Renew AI: Optimizing Renewable Energy Grids

A Data-Driven Solution for Grid Efficiency, Reliability, and Sustainability

Energy Flow Designer:

1.Rohit Babu S.B.
2.Shrish kumar N.S
3.Muhamed Ibrahim H
4.Mohammed Nafees M
5.Siddhaarth K
6.Siva Sangaran S

The Challenge:

Datathon Project: Designing robust, predictive models for modern energy systems.

Introduction: The Imperative for Grid Optimization

Renewable energy sources, while critical for a sustainable future, introduce inherent variability into the power grid. Optimization is necessary to manage this irregular nature of renewable energy sources. efficiently.

What is a Renewable Grid?

An energy network powered primarily by variable sources like solar and wind, requiring intelligent management systems.

Why Optimization is Essential?

Maximizing energy capture, minimizing waste, and ensuring continuous supply despite fluctuating generation levels.

Problem Statement: Balancing Volatility

The core challenge of modern grids is achieving equilibrium between the highly variable supply from renewables and non-negotiable consumer demand, compounded by limited storage capacity.

Intermittent Supply

Solar and wind output is dependent on weather, creating unpredictable power fluctuations.

Dynamic Demand

Consumption patterns vary rapidly, requiring real-time response mechanisms for load balancing.

Storage Limitations

Current battery infrastructure is costly and insufficient to store massive energy surpluses for long periods.

Project Objectives: Defining Success

Our project targets three critical areas to enhance overall grid performance and resilience.

Reduce Energy Curtailment

Minimize the intentional dumping of excess power by optimizing when and where energy is utilized or stored.

Accurate Demand Prediction

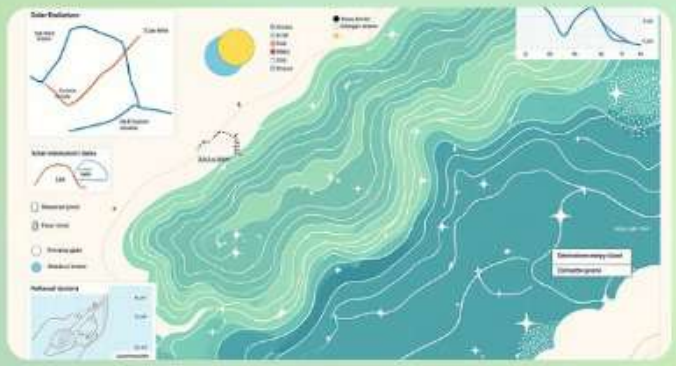
Develop high-fidelity predictive models to forecast energy generation and consumer demand 24-48 hours ahead.

Enhance Grid Stability

Provide operators with actionable insights to mitigate voltage fluctuations and frequency instability caused by supply variability.

Data Sources: Fueling Predictive Models

Effective optimization requires blending high-resolution operational data with external variables that drive supply and demand.



Environmental Data

- Local weather forecasts (temperature, cloud cover, wind speed)
- Seasonal and geographical factors
- Utilizes **satellite and IoT sensor data** for enhanced forecasting precision

Operational Data

- Real-time generation output from solar/wind farms
- Historical consumption patterns by sector
- Peak demand periods and load curves
- Grid frequency and voltage measurements

Grid Infrastructure

- Monitors **transformer load levels** and **real-time grid health** to prevent overload.
- Tracks **storage charging/discharging rates** for efficient energy utilization.

Methodology: From Data to Decisions

Our approach combines robust data engineering with state-of-the-art machine learning and optimization algorithms.

Data Preprocessing

Cleaning, normalization, and feature engineering to handle time series dependencies and outliers.

Tooling & Validation

Leveraging Python libraries (Pandas, Scikit-learn, TensorFlow) for rapid iteration and model validation.

Predictive Modeling

LSTM and XGBoost models for high-accuracy forecasting of intermittent supply and consumer load.

Optimization

Linear Programming (LP) and Reinforcement Learning (RL) to determine optimal dispatch schedules.

Proposed Solution: The Predictive Dispatch System (PDS)

PDS is a closed-loop system that uses predictive modeling to drive real-time grid operation decisions.

Key Component: Optimization Engine

This module leverages a 48-hour energy forecast to optimize power generation and grid operations, minimizing operational costs and curtailment penalties through predictive scheduling and smart load balancing.

Results and Outcomes

Results and Expected Outcomes:

Based on historical simulations, implementing the PDS model is expected to deliver significant improvements across key metrics.

12-15%

Reduction in Curtailment

More efficient use of generated renewable power, minimizing wasted clean energy.

