Energy Usage Analysis

An Analysis of Solar Generation Effectiveness

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Introduction (20 marks)

(20 Marks)

- Origin
- Why is it important to me
- Show first 5 or 6 lines of data to help understanding

Objectives

This report looks at the use of solar energy during September 2024 in a domestic property in the southern highlands of Scotland. The property previously used oil for heating and electricity for lighting plus cooking but this was changed in order to reduce running costs and the carbon-footprint of the property. A solar array, battery and ground source heat pump were installed in order to attempt to rely solely on solar generated electricity and supplemented with import from the electricity grid only to compensate for short-falls.

The main aims of this data analysis is to answer the following questions:

1. How effectively does the solar generation cover energy consumption?
2. When specifically does the solar generation fall short and require grid import?
3. Would additional battery storage capacity cover these shortfalls?
4. Does the installation meet the expectations at the time of purchase?

WIP - Analysis, expected conclusions:

1) Consumption is covered by solar .. or not? how much? how much grid still needed
2) Consumption is linked to temperature and house occupancy
3) Solar generation is linked to irradiance .. but how much?
4) Any other links such as temperature? .. probably not usage or occupancy though?
5) ?? Cannot account for £ cost and different costs at times of day .. battery importing then for example
6) ?? Battery timing in and out complicates the analysis?
7) Increased battery will smooth out across days? forecast storage/impact .. but can't see the intra-day detail to better analyse
8) Solar generation meets the forecasts at purchase .. need original data/estimates!?

Summary of The Data

The data analysed comprises four parts, all daily data, 30 observations, for each day in September 2024:

- Weather: Temperature and solar irradiance readings
- Energy Use: Electricity consumption
- Energy Source: The source of electricity: solar, battery or import from the grid
- *Occupied*: A Y/N flag to indicate if the house is occupied or not

All data and supporting files can be found online at Github[1].

Weather

Weather data is sourced from the Balquhidder Weather Station[2] and consists of:

- *Temp* - the mean daily temperature in °C and is derived from 6 readings taken at 4 hourly intervals over a 24 hour period
- *Irrdnce* - irradiance, a measure of the solar energy experienced over a specified area, units are W/m^2 and his is used to actually calculate the power generated from an array of solar panels[3]

Energy Use & Source

The distribution of power for the house is managed by a Tesla Powerwall and Controller and an iPhone app is used to monitor this, see Figure 1. All electricity data was downloaded from this app. Electricity is measured in kWh.

Electricity is sourced from:

- *From_Solar* - solar power generated by an array of 36 solar panels
- *From_Battery* - battery storage
- *From_Grid* - the national power grid

The controller then intelligently routes electricity to:

- *Home* - consumption by the house
- *To_Battery* - for battery storage
- *To_Grid* - export to the national power grid

[1] https://github.com/StuartG24/Home-Solar-Usage-Analysis
[2] https://www.blscc.org/weather
[3] Wikipedia: https://en.wikipedia.org/wiki/Solar_irradiance

