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Gujarat's Solar Revolution: A Comprehensive Analysis of the Implementation of Solar Roof Top System Under PM Surya Ghar Muft Bijali Yojna

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Abstract: ***Gujarat has emerged as a frontrunner in India's renewable energy transition, especially in the realm of rooftop solar (RTS) adoption. This paper delves into the intricate ecosystem of RTS in Gujarat with a special focus on the PM-Surya Ghar: Muft Bijli Yojana, the challenges that have surfaced after its implementation, and the prospects brought forth by the new PM-Surya Ghar: Muft Bijli Yojana. Employing a mixed-methods approach that includes policy analysis in the different States of India, the study focused on the effectiveness of State's Policies. It further identifies key barriers to widespread adoption and provides a comparative assessment of state and central government schemes. The research finds that, though Gujarat's initiatives have significantly advanced solar capacity in the state, ongoing impediments such as protracted subsidy disbursal, financing challenges, and grid integration issues remain. The recently launched PM-Surya Ghar Scheme offers a promising alternative, but its success depends on improved alignment with existing state policies to ensure smooth implementation. The study concludes with strategic recommendations, emphasizing the need for expedited subsidy processes, enhanced public awareness, and stronger policy coordination across governance levels.***

Keywords: Rooftop solar, Surya Gujarat Yojana, PM-Surya Ghar, renewable energy policy, solar subsidies, net metering

1. Introduction

India's commitment to renewable energy is reflected in its ambitious target of reaching 500 Gigawatts of installed capacity by 2030, with rooftop solar expected to contribute a crucial 100 Gigawatts to this goal. Gujarat is a leader in this journey, owing to its early policy initiatives, such as the groundbreaking Charanka Solar Park and the widely cited policies like Solar Policy 2009, Gujarat Solar Power Policy 2015 and, Residential Solar Rooftop Systems Scheme 2016, Gujarat Solar Power Policy 2021 and Gujarat Renewable Energy Policy-2023. These policies set a model for other states and positioned Gujarat as a pacesetter for both utility-scale and distributed solar generation.

Among the various solar initiatives, rooftop solar systems are crucial for urban sustainability, reducing dependence on traditional energy sources, and lowering carbon emissions. revolution (GEDA, 2021; MNRE, 2022).

The state's rapid advances in RTS are not merely a result of favourable policies but also stem from the sector's critical role in reducing technical and financial losses suffered by electricity distribution companies (DISCOMs). Furthermore, RTS empowers consumers by enabling them to produce and manage their own power, thereby contributing to greater energy democracy.

The present research paper aims to assess the actual status of RTS adoption in Gujarat, analyse the roll-out, and outcomes of the Solar Roof top Systems, and scrutinize the persistent challenges that have surfaced since implementation including issues related to subsidies, grid management, and the behavioural patterns of consumers. A comparative lens is employed to examine the intersections and redundancies among the states of India with respect to newly announced central government program, the PM-Surya Ghar Yojana.

To address these questions, the study adopts a Desk research strategy. It draws data collected from secondary sources including government reports, academic journals, and policy analyses from credible institutions such as GEDA, MNRE, and CEEW.

2. Methodology

Relevant information from open-source or grey literature is needed for this type of comprehensive review. A framework based on keyword searches is combined with an intensive approach to data management. For determining the keywords, thorough discussions are first held. These discussions inform the selection of the keywords used to collect data from open-source and gray literature. In this context, technical reports, policy-related papers, and online resources are commonly referred to as grey literature, whereas scientific articles published in recognized journals and conferences are considered open-source literature.

During data collection, it is ensured that preferably peer-reviewed articles from the database would be considered. Only relevant publications which were carefully selected are considered during the initial screening, even though thousands of papers were discovered throughout the open-source literature searches. The articles which had been determined inappropriate for this review work were dropped and after these shortlisted articles were further preparatory processing. Some articles have been eliminated through the screening process. A manual process was carried out for

assessing the articles' acceptability for the review during the screening process. Following this procedure, the articles deemed most appropriate for gathering data were included to the overall analysis. The technical reports of relevant organizations and the official and supportive web sites maintained by different Government and Private sector organizations related to energy, the environment, policy, and economic development have been identified as offering information relevant to grey literature.

