Program: Graduate Diploma in Engineering Technology - Mechanical

Module: MG7022 Energy Engineering

RESIDENTIAL ENERGY AUDIT REPORT

Located at 311 Ohaupo road, Waikato region.

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27/AUGUST/2020

Executive Summary

This energy audit is carried out on a six-person dwelling located in Hamilton East. The audit represents a level one and two energy audits defined by the Australian / New Zealand Energy Audit standard: AS/NZS 3598:2000.

We collected the power consumed by each household appliance based on daily usage and compared the estimated daily and yearly use with the energy bill received from the current energy provider Mercury. The percentage of error between the values is 1.5%.

This report's key finding is that the energy saved from standby savings is to power everyday kitchen appliance, which includes water kettle, toaster, and mixer grinder.

Table 1 Summary of results

	Usage in kWh	Cost in NZD
Annual	10601.025	3164.99
Monthly	883.418	263.749
Daily	29.5	8.791
Annual per person	1766.83	527.49
Daily per person	4.840	1.44

A benchmarking assessment proved that the total annual power consumption of the dwelling under the audit is much lower than average New Zealand. The house is well insulated. Hence, the power consumption for space heating is lower than the average New Zealand household. Although the dwelling's average power consumption is much lower than the average New Zealand homes, the Water heater exceeds the standard limit.

Interestingly, the highest consumptions fall under the pump room over 38 percent; this is because the Pump room consists of a water heater, motor pump, electric, and water filtration system. Water heating accounts for the highest consumption among all the appliances, 3835.5 kWh annually. The bedrooms' consumption is high because the master bedroom is equipped with a 42 inches plasma Television and an Xbox 360.

Top ten recommendations were made to reduce the overall power consumption. The most significant long-term investment is to replace the existing showerhead with an energy-efficient shower head; this reduces the hot water consumption to about 50 percent. Connecting the ground-level rainwater harvesting tank with the additional elevated tank will help us cut down the electricity required to pump water by 70 percent. Switching the electricity provider from Mercury to low-cost provider Nova will help us pump the water to an elevated tank during the one-hour free off-peak hour of Nova's electricity.

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1. Objective

This objective is to conduct an energy audit in accordance with level 2 energy audit as described by the Australian / New Zealand Energy Audits standard: AS/NZS 3598:2000 to analyze the energy performance of a six-person dwelling located in Ohaupo road, Waikato region.

Here we investigate the sources of energy to the residence, energy bills and identify how efficient energy is being utilized. The report also highlights energy wastage, recommends solutions to save energy, provides a statement of costs and potential savings.

As discussed, audit consists of the following phases:

Figure 1Various stages of the energy audit

The report covers the following:

- Configuration of the dwelling
- Occupancy of the dwelling
- Historical data, including yearly, monthly, weekly, and daily energy consumption. Energy consumption analysis and comparison plots of various electronic appliances.
- Energy performance indicators and benchmarks
- Recommendations — listed from lowest investment to highest

2. Description about the Dwelling

The residential unit, as shown in image 1, is located at Ohaupo road. The property features four bedrooms, a lounge, garage, laundry room, and a rainwater harvesting tank.

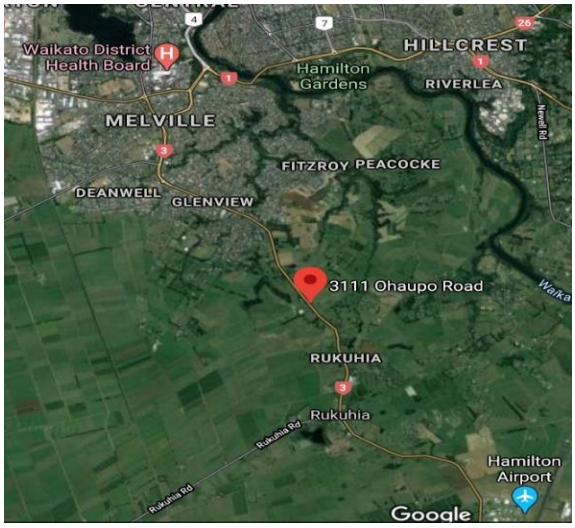


Figure 2 location and image of the dwelling

The residential unit's position is oriented to take full advantage of the sun. The North-facing windows utilize the winter sun and summer shade, and three moderate east-facing windows utilize the morning sun, and two west-facing windows target the afternoon sun. The below table depicts the configuration of the dwelling.

Table 2 Building configuration

General	
Location	3111 Ohaupo road, Glenview
Building Type	4-bedroom unit
Ownership	Owned
Floor Area	275 m^2
Insulation Details	
Windows type and quantity	Double glazed glass. Qty:0 8
Walls construction	Brick
Roof construction	Steel/G-Iron
Floor	Wood

Floor plan of the Dwelling

As depicted in the floor plan, the house's entryway opens onto a large lounge and a dining space with an open kitchen. The kitchen features an adjacent laundry room. Apart from this, there are four bedrooms and two bathrooms. The pumproom is next to the garage. The total floor area is 275m^2.

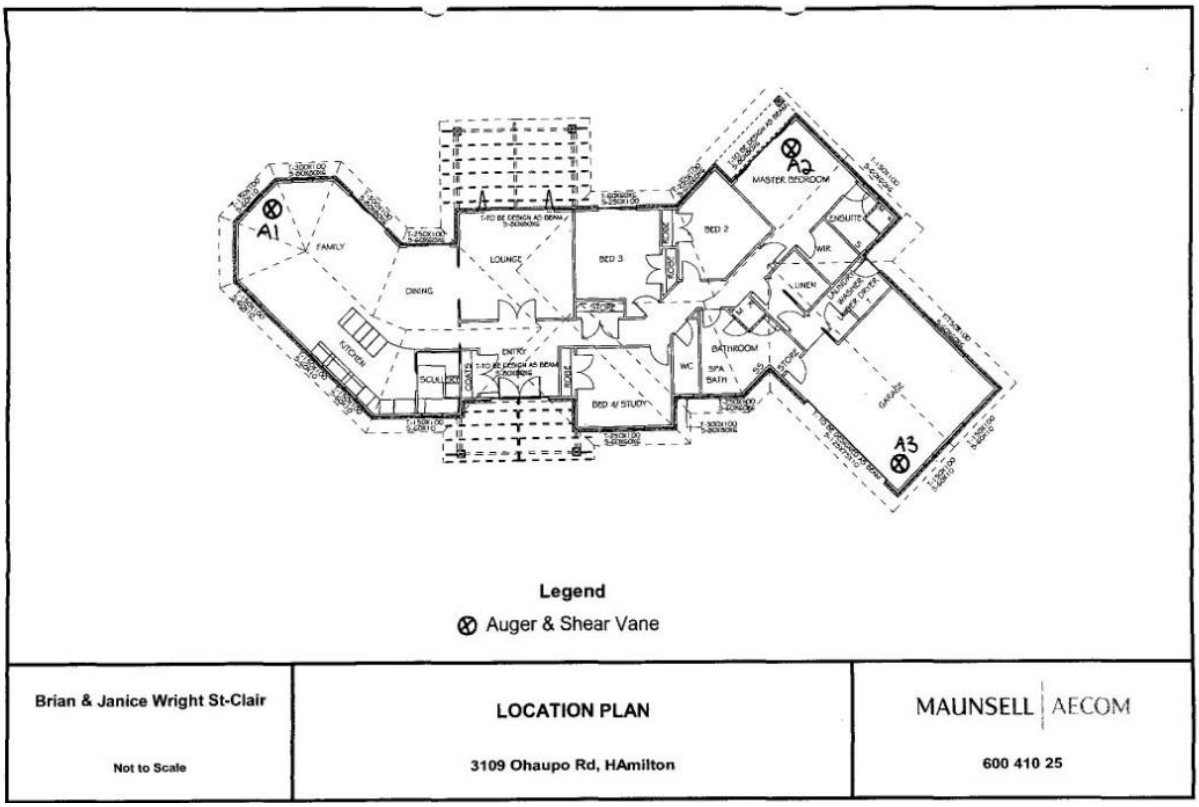


Figure 3 Floor plan

3. Occupancy of the Dwelling

The dwelling is occupied by six adults, including 5 busy full-time health care professionals in their early 30's and one full-time student studying at Wintec. During the daytime, th house is relatively empty; however, occupancy is inconstant with friends' visitors on weekends. During the holidays, tenants stay at home most of the day, and this increases energy consumption. The below plot shows the occupancy of the dwelling.