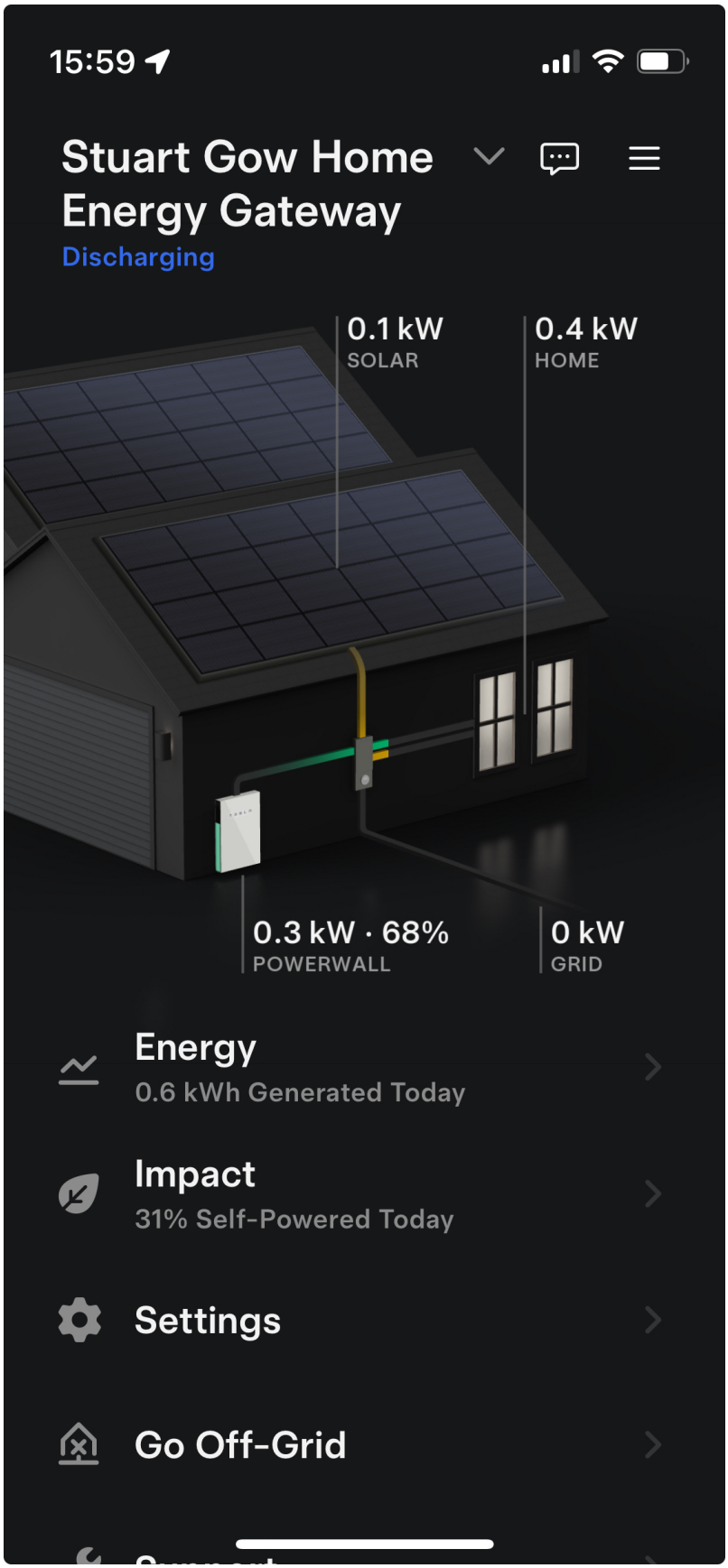

Figure 1: Tesla Powerwall

Initial Data Examination

TO DO: *Tidy up table columns display .... look at Pandoc options etc to change layout for table and whole document? https://pandoc.org/MANUAL.html#synopsis*

Once the three sources of data have been collated the dataset for analysis consists of the below:

```
# Display the first 6 rows of the data
kable(head(energy_df), caption = 'First 6 Rows of the source dataset')
```

Table 1: First 6 Rows of the source dataset

Date	From_Solar	From_Grid	From_Btry	To_Home	To_Grid	To_Btry	Temp	Irrdnce	Occupied
2024-09-01	2.4	11.4	11.7	19.0	0.0	0	12.9	365.9	1
2024-09-02	1.2	17.3	5.2	11.3	0.0	0	13.4	335.4	0
2024-09-03	6.4	10.5	7.1	13.9	0.0	0	9.9	1346.8	0
2024-09-04	6.8	7.4	9.3	16.2	0.0	0	9.5	1722.5	0
2024-09-05	11.0	11.5	9.1	18.0	0.1	0	14.5	1681.8	1
2024-09-06	14.7	0.4	11.0	16.0	1.0	0	16.6	1489.4	1

The following plots etc etc

```
plot(energy_df$To_Home ~ energy_df$Date, type = 'l', col = 'red')
lines(energy_df$Date, energy_df$Temp, type = 'l', col = "blue")
lines(energy_df$Date, energy_df$Occupied*20, type = 'h', col = "green")
legend("topright", legend = c("Home", "Temp", "Occupied"),
       col = c("red", "blue", "green"), lty = 1)
```

```
plot(energy_df$Date, energy_df$From_Solar, type = 'l', col = "red")
lines(energy_df$Date, energy_df$Irrdnce/150, type = 'l', col = "blue")
legend("topright", legend = c("Solar", "Irradiance", "xx"),
       col = c("red", "blue", "green"), lty = 1)
```

