A QUANTITATIVE REVIEW OF ROOFTOP SOLAR PHOTOVOLTAIC DEPLOYMENT IN INDIA WITH CASE STUDY OF MYSURU, KARNATAKA, INDIA

O RECENZIE CANTITATIVĂ A IMPLEMENTĂRII PANOURILOR SOLARE FOTOVOLTAICE PE ACOPERIȘURI ÎN INDIA CU STUDIU DE CAZ AL ORAȘULUI MYSURU, KARNATAKA, INDIA

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Abstract: *India's rooftop solar photovoltaic (RTS PV) sector is crucial for meeting its national renewable energy target of 280 GW by 2030. Despite favorable solar irradiation and ambitious schemes such as the PM Surya Ghar Yojana and the Grid-Connected Rooftop Programme, India's installed RTS PV capacity reached only 11 GW by early 2025, far below policy targets. This paper presents a comprehensive quantitative review of the RTS PV landscape in India, contrasting national and regional progress with a focused analysis of Mysuru, Karnataka. Using secondary data from the Ministry of Renewable Energy (MNRE), the International Energy Agency (IEA), Solar Energy Corporation of India Limited (SECI), and recent policy assessments, the study identifies gaps in deployment, explores barriers in financing, grid integration, and public awareness, and proposes policy and technical interventions. The Mysuru case study highlights district-level dynamics that shape RTS adoption. Findings suggest that leveraging local incentives, simplifying approval processes, and incentivizing the participation of Distribution Companies (DISCOMs) are essential for accelerating the scale-up of RTS.*

Keywords: Rooftop solar photovoltaic (RTS PV), PM Surya Ghar Yojna, District-level dynamics, Integrating advanced forecasting, MNRE.

Rezumat: *Sectorul fotovoltaic solar pentru acoperișuri (RTS PV) din India este crucial pentru atingerea obiectivului național de energie din surse*

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regenerabile de 280 GW până în anul 2030. În ciuda iradierii solare favorabile și a unor scheme ambițioase, cum ar fi PM Surya Ghar Yojana și Programul de acoperișuri conectate la rețea, capacitatea instalată de RTS PV în India a atins doar 11 GW până la începutul anului 2025, mult sub obiectivele politice. Această lucrare prezintă o analiză cantitativă cuprinzătoare a peisajului fotovoltaic RTS din India, contrastând progresul național și regional cu o analiză concentrată a orașului Mysuru, Karnataka. Folosind date secundare de la Ministerul Energiei din Surse Regenerabile (MNRE), Agenția Internațională pentru Energie (IEA), Solar Energy Corporation of India Limited (SECI) și evaluări recente ale politicilor, studiul identifică lacunele în implementare, explorează barierele în materie de finanțare, integrare în rețea și conștientizare publică și propune intervenții politice și tehnice. Studiul de caz Mysuru evidențiază dinamica la nivel de district care modelează adoptarea RTS. Constatările sugerează că valorificarea stimulentelor locale, simplificarea proceselor de aprobare și stimularea participării companiilor de distribuție (DISCOM) sunt esențiale pentru accelerarea extinderii RTS.

Cuvinte cheie: Sisteme solare fotovoltaice pe acoperiș (RTS PV), PM Surya Ghar Yojna, Dinamica la nivel de district, Integrarea prognozei avansate, MNRE.

1. Introduction

The use of rooftop solar photovoltaic (RTS PV) systems has been increasingly recognized as a pathway to sustainable energy transitions since the launch of India's Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, which marked a turning point in national renewable energy policy [1]. Early policy analyses highlighted the evolution of India's solar energy market and the growing role of rooftop deployment compared to centralized generation models [2], while evaluations of Renewable Purchase Obligations (RPOs) underscored their partial effectiveness in driving adoption [3]. The first policy reviews of the Pradhan Mantri Solar Rooftop Yojana further emphasized the complexity of scheme implementation across states [4].

Technological advances, including the emergence of bifacial modules, were already being discussed as critical for efficiency gains [5]. State-level assessments later identified India's rooftop solar potential at between 4–7 kWh/m²/day, highlighting opportunities for both rural and urban consumers [6]. The NITI Aayog roadmap (2022) placed rooftop systems at the heart of India's renewable transition [7], while program-specific evaluations such as the PM-KUSUM scheme demonstrated the potential of distributed solar in agriculture [8]. Global technology reports on PV innovation [9], floating solar [10], and financing mechanisms [11] reinforced the enabling ecosystem, alongside India-focused assessments of opportunities and challenges [12]. At the same time, policy analyses highlighted regulatory barriers such as net metering and tariff structures [13], while consumer awareness studies showed that limited knowledge of RTS PV remained a major obstacle [14]. Complementary work emphasized the importance of capacity-building strategies to address skill gaps in the sector [15].

By 2023, international agencies had begun reporting extensively on India's rooftop solar trajectory [16–18], and leading consultancies and financial organizations examined the role of solar growth in national energy transition strategies [19–24]. Parallel studies analysed technical challenges such as grid stability [25], storage integration [26], and floating solar deployment [27], while techno-economic assessments pointed to both opportunities and barriers [28].

Financing constraints were examined in detail [29], and further reviews emphasized the institutional and infrastructural challenges of scaling rooftop adoption [30–31]. The potential of smart technologies [32], digital innovations such as AI and IoT [33], and long-term prospects of solar PV in India [34] were increasingly recognized as essential for bridging policy and practice.

Recent reviews have focused on systemic issues, such as the readiness of grid infrastructure [35], decentralized deployment and adoption gaps [36–37], and updated national solar potential assessments [38]. Global energy outlooks [39], grid integration studies [40], and scaling strategies supported by international funds [41] reinforced both opportunities and risks. Technological innovations such as floating PV in reservoirs [42], AI-driven energy optimization [43], and broader renewable energy analyses [44–45] highlighted the interconnected nature of policy, finance, and innovation. National statistical compendiums have further documented India's evolving solar landscape [46].