3. Data Review and Analysis

Installation of Rooftop Solar (RTS) on a huge scale is among the most notable initiatives, as in such plants, land is not required and energy is consumed where it is generated; there would be no element of transmission loss or wheeling loss, and such plants would be in interest of public at large as well as State utilities. The PM Surya Ghar - Muft Bijli Yojana is a unprecedented step taken from the central Government of India, aimed at accelerating rooftop solar adoption across residential households. This ambitious initiative aims to install rooftop solar panels on one crore households across the country, significantly reducing household electricity costs and decreasing dependency on conventional energy sources. (pib.gov.in)

Key Features of PM Surya Ghar: Muft Bijli Yojana.
Gujarat has implemented progressive solar policies since 2009, with significant revisions in 2015 and 2021 to enhance efficiency and consumer participation. Policy for Net metering encouraged adoption of solar roof top System in residential and industrial sector, while DISCOMs (Distribution Companies) have vital role in integrating solar energy into the grid. Financial incentives, including subsidies, tax benefits, and incentives, have further propelled rooftop solar installations (GEDA, 2021; NITI Aayog, 2021).

The PM Surya Ghar: Muft Bijli Yojana provides households with free electricity through subsidised rooftop solar panels, enabling beneficiaries to generate and use up to 300 units of power each month while significantly reducing their energy costs. By encouraging widespread adoption of solar energy, the scheme also lowers the Government's electricity expenditure, promotes the use of renewable energy, and supports national sustainability goals. Additionally, the transition to solar power helps reduce carbon emissions, contributing to India's broader efforts to minimize its carbon footprint.

Parameters	Details
Scheme name	Pradhan Mantri Surya Ghar: Muft Bijli Yojana
Launch date	February 2024
Financial outlay	INR 75,021 crore
Target	30 GW of residential rooftop solar capacity
Households covered	1 crore (10 million)
Target year	FY2027
Status (November 2025)	6.9 GW of installed RTS capacity across approximately 2.3 million households. More than 13,000 Cr. subsidy released

The Pradhan Mantri Surya Ghar: Muft Bijli Yojana will be implemented through a two-tier system. At the national level, the scheme will be overseen by the National

Programme Implementation Agency (NPIA), while at the state level, State Implementation Agencies (SIAs) will be responsible for execution. These SIAs will consist of the Distribution Utilities (DISCOMs) or the Power/Energy Departments of the respective states and Union Territories. (DrishtiIAS, 2024).

Additional capital incentives across states for residential segment
To accelerate residential rooftop solar (RTS) deployment, many Indian States put in place a financial incentive that either supplement the central subsidy or independently support consumers.

States like Assam, Delhi, Goa, Uttar Pradesh, and Uttarakhand have introduced direct capital subsidies to offset high upfront installation costs. These subsidies are either offered as a fixed amount (ranging between INR 10,000-20,000 or USD 115-230 per kW) or total system cost percentage (ranging from 50% to 80%).