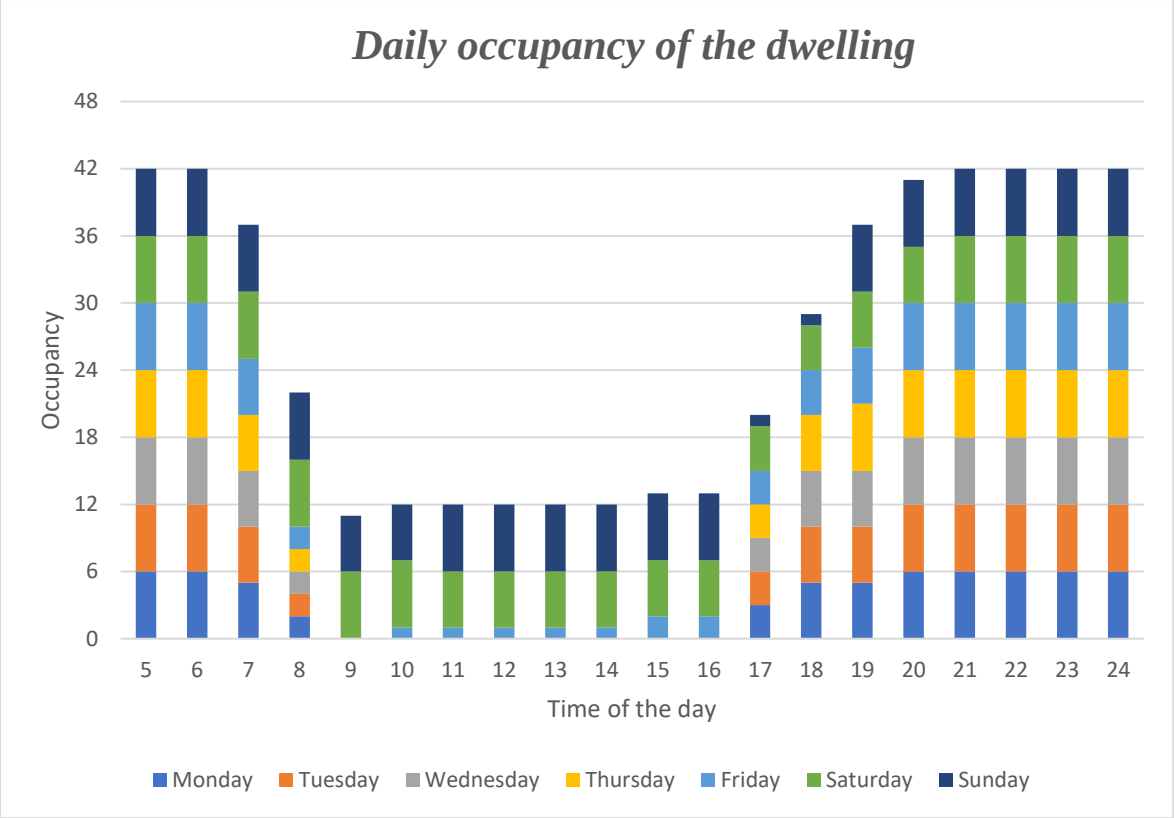


Figure 4 Daily occupancy of the dwelling

4. Energy Consumption Analysis

4.1 Historical Records

Historical data of the past 12 months are collected and analysed in this section.

4.2 Energy provider

Mercury NZ Limited is a New Zealand based electricity generation and electricity retailing company provides electricity to the residential unit. The company generates renewable energy with that said; the company holds and operates nine hydroelectric generating stations on the Waikato River and five geothermal plants located in the Taupo area. The residential unit is on the below plan.

Table 3 Billing criteria

Usage type	Amount in NZD	Remarks
Controlled	0.2073	
Uncontrolled	0.27	
In addition to the above-metered charge, the following charges also apply.		
Daily fixed charge :0.28 NZD Levy: 0.12 NZD GST: 15% of the billed amount		

4.3 Monthly electricity usage

We analysed the historical energy consumption of the dwelling. The below bar graph shows the annual energy consumption between September 2019 and August 2020, a period of 12 months.

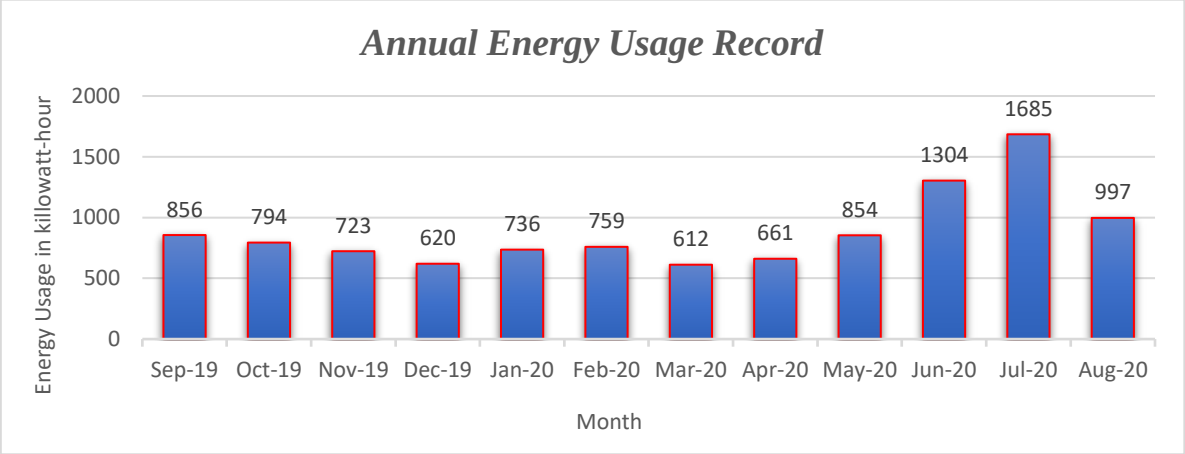


Figure 5 Annual energy usage record

In contrast to the relatively small change in electricity demand during typical summer days, the winter months' figures are almost double. The lowest recorded is 612kWh in March, and the highest is 1685kWh in the month of July. It is interesting to note that the demand for electricity during the winter nearly doubled compared to that during the summer. A sudden spike in June and July indicates the winter months and heaters' usage for space heating.

Average Controlled and uncontrolled usage

The below graph illustrates the controlled and uncontrolled usage. A controlled meter allows our energy provider to manage "control" usage throughout the peak use periods, and as a result, we pay a lower rate. The controlled meter of the dwelling has electricity available for 16 hours each day. Controlled meter powers water heating and heat pumps.

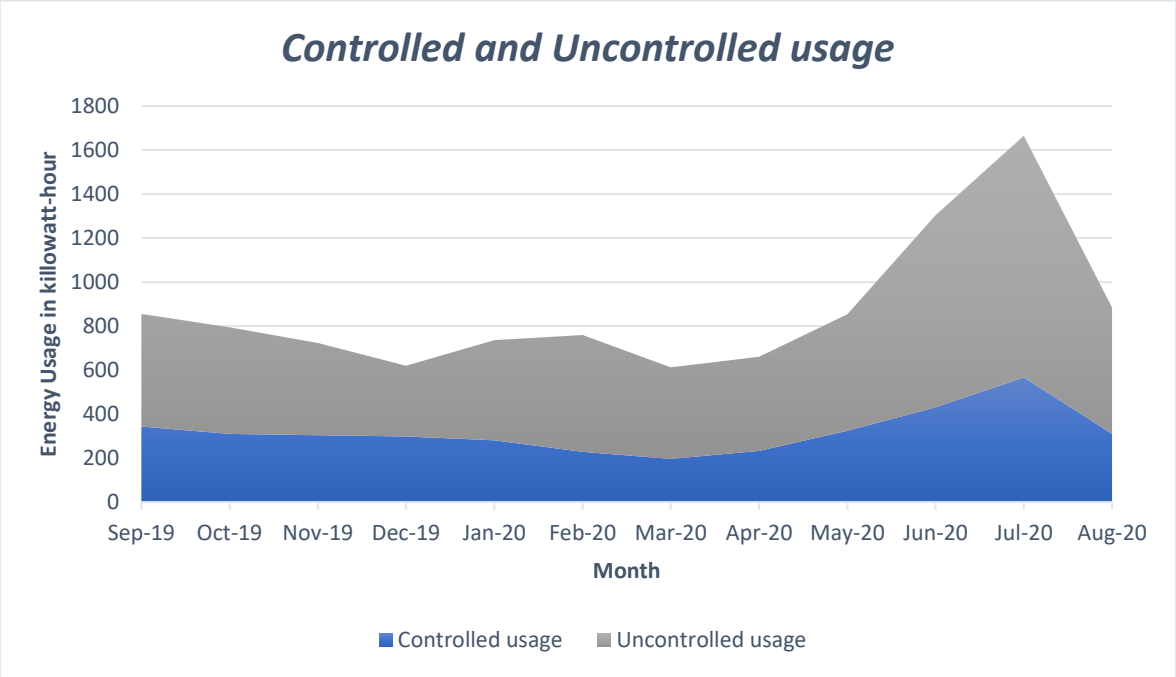


Figure 6 Annual controlled and uncontrolled usage

The most striking characteristic of the above line chart is that the heating accounts for 40 percent of the energy consumption, which falls under the controlled usage; however, uncontrolled use accounts for the highest.

