Optimization of Solar Tilt Angles & Cost Efficiency across India's Climatic Zones

BUILDING A SUSTAINABLE FUTURE

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~ Minor Project Presentation

INTRODUCTION

- Solar radiation varies by location and is influenced by factors like latitude and climate. Understanding these variations is crucial for optimizing solar energy systems.
- **Using ASHRAE Model:** The ASHRAE model is used to calculate direct, diffuse, and reflected solar radiation, which is vital for designing effective solar installations.
- **Optimizing Tilt Angles and Installation Area:** Determining the optimal tilt angles and installation areas is essential for maximizing solar energy efficiency in different climatic zones across India.
- **Significance of Tilt Angles:** Proper tilt angles are crucial for maximizing solar irradiance and improving energy yield, especially in regions with varying latitudes and seasonal changes.

Our project aims to optimize the solar panel setup for high energy efficiency in High-Income Group (HIG) houses.

Energy Efficiency

Urban Applicability

Sustainability

Enhancing solar panel output by optimizing tilt angle based	Tailoring solutions to meet the needs of urban residences.	Reducing the carbon footprint of residential buildings in high-income urban areas.

OBJECTIVES

Determine Optimal Tilt Angles

Use code to determine the optimal tilt angles for solar panels in various Indian climatic zones to maximize solar energy absorption.

Optimize Installation Area

Develop a code-based approach to calculate the optimal installation area for solar panels, ensuring maximum energy generation.

Maximize Cost Savings

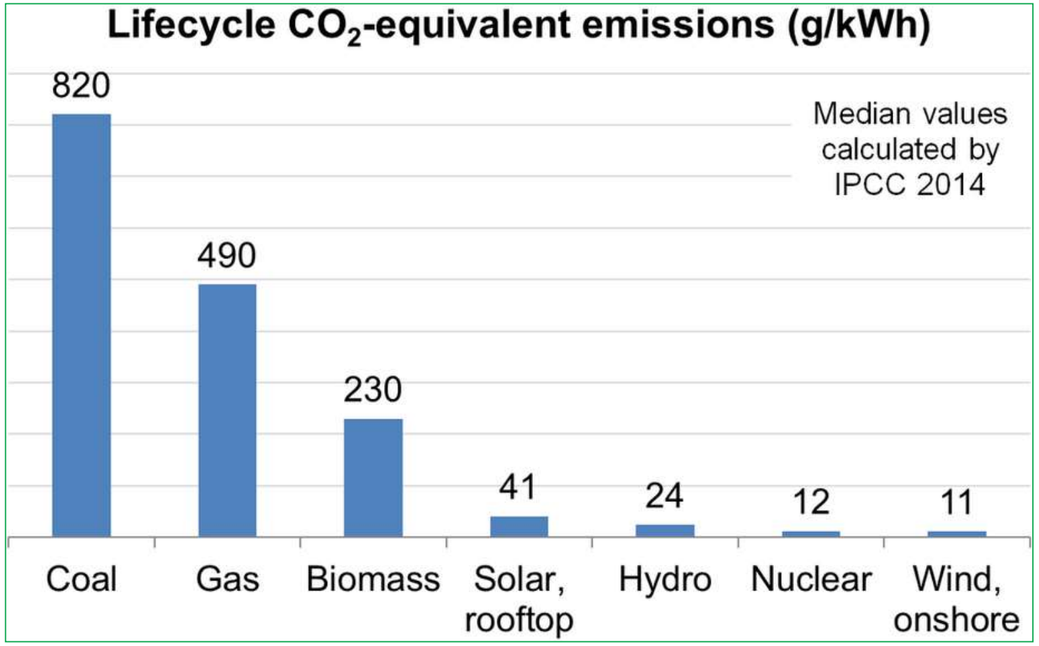
Contribute to sustainable energy solutions by optimizing solar power generation across diverse environmental conditions in India.

Apply ASHRAE Model

Leverage the ASHRAE model to accurately assess direct, diffuse, and reflected solar radiation for different regions.

Reduce Carbon Footprint

Provide data-driven recommendations to improve the efficiency of solar energy systems based on location-specific parameters.

