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SOLAR ROOFTOP-PLUS-STORAGE

April 2021

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CONSULTATION PAPER

SOLAR ROOFTOP-PLUS-STORAGE

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ACRONYMS

ABT	Availability Based Tariff
C&I	Commercial and Industrial
CEA	Central Electricity Authority
CEI	Chief Electrical Inspector
DISCOM	Distribution Company
GERC	Gujarat Electricity Regulatory Commission
GW	Gigawatt
GWh	Gigawatt Hour
HT	High Tension
IEC	International Energy Code
kW	Kilowatt
kWh	Kilowatt Hour
LBNL	Lawrence Berkeley National Laboratory
LT	Low Tension
MNRE	Ministry of New and Renewable Energy
MSME	Micro, Small and Medium Enterprises
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
RE	Renewable Energy
TOD	Time of Day

ACKNOWLEDGEMENT

This paper was prepared under the Partnership to Advance Clean Energy-Deployment (PACE-D 2.0 RE) Technical Assistance Program, which is funded by the United States Agency for International Development (USAID).

The authors thank Anurag Mishra, Project Manager PACE – D 2.0 RE and Energy Team Leader - USAID for his support and vision.

The team also appreciates and is grateful to Gujarat Electricity Regulatory Commission (GERC) for their interest in understanding how enabling consumer-sited, behind-the-meter solar-plus-storage systems can support both retail electricity consumers and the grid, and what role consumer-sited solar-plus-storage can play to support Gujarat's clean energy and development goals. The PACE-D 2.0 RE team thanks Mr. Anand Kumar, Ex Chairman GERC, Mr. Satyendra R. Pandey, Member (Technical) and Mr. Mehul M. Gandhi, Member (Legal) for their personal interest and technical guidance.

The team is grateful for the overall guidance provided by Ministry of New and Renewable Energy (MNRE) and valuable support to the program.

We also wish to thank the following individuals for their detailed review comments, insights, and contributions to this report (names listed alphabetically by organization and last name).

Lawrence Berkeley National Laboratory (LBNL) —Naim Darghouth

National Renewable Energy Laboratory (NREL) — Owen Zinaman and Carishma Gokhale-Welch

Tetra Tech — Devina Anand, Rakesh Kumar Goyal, Sumedh Agarwal and Ronnie Khanna (Ex-employee)

Nexus Energy Tech Private Limited — Arvind Karandikar

BACKGROUND

India's power sector is in transition as the county aims to add 175 GW of renewable energy capacity by the year 2022 and scale this up further to 450 GW by 2030. If this target is achieved, 40 percent of India's total installed capacity will come from non-fossil fuel energy sources by 2030. In particular, the National Solar Mission has set a target of 60 GW of utility scale solar and 40 GW of distributed solar by 2022, and the Ministry of New and Renewable Energy has developed state-specific targets. In response, states in India are developing road maps to achieve these targets and scale RE deployment.

Although rooftop solar deployment has been slow in the early years of the market, as India works steadily to meet targets, the increased solar supply will modify supply and net load curves, eventually leading to certain grid management issues. The modified net load curve with additional solar deployment will create variations of the duck curve, which to some extent can be addressed by pairing rooftop solar with energy storage, with the right rate structures to align utility and consumer value. Furthermore, forecasted cost reductions in storage prices over time and well-designed energy policy could make it possible to cost-effectively shift solar generation from low to high demand periods using storage, helping to alleviate some of the grid integration challenges.

A quick overview of the current state of rooftop PV sector in India reveals the following considerations for any newly suggested policy or regulatory changes. The considerations are not discussed here in any detail, but only listed for immediate reference.

In many states, regulatory frameworks and established DISCOM programs and practices can be an impediment to achieving rooftop solar deployment goals. Many DISCOMs in India are expressing concerns over revenue sufficiency, fixed cost recovery, cross-subsidization, grid integration challenges, and also other perceived issues related to distributed solar PV.

- Forum of Regulator's 2013 Model Net Metering Regulations
- Owing to the perception that due to this overly generous compensation for rooftop solar exports, many DISCOMs hardened their stance against rooftop solar with the fear of revenue insufficiency.
- Forum of Regulator's Draft Model Regulation for Grid Interactive Distributed Renewable Energy Sources in 2018-19
- Procurement of high quantum of cheap solar PV power through competitive bidding from utility scale projects
- High adoption by its best consumers (C&I) is driving discoms to oppose distributed and rooftop solar.
- Limited rollout of Time-of-Day Billing and Metering

GUJARAT CONTEXT

Gujarat has high solar PV and wind renewable energy targets, which are based on forecasted energy demand, with good underlying resources and siting availability in many parts of the state (Power Grid Corporation of India 2012). It is forecasted to have a total annual energy demand and peak demand of 98 GWh and 15 GW, respectively (CEA 2018). Net energy metering is the primary compensation mechanism

for rooftop solar exports, although Gujarat has recently created a net billing scheme as an alternative to its net energy metering scheme (Gujarat Electricity Regulatory Commission 2020). For net metering, any net surplus energy generated at the end of the billing cycle in Gujarat is purchased by the utility at the average pooled purchase cost, as decided by the Gujarat Energy Regulatory Commission annually (Gujarat Electricity Regulatory Commission 2016). For net billing in Gujarat, the sell rate at which injections from to the grid are rewarded depends on the consumer class of the solar system owner (Gujarat Electricity Regulatory Commission 2020). The recent Gujarat Solar Power Policy 2021 introduces changes that impact the economic viability for solar-plus-storage for some consumers, which is discussed later in the paper

WHY IS ENABLING CONSUMER-SITED ENERGY STORAGE IMPORTANT?

Energy storage has the ability to provide a number of services to both the consumer and the grid; enabling consumer sited energy storage can also support Gujarat to meet state and national rooftop solar goals.