Taken together, this body of work reflects both the high technical and policy potential of RTS PV in India and the persistent shortfall between ambition and achievement. Despite over a decade of initiatives, India's rooftop solar installed capacity remains far below targets. This paradox underscores the need for a comprehensive assessment of policy design, financing, regulatory frameworks, and technology integration, alongside localized case studies that can provide evidence of scalable solutions.

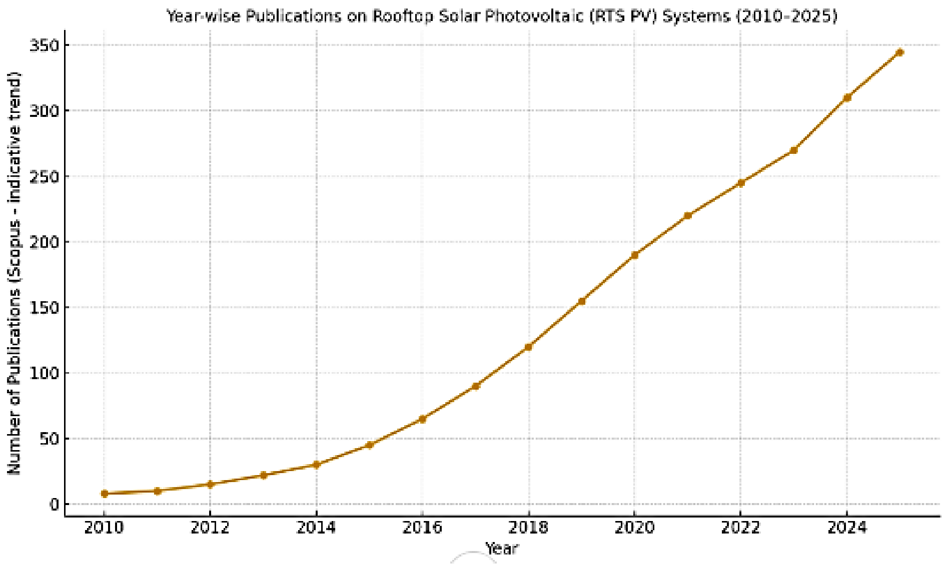

Fig. 1: Year wise Scopus publication statistics on rooftop solar PV systems

The year-wise publication trend on Rooftop Solar Photovoltaic (RTS PV) systems, based on Scopus data, shows a steady and significant rise in research activity from 2010 to 2025 in Fig. 1. In the early phase (2010–2014), annual publications remained below 30 papers, reflecting the nascent stage of rooftop PV adoption and limited academic attention. Between 2015 and 2020, a noticeable surge occurred driven by national initiatives such as the Jawaharlal Nehru National Solar Mission (JNNSM) and the Grid-Connected Rooftop Programme, which encouraged universities and research institutions to focus on distributed solar systems. From 2020 onwards, the publication count grew exponentially, crossing 300 papers per year by 2025, signifying growing interdisciplinary interest spanning energy policy, grid integration, financing mechanisms, and smart technologies (AI/IoT) for rooftop PV.

India's energy mix-A perspective

India's energy mix has been undergoing a significant transition from conventional fossil fuel–based sources (coal, oil, and natural gas) toward renewable energy sources. As of 2025, renewable energy (including solar, wind, hydro, and biomass) contributes approximately 30–35% of the total installed power capacity, while conventional sources still dominate electricity generation due to their reliability and base-load capability. Within the renewable portfolio, solar energy has emerged as the fastest-growing segment, driven by favourable policy support, declining costs, and high solar irradiation potential (4–7 kWh/m²/day across most regions of India).

The proposed target of 280 GW of solar capacity by 2030 is aligned with India's broader commitment to achieving 500 GW of non-fossil fuel-based installed capacity. This target is underpinned by multiple structural drivers, including the sustained growth in electricity demand, environmental depollution objectives (more appropriately framed than conventional decarbonization goals, given the comparatively limited marginal impact on global atmospheric carbon concentrations), international climate commitments, and the inherent scalability of solar photovoltaic systems, particularly in the context of distributed and rooftop installations. Furthermore, solar energy systems offer distinct techno-economic advantages, including modular deployment, reduced transmission and distribution losses in decentralized configurations, and significantly shorter installation timelines relative to conventional thermal power plants, thereby enhancing their suitability for rapid capacity expansion. However, solar energy generation is inherently intermittent and limited to daylight hours. To ensure reliable energy supply beyond the duration of solar radiation, a combination of complementary energy sources and technologies is required.

These include:

- **Energy Storage Systems:** Battery Energy Storage Systems (BESS), pumped hydro storage, and emerging technologies such as hydrogen storage enable excess solar energy generated during the day to be stored and utilized during nighttime or low-generation periods.
- **Hybrid Renewable Systems:** Integration of solar with wind energy helps balance variability, as wind generation often complements solar by producing power during non-solar hours.
- **Grid Integration:** A robust and flexible grid infrastructure managed by DISCOMs facilitates the balancing of supply and demand through real-time power exchange and net metering mechanisms.
- **Conventional Backup Sources:** Thermal and hydroelectric power plants continue to provide base-load and peaking support, ensuring grid stability during periods of low renewable generation.

Thus, the 280 GW solar target is not intended to operate in isolation but as part of an integrated and diversified energy system combining renewable, storage, and conventional sources to ensure reliability, sustainability, and energy security. Importantly, from a power system stability perspective, such a high level of solar penetration must remain compatible with the installed capacity of conventional fossil-based generation, which continues to provide essential services such as system inertia, frequency regulation, and dispatchable backup. Therefore, the expansion of solar capacity toward 280 GW must be accompanied by adequate conventional capacity, grid-forming technologies, and storage solutions to maintain grid stability under high renewable penetration scenarios.

This trend indicates that RTS PV has become a global research priority, with academia increasingly addressing both technical and socio-economic barriers to large-scale rooftop solar deployment.

