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WORKING PAPER - 83
OCTOBER 2024

Green Electricity Tariffs

Pricing and Other Challenges

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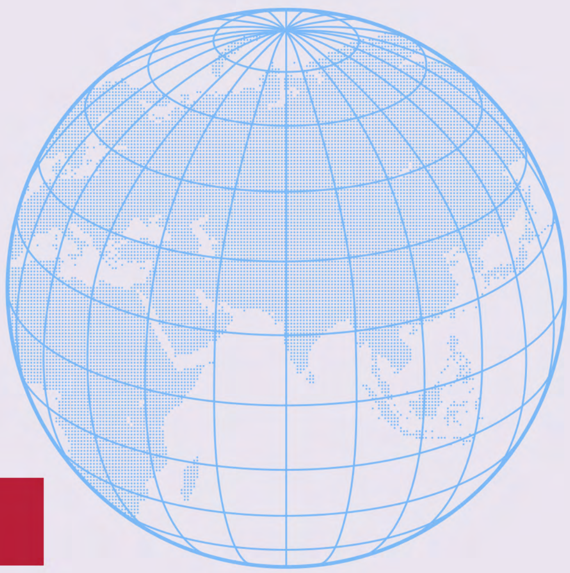

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Recommended citation:
Tyagi, N., Rao, S., and Tongia, R. (2024). *Green Electricity Tariffs: Pricing and Other Challenges* (CSEP Working Paper 83). New Delhi: Centre for Social and Economic Progress.

Designed by Umesh Kumar

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The authors would like to express their sincere gratitude to Rajasekhar Devaguptapu for his contributions and support during the study. We also benefited from inputs, comments, or a full review from (in alphabetical order) Ann Josey, Laveesh Bhandari, Pooja Vijay Ramamurthi, Rohit Vijay, and Shishir Gupta. Editorial assistance was graciously provided by Aruna Bose and Malvika Sharad, with special thanks to Renu Gupta for her exceptional contributions.

The copyediting was expertly handled by Editrix Solutions Private Limited. The paper was elevated by the refined graphic design contributions of Mukesh Rawat and Umesh Kumar.

Any omissions or errors remain the responsibility of the authors.

Table of Contents

List of Tables

List of Figures

Abbreviations

ABR	Average Billing Rate
ACoS	Average Cost of Supply
APPC	Average Power Purchase Cost (also Average Power Procurement Cost)
ARR	Annual Revenue Requirement
BESS	Battery Energy Storage System
BTM	Behind-the-Meter
C&I	Commercial and Industrial
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CUF	Capacity Utilisation Factor
Discom	Distribution Company
FY	Financial Year (April 1st to March 31st); FY 22 is FY 2021-22
GW	Gigawatt
GDAM	Green Day Ahead Market
HT	High Tension (i.e., High Voltage)
kWh	Kilowatt-hour
kWp	Kilowatt-peak
LT	Low Tension
MCP	Market Clearing Price
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MW	Megawatt
MWh	Megawatt-hour
MU	Million Units (million kWh)
O&M	Operation & Maintenance
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PV	Photovoltaics
RE	Renewable Energy
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
RTC	Round-the-clock
RTPV	Rooftop Photovoltaic
SERC	State Electricity Regulatory Commission
SECI	Solar Energy Corporation of India Limited
SLDC	State Load Despatch Centre
ToD	Time of Day
VRE	Variable Renewable Energy

Executive Summary

The Ministry of Power has notified a formula for "green tariffs" for large (greater than 100 kW) electricity consumers to encourage green power uptake from distribution companies. Our analysis finds that this push to create demand for green power (based on Renewable Energy, or RE) has several limitations, including:

1. **Financials**: Losses to the distribution companies compared to today's tariffs (i.e., regulated retail prices).
2. **Operations**: Lack of clarity on the ability of the distribution company to supply the required incremental green power; this includes challenges in matching the demand by time of day through RE and the likelihood that this is likely to be a reallocation of already procured RE.

To study green tariffs, we analysed current cost and retail pricing structures across twenty-three distribution companies in 11 states, which cover almost two-thirds of units sold across India. Costs include both fixed and variable costs of generation, transmission, and distribution of electricity. We also quantified pricing distortions that include cross-subsidies, where commercial and industrial (C&I) consumers typically overpay compared to the average cost of supply.

The primary difference between the current electricity retail pricing norms and the proposed green tariff lies in the cost components. Current norms start with the average power procurement cost (APPC) and then add utility distribution costs and cross-subsidies. The proposed green tariff is solely based on renewable energy procurement costs, with caps on costs for both distribution costs and cross-subsidies.

The calculated average cost of supply for the 11 major states was determined to be Rs 7.47/kWh, but the green tariff works out to only Rs 6.50/kWh—15% lower and thus loss-making.

If such green tariffs are approved by the respective state electricity regulatory commissions, this could lead to a large-scale migration of high-paying utility consumers, leading to fewer avenues for cost recovery, which would affect distribution company revenues or raise prices for other consumers.

While the Ministry's green open access order and green tariff notification are well-intentioned, in their present form, they ignore critical issues that affect the distribution companies today, and may also distort the RE industry because:

1. The proposed formula does not reflect the cost of supply.
2. Offering and making available 24x7 green energy—one of the conditions in the green order—is possible only by charging a premium.
3. The load profiles of C&I consumers are heterogeneous and may or may not coincide with the corresponding RE generation profile, so a uniform green tariff across the consumers is not efficient.
4. If the renewable energy procured is not new and incremental, this could lead to a zero-sum game, with a skew—there appears to be a disparity in access to affordable renewable energy sources. Premium, i.e., C&I consumers have greater access to cheaper renewable options, potentially resulting in a situation where less affluent and poorer consumers are left with more expensive conventional energy sources.

If the motivation for the green tariff is to increase renewable energy purchases, then its design and features should benefit both distribution companies and consumers. The following could aid distribution companies and improve the scaling of renewable energy:

1. Distribution companies must calculate the true costs of supplying green power and set the tariff at levels that recover their costs.
2. Distribution companies should increase procurement of green power, but such power should be available to all consumers, not just a subset of consumers.
3. There must be consistent norms for defining green power, especially those that reflect time-of-day differentials. For example, banking of renewable energy should not qualify as green power if some of the delivered power is procured by non-renewable energy means.

4. Consumers should be incentivised to increase usage during periods of cheaper green supply (typically mid-day, with solar, and focused on renewable energy without storage). One option is time-of-day pricing.

5. Increasing renewable energy beyond a threshold will require storage and system overhauls, e.g. improved flexible supply and ancillary services, the cost of which must be factored in.

Achieving the ambitious target of 500 GW of non-fossil capacity by 2030 necessitates a substantial annual increase of close to 46 GW in non-carbon dioxide-emitting technologies. Variable renewable energy is anticipated to be the primary contributor to this growth. While behind-the-meter renewable energy procurement, such as rooftop solar, is gaining traction, distribution companies remain, and will continue to be, the key source of renewable energy procurement. To ensure the long-term viability of this endeavour, the financial health of distribution companies is paramount.

1. Introduction

India has ambitious renewable energy targets, aiming to deploy 500 GW of non-fossil-based capacity by 2030, nearly tripling the capacity recorded in 2023 (CEA, 2023a). The bulk of this is expected to come from solar energy, though the growth also envisages a substantial addition of wind power.

Moreover, state governments have introduced various modes to bolster consumer demand for clean energy, such as behind-the-meter (particularly rooftop solar) and green open access—a subset of open access which allows consumers to directly purchase from any generator other than the distribution licensee in their area of supply (DERC, 2006).

Notably, the Ministry of Power (MoP) sanctioned "green open access" in June 2022, lowering the load consumption threshold for eligibility for availing open access (which allows consumers to procure from any supplier, not just the Distribution Company, or Discom) from the 1 MW threshold applicable for general open access to 100 kW for green open access (Ministry of Power, 2022a). The same notification also enables consumers with a sanctioned load of 100 kW or more to procure green energy from a Discom by paying a "green tariff."

Furthermore, the notification required all State Electricity Regulatory Commissions (SERCs) to formulate operational guidelines and declare a green tariff.

The MoP's (2022a) motivation behind issuing the green energy open access rules was to encourage the extensive adoption of renewables. Despite various states notifying green energy open access regulations and publishing green tariffs, the Ministry perceived a need for further action.

On 13 May 2023, it issued a circular chastising states that had delayed in publishing green energy regulations. Under this circular, the Ministry of Power (2023a) asked the states to:

- Notify Green Energy Open Access regulations and those who have already done so to align it with MoP's (2022a) notification.
- Establish the green tariff according to a specific formula.

As of 2023, SERCs from 17 states had published green open access rules, with 15 states issuing green tariffs (Ramesh, 2023). That said, none of the states has adopted the MoP formula to establish its green tariffs.

The primary objective of this study is to compare the MoP-proposed green tariff for different states with the prevailing C&I tariffs of the respective states. The C&I tariffs have been calculated as per the methodology engaged by the respective SERCs. Secondly, we study the financial implication of the green tariff on Discoms. We also compare this tariff with other forms of consumers going green, viz., self-generation and green open access.

The study is divided into two parts. The first part examines the viability of the green energy offered through Discoms and open access along two dimensions—cost and delivery. We do this in detail for 11 states, covering the majority of power sold in the country.

In the second part, we examine alternative modes of going green from a Discom perspective, viz., self-generation (like rooftop solar) and green open access (third-party green supply). Subsequently, we examine the delivery of green power, which touches on factors such as time of day, scalability, and whether the energy can be truly green. Finally, we propose policy suggestions to facilitate cost-reflective 24x7 green supply.

2. Renewable Energy: Options for Consumers

Consumers can access green electricity primarily through one of three options: the proposed or any other "green tariff" set by the Discom, self-generation, and third-party supply under green open access. In some states, other modes for green supply exist, such as "group captive RE", but these are outside the scope of this paper.

1. **Self-Generation:** This is equivalent to behind-the-meter (BTM) generation, where a consumer generates some portion—if not all—of their energy requirement. All types of consumers (i.e., residential, commercial, industrial, cooperatives, associations, etc.) are eligible to generate power within their premises.[1] **Grid-connected rooftop solar** is a subset of this mechanism, partly incentivised by the government, which has gained traction in recent years. To promote rooftop solar, the central government has offered residential users a capital subsidy, recently upgraded to a cap of Rs 78,000 towards the purchase of solar rooftop systems (MNRE, 2024a). This subsidy is enough to cover approximately one-third to one-half of the cost for small-to-medium installations.

2. **Discom-Offered Green Power:** This corresponds to the MoP notification dated 6 June 2022, which stipulated that any consumer with a contracted demand of 100 kW or more may avail (partly or 24x7) renewable energy from a distribution licensee. This category applies to large-sized consumers, thus excluding almost all households and individual pump sets. Further, SERCs were asked to determine the "green tariff" applicable to procuring green energy. Two motivations appear to be behind introducing this mode of green energy. First, the MoP believed that green energy was available at a lower price than the average procurement cost and that this benefit should be passed on to the consumer; for new RE, this is true. Second, the Ministry wanted to introduce another mechanism for entities to meet Renewable Purchase Obligation requirements.

3. **Third-Party Supply:** This refers to energy supplied to the consumer via open access means. Open access refers to the unfettered access to transmission and distribution networks. The Electricity Act (2003) mandates SERCs to provide rights to consumers with a load of 1 MW or more to choose and directly purchase from any generator other than the Discom. This was the case with contracts engaging renewable energy until 6 June 2022. After this date, green open access rules were notified, and the ruling lowered the capacity to 100 kW. As in conventional open access, green energy open access covers all consumers, but due to the threshold size, it is typically C&I users who would be eligible for contracting renewable energy from an independent third party.

3. Nominal and Green Tariffs

Both regular (or nominal) category-wise (commercial, residential, etc.) and green tariffs are meant to be calculated using the same philosophy, as prescribed by the Electricity Regulatory Commissions. The rationale is to cover the costs incurred by the Discom to supply energy to the consumer, along with a regulated rate of return. The MoP too, has followed the same approach in prescribing the green tariff formula (Ministry of Power, 2023a). The two tariffs are mentioned next to each other in **Equation 1**.

Equation 1: *Nominal and Green tariffs*

$$\textit{Nominal Tariff} = APPC_{Discom} + \textit{Distribution Costs} \pm \textit{Cross-subsidy}$$

$$\textit{Green Tariff} \leq APPC_{RE} + \textit{Surcharge @20\% of ACoS} + \textit{Margin of 25 paisa}$$

$APPC_{Discom}$ = *Average Power Purchase Cost (at discom network periphery)*

$APPC_{RE}$ = *Average Power Purchase Cost of Renewable Energy (at the distribution network periphery)*

The equivalent constituents in the two formulas follow the same colour coding. The red component is the cost of procuring power, which constitutes the majority of costs today. The blue portions are meant to cover operating costs and statutory profits. The green portion is meant to cover allowed deviations from the average based on consumer categories—i.e., a cross-subsidy where C&I users typically pay more to offset underpayments by households and agricultural consumers.