- **Consumers:** Allowing the interconnection of storage systems with rooftop solar can potentially provide:
    - additional value to the consumer in terms of bill savings (for example, through arbitrage and demand charge savings)
    - improved power quality and
    - additional resilience and reliability benefits.
- **Electric grid:**
    - Storage can allow for higher levels of solar integration without adverse technical impacts.
    - Rooftop solar systems will become more grid friendly with storage
    - has the potential to bring additional investment into Gujarat electric grid from new sources of capital.
    - Solar-plus-storage can also be a capacity resource for DISCOMs, potentially offsetting infrastructure investments
- **State**: Coupled storage systems is a means to accelerate rooftop solar deployment in a more grid-friendly way and meet stated rooftop solar deployment goals (both state and national).
    - Behind-the-meter storage is an important future grid resource, and Gujarat is well-positioned to be a leader in this space.
    - It can also support job creation and economic activity in the state.

OVERVIEW OF KEY REGULATORY ISSUES FOR CONSUMER-SITED SOLAR-PLUS-STORAGE INTERCONNECTION IN GUJARAT AND SOLUTIONS TO CONSIDER BASED ON GLOBAL BEST PRACTICES

Designing a framework for consumers sited solar-plus-storage to enable rooftop solar goals, support DISCOM priorities, provide consumer choice, and meet other social objectives requires thinking through a range of technical and economic issues. Below are important elements for Gujarat to consider as it begins to develop solar-plus-storage regulations. For more information on designing a solar-plus-storage program, see *An Overview of Behind-the-Meter Solar-plus-Storage Program Design: with Consideration for India* (Zinaman et al, 2020).

1 ***Preserving Net Metering Integrity***: A key issue to be considered is that the Net Metering scheme is explicitly designed to promote self-consumption and provide a financial credit for energy exports from rooftop solar. However, storage has the ability to charge and discharge both the solar energy and grid-supplied energy. Thus, a measure must be put in place to ensure that grid-supplied energy that is stored in the storage system and later exported does not receive Net Metering credits – this is referred to as preserving the "integrity" of the Net Metering compensation scheme.

2 ***Export Limitations and Storage Discharge:*** GERC may consider setting export limitations for all solar-plus-storage consumers to maintain the original intent of the rooftop solar regulations. For example, non-residential and non-MSME consumers who are subject to a solar capacity constraint of 50% of sanctioned load / contract demand under current solar regulation could also be subject to a maximum allowed combined grid export from their solar-plus-storage system (in kW) not to exceed 50% of sanctioned load / contract demand. For MSME and residential consumers who are not subject to the 50% limit under current regulations, GERC would not need to add an export limitation, provided the Rated Power Capacity of the storage system does not exceed the rated capacity of the distribution transformer. Other versions of regulations related to export limitations are also possible (see Zinaman et al, 2020).

3 ***Maximum Storage System Sizing for Net Metering Consumers***: Instituting maximum storage system sizing requirements for all consumers who wish to be eligible for net metering can ensure that the function of the storage is to augment the value of paired rooftop solar and satisfy on-site demand, instead of performing arbitrage activities using time-of-day (TOD) rates.

In California, for example, regulators instituted a storage sizing requirement for larger batteries (defined as greater than 10 kW in California) to ensure its primary functions are to augment the value of the paired rooftop solar and satisfy on-site demand, instead of performing arbitrage activities using TOD rates. The maximum rated power capacity of these paired storage systems cannot exceed 150% of the paired solar system's nameplate capacity, and the storage system's energy capacity is limited to a maximum of the energy equivalent of 12.5 hours of discharge at the maximum rated power capacity of the storage system.

Gujarat could consider similar maximum sizing requirements for storage systems with a rated power capacity larger than 10 kW as an upper bound, for example. This constraint for larger storage system would apply to all non-residential and non-MSME consumers.

4 ***Technical and Safety Standards:*** In the United States, it is common practice to offer streamlined interconnection for non-exporting storage systems, whether they are standalone systems or coupled to an existing rooftop solar system. Gujarat has a fairly established interconnection procedure for solar system approvals. With only few changes in some of the steps in this procedure the solar-plus-storage approvals could be handled. For the existing solar consumers who wish to install a storage system, the application needs to be handled in the same procedure, mainly because the newly added storage, being an electrical component, needs safety approval from State Electrical Inspectorate (CEIG), either directly or through DISCOM engineers. The component specifications and configuration compliance will need to be checked, confirmed, and approved by the CEIG and/or DISCOM. Therefore, similar interconnection process is suggested for this category of consumers who have already installed solar under net metering.

5 ***Grid-friendly Operation through TOD Tariffs***: If all solar-plus-storage consumers are on TOD tariffs, this would provide incentives for those consumers to dispatch their batteries to charge during off-peak periods and discharge during on-peak periods. Assuming the TOD periods are adjusted to reflect DISCOM generation costs differences, this could lead to lower total generation costs for the DISCOM. This grid-friendly operation of storage would be beneficial to DISCOMs while also providing bill savings for solar-plus-storage consumers, provided that the rate differential between on-peak and off-peak systems is sufficiently high to compensate for any roundtrip efficiency losses.

The annexure presents suggested changes to some important clauses in the current regulation of GERC. These are the major changes that would enable providing consumers a choice of coupling behind-the-meter storage with the rooftop PV system. In addition to these, GERC would also require additional work and an elaborate list of suggested amendments and 'statements of reasons' for further consultation.

Decisions on aspects such as introduction of time-of-day metering to new consumer classes and tariff design modifications to enhance consumer participation in the rooftop PV plus Storage growth need more study and deliberations that are beyond the scope of this paper.

PRESENT AND FUTURE FOR SOLAR-PLUS-STORAGE IN GUJARAT: IMPLICATIONS FOR CONSUMER AND UTILITIES

To gain a better understanding of the potential implications of consumer-site solar-plus-storage regulations in Gujarat, we developed initial insights on the financial implications of solar-plus-storage on potential investors and on DISCOMS, using simple analyses of the existing and potential future retail rate and electricity grid conditions.

