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Rooftop Solar Revolution in India

A Huge Success, but Many Holes to Fix

After the launch of PM Surya Ghar Muft Bijli Yojana (PMSGY) in 2024, the speed of installation of rooftop solar (RTS) systems in India has accelerated and by August 2026 installed over 4 million of RTS systems under the scheme, adding about 15 GW of capacity. India's total RTS capacity across all consumer segments has crossed 32 GW with 5 million RTS systems connected to the distribution grid. This has been a huge success. States like Gujarat, Maharashtra, Uttar Pradesh (UP) and Kerala have emerged as the leaders in adoption of RTS. At the present speed of about 500,000 installations per month, the PMSGY target of 10 million households is likely to be reached by mid-2027. MNRE has begun consultations on PMSGY 2.0, target of which is not made public yet. The redesign under consideration would link public support more closely to actual generation, battery storage, lifecycle maintenance and service delivery, rather than number of installations alone, through a split financial-assistance structure. According to a report by The Energy and Resources Institute (TERI) in 2025, the potential for RTS is 360 GW in urban areas and 600 GW in rural India[1]. Several state governments are planning schemes to promote RTS at state level for low and middle income households with monthly electricity consumption up to 200 units (or 400 units depending on the state) enjoying free electricity or state government subsidies to make them solarized with one-time capex rather than recurring monthly subsidies. Delhi government is about to launch such a program. These schemes will drive up the RTS to several more millions in the coming years. But how much electricity is generated by the existing RTS systems and how much of it is used by the prosumers inside their houses is not being measured. There are several key issues that need to be fixed on priority as the program is scaling up fast as mentioned above.

1. **Reverse Power Flow to the Grid**: The RTS systems (solar panels) generate electricity during the day for 6 to 8 hours depending on the location and the weather conditions. The RTS connection is made in such a way that the electricity generated by RTS is first consumed in the building and the surplus is exported to the grid. In most houses there is little electricity consumption during the day as people are at work outside their homes. The electric grid that we operate for over a century has been engineered for one-way flow of electricity from large power plants to millions of homes. It can absorb reverse flow only up to a limit which is referred as the hosting capacity. Beyond that limit, reverse power flow raises feeder voltages, overloads distribution transformers during the day and disturbs protection settings. Since most residential RTS systems are single-phase, uneven connection across the three phases also causes phase imbalance and further reduces hosting capacity. In pockets of high RTS concentration, these limits are already being crossed.

[1] *"Reassessment of Solar Potential in India: A Macro-level Study" by TERI in June 2025*

2. **Inverter Tripping owing to Reverse Power Flow**: The solar panels generate direct-current (DC) which an inverter converts to alternating-current (AC) and integrates with the grid. We consume AC power in the houses and offices. As mentioned above the RTS generation is exported to the grid during the day. In pockets where the concentration of RTS is very high the reverse power flows cause the voltage on the grid to increase. The low voltage grid that supplies electricity to the homes operates at a nominal voltage of 230 volts in India (240 volts in few states). The inverters are programmed to operate between +/- 10% of this nominal 230 volts. In towns where RTS adoption is very high, the voltage increases above 10% (that is 253 volts) by midday causing the inverters to trip. Some make of inverters reconnect once the voltage returns within the permissible band and the reconnection delay has elapsed, but it might again trip if the voltage rises above 253 volts. Some models remain disconnected until the next day. When an inverter trips, the solar generation is lost – it cannot be used even inside the house. In several pockets in Gujarat and other states with high uptake of RTS, the solar generation is lost for 3-4 hours during the day.

3. **Inverter Tripping owing to Low Voltage on the Rural Grid**: On rural feeders which are very long in many states, the voltage during the day is much lower than the nominal voltage. In such places, RTS inverters trip owing to under-voltage. In this situation also the RTS generation is lost. This issue is not often realized and reported by Discoms or understood by rural prosumers yet.

4. **Lack of Visibility of RTS**: As the share of RTS generation exported to the grid is increasing, the grid operators need clear visibility of which segment of the grid is receiving how much electricity during the day from RTS systems so that they could plan the day-ahead forecasting and scheduling. This visibility is presently lacking. The available registries of RTS do not indicate the feeder and distribution transformer identities and as a result the grid operators do not know the capacity of RTS connected to each feeder[2]. Discoms and SLDCs need to have clear visibility of RTS generation for accurate estimation of day-ahead demand. Presently they make estimates based on installed capacity of RTS. However, actual generation of RTS may be less than what is estimated leading to intra-day purchase of power from the market at high cost. Conversely if the RTS generation estimates are on the lower side, Discoms will contract more power from the market which will lead to surplus power during the day that they have to offload at low prices. Effective visibility requires two things: every RTS system mapped to its feeder and distribution transformer at the time of connection, and its generation aggregated at transformer, feeder and substation level in near real time for DISCOM and SLDC forecasting.

