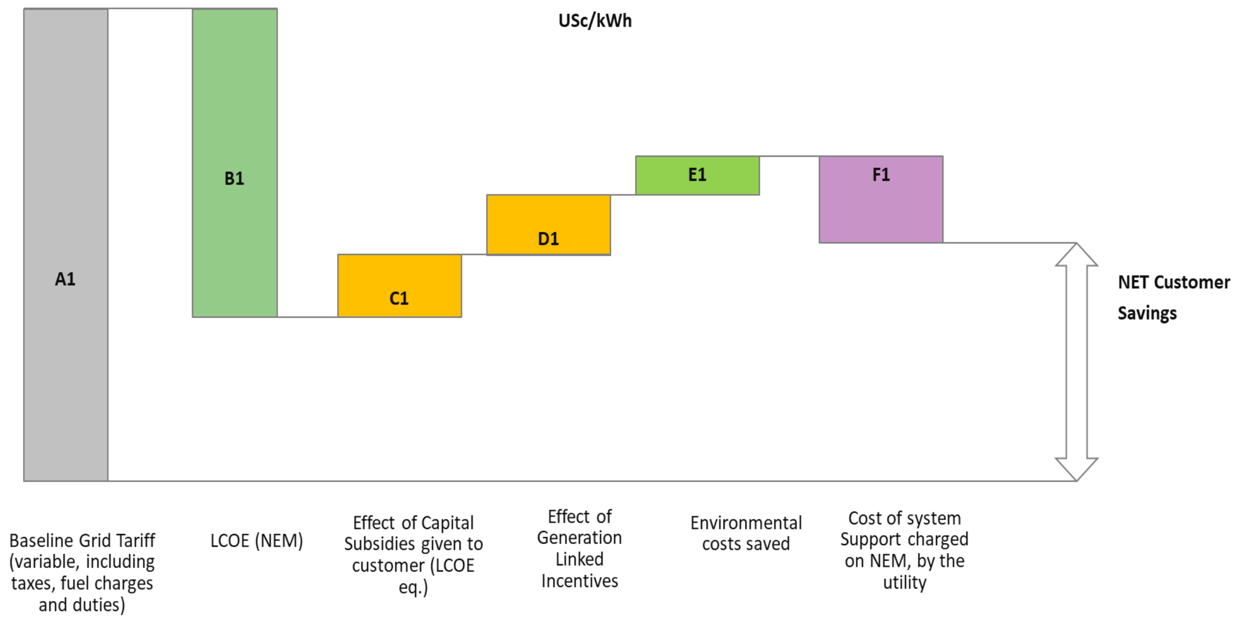


FIGURE 19: NEM SAVINGS FOR A CUSTOMER

NCS1 can be improved by C1 and D1 which are policy driven.

Customers will also save on net surplus energy exported to the grid.

This saving would be compensation received compared to LCOE of generation.

Net Customer Savings (NCS2) = Compensation for exports - B1

Overall savings for customer would then be

Total Customer Savings (TCS) = NCS1 x NEM energy consumed + NCS2 x Net Energy Exported.

Customers will invest in NEM technologies only if TCS remains positive.

[56] Fixed and demand charges which are payable on peak loads of the customer, can be saved by the use of Energy Storage.

[57] E1 may be valuable if the customer is obligated to a Renewable Portfolio Standard or is large enough to qualify and benefit from carbon credits.

[58] F1 is ignored because NEM implementation is at nascent stage in SAARC Member States and grid is easily able to support NEM technologies without additional costs.

Utility Savings

Utilities tend to see growth of NEM as negative, as it seems to take away their well-paying customers, whereas their commitment to procure energy remains, as procurement is based on long term contracts especially in developing countries. Hence the utilities may be left with fixed contractual commitments and fixed organizational expenses without sale.

However, this issue can be analysed under two different scenarios, requiring distinct analytical frameworks:

i. Scenario 1: When utility's energy sale is flat or declining.

ii. Scenario 2: When utility's energy sale is growing at rapid rates.

As seen in the case of Hawaii, NEM technologies can grow rapidly when the customer savings are large. In the case of Hawaii, solar grew from a very small share to become ~ 20% of supply mix in the period from 2012-2019. This translates to ~3% of capacity substituted by solar per year.

Growth of NEM technologies is much slower when savings are of the order of US¢ 3-5 /kWh (Cross-Call, Prince, & Bronski, 2020), which is the case in SAARC Member States. Hence, NEM penetration rates may vary between from 1-2% per annum in SAARC member states.[59]

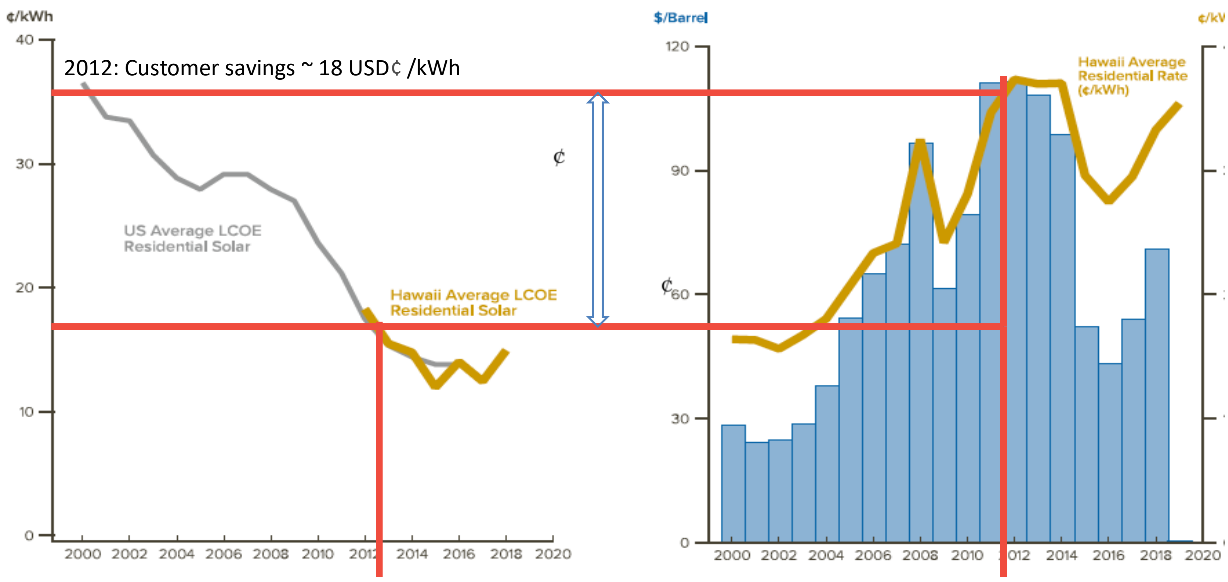


FIGURE 20: HIGHER SOLAR LCOE TO GRID TARIFF DIFFERENTIAL DROVE RAPID ADOPTION IN HAWAII (CROSS-CALL, PRINCE, & BRONSKI, 2020)

[59] Penetration = Share of NEM of overall capacity mix in the grid.

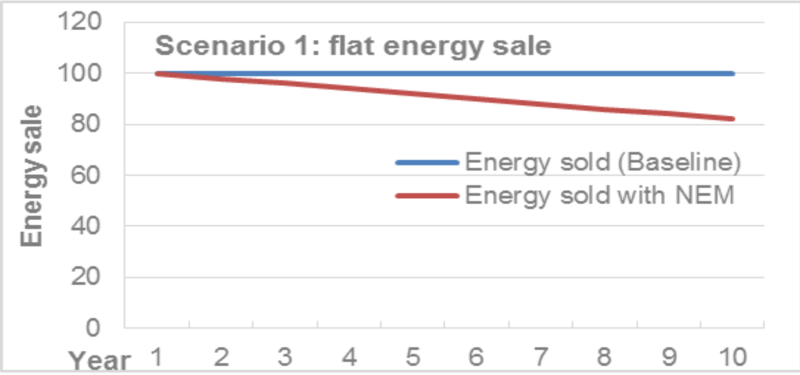


FIGURE 21: IMPACT OF NEM ON UTILITY GROWTH: SCENARIO 1- FLAT BASELINE SALE

Scenario 1: Baseline energy sales are flat (or declining)

This is the scenario in most developed and mature economies, where the adoption of energy efficiency measures, flat or declining population and lower GDP growths are resulting in flat or lower energy demand.

In the model with NEM implementation substituting 2% of energy per year, by the 10th year, energy consumption can be expected to decline by 18%. This scenario represents the situation where the utility has lost sale and is left with fixed commitments and costs. These may need to be passed on to non-NEM customers or may result in a loss for the utility. Financial assessment of the impact of NEM on the utility in such a scenario is outlined here:

Net Utility Savings (NUS) = B2 - A2 + C2 + D2 + E2 + F2 + G2 - H2

- A2 = variable tariff realized by the utility that is lost when NEM Technology substitutes grid electricity
- B2 = APPC for electricity paid by the utility, NEM implementation saves this cost
- C2 = Savings of T&D Losses = B2 x (T&D Loss%)
- D2 = % of NEM electricity supplied during peak period x cost of investment in T&D Infra /MW x (1/Yield (MWh/MW)) x Cost of Capital
- E2 = Value of environmental credits/kWh
- F2 = value of peak power procurement saved = % of NEM electricity generated during peak periods x premium for peak power over APPC
- G2 = value of incentives or subsidies given to the utility (eq. in LCOE)
- H2 = value of additional costs and resources needed to integrate NEM (e.g., energy storage, superior control technologies[60] etc.).

[60] Smart inverters, remote monitoring and control features, central monitoring systems (as the penetration increases), dynamic export cut-off (can be based on time of day, hourly market price of electricity, etc.), etc.

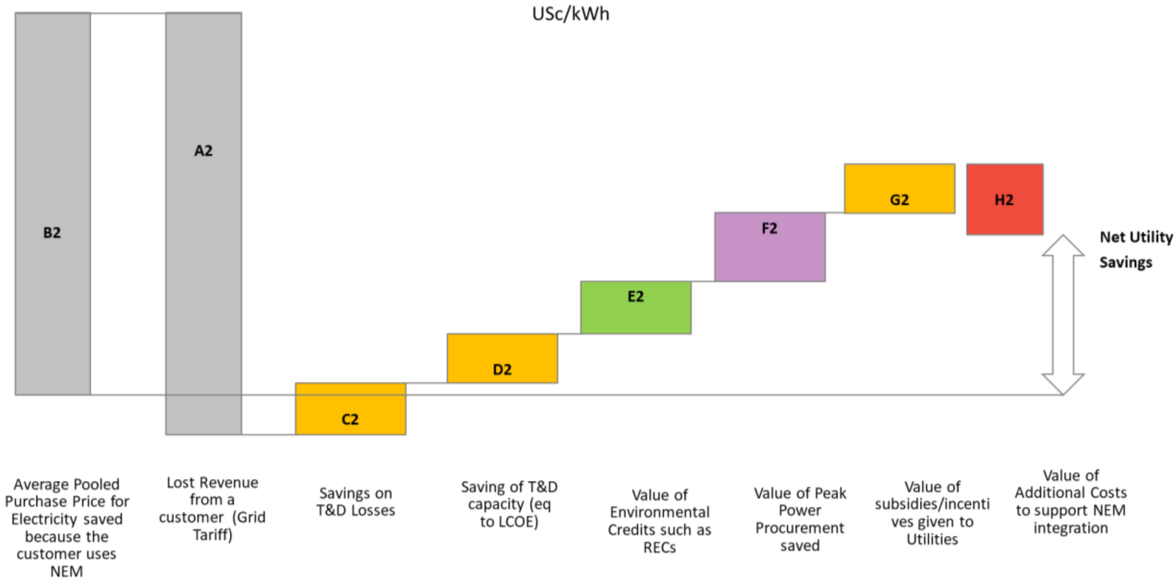


FIGURE 22: SAVINGS FOR A UTILITY UNDER SCENARIO 1: FLAT ENERGY SALES

If NUS is negative, the utilities may not support NEM initiatives, from a financial standpoint. As long as NES is positive (i.e., the economy gains with NEM), the government should think of incentivizing the utilities for NEM implementation, to make NUS positive and create financial incentives for utilities for adopting NEM.

Scenario 2: Baseline energy sales grow @5%+ every year, (the case for SAARC Member States), NEM substitute's grid energy @2% per year.

Under this scenario, net energy sales grow, even under NEM, although at a slower pace than the baseline. Therefore, by the 10th year energy consumption still grows by 27.2%. In this scenario the utility does not "lose sale", just grows relatively slowly. It does not carry costs of fixed commitments. Therefore, no net costs need to be passed on to non-NEM customers, except for the new costs and resources required to integrate NEM technologies to the grid.

Financial assessment of the impact of NEM on the utility in such a scenario is outlined here:

Net Utility Savings (NUS) = B2 - A2 + C2 + E2 + F2 + G2 - H2

- A2 = NEM compensation paid by the Utility to the Prosumer under NEM
- B2 = Average Pooled Purchase Price (APPC) for electricity paid by the Utility. With equivalent NEM injections, this is saved

In most NEM schemes A2 and B2 are equated (i.e., compensation to prosumer for surplus injection is priced at APPC price. The utility does not lose while sourcing energy from NEM source.

- C2 = Saving of T&D Losses = B2 x (T&D loss%). This energy would have been lost when procured from non-NEM sources
- E2 = Value of environmental credits/kWh
- F2 = Value of Peak Power Procurement saved = % of NEM electricity served during peak periods x Premium of Peak Power over APPC

- G2 = Value of Incentives or subsidies given to the Utility (eq. in LCOE)
- H2 = Value of additional costs and resources needed to integrate NEM (e.g., energy storage, superior control technologies etc.).

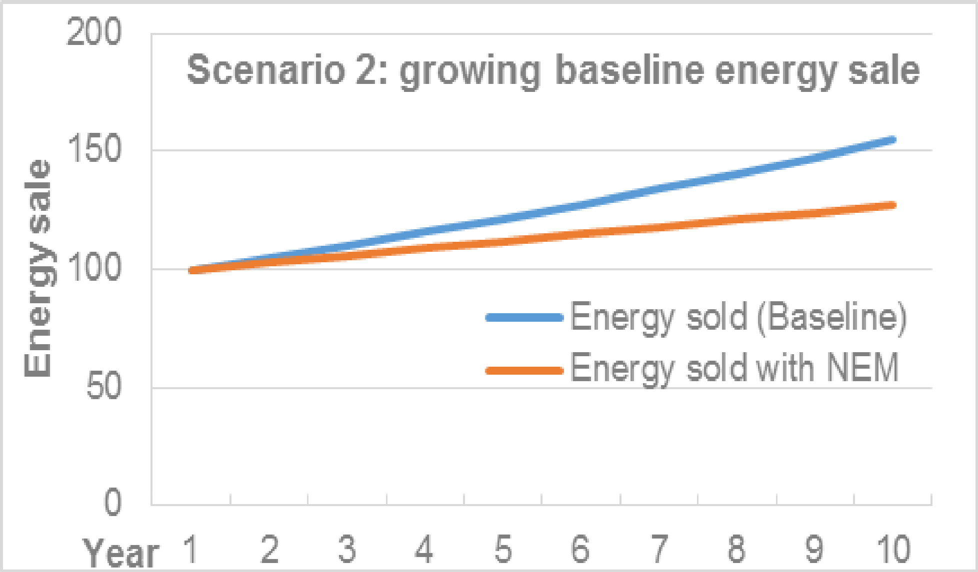


FIGURE 23: IMPACT OF UTILITY GROWTH: SCENARIO 2-GROWING BASELINE SALES

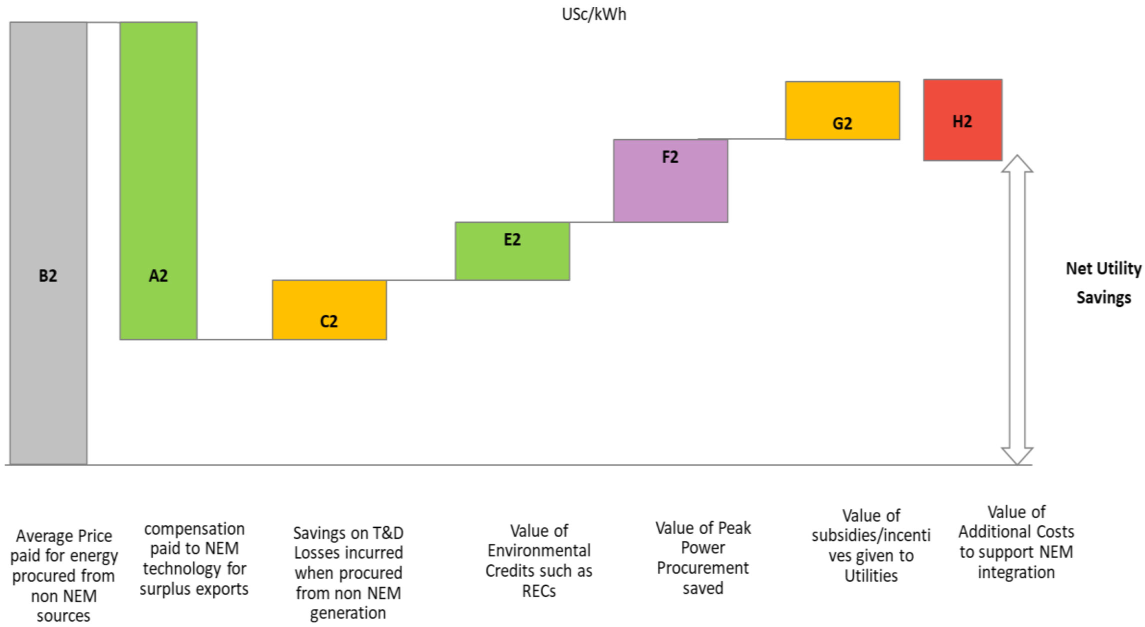


FIGURE 24: SAVINGS FOR A UTILITY UNDER SCENARIO-2, GROWING ENERGY SALES

This is clear that Scenario 2 will result in net savings for utility in most cases. H2 is expected to be low in the initial phases of NEM growth.

The author has adopted Scenario 2 calculations while analysing utility savings in SAARC Member States. H2 has been ignored.

NEM succeeds when the right financial and economic rationale drives it. This is brought out by the Author's analysis of the benchmark states.

Technical Analysis

In this part, policies and rules relating to permitted technologies, system sizing and grid codes to assess if policies unduly restrict NEM investments or may result in integration challenges for the grid are presented.

NEM Implementation Process and Organizational Analysis

The author reviewed the NEM implementation process from the perspective of 'ease' and 'time' taken for granting NEM permissions.

The author also reviewed organizational issues such as NEM goals, constitution of special NEM cells, help desks, customer engagement efforts, segment specific programs, effective processes for billing, monitoring and control, utility's perception regarding NEM, utility's efforts to undertake technical assessments (e.g., Hosting Capacity) and prepare the grid for high NEM penetration, utility's understanding of costs and benefits of NEM shared across the organization and so on.

The objective was to identify significant organizational bottlenecks that may prevent realization of the NEM goals.

Business Model and Financing Eco-system

In this part the operating business models within the jurisdiction of the utility, the number of qualified service providers, vendors and developers active in the market, and specialized financing products available to support NEM are discussed.

The objective of the analysis is to find if the eco-system is ready and capable to support scale -up of net-metering in the SAARC region.

6.5. Net Metering Assessments-Selected SAARC Member States

6.5.1 Overview of India

India launched NEM implementation in 2013 and took a target of 40 GW of roof top solar (by 2022). In 2019, India included solar pumps and agro-photovoltaic systems under NEM. The overall technical potential of Solar Roof Top in India has been estimated to be 120 GW+[61]. If solar pumps were to replace grid connected and diesel pumps, it will require a capacity of 120 GW+ of solar generation[62.]

Growth of Solar Roof-tops

Starting from a small base, the capacity for solar roof top has quickly grown over the last 8 years (CY12-CY19) ~103%/a (CAGR)[63]. By Dec 31st 2019, India had reached installations of 5,440 MW.

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[61] Reaching the sun with roof top solar, TERI, 2014. The report estimates technical potential as 352 GW (only for urban areas), and after putting in the screens relating to financial feasibility and distribution constraints, estimates market potential as 124 GW. The financial feasibility of solar roof tops has since then improved.

[62] The number of agricultural pumps in India (2019) are ~ 29.33 M, with ~ 21 M grid connected pumps, 8.2 M diesel pumps and 0.13 M solar pumps. https://energypost.eu/can-indias-30m-grid-diesel-irrigation-pumps-go-solar/. With average capacity of 4.0 kW, this can translate to 120 GW+ solar requirement.

[63] Source- Bridge to India (https://bridgetoindia.com/report/india-renewables-outlook-2024/); growth for future assumed to be 50%/a.

The commercial and industrial segments contribute about 73% of capacity and public buildings and residential segments contribute the balance 27% (split almost equally). CAPEX model is the pre-dominant mode (72% share) although RESCO model is growing.

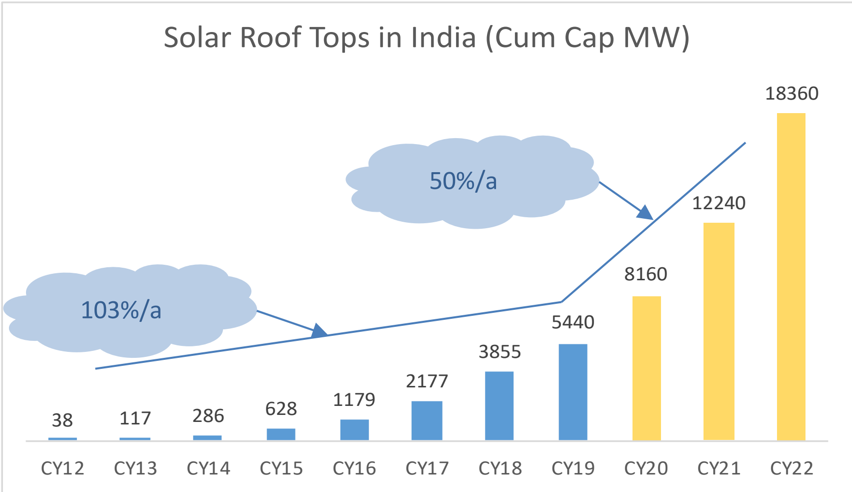

FIGURE 25: GROWTH OF SOLAR ROOF TOP IN INDIA (MNRE, 2020)

The high share of commercial and industrial segment is driven by very high grid tariffs compared to LCOE of solar PV. Residential segment tariffs are low for large % of customers, hence lower growth.

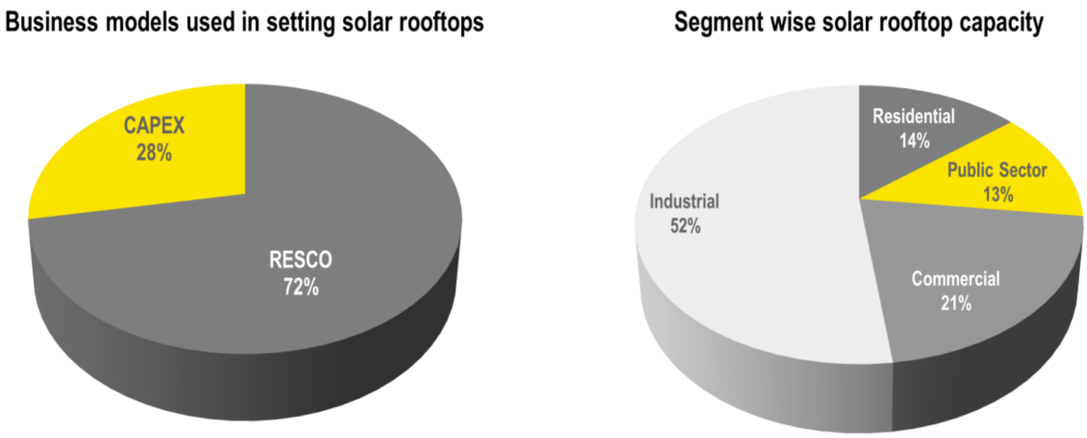

FIGURE 26: GROWTH OF NEM SOLAR IN INDIA AND SHARE OF KEY SEGMENTS (MNRE, 2020)

Public buildings were the first to be brought under NEM focus by the state and the national governments. The energy demand of these buildings was aggregated by Public Sector Units (PSUs) such as Solar Energy Corporation (SECI), Central Electronics Ltd (CEL), Rajasthan Electronics Industries Ltd (REIL) etc. Now Energy Efficiency Services Ltd. (EESL, another PSU) has started aggregating demand for Public Sector buildings.

Evolution of Indian NEM Policy

TABLE 8: EVOLUTION OF INDIAN NEM POLICY

	India
Launch year	2013, updated in April 2019.
Net-metering	For solar PV. Virtual Net Metering (VNM) and Group Net Metering are allowed in Delhi. The definition of NEM systems has been changed to include ground-based systems, as long as they are set up by residential customers within their premises. In 2019, NEM has also been approved for agricultural pumps and agro-photovoltaic systems, although policy for them is not fully mature.
National guiding agency	Forum of Regulators (FOR). This is a forum where all state regulators come together and deliberate on policy issues.
State regulations	National policy is used as a model document. States are allowed to modify the policy to suit their requirements.
System capacity	Maximum solar capacity limit of 1 MW or 40-100% of sanctioned load; varies from state to state. In some states like Delhi, maximum cap has been eliminated.
Limits on DT loading	Up to 15-75% of Distribution Transformer (DT) capacity; varies from state to state. Grid integration studies indicate this limit can be extended up to 100% of DT capacity without posing many challenges. The limit may be relaxed as penetration increases.
Exemption from any charges	Exemption from payment of electricity duty, wheeling charges, cross-subsidy, banking, wheeling loss, transmission loss; varies from state to state. In some states such as Maharashtra, there is a proposal to start charging NEM systems for 'grid support'.
Meter type	Bi-directional meter or 2 separate meters for import and export
Meter reading	Meter Reading Instrument (MRI), Advanced Metering Infrastructure (AMI); varies from state to state. Now most states are shifting to AMI
Rate applicable in case of export to the grid	Most states pay at APPC. However, the revised model document permits state regulatory commissions to determine compensation price, based on reference prices (e.g., renewable energy auctions) or price discovered from SECI/State utility's rooftop solar bids.
Settlement period	Model document defines one year; varies from state to state.
RPO compliance/ carbon credits/ green certificates	Units consumed by the consumer will qualify for Renewable Portfolio Obligations (RPO) compliance for the distribution licensee. However, the consumer may use it, if it is an Obligated Entity under RPO rules and needs the NEM generation to meet its RPO targets. Some states do not permit the latter benefit to the consumers if it applies for NEM permission to the utility.
Managing safety	The consumer must ensure safety of the system. Provisions allow auto-shut-off of solar plant when grid supply fails. Utilities inspect the installation for product safety and quality as per grid interconnection codes.
Central financial assistance (CFA)	► CFA for domestic consumers: ► @ 40% of CAPEX for capacity up to 3 kWp ► @ 20% for CAPEX beyond 3 kWp and up to 10 kWp

India	
	▸ @ 20% for Group Housing Societies (GHS)/Resident Welfare Associations (RWA) capacity up to 500 kWp (limited to 10 kWp per house and total up to 500 kWp) ▸ CFA is only available for domestically procured modules. ▸ CFA is also available to support utilities to integrate targeted NEM capacities; this varies between 5%-10% of the capital expenditure invested in NEMs. ▸ To determine CFA, benchmark rates are used as caps.
Other incentives[64]	▸ For CAPEX Models, profit making manufacturing companies may benefit from additional savings ▸ Accelerated depreciation (40%) and additional depreciation (20%) available to manufacturing companies. ▸ GST paid on NEM capacity can be claimed as GST credit in its operations. ▸ This gives a significant cost advantage to CAPEX investors. This may be one of the important reasons for the relative thriving of Capex models. ▸ RE systems up to INR 300 M (~US$4 M) costs are classified as priority sector lending. Banks need to have at least 40% of their lending to the priority sector. This facilitates the flow of credit and low costs of NEM systems. ▸ Residential customers can invest in NEM Solar by treating them as part of a home loan proposal. This reduces interest rates for loans significantly (bring them down to 8-8.5%/a).

India has achieved a NEM penetration level of ~ 3%[65] and is in the Transition Phase (refer section 7.8).

Market Conditions

Economics of roof-top solar is attractive to the economy and customers.

The net economic savings of NEM in India are ~ INR 2.5/kWh+[66] (US¢ 3.3/kWh+). With falling costs for solar PV, the savings are likely to increase.

Net customer savings for large commercial and industrial segments, high end residential segments are high and attractive.

NEM Policies are improving. In some progressive markets such as Delhi, the policy includes many forward-looking features such as virtual net metering, no-absolute caps[67] on NEM capacity[68] etc.

For the agricultural segment, KUSUM-C[69], program has been launched, this is expected to reduce the subsidy burden[70] on utilities, increase access to reliable power to farmers, and generate a cheap, clean source of energy for the grid.

A coal cess of INR 200/MT (~US$ 2.68/MT) has been imposed which is collected in the National Clean

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[64] For a manufacturing business, these incentives may mean ~20%+ improvement in LCOE.
[65] Compared to generating capacity in the national grid of 327 GW (Aug 2020), the solar roof top constitutes 1.5% share. Compared to grid peak of 175 GW (2019) solar roof top constitutes ~ 3% share.
[66] Refer to Analysis for BRPL section or other utilities.
[67] Other utilities have 1 MW caps in addition to a second cap of % of sanctioned load.
[68] It will still be subject to DT capacity constraints. Any DT upgrade will require the customer to share 50% of costs.
[69] A scheme launched in 2019 to substitute grid connected agricultural pumps with solar pumps, feeds electricity under NEM.
[70] Agriculture accounts for 20% electricity consumption in the country and results in subsidies of ~US$ 10 B+/a.

Energy Fund (NCEF) kept with the national government. These funds are planned to be used for financing renewable energy subsidies.

Aggregated public building programs kick-started the market

1 GW+ of rooftop solar PV projects were auctioned by various government bodies in the first nine months of 2017 (BNEF, 2017).

In one of the utility demand aggregation models supported by SUPRABHA[71], Madhya Pradesh discovered tariffs in the range of INR 1.38 -2.17/kWh (net of capital subsidies) for its 8.6 MW solar rooftop auction held in October 2018.[72]

A similar RESCO model auction for rooftop solar by the Delhi-based utility BSES Rajdhani Pvt Ltd (BRPL) obtained a tariff of INR 2.66/kWh (net of generation-based incentive) in Dwarka. More than 100 housing resident welfare associations and apartment complexes in Dwarka participated.

Indian Railways, in 2016, launched a program for installing solar roof tops on platforms, buildings and infrastructure owned by it. The program size was 500 MW (by 2022) of which more than 95 MW has been installed by Dec 2019, and bids have been conducted for more than 170 MW.

Utility participation is increasing, though misgivings persist

Since 2019, utilities are being encouraged by the Indian Government, to anchor demand aggregation for public buildings and residential segments. As per the analysis of specific utilities shows, in the small consumer segments such as residential and agricultural pumping, an increase in solar capacity will reduce utility losses.

Utilities are being supported with incentives under the government's SRISTI[73] program. Incentives are linked to meeting targets on solar roof tops and are equivalent to 5-10%[74] of capital expenditure incurred on solar roof tops in their area of operations.

Utilities continue to have misgivings about the negative impact of solar roof tops on their revenues, especially the loss of well-paying commercial and industrial segments.

Many feasibility assessments (some by international agencies like GIZ and the World Bank programs), highlight the positive impact of solar roof-top installations as well as the utility savings in transmission and distribution resources. However, the issue is not settled fully. At some time during the next 4-5 years of the transition phase, utilities may seek imposition of grid support charges on high paying customers or systems of large size, and move to value-based compensation for NEM.

Eco-system is maturing

The market now has several large RESCO and EPC players, financed by international as well as domestic investors for offering these services to customers. The sector has already raised close to US$ 1.0 billion

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[71] Technical Assistance Program supported by the World Bank, as part of its SEBI Credit Line

[72] EVI has been engaged with design and development of demand aggregation programs since 2015 and is part of SUPRABHA consortium as well. It has worked with bids for Madhya Pradesh, BRPL and Indian Railways.

[73] Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI)

[74] The payouts depend on the targets achieved by the utility beyond a baseline.

of capital investments. There are more than 50 RESCO operators nationwide[75] some with state specializations. A large number of market-makers are active and feeding deals to RESCOs.

Availability of finance is increasing

Significant multilateral credit has been lined up for supporting market evolution. A World Bank credit line of US$ 625 M is available through the State Bank of India (SBI)[76]. Another credit line of US$ 750 M from the Asian Development Bank (ADB)[77] and the New Development Bank (NDB)[78] is available through SBI, Punjab National Bank (PNB) and the Canara Bank. The German state development bank KfW[79] is also extending EUR 200 M in financial support for rural solar deployments and is considering a US$ 1.1 B loan support program for rooftop solar in India.

IFC is investing in privately owned RESCOs. They are also supporting a few state governments in initiating solar roof top programs.

The market in India therefore is ripe for growth and the installed capacity is expected to grow @50%/a. At this rate India can achieve 40 GW of distributed solar target by 2025 (3 years later than the original 2022).

A few start-ups are offering specialized project development finance and uncollateralized loans against cashflows from projects. Based on existing cashflows, green bonds or asset-based security (ABS) issuances are being conceptualized.

Technical Standards

India uses IEEE 519 and CEA 2013[80] as grid code for NEM solar integration into the grid. The codes are 'fault tolerant' for these small systems so that the nuisance of frequent tripping is avoided, and systems can ride through power quality disturbances. Key features of these standards are:

i. Frequency variation - upperside-50.5 Hz, lowerside-47.5 Hz, should have frequency trip functions with a clearing time of 0.2 sec. The upper band is much closer and the lower band much wider, allowing system to trip when the frequency is increasing due to over-injection. The wide lower band ensures that the system does not trip when the system needs power injection (the load on the system is high, the frequency is dropping and it needs power injection).

ii. Voltage variation - voltage operation-window minimizes nuisance tripping and sets the operating range of 80 to 110% of nominal connected voltage. Just as in the case of frequency, the standard asks the system to continue operating for a wide band on the lower side so that the system does not stop when power injection is required in the grid.

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[75] There is no common list but each state-specific empanelled vendors list e.g., this is the list empanelled for Chandigarh, India

[76] Details at https://www.suprabha.org/aboutus.html

[77] ADB India: Solar Rooftop Investment Program, https://www.adb.org/sites/default/files/project-document/199456/49419-001-fam.pdf

[78] Details at https://www.ndb.int/canara-india/

[79] Press Release from 2018-08-13 / Group, KfW Development Bank available at https://www.kfw.de/KfW-Group/Newsroom/Latest-News/Pressemitteilungen-Details_483136.html

[80] Refer Annexure 7.

iii. THD limit < 8%, (individual limit 5%) for <= 1kV and 5% (individual limit 3%) for > 1kV & <= 69 kV bus voltage. This standard thus permits higher harmonics for smaller systems operating at low voltage.

The adjustments in the standard have been carried out due to earlier experience of frequent tripping. Frequent tripping of systems, when the volume of power is high, will lead to instability.

These standards would need a further upgrade as outlined to incorporate features of 'fault ride through' and management of 'active power' and 'reactive power' of NEM systems in response to grid signals.

These changes would become necessary as the grid penetration of NEM increases.

Inverters with such capabilities are already available in the market. Perhaps India should adopt these standards now, 'in the transition phase', so that in future scale up, these issues do not become a problem.

These standards will also require evolution of the utility capabilities such as:

i. A digitally enabled control centre in the utility to receive data on loads and power injections from numerous sources, analyse the demand-supply balance and predict future requirements in the immediate future, short term and long term. AI capabilities will have to be built.

ii. Data access when customers apply for NEM, so that they can plan investments with confidence, using a fully automated digital application process with very simple data input requirements from the customer.

iii. Monitoring of NEM plant performance and sharing with customers, with appropriate alerts, so that they can sense a drop in performance and take corrective actions.

a) Delhi Utility - BSES Rajdhani Power Limited (BRPL)

TABLE 9: UTILITY PROFILE-BSES RAJDHANI (DELHI[81])

Area served	750 sq. km
Number of customers	2.87 M
Peak demand (till Aug 2020)	3,211 MW
FY-19 billed energy	12,190 MU[82] (GWh)
AT&C loss (FY 19)	8.06%
Solar roof-top target (2021-22)	294 MW
Solar roof-top Installed (Aug 2020)	69 MW

BRPL (is a public-private partnership utility) is the largest distribution utility operating in Delhi, serving about 40% of the energy requirement in Delhi. The residential segment is the largest for BRPL with 58%

[81] Data gathered by consultant from BRPL's ARR and website
[82] MU – Million Units

share, commercial segment contributes 27% share, while industry and agriculture segments are relatively small. Utility privatisation began in 2002 and the reliability of power supply has significantly improved under BRPL management.

The utility aims to have 1,300 MW of renewables (contributing to 29% share) in its power mix by 2022. They have already installed about 69 MW rooftop installations under NEM.

Delhi government estimates Delhi's solar roof-top potential to be close to 2.0 GW, distributed over government buildings (26%), commercial and industrial customers (25%) and residential customers (49%)[83]. The government aims to commission this capacity by 2025. In line with Delhi's potential of 2.0 GW, the BRPL assesses it can implement ~600-800 MW of NEM solar in its distribution jurisdiction. They believe this target can be achieved within the next 8-10 years, with declining solar costs and improving performance[84].

Solar Power Alleviates Peak Loads

Delhi has 2 peak periods (peak season is May-September), timings are given below:

i. Peak 1: 1400-1700 hrs

ii. Peak 2: 2200-0100 hrs

Analysis of solar generation pattern indicates 29% of solar energy generation takes place during peak 1[85].

Delhi Solar Policy, 2016

TABLE 10: DELHI STATE SOLAR POLICY

Delhi	
Launch year	Delhi Solar Policy 2016 Delhi Net Metering Regulations and Guidelines 2014
Net-metering	For solar PV, Virtual Net Metering (VNM) and Group Net Metering (GNM) is permitted. The solar plant can be set up at any site behind the meter (roof tops, ground mounted included).
NEM capacity	► 100% of sanctioned load ► Min 1 kW ► For GNM and VNM 5 kW-5 MW There were restrictions on solar roof-top systems going beyond 2m height. These have been removed (June 2020) to permit roof owners to use the roof for other purposes. The systems are therefore free from built up area restrictions.
Limits on DT loading	Earlier limit was 70%. This has been liberalized and cap has been removed. In case of high penetration, hosting capacity assessment will be carried out by the utility. Grid integration study in Delhi indicates this limit can be extended up to 100% of DT capacity.

[83] Presentation made by Department of Power, while announcing Delhi Solar Policy 2016.
[84] From the interaction with Mr. Abhishek Ranjan, Head – Renewables and DSM, BRPL
[85] % of NEM energy supplied during peak period can be assessed by analysing the generation pattern. RETSCREEN and PVwatt (NREL) models have been used to estimate this factor for Solar PV

Delhi	
Exemption from any charges	Exemption from payment of electricity duty and cess.
Meter type	Bi-directional meters
Meter reading	MRI and AMI both permitted.
Rate applicable in case of export to the grid	APPC ~ INR 5.19/kWh[86]
Settlement period	1 year
RPO compliance/ carbon credits/ green certificates	Units consumed by the consumer will qualify for the RPO compliance for the distribution licensee.
Subsidies	Consumer gets INR 2.0/kWh (~US¢ 2.7/kWh) Generation Based Incentive (GBI) for 3 years (state subsidy). CFA-from the central government for residential segments (40% capital subsidy up to 3 kW and 20% capital subsidy for systems between 3-10 KWp). Agricultural solar pumps will receive capital subsidy of 60% (30% Centre, 30% State[87]).
Mandates	Government buildings > 500 m^2 area to have a solar roof top as a mandatory requirement.

Financial and Economic Analysis

The baseline energy resource for Delhi is coal. Since energy demand is growing, the baseline would be a new coal-based generation plant. The economic cost of power generation from such a plant has been estimated by the author as INR 4.73/kWh[88].

Economic savings

TABLE 11: ECONOMIC SAVINGS ESTIMATED FOR BSES-DELHI

SN	Parameter	Value (INR/kWh)
1	Economic cost of marginal generation (coal)	4.73
2	Add: Value of T&D losses saved	0.49
3	Less: Cost of NEM Solar	(3.51[89])
4	Add: Cost of T&D capacity saved	0.42

[86] Annual Revenue Requirement (ARR) 18-19 filed by BRPL
[87] MNRE office memorandum available at https://mnre.gov.in/img/documents/uploads/8065c8f7b9614c5ab2e8a7e30dfc29d5.pdf
[88] This has been estimated for imported coal. The domestic coal is priced differently for power producers and is priced much cheaper (in energy equivalent terms). This implies subsidy. Economic cost analysis has to eliminate subsidies.
[89] Based on RETSCREEN and PV-WATT (NREL) software, using Capital costs discovered in auctions for roof top systems under Demand Aggregation Models. The effect of tax such as GST is removed.

SN	Parameter	Value (INR/kWh)
5	Add: Cost of environment (GHG)	0.47
	NES	**2.59**

Thus, significant savings (INR 2.59/kWh ~ US¢3.5/kWh) are realized in the economy by shifting to NEM (solar).

Net customer savings from NEM - for energy consumed by the Customer

Value of NEM solar customer segment wise

TABLE 12: BSES-DELHI- VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (INR/kWh) for substituting grid electricity					
	Customers Segments	**Residential**	**Commercial**	**Industrial**	**Agricultural**
SN	**Variable tariff**	**4-8.75**	**8.40-9.95**	**7.90-9.50**	**2.75**
1	Total variable tariff charged to a customer[90]	4.54	9.53	8.96	3.12
2	Less: LCOE of solar generation	(4.10)	(3.89)	(3.67)	(4.10)
3	Add: value of benefits/incentives available to a customer (levelized)	1.80	0.00	0.00	2.46
	NCS1[91]	**2.23**	**5.64**	**5.29**	**1.48**

It is evident that significant customer savings are possible with NEM. The highest benefit would be available to the commercial segment, which is also a very large segment in Delhi (25% of power consumption).