CONSUMER ECONOMICS OF SOLAR-PLUS-STORAGE

To evaluate whether solar-plus-storage would be an attractive investment to various types of electricity consumers, we used NREL's REopt[1] Lite (freely available here: https://reopt.nrel.gov/), a technical and financial modeling tool that helps evaluate the economic viability of grid-connected solar-plus-storage and optimizes storage size for a given rooftop solar system in order to maximize revenue. The financial modeling, taking the consumer's perspective, uses Gujarat-specific detailed tariffs, solar resource data, and consumer load data (collected as part of a previous NREL/LBNL project on the value of solar in Gujarat). The central cost assumptions are summarized in Table 1 below:

Table 1. Consumer economics modeling assumptions

ROOFTOP SOLAR	ENERGY STORAGE SYSTEM
CAPEX: 48 ₹/W	CAPEX: 51,500 ₹/KW, 25,750 ₹/KWH
O&M: 2 ₹/W-yr	GST: 18% on CAPEX
GST: 8.9% on CAPEX only	10% import duty (incorporated into CAPEX)

CURRENT TARIFF AND SOLAR-PLUS-STORAGE PRICE ENVIRONMENTS

With current storage prices and rates, our analysis suggests that solar-plus-storage is not a viable investment for any consumer type. That is, the payback time for the investment is greater than the assumed lifetime of the system and the net present value of the investment is negative, even when CAPEX assumptions—based on current US prices for storage—were halved. Generally, additional value from storage for consumers is from (a) arbitrage opportunities allowing a consumer to charge their storage system during low priced hours and discharging during high priced hours, hence avoiding more expensive electricity consumptions, (b) managing their demand charge by discharging their storage system during peak load hours for the consumer, hence reducing billing demand each month, when possible, and (c) with

[1] REopt is a mixed-integer linear optimization program used for techno-economic analysis of renewable and conventional generation, energy storage, dispatchable loads, and energy efficiency to meet cost savings and energy performance goals.

net billing, where electricity exported to the grid is compensated at a lower rate than the retail rate, electricity from the solar can be stored and used to reduce grid purchases later, hence avoiding lower compensation levels for excess solar generation. However, with current compensation mechanisms and tariffs in Gujarat, consumers cannot extract much value from storage. Arbitrage opportunities for consumers on time-of-use rates (e.g., HTP rates) are limited given the relatively low difference between the peak and off-peak price (currently around 1.25 ₹/kWh). In addition, storage in Gujarat cannot effectively reduce the demand charge due to minimum bill of 85% of contracted demand, which is not impacted by the solar-plus-storage. Finally, net metering regulations make it such that exports to the grid are valued at the same level than self-consumed solar generation and hence storage cannot reduce electricity bills by avoiding exports, as can be the case with net billing or net metering with a daily netting, for example.

POTENTIAL FUTURE TARIFF AND STORAGE PRICE ENVIRONMENTS

With increasing levels of solar on the grid, as is projected to be the case for Gujarat, the generation cost profiles are likely to change, in line with the "duck curve" net load shape. Specifically, marginal generation costs would fall during mid-day when PV generation peaks and would rise sharply at the end of the day when the sun sets, leading to high peak-to-off-peak cost differences. As retail electricity rates are updated in the future to be more cost-reflective, sending more accurate price signals to end use retail consumers, the peak-to-off-peak rate differential for time-varying rates would also increase to reflect grid conditions. Higher peak-to-off-peak rate differentials would provide consumers with more financial incentive to install storage with their solar system, especially since the times in which solar generates are likely to be in the off-peak period. The storage system would allow the consumer to charge the storage from their solar rooftop system instead of displacing the low-cost load or exporting to the grid receiving kWh credits for low-priced electricity consumption and then discharge their storage during the higher priced periods, a form of energy arbitrage. The higher the peak-to-off-peak differential, the lower the payback time for their solar-plus-storage. We would also expect dramatic decreases in the capital cost of batteries, also leading to even lower payback times.

"The higher the peak-to-off-peak differential, the lower the payback time for their solar-plus-storage."

To better understand the relationship between price differential and payback time for the solar-plus-storage system, we input capital cost and rate assumptions into the REopt Lite tool to understand how payback time for an optimally sized solar-plus-storage investment decreases as the peak-to-off-peak rate differential increases. This relationship, shown for three levels of capital cost assumptions for energy storage systems, is shown in Figure 1.

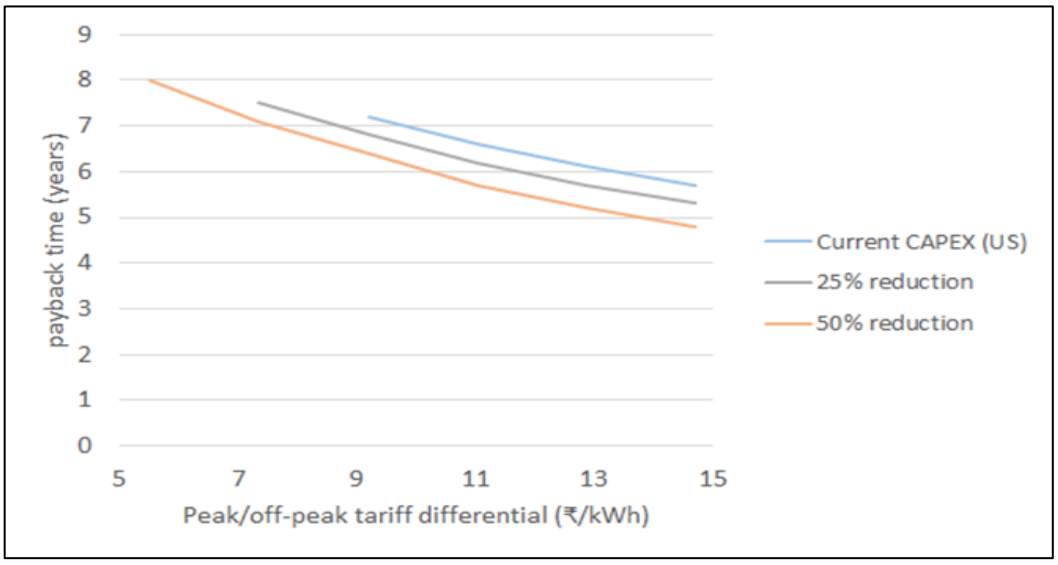

Figure 1. Decreasing payback time for an optimally sized solar-plus-storage with increasing peak/off-peak tariff differentials. Assumptions for CAPEX in the US: 51,500 ₹/kW, 25,750 ₹/kWh