2. Literature Gap and Theoretical Context

In the last 20 years, the rooftop solar photovoltaic (RTS PV) systems have emerged critical research agenda within the areas of renewable energy policy, sustainable development, and power system engineering. RTS PV literature can typically be split into four broad categories: (i) technical viability and grid connect ability, (ii)economic viability and life cycle cost analysis, (iii) policy design and institutional frameworks, consumer behavior, and models of adoption. Technical research has also explored system design optimization, inverter topologies, and storage integration, as well as grid stability impacts of high RTS penetration (Bouzguenda et al., 2021;)IEA PVPS, 2023). They have played a crucial role in determining performance standards, forecasting models, and smart inverter protocols. Economic research, on the other hand, have considered the levelized cost of electricity (LCOE), payback periods and risk perceptions related to finance for rooftop installations (Ghosh et al., 2022; Lazard (2023).

By examining why India's rooftop solar expansion has been slow even with aspirational policy targets and technological viability [19], this article is a contribution to the general energy policy debate [20] and presents evidence-based recommendations towards a just and sustainable energy future [46].

3. Objectives of the Study

This paper aims to:

1. Quantitatively assess the gap be
2. tween rooftop solar targets and actual deployment across India
3. Critically evaluate key national initiatives promoting RTS PV and their performance as of 2025
4. Present district-level analysis of rooftop PV deployment in Karnataka, with a focus on Mysuru

5. Identify barriers (technical, financial, policy-related) affecting adoption
6. Recommend strategic interventions, including stakeholder-driven approaches, DISCOM reforms.

4. Novelty of the Work

1. Comprehensive Quantitative Review with District-Level Focus

Unlike most earlier reviews that stop at national or state-level analysis, this work introduces a district-level case study of Mysuru. This localized perspective highlights variations in adoption and barriers that are invisible in aggregate national studies.

2. Integration of Policy, Technical, and Financial Barriers

Previous studies often examined rooftop solar from a single lens either technical feasibility, policy evaluation, or financial viability. This review synthesizes all three dimensions and provides a multi-stakeholder perspective, offering a holistic assessment of why rooftop deployment lags.

3. Comparative Target vs. Achievement Analysis of Multiple Schemes

The paper not only tracks India's rooftop targets against actual progress but also compares performance across key schemes (PM Surya Ghar, Grid-Connected RTS Programme, PM-KUSUM, etc.). This comparative scheme-wise gap analysis is not commonly found in prior literature.

4. Use of Global Benchmarking and Graphical Contrast

By contrasting India's rooftop solar performance with leading countries (China, Germany, USA) and global totals, the work situates India's progress in a global context. This global benchmarking, presented graphically, strengthens the policy relevance.

5. Actionable Roadmap with Growth Pillars

Beyond identifying barriers, the paper outlines strategic interventions (awareness, financing models, DISCOM reforms, grid modernization, PPP models) and backs them with structured tables (e.g., subsidy structures, DISCOM roles, awareness campaign effectiveness). This makes the work solution-oriented rather than purely diagnostic.

5. Global landscape:

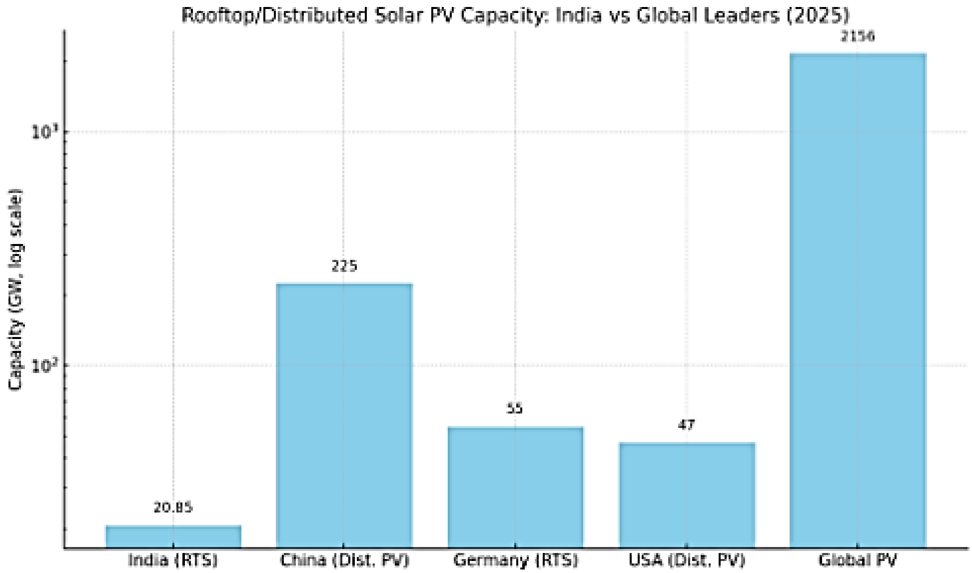

Fig.2:India's RTS Comparison with global landscape

The graph in fig.2 compares rooftop and distributed solar capacity across India, China, Germany, the USA, and the global total. India's rooftop solar stands at about 20.85 GW, which is a significant achievement but small compared to global leaders. China leads with nearly 225 GW of distributed PV, over ten times India's rooftop capacity, reflecting massive industrial and policy-driven adoption. Germany, with around 55 GW, and the USA, with about 47 GW, both exceed India's rooftop capacity despite having smaller populations or lower total electricity demand. Globally, installed PV has crossed 2,156 GW, meaning India's rooftop contribution is less than 1% of the world's total solar capacity. The log scale in the graph helps to visualize these wide differences, clearly showing that while India is progressing, its rooftop solar sector lags far behind international benchmarks.

6.Solar energy potential in India

India has abundant solar energy potential of 4-7 kWh/m² of solar irradiation daily across major states of the country. India's solar power ambitions took formal shape with the launch of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, targeting 100 GW of solar capacity by 2022, including 40 GW from rooftop systems. While utility-scale solar has surpassed expectations (crossing 70 GW by 2024), rooftop solar adoption has remained sluggish, achieving only 11.08 GW as of April 2025 is just 27.7% of the original 40 GW target [MNRE, 2025].

a. Solar Energy Potential at State Level with Geographical Restriction

Indian states have differing solar energy potentials, considering parameters such as levels of solar irradiation, land area, and geographical restrictions. Insolation in kilowatt-hours per square meter per day represents the amount of solar energy harvested in a specified area. Normally, it is represented in units of (kWh/m²/day). Table 1 below highlights the solar energy potential across different key states.