The second component of savings for the customer is on net surplus energy exported to the grid and settled at NEM compensation rate.

TABLE 13: BSES, DELHI - CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise Savings (INR/kWh) on NEM energy exported					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	NEM Compensation Rate = APPC[92]	5.19	5.19	5.19	5.19
2	Less: LCOE of solar generation	(4.10)	(3.89)	(3.67)	(4.10)
	NCS2	**1.09**	**1.30**	**1.52**	**1.09**

[90] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.
[91] NCS has been estimated w.r.t the lower end of tariffs. The savings are going to be higher for upper end of grid tariffs.
[92] Refer Annexure 8

This is positive too, for all customer segments.

The largest capacity of NEM would fall under the residential segment, as it provides 58% of electricity consumption in Delhi. This segment needs focus. Except for condominium complexes, the individual system size is expected to be small and therefore the segment attracts low interest from RESCOs.

Government buildings is the most attractive segment in Delhi, with potential for ~500 MW installations, large individual system size and low default risk. Other segments have high credit risks, which brings down RESCO interest.

It has been suggested that a special program for solar roof tops for low-income housing be launched. This segment avails free power up to 200 kWh consumption/month. Such a program will reduce subsidy levels for the utility.

Net utility savings (NUS) from NEM

The following table estimates the value of NEM solar for the utility, using the scenario 2 analysis framework (refer Section 6.4.1).

TABLE 14: BSES, DELHI- NET UTILITY SAVINGS

SN	Savings	INR/kWh[93]
1	Less: compensation paid for the NEM exports	(5.19)
2	Add: APPC (saved costs in procurement)	5.19
3	Add: value of REC/ renewable procurement	1.00
4	Add: savings of loss of power related to T&D	0.52
5	Add: value of Incentives to the utility	0.20
	Net utility savings (NUS)	**2.14**

Utility gains from permitting NEM. Therefore, the utility needs to maximize implementation of NEM, especially larger capacities that can export back to the grid.

Technical Analysis

i. Delhi has progressive policies in terms of sizing the NEM system. It permits large systems, larger than 1 MW, up to 100% of sanctioned loads.

ii. BRPL has carried out a detailed load analysis for different distribution transformers and has assessed the available surplus capacity for supporting NEM solar and electric vehicles deployment. This information will be shared with consumers to help them assess the technical feasibility.

iii. The future plans of the utility include:

[93] Refer Annexure 8 for the INR/kWh values mentioned in the table

a. BRPL plans to implement a blockchain based system to give effect to VNM, as it would involve groups of consumers setting up NEM capacities on available roofs and sharing credits. Blockchain technology would be useful in keeping track of sharing and generation across a multitude of facilities and consumers.

b. BRPL plans to share information on solar system generation with consumers. This will allow them to compare the performance of their solar plants with benchmark performance in their areas, identify performance gaps and take corrective actions.

c. BRPL is working on schemes for energy storage, Electric Vehicles (EVs), demand response, TOU tariff schemes, load and procurement forecasting, to create mutually beneficial programs in these areas.

Business Models and Financing

Most national RESCOs, EPC contractors, banks and Non-Banking-Finance Companies (NBFCs) are active in Delhi. Financing for customers with high credit rating or government institution is not a problem. The government has been successful in bringing government buildings, schools etc. under NEM and has got significant RESCO interest for them.

Utilities are also implementing demand aggregation models. They are registering customers, collecting data on solar potential in their buildings, aggregating them and inviting bids from solar implementers for both CAPEX as well as RESCO offers.

The government now hopes to get RESCOs interested in the residential segment. As seen earlier, serving the residential segment, especially those at the lower end of tariff and consumption, yields savings for the utilities. However, getting RESCOs interested in this segment has been difficult.

The problem of ‘small system size’ and ‘high credit risk’ for RESCO operators, applies to the residential segment as well as to the commercial segment. Utilities should look at ‘on bill financing’ or acting as ‘Super RESCO’ for smaller systems to challenge this problem.

NEM Implementation Process and Organizational Analysis

BRPL has taken many initiatives to support NEM implementation:

- They have set up a web portal with calculators to estimate solar PV size, expected generation savings, etc., based on location and site information. The web portal also hosts information on NEM policy, empanelled vendors, regulations, and a fully online NEM application process.
- BRPL has engaged customers through ‘SMS’ campaigns, flyers and customer group meetings. They hold 3-4 meetings/month with such groups such as Resident Welfare Associations (RWAs), market associations etc.
- The have dedicated help-desks and a team to support customers with queries on NEM.

BRPL’s pro-active engagements with think tanks and programs such as GIZ, PACE-D (USAID), SUPRABHA (the World Bank, SBI), CEEW, TERI, NREL etc. has resulted in a strong understanding of the benefits of adopting NEM, implementation challenges and preparation needed to meet such challenges.

BRPL senior management team understands the benefits that NEM can offer in terms of alleviating peak-loads[94]. Their work in the contiguous areas of Electric Mobility (EM), Energy Storage, Smart Grids and large-scale renewable procurement has helped them understand the beneficial relationship and complementary nature of these initiatives. This has further strengthened their commitment. These perspectives are enshrined in their vision and strategy statement[95].

BRPL's overall perspective on NEM is positive. They think that with increasing renewable energy in their portfolio, and their flexibility in changing their energy mix, they will be able to improve their cost and procurement terms. Finally, the loss of NEM penetration would have to be borne by fossil fuel generators.

BRPL feels that the utility perspective that NEM leads to 'loss of customers with paying capability' and that NEM imposes 'additional costs' would be addressed when cross subsidies are removed and the tariffs are rationalized. BRPL suggests that grid access charges can be levied on NEM energy exports to the grid for the large commercial and high-end residential segments. In such segments, the savings are significant and reasonable grid access charges would not impact the attractiveness to customers. They feel that a form of VDER can be implemented by utilities.

Conclusions

Overall, it appears that Delhi is on course to scale up NEM solar. The city needs to work on increasing RESCO interest in serving larger residential and commercial segments. Utilities could play a role by offering 'on-bill-financing' or 'super-RESCO' models. They can also support and even anchor community solar programs using VNM to attract users 'without roofs' to adopt NEM.

b) Punjab Utility - Punjab State Power Corporation Limited (PSPCL)

Punjab has only one utility, PSPCL, serving the entire state. This is a fully government owned entity.

TABLE 15: UTILITY PROFILE- PSPCL[96] (PUNJAB)

Area served	50,362 sq. km
Number of customers	9.2 M
FY 18-19 billed energy	45,507 MU (GWh)
T&D losses (FY 18-19)	15.44%
Solar roof-top target (by 2022)	No state target, the central government targets 2,000 MW by 2022
Solar roof-top installed (December 2019)	67.85 MWp achieved till 31st Dec 2019

[94] Delhi experiences peak load between 1400-1700 hours in May-Sep period. Solar generation helps in reducing this peak. The second peak between 2200-0100 is not helped by solar. They plan to procure wind to support during this period.
[95] BRPL's vision and strategy towards clean technology can be seen at https://www.bsesdelhi.com/web/brpl/renewable-energy
[96] Data gathered by the consultant from PSPCL ARR, website and survey

The industrial segment is the largest consumer of PSPCL of electricity, with a 38% share. Residential customers (29% share), and agricultural customers (24% share) are other important segments. Commercial customers contribute only 8% of demand.

Power consumption has grown in the state @4.3%/year in the last decade.

Close to 66 MW solar rooftop capacity has been commissioned in the state. The state is credited with taking an early lead and setting up the world's largest solar roof top system of 11.5 MW capacity at Radha Swami Satsang Beas Centre near Amritsar in Punjab. This was installed on a single rooftop, stretched over 42 acres. Since then, this system has been expanded to ~19 MW. Around the same time, many systems of 1-2 MW capacities were installed in vegetable markets and warehouses. Since then, the pace has decelerated, due to a limiting solar roof-top policy, likely fuelled by a utility perception that solar roof-tops take well paying customers away.

Punjab has defined only one peak period (in the season of June-September): 1800-2200 hrs. Evening peak means solar will not support peak loads.

PUNJAB NEM Policy

TABLE 16: PUNJAB STATE SOLAR POLICY

Punjab	
Launch year	Launched in a soft sense in 2012. ► New and renewable sources of energy (NRSE) Policy – 2012 (revised in 2019) ► PSERC (Grid interactive rooftop solar photo voltaic systems based on net metering) Regulations, 2015. ► KUSUM scheme, which offers NEM facilities to farmers, has been launched in 2019 by the Centre and the state is keen to implement due to its obvious benefits to farmers and the utility
Net-metering	For solar PV, now solar pumps for agriculture
NEM capacity	► 80% of sanctioned load ► Min – 1 kW, Max – 1 MW
Limits on DT loading	30 % of Distribution Transformer (DT) capacity
Generation limit w.r.t consumption	90%
Exemption from any charges	Exempted from various charges and provisions defined by PSERC for intra-state open access regulations, 2011
Meter type	Bi-directional meters
Meter reading	MRI, AMI both permitted
Rate applicable for grid export	APPC ~ INR 4.44/kWh (PSERC, 2020)
Settlement period	1 year
RPO compliance/ green certificates	Units produced by the consumer will qualify for RPO compliance of the distribution licensee

Punjab	
Subsidies	CFA available from central government for residential segment (40% capital subsidy up to 3 kW and 20% capital subsidy for systems between 3-10 KWp. Agricultural solar pumps will receive capital subsidy of 60% (30% central, 30% state).
Mandates	No mandates

The clauses on system sizing such as cap of 1 MW, 80% of sanctioned load, generation limited to 90% of consumptions (restricts exports), cumulative NEM capacity limited to 30% of DT capacity are restrictive. The analysis shows that this limits the export of energy to the grid, which reduces utility savings. The author's discussions with many potential NEM implementers, including Indian Railways, indicate that is a major bottleneck while considering investment in NEM facilities.

Financial and Economic Analysis

The baseline energy resource for Punjab is coal. Since energy demand is growing, appropriate baseline is a greenfield coal-based generation plant.

The author estimated the economic cost of power generation from greenfield coal plant as INR 4.73/kWh[97].

Economic Savings

TABLE 17: ECONOMIC SAVINGS ESTIMATED FOR PSPCL

SN	Parameter	Value (INR/kWh)
1	Economic cost of marginal generation (Coal)	4.73
2	Add: value of T&D losses saved	0.87
3	Less: cost of NEM solar	(3.38)[98]
4	Add: cost of environment (GHG)	0.47
5	Net Economic Savings (NES)	2.70

Thus, significant savings (INR 2.70/kWh ~ US¢ 3.7/kWh) are realized in the economy by shifting to NEM (solar).

Net Customer Savings (NCS1) from NEM

The author has estimated the customer segment wise value of NEM Solar as follows:

[97] This has been estimated for imported coal. The domestic coal is priced differently for power producers and is priced much cheaper (in energy equivalent terms). This implies subsidy. Economic cost analysis has to eliminate subsidies.

[98] Based on RETSCREEN and PVwatts (NREL) models, using CAPEX figures as discovered during bids.

TABLE 18: PSPCL- VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (INR/kWh) for substituting consumption of grid electricity				
Customers Segments	**Residential**	**Commercial**	**Industrial**	**Agricultural**
Variable tariff	4.49-7.30	6.35-7.29	5.37-6.41	5.57/kWh or 412/HP/month
Total variable tariff charged to a customer[99]	5.49	7.75	6.56	6.80
Less: LCOE of solar generation	(3.94)	(3.73)	(3.52)	(3.94)
Add: value of benefits/incentives available to a customer (levelized)	0.79	0.00	0.00	2.36
Net Customer Savings (NCS1)[100]	2.34	4.02	3.04	5.23

Customer saves significantly on substitution of grid imports.

The second part of customer saving is on net energy exported to the grid, settled at NEM compensation rate. This saving is estimated as below:

TABLE 19: PSPCL- CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise Savings (INR/kWh)- on net surplus energy exported to the grid					
	Customers Segments	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	NEM compensation rate for surplus exports = APPC[101]	4.44	4.44	4.44	4.44
2	Less: LCOE of solar generation	(3.94)	(3.73)	(3.52)	(3.94)
	Net Customer Savings (NCS2)	0.50	0.71	0.92	0.50

This shows that customer savings are attractive for grid exports too.

Highest benefit would be available to the agricultural segment (~24% of power consumption under PSPCL). Even without subsidy the benefit would be INR 2.87/kWh for self-consumption and INR 0.50/kWh on exports. The payment for agricultural electricity consumption is made by Punjab Government. NEM will therefore, create a large fiscal saving for the Punjab government currently subsidizing the entire electricity consumed by the agricultural consumers. The cost of subsidy would fall from INR 6.8/kwh to INR 3.94/kWh.

With NEM systems, farmers generate extra income from electricity exported to the grid. Farmers need to make only 10% of the investment. 60% CFA[102] is available along with 30% loans. Surplus power from

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[99] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.

[100] NCS has been estimated w.r.t the lower end of tariffs. The savings are going to be higher for upper end of grid tariffs.

[101] Refer Annexure 12 of PSPCL

[102] Central Financial Assistance (CFA) – The subsidy provided by Central Government

the solar powered pumps can be used to stabilize rural grids. Since export of power earns an income, under this scheme, the farmers are incentivised to use their pumps more efficiently. This will protect ground water resources.

The largest NEM capacity is likely to come from industrial customers, as they account for 38% of electricity consumption in PSPCL. They would have large ground or roof space available for these installations. The author's discussions with many consumers in this segment indicate that if capacity restrictions are removed and operating under RESCO is made easier, they would be keen to install such capacities.

Net Utility Savings (NUS) under NEM

TABLE 20: PSPCL - NET UTILITY SAVINGS

	Savings	INR/kWh[103]
1	Less: Compensation paid for the NEM exports	(4.44)
2	Add: APPC (saved costs in procurement)	4.44
3	Add: value of REC/ renewable procurement	1.00[104]
4	Add: savings of loss of power related to T&D	0.64
5	Value of peak power procurement from NEM	0.00
6	Add: value of incentives to the utility	0.20
	Net utility savings (NUS)	**1.84**

The analysis by the author shows that NEM exports are value creating for the utility as well.

Logic dictates that utility should try to maximize NEM exports to get cheap NEM power and increase savings. This would mean reducing constraints on NEM capacity alongside releasing export constraints. At present the generation is limited to 90% of consumption.

Technical Analysis

PSPCL, like other Indian utilities, follows national standards and grid codes of India. They are also looking to enhance their presence in EVs and would benefit from a positive reinforcing relationship between NEM solar and EVs.

Business Models and Financing

The pace of solar roof top implementation has been slow in the state, after its initial vigour. Restrictive NEM policies and seemingly low enthusiasm of the state may be the reasons.

PSPCL is now promoting utility anchored demand aggregation models and has recently carried out bids for small residential systems (Feb 2020). Including subsidy, the cost of a small 1-3 kW system was

[103] Refer Annexure 12 on PSPCL
[104] Low end of REC prices traded in power exchanges in 2020.

discovered to be INR 22/kWp, which will help the LCOE to come down to ~INR 2.3-2.5/kwh.

PSPCL needs to evolve a strong push for solar pumps and industrial segments to accelerate NEM.

NEM Implementation Process and Organizational analysis

PSPCL has started web-based application processing, in line with the national program design.

Conclusions

PSPCL will have to improve its existing NEM policy and increase its promotional efforts for the industrial and agricultural segments to enable rapid scaleup in NEM capacities. Targeted campaigns, policy measures like GBI, GNM and VNM, and easing of application process can be effectively adopted by Punjab (from the already existing ones in other Indian states) at least for promoting NEM to its residential segment.

c) Bengaluru Utility-Bangalore Electricity Supply Company (BESCOM)

Out of the five Indian utilities in the state of Karnataka, BESCOM (a government-owned entity) is the largest in terms of the number of customers and energy requirement (MoP, 2018).

TABLE 21: UTILITY PROFILE-BESCOM[105] (KARNATAKA)

Area served	41092 sq. km
Number of Customers	11.2 M
Peak Demand (till Aug 2020)	5,901 MW
FY-18 billed energy	25,967 MU (GWh)
T&D losses (FY 18)	Transmission-3.37%, Distribution-13.17%
Solar roof-top target (March 2021)	2,400 MW (Karnataka target), 1,000 MW-BESCOM
Solar roof-top installed (March 2020)	240 MW (Karnataka), 137 MW-BESCOM (till August 2020)

Residential segment is the utility's biggest consumer with 27% share of electricity sold, followed by agriculture (24%), industrial (22%), and commercial (18%).

Karnataka has 2 peak load periods. Peak 1 from 0600-1000 hrs and Peak 2 from 1800-2200 hrs.
Analysis of solar generation pattern indicates 38.5% of solar energy generation takes place during peak period 1.

[105] Data gathered by the consultant from BESCOM's ARR and websites

Karnataka Policy

TABLE 22: KARNATAKA STATE SOLAR POLICY

Karnataka	

Key policy instruments	Karnataka solar policy 2014-2021 (amended 2017). KERC implementation of solar rooftop photovoltaic power plants, regulations, 2016. KERC in its order dated 9 Dec 2019 has formally permitted the following models for implementation under NEM:
	▸ Utility anchored model
	  ▸ Consumer owned model (utility as demand aggregator; can serve all compensation models i.e., net-metering or all buy all sell)
	  ▸ Consumer owned model (utility as aggregator and EPC, can serve net-metering and all-buy, all-sell compensation)
	▸ Utility owned model
	In the utility owned model, the utility acts as the aggregator and investor-serves all-buy, all-sell compensation mechanism)
	▸ Third party owned model
	In third party owned models, the utility, as an aggregator and trader, serves all-buy, all-sell NEM compensation
	In the third party owned model only residential consumers connected to Low Tension (LT) grid are allowed to opt for net metering compensation or all-buy, all-sell method. All other customers connected to LT or High Tension (HT) grid, are allowed only all-buy, all-sell method. The consumer gets paid a roof lease rate. All-buy, all-sell rates would be discovered through auctions.

NEM capacity	100% of sanctioned load Min – 1 kW, Max – 1 MW
Limits on DT loading	80 % of distribution transformer (DT) capacity
Exemption from charges	NEM capacities are exempted from all open access charges
Meter type	Bi-directional meters
Meter reading	MRI, AMI both permitted
Rate for grid export	APPC ~ INR 4.04/kWh[106]
Settlement period	1 year
RPO compliance/ carbon credits/green attributed	Units consumed will qualify for the RPO compliance for the Distribution Licensee The consumer gets CDM benefit (carbon credit sale, if any) 100% in first year and decreases 10% annually until 50%. The utility gets CDM benefit 10% in 2nd year and increases 10% annually until 50%.

[106] https://karunadu.karnataka.gov.in/kerc/Regulations/Truing%20of%20APPC%20for%202019-20%20and%20procissional%20APPC%20for%202020-21.pdf

Karnataka	
Subsidies	CFA from the central government for residential segments (40% capital subsidy up to 3 kW and 20% capital subsidy for systems between 3-10 KWp). Agricultural solar pumps will receive a capital subsidy of 60% (30% center, 30% state).
Mandates	No mandates

The policy changes introduced in Dec 2019, seem to restrict consumer choices, when contracting under RESCO, to all-buy, all-sell mode. The only exception is for LT residential consumers who can contract a RESCO and operate under both types of compensation mechanisms.

This step will turn RESCOs away, as they ca not operate in commercial and industrial segments. As far as residential customers connected to LT grids are concerned, RESCOs are not interested in them due to 'small size' and 'low credit'.

Financial and Economic Analysis

The baseline energy resource for Karnataka is coal. Since energy demand is growing, the baseline would be greenfield coal-based generation plant. The economic cost of power generation from such as plant has been estimated by the author as INR 4.73/kWh[107].

Economic Savings

TABLE 23: ECONOMIC SAVINGS ESTIMATED FOR BESCOM-NEM

SN	Parameter	Value (INR/kWh)
1	Economic cost of marginal generation (Coal)	4.73
2	Add: value of T&D losses saved	0.57
3	Less: cost of NEM solar	(3.44) [108]
4	Add: cost of T&D capacity saved	0.57
5	Add: cost of environment (GHG)	0.47
	Net economic savings (NES)	**2.90**

Thus, significant savings (INR 2.90/kWh ~ US¢ 3.9/kWh) are realized in the economy by shifting to NEM (solar).

[107] This has been estimated for imported coal. The domestic coal is priced differently for power producers and is priced much cheaper (in energy equivalent terms). This implies subsidy. Economic cost analysis has to eliminate subsidies.

[108] Modelled using RETSCREEN and PVwatts (NREL). CAPEX costs taken at levels discovered in recent bids for small systems.

Net Customer Savings (NCS) from NEM

TABLE 24: BESCOM-VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (INR/kWh) for substituting consumption of grid electricity					
SN	Customers Segments	Residential	Commercial	Industrial	Agricultural
1	Total variable tariff charged to a customer[109]	5.20	8.03	5.80	5.04
2	Less: LCOE of solar generation	(4.02)	(3.80)	(3.59)	(4.02)
3	Add: value of benefits/incentives available to a customer (levelized)	0.80	0.00	0.00	2.41
	NCS1[110]	1.99	4.23	2.21	3.43

From the above table, it is evident that the customer savings are high under NEM. The commercial segment (18% consumer under BESCOM) would benefit the most, but customers across segments have a net gain under the NEM.

The second component of customer saving is on energy exported to the grid and settled at the NEM compensation rate.

TABLE 25: BESCOM-CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise Savings (INR/kWh) for NEM energy exported to the grid					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	NEM compensation rate-equal to APPC[111] in the state	4.04	4.04	4.04	4.04
2	Less: LCOE of solar generation	(4.02)	(3.80)	(3.59)	(4.02)
	NCS2	**0.02**	**0.24**	**0.45**	**0.02**

The APPC rate being very close to solar LCOE the savings are lower in residential and agricultural segments. However, they are positive across all segments.

Many commercial and industrial customers in Bangalore are also aligned with sustainable development and have plans to shift to renewable energy. Several of them have adopted 100% RE goals. These consumers have also been proactive in procuring renewable energy through open access.

BESCOM customers have adopted NEM and are poised for scale up. However recent changes in NEM

[109] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.
[110] NCS has been estimated w.r.t the lower end of tariffs. The savings are going to be higher for upper end of grid tariffs.
[111] Refer Annexure 11 of BESCOM

policy have come as a big dampener.

A previous work of the consultant's work on 'Challenges for Scaling Up Solar Rooftop in the BESCOM Region' (PACE-D, 2017) displays that even residential segment is very keen to adopt NEM solar. Residential segment, with a 27% share of electricity consumption, can bring about rapid growth in NEM.

The utility could consider promoting an on-bill financing mechanism for this segment since typically financing is the key bottleneck for them.

Net Utility Savings (NUS) from NEM

TABLE 26: BESCOM- NET UTILITY SAVINGS

SN	Savings	INR/kWh[112]
1	Less: compensation paid for the NEM exports	(4.04)
2	Add: APPC (saved costs in procurement)	4.04
3	Add: value of REC/ renewable procurement	1.00
4	Add: savings of loss of power related to T&D	0.53
5	Add: value of peak power procurement from NEM *(% of solar/RE power delivered during peak hours) x Peak Power Premium over APPC)*	0.39
6	Add: (value of) reduction in T&D capacity (% of RE power delivered during peak hours) x Capital cost factor x est. cost of capital	0.57
7	Add: value of incentives to the utility	0.20
	NUS	**2.69**

The above assessment shows that NEM is value creating for the utility.

Technical Analysis

BESCOM has developed a "Rooftop Evaluation for Solar" Tool (CREST[113]). Users can use CREST to analyse technical and economic feasibility of installing solar rooftop, considering the existing policy regime. BESCOM has also carried out a roof-top potential assessment for the city with the help of CSTEP, using light detection and ranging technology (drones).

BESCOM is the state agency for implementing electric vehicle charging Infrastructure. They have active energy efficiency and smart grid programs. Additionally, they have been evolving a plan, carrying out grid resource assessments, to integrate all these initiatives effectively and cohesively.

[112] Refer Annexure 11 of BESCOM
[113] http://demo.cstep.in/crest/#/

Business Models and Financing

Bangalore has many large EPCs, RESCOs and finance company headquarters. Hence all types of business models such as CAPEX, deferred payment, RESCO PPAs etc. are being explored to facilitate NEM adoption.

While significant progress was being made, recent policy changes ordered by KERC[114] have shut the doors for commercial and industrial segments to adopt RESCO models. This may set back the pace of roof top solar activity in the state.

BESCOM is also active in implementing demand aggregation models. They are currently focussed on residential segment demand.

NEM Implementation Process and Organizational Analysis

BESCOM has established a web-based application processing facility and have active help-desk to support customers.

Just like BRPL, BESCOM has been working with a number of think-tanks and support programs of GIZ, PACE-D (USAID), SUPRABHA (The World Bank), etc. It has also trained its engineers and staff on various aspects of NEM, its implementation challenges and grid modernization needs. Barring the recent state turn around on policy implementation, the organization appears ready and able to scale up NEM.

The process of NEM sanction can be further improved by increasing the level of automation, and further reducing low-efficiency physical steps in the process.

d) Maharashtra Utility-Maharashtra State Electricity Distribution Corporation Limited (MSEDCL)

MSEDCL is the largest utility (government-owned) of Maharashtra, covering almost the entire state. It is also one of the largest utilities in India.

TABLE 27: UTILITY PROFILE-MSEDCL[115] (MAHARASHTRA)

Area served	308,000 sq. km. 457 Cities. 41,095 Villages
Number of Customers	26.5 M
Peak Demand (till Aug 2020)	21,570 MW
FY-18 billed energy	105,135 MU (GWh)
T&D losses (FY 18)	14.70%
Solar roof-top target (March 2021)	Nil (state); 2,700 MW (Central target) by 2022
Solar roof-top installed (March 2020)	216 MW (till Dec 2019)

[114] KERC Order dated 9th Dec 2019 available at https://bescom.karnataka.gov.in/storage/pdf-files/DSM-Solar/OM%20Various%20Bussiness%20Model.pdf

[115] Data gathered from MSEDCL's ARR, Tariff Order, website (https://www.mahadiscom.in/)

Industrial segment is the majority consumer for MSEDCL with ~36% share of electricity sale followed closely by the agricultural segment (32% share) and the residential segment (19% share). Commercial sales are relatively low (7% share). This is the state with the highest GDP in India (2019-20, US$ 400 B).

Maharashtra has 2 peak periods: 0900-1200 hrs, and 1800-2200 hrs. Comparative analysis of solar generation pattern indicates 35.4% of solar energy generation takes place during morning peak period and a minor 0.28% during the evening peak period.

Maharashtra Policy

TABLE 28: MAHARASHTRA STATE SOLAR POLICY

Maharashtra	
Launch year	▶ Maharashtra Policy for Grid-connected Power Projects based on New and Renewable (Non-conventional) Energy Sources - 2015 ▶ MERC (Grid Interactive Rooftop Renewable Energy Generating Systems) Regulations, 2019
Net-metering definitions	▶ For solar PV, gross metering is permitted. Solar-pumps will be net-metered under KUSUM-C scheme. ▶ Both net-metering and net-billing settlement mechanisms are accepted (net-billing is in an All-Buy, All-Sell method and not as defined in this report). ▶ REC certificates are not granted to systems operating under net-metering or net-billing. ▶ Regulations permit RESCOs, utility-owned, and consumer-owned models.
NEM capacity	▶ 100% of sanctioned load ▶ Min – 1 kW, Max for NEM – 1 MW, under net billing no limit. ▶ Ground mounted or roof-top both allowed (any place within the premises allowed). ▶ Energy storage permitted to be part of NEM set-up, provided it complies with anti-islanding provisions. ▶ Any grid connected system not under net metering or net billing may be permitted after prior intimation to the utility. A grid service charge may be imposed.
Limits on DT loading	70% DT capacity. Beyond 70%, permission may be obtained on the basis of load flow analysis by the utility. Information regarding the available DT capacity as well as connected NEM capacity, will be updated quarterly on the utility's website
Exemption from any charges	▶ No charge on arrangements under net-metering or net-billing. ▶ Grid service charge may be applied for capacities not installed under either net-metering or net-billing.
Meter type	Bi-directional AMI; a renewable energy generation meter.
Meter reading	AMI permitted
Rate- grid export	APPC ~ INR 4.12/kWh[116] for Net Billing INR 2.83/kWh for Net Metering Customers

[116] MERC Tariff Order 2020, Pg 164 (available at https://www.mahadiscom.in/consumer/wp-content/uploads/2020/03/Order-322-of-2019.pdf)

Maharashtra	
Settlement period	1 year
RPO compliance/ carbon credits/ green certificates	Units generated by the NEM system will count towards MSEDCL's RPO compliance requirement.
Subsidies	CFA- from the central government for residential segments (40% capital subsidy up to 3 kW and 20% capital subsidy for systems between 3-10 KWp). Agricultural solar pumps will receive capital subsidy of 60% (30% center, 30% state).
Mandates	No mandates.

The policy appears to be balanced and incorporates a number of important features.

i. It incorporates net-metering, or All-Buy, All-Sell models.

ii. All-Buy and all-Sell model tariff rate is set as APPC which is attractive currently (INR 4.12/kWh). The rate for net metering exports is cheaper (INR 2.83/kWh).

iii. Incorporates consumer-owned, utility-owned, and RESCO owned business models.

iv. Allows ground-mounted installations within premises, to qualify under NEM.

v. Capacities can be set up without constraints, as long as it serves internal consumption or is used to serve under open access. Permits are subject to imposition of grid service charges (GSC). The sword of high GSCs makes NEM under this route risky.

vi. Allows energy storage to be integrated with solar PV.

However, compared to Delhi's policy which is very bold and supportive of NEM with innovative ideas such as GNM or VNM, Maharashtra policy seems conservative.

Financial and Economic Analysis

The baseline energy resource for Maharashtra is coal. Since energy demand is growing, the baseline would be a new coal-based generation plant. The economic cost of power generation from such as plant has been estimated by the author as INR 4.73/kWh[117].

Economic Savings

Table 29: Economic Savings Estimated for MSEDCL-NEM

SN	Parameter	Value (INR/kWh)
1	Economic cost of marginal generation (Coal)	4.73

[117] This has been estimated for imported coal. The domestic coal is priced differently for power producers and is priced much cheaper (in energy equivalent terms). This implies subsidy. Economic cost analysis has to eliminate subsidies.

SN	Parameter	Value (INR/kWh)
2	Add: value of T&D losses saved	0.57
3	Less: cost of NEM solar	(3.44)[118]
4	Add: cost of T&D capacity saved	0.52
5	Add: cost of environment (GHG)	0.47
	Net economic savings (NES)	**2.87**

Thus, significant savings (INR 2.85/kWh ~ US¢ 3.9/kWh) are realized by the economy under NEM with solar.

Net Customer Savings (NCS)

TABLE 30: MSEDCL- VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (INR/kWh) for substituting consumption of grid electricity						
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**
	Variable tariff (LT)	3.46-11.71	7.36-12.83	5.21-6.11	1.85-3.34	3.31-6.01
	Variable tariff (HT)	5.70	11.47	7.02	3.79	7.74
1	Total variable tariff charged to a customer[119]	5.70	10.22	7.16	3.30	7.74
2	Less: LCOE of solar generation	(4.00)	(3.79)	(3.58)	(4.00)	(3.79)
3	Add: value of benefits/incentives available to a customer (levelized)	0.80	0.00	0.00	2.40	0.97
NCS 1		2.49	6.43	3.58	1.70	4.76
NCS 1 (low tariff customers)		**10.24**	**10.17**	**4.58**	**2.76**	-

The high consumption customers with high grid tariffs would gain significantly under NEM.

[118] Based on RETSCREEN and NREL PV Watts Model.
[119] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.

TABLE 31: MSEDCL- CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise Savings (INR/kWh) for NEM energy exported to the grid						
	Customers Segments	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**
1	NEM compensation[120] for exports to the grid[121]	2.83	2.83	2.83	2.83	2.83
2	Less: LCOE of solar generation	(4.00)	(3.79)	(3.58)	(4.00)	(3.79)
NCS 2		**(1.17)**	**(0.96)**	**(0.75)**	**(1.17)**	**(0.96)**

The table shows that with NEM compensation fixed at very low rates, the export of power is not financially attractive. The policy will incentivise customers not to design capacities for power export.

However, since APPC for the utility is INR 4.12/kWh, the utility could have saved on power procured from NEM facilities, while incentivising prosumers, if it had kept the compensation rates between INR 3.8/kWh and INR 4.12/kWh.

i. The government is also keen to promote KUSUM program for agricultural pumping, which at present is heavily subsidized. Shifting to solar will save subsidies. Also, more than 50% generation may be exported, and utility's compensation for it would be lower than its APPC price. This will result in further savings for the utility.

ii. Industrial and residential customers also gain under NEM, especially those in the higher tariff bracket.

iii. Gains are also available to government buildings under NEM. India has been running programs for solarisation of government buildings nationwide. Maharashtra is also a participant in this program.

iv. A special program for solar roof-tops for low-income housing takes priority, as it will shelter the utility from high levels of subsidy incurred for such customers.

Net Utility Savings (NUS) from NEM

TABLE 32: MSEDCL- NET UTILITY SAVINGS

	Savings	INR/kWh[122]
1	Less: compensation paid for the NEM exports	(2.83)
2	Add: APPC (saved costs in procurement)	4.12
3	Add: value of REC/ renewable procurement	1.00

[120] Refer Annexure 10 of MSEDCL

[121] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.

[122] Refer Annexure 10 on MSEDCL

	Savings	INR/kWh[122]
4	Add: savings of loss of power related to T&D	0.61
5	Add: saved value of peak power procurement	0.29
6	Add: saved value of reduction in T&D investment	0.53
7	Add: value of incentives to the utility	0.20
	NUS	**3.91**

It is evident from the analysis that NEM is value creating for MSEDCL. The utility should encourage as much exports under NEM as possible to maximize savings. MSEDCL needs to change its perspective that 'NEM results in loss' by recognizing NEM as a cheap source of power. NEM also makes it possible to alleviate some of the peak power demands (35.4% of solar power is generated during morning peak) and save distribution losses (14%).

In contradiction to the analysis by the author, MSEDCL recently submitted a proposal to MERC for Grid Service Charge (GSC, applicable from 2020-21), which was set at a very high level, and was rejected. Some of the proposed GSC features were:

i. Exempt for < 10 kW systems
ii. Residential: INR 4.46-8.66/kWh
iii. Commercial: INR 5.06-8.76/kWh
iv. Industrial: INR 3.60-4.08/kWh
v. For LT connections deduction of energy would be 12%
vi. For H connections, deduction of energy would be 7.5%

Technical Analysis

The MERC order requires that grid capacities and NEM capacities connected to the grid be published on the website and updated quarterly.

This needs to be a dynamically updated dataset that can help both the customers and the utility to make a reasonable assessment. This should also incorporate data on capacities sanctioned and under implementation, the grid reliability data (shut down times) etc., to give an accurate picture to a potential NEM investor.

Business Models and Financing

Maharashtra hosts headquarters for many national EPC and RESCO contractors. Mumbai is also the financial capital of India. Hence all types of models including innovations such as deferred payment options from RESCO/EPC players are active in the state.

The high grid tariffs are a big draw for RESCO operators and consumers.

MSEDCL, with its unique position and size, can scale up NEM, especially in rural areas (agricultural pumps) and low end of residential segment through some form of utility anchored on-bill financing or super RESCO models.

NEM Implementation Process and Organizational analysis

MSEDCL has an online application process, customer help centres and trained manpower to undertake NEM. However, its perspective on NEM appears to be negative and it seems to view NEM with the 'takes away well-paying customers' lens. MSEDCL is also known to resist other customer centric approaches such as Open Access for a consumer to buy electric power from third party generators. As grid operation philosophy evolves and moves to separation of content (buying and selling of power) and 'carriage (providing distribution and managing grid services), this perspective is likely to undergo a change.

Conclusions

MSEDCL seems to have a supportive eco-system, good capital availability, high customer saving potential, large commercial and industrial customers and high paying residential segments. Therefore, NEM seems to have great potential for MSEDCL. However, MSEDCL's view of NEM would need to undergo a change.

e) Chhattisgarh Utility-Chhattisgarh State Power Distribution Company Ltd (CSPDCL)

CSPDCL is the only electricity distribution utility of Chhattisgarh and it is government-owned.

TABLE 33: UTILITY PROFILE-CSPDCL[123] (CHHATTISGARH)

Area served	135,194 sq. km. 457 Cities. 41,095 Villages
Number of Customers	4.9 M
FY-18 billed energy	120,362 MU (GWh)
T&D losses (FY 18)	23.28%
Solar roof-top target (2022)	Nil (state); 700 MW (Central target) by 2022
Solar roof-top installed (Dec 2019)	24 MWp (till Jul 2020), 4 MW pipeline

Residential customers consume (25%) of electricity in the grid. Other segments, in order of size are, agricultural (21% share), industrial (13% share), and commercial (4% share). There are large mines who have not been profiled here. Most residential customers are LT customers.

Chhattisgarh has one peak period (in the season of June-September): 1800-2300 hrs. Since this is an evening peak, solar energy does not reduce peak constraints.

[123] Data gathered by the consultant from CSPDCL's ARR, Tariff Order, website at https://cspdcl.co.in/

Chhattisgarh Policy

TABLE 34: CHHATTISGARH STATE SOLAR POLICY

Chhattisgarh	
Launch year	Chhattisgarh solar energy policy 2017-2027 CSERC grid interactive distributed renewable energy sources regulations, 2019
Net-metering applicability	Applicable to Solar PV roof tops Permits off-site capacities as well which are placed outside the customers premise, as long as it's owned by the same customers and used to offset grid electricity of the same customer.
NEM capacity	100% of sanctioned load Min - 1 kW Min - 500 KW for off-site facilities
Limits on DT loading	100% of DT capacity
Exemption from any charges	No charges applied to NEM
Meter type	Bi-directional meters
Meter reading	MRI & AMI both permitted
Rate applicable for grid export	APPC ~ INR 3.85/kWh (PSERC, 2020)
Settlement period	1 year
RPO compliance/ carbon credits/ green certificates	Units generated by the NEM system will count towards utility's RPO compliance requirement.
Subsidies, Central Financial Assistance (CFA)	CFA- from the central government for residential segments (40% capital subsidy up to 3 kW and 20% capital subsidy for systems between 3-10 KWp). Agricultural solar pumps will receive capital subsidy of 60% (30% centre, 30% state).
Mandates	No mandates

While Chhattisgarh has done pioneering work in bringing electricity to rural and tribal areas, they have been slow in NEM implementation.

Financial and Economic Analysis

The baseline energy resource for Chhattisgarh is coal. Since energy demand is growing, the baseline would be a new coal-based generation plant.

The economic cost of power generation from such a plant has been estimated by the author as INR 4.73/kWh[124].

[124] This has been estimated for imported coal. The domestic coal is priced differently for power producers and is priced much cheaper (in energy equivalent terms). This implies subsidy. Economic cost analysis has to eliminate subsidies.

Economic Savings

TABLE 35: ECONOMIC SAVINGS ESTIMATED FOR CSPDCL-NEM

SN	Parameter	Value (INR/kWh)
1	Economic cost of marginal generation (Coal)	4.73
2	Add: value of T&D losses saved	0.95
3	Less: cost of NEM solar	(3.51) [125]
4	Add: cost of environment (GHG)	0.47
	Net economic savings (NES)	**2.64**

Thus, significant economic savings (INR 2.64/kWh ~ USD¢ 3.6/kWh) are realizable in the economy by shifting to NEM (solar).

Net Customer Savings (NCS) under NEM

TABLE 36: CSPDCL-VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (INR/kWh)- for substituting grid imports					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
	Variable tariff (LT)	1.15-2.45	5.65-7.95	3.80-5.85	4.7
	Variable tariff (HT)	5.70	-	5.85-6.85	5.3
1	Total variable tariff charged to a customer[126]	1.43	6.52	4.09	4.87
2	Less: LCOE of solar generation	(4.09)	(3.88)	(3.66)	(4.09)
3	Add: value of benefits/incentives available to a customer (levelized)	0.82	0.00	0.00	2.46
	NCS 1 (customer tariff-low end)	**(1.85)**	**2.64**	**0.43**	**3.23**

The author's assessment suggests that while LT residential customers (largest numbers) would find NEM unattractive, commercial and industrial customers, especially those on the high end of tariff would find NEM attractive.

Agricultural segment, supported with high subsidy for solar, would also be attracted to NEM

The largest capacity of NEM would be supported by the residential segment, as it accounts for 25% of electricity consumption in CSPDCL. NEM would be attractive to high-end residential customers paying high tariffs.

[125] Based on RETSCREEN and NREL PV Watts Model.
[126] These are based on lower end of tariff range for a particular class of customers. For higher paying customers the benefits would be larger.

The second component of customer saving is related to exported energy to the grid. This is estimated below:

TABLE 37: CSPDCL - CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise NC Savings (INR/kWh)- for NEM energy exported to the grid					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	NEM compensation rate[127] (equal to APPC Rate)	3.85	3.85	3.85	3.85
2	Less: LCOE of solar generation	(4.09)	(3.88)	(3.66)	(4.09)
	NCS2	**(0.24)**	**(0.03)**	**0.19**	**(0.24)**

Exports are not very remunerative under NEM. This will lead to customers designing systems only for internal consumption.

Net Utility Savings (NUS) under NEM

TABLE 38: CSPDCL - NET UTILITY SAVINGS

SN	Savings	INR/kWh[128]
1	Less: compensation paid for the NEM exports	(3.85)
2	Add: APPC (saved costs in procurement)	3.85
3	Add: value of REC/ renewable procurement	1.00
4	Add: savings of loss of power related to T&D	0.62
5	Add: saved value of peak procurement	0.00
6	Add: value of Incentives to the utility	0.20
	NUS	**1.82**

The utility is seen to benefit substantially from NEM implementation.

