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Policy and Regulatory Framework Influencing Rooftop Solar Adoption in Karnataka

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Abstract

This study examines the policy and regulatory frameworks influencing the adoption of rooftop solar photovoltaic (RTPV) systems in Karnataka, India, with a specific focus on government subsidies, net metering, and tariff policies. Despite Karnataka's early leadership in renewable energy and progressive initiatives by institutions like the Karnataka Electricity Regulatory Commission (KERC) and Karnataka Renewable Energy Development Limited (KREDL), rooftop solar adoption remains below its technical and policy potential. Combining research and analysis of policies, this paper finds that major implementation problems, including strict capacity limits, delays in the process, less funding for utilities, and not enough awareness among consumers, are stopping the large-scale rollout of renewable energy. According to studies from India and around the world, the quality of Karnataka's regulations is not achieved due to poor implementation and misalignment among different entities. The paper ends by providing suggestions for increasing the use of the technology. Revising the tariffs, eliminating the restrictions on capacity, improving the way subsidies are handled, and increasing the level of transparency and consumer focus are needed. These changes are necessary to maximise RTPV's benefits and help Karnataka find climate and energy security.

Keywords: Rooftop Solar Photovoltaic (RTPV), Karnataka, Net Metering, Solar Tariffs, Renewable Energy Policy, Decentralised Energy, Government Subsidies, Energy Regulation, Distributed Generation, Solar Energy Adoption.

Introduction

Background on Renewable Energy and Climate Goals in India

The country is now a top performer in renewable energy due to the twin aims of keeping its energy supply safe and managing climate issues. As part of its commitment under the Paris Climate Agreement, the Indian government has set ambitious renewable energy targets — 175 GW by 2022 and 500 GW of non-fossil capacity by 2030 (Goel, 2016) [7]. Among these, solar energy plays a pivotal role, with 100 GW of the 175 GW 2022 target allocated to solar power, of which 40 GW is expected to come from rooftop photovoltaic (RTPV) systems (UmarTariq, 2017) [18]. This strategic focus on solar rooftop adoption is influenced by India's geographical advantage — the country receives more than 300 sunny days annually, making it one of the most solar-rich regions globally (Ali & Yadav, 2018) [1].

Apart from providing energy, rooftop solar is considered a fair solution that matches India's intent of sustainability and decentralised energy. Rooftop systems contribute to reducing the carbon footprint and dependence on coal-based power, which still dominates India's energy mix (Kumar, Jethani, & Bohra, 2023) [8]. Besides, the government has set up the National Solar Mission, provided state incentives, and introduced net metering rules to support the use of solar energy.

There have been strong initiatives, but the amount of actual rooftop solar installed is still below what was hoped for. This shows that understanding how regulations at the state level impact the transition is very important.

The Contribution of Rooftop Solar to Decentralisation of Power

Having rooftop solar systems is essential when building decentralised renewable energy solutions. Rooftop solar installations are different from large solar farms because they use the rooftops of buildings instead of needing large areas of land and new grid connexions. This allows for localised generation and consumption of electricity, reducing transmission losses and enhancing grid efficiency (Ghosh, Nair, & Krishnan, 2015) [6].

Rooftop solar in India also helps reduce the burden on state utilities, with people using it to become "prosumers" who generate and use their own energy. This transformation is pivotal in cities, where electricity demand is high and land availability is limited (Goel, 2016) [7]. Because of net metering, individuals are encouraged to return energy to the grid, so the relationship between consumers and the electrical

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system becomes two-sided.

Rooftop solar allows for energy independence both in homes and institutions. It is possible for schools, hospitals, government buildings, and homes to both save on electricity and prevent problems with the electricity supply. Besides, solar panels on roofs have led to the creation of jobs and financial growth in the local community.

However, challenges such as policy ambiguity, upfront costs, lack of consumer awareness, and bureaucratic hurdles in availing subsidies and interconnection approvals continue to limit widespread adoption (Ali & Yadav, 2018) [1]. As a result, there is a need for better policies and laws designed specifically for decentralised systems.