4.4 Monthly Energy bill

The below bar graphs present the billed electricity charge by Mercury limited between September 2019 and August 2020. The billed amount includes metered usage, daily fixed charge, levy, and GST. The billed amount in the peak winter month of July is 487.92, whereas the minimum billed amount is in summer months from December to March.

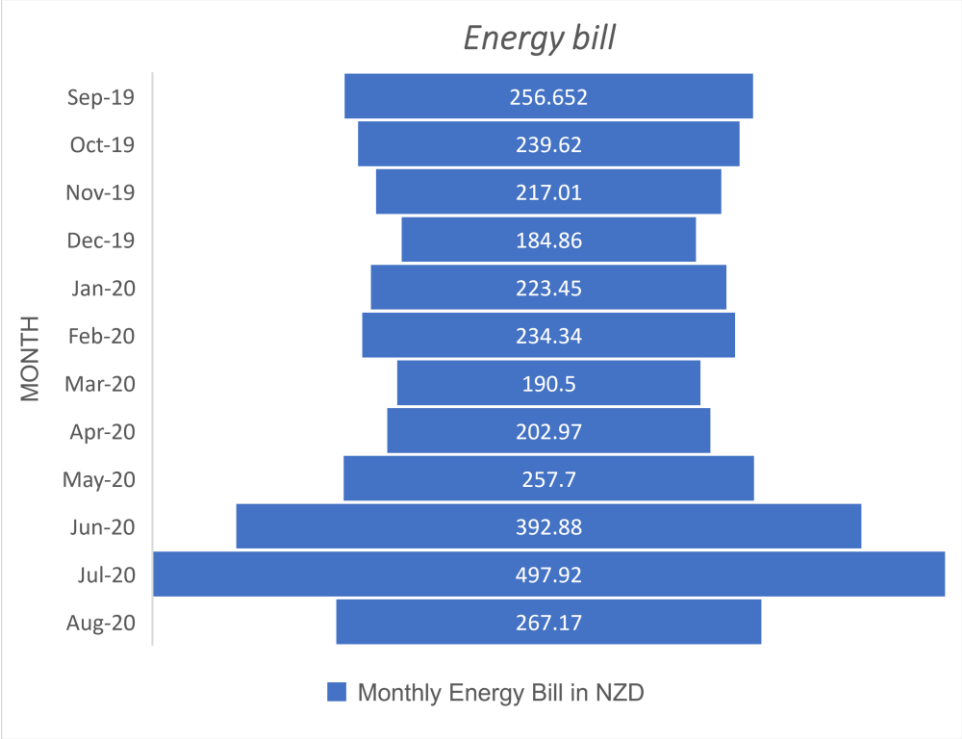


Figure 7 Annual Energy Bill

The bar graph shows that the energy bill is generally lowest in the summer months when the space heating need is nil.

Weekly average day energy usage:

The plot shows the energy consumption during the hours of a typical week. The line graph will help us further analyse the peak energy usage hours during the weekdays and weekends.

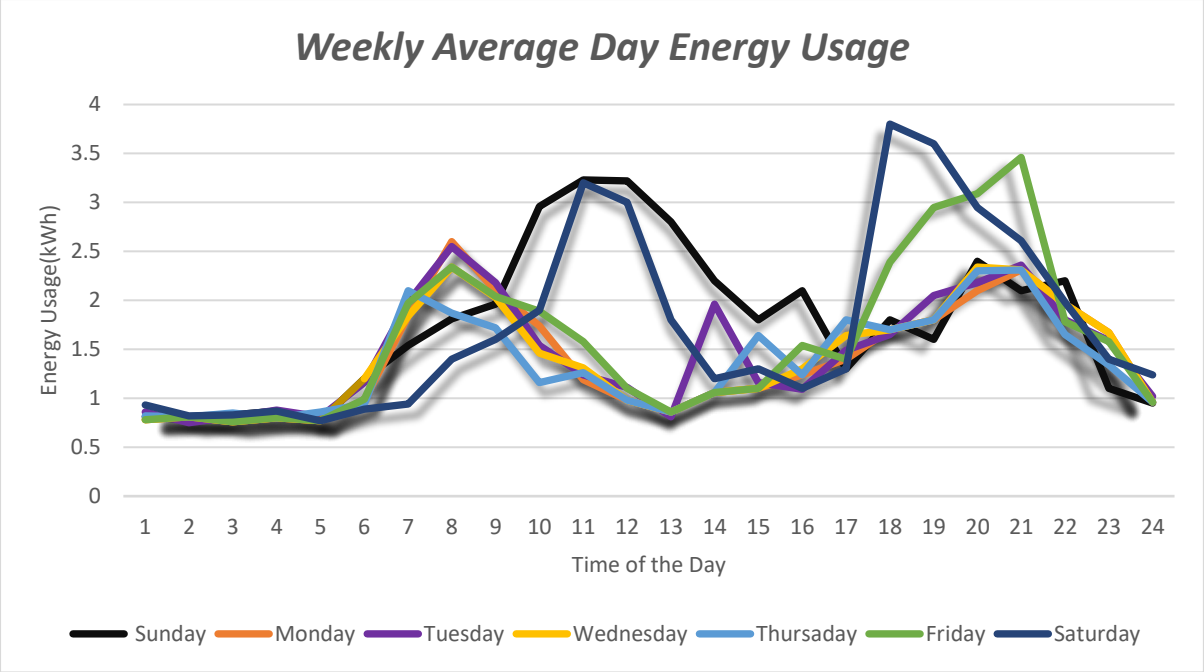


Figure 8 Weekly average day energy usage

On the weekdays, the peak usage hours are from 6 am till 9 am (recorded peak 2.6kWh) when tenants prepare their breakfast and take showers, and from 7 pm till 10 pm (recorded peak 2.36kWh) when occupants are at home, making dinner and using the entertainment appliances.

During the weekends, the peak usage hours are between 9 am till 12 pm (recorded peak 3.2kWh) and from 4 pm till 11 pm (recorded peak 3.46kWh) when occupants are at home, making meals, laundry, and using the entertainment appliances.

Overall, by looking at the graph, it can be seen that the least amount of electricity is consumed at night from 11 pm till 5 am a baseload of 0.8kWh when most people sleep; this applies to both weekdays and weekends. The demand level also tends to be the lowest between 10 am and 5 pm on weekdays when less occupied.

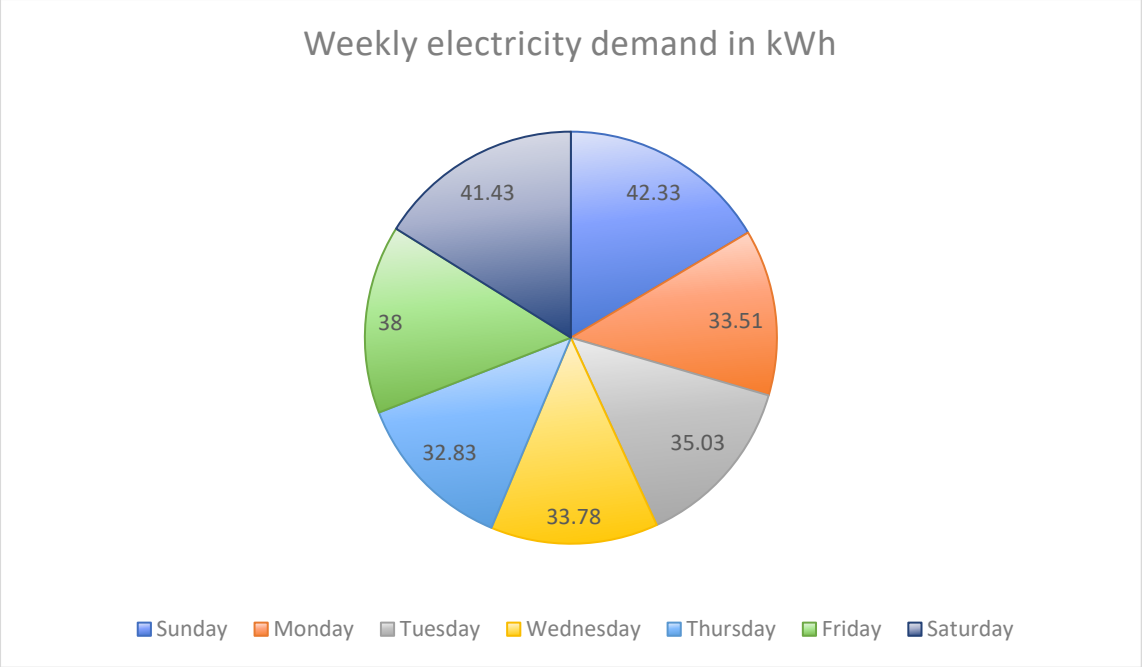


Figure 9 Weekly electricity demand in kWh

The above pie chart shows the total energy used in kWh each day on an average week. Saturday and Sunday account the maximum consumption that is 41.43 kWh and 42.33 kWh, respectively.