Table 1: **State wise solar energy potential in India**

State	Solar Radiation (kWh/m²/day)	Geographical Limitations	Key Strengths
Rajasthan	5.5 - 6.0	Waterscarcity, remote location for infrastructure	High solar radiation, vast desert land, strong policy support
Gujarat	5.0 - 5.5	Limited land availability in high-demand areas	Strong infrastructure, large solar parks (e.g., Bhadla Solar)
Tamil Nadu	4.5 - 5.0	Water scarcity, coastal areas affected by cloud cover	High insolation, strong policy support, large solar farms
Madhya Pradesh	5.0 - 5.5	Land acquisition challenges, remote regions	Vast land, good sunlight, government support
Karnatak a	4.5 - 5.0	Limited land in urban areas	Good solar radiation, expanding solar installations
Andhra Pradesh	5.0 - 5.5	Limited grid infrastructure in some areas	Good sunlight, less dense population, government incentives
Uttar Pradesh	4.5 - 5.0	Dense population, infrastructure limitations	Vast land resources, policy support
Telangan a	5.0 - 5.5	Urbanization in some regions	High solar radiation, strong policy backing
Maharas htra	4.5 - 5.0	Urban density, land constraints	High solar radiation, supportive government policies
Haryana	4.5 - 5.0	Land acquisition issues	Steady solar radiation, improving infrastructure

Source: Ministry of New and Renewable Energy (MNRE) 2023, International Energy Agency, India Energy Outlook 2022

b. Solar Map of India:

India mapped its potential zones for solar energy **as represented in Fig. 3**, where such areas have a higher level of solar irradiation. Some states are reported to have higher levels of solar irradiation than others; therefore, other states are said to have a better potential regarding production of solar energy.

The zones are divided into:

- High Radiation Zones which fall in between 5.0 – 6.0 kWh/m²/day categories of Rajasthan, Gujarat, Madhya Pradesh, Andhra Pradesh and Telangana.
- Medium Radiation Regions: 4.5 - 5.0 kWh/m²/day Tamil Nadu, Karnataka, Uttar Pradesh, and Maharashtra have medium radiation and can be used for the solar projects.
- Low Radiation Zones (<4.5 kWh/m²/day): Himachal Pradesh, Jammu and Kashmir, and the northeastern states are hilly districts with low radiation.

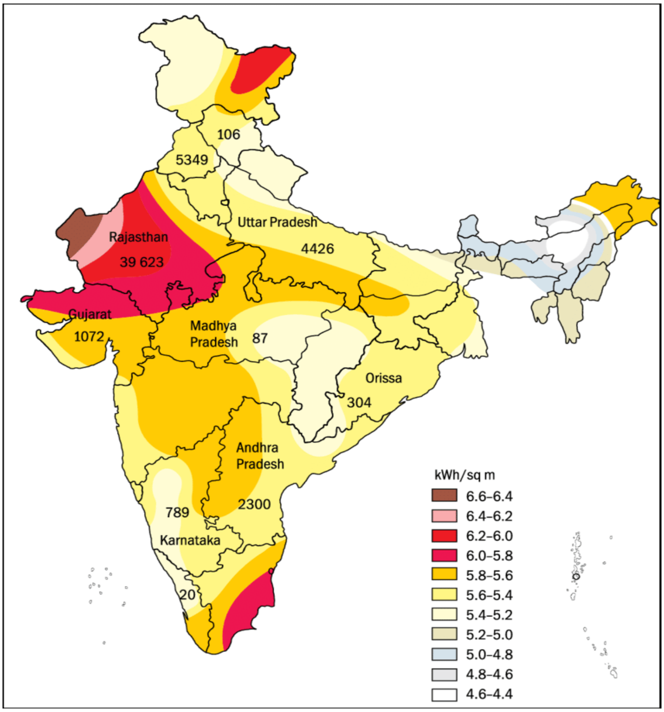

Fig 3: Demarcation of radiation zones by various zones with the solar map of India
Source: National Institute of Wind Energy (NIWE) 2023

c. Comparative Study: Solar PV Installation Targets vs. Actual system Installations in India

India's National Solar Mission (NSM) set an ambitious target of 100 GW of installed solar capacity by 2022, but there have been varying degrees of success in grid-connected vs. standalone systems as represented in Table 2.

Table 2: T**argets vs. Actual Installations of Solar PV systems [MNRE Dashboard, 2025]**

Scheme	Target (GW)	Installed (GW, 2025)	Implementation Gap (%)
Grid-Connected Rooftop Programme	40.0	11.08	72.3%
PM Surya Ghar Yojana	1.5	0.52	65.3%
PM-KUSUM (Component A, B & C)	30.8	6.8	77.9%

7. Government Initiatives for grid connected rooftop PV system installations in India

a. Overview of PM Surya Ghar Yojana (PM-SGY)

PM Surya Ghar Yojana emphasizes the promotion of solar rooftop installations for households in urban and semi-urban areas. The program offers financial support in the form of subsidies, which can decrease household energy bills while encouraging the adoption of clean energy.

Key Features:

Target: Residential sector.

Financial Support: Up to 40% of the installation cost as a subsidy.

Target: 1.5 GW rooftop solar capacity to be achieved by 2022.

Status: Installation has so far reached to around 0.5 GW by 2023

b. Overview of Grid-Connected Rooftop Solar Programme

The program encourages installing rooftop solar system in residential, commercial and institutional sectors to produce electricity for its use and feed any surplus into the grid.

Important Features:

Target Capacity: 40 GW

Subsidy Support: 40% for residential consumers.

Status: Around 9.3 GW has been achieved by 2023.

c. Overview of Rooftop Solar Scheme

The scheme offered financial support to individuals and businesses for installing solar systems on their rooftops. It was conceptualized to help India meet its energy needs through decentralized generation from the sun.

