Power Simulator: 3 Part Investigation

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Investigation 1 – Power Usage

Abstract:

The Power Usage investigation is an investigation which aims to display a house's energy usage rate throughout a set period, and observe the trends, patterns, and usage fluctuation of the house. In this investigation, there are various parameters and variables that are considered before recording data and forming a hypothesis. These variables are:

- Residents of the house: How many people are present during the times recorded, and do the presence of residents affect the daily energy usage and consumption of the house?
- Time: At what time will I record energy readings from the meter box, will it be once every morning, or an interval of hours during the day?
- Seasons: Does the transition from summer to winter affect the energy usage of my/the house?

Hence, by considering these parameters and other present factors through the investigation, there are different possible outcomes which could be evident in observing and analysing energy readings. Thus, the cumulative energy usage of the house could possibly increase day-by-day or the cumulative energy usage of each house could fluctuate due to the varying presence of residents within the house, i.e.; one day, the house could have all 3 residents of the house present, while the following days, only 1 or 2 residents are there.

Accuracy in data gathering is a major key in plotting a clear simulation, and thus various recommendations on how we can gather data and simulate energy usage has been considered for the investigation; Recording data 3 times a day, one early in the morning, afternoon and night time. Creating records for each time intervals could provide accurate readings as each time intervals take in account of the residents present, as i.e in the Morning, there would be less residents due to going to work/school etc, hence less usage during the morning, afternoon could see little to no change since people are only coming home then, and evenings and night where most residents are present and would hence increase power usage for the day. Taking recordings at the near/exact times every day could increase accuracy in data, as the data will be taken at the exact time, it wont have a possible time difference as to i.e recording an hour earlier or later. In other words, we could accurately see the difference from 8am to 8am the next day.

Furthermore, plotting the data through a line and bar graph will accurately portray the trends and energy fluctuations as a line graph can plot each highest and lowest energy usage points within the day, likewise with the bar graph, the fluctuations, increase and decrease in energy usage can be clearly visualise the levels of each energy usage of the day.

Background

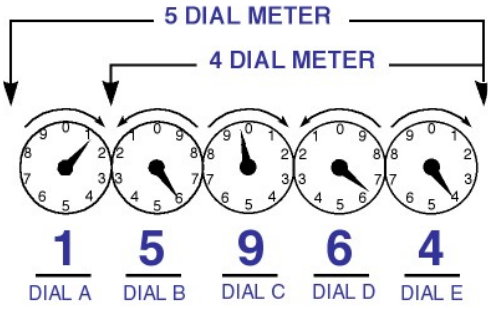
PowerUsageLauncher.py is the outcome program of the investigation. PowerUsageLauncher aims to plot and simulate the energy readings spanning in the time frame of 22 days data and creates a line and bar graph (for cumulative usage). Furthermore, the program can read in plot each reading for Morning, Midday (Afternoon) and Night. The parameters chosen, which includes the day of recording and time of the day recorded is plotted in the graph, where the time/date is the x-axis, and y-axis is the usages per day.

Date is a parameter chosen for the program/simulation as it allows the program to accurately represent when each readings were recorded, and as evident, the energy uses for morning to night time are used to as data for the program to take in and plot.

Methodology

There are various methods that have been undertaken for the PowerUsageLauncher to come into fruition.

The energy usage is recorded by reading the energy meter box located near the house's back door entrance. The energy usage is read from 5 dials representing the kW/h used by the house. *See figure 1 (accessed from seattle.gov)*

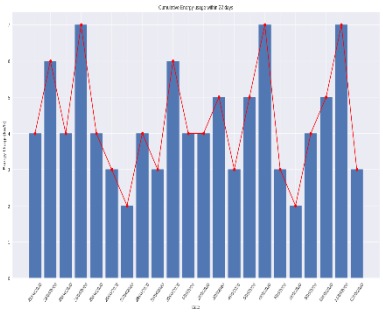


Energy readings for the day are then stored in a .csv(comma separated values) file, and put under the headings: 'Date' and 'Reading' and are saved accordingly to their times. Cumulative is manually calculated by taking the difference of Night and Morning readings. *See figure 2: Nightly.csv reading file*

Nightly.csv

	Date,Reading
2	21/04/2020,68628
3	22/04/2020,68635
4	23/04/2020,68640
5	24/04/2020,68649
6	25/04/2020,68658
7	26/04/2020,68665
8	27/04/2020,68669
9	28/04/2020,68674
10	29/04/2020,68678
11	30/04/2020,68687
12	1/05/2020,68695
13	2/05/2020,68698
14	3/05/2020,68705
15	4/05/2020,68710
16	5/05/2020,68719
17	6/05/2020,68729
18	7/05/2020,68736
19	8/05/2020,68742
20	9/05/2020,68749
21	10/05/2020,68756
22	11/05/2020,68768
23	12/05/2020,68773

