Special Article

SMART METERING IN INDIA: PAVING THE WAY FOR AN EMPOWERED ENERGY FUTURE

Abstract

India's ambition to digitize its electricity distribution network through the installation of 250 million (25 crore) smart meters under the Revamped Distribution Sector Scheme (RDSS) represents a transformative leap in energy governance. While smart metering has the potential to enhance billing efficiency, reduce Aggregate Technical & Commercial (AT&C) losses, and improve demand forecasting, its true promise lies in democratizing energy access and enabling data-driven utility reform. This article explores the current progress, challenges, and strategic interventions required to reframe smart meters not merely as billing devices, but as instruments for empowering consumers, strengthening DISCOMs, and realizing the broader vision of a digital, participatory power sector.

As with other energy transition technologies, the Indian Renewable Energy Development Agency Limited (IREDA) is expected to play a crucial role in financing and de-risking investments related to smart meter projects. IREDA has already demonstrated early momentum in this space, by sanctioning a good number of smart metering projects, underscoring its commitment to accelerating India's smart metering rollout and strengthening the backbone of its digital grid transformation.

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Introduction: The Role of Smart Meters in India's Energy Transformation

India's power distribution sector has long grappled with structural inefficiencies, including high AT&C losses, inaccurate billing, and financial stress on state-owned DISCOMs. Historically, the sector has suffered from weak metering infrastructure, manual billing practices, poor payment discipline, and widespread energy theft, which collectively undermine the financial health of utilities and discourage investments in system upgrades. These issues have led to a vicious cycle of operational inefficiency, low consumer trust, and insufficient cost recovery ultimately burdening state finances and consumers alike.

To address these long-standing challenges and modernize its power distribution framework, the Government of India launched the RDSS in 2021, with a total outlay of ₹3.03 lakh crore. A key component of this flagship initiative is the deployment of 25 crore smart prepaid meters by March 2026, aimed at improving billing accuracy, enhancing collection efficiency, and empowering consumers through real-time energy usage insights. The scheme aims to reduce the AT&C losses to pan-India levels of 12–15% and bridge the ACS-ARR (Average Cost of Supply – Average Revenue Realized) gap to zero—thereby restoring the financial viability of DISCOMs

and enabling sustained sectoral investment.

The total investment for installation of 25 crore smart meters is estimated at ₹1.25 lakh crore, to be financed as 75% in debt and 25% in equity contribution. Furthermore, under RDSS, the estimated budgetary support is ₹97,000 crore, including a specific allocation of approximately ₹900 per smart meter, which translates into ~₹25,000 crore in dedicated budgetary support for smart metering alone.

This well-calibrated financial structure is designed to catalyze private sector participation and accelerate AMISP (Advanced Metering Infrastructure Service Provider) deployment across states.

The smart meter initiative also complements other reforms such as the separation of carriage and content, time-of-day (ToD) tariffs, and decentralization of energy production. Equipped with two-way communications, smart meters are envisaged as a foundational element of Advanced Metering Infrastructure (AMI), enabling:

- Real-time energy monitoring,
- Remote disconnection/reconnection,
- Time-of-Day pricing and behavioral nudges,
- Integration of distributed energy resources,
- Load profiling and peak demand management,
- And eventually, decentralized and responsive energy markets.

A cornerstone of financial security in the smart metering ecosystem is the Direct Debit Facility (DDF), designed to ensure reliable cash flow for service providers. It is a critical financial safeguard built into India's smart metering framework to ensure timely payments to Advanced Metering Infrastructure Service Providers (AMISPs). Under this mechanism, DISCOMs are required to maintain minimum payment security—typically five times their monthly AMISP dues, sourced from consumer electricity collections routed through digital platforms. The objective is to protect vendors from payment delays and foster trust in the metering-as-a-service model.

At a systemic level, smart meters are expected to facilitate a shift from a reactive to a proactive grid operation model where data-driven insights allow utilities to make informed decisions on network planning, energy procurement, and load optimization. For consumers, they herald a new era of energy accountability, where informed usage patterns can lead to lower bills and environmental benefits.