95%

Forecast Accuracy

Mean Absolute Percentage Error (MAPE) reduction in 24-hour demand prediction.

$5.5M

Annualized Savings

Estimated yearly cost savings for a medium-sized utility through reduced balancing costs and minimized waste.

Impact: A More Sustainable Future

Our solution goes beyond cost savings, enabling a more robust and environmentally responsible energy transition.

Environmental Sustainability

Higher utilization of renewables means faster displacement of fossil fuel generation.

Grid Resilience

Improved predictive capacity strengthens the grid's ability to withstand unforeseen events and rapid fluctuations.

Innovation Catalyst

Lays the groundwork for integrating future smart devices and decentralized energy resources (DERs).

Next Steps and Conclusion

Future Work: Scaling the PDS

- Integrate dynamic pricing signals to incentivize consumer load shifting (Demand Response).
- Implement advanced Reinforcement Learning (RL) for continuous, adaptive optimization in complex scenarios.
- Expand model scope to include transmission constraints and regional interdependencies.

Thank You!

We appreciate your time and interest in Renew AI. Together, we can build a more resilient and sustainable energy future.

Please feel free to reach out with any questions or collaboration opportunities.

Contact Us:

Website: **https://future-energy-3.preview.emergentagent.com/**

Meet the Team & Connect

Our dedicated team of experts drives Renew AI's vision forward. Connect with us and explore further.