4.5 Current energy consumption analysis procedure

This section discusses the current energy consumption analysis of each room in the dwelling. We collected the following data and tabulated

1) The actual power consumption of electrical appliances used in each room (expressed in watt). Power ratings of most appliances are directly obtained from the appliance itself and from the user manual. The wattage listed is the maximum power drawn by the appliance (Wattage = current * voltage).

2) The total number of hours that the appliances are in use in a day. Usage is, however, an estimate based on the routine tasks of the tenants.

3) The number of days per year the appliance is in use. We also considered seasonal usage and standby timings to obtain accurate data.

4) Based on the usage, calculated the daily and annual cost average. Considered day and night tariffs as they differ.

4.6 Current energy consumption data:

This section shows the power rating of appliances in each room, estimates the daily usage, annual and yearly power demand to run the appliances, and the corresponding daily, monthly, and annual energy costs. The collected data are tabulated in the next page.

(Please turn over)

Table 4 Energy consumption analysis - Kitchen

Room	Appliance	Make	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
KITCHEN	Range hood	Fisher & Paykel	-	1	350	Daily	0.3	109.2	0.096	35.04	0.0266	9.71	**0**	**0**
	Air Fryer	Chefman	-	1	1500	weekly	0.07	25.55	0.1	38.32	0.029	10.62	**0**	**0**
	Microwave oven	Panasonic	-	1	1100	6 X Day	0.5	182.5	0.55	200.75	0.1525	55.66	**0**	**0**
	Microwave oven standby	NA	-	1	2	Constant	24	8760	0.048	17.52	0.0133	4.85	17.52	**4.85**
	Refrigerator	LG	-	1	130	Constant	24	8760	1.07	393	0.29	105.85	**0**	**0**
	Mixer grinder	Kenwood	-	1	500	Daily	0.1	36.5	0.05	18.25	0.013	5.06	**0**	**0**
	Water Kettle	Breville	-	1	1100	Daily	0.15	54.75	0.165	60.22	0.045	16.7	**0**	**0**
	Sandwich maker	T-Fal	-	1	800	Daily	0.1	36.5	0.08	29.2	0.022	8.09	**0**	**0**
	Dish washer	Bosch	-	1	1500	Daily	0.2	73	0.3	109.50	0.083	30.36	**0**	**0**
	Electric grill		-	1	2400	Weekly	6.28	2292.2	0.68	250.28	0.19	69.4	**0**	**0**
	Blender	Kenwood	-	1	400	Daily	0.05	18.25	0.02	7.3	0.005	2.02	**0**	**0**

	Toaster	Cuisinart	-	1	1200	Daily	0.1	36.5	0.12	43.8	0.033	12.14	**0**	**0**
	Lights	Philips	-	6	20	Daily	4	1460	0.48	175.2	0.133	48.58	**0**	**0**
Total				**18**	**11002**		**59.85**	**21845.2**	**3.759**	**1372.03**	**1.0354**	**379.04**	**17.52**	**4.85**

Table 5 Current energy consumption analysis – Lounge

Room	**Appliance**	**Make**	**Comment**	**Qty**	**Average Power Rating (W)**	**Usage (General)**	**Daily Use (h)**	**Annual Use (h)**	**Daily Power (kWh) Average**	**Annual Power (kWh)**	**Daily Cost ($) Average**	**Annual Cost ($)**	**Annual Standby Power (kWh)**	**Standby Savings ($)**
LOUNGE	Television-plasma	LG	50 inches	1	300	Daily	5.5	2007.5	1.65	602.25	0.457	166.82	0	0
	Television standby	Samsung	-	NA	1.8	Daily	24	8760	0.0334	14.016	0.0092	3.376	14.016	3.89
	Modem	Linksys	-	1	18	Daily	24	8760	0.432	157.68	0.119	43.7	0	0
	X Box 360	Microsoft	-	1	100	2 x weekly	0.71	259.15	0.071	25.91	0.019	7.18	0	0
	Music system	Sony	-	1	150	Daily	4	1460	0.60	219	0.1662	60.663	0	0
	Lights	Philips	-	4	20	Daily	4	1460	0.08	29.2	0.022	8.08	0	0

	Fish Tank-Temp controlled	Aqua	-	1	30	Daily	24	8760	0.72	262.8	0.199	72.8	0	0
	Heat Pump	Panasonic	-	1	1875	Daily (4 months)	0.66	121.66	0.625	228.125	0.173	63.19	0	0
Total				10	2494.8		86.87	31588.3	4.209	1538.97	1.1644	425.43	14.01	3.89

Table 6 Current consumption analysis - Bedrooms

Room	Type	Appliance	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
BEDROOM	**MASTER BEDROOM**	Television	LCD-42’	1	120	Daily	1	365	0.12	43.8	.033	12.13	0	0
		Play Station	Sony	1	80	Weekly	0.28	104.28	0.022	8.34	0.006	2.31	0	0
		Heat Pump	Fujitsu	1	1875	Daily (4 months)	0.66	121.66	0.625	228.12	0.173	63.19	0	0
		Hair dryer	Asos	1	350	Daily	0.14	51.1	0.05	18.25	0.013	5.005	0	0
		Hair straightener	GHD	1	90	Weekly	.01	36.5	.009	3.28	0.002	0.909	0	0

		Printer	HP	1	35	Daily	0.05	18.25	0.017	0.63	0.0004	0.17	0	0
		Lights	Philips	2	20	Daily	4	1460	0.12	43.8	0.033	12.13	0	0
		Fan	Dyson	1	70	Daily (4 months)	1.3	480	0.09	33.6	0.025	9.125	0	0
		Desktop computer	Dell	1	200	Daily	1	365	0.2	73	0.05	20.24	0	0
		Sleep light		1	0.5	Daily	8	2940	0.004	1.46	0.0404	147.61	0	0
	TOTAL			11	2840.5		16.44	5941.7	1.257	454.28	0.3758	272.81	0	0
	ROOM 1	Lights	Philips	2	20	Daily	4	1460	0.12	43.8	0.033	12.13	0	0
		Fan	Honeywell	1	70	Daily (4 months)	1.3	480	0.09	33.6	0.025	9.125	0	0
		Coil heater		1	1500	Daily (4 months)	1.3	480	1.97	720	0.54	199.65	0	0
		Sleep light	Lumni	1	0.5	Daily	8	2940	0.004	1.46	0.0404	147.61	0	0
	TOTAL			5	1590.5		14.6	5360	2.184	798.86	0.6384	278.51	0	0
	ROOM 2	Lights	Philips	2	20	Daily	4	1460	0.12	43.8	0.033	12.13	0	0
		Fan	Dyson	1	70	Daily (4 months)	1.3	480	0.09	33.6	0.025	9.125	0	0
		Coil heater		1	1100	Daily (4 months)	1.8	657	1.44	528	0.49	181.98	0	0

		Sleep light		1	0.5	Daily	9	3285	0.0045	1.64	0.0012	0.438	0	0
	TOTAL			**5**	**1190.5**		**16.1**	**5882**	**1.6545**	**607.04**	**0.5492**	**203.68**	**0**	**0**
	ROOM 3	Lights	Philips	2	20	Daily	3	1095	0.06	21.9	0.016	6.06	0	0
		Coil heater		1	1300	Daily (4 months)	1	365	1.3	474.5	0.36	131.43	0	0
		Fan	Dyson	1	70	Daily (4 months)	2	730	0.14	51.1	0.038	14.15	0	0
		Sleep light	Lumni	1	0.5	Daily	7	2555	0.0035	1.277	0.00096	0.35	0	0
	TOTAL			5	1390.5		13	4745	1.5035	548.777	0.41496	151.99	0	0
TOTAL BEDROOM				**26**	**7012**		**60.14**	**21928**	**6.599**	**2408**	**1.978**	**907**	0	0