The following section examines both formulas in greater detail. First, we examine the traditional method of determining the nominal tariff, which

[1] A consumer can, under certain circumstances, also generate green power off-site and treat it like captive power, but this has restrictions like on minimum size or type of consumer.

forms a base for green tariffs. This helps to understand the frameworks, nomenclature, and relevant issues affecting the electricity sector.

3.1 Average Cost of Supply

In a regulated power sector, as practised in India, the retail cost of supply is based on a cost-plus framework, which means every rupee spent on the supply of electricity is added to the total cost, conditional to SERC norms (typically on prudency and performance). Discoms nominally seek yearly tariff revisions to meet the anticipated costs or expenditures.

SERCs issue tariff orders based on the petition for Annual Revenue Requirement (ARR), which represents the cost of supply submitted by the Discoms. ARR is used as the benchmark for Discoms' viability. The ARR is calculated anticipating the demand of the different consumer categories in the oncoming financial year, after which tariffs are determined for the respective categories (Tyagi & Tongia, 2023).

The projected yearly ARR divided by the total anticipated units sold to all categories of consumers results in the Average Cost of Supply (ACoS). In principle, ACoS should equate to the Average Billing Rate (ABR), which is the average rate at which consumers are billed. In practice, for a range of reasons, the ABR often falls short of the ACoS.

Importantly, due to norms of social welfare redistribution, regulators allow a cross-subsidy across consumer categories, which means that all consumers do not pay the same ABR. Some consumer categories are charged lower tariffs, usually, domestic (residential) consumers and agriculture. In contrast, C&I consumers typically pay higher tariffs, thus cross-subsidising low-paying consumers. In aggregate, the differential tariffs are still meant to yield full cost recovery,[2] as Tyagi & Tongia (2023) show.

It is worth mentioning two important nuances in the tariff process that do not affect our analysis in this paper. First, states are free to offer consumer subsidies that sit on top of regulator-set tariffs (which may embed cross-subsidies), e.g., "free power" for selected users. This should not affect total Discom revenues, in theory. Second, tariff orders are designed to recover allowed costs, but those are *ex-ante* instruments.

As Tyagi & Tongia (2023) showed, the actual efficacy of tariffs *ex-post* typically falls measurably short of projections, leading to a revenue gap for Discoms. This is meant to be fixed subsequently through true-up mechanisms but is rarely covered in full. Given our focus in this paper is on tariffs, we ignore both these issues. Unless stated otherwise, we rely on *ex-post* numbers for the true costs and ideal ABRs, since our focus is on category-wise differentials for consumers—a green tariff is simply a new category.[3]

Broadly, ACoS has two components: power purchase cost and non-power purchase cost (see **Equation 2**). The power purchase cost, also referred to as $APPC_{Discom}$, is the average cost of power purchased at the Discom's periphery, which is the generator cost plus the inter- and intra-state transmission charges. Power Finance Corporation data show power purchase costs account for approximately 75% of the total *ex-post* cost of supply (PFC, 2023). The remaining 25% are distribution costs, which encompass all other expenses, including normative losses incurred by a Discom.[4]

The above information is included in the Discom's tariff petition. The regulatory commission looks at the merits of the case and issues an impartial tariff order meant to ensure both the consumers and the Discoms are safeguarded. Normally, the tariff order for the subsequent financial year is issued at or near the end of the previous financial year.

APPC can be further decomposed into fixed and variable costs. A thermal power plant comprises capital costs and variable costs, primarily fuel. Renewable energy plants have no fuel, and the overwhelming majority of costs are capital costs, with limited O&M expenses to run them. While it might appear inconsistent, under today's norms, RE's capital costs, together with other expenses, are treated as variable expenses *from a load despatcher's perspective.*

[2] Depending on the ARR approved by a SERC, there could still be a difference between ACoS and ABR. This is primarily due to the use of *regulatory assets*. Regulatory assets are costs recognised and approved by a regulator but deferred for recovery through future tariff changes. The regulator may want to shield consumer from tariff shocks and hence, orders the course of action. In FY19 itself, all India total regulatory assets stood at Rs 50,301 crore. Until recently, four states–Delhi, Karnataka, Maharashtra, and West Bengal–shared all these assets between them (Rajasekhar & Tongia, 2020). By 30 June 2022, this figure stood at Rs 88,720 crore (Business Standard, 2022).

[3] Calculating using an *ex-ante* basis would show similar trends as our analysis, even if the numbers would shift around slightly.

[4] Normative loss is the distribution loss, i.e., technical as well as commercial, which is approved by a regulator in the tariff order (CRISIL, 2010). In energy (kWh) terms, this is also called the billing loss. An additional component of aggregate technical & commercial losses is the collection loss, which is non-payment after billing the consumer (or the state government if they had promised a subsidy).

Equation 2: *Different components of ACoS*

ACoS = $\mathbf{APPC_{Discom}}$ + Distribution Costs

$APPC_{Discom}$ = $APPC_{Ex\text{-}Bus}$ + Inter-state Transmission charges + Intra-state Transmission charges

$APPC_{Ex\text{-}Bus}$ = Average Power Purchase Cost of Discom at Ex-Bus (i.e., the point at which a generating station injects electricity to the grid)

Distribution Costs = O&M Expenses# + Depreciation + Interest Expenses + Return on Equity + Others^

#O&M Expenses include Administration & General Expenses

^Others includes SLDC/Grid India charges, Amortisation of regulatory assets, Provision for bad debts, Insurance expenses, Other finance charges, etc.

Table 1 highlights the constituents of ACoS incurred by Discoms in 11 major states in India. The 11 states comprise 23 Discoms, whose details are in **Appendix 1**. The units sold in these states are almost two-thirds of the country's sales. Moreover, the C&I category in these states represent approximately 40% of total electricity sold and is accountable for 50% of revenues *ex-post*.

The total generation cost, i.e., $APPC_{Ex\text{-}Bus}$, varies in the range of Rs 3.15 to 6.12/kWh. The phrase *ex-bus* means entering the grid busbar and is post "auxiliary consumption," i.e., in-house consumption by the generator.[5] Kerala incurred the lowest generation costs and Tamil Nadu represents the highest. The 11-state average was around 5.24 Rs/kWh.

Table 1: Components of Fully Loaded *ex-post* Average Cost of Supply Incurred by Various Discoms Across the Different States in FY 22

State	(A) $APPC_{Ex\text{-}Bus}$ (Rs/kWh)	(B) Inter-state Transmission (Rs/kWh)	(C) Intra-state Transmission (Rs/kWh)	D = A + B + C $APPC_{Discom}$ # (Rs/kWh)	(E) Distribution Costs (Rs/kWh)	D + E *Fully Loaded ex-post* ACoS^ (Rs/kWh)
Andhra Pradesh	5.05	0.17	0.37	5.59	1.4	6.99
Delhi	5.24	0.78	0.27	6.29	2.63	8.91
Gujarat	5.23	0.32	0.42	5.97	0.76	6.73
Karnataka	5.38	0.39	0.83	6.60	1.6	8.20
Kerala	3.15	0.39	0.47	4.02	2.31	6.32
Madhya Pradesh	4.87	0.44	0.74	6.05	1.64	7.70
Maharashtra	5.58	0.28	0.50	6.36	1.73	8.10
Punjab	4.37	0.32	0.27	4.96	1.85	6.81
Rajasthan	5.29	0.36	0.88	6.52	2.59	9.11
Tamil Nadu	6.12	0.75*		6.88	2.17	9.05
Telangana	5.51	0.25	0.47	6.23	1.04	7.27
11 States (Average)	**5.24**	**0.29**	**0.55**	**6.08**	**1.7**	**7.78**

Source: Authors' calculation based on actual numbers from Discoms' True-up petitions.

Notes: Transmission costs are paid on contracted capacity. However, we have considered these costs on per kWh basis for ease of comparison.

#This APPC is the actual cost as realised, which reflects the Discom performance failures. Higher AT&C losses than targeted mean more power procurement, raising APPC compared to the normative APPC.

^This ACoS is calculated from the actual (ex-post) costs incurred for each of the cost components, and not on the ex-post costs based on normative AT&C loss levels. The fully loaded ex-post ACoS refers to the actual ACoS as realised. This can differ based on performance failures or changes in assumptions.

**Break up of intra- and inter-state transmission charges for Tamil Nadu is not available.*

[5] India is one of the few countries to measure gross generation before in-plant auxiliary consumption. Ex-bus is what is delivered to the grid and can be considered as the net generation.

Importantly, the calculations in Table 1 are based on the *ex-post* true-up tariff petitions and thus, reflect actual costs. These are "fully loaded" costs and embed any failures of performance, i.e., not meeting normative operating performance targets. For most of our analysis, we also focus on *ex-post* numbers but adjust for failures of performance—i.e., we focus on *ex-post* normative tariffs, unless stated otherwise.

3.2 Nominal Tariff Determination

Regulators use ACoS to determine the consumer-wise billing rate/tariffs. The ACoS, as calculated *ex-ante,* determines the ABR in the tariff for all consumers—or at least it should, in principle.

However, tariffs are determined in advance (*ex-ante*), and the costs as realised (*ex-post*) are typically higher. *Ex-Post* costs can be higher because of both allowed changes from *ex-ante* calculations, like higher power procurement costs, and disallowed differences, such as excessive distribution (billing) losses, which are a subset of AT&C losses. Higher billing losses raise costs, while poor collection hurts revenues. We focus on billed revenues for consumers when calculating ABRs and thus ignore collection lapses. Even average revenues (ABR) per consumer category can be different *ex-post* because of changes in which consumers used how much electricity, given that many tariffs have telescopic tiers or slabs. In this study, we use ABR and nominal tariff interchangeably.

Equation 3 shows nominal tariff calculations.

Equation 3: *Nominal tariff*

$$\textit{Nominal Tariff} = \textit{APPC}_{\textit{Discom}} + \textit{Distribution Costs} \pm \textit{Cross-subsidy}$$

Table 2 shows the *ex-post* (based on actuals) ACoS and ABR for C&I consumers. The second column is the *ex-ante* ACoS as shown in Tariff Orders. We can see these are lower than the normative *ex-post* cost for most of the states, by up to about 10%. This normative ACoS is based on actual allowable costs but excludes the additional costs borne by the Discom due to any failure to perform, i.e., higher billing losses (a subset of AT&C losses). If those performance failures were included, those would have been the fully loaded *ex-post* ACoS numbers, shown for reference in the last column. While it is true that consumers face tariffs based on *ex-ante* calculations, our objective is to compare cost coverage, and hence we focus on normative *ex-post* numbers for our paper.

The 11-state average normative *ex-post* ACoS calculated for determining the appropriate ABR is Rs 7.47/kWh. This ABR is used to derive the effective consumer-wise tariffs, allowing for cross-subsidies, with commercial over-payment typically being higher than industrial, and an equivalent under-payment cross-subsidy, not shown, is in place for residential and agricultural categories such that the sum-total should match the Discom ABR.

Tyagi & Tongia (2023) studied multiple years of tariffs and showed *ex-post* costs are almost always higher than *ex-ante*, perhaps due to pressures to keep tariffs low. However, even within *ex-post* costs, due to performance lapses, the fully loaded *ex-post* costs are mostly higher than the normative *ex-post* costs and are shown in the last column. In our data set, only Kerala shows an improved fully loaded *ex-post* cost structure compared to the normative *ex-post*, meaning their performance in terms of losses exceeded the targets. The costs increase due to performance failures raises the true costs by Rs 0.06 to 0.87/kWh compared to normative costs. For a few of our calculations, we use fully loaded *ex-post* costs as the benchmark.

Table 2: ACoS Based on Three Calculation Approaches and C&I Tariff in FY 22

State	*Ex-ante* ACoS^ in the tariff order (Rs/kWh)	Normative *ex-post* ACoS# (Rs/kWh)	Commercial ABR (Rs/kWh)	Industrial ABR (Rs/kWh)	Fully loaded *ex-post* ACoS* (Rs/kWh)
Andhra Pradesh	6.33	6.86	10.54	7.14	6.99
Delhi	7.67	8.55	13.27	11.15	8.91
Gujarat	6.10	6.45	7.27	7.12	6.73
Karnataka	8.42	7.76	12.36	9.33	8.20
Kerala	6.36	6.83	10.02	7.51	6.32
Madhya Pradesh	6.60	7.00	9.42	7.81	7.70
Maharashtra	7.10	7.92	15.40	8.42	8.10
Punjab	6.56	6.53	8.05	7.03	6.81
Rajasthan	7.66	8.24	10.64	8.15	9.11
Tamil Nadu	n.a.	8.69	9.57	7.90	9.05
Telangana	n.a.	7.21	10.47	7.99	7.27
11 States (Average)	**6.86**	**7.47**	**10.17**	**7.79**	**7.78**

Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes: Tariffs are always determined ex-ante based on normative performance and lead to ex-post consumer ABRs that reflect the tariffs as they manifested in practice based on performance targets. Failures (or occasional over-achievement) of performance targets are what lead to the fully loaded ex-post ACoS. The ACoS relevant for our calculations to benchmark consumer tariffs is the ex-post one based on normative AT&C losses.

