Predicting the Clean Energy Future: Strategic Modeling for Renewable Transformation

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1. Summary

This proposal presents a comprehensive, data-driven strategy to advocate for renewable energy as the foundation of future energy systems. By combining historical data analysis (2018–2023) with advanced machine learning forecasting, the evidence reveals that renewable energy is not only clean and emission-free, but also increasingly reliable, cost-efficient, and capable of delivering sustainable energy supply year-round. The centerpiece of this analysis is the creation and modeling of a unified target variable: renewable_strength_score, which quantifies renewable performance in operational and economic terms.

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2. Objective

To demonstrate that renewable energy is:

- A permanent and reliable electricity source.
- A clean alternative to fossil fuels with zero direct emissions.
- A cost-effective energy solution.
- Consistently available throughout the year via wind, solar, hydro, and more.
- A strategic investment for climate resilience and energy security.

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3. Data and Methodology

The analysis used a cleaned dataset of hourly and seasonal energy data from 2018 to 2023. Key stages included:

- Exploratory Data Analysis (EDA) to identify trends, anomalies, and renewable vs. nonrenewable patterns.
- Feature engineering for extracting time, season, and energy-type attributes.
- Development of a composite target variable (renewable_strength_score) to evaluate renewable energy quality.

- Machine learning models (Linear Regression, Random Forest) trained to forecast this score and validate trends.
- Visualizations using Seaborn and Plotly for clarity and communication.

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4. Why We Created the renewable_strength_score

The goal was to create a single metric that reflects the strategic qualities of renewable energy. This target integrates:

- Total renewable energy output (MWh)
- Renewable share of total generation
- Electricity cost (TRY/MWh)

These components were normalized and combined with this weighted formula:

renewable_strength_score = 0.4 * scaled_renewables + 0.4 * scaled_share + 0.2 * (1 - scaled_price)

This allows the score to reflect high output, low cost, and a dominant share in the energy mix.

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5. Interpretation of the Target

renewable_strength_score ranges from 0 to 1. Its interpretation:

- 0.80–1.00: 🌟 Excellent — high renewable output, dominant share, low cost
- 0.60–0.79: ✅ Strong — reliable and cost-effective
- 0.40–0.59: ⚠️ Moderate — good, but room for improvement
- 0.20–0.39: ❌ Weak — high fossil reliance or energy cost
- 0.00–0.19: 🚨 Very Poor — unsustainable conditions

Average score in the dataset: 0.511 This indicates moderate performance, validating the need for targeted investment and policy.

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6. Machine Learning Validation

The score is ideal for regression:

- Continuous and normalized
- Model-friendly
- Stakeholder interpretable

Model results:

- Linear Regression: $R^2 \approx 1.00$
- Random Forest: $R^2 \approx 0.998$

This confirms the score's validity and the models' ability to generalize patterns in the data.

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7. Key Findings

- Steady increase in renewable output, especially wind and solar.
- Seasonal balance through wind, hydro, and solar.
- Decline in fossil fuel use, especially post-2020.
- High accuracy in modeling renewable performance.
- Reliable, well-prepared dataset with no missing or duplicate data.

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8. Investment and Policy Implications

- Governments should prioritize grid modernization, storage, and incentives for renewables.
- Private investors should consider solar, wind, and hybrid systems as scalable and profitable ventures.
- renewable_strength_score can serve as a performance KPI for sustainability benchmarks.

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9. Next Steps

- Integrate economic and weather data for sharper forecasting.
- Launch a public-facing dashboard to monitor trends.

- Extend the model for regional performance comparisons.
- Support education and advocacy based on the model's outputs.

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10. Conclusion

Renewable energy is not just an alternative — it is the most logical, scalable, and sustainable energy path forward. With decreasing costs, year-round availability, and the ability to reduce emissions drastically, investing in renewables is a strategic move for both the public and private sectors. The use of renewable_strength_score empowers us to quantify, forecast, and advocate for this transition through sound data science and clear evidence.

11. Data Source

https://www.kaggle.com/code/pythonafroz/eda-on-energy-deficit/notebook