Technical Analysis

CSPDCL is finally dipping its feet towards implementing NEM. At present the utility has not faced any technical constraints.

Business Models and Financing

The commercial and industrial customers (both high voltage and low voltage) are showing an inclination towards setting up the solar rooftop plants under CAPEX model. With additional benefits related to

[127] Refer Annexure-9 on CSPDCL
[128] Ibid

accelerated depreciation and GST inputs, the profit-making companies realize significant value in setting up systems in CAPEX mode.

The Punjab National Bank (PNB) is making financing available for the residential solar segment.

The RESCO business model is receiving poor response in Chhattisgarh, even when the demand has been aggregated by the utility and state nodal agency. This must be arising from less remunerative economics (low NCS1, negative NCS2) for RESCOs under NEM.

The 20 MW tender for RESCO on government buildings in June 2020 has not elicited any response from the project developers. Hence a new business model is being explored – an EMI or on-bill financing model. The central government company Energy Efficiency Services Ltd (EESL) will install the solar rooftop plants on public buildings and will collect monthly instalments, based on the savings achieved from power bills. This model will not be available for the private sector.

NEM Implementation Process and Organizational Analysis

i. CREDA (the state nodal agency) and CSPDCL are taking an active part in promoting solar in Chhattisgarh. They are developing an online web portal. At present applications are taken offline.

ii. Both CREDA and CSPDCL have empanelled vendors (developers) at costs of INR 40 per watt for 1-10 kW systems, INR 38 per watt for 10-100 kW systems, INR 36 per watt for 100-500 kW systems.

iii. The major challenge faced is insufficient capacity building and training for utility personnel for faster application processing, testing and inspection of systems, LT meters, etc.

Conclusions

CSPDCL is just initiating its NEM journey with some seriousness. In other programs such as off-grid solar, they have been very proactive. It is expected they will bring the same zeal to NEM implementation. Commercial and industrial customers grow more rapidly than other segments since the business case is strongest for this segment. CSPDCL will have to launch a special program for LT residential customers. Solar pumps under KUSUM-C scheme must also be implemented under NEM regimes.

6.5.2 Pakistan Country Overview

Pakistan has aggressive power capacity expansion plans. Demand is expected to grow in the country at @ 7%/year. The country plans on making its energy mix increasingly green. Pakistan's installed PV capacity will likely increase from around 1.3 GW at the end of 2019 to 12.8 GW by 2030 and 26.9 GW by 2047, according to the Indicative Generation Capacity Expansion Plan–IGCEP 2047, prepared by the National Electric Power Regulatory Authority, NEPRA.

Key features of the current power situation in Pakistan are as follows:

i. Furnace oil (14%), Natural Gas (31%), Coal (16%) make up ~ 61% fossil fuel-based generation in the national grid. Hydropower constitutes 29% and renewables 6% (Saleem, 2020) fossil fuels add up to big import bills.

ii. Cost of electricity is high. The merit order despatch is not fully practiced.

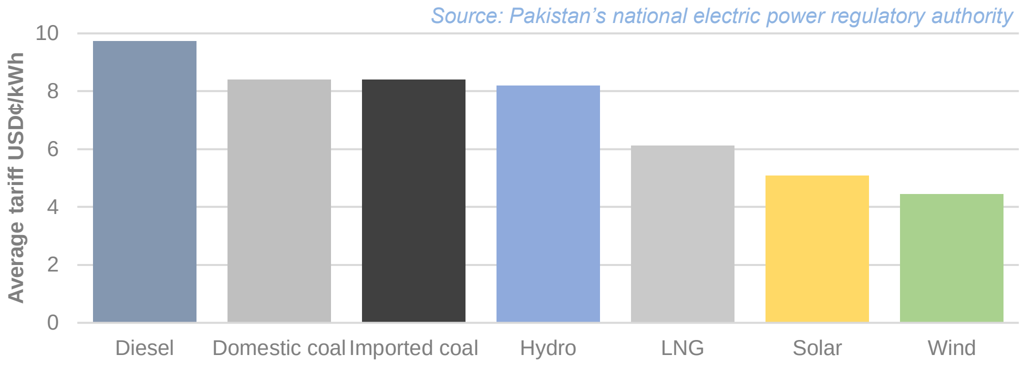


Figure 27: COST OF ELECTRICITY IN PAKISTAN (NEPRA)

For example, in Jan 2020, the variable cost of furnace-oil based electricity ranged from PKR 12.54 - 20.73/kWh, gas/LNG PKR 4.32 – 16.68/kWh and coal PKR 8.30 – 14.22/kWh. In renewables, tariffs ranged for solar from PKR 19.59 – 26.60/kWh and wind from PKR 16.66 – 26.85/kWh. The variation is due to the age of the plant, technology and policy choices. Renewable PPAs are USD linked.

iii. New capacities additions would yield expensive power (Nicholas & Ahmed, 2020)

iv. Current grid capacity is ~37GW and peak load is ~25 GW with transmission and distribution capacity at ~ 22 GW. This shows that despite adequate generation, T&D infrastructure constraints lead to power shortages.

v. On the distribution side T&D losses for 2017-18 stood at 18.32%. Around 12.29% of electricity bills are not paid by consumers.

vi. Pakistan has 10 electric utilities (9 public and 1 private) serving regions across the country. IESCO and K-Electric have been selected for this study, one being public and one being private (K-Electric). This is to better understand the NEM adoption, interest levels, difficulties encountered, etc. from both public and private entity perspective.

vii. Pakistan faces power shortages and shutdown. Some areas have 8-10 hours power shutdown. K-Electric, the utility serving Karachi, highlights in its 2019 report that they can only serve about 70% of customers without shutdowns. Power sector performance data for 2017 (NTDC, 2019) indicates ~22% demand unmet by the grid.

viii. Pakistan also faces high inflation in energy costs. Its inflation (2000-2017) in power tariffs has ranged between 6.4% per annum to 9.4% per annum across various segments.

NEPRA's base-case scenario predicts that overall generation capacity will grow from 33,000 MW in 2020 to around 168,200 MW in 2047. But coal and hydropower will still account for 36% and 42% of total capacity, at 32,948 MW and 55,836 MW, respectively.

The key power sector challenges for Pakistan, therefore, are high energy costs, high transmission and distribution losses, constraints in transmission and distribution capacity, frequent power shutdowns, resulting in costly diesel-based power use by the customers, and the need to shift to green to minimize environmental challenges and also to reduce foreign exchange outgo.

NEM solar implementation can help, in meeting these challenges.

i. It will reduce the cost of energy. The LCOE model by the author suggests a cost of PKR 6.5-8.35/kWh if low-cost loans are available, as promised by State Bank of Pakistan scheme. This is much cheaper than current average cost of procurement for utilities.[129]

ii. NEM will save on T&D losses and require less capacity of T&D.

iii. NEM, coupled with energy storage, will improve local reliability of power.

iv. The energy supplied would of course be green.

A recent study supported by USAID for NEPRA highlights the positive impact of NEM on utilities[130]. This will help in positive orientation of the utilities for NEM.

PAKISTAN's NEM Policy

TABLE 39: EVOLUTION OF PAKISTAN NEM POLICY

Pakistan	
Launch year	Pakistan alternative and renewable energy policy 2019 NEPRA (alternative and renewable energy) distributed generation and net metering regulations 2015 (amended in 2017 and 2018)
Net-metering	For solar PV and wind
NEM capacity	150% of sanctioned load (in terms of DC capacity) Min – 1 kW, max for NEM – 1 MW. Permitted only for 3-phase connections.
Limits on DT loading	15% of Distribution Transformer (DT) capacity
Exemption from any charges	It is not clarified in the policy whether any tax is applicable for energy exported and then re-imported into the consumer's premise.
Meter type	Single bi-directional meters or two separate meters
Meter Reading	MRI and AMI both permitted
Rate applicable in case of export to the grid	Applicable tariff will be determined by NERPA. For the analysis its assumed to be equal to APPC ~ PKR 11.02/kWh (CPPA, 2019) Agreement between the utility and prosumer for 7 years during which NEPRA determined tariff would hold.
Electrical Inspection	Requirements for such inspection under schedule I and II omitted

[129] In 2019, K- Electric, APPC is PKR 11.02/kWh and IESCO 12.14/kWh (https://nepra.org.pk/Admission%20Notices/2019/09-September/CPPA-G%20Report%20on%20PPP.pdf)
[130] Information gathered in the interviews conducted by the author. This report has not been published yet.

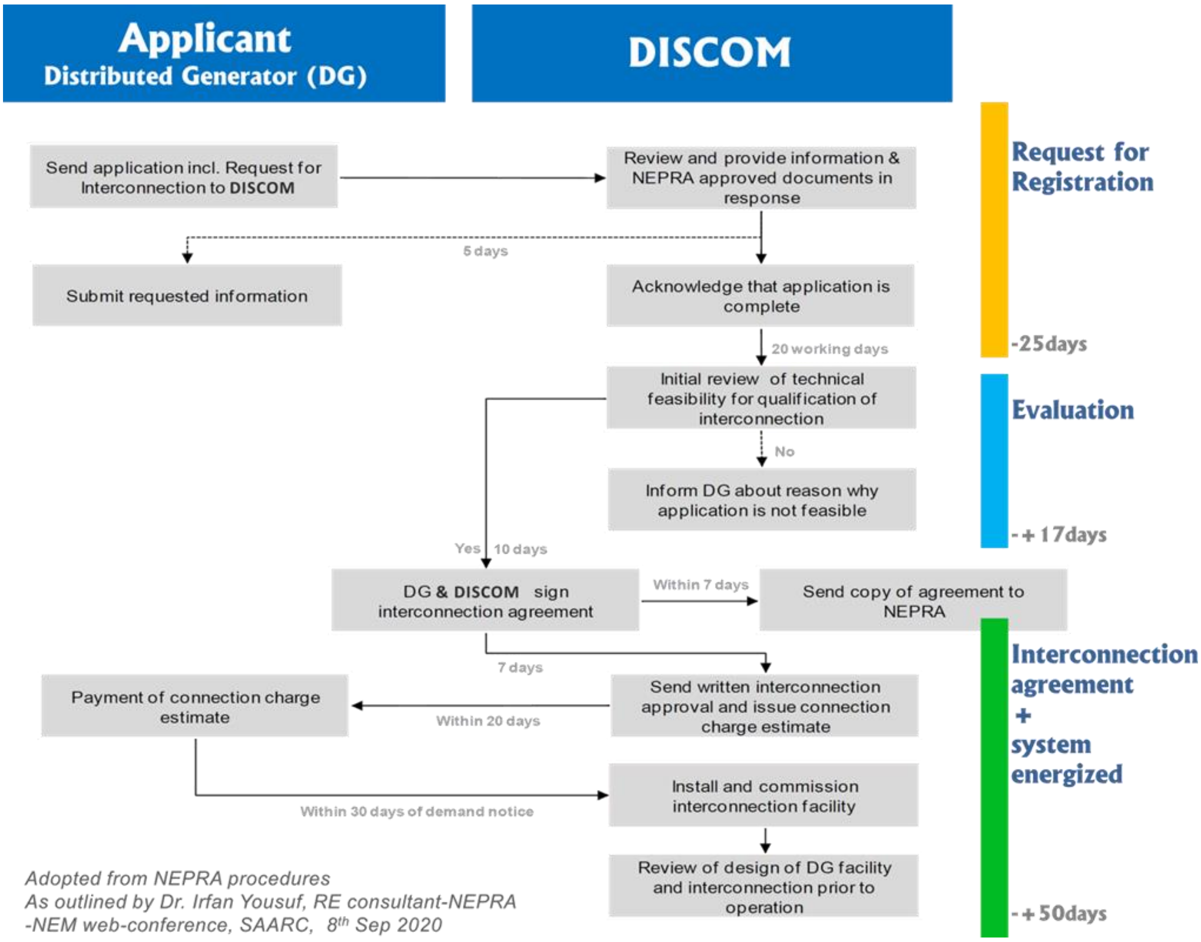
Although wind is permitted for NEM, only solar PV is the technology being adopted under NEM.

The restriction of cumulative NEM connections in a DT <15% of DT capacity is very restrictive and can be relaxed as the market picks up. As shown in many grid simulations carried out in India, it can be upgraded to 70-100% of DT capacity without facing any major challenges.

NEPRA should also clarify the pricing philosophy for NEM power exported to the grid.

The NEM application process defined by NEPRA, specifies an overall time of 90 days before an applicant can start project implementation:

The process is not entirely web-based and automated. Embedding decision making in an automated process flow can make it very easy for a customer to invest in NEM. Vendors should be allowed to operate the process on behalf or in parallel with the customer.



Technical Standards

Pakistan has adopted IEEE 1547-2003[131] standard. The standard defines tight operating bands for frequency and voltage. For example, voltage variation allowed is +/- 5% which is very tight compared to the specifications in IEEE 1547-2018 standard being adopted in USA, or IEEE 519/CEA 2013 standards adopted by India.

In the stressed power systems of Pakistan, such tight operating bands may lead to frequent tripping,

[131] Refer Annexure 7

losing valuable power generation as well as impacting grid operation. Therefore, the technical standards may need to be revised now. Inverters capable of performing with new standards, including ride through capability, are already available in the market.

Also, as market penetration of NEM and RE grows, utilities will have to invest in modern control centres with forecasting, planning, and remote-control capabilities.

Start of 'Growth' of Solar Roof-tops

The NEM policy was announced in 2006, but the NEM regulations came into force in September 2015, and the first system, on parliament house, was set up in Feb 2016. An improved framework for NEM implementation was announced in Jan 2018.

The Sept 2020 capacity status of solar roof tops in Pakistan is 94 MW.[132] Pakistan plans 1,000 MW capacity by end of 2021 and 3,000-4,000 MW by 2025.

Market Conditions and ECO-System are Maturing, RESCOS Need Support

Market conditions appear to be ripe. Customers are very keen to adopt NEM, because it helps them reduce power costs significantly, apart from improving energy security and reliability. Eco-system of EPC contractors is strong, having been in the market for 4-5 years with large utility scale solar and wind projects under implementation. There are more than 100 ECP contractors working in different market segments.

As a result, the EPC market has become very price sensitive with low net margins, which is forcing quality players out of the market.

NEPRA, the national authority overseeing NEM implementation has started a certification program for companies providing contracting services. Certification would be carried out by the Alternative Energy Development Board (AEDB). Only pre-qualified vendors will be allowed to sign agreements with power-distributing companies for setting up net-metering systems.

RESCO operations are picking-up and need to be supported for scale up of NEM. It appears that RESCOs can't enter into contract with the consumer and the utility under NEM. A tri-partite agreement would help them realize the value of the exported electricity directly from the utility.

Finance is being made available at low costs

Lending conditions are easing. State Bank of Pakistan (SBP, scheme 2009, revised in 2016) provides concessionary financing for renewable energy projects by offering debt financing at fixed subsidized interest rates of only 6.00% per annum. SBP lends at 2% per annum to the banks (ADB, 2018)

Many banks such as Habib Bank, Nizam Bank are beginning to offer these subsidized loans.

However, the security for NEM loan is a major problem. The key risks perceived by the Banks are (ADB, 2018):

i. Asset security: the systems can be uninstalled and moved. Lack of appropriate insurance covers.

[132] Source NEPRA presentation to SAARC Energy Center (Sep 2020)

ii. No mature market for resale of systems in case of default.

iii. System is installed within the private premises of a customer and is often difficult to access.

The commercial market for debt imposes high interest rates. Interest on unsecured personal loans may range from KIBOR + 16% to KIBOR + 20%. With KIBOR close to 8% this means unsecured loans could be priced at around 24–28%. This problem is getting resolved with the SBP scheme. However, security and collateral requirements remain restrictive.

Individuals are the least preferred segment for banks, possibly due to security issues. Security can be ensured through mechanisms like charge on 'salary' for borrowing by salaried people, or 'on-bill financing' by the utility for smaller consumers etc. Utilities, due to their regular collections from customers can lower the default risk. Further such financing could be limited to only those customers who have a regular payment track record. Fin-tech could be used to do additional credit risk assessments.

Another option for lending to the sector could be to finance RESCO/EPC players. RESCOs or EPC players could then finance the customers. RESCOs can control the operation of the plant[133] and therefore exercise a lever against default.

Islamic Finance can be used for 'leasing' or 'deferred payment' options. This will open up new sources of finance for this sector.

Conclusion

The fundamental reasons for NEM to flourish in Pakistan are present- high potential for cost reduction, improved energy reliability, a strong commitment from the government and a competitive eco-system. The journey for NEM growth has begun. It needs responsive governance to flourish and achieve ambitious targets.

f) K-Electric (formerly Karachi Electric Supply Company - KESC)

K-Electric is the private electric utility in Pakistan operating across Karachi, Dhabeji and Gharo in Sindh, and Uthal, Vinder and Bela in Balochistan.

TABLE 40: UTILITY PROFILE- K-ELECTRIC134 (KARACHI)

Area served	6,500 sq. km
Number of Customers	2.8 M
Peak Demand (till Aug 2020)	3,560 MW (The News, 2020)
FY 18-19 Billed Energy	14,318
T&D Losses (FY 19)	19.1%
Solar Roof Top target	20 MW in Karachi (MESIA, 2020)

[133] For example, RESCOs can switch off the plant remotely
[134] Data gathered by the consultant from K-Electric website

Area served	6,500 sq. km
Solar Roof Top Installed (August 2019)	6.15 MW

Karachi has 2 peak periods (2 seasons):

i. April-October: 1830-2230 hrs.

ii. November-March: 1800-2200 hrs.

Analysis of solar generation pattern indicates a minimal 0.69% of solar energy generation takes place during the peak periods.

Financial and Economic Analysis

The baseline energy resource for Karachi is coal. Since energy demand is growing, the baseline would be a new coal-based generation plant. The economic cost of power generation from such as plant has been estimated by the author as PKR 9.23/kWh[135].

Economic Savings

TABLE 41: ECONOMIC SAVINGS ESTIMATED FOR K-ELECTRIC NEM

SN	Parameter	Value (PKR/kWh)[136]
1	Economic cost of marginal generation (Coal)	9.23
2	Add: value of T&D losses in the system saved	2.56
3	Less: cost of NEM solar	(6.50)[137]
4	Add: cost of T&D system saved	0.02
5	Add: cost of environment (GHG)	0.56
	Net Economic Savings (NES)	**5.88**

Thus, significant savings (PKR 5.88/kWh ~ US¢ 3.5/kWh) are realized in the economy by shifting to NEM (solar).

[135] This cost estimate is based on a model developed by the consultants for CPEC type coal-based plants. A similar cost estimate has been made by Institute for Development and Economic Alternatives (IDEAs) working paper of Sep 2019, which estimates the cost as PKR 9.0/kWh.

[136] Refer Annexure 15 of K-Electric

[137] The estimate is based on market information for capital expenditure on solar roof tops in Pakistan, RETSCREEN and PVwatts (NREL) models for solar resource modeling.

Net Customer Savings (NCS) under NEM

TABLE 42: K-ELECTRIC - VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE[138]

Customer Segment Wise Savings (PKR/kWh) for NEM power substituting grid imports					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
	Off Peak PKR/kWh	14.38	15.63	12.0	10.8
1	Total variable tariff (inclusive of taxes, cess etc.)	19.67	21.25	16.84	15.34
2	Less: LCOE of solar generation[139]	(7.49)	(7.00)	(6.50)	(7.49)
3	Add: Value of benefits/incentives available to a customer (levelized)	0.00	0.00	0.00	0.00
	NCS1[140]	**12.18**	**14.26**	**10.34**	**7.85**

From the above table, it is evident that the customer savings are significant. Highest benefit would be available to the commercial segment.

The customer savings on the export of power are profiled below:

TABLE 43: K-ELECTRIC - CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise Savings (PKR/kWh) for NEM power exported to the grid					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	Compensation for NEM Exports	11.02	11.02	11.02	11.02
2	Less: LCOE of solar generation[141]	(7.49)	(7.00)	(6.50)	(7.49)
	NCS2	**3.53**	**4.02**	**4.52**	**3.53**

It is valuable for customers to export as well. Hence the customers would prefer to set up the largest feasible NEM capacities. This will be good for all the stakeholders- the country, the utility and the customers.

[138] Refer Annexure 15 of K-Electric

[139] Estimated based on no duties and taxes, CAPEX at PKR 65/W_p for large industrial systems, low interest rates (6%/a) and the resource modelled from RETSCREEN and PVwatt (NREL). For systems of 10-50 kWp, the market cost is at PKR 75/kWp and for very small systems of 1-10 kW is PKR 100/kWp. This is expected to improve as the market picks up and volumes build.

[140] NCS has been estimated w.r.t off peak tariffs, because most large customers pay with Time of Use (TOU) tariffs. Solar is generated during day time which is off peak.

[141] Estimated based on no duties and taxes, CAPEX at PKR 65/Wp for large industrial systems, low interest rates (6%/a) and the resource modelled from RETSCREEN and PV_watt (NREL). For systems of 10-50 Kwp, the market cost is at PKR 75/kWp and for very small systems of 1-10 kW is PKR 100/kWp. This is expected to improve as the market picks up and volumes build.

Net Utility Savings (NUS) under NEM

TABLE 44: K-ELECTRIC - NET UTILITY SAVINGS

SN	Parameters	PKR/kWh[142]
1	Less: compensation paid for NEM exports	(11.02)
2	Add: APPC	11.02
3	Add: value of REC/ renewable procurement	0.00
4	Add: savings of loss of power related to T&D	2.07
5	Value of peak power procurement	0.04
6	Value of T&D investment reduction	0.00
7	Value of incentives to the utility	0.00
	Net Utility Savings (NUS)	**2.13**

It can be seen that NEM is beneficial to the utility and its expansion should be encouraged.

As NEM grows, in the next 3-4 years, the NEM compensation could be lowered to somewhere between the LCOE levels for solar plants and the APPC, which will maximize benefits for the utility while still keeping the NEM system attractive for customers.

NEM Implementation Process and Organizational Analysis

K-Electric has strong customer engagement processes including mobile apps. They have a help desk to take care of NEM applications.

K-Electric shows commitment to sustainability, and publicly communicates this on its website and public announcements. K-Electric won the best project award in the category of 'Corporate solar sustainability program of the year' at the Middle east solar industry association's (MESIA) solar awards 2018 as part of the world future energy summit held in Abu Dhabi. They have set up a solar plant of 50 MW at Gharo and are planning a 100 MW plant in Baluchistan. They are also in discussion with 3 IPPs each with 100 MW capacity.

K-Electric seems to be well organized to take up programs of renewable energy.

K-Electric has set up a facilitation desk to receive applications from eligible residential, commercial and industrial customers interested in availing net metering facilities. The application process has been kept simple with all necessary information and forms available on K Electric's website[143]. Net metering facilitation desk manned by a dedicated team will serve as a single point of contact for the customers.

[142] Refer Annexure 15 of K-Electric
[143] www.ke.com.pk/NetMetering

Conclusions

Distributed solar can help K-Electric operations:

i. Reduce cost and energy losses

ii. Improve customer's access to reliable power

With the richest city of Pakistan (Karachi) under its service jurisdiction, ripe customer mind-sets and its relationships in the West Asian market, it can help scale up NEM implementations. K-Electric can also explore utility anchored business models such as 'on-bill financing' or 'super RESCO'. Using the soft loan scheme of the State Bank of Pakistan, perhaps with a partner Bank, K-electric can ease the financing challenges of its customers and become an efficient channel for finance into the NEM market. As a utility, its collection risks will be lower than other market participants. It will also have better access to credit information (e.g., payment record of the utility bills).

g) Islamabad Utility-Islamabad Electric Supply Company (IESCO)

Islamabad Electric Supply Company (IESCO) is a public sector utility and operates in the capital of Pakistan and serves the circles of Islamabad, Attock, Rawalpindi, Jhelum, and Chakwal.

TABLE 45: UTILITY PROFILE- IESCO[144] (ISLAMABAD)

Area served	23,160 sq. km
Number of customers	3.1 M
Peak demand (till Aug, 2020)	NA
FY 18-19 billed energy	NA
T&D losses (FY-19)	8.9%
Solar roof-top target	NA
Solar roof-top installed (Sep 2020)	18.45 MW

Islamabad has peak period during 1800-2200 hrs, which shifts to 1700-2300 hrs in summers.

Analysis of solar generation pattern indicates a minimal 0.39% of solar energy generation takes place during the peak periods.

Financial and Economic Analysis

The baseline energy resource for Islamabad is coal. Since energy demand is growing, hence for estimations the baseline is considered to be a new coal-based generation plant.

The economic cost of power generation from such as plant has been estimated as PKR 9.23/kWh[145].

[144] Data gathered by the consultant from IESCO's Annual Reports and website
[145] This has been estimated for imported coal, based on recent CPEC investments.

Economic Savings

TABLE 46: ECONOMIC SAVINGS ESTIMATED FOR IESCO-NEM

SN	Parameter	Value (PKR/kWh)
1	Economic cost of marginal generation (Coal)	9.23
2	Add: value of T&D losses in the system saved	1.42
3	Less: cost of NEM solar	(8.35)[146]
4	Add: cost of T&D system saved	0.01
5	Add: cost of environment (GHG)	0.56
	Net Economic Savings (NES)	**2.88**

Thus, significant savings (PKR 2.88/kWh ~ US¢/ 1.7/kWh) are realized in the economy by shifting to NEM (solar).

Net Customer Savings (NCS) under NEM

TABLE 47: IESCO - VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise Savings (PKR/kWh) for NEM power substituting grid imports					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
	Off Peak PKR/kWh	14.38	15.63	12.0	10.8
1	Total variable tariff charged to a customer	19.67	21.25	16.84	15.41
2	Less: LCOE of solar generation	(9.62)	(8.99)	(8.35)	(9.62)
3	Add: value of benefits/incentives available to a customer (levelized)	0.00	0.00	0.00	0.00
	NCS1[147]	**10.04**	**12.16**	**8.49**	**5.79**

From the above table, it is evident that the customer savings are significant. The highest benefit would be available to the commercial segment.

The second component of customer saving is on net power exported to the grid. The estimates are given in Table 48.

[146] Based on resource analysis for Islamabad using RETSCREEN and PVwatt (NREL) models. CAPEX based on market information. LCOE for Islamabad is much higher due to lower solar resource compared to Karachi.

[147] NCS has been estimated w.r.t Off Peak Tariffs. Large customers have applicability of Time of Use (TOU) Tariffs. Since solar generation takes place in off peak time, the electricity it substitutes is the off-peak supply.

TABLE 48: IESCO - CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

SN	Customer Segment Wise Savings (PKR/kWh) for NEM power exported to the grid				
SN	Customers Segments	Residential	Commercial	Industrial	Agricultural
1	NEM compensation[148] for exports (equal to APPC)	12.14	12.14	12.14	12.14
2	Less: LCOE of solar generation	(9.62)	(8.99)	(8.35)	(9.62)
	NCS 2	**2.52**	**3.16**	**3.79**	**2.52**

These savings are also positive and significant. Hence customers would maximize size of NEM systems and generate power for both internal consumption as well as exports. This will be good for all the stakeholders i.e., the nation, the customer and the utility.

Net Utility Savings (NUS) from NEM

TABLE 49: IESCO - NET UTILITY SAVINGS

SN	Parameters	PKR/kWh[149]
1	Less: compensation paid for NEM exports	(12.14)
2	Add: APPC	12.14
3	Add: value of REC/ renewable procurement	0.00
4	Add: savings of loss of power related to T&D	1.05
5	Value of peak power procurement	0.02
6	Value of T&D investment reduction	0.00
7	Value of incentives to the utility	0.00
	NUS	**1.09**

NEM will result in net saving for the utility for each kWh exported to the grid.

As in the case of K Electric, as the NEM penetration grows, the compensation for NEM exports to the grid can be brought down below APPC. This will increase the levels of NUS for the utility. This will also ensure an equitable share of value between the utility and the customer.

NEM Implementation Process and Organizational Analysis

IESCO was the first mover in Pakistan in NEM implementation after NEPRA introduced the NEM regulations in 2015. It now leads the utilities in Pakistan in terms of NEM connections (nos. 672 in 2019)[150].

[148] Refer Annexure 16 of IESCO
[149] Refer Annexure 16 of IESCO
[150] https://www.saarcenergy.org/wp-content/uploads/2019/10/3-Licensing-Presentation-Net-Metering.pdf

IESCO has proposed a very well laid out process on their web-portal which also displays feeder wise net metering capacity available. Such information availability makes it easier for the applicants to consider NEM.

Conclusions

Despite comparatively lower solar resource in IESCO's area of operation, customer saving is high which ensures the financial attractiveness of NEM. Islamabad being the capital, it may get a significant opportunity to implement NEM in public sector buildings.

IESCO can scale up NEM through prioritization of customer segments and promotional efforts, launching targeted customer enrolment campaigns, making its application process online and automated. It can focus on public buildings and residential and small commercial customers with utility anchored business models such as 'on-bill financing' and 'super RESCO'.

6.5.3 Bangladesh Country Overview

Bangladesh is heavily fossil fuel dependent and its recent power sector master-plans envisage continuing dependence on non-renewables (Nicholas & Ahmed, 2020).

i. Under its Master Plan, installed capacity grows from 20 GW today to 40 GW in 2030 and 60 GW in 2040. Fossil fuels continue to provide more than 80 per cent of the fuel for power generation. The peak demand in 2020 is ~ 15GW[151]

ii. About 3 per cent of the country's power currently comes from coal, but the plans to build 29 new coal-fired power plants in the next two decades would boost that to 35 per cent (Naimul, 2020).

iii. An alternative scenario by Institute for Energy Economics and Financial Analysis (IEEFA) projects a 20 per cent lower demand case with an aggressive renewable energy growth to 22 per cent in 2030 and 30 per cent in 2040, with reduced coal capacity and a doubling of gas capacity by 2040.

Bangladesh has huge untapped renewable potential: Onshore wind 16 GW, offshore wind 134 GW, solar PV rooftop 35 GW, solar PV 156 GW, and floating PV 31 GW (Teske, Morris, & Nagrath, 2019).

Bangladesh is one of the countries that will be severely impacted by climate change by 2050. Due to its low elevation and high population density, one in every seven persons in Bangladesh will be displaced due to climate change by 2050 (EJF, 2020). Hence, from a climate change perspective it is important for Bangladesh to increase its uptake of RE in its power mix, as one of the measures in countering climate change. However, a more important rationale is cost.

i. The current average cost of electricity generation by both public and private sectors is estimated to be BDT 13-14/kWh for furnace oil-based plants, BDT 25-30/kWh for diesel-based plants and BDT 2.5-3.0/kWh for natural gas-based plants. The cost of per kWh supply of electricity at the bulk level, for Bangladesh Power Development Board (BPDB), is BDT 5.82/kWh and its average selling price at the bulk level is BDT 4.80/kWh (Rahman, 2020).

[151] Bangladesh Power Development Board (website): 15-09-2020 Peak Load evening was planned to be 15,045 MW and, in the day time it was 14,230 MW. Actual load was 12,040 MW in the evening and 10,467 MW in the day-time.

ii. Grid tariff has been escalating @5.01% for industrial use[152]. Government forecasts that, with tariff reforms and new capacities coming up, electricity tariffs may increase @10.3% annually. This is making technologies such as solar very attractive, because costs can be locked-in.

iii. Average Grid tariff is high: 9-11 US¢/kWh (Nguyen, 2020) .

iv. Country's own natural gas supply is diminishing, and it will have to resort to LNG imports. The author has estimated the cost of power from such plants, based on recent investment proposals of Summit Power[153]. The cost is estimated to be BDT 6.9/kWh which may inflate with time.

v. NEM solar will definitely be competitive with much more expensive (BDT 13-14/kWh) oil-based generation (34% share).

Bangladesh faces power shortages and despite having become power surplus, power reliability is not very high in many parts of the country. At present they have much greater dependence on diesel generation sets. NEM can provide a local source of power for consumers. Supported by energy storage, they can get access to power with higher reliability.

Bangladesh has had difficulty in meeting peak electricity demand, which reached 14,796 MW on May, 2019, against generation of 12,893 MW. Peak demand was more than 3,500 MW higher than the recorded level of 11,387 MW on July, 2018.

Access to the power grid is also a major issue in Bangladesh. A total of 21.8 million consumers (out of which 16 million are domestic connections - households), which represents ~50% of all households (30-40 million), were connected to the grid. Another 15% of the households had access to off-grid electricity.

The country is aligning its plans with renewable energy now. The government has fallen short on its stated target of ensuring a 10 per cent renewable energy in the total energy mix by 2020. It is just below two per cent now.

Land is scarce in Bangladesh and will pose problems for their on-shore wind and ground mounted solar capacities. Roof mounted solar, or floating solar projects would therefore be very useful.

Bangladesh Policy

TABLE 50: EVOLUTION OF BANGLADESH NEM POLICY

Bangladesh	
Launch year	Bangladesh renewable energy policy – 2008 Sustainable and renewable energy development authority (SREDA) net-metering guidelines 2018[154] (revised in 2019)
Net-metering	For solar PV systems; includes pumps. Can be roof top or ground mounted within premises.[155]

[152] CAGR: 2010-2020

[153] In March 2018, a US$3 billion investment was proposed between Summit Power and Mitsubishi subsidiary Diamond or a two, 1,200 MW unit plant based on imported LNG.

[154] Revised Guidelines released in 2019 but available only in Bangla language as of now

[155] Current interpretation of the market.

Bangladesh	
NEM capacity	< 70% of sanctioned load Max – 3 MW (in terms of DC capacity) Open only to 3-phase customers.
Limits on cumulative NEM capacity	< 70% of DT capacity
Exemption from any charges	No other charges levied If DT capacity needs expansion to integrate the NEM system, the cost will have to be borne by the consumer.
Meter type	3-phase bi-directional meters
Meter reading	AMI permitted
Rate for grid export	Bulk Purchase Price of electricity ~ TK 5.17/kWh (TBS, 2020)
Settlement period	Yearly
RPO compliance/ carbon credits/ green certificates	Not applicable
Subsidies	No subsidies defined, except for low-cost loans offered by multilateral finance facility operated by IDCOL and supported by Bangladesh Bank.
Mandates	Not defined

The policy has evoked interesting responses from different stake holders (TBS, 2020).

i. Only three-phase electricity consumers are eligible for the net metering system. This effectively excludes single-phase consumers – the largest part of grid-connected consumers.

   a. Officials fear that managing numerous single-phase customers will be tough and will lead to instabilities in the grid.

   b. Consumers have questioned the capacity limit of 3 MW.

   c. Consumers have asked for the reason behind capacity limited to 70% of the sanctioned load. Some official comments outlined the fear that consumers may start to sell power without these limits.

   d. Officials believe that power produced at commercial plants may remain unused if a capacity ceiling is not created for net metering users.

ii. Some accounts indicate that distribution companies had objected to the idea of opening up NEM for every grid-connected consumer due to fear of grid instability, considering that grid upgrade costs may become prohibitive for the utilities.

It does appear that distribution companies and power board officials have some reservations around NEM implementation even though experience from other Member States including India, Sri-Lanka, shows that such fears are often misplaced and with time and learning are easily addressed.

The problem of loss of sale, as perceived by distribution companies, will need to be dealt with sensitively, with focus on creating awareness of real cost benefits. The revenue loss perception is globally shared, without consideration of the country specific conditions. While in countries with no demand growth, NEM could have some real loss implications (because fixed costs remain while revenue declines), it is not a valid view in case of countries with growing electricity demand. In the latter case, with NEM, the demand may grow slowly but not reduce. Utility fixed costs can easily be recovered from such growth.

SREDA believes that mandates would drive all distribution companies to promote renewables[156] and does not share the negative view which seems prevalent among utilities. To take care of grid support costs, at some point of time, a grid support charge, BDT/kWh or % of electricity using the grid support e.g., banking and wheeling, may be charged to cover costs.

Solar pump owners have highlighted certain concerns relating to NEM. As per the current policy, if a solar pump is made grid interactive, the owner will be classed as an electricity consumer and will have to pay demand charges and line rent. At present the solar pump owners who are not grid connected don't need to pay such charges. This will create an additional financial burden on users who are considering NEM.

Technical Standards

Bangladesh uses the standard IEC 61727:2004, which defines specifications for utility interface. Key specifications are:

i. Response to frequency variation: Inverter should be capable of producing power at the frequency band of at least +/-6%. When outside the nominal 50 Hz value by ±2%, trip time shall be within 0.20 sec.

ii. Response to voltage variation: LV – 230-400 V, MV – 11-33 kV. Maximum inverter voltage fluctuation range allowed is 6%.

    a. Voltage imbalance: Infrequent short duration peaks with a maximum value of 2% over 1-minute duration are permitted. Unbalanced voltage shall not exceed 1% on 5 occasions within any 30-minute period.

    b. Voltage disturbance: Defined for V < 50% (trip time: 0.10 sec) to 110% < V < 135% (trip time: 2 sec).

The standard may need change to incorporate 'fault ride through', and 'remote control' (active and reactive power) features. These features gain importance as penetration increases. Compliant inverters are already in the market. Utilities will also need to invest in good digital monitoring, forecasting and automated remote-control capabilities to facilitate high NEM integration as well as adoption.

Growth of Solar Roof-tops

i. 15.2 MW capacity has been set up so far (June 2020)[157]

[156] Based on inputs shared by SREDA officials in Aug, 2020
[157] Based on inputs shared by SREDA officials in Aug 2020

ii. The potential identified for solar roof top is 10 GW (Nguyen, 2020).

iii. There are a number of export-oriented sectors with presence of international companies, who desire to shift to NEM solar because of corporate commitments. For example, there are 5000 textile companies, 112 of whom are platinum rated and 519 are LEED certified[158]. Many of them have goals to become 100 % RE powered. They will become good initial adopters.

Market Conditions

EPC and RESCO operators, including those from India, are gaining market access. Most projects happen under CAPEX model. Only a few RESCO operators offer PPAs to large off-takers with good credit.

The initial uptake is expected in commercial and industrial segments. Residential and agricultural sectors may gain importance at a more mature stage of the market.

RESCO contracts can have flexible PPA structures:

i. Price escalation: 5% annual inflation, USD¢ 13.5/kWh, 10-year contract signed by Dhaka Power Distribution Company for Solar Roof Top.

ii. Discount to grid – e.g., 5% discount to grid, 12-year contract by a private company.

After PPA, the asset is transferred to the customers.

Utility Engagement Status

Utilities have been engaged by the government targets to have 10% renewables in the energy mix. Although there are no penalties, such targets are taken seriously.

Availability of Finance

A large financing facility created by ADB (US$ 185 M), KfW (US$ 60 M) has been created and is being implemented by IDCOL. This is complemented by green finance scheme of Bangladesh Bank (the national bank), a US$ 23.5 M scheme.

The final loan to a borrower is at 6% per annum, with 10-year tenure.

IDCOL facility can work with liberal security norms such as:

i. Security value can vary between 10-100% of loan

ii. Can include fixed and floating assets

iii. Or personal guarantees of the shareholders, corporate guarantees, lien on shares

iv. Or lien on project account.

Commercial banks are however not very comfortable with risks on solar NEM.

[158] Leadership in Energy and Environmental Design (LEED) provides a framework for healthy, highly efficient, and cost-saving green buildings. LEED certification is a globally recognized symbol of sustainability achievement and leadership.

As understood RESCO projects carry risks which need to be mitigated for attracting lenders. However, there are no risk protection products (e.g., insurance, partial risk guarantees etc.). Banks are therefore wary of financing NEM projects.

h) Dhaka Power Distribution Company-DPDC

DPDC is the biggest electric utility (government-owned) of Dhaka and its surroundings in Bangladesh[159].

TABLE 51: UTILITY PROFILE-DPDC[160] (DHAKA)

Aspect	Value
Area Served	250 sq km
Number of customers	1.3 M
Peak demand (till Aug 2020)	1,670 MW
FY 18-19 billed energy	8,719 MU (GWh)
T&D losses (FY 18-19)	7.29%
Solar roof-top target	No target
Solar roof-top installed (June 2020)	1.82 MW (SREDA, 2020)

DPDC has the most densely populated area to cater to, compared to other utilities covered in the study. It displays excellent control over transmission and distribution losses.

Dhaka has one peak period: 1700-2300 hrs. Analysis of solar generation pattern indicates that no solar energy generation takes place during the peak period.

Financial and Economic Analysis

The baseline energy resource for Bangladesh is gas. Since energy demand is growing, the baseline assumption would be expansion/ set-up of new gas-based generation plant (Combined Cycle Gas Turbine Plant - CCGT).

The economic cost of power generation from such as plant has been estimated by the author as BDT 6.90/kWh[153].

Economic Savings

TABLE 52: ECONOMIC SAVINGS ESTIMATED FOR DPDC-NEM

SN	Parameter	Value (TK/kWh)
1	Economic Cost of Marginal Generation (CCGT)	6.90

[159] Bangladesh has 6 electric utilities in total, 2 of which operate in Dhaka (DPDC and DESCO)
[160] Data gathered by the author from DPDC's Annual Reports and website

SN	Parameter	Value (TK/kWh)
2	Add: Value of T&D losses saved	0.69
3	Less: Cost of NEM Solar	(7.97)
4	Add -Cost of T&D capacity saved	0.00
5	Add: Cost of Environment (GHG)	0.37
	Net Economic Savings (NES)	**-0.01**

Solar NEM can compete with the most competitive energy source for Bangladesh. However, if one considers high-cost oil-based generation being substituted (BDT 13-14/kWh), solar NEM will have a significant advantage. Solar LCOEs will also improve with time.

Net Customer Savings (NCS) under NEM

TABLE 53: DPDC - VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

SN	Customer Segment Wise Savings (BDT/kWh) for NEM generation replacing grid				
	Customers Segments	**Residential**	**Commercial**	**Industrial**	**Agricultural**
	Variable tariff	3.75-11.46	10.3	8.53	4.16
	Peak		12.36	10.24	
	Off-Peak		9.27	7.68	
1	Total variable tariff charged to a customer	5.34	9.27	7.68	4.16
2	Less: LCOE of solar generation	(6.48)	(6.29)	(6.10)	(6.48)
3	Add: value of benefits/incentives available to a customer (levelized)	0.00	0.00	0.00	0.00
	NCS1[161]	**(1.15)**	**2.98**	**1.58**	**(2.32)**

NCS assessment shows that NEM is likely to be attractive to commercial and industrial customers and not for residential or agricultural customers. The lower tariff of residential segment was used in the analysis; thus, savings seem muted. The savings would be larger for high paying residential customers.

