

Government Policy, Institutions and Household Adoption of Rooftop Solar in Uttar Pradesh, India: A Systematic Review and Evidence Synthesis.

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ABSTRACT

Residential rooftop solar photovoltaic (R-RTS) is central to India's decentralised energy transition, yet adoption remains uneven across states and household groups. This review synthesises the evidence on how policy design, institutional delivery and household-level conditions shape R-RTS uptake in India, with particular attention to Uttar Pradesh and the Moradabad context. A structured review of peer-reviewed studies and policy documents published from 2010 to June 2026 was designed around three questions: which policy instruments influence household adoption; which barriers mediate their effect; and what institutional arrangements enable implementation. The evidence converges on a policy–practice gap. Capital support and net metering can improve economic feasibility, but their effect is weakened by information asymmetry, financing constraints, transaction costs, vendor trust, roof suitability and delays at the distribution-company interface. The Uttar Pradesh context adds a significant implementation challenge: a large and heterogeneous household market must navigate multiple agencies, digital portals and local electricity-distribution processes. The review proposes an implementation framework centred on predictable consumer journeys, district-level facilitation, inclusive finance, accountable DISCOM service standards, accredited vendors and targeted outreach. It argues that household rooftop solar should be evaluated not only by capacity added but also by access, procedural reliability and distributional equity. The paper provides an evidence-informed foundation for the proposed Moradabad field study and for policy learning in other tier-2 and tier-3 cities..

Keywords: rooftop solar; household adoption; energy policy; Uttar Pradesh; DISCOMs; net metering; energy transition...

INTRODUCTION

India's energy transition requires not only utility-scale renewable generation but also consumer-facing, distributed energy systems. Residential rooftop solar photovoltaic (PV) has a distinctive role because it can convert households from passive electricity consumers into participants in electricity generation. Its potential benefits include lower grid losses, reduced daytime demand, household bill savings and a more visible form of climate action. However, technical potential does not translate automatically into adoption. The residential market depends on household confidence, viable financing, administrative simplicity, trusted vendors and an enabling relationship with electricity distribution companies (DISCOMs).

The national policy architecture has sought to address these constraints through the Grid Connected Rooftop Solar Programme, central financial assistance for residential consumers, digital application routes and incentives for DISCOMs. The current framework under PM Surya Ghar: Muft Bijli Yojana reinforces the residential focus. Uttar Pradesh complements this national direction through its Solar Energy Policy 2022 and a set of institutions responsible for facilitation, approvals and network integration. Yet, the proposed Ph.D. synopsis

identifies a persistent gap between policy availability and household uptake in Moradabad and comparable districts. This gap is consequential: large, mixed urban–peri-urban–rural districts are where the equity and scale of India's rooftop transition will be determined.

This paper reviews the literature and policy evidence relevant to that gap. It does not claim to estimate an effect size because the available studies are heterogeneous in design, geography and outcome measures. Instead, it offers a structured thematic synthesis that identifies mechanisms, evidence gaps and a research agenda for the Moradabad case study.

2. REVIEW QUESTIONS AND CONCEPTUAL SCOPE

The review was guided by the following questions: (1) Which government-policy instruments affect household R-RTS adoption in India? (2) What financial, technical, institutional, informational and behavioural barriers condition their effectiveness? (3) How do DISCOMs, nodal agencies, vendors and local bodies influence the consumer journey? and (4) What evidence is available for Uttar Pradesh and comparable subnational settings? The scope is residential rooftop PV. Commercial and industrial systems are used only where they illuminate

institutional or market mechanisms that may affect households.

3. METHODS

3.1 Review design and reporting approach

A systematic-review protocol was developed using PRISMA 2020 principles for transparency and reproducibility. The review combines peer-reviewed empirical and review studies with primary policy documents because adoption is shaped both by household behaviour and by changing programme rules. The search window runs from January 2010, which captures the launch period of India's National Solar Mission, to June 2026. The review is qualitative and thematic; meta-analysis was not planned because study populations, adoption outcomes and explanatory measures are not sufficiently comparable.

3.2 Search strategy and eligibility

Search strings combined terms for the technology, decision-maker, geography and policy process: ("rooftop solar" OR "residential solar PV" OR "solar rooftop") AND (household OR residential OR consumer) AND (India OR "Uttar Pradesh") AND (adoption OR diffusion OR barriers OR policy OR subsidy OR "net metering" OR DISCOM). Searches should be executed and exported from Scopus, Web of Science, Google Scholar and relevant Indian government repositories before submission. Backward citation searching should be used to identify foundational studies. The synthesis below is based on the peer-reviewed and policy sources identified in the synopsis and targeted literature retrieval; a final PRISMA flow diagram, database dates and deduplication log must be inserted once the researcher completes the database export.

