WORKING PAPER | EXECUTIVE SUMMARY

Rooftop Solar

A Trade-off Between Consumer Benefit and Discom Finances

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India's energy and decarbonisation goals are closely linked to solar power—both grid-scale and rooftop. Rooftop solar (RTS) has gained global traction as a form of distributed renewable energy (DRE), offering households the potential for lower electricity bills and greater energy independence. With more than 300 sunny days a year, India is well positioned to harness solar energy. However, despite extensive government initiatives, RTS deployment has fallen short of targets. As of February 2025, only about 16.67 GW of the original 2022 target of 40 GW RTS has been achieved.

The *Pradhan Mantri Surya Ghar Muft Bijli Yojana* (*PM Yojana*), launched in February 2024, targets one crore households with RTS systems. The scheme provides capital subsidies of up to Rs 78,000 for grid-connected RTS installations and streamlines the process through a unified portal integrating vendors, distribution companies (Discoms), and consumers. While the programme is positioned as a tool for empowering lower-income households through reduced electricity bills ("*Muft Bijli*"),[1] its real-world impact hinges on household economics and utility finances: households must generate enough electricity to offset bills, and Discoms must withstand the revenue loss from widespread adoption. This tension is magnified by India's progressive, slab-based residential tariff structure, where higher-usage households shoulder much of the system's cross-subsidy.

When these high-consumption households adopt RTS, their electricity purchases from the Discom decline sharply, eliminating the cross-subsidy that keeps tariffs low for smaller users. Because Discoms recover most fixed costs[2] through per-unit energy charges (ECs)[3] (Tyagi, Rao, & Tongia, 2024), yet another distortion—the lost sales create a sizeable revenue shortfall. Net-metering deepens the gap: daytime solar exports from households are credited at the same rate as evening imports, despite higher costs to the

1 *Muft Bijli* in Hindi literally translates to "free electricity."

2 A Discom's "fixed costs" refer to the non-energy expenses, primarily generation-capacity payments, bulk-transmission charges, and distribution-line infrastructure.

3 A household's electricity bill comprises two principal components: the fixed charge and the energy charge. The fixed charge is levied on the sanctioned load (and supply phase, where applicable), while the energy charge is applied to each unit of electricity consumed. The fixed charge is intended to recover the Discom's "fixed costs." In practice, tariff orders indicate that only a modest share of fixed costs is recovered through the fixed component; most states still embed the majority of these costs in the per-unit energy tariff.

Discom, effectively turning the grid into a nearly free "virtual battery."[4] Being an average-cost regulated system,[5] some of the shortfall is then redistributed across the remaining fully grid-reliant customers—mostly lower-consumption, lower-income households. Against this backdrop, the study addresses two research questions:

1. How do current net metering rules influence system sizing, payback periods, and adoption likelihood across consumer categories?
2. What are the resulting financial impacts on Discoms?

To address these questions, we develop a bottom-up analytical model to assess the impact of RTS adoption across four states: Delhi, Gujarat, Karnataka, and Madhya Pradesh—each representing different tariff structures and policy environments. The model incorporates key parameters, including household sanctioned load, annual electricity consumption, average power procurement cost (APPC), residential energy charges, and feed-in tariffs (FiTs), among others.

i. Right-Sizing RTS Benefits Consumers but Hurts Discoms

The results indicate that consumers benefit most when the RTS system size closely matches their monthly electricity consumption. However, oversizing the RTS does not yield additional gains, except in Delhi, where a high FiT makes excess generation more profitable. While net metering allows for energy offsets, any surplus beyond a household's monthly consumption is compensated at a lower FiT, limiting consumer gain.