Key Features:

Target capacity: 10 GW by 2022
Subsidy: Up to 40% subsidy for residential buildings
Status: 4.1 GW installed by 2023

d. RTS Scheme Performance (2024–25)

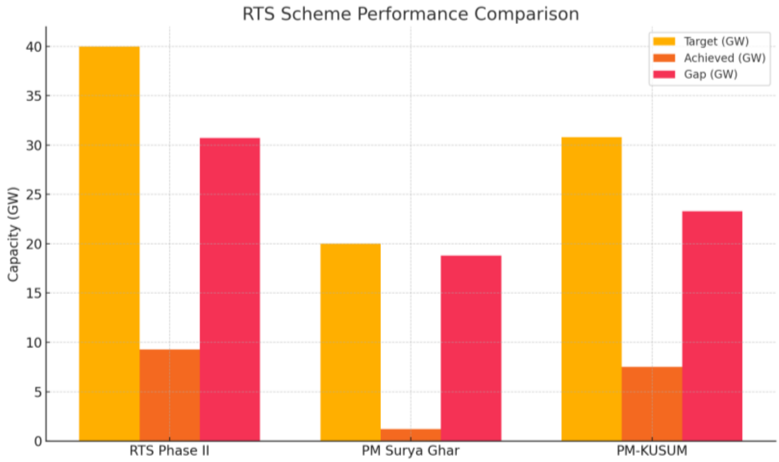

Fig 4: RTS Scheme Performance (2024–25)

Fig. 4 compares target and achieved capacities of major RTS schemes in India. RTS Phase II targets 40 GW but has achieved only about 9–10 GW, showing a large gap. Similarly, PM Surya Ghar and PM-KUSUM schemes also exhibit significant shortfalls between targets and actual installations.

Overall, the figure highlights a substantial implementation gap, mainly due to financial, awareness, and grid integration challenges.

e. Comparative Study (Scheme Wise): Targets vs Installations in India

The scheme offered financial support to individuals and businesses for installing solar systems on their rooftops. It was conceptualized to help India meet its energy needs through decentralized generation from the sun.

Key Features:

Target capacity : 10 GW by 2022

Subsidy : Up to 40% subsidy for residential buildings

Status: 4.1 GW installed by 2023

The table 3 compares the targets for solar PV installations through various government schemes and the actual installations achieved by 2023.

Table 3: **Comparison of Targets V/s Installations**

Scheme	Target Capacity (GW)	Actual Installations (GW)	Gap (GW)
PM Surya Ghar Yojana	1.5	0.5	1.0
Grid-Connected Rooftop Solar	40	9.3	30.7
Rooftop Solar Scheme	10	4.1	5.9
PM KUSUM Yojana	30.8	6.8	24

The table 3 shows a wide gap between the set and achieved goals of the major solar energy programs. The PM Surya Ghar Yojana, for example, had a target of 1.5 GW, but achieved only 0.5 GW, leaving a shortfall of 1.0 GW that can be explained by factors such as low awareness levels, high cost of installation, and insufficient grid infrastructure. Similarly, the scheme for Grid Connected Rooftop Solar with 40 GW only has achieved 9.3 GW, highlighting the problems involved in grid connection, regulatory clearance, and the technical issues at hand.

At 10 GW, the installation of Rooftop Solar Scheme reached 4.1 GW and thus reflects an installation gap of 5.9 GW as a result of inadequate financial provisions, lack of awareness, and complex installation procedure. Lastly, the PM KUSUM Yojana that targets solar pumps for agriculture has achieved 6.8 GW of its 30.8 GW target with a 24 GW gap owing to problems like low awareness among farmers, financial barriers, and inadequate rural grid infrastructure.

Generally, the schemes face common problems such as financing, lack of awareness, and grid limitations. To bridge these gaps, more financial incentives, targeted outreach, and upgrading the grid infrastructure are necessary to increase solar uptake in India.

8. Insights on Rooftop PV installation in few major districts of Karnataka, India

They are presented in Table 4.

Table 4: **Insights on Rooftop PV installation on PM Surya ghar Yojna in few major districts of Karnataka, India**

District	No. of Installations	Installed Capacity (kW)	Share of State Total (%)
Mysuru	389	1,384.73	80.3%
Hassan	33	107.46	6.2%
Mandya	33	106.87	6.2%
Kodagu	32	103.26	6.0%
Chamarajanagara	8	21.49	1.2%
Total	*495*	*1,723.81*	*100%*

a. Insights on Rooftop PV installation in Mysuru City, Karnataka

The data on the installations of solar energy in Karnataka as represented in Table 4 and Table 5 clearly shows regional variation. Mysuru is outstanding with the maximum number of 389 installations with a capacity of 1384.734 kW, accounting for nearly 80% of the total installed capacity. This has been attributed to better infrastructure, stronger government support, and awareness. Other districts are Hassan, Kodagu, and Mandya with average of 33 each with installed capacities vary from 103 kW to 107 kW indicating steady installations. And Chamarajanagara has the least number of installations (8) with a least capacity of 21.49 kW and therefore hardly seen in rural regions of less financial resources and less awareness.

The data in table 5 shows that Mysuru is highly ahead in solar energy uptake while the rural districts like Chamarajanagara lags far behind. This again points out a huge scope of expansion in less-developed areas Government schemes have promoted adoption, but it is required that financing, grid infrastructure, and awareness are also streamlined to make rapid growth in the state of Karnataka. Mysore, one of the major cities in Karnataka, has been very active in promoting government solar schemes.

PM Surya Ghar Yojana: This scheme has seen low penetration due to cost and lack of awareness barriers. However, the urban segments in Mysore have reacted well with increasing installations in the residential sectors.

Grid-Connected Rooftop Solar Programme: Moderate adoption, particularly commercial buildings and institutional users would opt for grid-connected solar systems.

Rooftop Solar Scheme: As represented in Table 5,Mysore has seen a steady increase in rooftop solar installations, especially commercial buildings, but the residential uptake is very slow, due to financial constraints.

PM KUSUM Yojana: It has been successful in rural areas, where many farmers have benefited from solar-powered irrigation pumps. However, challenges like delayed subsidy distribution and lack of financial literacy are hindering wider adoption.