^*Ex-ante ACoS: The planned ACoS as notified in the tariff order. This assumes normative performance and projected consumer mix.*

#*Normative ex-post ACoS: The realised ex-post ACoS, which factors in changes in sales to different consumers and cost structure changes. However, this excludes cost changes that should not be allowed into tariffs, especially Discom performance failures like excessive AT&C losses.*

**Fully loaded ex-post ACoS: The ACoS that includes the impact of performance failures (like excessive AT&C losses compared to the regulator-set targets).*

3.3 Green Tariff as per MoP Proposal

As demonstrated in the previous section, the general retail pricing mechanism relies on aggregation and socialisation based on the ACoS. Furthermore, all power procurement—regardless of cost variations—is combined into the APPC. The MoP's proposed formula for determining green tariffs **(Equation 4)** deviates from this approach by breaking the aggregation. It treats both RE procurement and selected RE consumers as distinct categories. Additionally, the formula specifies that the tariff can be equal to or less than the sum of its components, suggesting that regulators have the discretion to under-price green tariffs if desired. However, this would necessitate a new layer of cross-subsidy from other consumer categories.

Equation 4: *MoP proposed green tariff*

Green Tariff ≤ ***$APPC_{RE}$*** + ***Surcharge @20% of ACoS*** + ***Margin of 25 paisa***

In the following sections, we examine each component of the formula in greater detail to evaluate its cost coverage.

Average Power Purchase Cost of Renewable Energy

The $APPC_{RE}$ comprises the pooled purchase cost of RE procured by the distribution company, while $APPC_{Discom}$ covers all fuels. Because the government classifies large hydro as renewable, we include it as RE for our calculations. Hydropower displays a spread of costs—older hydro is very cheap; its inclusion lowers the $APPC_{RE}$. However, new hydro growth is limited and more expensive.

$APPC_{Discom}$ includes both intra - and inter-state transmission charges. In contrast, the revised Tariff Policy notified by the MoP on 28 January 2016, states that no *inter-state* transmission charges may be levied for generation from renewable energy technologies (Ministry of Power, 2016). A subsequent notification by the MoP allowed a waiver of inter-state transmission charges for solar and wind plants commissioned on or before 30 June 2025 (Ministry of Power, 2023b), and the industry is asking for an extension.

Table 3 highlights the FY 22 $APPC_{RE}$ of the 11 states, calculated bottom-up. Kerala has the lowest RE procurement cost at Rs 1.30/kWh and Rajasthan the highest at Rs 5.86/kWh. This could be attributed to:

i. Rajasthan having a higher share of wind, whose procurement cost is higher than solar, whereas Kerala's renewable source is dominated by larger, older hydro;

ii. Rajasthan beginning its procurement of solar when costs were high, whereas solar costs reduced significantly post-2016.

This also means, going forward, as the proportion of cheaper solar grows, $APPC_{RE}$ is expected to decline. The 11-state average RE procurement cost was Rs 4.76/kWh.

The FY 22 $APPC_{Discom}$ of all the states (Rs 5.84/kWh) was higher than their corresponding $APPC_{RE}$, which shows that the cost of procuring energy from renewable sources is cheaper than a mix of renewables and fossil fuels. The difference in percentage terms is highest for Kerala at close to 210% and lowest for Telangana at 8%, with an 11-state average of 28%. However, it's worth noting that some of the differential is because of waived inter-state transmission costs, which are in the range of 4% to 30% of $APPC_{RE}$.

In the future, this difference is likely to increase with the growing share of renewable energy in the procurement portfolio. There are two reasons for this:

i. As renewables with lower prices are commissioned, they begin contributing to the Discom procurement portfolio, driving down both $APPC_{RE}$ and $APPC_{Discom}$ prices. However, the effect is only pro-rata for $APPC_{Discom}$.

ii. Renewable energy, being the lowest-cost source of new energy generation, would constitute the largest share of Discoms' *future* energy procurement portfolios. We anticipate this trend despite renewable energy costs already bottoming out in nominal terms, at least in the near term. Importantly, we focus on variable RE (VRE), which is intermittent RE without storage. This is because storage is expensive, and its use will be limited for the foreseeable future.

In FY 23, the all-India RE share excluding large hydro was around 14.4% of the total energy generation (including large hydro, it was 25.9%) (CEA, 2023b). Going forward, as the share increases and with the addition of cheaper RE, the cost difference between $APPC_{Discom}$ and $APPC_{RE}$ will continue to widen until further intermittent renewables cannot displace thermal sources in the Discom portfolio. Dealing with variability—e.g., through storage and other grid upgrades—means costs to provide incremental RE would subsequently rise, and tariffs levied by Discoms would need to increase accordingly to cover these costs.

Table 3 also shows the MoP-formula-based Green Tariff. We subsequently examine the components in more detail.

Table 3: Green Tariff (Rs/kWh) of Different States in FY 22 Calculated per the MoP Formula

State	$APPC_{Discom}$	(A) $APPC_{RE}$	(B) Surcharge @ 20% of ACoS	(C) Margin @ 25 paise	A + B + C Green Tariff
Andhra Pradesh	5.49	4.56	1.37	0.25	6.18
Delhi	6.03	4.17	1.71	0.25	6.13
Gujarat	5.72	5.02	1.29	0.25	6.56
Karnataka	6.25	4.47	1.55	0.25	6.27
Kerala	4.34	1.30	1.37	0.25	2.92
Madhya Pradesh	5.50	5.30	1.40	0.25	6.95
Maharashtra	6.23	5.60	1.58	0.25	7.43
Punjab	4.76	3.00	1.31	0.25	4.56
Rajasthan	5.90	5.86	1.65	0.25	7.76
Tamil Nadu	6.60	5.65	1.74	0.25	7.64
Telangana	6.18	5.79	1.44	0.25	7.49
11 States (Average)	**5.84**	**4.76**	**1.49**	**0.25**	**6.50**

Source: Authors' calculations based on Discom's true-up petitions filed with respective SERCs.

Notes: All headings are in Rs/kWh.

Surcharge

Per the formula, the "Surcharge" is proposed at 20% of ACoS. Following the MoP recommendation, the surcharge stands in the range of Rs 1.29 to Rs 1.74/kWh, with an average of Rs 1.49/kWh across the 11 states.

This component ostensibly covers the cross-subsidy shortfall from C&I consumers migrating to green power. Their normal tariffs embed significant cross-subsidies. Why 20%? This figure represents the cap, as per the revised Tariff Policy 2016, which requires retail tariffs to be within ±20% of ACoS (Ministry of Power, 2016). However, Tyagi & Tongia (2023) showed that the actual and even the ex-ante cross-subsidy varies across states and falls within the range of 10–60% of ACoS. Thus, the practical loss of revenue for Discoms is substantial. If and when regulators reduce cross-subsidies for C&I users, this difference would decrease, but there are no indications that this is about to happen across most of India.

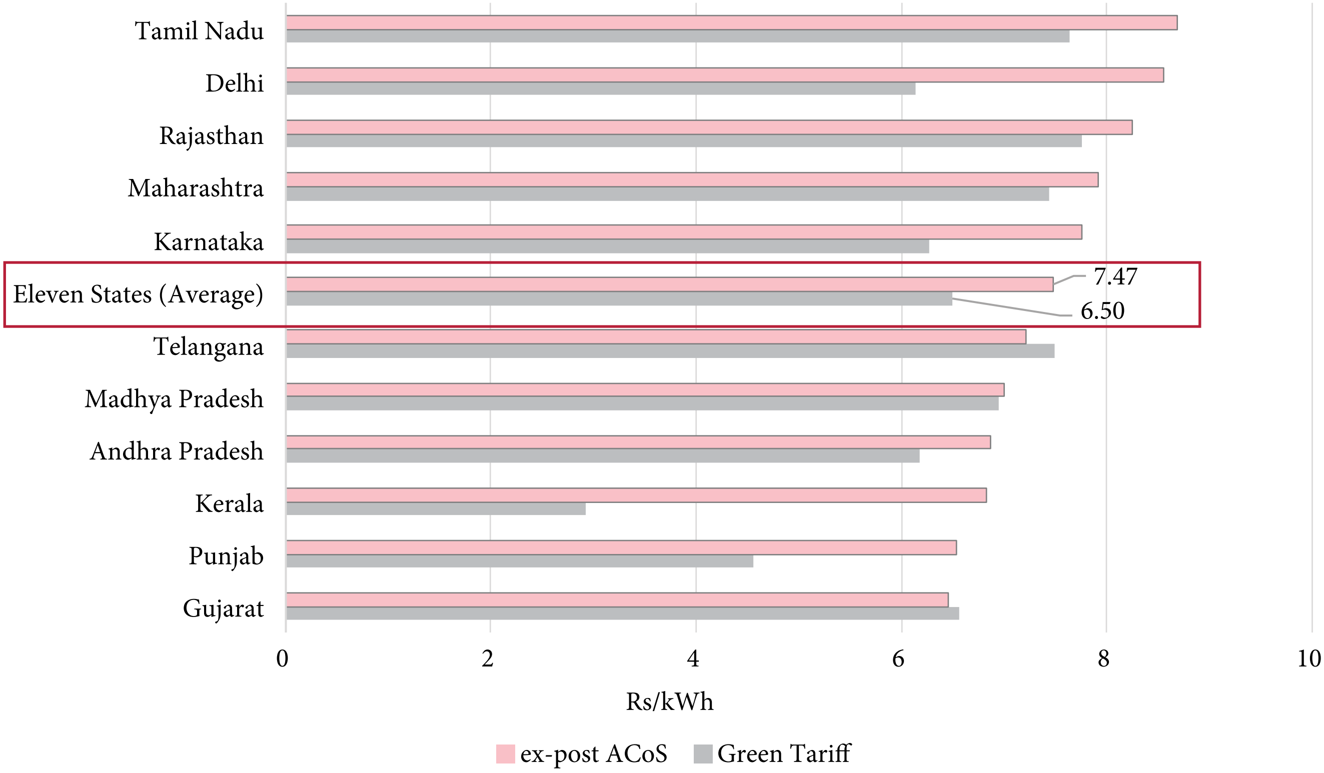
Cost Coverage Including Margin

To deliver power, a Discom must build and maintain last-mile infrastructure and employ staff. It also faces financial charges spanning both debt and equity, the latter of which enjoys a statutory rate of return. Ostensibly, the 25 paise charge is meant to cover these items.

However, the 11-state average Discom distribution cost structure was 22% of the ACoS. While this figure is *ex-post* and fully loaded with all costs, even tightened operating norms and efficiency improvements to meet normative performance targets will not bridge the gap. In this study, we find that about Rs 1.63/kWh would be a sufficient margin based on FY 22 data, which also considers the Return on Equity. This is *far* higher than the proposed Rs 0.25/kWh for Discom costs and margin.

Figure 1 compares the normative *ex-post* ACoS with the calculated green tariff for the 11 states. The 11-state average normative *ex-post* ACoS is approximately 20% higher than the green tariff. The highest difference is observed for Kerala, at 117%. We also observe that, barring Gujarat and Telangana, the green tariff is lower than the normative *ex-post* ACoS for the remaining states. Even for Gujarat and Telangana, the difference is small and likely to shrink and then reverse as more RE enters the mix at lower procurement costs.

Figure 1: Comparison of Normative *ex-post* ACoS and Green Tariff of Different Discoms in the 11 States in FY 22



Source: Authors' calculations based on Discom's true-up petitions filed with respective SERCs.

The above calculation only considers average costs, which should (theoretically) match average tariffs. But how do per-segment tariffs compare? **Table 4** compares green tariffs with C&I tariffs for the 11 states. C&I tariffs are much higher than their respective green tariffs—by Rs 3.67/kWh for commercial consumers and Rs 1.29/kWh for industrial consumers. *This difference emphasises that the MoP-proposed green tariff is lower than C&I tariffs and would be appealing to such consumers.* Any migration from these higher-paying consumers would further hurt Discom revenues.

Table 4: Comparison of Green Tariff With Commercial and Industrial Tariff of 11 States in FY 22 (All Headings Are in Rs/kWh)

State	Green Tariff	Commercial Tariff	Industrial Tariff
Andhra Pradesh	6.18	10.54	7.14
Delhi	6.13	13.27	11.15
Gujarat	6.56	7.27	7.12
Karnataka	6.27	12.36	9.33
Kerala	2.92	10.02	7.51
Madhya Pradesh	6.95	9.42	7.81
Maharashtra	7.43	15.40	8.42
Punjab	4.56	8.05	7.03
Rajasthan	7.76	10.64	8.15
Tamil Nadu	7.64	9.57	7.90
Telangana	7.49	10.47	7.99
11 States (Average)	**6.50**	**10.17**	**7.79**

Source: Authors' calculations based on Discom's true-up petitions filed with respective SERCs.

4. Delivery of Green Energy

In the previous section, we reviewed the economics of green tariffs and found that, based on the MoP formula, these tariffs are much lower than existing tariffs for C&I customers. The second underlying issue with green tariffs concerns their delivery, where prominent challenges exist, which we discuss in this section. These challenges include time-of-day (instantaneous) matching, scalability, and 24x7 availability of green energy.