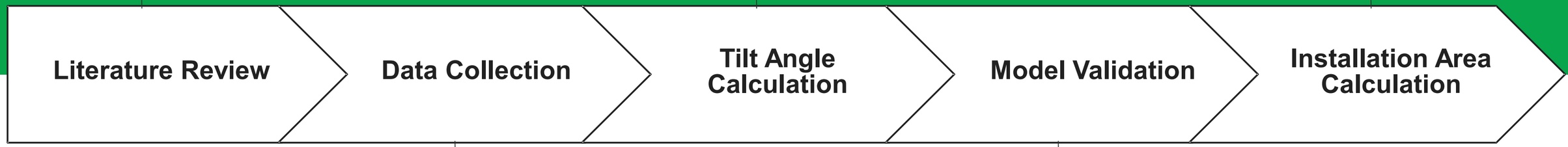


METHODOLOGY

Conduct a comprehensive review of existing studies on solar radiation, tilt angles, and installation area optimization.

Use coding and the ASHRAE model to compute optimal tilt angles for solar panels based on solar radiation data.

Develop and apply a code-based approach to determine the optimal installation area for maximizing solar energy generation.



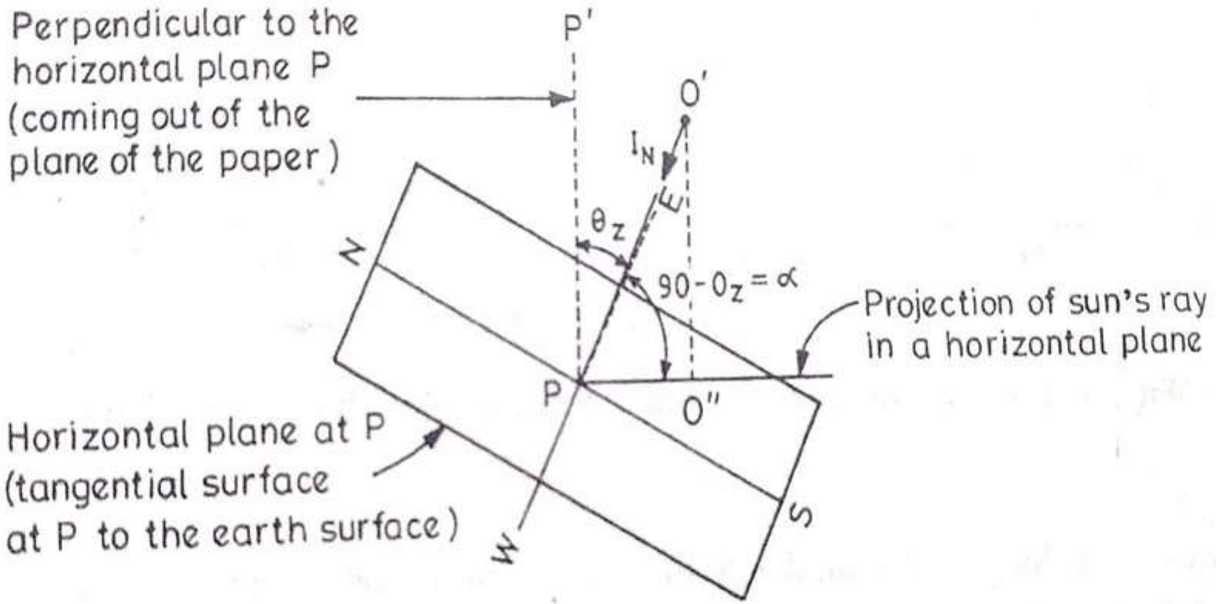
Gather climatic data, solar radiation levels, and geographical information for different zones in India.

Validate the calculated tilt angles using simulations and compare them with existing models for accuracy.

