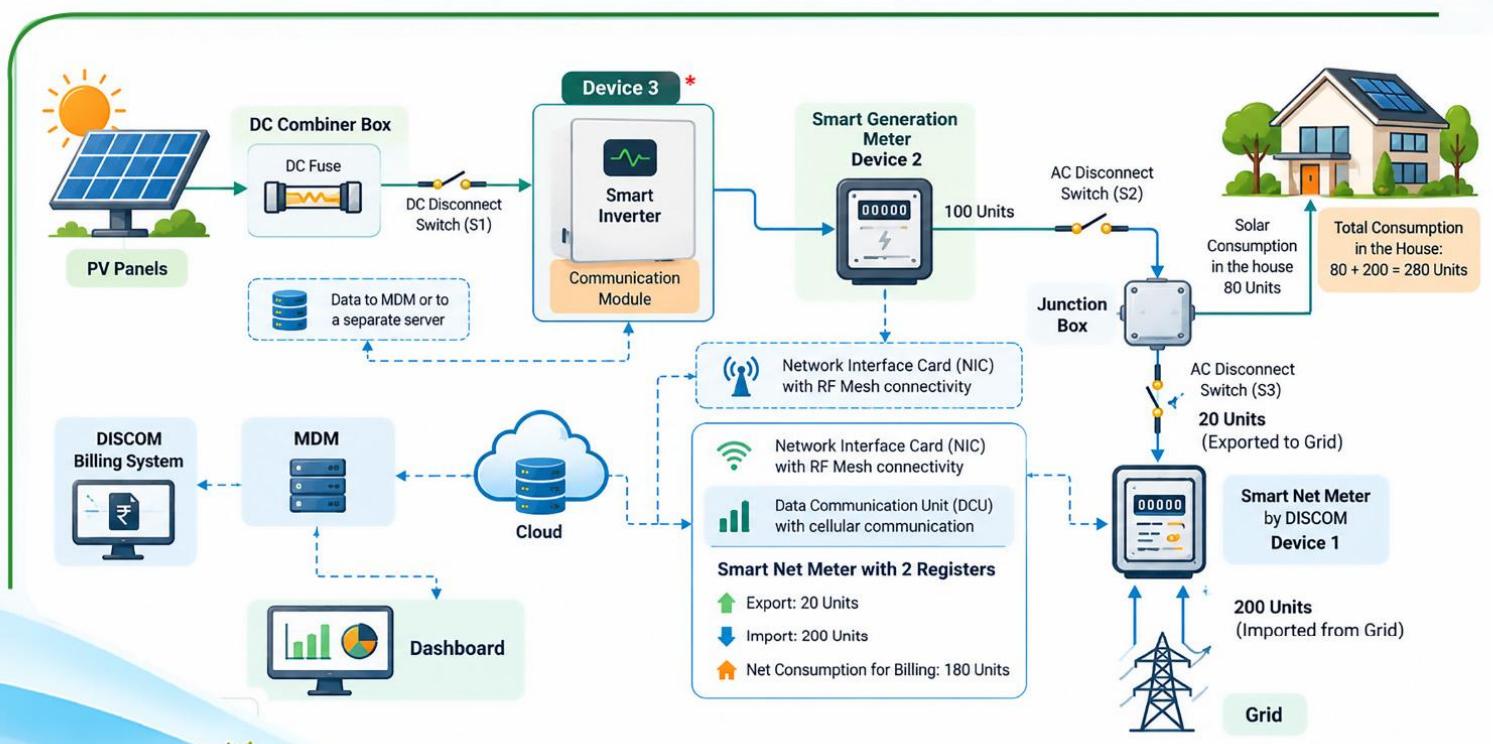
ISGF
India Smart Grid Forum

ISGF WHITE PAPER ON

ROOFTOP SOLAR (RTS) MONITORING SYSTEM





Abstract

The number of rooftop solar (RTS) systems connected to the low-voltage (LV) grid in India has crossed 5 million, with a cumulative capacity of over 32 GW. Yet there is no reliable system in place to measure how much electricity they generate. Net meters installed by the Distribution Utilities (Discoms) record only the energy exported to the grid, not what is consumed within the building. In the few states where separate generation meters for RTS are installed, these are non-smart meters read manually once a month. Some prosumers have installed data loggers on their RTS inverters to monitor generation. These data loggers are mostly imported from China, and the data goes first to the OEMs' servers in China before being relayed to the prosumers' mobile apps. These data loggers use proprietary protocols, and their accuracy is not tested. The routing of data through overseas servers also raises concerns about data sovereignty and cybersecurity. Without visibility of RTS generation, Discoms struggle to forecast demand and supply and rely on inconsistent capacity utilization factor (CUF)-based estimates for Renewable Purchase Obligation (RPO) compliance. RTS generation data is required for day-ahead forecasting and scheduling, grid planning, demand response, virtual power plant (VPP) aggregation and ancillary services. This paper examines the technical issues in RTS monitoring and proposes smart meters conforming to Bureau of Indian Standards (BIS) specifications as auditable RTS generation meters. For existing installations, these may be rolled out in phases, starting with feeders that have the highest RTS penetration. All new RTS installations should be connected through smart inverters conforming to IS 18968:2025. The paper also proposes connection arrangements that integrate RTS monitoring with the ongoing smart metering program under the Revamped Distribution Sector Scheme (RDSS), with the net meter, generation meter and smart inverter set up as separate devices in the Discom's Meter Data Management (MDM) system.

Although this Paper is focused on the present situation in India with RTS and its efficient management, the issues and solutions presented are relevant to electric utilities in all countries pursuing RTS programs.

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Authors

Akash Kumar
Anand Singh
Balasubramanyam K
Disha Khosla
Reena Suri
Reji Kumar Pillai
Rohan Banik

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About India Smart Grid Forum

The India Smart Grid Forum (ISGF) is a Think-Tank of global repute on Smart Energy, Electric Mobility, Grid Modernization and Energy Transition. ISGF, established as a Public Private Partnership (PPP) initiative of the Government of India in 2011, is spearheading the mission to accelerate electric grid modernization and energy transition in India. ISGF is registered as a Not-for-Profit Society under Indian Societies Act and has its head office at CBIP Building, Malcha Marg, Chanakyapuri, New Delhi 110021.