Table 7 Current consumption analysis - Laundry room

Room	Appliance	Make	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
LAUNDRY ROOM	Washing machine	Panasonic	-	1	500	Weekly	0.28	102.2	0.14	51.1	0.038	14.17	0	0
	Iron box	Philips	-	1	2300	Daily	0.2	73	0.46	167.9	0.127	46.55	0	0
	Lights	Philips	-	1	10	Weekly	0.15	54.75	0.001	0.54	0.0004	0.15	0	0
Total				3	2810		0.63	229.95	0.601	219.54	0.165	60.87	0	0

Table 8 Current consumption analysis -Garage

Room	Appliance	Make	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
GARAGE	Carbon sensor	Nest	-	1	20	Daily	24	8760	0.12	43.8	0.03	12.74	0	0
	Electric shutter	Ara	-	1	400	4 x Daily	0.1	36.5	0.04	14.6	0.011	4.04	0	0
	Electric shutter standby	NA	-	1	2.8	Constant	24	8760	0.067	24.528	0.018	6.77	24.528	6.79
	Lights	Philips	-	6	5	Daily	4	1460	0.48	175.2	0.133	48.58	0	0

Total				**8**	**427.8**		**52.1**	**19016.5**	**0.707**	**258.12**	**0.192**	**72.13**	0	0

Table 9 Current consumption analysis -General

Room	**Appliance**	**Make**	**Comment**	**Qty**	**Average Power Rating (W)**	**Usage (General)**	**Daily Use (h)**	**Annual Use (h)**	**Daily Power (kWh) Average**	**Annual Power (kWh)**	**Daily Cost ($) Average**	**Annual Cost ($)**	**Annual Standby Power (kWh)**	**Standby Savings ($)**
GENERAL	Outside Lights	Philips	-	4	10	Daily	2	730	0.08	29.2	0.022	8.08	0	0
	Vacuum cleaner	Dyson	-	1	1400	Weekly	0.03	10.95	0.042	15.33	0.011	4.25	0	0
	Printer	HP	-	1	40	Weekly	0.014	5.11	0.00056	0.20	0.0001	0.05	0	0
Total				**6**	**1450**		**2.044**	**746.06**	**0.1225**	**44.73**	**0.0331**	**12.38**	0	0

Table 10 Current consumption analysis-Pump room

Room	Appliance	Make	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
PUMP ROOM	Electric motor pump	Omega	-	1	373	Daily	6	2190	2.23	816.87	0.62	226.51	0	0
	Electric motor pump standby	NA	-	1	2.8	Constant	24	8760	0.067	24.528	0.018	6.77	24.528	6.79
	Water heater	Ecosmart	-	1	3000	Daily	3.5	1277.5	10.5	3835.5	2.17	793.41	0	0
	Electric Water filter	Trevoli-UV filters	-	1	110	Daily	3	1095	0.33	120.45	0.09	33.39	0	0
	Electric Water filter standby	NA	-	NA	2	Constant	24	8760	0.048	17.52	0.0133	4.85	17.52	4.85
Total				**4**	**3487.8**		**60.5**	**22082**	**13.175**	**4814.8**	**2.9113**	**1064**	**42.048**	**11.64**

Table 11 Current consumption analysis -Bathrooms

Room	Type	Appliance	Comment	Qty	Average Power Rating (W)	Usage (General)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily Cost ($) Average	Annual Cost ($)	Annual Standby Power (kWh)	Standby Savings ($)
BATHROOMS	ROOM 1	Light	-	1	10	Daily	3	1095	0.03	10.95	0.0083	3.02	0	0
		Exhaust Fan	-	1	60	Daily	3	1095	0.18	65.7	0.049	17.88	0	0
	Total Room 1		**-**	**2**			**6**	**2190**	**0.21**	**76.65**	**0.0573**	**20.9**	0	0
	ROOM 2	Lights	-	1	10	Daily	1.2	438	0.012	4.38	0.0033	1.20	0	0
		Exhaust Fan	-	1	60	Daily	1.2	438	0.072	26.28	0.0199	7.26	0	0
	Total Room 2		**-**	**2**			**2.4**	**876**	**0.084**	**30.66**	**0.0232**	**8.46**	0	0
Total Bathrooms				**4**	**140**		**8.4**	**3066**	**0.294**	**107.31**	**0.0805**	**29.36**	0	0

4.7 Total Energy Consumption Analysis

This section shows the total energy consumed by each room; this is, however, an estimate. In the next section, we will compare the numbers with the actual energy bill received from the service provider Mercury New Zealand Limited.

Table 12 Total consumption in each room

Room	Quantity	Average Power Rating (W)	Daily Use (h)	Annual Use (h)	Daily Power (kWh) Average	Annual Power (kWh)	Daily cost ($) Average	Annual cost ($)	Annual standby Power (kWh)	Standby Savings ($)	%
Total Lounge	10	2494.8	86.87	31588.3	4.209	1538.97	1.1644	424.86	0	0	15.383
Total Kitchen	18	11002	59.85	21845.25	3.759	1372.035	1.0354	377.921	17.52	4.853	13.684
Total bedroom	26	7012	60.14	21951.1	6.599	2408.635	1.978	721.97	0	0	26.139
Total Laundry room	3	2810	0.63	229.95	0.601	219.365	0.165	60.225	0	0	2.18
Total Bathroom	4	140	8.4	3066	0.294	107.31	0.0805	29.36	0	0	1.063
Total Garage	8	427.8	52.1	19016.5	0.707	258.12	0.192	70.08	24.528	6.79	2.537
Total Pump room	4	3487.8	60.5	22082.5	13.175	4814.86	2.9113	1064.93	42.048	11.64	38.56
Total General	6	1450	2.044	746.06	0.1225	44.73	0.0331	12.38	0	0	0.448
TOTAL	**79**	**28824.4**	**330.554**	**88937.36**	**29.466**	**10764.025**	**7.559**	**2761.726**	**84.096**	**23.283**	**100**

Discussion on the total energy consumption:

- There are 79 household electronic appliances in use with a combined average power rating of 28685 W.

- The daily power demand to use these appliances is 29.466 kWh, which cost around 7.5 NZD a day, and the annual cost is about 2761.NZD

- The highest consumptions fall under the pump room just over 38 percent (Pump room consist of electric water heater and water filtration system). At the same time, total bedrooms account for 26.13%; however, the Total lounge consumes15.38%, followed by the kitchen. Furthermore, the total bathroom and total general account for the lowest 1.063 % and 0.448 %, respectively.

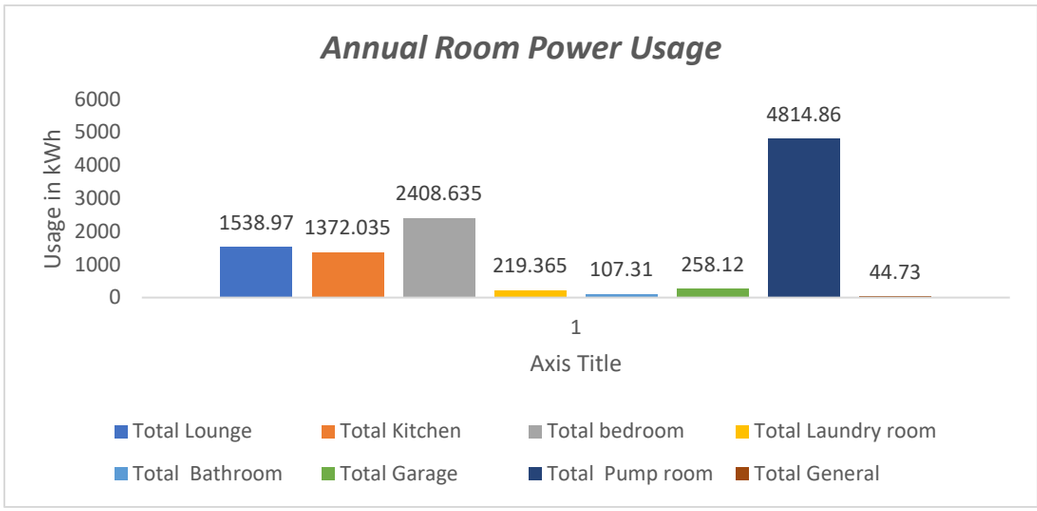
- The table also depicts the maximum time the appliances are in use. The lounge has peak usage, with a total of 86.7 hours daily, the reason for this is because of the standby timing, and tenants spend most of their time at the lounge to watch tv and entertainment system.

4.7.1 Total Rooms

This section of the report examines each room's total energy by using a comparison bar graph. It is important to know which room consumes the most. The below bar chart illustrates the total power used in kWh annually by each room of the dwelling.