SREDA intends to focus on commercial and Industrial segments, as big savings are possible, they have corporate mandates and commitment, and can get good financing options for investments.

The second component of customer saving is based on compensation on electricity exported to the grid. This assessment is provided in Table 54.

[161] NCS has been estimated w.r.t the lower end of tariffs. The savings are going to be higher for upper end of grid tariffs in residential segment. The savings for commercial and industrial segment assessed based on day (off peak) tariffs.

TABLE 54: DPDC-CUSTOMER SEGMENT WISE NEM ENERGY EXPORTED

Customer Segment Wise NC Savings (BDT/kWh) for NEM generation exported to the grid					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	NEM Compensation for exports to the grid[162]	5.17	5.17	5.17	5.17
2	Less: LCOE of solar generation	(6.48)	(6.29)	(6.10)	(6.48)
	NCS 2	**(1.31)**	**(1.12)**	**(0.93)**	**(1.31)**

The savings are negative. Hence at present there is no incentive to customers for export. They will design systems to maximize the internal consumption.

Net Utility Savings (NUS) under NEM

TABLE 55: DPDC-NET UTILITY SAVINGS

SN	Parameters	BDT/kWh[163]
1	Less: compensation paid for NEM exports	(5.17)
2	Add: APPC of power procurement	5.17
3	Add: value of REC/ renewable procurement	0.00
4	Add: savings of loss of power related to T&D	0.31
5	Value of peak power procurement	0.00
6	Value of T&D investment reduction	0.00
7	Value of incentives to the utility	0.00
	NUS	**0.31**

The author's assessments indicate a net gain for the utility from NEM implementation.

NEM Implementation Process and Organizational Analysis

SREDA is the nodal agency coordinating NEM implementation in the country. Its priority focus is on commercial and industrial segments. DPDC, the utility, doesn't appear to be keen on NEM. As of now, NEM applications are processed manually.

SREDA is carrying out activities like engagement with industry bodies like Bangladesh Garment Manufacturers and Exporters Association-BGMEA (to promote NEM with them), and holding public workshops, webinars, meetings, etc. Bangladesh has been divided into 8 segments (geographies or sectors) and the work on NEM is happening segment wise, like hosting capacity analysis, gathering

[162] Refer Annexure 13 of DPDC
[163] Ibid

information on shadow-free rooftop areas, feasibility of solar rooftop, etc.

Conclusions

Awareness building, sectoral promotions, and decreasing the cost of initial investment through aggregation could be major drivers to scale-up markets. For example, SREDA could aggregate demand for public buildings. SREDA could also work with industry associations so as to target sectors with large potential (e.g., textiles, garments and leather)

Utilities like DPDC can use 'on-bill financing' or 'super RESCO' models to derive the benefits of aggregation of demand, reduced collection risks, reduced finance costs etc.

The commercial and industrial customers will be the first ones to adopt NEM based on net savings. Economics doesn't favour residential or agricultural customers. It also doesn't support export to the grid.

6.5.4 Sri Lanka Country Overview

Sri Lanka has a fast-growing energy market. Annual sales growth in the past five years was just below 9% per year, while the growth in peak demand was around 7% per year (ADB, 2019).

Mandatory Time-of-Use (TOU) tariffs were introduced for industries (2011) and commercial customers (2013). This has improved the grid load factor from 63% to 68%.

Sri Lanka's current (2018) energy mix is dominated by coal and oil. They contribute 50% share of generation capacity (MW) and about 55% of GWh generated. Hydro power is the dominant source after these fossil-fuels. Sri Lanka has plans to expand renewable energy rapidly. The share of renewable energy including hydro is expected to rise from 50% in 2018 to ~75% by 2030. The capacity of renewables, 611 MW in (2018) is expected to cross 6,000 MW by 2030, utilizing the island's rich wind and solar resources. Wind and solar parks are being developed and recent auctions (2016) have delivered very competitive energy prices (Dutt, 2020) of US¢ 6.6-6.8/kwh, declining from US¢ 12-13/kWh just 2 years back.

The current day time grid tariff for domestic customers, in comparison, is US¢ 14/kwh, and average purchase price for power by CEB, its biggest distribution utility, is US¢10.3/kwh. These are both significantly higher than LCOE of renewables. This proves the case for Sri Lanka to aggressively seek renewable expansion.

Such a strategy is directed at making Sri Lanka's energy mix more sustainable, less costly, as well as reducing stress on precious foreign exchange used in fossil fuel imports.

CEB has been under-recovering its costs for many years (Dutt, Accelerating Renewable Energy Investments in Sri Lanka, 2020) ranging from 8%-26% of its revenues (2010-2017). This is putting stress on its ability to undertake modernizations.

Sri Lanka Policy

TABLE 56: EVOLUTION OF SRI LANKA NEM POLICY

Sri Lanka	
Evolution of the policy	CEB Net Energy Metering manual 2014 Sri Lanka Soorya Bala Sangramaya (the battle for solar energy) - the roof-top Initiative (2016)- introduced Net Accounting and Net Plus options. Thus, all the three components of the scheme- Net Metering, Net Accounting, Net Plus are in operation now.
Net Metering (2008)	Classic net-metering model. exported energy is credited and can be imported back from the grid and used. Utility bill is raised for net-electricity consumed (imports- exports). The credits can be accumulated for 10 years.
Net Accounting (2016)	Customers are paid in cash for any surplus they generate at the end of their monthly billing cycles at the following rates: ► Year 1 to year 7 at SLRs 22.0/kWh, and ► Year 8 to year 20 at SLRs 15.5/kWh Other features are the same as for Net Metering.
Net Plus (All Buy All Sell, 2016)	Customer pays full value for electricity consumption. Utility pays the customer for the entire generated electricity at an announced rate: ► Year 1 to year 7 at SLRs 22.0/kWh and ► Year 8 to year 20 at SLRs 15.5/kWh
NEM capacity	< 100% of sanctioned load < Max limit 1000 kVA
Limits on DT loading	NA
Exemption from charges	None mentioned
Meter type	Bi-directional meters
Meter reading	MRI, AMI both permitted
Grid export rate	FIT ~ SLR 22.0/kwh (for first 7 years) and SLR 15.5/kwh for the rest of project life of 20 years.
Settlement period	10 years for Net Metering. Any credit after 10 years lapses.
RPO compliance/ carbon credits/ green certificates	
Subsidies	No subsidies
Mandates	No mandate

It seems the rates for Net Accounting and Net Plus are proposed to be revised downwards to SLR

19.75/kWh for <50 kW systems and to SLR 18.75/kWh for >50 kW systems.[164]

This seems justified. Such reduction would take away the objection of utilities regarding paying higher price for NEM electricity than paid for more firm power from non-NEM sources.

CEB has also been concerned about high pay-outs for NEM customers when solar costs have come down. Compensation revision would allay such fears.

The three schemes seem to attract a different type of customers:

i. The Net Metering scheme has been adopted more aggressively by residents, as opposed to commercial and industrial segments in other countries. More than 95% applicants come from residential segment. This happens to be so because high consumption (top 10%) residents have the highest grid tariff amongst all segments (ADB, 2018).

ii. Net accounting scheme is considered good for residential and commercial customers such as hotels, offices, malls etc., with tariffs ranging from SLR 22-27/kWh.

iii. Net Plus scheme is good for large building owners, who may have low internal loads or low grid tariffs (example, warehouses, industries, religious places, schools, sports complexes etc.). They will derive bigger financial benefit by exporting all the electricity at a rate higher than their grid tariff.

Technical Standards

Sri-Lankan grid code has defined operating bands for frequency and voltage.

Frequency variation: Over (max +2%) and under (min- 6%) frequency (50 Hz) trip functions and clearance times defined (0.5 seconds)

Voltage variation: Over (max +10%) and under (min -6%) voltage (230 V) trip functions and trip settings (0.2-1.5 sec). Withstand voltage and current surges in accordance with the environments defined in IEEE 1547[165].

The voltage band appears to be tight and may lead to frequent tripping specially in LV network, when voltage increases as solar generation increases vis-à-vis loads.

The standards may need to be revised. Inverters with advanced capabilities for 'fault-ride-through' and 'reactive power' support capability are available in the market.

ECO-system Maturity

CAPEX model is the most popular, although few RESCOs have entered the market recently.

Well known Indian RESCOs and EPC players such as NTPC, Fourth Partner Energy, Thermax have shown interest in the Sri Lankan market. NTPC is planning a solar park.

According to CEB, capacity of local vendors to undertake projects is adequate. A large number of vendors are active in the market.

164 From the authors' interactions with CEB officials
165 Refer Annexure 7

Financing

Financing can now be scaled up, if well designed programs are put in place, reducing risks for RESCO operators, lenders and investors.

ADB loan was the first multilateral financing (US$ 50 M,) made available in 2017. It financed up to SLR 1.5 M for NEM investments at interest cost of 8% and tenor of 5-7 years. It was limited to a maximum capacity of 50 kW, for any customer category.

Indian government (Exim Bank) has granted a soft loan (US$ 100 M) in June 2020, to set up solar roof tops on government buildings and low-income housing. This will help reduce subsidies incurred by CEB in serving these segments with under-recovery of costs. It is not known how the loan is proposed to be used.

One of the innovative ways this fund could be used would be to finance CEB, acting as a super ESCO. CEB would enter into a RESCO agreement with the customers and get the system built by high quality EPC contractors/RESCOs.

With aggregation, the cost of plants or tariffs can be brought down and payment for RESCO guaranteed, CEB being the anchor. CEB pays out of the savings on subsidized electricity supplied to these customers.

Such a plan may attract very high quality international RESCOs. Such RESCOs, when they start operating in the country, will transition to other customer segments.

The US$ 100 Mn Fund could be operated as a Revolving Fund and generate increasing cashflows to support increased investments in the sector.

i) Sri Lankan utility-Ceylon Electricity Board (CEB)

CEB covers 97% of the geographical area of Sri Lanka. The only other utility LECO in Sri Lanka is also majorly owned by CEB itself.

TABLE 57: UTILITY PROFILE-CEB[166]

Area served	63,642 sq. km
Number of Customers	6.3 M
Peak Demand (till Aug 2020)	2,616 MW
FY 18 Billed Energy	14,091 MU (GWh)
T&D Losses (FY 18)	8.34%
Solar roof-top target	200 MW by 2020 and 1,000 MW by 2025 (SLSEA, 2020)
Solar roof-top installed (2020)	260 MW

[166] Data gathered by the consultant from CEB's Annual Reports, website

Large electricity consumers are residential (37% share), industries (32% share), commercial (29% share). As the economy moves toward higher growth in the services sector, the share of electricity sold to industries is declining.

About 82% of household customers use less than 90 kWh/month. According to the Sri Lanka electricity pricing model of 2016, household customers using below 120 kWh/month are subsidized. Only 10.3% of household (approximately 530,000) customers use above 120 kWh/month, and they use 28% of electricity sold to households (SLSEA, 2020).

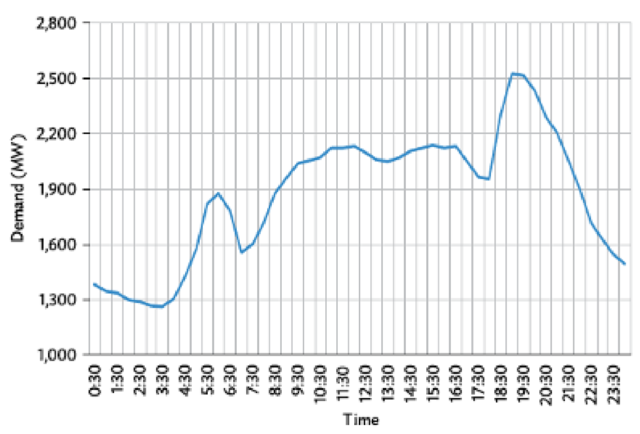
The high consuming residential segment is the one to benefit most from NEM and will have the capability to make own investments. The solar LCOE of SLR 12.2/kWh will be attractive for such customers (having a high grid tariff of SLR 25/kWh+).

The rest of residential customers may need some financing mechanism and subsidy to participate in NEM.

Solar power alleviates peak loads

Sri Lanka has its peak period during 1830-2230 hrs. Solar therefore may be seen as not contributing to alleviation of peak loads.

However, experts in Sri Lanka point out that day peaks in Sri Lanka are increasing, and the gap between the day peak and night peak has reduced to just 200 MW in the last year. As seen in the load curve alongside, in 2017, it was ~ 350 MW. The evening peak has increased to 3,500 MW in 2019, however the day peak has grown faster and gap has reduced.



MW = megawatt.
Note: System peak demand has been adjusted to include wind generation small power producers connected to the 132-kilovolt network.
Source: Sri Lanka Sustainable Energy Authority. 2019. *Sri Lanka Energy Balance 2017*.

FIGURE 28: SRI LANKA LOAD PROFILE, 2017

The hydro plants which are the largest, low-cost energy resource for Sri Lanka, are serving the increasing day loads and by the evening they run low on capacity. Hence if solar could take care of day's energy demand, hydro could easily serve night loads and the energy mix can continue to remain green.

It has been suggested by some experts that NEM could be extended to floating solar, for which there exists a large potential capacity ~35 GW[167] in the country.

Financial and Economic Analysis

The baseline energy resource for Sri Lanka has been assessed to be coal. Power from coal is expected to be cheaper than imported gas or oil-fired generators. Sri Lanka has been planning of maintaining the capacity level of oil powered energy in the next decade (no growth or reduction is planned). Hence, the author has assumed NEM will substitute potential green field coal power.

The economic cost of power generation from such a plant is estimated as SLR 16.29/kWh. The Sri-Lankan power sector plans include a few, large, coal-based projects.[168]

Economic Savings

TABLE 58: ECONOMIC SAVINGS ESTIMATED FOR CEB -NEM

SN	Parameter	Value (SLR/kWh)
1	Economic cost of marginal generation (Coal)	16.29
2	Add: value of T&D losses saved	2.04
3	Less: economic cost of NEM solar	(11.03)[169]
4	Add: value of T&D capacity saved	0.00
5	Add: cost of environment (GHG)	1.05
	Net Economic Savings (NES)	**8.35**

Thus, significant savings (SLR 8.35/kWh ~ US¢ 4.5/kWh) are realized in the economy by shifting to NEM (solar).

Net Customer Savings (NCS) under NEM

The following table estimates the value of NEM Solar customer segment wise:

TABLE 59: CEB - VALUE OF NEM SOLAR CUSTOMER SEGMENT WISE

Customer Segment Wise NC Savings (SLR/kWh) substituting grid electricity					
SN	**Customers Segments**	**Residential**	**Commercial**	**Industrial**	**Agricultural**
1	Total variable tariff (day-time)	25.0	18.30	10.20	14.65
2	Less: LCOE of solar generation	(12.19)	(11.61)	(11.03)	(11.61)

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[167] https://www.eqmagpro.com/powering-sri-lanka-through-renewables-the-floating-solar-opportunity. NEM could apply to smaller projects. Larger projects could be auctioned.

[168].LCOE for coal plants in Sri Lanka 2019, pg 183 http://www.energy.gov.lk/images/vidulka-energy-exhibition/symposium-2019.pdf.

[169] Based on solar resource analysis for Sri Lanka using RETSCREEEN and PVwatts (NREL). Capital costs assumed based on market feedback.

Customer Segment Wise NC Savings (SLR/kWh) substituting grid electricity					
3	Add: value of benefits/incentives available to a customer (levelized)	0.00	0.00	0.00	0.00
	NCS[170]	**12.81**	**6.69**	**(0.83)**	**3.04**

It can be observed that the customer savings are significant for the residential and commercial segments. This is the main reason behind high demand for NEM in the residential segment.

Net Utility Savings (NUS) under NEM

Table 60: CEB- Net Utility Savings

	Parameters	SLR/kWh
1	Less: compensation paid for NEM exports	18.75
2	Add: APPC	19.12
3	Add: value of REC/ renewable procurement	0.00
4	Add: savings of loss of power related to T&D	1.63
5	Value of peak power procurement	0.00
6	Value of T&D investment reduction	0.00
7	Value of incentives to the utility	0.00
	NUS	**2.00**

The Tariff for NEM compensation has been assumed to be revised downwards. Thus, NEM is beneficial to the utility too. The utility savings will increase as solar costs fall, grid costs rise, and NEM compensation tariffs are revised downwards.

Technical Analysis

Author's discussions with CEB officials, presented some interesting insights:

CEB has observed a few technical issues in implementing solar roof tops in LV grids. After solar roof-top reaches 40-50% of distribution transformer capacity, rapid voltage rise is experienced during the day, leading to system trips.

System upgrades are required to control solar output as well as improve distribution transformer capacity to absorb more solar. A study on this was carried out 5-6 years ago. Upgrades are expected to be implemented by 2022.

A detailed hosting capacity assessment may be carried out to understand how much NEM capacity is possible to host in a distribution grid. Adoption of modern IEEE 1547-2018 type of standard will help the

[170] NCS has been estimated w.r.t the lower end of tariffs. The savings are going to be higher for upper end of grid tariffs.

solar plants integrate well into the grid with capabilities to provide reactive voltage support, and automatic response to grid conditions.

CEB will need to build a digitally enabled control centre with capabilities to forecast, interact with and control the RE capacities within the grid.

NEM Implementation Process and Organizational Analysis

The current NEM application process is a hybrid web-based system with some sections automated. The normal time for approval is defined: first stage approval takes 2 days, and after project completion - grid synchronization approval takes 4 days. Complete automation of this process is planned by 2022[171].

CEB is actively engaged in promoting NEM.

Since 2016, CEB has promoted the NEM scheme very strongly, including segment focused campaigns. ADB, as part of its loan facility of (US$ 50 M) had provided a technical assistance grant (US$ 1 M), which was used for awareness generation and capacity building.

CEB launched the 'convert public sector buildings into green energy' program in 2017, with a budget proposal of SLR 245 million. Under this program 77 government institutions were to adopt green energy by installing solar rooftops.

'Rivi Aruna' was launched by the Ministry of Power and Renewable Energy and CEB, to provide solar rooftops to religious places with a cost of SLR 58 million. This was expected to reduce the subsidy/losses of CEB due to supporting low tariffs for religious places.

Vendors are being certified and empanelled. There are enough good quality vendors available in the market.

Conclusions

Overall, it appears that Sri Lanka is poised for a faster scale up of NEM. It seems to be completing the 'transition' phase (~5%+ of grid peak is NEM solar) and entering into the 'growth' phase, supported by CEB's investment in processes and grid network to support the scaling up of NEM.

In a growing demand scenario, Sri Lanka is going to benefit significantly by NEM, as analysed by the author it's indicated that:

i. Savings for the economy, the customers and the utility.
ii. Reduced use of scarce land resources.
iii. Savings of investment in transmission and distribution infrastructure.

CEB can make the schemes more attractive for itself by rationalizing NEM compensation tariffs, as seems feasible in the current tariff structure.

CEB can help scale up the market by implementing utility anchored models, like ''on-bill financing' and super-RESCO', especially for high paying customers (top-end residential, commercial, industrial) segments. Such anchoring by CEB can attract large RESCOs and investors to the market.

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[171] From Authors' interactions with CEB officials

CEB can channel finance into NEM using low-cost facilities such as India's US$100 M loan. It can also aggregate and set up solar capacities under net-plus schemes for low-income housing and segments with low electricity consumptions which are heavily subsidized at present. This will reduce the subsidy burden on CEB.

Sri Lanka should also consider expanding the NEM definition to include small floating solar projects these schemes.

7. Analysis of NEM Maturity and Forecasts

7.1. Summary of Financial and Economic Assessments

Economic Savings of NEM

As seen from the analysis, all utilities have positive economic savings, except in the case of DPDC Bangladesh, where NEM solar is just matching the costs with the baseline gas-based-generation option. In view of the rapidly improving cost performance of solar, it would make sense to promote solar NEM in Bangladesh too.

i. India, Pakistan and Sri Lanka have been analysed with greenfield coal-based generation as the BAU scenario. For Bangladesh, BAU scenario is gas (LNG) based generation.

ii. In Bangladesh, Pakistan and Sri Lanka compared to the existing oil-fired generation capacities, the savings are significantly higher than with the baseline scenario.

iii. Large economic savings underscore the need to accelerate NEM adoption, even if subsidies and mandates are used to incentivise adoption by customers and utilities[172].

iv. There is an economic gain at the country-level due to the adoption of NEM. Governments will have to find ways to gain commitment from utilities, who sometimes seem to be reluctant participants, perceiving NEM to be taking away their customers. The study demonstrated in the analysis, that in growing markets, NEM does not result in a net loss, but just a slower growth. However, savings in terms of reduced cost of procurement (NEM can provide cheaper electricity), reduced transmission losses and reduced requirement of transmission and distribution network infrastructure, result in net financial gains, and improvement in profit margins for the utility.

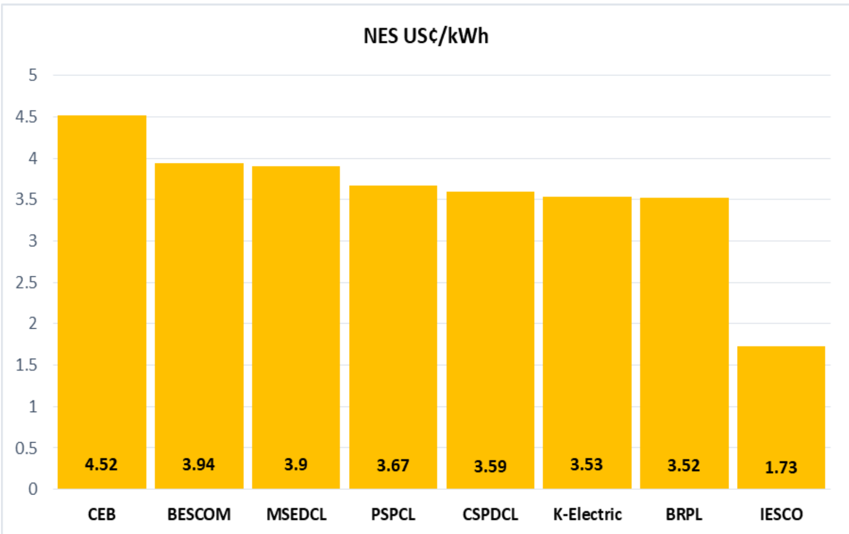

FIGURE 29: NET ECONOMIC SAVING FROM NEM

The author has not included cost analysis for Afghanistan Bhutan, Maldives and Nepal, as part of this report. However, the author would like to comment on the potential of solar NEM as follows:

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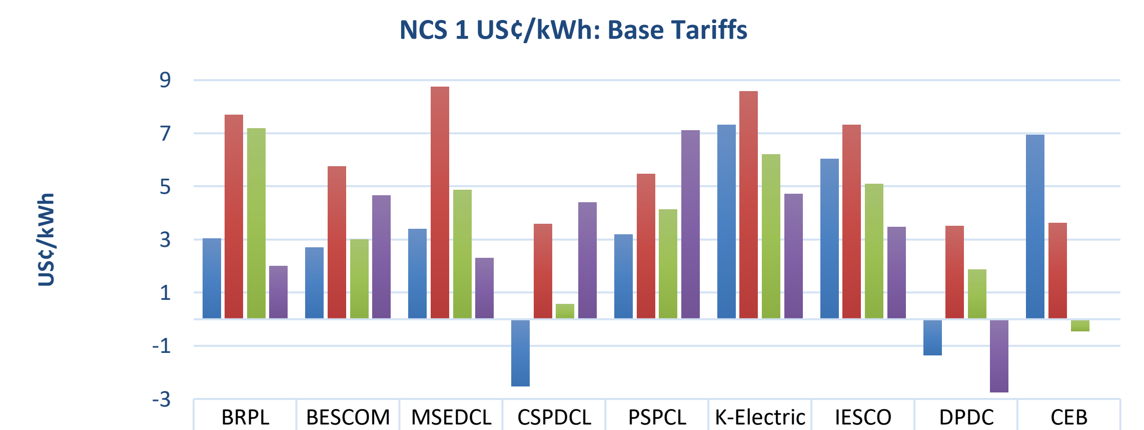
[172] Subsidies are not a net reduction from economic values being transferred from one part of the economy to another.

i. The Maldives, being dependent on fossil-based generation entirely (99%), will benefit immensely from the solar NEM, reducing cost, improving environmental footprint and reducing outgo of foreign exchange. Fossil fuel fired generation is very costly in islands due to the high import cost of fuel.

ii. In the same way, Afghanistan will benefit from solar NEM, having 50% dependence on expensive oil.

iii. Bhutan and Nepal have abundant hydro resources. However, the cost of power generation from hydro is increasing with higher cost of environment preservation and resettlement of people. NEM solar, providing local generation, eliminating transmission losses, reducing transmission and distribution network requirement, and rapidly improving in costs, will be a more valuable part of the mix[173].

7.1.1 Customer Savings from NEM



	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
Residential	3.03	2.7	3.39	-2.51	3.19	7.32	6.04	-1.35	6.93
Commercial	7.7	5.75	8.74	3.59	5.46	8.57	7.31	3.51	3.62
Industrial	7.19	3	4.87	0.58	4.13	6.21	5.1	1.87	-0.45
Agricultural	2.01	4.66	2.31	4.39	7.1	4.72	3.48	-2.74	0

FIGURE 30: NET CUSTOMER SAVINGS (NCS1) FROM CONSUMPTION OF NEM POWER SUBSTITUTING GRID.

Customers benefit significantly from NEM implementation, except in highly subsidized customer segments such as residential and Agricultural segments (cases of CSPDC-Chhattisgarh and DPDC-Dhaka). Commercial and industrial segments show the highest levels of savings. This is in line with global trends with commercial and industrial segments driving NEM growth. The reasons for such growth include:

i. Easier access to financing from existing banking relationships, no need for additional security etc.

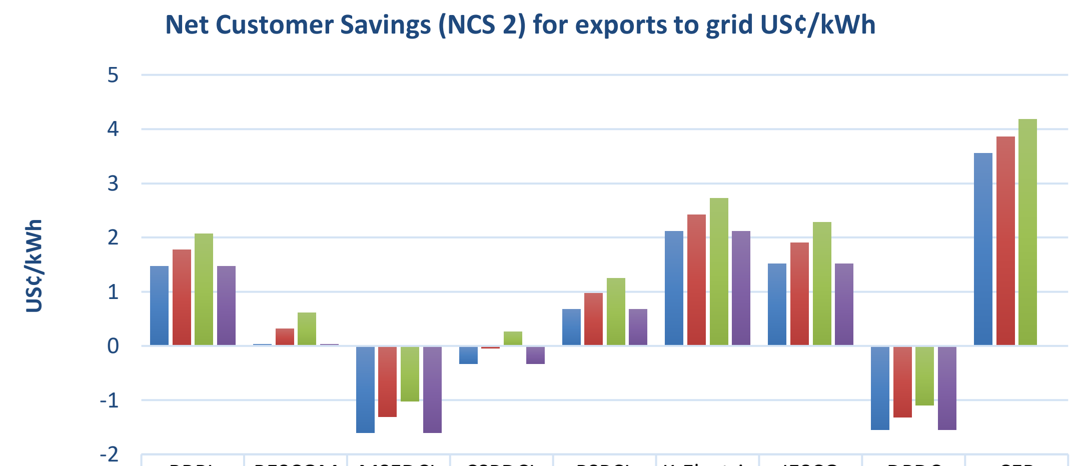
ii. RESCO operators like to serve them due to ‘larger system size’ and better ‘credit’.

In all SAARC Member States, high end[174] residential segments will also find NEM schemes very attractive.

[173] In India, new hydro projects wouldn’t be able to compete with solar or on shore wind. This of course excludes the value of flexibility (hydro generation can be timed within a range) in the grid and its complementarity with solar and wind.

[174] Residential customers with high consumption and in high tariff slabs

This is especially true in Sri Lanka where the residential segment is the largest adopter of NEM. Pakistan utility K- Electric and Sri Lankan CEB offer the highest savings for customers. Pakistan's IESCO ranks third in this respect. Customer savings in DPDC-Bangladesh is comparatively lower. The following figure presents the savings from NEM exports to the grid:



	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
Residential	1.47	0.03	-1.6	-0.33	0.68	2.12	1.52	-1.55	3.55
Commercial	1.77	0.32	-1.31	-0.04	0.97	2.42	1.9	-1.32	3.86
Industrial	2.07	0.61	-1.02	0.26	1.25	2.72	2.28	-1.09	4.18
Agricultural	1.47	0.03	-1.6	-0.33	0.68	2.12	1.52	-1.55	0

FIGURE 31: CONSUMER SAVINGS BY EXPORT OF SURPLUS POWER TO THE GRID

The figure presents a mixed picture. NEM is not remunerative for power exports in MSEDCL, DPDC and CSPDC. In these utilities, customers will limit the capacity so as not to export. In such a case the utilities will lose the benefit of a cheap source of power.

NEM energy export is highly remunerative in K Electric, IESCO (Pakistan), CEB (Sri Lanka), BRPL (Delhi). In these utilities, the customers would like to design capacities to maximize exports of power to the grid. With positive Net Utility Savings (NUS)/kWh of export, these utilities will also benefit from such strategies.

Utilities can play important roles in scaling up NEM implementation for subsidized residential, agricultural, government and public building segments. Agricultural pumping constitutes 20%-35% of the overall demand in Indian states and is a large receiver of subsidies.

The subsidized segments can be served by utility anchored models explained later in the analysis, reducing subsidy bills for the government or the utility.

7.1.2 Utility Savings from NEM

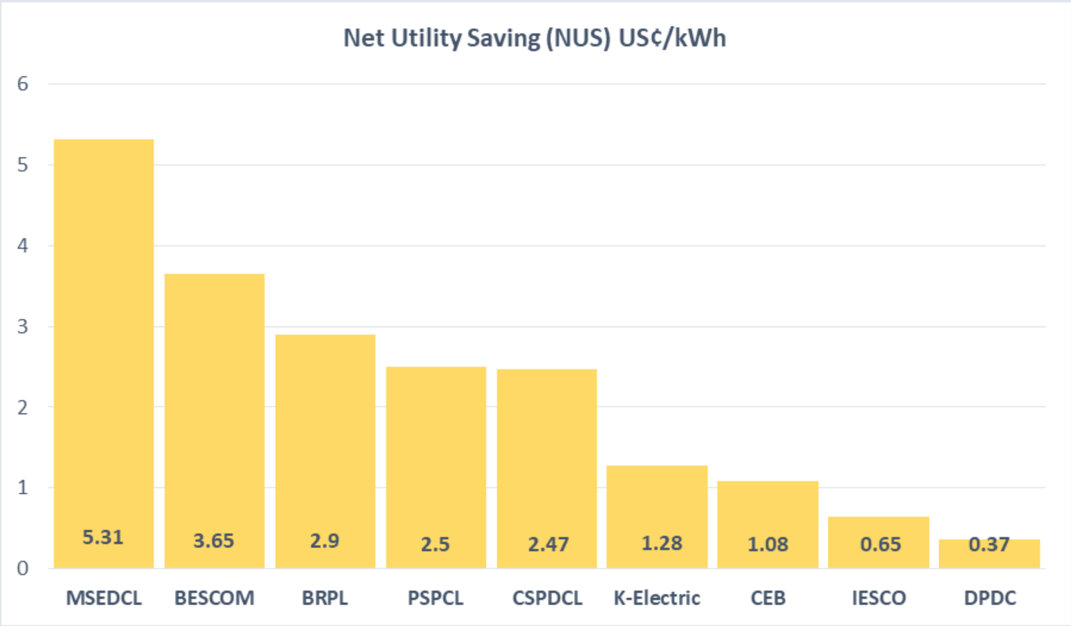


FIGURE 32: NET UTILITY SAVINGS FROM NEM IN THE CHOSEN SAARC UTILITIES

MSEDCL and other Indian utilities have the highest savings per kWh of exported power from NEM. This is primarily because Indian utilities pay the lowest compensation for NEM exports.

With significant savings/ kWh, the utilities should try to maximize exports from NEM facilities. Yet they tend to seek restriction on such exports, driven by their perception that NEM leads to 'lost revenue'. Instead, when they realize that NEM is a cheap source of power, and a means to save T&D loss and infrastructure investments, they would be able to promote NEM aggressively.

7.2. Policy Summary

The following table presents the key policy parameters for the utilities studied in the report.

TABLE 61: SUMMARY OF POLICIES IN SAARC MEMBER STATES

Utility	Min Cap	Max Cap	% of Sanctioned Load	% of DT Cap	Definition of NEM Cap	Compensation for Exports	Social Credit Mechanism	NEM Models
BRPL- NEM	1 kW	No cap	100%	No Cap. Will be set after a load-flow study	• RT, GM, or any other part of premises • Agricultural pumps included for NEM	APPC	VNM, GNM	NEM (TOU credits for commercial and industrial)
BRPL[175]	5 kW	5 MW	100%					
BESCOM	1 kW	• 1 MW- NEM • No cap for NB (AB-AS)	100%	<80%	RT, Agricultural pumps	Regulator defined Tariff		• NE[176] • AB-AS
MSEDCL	1 kW	• 1 MW-NEM • No cap NB (AB-AS)	100%	• <70% • Above 70% allowed based on load study	• Agriculture, RT or any other mounting structure • Energy Storage permitted	• NB (ABAS)- APPC • NEM exports (US¢3.8/kWh)		• NE • NB[177](AB-AS)
CSPDCL	• 1 kW On Site	No cap-NEM	• 100% On Site	<100%	RT, Agriculture Energy storage permitted	Min Tariff discovered in solar auctions		NE

[175] This is for VNM and GNM of BRPL
[176] NE-Net Energy Credit
[177] NB-Net Billing, AB-AS- All Buy, All Sell

Utility	Min Cap	Max Cap	% of Sanctioned Load	% of DT Cap	Definition of NEM Cap	Compensation for Exports	Social Credit Mechanism	NEM Models
	• 500 KW off site		• No Limit Off Site					
PSPCL	1 kW	1 MW	80%	30%	RT, Agriculture	Retail tariff approved by SERC ~ APPC		NE
K Electric	1 kW	1 MW	150% (DC)	15%	3 phase Not defined (e.g. RT, GM)	APPC		NE
IESCO	1 kW	1 MW	150%(DC)	15%	3-phase Not defined (e.g. RT, GM)	APPC		NE
DPDC	Not defined	3 MW (AC)	70%	Not defined	3-phase RT, GM, Facades or any part of premise	APPC		NE
CEB	Not defined	1000 kVA	100%	Not defined Subject to available capacity in DT as assessed in load flow studies.	All behind the meter systems	Tariff (applicable to NB, AB-AS) define as follows: (values in US¢/kWh) • 11.91/kWh (first 7 yrs) • 8.12/kWh (8-20 years) • The tariff for the first 7 years may be revised downwards: ✓ 10.69/kWh <50kW		• NE (NEM) • NB (Net Accounting) • AB-AS (Net+)

Utility	Min Cap	Max Cap	% of Sanctioned Load	% of DT Cap	Definition of NEM Cap	Compensation for Exports	Social Credit Mechanism	NEM Models
						✓ 10.15/kWh (>50KW)		

RT = Roof Top GM = Ground Mounted

i. BRPL and CEB have the most liberal policies. BRPL also has provisions for Virtual Net Metering and Group Net Metering, which allows transfer of credits. This will help maximize the utilization of roofs and encourage the participation of residents with 'no roof'.

ii. CEB offers multiple options for its customers to choose from: NEM, as well as attractive tariff (US¢ 11.9/kWh) based Net Billing (Net Accounting) and All-Buy, All Sell (Net Plus) schemes. This is the most attractive compensation scheme in all the utilities.

iii. MSEDCL, CSPDC and PSPCL have tariff structures that are likely to be perceived as non-remunerative and will lead to the minimization of exports from the NEM system. The utilities would thus lose out a cheap power source.

iv. Utilities define the cumulative cap of NEM capacity as a % of DT capacity and it has been kept between 70%-100% by most. However, K Electric, IESCO have kept the limit to <15% of DT capacity, which is very restrictive and should be liberalized to levels closer to 100%. PSPCL also has kept it to <30%, which needs correction.

v. CEB and BRPL have put away the maximum distribution transformer capacity caps. BRPL has also done away with the maximum 1 MW cap. This is a good practice for these caps are unnecessary.

vi. K-Electric, IESCO and DPDC have limited the NEM scheme to 3-phase customers. This may be good in the beginning, focusing on large customers. However, this should be liberalized to all the customers to encourage mass participation and access to large roof areas.

vii. K Electric and IESCO have let individual systems be sized at 150% of the sanctioned load (DC terms), which is a good norm. In AC terms this would come down to 100%-110% of the sanctioned load depending on the AC:DC ratio of the solar system. This can be supported by the distribution network without a capacity upgrade. Other's utilities have kept it at 100%, except PSPCL (80%), DPDC (70%). These restrictions should be liberalized and brought up to 100% at least.

Afghanistan

Apart from these select cases, in the SAARC region, Afghanistan has incorporated NEM in its National Renewable Energy Policy (NREP) 2015. According to this policy, PV systems between 0.5 kW to 1 MW capacities can be connected under NEM and enjoy the benefits of credit of exported electricity and use of the credit for import from the grid at a future point of time. The maximum capacity permitted is < 100% of the sanctioned load and cumulative capacity in a distribution system is < 50% of the distribution transformer's capacity.

In the country, ~ <1 MWp systems have been set up. It appears that the procedures and rules to operate under NEM are not fully in place. The potential capacity that the government targets is 1.5 GW.[178]

Bhutan

Bhutan has an Alternative Renewable Energy Policy (AREP) which was enacted by the Royal Government of Bhutan (RGoB) in 2013. The AREP defines Decentralised Distributed Generation (DDG) projects which are serving remote villages and rural communities as micro or mini-grids and not envisaged as connected to the national grid. The AREP also defines grid-connected renewable energy projects as those that are connected to the High-Voltage (HV) electrical networks rather than being connected to the Low-Voltage (LV) electrical distribution networks.

But Bhutan is yet to start working on its Net Metering policy and guidelines. Most of the RE in Bhutan is limited to the large and small hydro projects. Considering the decent levels of available solar resource (insolation of 4.63 kWh/m^2/day (Parthan, 2016)) within the country, Bhutan can build on its fellow SAARC Member States' experience in NEM.

Maldives

NEM regulations were first published in Maldives in 2016 and were revised in June 2020 to include clauses to allow customers to obtain payments for the excess amount of electricity generated from the solar PV systems installed by them that are rolled over continuously for 6 months. The major guiding documents for NEM in Maldives are Strategic Action Plan 2018-2023 and Net Metering Regulations published in June 2020. Currently, only solar PV is considered under net metering in the Maldives.

Current installations under net metering regulation[179]:

- Domestic: 639.6 kWp
- Government: 671.11 kWp
- Business: 473.36 kWp

Net-metering tariff arrangement: Units generated from solar PV are deducted from total consumption and then billed under the below tariff structure. If the number of units generated from solar PV exceeds the consumption, the excess units are rolled over to the next month up to 6 months. After 6 months, the customers will be paid for the excess generation. The Maldives, being dependent on fossil-based

[178] Afghanistan GIZ initiative https://www.ez-afghanistan.de/en/story/solar-power-brighter-future
[179] Information as received from the Energy Department, Ministry of Environment, Republic of Maldives

generation entirely (99%), will benefit immensely from the solar NEM, reducing cost, improving environmental footprint and reducing outgo of foreign exchange. Fossil fuel fired generation is very costly in islands due to the high import cost of fuel.

The islands have about 366 MW of diesel generators and the cost of generation is 30-70 US¢/kWh[180]. Under various generation models developed so far, it appears that about 40% of diesel capacity can be competitively replaced by solar PV and Energy Storage System (ESS).[181] Hence, Maldives can set up 150 MW of distributed solar plants with battery storage.

Nepal

Nepal has announced a NEM Policy in 2018. The policy applies to systems between 500 Wp to 1 MWp capacity. The NEM compensation rate is NPR 7.3/kWh. The current capacity under NEM is < 10 MW and solar PV, hydro, wind, etc. technology options are considered. For operational reasons, the consumer classification is: residential systems are defined as 0.5-10Kwp, institutional >10Kwp, commercial >500Kwp, and systems >1MW are considered as utility scale.

World Bank estimates 266 Mn sq.m of roof area available to set up Solar Roof Tops. Another estimate puts solar roof top potential in 20 out of 276 municipalities at 1.3 GWp. The peak load in Nepal is ~1500 MW at present and can reach 5300 MW by 2030 (Bhattarai, 2019). Thus, Nepal can achieve grid penetration levels of ~20%+. About 10 MWp peak capacity has already been installed in the country.

7.3. Business Models

The table below summarizes the status of business models used in the NEM implementation.

Table 62: Summary of Business Models used in the chosen SAARC Member States

Utility	Business Models Used			
	CAPEX	RESCO	Utility Anchored	Community Anchored
BRPL		Commercial and Residential Segment	Being practiced. Useful for Public and Residential buildings.	Being looked at in the context of VNM policy. No concrete program yet.
BESCOM		Now less interest due to policy problems. [182]	Being Practiced. Useful for Public and Residential Buildings	

[180] Ministry of Environment and Energy Maldives, 9-10 May Colombo, SAARC Energy Conference
[181] Progress of JCM and Climate Change Related Policies, Ministry of Environment and Villa College 1 March 2019
[182] Most of these negative policies toward RESCOs have been defined in 2019. This is considered as a dampener by the industry.