1 INTRODUCTION

Rooftop Solar (RTS) installations are progressing very fast in India, and more than 5 million RTS systems are now connected to the low-voltage (LV) grid. At the present installation rate of about 500,000 new RTS connections a month, there could be close to 10 million RTS systems by June 2027. The cumulative capacity presently is over 32 GW, which should ideally generate more than 120 GWh of clean energy every day. However, there is no reliable, verified record of how much electricity is generated by the RTS systems. Neither the RTS owner, nor the Discom or State Load Dispatch Centres (SLDC) nor Ministry of Power (MOP), Ministry of New and Renewable Energy (MNRE) or Central Electricity Authority (CEA) have visibility of RTS generation data since there are no reliable systems to monitor and measure it in place as of now. In some states (for example: Gujarat, Uttar Pradesh, Delhi, Rajasthan etc.) there are separate generation meters installed to capture the generation data of RTS near the distribution board (on the AC side), but these are non-smart meters read manually once a month. These meters are installed on rooftops, and meter readers often do not have easy or unrestricted access to these generation meters.

In a typical RTS connection, the electricity generated is first consumed by the load in the building during the day, and only 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 building. 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 framework.

Many prosumers have installed data loggers on their RTS inverters to monitor RTS generation. They install a mobile app by scanning the QR code on the data logger and receive near real-time generation data on the app. However, this data reaches the app via the OEM's server, as the data logger sends data only to that server. The majority of inverters and data loggers are imported from China, which poses a major security risk. This issue and the fear of additional communication equipment in the Chinese inverters that can be remotely activated was highlighted in ISGF White Paper in May 2025 (Link: https://bit.ly/4djGIjF) on which MNRE took immediate actions.

The data loggers deployed with RTS inverters use proprietary communication protocols and data models. There are dozens of OEMs whose systems are deployed in India, and it is nearly impossible to standardize them. To streamline the data model, MNRE issued guidelines (OM dated 24 December 2025) specifying Remote Monitoring System (RMS) communication to a central IoT platform through JSON messages. MNRE has also urged State Electricity Regulatory Commissions (SERCs) to adopt M2M SIM-based RMS for recording RTS generation, following the Odisha Electricity Regulatory Commission's November 2025 amendment that allows such inverter data to be used in lieu of a generation meter. However, this approach primarily standardizes the data model for logger-to-platform communication and does not resolve the underlying issues of data sovereignty, data accuracy or cybersecurity. Standardization of the JSON schema alone neither ensures instrument-grade data quality nor enables migration of the

data onto Discom-controlled infrastructure. These are distinct challenges that require independent and dedicated solutions.

The present RTS connection diagram and generation data monitoring system used by prosumers are depicted in *Figure 1*.

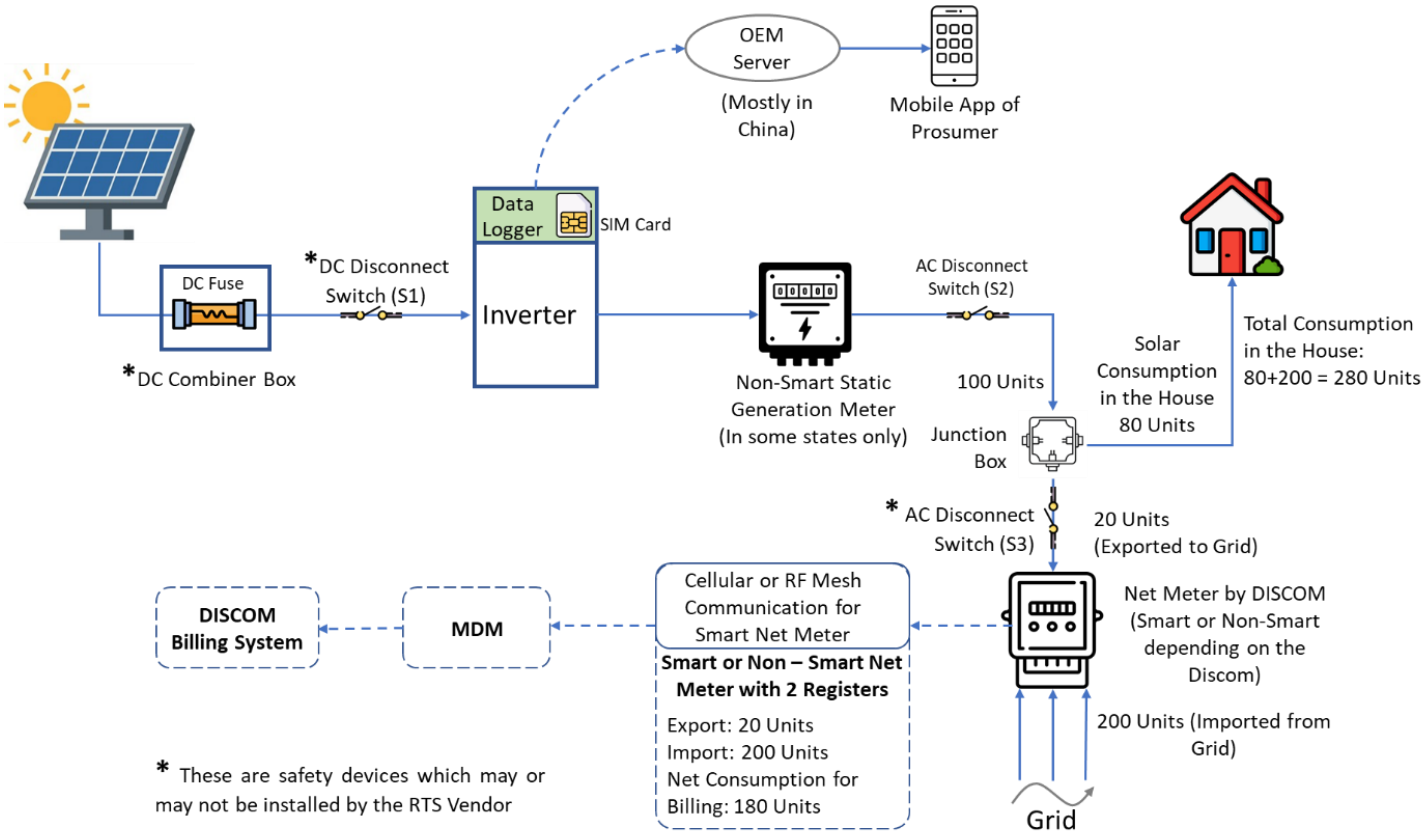


Figure 1: *Present RTS Connection and Generation Data Monitoring System by Prosumers*[1]