Overall, all it can be seen that the total pump room consumed the most about 4814.86 kWh annually. The pump room consists of a water heater, a motor pump, and a water filtration system. The reason for the high demand is continuous usage and standby consumption. The second largest consumption is in the bedroom, about 2408.635 kWh, where the appliances like 42 inches plasma television, Xbox 360, coil heaters, fans, and heat pumps are in use frequently, followed by Kitchen and the lounge 1372.035 kWh and 1538.97 kWh, respectively.

The consumption in the bathroom laundry room, garage, and bathrooms remained relatively low throughout the year



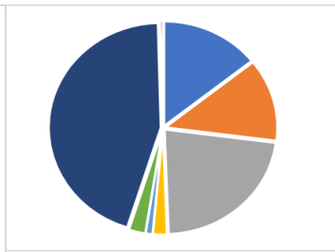
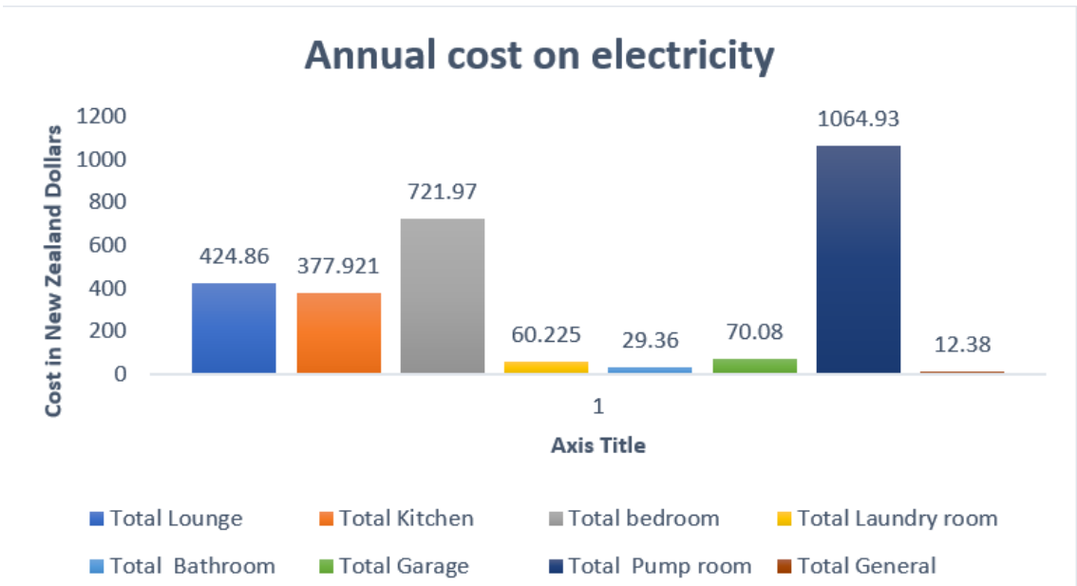


Figure 10 Annual room power usage

We plotted the total annual room electricity bill based on the power consumption plot. By looking at the plot, we can see that the energy bill matches the energy consumption in figure 10; this is because we considered standby power consumption to get accurate consumption. Also, there is no significant difference in day and night tariffs. The dwelling consumed 10764.025kWh electricity in a year and billed 2761.726 New Zealand dollars in 12 months.



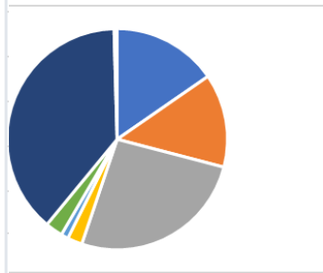


Figure 11 Annual room electricity cost

4.7.2 Total Appliances

The multicategory bar chart depicts the annual power consumption of various household electronic appliances. Here we classified home appliances into related subcategories.

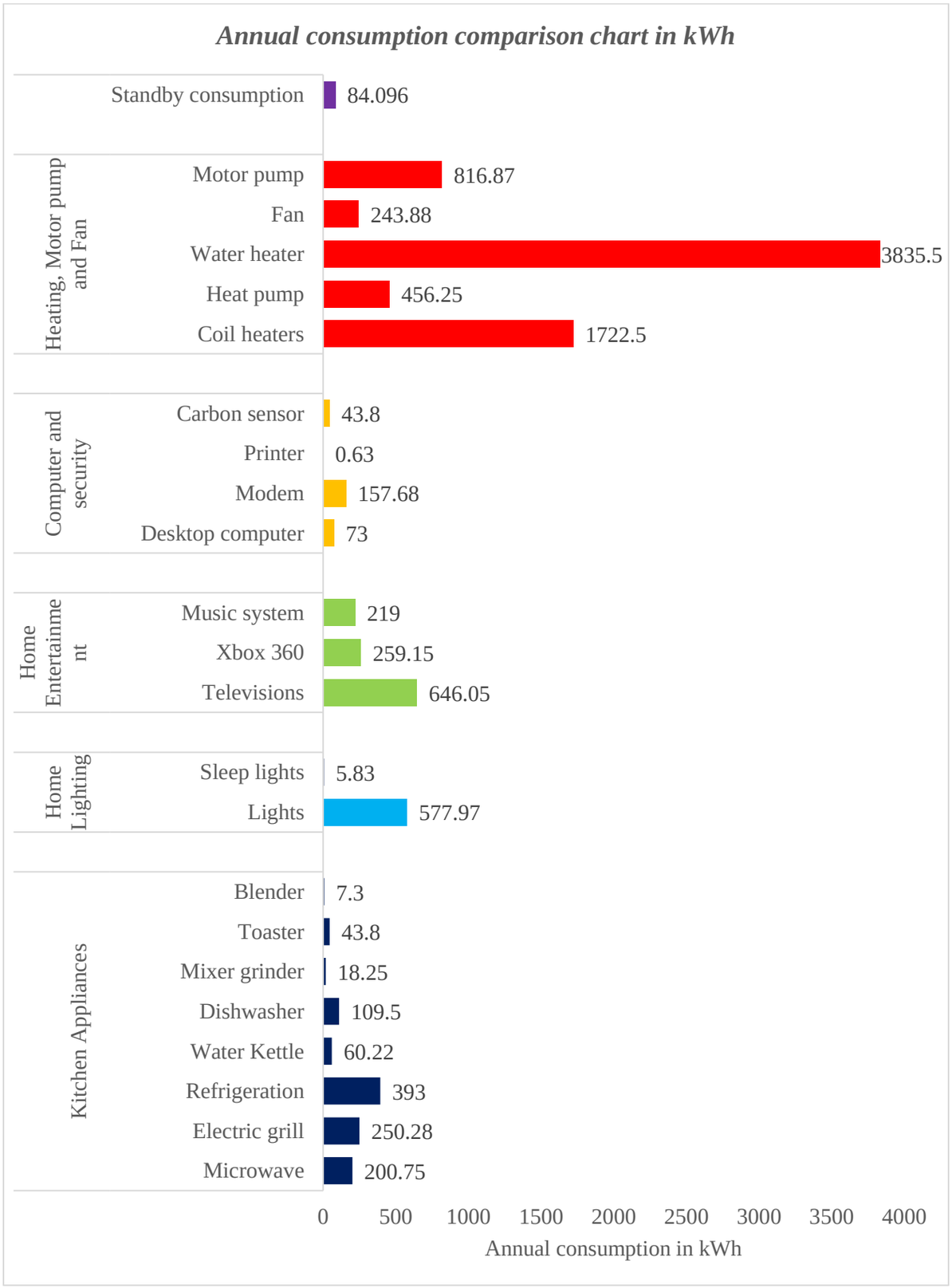


Figure 12 Annual consumption in kWh -Multicategory chart

Key findings from the above multicategory bar chart are listed below:

- Heating appliances consume the most. The water heater's annual consumption accounts for the highest 3835.5 kWh, followed by coil heaters 1722.5 kWh, and the motor pump takes 816.87 kWh.

- The television consumes the highest 646.05 kWh in a year among the home entertainment, followed by Xbox 360. Home lighting consumes 577.97 kWh annually.

- Under the kitchen appliances, refrigeration consumes 393kWh annually, followed by the electric grill and microwave 250.28 and 200.75 kWh, respectively.

- Among the appliances, microwave, motor pump, water heater, Xbox 360 are always in standby mode. During standby mode, these appliances are not giving any useful input but consume energy. Annual standby consumption accounts for 84.096 kWh.