IMPACTS OF 2021 GUJARAT SOLAR POWER POLICY ON THE CONSUMER ECONOMICS OF CONSUMER-SITED SOLAR-PLUS-STORAGE

In January 2021, the state of Gujarat announced several changes which impacts net metering policy for rooftop solar systems. The changes announced for residential and low-tension (LT) captive consumers do not impact the consumer economics of storage for those consumers, as the energy accounting remains on a monthly basis (i.e. bill credits are provided for exports to the grid to be used within the billing cycle, converted to payments at the end of the month). Since residential and LT captive use consumers are not on time-varying rates and solar exports are only netted on a monthly basis, there are no additional value streams available for those consumer types with this new policy. The new Gujarat Solar Power Policy leads to additional value streams for high-tension (HT) captive use consumers, however. Under the new policy, the energy accounting is daily rather than monthly, so any surplus solar generation in the 7 am to 6 pm period is purchased by the DISCOM at a specified rate. Therefore, HT consumers with an energy storage system can charge their storage system instead of exporting to the grid hence avoiding the lower compensation for the daily surplus generation. In this case, the added consumer value from the storage system resulting from the policy change will be:

Added value from storage system (₹/kWh)

$$= \text{peak period tariff} \bullet \text{roundtrip storage efficiency} - \text{surplus solar rate}$$

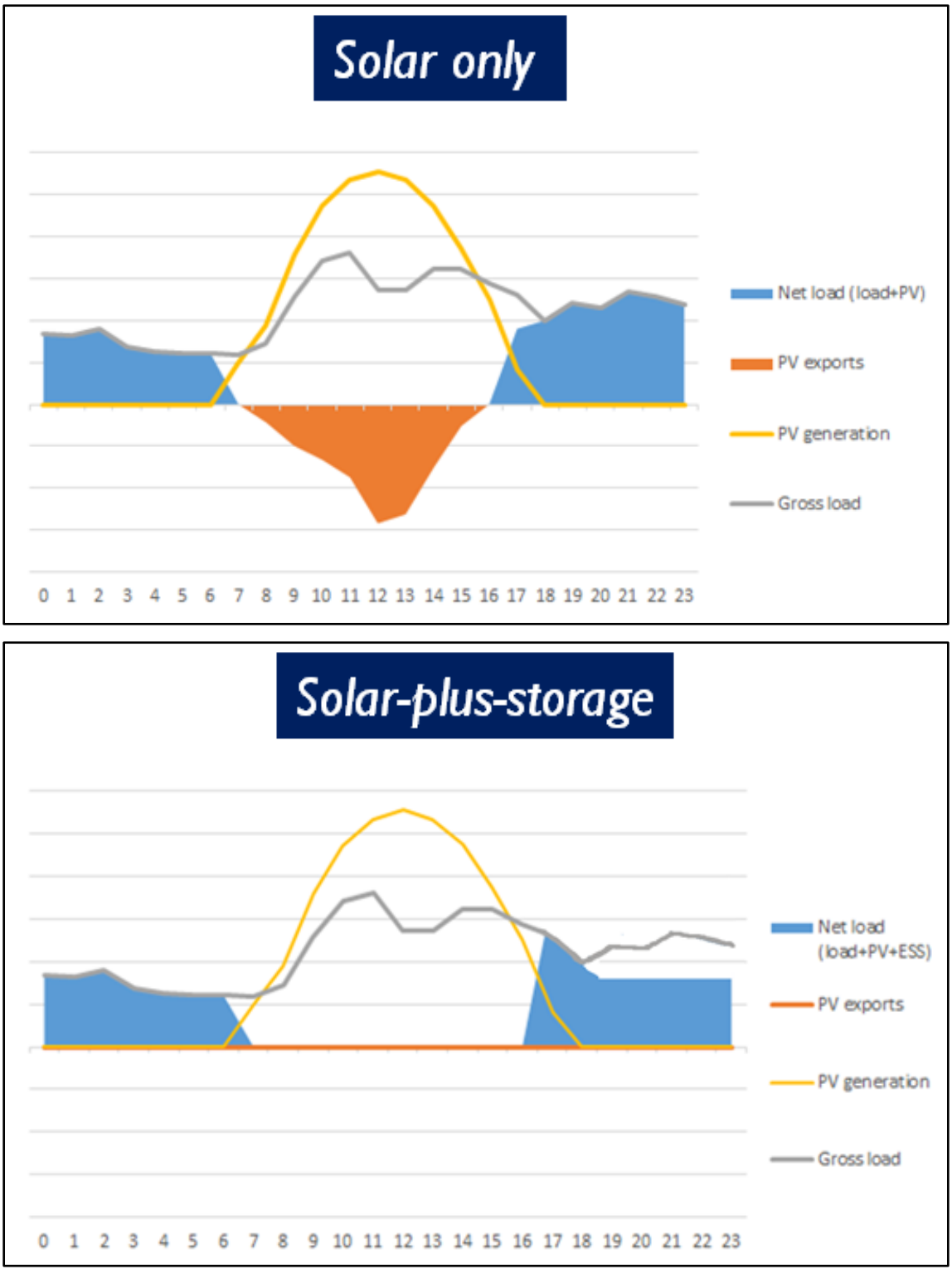

Figure 2. Example daily net and gross load, PV generation exports curves for a consumer with rooftop solar only (top) and solar-plus-storage (bottom)

Figure 2 above shows how a HT captive use consumer may dispatch their storage system with the 2021 Solar Power Policy. Note that the PV exports are avoided in this example and the storage is discharged later in the day.

POTENTIAL BENEFITS OF CONSUMER-SITED SOLAR-PLUS-STORAGE TO DISCOMS

Consumer-sited energy storage systems have the potential to provide value to DISCOMS by lowering their operational and infrastructure costs, but only if the consumer is sent effective price signals to dispatch their storage in a way that maximizes value to the utility. This highlights the importance of aligning the consumer and utility value of solar-plus-storage, connecting these two via efficient rate design. When a consumer storage system is charged during hours of low generation cost for the utility and discharged during high generation cost hours, consumer-sited storage can reduce total generation costs for the DISCOM. We can estimate the value of the storage to the utility using the optimal hourly storage dispatch profile and the hourly marginal cost of electricity. The optimal storage dispatch profile would be to charge during highest cost hours and discharge during lowest cost hours, and marginal cost of electricity curves from NREL PLEXOS modeling (also used in the *Gujarat study on the value of solar*).