The success of this transformation hinges not only on hardware deployment and financing but also on the creation of a robust ecosystem of data management, capacity building, and consumer engagement. Institutions such as IREDA, which have previously supported financing for green hydrogen, bioenergy, and electric vehicles, are now actively contributing to the smart metering landscape.

However, despite this policy push and institutional support, ground-level implementation faces several hurdles including consumer resistance, DISCOM capacity gaps, and funding bottlenecks. Addressing these challenges through coordinated action will be crucial to realizing the full potential of India's digital grid vision.

Progress and Potential: Financial & Operational Gains

The rollout of smart meters under the RDSS is one of India's most ambitious digital infrastructure initiatives within the power sector. With a target to install 25 crore prepaid smart meters by March 2026, the program promises to transform how electricity is consumed, monitored, and billed. However, as of June 2025, the pace of implementation reflects a gap between intent and execution.

Current Status: Targets vs. Ground Reality

According to the latest data, approximately **22.4 crore smart meters have been sanctioned**, with **14.3 crore awarded** to AMISPs. However, about **3.37 crore smart meters have been installed**, amounting to less than **14% of the national target**. Although the total installations hasn't achieved the targets, the new installations have increased ~10x in the last two years reflecting strong intent and improvement in execution efficiency.

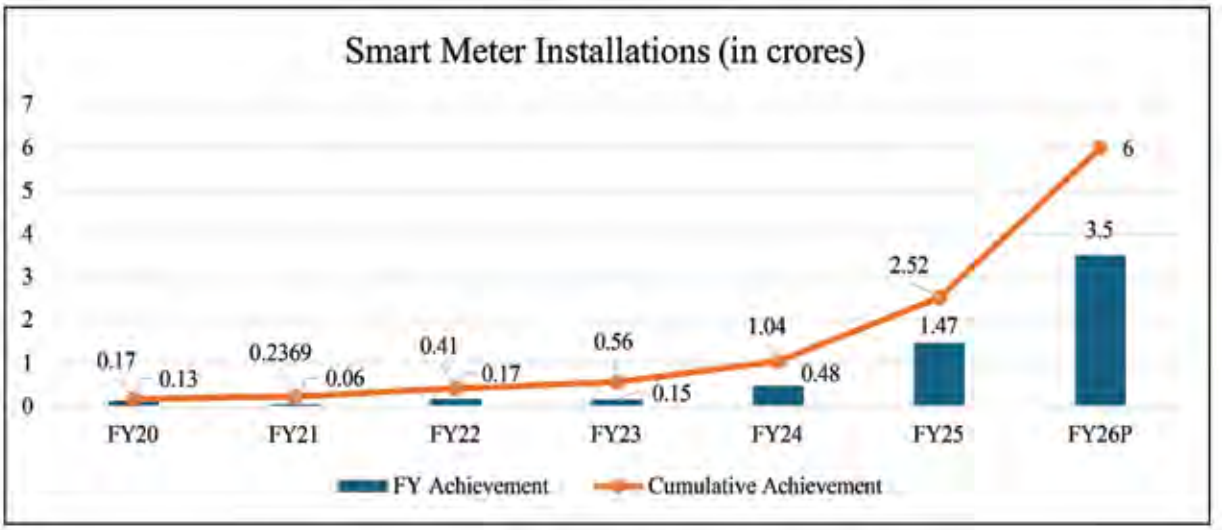

Figure 1: YoY installation of smart meters (Source: NSGM portal)

Performance Gains: Emerging Operational and Financial Benefits

Despite the modest rollout so far, smart meters have already demonstrated early wins for DISCOMs, particularly in operational efficiency and revenue assurance. As per a report from CareEdge ratings:

- **AT&C losses reduced from 20.7%** in FY20 **to 17.6%** in FY24, driven primarily by better collection mechanisms enabled through AMI systems,
- **Billing efficiency improved from 82.5%** in FY23 **to 83.6%** in FY24, while **collection efficiency** saw **a rise from 96.1%** in FY23 **to 96.4%** in FY24, signaling better revenue realization by utilities.
- The **ACS-ARR gap**—the difference between average cost of supply and average revenue realized—narrowed sharply from **₹0.72/unit in FY19** to **₹0.21/unit in FY24**. Although closing this gap entirely remains aspirational, the trajectory points to improved financial viability for DISCOMs.
- Experts estimate that enhanced billing and collection efficiency from smart meters could unlock **₹4 lakh crore in additional revenues** over the next seven years.

These metrics demonstrate that even limited-scale deployments can yield measurable impact, reinforcing the case for expediting the national rollout.

State-Level Trends: Mixed Execution Across Regions

Deployment progress varies significantly across states, shaped by institutional capacity, administrative will, and consumer engagement:

- **Bihar** is one of the leaders in implementation with **60 lakh meters installed**, representing **30% of the national total** and **35% of its sanctioned meters as of FY25**. The state's success is largely attributed to aggressive vendor mobilization and strong political ownership.
- **Assam** follows with commendable execution, benefiting from early awards and relatively smoother on-ground coordination.
- On the other end of the spectrum, major states such as **Uttar Pradesh, Maharashtra, and Tamil Nadu**, despite having sanctioned and awarded contracts, have recorded sluggish installation progress. Issues range from delays in backend IT integration to resistance from consumers unfamiliar with prepaid metering systems.

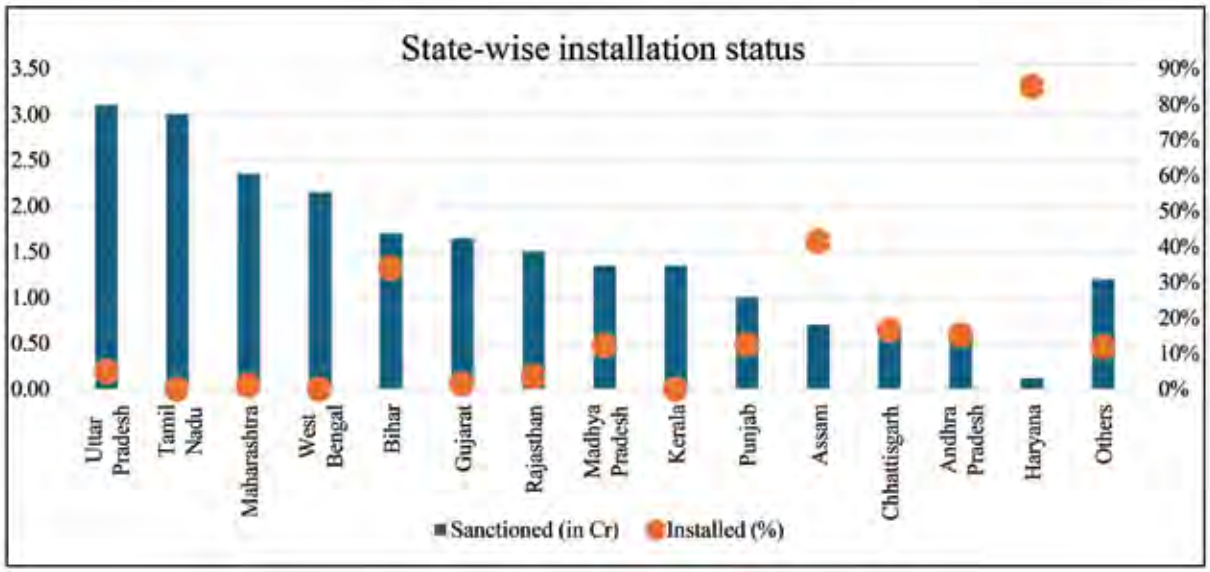

Figure 2: State-wise installation of smart meters (Source: CARE, NSGM Portal)

The disparity underscores the need for localized implementation strategies, responsive grievance redressal mechanisms, and robust digital literacy campaigns to improve acceptance and uptake.