(Where net meters are non-smart, readings are taken manually and fed to the billing system, and there is no MDM or RF mesh/cellular communication system)

Almost all RTS inverters come with a Wi-Fi data logger that can be connected to the Wi-Fi network in the building. However, these data loggers are not installed, or are not operational, in many buildings for the following reasons:

- RTS is installed on the roof, and extending Wi-Fi to the roof requires an additional router and power connection, which is not feasible in many houses
- Many low-income households do not have broadband internet
- Every time the Wi-Fi password or router is changed, the inverter's data logger needs to be reconfigured, for which most prosumers require technical assistance

The accuracy of the generation data reported through data loggers is also questionable, and there is at present no means to test it. Data loggers are usually supplied and installed by local

[1] *Note: For illustration, it is assumed that the RTS generates 100 kWh (units) in a month, of which 80 units are consumed in the building and 20 units are exported to the grid, while total import from the grid is 200 units. Thus, the total monthly consumption in the building is 80 + 200 = 280 units, and the prosumer's net monthly bill is for 200 – 20 = 180 units. The same assumptions are used in all figures in this paper.*

RTS vendors who have limited expertise in data communications. Moreover, the generation data shown in the mobile app cannot be cross-checked against the Discom's net meter, as its export register records only the surplus exported to the grid after part of the RTS energy is consumed inside the building.

As RTS installations are increasing rapidly, there is an urgent need to monitor RTS generation accurately, for the following reasons:

- Discoms and SLDCs need clear visibility of RTS generation for accurate day-ahead forecasting and for scheduling generation to match estimated demand. At present, they estimate RTS generation from installed capacity. If actual generation is lower than estimated, Discoms must buy power intra-day from the market at high cost. Conversely, if RTS generation is underestimated, Discoms will have surplus power during the day, which they have to sell at low prices
- Discoms need to account for and report RPO compliance accurately, for which actual RTS generation data is essential
- MNRE, MOP, CEA, SLDCs and Discoms need to monitor daily RTS generation for program planning, monitoring and financing
- RTS Aggregators, Renewable Energy Service Companies (RESCOs) and funding agencies need to monitor the revenue realized by prosumers and aggregators
- Distribution Grid Planning, Demand Response, Demand Flexibility Portfolio Obligation (DFPO)[2], Virtual Power Plant (VPP) Aggregation and Ancillary Services Markets require real-time, verified generation data at the asset level, together with the ability to control these assets

2 THE KEY CHALLENGES WITH RTS

Feeders with a high concentration of RTS are experiencing reverse power flow from the RTS into the LV grid, and from the LV grid to 11 kV (or 22 kV) lines and up to 33 kV (or 66 kV) substations[3]. This happens because consumption within the buildings is very low during the daytime as people are out at work, when RTS generation peaks. Reverse power flow raises the voltage on the LV grid, and when the voltage rises more than 10% above the nominal voltage, RTS inverters trip and the solar generation is lost. The inverters reconnect only after the voltage returns to the permissible range and the reconnection delay has elapsed, and they trip again when the voltage exceeds this limit. Some inverters will reconnect only the next day. This phenomenon is already being experienced in many towns, resulting in the loss of two to three hours of solar generation on typical days when daytime consumption in the buildings is very low. Discoms also face other technical challenges in managing RTS, such as voltage swings, power quality issues and large variations in the demand–supply balance between day and night. To mitigate these issues, ISGF has proposed connecting RTS through smart inverters that can be remotely monitored and controlled by Discoms (or aggregators). The Bureau of Indian Standards (BIS) has adopted the IEEE 1547-2018 standard for smart inverters as IS 18968:2025. ISGF, in collaboration with the National Institute of Solar Energy (NISE), has tested the functionalities of smart inverters and issued the **Roadmap and Recommendations for Rollout of Grid Integrated Smart Inverters for Distributed Energy Resources** in March 2026 (Link: https://bit.ly/4d7AsNm).

[2] *DFPO is a recent regulatory concept. Issued by Rajasthan's RERC DF/DSM Regulations, 2026; other SERCs have draft DF/DSM frameworks*

[3] *Note: While most states in India use 11 kV and 33 kV for the medium-voltage grid, some states use 22 kV and 66 kV.*

3 GLOBAL SCENARIO ON RTS MONITORING AND CONTROL

Based on our studies, no country has yet achieved complete, utility-grade visibility of all rooftop solar (or, more broadly, DER) generation, although several have made significant progress through registries, metering mandates and standardized inverter communications. International experience is summarized below.

1. In the USA, the UK and Australia, utilities have generally installed only net meters (smart or non-smart) with separate import and export registers and therefore have no direct visibility of gross solar generation. Some utilities apply Machine Learning (ML) techniques to smart meter interval data to disaggregate and estimate behind-the-meter generation, but such estimates are not defensible for subsidy audit or RPO compliance.
2. Exceptions exist where payments or compliance depend on generation. Under the UK Feed-in Tariff scheme (2010–2019), generation payments were based on readings from a dedicated generation meter, with exports deemed at 50% unless separately metered. Several US states, such as Massachusetts, require revenue-grade (ANSI C12) production meters for solar systems that earn renewable energy certificates, while the PJM-GATS certificate registry accepts modelled production estimates for small systems where the state permits.
3. In Australia, distribution network service providers (DNSPs) have no real-time access to smart meter data, which is managed through retailer-appointed metering coordinators. DNSPs receive it a day later; hence they have historically managed feeders with high RTS penetration using blanket (static) export limits rather than dynamic limits based on real-time visibility. This is changing: AEMO has maintained a register of DER installations in the National Electricity Market (the DER Register) since 2020; DNSPs in South Australia and Queensland now offer 'flexible exports' (dynamic operating envelopes) communicated to inverters through the IEEE 2030.5-based CSIP-AUS protocol; new rooftop systems in several states must support remote 'emergency backstop' curtailment (South Australia since 2020, Victoria since 2024); and the Australian Energy Market Commission (AEMC) has mandated universal smart meter deployment by 2030, with better access to power quality data for DNSPs.
4. Some system operators estimate aggregate rooftop PV output statistically instead of metering every system. In Great Britain, the system operator (NESO) uses the University of Sheffield's PV_Live service, which scales up measured output from a sample of PV systems to national and regional estimates. In Australia, AEMO's Australian Solar Energy Forecasting System (ASEFS2) combines sample measurements from household systems, postcode-level installed capacity and satellite imagery to estimate and forecast rooftop PV output for dispatch.
5. In Europe, monitoring of small PV systems has relied largely on inverter-embedded data loggers and OEM cloud platforms. In December 2025, the European Commission's Economic Security Doctrine identified dependence on Chinese solar inverters as a high-risk dependency; in January 2026, the Commission proposed a revised Cybersecurity Act that would enable restrictions on high-risk suppliers; and in April 2026, it restricted EU funding for projects using inverters from high-risk suppliers.
6. Lithuania has banned remote access by entities from high-risk countries, including China, to solar, wind and storage installations above 100 kW (in force for new installations from May 2025 and for existing ones from June 2026). The Czech cybersecurity agency (NÚKIB) has warned against remote administration of PV inverters

