PYTHON PROGRAMMING FOR MACHINE LEARNING

FINAL PROJECT

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Predicting the Electricity Tariff for a House with Both PV and Grid Electricity Supply

Introduction

With the rising adoption of renewable energy solutions, residential solar power systems have become increasingly common. However, for most households, complete independence from the electricity grid is impractical due to varying solar power generation and energy demands. This project aims to develop a machine learning (ML) model that predicts daily electricity tariffs by integrating data from both photovoltaic (PV) systems and grid electricity usage.

The study uses real-world solar insolation data under ideal weather conditions, combined with household energy consumption patterns, to estimate the required grid electricity and calculate the associated tariff. The project is designed to assist in energy planning and cost optimization for hybrid energy systems.

Objective

- To predict the daily electricity tariff for households using both solar PV and grid electricity supply.
- To analyze the contribution of solar energy to meeting household energy demand.
- To enable long-term cost estimation and planning for households adopting renewable energy systems.

Dataset:

For preparing the dataset, irradiance data from National Renewable Energy Limited (NREL) is used. The solar insolation values are taken from these primary datasets of 2019 and 2020. These datasets are for the location Kovilpatti, Tutucorin.

Coordinates-(9.18611111,77.85972222)

The secondary dataset includes:

- **Features**: Solar insolation ($W/m^2/day$), input power to the panel (kW), and output power from the panel (kW).
- **Target**: Daily electricity tariff in Rs.
- **Time Period**: January 1 to January 10 for the years 2019 and 2020.
- **Assumptions**:
    - A constant daily energy demand of 8.333333 kW.(one day usage for a system utilizing 200units of current per month.)
    - Ideal weather conditions for solar energy generation.

For preparing the secondary dataset, a python code is used which contains the photovoltaics calculations for preparing the dataset.

90% data was used for training the model, and 10% data was reserved for testing.

Model Development

1. **Preprocessing**:
    - The dataset was cleaned and relevant features were extracted.
    - A column for grid electricity supply (demand - solar output) was computed.
2. **Model Selection**:
    - A Linear Regression model was chosen due to its simplicity and effectiveness for regression tasks.
3. **Training and Testing**:
    - The model was trained on the January 1–8 data from both years.
    - The model was tested on January 9–10 data from both years.
4. **Performance Metrics**:
    - **Mean Absolute Error (MAE)**: To measure the average prediction error.
    - **R-squared (R^2)**: To evaluate the proportion of variance explained by the model..

Discussion

- **Insights**:
    - The model effectively predicts daily electricity tariffs based on solar energy generation and grid electricity usage.

  - Significant savings can be observed when solar energy contributes a higher share of the daily demand.
- **Limitations**:
  - The model assumes ideal weather conditions, which may not reflect real-world variability.
  - The tariff rate is fixed, whereas real-world rates can vary based on location and consumption patterns.
- **Future Scope**:
  - Incorporating weather forecasts and real-time solar insolation data to improve prediction accuracy.
  - Extending the model to predict monthly or annual electricity costs.
  - Adding dynamic tariff rates and battery storage options to the analysis.

Conclusion

This project demonstrates the potential of machine learning in optimizing energy usage and reducing costs for households with hybrid energy systems. By accurately predicting daily electricity tariffs, the model provides valuable insights for homeowners and energy planners, promoting sustainable energy solutions.

References

1. Solar Energy Data: [NREL]
2. Machine Learning Techniques: Scikit-learn Documentation (https://scikit-learn.org)
3. Tariff Rates: [TNEB]