4.1 Time of Day

As widely discussed in the literature, the key concepts for green power and its consumption should be *additionality, deliverability, and timely matching* (Ricks, Xu, & Jenkins, 2023). If green demand isn't met by additional green supply, then it's a zero-sum game—one consumer becoming greener means another becomes less green. Deliverability is a practical requirement and needs appropriate siting and transmission. Timely matching means the RE should be supplied as and when the demand arises, assuming one isn't relying on storage. This means accounting-based tools like offsets or Renewable Energy Certificates (RECs) are not sufficient. Tongia (2023) expands on this issue of defining and measuring green power.

Time-of-day (ToD) is another important attribute missing from the MoP-proposed green tariff. In general, ToD pricing reflects the state of the grid (supply and demand) and can apply to both procurement—i.e., wholesale pricing, as with a power market—and consumers—i.e., retail pricing. Very few consumers in India have ToD tariffs, which would incentivise them to shift or reduce their peak load.

A step in this direction was MoP's 14 June 2023 notification, which amends the Electricity (Rights of Consumers) Rules, 2020. This amendment requires C&I consumers with a maximum demand of more than 10 kW to have a ToD tariff effective 1 April 2024. Technically, this is subject to—and assuming they have—the necessary metering infrastructure for ToD billing. For the rest of the consumers (barring agriculture), the directive is for ToD to take effect on or before 1 April 2025 (Ministry of Power, 2023c). One of the bottlenecks for this is the deployment of smart meters or appropriate digital metering that can measure time-of-day consumption.

The load profile and the corresponding peak load consumption vary across consumers. **Appendix 3** shows the all-India average ToD profile and corresponding fuel mix.

If we dig deeper, we find two underlying issues:

i. Heterogeneous load profiles.

ii. Non-coincident generation profile (as in the case of commercial and residential consumers).

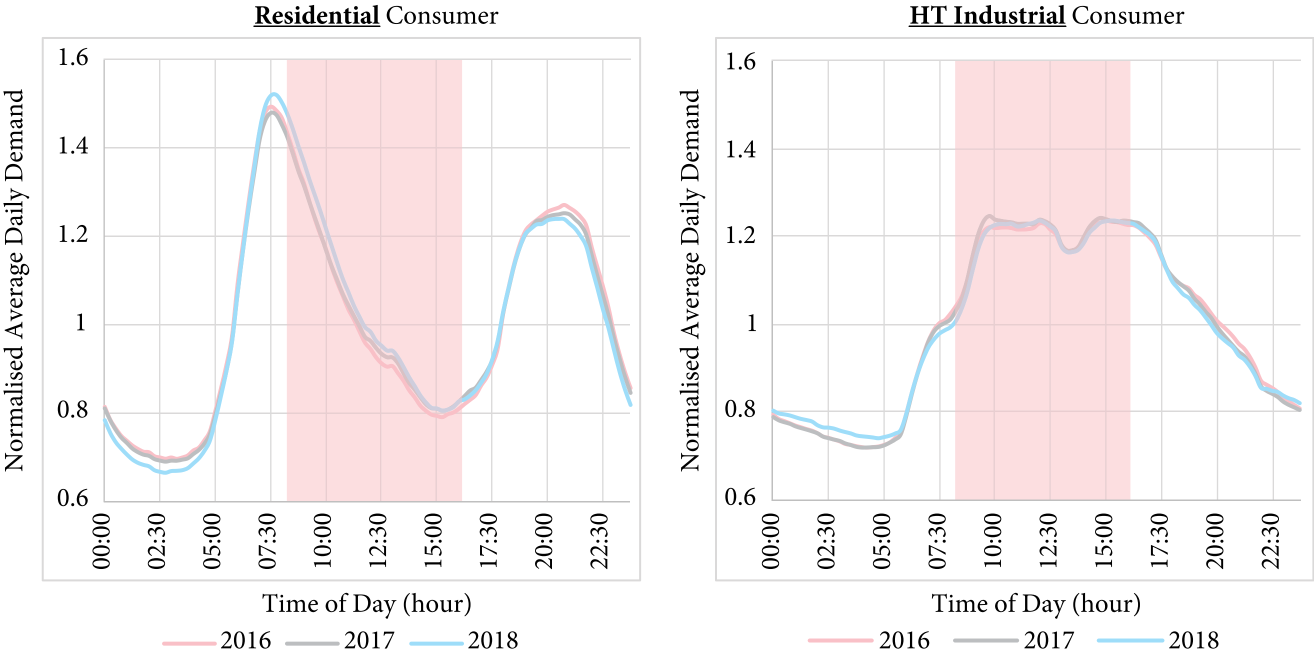
The former affects equity across consumers, while the latter affects costs of procurement for the Discom. These factors should have a bearing on the green tariff design for the respective consumer category.

Heterogeneity is today handled by socialisation, but in theory, those consumers who consume more at peak and at more expensive times for Discom procurement should pay more. A typical industrial bulk high tension (HT) load matches the profile of solar generation quite well, more so for non-three-shift industries. **Figure 2** shows the time-of-day load profiles for select consumer categories with the red shade for high solar overlap; this is using analysis for Bengaluru, within BESCOM, the largest Karnataka Discom. This may not be the exact shape for residential loads across India, but almost all of them typically observe both early morning and evening peaks, as also highlighted in **Figure 2**. Many commercial loads also show high evening demand.

The morning peak in the case of residential load can be attributed to heating water using geysers and the operation of pumps to lift water, and perhaps some morning routine use like cooking. Some parts of India may not have such high geyser use, but the evening peak is typical across much of India for households, and areas with high air conditioner use will have even higher evening and early night demand.

Consumers under the proposed MoP green tariff do not worry about demand profiles–that is left entirely to the Discom, which must procure peak power for peak demand, and ideally, green power 24x7. Because the green tariff is for energy only, without any ToD considerations, many eligible C&I consumers would migrate to such a tariff. We subsequently model the financial effects of such a shift.

Figure 2: Bengaluru End-Consumers Normalised Average Daily Demand in July 2018



Source: (Parray & Tongia, Forthcoming).

Notes: The red shade represents approximate maximum solar hours between 8:00 am and 4:00 pm. If we consider smaller LT industries, which are less likely to work overnight, then the solar coincidence would be much higher. While the two figures here appear similar, for residences, the consumption is disproportionately lumped into grid-supply-peak coincident periods (see **Figure 7** *in* **Appendix 3***), which creates a greater financial cost of procurement for Discoms.*

4.2 More RE Means More System Costs, Which Can Limit RE's Scalability

This section considers the broader grid issues of higher RE. We recognise that a consumer may become green not just through the green tariff but also through other options that can sometimes complement a green tariff. As we've shown, the most financially disruptive green consumer is one who becomes green outside the Discom system, e.g., from rooftop solar.

While rooftop solar is a particularly complex issue, all RE as a supply form raises complexities for procurement planning. Solar power output can decrease dramatically in seconds with cloud cover, while wind power is highly seasonal in much of India. Ultimately, this will entail new frameworks, both operational and pricing, to support grid stability and system-level least-cost resource adequacy. RE availability in India—especially wind—is mainly locational, and this attribute should also be factored in, failing which transmission congestion could lead to RE curtailment.

As Tongia and Dave (2023) showed, even with just about 12% RE (excluding hydro) from a few years back, India has higher ramping requirements for net demand[6]—i.e., demand minus VRE—than for demand, *which means RE makes grid management harder*.

To enable more and more RE, regardless of whether consumers self-generate or go through the Discom, the growing need is flexibility in the power system, which requires (Thukral, Wijayatunga, & Yoneoka, 2017):

(i) Upgraded grid infrastructure

(ii) Demand response (dynamic demand side management)

(iii) Energy storage

(iv) Generation flexibility

(v) Enhanced policy and regulatory frameworks

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[6] Net Demand is also called Net Load.

4.3 Is the Energy Truly Green?

Discoms cannot provide 24x7 green power at scale in the short-to medium-run because of a range of reasons:

i. Present RE supply is much lower than the applicable universe of potential bulk users.

ii. Even with scaling RE, most RE supply is VRE, and solar dominates much of the growth.

iii. Storage technologies are still expensive, more so for large volumes of time-shifting.

The MoP notification requires utilities to make 24x7 green power available to consumers to meet any quantum of demand. Currently, the electricity industry in India lacks the capability to supply 24x7 green power economically. Storage via pumped hydro has locational and land constraints, and greenfield systems will take time to build, and electro-chemical storage—i.e., batteries—is presently very expensive, except in niches or at a limited scale.

A 2022 e-reverse auction conducted by the Solar Energy Corporation of India Limited (SECI) for a standalone battery energy storage system (BESS) of 500 MW/1000 MWh (500 MW x two hours of storage) resulted in a winning bid of Rs 10.84 lakh/MW/month for 12 years (JSW Energy, 2022). Back-calculating, this works out to capital expenditure as high as $525/kWh of battery if it lasts for 12 years, and a cost above Rs 10/kWh of electricity, excluding the RE to power the battery, based on analysis from Tongia (2023). More recent bids have more than halved the capital costs but still lead to much higher costs than VRE.

The true cost of making renewable energy available at scale should not only consider the cost of storage but also ensure that the variable nature of renewables upon the rest of the grid is also addressed—both physically and financially. VRE can create more burdens on stable grid operations, requiring greater engagement of ancillary services. These are non-energy services to keep the grid stable.

As RE output goes up, say, mid-day, other plants (like thermal) must back down their output. This lowers their efficiency and causes higher wear-and-tear. Additionally, the cost of procurement must include the transmission costs of renewable energy, which, due to their lower plant load factor (PLF) and intermittency, would be higher than average transmission costs. Virtually all these costs are socialised today. They should be calculated as part of true RE costs.

There is a difference between the accounting of green and the physics of green. Most states in India allow green energy banking, where an RE producer can over-generate parts of the day, give that excess power to the Discom, and take it back later, say, in the evening. As highlighted by Tongia (2023) in his paper on defining "green electricity," a banking mechanism only allocates green power through accounting norms and fails to actually enable 24x7 green energy. Banking in its present form should not qualify as green power, as power is being procured from non-RE means during non-RE hours—for now, expensive storage is not engaged. Even worse, even if a Discom finds surplus RE availability mid-day, they would struggle to meet demand in the evening peak.

5. Financial and Other Implications of Green Tariff

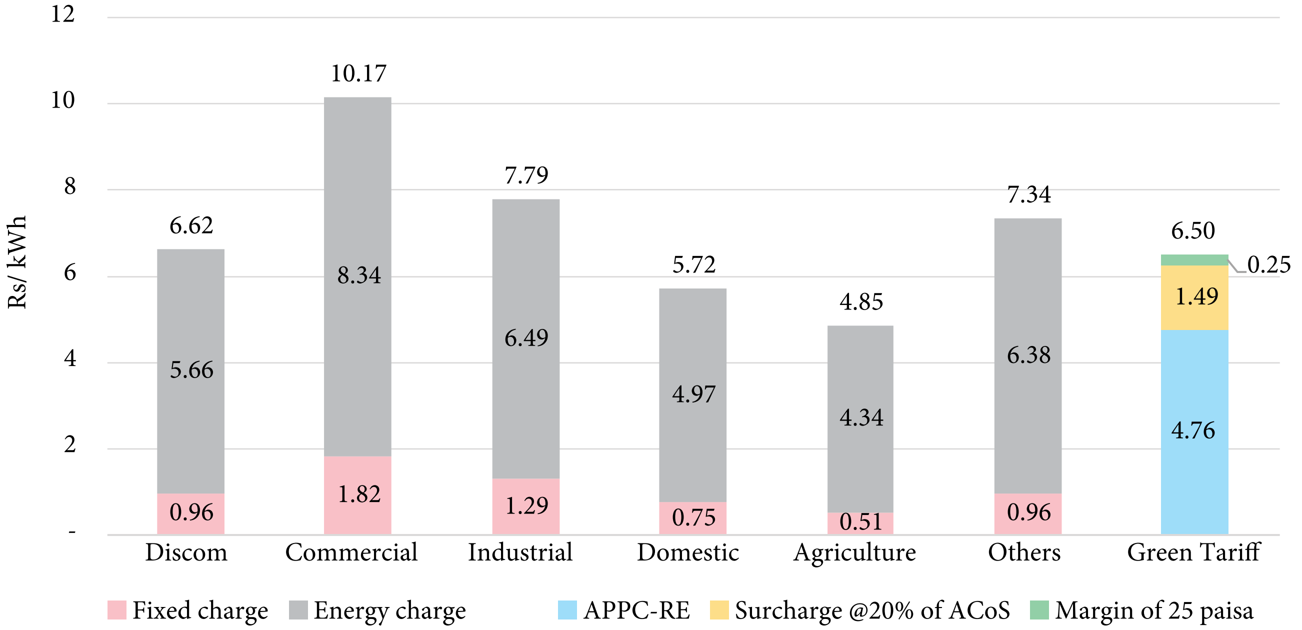
This section examines two issues. First, what are the financial implications of the proposed Green Tariff on Discoms? Second, what is the implication for non-green tariff consumers?