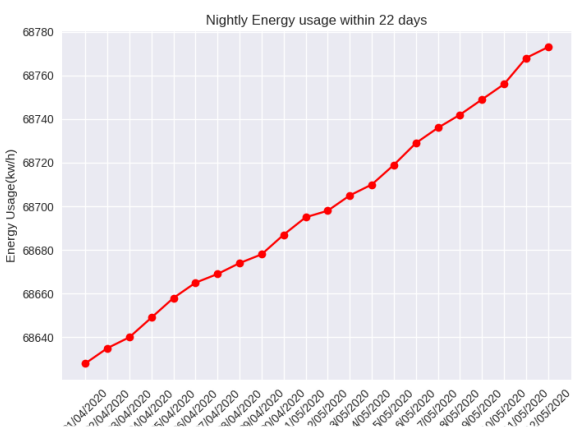
The data is then inputted into the program accordingly to the user's selection. Which is then plotted by the program and is plotted through a line a bar graph (bar graph if user chooses to simulate the cumulative readings). The plot produced by the program is then saved and used for data observation, observing the increase and fluctuation of energy usages within each time intervals. These observations are then taken note of to create a conclusion based on the recorded readings and visualisation of the energy readings. The Cumulative energy usage once plotted is observed for increase and decrease and energy uses for each day and to see the differences in usage for each day recorded.



The graph is visualised likewise to the following figure 3 (Cumulative.csv plot).

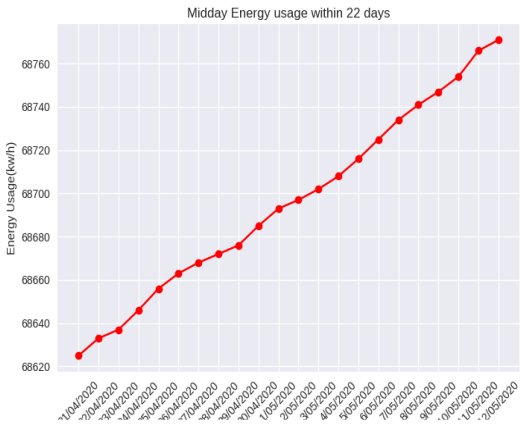
Results and Conclusions

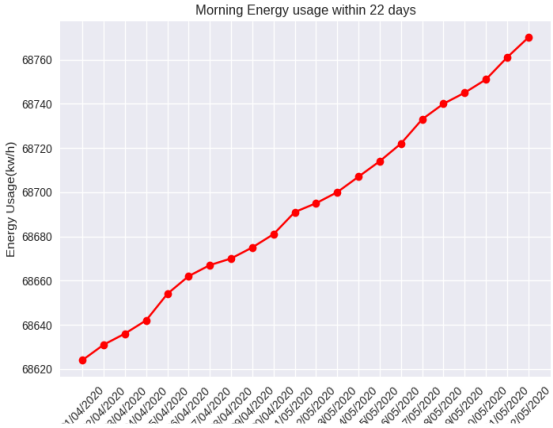
The Investigation, with the aid of the PowerUsageLauncher program and the 3 interval readings from Mornings, Afternoon



and Night-time energy readings we can see a common trend and within each reading by the program and its plot function capability.

For all morning, afternoon, and night-time readings, it is visually obvious that the energy usage of the house will continue to increase, if there are present residents currently living within the house.





However, there are also notable differences between each reading. It is evident from both recordings and data visualisation that Nightly energy usages are much higher, compared to energy usages visualised and recorded for Morning and Midday/Afternoon. This is because the residents of the house are more likely to be present during evening and nights, as during the morning and afternoons, the residents are working or at school and thus leaves only 1 resident to no resident present at the house for most of the day. Furthermore, the Cumulative graph shows that there's fluctuation in energy usage per day, the house's usage per day is not constant, but decreases and increases.

The obvious conclusion to the investigation as aforementioned is that the energy usage of the house will continue to increase given that there are people living in the house, however, the cumulative usage per day may vary from house to house. The house used in the investigation has 3 residents, where 2/3 of its residents are not present most of the time except at night, therefore, its not fair to conclude that every house will show the same energy readings and cumulative usage. Hence external data could be used to compare it against one another and see if the trends observed in this house is also present or not. The houses compared against the first observed house should have some significant difference such as, residents present during the day, amount of residents living in the house, type of energy being used by each house i.e. one house could be using solar energy rather than electric energy use.

Future Work

In the case of working on a similar or extended version of this investigation, there are some things that could be changed. We could use different houses instead of one house to observe energy usages and conclude to see if all of they share a common trend in terms of usage during the day, and their total usage. Secondly, the time frame should be longer for better observation, as usages change not only within a span of months, but also years and further. Also see the average daily usage of each house and see if this average aligns to all of Australia's average daily home energy usage.

Please find the references at the end of this document.