from China (September 2025), and Germany is examining regulatory measures to restrict Chinese inverters in its energy infrastructure (June 2026).

7. In Germany, every PV system, including small rooftop systems, must be registered in the Federal Network Agency's Core Energy Market Data Register (Marktstammdatenregister). Under the Solar Peak Act (in force since February 2025), new PV systems above 7 kW are to be equipped with a smart metering system and control device so that the grid operator can control their output; until a smart meter is installed, new systems may feed in no more than 60% of their rated capacity.
8. In the USA, NERC CIP-003-9, effective 01 April 2026, requires owners of low-impact bulk electric system (BES) cyber systems, including inverter and plant controls at utility-scale renewable plants, to identify, disable when needed, and monitor vendor electronic remote access. It does not apply to distribution-connected rooftop systems, but it indicates the direction of regulation on vendor remote access.
9. In California, CPUC Rule 21 requires grid-connected inverters to provide smart inverter functions (aligned with IEEE 1547-2018) and specifies IEEE 2030.5, through the Common Smart Inverter Profile (CSIP), as the default protocol for utility–DER communication, giving utilities a standardized, vendor-neutral channel for monitoring and control.
10. In China, the National Energy Administration's Administrative Measures for Distributed PV (January 2025) require new distributed PV projects to be observable, measurable, adjustable and controllable, and require grid companies to meter the total generation and the grid-fed electricity of each distributed PV project separately, with meters supplied and installed free of charge. Historically, generation-linked subsidies settled through the grid companies reinforced this practice of utility generation metering, although central subsidies for new distributed PV ended in 2021.
11. Tesla Powerwall (USA - Behind-the-Meter Battery Model): In a typical installation, the utility's revenue meter at the grid connection point records only net import/export, while the Powerwall Gateway uses internal current-transformer (CT) metering to monitor site load, solar production and battery flows separately. Under Net Energy Metering/Net Billing, customer compensation for solar exported to the grid is determined from the utility meter. In addition, several US utilities operate Tesla-supported Virtual Power Plant (VPP) programs in which customers receive separate bill credits for allowing the utility or Tesla to dispatch the Powerwall during grid events; compensation may be based on battery capacity, delivered power, performance or event participation.

4 ISGF RECOMMENDATIONS FOR RTS GENERATION MONITORING

As noted in Section 1, there are at present no reliable systems for measuring and monitoring RTS generation. Discoms and SLDCs have no visibility of the data collected by inverter OEMs, nor is its accuracy tested. ISGF has studied and analysed various options for RTS generation monitoring, which are presented below.

4.1 Generation Monitoring Arrangement for Existing RTS Installations

ISGF recommends installing Smart Meters as Generation Meters in all existing RTS installations, as shown in *Figure 2*. Since there are already about 5 million RTS connections, this may be implemented in phases:

- **Phase 1:** Install smart generation meters for RTS connected to distribution feeders where the cumulative RTS capacity exceeds 50% of the respective Distribution Transformer (DT)

capacity. Also replace the existing non-smart RTS generation meters with smart generation meters in states where such non-smart meters are installed

- **Phase 2:** Next, install smart generation meters for RTS connected to feeders where the cumulative RTS capacity exceeds 30% of the DT capacity
- **Phase 3:** Install smart generation meters for the remaining RTS connections