Utility	Business Models Used			
	CAPEX	RESCO	Utility Anchored	Community Anchored
MSEDCL		Now the policy is negative for RESCO operators[182]		
CSPDCL		Early stage, low interest of RESCO due to low tariffs	Demand Aggregation- first bid invited	
PSPCL		Now[182] Low interest due to policy constraints	Early stage- for the residential segment	
K Electric		Early stage; Policy needs to incorporate RESCO		
IESCO				
DPDC		Early stage; may take off due to focus of SREDA. A few RESCOs are active	SREDA is designing sectoral programs. May aggregate informally. Not known if DPDC will anchor aggregation.	
CEB		Few RESCOs active. Need to be attracted through aggregation.	Launching a program for low-income residents and public buildings. Not known if CEB will anchor.	

Cell colour legend

(green)	Most business models applied
(purple)	Early-stage progress (few business models applied)
(orange)	No business models applied

RESCOs focus on commercial and industrial customers due to their large size and better credit. They are also interested in Public Building programs, if aggregated, as that presents a better credit profile. In India, RESCOs have raised close to US$1 B private equity to invest in NEM capacities.

Many utilities in India have begun to look at RESCOs as agents accelerating the erosion of their customer base. This is a faulty perspective as highlighted before. However, this view seems to be behind restricting the commercial and industrial segment from using RESCOs in Karnataka (BESCOM). There RESCOs can only be used by the residential customers. RESCOs are also being restricted in Maharashtra (MSEDCL) but RESCOs can however be engaged by all customer segments for only All Buy All Sell (Gross Metering) programs.

Discussions[183] in Bangladesh, Pakistan and Sri Lanka reveal a strong desire to attract and develop RESCO business.

RESCOs will require 'system size' and 'credit' assurance. Attractive system size can be assured through 'demand aggregation' or other 'utility anchored' program designs. 'Credit assurance' can be provided by contracting through public intermediaries such as utilities or super RESCOs (ex: EESL, India). Structures that improve credit profiles include 'on-bill financing' and 'super RESCO' models of utilities. Credit profile can also be improved through Partial Risk Guarantee Facilities (PRGF).

As outlined earlier, utility anchored models help bring down 'costs', and 'risks' while improving design, construction and operational standards of the plants. They also help NEM penetration in those market segments which are traditionally ignored by the RESCOs.

Community solar programs are not being implemented anywhere. Delhi (BRPL) is at an early stage of developing some programs to give effect to the policy of Virtual Net Metering.

7.4. Financing of Net Metering Investments

Financing is a critical input to NEM growth. The following table sums up the status of financing, and the most used financing instruments so far.

TABLE 63: SUMMARY OF FINANCING OPTIONS USED BY THE CHOSEN SAARC MEMBER STATES FOR NEM

Country	Credit Lines	Risk Guarantee Products	Bundled Loans	Project Development Finance	Other
BANGLADESH	ADB (US$185 M) + KfW (US$ 60 M) + Bangladesh Bank (US$23.5 M) Line – IDCOL grants loans at 6% per annum, 10-year tenure with low collaterals (2019)				
INDIA	ADB + NDB (2018) = US$ 750 M line with SBI, PNB, Canara Bank.	Existing risk guarantee products for Energy Efficiency could be used for SME	Home loan providers provide loans for solar roof	Specialized start-ups have come up to finance the development value chain	Efforts at Asset Based Security (ABS) issuance and

[183] With NEPRA in Pakistan, SREDA in Bangladesh and CEB in Sri Lanka

Country	Credit Lines	Risk Guarantee Products	Bundled Loans	Project Development Finance	Other
	World Bank (SBI, 2018) = US$ 625 M line KfW (2019) = US$ 200 M for rural solar and US$ 1.1 B for Roof Top Solar (being developed) Many Commercial Banks and NBFCs stay away due to risk perception.	solar implementation. No insurance product as yet	tops in residences @8%-9%/. The same security as available for a home loan, is taken.	(e.g., component warehouses, EPC contractors, Installation and commissioning service providers and small RESCOs etc.	Warehousing facilities.
PAKISTAN	State Bank of Pakistan (2019) re-financing scheme for NEM solar 6% per annum interest. Some banks have started offering loans. Security still a problem				
SRI LANKA	ADB US$ 50 M (2017) line used to grant loans at 8% per annum for 5-7 years. Indian (Exim Bank) loan of US$100 M-announced in June 2020 (Prasad, 2020)				

Cell colour legend

Green	Most business models applied
Purple	Early-stage progress (few business models applied)
Orange	No business models applied

Credit lines supported by Multilateral Banks are most frequently used during launch of NEM. Credit lines are channelled through established participating banks and most credit lines are low-cost loans (much lower cost than the interest on normal commercial borrowings).

Bundled loans can be used to mainstream solar NEM. These loans can be bundled with home loans or regular commercial loans for customers already using a loan facility. India has permitted residential solar loans to be linked to home loans.

India has defined investments up to INR 300 M (~US$ 4 M) in Renewable Energy (includes NEM solar), as 'priority sector'. It will help drive down the cost and provide larger capital flows to the sector, as banks need to have 40% of their credit to be allocated to the priority sector.

A few start-ups are offering specialized project development finance and uncollateralized loans against cashflows from projects. Based on existing cashflows, green bonds or Asset Based Security (ABS) issuances are being conceptualized.

Attracting private equity can provide a much-needed lever to attract other forms of capital or debt. However private equity is attracted to markets where scalability is seen. Scalability can be demonstrated through aggregation programs.

7.5. Technical Standards

The author has summarized key aspects of Technical Standards, in Annexure 7. Important concerns and strategies regarding NEM operation are summarized below:

i. The 'ability of the systems' to continue operations while grid frequency or voltage vary in a wide band. In LV grids, the voltage tends to rise up quickly as solar generation increases during the day and the loads are less.

   a. India has adopted a wider range below (-20%) the system voltage to ensure that NEM systems don't drop out when the grid requires them to continue to meet increased loads.

   b. The wide bands within which the system should continue to operate, 'fault ride through' capabilities and the ability to respond to grid conditions by adjusting 'active and reactive powers', have been defined in IEEE 1547-2018, which can be adopted in the SAARC Member States.

ii. A study conducted by GIZ in Delhi, regarding the voltage problems faced in the distribution grid while integrating distributed solar, concluded the following:

   a. PV penetration levels of 75% of distribution transformer capacities or more can be undertaken without worrying about voltage problems (high or low).

   b. At penetration levels close to 100%, active power capping of inverters or use of peak shaving energy storage device may sometime be required to manage voltage or overload issues.

   c. Automatic voltage control by tap changing transformers should be implemented in all MV/HV lines for efficiency purposes.

d. A wide area measurement and control strategy, where in, voltage measurement at multiple points in the grid is used for controlling the transformer voltage, can be effective in managing the overload or overgeneration issues.

e. Voltage control capabilities of modern inverters may be used by the grid operator to manage voltage.

As penetration grows, the grid operators would have to invest in digital platforms with AI capabilities to collects data on loads and generation from multitude of prosumers, forecast demand and supply balance, and initiate response from distributed grid resources to keep the grid stable.

7.6. Incentives and Policy Support

India has used capital subsidies (varying between 30-90%) to support the initial efforts at NEM implementation.

Subsidies were quickly withdrawn from commercial and industrial segments, once the LCOE of solar came below grid tariffs. Subsidies have been continued for segments where grid tariffs are low such as small size residential connections (<10 kw) and agricultural segment.

The subsidies were funded by National Clean Energy Fund (NCEF) which was built by collection of cess on coal @ INR 200/T (Seemann, 2014). In case of Delhi (BRPL), it also provides an additional Generation Based Incentive (GBI) for NEM systems. This is available for 3 years.

Commercial and Industrial segments derive benefits from accelerated depreciation (40-60%) and claim of GST on solar investments as input that can be set off against GST payable on their sales. Electricity generation also qualifies for lower income rates (15%), a provision that helps RESCOs.

India also levies low rates of GST on solar projects and solar custom duty on components imported.

In Pakistan, Bangladesh and Sri Lanka, no subsidy provisions exist. However, they have NEM systems exempted from all taxes. They also provide low-cost loans with interest much lower than market rates.

In the case of Bangladesh, where residential and agricultural segments have negative customer savings, some capital subsidy may be useful to make NEM attractive. The subsidy can be withdrawn as LCOE of solar falls and grid costs increase.

7.7. Organization for Scale-up and Eco-system Development

NEM Application Management

Most Indian states have an online process for application submission and processing. However, the level of automation varies and in most cases it is low. The application process times in some states have been monitored and have declined to less than 90 days. However, the performance varies across states.

Online tools for roof top assessment, savings assessment etc. have been provided to help customers make decisions regarding investing in NEM technologies.

Certification of Vendors

Empanelment or certification of vendors has been used in all the four countries to ensure that customers get a certain minimum quality of service. However, the quality of vendor's work varies significantly. Stricter monitoring, regular review of certification, and penalties may be needed to ensure service quality.

Third party certifiers/verifiers may be used to support grid synchronization and verification of final system (e.g., as applied in Singapore).

Market development

Segment focused programs help scale up NEM and kicks start the launch phase by bringing a sizable demand to the market. India has successfully developed programs covering Public Buildings, Railways, Schools, Universities, Public Health Facilities, Defence Infrastructure, Airports, Telecom Towers, Petrol Pumps etc. This helped generate the interest of high-quality investors and contractors.

A similar strategy is being adopted by Bangladesh. SREDA is looking at dividing the country in 8 sectors and developing focused programs for them. In Bangladesh Industry wise focus (e.g., textiles, leather, footwear etc.) and voluntary mandates adopted by the Industry Association may work well.

Sri Lanka has also implemented segmented strategies. In 2020, the country was planning to launch programs for low-income households and public buildings using the loan (US$ 100 M) from India.

Training

India has developed a dedicated program to train technicians called *'Surya Mitra'* (the 'Friends of the Sun'). This program is coordinated by the National Institute of Solar Energy, but the training takes place all across India, in partner organizations. The database of trained technicians is maintained and is accessible to the industry. This makes it easy to hire trained local manpower for project implementation as well as for operations and maintenance.

Training is also available for engineers, entrepreneurs and other stakeholders involved with NEM implementations. International Solar Alliance (ISA), headquartered in Gurgaon, India, can be approached for organizing training initiatives in various member states.

Monitoring and Control of Plants

Indian utilities such as BRPL, BESCOM, MSDECL are implementing central control rooms where performance data from NEM solar plants can be collected and processed to support forecasting and control functions.

Monitoring and automated controls of distributed renewable capacities using digital platforms and AI tools will soon become necessary and also feasible. Utilities need to start planning for such systems.

7.8. NEM Maturity Assessment and Growth Forecasts for reference SAARC Member States

As outlined in section 5.10, there are three phases of evolution of NEM i.e., 'Launch', 'Transition' and 'Growth'. A measure of the evolution is the grid penetration achieved by the NEM, which is defined as a % of the peak capacity of the grid.

The following graph presents the grid penetration levels achieved by NEM in the benchmark utilities:

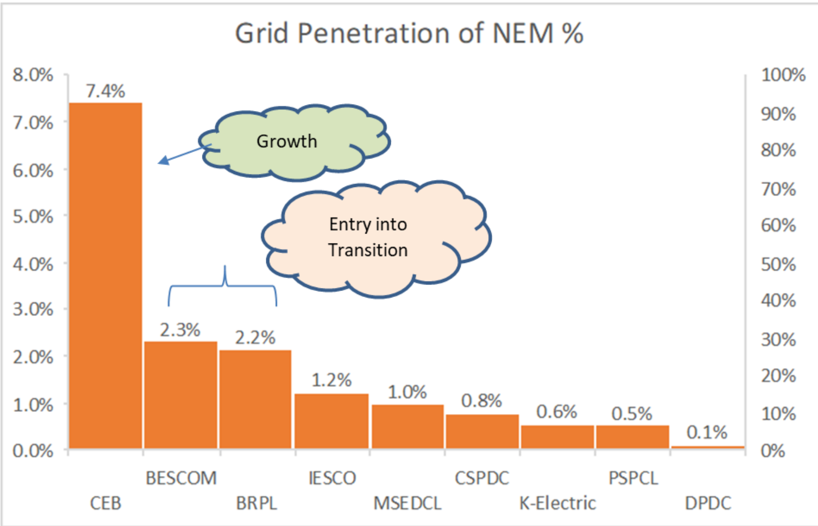


FIGURE 33: GRID PENETRATION ACHIEVED BY NEM (NEM CAPACITY/GRID PEAK LOAD %)

In Sri Lanka, CEB has achieved impressive growth since they reformed the policy in 2016, about the same time as other SAARC Member States. CEB is supported by high grid tariffs, excellent savings for customers, and positive government commitment. Customers have a bouquet of options for net-metering compensations and limits on capacity or exports have not been imposed. This is evidence that good policies and committed implementation can lead to very quick adoption.

Based on the assessments carried out, the author developed a framework for the 'maturity' of the NEM model and its 'readiness to scale up'. The framework is summarized below:

TABLE 64: NEM MODEL FRAMEWORK FOR 'MATURITY' AND 'READINESS TO SCALE-UP'

	Parameter	Value	Rating	Comments
Stakeholder (Government)	NES: Net Economic Saving US¢/kWh	<0 0-1 1-2 2-3 3 +	VL L M H VH	This saving provides a reason for governments to scale up NEM. This may also facilitate decision on subsidies and incentives.
	Government Commitment		VL→VH	Qualitative assessment of government or regulatory behaviour to encourage NEM, enforce discipline (utilities and other stakeholders), announcement of public targets, presence of central institution to

	Parameter	Value	Rating	Comments
				support NEM, procurement of NEM for public, forward thinking on policies etc.
Stakeholder (Customer)	NCS1: Net customer saving from self-consumption) US¢/kWh	<0 0-2 2-4 4-6 6+	VL L M H VH	This saving leads to design of system to maximize self-consumption.
	NCS2: Net customer saving from export to the grid (US¢/kWh)	<0 0-1 1-2 2-3 3+	VL L M H VH	High NCS leads to NEM plants being designed to maximize exports.
	Level of subsidies and incentives		VL→VH	Subsidies/incentives which change the economics for a customer to VH will be rated as VH.
Policy Maturity			VL→ VH	No constraints in the policy on capacity, integration with the grid --- VH Significant constraints on the capacity, high costs of integrating with the grid-- VL
Stakeholder (Utility)	Utility perception and Commitment		VL→ VH	Qualitative assessment of the utility in supporting NEM implementation. Understanding of how NEM benefits the utility etc.
	Utility Organization		VL→VH	Qualitative assessment of speed of sanctions; presence of help desks, web portal and online processes to support NEM; time taken to grant permissions; trained utility staff; NEM progress included as part of performance parameters of the utility; investment in control and monitoring centre.
	NUS (Net Utility saving US¢/kWh	<0 0-1 1-2 2-3 3+	VL L M H VH	High NUS would encourage a utility to support grid exports by prosumers.
Maturity of Eco System			VL→VH	Quality of vendors, RESCOs, technical standards etc.
Availability and Cost of Finances			VL→VH	Extent to which lenders are keen to finance NEM, security needed, perceived risks, availability of risk mitigation covers, and reasonableness of costs in the context of the country.

	Parameter	Value	Rating	Comments
Maturity of Business Models			VL→VH	Rich diversity of Business Models which operate in the country. - CAPEX - RESCOs (different types) - Utility Anchored Models.

The author has used this framework to rate the utilities and got the following results:

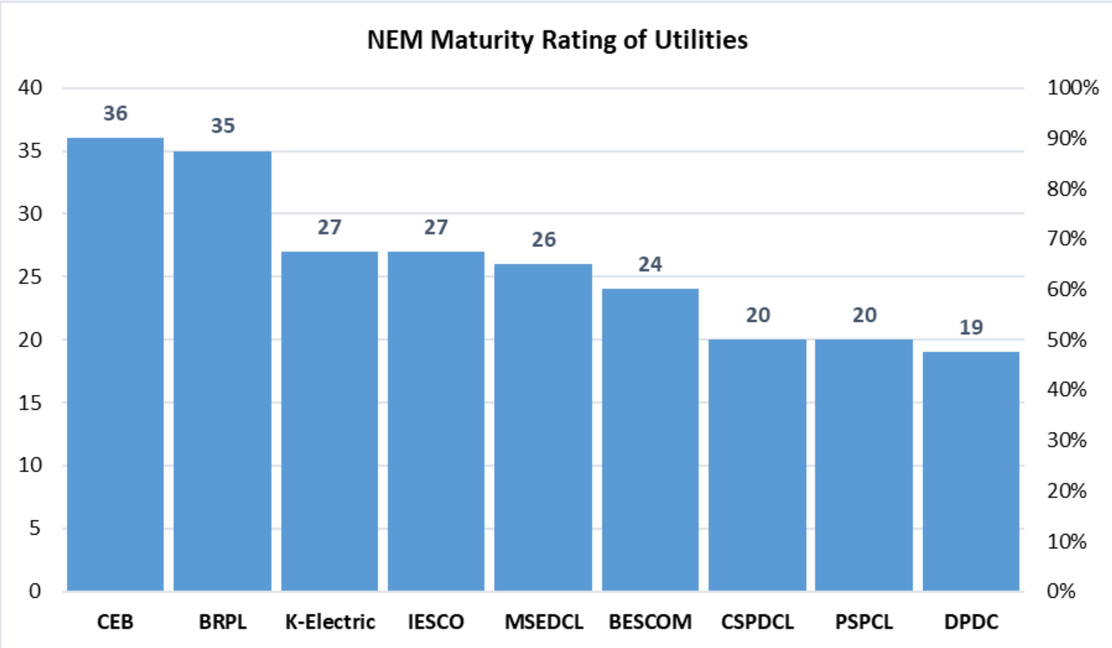


FIGURE 34 : NEM MATURITY RATINGS OF UTILITIES

Author's observations on the ratings, and the likely growth trajectories they will have, are outlined below:

CEB has been highly successful and has grown in last 4 years to ~7.5% of grid penetration. It also has the highest ratings, proving the basis for its success. The key factors of success for CEB have been very high levels of savings (NES, NCS1, NCS2 and NUS) which make NEM very attractive to all stakeholders, committed actions by the government, full range of NEM options to customers (NEM, Net Billing, All Buy All Sell).

CEB can continue on its growth path to achieve 1,000 MW target. It may need additional efforts on the following areas:

Targeted programs for low-income customers (already being planned), use of utility anchored models for aggregation, opening doors for RESCO operators. 'On-bill-financing' can be used to bring in higher share of residential customers. RESCO programs could be designed for subsidized customers and serviced by the subsidy saved or from the income of 'Net Accounting' or 'Net Plus' models, improving technical standards and distribution infrastructure to incorporate high % of NEM in the grid.

i. Adoption of IEEE 1547-2018 or equivalent standards.

ii. Distribution Transformer upgrade, including tap changing of voltage[184], wide area measurement and control system for voltage etc. CEB is facing voltage problems in LV grids, where high penetration has been achieved.

BRPL has the second highest rating. At 2.3% grid penetration by NEM, it has just entered the 'Transition Phase'. The reasons for BRPL's high rating are high levels of savings (NES, NCS1, NCS2 and NUS), commitment of both the utility and the government.

i. The utility has a holistic view of NEM along with other evolving technologies such as smart grids, EVs, energy storage etc. An integrated vision helps NEM solar.

ii. It has a positive appreciation of the benefits of NEM.

iii. It holds intensive interactions with its customers to promote solar.

Also, Delhi has a very progressive policy for NEM. It has elements of Virtual Net Metering and has removed most of limiting constraints on capacity. BRPL can accelerate its 'Transition' and enter into 'Growth' phase in 2-3 years. During this time, further support may come by improving cost-performance of solar PV.

Utilities in Pakistan are next in ratings. K-Electric and IESCO are both blessed with high grid tariffs which result in high levels of savings (NES, NCS1, NC2 and NES). The savings increase with time because of high level of inflation in grid tariffs. Implementation of NEM is a need for customers, due to power-shortage and costs. Pakistan has launched NEM with reasonably good policies. A low-cost financing scheme supported by State Bank of Pakistan provides good support to NEM adoption. However, the country will have to look at reducing the risk perception of commercial banks and expand access of consumers to loans. Utility anchored business models can be explored – specially 'on-bill financing' targeted at regularly paying customers. Super RESCO models may also be successful. Target of 3 GW by 2025 however appears to be ambitious. 3 GW translates to ~10% of grid peak capacity by 2025. Achieving such a target would require significant efforts on policy, keeping the policy direction consistent, financing and business model development. Frequent grid shutdowns and faults may become bottlenecks.[185]

Indian utilities such as MSEDCL, BESCOM are next in ratings. Their ratings are low because of the following factors: Policy revisions which restrict RESCOs from accessing commercial and industrial customers for NEM implementation such as withdrawing the basic net-metering facilities and benefits for consumers, putting up low DT cap barriers, etc. (Parikh, 2019) and a negative bias towards NEM (Chandrasekaran, 2020).

PSPCL rating is low because state policy puts constraints on NEM capacity, export to the grid etc. Also, customer saving levels in PSPCL area are low.

CSPDCL rating is low because of low saving levels for customers.

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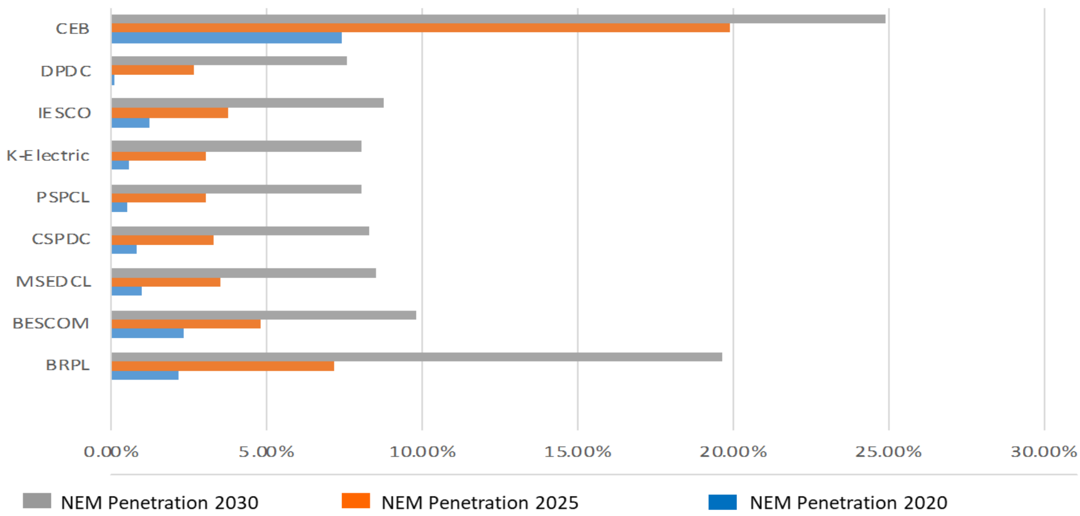
[184] The purpose of a tap changer is to regulate the output voltage of a transformer. It does this by altering the number of turns in one winding and thereby changing the turns ratio of the transformer.

[185] IESCO and K-Electric both experience average grid shutdown of 1.62-1.77 h/day - ref: (NEPRA, 2019)

DPDC has low ratings too. The reason is low savings from NEM (NES, NCS1, NCS2 and NUS). This situation is a result of higher LCOE of solar[186] and subsidized grid tariffs. However, the author observed that the commitment of SREDA is high and the country is designing NEM programs looking at different sectors and areas of the country. Export oriented sectors such as textile mills, foot wear, leather industries, etc. are motivated to set up solar systems because of their sustainability commitments. DPDC's rating therefore may improve with time.

Based on these observations and the past patterns of increase in grid penetration of NEM during 'Launch', 'Transition' and 'Growth' phases, the author arrived at the following forecast of NEM penetration in different utilities.



	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
NEM penetration 2030	19.7%	9.8%	8.5%	8.3%	8.0%	8.1%	8.7%	7.6%	24.9%
NEM penetration 2025	7.2%	4.8s%	3.5%	3.3%	3.0%	3.1%	3.7%	2.6%	19.9%
NEM penetration 2020	2.2%	2.3%	1.0%	0.8%	0.5%	0.6%	1.2%	0.1%	7.4%

Figure 35: Forecast NEM Penetration in Utilities

CEB will reach high levels (25%) of penetration by 2030. Once such high levels are achieved, penetration rates would come down. CEB may encounter lack of space to support NEM solar unless it expands the scope to include floating solar in the NEM scheme.

It should be noted that

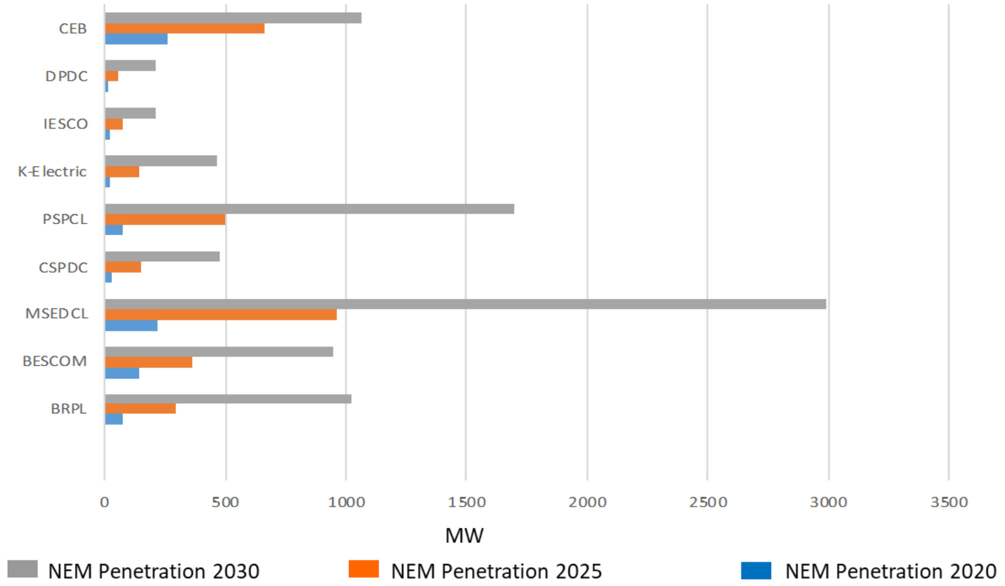
i. This forecast is derived from a qualitative understanding of factors affecting NEM penetration. It is not the result of a precise numerical model.

ii. This uses growth patterns observed in the past. Future may have different dynamics, particularly due to significant improvement expected in cost-performance of solar systems.

[186] The solar resource in Dhaka and surrounding areas is low compared to other Member States.

iii. The factors underpinning a utility may change over time as many of the utilities are at a very early stage of NEM implementation.

Therefore, the results of this forecast should be taken as indicative. Using this grid penetration forecast, the author arrived at NEM capacity forecast as depicted in the figure below.

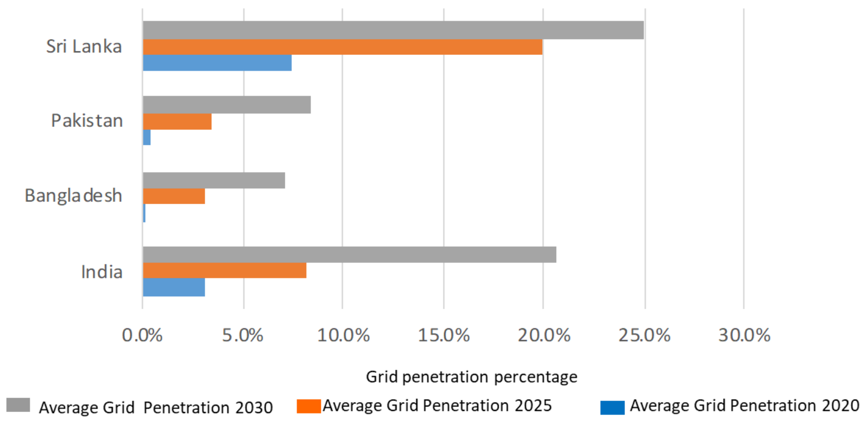


	BRPL	BESCOM	MSEDCL	CSPDCL	PSPCL	K-Electric	IESCO	DPDC	CEB
2030	1,025	944	2,987	473	1,699	467	211	207	1,062
2025	292	363	964	147	501	139	71	56	665
Sep 2020	69	137	216	28	67.8	19	18.45	1.82	260

FIGURE 36: NEM CAPACITIES EXPECTED BY 2025 AND 2030

PSPCL and MSEDCL, being very large utilities achieve high capacities by 2030 despite low NEM penetration rates. BRPL (target 800 MW) reaches its target by 2029 and CEB (target 1,000 MW) reaches its targets by 2030.

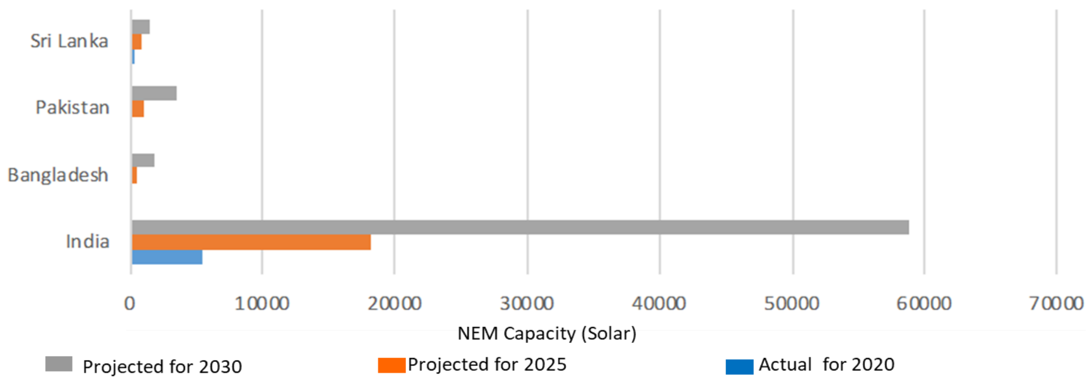
Using the same rationale as for utilities the author forecasted potential grid penetration levels in the four reference SAARC Member States as follows:



	Bangladesh	India	Pakistan	Sri Lanka
Average grid penetration in 2030	7.1	20.6	8.4	24.9
Average grid penetration in 2025	3.1	8.1	3.4	19.9
Average grid penetration in 2020	0.1	3.1	0.4	7.4

FIGURE 37 : GRID PENETRATION OF NEM IN REFERENCE SAARC MEMBER STATES

Using these grid penetration rates and forecast peak loads of the member states, the author arrived at the following capacities for NEM solar in the reference Member States:



	Bangladesh	India	Pakistan	Sri Lanka
2030 (Forecasted)	1,735	58,746	3,411	1,462
2025 (Forecasted)	594	18,110	1,077	916
2020 (Actual value)	15	5,440	94	267

FIGURE 38 : NEM PENETRATION FORECAST FOR THE REFERENCE SAARC MEMBER STATES

This forecast is based on the assessment that India has already entered the transition phase (having achieved grid penetration levels of 3.1% in 2020). India enters into growth phase by 2025. This assumes that the confusion and blow-back to NEM received from some utilities in India, is resolved by 2025. Bangladesh and Pakistan complete transition phases by 2028-2029, having begun their NEM journeys seriously in 2019.

This forecast is conservative when viewed from industry expectations in India which expects 18,000 MW capacity to be reached by 2022 (ref: Figure 25), instead of 2025, as forecasted here.

A brief analysis of the remaining SAARC Member States i.e., Afghanistan, Maldives and Nepal is presented in the following table (Bhutan is not covered for there is no NEM action in the country):

TABLE 65: BRIEF ANALYSIS OF NEM IN AFGHANISTAN, NEPAL AND MALDIVES

Parameters	Afghanistan	Nepal	Maldives
NEM Capacity (est.) 2020 (MW)	1	10	4
Policy	NREP 2015	NEM Policy 2018	NEM Policy 2015
2020 Peak Load MW	2,200	1,500	150
2025 (Forecast)	2,944	2,007	182
2030 (Forecast)	3,940	2,686	222
General Conditions	The country has commitment to renewables. There is significant cost advantage of NEM solar vis-à-vis diesel generators used in the country. Financing, ecosystem, policy and business models are at early stage of evolution	The country has commitment to renewables. Visa-vis hydro NEM solar doesn't possess great cost advantage, although solar is competitive vs DGs used by private consumers due to unreliable grid. Financing, ecosystem, are slightly mature; midway in the launch phase.	The country has significant commitment to renewables, and cost advantage of solar generation vis-vis diesel (98% mix) is very high. BML loans have been made available at low costs to consumers with little security requirements.
Grid penetration Levels 2020	0.05%	0.67%	2.67%
2025	2%	3.5%	15%
2030	5%	8%	40%
NEM MW 2025	44	70	27
NEM MW 2030	197	215	89

It is pointed out that this analysis is based on observed patterns of maturing in other countries and if these Member States resolve and develop underlying areas of policy, finance, business models, grid quality, etc., they can achieve faster growth. The strongest case for fast adoption is in the Maldives.

8. Proposals for Improvements in Net Metering

The author presents its proposals below for the following areas:

i. NEM Policy
ii. Technical Standards
iii. Financing
iv. NEM Implementation processes

8.1. Improvements in Net Metering Policy

In the context of significant positive savings for all the stakeholders i.e., the economy (the state), the customers, and the utility; a policy to remove restrictions on system capacity is recommended. Such a policy is adopted by Germany and Singapore.

The focus of this section is to provide a best practice guide for utilities. The recommendations are for all utilities to adopt these ideas, from wherever they are.

i. The author recommends free choice of Net Metering, Net Billing or All Buy All Sell systems to customers, as this creates the highest probability of meeting the needs of specific customers. For large customers, Time of Use (TOU) credits could be applied.

ii. The author recommends a balanced view on NEM compensation rates to keep it interesting for NEM investors to maximize exports to the grid, while benefiting utilities.

iii. The author also proposes that NEM policy should support all business models i.e., RESCO, Utility Anchored and Community Solar Business Models.

These proposals are explained further in the table below:

Table 66: Suggestions for Improvement in NEM Policy

Area	Suggested improvement	Explanation
	NEM Capacity	
Placement	Solar PV systems (or other accepted NEM technologies) can be placed anywhere within the premises – roofs, ground, facades or any feasible place.	Many NEM policies restrict PV placement only on roofs. This is unnecessary.
Capacity definition	Capacity should be defined by the net AC capacity that is injectable into the grid.	If ESS shaves the peak capacity, the net injectable capacity should be the defining capacity of the system.[187] Designs are normally optimized with DC: AC ratios of 1.0-1.5 hence DC capacities can be much higher. Therefore, it is

[187] Similar idea is accepted in Hawaii. From applicants they seek complete Single Line Diagram to assess the capacity.

Area	Suggested improvement	Explanation
	Energy storage systems (ESS) should be permitted to be part of the NEM system.	important not to define the capacity by DC, which many NEM policies do. The grid only 'sees' the AC capacity.
Min and Max capacities	System capacity < 100% of Sanctioned Load. Beyond this limit, case by case approval may be granted with sharing of grid upgradation charges. Absolute minimum and maximum capacity limits can be removed.	For large roof areas, 1 MW can sometimes be restrictive. India has set up one of the world's largest roof top projects of 11.5 MW in Punjab (Beas). Numerical maxima restrict the utilization of available space.
Cumulative capacity of NEM in a grid	<100 % of DT capacity for automatic approvals. When this cap is reached, hosting capacity assessment would be carried out to grant permission.	Again, the idea is to remove restrictions and permit full utilization of space/ resources available.
NEM Compensation		
Compensation Modes	All three modes permitted: - Net Metering - Net Billing - All Buy All Sell (Gross Metering)	Based on their needs, customers should have a choice to select the most appropriate model.
Compensation for Net Surplus Export to the Grid	(Somewhere) between APPC price and LCOE of solar[188]	The compensation rate should be attractive for customers to set up large capacities and maximize exports. At the same time, because the compensation is < APPC, the utility is acquiring each unit exported at a lesser price than its average. The compensation rates can be gradually adjusted downwards as solar LCOE falls. Too low a compensation rate turns away investors. Indian utilities tend to keep the rate below LCOE of solar. They benchmark it below the tariffs discovered for utility solar in large auctions. This has a negative impact on NEM.

[188] Based on the premise that APPC is higher than solar LCOE, which is the case in the reference SAARC Member States

Area	Suggested improvement	Explanation
Business Models		
Business Models	RESCO Utility Anchored Business Models Community Models Are permitted in the NEM Policy Based on contractual arrangements of investment, operations and sales management between parties (roof owners, consumers and investors) Electricity Credits (value, kind) can be transferred to designated parties. For utility anchored models, the principles of transparency and reasonable margins, fairness and equitable treatment of customers may be set. Detailed procedures for the implementation of utility anchored models can be defined using these principles.	Such a policy will greatly help make NEM accessible to a wide range of customer segments. Depending on the context, business models suit the special needs of a few customer segments. No business model suits the needs of all segments. 'Demand Aggregation', 'EPC Aggregation' Utility Anchored Models may be introduced first. 'On Bill Financing' and 'Super RESCO' models may be introduced later during the growth phase.
Subsidies and Incentives	For subsidized segments such as low paying residential or agricultural segments, subsidies could be given: - Capital subsidy - Generation based incentives These could be given for a time till the tariffs are corrected or till LCOE of solar falls to justify market-based investments in NEM.	

8.2. Improvements in Technical Standards and Codes

As NEM penetration of the grid increases, the grid experiences stability issues. These variations may arise due to rapid changes in loads and power generation. As explained in the analysis of reference SAARC Member States, the current standards have, in certain cases, tight operating bands for frequency and voltage which may lead to frequent tripping. The tripping may reinforce the effects of the initial fault, leading to a rapid escalation of instability. For example, if the load increases, voltage may fall. If in response to voltage drop, NEM capacities are shut down, load and generation gap will further increase, worsening the situation.

At some appropriate time, as the NEM penetration reaches significance (say 5% of grid penetration), the following improvements in grid interconnection code and grid infrastructure will need to be introduced:

i. Temporary remote control over power injection from NEM plants, limiting output to 60%, 30% or 0%. Automatic reduction of power output, once frequency goes past a limit (+0.4%/ 50.2 Hz).

ii. Remote setting of reactive power values from the NEM system to provide grid support, in response to grid conditions.

iii. Fault-ride through capabilities

iv. Tap changing of voltage in distribution transformers in response to signals from the grid.

v. Wide area measurement of voltage to provide appropriate signals to distribution transformers and to the NEM systems.

8.3. Financing

Credit lines are already providing the base structure for Bank Finance. Commercial banks find NEM investments risky. Key risks include 'risk of access to the site'[189] and 'credit risks'[190] of the customer. The paragraphs below outline a few financial instruments that may help address 'risks' and 'access to finance' issues.

Utility as the channel for NEM finance

While RESCO's serve large commercial and industrial customers, utilities could channel finance to Small and Medium Enterprises (SMEs), residential customers, schools, small market places, offices etc. The utilities have information on their bill payment behaviour. The customer information available with them could be used to assess customer 'credit worthiness'.

For such customers, the utility can use on-bill financing or super RESCO models, which will reduce 'credit' and 'access' risks. Utility has stronger 'lever' to collect, as they have control of customer's electricity supply.

The utility can receive re-finance from banks or through bond issuance. In this way utilities can intermediate the flow of finance to small users, so far neglected. Utilities can have private RESCOs at the back end to serve their RESCO or on-bill-financing contracts with the customers.

Bundled Finance, Priority Finance norms.

SMEs and Residents can use their existing loan relationships. SMEs can use their working capital finance

[189] Being inside customer premises, NEM systems are difficult to access.
[190] NEM customers are 'many' and 'small sized'. It is difficult to collect from such groups.

providers to seek solar roof top loans. NEM solar is covered as a priority sector lending in India and will be of interest to commercial banks for their existing clients. They could launch special campaigns to promote NEM solar investments.

In the same way, home loan providers could extend the loan to solar NEM. It could be given as a top-up loan on the active home loan. Similar ideas could be introduced in other SAARC Member States.

Re-financing of debt for operating portfolios, through bonds

For example, issuance of Green Bonds or Sustainable Impact Bonds (SIBs) serviced by the cashflows of a solar roof top portfolio. These can be structured as Asset Based Securities (ABS). A few solar financing start-ups have used SIBs.

Risk mitigation products

Partial Risk Guarantee Funds have been used in the energy efficiency area in India (e.g., Small Industries Development Bank of India (SIDBI) with the support of the World Bank). The same facility could be extended to solar roof tops, especially focused on SMEs. Or a new fund could be developed. Similar ideas could be explored in other Member States.

Warehousing Facility

The warehousing facility provides loans during project development. Once the project is commissioned and its operating performance is proven, the operating assets are ring-fenced and their cashflow is used to issue green bonds. The money so released is utilised to develop new projects.

Islamic Finance

Islamic finance products equivalent to ‘leasing’ or ‘deferred payment structure’ which could be used to support small borrowers. Such products would be useful in member states like Afghanistan, Bangladesh, Maldives, Pakistan, etc.

8.4. Process for Net Metering Approvals and Implementation

The key aspect of the process is the ‘degree of automation’ and ‘the time taken’ to grant approvals.

