

# Solar Power Forecasting Using Machine Learning

**AI-Based Prediction System for Grid Stability**

**Sector: Renewable Energy – Solar**



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**Gen AI Capstone Project**



# Why Solar Forecasting Matters

**Context :** India is expanding solar rapidly, but solar power is volatile and weather-dependent.

**Core Problem :** Grid operators must balance supply and demand in real time .

- Solar power is weather-dependent and unpredictable
- Grid system require exact supply-demand power drop
- Sudden cloud cover → massive power drop
- Poor forecasting leads to:
  1. Grid instability
  2. Voltage fluctuations
  3. Backup fossil activation

**Objective :** Build a Machine Learning model to accurately forecast solar DC power generation using historical weather and inverter data.



# Model Inputs & Prediction Target

## Output:

DC\_POWER (Watts)

Target variable to predict.

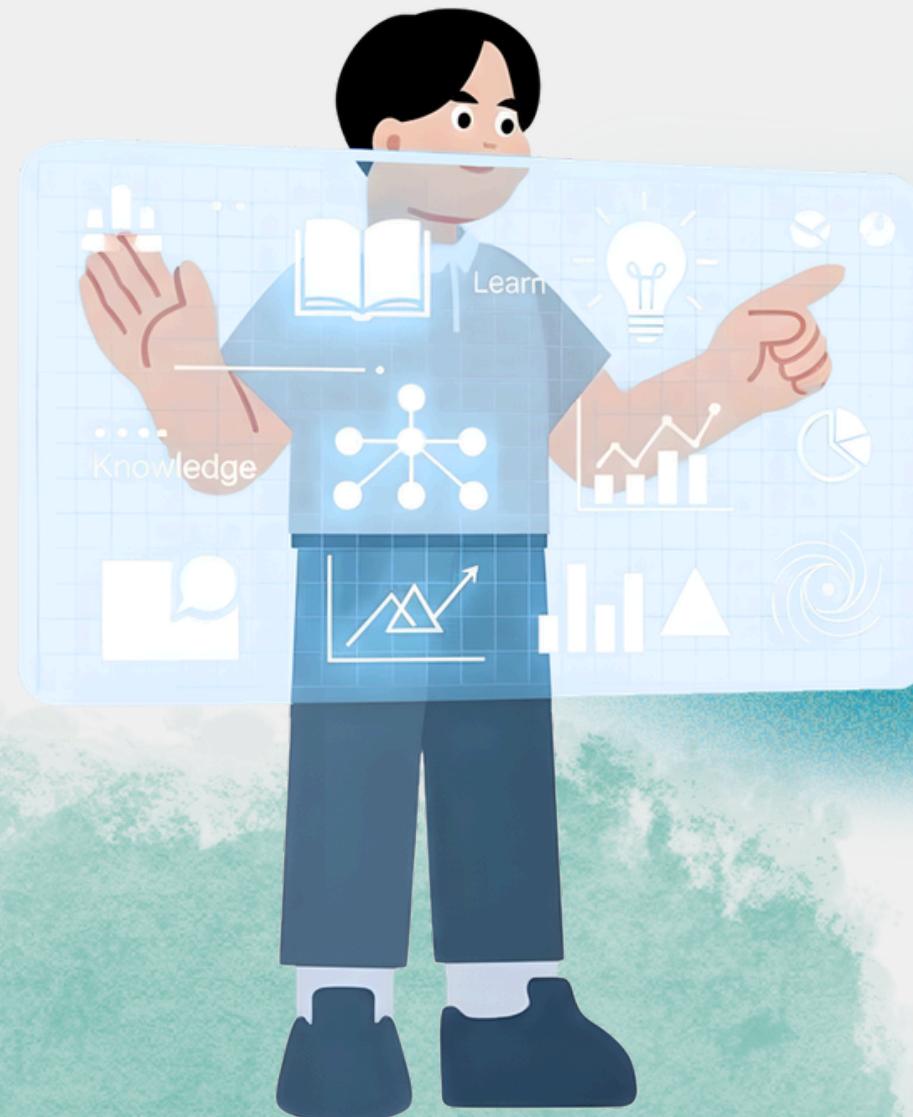
## Inputs:

- IRRADIATION → sunlight intensity
- MODULE\_TEMPERATURE → panel efficiency impact
- AMBIENT\_TEMPERATURE → environmental cooling
- SOURCE\_KEY → inverter identity
- hour → daily pattern
- month → seasonal pattern

## Data Engineering:

Feature Engineering

- Label encoding
- Chronological 80–20 split



# ML Architecture & Design

## Pipeline Flow:

- Load historical solar CSV data
- Feature engineering
- Time-based train-test split
- Train Random Forest Regressor
- Evaluate model
- Deploy as Streamlit web application

## Why Random Forest?

- Handles non-linearity
- Works well for solar bell-curve behavior
- Robust to noise
- Low overfitting risk

They link exactly to the problem of underperformance and misallocation.



# Performance & Validation

## Metrics Achieved:

- $R^2 = 0.93$
- $MAE = 460 \text{ W}$
- $RMSE = 933 \text{ W}$
- TimeSeries Cross-Validation  $R^2 = 0.81 \pm 0.09$

## Interpretation:

- Model explains 93% of solar generation behavior
- Very low average prediction error
- Stable performance across time windows
- Prevented data leakage using chronological split

# Deployment & Real-World Impact

## Application Features:

- Single prediction via sliders
- Batch CSV prediction
- 24-hour solar forecast simulation
- Feature importance visualization
- Downloadable results

## Real-World Benefits:

- Improves grid stability
- Reduces fossil backup dependency
- Helps plant managers schedule generation
- Enables smarter renewable integration