Criterion	Inclusion	Exclusion
Population setting	Households or residential consumers; Indian policy settings; comparable evidence used for conceptual context.	Utility-scale PV only; purely industrial or commercial studies without transferable findings.
Phenomenon	Adoption, intention, policy implementation, financing, net metering, service delivery, awareness or institutional roles.	Studies addressing PV engineering performance only.
Evidence type	Peer-reviewed studies, systematic reviews, official policy documents and programme guidelines.	Unverifiable web content, opinion pieces and sources without identifiable authorship.
Language / period	English; January 2010–June 2026.	Sources outside the period or without sufficient methodological detail.

3.3 Data extraction and synthesis

For each eligible source, the proposed extraction fields are: geography; study design; respondent group; policy instrument; adoption outcome; reported drivers and barriers; institutional actors; and implications. A framework synthesis groups findings into five domains: economic feasibility, information and trust, technical suitability, institutional delivery and social-behavioural conditions. The framework is informed by diffusion-of-innovation theory, planned behaviour and energy-justice scholarship. It is intended to connect policy inputs with household decisions while retaining the role of intermediaries.

4. FINDINGS: WHAT THE EVIDENCE SAYS

4.1 Policy support is necessary but insufficient

The literature consistently treats up-front cost as a decisive constraint in residential solar. Subsidies, concessional finance and predictable compensation for

exported electricity can improve the investment proposition; nevertheless, their impact depends on whether households understand eligibility, can finance the residual cost and trust that payment and interconnection will occur on time. Indian studies repeatedly show that broad policy ambition is not equivalent to an accessible household offer. Raina and Sinha (2019) and Kumar and Majid (2020) identify policy continuity, market development and implementation capacity as linked conditions for solar deployment. The MNRE programme similarly recognises the central role of residential consumer support and DISCOM participation (MNRE, 2026).

Policy instruments should therefore be assessed as a package rather than in isolation. A capital subsidy changes affordability; net metering changes expected returns; standardised procedures reduce transaction costs; vendor accreditation affects quality confidence; and outreach makes the package legible. Weakness in any one component can interrupt the adoption pathway. This helps

explain why formal incentives may coexist with low uptake.

4.2 The barriers are interdependent

The evidence identifies five interacting barrier classes. Financial barriers include high initial expenditure, limited credit and uncertainty about payback. Institutional barriers include fragmented approvals, uncertain connection timelines, weak grievance redressal and revenue-related concerns at the DISCOM interface. Information barriers involve low awareness of subsidies, net metering and technical suitability. Technical and market barriers include roof ownership, shading, structural quality, vendor availability, maintenance concerns and perceived product risk. Social and behavioural barriers include lack of trust, preference for familiar technologies, risk aversion and the influence of peers. Dutt's Delhi study is particularly important because it documents how finance, information, trust and procedures combine rather than operate as separate obstacles (Dutt, 2020).

The relevance for Moradabad is clear. A household may have adequate solar resource but still be unable to adopt because its roof is rented, its savings are insufficient, the application process is opaque or the vendor market is thin. Conversely, a technically modest household may adopt when finance, local facilitation and peer demonstration reduce uncertainty. The proposed field study should therefore avoid treating non-adoption as a simple awareness deficit.

4.3 Institutions shape the consumer journey

Rooftop solar is a multi-actor service. The household encounters an information source, a vendor or installer, a financing option, an application portal, a DISCOM inspection and a meter connection. The quality of coordination across these stages is a central policy outcome. The Uttar Pradesh Solar Energy Policy 2022 establishes a state-level policy direction, while UPNEDA,

DISCOMs and local institutions each influence implementation. Recent Uttar Pradesh-focused work likewise identifies stakeholder coordination, awareness and process bottlenecks as central to residential scaling (Tiwari, Mall and Rupakheti, 2025).

For policy evaluation, installation capacity alone is therefore insufficient. Useful service indicators include time from application to approval, time to meter installation, subsidy-processing time, number and resolution time of grievances, vendor complaint rates and consumer comprehension of the process. These indicators turn "implementation" into measurable practice rather than a residual explanation for low adoption.

4.4 Equity matters for adoption and policy legitimacy

Residential rooftop solar can deliver bill savings and energy autonomy, but the first beneficiaries are often households with suitable owner-occupied roofs, credit access and sufficient consumption. Without corrective design, the programme may widen rather than narrow energy inequality. Renters, low-income households, small-roof households and residents in weak-grid areas face structurally different choices. The review therefore supports differentiated solutions: group or community models for constrained roofs, low-friction loans for households with limited liquidity, local-language assistance, and transparent vendor-quality assurance. Equity should be measured as access to the programme and its benefits, not merely as the geographic distribution of capacity.