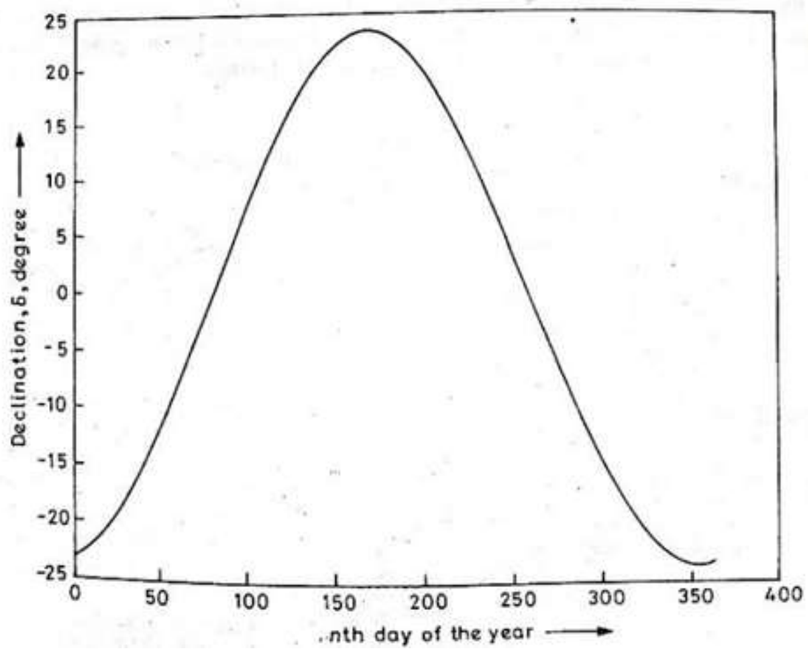
LITERATURE REVIEW

Sl. No.	Title	Authors	Important Outcomes
01	Comparison of solar radiation models and their validation under Algerian climate - The case of direct irradiance	Behar O, Khellaf A, Mohammedi K.	ASHRAE model provides highly accurate DNI estimates, outperforming other models.
02	Adjustment factorsfor the ASHRAE clearsky model based on solar-radiation measurements in Riyadh	Al-Sanea SA, Zedan MF, Al-Ajlan SA	Applying regional correction factors to ASHRAE improves accuracy for locations like Riyadh.
03	Estimation of clear-sky solar radiation using ASHRAE model for Aligarh, India Solar Energy View project Energy Systems Planning and Operation under High Penetration of Renewable Energy Sources Using ASHRAEModel for Aligarh, India	Jamil B, Khan MM, Maroof Khan M.	ASHRAE is effective for evaluating solar radiation on various surfaces and components.
04	Computing global and diffuse solar hourly irradiation on clear sky. Review and testing of 54 models	Badescu V, Gueymard CA, Cheval S, Oprea C, Baciu M, Dumitrescu A, et al	ASHRAE is among the top models for diffuse radiation, though no single model is universally optimal.

THEORETICAL CONCEPTS USED

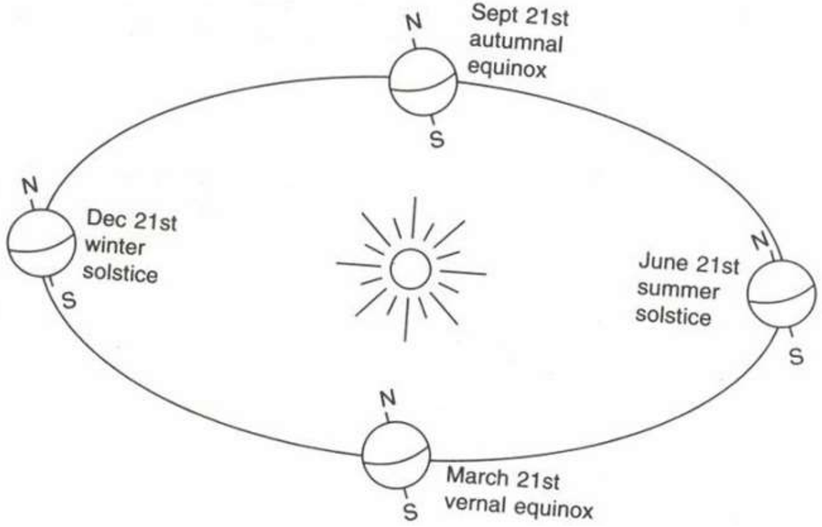


Zenith Angle



Decilnation Angle Vs Day Number

- Beam radiation ratio:
  rb= (cosθ /cos (θz))
- Direct radiation:
  Direct radiation (IDN)= A.exp(−Bcos(θz))
- Diffuse radiation (Id):
  Diffused radiation (Id)= C×IDN
- Direct radiation on the wall (Ib):
  Direct radiation on the wall (Ib)= IDN × cos(θz)



Solar Geometry

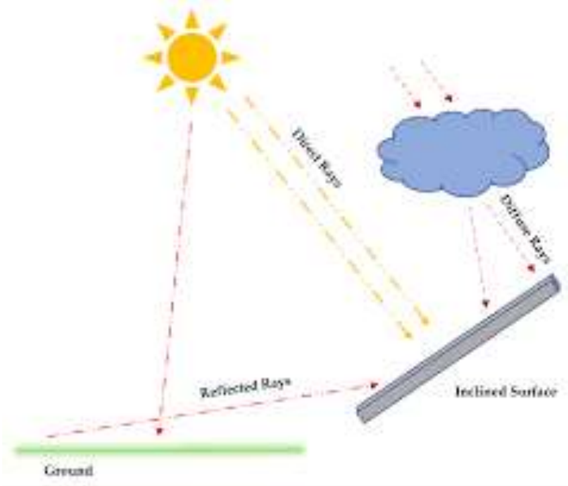
VALIDATION

Comparison with Actual Data: Solar energy outputs & optimal tilt angles validated using real-world solar radiation datasets.