From the Discoms' perspective, a right-sized RTS system is the least favourable outcome. An undersized RTS still retains revenue from grid consumption, albeit at lower tariff slabs, while an oversized RTS allows Discoms to procure power at a lower FiT. However, when consumers right-size their systems, Discoms experience the greatest revenue loss, as these households maximise self-consumption while minimising their dependence on the grid.

ii. Higher-Income Households are More Likely to Adopt RTS

Net-metering policies in India create disparities in the value of electricity depending on who generates it and when. Our model indicates that lower-consumption consumers—often a proxy for lower-income households—experience longer payback periods than wealthier consumers who have optimally sized their RTS installations. This is primarily because lower-income households typically fall under lower tariff slabs, resulting in less financial benefit from solar generation. In some instances, state electricity subsidies further diminish the value of the energy they produce, sometimes even reducing it to zero. Conversely, high-consumption households derive the greatest benefits, as they can offset their higher electricity costs with self-generated solar power. This raises critical concerns about the efficacy of subsidies: are capital subsidies and net-metering benefits disproportionately favouring those who can already afford RTS, rather than those who need it most?[6]

iii. Rooftop Solar with Net Metering is a Zero-Sum Game

Higher-consumption households maximise their savings through net metering by offsetting grid purchases with self-generated power, often reducing their electricity bills to zero or moving into lower tariff slabs. Crucially, they can achieve these savings without altering their consumption patterns. Given that most states have telescopic tariff structures, wealthier households—who typically have high[7] electricity consumption, higher tariff rates, and reliable roof access—are more likely to adopt RTS. This creates a revenue challenge for Discoms, as high-paying consumers shift away from the grid, leaving a larger financial burden on lower-paying consumers.

For Discoms, RTS adoption presents both benefits and challenges. While it can reduce daytime demand, transmission losses, and overall power procurement costs—particularly during supply shortages—it also disrupts revenue models. This challenge is most pronounced during non-solar hours, when high-consumption RTS users rely on the grid. Discoms must procure electricity at higher costs without adequate compensation during these periods, exacerbating

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[4] In utility-scale parlance, this can be referred to as "banking." In most states, the banking of utility-scale solar energy is permitted on a monthly billing basis, with a percentage of the banked energy retained by Discoms as a charge, rather than a separate monetary payment. Limits are also imposed on the total amount of banked energy. Additionally, states such as Punjab and Rajasthan restrict the withdrawal of banked power during peak hours, requiring consumers to pay the applicable tariff for electricity used during these periods (PSERC, 2023; RERC, 2023).

[5] In India's electricity sector, an "average cost regulated system" sets consumer tariffs based on the Average Cost of Supply (ACoS), allowing Discoms to recover their total costs—power procurement, transmission, and distribution, operations and maintenance, and regulatory asset recovery (if applicable)—averaged over all units sold. This model ensures Discoms recover their aggregated costs across all consumers (Ministry of Power, 2005; 2016).

[6] In today's system, low-consumption households—lacking capital, rooftop access, or secure tenure—must absorb all or part of the transition costs when high-consumption households adopt subsidised net-metered RTS. Excluded from these benefits, they bear a disproportionate financial burden.

[7] In this analysis, we classify systems of 5 kW and above as large; accordingly, an equivalent sanctioned load or RTS of this size is considered large.

their financial losses. Additionally, net metering does not differentiate between peak and off-peak hours, valuing electricity uniformly throughout the day. This further distorts financial outcomes for Discoms. The current net metering framework, therefore, does not create a mutually beneficial arrangement—consumer gains come at the expense of Discoms, reinforcing the importance of understanding which consumers are shifting to RTS.

iv. Time-of-Day Tariffs Matter-Policy Should Encourage Solar-Aligned Demand

Comparing consumer tariffs and FiTs with the APPC overlooks a critical factor: the time-of-day (ToD) variation in Discoms' procurement costs. Midday energy prices are generally lower because of cheaper utility-scale solar, whereas evening and night-time prices are higher. Households with higher solar-aligned consumption reduce their reliance on the grid during expensive, non-solar hours, thereby mitigating revenue losses for Discoms.

