

# Bridging Awareness and Adoption: Rooftop Solar Explorer (RTSE) as a Scalable Geospatial Solution for India<sup>#</sup>

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## ABSTRACT

Rooftop solar holds immense promise for developing countries, where rapid urbanization, rising electricity demand, and land constraints require innovative clean energy solutions. Yet, adoption is often limited by consumer unawareness of rooftop potential and the absence of accessible decision-making tools. To address this, the Center for Study of Science, Technology and Policy (CSTEP), India, developed the Rooftop Solar Explorer (RTSE), a geospatially enabled, consumer-oriented tool that integrates high-resolution imagery, and solar irradiance data to deliver roof-level assessments of solar potential and financial feasibility. Aligned with India's flagship PM Surya Ghar - Muft Bijli Yojana (PMSG), RTSE provides actionable insights for consumers, utilities, and policymakers by estimating shadow-free areas, optimal system sizing, generation output, and 25-year savings. RTSE has been integrated into the Government of India's National Portal for Rooftop Solar, allowing consumers from across the country to access it. Over the last one year, RTSE has empowered over 2,00,000 users to evaluate their rooftop solar feasibility, enhancing decision-making and accelerating adoption. As a scalable and replicable model, RTSE illustrates how geospatial intelligence can bridge the awareness-adoption gap in developing countries, thereby supporting national renewable energy targets, advancing climate goals, and fostering inclusive energy transitions.

**Keywords:** developing countries, rooftop solar, geospatial analysis, digital surface models, consumer awareness, renewable energy adoption.

## 1. INTRODUCTION

Rooftop solar represents a vital pathway for cities seeking to achieve renewable energy targets, but progress has been hindered by limited consumer awareness and the absence of reliable, accessible

rooftop potential data. To address these challenges, CSTEP developed RTSE, a tool designed to translate technical evaluations into intuitive insights on feasibility, system design, and long-term financial returns. By offering clear, user-friendly information, RTSE enables households to make confident investment decisions and engage more actively in the energy transition, while also equipping policymakers with tools to accelerate large-scale adoption and strengthen urban sustainability strategies.

The tool is built to serve a wide range of stakeholders through a comprehensive, scalable, and accessible framework:

For Consumers:

- Accurately estimates shadow-free usable rooftop area, optimal system size, 25-year savings, and payback periods.
- Allows customization options for system design based on preferred capacity or selected roof segments.
- Delivers interactive visualizations and tailored projections for better decision-making.

For Governments and Developers:

- Functions as a data repository for demand aggregation and high-potential rooftop identification.
- Supports policy rollouts like the PM Surya Ghar scheme by pinpointing viable rooftops.
- Streamlines consumer acquisition through and integrated web-based portal for electrical utilities, developers, and policymakers.

For vendors and solar Installers:

- Minimizes the need for labor intensive site surveys by providing accurate rooftop assessments.

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## 2. METHODOLOGY AND SCIENTIFIC INNOVATION

### 2.1 Methodology

RTSE combines advanced data processing techniques with user-centric design. The methodology includes:

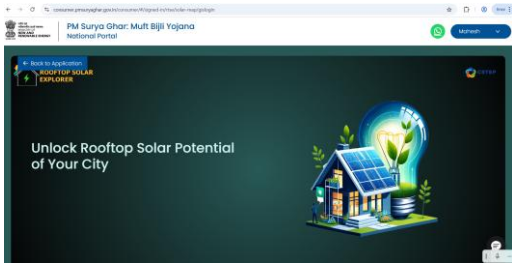


Fig. 1 Rooftop Solar Explorer (RTSE) Homepage

**Data Acquisition:** High-resolution drone and satellite imagery (5-50 cm Ground Sampling Distance (GSD)) is used to digitize rooftops, identify shadow-free areas, and generate precise 3D building models for visualization.

**Rooftop Analysis:** Digital Surface Models (DSM) assess slope, aspect, and shading, ensuring optimal system design for each rooftop.