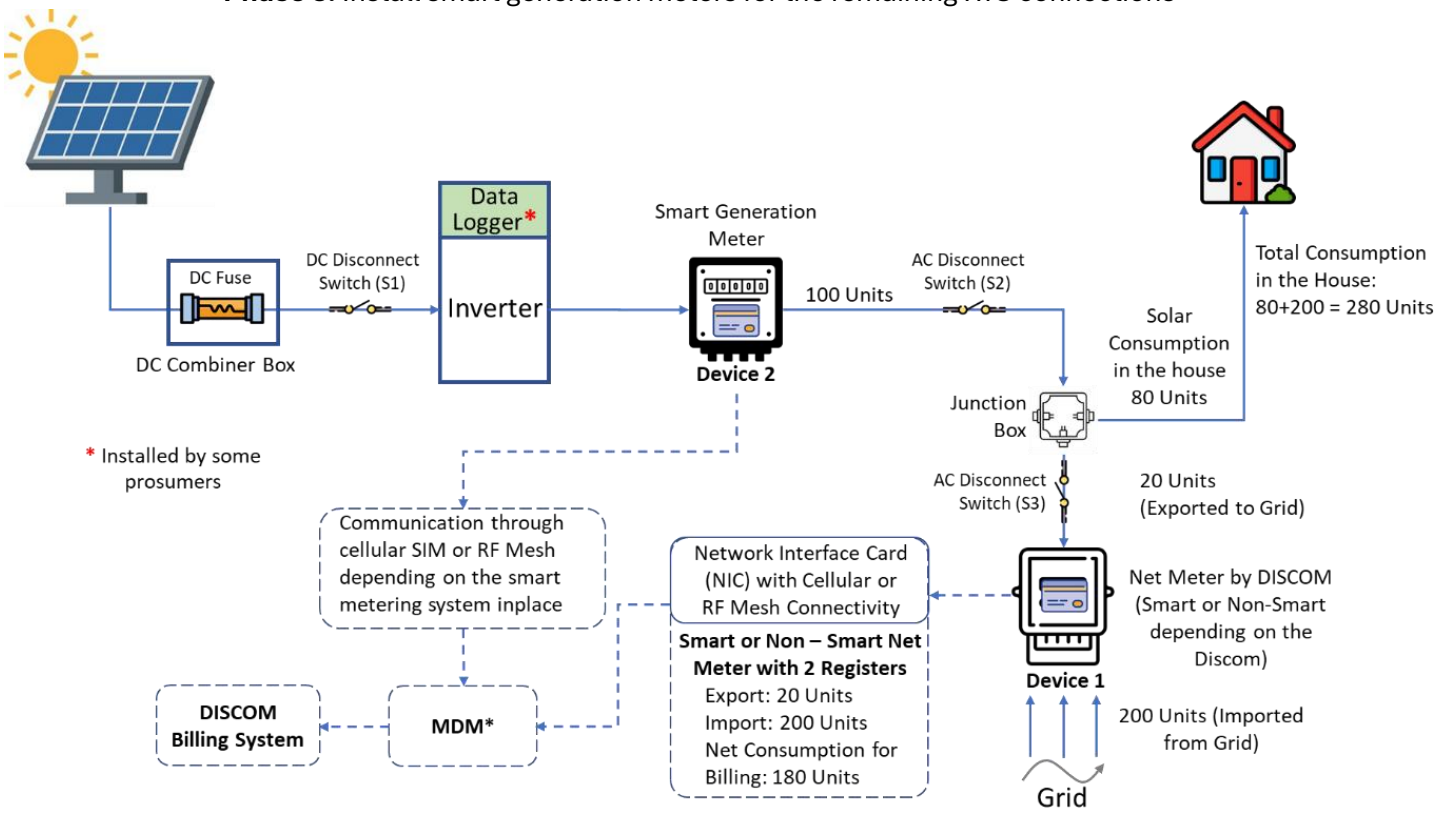


Figure 2: *Proposed Generation Monitoring System with Smart Generation Meter for Existing RTS*

**Smart metering projects under RDSS are progressing well in most states in India, but a few states are yet to begin smart metering in earnest. In states where smart metering has been initiated, the Discoms will have Meter Data Management (MDM) systems that can also host the RTS Generation Meter data. Discoms without an MDM can direct the RTS generation data to a separate server with a suitable digital platform to store it in an organized form.*

We have examined in detail the feasibility of both Data Loggers and Smart Meters for capturing RTS generation data and are of the opinion that Smart Meters are the better option, for the following reasons:

- Smart meters and their communication protocols are standardized (IS 16444 and IS 15959 Part 2); there are more than 50 approved manufacturers of smart meters in India, and all meters are interoperable
- Millions of smart meters are being installed by Discoms under RDSS[4] through Advanced Metering Infrastructure Service Providers (AMISPs). Over 72 million smart

[4] *Revamped Distribution Sector Scheme (RDSS) is a Government of India program managed by MOP. Key component of RDSS is rollout of 250 million smart meters on a services model in which utilities do not have to make any capex investments. MOP provides 15% of the project cost as grant and the rest is paid by utilities over 93 months on per meter per month based on mutually agreed service level agreements (SLAs)*

meters had been installed by June 2026, and another 146 million are approved for installation under RDSS

- Smart meters are readily available in large numbers, and AMISPs can install them quickly at incremental cost with amendments to their existing contracts
- The majority of data loggers sold in India are from Chinese OEMs; there are a few domestic OEMs, but most are start-ups that may not be able to scale up to millions of units in the near term
- Data loggers come in several makes and models, each with its own proprietary data model, and their accuracy is not tested
- Although a smart meter costs more upfront (approximately INR 3,000 for a single-phase meter with a communication module and INR 4,500 for a three-phase meter, against INR 1,500–2,000 for a data logger with SIM connectivity), it comes with a 10-year warranty, compared with 2 years for a data logger
- Where smart metering has been completed, the new smart meter for RTS generation can be integrated with the existing smart metering system
- Where smart metering uses RF mesh for last-mile connectivity, the new RTS smart generation meters can also be connected to the same RF mesh network, with no need for a cellular SIM card and monthly fees
- Where smart metering in a prosumer's area uses cellular connectivity, the new RTS smart generation meter can also use a cellular SIM and connect to the same smart metering network
- In all the above scenarios, the RTS smart generation meter can be configured as Device 2 of the prosumer, and the smart net meter (installed by the Discom under RDSS) as Device 1, in the MDM system

Where smart net meters are not yet installed at prosumers' premises, smart generation meters with cellular communication modules may be installed alongside the existing inverters to capture RTS generation data and transmit it to a server designated by the Discom, MNRE or CEA.

There is another ongoing discussion on capturing the generation data from the data loggers of OEMs for the existing RTS. MNRE has directed inverter OEMs (August 2026) to share the daily generation data captured through their data loggers with the PMSGY National Portal. We consider this approach impractical as a basis for generation accounting, for the following reasons:

- **Data Accuracy:** As stated in the previous sections, the accuracy of readings reported through an inverter's data logger is questionable, since the measurement is made by the inverter (not the data logger), which is not tested for metrology. The readings may deviate by 1% to 5% or more in certain makes[5]. Even a 1% error across millions of inverters is a significant quantity for Discoms and SLDCs in estimation and scheduling.
- **Installed Base of Data Loggers**: There are over 5 million RTS connections, but it is not known how many have data loggers that are actively sending data to OEM

[5] *We recognize that the accuracy of BIS certified smart meters is also ±1%, but that is the upper limit, and most meters have much less error. Since the meters are certified, their readings can be defended for commercial settlements and RPO accounting*

servers[6]. Typical inverters are sold with a Wi-Fi data logger (not cellular SIM-based), which costs INR 800-1000. As noted in Section 1, many of these data loggers are never connected or not communicating. The PMSGY was launched in 2024, but M2M SIM-based remote monitoring was mandated only from July 2025 (MNRE OM dated 21 July 2025, followed by detailed guidelines in December 2025). Hence, not all PMSGY connections have such data loggers. OEMs charge an additional INR 1200 – 1500 for cellular SIM-based data loggers.