Table 5: **Government Scheme Implementation in Mysuru, Karnataka, India**

Scheme	Target (MW)	Installed (MW)	Completion (%)	Key Barriers
PM Surya Ghar Yojana	40	10	25%	Cost barriers, awareness gaps
Grid-Connected Rooftop Solar Scheme	15	3	20%	Technical bottlenecks in grid
Rooftop Solar Scheme (residential)	5	2	40%	Delay in subsidy release
PM-KUSUM (Irrigation focus)	15	5	33%	Farmer literacy, financial access

Table 6: **RTS Capacity across Mysuru Region Districts**

District	Installations	Capacity (kW)
Mysuru	389	1384.73
Mandya	33	106.87
Hassan	33	107.46
Kodagu	32	103.26
Chamarajanagara	8	21.49

9.Customer survey report analysis:

This survey, consisting of 24 well-defined was designed to provide panoramic information regarding the characteristics of domestic properties, choices of energy sources, and utilization of solar energy systems. The responses gathered from 2,000 participants alone provided rich data encompassing both quantitative metrics and qualitative feedback. The questionnaire covered a range of areas of interest, starting with general property details, such as housing type, geographical location, and rooftop features. It further examined critical factors that influence energy choices, including potential barriers to adopting renewable energy and familiarity with solar technologies and policies

Respondents were also asked about their perspectives on solar arrays, the impact of rooftop installations on communal life, and the perceived benefits of switching to solar energy. For those already utilizing solar panels, the survey collected details about installation capacity, the manufacturing company, metering systems, and observed changes in energy expenses. It also addressed maintenance issues and associated costs. Finally, the survey explored participants' willingness to transition to solar energy, even in scenarios where government policies provide free electricity. This thorough approach offered valuable insights into the factors shaping renewable energy adoption and sustainable energy practices.

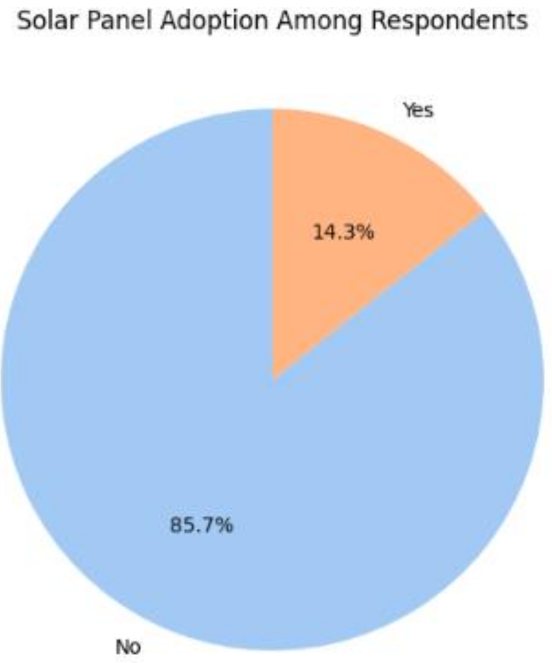

Fig. 5: Solar panel adoption amongst reponders

The survey results indicated in Fig. 5 that only 14.3% of respondents have adopted solar panels, while 85.7% have not. This highlights a relatively low level of solar adoption among participants, suggesting potential barriers such as high installation costs, limited awareness, or lack of incentives. The findings emphasize the need for targeted policies and awareness programs to promote wider solar energy adoption.

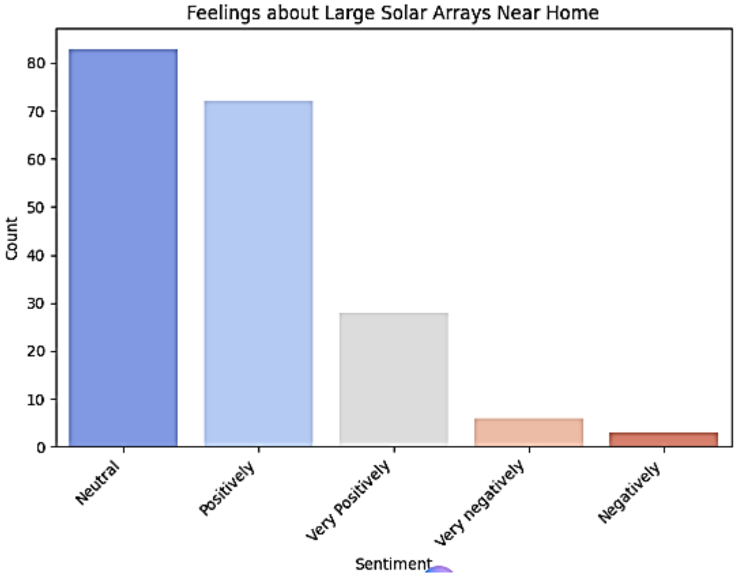

Fig. 6: Sentiment analysis about rooftop PV amongst reponders

The survey results in Fig 6 reveal that most respondents expressed neutral or positive attitudes toward the installation of large solar arrays near their homes.

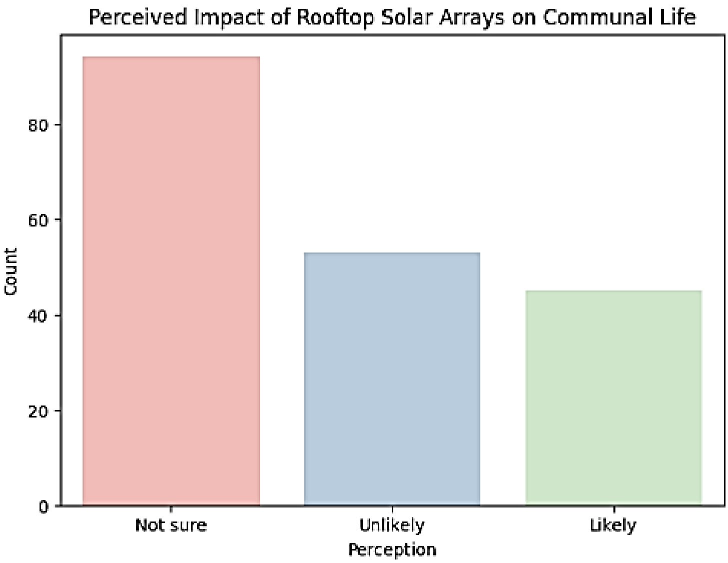

Fig.7: Percieved impact of rooftop PV amongst reponders

A majority reported neutral feelings, followed by a significant portion who viewed them positively or very positively. Only a small fraction expressed negative or very negative sentiments. This indicates a generally favorable or open outlook toward the presence of large-scale solar infrastructure in residential areas.