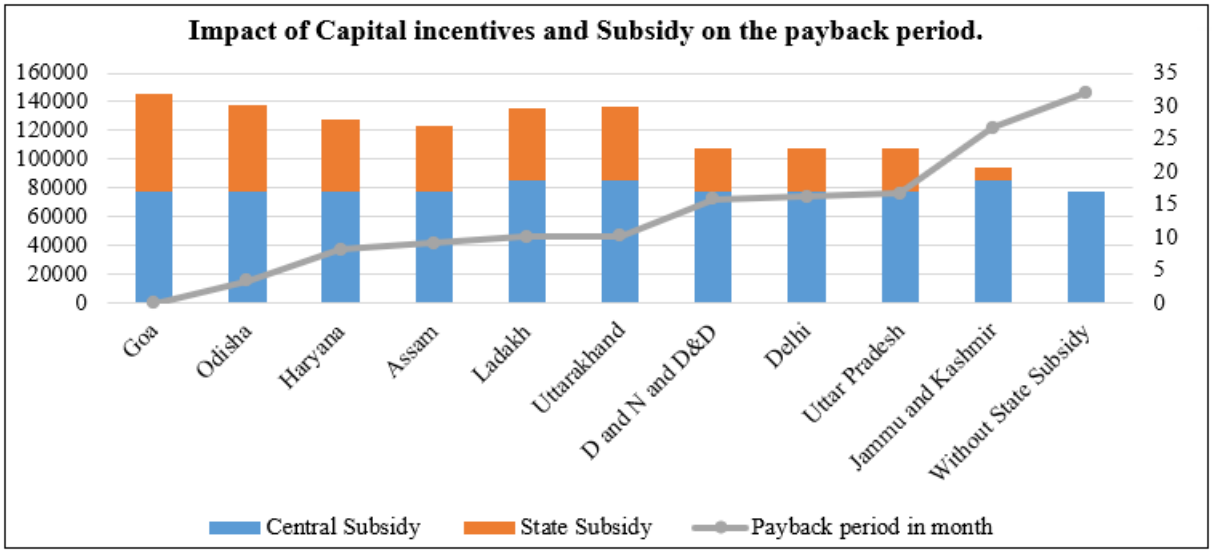
Some states also promote RTS through tax and duty exemptions. For instance, Andhra Pradesh is reimbursing 100% SGST for residential rooftop solar installations from 2024 to 2029, Telangana is providing 100% reimbursement from 2025 to 2035, and Uttarakhand is offering 50% reimbursement from 2023 to 2028. While states like Tripura, Delhi, and Mizoram also offer SGST exemptions, they have not specified the quantum or time-period. Madhya Pradesh incentivises rooftop solar by offering property tax exemptions for installations.

Sr No	States / UT	Additional Subsidy provided from State	Amount Rs/Kwh paid to the Consumers for Additional Unit Generated and Supplied to Grid
1	Uttar Pradesh	Rs 15,000/kW up to 2 kW	2
2	Haryana	Up to Rs 25,000/kW up to 2 kW (only for poor families)	Nil
3	Uttarakhand	Rs 23,000/kW for up to 1 kW; Rs 17,000/kW up to 3 kW	2
4	Goa	50% till 10 kW, 10% till 30 kW	3.71
5	Dadra and Nagar Haveli and Daman and Diu	Rs.10,000/kW up to 3 kW	3.99
6	Ladakh	Rs. 20,000 /kWp up to 2 kWp; Rs. 10,000/kWp for additional 1kW	4.18
7	Delhi	Rs. 10,000/kW up to 3 kW, generation-based incentive	3.00
8	Assam	Rs. 15,000/kW up to 3kW; capped at Rs. 45,000	5.33
9	Odisha	Rs 20,000/kW up to 3 kW	Nil
10	Jammu and Kashmir	Rs 3,000/kW up to 3kW	5.53

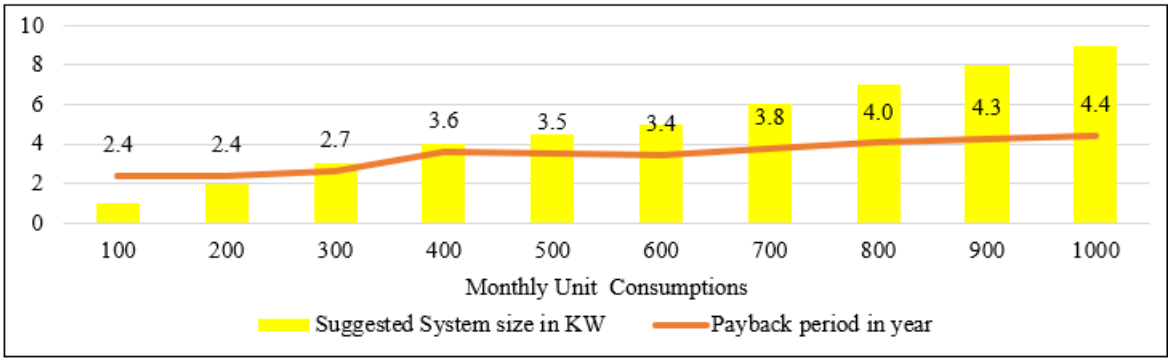
Impact of Capital incentives and Subsidy on the payback period.