5. **Measurement and Monitoring of RTS Generation:** As already mentioned, RTS connections are made in such a way that the electricity generated by RTS is first consumed in the building and the surplus is exported to the grid. The net-meters (having both export and import registers) installed by the Discoms record only what is exported to the grid – not what is consumed in the house. This gives rise to two interrelated challenges: an operational challenge, wherein the actual generation remains invisible to the Discom, and a regulatory challenge, wherein Renewable Purchase Obligation (RPO) accounting based solely on net export leads to systematic underestimation of renewable energy generation due to the exclusion of self-consumption. In the absence of direct generation visibility, some Discoms are relying on CUF based proxy methodologies to estimate RTS generation for RPO compliance. However, the CUF assumptions adopted by Discoms vary widely, from 12% to 20%, resulting in substantial inconsistencies in the estimated generation, with no standardized methodology or verification

[2] *India Smart Grid Forum (ISGF) prepared a national registry of RTS (https://bit.ly/4sfaP2Q) which clearly indicate where on the grid the RTS are connected. ISGF compiled and uploaded the RTS details from Pachim Gujarat Vij Company Ltd (PGVCL) which has the highest RTS concentration and from Madhya Pradesh Pachim Kshetra Vidyut Vitran Nigam Ltd (MPPKVVNL) in 2024. This registry is designed to scale up to billions of RTS and other distributed energy resources (DER). The registry was expected to be integrated with PMSGY portal, which is still to be completed.*

framework. In some states (for example: Gujarat, Uttar Pradesh, Delhi, Rajasthan etc.) there are separate generation meters provided to capture the generation data of RTS. These generation meters are installed near the distribution board (on the AC side), but these are non-smart meters read manually once a month. These generation meters are installed on rooftops, and meter readers often do not have easy or unrestricted access to the generation meters. Many prosumers have installed dataloggers on their RTS inverters to monitor RTS generation. They install a mobile app by scanning the QR code on the datalogger and receive near real-time generation data on the app. However, this data reaches the app via the OEM's server, as the datalogger sends data only to the OEM server.

6. **Data Security of Inverter Communications**: Most inverters and data loggers used in RTS systems are imported, predominantly from China. Their data reaches the prosumer's app through the OEM's server, often located outside India, and the DISCOM has no access to it. The same communication channel can be used to change inverter settings remotely or switch inverters off. With millions of systems on the grid, this is a risk to grid security. ISGF highlighted this issue, including the risk of undeclared communication components in imported inverters that could be activated remotely, in our White Paper of May 2025 (Link: https://bit.ly/4djGIjF), following which MNRE took immediate action.

In view of the issues described above, ISGF Recommends the following:

1. **Smart Inverters for RTS:** All new RTS should be connected to the grid through smart inverters which can be remotely monitored and controlled. Bureau of Indian Standards (BIS) adopted IEEE 1547-2018 standard for smart inverters as IS 18968-2025. ISGF in collaboration with National Institute of Solar Energy (NISE) conducted tests on a smart inverter for its compliance with IS 18968 for the functionalities such as voltage and frequency ride-throughs, volt-VAR and volt-Watt and published a joint white paper "**Roadmap and Recommendations for Rollout of Grid Integrated Smart Inverters for Distributed Energy Resources"** in March 2026 (Link: https://bit.ly/4d7AsNm). Central Electricity Authority (CEA) is expected to amend the Central Electricity Authority (Technical Standards for Connectivity of the Distributed Generation Resources) Amendment Regulations, 2019 to include the recommendations in this roadmap. In ISGF's consultations, several equipment manufacturers have indicated that there will be no cost difference between the regular inverters sold presently and the smart inverter conforming to IS 18968. Only additional cost will be the communication cost – ideally a cellular SIM and its monthly charges. With smart inverters that can be remotely monitored, the Discoms can control the voltage profile on the feeders and limit inverter tripping. Thus, the amount of RTS generation lost today can be considerably reduced. Smart inverters with low-voltage ride-through and volt-VAR capability can also keep RTS systems connected on long rural feeders where daytime voltage sags. On feeders where voltage is chronically low, feeder strengthening under Revamped Distribution Sector Scheme (RDSS) may be taken up. Further, if smart inverters communicate through secure, DISCOM-controlled channels rather than OEM servers, the security risk mentioned above (Issue 6) is also addressed.