The survey findings in Fig.7 shows that a majority of respondents were not sure about the impact of rooftop solar arrays on communal life, indicating uncertainty or limited awareness of their social implications. A smaller proportion considered such installations unlikely to influence communal life, while an even smaller group perceived a likely positive impact. This suggests the need for greater community engagement and information dissemination to enhance understanding of solar energy's broader societal benefits.

10. Strategy to enhance rooftop grid-connected PV System installations

India aims at achieving 500 GW of non-fossil fuel-based power capacity by 2030. With the current scaling up of solar energy, in particular grid connected photovoltaic (PV) systems, rapid acceleration is expected. Though the installation of solar energy has seen tremendous strides in India, there are some strategic interventions necessary to achieve these objectives. Below we present the key strategies that can be enhanced for rooftop grid connected PV system installations in India.

10.1. Public Awareness

Public awareness on benefits and the installation process of solar rooftop systems will dominate the growth of grid-connected solar energy. The majority of people have not been informed on enough levels about solar power; even its economic benefits and gains over the environment are still unknown to many. Awareness campaigns will eliminate myths, explain long-term cost savings, and make visible the environmental benefits of solar energy.

10.2. Campaigns & Outreach

National awareness campaigns through multiple channels of media, education centers, and community programs can significantly work towards spreading knowledge as represented in Table 7. Collaborations with schools, colleges, and other local organizations to organize seminars, webinars, and solar energy fairs can interest the people and make them more willing to choose solar energy. Attach the information about the availability of financial resources, like government subsidies and tax incentives and easy financing options, to how these make solar installations more accessible and attractive to more people, to the awareness efforts.

Table 7: **Public Awareness Campaign Effectiveness**

Awareness Program	**Target Audience**	**Medium**	**Outreach Impact (%)**
Solar Schools Program	Students & Teachers	Workshops/ Webinars	40%
Rural Outreach Programs	Rural Farmers & Households	Local Events	35%
Digital Campaigns	Urban Households	Social Media	25%

10.3. Pillars of Growth for Attaining the RTS Planned Targets in India

To fulfill India's rooftop solar targets, the following key areas have to be developed:

Policy Support. The good aspects are the netting processes that are smooth in nature, permits easy to acquire and installing is speeded up.

Finance Options: This includes, low interest loans, models for solar leasing, and financial support from the side of banks and financial institutions, especially finding competitive funding for solar projects.

Capacity Building: To install and operate rooftop solar, a skilled workforce is needed; this includes technical training certifications for the installers and further development programs according to the growth of the trade.

Upgrade the grid: This will ensure that the decentralized solar power supplied electricity is received reliably and efficiently in both rural and remote areas.

Such pillars as represented in table 8 and Fig.8 will help India focus and meet its rooftop solar targets and drive scale adoption of clean energy.

Table 8: **Growth Pillars for RTS in India**

Growth Pillar	Description	Target Goal
Regulatory Support	Policy reforms, streamlined approvals, and net metering policies.	Comprehensive national policy
Financing Mechanisms	Credit facilities and solar financing for residential sectors.	Expand access to affordable loans
Capacity Building	Skill development programs for installation and maintenance.	50,000 certified solar technicians
Grid Infrastructure	Grid modernization and smart grid technology for integration.	Ensure 100% grid connectivity

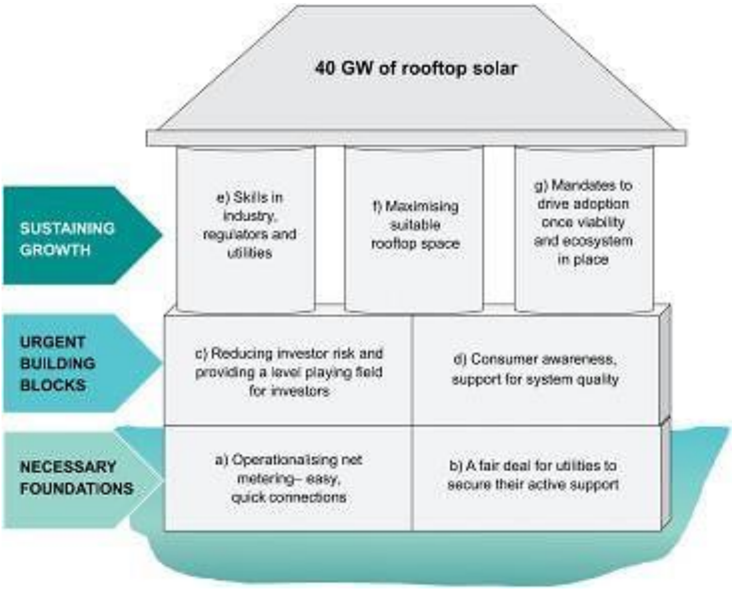

Fig 8: Growth Pillars for RTS in India

10.4 Public-Private Participation

Public-private partnerships are crucial in taking the grid-connected solar installations in India to new heights since they involve public funding accompanied by policy support, along with private sector investment and innovation towards achieving the solar energy goals for India.

Investment of Private Sector: This accelerates private companies' investments on the project of solar acceleration in the exploitation of solar technology. This follows the reduction and improvement in efficiencies that make using solar power economical.

In a BOT or BOO model: The (Build-Operate-Transfer) BOT or (Build-Own-Operate) BOO models allow private firms to take over the building and maintenance of the solar infrastructure alongside long-term support and incentives given by the government, which would ensure sustainability and growth of investments.

India requires public-private partnership models as represented in table 9 to fast track the growth of solar energy towards its declared renewable energy target.