5.1 Comparing the Economic Impact on Discoms of C&I Consumers Going Green

Figure 3 shows the ABR of each category of consumers, calculated for the 11 states in aggregate. The commercial category has the highest ABR, followed by the industrial, domestic, and finally, the agriculture category, which pays the least. The "Others" in the figure mainly correspond to public utilities (water, wastewater, streetlights, etc.), railways, temporary connections, etc.

As shown before, the proposed green tariff is 36% and 16% lower than the ABR of commercial and industrial category consumers, respectively. The overall Discom ABR is two percent more than the green tariff, which itself indicates that the green tariff, in its present form, is a loss-making proposal for Discoms, above and beyond breaking the cross-subsidy upon which the social welfare redistribution equilibrium is balanced. As this figure shows, more than the average priced consumer, a C&I consumer would be eager to sign up for the financial savings of the green tariff and take the benefit of the green attribute—i.e., Renewable Energy Credit—if eligible/applicable.

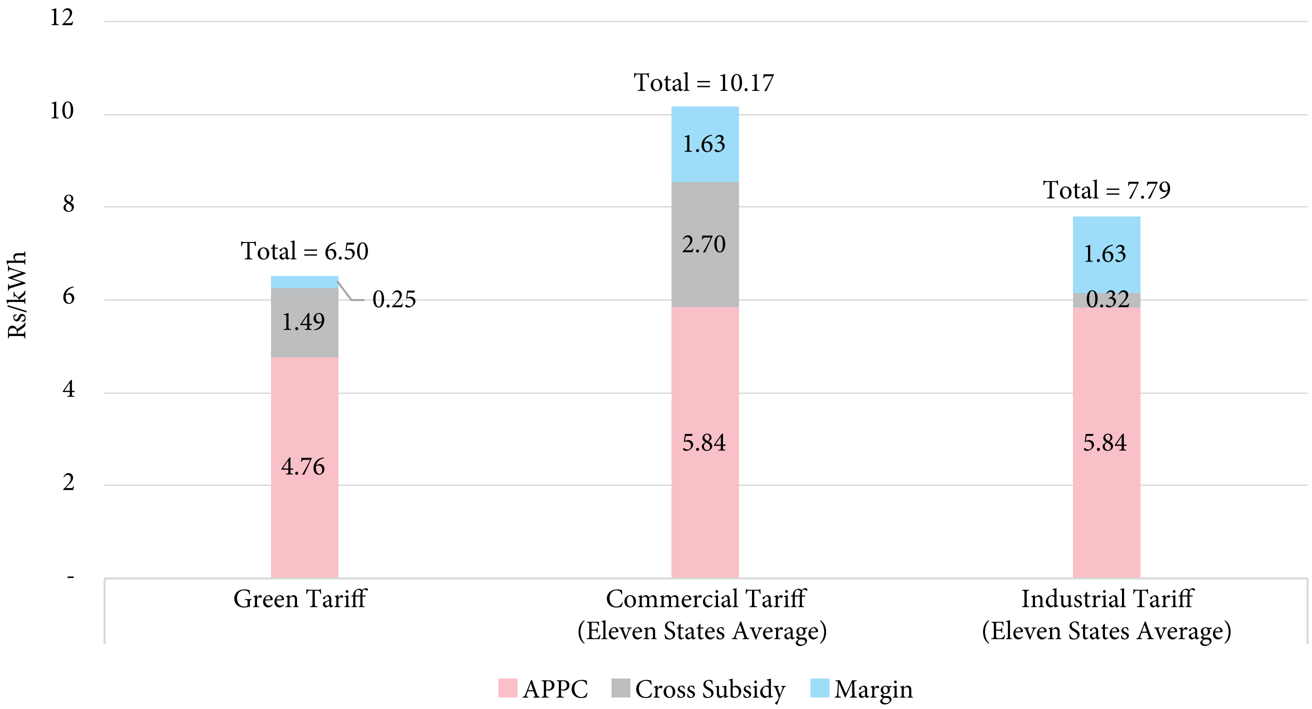
Figure 3: 11 States Average Billing Rate for Different Consumer Categories on *ex-post* Energy Sold Basis in FY 22 (Rs/kWh)



Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes: "Others" includes public utilities (water, wastewater, streetlights etc.), railways, temporary connections, etc., and is a small fraction of load served. These are the ex-post figures for tariffs and differ slightly from the original ex-ante tariffs.

Figure 4: Comparison of Constituents of Green Tariff With Equivalents in 11 State Average C&I Tariff in FY 22 (Rs/kWh)



Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes: In the Green Tariff, the legend APPC corresponds to APPC of Renewable Energy, which includes intra-state transmission costs. Cross-Subsidy corresponds to the notional maximum Cross Subsidy Surcharge of 20% based on ACoS. In the C&I tariff, APPC corresponds to the 11-state average normative ex-post APPC of Discom, which includes normative ex-post intra- and inter-transmission costs. The Cross Subsidy legend represents the charge applied on top of the Discom ABR for the two categories. The Margin corresponds to the normative ex-post distribution costs, including return on equity.

The constituents of a green tariff differ from their equivalent counterparts in commercial and industrial tariffs. Figure 4 shows the constituents of both green and C&I tariffs. Whereas the APPC of a green tariff is Rs 4.76/kWh, the equivalent normative *ex-post* APPC for the 11-state average is found to be Rs 5.84/kWh—an increase of 23%. The corresponding operating margin (allowed as Rs 0.25/kWh only) differs by Rs 1.38/kWh from the ex-post normative Discom costs. The cross-subsidy also differs significantly. Whereas the commercial category cross-subsidy is levied at Rs 2.70/kWh, the industrial category is applied a cross-subsidy of Rs 0.32/kWh on top of the respective Discom average billing rate. We observe that only for industrial consumers is the green tariff cross-subsidy lower, and this varies slightly by state.

The Three Modes of Green Energy Are Not Fungible

While a Discom will procure a mix of sources of supply, and RE represents a large fraction of the growth of supply in India, as mentioned previously, consumers can avail green power in several ways. These are self-generation (such as rooftop solar), Discom-offered green energy or green tariff (the focus of our analysis), and third-party supply or open access.

High traditional tariffs are one reason many consumers opt for such green power through any form. Tyagi and Tongia (2023) observed that the average monthly consumption of industrial consumers in BESCOM (Karnataka) reduced by about 20% across FY14–FY19. There could be several reasons for this, but Kokate & Josey (2021) observed that the increase in open access can be primarily attributed to high electricity charges levied by utilities.

In addition, Karnataka introduced a favourable solar policy in 2014, which specifically promoted rooftop solar engaging net metering (Government of Karnataka, 2014). The terms of the Power Purchase Agreement (PPA) with rooftop solar users, who would feed in power, also favoured all categories of consumers, while C&I consumers benefited the most with both "net metering" as well as accelerated depreciation, which ensured:

i. Faster/early recovery of capital investment.

ii. A 25-year term of the contract and the life of the system, which protected the consumers from the typical rise in electricity prices.

While we examine the economics below, the three forms of supply are not the same when it comes to the times-of-day when green power is available (we assume this is without storage).

Rooftop solar is opportunistic and not meant to be 24x7. Such users come back to the grid for their evening supply and also feed into the grid when they generate more than their instantaneous self-consumption, which happens in the middle of the day. This design means the Discom cannot avoid any infrastructure costs.

Green tariffs by the Discom are meant to cover all supplies, but how the Discom provides such supply is a black box. Even if they wanted to procure more green power to meet such green demand, the time-of-day limitation on VRE is severe.

Open access means the consumer is choosing their own supply, but to what extent can such a supplier provide 24x7 or on-demand green power? In traditional open access, some consumers would earlier arbitrage third-party vs Discom supply (Singh, 2017), until the point that some Discoms said such users should be treated as temporary supply consumers, who pay a premium. This issue is still not resolved.

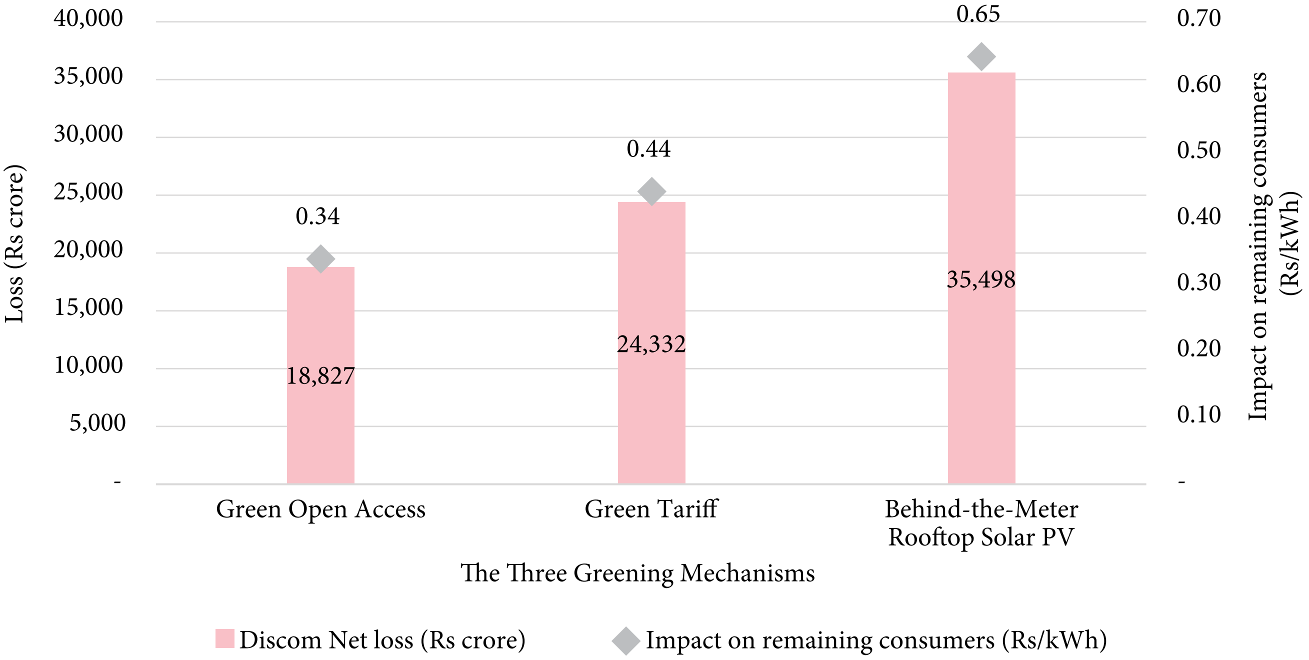
To the extent any option either places a burden of supply on the Discom or, worse, places a peak-period burden on the Discom, this has to be priced into the charges for all three options.

We examine the financial implications of the three options on Discoms (summarised in **Figure 5**). To give a sense of scale, in all the scenarios, we have assumed that approximately 50% of the total energy consumed by the C&I category is replaced by the equivalent green energy. We have data for the same 11 states, which represent the majority of units sold by public Discoms.

In the case of Green Open Access, a third-party consumer is not subjected to interstate transmission charges and an additional surcharge. The latter yields a loss of fixed charges in the tariff—i.e., capacity charges—for a Discom when these consumers leave the distribution licensee and procure from a green energy generator. Such a migration would yield a net loss of Rs 18,727 crores across the 11 states. The consumers in Maharashtra, Gujarat, and Tamil Nadu are responsible for about 50% of the losses.

To keep the Discom revenue neutral, this lost revenue under Green Open Access would need to be recouped from other users. For them, this would result in a tariff increase of Rs 0.34/kWh.

Figure 5: Financial Implication on Discoms and Impact on Remaining Consumers' Tariffs If 50% of C&I Consumption Engages the Three Greening Mechanisms (FY 22)



Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes: PV = Photovoltaics; this is for 50% of C&I units across 11 states choosing one of three options for going green.

On average, across these 11 states, C&I consumers migrating to the MoP-proposed green tariff would pay 36% and 16% lower tariffs compared to the nominal tariff. The C&I consumers in Kerala, followed by Delhi and Punjab, experience the highest reduction in tariffs from migration.

If 50% of the C&I energy in the 11 states is procured via the green tariff, then the Discoms' total revenue would suffer by Rs 24,332 crores. Maharashtra, Punjab, Kerala, and Delhi would contribute over 50% of the total losses. If the effect of the losses must be negated, then this would require Discoms to increase the tariff for the rest of the consumers by Rs 0.44/kWh.

Rooftop solar by the same 50% of C&I users in these 11 states yields a net Discom loss of Rs 35,498 crore, which corresponds to 8% of the 11 states' Discom revenues. In the case of a consumer moving to rooftop solar, like with other migrations away from Discom supply, this loss is after factoring in the Discom procurement savings from other sources to the tune of the energy or variable charges from existing PPAs (based on average procurement costs, since we don't have time-of-day-linked procurement data). Revenue losses are similar to the other modes of going green and are due to consumers not buying from the Discom, which hurts disproportionately because of the higher tariffs for the C&I category. The total loss recovery through remaining consumers requires Discoms to raise their per-unit price by Rs 0.65/kWh.