Investigation 2 – Power Modelling

Abstract

The Power Modelling Investigation is an investigation which aims to observe how different factors affect the hourly usage of different common appliances around the house. The investigation will involve observing the hourly usage of common appliances around the house, and record their on and off times during each hour and calculate their total watt usage during the whole day, their power rate is gathered from i.e. a fridge would have a sticker or user info containing the energy rate of the fridge. The on and off is represented by 1(on) and 0 (off). There are various parameters and variables used and considered while undertaking the investigation:

- Seasons – How often are each appliance used in each season? Particularly to the recent summer to winter season transition. How does each appliance usage affect energy consumption of the appliance i.e. Is the appliance consuming a lot more energy than it is expected?
- Time – How long are each appliance used within an hour and how does their usage time affect the energy consumption of the appliance.
- Residents – How many residents are currently present in the house and how are they affecting the usage of each appliance.

Hence, by considering the parameters and variables, there are different possible outcomes that the investigation could present. Seasonal changes could affect the usage (on/off times) of each appliance, i.e. in winter, a clothe dryer would be used more often as residents will not be hanging their clothes during rainy days. The time usage of each appliance also needs to be accurately recorded and be within a 1-hour time frame to produce possible hourly usages. Lastly, a house with more residents present in the house, are more likely to use appliances for longer within 1 hour, or use the appliances at a short a mount of time, but use them more often in the span of 24 hours.

As with investigation 1, accuracy in data gathering is a key participant in creating a clear and functional model for each appliance. To ensure data accuracy, it is recommended that we ensure that usage for each appliance are recorded within the given time span and hourly time intervals as often as possible, i.e. record usage of microwave from exactly 9am to 10pm. It is also recommended to be consistent with the unit of measurement, as most appliances use watts, ensure that each appliance energy rate are in watts or converted to watts. Finally, it is recommended that the on and off times of each appliances are to be plotted in a line graph, so that we are able to observe spikes in usage, in other words, when the usage of each appliances peak, and also see the times it is less likely used in.

Background

PowerModelLauncher.py is the resulting program of the Power Modelling investigation 2. PowerModelLauncher aims to build an inventory of appliances gathered in a .csv file and simulate their hourly usage (on and off times) during the day, by plotting a moving live plot that simulates the hourly usage of each appliances. The parameters chosen are, the on/off times of the appliances plotted in the y-axis, and the hour it was used in in the x-axis. Furthermore, the power rating of each

appliances we are also used as parameters for the investigation as they will be the key to find the consumption usage of each appliances when they are on and off, along with the residents being a prime parameter, as they affect how long and how much an appliance is being used.

Methodology

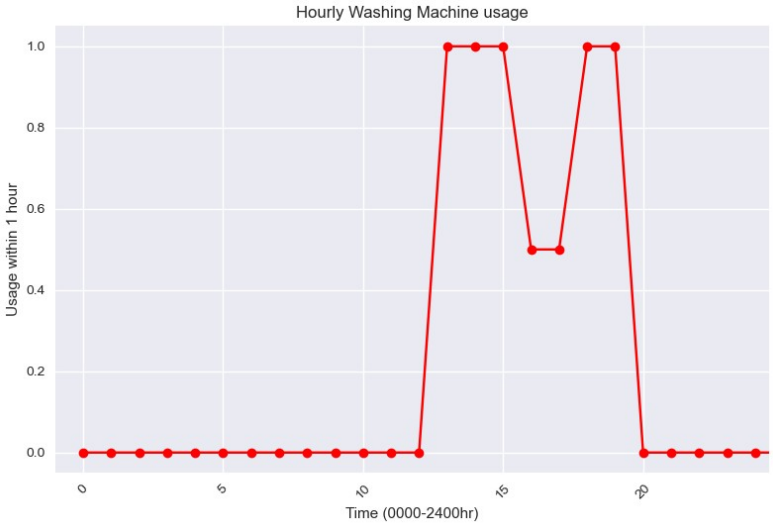
There are different methodologies that have been undertaken for the Investigation and the PowerModelLauncher to take place. As we are trying to build an inventory of appliances, we have listed 10 appliances that are common in a household, these are:

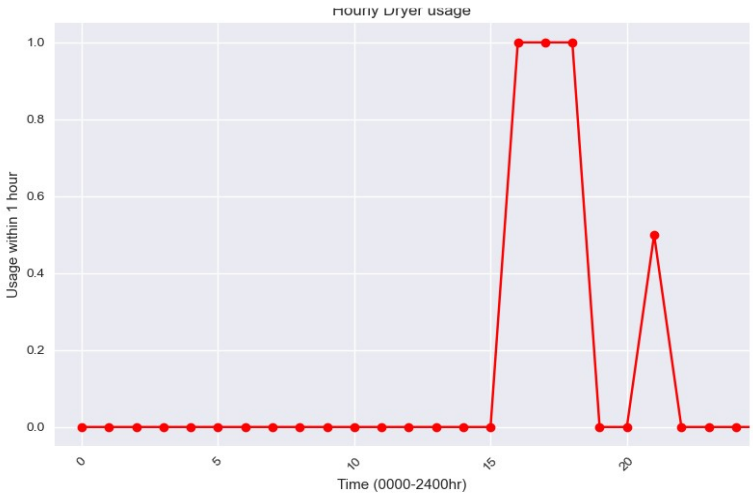
- Television
- Fridge
- Oven
- Washing Machine
- Microwave
- Dryer and Hairdryer
- Lamps
- Computer and Laptop