Assumptions:

1) Rooftop System Size is 3 KW
2) Installation Cost (in Rs. For 3 KW System): 145000 or 159500 (i.e. Benchmark Cost as per MNRE)
3) 4 (Four) Units / Day / KW Generation from Solar Roof top system per day
4) Electricity Charge in 7 Rs /unit



The data shows that the combined effect of central and State subsidies have significant impact on the payback period for rooftop solar system installed in the various States of India. Goa offers the most attractive scenario, where high state support results in a zero-month payback period, meaning households recover their investment immediately. States such as Odisha, Haryana, Assam, Ladakh, and Uttarakhand also perform well, with substantial state subsidies reducing the payback period to under ten months. On the other hand, States like Delhi, U.P., and the Union Territories of Dadra & Nagar Haveli and Daman & Diu provide moderate subsidies, leading to payback periods between 16 and 17 months. Jammu & Kashmir, despite receiving a relatively higher central subsidy, has a long payback period of 27 months due to minimal state support. The absence of any state subsidy results in the longest payback period of 32 months, highlighting the critical role state-level incentives play in making rooftop solar financially viable for consumers.



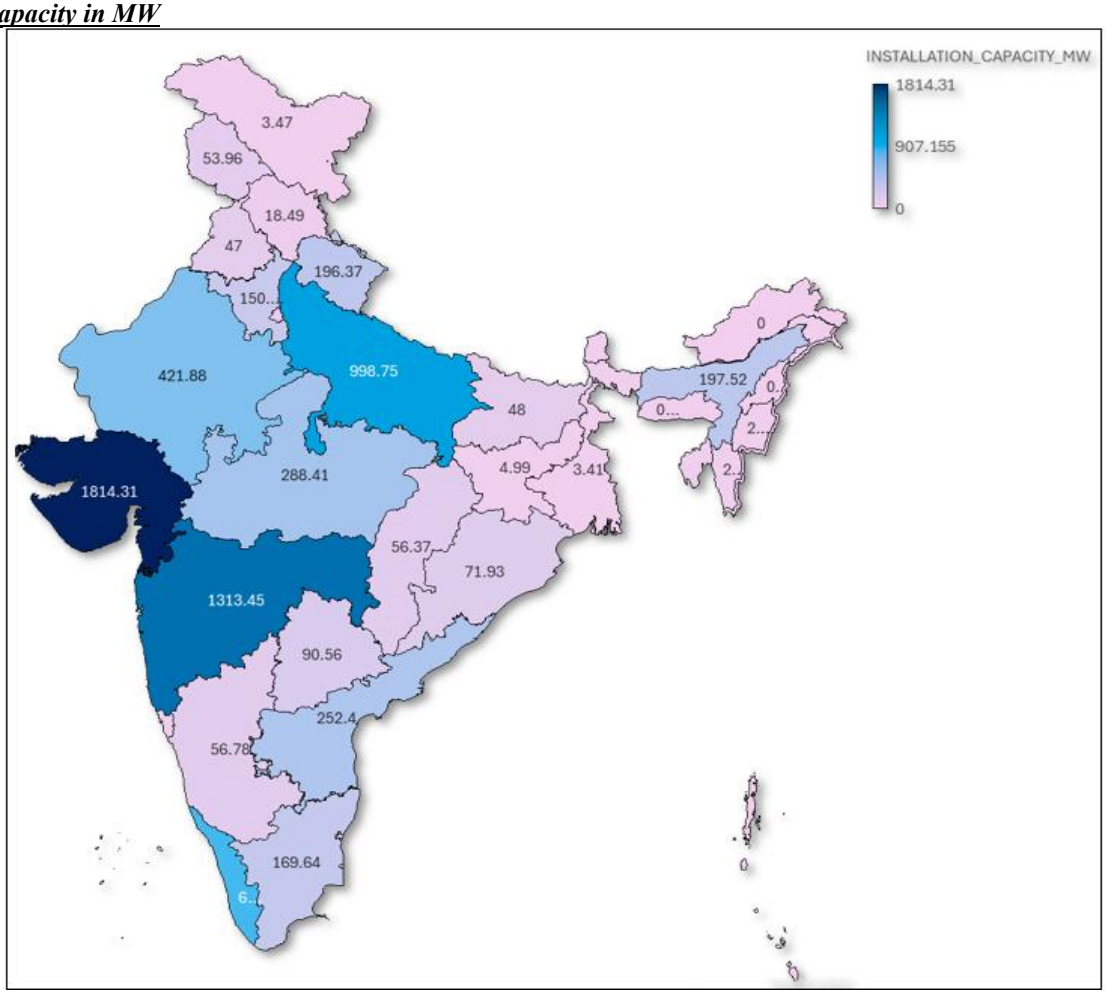
In other way the analysis based on the monthly unit consumptions of the consumers indicates that rooftop solar systems offer attractive payback periods across all consumption levels, ranging from just 2.4 years for smaller households to about 4.4 years for larger consumers. While higher consumption requires bigger system sizes and slightly longer recovery times, the investment remains financially viable and sustainable. Overall, adopting solar energy ensures consistent long-term savings, energy independence, and contributes meaningfully to clean energy transition.