- **Databases of Inverter OEMs**: Inverter OEMs typically supply inverters to many countries. It is not clear how they store the daily generation data received from inverters across different utilities and countries, or whether they organize it country-wise and by PIN code on an MDM-type platform. Managing daily generation data from millions of inverters in an organized manner requires sophisticated platforms that need constant technical support, and OEMs have little incentive to organize their data by Discom or feeder. Even if an OEM maintains such a platform and can aggregate daily generation data by PIN code, a typical Discom with dozens of inverter makes would have to collect data from every OEM and aggregate it for day-ahead forecasting and scheduling which is a very tedious exercise.
- **Location of RTS:** At present, there is no geo-referenced, feeder-wise record of RTS installations, as the latitude and longitude of RTS locations are not captured. Hence, inverter OEMs may not be able to provide RTS generation data feeder-wise or even Discom-wise. While configuring a data logger, the installer enters the address and PIN code, but local installers can make mistakes and there are no checks on these entries. Aggregate generation data from an OEM's inverters across different Discoms is of little use to individual Discoms and SLDCs. In 2024, ISGF developed a feeder-wise Rooftop Solar Registry with latitude–longitude data of RTS and populated it with the RTS installations of PGVCL and MPPaKVVCL. This registry can be integrated with the PMSG Portal 2.0 and scaled up nationwide[7].

4.2 Generation Monitoring Arrangements for New RTS Installations

ISGF recommends that all new RTS installations be connected through a Smart Inverter conforming to IS 18968:2025. Although smart inverters with communication modules can transmit RTS generation data to a designated server, we recommend a smart generation meter for all new RTS installations, for the reasons explained below.

As noted in Section 1, the RMS framework under MNRE's OM of 24 December 2025 standardizes the data model for logger-to-platform communication but neither ensures instrument-grade data quality nor moves the data onto Discom-controlled infrastructure. Even if inverter data is routed through an India-based centralized communication platform, the underlying generation value still originates from proprietary inverter firmware, which is neither independently certified nor designed to function as an auditable metering instrument. Communication architecture can improve visibility and interoperability, but it cannot by itself resolve concerns about data accuracy, data sovereignty, cybersecurity or regulatory-compliant energy accounting. For this reason, ISGF recommends a smart meter as the RTS generation meter.

[6] *A recent press article indicates that only 15% of the RTS have active data loggers which are API-capable (Business Standard, 26 Aug 2026)*
[7] https://bit.ly/4hI2Vdr

In RTS installations with Smart Inverters (which needs to be made mandatory), the Communication Module of the smart inverter can be configured as Device 3 of the prosumer in the MDM. Under this arrangement, the Smart Generation Meter becomes the primary and auditable source of RTS generation data, while the Smart Inverter Communication Module supports telemetry, diagnostics, remote control, Volt-VAR/Volt-Watt control, curtailment and other grid-support functions[8]. This inverter communication layer can also be managed by an aggregator allowing flexibility for future DER services without burdening the Discom's smart metering system with proprietary inverter integration challenges.

Three different connection arrangements for RTS generation monitoring are depicted below.

4.2.1 Option 1: Smart Net Meter + Smart Inverter + Smart Generation Meter using RF Mesh Communication for Last Mile Connectivity

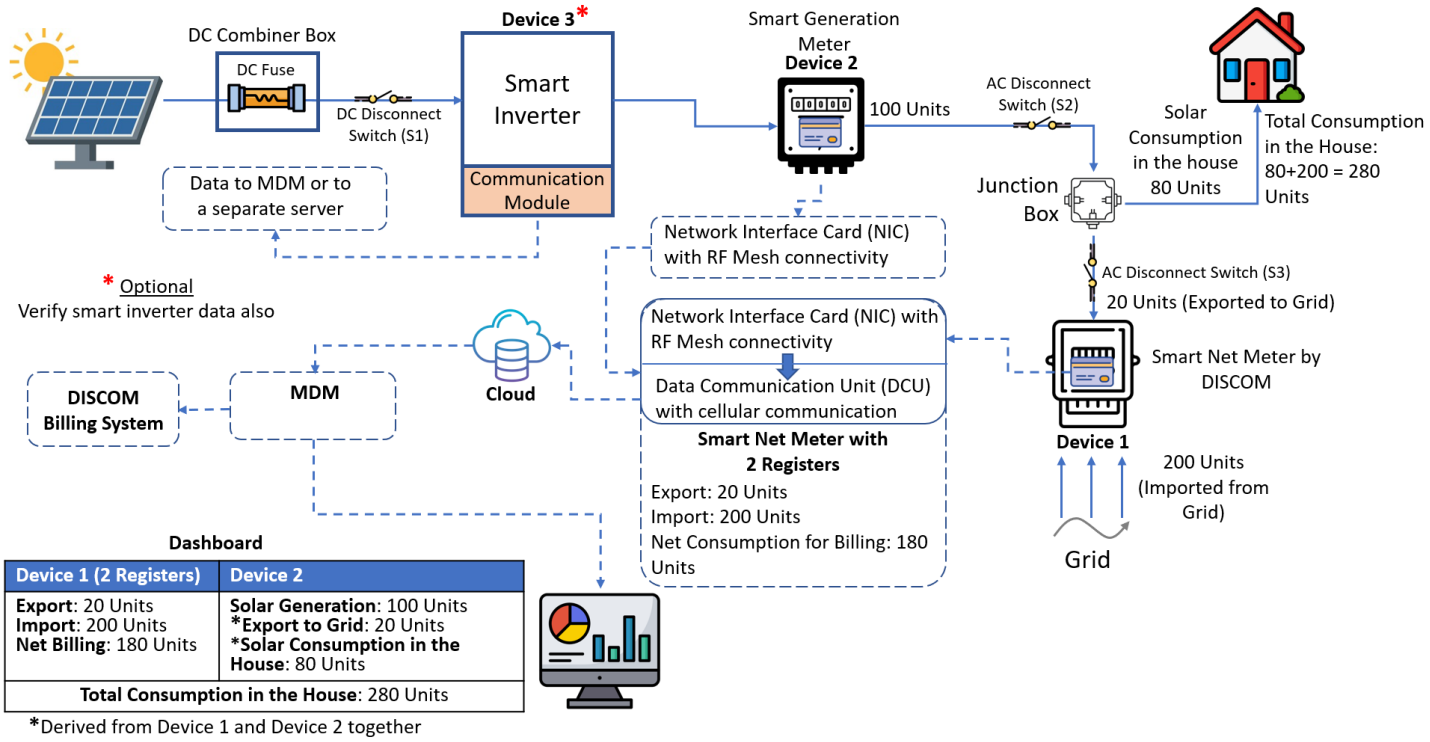


Figure 3: *Proposed Generation Monitoring System with Smart Generation Meter for New RTS Connections where Smart Metering has RF Mesh for Last Mile Connectivity*