As described in the previous section, higher solar levels can lead to higher value from consumer-sited storage as retail rates are updated to become more cost-reflective. Updating time-varying rates and solar compensation mechanisms would also lead to higher value for the DISCOM, as this aligns consumer and DISCOM interests. Using simple methods and assumptions, we calculated difference in DISCOM marginal generation cost assuming current TOD periods as well as optimal TOD periods which better align consumer storage dispatch with maximum value to the DISCOM. We did this using two sets of hourly generation costs: (1) a base case using 2019 load and generation characteristics and (2) MNRE goals, using net load and generation characteristics in a scenario with much higher PV levels in the grid, having achieved MNRE goals. The results are shown in Table 2 below.

"Consumer-sited energy storage systems have the potential to provide value to DISCOMS by lowering their operational and infrastructure costs, but only if the consumer is sent effective price signals to dispatch their storage in a way that maximizes value to the utility."

Table 2. Marginal value of consumer-sited storage to the DISCOM – Summary results

	BASE CASE	MNRE SOLAR GOALS
Difference in marginal generation cost assuming current TOD period	0.1 ₹/kWh	0.4 ₹/kWh
Difference in marginal generation cost assuming optimal* TOD periods and differentials	0.6 ₹/kWh	1.6 ₹/kWh

The above table summarizes the value of the storage system to the DISCOM under various scenarios, but the *net* impact on utility finances will depend on what rates are available to consumers. More cost reflective rates will lead to more bill savings for solar-plus-storage consumers and therefore more revenue losses for utilities. However, more cost reflective tariffs will also lead to more cost savings for utilities from Solar-plus-storage, so the net impact will depend on future tariffs and further analysis is required to

develop a more nuanced understanding on whether allowing storage to be added to rooftop solar is a net benefit to DISCOMS.

CONCLUSION

This memo summarizes some of the key considerations in the development of new regulations to allow for consumers to adopt energy storage systems in Gujarat, including the main regulatory issues around solar-plus-storage and selected analyses to further understand the consumer economics of solar-plus-storage as well as potential benefits for the DISCOMS.

> Consumer-site storage policies could be designed to complement and maintain the core structure of existing GERC solar net metering regulations while allowing for consumers to adopt storage system in conjunction to their rooftop solar system. Although our initial findings would indicate that the current consumer economics are not favorable for the adoption of storage, battery prices could decline significantly and future changes in policy—such as those brought with the 2021 Gujarat Solar Power Policy—could change the consumer economics leading to solar-plus-storage investments becoming profitable in the relative near term. As rates designs continue to become more cost-reflective, consumers will be incentivized to deploy their storage systems in a manner that also maximizes value to the DISCOMS, potentially being a beneficial outcome to both electricity consumers and DISCOMS while supporting state targets for and enabling high levels of rooftop solar.

ANNEX I: PROPOSED MODIFICATIONS TO EXISTING GERC REGULATORY TEXT TO ENABLE BEHIND-THE-METER ENERGY STORAGE SYSTEMS

1. Short title, and commencement

Original Text

These Regulations shall be called the Gujarat Electricity Regulatory Commission (Net Metering Rooftop Solar PV Grid Interactive Systems) Regulations, 2016.

Proposed Modification

These Regulations shall be called the Gujarat Electricity Regulatory Commission (Net Metering Rooftop Solar PV Grid Interactive Systems ***with and without Energy Storage Systems****) Regulations,* ***Amendment 2021***

2. Definitions and Interpretations

Original Text

No amendment of existing text required. Only addition of new text is required.

Background Information

It is international good practice to offer a clear, technology-neutral definition of energy storage in regulations in order to avoid introducing unnecessary market barriers.

For instance, the U.S. state of Colorado defines an energy storage system as "any commercially available, customer -sited system, including batteries paired with on-site generation, that is capable of retaining, storing, and delivering energy by chemical, thermal, mechanical, or other means." This definition offers a technology-neutral definition of storage while also being inclusive of systems paired with on-site generation.

The U.S. state of California has a similar definition, defining an Energy Storage System as "commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy." Notably, the definition in California also discusses ownership possibilities, noting that the Energy Storage System can "either owned by a load-serving entity or local publicly owned electric utility, a customer of a load-serving entity or local publicly owned electric utility, or a third party, or is jointly owned by two or more of the above."

Proposed Modification

We propose adding the following definitions in this section:

*"**Eligible Consumer**" means a consumer of electricity in the area of supply of the distribution licensee, who has installed or intends to install and use a Rooftop Solar PV System with or without Energy Storage System (ESS), given that such system is self-owned, to offset part or all of the consumer's own electrical requirements.*

*"**Energy Storage System**" means any commercially available, customer-sited system, including a system paired with on-site generation, that is capable of retaining, storing, and delivering energy by chemical, thermal, mechanical, or other means. Energy Storage Systems may be owned by consumers, distribution licensees, or third parties, or may be jointly owned by two or more of the above.*

3. Scope and Application

Original Text

3.1 These Regulations shall apply to the distribution licensee and consumers of electricity of distribution licensee availing supply from it in its area of supply in the State of Gujarat, or consumers who are receiving electricity from its own generating source but situated in the distribution licensee area.

3.2 The Eligible Consumer may install the Rooftop Solar PV System under net metering arrangement which,

a) shall be within the permissible rated capacity as defined under these Regulations.
b) shall be located in the consumer's premises.
c) shall interconnect and operate safely in parallel with the distribution licensee network.

3.3 These Regulations do not preclude the right of relevant Distribution licensee or State Government Department/authorities to undertake Rooftop Solar PV projects above 1 MW capacity through alternative mechanisms.

Background Information

No background information required. See 'Original Text' above.

Proposed Modification

The Eligible Consumer may install the Rooftop Solar PV System ***with or without an Energy Storage System*** under net metering arrangement which,

d) shall be within the permissible rated capacity as defined under these Regulations.
e) shall be located in the consumer's premises.
f) shall interconnect and operate safely in parallel with the distribution licensee network.

4. General Principles

Original Text

The distribution licensee shall provide the net metering arrangement to the eligible consumer, who intends to install grid connected Rooftop Solar PV System, in its area of supply on non-discriminatory and first come first served basis.