4.8 Energy Balance

The below bar chart compares the estimated usage and cost with the Energy bill obtained from electricity provider Mercury. The estimated use is 10764 kWh, and the energy bill received from Mercury is 1061 kWh; similarly, the estimated cost is 3281 New Zealand dollars, and the actual cost is 3164 New Zealand dollars. Overall, we can say that estimated data is a relatively good representation of the actual energy bill received from the provider. The percentage of error is 1.5

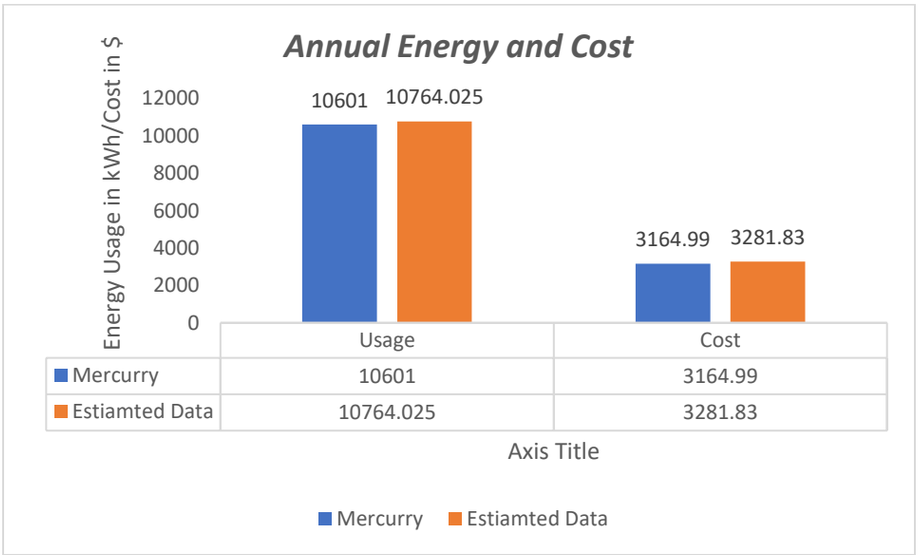


Figure 13 Energy Balance

One or more factors listed below contribute to the error in the above plot:

- × Errors in the estimation of usage hours of appliances: The appliance usage hours are an estimate based on the average usage.

- × Operational characteristics of the devices: The appliances like the refrigerator, heat pump depends on the temperature and compressor running time.

- × Calibration errors in the energy monitor: We are unsure about the calibration history of the energy monitor *used* to estimate the appliances' power rating.

- × The behaviour of the tenants: The usage of the entertainment system and heat pumps depend on the individual behaviour of the tenants; we took an average here.

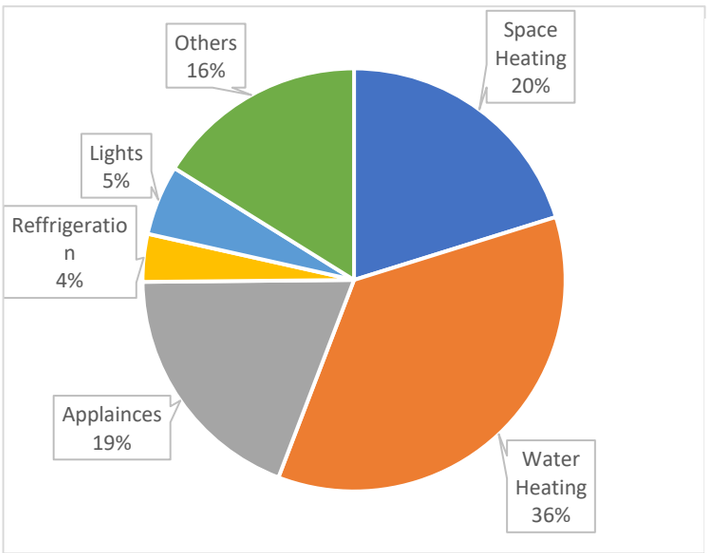
- × Holiday and weather conditions: The possible errors might occur while estimating usage during holidays, National COVID 19 lockdown, and seasonal changes.

- × Time of the day, day of the week: The dwelling occupancy is inconsistent during the weekends and weekdays due to the varying number of visitors and impacts energy consumption estimates.

5. Energy Performance Indicators

Here we did a benchmarking assessment where we compared our dwelling with a similar dwelling. The pie chart on the left shows the residential under audit, the right similar residential unit in Hamilton. The figures in the pie chart is from Mercury energy bill over 12 months. The dwelling under the audit depended entirely on electricity, while some of the household in New Zealand use solid fuel (Michael, Lisa 2006). The residence under this audit is constructed in the year 2006; however, fully insulated.

Dwelling Under the Audit



Average New Zealand Household

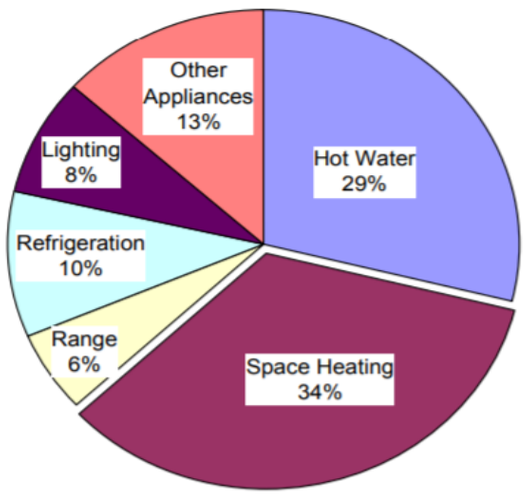


Figure 14 Energy performance indicator - Nigel Isaacs (ed)

The average New Zealand home consumes 2350 ~2870 kWh annually; however, the building under the investigation consumes only 1794 kWh yearly. The consumption is lower than the average New Zealand homes. Interestingly, the average New Zealand home with three occupants uses 34% of energy for space heating, but the building under the investigation with three occupants consumes only 20 %; this is because of well insulation.

Table 13 Performance indicator -comparison

	Dwelling under the audit	Average New Zealand household	Commends
Yearly consumption in kWh	10601.025 (6 occupants)	7050 ~ 8630 (3 occupants)	Dwelling under the investigation consists of six occupants, while average New Zealand house has 3 occupants
Yearly consumption/person in kWh	1766.837	2350 ~ 2870	

Although space heating consumes less, the water heating accounts 36 % (Average New Zealand household consumes 29 %); however, we recommended solution for this in the recommendation section

The motor pump falls under the ‘other appliances’ category in the pie chart which shows the spike of 3 % when we compare that with average New Zealand household. Other sections including lighting, refrigeration and range falls less than the average New Zealand household consumption. Reason for this is that dwelling under investigation is equipped with energy star rated appliances and consumption much low.

6. Recommendations:

The audit found several areas of improvement, and our top ten recommendations are explained in detail here.

I. Energy efficient shower head

About 40% of the household’s total energy use goes to water heating 3835kWh. Six people share the dwelling, and each of them takes 15 minutes of shower. Our investigation shows that showerheads in bathroom 1 and 2 pump-out ten litters/minute. Combined hot water shower and dishwasher use account for 70 percent.

Since water heating accounts for 40% of the energy bill, switching to a water-saving showerhead is a great way to save energy. The below table depicts a comparison between the currently installed shower head and the energy-saving (4 stars rated) showerhead available in the market.

Table 14 Comparison on consumption

	Current shower head	**Energy efficient shower with 4-star rating**
Flow rate	10 litres per minute	5 litres per minute
Hot water usage (per day)	750 litres	375 litres
Hot water usage (Yearly)	273750	136875

As depicted in the above table, energy efficient shower drain can save 4.5 kWh/day

According to current plan: 4.5kWh * 0.207 = $ 0.9315/day

Therefore, yearly savings is $ 340. Switching Energy efficient shower drain will cost us $620, so the payback time is within 22 months; however, it is much lower than that, especially for the dwellings in Auckland where water is billed.

II. Switch to Solar water heating

Conventional solar water heating systems in the North Island of New Zealand can deliver around 75% of the household's water heating in summer and between 20 – 40% in winter. Switching to solar water heater comes with the following advantages.

- ♣ Contribute up to 75 % of annual hot water needs of the dwelling
- ♣ Cut about 1800 kWh from yearly electricity use
- ♣ Estimated savings is around $400-$500 a year

Table 15 Payback period of solar water heater

Solar water heater	**Cost**	**Savings/year (NZD)**	**Payback time**
	$3850	450	8.5 years

III. Change Tariff plan

Many New Zealanders do not compare or swap their power providers. We compared the plans and prices offered by different providers and narrowed down to Nova energy. Nova energy provides a competitive price compared to Mercury in rural Waikato regions. The below table compares the Nova energy plan with the current provider (Mercury).