[8] *Device 3 telemetry may be stored in the MDM, while control is exercised through a Distributed Energy Resources Management System (DERMS) or an Aggregator Platform. MDM is not designed to send set-points (Volt-VAR/Volt-Watt, curtailment) to inverters*

4.2.2 Option 2: Smart Net Meter + Smart Inverter + Smart Generation Meter – all with Cellular Communication

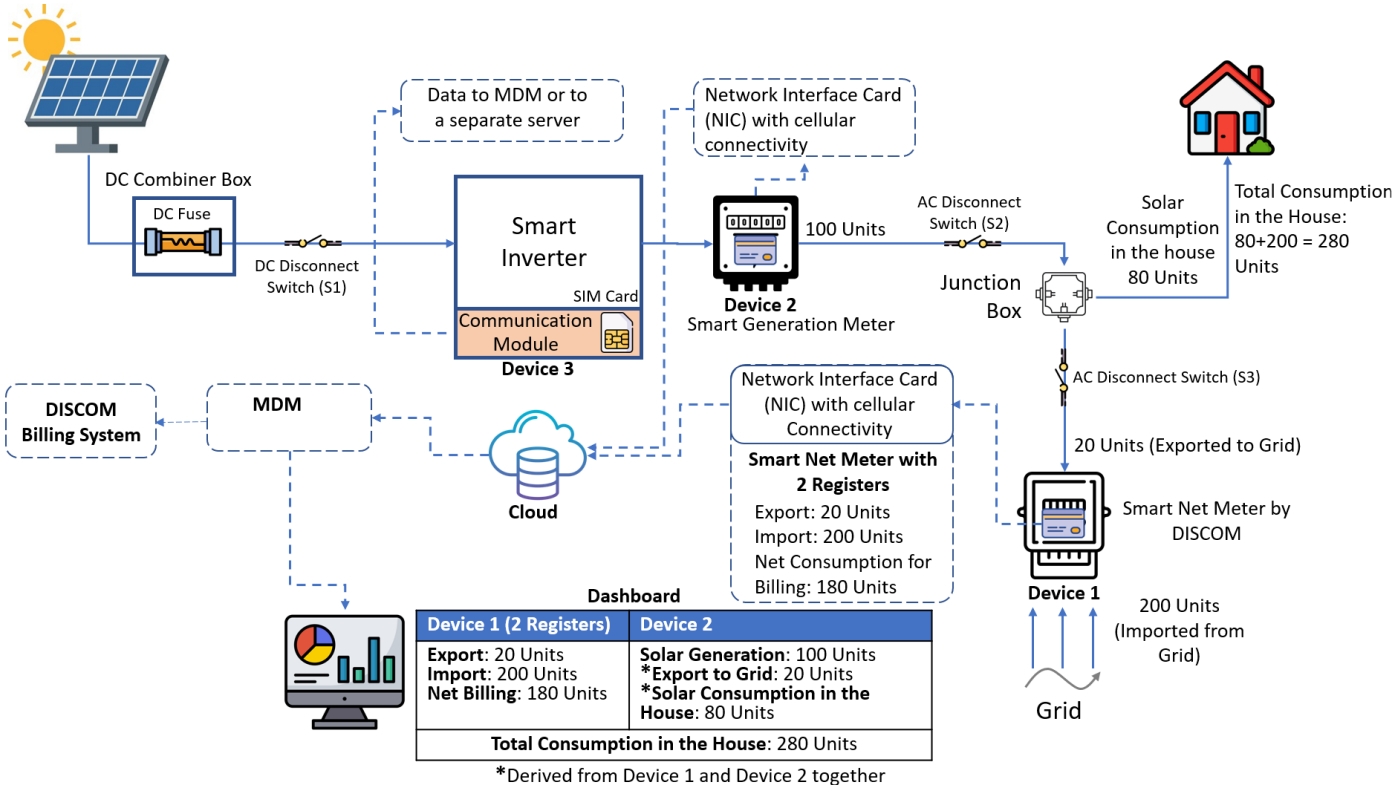


Figure 4: *Proposed Generation Monitoring System with Smart Generation Meter for New RTS Connections where Smart Metering has Cellular Communication System*

In both Options 1 and 2, the Smart Inverter's communication module can be configured as Device 3 in the MDM, as described above, and can also provide solar generation data. If a Discom does not wish to handle Device 3 data, it can be directed to a central server managed by MNRE or CEA, as shown in *Figure 4*.

The Smart Generation Meter provides accurate RTS generation data, although this adds to the cost. Since this cost of the RTS generation smart meter is not covered under RDSS, it may be funded under the PMSGY or other MNRE/MOP programs. If the RTS smart generation meter is included in the scope of AMISPs, they can be paid a small incremental monthly fee to their existing services-based contracts for smart metering which is for 93 months.