The Role of Leaders in Promoting Rooftop Solar in Karnataka

Wind and solar energy are areas where Karnataka has led Indian states for years. The state has reached and surpassed the goals it set for grid-connected solar energy. In particular, Bengaluru has led the way in installing rooftop solar installations. Through agencies like the Karnataka Renewable Energy Development Limited (KREDL) and the Karnataka Electricity Regulatory Commission (KERC), the state has introduced pioneering initiatives such as net metering and feed-in tariffs (Ghosh *et al.*, 2015) [6].

By 2015, the government of Karnataka aimed to instal 250 MW of rooftop solar power in Bengaluru, although the area's technical potential was much higher at 560 MW. The KERC introduced consumer-friendly tariffs of Rs. 9.56/kWh without a central subsidy and Rs. 7.2/kWh with the MNRE capital subsidy (Ghosh *et al.*, 2015) [6]. As a result, building rooftop solar systems seemed reasonable financially. Yet, real-world adoption remained sluggish.

A significant policy challenge has been the cap on system capacity — limited to 75% of the consumer's sanctioned load — effectively discouraging consumers who produce more electricity than they consume (Ghosh *et al.*, 2015) [6]. Financial strain on BESCOM (the state utility) and poor implementation further impeded momentum.

Karnataka has led in rooftop solar in the past, but now it is stagnating because of regulations that are too strict, lack of outreach to end-users, and opposing views by utilities. Recognising these barriers is key to designing successful policy changes.

The Policy Only Covers Subsidies, Net Metering, and Tariffs

Although many things affect rooftop solar, such as proper technology, awareness in the public, and funding models, this study aims to analyse how subsidies, net metering, and tariff policy influence it. These areas are selected because they are directly governed by state and central regulations and have shown significant influence on rooftop solar economics and adoption behaviour (Goel, 2016; Kumar *et al.*, 2023) [7, 8].

Because subsidies lower the starting costs, rooftop systems become an option for a larger group of users. The value of the energy sent to the grid is established by the tariff policy, and net metering helps you profit financially from that energy. All these policies impact whether rooftop solar becomes a good option for most homeowners.

By dealing with these particular policy areas, a thorough and well-organised review of Karnataka's regulations can point out its strengths, weaknesses, and areas in need of improvement. The result is clear and practical data that matters to those working on solar adoption policies.

Objectives of the Study

i). To Investigate the Effect of Regulatory and Policy Frameworks on Adoption in Karnataka

ii). The study aims to identify what is helping and what is holding back by studying Karnataka, one of the first states to implement net metering and rooftop incentives.

iii). The paper suggests steps to ensure that rooftop solar can be used widely and effectively in Karnataka.

Literature Review

Overview of the Top National Factors Influencing the Use of Rooftop Solar: India's solar energy expansion has been driven by ambitious national targets, including achieving 100 GW of solar capacity by 2022, with 40 GW dedicated to rooftop solar (UmarTariq, 2017) [18]. Even with strong government support under the National Solar Mission, fewer than half of the intended rooftop solar installations were in place by 2021. The reasons for this lag include high upfront costs, inconsistent policy implementation across states, and limited consumer awareness (Stanford, 2014) [16].

A number of financial incentives are in use, such as capital subsidies, feed-in tariffs, and net metering, though how effective they are depends on the region. A comparative analysis by Stanford (2014) [16] found that while financial incentives have a statistically significant impact on rooftop PV adoption, other factors such as high electricity prices and falling solar technology costs also play critical roles. Additionally, studies such as Zitelman (2017) [19] showed that net metering policies offering compensation at retail rates led to significantly higher residential rooftop installations.

