**Documentation for Naomi's Solar Panel and Battery Cost Analysis Model**

## **Purpose of the Model**

The model is used to calculate Naomi's potential savings in electricity expenditures when she installs solar panels on her home. The model calculates the cost effectiveness of purchasing and installing a new battery to store extra electricity generated by solar panels. The model also calculates the additional amount of electricity that can be met with the new combination of batteries and solar panels rather than simply a solar panel, as well as the savings in electricity prices she gains. Furthermore, it computes the Net Present Value (NPV) and Internal Rate of Return (IRR) of the battery investment in two scenarios. When the inflation rate rises by 4%, as previously announced by the government, and the second is Naomi's prognosis of a 0.25% increase in inflation per year on top of the previous years.

## **The Data**

The data presented is for solar electricity generated and electricity utilized in hourly increments in the year 2020. Naomi has also supplied facts such as her current funds, the length of time she intends to use the solar panels, the government, and her own inflation rates and annual discount rate. The dataset has four columns: the time of day, the date and time, the quantity of solar energy generated, and the amount of energy spent in electricity. The model is designed to function with these columns.

### **The checks;**

1. **The Dataset Information**

The data includes for columns each with 8760 rows and no null values;

1. Hour an integer datatype the hour of the day when the energy was either generated or consumed
2. Date/hour start datetime datatype containing the date and time in 2020
3. Solar electricity generation (kWh) float datatype containing the amount of solar energy generated per hour in 2020
4. Electricity usage (kWh) float datatype containing the amount of energy consumed per hour in 2020
5. There were no null values in the dataset, however, there were irregular values (outliers) present.
6. **The Outlier**

* The outliers were detected through the Z-Score statistical method that identifiers any irregular values outside a dataset’s mean. For example, we notice a significant outlier at 12pm on the 12th of January 2020 where over 46000KWh of electricity was consumed.
* I decided to use winsorization as a way to handle the outliers as it limits their impact by replacing them with a value closer to a percentile. For me, I set my lower percentile at 0.01 and my highest percentile at 0.99

The model verifies the data's availability and accuracy.

- It ensures that the data on solar energy generation and power usage is complete and covers all important hours of the year.

- It ensures that the information on electricity prices is consistent and appropriate.

### **Assumptions**

* The battery has a maximum storage capacity of 12.5 kWh and a minimum storage capacity of 0 kWh.
* Any excess electricity produced when the battery is fully charged cannot be kept.
* Current solar electricity generation is used first, followed by any stored battery energy, and ultimately by purchasing electricity from the provider.
* The installation of the battery costs $7,000, and its projected working life is 20 years.
* The annual discount rate for NPV calculations is 6%.

### **Methodology**

The methodology is to build a model using Python that can analyze the cost-effectiveness of the battery installation:

### **Step 1: Data Validation –**

The model validates the provided data for availability and accuracy.

* It ensures that the data on solar energy generation and power usage is complete and covers all important hours of the year.
* It ensures that the information on electricity prices is consistent and appropriate.
* The model also handles the irregular data to ensure that it has no impact with our calculations.

### **Step 2: Determine Extra Electricity and Cost Savings**

* The model computes the additional quantity of electricity that can be generated by the solar panel and battery combo above only solar panels by subtracting the solar electricity generated from the electricity usage for each other. The values are then clipped to a minimum of zero to ensure that negative values are set to zero.
* The savings are then determined by multiplying the difference between the electricity purchased and the excess solar electricity by the electricity price in 2022. Finally, the total savings over 2020 are determined by adding the savings for each hour.

- To determine the additional electricity met, it considers solar electricity generation, battery storage capacity, and electricity usage.

- By multiplying the excess electricity met by the electricity price, the model determines the estimated cash reduction in power costs.

### **Step 3: Determine the Net Present Value (NPV).**

- The NPV calculates the present value of a sequence of future cash flows while considering the time value of money.

* In Scenario 1, where power prices rise by 4% per year, the code first computes the annual savings using an assumed beginning dollar saving value. These annual savings are then multiplied by the increase in electricity rates for each succeeding year. The net present value (NPV) is calculated by adding the discounted values of annual savings for each year using the supplied discount rate.
* In Scenario 2, where power price rises begin at 4% and continue to rise by 0.25% each year, the code uses the same approach to determine annual savings and then the NPV. The NPV values that arise provide insight into the financial ramifications of various electricity price escalation scenarios. The printed outputs provide the annual savings and NPV values for both scenarios, which can be used to make decisions by comparing the financial results of both scenarios over time.

### **Step 4: Calculation of the IRR.**

* The Internal Rate of Return (IRR) is calculated using the 'fsolve' function from the'scipy.optimize' package. The IRR is the discount rate at which the predicted annual savings' Net Present Value (NPV) equals the initial cost of the battery. The code constructs a function that calculates the NPV for a given discount rate and annual savings, and then employs 'fsolve' to discover the discount rate that solves the NPV equation. For each case, the IRR is printed. Naomi may analyse the profitability of the battery investment by calculating the IRR, with a larger IRR signifying a better investment.

**5. Additional Checks:**

The model performs the following additional checks:

- It confirms that the excess electricity calculated is within the storage capacity restrictions of the battery.

- It verifies that the estimated monetary savings in energy expenses are fair and consistent with the facts presented.

- It verifies the accuracy of the NPV and IRR computations.

Please keep in mind that the model assumes that no other factors, such as maintenance or replacement prices, have a substantial impact on the cost-effectiveness analysis. If these factors are available, they can be incorporated into the model.