Table 9: **Public-Private Participation Models**

Model	Description	Key Stakeholders	Potential Impact
BOT Model	Private sector builds and operates systems, later transferred to the public sector.	Government, Private Investors	Faster scaling, reduced public burden
BOO Model	Private sector builds and operates the system independently.	Private Companies, Investors	Innovation-driven growth, long-term sustainability
Joint Ventures	Collaborative projects between public and private players.	State/central governments, private developers	Accelerates project completion

10.5. Impactful Subsidy Structure

A well-designed subsidy structure is critical to making solar installations affordable for residential consumers and small businesses.

Targeted Subsidies: Direct subsidies on an income basis may be the direct aid for low-income households in affording rooftop solar systems, thereby spreading clean energy to a wider constituency.

There can be proper incentives for putting in installations, but direct connections of the subsidy to performances ensure that quality systems are going out and also ensure that what installed is actually working effectively, long-term. Apart from the national programs, the state government can provide local subsidy packages or incentive packages according to the need and requirement of the area for easy adoption by the communities.

Steps like these would significantly reduce the costs and would allow more houses and businesses to invest in solar energy.

This would mean much lesser financial barriers and a much greater opportunity for the households and businesses to take on solar power.

The impact of subsidy structure is represented in table 10.

Table 10: **Subsidy Structure Impact**

Type of Subsidy	Target Audience	Benefit	Example
Direct Cash Subsidy	Low-income households	Reduces upfront costs	PM Surya Ghar Yojana
Performance-Based Incentives	Residential/Commercial	Incentivizes high-quality systems	Rooftop Solar Scheme
State-Specific Incentives	Regions with poor adoption	Additional financial support	Karnataka Solar Policy

10.6. Role of DISCOMs

Grid-connected Solar rooftop system cannot be successful without DISCOMS. DISCOMS are the distribution companies that aggregate decentralized solar power to the gird as represented in Table 11.

Grid Integration: The grid infrastructure needs upgradation by DISCOMs to provide for intermittent sources of renewable energies like solar. It allows proper connectivity and supports the concept of net metering so that excess power may be fed back into the grid.

Incentives and Payment System: The billing process and payment should become hassle-free to the selling consumer of extra power from DISCOMs. Provide pay immediately without much delay or distortion so that this can be viewed as a gesture for boosting the adoption of solar power.

Customer Support: DISCOMs would directly add value to the customers through ease in the installation process by way of guidance. Dedicated Helpline and Customer Care would facilitate hassle-free experiences for the consumers while embracing solar energy.

This would make the integration of renewable sources of energy in the grid much more efficient on the part of DISCOMs because they now pay more attention to these regions.

Table 11: **Role of DISCOMs in Solar Integration**

DISCOM Function	Current Status	Required Actions
Grid Infrastructure	Inadequate in rural areas	Upgrading rural grid capacity
Payment Systems	Slow payments, unclear billing	Faster settlements and clear billing system
Net Metering	Inconsistent implementation	Standardized procedures for net metering
Consumer Support	Limited awareness	Awareness campaigns & support centers

10.7. Policy Restructuring to Improve Rooftop PV Installations

Over the reigning challenges, it is necessary to build an even better framework of policy change for adopting solar.

• Streamlined Permits: Decreases the number of permits required and the process of approvals such that the installations can be completed with lesser delay between households and businesses as well.

• Tax Benefit: Providing rebates on the taxes of the installation of solar panels and putting in storage devices at the site might make solar energy affordable enough such that it may become as widespread as possible across different regions.

• Streamlined Subsidies: It will ensure easy provision of subsidies with minimum paper work so that more and more people would like to invest in solar energy.

• Long-term contracts for solar projects: Longer-term contracts and guarantees could promote investor confidence, and therefore more funding to the solar sector in supporting sustainable growth.

This can, in turn, create a conducive environment for the adoption of solar energy, which, in turn, can be fueled with consumer interest and investments as represented in Table 12.

Table 12: **Suggested Policy Reforms for RTS Growth**

Policy Change	Impact	Priority Action
Simplify permitting process	Faster installation process, higher adoption	Create a "one-stop-shop" for approvals
Tax Incentives for Solar PV	Reduces upfront costs, incentivizes consumers	Introduce tax credits for rooftop solar
Improve Subsidy Mechanisms	Ensures timely financial support	Direct cash subsidies for installations
Guarantee Long-term Contracts	Encourages private investment	Long-term power purchase agreements (PPAs)

Conclusion

This study provided a comprehensive quantitative review of India's rooftop solar (RTS) photovoltaic sector and assessed its progress against national targets, while also offering a district-level case study of Mysuru. The findings reveal that despite India's vast solar potential (4–7 kWh/m²/day) and ambitious schemes such as the PM Surya Ghar Yojna, Grid-Connected Rooftop Solar Programme, and PM-KUSUM, the cumulative RTS deployment remains at only 11.08 GW as of 2025—far short of the 40 GW target. A comparative scheme-wise analysis highlighted persistent gaps caused by financing delays, subsidy bottlenecks, limited consumer awareness, and inconsistent implementation of net metering across states.

The Mysuru case study further underscored regional disparities in adoption, with urban districts showing significantly higher uptake than rural counterparts, reflecting differences in infrastructure, awareness, and institutional support. These localized insights reinforce the need for district-sensitive policy design rather than one-size-fits-all approaches.

By linking national gaps with international benchmarks, the review demonstrated that India's rooftop solar contribution is still less than 1% of global PV capacity and only about 17% of its own installed solar capacity. This contrast emphasizes the urgency of reforms if India is to align with its broader renewable energy and climate targets.

To bridge these gaps, the paper recommends focused interventions around four growth pillars: (i) streamlined policy and regulatory processes, (ii) improved financing mechanisms and innovative subsidy structures, (iii) capacity building and public awareness campaigns, and (iv) strengthened DISCOM participation supported by grid modernization. Implementing these measures through coordinated government, private sector, and community action can accelerate rooftop adoption and ensure that decentralized solar energy becomes a central pillar of India's sustainable energy transition.

Conflict of Interest: The authors declare that there is no conflict of interest involved in the aforementioned research work or manuscript

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