In the past few years, more attention has been given to improving the effectiveness of incentives, mainly where there are lots of cities and high demand for electricity. The lack of proper regulations, a standard process, and delayed subsidy payments have hurt consumer confidence in the system. Despite these barriers, the policy landscape remains dynamic, with new schemes such as PM Surya Ghar Yojana and DISCOM-driven programmes offering hope for accelerated adoption (Paul *et al.*, 2025) [14].

The Use of Regulatory Incentives Outside of Karnataka and Globally: Incentives like net metering, gross metering, and performance-based feed-in tariffs have been very important for promoting the use of rooftop solar both in India and abroad. Guajrat and Maharashtra states in India, with their active regulatory systems, have made it possible for more rooftop solar systems to be used. Zitelman (2017) [19] showed that states offering generous net metering benefits — such as full retail rate compensation and no additional fixed charges — saw significantly greater uptake of rooftop systems.

In many parts of the world, Germany and Australia have achieved success in expanding rooftop solar with continued feed-in tariffs and simpler ways to join the grid. These mechanisms have not only reduced the payback periods for consumers but also created robust markets for solar service providers (Pacudan, 2018) [13]. In contrast, where net billing or reduced compensation schemes replaced full retail net metering, adoption rates dropped significantly, as observed in Saskatchewan, Canada (Dolter *et al.*, 2023) [3].

Across India, the regulations are not always clear, which can make both consumers and developers confused. For example, Delhi and Tamil Nadu have chosen to offer flexible choices by creating time-of-day tariffs or encouraging group net metering. But when states do not have clear or flexible net metering rules, adoption is still low, regardless of the area's

great solar potential.

Thus, proper and accessible rules for consumers are necessary to increase the number of homes with solar panels. To know what's successful and what isn't in Karnataka, we should look at these wider regulatory changes.

Review of Karnataka-Specific Research

Financial Viability of RTPV in Bengaluru (Ghosh *et al.*, 2015) [6]: Ghosh, Nair, and Krishnan (2015) [6] conducted one of the most comprehensive techno-economic analyses of rooftop photovoltaic (RTPV) systems in Bengaluru, Karnataka. Researchers learned that with approved feed-in tariffs, both homeowners and business owners could find rooftop solar systems to be financially suitable, with tariffs of Rs. 9.56/kWh and Rs. 7.2/kWh, respectively. Even though the policy was considered financially viable, it still faced challenges in being put into practice.

The results showed that because of financial issues, BESCOM introduced a regulation that allows only 75% of a consumer's total connected load to be covered by rooftop solar. It made it difficult for homes and small companies to add more energy to the grid. Ghosh *et al.* also noted that without a sustainable financing framework or additional revenue streams (such as renewable energy certificates), Karnataka would fall short of its 250 MW RTPV target.

Overall, the introduction of tariffs seemed promising for rooftop solar, but practical factors such as capped investment and slow payment led many to lose faith in the sector. It is clear from the findings that Bengaluru can make full use of solar rooftops only with proper integration of financial and regulatory policies.

Net Metering Adoption Trends (Martin & Ryor, 2016) [10]: Martin and Ryor (2016) [10] examined Bengaluru's net metering program and found mixed success. The main purpose of the policy was to help residential and commercial customers become "prosumers," where they both supply and use electricity. Even though more businesses started using solar, not many families took up solar because of a lack of proper information, complex processes, and insufficient advertising.

In 2016, to solve some of these problems, a gross metering system was put in place mainly for bigger facilities. At the same time, there were still worries about delayed approvals, the integration of electricity grids, and a lack of open data in energy accounting. These procedural inefficiencies significantly reduced the scheme's appeal, especially to individual households.

These findings indicate that net metering will only work if users find it easy to use, are kept well-informed, and if local installers and communities are regularly involved. Even policies that appear to be well-written can fail if there is no support for their implementation.

Utility Pricing and Financial Burdens (Gajjar *et al.*, 2019) [5]: Gajjar *et al.* (2019) [5] explored how rooftop solar adoption affects electricity distribution companies (DISCOMs), with a focus on BESCOM in Karnataka. The analysis found that high levels of rooftop solar might result in an increase of retail tariff by Rs. 0.68 to Rs. 2.32 per kWh over the next seven years. It is mainly due to higher electricity purchasing costs and a lower income from selling old-style electricity.