**Digitalization, Artificial Intelligence (AI) and Technology Integration:** Digitalization and the use of AI in RTSE

enables fully automated rooftop solar assessments by integrating high-resolution imagery, 3D rooftop modelling, shading analyses and city-specific solar irradiance profiles. The base radiation data layer is derived from the “Typical Meteorological Year (TMY)” data provided by NREL’s National Solar Radiation Database (NSRDB). TMY represents a year composed of 12 months chosen to be representative of a location’s weather patterns. These datasets are hourly and have been assimilated using 14 years historical data for India from 2000-2014 at a 10 km resolution. Shading assessment is then conducted on 50 x 50 cm grids on individual rooftops taking the corresponding TMY values as the base radiation profile. The resultant profiles are critical in evaluating the actual energy generation potential for each rooftop segment. RTSE digitally identifies shadow-free, optimal rooftop areas, overlays calculated irradiance data based on 3D building reconstructions and subsequent shading analyses, and automatically calculates system sizing, energy generation, and financial returns customized for each user. These calculations are conducted within a cloud-based tool, thereby ensuring scalability across cities, while seamless integration with the Government of India’s national rooftop portal accelerates solar adoption and offers seamless experience for users.

**Financial Feasibility:** The tool integrates state-specific solar policies, tariffs, and consumer electricity consumption patterns to provide customized techno-economic analyses.

### 2.2. Scientific Innovation

Rooftop Solar potential assessment through RTSE represents a significant advancement in rooftop solar mapping, enabled by its combination of technology, scalability, and stakeholder alignment:

**High-Precision Imaging:** By leveraging drone and satellite-based true-ortho imagery, RTSE ensures detailed rooftop assessments, including shadow-free areas and optimized panel placements.

**3D Visualization:** Point cloud data allows for 3D models of buildings, enabling enhanced visualization and understanding for users.

**Automated Calculations:** The tool automates shading analysis, potential estimation, and financial projections, reducing reliance on manual interventions and enhancing accuracy.

**Scalability:** RTSE has been successfully implemented in over 120 cities, with the flexibility to expand nationwide and beyond India’s borders.

**User-Centric Design:** The intuitive interface empowers users by providing actionable insights in a language they understand, bridging the gap between technology and end-user adoption.

Furthermore, its seamless integration with the Government of India’s National Rooftop Portal accelerates adoption and provides users with a unified, hassle-free experience.

RTSE is fully aligned with India’s climate and energy goals. Its design and methodology can be adapted globally, making it a scalable and replicable model.

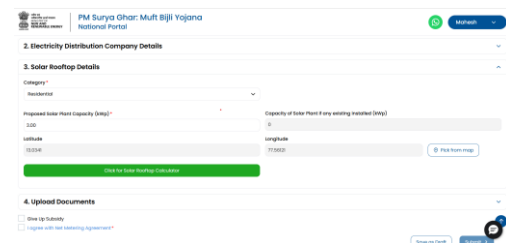


Fig. 2 RTSE as Solar Calculator in PMSG Portal

## 3. RESULTS AND CONCLUSION

RTSE has emerged as a highly effective tool for accelerating rooftop solar adoption, bridging the divide

between advanced technological innovation and grassroots implementation. Beyond serving individual consumers, it plays a vital role in advancing India's

and align local implementation with national solarization targets.