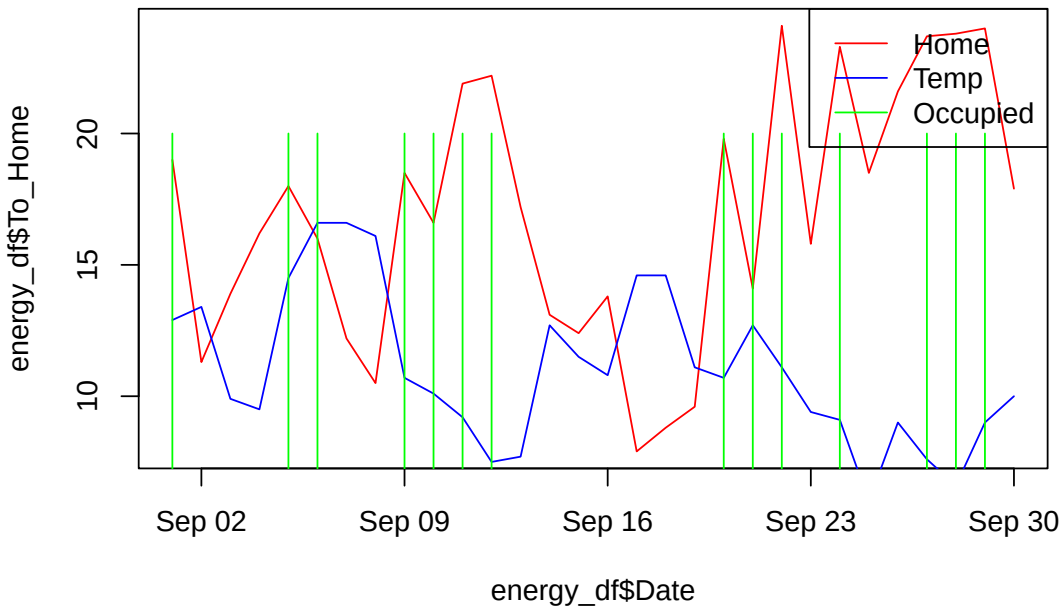

Figure 2: First plot

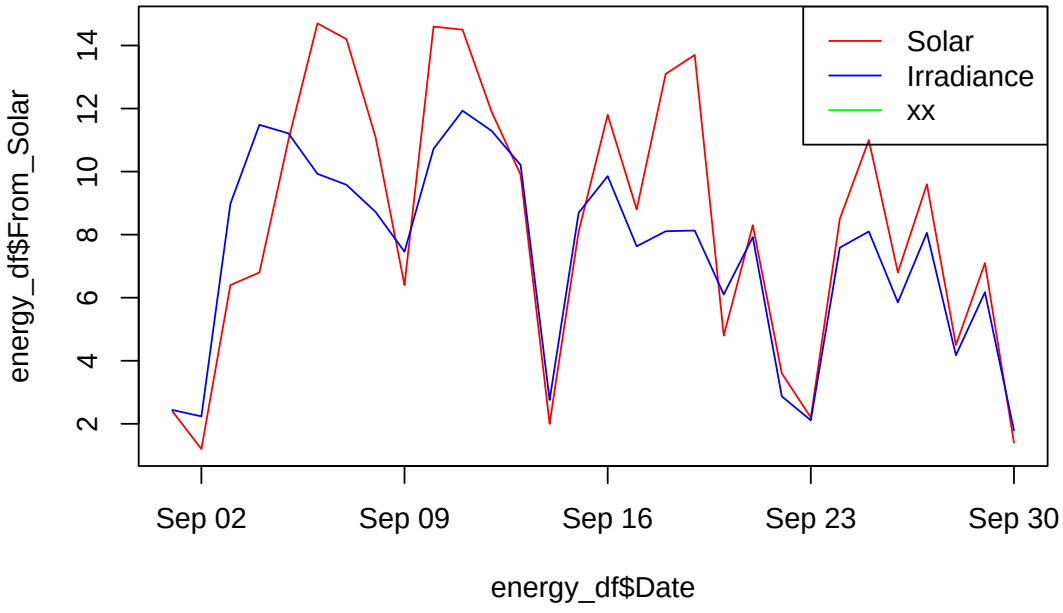

Figure 3: Second plot

Methods and Results

(40 marks)

Method

TO DO: Should data introduction and visualisation be here instead?

Results

TO DO: Have a look back at the Bran Lab report for Spring 2018, for how to present means, SD etc etc

Conclusions

(20 marks)

##?? Discussion

TO DO: Structure into two sections

##?? Conclusion

Test citations (Crawley, 2014) and as Fraix-Burnet (2016)

Spiegel and Schiller (2012)

References

Crawley, M.J. (2014) *Statistics: An introduction using R.* 2nd Edition. John Wiley & Sons.

Fraix-Burnet, D. (2016) 'Introduction to R', *Statistics for Astrophysics: Clustering and Classification*, Volume 77(2016), pp. 3–12. Available at: https://doi.org/10.1051/eas/1677002.

Spiegel, M.R. and Schiller, J. (2012) *Schaum's outline probability and statistics.* 4th edn. McGraw Hill.