Provided that the consumer is eligible to install the grid connected Rooftop Solar PV System of the rated capacity as specified under these Regulations;

Provided further that the interconnection of such system with the grid is undertaken as specified under the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 read with Central Electricity Authority (Technical Standards for Connectivity of Distributed Generated Resources) Regulations, 2013 and provisions of GERC (Terms and Condition of Intra-State Open Access) Regulations, 2011 as amended from time to time.

Background Information

No background information required. See 'Original Text' above.

Proposed Modification

The distribution licensee shall provide the net metering arrangement to the eligible consumer, who intends to install grid connected Rooftop Solar PV System ***with or without an Energy Storage System***, in its area of supply on non-discriminatory and first come first served basis.

Provided that the consumer is eligible to install the grid connected Rooftop Solar PV System ***with or without an Energy Storage System*** of the rated capacity as specified under these Regulations;

Provided further that the interconnection of such system with the grid is undertaken as specified under the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 read with Central Electricity Authority (Technical Standards for Connectivity of Distributed Generated Resources) Regulations, 2013 and provisions of GERC (Terms and Condition of Intra-State Open Access) Regulations, 2011 ***and this regulation*** as amended from time to time.

5. Capacity Targets for Distribution Licensee

Original

The Distribution Licensee shall provide net metering arrangement to Eligible Consumers.

Provided that the cumulative capacity to be allowed at a particular distribution transformer shall not exceed 65% of the peak capacity of the distribution transformer.

5.1 The distribution licensee shall update distribution transformer capacity available for connecting Rooftop Solar PV Systems under net metering arrangement on yearly basis and shall provide the information to the Commission.

Provided that if augmentation of transformer/distribution network is required, the cost of such augmentation shall be borne by the consumer.

The capacity of Rooftop Solar PV System to be installed at the premises of any consumer shall not be less than one Kilo Watt (1kW).

Provided that the consumer is eligible to install the grid connected Rooftop Solar PV System of the rated capacity as specified under these Regulations;

Provided further that the interconnection of such system with the grid is undertaken as specified under the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 read with Central Electricity Authority (Technical Standards for Connectivity of Distributed Generated Resources) Regulations, 2013 and provisions of GERC (Terms and Condition of Intra-State Open Access) Regulations, 2011 as amended from time to time.

Background Information

In order to ensure the safety of the grid, the regulator has limited the overall solar PV rooftop capacity addition downstream of a particular distribution transformer to 65% of the peak capacity of that transformer. The regulators are particularly worried about time periods when rooftop solar PV production is high (e.g., mid-day, summer season, etc.) and demand is low. Such conditions might result in "backflow", and if the backflow is higher than the rated capacity of the distribution transformer, this may lead to failure of the transformer. The GERC Net Metering Regulation states that the maximum loading of a Distribution Transformer can only be 100% for the solar PV rooftop systems attached to this transformer. The regulation allows for system upgradation (on payment of upgradation costs) for consumers willing to establish solar rooftop systems which load the distribution transformer beyond 100%.

Proposed Modification

The Distribution Licensee shall provide net metering arrangement to Eligible Consumers.

Provided that the cumulative capacity of all the grid connected solar PV, rooftop systems connected downstream of a particular distribution transformer and allowed on that particular distribution transformer, shall not exceed capacity of the distribution transformer.

Provided that in cases where the such installed cumulative capacity at a particular of the distribution transformer has reached the allowed capacity, been achieved (reached) by grid connected solar PV rooftop systems, any excess capacity shall only be allowed if such new rooftop solar PV system is installed in combination with a storage device and which meets the following parameters:

1) Sizing of the storage unit (like a battery) is equal to or more than the excess capacity (capacity exceeding the rated capacity of the distribution transformer).
2) The storage and solar PV rooftop system have a Load Management System working in combination to ensure the following:
    a. All power generated by such rooftop solar PV system is only stored and not exported to the grid
    b. Battery does not discharge before sunset everyday
    c. Daily battery discharge is mandatory

5.1 The distribution licensee shall update distribution transformer capacity available for connecting Rooftop Solar PV ***with or without Energy Storage Systems*** under net metering arrangement on yearly basis and shall provide the information to the Commission. ***Distribution licensee should distinguish availability for Rooftop Solar PV with Storage and Rooftop Solar PV without Energy Storage System.***

Provided that if augmentation of transformer/distribution network is required, the cost of such augmentation shall be borne by the consumer.

The capacity of Rooftop Solar PV System to be installed at the premises of any consumer shall not be less than one Kilo Watt (1kW).

6. Eligible Consumer and individual project capacity

Original

6.1 In addition to the general eligibility defined in Regulation 2.1(l) of these Regulations, the Eligible Consumer for the Rooftop Solar PV System with net metering shall:

- be a consumer of the local distribution licensee;
- own or be in legal possession of the premises including the rooftop or terrace or building or infrastructure or open areas of the land or part or combination thereof on which the Solar PV System is proposed to be installed;
- connect the proposed Rooftop Solar PV System to the Distribution System of the Licensee;
- consume all of the electricity generated from the Rooftop Solar PV System at the same premises. If the consumer is not able to consume all of generated electricity in the same premises, he shall be governed by Regulation 9 of these Regulations.

6.2 The maximum Rooftop Solar PV System capacity to be installed at any Eligible Consumer's premises except Residential Consumers (including connections for common utilities such as water works, elevators, common passage lights, street lights, garden, gym, swimming pool etc. which are being charged residential tariff) and MSME (Manufacturing) Enterprise shall be up to a maximum of 50% of consumer's sanctioned load/contract demand; whereas in case of Residential Consumers (including connections for common utilities such as water works, elevators, common passage lights, street lights, garden, gym, swimming pool

etc. which are being charged residential tariff) and MSME (Manufacturing) Enterprise, the Rooftop Solar PV System capacity shall be irrespective of their sanctioned load/contract demand.

Provided that the installed capacity shall not be less than 1 kW and shall not exceed 1 MW;

Provided also that the installed capacity is aligned with the provisions for permitting consumer connections as stated in the Gujarat Electricity Regulatory Commission (Electricity Supply Code and Related Matters) Regulations, 2015 as amended from time to time, read with the provisions of GERC (Terms and Conditions of the Intra-State Open Access) Regulations, 2011 as amended from time to time.