Key Challenges Hindering Scale-Up

Despite the clear benefits and high policy priority, the national smart metering rollout continues to face several complex and interrelated challenges. These roadblocks span technical, institutional, financial, and socio-behavioral domains, and addressing them is critical for unlocking the full value of this transformational reform.

Consumer Resistance and Behavioral Barriers

In many regions, particularly rural and low-income urban areas, consumers have expressed concerns about smart meters leading to inflated bills or causing unexpected disconnections. Misinformation, coupled with a lack of targeted awareness campaigns, has made meter acceptance difficult. The transition to prepaid billing, though beneficial in the long term, has been perceived as abrupt in some areas, further fueling distrust. For instance, prepaid metering often conflicts with traditional postpaid billing expectations, particularly where subsidies and delayed payments are common. Studies conducted by Energy Policy Institute and anecdotal surveys in Bihar and Uttar Pradesh reveal that users fear being "cut off" in emergencies, worry about recharge accessibility, and misunderstand the functionality of Time-of-Day tariffs.

Utility Capacity and Implementation Readiness

Many DISCOMs still operate on legacy IT systems that are not fully compatible with smart metering infrastructure. Challenges related to integration with billing software, meter data management systems (MDMS), and outage management systems have delayed commissioning even after physical meter installation. Further, DISCOMs often lack sufficient manpower trained in handling AMI systems, leading to delays in activation and issue resolution.

Delays in Fund Disbursement and Cash Flow Mismatches

Although substantial financial commitments have been made under RDSS, the actual flow of funds has been sluggish. AMISPs and vendors often face delayed payments due to lack of timely disbursements from central or state agencies. This disrupts project timelines and creates uncertainty in vendor participation, particularly in smaller or financially weaker states.

Digital Infrastructure and Communication Gaps

Smart meter operations depend heavily on uninterrupted communication for real-time data capture and remote operability. In areas with poor telecom or RF mesh network coverage, communication failures result in meters operating

in offline or fallback modes, undermining the core benefits of smart metering. Investments in hybrid communication solutions and last-mile connectivity infrastructure remain inadequate in many locations. Each smart meter continuously generates granular data on consumption patterns, which if mishandled could compromise user privacy. Moreover, AMI networks are susceptible to cyberattacks, especially if built on unsecured protocols or legacy IT systems.

Fragmented Monitoring and Lack of Inter-State Learning

While several states have made good progress, others have lagged due to weak institutional coordination and a lack of proactive monitoring. There is limited use of benchmarking, best- practice sharing, or independent third-party evaluations across DISCOMs. This has resulted in redundant errors and implementation inefficiencies repeating across states.

Case Studies Across the Globe

- ***Italy*** was one of the first countries in the world to implement a large-scale rollout of smart meters. Between 2001 and 2011, the Italian utility Enel installed over 35 million smart meters across households and small businesses. The implementation led to significant reductions in meter reading costs, improved detection of non-technical losses (electricity theft), and enabled remote disconnection/reconnection services. Italy's experience demonstrated how centralized planning, combined with strong regulatory support and investment in AMI systems, can drive operational efficiency and enable dynamic tariff models.
- ***China's*** smart meter deployment is the largest globally, with over 500 million meters installed as part of its state-driven smart grid agenda. Led by the State Grid Corporation of China (SGCC), the program integrates AMI with AI-driven analytics, wide-area communications, and renewable energy management systems. Meters are designed for two-way communication, enabling real-time pricing, remote load control, and seamless integration with rooftop solar and EV infrastructure. The rollout was centrally planned, financed by utility capital with government backing, and executed with standardized technologies across vendors. China's success demonstrates the power of scale, regulatory mandate, and technological integration in achieving grid modernization.
- ***The United States*** adopted a decentralized approach to smart metering, with utilities leading implementation and federal grants under the 2009 American Recovery and Reinvestment Act (ARRA) providing financial impetus. By 2023, over 120 million smart meters were installed, covering 75% of electricity consumers. Utilities like PG&E and Florida Power & Light used AMI systems to launch demand response programs, improve outage detection, and engage consumers with real-time usage data and customized tariff plans. The U.S. experience highlights the effectiveness of blending federal support with utility-driven innovation and market responsiveness, though outcomes vary widely across states due to regulatory fragmentation.