Time:	TV_Living:400	Fridge:250	Oven:2400	Washing_Machine:730	Microwave:1150	Dryer:520	Hairdryer:1600	StudyTable_Lamp:5	Computer:550	Laptop:45
0:00	0	1	0	0	0	0	0	0	0	0
1:00	0	1	0	0	0	0	0	0	0	0
2:00	0	1	0	0	0	0	0	0	0	0
3:00	0	1	0	0	0	0	0	0	0	0
4:00	0	1	0	0	0	0	0	0	0	0
5:00	0	1	0	0	0	0	0	0	0	0
6:00	0	1	0	0	0.25	0	0.25	0	0	0
7:00	0	1	0	0	0	0	0	0	0	0
8:00	0	1	0	0	0	0	0	0	0	0
9:00	0	1	0	0	0	0	0	0	0	0
10:00	0	1	0	0	0	0	0	0	0	0
11:00	0	1	0	0	0	0	0	0	0	0
12:00	0	1	0	0	0	0	0	0	0	0
13:00	1	1	0	1	0	0	0	0	1	0
14:00	1	1	0	1	0	0	0	0	1	0
15:00	1	1	1	1	0	0	0	0	0	0
16:00	0	1	0	0.5	0	1	0	0	0	0
17:00	0	1	0	0.5	0.25	1	0	0	1	0
18:00	1	1	0	1	0	1	0.25	0	1	0
19:00	1	1	0	1	0	0	0	1	1	1
20:00	1	1	0	0	0	0	0	1	1	1
21:00	0	1	0	0	0	0.5	0	1	1	1
22:00	0	1	0	0	0	0	0	1	1	0
23:00	0	1	0	0	0	0	0	1	1	0

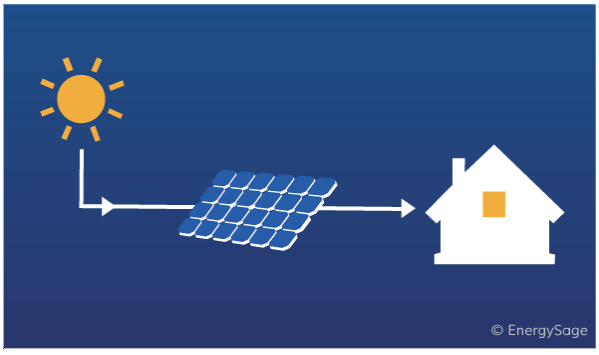
Each appliance has varying consumption rate; therefore, their watt usages are recorded down, this is done by checking informative stickers or markers on the appliance, usually found at the back or front of an appliance. For the computer's case, the power consumption rate was found on the PSU's (Power Supply Unit) sticker inside the computer. Using a total of 10 appliances, each on/off times are recorded every hour and is represented as: 1 – indicating on for one hour, and 0, off the whole hour. However, if an appliance was used for I.e. 30 mins, on representation is represented as '0.5' as it was used/on for half an hour. These recorded on/off times are recorded in a csv (see figure 4 (above): AppliancesUsage.csv). These recorded on an off hours are then loaded in to the PowerModelLauncher where user is prompted which appliance they want to simulate the usage of, extracts this data from the csv and simulates it's hourly usage in a live line graph. A live line graph is used to see the peak usage times of each houses, so that we can observe at which times the appliances are being used the most, and when they are the most inactive. The program then finds the total watt consumption of the appliance/s and usage per hour.

