Solar Battery Cost-Effectiveness Model Documentation

Introduction

In this document, we present an analysis of the potential savings achieved by installing a battery to store excess solar electricity generated by Naomi's solar panels. The project involves data analysis, time series modeling, and financial calculations to evaluate the economic feasibility of battery installation.

Objective of the Model

The goal of this model is to evaluate if building a battery to store extra electricity produced by solar panels is cost-effective. The model seeks to shed light on potential electricity cost reductions by taking into account various assumptions, scenarios, and financial considerations.

Data Source: Hourly solar electricity generation and electricity usage data for the year 2020.

Data Checks:

Missing Information: Since it was a leap year, the statistics for February 29 were omitted.

Data Consistency: The logical coherence of solar generation, electricity consumption, and other derived numbers was examined.

Negative Values: All calculated values (such as extra solar generation and cumulative battery charge) were checked to make sure they are not negative.

Assumptions and Limitations

We assumed a constant battery capacity and did not consider battery degradation over time.

The provided electricity price increase estimates were utilized for scenarios.

We ignored potential regulatory changes or technology advancements that could impact savings.

Naomi’s figures for calculation

Battery cost: $7,000

Battery lifetime: 20 years

Battery capacity: 12.5 kWh

Electricity purchase price: $0.17 per kWh

Electricity price inflation: Starts at 4% and increases by 0.25% annually

Initial battery charge: 0 kWh

Methodology

Calculating Excess Solar Generation: The cumulative battery charge level was modeled hour by hour, considering battery discharge and excess solar electricity generated.

Calculating Electricity Bought from Provider: The amount of electricity bought from the provider was determined by subtracting excess solar electricity from electricity usage.

Monthly Aggregates: Monthly aggregates are calculated for solar generation, electricity usage, electricity bought (with and without battery), and excess solar generation. These aggregates are plotted to visualize trends.

Internal Rate of Return (IRR) Calculation: The Internal Rate of Return (IRR) was computed for each scenario to determine the discount rate that makes the NPV of future annual savings equal to the initial battery cost.

Calculating Electricity Bought with Battery: I calculated the electricity bought from the provider when a battery is installed. This considered the difference between electricity usage and the sum of excess solar electricity generated and battery discharge.

Tabulating and Charting Monthly Data: Monthly data was tabulated and charted to visualize solar generation, electricity usage, and electricity purchased with and without the battery. This graphical representation provides insights into seasonal trends.

Time Series Analysis and Forecasting

i)Decomposition and Analysis

Time series analysis was performed on the solar electricity generation data to understand its components: trend, seasonality, and residuals. This information provides insights into the patterns and potential forecasting.

ii) ARIMA Modeling and Forecasting

An ARIMA model is applied to the excess solar generation data to forecast future values. The model's parameters (p, d, q) are determined based on ACF and PACF plots.

Projecting 20-Year Savings and NPV Calculation

The involved projecting savings over a 20-year period for two scenarios: government-expected electricity price increase and Naomi's estimated higher price increase. We calculated the Net Present Value (NPV) for both scenarios to assess their economic viability.

Graphical Analysis: ACF and PACF plots are generated to assess the ARIMA model's parameters.

Scenario Analysis: Different scenarios are evaluated to understand the impact of changing electricity price inflation rates on savings.

Interpretation of the calculations:

IRR Comparison: The Internal Rate of Return (IRR) for both Scenario 1 and Scenario 2 is calculated to be 2.00%. This indicates the expected annualized return on investment for each scenario. Since the IRR is the same for both scenarios, it suggests that the financial returns are similar under both cases.

Scenario Comparison: The analysis presents the potential savings for both Scenario 1 and Scenario 2 over the 20-year period. These savings are summarized for each year, demonstrating how much Naomi could potentially save by installing a battery. In Scenario 1, the savings start at $35,643.43 in the first year and decrease gradually. In Scenario 2, the savings start at $35,643.43 and increase slightly over the years due to the higher electricity price inflation rate.

Net Present Value (NPV) Comparison: The NPV for Scenario 1 is calculated to be $292,518.66, while the NPV for Scenario 2 is calculated to be $401,057.16. These values represent the present value of the expected future savings from installing a battery, accounting for the time value of money and the estimated electricity price increases. A higher NPV indicates a potentially more favorable financial outcome.

Forecasted Values: The forecasted values show the predicted excess solar electricity generation for the year 2021. These values can help Naomi understand the potential fluctuations in solar generation and estimate how much energy the battery could potentially store during the year.

Recommendations

Battery Installation Benefit: Installing a battery can positively impact Naomi's finances by reducing her electricity costs over time. The positive Net Present Value (NPV) values for both scenarios (Scenario 1 and Scenario 2) indicate potential savings that could offset the initial investment in the battery.

Scenario Selection: While both scenarios have the same Internal Rate of Return (IRR) of 2.00%, Scenario 2 stands out due to its higher NPV ($401,057.16). This suggests that Scenario 2, which considers additional electricity price inflation due to climate change concerns, could lead to more significant financial gains over the 20-year period.

Consider Long-Term Benefits: Installing a battery aligns with sustainability efforts and reduces reliance on traditional energy sources. Beyond financial gains, Naomi can contribute to environmental conservation by using stored solar energy, which could positively impact her community and the planet.

Acknowledging Uncertainty: It's important to note that the analysis is based on certain assumptions, such as electricity price inflation rates. Naomi should be prepared for potential variations in actual price increases. Exploring sensitivity scenarios can provide a clearer picture of potential outcomes under different circumstances.

Final recommendation: Based on the analysis, the installation of a battery for storing excess solar electricity could result in significant savings over time, particularly if electricity prices increase as estimated.