India's projected ₹1.25 lakh crore smart metering investment, covering 25 crore meters, amounts to approximately ₹5000 per meter (or ~$60). In comparison, the cost per meter in Europe and the U.S. ranges between $150–$200, owing to higher feature sets and labor costs. Operational savings in India are also comparatively higher due to legacy inefficiencies—manual meter reading, theft, and subsidy leakage.

For instance, Enel in Italy saved over €500 million annually through smart meter deployment, while U.S. utilities reduced outage response times by 15–20%. Similarly, in India, studies suggest AT&C loss reductions of 3–5% and revenue increases of ₹4 lakh crore over 7 years. A comparative cost-benefit analysis clearly establishes that India's return on investment is among the strongest globally—particularly when factoring in the reduction of financial burden on DISCOMs and the improved billing experience for consumers.

Strategic Interventions to Accelerate Rollout

Consumer-Centric Awareness and Onboarding

Building consumer trust is essential to accelerate

smart meter adoption. Resistance among users often stems from limited understanding of the benefits, fear of bill hikes, and confusion over prepaid functionalities. To overcome this, DISCOMs must initiate sustained and localized awareness campaigns. These should leverage community influencers, self-help groups, resident welfare associations, and local media in regional languages to explain how smart meters work, how to recharge, and how to monitor usage. Interactive demonstrations, meter literacy drives, and mobile apps with user-friendly dashboards can go a long way in reducing apprehension and improving participation. Communication must be an ongoing process—not a one-time effort— covering onboarding, usage behavior, and grievance redressal.

DISCOM Capacity Building

Many DISCOMs are underprepared for the operational complexities that come with smart metering. The transition from manual to automated metering requires significant upskilling of utility staff in areas such as meter installation protocols, Meter Data Management System (MDMS) operations, handling consumer queries, and managing remote disconnection- reconnection processes. Centralized training programs, supported by institutions like REC, and state electricity academies, should be expanded with a focus on real-world implementation challenges. In parallel, DISCOMs must invest in digital infrastructure upgrades to enable seamless integration of smart meters with their legacy ERP, billing systems, and consumer service platforms. Without this foundational readiness, the benefits of smart metering will remain underutilized.

Standardization and Interoperability of AMI Infrastructure

Interoperability remains a major challenge, as many DISCOMs have adopted vendor-specific or proprietary solutions that create integration silos. To overcome this, the adoption of open architecture and BIS-compliant standards must be enforced at the national level. Ensuring that meters, communication modules, and software platforms can work across vendors will enhance competition, reduce costs, and prevent technological lock-in. Utilities should also maintain central AMI repositories with clearly defined data formats, protocols, and APIs to enable flexible scaling and smoother integration with third-party service providers and evolving market platforms.

Dedicated Project Governance and Real-Time Monitoring

Effective coordination among the three main stakeholders: central and state governments, DISCOMs, and AMISPs is essential to smart metering success. A streamlined governance framework is needed to bridge these roles. Joint monthly reviews chaired by the Ministry or SERCs can monitor compliance, resolve bottlenecks, and align timelines. Without such institutional clarity, duplication of efforts and miscommunication will continue to delay outcomes. States should establish dedicated Project Management Units (PMUs) within DISCOMs or energy departments to drive the implementation. These PMUs should be staffed with technical, financial, and project management professionals tasked with coordinating between AMISPs, regulators, and consumers. Their responsibilities would include tracking meter deployment progress, managing contract milestones, resolving field-level challenges, and maintaining quality control. PMUs should be supported by a centralized dashboard preferably hosted by the Ministry of Power that allows real-time tracking of state-wise performance, funding status, and vendor accountability.