They point out that while rooftop PV is good for consumers, it can cause financial difficulty for utilities facing challenges. What this means is DISCOMs should try to link their customers' rewards with the sustainability of their operations. The authors advise improving how the network operates and adjusting the tariff rates to ensure that consumers and the utility sector both benefit.

This study adds a critical perspective to the policy discourse, highlighting that incentives for one group (consumers) can unintentionally create burdens for another (utilities), necessitating a more balanced regulatory approach.

How policy incentives help or hinder people's decisions to use new energy technologies: In many places, including Karnataka, it seems that policies can drive more people to use solar on their rooftops; however, these incentives need to be designed and used properly to achieve results. Financial subsidies and feed-in tariffs increase the attractiveness of investment, while net metering provides operational returns that further improve payback periods (Ghosh *et al.*, 2015; Martin & Ryor, 2016) [6, 10].

Nevertheless, flaws in designing policies, such as setting high limits, introducing delays in processes, and resistance from DISCOMS, usually nullify these advantages in practice. It has been shown that adoption behaviour is not only related to money. Trust in the policy framework, ease of access to information, and transparency in billing also matter significantly (Stanford, 2014; Zitelman, 2017) [16, 19]. The value of being clear, consistent, and involving stakeholders is highlighted by success stories from other states in India and from abroad. It involves Karnataka looking past incentives to concentrate on smoother procedures, better DISCOM working, and ensuring that its policy improvements are sustainable.

Policy Analysis

1. **Government Subsidies:** The Government of India, through the Ministry of New and Renewable Energy (MNRE), offers capital subsidies under schemes like the Grid-Connected Rooftop Solar Program. In Karnataka, these subsidies have been implemented in conjunction with support from the Karnataka Renewable Energy Development Limited (KREDL). The MNRE initially provided up to 30% capital subsidy for residential installations of up to 3 kWp, which significantly reduced upfront costs (Ghosh, Nair, & Krishnan, 2015) [6].

   In Bengaluru, the KREDL and Karnataka Electricity Regulatory Commission (KERC) offered feed-in tariffs of Rs. 9.56/kWh (without MNRE subsidy) and Rs. 7.20/kWh (with MNRE subsidy), making rooftop PV financially attractive on paper (Ghosh *et al.*, 2015) [6]. Because of these incentives, some efficient systems were built for high-demand residential and small-scale commercial users. However, delays in releasing subsidies, poor knowledge about the programme, and a complicated application process have made fewer people apply for them.

   Despite the fact that subsidies make solar more financially worthwhile, the industry has struggled due to difficulties in granting funds and long delays in approvals. The results suggest that subsidies are important, but they should be used with easy and clear approaches to benefit those who need them and grow the use of solar energy in the country.
2. **Net Metering Regulations:** The government introduced net metering in Karnataka in 2014, and it has been expanded to cover a variety of consumers. Users could sell any extra electricity they generated back to the grid and receive credits for it. Special limits were set by regulators on the utility's exposure to financial risks. Specifically, RTPV installations were limited to 75% of

the sanctioned load for a consumer, effectively curtailing the system size and economic returns for high-potential users (Ghosh *et al.*, 2015) [6].

Thanikonda and Krishnan (2017) [6] found that while net metering regulations were moderately successful among commercial and industrial users, residential uptake remained slow. Some of the issues were not enough people knowing about solar energy, scarcity of trained installers, and frequent delays in doing inspections and giving the green light to meters. Although a new gross metering choice was introduced in 2016, it did not pick up popularity because the buy-back prices were low, and there was hesitance from power companies.