Background Information

This section of the regulation ensures that any consumer consuming electricity within the ambit of the local distribution utility should be eligible for Net Metering. It also details capacity limits for rooftop solar systems for various customer classes, beyond which the consumer is no longer eligible for Net Metering. It is the understanding of this team that the 50% limit on maximum Rooftop Solar PV System capacity was put in place to blunt reduced retail sales impacts for DISCOMs, as well as distribution network impacts.

Proposed Modified

6.1 In addition to the general eligibility defined in Regulation 2.1(l) of these Regulations, the Eligible Consumer for the Rooftop Solar PV ***with or without Storage System*** with net metering shall:

- be a consumer of the local distribution licensee;
- own or be in legal possession of the premises including the rooftop or terrace or building or infrastructure or open areas of the land or part or combination thereof on which the Solar PV with or ***without Storage System*** is proposed to be installed;
- connect the proposed Rooftop Solar PV ***with or without Storage System*** to the Distribution System of the Licensee;
- consume all of the electricity generated from the Rooftop Solar PV ***with or without Storage System*** at the same premises. If the consumer is not able to consume all of generated electricity in the same premises, he shall be governed by Regulation 9 of these Regulations.

All eligible consumers (as defined above) would be eligible for connecting the proposed rooftop solar PV system with or without storage to the Distribution System of the Licensee. Consumers who already have approved Net Metered rooftop solar PV system are eligible for installing storage (coupled with the solar PV rooftop system) based on the capacity sizing rules laid down in the regulation.

6.2 The maximum Rooftop Solar PV System capacity to be installed at any Eligible Consumer's premises except Residential Consumers (including connections for common utilities such as water works, elevators, common passage lights, street lights, garden, gym, swimming pool etc. which are being charged residential tariff) and MSME (Manufacturing) Enterprise shall be upto a maximum of 50% of consumer's sanctioned load/contract demand; whereas in case of Residential Consumers (including connections for common utilities such as water works, elevators, common passage lights, street lights, garden, gym, swimming pool

etc. which are being charged residential tariff) and MSME (Manufacturing) Enterprise, the Rooftop Solar PV System capacity shall be irrespective of their sanctioned load/contract demand.

New consumers availing Net Metering shall be eligible for sizing their systems upto the sanctioned load/contract demand-based limits laid down in Provision 6.2 of the Regulation for different consumer categories. However, to ensure the safety of the grid, the discharge from these solar PV rooftop and storage systems would need to be capped (during solar generation hours) to the connected load of the consumer.

In specific cases, where the consumer wishes to oversize their capacity of the solar PV rooftop system in excess of the limits laid down in Provision 6.2 for their respective consumer categories, consumers shall be allowed to oversize their system (in excess of the Provisions in 6.2) provided that these are coupled with appropriate capacity of storage to limit backflow to the grid. The storage capacity so installed would be higher than or equal to the potential energy generation from the solar PV rooftop capacity in excess of the defined limits. At the same time, a load management unit would also be installed to ensure the following:

- Rooftop solar PV system with storage does not feed into the grid before sunset everyday
- Storage system must discharge XXXXX daily after sunset
- Sizing of battery is equal to or more than the excess capacity (capacity exceeding the connected load of the consumer).

Provided that the installed capacity shall not be less than 1 kW and shall not exceed 1 MW;

Provided also that the installed capacity is aligned with the provisions for permitting consumer connections as stated in the Gujarat Electricity Regulatory Commission (Electricity Supply Code and Related Matters) Regulations, 2015 as amended from time to time, read with the provisions of GERC (Terms and Conditions of the Intra-State Open Access) Regulations, 2011 as amended from time to time.

7. Procedure for Application

Original

The original procedure for the Interconnection Process is given in Annexure II

Background Information

No background information required. See 'Original Text' above.

Proposed Modification

The interconnection process is a standard one and has now been internalised by the utility personnel, the electrical safety inspector, the EPC contractors and the developers. Making changes to this process will lead to unnecessary inconvenience. To integrate Grid Connected Solar PV Rooftop Plus Storage, the

regulation needs to weave and integrate the necessary technical, process and safety requirements into the existing interconnection process. Based on the study of the existing regulation, GERC has prescribed the interconnection process (Point 7 of the GERC Regulation). Within this process, specific additions need to be made to accommodate storage:

1) In Step 2 of the interconnection process, the Grid Connected Solar PV Rooftop Plus Storage regulation will require that the Chief Electrical Inspector approve the Single Line Diagram, the Earthing and Wiring Diagrams and add safety precautions and associated requirements related to fire hazard from the battery storage system.
2) In Step 3, the Grid Connected Solar PV Rooftop Plus Storage guidelines will need the developer to highlight the capacity of the solar PV rooftop system (in kW) as well as the size of the storage system (in kWh). This step will also require that the Interconnection Process give guidelines on how the storage system can be sized based on the sizing of the solar PV rooftop system.
3) In Step 11, which outlines the technical specifications of the solar PV rooftop system, the Grid Connected Solar PV Rooftop Plus Storage system would need to be specified. **This means that we will need specific inputs for the design and sizing of batteries, their storage and location, their safety especially fire safety, requirements for structures to house these batteries.**
4) In Step 13, the Grid Connected Solar PV Rooftop Plus Storage regulation would need to specify the number of meters, the type of meters, their accuracy levels and the locations where they will be installed for integrating storage into the solar PV rooftop system architecture. Metering requirements shall have to consider the multiple ways in which the power from the storage system can be utilized and the manner in which the storage system is charged.

