Analytical Exercise: Modeling Solar Electricity Generation, Usage, and Battery Installation

Purpose of the Model

The purpose of this model is to conduct an in-depth analysis of solar electricity generation, electricity usage patterns, and potential savings resulting from the implementation of a battery storage system.

The model aims to achieve the following objectives:

- **Gain Insights**: Uncover meaningful insights into the temporal patterns of energy generation and consumption, enhancing our understanding of solar power utilization.
- **Financial Assessment**: Evaluate the financial benefits and feasibility of integrating a battery system to store excess solar energy and optimize electricity usage.
- **Future Projections**: Project potential savings over a 20-year period based on varying scenarios of electricity price increases.
- **Decision Support:** Provide robust data-driven insights to support informed decisions regarding the installation of a battery storage system.

Data

The model uses a dataset containing hourly solar electricity generation and electricity usage data for the year 2020. The dataset has four columns:

- Hour: Hour of the day (0-23)
- Date/hour start: Timestamp of the data
- Solar electricity generation (kWh): Amount of solar electricity generated in kilowatt-hours (kWh)
- Electricity usage (kWh): Amount of electricity consumed in kilowatt-hours (kWh)

Data Quality Assurance

A series of data quality checks were meticulously executed to ensure the reliability and integrity of the dataset:

- **Basic Data Checks**: The dataset was imported from an Excel file, and preliminary assessments were performed to validate the data's structure.
- **Data Consistency:** A thorough examination of value counts was conducted to identify any anomalies or inconsistencies in the data.
- **Data Correction:** Negative electricity usage values were treated as data entry errors and rectified to accurate positive values.
- **Outlier Identification:** Box plots were employed to detect outliers in both solar electricity generation and electricity usage data..

Assumptions Used
1. The data is assumed to be representative of a typical year in terms of solar electricity generation and electricity usage patterns.
2. Negative electricity usage values were assumed to be data entry errors and were corrected to positive values.
3. The battery capacity is assumed to be 12.5 kWh.
4. Electricity prices are assumed to increase annually according to the specified scenarios.

Methodology
Data Preparation
1. The dataset was read from an Excel file and basic data checks were performed.
2. Data inconsistencies were checked using value counts for each column.
3. Negative electricity usage values were corrected to positive values.
4. Box plots were used to identify outliers in solar electricity generation and electricity usage data.

Data Analysis
1. Average solar electricity generation and electricity usage were calculated for each hour of the day and visualized in a graph.
2. The amount of electricity bought from the electricity provider was calculated for each hour in 2020, both with and without a battery system.
3. Excess solar electricity generated over electricity used was calculated for each hour in 2020.
4. Cumulative battery charge level was modeled for each hour over 2020, considering excess solar generation and electricity bought.
5. The savings from installing a battery compared to using existing solar panels alone were calculated for 2020.

Future Projections and Financial Analysis
1. Annual savings for the next 20 years were projected based on specified scenarios of electricity price increases.
2. Net Present Value (NPV) of future annual savings was calculated for each scenario, using a discount rate of 6%.
3. Internal Rate of Return (IRR) was calculated for each scenario by finding the discount rate that equates NPV to the initial battery cost.

Further Checks
The data, calculations, and results were thoroughly reviewed and validated.. The analysis took into account the distinctive characteristics of solar energy patterns and

was tailored to provide a comprehensive understanding of potential benefits and challenges. Outliers and potential anomalies were retained in the analysis, considering the unique nature of solar electricity generation and consumption patterns.

Conclusion

This model provides a comprehensive analysis of solar electricity generation, electricity usage, and potential savings from installing a battery system. The results indicate the financial viability of the battery installation under different scenarios of electricity price increases. The model offers insights for decision-making regarding the adoption of battery systems to optimize energy consumption and cost savings.

Note: The model is constructed using python programming language. For detailed code verification, please refer to the notebook:jupyter notebook