Financial Risk Mitigation and Secure Payment Mechanisms

The current TOTEX model expects AMISPs to bear upfront capital costs and recover them over time via service fees. This structure creates financial risk, particularly in states with weak digital billing or low consumer compliance. To mitigate this, escrow-backed payment mechanisms should be made mandatory to ensure timely vendor payments under the Direct Debit Facility (DDF). Further, milestone-based disbursements linked to verified KPIs (such as number of meters installed, data accuracy, and communication uptime) should replace lump-sum payments. For difficult geographies or low-income zones, the government could consider viability gap funding or partial credit guarantee schemes to attract qualified AMISPs and reduce market concentration risks.

Early Use of Meter Data to Unlock System Value

Smart meters generate rich, granular data that can transform distribution management but only if used effectively. DISCOMs should begin using real-time data analytics immediately after initial installations. Applications include load forecasting, energy theft detection, outage mapping, and targeted Time-of-Day tariff deployment. Early adoption of these use cases will demonstrate tangible benefits to consumers and utilities alike, justifying investment and accelerating policy support. Moreover, data-driven insights can help optimize grid operations, reduce AT&C losses, and improve system resilience, making the business case for smart metering even stronger.

> Smart metering is revolutionizing India's power sector by enhancing transparency, efficiency, and consumer empowerment for a resilient energy future

Smart Meter Technology, Data Privacy and Security Concerns

Strict enforcement of BIS cybersecurity guidelines and CEA's cyber audit protocols is essential. Each meter and head-end system must be certified for encryption, firewalling, and secure firmware updates. Additionally, a national framework for smart meter data governance—covering consent management, anonymization, and third-party data sharing—should be introduced. India's upcoming Digital Personal Data Protection Act can serve as the legal foundation for these protections. Building consumer confidence in the safety of their data will be as important as the physical meter itself.

Conclusion and the Role of IREDA

India's smart metering program stands at a pivotal moment. With over 22 crore smart meters sanctioned but about 3.37 crore installed, the challenge is not in the lack of ambition or funding, but in execution. Smart meters are not just devices—they are a gateway to a more resilient, transparent, and participatory power system. Their full potential lies in reducing AT&C losses, bridging the ACS-ARR gap, enabling demand-side management, integrating renewable energy, and improving the financial sustainability of DISCOMs. However, realizing these outcomes requires much more than hardware installation; it demands systemic reform, seamless digital infrastructure, behavioral change among consumers, and most critically, consistent and risk-mitigated financing.

In this transformation, IREDA plays a catalytic role. As India's premier green financing institution, IREDA has a proven track record of supporting clean energy infrastructure, including solar, wind, green hydrogen, and energy storage. Its entry into the smart metering space is both timely and essential. By extending financial support to smart metering projects, IREDA is actively helping to overcome the financing challenges that have hindered the implementation of several awarded projects, paving the way for their timely execution. By offering project-specific loans, milestone-linked disbursements, and technical due diligence, IREDA ensures that capital flows are aligned with execution milestones and quality benchmarks.

Beyond capital, IREDA's role extends to enabling risk mitigation mechanisms such as escrow-based payments and exploring blended finance models. It's deep engagement with DISCOMs and AMISPs allows it to design financial instruments that are responsive to the sector's realities particularly in states where digital billing and prepaid adoption remain nascent. IREDA is also well-positioned to support DISCOMs in upgrading their digital infrastructure, training human resources, and integrating AMI data into broader distribution reforms.

As India marches toward a digitally enabled, consumer-empowered power grid, IREDA's contributions go beyond finance—they reflect institutional leadership. Its ability to fuse technical, financial, and operational insights makes it a cornerstone of India's smart grid future. With coordinated efforts from central ministries, regulators, utilities, and financing partners like IREDA, the vision of universal smart metering can become a reality unlocking lasting gains for consumers, utilities, and the energy economy. MA