Martin and Ryor (2016) [10] further highlighted that net metering adoption in Bengaluru was hindered not by technical issues but by institutional challenges. The benefits were not clear to residential users, so BESCOM and other DISCOMs avoided pushing this scheme as it might mean losing their highest-paying customers. It means that regulations alone cannot solve all the problems. For net metering to be successful, it needs to be planned carefully, promoted well, and stakeholders must be more united.

3. **Tariff and Financial Framework:** The rooftop solar tariff structure in Karnataka has evolved between feed-in tariffs (FiTs) and net metering-linked retail tariffs. Initially, the FiT model offered generous compensation rates (up to Rs 9.56/kWh), incentivising adoption. With time, attention shifted to net metering, which paid consumers a fee linked to their normal electricity tariff.

Gajjar *et al.* (2019) [5] found that while this approach promoted equity and decentralised generation, it placed significant financial stress on BESCOM. According to the study, retail electricity rates could increase from Rs. 0.68/kWh to Rs. 2.32/kWh over the next seven years due to higher costs of procuring power and income losses from a decrease in grid consumption by prosumers.

In comparison, Delhi and Gujarat have changed their strategies to give equal focus to the environment and to making electricity affordable for people. The Delhi state permits group net metering, and community solar in Gujarat now uses more innovative methods of metering. These models provide a more flexible and resilient approach to managing tariff risks (Narula & Reddy, 2015) [12]. In conclusion, while feed-in tariffs support initial increased use of solar, they are not sustainable for the long term if there are no cross-subsidies. Introducing dynamic tariff schemes with time-of-use rates, charges for grid use, or value-of-solar systems will ensure both consumers and DISCOMs have a stable financial situation. Table 1 compares the main solar policies of leading Indian states to demonstrate how Karnataka compares to them.

Table 1: Comparative Analysis of Rooftop Solar Policies across Indian States

State	Net Metering (Yes/No)	Subsidy (% Residential)	Tariff Compensation (₹/kWh)	Capacity Cap (% of Load)	Implementation Transparency
Karnataka	Yes	30%	7.20	75%	Moderate
Gujarat	Yes	40%	7.00	No Cap	High
Delhi	Yes	30%	5.50	100%	High
Maharashtra	Yes	20%	6.00	80%	Moderate
Tamil Nadu	Yes	25%	6.25	90%	Moderate

Source: *Compiled from state energy department websites, regulatory commission documents, and secondary literature (2023–2024).*

Methodology

1. Literature Review (LR)

In this study, the authors carry out a literature review to form a baseline view of rooftop solar use in Karnataka, with a specific focus on how subsidies, net metering, and tariffs impact its growth. Peer-reviewed journal papers, policy white papers, official government documents, and industry reports were all reviewed and analyzed in the study. Studies and data found in well-regarded academic databases and official sources were considered most important to attain accuracy and relevance.

It was designed to find overarching themes, notice recurrent issues, and identify where researchers agree in the current literature. For instance, Sarangi (2021) [15] performed a comprehensive mapping of policy strengths across Indian states and found that Karnataka was relatively progressive but still faced hurdles such as financial risk to consumers in capital expenditure (CAPEX)-based models. Similarly, Ghosh, Nair, and Krishnan (2015) [6] provided critical insights into the financial viability of rooftop systems in Bengaluru, showcasing how state-led incentives significantly influence adoption but are limited by policy design constraints like capacity caps.

According to the analysis, institutional challenges and spotty regulations are often pointed out as the main reasons for poor scaling. Dhingra, Sengar, and Sajith (2023) [2] categorised barriers into five groups—financial, institutional, technical, location-based, and market-driven—and used analytical hierarchies to prioritise these challenges. The findings from these studies helped to form the analytical framework used in this paper and to recognise areas where targeted policy analysis can help.

2. Policy Analysis

To complete this study, policy analysis is focused on Karnataka's rooftop solar energy system. This includes a critical review of solar policies and regulations implemented by key institutions such as the Karnataka Electricity Regulatory Commission (KERC), Karnataka Renewable Energy Development Limited (KREDL), and the Ministry of New and Renewable Energy (MNRE) at the central level.