Table 5 below shows state-level variations in the financial impacts of going green, focusing on four RE-rich states. The 11-state average ex-post FY2022 ACoS was Rs 7.47/kWh, whereas the ABRs earned from the C&I categories were 10.17 and 7.79, respectively. On a normative ex-post cost basis, Discoms enjoy a cross-subsidy of Rs 2.70/kWh and Rs 0.32/kWh from the two consumer categories, respectively. The table shows that Green Open Access—with its distortions (Inter-State Transmission System waiver, additional surcharge waiver, etc.)—yields a net unit loss of Rs 1.82 and Rs 1.29 by the C&I categories, respectively, to the Discoms. The proposed Green Tariff yields a higher loss compared to Green Open Access: Rs 3.66/kWh and Rs 1.28/kWh, respectively. The highest Discom losses are from rooftop solar usage, of Rs 3.80/kWh and Rs 1.95/kWh from C&I users, respectively. This is because, with rooftop solar, very few mechanisms exist for separate cost recovery, e.g., any surcharges on self-generation. At best, states are now considering different tariff structures—something already being done in places like California that are grappling with how to handle large volumes of rooftop solar power.

Table 5: Per Unit Energy Financial Losses Incurred by Discom if 50% of C&I Energy Consumption Engages the Three Greening Mechanisms (FY 22 Basis)

States	Green OA (Rs/kWh)		Green Tariff (Rs/kWh)		BTM-RTPV (Rs/kWh)		Energy Sold by Discoms (MU)	
	C	I	C	I	C	I	C	I
Gujarat	0.76	1.00	0.71	0.56	1.78	1.39	14,443	42,546
Karnataka	1.95	1.07	6.09	3.06	4.08	2.13	3,242	5,556
Maharashtra	2.98	1.24	7.97	0.99	7.48	2.23	5,816	42,886
Rajasthan	1.95	1.07	2.88	0.39	3.61	2.00	4,369	17,099
11-State Average	**1.82**	**1.29**	**3.66**	**1.28**	**3.80**	**1.95**	**60,890**	**205,257**

Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes: Green OA = Green Open Access; BTM-RTPV = Behind-the-Meter Rooftop Solar Photovoltaic; C = Commercial; I = Industrial; The energy sold to C&I consumers by the respective Discoms is shown for reference in the last column.

One should bear in mind that the total energy sold in the four states to industrial consumers is four times that of the energy sold to the commercial category. This disparity implies green energy migration can hurt the Discoms the most because of the higher volumes. Industrial migration also hurts disproportionately because they lose the consumer who had the highest coincident demand to solar (except, perhaps, agriculture if such supply is moved to solar-aligned supply). Of the four states, considering the three modes of consumer energy migration, Maharashtra and Gujarat would face 75% of the Discom revenue loss.

5.2 The Problem of Consumer Shifts

As the proposed green tariff is measurably lower than the C&I tariffs, we anticipate a sizeable fraction of eligible customers will prefer green over conventional tariffs—it's cheaper *and* labelled as clean! The new and higher balance ACoS—i.e., ACoS without RE post-migration of consumers—will have to be shared among the consumers left behind. These comprise C&I consumers who haven't subscribed for green tariffs, which inherently includes all the smaller ones below 100 kW.

There are other nuances in the above tariff comparison. As of now, a substantial portion of the charges in the green tariff comprises variable charges. This will further distort the finances in favour of consumers if the user has a large sanctioned load but lower-than-average consumption for such a connection. This is because fixed cost charges are typically higher than average for such bulk users.

Allocating cheaper RE for green tariff consumers inherently means higher costs for other consumers. For the remaining consumers, the higher costs are attributed mainly to procuring power, dominated by power from thermal plants, which comprises both fixed—i.e., capacity—and variable—i.e., fuel and O&M—costs. Importantly, under a power purchase agreement (PPA), the thermal generator must be paid capacity costs independent of whether the system is being operated at partial or firm/contracted capacity. More RE is likely to lower the PLF of traditional RE generators, still leaving Discoms on the hook for fixed generator (capacity) costs. Under the above conditions of keeping Discoms revenue-neutral and not saddling poorer consumers with higher costs, the regulators would need to charge for green power at a rate higher than the MoP-proposed green tariff.

6. Policy Issues and Recommendations

As we move towards a green economy, it is imperative to continue adding more and more renewable energy supply. Green consumer tariffs could play an important role, along with other greening mechanisms, and ensure the demand for green energy remains. However, our analysis has identified issues in the current MoP green tariff proposal—including Discom revenue reductions, the ability to be green (24x7), and consumer equity—which may make it difficult for states to adopt as-is. This section offers a few measures which, if incorporated, could improve the economics and other dimensions, such as power procurement, for Discoms.

6.1 Green Tariff Should Be Cost Reflective

First and foremost, to sustain the momentum, any green tariff should be priced to be cost-reflective. If such tariffs aren't cost-reflective, this either means someone else has to pay, or Discoms may resist covertly, as has happened in the past with top-down norms on open access (Singh, 2017) or rooftop solar, both of which hurt Discoms. For rooftop solar, the resistance has been so significant that the central government recently notified norms mandating quicker compliance with existing policy through the Electricity (Rights of Consumers) Amendment Rules, 2024 (Ministry of Power, 2024).

We have observed that though the ex-bus cost of renewables—especially solar—has decreased significantly and is presently in the range of about Rs 2.50–3.25/kWh, the average present cost to deliver RE to a final consumer is in the range of Rs 4.08 to Rs 9.33. This range includes transmission and legacy RE costs. The 11-state normative *ex-post* ACoS is Rs 7.47/kWh. If we include only the APPC of RE and add to this the transmission cost (Rs 0.53/kWh) and distribution (Rs 1.63/kWh), or a bit higher, adjusting for FY 22 costs, the cost to supply RE works out to Rs 6.92/kWh. In contrast, the proposed green tariff would be levied at Rs 6.50/kWh—a loss of revenue of Rs 0.42/kWh. And while this number is close to the normative ex-post ACoS of Rs 7.47/kWh, that is only the comparison to the average cost. For C&I users, the present 11-state average tariffs are Rs 10.17 and 7.79/kWh, respectively. Clearly, one cannot expect the Discoms to provide green energy at this price and sustain operations as-is.

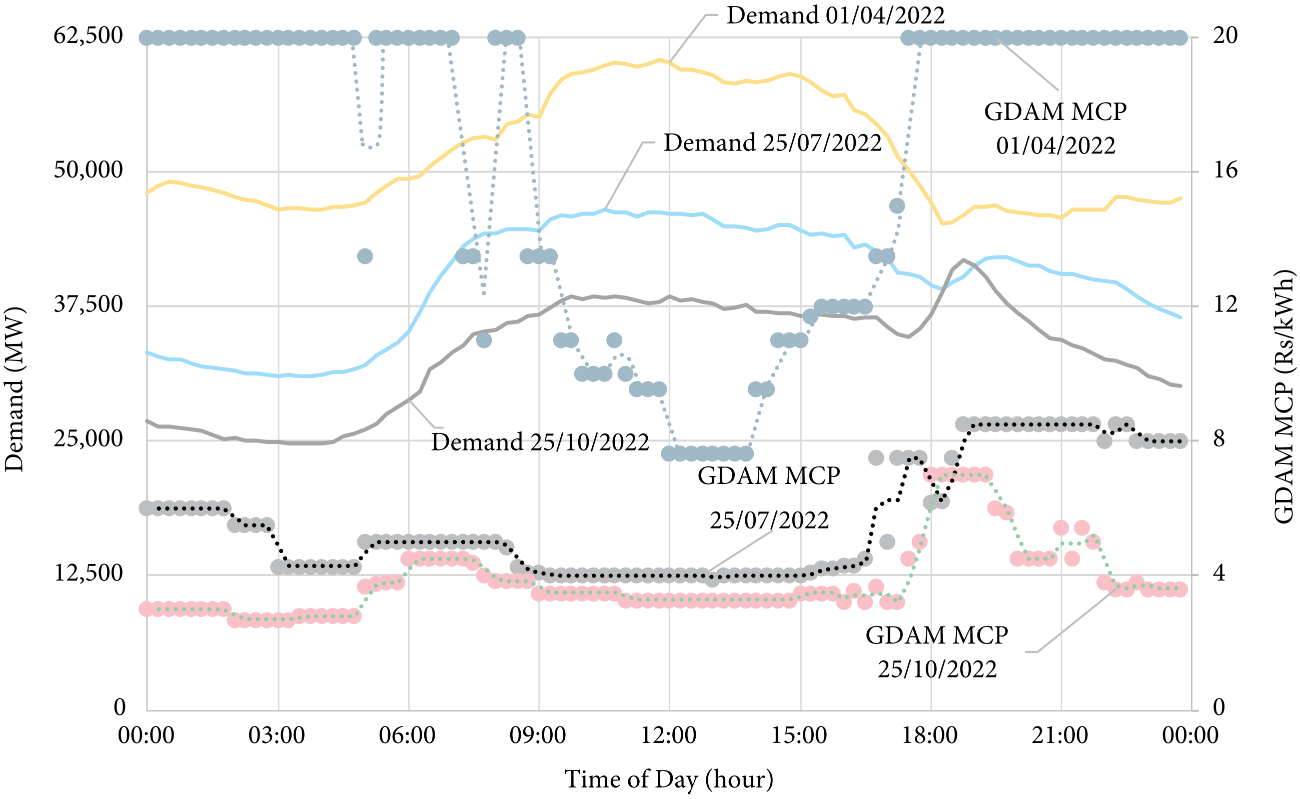
The price also does not consider the provision of making green energy available during non-RE hours. This price is purely reflective of the basket of RE as procured today, which doesn't entirely align with consumer demand. Large-scale storage is cost-prohibitive in the short run.

One way to examine the time-linked aspect of RE is based on market prices for green power. Admittedly, the green power market is very shallow—only 562 MU typically transacted in May 2024, or 0.39% of all-India monthly generation—but the volumes should rise over time. The market clearing price (MCP) available on the Green Day Ahead Market (GDAM) at the largest power exchange, Indian Energy Exchange, for non-VRE hours could serve as a proxy for the cost implications of the procurement of green power for Discoms.

There is a challenge in such a calculation because we don't know if any particular Discom is short of power after its existing PPAs or has existing PPAs with slack capacity, where it must pay fixed costs and thus only saves the variable cost of the PPAs. One bound is the MCP of green DAM prices, while another measure would be the difference between green and non-green day-ahead prices. It's also worth noting that day-ahead markets are very small in volume, and hence, this is only an illustrative example with present volumes.

Figure 6 shows the demand and prices (MCP) for the southern region in the Indian Energy Exchange trading platform—the southern region is high-RE. We observe that the MCP for green energy is lowest during overall grid peak demand hours—i.e., between 11:00 am and 3:00 pm—because RE is plentiful. We also observe that the prices attain the peak (i.e., the price ceiling) during non-RE hours. Currently, the price ceiling for GDAM is set at Rs 10/kWh (IEX, 2023).

Figure 6: Overall Demand for Southern Region and Green Day Ahead Market MCP (Market Clearing Price) Observed on Highest, Lowest, and Monsoon Consumption Days in FY 22



Source: Demand for Southern Region obtained from Grid Controller of India Limited and GDAM MCP obtained from the Indian Energy Exchange Limited website.

Notes: Before 16 April 2022, the GDAM MCP had a ceiling of Rs 20/kWh. After which, this was lowered to Rs 12/kWh. This was further brought down to Rs 10/kWh on 4 April 2023 (Goswami, 2023).

In addition, the variable and uncertain nature of renewables requires the support of ancillary services and possibly higher buffers to maintain a stable grid, covering both frequency and voltage requirements. This function has costs associated with it, which need to be covered in any green tariff.

Further, prices should be set so that they not only consider all the costs involved in delivering green energy but also incentivise consumers to consume power in alignment with the RE supply profile. This approach requires the deployment of retail ToD tariffs.

In its 14 June 2023 notification, MoP amended the Rights of Electricity Consumers and asked for a tariff for solar hours at 20% less than the normal tariff. This norm is meant to come into force by 2025, but it is unclear if the requisite metering infrastructure for ToD can be deployed in time. Further, the peak hours and solar hours are to be set at 8 hours each (Ministry of Power, 2023c). A forthcoming CSEP paper will examine this notification in greater detail. A major unknown is how the ToD tariff would overlap/intersect/conflict with green tariffs.

Finally, at present, RE supply is available at competitive rates, so the tariff should ensure that various distortions—such as the Additional Surcharge waiver, non-cost-reflective Banking charges, etc.—are removed in a phased manner.

There is yet another policy distortion that can hamper consumer demand for green power: the rise of government subsidies, giving free or cheap power. As long as power is excessively cheap or free, consumers have limited incentive to go green, either through rooftop solar (the focus of another ongoing CSEP study) or via procurement.