Results



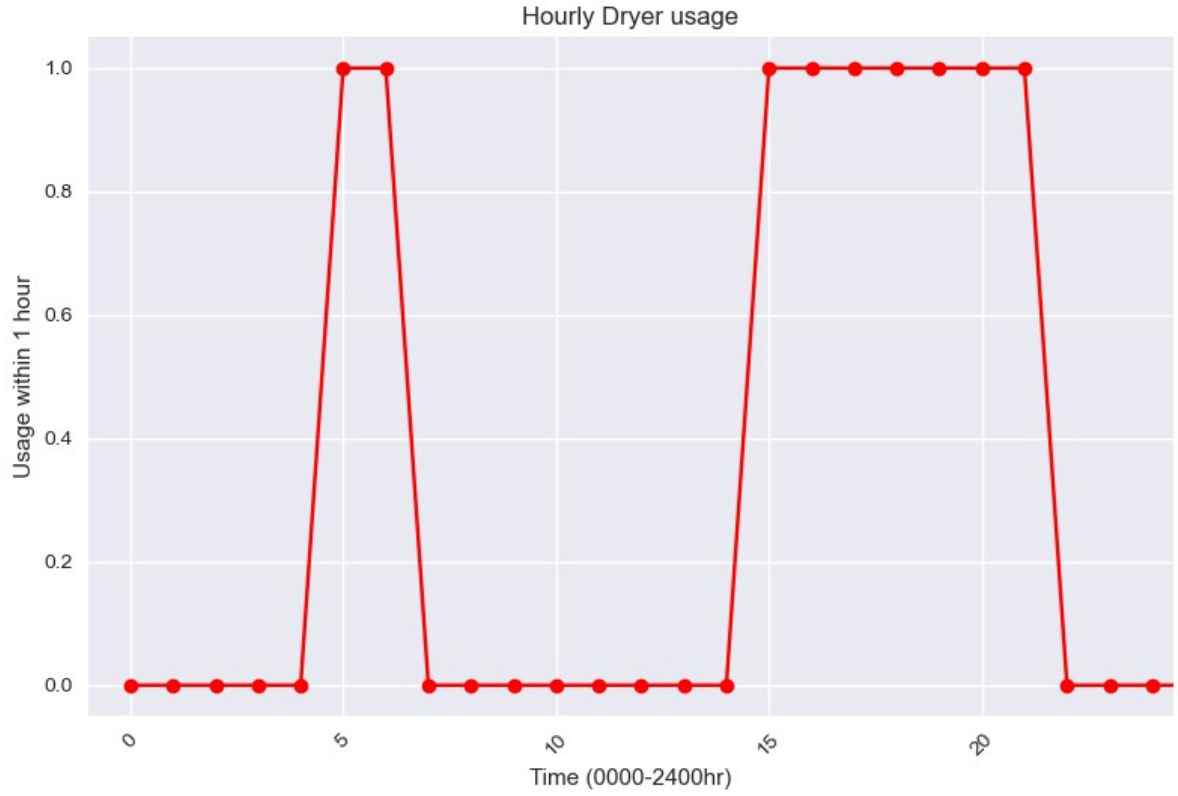


In the second Investigation, it is evident that the presence of residents within the house greatly affects appliances usage in the house. For example., in the following 2 graphs, showing the Washing Machine and Dyer hourly usage, it is visible that both appliance usage peak during the later time of the day, 12-9pm. As mentioned, following hourly usages are affected by the residents present in the house, and shows true in the graph. Both dryer and washing machine is used in the time frame of 12-9pm due residents being most present during later times of the day, hence the hourly usage of the Dryer, Washing machine and other aforementioned appliances are used more later on the day, with the exception of the Fridge since it is always open and thus maintains the same use time (as it is being used 24/7), only off when there is a power outage and/or the fridge is being fixed or replaced. Furthermore, the use of solar energy could be beneficial to the house. Although using solar energy won't affect the power consumption of the appliances as shown in the model, appliances however, will consume a cleaner form of energy which relies less on traditional fossil fuel energy production but rather stores and uses the energy from the sun as an energy source. Therefore, reliance on burning fossil fuels lessened, and thus emissions created from power plants are reduced and thus lessening the damage to the atmosphere. In addition, solar energy could cut back house electricity bills, as a household and its appliances use less power from the power grid/plant, as it is using its self-produced power. (figure: Solar Energy).



Conclusion and Future Work

By analysing the results of the investigation, it is safe to assume that the parameters chosen were fair to the investigation, as assumed, the amount of residents the usage of each appliance, as the more residents in the house and the time they are present, the more the usage of an appliance increases. However, it is also visible that appliance usage could also affect the usage of an appliance. For example, during winter, it's mostly raining or cold, hence a clothe dryer would be used more and hence change the hourly usage of the appliance: An example figure shows simulates this change: We can see here that the dryer is used at a total of 9 hours within a day.



In the case of working on a similar or extended version of this investigation, there could be some changes to how the investigation could be conducted. For example, instead of using a 1-day appliance usage as a model data reference, we could use a daily average appliance usage within a month. The reason for this is to make the investigation more fair, as appliance usage patterns within 1 day could be different for the next day, such as if a dryer was used for a total of 9 hours in one day, what if the dryer was never used for the rest of the week? This would completely change how the model would look. The usage of an appliance within i.e. a month could be completely different to how it would look like in just one day, a monthly model would take into account all days and not just one, hence making the investigation more fair.

Please find the references at the end of this document.

Investigation 3 – Power Simulation

Abstract

The Power Simulation Investigation, similarly, to Investigation 2, aims to observe how the hourly usage of different appliances are affected by different factors such as residents and seasons. However, Investigation 3, aims to simulate the hourly usages of an inventory of appliances within a street of houses. The process and parameters taken for Investigation 3 is like Investigation 2. Investigation 3 involves involve observing the hourly usage of common appliances within 5 houses and record their on and off times during each hour and calculate their total watt usage during a whole day. The on and off times are represented as 1 (on time) and 0 (off time). The parameters and variables which have been considered are:

- Seasons – How often are each appliance used in each season, particularly to the recent summer to winter season transition. How does each appliance usage affect energy consumption of the appliance i.e. Is the appliance consuming a lot more energy than it is expected?
- Time – How long are each appliance used within an hour?
- Residents – How many residents live in each house and how are the appliances in each house affect.
- How can electricity providers service the needs of the streets?
- How does solar energy impact the simulations?