Policy documents were evaluated using four key criteria:

i). **Clarity:** Whether the policy goals, eligibility requirements, and implementation steps are clearly articulated.

ii). **Effectiveness**: The degree to which the policy achieves its stated objective, such as increasing installed capacity or reducing costs.

iii). **Financial Viability:** Assessment of how tariff rates, subsidies, and net metering provisions impact consumer ROI and utility revenues;

iv). **Barriers to Implementation:** Identification of

administrative delays, regulatory loopholes, and utility resistance.

Ghosh *et al.* (2015) [6] noted that despite attractive feed-in tariffs, a cap imposed by BESCOM limiting RTPV systems to 75% of consumer load hindered expansion. Sarangi (2021) [15] emphasised the inconsistency in policy strength among Indian states and argued that Karnataka's policy was relatively strong but faced issues in consumer risk allocation and business model diversity.

The analysis also considered how state and central schemes affect each other. For example, MNRE's capital subsidy mechanisms are often not effectively aligned with state disbursement practices, causing confusion and delay at the consumer level (UmarTariq, 2017) [18]. Moreover, Dutta *et al.* (2024) argued that the lack of standardised solar mapping and data transparency hinders localised planning and rollout of rooftop systems. Integrating these policies, the paper tries to find problems facing rooftop solar and offer effective solutions for Karnataka.

Discussion

Integration of Literature Findings with Policy Evaluation: From the literature and policy analysis, it appears that the rooftop solar programme in Karnataka is guided by ambitious targets but has difficulties in carrying them out. Financially, policies like MNRE capital subsidies and KREDL's feed-in tariff offerings were designed to make RTPV attractive (Ghosh, Nair, & Krishnan, 2015) [6]. Additionally, policies such as net metering and changes to energy tariffs were put in place to encourage both residential and commercial use.

Literature, on the other hand, raises several concerns. Studies such as Martin and Ryor (2016) [10] emphasise that despite a robust regulatory framework, limited public awareness and procedural delays have curtailed widespread adoption. Gajjar *et al.* (2019) [5] further demonstrate that utilities like BESCOM experience significant financial strain due to lost revenues from reduced grid consumption, despite long-term cost savings from solar adoption. When seen together, these observations clash with one another. Although the policies are well-made, they do not work well in practice due to inefficient institutions and a lack of consumer involvement. When results are not as planned, it shows that the system needs to be adjusted.

Differences between Planned and Practical Steps: While Karnataka was an early state to offer net metering and favourable tariffs, installations of rooftop solar panels are still much less than originally projected. Ghosh *et al.* (2015) [6] estimated a 560 MW potential for Bengaluru alone, yet implementation lagged far behind. Potential advantages for the RTPV scheme are being held back due to BESCOM only allowing RTPV systems to provide 75% of a consumer's contracted power level. Martin and Ryor (2016) [10] highlight that residential users, in particular, faced ambiguity regarding approval processes, limited access to certified installers, and poor visibility into grid integration procedures. Such problems make it hard for new users to trust the system.

Dhingra, Sengar, and Sajith (2023) [2] further point out that regulatory uncertainty and bureaucratic red tape are leading institutional barriers. Despite the state pushing for RTPV, misalignments in actions among KERC, KREDL, and BESCOM have made it difficult for RTPV to succeed. Based on available studies and information from government policies, the main hurdles to Karnataka rooftop solar adoption are shown in Table 2.