6.2 States Should Determine Their Green Tariffs

As shown, two layers exist at which the economics of green tariffs hurt Discoms. First, the projected revenues are typically lower than average costs. Second, those who will opt for this (in part due to size thresholds of 100 kW) have higher-than-average tariffs, viz., C&I consumers. Fixing or even limiting cross-subsidies borne by C&I users is a complex problem of political economy. Green power must operate within this equilibrium.

Other complexities are associated with green power, including the need for power procurement. Today, power purchase costs are socialised, independent of ToD considerations in procurement. A consumer—or rather, a consumer category—that only consumes during the non-RE peak (say, evening) periods, does not pay higher for such use.

Discoms have a strong understanding of the customer demand profile, power procurement costs, distribution expenses, etc.—a standard national rule may create unequal implications for different states. In addition, Discoms are the key interface balancing generation and demand, and they also undertake real-time action for maintaining grid stability. Furthermore, they have an established yearly process to raise tariff petitions through presentations before the regulators, who have the ultimate responsibility of declaring tariffs. They are also undertaking detailed Resource Adequacy plans at the time of writing. It is unclear to what extent the Central Government can mandate norms instead of providing impetus or supporting guidelines for taking suitable action.

If Discoms want to allow green as an "exit", they must ensure not only that the cost differentials are covered (unless they are willing to have higher prices for others), but they must also factor in the time of day when calculating differences. As of now, cross-subsidy surcharges are only based on averages for costs—but we know procurement costs vary with ToD. At some point, pricing will have to reflect such differences, more so because green power has a tangible skew in terms of time of day, as do selected consumers who are more likely to avail green power.

After the MoP (2023) notification, many states have proposed green energy regulations, e.g., Maharashtra, Gujarat, Odisha, Rajasthan, and Telangana. These states have followed the Centre's earlier guidelines (pre-formula) and included the different charges that need to be levied to determine the green tariff—Transmission Charges, Wheeling Charges, Cross Subsidy Surcharge, Banking Charge, etc. (GERC, 2023) (RERC, 2023). The next rightful step would be for the respective SERCs to declare the green tariff based on the realised costs incurred by the Discoms.

6.3 States Should Be Free to Offer Least Cost Greening Options

Currently, Discoms are mandated to offer a bouquet of greening options to consumers. Of the several options, when the customer has an alternate source of supply, as in the case of rooftop solar, we have found that it leads to the maximum loss to a Discom.

Under present norms, in terms of economics, a Discom is much better off procuring utility-scale renewable energy—i.e., a bilateral contract with a large-scale RE generator—than allowing self-generation BTM. A subtle, and not even well-quantified, reason is that with BTM, the consumer only partially exits Discom supply, coming back in the evening. This behaviour doesn't lower infrastructure costs for the Discom, and it also makes their procurement disproportionally peak-oriented. Importantly, self-generation appears attractive to end-users because they find cheap solar without paying the rest of the delivery costs. Stated another way, they get to arbitrage wholesale solar costs with retail Discom costs—an unfair choice.

If the onus or ability to "go green" rests with consumers, this will lead to self-selection, as well as distortions in tariff setting, for the rest of the consumers. Instead, if the Discom procures more and more green power, it will be consumed by all consumers. Making the entire system green is important, instead of making just a niche or subset green. The same principle applies against claims by some stakeholders who have asked for allocating "cheap power" to farmers—being a zero-sum game, this simply distorts the equilibrium for others.

6.4 Green Tariff Should Engage New and Incremental Renewable Energy

One theoretical value of a green tariff is if this spurs green supply. The MoP proposal fails to do so, both on the grounds of additionality and the economics required to pay the premium for true green power 24x7.

It is not clear if the green energy offered towards a green tariff is meant to be incremental or, more likely, the existing procured RE itself is being labelled as green. As already discussed, if it is the latter, and is being consumed by the premium consumers, we have a zero-sum game, but with a skew. In its present state, the cheaper renewable energy will be engaged by the premium category consumers, leaving the less green and more expensive power targeted at the cross-subsidised categories of users that comprise large sections of economically backward and weaker households.

There are now "green purchase" obligations for selected entities—these should not be met by *zero-sum-game* green supply and instead, ideally, be only for additional green supply. Thus, consumers of today's green tariff wouldn't qualify until it is proven to be additional green procurement. Policies are yet to reflect this nuance.

6.5 24x7 Green Energy is Only Available at a Premium

To make 24x7 green energy available, green supply must be *firm* and *despatchable*—i.e., available on demand—while keeping the grid stable. This means, in the long run, we have to overcome RE's intermittency.

This intermittency can be managed by true round-the-clock (RTC) RE. We use the qualifier "true" because most present RTC bids are not true round-the-clock in terms of using storage or other means for matching demand in full, especially at peak, and to the extent they are firm, they may rely on thermal power, third parties, etc.

At the time of analysis, SECI has issued four RTC tenders, of which only RTC–I has yielded in an awarded bid. **Appendix 4** has more details on these bids, a follow-on to which are FDRE (firm and despatchable RE) tenders, which focus only on a few hours of peak supply. Even these allow 85% monthly averaging for peak periods, which means the power isn't truly on-demand.

Storage isn't ready for extensive on-demand power. An India Clean Energy equity research report by Goldman Sachs states that the cost of RTC RE with a BESS works out to Rs 10/kWh and that with a Pumped Storage System is Rs 4.9/kWh (Bahadur & Bhandari, 2023). If we use these numbers, then to make 24x7 firm and despatchable green energy would cost Rs 12.16/kWh and Rs 7.06/kWh for the two storage options, after the average 11-state normative *ex-post* intra-state transmission and distribution costs are added. For such storage costs, this is the minimum amount that C&I consumers need to be levied, *without considering the cross-subsidy component or the Discom Margin*, which are conventionally added to derive their respective tariffs. While storage costs are declining, it always represents a premium to variable RE.

7. Conclusion

As this analysis shows, the MoP-proposed Green Tariffs are unattractive for Discoms and also fail to sufficiently spur incrementally green supply. Importantly, while there is a formula specified, the ultimate decision remains with SERCs. Thus far, no state has followed this formula, instead keeping Green Tariffs as a premium on top of existing tariffs.

The adoption of green tariffs by Discoms depends heavily on SERCs' ability to pass on the entire costs associated with supplying green energy and also offset the revenue loss resulting from the migration of high-paying consumers. Otherwise, the proposed MoP formula appears difficult for many Discoms, especially considering that they are already grappling with existing financial losses. In this context, careful consideration of cost implications and revenue dynamics is imperative for the effective implementation of green tariffs by Discoms.

Larger distortions in Discom pricing need addressing, including excessive cross-subsidies, disproportionate emphasis on variable costs in retail tariffs, and non-cost-reflective tariffs overall. Extensive socialisation also exists, which removes micro-economic efficiency, e.g., from the relative absence of time-of-day pricing. All these issues will only become more pressing as the RE transition continues, including based on consumer-driven RE.

The 2015 Paris climate change commitment, coupled with the Government of India's ambitious renewable energy targets, requires the procurement of renewable energy technology at a large scale—approximately 46 GW/year between the end of March 2024 and the end of 2030. Discoms will be key, and a green tariff could be one of several approaches to help meet the target. For a green tariff to be a popular RE-supporting mechanism, a few—if not all—of the recommendations made in this study should be considered. This will help align economics, scalability, and equity with greenness.

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Appendix

Appendix 1: Distribution Companies Engaged in The Study

Table 6: FY 22 Electricity Sales and Corresponding Revenues of the Different Utilities Across 11 States

Sl. No.	State	Discom	Expanded Form	Energy Sales (MU)	Energy Sales Share (Share of Total State Sales)	Revenue from Sale of Power (Rs Crore)	Revenue Share (% of Total State Energy-Related Revenues)
1	Andhra Pradesh	APEPDCL	Andhra Pradesh Eastern Power Distribution Company Limited	14,010	23%	8,685	23%
		APCPDCL	Andhra Pradesh Central Power Distribution Company Limited	23,130	38%	14,634	39%
		APSPDCL	Andhra Pradesh Southern Power Distribution Company Limited	23,173	38%	14,038	38%
2	Delhi*	BRPL	BSES Rajdhani Power Limited	11,478	44%	8,957	43%
		BYPL	BSES Yamuna Power Limited	6,145	23%	4,705	23%
		TPDDL	Tata Power Delhi Distribution Limited	8,752	33%	6,960	34%
3	Gujarat	DGVCL	Dakshin Gujarat Vij Company Ltd.	24,746	27%	16,704	29%
		MGVCL	Madhya Gujarat Vij Company Ltd.	11,541	12%	7,297	13%
		PGVCL	Paschim Gujarat Vij Company Ltd.	31,438	34%	19,251	34%
		UGCVL	Uttar Gujarat Vij Company Ltd	25,265	27%	14,187	25%
4	Karnataka	BESCOM	Bangalore Electricity Supply Company Limited	26,685	45%	20,939	59%
5	Kerala	KSEBL	Kerala State Electricity Board Limited	25,923	100%	16,205	100%
6	Madhya Pradesh	MP Central	MP Madhya Kshetra Vidyut Vitaran Co. Ltd.	20,824	33%	14,045	33%
		MP East	MP Poorv Kshetra Vidyut Vitaran Co. Ltd.	18,339	29%	12,263	29%
		MP West	MP Paschim Kshetra Vidyut Vitaran Co. Ltd.	24,549	39%	16,349	38%
7	Maharashtra	MSEDCL	Maharashtra State Electricity Distribution Company Limited	1,18,559	87%	85,903	87%
8	Punjab	PSPCL	Punjab State Power Corporation Limited	53,481	100%	34,013	100%
9	Rajasthan	AVVNL	Ajmer Vidyut Vitaran Nigam Limited	19,988	29%	15,592	29%
		JDVVNL	Jodhpur Vidyut Vitaran Nigam Limited	23,175	33%	17,480	33%
		JVVNL	Jaipur Vidyut Vitaran Nigam Limited	26,534	38%	20,264	38%
10	Tamil Nadu	TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited	80,759	100%	46,803	100%
11	Telangana	TNSPDCL	Northern Power Distribution Company of Telangana	18,642	30%	11,581	33%
		TSSPDCL	Southern Power Distribution Company of Telangana	43,099	70%	23,587	67%

Source: Discom's true-up petitions filed with respective SERCs.

*Notes: *Excludes government suppliers like NDMC and MES, which are small.*

Appendix 2: $APPC_{Ex\text{-}Bus}$ of Different States

Table 7: Fuel-Wise per Unit Cost of Power Purchased on Energy Sold Basis in FY 22

		In Rs/kWh							
State	**Coal**	**Large Hydro**	**Gas**	**Nuclear**	**RE (Excluding Large Hydro)**	**RE (Including Large Hydro)**	**$APPC_{Ex\text{-}Bus}$**	**Thermal (Coal + Gas) Share**	**Total RE Share^**
Andhra Pradesh	5.32	1.86	3.12	3.78	4.81	4.19	5.05	66%	27%
Delhi	4.65	3.86	10.12	3.96	3.96	3.90	5.24	79%	18%
Gujarat	5.12	1.55	24.20	3.70	4.85	4.60	5.23	67%	14%
Karnataka	6.88	1.40	-	4.47	5.2	3.64	5.38	59%	47%
Kerala	4.02	0.70	-	4.14	2.59	0.84	3.15	60%	39%
Madhya Pradesh	5.06	3.38	4.33	3.96	5.44	4.56	4.87	83%	17%
Maharashtra	5.78	2.51	4.63	3.90	5.96	5.09	5.58	79%	15%
Punjab	4.84	1.64	9.68	4.02	7.44	2.73	4.37	61%	20%
Rajasthan	5.44	3.23	5.63	4.44	5.69	4.98	5.29	71%	25%
Tamil Nadu	6.41	4.66	13.47	4.69	5.02	4.90	6.12	74%	16%
Telangana	5.64	3.90	-	4.11	6.52	5.32	5.51	72%	17%
11 States (Average)	**5.48**	**2.39**	**8.35**	**4.26**	**5.38**	**4.21**	**5.24**	**72%**	**20%**

Source: Authors' calculation based on Discom's true-up petitions filed with respective SERCs.