Hence, there are different possible outcomes that can be produced for this investigation. Seasonal changes could affect the on/off hours of each appliances, such as in summer, appliances such as a clothe Dryer will have less on/off times as residents are more likely to hang their clothes outside, in the sun instead of using the dryer. Furthermore, as we are taking a street of appliances inventory, the residents present within each house could affect the usage hours of appliances present in the house. For example, a house with 3 residents would have lesser times using appliances, whereas say a house with 7 residents would use an appliance for longer times due to more people using the appliances.

There are various recommendations that have been considered when conducting this experiment. Making sure that each inventory of appliance within each house contains the same appliances, as we're able to see the usages of each appliances within different houses, and thus make it fair, because some houses don't have appliances that other houses may have, for example, 1 house may not have i.e. an electric towel rack, but the another house could have 3 of this appliance in their house. Hence, the following data on the appliances below will be gathered, similarly to Investigation 2:

- Television

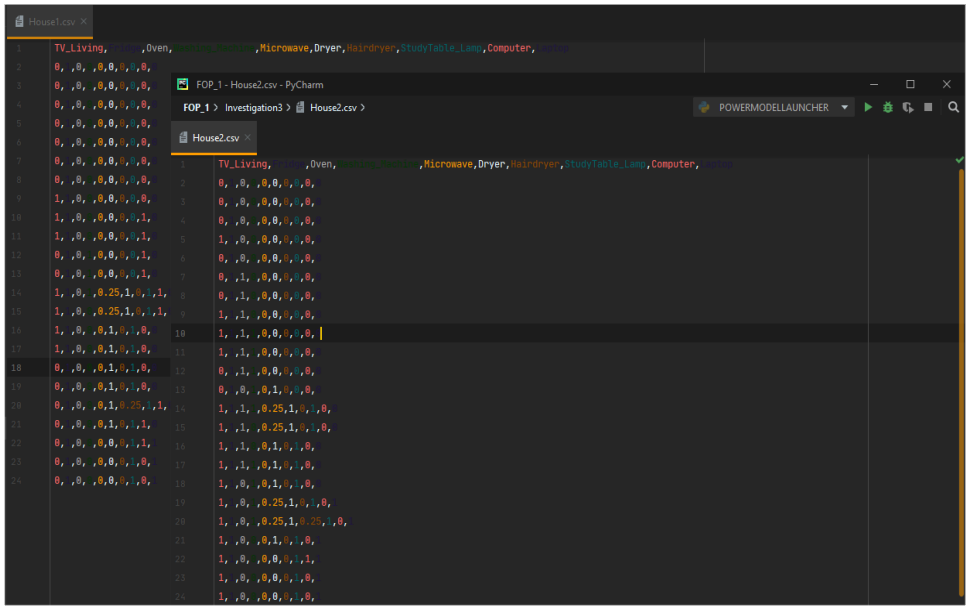
- Fridge
- Oven
- Washing Machine
- Microwave
- Dryer and Hairdryer
- Lamps
- Computer and Laptop

Background

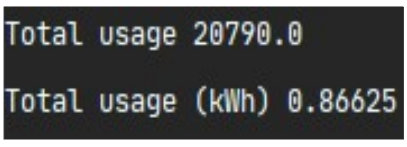
PowerSimulatorLauncher.py is the outcome program created in Investigation 3. The program, like the PowerModelLauncher program loads in multiple inventories of appliances for each different house and simulates each appliance's hourly usage. The program allows the user to choose a selected house in which they want to simulate and observe. The program then plots a live plot simulation for each house for observation and calculates the accumulated usage of all appliances. The parameters used are, time, recording the time used for each appliance within 24 hours along with each appliance's power rate. Other parameters such as residents within each house play a vital factor in the investigation, as they greatly affect the usage time of each appliance within houses.

Methodology

Different methods have been used to undertake the investigation. For the input files, we use the recorded csv files for each house, containing each appliance's hourly usage for the individual houses. (see csv/s below):



Each appliances watt consumption rate also varies from house to house and has therefore been implemented on to the program for later total computation. As the user is prompted to select a house, the program loads in i.e. 'House1.csv' containing the csv file and creates a live plot which simulates the hourly usage of each appliances. The on/off hours are represented as 1s and 0s as aforementioned, and half hours are represented as 0.5 and so forth. The total consumption of the appliances is then calculated and outputted for user observation. (example image):