Although limited in residential settings, ToD tariffs offer a potential mechanism to reduce those losses. For consumers with smart meters, existing regulations recommend a 20% discount for solar-hour consumption and a 20% surcharge for non-solar hours, lowering losses compared with a non-ToD scenario. **Figure 1** examines the impact of ToD pricing for consumer profiles across three RTS sizes. A more dynamic ToD design, better aligned with real-time supply conditions, could enhance Discoms' financial sustainability while facilitating RTS integration.

However, as **Figure 1** shows, a 5 kWp RTS system, optimally sized at approximately 5,500 kWh, results in the lowest net present value (NPV) for Discoms—even when the household has a high solar-aligned consumption rate of 90%. That said, a well-designed ToD tariff can help mitigate the losses associated with right-sized RTS users, as seen in a right-sized 10 kWp RTS system with around 9,000 kWh consumption. While ToD tariffs can reduce losses from right-sized consumers, they may also diminish gains from oversized or undersized consumers, such as a 1 kWp RTS system with 9,000 kWh consumption. However, such extreme cases are uncommon, as most consumers install RTS systems based on a mix of economic and technical considerations rather than on extreme oversizing or undersizing. This also highlights that ToD tariffs alone cannot address the fundamental challenges of net metering, telescopic tariffs, and solar-aligned consumption.

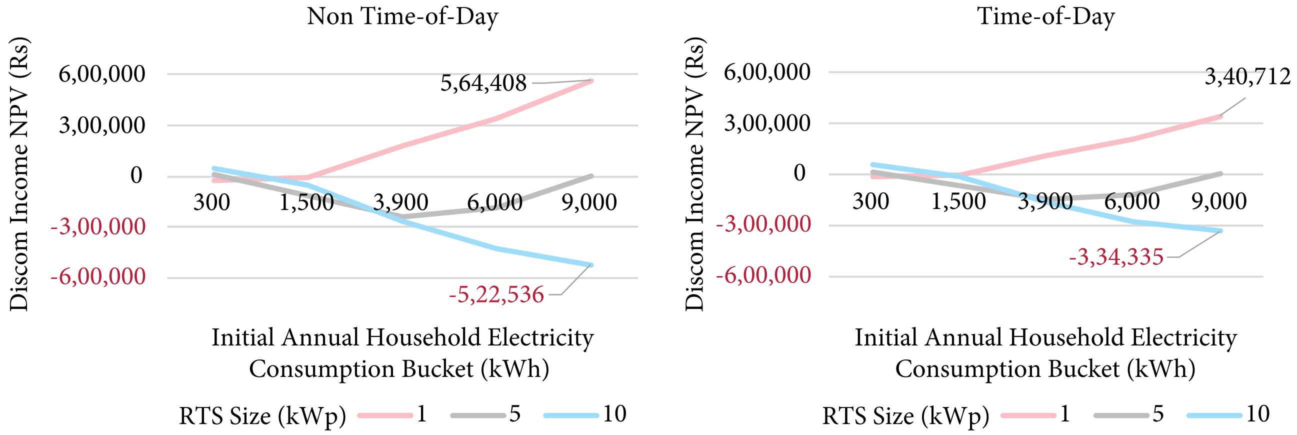
Towards Equitable Net-Metering Reforms

Although net metering has been an essential policy tool for incentivising RTS, it may not be the most efficient approach. While gross metering eliminates offsets, it still does not dynamically reflect the value of electricity based on time-of-day (ToD) considerations. To ensure the financial stability of Discoms while safeguarding consumer interests, this paper proposes the following policy recommendations:

1. **Align Fixed Costs to Ensure Discom Recovery:** Net metering allows large consumers (greater than 5 kW) to derive greater value from RTS, significantly reducing their grid consumption. Since Discoms recover most fixed costs through energy charges, this shift places a disproportionate financial burden on non-RTS commercial and industrial consumers and smaller, lower-paying households. Without proportional fixed cost adjustments, this imbalance will intensify as more high-paying consumers adopt RTS.