Table 16 Comparison of tariffs

Usage type	Mercury (Amount in NZD)	Nova Energy (Amount in NZD
Controlled	0.2073	0.11
Uncontrolled	0.27	0.16
Daily fixed charge	0.28	1.8
Levy	0.12	0.12
GST	15%	15%

Nova Energy also offers an hour of free off-peak power every day. The off-peak time slots are between 10 am-5 pm and 10 pm-6 am every day. Occupants can use appliances, including a washing machine, Dishwasher, electric grill, motor pump, and microwave during the free one-hour off-peak time; this can significantly reduce the annual electricity bill.

IV. Consider Standby savings

Appliances, including Television, PlayStation, and microwave, are kept in standby mode. During standby mode, these appliances are not providing useful output but still consume energy. Standby

power can be saved by turning above mentioned electronic appliances off at the wall if they are not in use. The below table depicts the overall standby savings.

Table 17 Annual standby savings

Annual standby power	Annual standby savings
84.096 kWh	$ 23.28

The key finding is that 84.096 kWh/year saved from switching off the appliances when not in use can power the kitchen appliances – water kettle, toaster, and mixer grinder for an entire year.

V. Replace the Lights

We examined the light bulbs in the dwelling, and it is clear that energy for lighting accounts for about 10% of the dwelling's electric bill. Replacing an inefficient bulb with a more efficient xxx will make a massive difference in the energy bill. The below table depicts the estimated difference in the energy bill

Table 18 Features of different lights

		LED	**CFL**	**HALOGEN**	**INCANDESCENT**
Brighter…. Dimmer	**LIFESPAN (Hours)**	10,000-50000	6000-15000	2000	1200
	LUMENS	**Watts**			
	220	4W	5-7W	18W	25W
	420	6W	7-8W	28W	40W
	720	10W	14-18W	42W	60W
	930	13W	18-20	52W	75W
	1300	20-30 W	18-23	70W	100W
		More Efficient ----------Less Efficient			

- ♣ Replace incandescent and CFL lamps with LED lamps. As depicted in the above table, LED uses only about a quarter of the energy and can last up to 35 times longer. While they may cost more, a LED will Pay for itself in energy savings in less than eight months.

VI. Connect rainwater harvesting tank with gravity fed water tank

The dwelling is located in the rural Waikato region and is equipped with a rainwater harvesting unit, and there is no external source of water supply to the residence. Since the tank is on the ground level, the electric pump runs very frequently and always remains in standby mode. The annual consumption of the motor pump is 816kWh.

Existing Layout | Proposed Layout

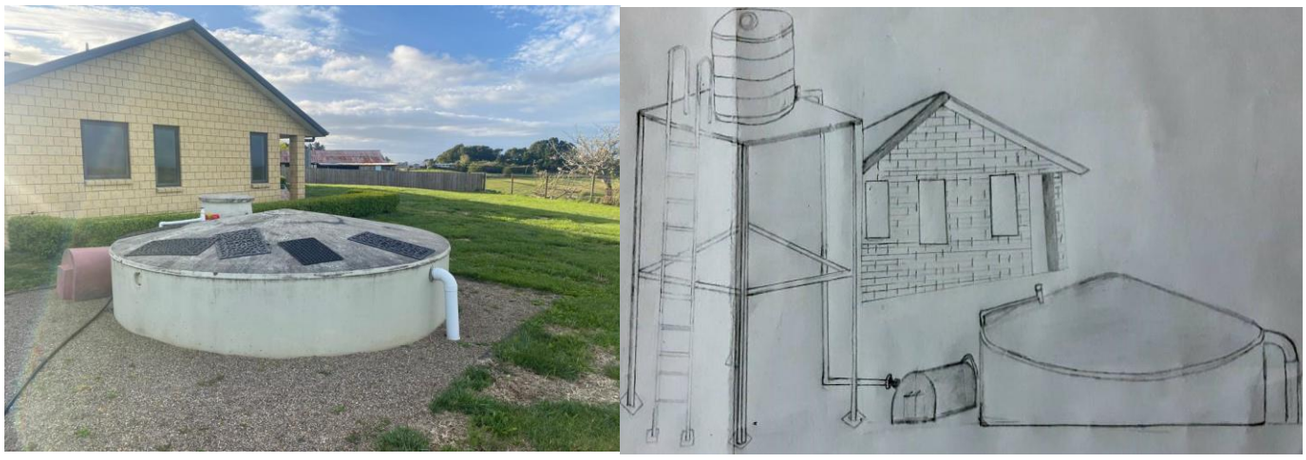


Figure 15 Existing and proposed layout

Our suggestion is to install an additional elevated water tank, as depicted in the proposed layout. The gravity-fed tank can create enough pressure without the need of a motor. Occupants can utilize a free one-hour off-peak time slot to pump the water to the elevated tank. The proposed layout saves standby electricity and cuts down energy usage. The estimated cost for constructing the gravity-fed tank is $2600 and the pack back period is approximately ten years.

VII. Efficient use of Dish washer

The dishwasher consumes 250.28 kWh of energy. We offer the following suggestions to reduce energy consumption.

- Always run the dishwasher on full load.
- Set the external water heater to the least adequate hot water temperature at about 49-degree Celsius
- The measured distance between the water heater and the dishwashing unit is 1 meter. Minimize the length of the plumping and insulate it.

VIII. Consider Light sensor

Motion sensors, traditionally used in the security industry, are becoming more popular for delivering significant energy savings in residential units.

It is reported that tenants forget to turn off the lights, especially at night before bed. Our suggestion is to employ automatic light sensors. An On/off sensors detect movement. When an activity is detected, the sensor activates, and this turns the lights on. The light turns off again after a set period after the last movement has been detected. It is important to note here that traditional CFLs (compact fluorescent lights) may not work well with timers, sensors, and controllers.

IX. Replace Outdated Appliances

The 50 inches plasma television installed in the lounge consumes 300 watts; however, 50 inches LED installed in the master bedroom consumes just 120 watts. That is a substantial 85% energy saving.

Table 19 Comparison Plasma VS LED Televisions

	Average Power rating	Daily usage hours	Daily power kWh	Annual cost kWh	Daily cost	Annual cost
Plasma TV	**300**	**5.5**	**1.65**	**602.25**	**0.45**	**164.25**
LED TV	**120**	**5.5**	**0.66**	**240.90**	**0.18**	**65.7**

One of the most prominent and tangible benefits of switching from Plasma to more energy-efficient LED TV is that occupants can save 362kWh electricity yearly, which accounts for 99$ / year. A 50 inches LED TV will cost us $1020; therefore, the payback period is within ten years.

X. Replace Electric heaters with heat pump

Although electric heaters used in standard bedrooms have a low initial cost, they are relatively inefficient in heat output and operational costs. An appropriately sized heat pump offers a low running cost and a better output. Heat pumps are also easy to control in terms of both timers and temperature than electric heaters.

- ✓ Heat pumps are also easy to control in terms of both timers and temperature than electric heaters.
- ✓ The electricity consumed by heat pumps is used to power the two fans. (evaporator and condenser), compressor, and pump to concentrate heat outside and bring it into the dwelling. Heat pumps can deliver three units of heat for every unit of electricity used for efficiency rates over 300%.

7. References

1) Solar Water Heating - The Facts | Solar Electric Technology. (2020). Retrieved 26 September 2020, from https://www.esolar.co.nz/solar-water-heating-the-facts/

2) Isaacs, N., Camilleri, M., Burrough, L., Pollard, A., SAville-Smith, K., Fraser, R., et al. (2010). Energy Use in New Zealand Households - Final Report on the household energy end-use project (HEEP). Judgeford: BRANZ Ltd.

3) Energy, N. (2020). Great value energy plans. Retrieved 2 October 2020, from https://www.novaenergy.co.nz/energy.

8. Appendix

YOUR **METER READING(S)**3111 Ohaupo Road, Peacocke, Hamilton 3282

ICP Identifier **0000028019WE296**

Billing Period **16 Sep 19 - 14 Oct 19**

Price Plan	Meter no	Prev reading	Latest reading	Units used
Low User - Combination				
Anytime	210256577	39122 (act)	39306 (act)	184 kWh
Anytime	210256577	24479 (act)	24928 (act)	449 kWh
Controlled	210256577	33600 (act)	33915 (act)	315 kWh

VARIABLE USAGE CHARGE

Low User - Combination

Anytime

Figure 16 Meter reading - September 2019

9. List of Abbreviations:

Abbreviation	Description
kWh	Kilowatt hours
AS/NZS	Standards Australia and Standards New Zealand
HVAC	Heating, Ventilation, Air Conditioning
TV	Television
MW	Megawatt
LED	Light Emitting Diode
CFL	Compact Fluorescent Lamp