Team Members & Contributions

Developers / Programmers

S.B. Rohit Bapu

Muhamed Ibrahim

Team Leader / Project Manager

Siddhaarth K

Research & Documentation Lead

Muhamed Nafees

Documentation Lead

Sivasangaran S

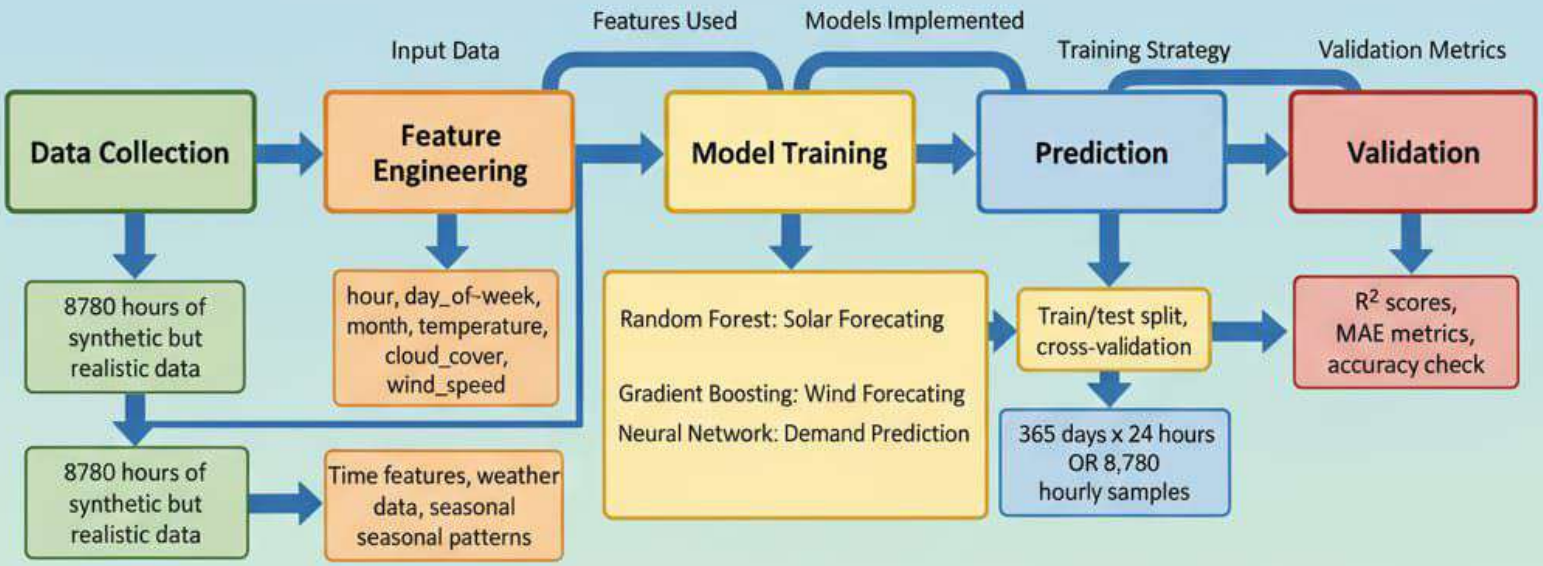
Presentation & Pitch Expert

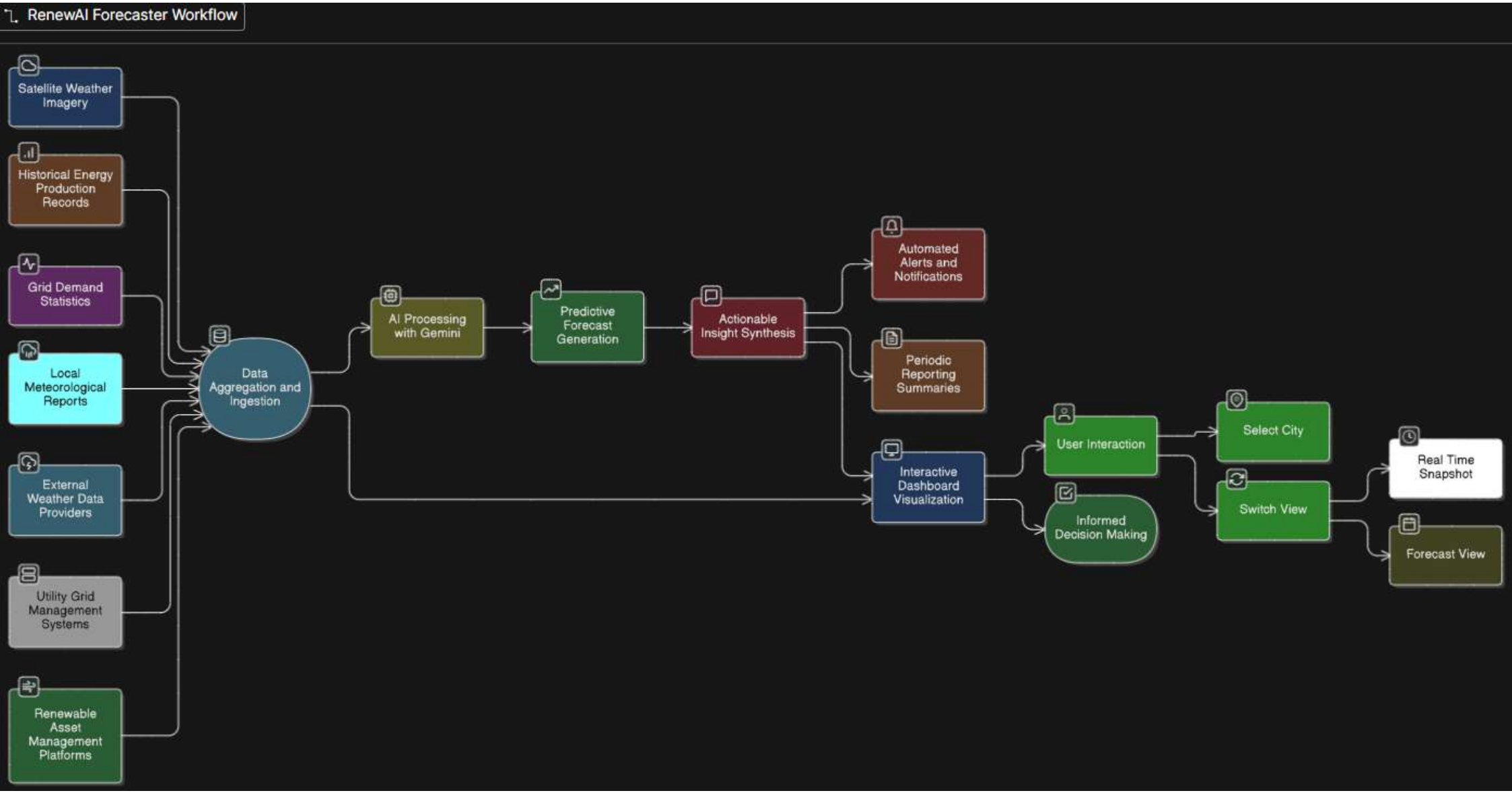
Shrish Kumar N S

Connect with Renew AI

Scan the QR code to visit our website and learn more about our innovative solutions for renewable energy optimization.

Machine Learning Workflow




RenewAI Forecaster Workflow
Satellite Weather Imagery
Historical Energy Production Records
Grid Demand Statistics
Local Meteorological Reports
External Weather Data Providers
Utility Grid Management Systems
Renewable Asset Management Platforms
Data Aggregation and Ingestion
AI Processing with Gemini
Predictive Forecast Generation
Actionable Insight Synthesis
Automated Alerts and Notifications
Periodic Reporting Summaries
Interactive Dashboard Visualization
User Interaction
Informed Decision Making
Select City
Switch View
Real Time Snapshot
Forecast View