State-wise RTS installed capacity under PMSGY

State	Application No (%)	Installation No (%)	Application to Installation Ratio
Gujarat	563046 (10.35%)	483708 (25.74%)	85.91%
Mizoram	856 (0.02%)	708 (0.04%)	82.71%
Tamil Nadu	60045 (1.10%)	47358 (2.52%)	78.87%
Kerala	224244 (4.12%)	164937 (8.78%)	73.55%
Lakshadweep	953 (0.02%)	667 (0.04%)	69.99%
Puducherry	2850 (0.05%)	1989 (0.11%)	69.79%
Ladakh	1496 (0.03%)	1040 (0.06%)	69.52%

State	Application No (%)	Installation No (%)	Application to Installation Ratio
Maharashtra	512905 (9.42%)	351183 (18.69%)	68.47%
Chandigarh	1427 (0.03%)	938 (0.05%)	65.73%
Uttarakhand	85592 (1.57%)	53873 (2.87%)	62.94%
Madhya Pradesh	123358 (2.27%)	75419 (4.01%)	61.14%
Punjab	17446 (0.32%)	10301 (0.55%)	59.05%
Himachal Pradesh	9520 (0.17%)	5340 (0.28%)	56.09%
Goa	2385 (0.04%)	1253 (0.07%)	52.54%
Manipur	1264 (0.02%)	654 (0.03%)	51.74%
Rajasthan	215533 (3.96%)	103864 (5.53%)	48.19%
Haryana	91110 (1.67%)	43534 (2.32%)	47.78%
Delhi	14010 (0.26%)	4904 (0.26%)	35.00%
Telangana	67666 (1.24%)	22804 (1.21%)	33.70%
Uttar Pradesh	971422 (17.85%)	288605 (15.36%)	29.71%
Bihar	52849 (0.97%)	13350 (0.71%)	25.26%
Dadra and Nagar Haveli and Daman and Diu	1913 (0.04%)	472 (0.03%)	24.67%
Nagaland	529 (0.01%)	127 (0.01%)	24.01%
Andaman & Nicobar Islands	600 (0.01%)	134 (0.01%)	22.33%
Tripura	7238 (0.13%)	1477 (0.08%)	20.41%
Jammu and Kashmir	79882 (1.47%)	14985 (0.80%)	18.76%
Jharkhand	7128 (0.13%)	1242 (0.07%)	17.42%
Chhattisgarh	96244 (1.77%)	14514 (0.77%)	15.08%
Odisha	163359 (3.00%)	22066 (1.17%)	13.51%
Assam	449644 (8.26%)	59954 (3.19%)	13.33%
West Bengal	11524 (0.21%)	1094 (0.06%)	9.49%
Karnataka	152952 (2.81%)	14180 (0.75%)	9.27%
Sikkim	226 (0.00%)	20 (0.00%)	8.85%
Andhra Pradesh	1449144 (26.63%)	72561 (3.86%)	5.01%
Meghalaya	1902 (0.03%)	31 (0.00%)	1.63%
Arunachal Pradesh	87 (0.00%)	1 (0.00%)	1.15%
Grand Total	5442349 (100.00%)	1879287 (100.00%)	34.53%

Installed Capacity in MW



At the national level, out of 54.42 lakh applications, only 18.78 lakh installations were completed, giving an overall conversion ratio of 34.53%, which indicates that nearly two-thirds of applicants do not progress to installation. Gujarat stands out as the strongest performer with both the highest number of applications and installations, achieving an impressive 85.91% conversion rate, followed by states such as Mizoram, Tamil Nadu, Kerala, Lakshadweep, and Puducherry, all showing high efficiency in converting applications into successful installations. In contrast, several states perform poorly, particularly Arunachal Pradesh, Meghalaya, Andhra Pradesh, Sikkim, Karnataka, West Bengal, and Odisha, where conversion ratios fall between 1% and 13%, reflecting major gaps in implementation.