Error Analysis: Differences b/w predicted & observed solar irradiation values were minimal (<5%)

Consistency Across Seasons: Variations in solar output due to tilt adjustments were consistent with theoretical expectations.

Started initial coding for calculating installation areas based on optimized tilt angles.



~ Source: Center for Policy Research | [NITI Aayog Energy India]

RESULTS AND CONCLUSION

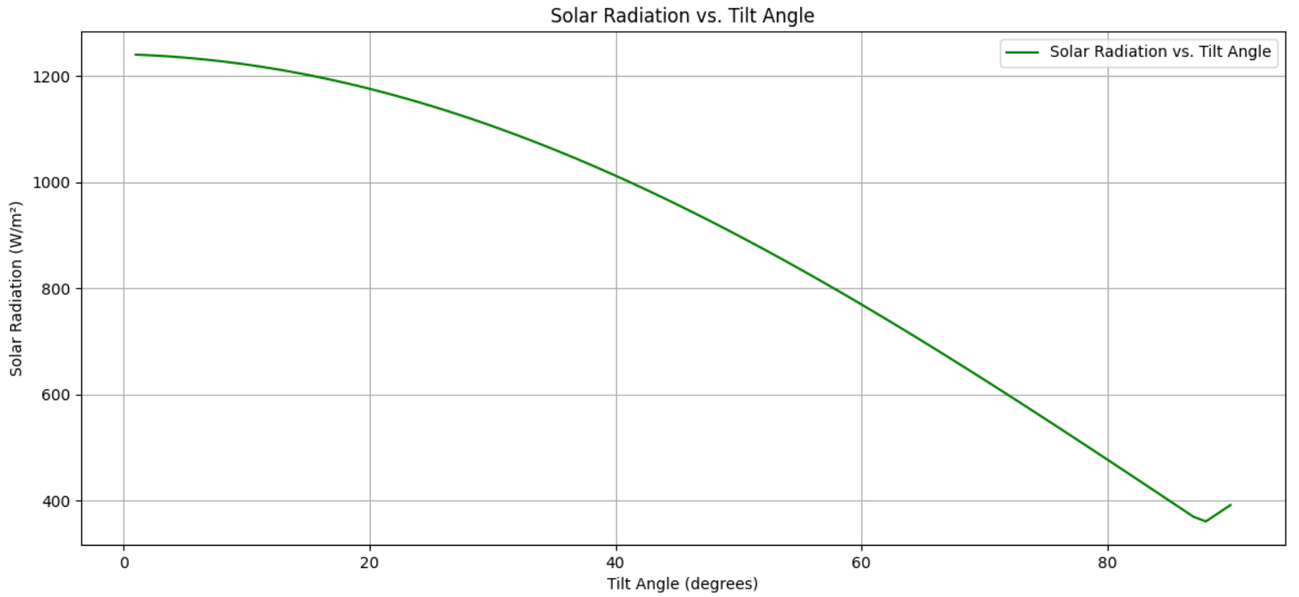
The project focuses on optimizing solar panel installations for better energy generation across diverse climates in India.

Using the ASHRAE model, we calculated optimal tilt angles and installation areas for different regions.