Using a review of processes used by a few benchmark utilities, vision for a high quality NEM approval process is outlined below:

i. The process has a high degree of automation. This includes document uploads, validation of customer identity, vendor identity, availability of data on location of the customer premises, meter numbers, customer loads, consumption patterns, tariffs, billing, payment track record etc.[191]

ii. The customer interface displays important grid details such as NEM capacity already sanctioned, waiting for sanction, the capacity of the distribution grid, grid availability data, NEM capacity that can be further granted. This is available for each meter owned by the customer. The customer at

[191] Utility bill payment track record is sometimes used as criteria to grant NEM permissions.

this stage can make an assessment of his income from the NEM, based on his consumption pattern, forecast generation pattern at the location of his premise, tariffs and export compensation available under NEM, the expected cost of his system etc. He can create scenarios which maximise his returns.

iii. The NEM technical profile (specifications of the system, capacities of key components, Single Line Diagram- SLD etc.), is inserted by either the customer or the customer's vendor. Vendors need to be empanelled/ registered with the utility.

iv. Based on the data entered, and the technical profile of the grid, the first, in-principle sanction can be given. Queries on the points which need further investigation are raised. The queries can be responded to online. If responses are found acceptable, up to a certain size of the system, the sanction-to-build is granted on line.

v. For larger systems and for cases which need load assessments, a third-party verifier visits the site, collects photos, data, and observations, and submits report to the utility online.

vi. Based on this report, the sanction to build is granted. A decision support for helping the evaluation of the technical data submitted is built into the system.

vii. NEM agreement is then signed between the utility and the customer, on line.

viii. The customer notifies the completion of the system.

ix. The built system, up to a certain size, is allowed to be synchronized based on self -certification (of vendor and the owner) that the system has been built as per existing codes and the specifications submitted to the utility. Photographs, SLDs and other verifiable data may be submitted by the vendor, for the as-built system. For larger systems a field visit by an independent verifier is made and submitted to the utility.

x. The synchronization is accepted and metering starts.

xi. The time taken to grant the first 'in-principle sanction', the 'sanction to build' and the 'sanction to start' the NEM system are monitored and reviewed by the utility management and the performance is visible to the customers and the public.

xii. All the documentation, data uploads, decisions made and basis of the decisions are all recorded online, except for the physical site visits.

xiii. The utility web portal also facilitates the following:

xiv. Facilitates development of a feasibility report, using the data available or submitted to the system

xv. Apply for loans to banks – they may be present on the portal.

xvi. Apply or register for subsidies and incentives to the government.

The system registration number with the utility can be the common link.

In the reference SAARC utilities, the process has much lower level of automation vis-à-vis the process vision outlined above.

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Annexure

Annexure 1: California, USA NEM Profile

California is one of the pioneers of NEM across the globe and has one of the longest running NEM programs. The NEM program was established by the California Senate Bill in 1995 and has been running with many changes, with the latest being introduced in 2016[192].

The state has 4 major players that formulate, regulate and implement the NEM program – the regulator (California Public Utilities Commission) and the three major utilities (PG&E, SDG&E, SCE). California allows a diverse range of RE under its NEM program: solar, wind, biogas, and fuel cell generation for all the customers (residential, commercial, industrial, and agricultural).

RE system capacity limits

Removed the cap of 1 MW and now the customer's onsite load is the limit for NEM capacity.

NEM models allowed (CPUC, 2020)

- Net-metering: Participating customers receive a bill credit for excess generation that is exported to the electric grid during times when it is not serving onsite load, offsetting energy costs. On a month-to-month basis, bill credits for the excess generation are applied to a customer's bill at the same retail rate (including generation, distribution, and transmission components) that the customer would have paid for energy consumption according to their otherwise applicable rate structure
- Virtual Net-metering (VNM): VNM is a tariff for multi-unit customers, like apartment complexes and office buildings that generally have one system, multiple users. It is a program for residential and commercial customers. The owner or property manager determines what percentage of the generation benefit will be allocated to each tenant/unit
- NEM Aggregation (NEMA): NEMA allows an eligible customer-generator to aggregate the electrical load from multiple meters, and NEM credits are shared among all property that is attached, adjacent, or contiguous to the generation facility. A customer-generator must be the sole owner, lessee, or renter of the properties in order to utilize NEMA

Compensation for excess generation

The bill credits are on a month-to-month basis and the final true-up and settlement happens for every 12 months. The excess generation is eligible for two types of compensation:

- Net Surplus Compensation (NSC): Any balance of the surplus generation is trued-up at the end of 12-month billing period for the NSC rate. NSC rate is based on a 12-month rolling average of the market rate for energy. That rate is currently approximately US$0.02 to US$0.03 per kWh (varies from utility to utility).

192 'Decision adopting successor to net energy metering tariff' available at https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K181/158181678.pdf

- Renewable Energy Credit (REC) (SDGE, 2020): The generation from renewable energy source is eligible for REC, including the excess RE generation under NEM. The RECs, associated with the net surplus electricity, are to be transferred to the utility and will be compensated at a rate that is updated annually called the Renewable Attribute Adder.

Tariff expiration/ PPA period (Transmission Code, 2016)

The NEM tariff in California is made available for 20 years for the customers from the original year of interconnection of the customer's system.

Hosting capacity

California adopted iterative methodology for its hosting capacity analysis, prioritizing 'accuracy' as absolutely paramount in interconnection decisions (Stanfield, 2018). Also, there is no limitation on the amount of generating capacity or number of new eligible customer-generators under the NEM program (Legislative Counsel's Digest, 2020) but all the generating facility capacity not to exceed 15% of the maximum loading of the line section (Edison, 2018).

NEM fees/ charges[193]

Generating facility type	Interconnection request fee	Supplement review fee	Detailed study deposit	Additional commissioning test verification	Non-bypassable charges	T&D upgrades cost
NEM > 1 MW	US$ 800	US$ 2500	For < 5 MW: US$ 10,000-US$ 15,000 For > 5 MW: US$ 50,000 + US$ 1,000 per MW, up to max of US$ 25,0000	US$ 150/ person hour	2-3 US¢/kWh	✓
NEM <= 1 MW	US$ 75-US$ 145*	X	X	X	2-3 US¢//kWh	X

* *Low-income single families under SASH program (system limits 1-5 kW) exempted from Interconnection Request Fee*

Technical and interconnection requirements (SCE, 2018)

Particular	Details
Voltage flicker	Any voltage flicker at the point of common coupling (PCC) must not exceed the limits defined in IEEE 519, Rule 2, Rule 21
Inverter	Must meet all required criteria specified in Rule 21, IEEE 1547, UL 1741, UL 1741 SA,
Anti-islanding	A voltage and frequency sensing and time-delay function to prevent the Generating Facility from energizing a de-energized grid within two seconds of the formation of an unintended island and reconnecting when conditions are normal and stable for at least 60 seconds (IEEE 1547-4.2.1 and IEEE 1547-4.2.2)

193 Rule on Generating Facility Interconnections available at https://www.sce.com/sites/default/files/inline-files/Rule21_1_1.pdf

Particular	Details
Voltage relay trip	V < 50 V (1 second ride-through, max trip time: 1.5 seconds) to V>= 120 V (max trip time: 0.16 seconds) – 6 levels defined in total
Frequency relay trip	F <= 57 Hz (no ride-through, max trip time: 0.16 seconds) to F > 62 (no ride through, max trip time: 0.16 seconds) – 5 levels defined in total
Sizing Requirements for RE paired with Energy Storage	Inverter rating < 10 kW: no sizing restrictions or requirements for the storage device Inverter rating > 10 kW: maximum output power of the storage device cannot be larger than 150% of the NEM Renewable Electrical Generating Facility's (REGF) capacity
Harmonics	Harmonic current limits as outlined in IEEE 519-2014
Warranty	Warranty of 10 years compulsory for all equipment and installation

Targets

Renewables Portfolio Standard (RPS) requires California utilities to ensure that 50% of their retail sales must come from RE by 2030 (NREL, 2020).

Incentives

PACE (Property Assessed Clean Energy) Program for commercial and residential customers: RE and EE projects of any property owner/dweller gets access to low-cost financing (subject to selection after scrutiny of application) and the property owner pays back over certain time-period of 10-20 years

Low-income single-family homes given access to solar PV installations through California SASH program; system limits 1-5 kW. Installations will be provided a one-time payment under the Expected Performance Based Buydown (EPBB) structure to help reduce the cost of installation. Incentive payments are issued by the utility (10% of California Solar Initiative funds set aside for programs assisting low-income households) incentive level is US$ 3.00/W

Low-income multiple family homes given access to solar PV installations through California MASH program. Incentives of US$ 1.10-1.80/W

Residential Renewable Energy Tax Credit of 26% for the qualified RE systems (Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Wind (Small), Fuel Cells using Renewable Fuels) installed

Business Energy Investment Tax Credit of up to 30% off qualified system and installation (eligible techs in the link) for commercial, industrial, agricultural, etc. units

Partial Sales and Use Tax Exemption for Agricultural Solar Power Facilities: PV systems used to provide power to farm equipment are eligible for a partial exemption for state sales and use taxes

Renewable Market Adjusting Tariff (Re-MAT) for Small Renewable Generation: An Applicant that is a net energy metering (NEM) customer can only participate in Re-MAT if the Applicant terminates its participation in the NEM program. Through Re-MAT, the utility will offer power purchase agreements to distribution level renewable projects sized at 3 MWs or below from three product categories; baseload (typically including geothermal, bioenergy and hydro), peaking (typically including solar) and non-peaking (typically including wind). The starting price for these resources will be US$89.23/MWh (before time of delivery adjustment). Customers can select a contract term of 10, 15, or 20 years.

ANNEXURE 2: HAWAII, USA NEM PROFILE

Since its inception in 2001, the NEM program of Hawaii was a success with over 60,000 installations. This program has undergone many changes and now the NEM program has been replaced with new rooftop PV programs in 2015.

Permitted RE definition

Hawaii allows all types of renewable technologies but has relatively focused more on the deployment of solar PV as the distributed energy source.

RE targets (NREL, 2016)

Hawaii is one of the few states with a 100% binding renewable portfolio standard (RPS) - each utility company that sells electricity for consumption in Hawaii to source 100% of its net electricity sales from renewable energy by December 31, 2045.

RE system capacity limits

100 kW for the three Hawaiian Electric Company's customers; 50 kW for KIUC customers (NREL, 2016).

NEM business models

- Customer Grid-Supply (CGS): Participants receive a PUC-approved credit for electricity sent to the grid and are billed at the retail rate for electricity they use from the grid. This program has currently reached its intended capacity and the new applications are held in queue, until space in the program becomes available (Hawaiian Electric, 2020).
- Customer Grid-Supply Plus (CGS Plus) (Hawaiian Electric, 2020): Participants can export energy to the electric grid throughout the day. CGS Plus also requires the use of equipment that allows the utility to manage output to maintain safe, reliable grid operation. In the event of a significant grid emergency, the utility can disconnect the system from the grid, but only after almost all other generation sources (including the utility's own power plants) have been curtailed. The CGS Plus program has a capacity limit that varies by utility.

The available capacity is shown here and CGS Plus+ will remain open until the installed capacity is reached:

Utility	CGS Plus Program Capacity
Oahu	35 MW
Maui County	7 MW
Hawaii Island	12 MW

- Customer Self-Supply (CSS) (Hawaiian Electric, 2020)*:* Participants do not export power to the utility grid. These systems can incorporate the use of energy storage devices, like batteries. All power produced by the customer either must be used as it is produced or stored for later use. They are eligible for expedited review and approval even in areas with existing voltage limitations.

- Smart Export (Hawaiian Electric, 2020)*:* Smart Export allows customers to install a private rooftop solar or other renewable system and a battery energy storage system. Customers are expected to charge the battery storage system from the rooftop solar or other renewable system during the daylight hours (0900 – 1600 hrs) and use that energy to power their home in the evening. However, customers can receive a credit for any energy exported to the grid during the evening, overnight and early morning hours

Compensation for excess generation

The different business models in Hawaii, stated above, have different compensation mechanisms for the excess RE generation by the customers. Though these vary from FIT to fixed tariff based on time of export, the final financial/monetary benefit after true-up is not available in Hawaii.

- CGS: CGS provides eligible customers with credits on their electric bills for excess electricity sent to the grid. These export credits may only be used during the month they are generated. Excess monthly credits expire with the utility cost reductions benefiting all customers. The credit rates (compensated against the retail grid consumption rates) are in the range of 15.07-27.88 US¢//kWh (varying across the utilities)
- CGS Plus: Customers receive a monthly bill credit for energy delivered to the grid, which helps to offset the cost of energy pulled from the grid when the system is not producing enough energy to meet the household demand. Export credits will be trued-up on an annual basis and any remaining credits left over at the end of the year expire with the utility cost reductions benefitting all customers. The credit rates (compensated against the retail grid consumption rates) are in the range of 10.08-20.80 US¢/kWh (varying across the utilities)
- CSS: Credits are not available for CSS systems and customers are not compensated for any export of energy
- Smart Export: Customers can receive a credit for any energy exported to the grid during the evening, overnight and early morning hours. Energy exported to the grid during the daylight hours is not compensated. The export credits during the different times are:

12 am to 9 am	9 am to 4 pm	4 pm to 12 am
11-20.79 US¢/kWh	No credit	11-20.79 US¢/kWh

Export credits will be trued-up on an annual basis and any remaining credits left over at the end of the year expire with the utility cost reduction benefitting customers.

NEM credit carry forward period

- CGS: No carry forward. To be utilized within the generation month
- CGS Plus: Carried forward for a 12-month period, after which it expires

- Smart Export: Carried forward for a 12-month period, after which it expires

Tariff expiration/PPA period

Not available

Interconnection application process

- Upon request, the utility provides Interconnection Application, technical standards, and an appropriate interconnection agreement to the customer within 5 days
- Customer submits completed Interconnection Application along with supporting materials within 15 days
- Utility conducts technical review, which may include Initial Technical Review (within 15 days), Supplemental Review (only if needed, within 20 days), and Interconnection Requirement Study - IRS (only if required, within 150 days)
- Customer works with utility to finalize single-line diagram, relay list, trip scheme and settings so that the customer can complete Facility Equipment List
- Utility identifies any interconnection facilities that will be needed that will be owned by the utility and customer also completes insurance coverage within 15 days
- Customer and utility execute an interconnection agreement within 5 days

Process automation

- Entire application process is automated (includes vendor selection, drawings, spec sheets, etc.)
- The level of automation achieved in the subsequent steps of technical reviews, identifying interconnection requirements, execution of agreement is not known

Interconnection charges

- There no application and processing fees or charges during the process of interconnection. Even the initial technical review is of no cost. If additional study or review like IRS is needed, the cost of such additional review will be borne by the customer
- The customer shall pay to the utility for utility Interconnection Facilities, Review of Facility, and Review of Verification Testing (Maui Electric Company, 1988)

Grid codes and standards

- Hawaii has adopted the IEEE 1547-2018 standard for customer's generation systems to interconnect and operate
- The qualified equipment list has been made available to the public: https://www.Hawaiianelectric.com/documents/clean_energy_Hawaii/qualified_equipment_list.pdf

Grid unavailability or back-down request (Maui Electric Company, 1988)

- For emergency work on grid or grid disturbances, the customer's generating facility can be disconnected with or without prior intimation and the disconnection will remain until the utility is satisfied that the endangering condition or glitch has been corrected. And within 15 days (or a mutually agreed upon period) of this, the utility shall provide the customer with written documentation of the occurrence and nature of the utility's work and/or emergency condition
- No compensation is provided due to the generation loss during this downtime

Other operating requirements

Operating requirement	Description
Synchronization	At the Point of Interconnection, the frequency difference shall be less than 0.2 Hz from rated frequency, the voltage difference shall be less than 5% of nominal voltage, and the phase angle difference shall be less than 10 degrees
Voltage regulation	The generating facility shall not attempt to control or regulate the utility system voltage while operating in parallel with the utility distribution system. The generating facility shall not degrade the normal voltage provided by the utility outside the limits stated in the utility tariff (± 5% of nominal voltage)
Unintended islanding	Shall be equipped with protective equipment designed to prevent the generating facility from being connected in parallel with a de-energized utility line. Must automatically disconnect from the utility distribution system upon loss of utility source, and remain disconnected until the voltage and frequency have stabilized for at least 5 minutes, unless earlier directed by the utility
Frequency disturbances	Shall set protective equipment to (1) disconnect the generating facility within 10 cycles if the frequency exceeds 60.5 Hz, (2) be capable of time delayed disconnection of 300 seconds with the adjustable underfrequency setting set to 57 Hz, and (3) disconnect the generating facility within 10 cycles if the frequency is less than 57.0 Hz
Power factor	Shall operate at a power factor ≥ 0.85 (lagging or leading)
Voltage flicker	Shall not exceed the limits defined in IEEE Standard 1453 2015 (or latest version)
Harmonics	Shall not exceed the limits stated in IEEE Standard 519-2014 (or latest version)
Direct current injection	Shall not inject DC current greater than 0.5% of the full rated output current
Voltage disturbances	V < 60 V (clearing time-10 cycles), 144 V < V (clearing time – 10 cycles); 5 ranges defined in total

Hosting capacity

- In the early days of rooftop PV, i.e., pre-2013, the historical utility rule-of-thumb for synchronous generation was 15% of the circuit peak load. Utilities only tracked circuit peaks for planning

- In 2013, the utility established a new feeder penetration metric that was '% of Daily Minimum Load (DML)'. Studies were carried out at PV penetration levels of 50%, 75%, 100%, and 120% of the DML and these gave the utility the confidence to raise (conservatively) their PV hosting limits system-wide across all circuits without conducting expensive/lengthy project specific interconnection requirements studies – The modelling and lab tests revealed that higher than acceptable transient over-voltages (TOV) may occur when PV penetration exceeds 120% of DML
- Lab testing of inverters determined TOV was solvable even when the penetration levels 250% of DML. Inverters must disconnect from the grid within 1-cycle (16 ms) if it detects that its terminal voltage has reached 120% of its nominal voltage. TOV inverter performance requirement added to Grid Code
- In 2015, individual circuit by circuit modelling of the distribution grid was performed to determine feeder specific Hosting Capacity on the Hawaii power grids to enable efficient interconnection process, proactively mitigate impacts and also check the feasibility of achieving beyond the 250% DML hosting limit
- Currently PV penetration on some circuit lines exceeded 300% of DML
- The map of the % of hosting capacity available has been made available to the public: https://www.Hawaiianelectric.com/clean-energy-Hawaii/integration-tools-and-resources/locational-value-maps/oahu-locational-value-map-(lvm)

Incentives (NREL, 2020)

- Farm and Aquaculture Alternative Energy Loan: Agriculture and aquaculture solar PV projects are eligible for 3% and 5% interest rates loans, respectively, for up to 85% of the project cost (capped at US$ 1,500,000)
- Solar and Wind Energy Credit: Commercial system owners are eligible for a tax credit worth 35% of the system's value. The Hawaii tax credit is capped at US$ 500,000 for commercial properties. Solar system owners are also eligible for a rebate for the value of the state's capital goods excise tax paid on the system (4% of system cost)

Annexure 3: Germany NEM Profile

Permitted RE definition

Germany allows mine gas (methane) and all RE

- Hydropower including wave, tidal, salinity gradient and marine current energy
- Wind, solar radiation (rooftop and ground-mounted), geothermal
- Biomass including biogas, biomethane, landfill gas and sewage treatment gas and from the biologically degradable part of waste from households and industry

RE targets (Wirth, 2020)

Goal to increase the share of renewable energies (RE) to 65 per cent of gross electricity consumption by 2030

RE system capacity limits

100 kW for FIT, > 100 kW (market premium auctions, can participate in tenders which are limited annually), > 750 kW (must participate in tenders, limited annually)

NEM business models

- Self-consumption and export: Plant operator sets up own plant (of < 100 kW) and excess generation is eligible for FIT
- Direct marketing: The plant operator must sell his electricity directly (allowed for plants till 750 kW), i.e., to a third party by a supply agreement or at the stock market, and claim the so-called market premium from the grid operator
- Utility-anchored
    - Auctions for systems of bigger size (> 750 kW) but at a limited volume annually. Entire generation to be exported, no self-consumption allowed

Compensation for RE generation

- Feed-in-Tariff (FIT) (Sternkopf, 2019): FIT is available for all the electricity that is not consumed in the immediate vicinity of the installation and that is fed through grid (for plants < 100 kW). Plants > 100 kW are eligible in exceptional cases for a feed-in tariff reduced by 20%, however no longer than 3 consecutive months and no more than 6 months within a calendar year. For systems > 10 kW, 40% of EEG Surcharge (netztransparenz, 2020) is levied on self-consumption (Wirth, 2020).
- Market Premium (Sternkopf, 2019): Tenders for RE systems through which a market premium that is to be paid for the renewable electricity is discovered. Those plants left out after auctions are paid a classical market premium - calculated as the difference between a fixed feed-in and the monthly market value of the sold electricity. The buyer to have remote control for curtailment or call-up for feed-in
- Landlord to tenant supply premium: For electricity from solar installations with a total installed capacity of up to 100 kilowatts which are installed on or in a residential building as long as it has been supplied to a final consumer and consumed within the premises and no feeding to the grid. This support is lower than the feed-in tariff, but other cost factors like network charges, taxes etc. are avoided

Tariff expiration/ PPA period

20 years for all compensation mechanisms

Interconnection application process

- Those interested in feeding in electricity apply for connection to the grid ("grid system connection request")
- The grid operator shall, without delay, provide those interested in feeding in electricity with a precise timetable including the procedural steps for processing their connection requests and a list describing all information required by the grid operator to determine the grid connection points or to plan the expansion of the grid
- Everyone interested in feeding in electricity shall submit the required information to the grid operator
- The grid operator shall, without delay and within 8 weeks after receipt of the information, submit to those interested in feeding in electricity a timetable for establishing grid connection, all information required by those interested in feeding in electricity to test the grid connection point, a comprehensible and detailed estimate of the costs the plant operators will incur for the establishment of grid connection and the grid system data required to test grid compatibility and the necessary information on the technical requirements which the plant has to fulfil
- The grid operator assigns a connection point and makes a connection offer
- The grid operator and the plant operator conclude a connection agreement (optional)
- The plant is connected and electricity is exported to the grid
- (The EEG does not specify any deadlines by which the grid operator shall carry out the grid stability test. This test may take three weeks to three months, depending on the number of the grid operator's staff)

Process automation

- The procedure and the required application forms are usually published on the grid operator's website

Interconnection charges (RES-Legal, 2019)

- The plant operator bears the costs of connecting the plant to the most closely located or technically and economically most suitable grid connection point as well as the costs of the measuring devices necessary to record the electricity transmitted and received
- If the grid operator assigns to a plant a grid connection point other than the most closely located or technically and economically most suitable one, the grid operator shall bear the resulting incremental costs

Grid priority

- Plants for the generation of electricity from renewable sources shall be connected to the grid as a priority, i.e., prior to plants that generate electricity from traditional sources[194]

[194] Renewable Energy Sources Act (EEG 2017) - Section 8 (https://www.bmwi.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf%3F__blob%3DpublicationFile%26v%3D3)

Grid unavailability or backdown request[195]

If the revenue lost in a year due to grid system bottleneck exceed 1% of the revenues of that year, the operators affected by the curtailment are to be given 100 per cent compensation from that point in time

Grid Codes (VDE FNN, 2018): Germany follows BDEW, VDE 4105 (for low voltage), VDE 4110 (for medium voltage), VDE 4120 (for high voltage) guidelines, which are available on a purchase-basis. These have key innovations like:

- Dynamic network support: In future, new power generating plants will have to remain on grid during short voltage drops or increases thus supporting it
- Feeding in reactive power depending on voltage (Q(U) control) can be used: Thus, more power generating plants can be integrated in an existing grid depending on local circumstances
- Active-power output at underfrequency: When power is lacking in the system, power generating plants and accumulators will in future feed into a greater degree thus supporting the system
- Expanded requirements for fault ride-through of short voltage drops as well as for providing reactive powers through decentralized power generating plants
- Defines the requirements on storage as well as combined facility of generation/ demand/ storage

Hosting capacity (RES-Legal, 2019)

The grid operator is obliged to connect plants even where the purchase of electricity is only possible by optimising, boosting or expanding the grid. However, this obligation does not apply when optimising, boosting or expanding the grid is economically unreasonable. Whether the expansion of the grid is economically reasonable in each case will be determined by weighing the plant operator's interests against the grid operator's interests

Other incentives apart from compensation (Sternkopf, Promotion in Germany, 2019)

- The KfW Renewable Energy Programme–Standard provides low-interest loans with a fixed interest period of 10 years including a repayment-free start-up period for investments in installations for electricity production
- The KfW Consortium Loan Energy and Environment Programme provides a consortium loan between up to EUR 4 billion for on-shore wind farms and photo-voltaic installations
- The KfW Renewable Energy Programme Premium provides amongst others low interest loans and grant repayment support for electricity generation in deep geothermal installations
- The KfW Renewable Energy Programme "Storage" supports the usage of stationary battery storage systems, related to a PV installation, which is connected to the electricity grid
- The BMU Innovation Programme provides low interest loans and subsidies for innovative pilot projects for RES

[195] Renewable Energy Sources Act (EEG 2017) - Section 15 (https://www.bmwi.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf%3F__blob%3DpublicationFile%26v%3D3)

ANNEXURE 4: ITALY NEM (SSP) AND '*RITIRO DEDICATO*'

The Italian net metering scheme (Scambio Sul Posto, SSP) was formally established in 2003, but it started operating from 1 January 2009. The latest amendment happened in 2015, increasing the allowed capacity from 200 kW to 500 kW. The Italian Energy Services Operator (Gestore dei Servizi Energetici, GSE), a public company owned by the Ministry of Economy, holds the pivotal role of managing the SSP and paying the remuneration.

Permitted RE

Technology-neutral – allows almost all solar, wind, geothermal, biomass, biogas, hydro but as of 2018, the SSP scheme comprised 656,717 installations (99% of which are solar PV)

RE targets (CEER, 2018)

According to Italian Energy Strategy defined in 2017, Italy should reach an objective of 28% share of RES with respect to total final consumption and an objective of 55% RES electricity (defined as the ratio between RES gross electricity production and total gross electricity production) by 2030

RE system capacity limits

500 kW for SSP, 100 kW => 1 MW for Ritiro Dedicato

NEM business models

- NEM (SSP): The SSP differs from traditional net metering, as the individual plant operator pays the supplier for the electricity consumed, while the GSE gives credit for the electricity fed in. It is balance of the energy fed-in and consumed. Hence SSP can be characterized as a net billing scheme
- Virtual NEM: installations owned by municipalities with less than 20,000 inhabitants (and the Ministry of Defence) can access SSP without being obliged to use the same connection point to supply and receive electricity.
- Ritiro Dedicato: Renewable Energy producers can decide between selling the produced energy on the free market themselves or sell it to the GSE, who then sells the energy on the free market on their behalf. Producers can decide whether they want to receive a guaranteed minimum price or the market price. In case the market price is higher than the guaranteed minimum price, the producer receives an annual adjustment.
- Both CAPEX and third-party ownership models are allowed for the above models

Compensation for RE generation

- SSP (Schwarz, 2019): The owner of such an installation will receive a remuneration equal to the difference between the value of the electricity fed into the grid (e.g., for solar PV installations the energy fed in during daytime) and the value of the electricity consumed in a different period. If more energy is fed in than consumed, plant operators are entitled to have an economic compensation. If they feed in less than they consume, the difference is subject to a payment. Plant operators receive credit for the produced electricity. This credit will be available for an unlimited period of time (Ayrookuzhy, 2020). Currently, this compensation amounts to 0.16 EUR/kWh (Iliopoulos, Fermeglia, & Vanheusden, 2020).

- Premium Tariff (*Ritiro dedicato*) (Schwarz, Premium tariff (Ritiro dedicato), 2019): Producers can decide whether they want to receive a guaranteed minimum price or the market price. In case the market price is higher than the guaranteed minimum price, the producer receives an annual adjustment

NEM credit carry forward period

The balance is calculated once a year (Iliopoulos, Fermeglia, & Vanheusden, 2020)

Tariff expiration/ PPA period

Unlimited period (as long as the life of the plant) for SSP and 1 year for Ritiro Dedicato

Interconnection application process and timelines (Schwarz, 2019):

- Application submitted by the customer
- Grid operator responds to application and submits the customer an estimation of costs (varies from 20-90 days based on the kW capacity of the RE plant
- Applicant must communicate the acceptance of cost estimate within 45 days for capacity < 10,000 kW and 120 days for capacity > 10,000 kW
- Request of authorisation for construction and operation of the plant and/or request of initiation of the authorisation procedures takes 60-180 working days
- The authorisation procedure is ruled under a comprehensive procedure ("procedimento unico") in which all involved administrations participate. This procedure starts within 30 days from the date in which the request of authorisation is received and can last up to a maximum of 90 days, excluding additional time needed for carrying out specific verifications, where necessary
- The applicant is obliged to start the construction of the production plant within 12 months for connections in low and medium voltage and 18 months for connections in high or extra high voltage
- The distribution grid operator must connect a plant within the following timescales: 30 working days for basic works 90 working days for complex procedures, plus 15 working days for every kilometre of connection line except the first kilometre

Process automation

Not available

Interconnection charges (Schwarz, Use of the grid, 2019)

- The costs of connection are borne by the applicant for connection. Renewable energy plants are subject to lower connection fees than plants fuelled by conventional sources
- The following fees must be paid for connection to the transmission grid:
- Fee for the development of the technical solution
- Fee for connection to the grid
- Since 1 January 2015, RES plant operators that present, for at least one day during the year, a valid Net-Metering Convention - except for facilities with a capacity up to 3 kW - must pay to GSE a fee to cover the costs of management, verification and control (Schwarz, Net-Metering (scambio sul posto), 2019)
- Tariffs are applied annually. There is a fixed fee of EUR 30 per each Net-Metering Convention and a variable fee depending on the RES plant capacity. Variable fee is about € 1 /kW and only applies for RES units with a capacity between 20 kW and 500 kW
- For cases in which net metering is used under several off-take and injection points, an additional contribution of EUR 4/year for each connection point applies

Grid priority

- Plants for the generation of electricity from renewable sources shall be connected to the grid as a priority, i.e., prior to plants that generate electricity from traditional sources (Schwarz, Use of the grid, 2019)

Grid unavailability or back-down request (Schwarz, Use of the grid, 2019)

- For reasons of security of the national energy grid, capacity limits might be imposed. However, the outputs limits should be minimized as far as possible to avoid losses of renewable energy production
- Wind producers are compensated for the amount of electricity curtailed when it is higher than the equivalent energy that should be produced in 80 hrs. No compensation is defined, at the moment, for other renewable plants because the amount of electricity curtailed has never been higher than the equivalent energy that should be produced in 60 hrs. for PV plants and 240 hrs. for other plants (CEER, 2018)

Grid codes

- CEI 0-21 standard governing the connection of power generation and consumption plants in the low-voltage grid was published in Italy in December 2011 also AEEG 084-12 from March 8, 2012

Requirements in case frequency and voltage deviations (Iaria, 2017)

In Italy, a 100% voltage dip has to be overcome without tripping respectively for:

- At least 200 ms, in case of PV plants with rated power Prated≥6kVA and connected to distribution MV and LV level
- At least 150 ms, in case of PV plants connected to transmission HV and EHV levels
- Concerning frequency relays protection, islanding operation of distribution grid must be avoided. Therefore, protections of MV level PV have to distinguish between the fast frequency perturbations, due to distribution grid islanding or faults, and the usually slow frequency deviations due to perturbations at transmission level. In case of fast frequency variations, the narrow operational range “$49.7 \leq f \leq 50.3$” has to be enabled while, in case of slow variations, the larger range “$47.5 \leq f \leq 51.5$” has to be ensured
- In case of LV level PV, the required frequency range is only the largest one “$47.5 \leq f \leq 51.5$”

Hosting Capacity

- Works on the grid aimed at allowing connection of a plant are automatically considered in the connection process
- A given applicant is entitled against the grid operator to the expansion of the grid, if this expansion is required to satisfy the claim for connection to the grid (Schwarz, Grid expansion, 2019)

Other incentives apart from compensation

Tax deductions for RES-related expenses incurred when refurbishing buildings, and for interventions aimed at enhancing energy savings, with regard to RES installations, including photovoltaic (D'Ostuni, Bellia, & Tremolada, 2020).

ANNEXURE 5: NEM PROGRAM-SINGAPORE

PERMITTED RE

Solar PV

RE Targets (SERIS, 2020)

Goal to reach 350 MWp of installed solar power capacity by 2020

NEM business models

- CAPEX
- Solar PPAs or solar leasing (SERIS, 2020): Such contracts allow consumers and solar developers to enter an arrangement that entitles the consumer to purchase solar electricity from the developer, usually at a discount from their prevailing contractual electricity prices

Compensation for RE generation (EMA, 2020)

Contestable Consumers (CC) are those who choose to buy electricity from a retailer of their choice or from the wholesale electricity market at the wholesale electricity price. Non-contestable consumers (NCC) are consumers who choose to buy electricity from SP Services at the regulated tariff.

Type of compensation scheme	System Size	Details
Simplified Credit Treatment Scheme (SCT)	< 1 MWac	Non-Contestable Consumers (NCC) to directly register with SP Services. NCCs that sell any excess energy to the market will be paid at the prevailing regulated tariff minus grid charges
Enhanced Central Intermediary Scheme (ECIS)	< 10 MWac	Contestable Consumers (CCs) can register with SP Services directly, reducing regulatory barriers and administrative matters. CCs that sell any excess energy to the market will be paid at the prevailing half-hourly wholesale energy prices
Market Participant (IGS Non-Exporting)	< 10 MWac	Consumers with no intention to export are not required to provide credit support or to submit generation meter readings to EMC. Consumers will not be paid for injecting any excess energy to the grid. Consumers are required to pay EMC an estimated fixed charge on the IGS capacity every six months. This will be based on a standardised IGS Generation Profile for all consumers.
Market Participant (exporting)		Consumers need to register as a Market Participant with EMC, subject to the relevant Market Rules. Any excess solar energy sold back to the market will be paid at the respective nodal price

- Solar Generation Profile (SGP) (EMA, 2018): Eligible CCs with embedded generating systems of ≥ 1 MWac under the above compensation options can also opt for a no-meter requirement for their system. And instead use an alternative arrangement to determine the system output for the settlement of the relevant market charges. One such example is to use an estimated IGS profile that is approved, obviating the need for such consumers to install M1 meters

NEM credit-carry forward period

No credit under ECIS, sold half-hourly. For others, not available

Tariff expiration/ PPA period

Not available

Interconnection application process and timelines (EMA, 2020)

- Consumers installing a solar PV system should engage a Qualified Person (QP) to ensure appropriate physical installation and compliance with regulations
- Depending on the individual consumers' requirements, the QP may need to seek approval from the authorities, e.g., BCA (structural safety), URA, (planning permission), SCDF (fire safety), CAAS (aviation zone) for the solar PV installation

- After the solar PV system has been installed, the consumer should engage a Licensed Electrical Worker (LEW)[196] to commission and turn on the solar PV system, including applying for the relevant electrical licences and assessing the electrical connection requirements
- The consumer may also need to apply for a generation licence and market registration, if the solar PV system is 1 MWac and above
- Licensing requirements:

Installed Capacity of Solar PV system	Connected to power grid?	Type of Licence
Below 1 MWac	Yes	Exempted
	No	
1 MWac or more but less than 10 MWac	Yes	Wholesaler (generation) licence
	No	Exempted
10 MWac or more	Yes	Generation licence
	No	

Time schedule (EMA, 2017)

Connection Voltage	Time Schedule
230 kV and 400 kV	80-100 business days
66 kV	60 business days
22 kV and below	10 business days

Process automation

Automated to some extent with regard to application, selection of QP, LEW

Interconnection charges

- For consumers with embedded IGS, the applicable grid charges depend on the voltage level at which the consumer's load is connected to the grid (EMA, 2018)
- EMC Fees: Yearly revised EMC Fees
- Power System Operator (PSO) Fees: Daily revised PSO Fees
- Market Support Services (MSS) Charge: Yearly revised MSS charge
- Monthly Energy Uplift Charge (MEUC): Monthly revised MEUC prices

[196] https://elise.ema.gov.sg/elise/findworkerservlet?Operation=GetOffer&Item=EL

Grid codes

Governed by the 'Transmission Code 2017' of the Energy Market Authority of Singapore (EMA, 2017)

Requirements in case frequency and voltage deviations (EMA, 2017)

- Voltage fluctuation: Shall not cause voltage fluctuation at a common point of coupling to exceed 3% of nominal voltage
- Harmonics

Voltage level	Total Harmonic Distortion Limit
At 400 V and 230 V	5% (odd harmonic ≯ 4%, even harmonic ≯ 2%)
22 kV and 6.6 kV	4% (odd harmonic ≯ 3%, even harmonic ≯ 2%)
66 kV	3% (odd harmonic ≯ 2%, even harmonic ≯ 1%)
230 kV	1.5% (odd harmonic ≯ 1%, even harmonic ≯ 0.5%)
400 kV	1.5% (odd harmonic ≯ 1%, even harmonic ≯ 0.5%)

- Phase imbalance: Planned outages or operation of an installation shall not cause maximum negative phase sequence component of the phase voltage to exceed 1%
- Frequency range

Frequency range	Requirement
52 Hz – 47.5 Hz	Continuous operation is required
47.5 Hz – 47 Hz	Generating unit is required to remain in operation for at least 20 sec each time it falls below 47.5 Hz
50.5 Hz – 49.5 Hz	Normal limits

- Disconnecting device: Should install disconnecting devices between transmission system and the installation
- Remote monitoring and automatic generation control: The generating unit will provide the power system operator with a remote monitoring, control and data acquisition of the equipment and shall also provide remote terminal unit(s) for remote monitoring of output and operating conditions as well as facilities for automatic control of generating unit's output from PSO's energy management system.

Hosting capacity

As there may be physical constraints of each network ring, there could be a limit to the amount of solar PV systems that the network circuit can support. Therefore, depending on the limitations in that area, the permissible capacity of solar PV systems in each location may differ. Hence, parties who wish to invest in solar PV systems should check if there are possible network constraints in their preferred locations, before making their investment decisions (SP Group, 2018).

Other incentives apart from compensation (Joshi, Anuradha, Yadava, & Bunye, 2020)

- Carbon tax scheme put into effect by the Carbon Pricing Act, 2018, which came into operation on 1 January 2019, to impose taxes on certain greenhouse gas emissions of facilities in Singapore. This would not directly affect PV plants but will make their generation cost-effective as compared to polluting sources like natural gas
- The government launched the SolarNova Programme to help promote and aggregate demand for solar photovoltaics (PV) across government agencies

ANNEXURE 6: NEM PROGRAM-VIETNAM

Vietnam had an NEM policy for solar rooftop plants till 2019, in which the carried over credits were compensated at the end of the year (or on PPA termination) at the purchase price (based on the central rate of VND and US$ quoted by the State Bank of Vietnam) promulgated by Ministry of Industry and Trade (MoIT) (Prime Minister, 2017). Starting January 2019 (E&REA, 2019), this NEM has been discontinued for the solar rooftop projects and the All Buy All Sell (ABAS) scheme has been put in place, where the prosumer pays at the regulated grid tariff for all the consumption from the grid and is paid by Vietnam Electricity Corporation (EVN) at the price same as in NEM regime.

The solar rooftop segment has seen tremendous growth in Vietnam, growing from a 2019 base of 378 MWp to 9.583 GWp, spread throughout nearly 102,000 systems (Gunther, 2021). It is also interesting to note that there has been exponential increase from ~2.5 GW in November 2020 to ~9.5 GW in December 2020 (when FiT2 ended). This huge jump in numbers in just one month might be due to the utility including the solar rooftop systems installed on agricultural rooftops, in which the structures have been modified by constructing walls in order to qualify for the FiT2 (ending in December 2020). The total solar PV capacity in the country reached 16.5 GWp by December 2020 (Gunther, 2021).

Tech allowed/ RE Definition:

Solar PV rooftop, with a maximum capacity of 1 MW, installed on a rooftop which has a genuine construction purpose beyond that of merely existing to hold solar equipment is eligible under FiT2. Solar systems installed on a rooftop which has a genuine pre-existing agricultural or farming function on agricultural lands also qualify under the definition of solar rooftop in Vietnam (Cooper, 2020).

RE Targets (SERIS, 2020)**:**

The Government of Vietnam in its National Power Development Master Plan VII targets 12,000 MW by 2030 and 3.30% of entire electricity production[197].

NEM business models (LECL, 2020):

In Vietnam, the rooftop solar segment based on business operation can be divided into various business models. The first two models (roof rental & joint venture) are the most common types of business

[197] Vietnam RE Targets available at: https://www.vietnam-briefing.com/news/wp-content/uploads/2019/03/VN-PDP.jpg

models to be used in Vietnam rooftop solar projects.

i. Roof Rental Business Model: It consists of three key players: 1) the roof owner, 2) the developer company, and 3) the utility. Under this model, the roof owner agrees on a 25-year roof rental contract with the developer company, while the developer company acquires a 25-year power purchase agreement (PPA) from the utility. After installing and operating the solar system on the rented roof by developers, every kWh produced by the system will be exported to the grid. The revenue from the sales of electricity will go to the developer; and the roof owner will receive a rental fee as agreed in the contract.

ii. Joint Venture with Developers: the roof owner will lend their roof to the developers for the solar system installation. Also, the roof owner themselves are also likely to contribute part of the investment to the rooftop solar project. After installing and operating the solar system on the rented roof by developers, every kWh produced by the system will be exported to the grid. The revenue from the sales of electricity will go to both roof owner and the solar developer, which will be shared depending on the contract signed.

iii. Solar Shared Saving: This model is proposed for energy-intensive buildings and factories to reduce electricity cost. The roof owner, who wants to reduce electricity costs, agrees on a shared saving contract with the developer company. The contract typically lasts 20 to 25 years. The developer installs, owns, and operates the commercial-scale solar PV system on the site. Then, PV electricity units are sold at a discount, typically 5–10% lower than the grid electricity tariff

iv. Solar Leasing: allows the consumers to pay for the solar system over time and avoid the high upfront cost. The leasing company (or solar lessor) enters a leasing contract with the customer (solar lessee), allowing the lessor to own, install, and operate a rooftop solar system on the customer’s roof. The solar lessee pays for the solar system through a combination of down payment and monthly instalments and uses the solar electricity or sell it to receive feed-in tariff

v. Solar Loans: a loan that allows you to purchase a solar energy system and pay it off over time. Unlike with solar leasing, you own the system outright. For example, HSBC Bank (Vietnam) Ltd has unveiled a loan product named “Green Loan” with the special preferential interest rate from 11.99% when installing the rooftop solar energy system. However, solar loans are not considered as the common types of rooftop solar financing option in Vietnam due to its lack of cost-effectiveness

Compensation for RE generation:

The EVN paid a Feed-in-Tariff to the prosumer at VND 2.086/kWh (US¢ 9.35/kWh), as per the April 2017 Decision (Prime Minister, 2017). This is then revised to a FiT2 of US¢ 8.38/kWh, starting from April 2020 (Gunther, 2021) and ending in December 2020. As of now, new PPAs of rooftop solar power would stop with the expiration of the FIT2 policy. There are proposals for moving to solar auctions for direct sale of electricity to EVN. The initial pilot program, outlined in a draft decision, limits participants to ground mount or floating solar farm projects already included in the Power Development Master Plan. There is also a proposed virtual renewable Direct Power Purchase Agreement (DPPA) program that would allow factories and business to source 100% renewable energy from private firms via the EVN grid.