	ACTIVITY	SUB ACTIVITY	DURATION IN DAY(S)
I	Application to Distribution Licensee	Applicant shall submit application in the prescribed format along with following compliance and documents to Distribution Licensee: ***Capacity of the Grid Connected Solar PV Rooftop and Storage System*** to be installed (Subject to Regulation 6.2)	

2	On completion of work by applicant	Intimation to applicant to submit following documents within 5 days: (if not submitted along with intimation of commissioning by applicant) 1. Ownership of Solar PV system 2. Installation charging approval of Chief Electrical Inspector (CEI) 3. Meter/ CTPT testing certificate from High-tech lab and ERDA. 4. All equipment should comply with IEC standards. Applicant to submit relevant IEC certificate/test reports for all equipment, i.e. for modules/SPV/inverters/storage system/ battery/ safety sub-systems for the storage/ cables/ junction box/Transformer /RMU/CTPT/meter etc. 5. Installation of proper protection system (inverter shall have anti islanding feature) along with second line of protection such as no volt relay (for Solar PV system above 10 Kw or for any capacity system with storage), applicant has to pay connectivity charges and execute connectivity agreement with Distribution Licensee	5 days from receipt of completion letter from applicant
3	Report from field/sub-division	Installation of meter (Solar meter to record total generation, bidirectional /ABT meter for net metering and storage energy meter (to record energy flow between storage and grid) and intimate to applicant and report to HO	7 days from receipt of letter from HO

ANNEX II: ORIGINAL PROCEDURE FOR THE INTERCONNECTION PROCESS

7. Procedure for Application

Various activities and different authorities are associated with the Solar Rooftop PV project. It is necessary that the different entities carry out the works within prescribed time limit. Therefore, time frame prescribed in the table below shall be scrupulously followed by the concerned authorities.

Sr. No.	Activity	Sub Activity	Duration in day(s)
1.	Registration at GEDA	GEDA shall issue Registration Certificate	5 days from receipt of duty completed application
2.	Approval from Chief Electrical Inspector	CEI shall approve Single Line Diagram, Earthing Diagram and Wiring Diagram	10 days from receipt of duly completed application
3.	Application to Distribution Licensee	Applicant shall submit application in prescribed format along with following compliance and documents to Distribution Licensee • Capacity of Solar Rooftop to be installed (Maximum shall be 50% of the Consumer's sanctioned load) • Copy of registration at GEDA • Documents related to legal possession of roof-top /NOC of co- owners, in case of joint ownership. • Approval of Chief Electrical Inspector (CEI) for Single Line Diagram, Earthing Diagram and Wiring Diagram.	
4.	Technical Feasibility Report (TFR)	On Registration with Distribution Licensee, letter to concerned Circle/Division for TFR and informing applicant regarding specifications of CTPT, meter.	5 days from receipt of duly completed application
5.	TFR from field	TFR to include following	10 days from the

Sr. No.	Activity	Sub Activity	Duration in day(s)
		a) Name of Consumer. b) Load details of the building where roof-top is to be installed as under: Name of Division, Sub-Division, Consumer Name, Consumer No., Address, Tariff, Contract Demand/ Load, Connected Load c) Name of 11KV feeder, Transformer capacity, Solar Rooftop capacity already connected as well as approved/sanctioned on this transformer including this proposed Solar Rooftop capacity whether total Rooftop solar capacity is within the rated capacity of transformer. d) Maximum demand recorded during last one year. e) No dues certificate. f) No legal disputes pending certificate. g) Detailed estimate to be recovered from applicant for strengthening of Distribution Licensee's system for the work to be carried out for providing connectivity and evacuation facility of surplus power to be injected by the applicant. Note: Solar installation to be restricted up to T/C capacity, and if required, it is to be strengthened at the cost of Solar Rooftop Generator.	letter of Head Office
6	Post TFR	On receipt of TFR from field, Head Office shall issue letter to applicant regarding In principle consent for connectivity, payment of connectivity charges and execution of connectivity agreement within 15 days. OR Issuing estimate to applicant for system strengthening (if required) to be paid	5 days from receipt of TFR from field office

Sr. No.	Activity	Sub Activity	Duration in day(s)
		within 30 days, payment of connectivity charges and execution of connectivity agreement.	
7	Signing of connectivity agreement and issuance of letter to applicant for completion of project work	Case 1 (No system strengthening required) On payment of Connectivity Charges and execution of Connectivity Agreement within 15 days of consent. Letter to applicant to complete the project work within 6 months Case 2 (If system Strengthening required) On payment of Connectivity Charges and execution of Connectivity Agreement within 30 days along with payment of estimate. Letter to applicant to complete the project work within 6 months.	5 days from execution of agreement 5 days from execution of agreement
8	System strengthening by Distribution Licensee	Distribution Licensee to complete the work of system strengthening on payment of estimate.	45 days in parallel to project installation
9	Notice to applicant for commissioning	Issuance of two months notice to applicant for commissioning of the project on expiry of 6 months project completion period.	Within 5 days on expiry of 6 months
10	In case of non-completion of work by applicant	If no intimation received from applicant on expiry of 2 months notice period, application shall be cancelled informing the applicant within 30 days forfeiting all charges paid for Solar Rooftop Project.	Within 5 days on expiry of 2 months
11	On completion of work by applicant	Intimation to applicant to submit following documents within 5 days: (if not submitted along with intimation of commissioning by applicant) 1. Ownership of Solar PV system 2. Installation charging approval of Chief Electrical Inspector(CEI) 3. Meter/ CTPT testing certificate from High-tech lab and ERDA. 4. All equipment should comply with	5 days from receiptof completion letter from applicant

Sr. No.	Activity	Sub Activity	Duration in day(s)
		IEC standards. Applicant to submit relevant IEC certificate/test reports for all equipments ,i.e. for modules/SPV/inverters/cables/junc tion box/Transformer /RMU/CTPT/meter etc. 5. Installation of proper protection system (inverter shall have anti islanding feature) along with second line of protection such as no volt relay, applicant has to pay connectivity charges and execute connectivity agreement with Distribution Licensee Note: If applicant is not submitting above documents within 5 days, application shall be cancelled forfeiting all charges paid for Solar Rooftop Project.	
12	Intimation to Field Office	On receipt of documents from the applicant, intimation to Field Office/Sub- division for installation of meter (Solar meter to record total generation and bidirectional/ABT meter for net metering).	5 days from receiptof documents from the applicant
13	Report from field/sub- division	Installation of meter (Solar meter to record total generation and bidirectional/ABT meter for net metering) and intimate to applicant and report to HO	7 days from receipt of letter from HO
14	Intimation to GEDA	Distribution Licensee shall intimate to GEDA for issuing commissioning certificate	5 days from receipt of letter from Distribution Licensee
15	Issuance of Commissioning Certificate from GEDA	GEDA shall visit the site in consultation with Distribution Licensee and applicant and issue Commissioning Certificate	5 days from the receipt of intimation from applicant

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