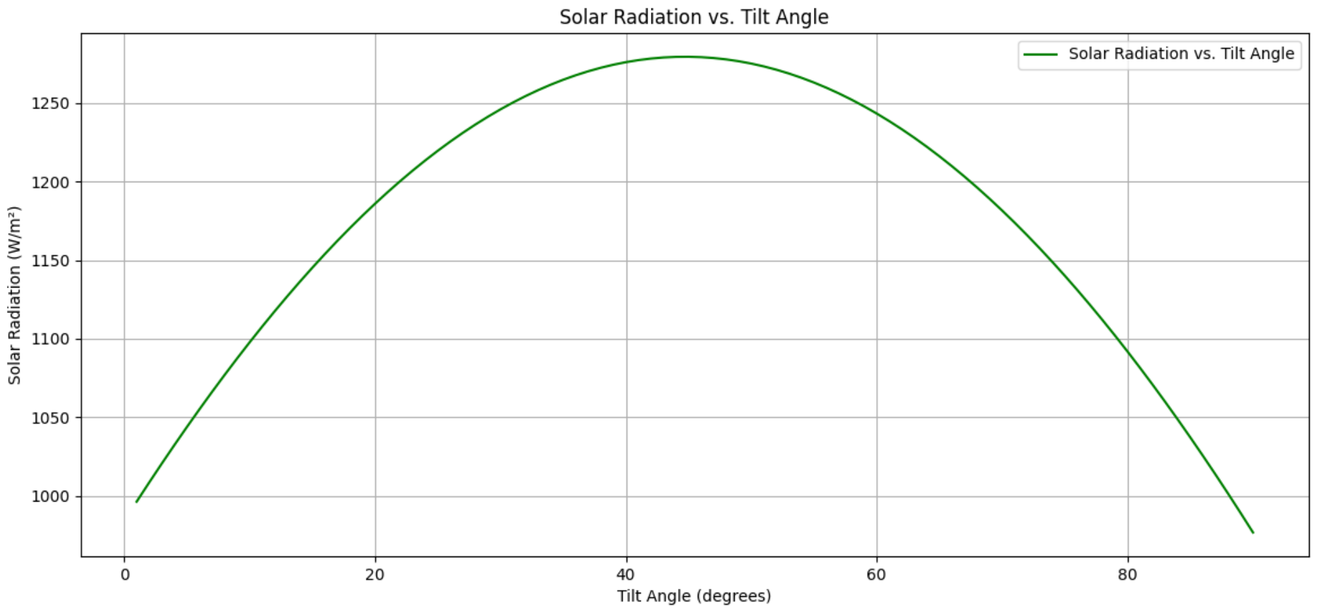
Results indicate significant variation in solar radiation across cities, stressing the need for tailored strategies.

This research aids in maximizing solar energy capture, promoting sustainable energy use, and reducing reliance on non-renewable sources.

For Summer Season - Raipur



For Winter Season - Raipur



FUTURE WORK & APPLICATIONS

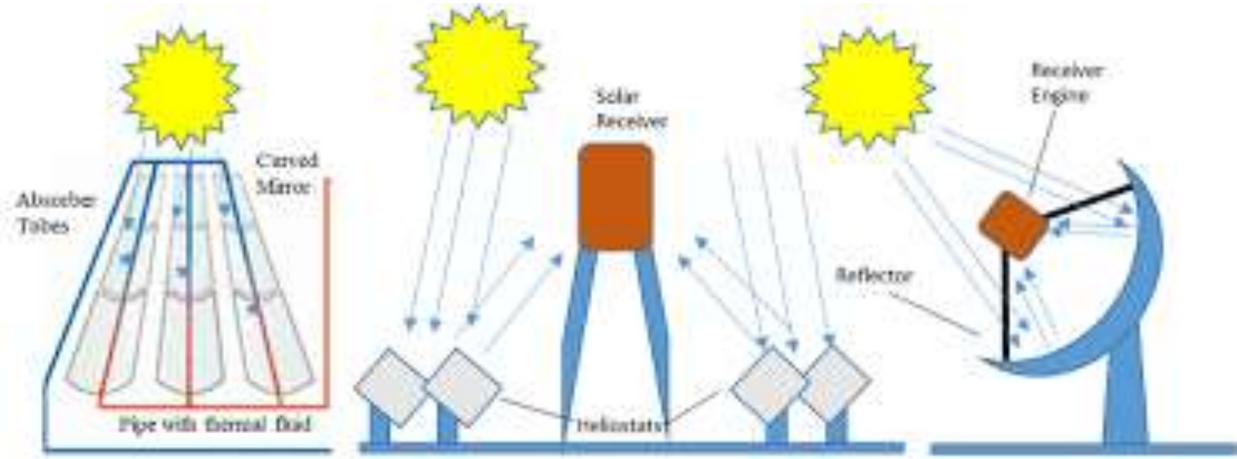
Expand the model to include different types of buildings beyond HIG houses.

Calculations for:
- Government buildings
- Corporate Houses

Integrate real-time weather data for dynamic optimization of solar panel configurations.

Dynamic tilting solar panel for optimal tilt angle

Application of findings in government policy-making and urban planning for sustainable energy solutions.



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- e-websites https://nptel.ac.in/courses/112105129
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- **Resolution:** To overcome these challenges, we validated data sources, adapted the model, employed advanced data integration techniques, and rigorously tested the code to ensure accuracy and reliability.

THANK YOU