Table 2: Key Barriers to Rooftop Solar Adoption in Karnataka

Barrier Category	Examples	Severity
Financial	High upfront costs, delayed subsidy disbursal	High
Institutional	Coordination issues between KERC, KREDL, and BESCOM	High
Technical	Limited installer availability, grid readiness	Medium
Regulatory	Capacity cap, lack of dynamic tariffs	High
Consumer Awareness	Low awareness about net metering, process complexity	Medium

Source: *Synthesised from literature and policy analysis (Ghosh et al., 2015 [6]; Martin & Ryor, 2016 [10]; Dhingra et al., 2023) [2].*

Economic and Regulatory Barriers to Faster Adoption

Because the initial costs are still high, and there are uncertainties about earnings, subsidies and feed-in tariffs have not solved the problem of economic feasibility. Gajjar *et al.* (2019) [5] found that rooftop penetration increases BESCOM's retail rate by up to Rs. 2.32/kWh, creating resistance from utilities toward RTPV adoption. For this reason, utilities have been reluctant to join in implementing net metering. Regulatory rigidity further limits progress. The 75% capacity cap, lack of time-of-day tariffs, and resistance to peer-to-peer energy models restrict the evolution of innovative RTPV models (Thanikonda & Krishnan, 2017) [6]. Even with government incentives, lower-income individuals are not able to participate when there is not enough third-party financing or lease options available. Studies from other Indian states and abroad show that factors like information accessibility, simplified approval processes, and performance-based incentives significantly influence adoption behaviour (Stanford, 2014; Lemay & Rand, 2023) [16, 9]. Failing to handle these matters comprehensively reduces the success of Karnataka's policies.

Assessing How Karnataka's Strategy Compares to the Best Practices

Although the foundation for development is much stronger in Karnataka, the state has advanced more slowly than Gujarat and Delhi. Gujarat's innovative utility-driven rooftop programmes and Delhi's promotion of group net metering and simplified subsidy flows have shown better adoption metrics (Narula & Reddy, 2015) [12].

Internationally, countries like Germany and Australia have complemented policy incentives with seamless implementation, extensive consumer education, and DISCOM-neutral models (Pacudan, 2018) [13]. Its model depends entirely on BESCOM and other utilities whether they want to cooperate or not, even if there are no financial motivations for them.

Additionally, while Karnataka offers high solar potential and decent grid infrastructure, it lacks a robust consumer-facing digital portal for tracking approvals, meter installations, and subsidy flows—a standard now in many global programmes (Mathew & Pandian, 2024) [11].

To address this mismatch, Karnataka should follow the best practices used in open regulation, incentives for utilities, and helpful customer assistance.

Recommendations

i). **Make the Rules for Subsidies and Net Metering More Understandable to Consumers:** In spite of Karnataka's advances, reports and surveys reveal that several

residents have not learned about the benefits or the procedures for rooftop solar in their homes. Martin and Ryor (2016) [10] found that the lack of effective information campaigns significantly slowed residential adoption in Bengaluru. Similarly, Dhingra *et al.* (2023) [2] emphasised that informational barriers — including confusion over eligibility, technical requirements, and application steps — remain one of the top five adoption deterrents across India.

To solve this, Karnataka's authorities, like KREDL and KERC should focus on educating people through programmes in different languages, using online resources, and arranging workshops. The success of Delhi's "Solar Rooftop Portal", which integrates application tracking and consumer support, could serve as a model. It is important that all digital platforms provide up-to-date information on the disbursement of subsidies, connectivity for net metering, and the process of resolving complaints.

ii). **Change/remove limits on how many people can be adopted to ensure more flexibility:** The cap restricting rooftop solar systems to 75% of the consumer's sanctioned load has emerged as a major barrier to broader adoption in Karnataka. Ghosh, Nair, and Krishnan (2015) [6] found that this restriction undermines the potential of high-generating users and discourages investment in larger systems. As a result, rooftop solar is less able to make a significant contribution to the state's energy supply.

If the export cap is lifted or made more flexible for prosumers, it would further increase the uptake of solar technology by commercial and institutional customers. As seen in states like Gujarat and international examples like Germany, higher capacity limits foster better economics and grid integration when combined with smart metering and forecasting tools (Pacudan, 2018) [13].

iii). **Consider flexible tariff schemes to help maintain the utility's operations and encourage people to use less energy:** Net metering, with the retail rate paid by Karnataka utilities, is causing problems and disagreements between the utilities and consumers. Gajjar *et al.* (2019) [5] projected an increase in retail tariffs of up to Rs. 2.32/kWh for BESCOM due to lost revenue from rooftop penetration. Ensuring the long-term health of the nation means the state needs to use flexible tariff structures.