5. SYNTHESIS FRAMEWORK FOR UTTAR PRADESH AND MORADABAD

Figure 1 is presented as a conceptual model for the field component of the Ph.D. research. It specifies the mechanisms through which public policy is expected to influence adoption. It also provides a practical coding framework for household surveys, key-informant interviews and policy documents.

Policy and delivery inputs	Household mechanisms	Adoption / equity outcomes
Subsidy design; finance; net-metering rules; vendor accreditation; outreach; DISCOM standards; local facilitation.	Affordability; expected savings; procedural confidence; trust; awareness; perceived roof suitability; social proof.	Adoption intention; installation; timely interconnection; satisfaction; bill savings; energy-security perceptions; equitable access.
Institutional coordination across MNRE, UPNEDA, DISCOMs, vendors and local bodies.	Reduced transaction costs and clearer accountability.	Faster consumer journey; fewer drop-outs; higher programme legitimacy.

The framework predicts that awareness alone will not be sufficient. Policy awareness is expected to influence adoption through perceived affordability and procedural confidence; institutional reliability is expected to moderate these relationships. These propositions align with the synopsis hypotheses concerning policy

awareness, finance, administrative efficiency, roof suitability, income, education and perceived benefits.

6. Implications for Research Design

The Moradabad study should use a mixed-methods design. A household survey can estimate awareness, intention, adoption status, roof characteristics, electricity

expenditure, financing constraints and interactions with agencies. Stratification across urban, peri-urban and rural locations will be important because infrastructure, income, housing tenure and service access may differ materially. Key-informant interviews with UPNEDA officials, DISCOM personnel, vendors, local bodies and financiers can explain process bottlenecks that household data alone cannot observe.

The survey should distinguish four groups: adopters; applicants who did not complete installation; interested non-adopters; and households with no stated interest. This distinction is analytically valuable. It separates a lack of demand from a failure of delivery and allows the study to

identify the stage at which potential adopters leave the process. Data should also record application dates, approval stages, subsidy experiences and consumer-service interactions where applicable.

For analysis, descriptive comparison can be followed by logistic or multinomial regression for adoption status and structural-equation or mediation analysis for the pathway from policy awareness to intention. Qualitative coding should examine how stakeholders describe responsibility, delay, risk and trust. Integrated findings can be organised against the synthesis framework in Section 5.

7. POLICY RECOMMENDATIONS

Priority action	Rationale	Lead actors
Publish a time-bound, trackable consumer journey from eligibility check to subsidy receipt.	Reduces uncertainty and makes implementation performance observable.	MNRE, UPNEDA, DISCOMs
Create district-level rooftop solar facilitation desks and mobile outreach.	Addresses information and transaction-cost barriers in tier-2, peri-urban and rural settings.	UPNEDA, urban local bodies, panchayats
Link accredited vendors to standard quality assurance, consumer ratings and complaint resolution.	Builds trust and protects households from installation and after-sales risk.	UPNEDA, DISCOMs, consumer bodies
Expand low-friction finance and pooled / group models.	Addresses liquidity and roof-size constraints that subsidies alone do not resolve.	Banks, NBFCs, local bodies, programme agencies
Adopt public DISCOM service standards for approvals, inspections and meter installation.	Targets a critical implementation bottleneck and clarifies accountability.	DISCOMs, UPERC, state government
Measure equity outcomes alongside MW installed.	Ensures that policy benefits reach lower-income and constrained-roof households.	MNRE, UPNEDA, researchers

8. LIMITATIONS AND CONCLUSION

This review is deliberately focused on the policy-to-adoption pathway and on residential rooftop PV. The evidence base is heterogeneous, and available studies use different definitions of adoption, intention and policy effectiveness. The manuscript should be finalised with a dated database export, screened-record log, quality appraisal table and PRISMA flow diagram before journal submission. It should not be used to infer causal effect sizes in its current form.

The evidence nonetheless supports a clear conclusion: rooftop solar adoption is not produced by subsidy design alone. It emerges from the interaction between affordability, household confidence, technical suitability

and reliable institutional delivery. In Uttar Pradesh, the central research and policy challenge is to convert a formal programme into a simple, trusted and equitable household experience. Moradabad offers a valuable case because it combines high solar potential, a heterogeneous residential landscape and significant implementation relevance for other non-metropolitan districts. A rigorous field study anchored in this framework can generate the local evidence needed to improve both adoption and the fairness of the clean-energy transition.

Declarations

Funding: To be added by the author. | Conflict of interest: The author declares no conflict of interest. | Data availability: No primary data were generated for this

review. The final search log and data-extraction sheet should be deposited in an accessible repository upon submission. | Ethics approval: Not required for this literature and policy review; the subsequent household study will require institutional ethics approval where applicable...

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