2. **RTS Generation Monitoring with Smart Generation Meters**: Presently there are no systems in place to accurately measure how much electricity is generated by RTS systems. Part of the generation is consumed in the building, and the rest is exported to the grid. The net meters installed by the Discoms record only the energy exported to the grid, not what is consumed within the building. The dataloggers installed by prosumers use proprietary protocols, and their accuracy is not tested. ISGF has studied this issue in detail and strongly advocates for a smart meter as generation meter to be installed next to the RTS inverter. ISGF recently published a White Paper that examines the technical issues in RTS monitoring and proposes smart meters conforming to BIS specifications as auditable RTS generation meters[3]. For existing installations, these may be rolled out in phases, starting with feeders that have the highest RTS penetration. The paper also presents connection arrangements that integrate RTS

[3] *https://bit.ly/4sfaP2Q*

monitoring with the ongoing smart metering program under the RDSS, with the net meter, RTS generation meter and smart inverter configured as separate devices in the Discom's Meter Data Management (MDM) system.

3. **Moving the RTS Subsidies to Storage and Discoms**: Under PMSGY, central financial assistance covers roughly 70% of the cost of a typical 1 kW and 2 kW residential RTS systems (at the rate of ₹30,000 per kW), and with state top-ups the combined subsidy reaches above 80% or more in several states. At the prevailing market rates, the payback period of an RTS system for prosumers in higher tariff slabs is about 5–7 years even without subsidy, depending on the state's tariff. MNRE officials have reportedly noted that adoption remains strong as long as payback stays below seven years, and that higher-income households may continue to adopt with lower financial support (Financial Express, July 2026). Hence ISGF has been arguing that the subsidy should move to following components: (a) battery storage at customer premises, (b) battery storage at substations; and (c) investment by Discoms in digital tools such as Distributed Energy Resources Management Systems (DERMS) for remotely monitoring and managing millions of RTS systems and enhancing its utility. This is in line with the direction MNRE is reported to be considering for the next phase of PMSGY: a split financial-assistance structure, with one component linked to generation, O&M, battery storage or service delivery over the life of the asset, and storage at both consumer premises and in the distribution network. ISGF strongly supports this shift, with two caveats. First, a generation-linked subsidy needs auditable generation data, which makes the smart generation meters in Recommendation 2 a precondition rather than an option. Second, any sharing of Discom savings with households that host batteries should be tied to battery operation that Discom can see and verify. State programs for RTS promotion may adopt the same principles.

4. **Rebate on Electricity Tariff during High Solar Generation Hours**: For the past few years, electricity is surplus on the grid during the day for 200+ days in a year. The price of power on the exchanges goes well below one rupee per unit. Negative prices, now common in Europe and the USA, are prevented in India only by the exchange price floor; the economic signal is the same. It is advised to offer deep discounts for consumption during high solar generation hours. The Electricity (Rights of Consumers) Amendment Rules, 2023 already require Time-of-Day tariffs, with solar-hour tariffs 10–20% below the normal tariff but it is yet to be notified by state regulators. This discount needs to be considerably deeper. We recommend offering 50% or more discounts so that green energy produced during solar generation hours are utilized than curtailed.

5. **Promotion of EV Charging and Electric Cooking during the Day:** It is suggested to promote public, workplace and fleet electric vehicle (EV) charging stations on feeders experiencing reverse power flows; and offer deep discounts or even free electricity to charge the EVs during high solar generation hours (typically from 1pm to 4pm). Similarly, restaurants, canteens and other commercial kitchens may be motivated to use electric cooking appliances and offer them discounted electricity so that they shift to electric cooking during the day. These measures not only help mitigate the reverse power flow problem on the grid but also help increase utilization of green electricity and reduce emissions.

6. **RTS Registry and its Integration with Smart Inverters**: As indicated, ISGF has prepared an RTS registry which was launched by the Union Power Minister at the Distribution Utility Meet in November 2024. This registry clearly indicates the RTS systems are connected to which electricity pole, which distribution transformer and which substation. The existing RTS data from one Discom in Gujarat and another in Madhya Pradesh were entered in the registry. It was agreed that MNRE/CEA will take over the registry and integrate with PMSGY Portal 2.0 which is still to be completed. The architecture of the registry is massively scalable to hundreds of millions of RTS and other DERs.

The Australian Energy Market Operator (AEMO) launched a national DER Register in 2019, covering rooftop solar and all other DERs. Similar registries for RTS and DERs are used by utilities and regulators in other geographies also where RTS concentration has reached unmanageable levels. Smart inverters with communication devices can be integrated with such registries to capture real-time data of RTS generation. It is advised that the registry prepared by ISGF may be adopted or a new registry may be prepared that clearly indicates to which part of the grid the RTS systems are connected. As an immediate step, MNRE and CEA could pilot the registry in two high-penetration Discoms, mapping every RTS system to its feeder and distribution transformer and linking it to the PMSGY National Portal through APIs. With the next phase of PMSGY expected to extend to virtual and group net metering, balcony solar, building-integrated PV and community solar plants, a registry that locates every DER on the grid becomes even more essential.

As MNRE redesigns the next phase of PMSGY, the issues raised here must be built into its design, so that millions more RTS systems do not join the grid only to lose their generation to inverter tripping. The time to fix these foundational issues is now, while the program continues to scale.