- **Time-of-day pricing**, where exports during peak hours are rewarded more;
- **Value-of-solar tariffs**, which reflect the locational and temporal grid benefits of solar generation;
- **Fixed service fees** for grid maintenance, regardless of energy exports.

These hybrid models, already used in parts of the U.S. and Europe, balance economic viability for utilities while still incentivising consumers to adopt solar.

iv). **Improve Transparency in the Implementation Process:** Many policy intentions fail during execution due to bureaucratic inertia, lack of accountability, and poor monitoring mechanisms. As highlighted by Mathew and Pandian (2024) [11], procedural opacity — particularly in inspections, net metering approvals, and subsidy releases — erodes public trust and discourages adoption.

Karnataka must prioritise transparency by:

- Mandating service-level agreements (SLAs) for utility approvals;
- Launching real-time dashboards for application status;
- Publishing periodic implementation reports accessible to the public.

This will not only improve public perception but also enable data-driven policy tweaks in real time. Effective examples include Maharashtra's integrated utility portal and Delhi's open-data initiatives, which empower consumers and policymakers alike.

Conclusion

The state of Karnataka's rooftop solar energy sector is a result of early policy steps and strong determination from its institutions. Net metering, attractive feed-in tariffs, and capital aid from government agencies through different programmes greatly contributed to more energy being generated at the local level. These policies have played a crucial role in laying the groundwork for the rooftop photovoltaic (RTPV) sector in Karnataka, providing consumers with financial and regulatory motivation to transition to solar energy.

Even with this good start, the use of rooftop solar systems has not reached the levels expected. Despite having high technology and solar resources, especially found in Bengaluru, the current policy has failed to significantly increase solar installations. The problem is due to difficulties in executing their vision, issues with the design of apps, and different kinds of bottlenecks that make it inconvenient for users.

Many are concerned about policies that put limits on capacity, for instance, by only allowing a system to be 75% of what a consumer is allowed to use. As a result, this rule makes it less attractive for major users in the commercial and industrial areas to use rooftop solar energy. Moreover, giving out subsidies is carried out in a confusing manner and takes too much time, leading to less consumer trust in support initiatives. Even with promised financial benefits, the time-consuming approval steps and paperwork make it less acceptable for middle-income homes.

BESCOM and other utilities are also under financial pressure because of reduced income from net metering and decentralised generation. If utilities do not make changes to ensure they can operate sustainably, they tend to act as passive players or even resist being part of the rooftop solar space. As a result of this difference, growing and maintaining distributed energy programmes becomes more challenging.

For rooftop solar to flourish in Karnataka, the government needs to update policies and handle the main problems that arise in its operation and cost. To begin, it is important to simplify subsidy programs and digitalise their approval process so that aid is delivered faster, less red tape is involved, and people can view their application on the spot. The net metering scheme needs to be improved so that it allows more flexibility. Among these measures are taking off fixed power limits, making it possible for households to trade energy with each other, and developing group metering for residents of apartment blocks or shared rooftops.

Additionally, Karnataka should test different types of pricing schemes that reward consumers while also supporting the earnings of utilities. Using time-of-day rates, solar pricing, or grid care charges helps to fairly reward distributed generation without harming the finances of utility companies. They will make it possible for rooftop solar to depend less on subsidies

and be taken up more widely in the industry.

Finally, increasing transparency, spreading information among consumers, and joint efforts among different agencies will play a major role in making sure policy goals are met. To become a leader in rooftop solar, Karnataka will need to make significant changes to its policy implementation. Making strategic changes today can guarantee a fair, lasting, and efficient supply of energy in the days to come.

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