NEM Credit carry forward period:

No credit. Compensated monthly

Tariff expiration/ Power Purchase Agreement (PPA) Period:

20 years

Interconnection Application Process and Timelines[198]:

- The power Seller (Seller) registers its grid connection with the power Buyer (Buyer) and provides information on installation location, capacity (no more than 1 MW and 1.25 MWp), transmission line and expected connection point to the Buyer
- The Buyer gives feedback on the ability of connection and capacity transmission of the rooftop solar system of the Seller registering its grid connection with the Buyer. The response time is no more than 5 business days since the date that the Buyer receives the Seller's registration
- The Seller and the Buyer realize the agreement for connecting the Seller's rooftop solar system to the Buyer's grid system. If the rooftop solar system of the Seller is connected to the grid which is not the Buyer's asset or the grid of a power distribution and retail unit, the Buyer and the Seller will negotiate with the grid owner (organization or individual) to implement the connection agreement. The Buyer receives all grid connection documents and the written connection agreement of the grid owner (if any)
- The Seller installs the rooftop solar system with size satisfying contents
- The Seller sends request documents for electricity sale from the rooftop solar system including the request letter for electricity sale; technical documents of the PV panel and AC/DC inverter; transmission lines and transformer (if any); factory certificate and equipment quality certificate (certified true copy)
- Stakeholders conduct the technical examination and installation of electric meter; meter reading confirmation; signing of PPA and power generation to put the rooftop solar system into operation. Deadline for the Buyer to sign the PPA is 5 business days since the date of receiving request documents for electricity sale from the Seller. In case that the Buyer is the EVN or its authorized member, then the Buyer and the Seller shall sign the PPA according to regulations
- The Seller shall ensure that the AC/DC inverter has the anti-islanding function when the grid has no power to avoid the interference into and control of operation and follows legal norms and regulations on power quality
- The rooftop solar system is exempted from the operating license for power generation

[198] Circular on Solar Project PPA available at http://vepg.vn/wp-content/uploads/2020/08/Circular_18_TT-BCT_EN_final.pdf

Hosting Capacity (Sanseverino, Le, Hải, & Silvestre, 2020)**:**

Vietnam's transmission grid is divided into six geographical regions—including North, North Central, Center-Central, South-Central, Highland, and South—with transmission voltage levels of 500 kV and 220 kV. The voltage level of distribution grid is below 110 kV, and most of power generating plants using renewables (including solar PV power) are connected to this grid. In fact, the electricity consumption is uneven across regions, of which the largest is the South with nearly 50% of total consumption, followed by the North with more than 35%. The South-Central region accounts for only about 7% of total consumption in whole country.

The existing grids mainly transfer traditional configurations for electricity supply in the whole country, such as coal-fired power plants, oil-fired power plants, gas turbine power plants or hydropower plants. This has led to the fact that the grid infrastructure of 110–500 kV has been built mainly in areas with a rich potential for traditional fuels, such as the North, South, and Highlands regions. In other regions, the grid infrastructure major has been reinforced with voltage levels of 22–35 kV, including provinces having good wind and solar potential such as Ninh Thuan and Binh Thuan. The boom of solar PV plants in 2019 has put great pressure on existing infrastructure and called for the need to reinforce and establish new connections to the grid in a short time. In particular, this has happened in the two provinces of Ninh Thuan and Binh Thuan, where solar power plants are concentrated with high density but the demand for electricity on-site is very low. Specifically, in Ninh Thuan, the total planned and installed capacity is currently so big with over 2500 MW, while the grid-connected capacity is still very low, less than 1000 MW. With such an overloaded situation, the power system would be very likely to encounter problems of power line and substation congestion, possibly causing system instability and dangerous situations for the devices.

Annexure 7: Technical Standards Followed in the Reference SAARC Member States

Aspect	India[199]	Pakistan[200]	Sri Lanka[201]	Bangladesh[202]
Inverter	Should comply with IEC 61683/IS 61683 for efficiency and measurements and with IEC 60068-2 (1,2,14,30) / equivalent BIS standard for environmental testing	To comply UL 1741, IEEE 1547 2003, IEC 61215, EN or other international standards	Inverters used for interconnection shall be only those which have received the Type Approval by the utility	BDS IEC 62109 – General requirements and requirements for inverters, IEC 61727:2004 - Characteristics of the utility interface, IEC 62116:2014 - Test procedure of islanding prevention
Fault Ride-Through	Not envisaged at present. Will			

[199] Refer to Indian utility's Annexure (Annexure 8 to Annexure 12)
[200] Refer to Annexure 16 (on IESCO)
[201] Refer to Annexure 14 (on CEB)
[202] Refer to Annexure 13 (on DPDC)

Aspect	India[199]	Pakistan[200]	Sri Lanka[201]	Bangladesh[202]
	consider once PV penetration increases			
Frequency	IEEE 519 and CEA 2013: Upperside- 50.5 Hz, Lowerside- 47.5 Hz, should have frequency trip functions with clearing time of 0.2 sec	Under and over frequencies and their trip times in accordance with IEEE 1547 and IEC 61727	Over (max +2%) and under (min -%) frequency (50 Hz) trip functions and clearance times defined (0.5 seconds)	Inverter should be capable of producing power at the frequency band of at least +/-6% When outside the nominal 50 Hz value by ±2%, trip time shall be within 0.20s
Voltage	IEEE 519 and CEA 2013: Voltage operation-window should minimize nuisance tripping and should be in operating range of 80 to 110% of nominal connected voltage	Under and over voltages and their trip times in accordance with IEEE 1547 and IEC 61727.Fluctuation variation of +/-5% allowed	Over (max +10%) and under (min - 6%) voltage (230 V) trip functions and trip settings (0.2-1.5 sec). Withstand voltage and current surges in accordance with the environments defined in IEEE 1547	LV – 230-400 V, MV – 11-33 kV. Maximum inverter voltage fluctuation range allowed is 6% Voltage imbalance: Infrequent short duration peaks with a maximum value of 2% over 1-minute duration are permitted. Unbalanced voltage shall not exceed 1% on 5 occasions within any 30-minute period Voltage disturbance: Defined for V < 50% (trip time: 0.10 sec) to 110% < V < 135% (trip time: 2.00 sec)
Harmonics	IEEE 519 and CEA 2013: THD limit < 8% (individual limit 5%) for <= 1kV and 5% (individual limit 3%) for > 1kV and <=69 kV bus voltage	In accordance with IEEE 1547. The THD should be less than 5% at 100% rated power of the inverter	THD max limit 5%	Should have low current-distortion levels. THD shall be less than 3% of the rated inverter output at the cable connected to the interconnection point
Power Quality	While the output of the inverter is > 50%, a lagging power factor of > 0.9 should operate	Shall have pf > 0.9 when generation > 50% of system rating. Larger systems (like industrial) maybe required to install	Power quality measurement shall be complied with IEC 61400-21	Shall have a leading or lagging power factor greater than 0.9 when load is 20% greater than the rated inverter output power

Aspect	India[199]	Pakistan[200]	Sri Lanka[201]	Bangladesh[202]
		additional systems for pf correction		
Anti-islanding	In event of fault, voltage or frequency variations, must island/disconnect itself in line with IEEE 1547	Shall detect the island and cease to energize the area EPS within 2 sec of the formation of an island. Adjustable delay of up to 5 min that delays reconnection till voltage and frequency restored to normal levels	Anti-islanding feature compulsory and should cease to energize within 0.5 sec of the formation of island. Not to reconnect unless CEB distribution system service voltage is within 6% of the nominal supply voltage and frequency is within 47 Hz to 52 Hz and are stable for at least 3 minutes. IEEE 1547	Shall disconnect from the Utility's system for loss of main within one second Inverters used by the NEM consumer shall provide the following anti-islanding detection techniques: Under voltage Over voltage Under frequency Over frequency Should also include at least one of the following active anti islanding techniques: Negative-sequence current injection Impedance measurement Slip mode frequency shift Frequency bias, etc.
Flicker	Should not cause voltage flicker in excess of the limits stated in IEC 61000 standards or equivalent Indian standards		As per IEC 61000-3-7	
Paralleling Device	Capable of withstanding 220% of normal voltage at interconnection point		Shall be capable of with-standing 220% of the interconnection facility rated voltage (IEEE 1547 – 4.1.8.3)	
Overload/heat	IEEE 519 and CEA 2013: Inverter to switch off automatically in case of overload or overheating and		Shall have the capability to withstand voltage and current surges in accordance with the environments	The fault current contribution by the inverter will be limited usually by the inverter control. Based on IEC 61727 or, IEEE 1547,

Aspect	India[199]	Pakistan[200]	Sri Lanka[201]	Bangladesh[202]
	restart when normal		defined in IEEE 1547 – 4.1.8.2	the typical range of short circuit current is between 100% and 200% of the rated inverter current
Synchronization	IEEE 519 and CEA 2013: RE system must have grid frequency synchronization device. Shall not cause voltage fluctuation > +/-5%			Should be equipped with automatic synchronization system. For solar PV system the synchronization is to be done at the inverter
DC Injection	Not more than 0.5% of full rated output at interconnection point or 1% of rated inverter output current into distribution system			Shall not inject DC current greater than 1% of the rated inverter output current into the Utility interface
Utility Curtailment	Systems > 200 kWp shall provide remote curtailment or reduction power to utility		Shall furnish and install an appropriately sized ganged isolating switch near the point of common coupling (PCC) to isolate the generating facility from the grid	Must incorporate Utility interface disconnect switch to allow disconnection of the system output from interconnecting with the Utility for safe Utility line works. Switch shall be manual and lockable

Utility and Consumer Profile – BRPL						
As on: September 2020	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
HT/MT/LT Sale MU[203]	7,018	3,345	510	24	-	10,897
Utility System Profile						
Transmission and Distribution Losses % - Target	6%	6%	6%	6%	-	6%
FY19[204]	8.06%	8.06%	8.06%	8.06%	-	8.06%
Average Pooled Purchase Price (INR/kWh) FY 17-18[205]	5.19					
Peak Period (Hours)[206]						
Period 1	1400-1700	1400-1700	1400-1700	1400-1700	-	-
Period 2	2200-0100	2200-0100	2200-0100	2200-0100	-	-
Period 1 Generation %	29%	29%	29%	29%	-	-
Period 2 Generation %	0%	0%	0%	0%	-	-
Peak hour power purchase premium INR/kWh	1					
Targets and Achievements						

[203] BRPL Petition for Truing-up upto 2017-18 and ARR and Tariff for FY 2019-20
[204] From the presentation of Mr Abhishek Ranjan (AVP-BRPL) in SEC webinar on 8th September 2020
[205] BRPL Tariff Order for FY 2019-20 (https://www.bsesdelhi.com/documents/55701/92678/BRPL_Tariff_Schedule_2019_20.pdf/0746b0ce-9afa-335c-2015-12cc70f5168e?t=1567754070763)
[206] Ibid

Utility and Consumer Profile – BRPL				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target (17-18)[207]	2.75	268	8.75	854
Actual (17-18)[208]	0.6	59	1.29	126
Future targets[209]	- 20-21: 7.25% - 21-22: 8.75% - 22-23: 10.50%	-	- 20-21: 10.25% - 21-22: 10.25% - 22-23: 10.50%	-
Any other RE targets (GNCTD, 2016)	Delhi state government solar capacity targets – FY 16: 30 MW, FY 17: 84 MW, FY 18: 193 MW, FY 19: 294 MW, FY 20: 385 MWFY 21: 285 MW, FY 22: 228 MW, FY 23: 187 MW, FY 24: 161 MW, FY 25: 145 MW			
Achieved[210]	Cumulative grid-connected solar capacity in entire Delhi (not just BRPL jurisdiction) till 31-12-2019: 156.12 MW			

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential[211]	500 MWp under BRPL area						
Target[212]	2015-22: 1,100 MW (Central govt target)	-	-	-	-	-	-
Actual (as on Aug 2020)[213]	Under BRPL: 69 MW; 146 MW in entire Delhi (November 2019 figure)	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**

207 http://www.derc.gov.in/Regulations/DERCRegulations/Regulations%202017/DERC%20BPR%202017---.pdf
208 BRPL Tariff Order for FY 2019-20 (https://www.bsesdelhi.com/documents/55701/92678/BRPL_Tariff_Schedule_2019_20.pdf/0746b0ce-9afa-335c-2015-12cc70f5168e?t=1567754070763)
209 http://www.derc.gov.in/Regulations/DERCRegulations/Regulations%202019/Business%20Plan%20Regulations%202019.pdf
210 Govt of India MNRE Annual Report 2019-2020 (https://mnre.gov.in/img/documents/uploads/file_f-1597797108502.pdf)
211 From the presentation of Mr Abhishek Ranjan (AVP-BRPL) in SEC webinar on 8th September 2020 (https://www.saarcenergy.org/wp-content/uploads/2020/09/Abhishek-presentation-Utilities-perspective.pdf)
212 MNRE 30 June 2015 Letter to all states/UTs
213 From the presentation of Mr Abhishek Ranjan (AVP-BRPL) in SEC webinar on 8th September 2020 (https://www.saarcenergy.org/wp-content/uploads/2020/09/Abhishek-presentation-Utilities-perspective.pdf)

NEM Implementation Details					
Solar Rooftop MW					
Solar Rooftop MW% (As on Aug 2020)[214]	17%	39%	1%	4%	39%
NEM connections – Capacity-wise %	**0-10 kW**	**11-50 kW**	**51-100 kW**	**100 kW+**	
Solar Rooftop %[215]	53%	35%	8%	4%	

Utility Tariffs[216]					
As on: 2017-18	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) INR/kWh					
LT/MT/HT	4-8.75	8.40-9.95	7.90-9.50	2.75	-
Other charges (e.g. FSC etc.)					
LT/MT/HT	4.5% on energy charges	4.5% on energy charges	4.5% on energy charges	4.5% on energy charges	-
ED% on Variable + Other charges					
LT/MT/HT	13.4%	13%	13%	13%	-
Total Variable Tariff INR/kWh					
LT/MT/HT	4.54	9.53	8.96	3.12	-
Grid Tariffs without Cess, duties, used for calculations (lower end)	4	8.40	7.90	2.75	-

[214] Ibid
[215] Ibid
[216] BRPL Petition for Truing-up upto 2017-18 and ARR and Tariff for FY 2019-20 and an available BRPL electricity bill of the consultant

NEM Policy[217]

	Solar	Wind	Biogas, Biomass	Small Hydro	Geothermal	Agri & Municipal Waste	Other
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							

Applicable to Customers	Residential	Commercial	Industrial	Agricultural	Government	Others
NEM% of Sanctioned Load permitted for the customer	100%	100%	100%	100%	100%	100%
Comments						

Definition of type of RE plant	Rooftop, ground-mounted and any part of the premises. Agricultural pumps also included (Energy Storage permitted)

Limits on Capacity	**Min (kW)**	**Max (kW)**
	- Min 1 kW for NEM - Min 5 kW for VNM & GNM	- No max limit for NEM (will allow the max cap proposed after load study) - Max 5 MW for VNM & GNM

The capacity definition (mark by X)	**AC Capacity**	**DC Capacity**	**Synchronized Capacity (injected capacity – support by ESS)**	**Not Defined**
	-	-	-	X
Cumulative Connected Load on a DT	**Peak PV as % of DT Capacity**	**Peak PV as % of DML (Daily Minimum Load)**	**Based on Hosting Capacity Assessments**	**Not Defined**
Limit	-	-	Will allow the proposed capacity after load study	-

Tariff for compensation of surplus export to the grid	**Mode**	**Comments**
	Fixed Grid Tariff or a % of Grid Tariff	-
	Average Pooled Purchase Cost	APPC Rate

[217] DERC Net Metering Regulations 2014 and DERC GNM and VNM Guidelines 2019

NEM Policy[217]			
		The credits for off peak/normal time generation can only be settled against off peak/normal time consumption at present at INR 5.19/kWh	
	Time of Use (TOU) Grid Tariff	-	
	FIT (Feed-in-Tariff)	-	
	Benchmark Solar Tariffs from Auctions	-	
	VDER (Value of Distributed Energy Sources)	-	
Settlement basis	**Net Energy Credit**	**Net Billing**	
(mark by X)	X	-	
Settlement period	Annual	-	
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**
(mark response by X)	X	X	X
Any net-work charges applied	No, all network charges waived off		
One-time Connection	Cost of the new meter borne by the applicant. Application Fee: INR 500 for NEM, INR 1000 (for GNM/VNM)		
Fixed	Charges: 1-10 kW: INR 1000, > 10-50 kW: INR 3000, > 50-100 kW: INR 6000, > 100-300 kW: INR 9000, > 300-500 kW: INR 12000, > 500 kW: INR 15000		
Variable	-		
Metering (MRI/AMI)	AMI		
Grid Codes and Standards			
Inverter	Should comply with IEC 61727:2014 and IEC 62116:2008		
Fault Ride-Through	Not envisaged at present by CEA. Will consider once PV penetration increases (Voltage and frequency ride throughs mandated by BRPL Delhi for inverters > 5 kW capacity)		
Frequency	IEEE 519 & CEA 2013: Upperside-50.5 Hz, Lowerside-47.5 Hz, should have frequency trip functions with clearing time of 0.2 sec. Reconnection allowed only after voltage reaches prescribed limits and is stable for at least 60 seconds		

NEM Policy[217]	
Voltage	IEEE 519 & CEA 2013: Voltage operation-window should minimize nuisance tripping & should be in operating range of 80 to 110% of nominal connected voltage. System should get disconnected within 2 seconds if out of limits. Reconnection allowed only after voltage reaches prescribed limits and is stable for at least 60 seconds
Harmonics	IEEE 519 & CEA 2013: THD limit < 8% (individual limit 5%) for <= 1kV and 5% (individual limit 3%) for > 1kV & <=69 kV bus voltage
Power Quality	While the output of the inverter is > 50%, a lagging power factor of > 0.9 should operate
Anti-Islanding	In event of fault, voltage, or frequency variations, must island/disconnect itself in line with IEEE 1547 and CEA 2013. Should sense abnormal conditions and disconnect within 2 sec of the formation of an unintended island (Few Indian utilities allow intentional islanding, wherein a PV system can disconnect from grid and continue to supply power to consumer loads using a battery storage system. Manual isolation switch also to be provided 24*7 accessible at the location
Flicker	IEC 61000 standards or equivalent Indian standards: - Inverter <= 16A AC Current per phase (IEC 61000-3-3) - Inverter > 16A AC Current per phase (IEC 61000-3-11) - Inverter >= 75A AC Current per phase (IEC 61000-3-5)
Paralleling Device	Capable of withstanding 220% of normal voltage at interconnection point
Overload/Heat	IEEE 519 & CEA 2013: Inverter to switch off automatically in case of overload or overheating and restart when normal
Synchronization	IEEE 519 & CEA 2013: RE system must have grid frequency synchronization device. Shall not cause voltage fluctuation > +/-5%
DC Injection	Not more than 0.5% of full rated output at interconnection point or 1% of rated inverter output current into distribution system
Utility Curtailment	Systems > 200 kWp shall provide remote curtailment or reduction power to utility (This is applicable only for Delhi)

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% Of Capital Expenditure		20%	-	-	60%	-
	INR/kWh	2	-	-	-	-

Generation based incentive[218]	*Period (years)*	3	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
Capital Expenditure[219]	*SRISHTI Scheme (INR/Watt)*	1.89	1.79	1.69	1.89	-
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates/ Credits (Bharvirkar & Athawale, 2019)	*INR/kWh*	1	1	1	1	-
Others (specify)		-	-	-	-	-

[218] Guideline for claim of Generation Based Incentive (GBI) available at http://web.delhi.gov.in/wps/wcm/connect/b97cdb8040142e9cb510fdd74088f250/Guidelines+on+Disbursement+of+Generation+Based+Incentive%28GBI%29.pdf?MOD=AJPERES&lmod=-

[219] Summary of Rooftop Phase II (SRISTI scheme) available at https://jmkresearch.com/wp-content/uploads/2019/08/SRISTI-scheme.pdf

Annexure 9: Utility Assessment-Chhattisgarh State Power Distribution Company Ltd, India

Utility and Consumer Profile – CSPDCL						
As on: FY 17-18	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT Sale MU[220]	4800	855	525	4200	-	10380
HT Sale MU	191	0	2150	0	-	2341
Utility System Profile						
Transmission and Distribution Losses % - Target	16%	16%	16%	16%	16%	16%
FY 17-18[221]	23.28%	23.28%	23.28%	23.28%	23.28%	23.28%
Average Pooled Purchase Price (INR/kWh) - FY 17-18[222]	3.85					
Peak Period (Hours)						
Period 1[223]	1800-2300	1800-2300	1800-2300	1800-2300	1800-2300	1800-2300
Period 2	-	-	-	-	-	-
Period 1 Generation %	0%	0%	0%	0%	0%	0%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase	1.20					

220 CSPDCL Final True-up for FY 2017-18, Provisional True-up for FY 2018-19, Determination of Revised Aggregate Revenue Requirement for FY 2020-21
221 CSERC Tariff Order FY 2019-20 available at https://sldccg.com/tariff_order/Final_Operative_Order-FY_2019-20.pdf
222 Ibid
223 Ibid

Utility and Consumer Profile – CSPDCL				
premium INR/kWh[224]				
Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target (17-18)[225]	2.00	406	7.00	1422
Actual (17-18)[226]	1.64	333	4.92	999
Future targets[227]	- 20-21: 6.50%	-	- 20-21: 8.50%	-
Any other RE targets[228]	State government previous target of solar power capacity between 500 MW and 1000 MW by 2017. No target mentioned in the new 2017-2027 policy that has been proposed			
Achieved (MNRE, 2020)	Cumulative grid-connected solar capacity till 31-12-2019: 231.35 MW			

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target[229]	2015-22: 700 MW (Central govt target)	-	-	-	-	-	-
Actual (as on December 2019) (MNRE, 2020)	10.39 MWp	-	-	-	-	-	-

224 CSERC Tariff Order FY 2019-20 available at https://sldccg.com/tariff_order/Final_Operative_Order-FY_2019-20.pdf
225 Gazette notification available at https://rpo.gov.in/ProjectFiles/CHHATTISGARH/CSERC%20Regulations,%202016.pdf
226 CSERC Tariff Order FY 2019-20 available at https://sldccg.com/tariff_order/Final_Operative_Order-FY_2019-20.pdf
227 Gazette notification available at https://rpo.gov.in/ProjectFiles/CHHATTISGARH/CSERC%20Regulations,%202016.pdf
228 Chhattisgarh State Solar Energy Policy 2012 available at http://www.cbip.org/Policies2019/PD_07_Dec_2018_Policies/Chhattisgarh/1-Solar/1_Chhattisgarh%20State%20Solar%20Energy%20Policy%202012.pdf
229 MNRE 30 June 2015 Letter to all states/UTs

NEM Implementation Details					
NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

Utility Tariffs					
As on: 2019	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) INR/kWh[230]					
LT	1.15-2.45	5.65-7.95	3.80-5.85	4.70	-
HT	5.70	-	5.85-6.85	5.30	-
Other charges (e.g., FSC etc.) INR/kWh[231]					
LT/HT	0.17-0.37	0.17-0.37	0.17-0.37	0.17-0.37	-
ED% on Variable + Other charges[232]					
LT	8%	12%	3%-10%	-	-
HT	8%	20%	20%	-	-
Total Variable Tariff INR/kWh					
LT	1.43	6.52	4.09	4.87	-
HT	6.56	9.98	8.66	5.67	-

NEM Policy[233]							
	Solar	**Wind**	**Biogas, Biomass**	**Small Hydro**	**Geothermal**	**Agri & Municipal Waste**	**Other**
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							
Applicable to Customers	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**	**Others**	

[230] CSERC Tariff Schedule for FY 2018-19
[231] https://cspdcl.co.in/cseb/(S(c0dqmrafurycluf5roips4ny))/Files/VCA%20182-13052020.pdf
[232] http://www.bareactslive.com/Ch/cg215.htm
[233] CSERC Grid Interactive Distributed Renewable Energy Sources Regulations, 2019

NEM Policy[233]				
NEM% of Sanctioned Load permitted for the customer	100% for on-site systems and no limit for off-site systems			
Comments	Chhattisgarh allows both on-site and off-site solar PV systems to get an NEM connection			
Definition of type of RE plant	Rooftop. Agricultural pumps also included (Energy Storage permitted)			
Limits on Capacity	**Min (kW)**		**Max (kW)**	
	1 kW – On-site systems 500 kW – Off-site systems		No limit	
The capacity definition (mark by X)	**AC Capacity**	**DC Capacity**	**Synchronized Capacity (injected capacity – support by ESS)**	**Not Defined**
	-	-	-	X
Cumulative Connected Load on a DT	**Peak PV as % of DT Capacity**	**Peak PV as % of DML (Daily Minimum Load)**	**Based on Hosting Capacity Assessments**	**Not Defined**
Limit	100% (DT capacity to be increased in case of excess installation, to avoid permission denial)	-	-	-
Tariff for compensation of surplus export to the grid	**Mode**		**Comments**	
	Fixed Grid Tariff or a % of Grid Tariff		-	
	Average Pooled Purchase Cost		-	
	Time of Use (TOU) Grid Tariff		-	
	FIT (Feed-in-Tariff)		-	
	Benchmark Solar Tariffs from Auctions		The policy announced in 2019, specifies minimum solar tariffs discovered in auctions. Assumed INR 2.50/kWh	
	VDER (Value of Distributed Energy Sources)		-	

NEM Policy[233]			
Settlement basis	**Net Energy Credit**		**Net Billing**
(mark by X)	X		-
Settlement period	Annual		-
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**
(mark response by X)	X		
Any net-work charges applied	Banking charges @ 2% of banked energy		
One-time Connection			
Fixed			
Variable	-		
Metering (MRI/AMI)	AMI with RS 485 or higher communication port		
Grid Code and Standards	Indian Grid Applies (all codes and standards same as mentioned for BRPL Delhi)		

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		20%	-	-	60%	-
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-

Incentives to Customers						
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility[234]						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
Capital Expenditure	*SRISHTI Scheme (INR/Watt)*	1.89	1.79	1.69	1.89	1.89
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates/ Credits	*INR/kWh*	1	1	1	1	1
Others (specify)		-	-	-	-	-

Annexure 10: Utility Assessment-Maharashtra State Electricity Distribution Company Limited, India

Utility and Consumer Profile – MSEDCL						
As on: FY 18-19	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT Sale MU[235]	19,719	7,277	6,763	33,853	-	67,612
HT Sale MU	-	-	31,026	-	-	31,026
Utility System Profile						
T&D Losses % - Target	8%	8%	8%	8%	8%	8%

[234] Refer to Annexure 9
[235] MERC Tariff Order of 2019 available at http://www.mercindia.org.in/Orders_2019.htm

Utility and Consumer Profile – MSEDCL						
FY 18-19[236]	14.70%	14.70%	14.70%	14.70%	14.70%	14.70%
APPC (INR/kWh) - FY 18-19[237]	4.12					
Peak Period (Hours)[238]						
Period 1	0900-1200	0900-1200	0900-1200	0900-1200	0900-1200	0900-1200
Period 2	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200
Period 1 Generation %	35.4%	35.4%	35.4%	35.4%	35.4%	35.4%
Period 2 Generation %	0.28%	0.28%	0.28%	0.28%	0.28%	0.28%
Peak hour power purchase premium INR/kWh[239]	0.80 for 0900-1200 and 1.10 for 1800-2200					

Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target (18-19)[240]	2.75	3380	11.00	13518
Actual (18-19)[241]	1.60	1958	9.44	11599
Future targets[242]	- 20-21: 4.50% - 21-22: 6.00% - 22-23: 8.00% - 23-24: 10.50% - 24-25: 13.50%	-	- 20-21: 11.50% - 21-22: 11.50% - 22-23: 11.50% - 23-24: 11.50% - 24-25: 11.50%	-

236 Ibid
237 Ibid
238 MSEDCL Final True Up for FY 2017-18 & FY 2018-19, Provisional True Up for FY 2019-20 and Multi Year Tariff for FY 2020-21 to FY 2024-25
239 MSEDCL Final True Up for FY 2017-18 & FY 2018-19, Provisional True Up for FY 2019-20 and Multi Year Tariff for FY 2020-21 to FY 2024-25
240 https://rpo.gov.in/ProjectFiles/maharashtra/Regulation%202016.pdf
241 MERC Tariff Order of 2019 available at http://www.mercindia.org.in/Orders_2019.htm
242 MERC Tariff Order of 2019 available at http://www.mercindia.org.in/Orders_2019.htm

Utility and Consumer Profile – MSEDCL	
Any other RE targets[243]	State government targets (2015 Solar Policy): solar capacity to be 7500 MW by 2020
Achieved (MNRE, 2020)	Cumulative grid-connected solar capacity in entire Maharashtra (not just MSEDCL jurisdiction) till 31-12-2019: 1663.42 MW

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target[244]	2015-22: 4700 MW (Central govt target)	-	-	-	-	-	-
Actual (as on December 2019) (MNRE, 2020)	216 MWp in entire Maharashtra	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

Utility Tariffs					
As on: 2019	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) INR/kWh[245]					
LT	3.46-11.71	7.36-12.83	5.21-6.11	1.85-3.34	3.31-6.01

[243] Maharashtra Solar Policy 2015
[244] MNRE 30 June 2015 Letter to all states/UTs
[245] MERC Tariff Order of 2019 available at http://www.mercindia.org.in/Orders_2019.htm

HT	5.70	11.47	7.02	3.79	7.74
Other charges (e.g., FSC etc.) INR/kWh (TBC, 2020)					
LT/HT	-	-	-	-	-
ED% on Variable + Other charges					
LT/HT	16%	16%	7.50% (Lewis & Sen, 2020)	0%	0%
Total Variable Tariff INR/kWh (ToI, 2020)					
LT	5.70	10.22	7.16	3.30	4.76
HT	14.24	13.97	8.16	4.36	8.31

NEM Policy[246]							
	Solar	**Wind**	**Biogas, Biomass**	**Small Hydro**	**Geothermal**	**Agri & Municipal Waste**	**Other**
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							
Applicable to Customers	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**	**Others**	
NEM% of Sanctioned Load permitted for the customer	100%	100%	100%	100%	100%	100%	
Comments							
Definition of type of RE plant	Rooftop or on any other mounting structure. Agricultural pumps also included (Energy Storage permitted)						
Limits on Capacity	**Min (kW)**		**Max (kW)**				
	1 kW		- 1000 kW for NEM - Customer's sanctioned load/contract demand for net billing				
	AC Capacity	**DC Capacity**	**Synchronized Capacity (injected**	**Not Defined**			

[246] MERC Grid Interactive Rooftop Renewable Energy Generating Systems Regulations, 2019

NEM Policy[246]				
The capacity definition (mark by X)			**capacity – support by ESS)**	
	-	**-**	**-**	X
Cumulative Connected Load on a DT	**Peak PV as % of DT Capacity**	**Peak PV as % of DML (Daily Minimum Load)**	**Based on Hosting Capacity Assessments**	**Not Defined**
Limit	70% (above 70% allowed after detailed load study)	-	-	-
Tariff for compensation of surplus export to the grid	**Mode**		**Comments**	
	Fixed Grid Tariff or a % of Grid Tariff		-	
	Average Pooled Purchase Cost		For net-billing (gross meter) connections @ APPC	
	Time of Use (TOU) Grid Tariff		-	
	FIT (Feed-in-Tariff)		Generic tariff @ INR 2.83/kWh for NEM[247]	
	Benchmark Solar Tariffs from Auctions		-	
	VDER (Value of Distributed Energy Sources)		-	
Settlement basis	**Net Energy Credit**		**Net Billing**	
(mark by X)	X		X	
Settlement period	Annual		Monthly	
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**	
(mark response by X)	X			
Any net-work charges applied	Banking Charge: LT - deduction of energy would be 12% HT - deduction of energy would be 7.5%			
One-time Connection	Cost of the new meter borne by the applicant. LT consumer: INR 500 for consumer having Sanctioned Load or Contract Demand up to 20 kW and INR 100 thereafter for every 20 kW or part thereof HT consumer: INR 5000			

[247] http://www.eqmagpro.com/wp-content/uploads/2020/04/Order-77-of-2020_compressed-1.pdf

NEM Policy[246]	
Fixed	Proposed new grid support charge from 2020-21 varying (exempt for < 10 kW systems) - Residential: INR 4.46-8.66/kWh - Commercial: INR 5.06-8.76/kWh - Industrial: INR 3.60-4.08/kWh Regulatory Commission postponed the implementation of this proposal
Variable	-
Metering (MRI/AMI)	AMI with RS 485 or higher communication port
Grid Code and Standards	Indian Grid Applies (all codes and standards same as mentioned for BRPL Delhi)

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		20%	-	-	60%	-
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	Commercial	Industrial	Agricultural	Government
Capital Expenditure	*SRISHTI Scheme (INR/Watt)*	1.89	1.79	1.69	1.89	1.89
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates/ Credits	*INR/kWh*	1	1	1	1	1
Others (specify)		-	-	-	-	-

ANNEXURE 11: UTILITY ASSESSMENT-BANGALORE ELECTRICITY SUPPLY COMPANY, INDIA

Utility and Consumer Profile – BESCOM						
As on: FY 18	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
HT/MT/LT Sale MU[248]	6918	4568	5656	6321	-	23464
Utility System Profile						
Transmission and Distribution Losses % - Target	8%	8%	8%	8%	8%	8%
FY 18 (KERC, 2019)	13.17%	13.17%	13.17%	13.17%	13.17%	13.17%
Average Pooled Purchase Price (INR/kWh)- 2018[249]	4.04					

[248] BESCOM Introduction: https://karunadu.karnataka.gov.in/kerc/Tarifforders2019/Tariff%20Order%202019/BESCOM/3-BESCOM%20-%20CHAPTER%20%20-%201.pdf

[249] Tariff order for Karnataka available at: https://karunadu.karnataka.gov.in/kerc/Regulations/Truing%20of%20APPC%20for%202019-20%20and%20procissional%20APPC%20for%202020-21.pdf

Utility and Consumer Profile – BESCOM						
Peak Period (Hours) (KERC, 2020)						
Period 1	0600-1000	0600-1000	0600-1000	0600-1000	0600-1000	0600-1000
Period 2	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200
Period 1 Generation %	38.5%	38.5%	38.5%	38.5%	38.5%	38.5%
Period 2 Generation %	0%	0%	0%	0%	0%	0%
Peak hour power purchase premium INR/kWh (KERC, 2020)	1					

Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target (17-18)[250]	2.75	859	12.00	3746
Actual (17-18) (KERC, 2020)	4.11	1211	11.95 (includes excess solar procurement)	3517
Future targets[251]	- 20-21: 8.50% - 21-22: 10.50%	-	- 20-21: 11.00% - 21-22: 12.00%	-
Any other RE targets[252]	State government targets (announced in 2017): solar capacity to be 6000 MW by March 2021 (out of which 2400 MW would be solar rooftop)			
Achieved (MNRE, 2020)	Cumulative grid-connected solar capacity in entire Karnataka (not just BESCOM jurisdiction) till 31-12-2019: 7274.92 MW			

[250] Karnataka Electricity Regulatory Commission RPO summary available at: http://www.cbip.org/RegulationsData/Karnataka/KR%20RPO%20Summary%20Modified.pdf

[251] Ibid

[252] Karnataka Solar Policy 2014-2021 available at https://www.kredlinfo.in/solargrid/Solar%20Policy%202014-2021.pdf

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target[253]	2015-22: 2300 MW (Central govt target), 2400 MW by March 2021 (State govt target). These targets are for the entire state of Karnataka	-	-	-	-	-	-
Actual (as on August 2020)[254]	Under BESCOM: 138 MW (2387 connections); ~240 MW (entire Karnataka)	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

Utility Tariffs					
As on: 2019	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) INR/kWh (KERC, 2020)					
LT	4.65-7.65	7.25-8.75	5.20-6.40	Free (0.00)	6.10
HT	6.45	8.50-8.80	6.80-7.20	4.50	5.00
Other charges (e.g., FSC etc.) INR/kWh[255]					
LT/HT	0.11-0.12	0.11-0.12	0.11-0.12	0.11-0.12	0.11-0.12

[253] MNRE 30 June 2015 Letter to all states/UTs and Amended Karnataka Solar Policy 2014-2021

[254] https://bescom.karnataka.gov.in/new-page/Solar%20Roof%20Top%20Scheme/en, https://kredlinfo.in/General/KERC%20tariff%20orders/Extension%20of%20Tariff%20Order%201st%20August%202019%20for%20Solar%20Power%20Projects%20including%20Solar%20Rooftop%20Photovoltaic%20Projects%20for%20FY21.pdf

[255] KERC Order https://bescom.karnataka.gov.in/storage/pdf-files/Customer%20Relations/FAC-Order-2nd-Quarter-for-the-FY-19-20.pdf

Utility Tariffs					
ED% on Variable + Other charges[256]					
LT/HT	9%	9%	9%	9%	9%
Total Variable Tariff INR/kWh					
LT	5.20	8.03	5.80	5.00	6.78
HT	7.16	9.72	7.98	5.00	5.58

NEM Policy[257]							
	Solar	**Wind**	**Biogas, Biomass**	**Small Hydro**	**Geothermal**	**Agri & Municipal Waste**	**Other**
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							

Applicable to Customers	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**	**Others**
NEM% of Sanctioned Load permitted for the customer	100%	100%	100%	100%	100%	100%
Comments						
Definition of type of RE plant	Rooftop. Agricultural pumps also included					
Limits on Capacity	**Min (kW)**			**Max (kW)**		
	1 kW			1000 kW		

The capacity definition (mark by X)	**AC Capacity**	**DC Capacity**	**Synchronized Capacity (injected capacity – support by ESS)**	**Not Defined**
	-	-	-	X

256 https://ksei.gov.in/electricity_tax.htm
257 KERC Implementation of Solar Rooftop Photovoltaic Power Plants Regulations 2016 (https://karunadu.karnataka.gov.in/kerc/Regulations/Regulations/KERC%20%28Implementation%20of%20Solar%20Rooftop%20Photovoltaic%20Power%20Plants%29%20Regulations,%202016.pdf)

<table>
<tr><th colspan="7">NEM Policy[257]</th></tr>
<tr><td>Cumulative Connected Load on a DT</td><td>Peak PV as % of DT Capacity</td><td colspan="2">Peak PV as % of DML (Daily Minimum Load)</td><td colspan="2">Based on Hosting Capacity Assessments</td><td>Not Defined</td></tr>
<tr><td>Limit</td><td>80%</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td></tr>
<tr><td rowspan="7">Tariff for compensation of surplus export to the grid</td><td colspan="3">Mode</td><td colspan="3">Comments</td></tr>
<tr><td colspan="3">Fixed Grid Tariff or a % of Grid Tariff</td><td colspan="3">-</td></tr>
<tr><td colspan="3">Average Pooled Purchase Cost</td><td colspan="3">-</td></tr>
<tr><td colspan="3">Time of Use (TOU) Grid Tariff</td><td colspan="3">-</td></tr>
<tr><td colspan="3">FIT (Feed-in-Tariff)[258]</td><td colspan="3">For residential (1 kW-10 kW):
- INR 3.99/kWh (without capital subsidy)
- INR 2.97/kWh (with subsidy)
For 1 kW-2000 kW:
- INR 3.07/kWh (without capital subsidy)
- INR 2.32/kWh (with subsidy)</td></tr>
<tr><td colspan="3">Benchmark Solar Tariffs from Auctions</td><td colspan="3">-</td></tr>
<tr><td colspan="3">VDER (Value of Distributed Energy Sources)</td><td colspan="3">-</td></tr>
<tr><td>Settlement basis</td><td colspan="3">Net Energy Credit</td><td colspan="3">Net Billing</td></tr>
<tr><td>(mark by X)</td><td colspan="3">X</td><td colspan="3">X</td></tr>
<tr><td>Settlement period</td><td colspan="3">Monthly</td><td colspan="3">Monthly</td></tr>
<tr><td>Credit allowed for</td><td colspan="2">Loads behind the connection, within the premises</td><td colspan="2">Loads across connections given to a customer (Group Net Metering)</td><td colspan="2">Loads across connections given to many customers (Virtual Net-Metering)</td></tr>
<tr><td>(mark response by X)</td><td colspan="2">X</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Any net-work charges applied</td><td colspan="6"></td></tr>
<tr><td>One-time Connection</td><td colspan="6">Cost of the new meter borne by the applicant. Application Fee: 5 kWp-50 kWp - INR 1000 per project, > 50 kWp-1000 kWp - INR 2000 per project</td></tr>
<tr><td>Fixed</td><td colspan="6">Facilitation Fee: 5 kWp-50 kWp - INR 2000 per project, > 50 kWp-1000 kWp - INR 5000 per project</td></tr>
</table>

[258] Tariff order for Karnataka available at: https://karunadu.karnataka.gov.in/kerc/Documents/Determination%20of%20tariff%20in%20respect%20of%20SOlar%20Power%20Projects%20(including%20Solar%20Rooftop%20Photovoltaic%20Projects%20for%20FY20.pdf

NEM Policy[257]	
Variable	-
Metering (MRI/AMI)	Both MRI and AMI
Grid Code and Standards	Indian Grid Applies (all codes and standards same as mentioned for BRPL Delhi)

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		20%	-	-	60%	-
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
Capital Expenditure	*SRISHTI Scheme (INR/Watt)*	1.89	1.79	1.69	1.89	1.89
Generation based incentive	*INR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates/ Credits	*INR/kWh*	1	1	1	1	1