2. **Promote RTS with Storage:** For appropriately sized large consumers (greater than 5 kW), RTS payback periods range from 5–10 years without central subsidies and improve only slightly to 4–9 years with subsidies, offering limited financial advantage. To enhance grid stability and financial sustainability, subsidies for larger RTS systems should be contingent on storage integration. This would help Discoms by reducing procurement costs during evening peak hours and mitigating the financial strain of net metering offsets.

Figure 1: Discom Income Net Present Value With 90% Solar Aligned Consumption: Comparison of Non Time-of-Day And Time-of-Day Tariff Scenarios (Karnataka)



Source: Analytical model calculations based on inputted primary variables and technical parameters.

Notes: The scenarios correspond to RTS households in Karnataka. "Initial Annual Household Electricity Consumption Bucket" represents the annual consumption of the household in the first year, capturing a spectrum of high- and low-consumption consumer profiles across sanctioned loads. Higher sanctioned loads correspond to lower consumption growth rates, reflecting a decreasing trend as the kW subscribed increases. The model captures all three consumer profiles—undersized, right-sized, and oversized RTS plants vis-à-vis their annual consumption. "Discom Income NPV" stands for Discom Income Net Present Value, a financial metric that calculates the total projected income a Discom is expected to earn from a specific RTS household over a 25-year period. This income is discounted at 10% to account for the time value of money, providing its present monetary value.

3. **Transition to a Modified Net Metering Framework for Fair RTS Valuation:** A differentiated approach is needed to ensure fair valuation of RTS electricity while maintaining consumer adoption and Discom sustainability. A modified framework could allow self-consumption, export valuation at wholesale rates or State Electricity Regulatory Commission-determined prices, and import charges at applicable tariffs to create a more balanced, equitable, and sustainable RTS integration.

4. **Implement ToD Tariffs with Real-Time Price Signals:** ToD tariffs can help reduce Discom losses by aligning consumer demand with solar generation patterns. However, for long-term sustainability, ToD tariffs should reflect real-time supply conditions and market price signals rather than fixed solar and non-solar hour distinctions. Implementing real-time pricing can improve cost recovery and enhance electricity market efficiency.

5. **Balance RTS Growth with Discom Financial Sustainability:** A hybrid approach is essential to scale RTS adoption while ensuring Discom financial health. This includes fixed cost recovery through appropriate charges, a differentiated metering mechanism to balance consumer and Discom interests, a flat tariff structure to minimise slab distortions, and ToD tariffs with real-time pricing for accurate market signals.

The *PM Surya Ghar Muft Bijli Yojana* represents a significant advancement in accelerating the adoption of RTS and enhancing consumer benefits across India. By implementing these recommendations, policymakers can achieve a balance that supports RTS growth while maintaining the financial viability of Discoms, thereby fostering a sustainable and equitable energy ecosystem. As the initiative progresses, it offers an opportunity to clearly define its overarching priorities, whether to focus on energy affordability, consumer equity, environmental sustainability, or the financial stability of Discoms. A well-structured policy framework can align these objectives, ensuring the long-term success of the *PM Surya Ghar Muft Bijli Yojana* and India's clean energy transition.

About the authors

Niteesh Shanbog holds a Master of Public Policy (MPP) degree from Indian Institute of Technology, Delhi. He also has a Master's and Bachelor's degree in Electrical Engineering from PES University and BMSIT, Bengaluru. Niteesh commenced his professional journey as a Junior Research Fellow at the Central Electronics Engineering Research Institute (CSIR CEERI). His academic and professional pursuits reflect his keen interest in the power sector, particularly the evolving areas of renewables and energy transition. He has also been involved in projects focusing on energy and capacity markets, design of indigenous water treatment plants and modelling the impact of droughts.

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