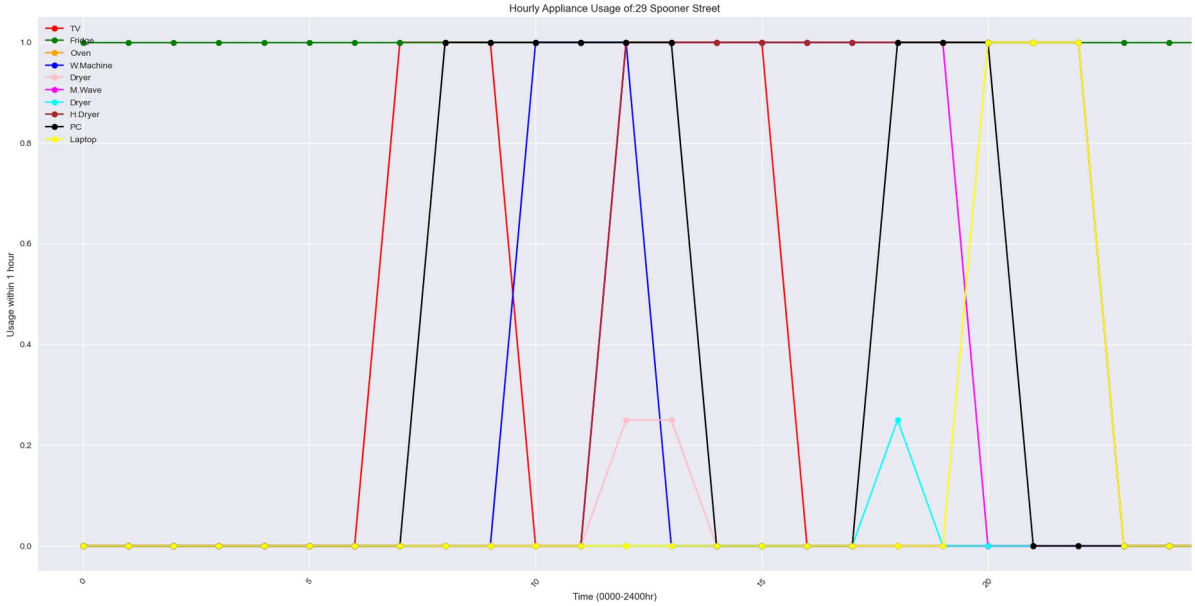
The data gathered is based on the Fundamentals of Programming Piazza (Question @355).

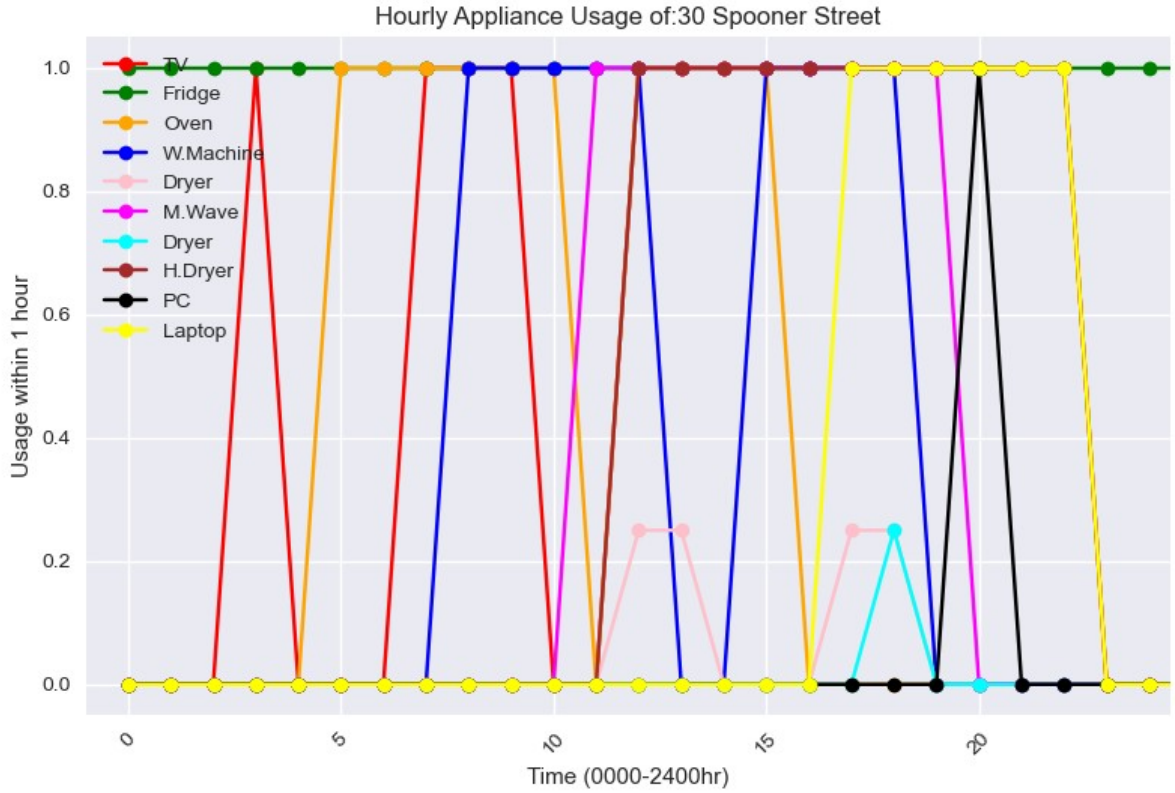
Each graph with different residents is then compared against one another and note down the differences in usage of each appliances. Note that the watt usages are converted into kw/h.