Annexure 12: Utility Assessment-Punjab State Power Corporation Ltd, India

Utility and Consumer Profile – PSPCL						
As on: FY 18-19	Residential (R)	Commercial (C)	Industrial (I)	Agricultural (A)	Government (G)	Total
LT/MT/HT Sale MU[259]	13,223	3,988	17,459	10,836	-	45,507
Utility System Profile						
Transmission and Distribution Losses % - Target	14.39%	14.39%	14.39%	14.39%	14.39%	14.39%
FY 18-19[260]	15.44%	15.44%	15.44%	15.44%	15.44%	15.44%
Average Pooled Purchase Price (INR/kWh) - FY 18-19[261]	4.44					
Peak Period (Hours)[262]						
Period 1	Jun-Sep 1800-2200	Jun-Sep 1800-2200	Jun-Sep 1800-2200	Jun-Sep 1800-2200	Jun-Sep 1800-2200	Jun-Sep 1800-2200
Period 2	-	-	-	-	-	-
Period 1 Generation %	0%	0%	0%	0%	0%	0%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase premium INR/kVAh (PSERC, 2020)	2.00 (applicable only to those customers having contract demand >100 kVA)					

[259] PSPCL Tariff order at http://pserc.gov.in/pages/2.%20Chapter%202%20PSPCL%20Tariff%20Order%20FY%202020-21.pdf
[260] Ibid
[261] Ibid
[262] PSPCL general conditions of tariff available at http://pserc.gov.in/pages/8.%20Annexure%20-%20I%20PSPCL%20Tariff%20Order%20FY%202020-21.pdf

Utility and Consumer Profile – PSPCL				
Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target (18-19) (Punjab Government, 2019)	2.20	872	4.30	2296
Actual (18-19)[263]	3.80	1506	3.14	1675
Future targets (Punjab Government, 2019)	- 20-21: 5.00% - 21-22: 6.50% - 22-23: 8.00%	-	- 20-21: 6.50% - 21-22: 8.00% - 22-23: 9.50%	-
Any other RE targets[264]	State government previous target of solar power capacity of 1000 MW by 2022. Draft 2019 RE Policy targets 3000 MW solar power (including rooftop, agri pumps, canal tops, floating, hybrid, IPP, etc.) by 2030			
Achieved (MNRE, 2020)	Cumulative grid-connected solar capacity till 31-12-2019: 947.10 MW			

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target[265]	2015-22: 2000 MW (Central govt target)	-	-	-	-	-	-
Actual (as on December 2019) (MNRE, 2020)	67.85 MWp	-	-	-	-	-	-

[263] PSPCL Annual Performance Review available at http://pserc.gov.in/pages/3.%20Chapter%203%20PSPCL%20Tariff%20Order%20FY%202020-21.pdf
[264] Punjab RE Policy 2012 and Punjab Draft RE Policy 2019
[265] MNRE 30 June 2015 Letter to all states/UTs

NEM Implementation Details					
NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

Utility Tariffs					
As on: 2020-2021	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) INR/kWh[266]					
LT/MT/HT	4.49-7.30	6.35-7.29	5.37-6.41	5.57/kWh or 412/BHP/month	-
Other charges (e.g., FSC etc.) INR/kWh[267]					
LT/MT/HT	0.05	0.05	0.05	0.05	-
ED% on Variable + Other charges[268]					
ED%	13%	13%	13%	13%	-
Octroi %	2%	2%	2%	2%	-
Infra Development Charge %	5%	5%	5%	5%	-
Total Variable Tariff INR/kWh					
Lower tariff limit considered for analysis	5.49	7.75	6.56	6.80	-

[266] PSPCL press note available at http://pserc.gov.in/pages/salient%20features%20of%20Tariff%20Order%202020-21.pdf
[267] PSPCL document available at http://pserc.gov.in/pages/13.%20Annexure%20%20-VI%20PSPCL%20Tariff%20Order%20FY%202020-21.pdf
[268]Ibid

NEM Policy[269]

	Solar	Wind	Biogas, Biomass	Small Hydro	Geothermal	Agri & Municipal Waste	Other
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							

Applicable to Customers	Residential	Commercial	Industrial	Agricultural	Government	Others
NEM% of Sanctioned Load permitted for the customer	80%	80%	80%	80%	80%	80%
Comments						

Definition of type of RE plant	Rooftop. Agricultural pumps also included

Limits on Capacity	**Min (kW)**	**Max (kW)**
	1 kW	1000 kW

The capacity definition (mark by X)	AC Capacity	DC Capacity	Synchronized Capacity (injected capacity – support by ESS)	Not Defined
	X	-	-	-
Cumulative Connected Load on a DT	Peak PV as % of DT Capacity	Peak PV as % of DML (Daily Minimum Load)	Based on Hosting Capacity Assessments	Not Defined
Limit	30%	-	-	-

Tariff for compensation of surplus export to the grid	**Mode**	**Comments**
	Fixed Grid Tariff or a % of Grid Tariff	-
	Average Pooled Purchase Cost	-

[269] PSERC Grid Interactive Rooftop Solar Photo Voltaic Systems based on Net Metering Regulations 2015 available at http://pserc.gov.in/pages/FinalOrder-in-Pt.%20No.-25-of-2018.pdf

NEM Policy[269]			
	Time of Use (TOU) Grid Tariff	-	
	FIT (Feed-in-Tariff)	Retail tariff as approved by Regulatory Commission. Can be equivalent to APPC	
	Benchmark Solar Tariffs from Auctions	-	
	VDER (Value of Distributed Energy Sources)	-	
Settlement basis	**Net Energy Credit**	**Net Billing**	
(mark by X)	X	-	
Settlement period	Annual	-	
Credit allowed for	Loads behind the connection, within the premises	Loads across connections given to a customer (Group Net Metering)	Loads across connections given to many customers (Virtual Net-Metering)
(mark response by X)	X	-	-
Any net-work charges applied			
One-time Connection	Application processing fee of INR 50/kVA, subject to a max of INR 10000		
Fixed			
Variable			
Metering (MRI/AMI)	MRI and AMI		
Grid Code and Standards	Indian Grid Applies (all codes and standards same as mentioned for BRPL Delhi)		

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		20%	-	-	60%	-
	INR/kWh	-	-	-	-	-

Incentives to Customers						
Generation based incentive	Period (years)	-	-	-	-	-
Interest Cost Subvention	%	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	Commercial	Industrial	Agricultural	Government
Capital Expenditure	SRISHTI Scheme (INR/Watt)	1.89	1.79	1.69	1.89	-
Generation based incentive	INR/kWh	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates / Credits	INR/kWh	1	1	1	1	-
Others (specify)		-	-	-	-	-

Annexure 13: Utility Assessment-Dhaka Power Distribution Company, Bangladesh

Utility and Consumer Profile – DPDC						
As on: 18-19	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT Sale MU[270]	3,676	1,590	610	0.12	-	5,877
HT Sale MU	-	-	2,177	-	-	2,177
Utility System Profile						
Transmission and Distribution Losses % - Target	8.25%	8.25%	8.25%	8.25%	8.25%	8.25%
FY 18-19[271]	7.29%	7.29%	7.29%	7.29%	7.29%	7.29%
Average Pooled Purchase Price (BDT/kWh) - FY 2020 (BDNews, 2020)	5.17					
Peak Period (Hours)						
Period 1 (Risad, 2017)	1700-2300	1700-2300	1700-2300	1700-2300	1700-2300	1700-2300
Period 2	-	-	-	-	-	-
Period 1 Generation %	0%	0%	0%	0%	0%	0%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase premium Tk/kWh	-					

[270] DPDC 2018-19 Annual Report available on https://dpdc.org.bd/page/view/32
[271] DPDC Executive Summary March 2020 available on https://dpdc.org.bd/page/vie w/33

Utility and Consumer Profile – DPDC				
Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target				
Actual				
Future targets				
Any other RE targets[272]	10% (2000 MW) of total energy generation from RE by 2020, 10% (4000 MW) of total energy generation from RE by 2030			
Achieved (Sajid, 2020)	RE installed (including hydro and off-grid solar) capacity till August 2020 is 647.44 MW			

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target		-	-	-	-	-	-
Actual (as in Dec 2020) (SREDA, 2020)	DPDC: 2 MW	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

[272] https://www.unescap.org/sites/default/files/Mohammad%20Hossain%20-%20Bangladesh%20Presentation.pdf

Utility Tariffs[273]					
As on: 18	Residential (R)	Commercial (C)	Industrial (I)	Agricultural (A)	Government (G)
Grid Tariff (Variable) BDT/kWh					
LT	3.75-11.46	Peak – 12.36 Off-peak – 9.27 Normal – 10.30	Peak – 10.24 Off-peak – 7.68 Normal – 8.53	4.20	-
MT	Peak – 10.50 Off-peak – 7.56 Normal – 8.40	Peak – 11.40 Off-peak – 8.21 Normal – 9.12	Peak – 10.69 Off-peak – 7.70 Normal – 8.55	Peak – 6.25 Off-peak – 4.50 Normal – 5.00	-
HT	-	Peak – 11.28 Off-peak – 8.12 Normal – 9.02	Peak – 10.56 Off-peak – 7.61 Normal – 8.45	-	-
Other charges (e.g. FSC etc.) BDT/kWh					
LT/MT/HT					
ED% on Variable + Other charges					
ED%					
GST%					
Total Variable Tariff BDT/kWh					
Rates considered	5.34	9.27	7.68	4.16	-

NEM Policy (CRESL & CER, 2018)							
	Solar	Wind	Biogas, Biomass	Small Hydro	Geothermal	Agri & Municipal Waste	Other
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							

[273] DPDC Executive Summary March 2020 available on https://dpdc.org.bd/page/view/33

<table>
<tr><th colspan="7">NEM Policy (CRESL & CER, 2018)</th></tr>
<tr><td>Applicable to Customers</td><td>Residential</td><td>Commercial</td><td>Industrial</td><td>Agricultural</td><td>Government</td><td>Others</td></tr>
<tr><td>NEM% of Sanctioned Load permitted for the customer</td><td colspan="6">70%</td></tr>
<tr><td>Comments</td><td colspan="6"></td></tr>
<tr><td>Definition of type of RE plant</td><td colspan="6">3-phase Rooftop, facades, ground-mounted, other parts of premises</td></tr>
<tr><td>Limits on Capacity</td><td colspan="3">Min (kW)</td><td colspan="3">Max (kW)</td></tr>
<tr><td></td><td colspan="3">Not defined</td><td colspan="3">3000 kW</td></tr>
<tr><td rowspan="2">The capacity definition (mark by X)</td><td>AC Capacity</td><td>DC Capacity</td><td colspan="2">Synchronized Capacity (injected capacity – support by ESS)</td><td colspan="2">Not Defined</td></tr>
<tr><td>X</td><td>-</td><td colspan="2">-</td><td colspan="2">X</td></tr>
<tr><td>Cumulative Connected Load on a DT</td><td>Peak PV as % of DT Capacity</td><td>Peak PV as % of DML (Daily Minimum Load)</td><td colspan="2">Based on Hosting Capacity Assessments</td><td colspan="2">Not Defined</td></tr>
<tr><td>Limit</td><td>70% for medium voltage consumers</td><td>-</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td rowspan="7">Tariff for compensation of surplus export to the grid</td><td colspan="2">Mode</td><td colspan="4">Comments</td></tr>
<tr><td colspan="2">Fixed Grid Tariff or a % of Grid Tariff</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Average Pooled Purchase Cost</td><td colspan="4">Bulk Purchase Price of Electricity</td></tr>
<tr><td colspan="2">Time of Use (TOU) Grid Tariff</td><td colspan="4">-</td></tr>
<tr><td colspan="2">FIT (Feed-in-Tariff)</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Benchmark Solar Tariffs from Auctions</td><td colspan="4">-</td></tr>
<tr><td colspan="2">VDER (Value of Distributed Energy Sources)</td><td colspan="4">-</td></tr>
<tr><td>Settlement basis</td><td colspan="2">Net Energy Credit</td><td colspan="4">Net Billing</td></tr>
<tr><td>(mark by X)</td><td colspan="2">X</td><td colspan="4">-</td></tr>
</table>

NEM Policy (CRESL & CER, 2018)			
Settlement period	Annual	-	
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**
(mark response by X)	X		
Any net-work charges applied	No, all network charges waived off		
One-time Connection			
Fixed			
Variable	-		
Metering (MRI/AMI)	AMI		
Grid Code and Standards			
Inverter	BDS IEC 62109 – General requirements and requirements for inverters, IEC 61727:2004 - Characteristics of the utility interface, IEC 62116:2014 - Test procedure of islanding prevention		
Fault Ride-Through	-		
Frequency	- Inverter should be capable of producing power at the frequency band of at least +/-6% - When outside the nominal 50 Hz value by ±2%, trip time shall be within 0.20s		
Voltage	- LV – 230-400 V, MV – 11-33 kV. Maximum inverter voltage fluctuation range allowed is 6% - Voltage unbalance: Infrequent short duration peaks with a maximum value of 2% over 1-minute duration are permitted. Unbalanced voltage shall not exceed 1% on 5 occasions within any 30-minute period - Voltage disturbance: Defined for V < 50% (trip time: 0.10 sec) to 110% < V < 135% (trip time: 2.00 sec)		
Harmonics	Should have low current-distortion levels. THD shall be less than 3% of the rated inverter output at the cable connected to the interconnection point		
Power Quality	Shall have a leading or lagging power factor greater than 0.9 when load is 20% greater than the rated inverter output power		
Anti-Islanding	- Shall disconnect from the Utility's system for loss of main within one second - Inverters used by the NEM consumer shall provide the following anti-islanding detection techniques : • Under voltage • Over voltage		

NEM Policy (CRESL & CER, 2018)	
	• Under frequency • Over frequency - Should also include at least one of the following active anti islanding techniques : • Negative-sequence current injection • Impedance measurement • Slip mode frequency shift • Frequency bias, etc.
Flicker	-
Paralleling Device	-
Overload/ Overheat	The fault current contribution by the inverter will be limited usually by the inverter control. Based on IEC 61727 or, IEEE 1547, the typical range of short circuit current is between 100% and 200% of the rated inverter current
Synchronization	Should be equipped with automatic synchronization system. For solar PV system the synchronization is to be done at the inverter
DC Injection	Shall not inject DC current greater than 1% of the rated inverter output current into the Utility interface
Utility Curtailment	Must incorporate Utility interface disconnect switch to allow disconnection of the system output from interconnecting with the Utility for safe Utility line works. Switch shall be manual and lockable

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		-	-	-	-	-
Generation based incentive	*Tk/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-

Incentives to Customers						
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
Capital Expenditure	*Tk/Watt*	-	-	-	-	-
Generation based incentive	*Tk/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates/ Credits	*Tk/kWh*	-	-	-	-	-
Others (specify)		-	-	-	-	-

ANNEXURE 14: UTILITY ASSESSMENT-CEYLON ELECTRICITY BOARD, SRI LANKA

Utility and Consumer Profile – CEB						
As on: 2018	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT Sale MU (CEB, 2019)	4,641	1,690	327	-	10	6,668
MT Sale MU	-	891	2,044	-	170	3,105
HT Sale MU	-	358	1,919	-	5	2,281
Utility System Profile						
Transmission and Distribution Losses % - 2019	8.52%	8.52%	8.52%	8.52%	8.52%	8.52%

Utility and Consumer Profile – CEB						
Averaged Div 1-4						
FY 2018 (CEB, 2019)	8.34%	8.34%	8.34%	8.34%	8.34%	8.34%
Average Pooled Purchase Price (LKR/kWh) - FY 2018 (CEB, 2019)	19.12					
Peak Period (Hours)						
Period 1 (PUC, 2019)	1830-2230	1830-2230	1830-2230	1830-2230	1830-2230	1830-2230
Period 2	-	-	-	-	-	-
Period 1 Generation %	0%	0%	0%	0%	0%	0%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase premium LKR/kWh (CEB, 2020)	14.00 (Average peak premium of all segments)					

Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target				
Actual				
Future targets				
Any other RE targets (MPRE, 2018)	- To generate 1000 MW by 100000 solar rooftops by 2025 under the Soorya Bala Sangramaya-I (Battle for Solar) program - Rivi Aruna program: Provide solar rooftops to religious places - Convert Public Sector Buildings to Green Energy by installation of solar rooftop - Soorya Bala Sangramaya-II: Construction of 150 MW solar plants planned			

Utility and Consumer Profile – CEB	
	- Soorya Bala Sangramaya-III: 50 MW solar capacity planned - Soorya Bala Sangramaya-IV: 400 MW solar planned (including 100 MW floating solar)
Achieved (MPRE, 2018)	- Achieved 215 MW solar rooftop (20,000 systems) by 2020 - Rivi Aruna: Established 270 kW (135 consumers) by 2018 - Convert Public Sector Buildings to Green Energy: Achieved 1400 kW (77 connections) by 2018

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target[274]	200 MW by 2020 and 1000 MW by 2025 (100,000 connections)	-	-	-	-	-	-
Actual (as in 2020)[275]	215 MW (20,000 connections)	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

Utility Tariffs (CEB, 2020)					
As on: 2019	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
Grid Tariff (Variable) LKR/kWh					
LT	2.5 - 45	18.30	10.80-12.20	-	14.65

[274] https://www.bioenergysrilanka.lk/renewable-energy-presidents-target-sabotaged-by-corrupt-officials/

[275] Ibid

Utility Tariffs (CEB, 2020)					
	Optional: Normal – 25 Off-peak – 13 Peak – 54				
MT	-	Normal – 21.80 Off-peak – 15.4 Peak – 26.60	Normal – 11.00 Off-peak – 6.85 Peak – 20.50	-	14.55
HT	-	Normal – 25.5 Off-peak – 14.3 Peak – 20.70	Normal – 10.25 Off-peak – 5.90 Peak – 23.50	-	14.35
Other charges (e.g., FSC etc.) LKR/kWh					
LT/MT/HT					
ED% on Variable + Other charges					
ED%					
GST%					
Total Variable Tariff LKR/kWh					
Normal rates considered	25.00	18.30-21.80	10.20-11.00	-	14.35-14.65

NEM Policy[276]							
	Solar	**Wind**	**Biogas, Biomass**	**Small Hydro**	**Geothermal**	**Agri & Municipal Waste**	**Other**
Applicable Technologies (mark X)	X	-	-	-	-	-	-
Comments							
Applicable to Customers	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**	**Others**	
NEM% of Sanctioned Load permitted for the customer	100%						
Comments							

[276] CEB Net Metering Manual 2014 and PUC's Guidelines on Rooftop Solar PV Installation for Utility Providers

NEM Policy[276]				
Definition of type of RE plant	Rooftop			
Limits on Capacity	**Min (kW)**		**Max (kW)**	
	Not defined		1000 kVA	
The capacity definition (mark by X)	**AC Capacity**	**DC Capacity**	**Synchronized Capacity (injected capacity – support by ESS)**	**Not Defined**
	-	-	-	X
Cumulative Connected Load on a DT	**Peak PV as % of DT Capacity**	**Peak PV as % of DML (Daily Minimum Load)**	**Based on Hosting Capacity Assessments**	**Not Defined**
Limit	-	-	-	X (Subject to availability in DT capacity)
Tariff for compensation of surplus export to the grid	**Mode**		**Comments**	
	Fixed Grid Tariff or a % of Grid Tariff		-	
	Average Pooled Purchase Cost		-	
	Time of Use (TOU) Grid Tariff		-	
	FIT (Feed-in-Tariff)[277]		Net Accounting and Net Plus: LKR 22.00/kWh for first 7 years and LKR 15.50/kWh from 8th to 20th year	
	Benchmark Solar Tariffs from Auctions		-	
	VDER (Value of Distributed Energy Sources)		-	
Settlement basis	**Net Energy Credit**		**Net Billing**	
(mark by X)	-		X	
Settlement period	-		Not mentioned	
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**	

[277] http://www.leco.lk/pages_e.php?id=85

NEM Policy[276]			
(mark response by X)	X		
Any net-work charges applied			
One-time Connection			
Fixed			
Variable	-		
Metering (MRI/AMI)	MRI and AMI		
Grid Code and Standards			
Inverter	Shall be only those which have received the Type Approval by utility		
Fault Ride-Through	-		
Frequency	Over (max +2%) and under (min -6%) frequency (50 Hz) trip functions and clearance times defined (0.5 seconds)		
Voltage	Trip settings: - 230 V + 10%: 0.2 sec - 230 V + 6%: 1.5 sec - 230 V – 6%: 1.5 sec Withstand voltage and current surges in accordance with the environments defined in IEEE 1547 – 4.1.8.2		
Harmonics	Voltage THD max limit 5%		
Power Quality	Power quality measurement shall be complied with IEC 61400-21		
Anti-Islanding	Anti-islanding feature compulsory and should cease to energize within 0.5 sec of the formation of unintended island. Not to reconnect unless CEB distribution system service voltage is within +/-6% of the nominal supply voltage and frequency is within 47 Hz to 52 Hz and are stable for at least 3 minutes (IEEE 1547-4.2.1 and 4.2.2)		
Flicker	As per IEC 61000-3-7		
Paralleling Device	Shall be capable of with-standing 220% of the interconnection facility rated voltage (IEEE 1547 – 4.1.8.3)		
Overload/Overheat	-		
Synchronization	-		
DC Injection	-		

NEM Policy[276]	
Utility Curtailment	Shall furnish and install an appropriately sized ganged isolating switch near the point of common coupling (PCC) to isolate the generating facility from the grid

Incentives to Customers						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
% of Capital Expenditure		-	-	-	-	-
Generation based incentive	*LKR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Interest Cost Subvention	*%*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Reduction in Demand Charges		-	-	-	-	-
Accelerated Depreciation		-	-	-	-	-
Investment Tax Credits		-	-	-	-	-
Government Mandates		-	-	-	-	-

Incentives to Utility						
		Residential	**Commercial**	**Industrial**	**Agricultural**	**Government**
Capital Expenditure	*LKR/Watt*	-	-	-	-	-
Generation based incentive	*LKR/kWh*	-	-	-	-	-
	Period (years)	-	-	-	-	-
Renewable Certificates / Credits	*LKR/kWh*	-	-	-	-	-
Others (specify)		-	-	-	-	-

ANNEXURE 15: UTILITY ASSESSMENT K-ELECTRIC, PAKISTAN

Utility and Consumer Profile: K-Electric						
As on:	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT/MT/HT Sale MU						
Utility System Profile						
Transmission and Distribution Losses % - 18-19 allowed	18.75%	18.75%	18.75%	18.75%	18.75%	18.75%
FY 2019[278]	19.10%	19.10%	19.10%	19.10%	19.10%	19.10%
Average Pooled Purchase Price (PKR/kWh) - FY 2019[279]	11.02					
Peak Period (Hours)						
Period 1[280]	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200
Period 2	-	-	-	-	-	-
Period 1 Generation %	0.69%	0.69%	0.69%	0.69%	0.69%	0.69%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase premium PKR/kWh[281]	6.00 (an approx. of average peak and off-peak for different consumer segments)					
Targets and Achievements						

[278] K-Electric Annual Report 2019
[279] https://nepra.org.pk/Admission%20Notices/2019/09-September/CPPA-G%20Report%20on%20PPP.pdf (Average of 2019-20 values in pg. 108)
[280] https://www.ke.com.pk/customer-services/tariff-structure/
[281] K-Electric's Tariff Rate SRO dated 22nd Jan 2020

Utility and Consumer Profile: K-Electric				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target				
Actual				
Future targets				
Any other RE targets	As per the Alternative and Renewable Energy Policy 2019, RE to be 20% of the total generation capacity by 2025 and 30% by 2030. Under the Sindh Solar Energy Program: Aim of developing 400 MW utility-scale solar, 20 MW solar rooftop on and around public buildings in Karachi and Hyderabad			
Achieved				

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target	20 MW under Sindh Solar Energy Program	-	-	-	-	-	-
Actual (as on August 2019)[282]	6.15 MW (340 connections)	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					

NEM connections – Capacity-wise %	**1-10 kW**	**10-100 kW**	**100-500 kW**	**500-1000 kW**	**>1000 kW (if allowed)**
Solar Rooftop %					

[282] https://www.saarcenergy.org/wp-content/uploads/2019/10/3-Licensing-Presentation-Net-Metering.pdf

Utility Tariffs					
As on: 2019	Residential (R)	Commercial (C)	Industrial (I)	Agricultural (A)	Government (G)
Grid Tariff (Variable) PKR/kWh[283]					
LT/MT/HT	2.00-20.70	18-19.68	14.78-15.50	11.22	-
Off-peak	14.38	15.63	12.00-13.28	10.80	-
Peak	20.70	21.60	15.78-15.84	16.50	-
Other charges (e.g., FSC etc.) PKR/kWh[284]					
LT/MT/HT	Financing Cost Surcharge: 0.43/unit Neelum Jhelum Surcharge: 0.10/unit Quarterly tariff adjustment: 1.65/unit				
ED% on Variable + Other charges					
ED%[285]	1.5%	2%	1.5%	1%	-
GST%[286]	17%	17%	17%	17%	-
Total Variable Tariff PKR/kWh					
Considered the > 5 kW customer tariff for residential and agri (off-peak rate), since NEM is allowed only for 3-ph customers in Pakistan	19.67	21.15	16.84	15.34	-

NEM Policy[287]							
	Solar	Wind	Biogas, Biomass	Small Hydro	Geothermal	Agri & Municipal Waste	Other
Applicable Technologies (mark X)	X	X	-	-	-	-	-

[283] K-Electric's Tariff Rate SRO dated 22nd Jan 2020
[284] Refer to IESCO in Annexure 16
[285] https://www.ke.com.pk/customer-services/tariff-structure/
[286] Refer to IESCO in Annexure 16
[287] NEPRA NEM Regulations of 2015 and the subsequent amendments in 2017, 2018

<table>
<tr><th colspan="7">NEM Policy[287]</th></tr>
<tr><td>Comments</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Applicable to Customers</td><td>Residential</td><td>Commercial</td><td>Industrial</td><td>Agricultural</td><td>Government</td><td>Others</td></tr>
<tr><td>NEM% of Sanctioned Load permitted for the customer</td><td colspan="6">150%</td></tr>
<tr><td>Comments</td><td colspan="6">NEM allowed only for 3-phase 400 V or 11 kV consumers</td></tr>
<tr><td>Definition of type of RE plant</td><td colspan="6">3-phase, No specific definition for the type of solar or wind plant</td></tr>
<tr><td>Limits on Capacity</td><td colspan="3">Min (kW)</td><td colspan="3">Max (kW)</td></tr>
<tr><td></td><td colspan="3">1 kW</td><td colspan="3">1000 kW</td></tr>
<tr><td rowspan="2">The capacity definition (mark by X)</td><td>AC Capacity</td><td>DC Capacity</td><td colspan="2">Synchronized Capacity (injected capacity – support by ESS)</td><td colspan="2">Not Defined</td></tr>
<tr><td>-</td><td>X</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td>Cumulative Connected Load on a DT</td><td>Peak PV as % of DT Capacity</td><td>Peak PV as % of DML (Daily Minimum Load)</td><td colspan="2">Based on Hosting Capacity Assessments</td><td colspan="2">Not Defined</td></tr>
<tr><td>Limit</td><td>15%</td><td>-</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td rowspan="7">Tariff for compensation of surplus export to the grid</td><td colspan="3">Mode</td><td colspan="3">Comments</td></tr>
<tr><td colspan="3">Fixed Grid Tariff or a % of Grid Tariff</td><td colspan="3">-</td></tr>
<tr><td colspan="3">Average Pooled Purchase Cost</td><td colspan="3">APPC of the DISCO</td></tr>
<tr><td colspan="3">Time of Use (TOU) Grid Tariff</td><td colspan="3">-</td></tr>
<tr><td colspan="3">FIT (Feed-in-Tariff)</td><td colspan="3">-</td></tr>
<tr><td colspan="3">Benchmark Solar Tariffs from Auctions</td><td colspan="3">-</td></tr>
<tr><td colspan="3">VDER (Value of Distributed Energy Sources)</td><td colspan="3">-</td></tr>
<tr><td>Settlement basis</td><td colspan="3">Net Energy Credit</td><td colspan="3">Net Billing</td></tr>
<tr><td>(mark by X)</td><td colspan="3">X</td><td colspan="3">-</td></tr>
</table>

NEM Policy[287]			
Settlement period	Quarterly		-
Credit allowed for	**Loads behind the connection, within the premises**	**Loads across connections given to a customer (Group Net Metering)**	**Loads across connections given to many customers (Virtual Net-Metering)**
(mark response by X)	X		
Any net-work charges applied			
One-time Connection	One-time fee: - 0-20 kW: Free - 20-50 kW: PKR 500 - 50-100 kW: PKR 1000 - > 100-1000 kW: PKR 5000		
Fixed			
Variable	-		
Metering (MRI/AMI)	MRI and AMI		
Grid Codes and Standards	Same as for IESCO. Refer IESCO table		

Annexure 16: Utility Assessment-Islamabad Electric Supply Company, Pakistan

Utility and Consumer Profile – IESCO						
As on: 2019 projection	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**	**Total**
LT/MT/HT Sale MU[288]	5,346	1,270	2,063	107	-	8,786
Utility System Profile						
Transmission and Distribution Losses % - 17-18 Target	8.65%	8.65%	8.65%	8.65%	8.65%	8.65%

[288] These are projected values in Nov 2019: https://nepra.org.pk/tariff/Tariff/Ex-WAPDA%20DISCOS/2019/TRF-100%20XWDISCOs%2026-11-2019%2025610-12.PDF

Utility and Consumer Profile – IESCO						
FY 2019[289]	8.90%	8.90%	8.90%	8.90%	8.90%	8.90%
Average Pooled Purchase Price (PKR/kWh) - FY 2019[290]	12.14					
Peak Period (Hours)						
***Period 1* (Mustafa, Khalid, 2019)**	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200	1800-2200
Period 2	-	-	-	-	-	-
Period 1 Generation %	0.39%	0.39%	0.39%	0.39%	0.39%	0.39%
Period 2 Generation %	-	-	-	-	-	-
Peak hour power purchase premium PKR/kWh (IESCO, 2019)	6.00 (an approx. of average peak and off-peak for different consumer segments)					

Targets and Achievements				
	Solar % of total procurement	**Solar MU of total procurement**	**Non-Solar RE % of total procurement**	**Non-Solar RE MU of total procurement**
Target				
Actual				
Future targets				
Any other RE targets	As per the Alternative and Renewable Energy Policy 2019, RE to be 20% of the total generation capacity by 2025 and 30% by 2030. No specific target from IESCO			

289 Presentation on K-Electric – Privatization Turnaround available at: https://www.ke.com.pk/assets/uploads/2020/07/Privatization-Turnaround.pdf

290 https://nepra.org.pk/Admission%20Notices/2019/09-September/CPPA-G%20Report%20on%20PPP.pdf (Average of 19-20 values in pg 102)

Utility and Consumer Profile – IESCO	
Achieved	

NEM Implementation Details							
NEM connections – Technology-wise MW	**Solar Rooftop**	**Solar Ground-mounted**	**Solar Pumps**	**Biogas, Biomass**	**Wind**	**Small Hydro**	**Others**
Potential							
Target	No target	-	-	-	-	-	-
Actual (as on August 2019)[291]	9.25 MW (672 connections) 960 connections by Feb 2020	-	-	-	-	-	-

NEM connections – Consumer-wise	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Others (Institutional)**
Solar Rooftop MW					
NEM connections – Capacity-wise %	1-10 kW	10-100 kW	100-500 kW	500-1000 kW	>1000 kW (if allowed)
Solar Rooftop %					

Utility Tariffs					
As on: 2019	**Residential (R)**	**Commercial (C)**	**Industrial (I)**	**Agricultural (A)**	**Government (G)**
***Grid Tariff (Variable) PKR/kWh* (IESCO, 2019)**					
LT/MT/HT	2.00-20.71	18-19.68	14.78-15.28	5.35	-
Off-peak	14.38	15.63	12.88-13.28	11.35	-
Peak	20.70	21.60	18.78-18.84	18.60	-
Other charges (e.g., FSC etc.) PKR/kWh[292]					
LT/MT/HT	Financing Cost Surcharge: 0.43/unit Neelum Jhelum Surcharge: 0.10/unit Quarterly tariff adjustment: 1.65/unit				

291 https://www.saarcenergy.org/wp-content/uploads/2019/10/3-Licensing-Presentation-Net-Metering.pdf
292 http://210.56.23.106:888/iescobill/general/06141130720600,

ED% on Variable + Other charges					
ED%	1.5%	2%	1.5%	1%	-
GST%	17%	17%	17%	17%	-
Total Variable Tariff PKR/kWh					
Considered the > 5 kW customer tariff for residential and agri (off-peak rate), since NEM is allowed only for 3-ph customers in Pakistan	19.67	21.15	16.84	15.41	-

NEM Policy							
	Solar	**Wind**	**Biogas, Biomass**	**Small Hydro**	**Geothermal**	**Agri & Municipal Waste**	**Other**
Applicable Technologies (mark X)	X	X	-	-	-	-	-
Comments							
Applicable to Customers	**Residential**	**Commercial**	**Industrial**	**Agricultural**	**Government**	**Others**	
NEM% of Sanctioned Load permitted for the customer	150%						
Comments	NEM allowed only for 3-phase 400 V or 11 kV consumers						
Definition of type of RE plant	3-phase, No specific definition for the type of solar or wind plant						
Limits on Capacity	**Min (kW)**			**Max (kW)**			
	1 kW			1000 kW			
	AC Capacity	**DC Capacity**	**Synchronized Capacity (injected**	**Not Defined**			

<table>
<tr><th colspan="13">NEM Policy</th></tr>
<tr><td rowspan="2">The capacity definition (mark by X)</td><td colspan="3"></td><td colspan="3"></td><td colspan="3">capacity – support by ESS)</td><td colspan="3"></td></tr>
<tr><td colspan="3">-</td><td colspan="3">X</td><td colspan="3">-</td><td colspan="3">-</td></tr>
<tr><td>Cumulative Connected Load on a DT</td><td colspan="3">Peak PV as % of DT Capacity</td><td colspan="3">Peak PV as % of DML (Daily Minimum Load)</td><td colspan="3">Based on Hosting Capacity Assessments</td><td colspan="3">Not Defined</td></tr>
<tr><td>Limit</td><td colspan="3">15%</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="3">-</td></tr>
<tr><td rowspan="7">Tariff for compensation of surplus export to the grid</td><td colspan="6">Mode</td><td colspan="6">Comments</td></tr>
<tr><td colspan="6">Fixed Grid Tariff or a % of Grid Tariff</td><td colspan="6">-</td></tr>
<tr><td colspan="6">Average Pooled Purchase Cost</td><td colspan="6">APPC of the DISCO</td></tr>
<tr><td colspan="6">Time of Use (TOU) Grid Tariff</td><td colspan="6">-</td></tr>
<tr><td colspan="6">FIT (Feed-in-Tariff)</td><td colspan="6">-</td></tr>
<tr><td colspan="6">Benchmark Solar Tariffs from Auctions</td><td colspan="6">-</td></tr>
<tr><td colspan="6">VDER (Value of Distributed Energy Sources)</td><td colspan="6">-</td></tr>
<tr><td>Settlement basis</td><td colspan="6">Net Energy Credit</td><td colspan="6">Net Billing</td></tr>
<tr><td>(mark by X)</td><td colspan="6">X</td><td colspan="6">-</td></tr>
<tr><td>Settlement period</td><td colspan="6">Quarterly</td><td colspan="6">-</td></tr>
<tr><td>Credit allowed for</td><td colspan="4">Loads behind the connection, within the premises</td><td colspan="4">Loads across connections given to a customer (Group Net Metering)</td><td colspan="4">Loads across connections given to many customers (Virtual Net-Metering)</td></tr>
<tr><td>(mark response by X)</td><td colspan="4">X</td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td>Any net-work charges applied</td><td colspan="12"></td></tr>
<tr><td>One-time Connection</td><td colspan="12">One-time fee:
- 0-20 kW: Free
- 20-50 kW: PKR 500
- 50-100 kW: PKR 1000
- > 100-1000 kW: PKR 5000</td></tr>
<tr><td>Fixed</td><td colspan="12"></td></tr>
</table>

NEM Policy	
Variable	-
Metering (MRI/AMI)	MRI and AMI
Grid Code and Standards	
Inverter	To comply UL 1741, IEEE 1547 2003, IEC 61215, EN or other international standards
Fault Ride-Through	-
Frequency	Under and over frequencies and their trip times in accordance with IEEE 1547 and IEC 61727 - fnominal < 47.5 Hz (0.1 sec) - 47.5 Hz <= fnominal < 51.5 Hz (continuous operation) - 51.5 Hz < fnominal (0.1 sec)
Voltage	Under and over voltages and their trip times in accordance with IEEE 1547 and IEC 61727. - V < 50% (0.1 sec) - 50% <= V < 85% (2.0 sec) - 85% <= V < 110% (continuous operation) - 110% <= V < 135% (2.0 sec) - 135% <= V (0.05 sec) Fluctuation variation of +/-5% allowed
Harmonics	In accordance with IEEE 1547. The THD should be less than 5% at 100% rated power of the inverter
Power Quality	Shall have pf > 0.9 when generation > 50% of system rating. Larger systems (like industrial) maybe required to install additional systems for pf correction
Anti-Islanding	Shall detect the island and cease to energise the area EPS within 2 sec of the formation of an island. System at a single point of common coupling (PCC) > 250 kVA should have provision for a monitoring device. Adjustable delay (or a fixed delay of 5 min) of up to 5 min that delays reconnection till voltage and frequency restored to normal levels.
Flicker	-
Paralleling Device	Shall be capable of withstanding 220% of the interconnection system rated voltage
Overload/Overheat	-
Synchronization	-
DC Injection	Should not be greater than 0.5% of full rated output current at the distributed generator connection

NEM Policy	
Utility Curtailment	-

Annexure 17: NEM Policies of Afghanistan and Nepal

NEPAL Net Metering Policy	
Launch year	2018
Net-metering	For Solar PV
System capacity	Max. solar capacity limit of 1 MW, Min 500 W Size classification: • 0.5kWp-10 kWp Residential • >10 kWp < 500 kWp Institutional • >500 kWp < 1 MWp Commercials • > 1 MWp Utility Scale
Feed In Tariff	NPR 7.3/kWh
Subsidies	▶ 50% interest on loans subsidized. ▸ Paid in 2018-2019 but stopped in 2020 due to lack of funds

AFGHANISTAN Net Metering Policy	
Launch year	National Renewable Energy Policy 2015
Net-metering	For Solar PV
System capacity	500 W, <1 MW, <100% of sanctioned load Cumulative capacity connected to a Distribution Transformer (DT) < 50% of DT capacity
Mechanisms	NEM: exported energy banked and allowed to be used by the consumer at a later date
	1-10 MW FIT tariffs 10 MW: PPA established through auctions.

Annexure 18: Selection of Power Utilities in selected SAARC Member States

Bangladesh:

As part of reform and restructuring, transmission was vertically separated as a subsidiary of BPDB and distribution was horizontally separated to create new distribution entities in capital city (DPDC & DESCO) and rural areas (REB). Further, a number of generation and urban distribution companies were created as a subsidiary of BPDB. The subsidiaries of BPDB are:

- Ashuganj Power Station Company Ltd. (APSCL)
- Electricity Generation Company of Bangladesh Ltd. (EGCB)
- North West Power Generation Company Ltd. (NWPGCL)
- Power Grid Company of Bangladesh Ltd. (PGCB)
- West Zone Power Distribution Company Ltd. (WZPDCL)
- Northern Electricity Supply company Ltd. (NESCO)

As of date, Bangladesh has implemented 16.163 MW, out of which 62.5% (10.094 MW) has been implemented in the rural areas by BREB and 22.3% by the utilities in Dhaka (DPDC and DESCO) (SREDA, 2019). The easy availability of data and the proximity to country-level authorities like the Sustainable and Renewable Energy Development Authority (SREDA), PowerCell, etc., have been the factors for choosing a utility from Dhaka for this study. Out of the two, DPDC's jurisdiction covers almost 250 sq. km (out of Dhaka's ~306.4 sq. km) and hence has been selected as the utility from Bangladesh for this net metering study.

India:

India has around 63 DISCOMs (distribution companies) serving the customers in different states. Few these are private or public-private partnership but most of them are public. Due to vast distribution of these DISCOMs across the country, it was decided that while bringing in the private and public utilities' perspective regarding NEM implementation in the country, the selection of utilities will have to be such that they are covered across the geography of India. Hence the following 5 power utilities were chosen from India for this NEM study:

- BSES Rajdhani Power Limited – BRPL (Public-Private, Northern India)
- Bangalore Electricity Supply Company Limited – BESCOM (Public, Southern India)
- Maharashtra State Electricity Distribution Co. Ltd – MSEDCL (Public, Western India)
- Chhattisgarh State Power Distribution Company Ltd – CSPDCL (Public, Central-Eastern India)
- Punjab State Power Corporation Limited – PSPCL (Public, North-Western India)

Pakistan:

There are 11 DISCOs (distribution companies) serving across Pakistan with most of them being public entities (IESCO, LESCO, GEPCO, FESCO, MEPCO, PESCO, TESCO, HESCO, QESCO, SEPCO) and one being private (KESC). To get a better perspective of the NEM implementation in Pakistan, one private utility (KESC) and one public utility were chosen for the study. Out of the 10 public utilities, IESCO (Islamabad Electric Supply Company) had the higher number of NEM licenses issued by 2019[293] and hence was chosen as the second utility (apart from KESC) for this study.

Sri Lanka:

Ceylon Electricity Board (CEB) and Lanka Electricity Company Limited (LECO) are the distribution utilities in Sri Lanka. CEB is state-owned and LECO is a private corporate entity (also of which CEB is one of the major shareholders) (ADB, 2019). LECO handles a small part (~10%) of the Sri Lankan power distribution in few areas between Galle and Negambo along the western coastal belt of Sri Lanka. Since CEB is the dominant power distribution player in Sri Lanka, it has been chosen as the power utility from Sri Lanka for this study.

[293] https://www.saarcenergy.org/wp-content/uploads/2019/10/3-Licensing-Presentation-Net-Metering.pdf