4.2.3 Option 3: RTS Monitoring System Configuration with Hybrid Inverter and Battery Energy Storage System (BESS)

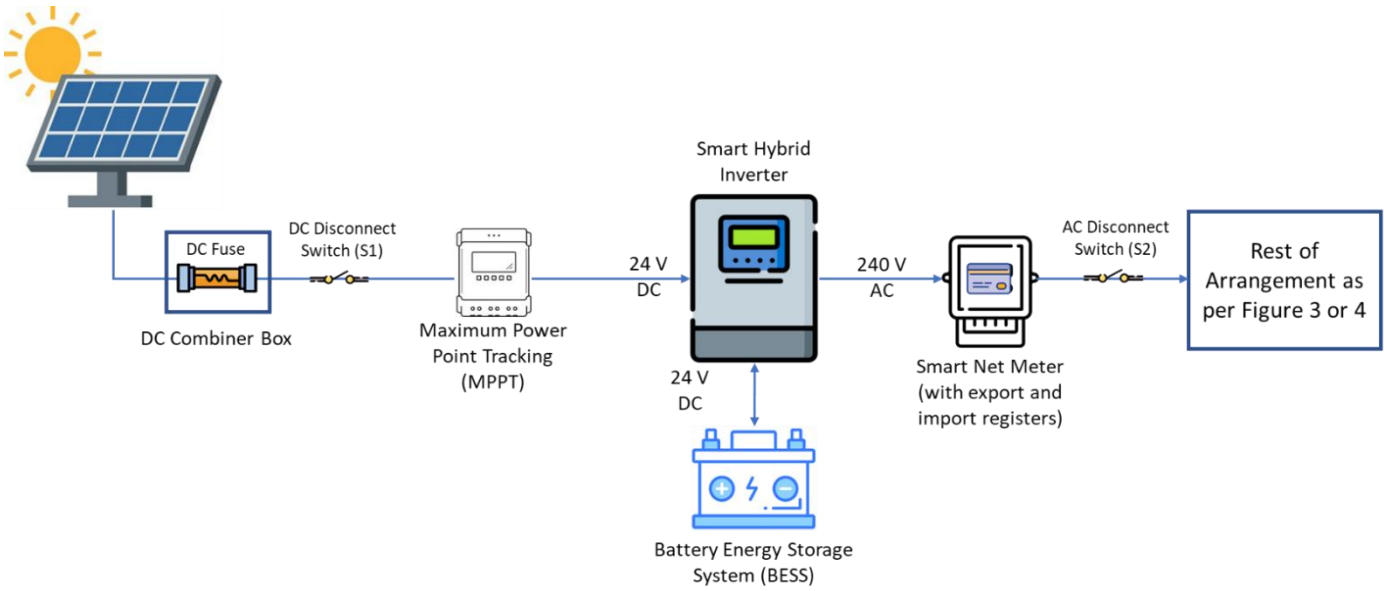


Figure 5: *Proposed Connection Arrangement for RTS with MPPT[9] and Hybrid Inverter and Battery Energy Storage System (BESS)*

In this scenario, the RTS Generation Meter is a net meter on the AC side of the hybrid inverter, capturing both the energy exported by the hybrid inverter (from PV and battery) and the energy it imports from the grid. At night, when the RTS is not generating, the hybrid inverter may draw power from the grid to charge the battery; this is recorded in the import register of this net meter. Net RTS generation should therefore be computed as the export register reading minus the import register reading, so that grid energy stored in the battery and later discharged is not counted as solar generation.

5 CONCLUSIONS AND RECOMMENDATIONS

1. All new RTS installations must be connected through a Smart Inverter conforming to IS 18968:2025. There is a debate on whether smart inverters should be required only for RTS above 5 kW or 10 kW. Restricting smart inverters to RTS of 5 kW or 10 kW and above would defeat the very purpose, as most residential RTS systems are smaller than this. We strongly recommend that all RTS have smart inverters to manage inverter tripping, loss of solar generation and reverse power flow. Several OEMs have confirmed that there is no price difference between a regular inverter and a smart inverter; the only additional cost is the communication charge if connected through a cellular SIM. Discoms may decide which inverters are to be remotely managed, depending on network conditions on each feeder.
2. Install Smart Meters as Generation Meters in all RTS installations – at commissioning for new installations, and in phases for existing installations, as set out in Section 4.1

[9] *Maximum Power Point Tracking (MPPT) is a control function in a solar PV inverter or charge controller that maximizes the power output of PV modules. The MPPT controller continuously adjusts the operating voltage of the PV array to track the voltage–current point at which the array delivers maximum power under the prevailing irradiance and temperature, so that the system can charge the battery with the maximum available power.*

3. Follow Option 1 or 2 (depending on the smart metering communication system) for the meter and inverter connection arrangements for monitoring RTS generation data, and Option 3 for RTS with a hybrid inverter and BESS
4. In states where smart metering is yet to start, all new RTS could follow the connection arrangement shown in Figure 2, with the generation data sent to a server designated by the Discom, MNRE or CEA
5. To test and demonstrate the integration of data from multiple devices (Smart Net Meter, Smart Generation Meter and Smart Inverter) in the MDM, we suggest a pilot involving a few hundred prosumer locations in a forward-looking Discom. This pilot could also quantify the accuracy gap between the data logger and the smart meter as well as test the DERMS based control of smart inverters and its cyber security preparedness.
6. We suggest following ownership and actions by respective authorities to implement these recommendations:
    - CEA to amend the metering regulations
    - SERCs to amend their net-metering/RPO regulations and mandate smart generation meters for RTS generation accounting
    - MNRE to align the PMSGY guidelines (RMS for telemetry, smart meter for accounting) and fund smart meters for RTS
    - Discoms to amend AMISP contracts to include additional RTS generation meters
    - MOP/MNRE/CEA/CERC to decide on ownership of RTS generation data as to who will own it, who all will have access rights, who will obtain and ensure consumer consent and privacy under Digital Personal Data Protection Act, 2023
7. Monitoring Systems for Existing RTS may be followed as described in Section 4.1
8. Smart Meter Advantage: Smart meters are tested for metrology, installed with the latitude–longitude of the premises, and their data is organized feeder-wise in the MDM. This is essential for Discoms and SLDCs to estimate RTS generation and to generate reports for regulatory compliance. Most important advantage of smart meters as RTS generation meter is the feasibility of integration with the ongoing smart metering projects. The contracts of AMISPs can be amended to add the second RTS generation meter which will add an incremental cost to their monthly charges instead of an upfront capex Data Loggers[10].
9. RTS Registry: Create a national, geo-referenced RTS registry linked to Discom consumer indexing (DT/feeder mapping), building on ISGF's registry and integrate with the PMSGY portal, as a prerequisite for phased metering of existing RTS and for feeder-level forecasting.

[10] *250 million smart metering rollout follows a business model first suggested by ISGF in our 2017 While Paper that recommended* ***Metering as a Service against a monthly fee per meter for 10 years****. The ongoing smart metering projects under RDSS are being implemented @ INR 80 per meter per month (average across the country). If a second meter is added this cost is not expected to increase more than INR 40- 50 per meter per month, which is much more affordable than direct capex for data loggers.*

NOTES

ISGF
India Smart Grid Forum

GET IN TOUCH

CBIP Building, India Smart Grid Forum, Malcha Marg, Chanakyapuri, New Delhi, Delhi 110021

WEBSITE
www.indiasmartgrid.org

EMAIL
contactus@indiasmartgrid.org