For Example: Using RTSE, we were able to identify a

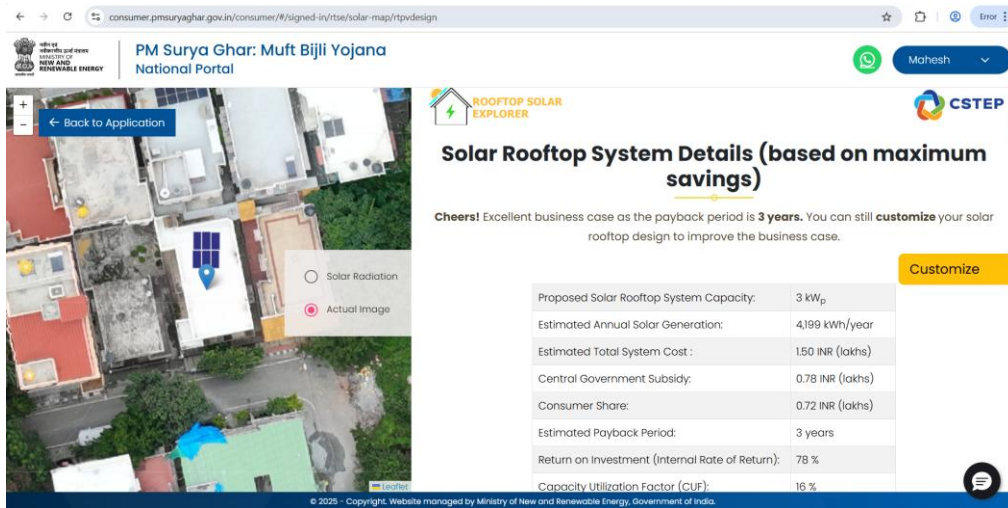


Fig. 3 RTSE functionality on the Government of India's National Portal for Rooftop Solar

broader climate commitments by offering a scalable solution to support the achievement of 500 GW of renewable energy capacity by 2030 and net-zero emissions by 2070. Looking ahead, future enhancements will include the integration of advanced AI and Machine Learning (ML) algorithms to further optimize system design and extend RTSE's reach to underserved regions as well as international markets.

Preliminary outcomes highlight RTSE's multi-dimensional impact:

**Consumer Empowerment:** With over 200,000 users across 120+ cities using the tool to evaluate their rooftop potential, the results include greater confidence, improved understanding of financial savings, and more informed decision-making.

**Policy and Planning Support:** Governments, municipal bodies and electricity utilities are leveraging RTSE to

potential of 1420 MW (using 500 Wp PV modules) across the city of Raipur, distributed across system sizes (Table 1). This granular breakdown helps policymakers design targeted programs for rooftop solar adoption.

Range (kW)	No. of Rooftop Polygons	Estimated Potential (MW)
0-3	93700	183
3-10	94760	540
10-50	27353	492
50-2000	2233	205
<b>Total</b>	<b>218046</b>	<b>1420</b>

Table 1 Raipur Rooftop Solar Potential

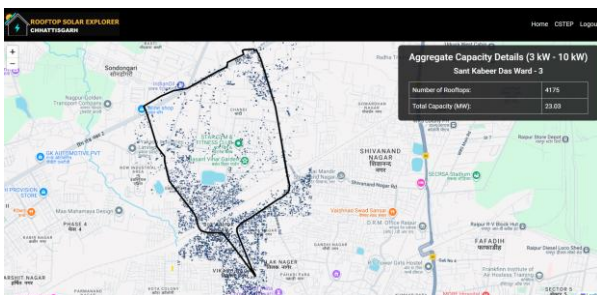


Fig. 4 Aggregate Capacity (3-10 kW) in Sant Kabeer Das Ward for Raipur, Chhattisgarh, India

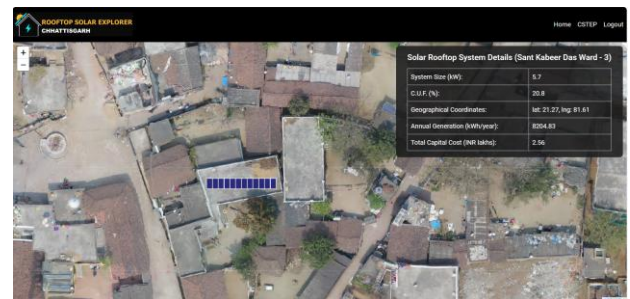


Fig. 5 Rooftop analysis for a roof in Raipur, Chhattisgarh, India

Thus, RTSE not only aggregates rooftop potential at the city and locality levels, but also allows users to drill down to the individual rooftop level. This multi-scale functionality enables policymakers to plan solarization strategies at the macro level while consumers and installers can access rooftop-specific insights including

pinpoint high-potential rooftops, aggregate demand,

usable area, optimal system size, expected generation, and financial returns. By linking city-wide planning with household-level decision-making, RTSE bridges the gap between policy design and on-ground implementation.