Notes:

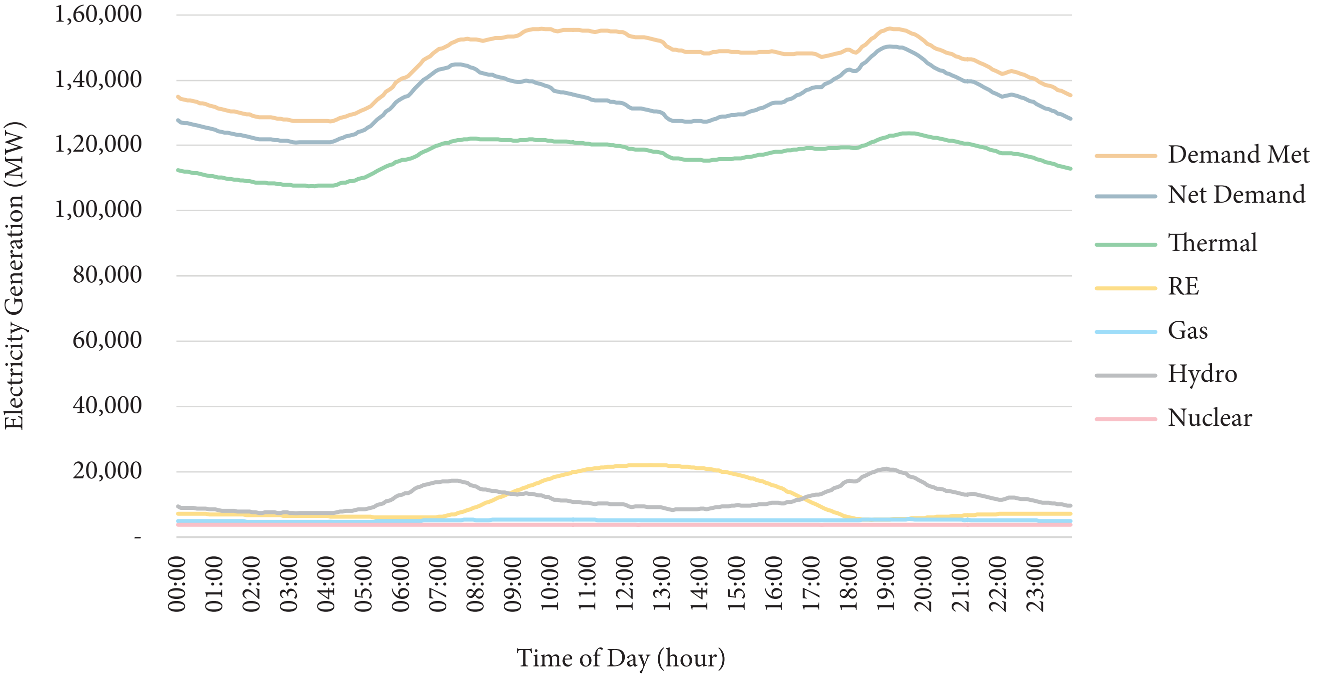
1. *Fuel-wise energy sales are estimated from the share of the respective fuel in total energy off-take ex-bus.*

   ^Includes large hydro but excludes the composition of export/import of energy to/from the short-term market. This exclusion, plus nuclear power, explains the gap in total supply compared to adding up thermal and total RE. The inclusion of large hydro lowers the total RE cost as most of the hydro plants are very old, and hence, a substantial portion of the fixed costs has already been recovered.

2. *Barring Delhi, Karnataka, and Maharashtra, the study covers all the utilities in the 11 respective states. In Delhi, we include the three major private Discoms but exclude the New Delhi Municipal Corporation. In Karnataka, we use only Bangalore Electricity Supply Company Limited (BESCOM), and in Maharashtra, we include MSEDCL but exclude the Mumbai Discoms (Adani Electricity Mumbai Limited, Brihanmumbai Electric Supply & Transport Undertaking, and The Tata Power Company Limited). In Karnataka, BESCOM accounts for about half of the state's energy sales, while in Maharashtra, MSEDCL represents 87.5% of the state's energy sales.*

Appendix 3: Time-of-Day Profile

Figure 7: 24-Hour Time-of-Day Profile of Load Consumption in 2019



Source: (Tongia & Dave, 2023).

Notes: Net Demand equals the total Demand after treating RE supply as negative demand; it is also called Net Load.

Appendix 4: Round-the-Clock RE

To mitigate the variability of RE, India has sought bids for more firm models of RE. Round-the-Clock RE (RTC)-I was announced in 2019, with contract capacity expected in the range of 50–400 MW. The tender allowed generation from RE technologies and the use of any form of storage technology; in most cases, storage has been optional.

While the term RTC implies continuous operation, the contract allowed flexibility in generation, as the annual and monthly capacity utilisation factors (CUFs, similar to plant load factors, or PLFs) were expected at 80% and 70%, respectively (SECI, 2019). ReNew Power won the e-Reverse auction bid at a tariff of Rs 2.90/kWh (SECI, 2020a). An escalation of 3% per year for the first 15 years was allowed in the contract, which led to a levelised tariff in the range of Rs 3.55 to 3.60/kWh, depending on the power generated from the project (Prasad, 2020).

RTC-II was announced in 2020. The initial tender document called for a supply of 5,000 MW from RE–thermal power hybrid. This was downsized to 2,500 MW. The annual CUF was restricted to 85% (SECI, 2020b). The e-Reverse auction comprised fifteen bidders, with a total bid capacity of 11,801 MW. Of these bidders, M/s Hindustan Thermal Projects Limited's winning bid of Rs 3.01/kWh was chosen, and it was awarded a capacity of 250 MW (SECI, 2021).

RTC-I and RTC-II cannot be treated as true RTC RE because, despite the high Capacity Utilisation Factor (CUF—70 to 85%), which is comparable with thermal power, the supplied energy does not meet the firm and despatchable criteria. Moreover, RTC-II allows the energy mix to comprise RE at 51% and the rest from thermal sources.

RTC-I yielded a levelised tariff in the range of Rs 3.55 to Rs 3.60/kWh. There is mixed information available on RTC-II. The Ministry of Power stated in the Rajya Sabha that 250 MW capacity was awarded to M/s. Hindustan Thermal Projects Limited, whereas a news periodical has claimed that the tender has been cancelled as the rest of the bidders were unable to match the lowest bid of Rs 3.01/kWh for the remaining 2,250 MW capacity (Ministry of Power, 2022b) (Shetty, 2023).

The request for the selection document for RTC-III (2,250 MW) has been issued. RTC-III, too, cannot address the long-term needs, overcoming intermittency and firmness/dispatchability, as storage is optional (SECI, 2022). RTC-IV requires a mandatory storage system, but beyond that, no further information is available (SECI, 2023). Even that storage isn't necessarily meeting all instantaneous demand in full.

REMC Limited, a joint venture company of the Ministry of Railways & RITES Limited, has also issued a tender for 1,000 MW of RTC power from RE. The annual availability of the project is 75% for the first four years, followed by 85% for the next twenty-one years. There is no compulsion to engage a storage system. The tender also has a provision to supply RE or non-RE energy equivalent to 15% of the contracted quantum on an annual basis until 31 March 2029 from medium-term/short-term open access or power exchange or any other arrangement. Beyond this period, non-RE power, if any, supplied must be balanced with an equivalent REC (REMC Limited, 2022). Sprng Energy (100 MW—Rs 3.99/kWh), NTPC Renewable Energy (500 MW, Rs 4.10/kWh), Ayana Power (300 MW, Rs 4.10/kWh), and O2 Power (60 MW, Rs 4.27/kWh) were the winners of REMC Limited's e-Reverse Auction (Joshi, 2023).

As of now, the existing SECI and REMC tenders have not been designed for 24x7 true RTC RE power. Adding more stringency to the ask will raise the price. A back-of-the-envelope calculation shows why. Say we can achieve a 50% CUF with over-sizing wind + solar hybrid power. That still leaves 50% to come through storage. If battery storage costs, say, Rs 8/kWh today, that adds Rs 4/kWh to the total. Present RTC bids often highly oversize wind/solar, but they can over- and under-produce at specific time blocks, relying on the market or other suppliers to buy/sell power as required. Such bids help in the short run but cannot scale, more so because, in the long run, the value of surplus generation will drop to near zero.

About the authors

Nikhil Tyagi is a former Research Associate at CSEP. His areas of research include operation of electricity distribution, retail tariff, distribution utility finances, cross border trade of electricity etc. He extensively worked on data driven projects connected with utility operational performance, efficiency, etc. He is currently working on smart meters, distributed energy resources and areas connected with energy transition. He specialised in renewable energy in his masters degree at TERI School of Advanced Studies. He is presently working as an independent researcher.

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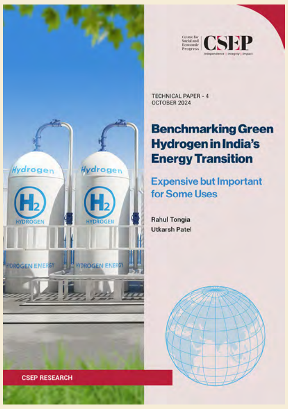
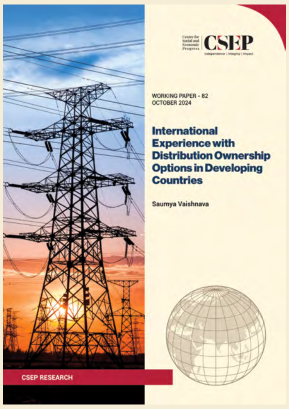
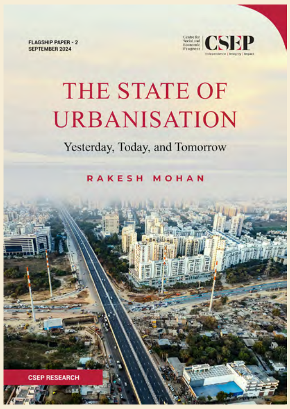
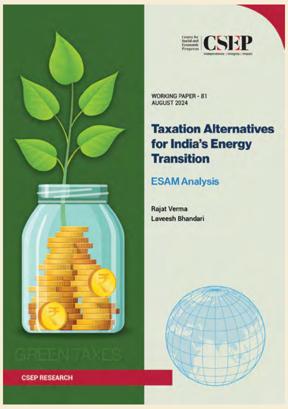
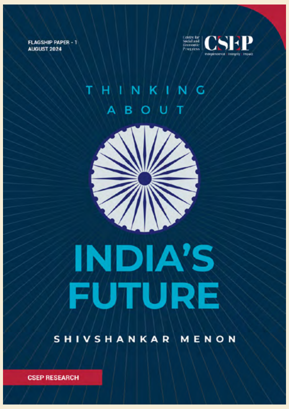
Other publications

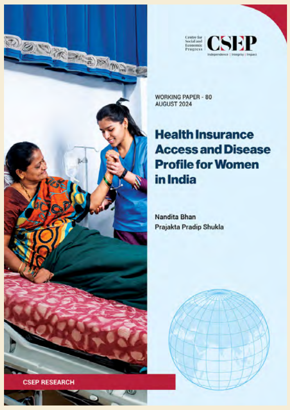


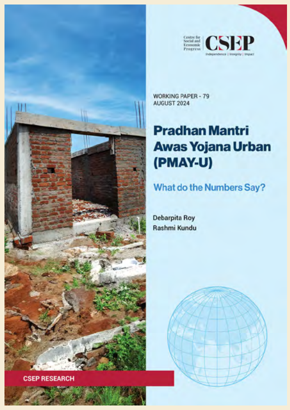


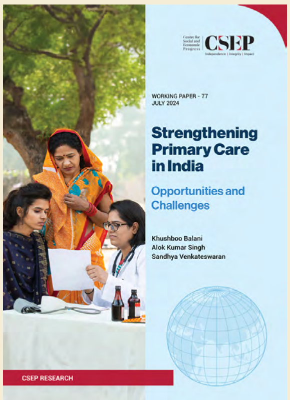


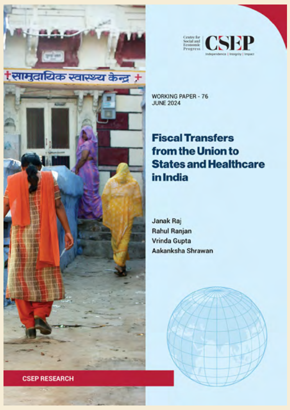


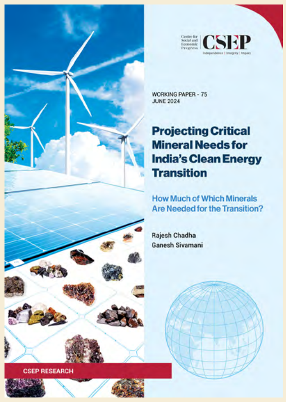


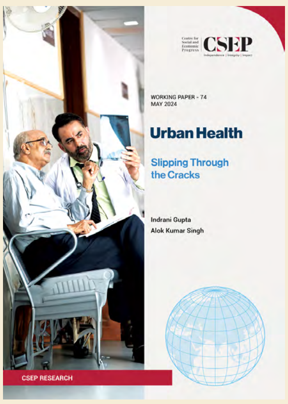


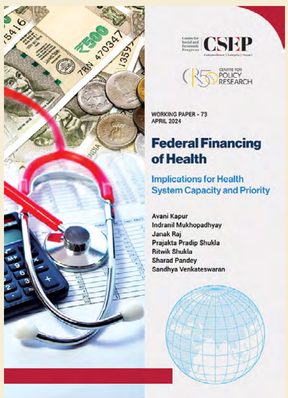


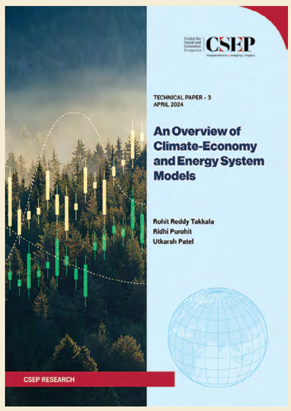












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