Results

There are varying results that can be seen in Investigation part 3. Houses with more residents, tend to have a higher usage time, hence higher consumption usage for each house. Furthermore, as there are more residents present within the house, the higher the hourly usage time. This is evident in the example graphs.

The hourly appliance usage for 29 Spooner Street shows the hourly appliance usage containing 1 resident, and 30 Spooner Street shows the hourly appliance usage containing 7 residents.





It is visibly evident from each graph that the more residents, the more each appliance are used within each day. This result shows true as more people in 30 Spooner Street are using appliances around the house at a different time interval, whereas in 29 Spooner Street, the single resident could have a uniform daily hourly usage, and thus his hourly usage greatly differs from the second house shown in the graph. However, as with investigation 2, both fridges in the houses stay at a constant on section, as the fridge is constantly being powered. Furthermore, the use of solar energy or it is implementation with houses not currently using solar energy, could become beneficial not only environmentally but also financially, particularly beneficial for houses which house more residents. Solar Energy works by gathering and powering the house by storing energy from the sunlight and is stored in a cell for later use during night-time. There are various benefits to using solar energy, as aforementioned in Investigation 2, uses a cleaner and renewable hence less reliance on fossil fuels, which is harmful to the atmosphere. Any excess electricity produced is brought back to the power grid. Usage of solar energy could greatly impact the energy usage of each household, saving them money, as it will cost them less to produce and use their own energy compared to completely relying on the power grid which would cost households more, particularly houses with many residents living in the house.

Conclusion and Future Work

By analysing the results of the Investigation, it is visible that the parameters chosen were fair to the investigation, as they were able to properly simulate each houses' hourly appliance usage. However, the simulation could still be different for different situations, for example, different seasons could greatly affect the usage of each appliances, but however would still show a similar result. As an example, a house with more residents could have a much greater usage of appliances, particularly appliances such as Dryers, Hairdryers etc, which would increase both energy consumption and hourly usage for each appliance.

If the investigation were to be further extended, a monthly simulation could be done instead of a 1-day simulation. This could make the investigation fairer as it would consider all days of i.e. a month, not just 1 day. To elaborate, it would make the investigation fairer as it could show us the pattern of appliance usage within individual day, the appliance usage of individual houses could be different daily, as one day an appliance could be used for the whole day, but barely used for the rest of the week/following days.

Please find the references at the end of this document.

Student Notes

- The inspiration for creating a live plot can be reference to various educational programming videos located into YouTube, which teaches how to create moving line graphs:
  https://www.youtube.com/watch?v=Ercd-Ip5PfQ (Corey Shafer)
  https://www.youtube.com/watch?v=ZmYPzESC5YY (sentdex)
- The usage of pandas library was to ease the manipulation and loading of data from a csv.
  https://www.youtube.com/watch?v=AFnUhiRXXWk (OSPY)
  https://www.youtube.com/watch?v=0P7QnIQDBJY&t=2m22s (Keith Galli

Reference

Galli, Keith. 2019. https://www.youtube.com/watch?v=0P7QnIQDBJY&t=2m22s.

Matasci, Sara. 2020. "2020 Health & Environmental Benefits Of Solar | Energysage". *Solar News*. https://news.energysage.com/health-environmental-benefits-of-solar-energy/#:~:text=Solar%20energy%20creates%20clean%2C%20renewable,greenhouse%20gases%20around%20the%20globe.&text=Most%20of%20the%20electricity%20generated,like%20coal%20and%20natural%20gas.

Maxville, Valerie. 2020. *LECTURE 3 ARRAYS AND PLOTS*. Ebook. Curtin University.

Maxville, Valerie. 2020. *LECTURE 4 MULTI-DIMENSIONAL ARRAYS*. Ebook. 1st ed. Curtin University.

Maxville, Valerie. 2020. *LECTURE 6 MODELLING THE WORLD WITH OBJECTS*. Ebook. 1st ed. Curtin University.

Maxville, Valerie. 2020. *LECTURE 7 OBJECT RELATIONSHIPS*. Ebook.

OSPY, Username. 2017. https://www.youtube.com/watch?v=AFnUhiRXXWk.

Richardson, Luke. 2018. "How Do Solar Panels Work? Step By Step Guide | Energysage". *Solar News*. https://news.energysage.com/solar-panels-work/.

sentdex, username:. 2015. https://www.youtube.com/watch?v=ZmYPzESC5YY.

Shafer, Corey. 2019. https://www.youtube.com/watch?v=Ercd-Ip5PfQ.

Solargain, AU. 2020. "How Much Does Solar Energy Save You?". *Solar Panels | Solar Energy & Power Systems - Solargain*. https://www.solargain.com.au/how-much-does-solar-energy-save-you#:~:text=Usage%20patterns,helps%20offset%20your%20power%20bills.