Large states with high applicant volumes, such as Uttar Pradesh, Maharashtra, Rajasthan, Madhya Pradesh, and Bihar, show mixed performance. Uttar Pradesh, despite receiving over 9 lakh applications, converts less than 30%, whereas Maharashtra performs relatively well with nearly 60% conversion. Overall, the data shows clear regional disparities, with western and southern states generally performing better, while many northern, eastern, and northeastern states lag significantly. This indicates the need for targeted interventions, better follow-up mechanisms, and strengthened execution processes to improve installation efficiency nationwide.
Gujarat has witnessed exponential growth in rooftop solar installations, with key urban centers such as Ahmedabad, Surat, and Vadodara leading the adoption. Statistical analysis shows a steady increase in installed capacity, supported by the State Agency like Gujarat Urja Vikas Nigam Limited and Gujarat Energy Development Agency (GEDA). Case studies of successful RTS projects highlight environmental as well as economic benefits for consumers (MNRE, 2022; Sharma & Mehta, 2020).

The adoption of rooftop solar has led to significant reductions in electricity costs for households and industries. It has critical role to play in mitigating Gujarat's energy deficit, ensuring power reliability. Environmentally, rooftop solar has contributed to reducing carbon footprints and aligning with India's climate goals. Additionally, it has created numerous jobs, boosting local economic growth (IRENA, 2020; World Bank, 2022).

Comparative analyses reveal that Gujarat's policy ecosystem has stayed ahead of most Indian states. The rapid adoption of residential solar technology (RTS) in Gujarat can be understood through its organic spread among various consumer segments. Previous solar programs in Gujarat established a positive policy environment that boosted consumer trust and ensured institutional stability. As a result, these factors made subsequent programs more effective.

Despite this robust policy legacy, there are notable research gaps. Few studies systematically address post-installation challenges such as the delay in subsidy disbursement, ongoing maintenance, and consumer service issues. Even fewer compare the nuances of state-led schemes with central government offerings—an area where this paper seeks to contribute.

4. Findings & Discussion

The Surya Gujarat Yojana has, by all accounts, played an instrumental role in scaling up adoption. The program offers a 40% subsidy for residential users (capped at 3 kW), a simplified net metering approval process that promises a sanction within seven days, and targeted outreach campaigns. More than 200,000 households have taken advantage of this scheme between 2020 and 2024, typically realizing a 20–30% reduction in their monthly electricity bills.

Before the launch of the PM Surya Ghar: Muft Bijli Yojana (PMSG: MBY) in February 2024, rooftop solar adoption was concentrated in the C & I segment (i.e. commercial and industrial), while the residential sector lagged due to high upfront costs and limited awareness. PMSGY addressed this gap by offering capital incentives and simplified procedures to make rooftop solar financially attractive for households.

In terms of Solar Rooftop installed capacity, Gujarat stands firmly at the forefront. As of November 2025, India had collectively installed about 22 GW of residential rooftop solar capacity, of which about 6.9 GW has been added under the PMSGY. This accounts for approximately 30% of the country's total residential rooftop capacity, achieved in just 22 months of the scheme's launch.

Financially, the upfront investment required for RTS, even after subsidies, remains significant for many households and small enterprises. The absence of widely available low-interest loan products further constrains adoption.

To accelerate residential rooftop solar deployment, several states have implemented financial incentives that either supplement the central subsidy or independently support consumers. States like Assam, Delhi, Goa, Uttar Pradesh, and Uttarakhand have introduced direct capital subsidies to offset high upfront installation costs.