**Environmental Benefits:** RTSE-enabled installations have already contributed to measurable CO<sub>2</sub> emission reductions, supporting India’s renewable energy transition and climate mitigation goals.

**Economic Growth:** By driving widespread rooftop adoption, RTSE has created demand for solar equipment and services, generating green jobs and attracting investment into the renewable energy sector.

**Institutional Recognition:** The tool has been acknowledged by both central and state-level ministries and featured in leading renewable energy forums and publications for its innovation and impact. Furthermore, it has been integrated into the Government of India’s National Portal for Rooftop Solar:

<https://pmsuryaghar.gov.in/>

**Validation by Solar vendors and Installers:** To ensure accuracy, RTSE’s rooftop potential assessments were cross-verified with results from on-ground surveys conducted by solar installers. Comparative analyses showed close alignment between RTSE estimates and installer-derived values for system sizing and generation potential, confirming the reliability of the tool and reducing the need for time-intensive site visits.

**Global Context and Distinctiveness of RTSE:**

Globally, most rooftop solar assessment tools provide only broad potential estimates using satellite imagery and standard system assumptions. These tools typically require consumers to manually enter their location and usually stop at giving basic information on rooftop potential or system size, without offering panel layout visualization or user-specific customization.

In contrast, RTSE leverages high-resolution aerial photogrammetry (50 × 50 cm grids), a detailed panel placement algorithm, and hourly shading simulations throughout the year. Unlike conventional tools, RTSE enables consumers to visualize solar panels directly on their own rooftops, making it easier to understand their roof’s solar potential.

Additionally, RTSE is linked to consumer electricity account IDs, allowing optimal system sizing that considers not only the available shadow-free roof area but also the consumer’s actual electricity consumption patterns, local tariffs, and subsidies. Consumers also have the flexibility to adjust the system size according to their requirements and select specific roof areas for panel placement.

With these features, RTSE provides consumers with a highly customized, interactive, and accurate assessment of their rooftop’s solar potential, along with bespoke technical and financial insights.



Fig. 6 System Design Customization option in RTSE

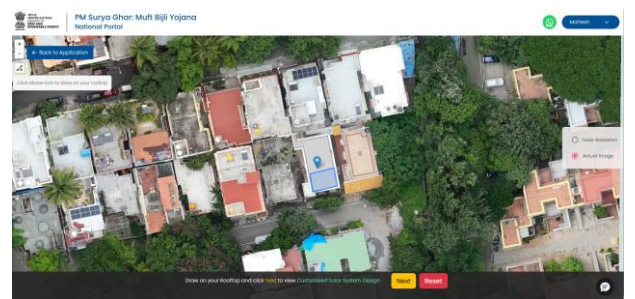


Fig. 7 Consumer drawing a polygon on a specific area of their rooftop

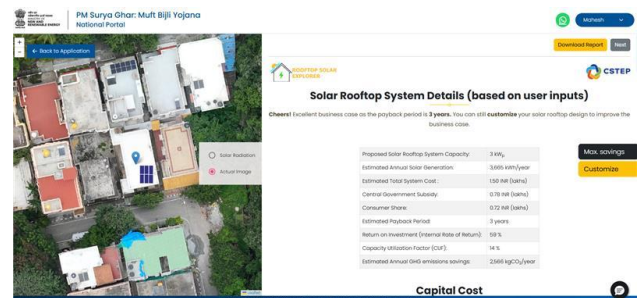


Fig. 8 Customised system design as per consumer’s inputs

## ACKNOWLEDGEMENTS, FEATURES AND MEDIA HIGHLIGHTS

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