Domestic Content Requirement (DCR) mandate: The MNRE has mandated that all ALMM-listed manufacturers are required to register their production facilities and upload their solar PV cell and module data on the Domestic Content Requirement (DCR) verification portal6. All past data from 1 January 2024 onward must be submitted on the portal. From 1 December 2024, only those modules whose DCR credentials are verified through the portal will be permitted under MNRE schemes, including PMSGY, Central Public Sector Undertaking (CPSU) Scheme Phase-II, and Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM).

A unified methodology has been created under this mandate, for the authentication of DCR compliance, with which unauthorised use of non-domestic components is expected to be reduced. However, it may add an additional compliance burden on manufacturers and temporarily constrain module availability.

The subsidies provided under PMSGY for rooftop solar installations have significantly reduced the payback period to 30 months for 3 kW rooftop solar systems, in contrast to approximately 54 months in the absence of any subsidy

support. Where additional state-level subsidies have been introduced, the payback period has been further reduced, as reflected in the figure below. The additional subsidies provided by states are intended to boost rooftop adoption within their respective jurisdictions.

Owing to the benchmark prices set by the Ministry of New and Renewable Energy (MNRE), a 3 kW rooftop solar system costs between ₹1,45,000 and ₹1,59,500 to install. Such a system is capable of generating approximately 4 units of electricity per day per kW, resulting in a total daily output of 12 units. At an average tariff of ₹7 per unit, this generation translates into substantial savings on electricity expenses. With the inclusion of a central subsidy of ₹78,000, the effective investment cost is significantly reduced. Furthermore, every additional subsidy of ₹10,000 reduce the payback period by nearly five months, thereby enhancing the financial viability and attractiveness of the rooftop solar installation.

The analysis demonstrates that a 3-kW rooftop solar system is a highly viable investment, with a payback period of just 2–3 years depending on installation cost. The inclusion of subsidies significantly accelerates cost recovery, and incremental subsidies further shorten the payback horizon. With annual returns exceeding 35–45%, rooftop solar offers both economic and environmental benefits, making it an attractive option for residential and commercial consumers.

Advancements in smart grids and digital technologies can optimize solar energy utilization. Enhancing policies to streamline the adoption process and increasing public awareness can further drive participation. Technological innovations in photovoltaic cells and battery storage will improve efficiency. Expanding solar parks and integrating hybrid renewable energy projects can ensure Gujarat remains a front runner in the shift to Energy transition of India (NITI Aayog, 2021; World Bank, 2022).

5. Conclusion & Recommendations

In summing up, Gujarat's rooftop solar revolution serves as a learning experience for other Indian states., demonstrating the role of progressive policies and public-private partnerships. Gujarat's progress in rooftop solar has been driven by progressive policies, targeted subsidies, and mature administrative processes. This progress has some challenges like, operational gaps, most notably in subsidy disbursement and rural outreach. The findings emphasize the importance of continued investment and innovation in solar energy to achieve long-term sustainability and energy independence.

The PM-Surya Ghar scheme offers the potential to further democratize solar adoption but needs to be woven more closely into state-level operations to avoid creating parallel bureaucracies.

To overcome these challenges, recommendations emerge from the research. Central and state Governments should prioritize the creation of a streamlined, single-window clearance mechanism for all solar subsidies, thereby minimizing bureaucratic friction. Financing accessibility must be improved by blending capital subsidies with affordable loan products. On the technical front, investment in smart grid integration along with Storage facility and the establishment of standardized maintenance protocols are essential to long-term reliability.

Equally important is a sustained investment in awareness campaigns, which should be multilingual and tailored toward rural audiences. DISCOMs are uniquely positioned to lead community workshops to promote the benefits of rooftop solar. Future research may concentrate to investigate the long-term financial health of DISCOMs given the changing revenue landscape and explore the potential for community solar models, especially in rural Gujarat.

However, despite these successes, the scheme grapples with persistent issues. Most notably, subsidy disbursement has suffered delays ranging from six to eight months, discouraging potential participants. Due to low knowledge and inadequate outreach initiatives, rural areas lag the metropolitan city. Meanwhile, technical bottlenecks continue to pose challenges: high-density solar generation has at times led to grid instability, and maintenance costs for inverters remain a concern.

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