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Introduction

The purpose of this report is to explore the idea of placing a microgrid and nanogrid system to support a community in Hicks Bay. This nano- and microgrid system's specifications include an analysis of the local environment, total load curve, and size of the nano- and microgrid. Additionally, the system must be off-grid and must service 95% of its load. We will analyse the cost and efficiency of both systems as well as their advantages and disadvantages to make a viable recommendation about load use and demand side management for this community.

Village Load and Resources Assessment

Hicks bay was picked as the subject of village load as it has both sufficient sun exposure as well as high wind currents due to being close to the sea. Furthermore, the exact location at which data will be collected from will be the coordinate of **-37.595915, 178.300842**. This would mean that the sunlight data and the wind data will be extracted from this location. Although not every solar panel and wind turbine can fit into this coordinate, this can be negligible when calculating the power provided to the village.

Topology

As the sun rises from the east and sets in the west, we would expect the location to not receive much sunlight before noon as it's stationed next to 2 hills [1]. Additionally, this may result in a potential shade for the solar panels leading to less power output. This can be observed in Figure 1. However, peak sunlight hours calculated from NIWA may prove these 2 variables to be negligible. Furthermore, there may be some anomalies regarding how wind would be harvested. This may be negligible as well since both wind frequency and wind speed will be considered when calculating the harvestable wind in that region.

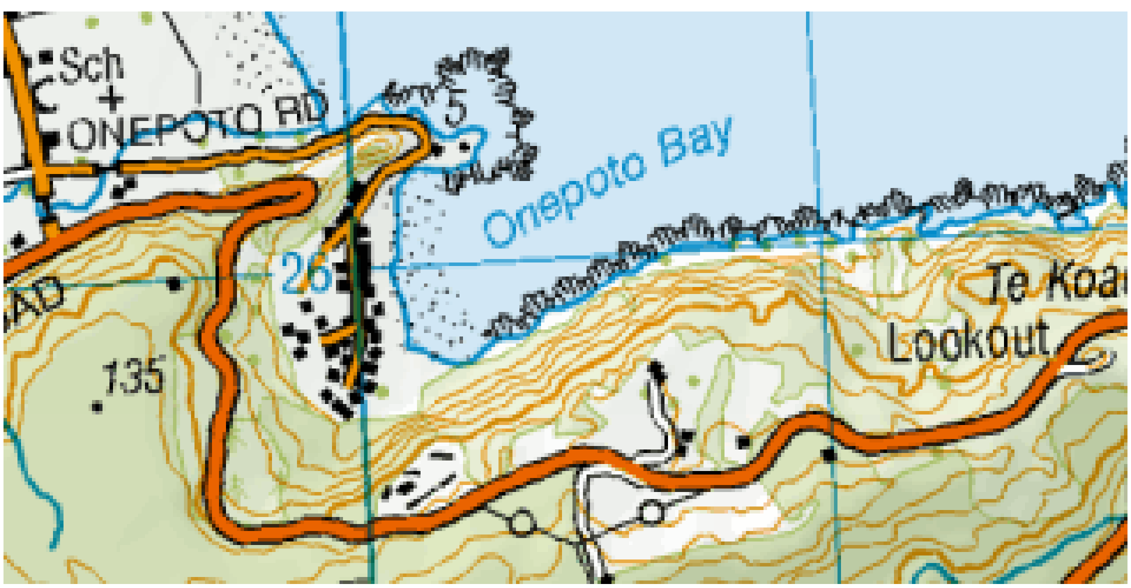

Figure 1: topology of the coordinate.

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Resource assessment

Solar analysis

On NIWA the location was exposed to 3.107 hours of peak sunlight hours during the winter month (June) on average [2]. As winter has the least amount of sunlight hours of all seasons, it will tell us what is the least amount of energy we can harvest from the sun. Additionally, this will provide us with the sufficient data to model an energy supply from solar power. As shown in Figure 2, peak sunlight hours was calculated from the total sunlight hour, summed up to provide a total number of hours providing 1kW. This makes sense as the sun would peak at noon but set in the evening.

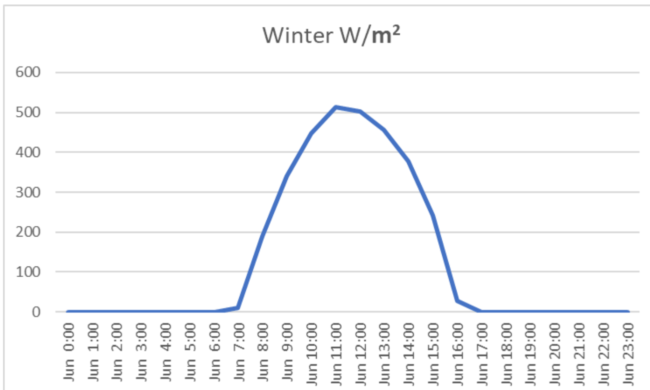

Figure 2: Mean sunlight hours during winter

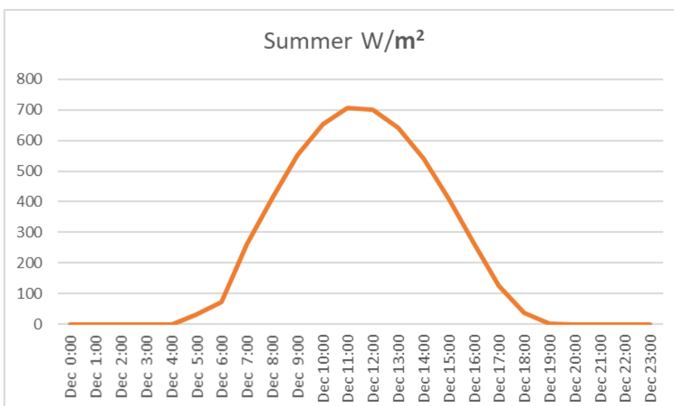

Figure 2: Mean sunlight hours during summer.

The Figure above is the sunlight hours during the summer month (December). This resulted in a peak sunlight hour of 5.417 hours during summer. Moreover, this may be considered as a constraint to determine the inverter power output when exporting power to the grid in the future. During the summer there may be network congestion due to other inverters exporting at the same time. However, this may be able to address future load growths during summer.

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Wind analysis

Using the meteorology data of NIWA, we have compiled the first week of June's wind speed to determine the average effective wind hours [2]. The effective wind hours that are available in a single day is calculated by considering the wind speed, wind frequency at that speed and the curvature of the turbines to determine an energy output (Figure 3). This resulted in an effective wind hour of 4.475 hours a day.

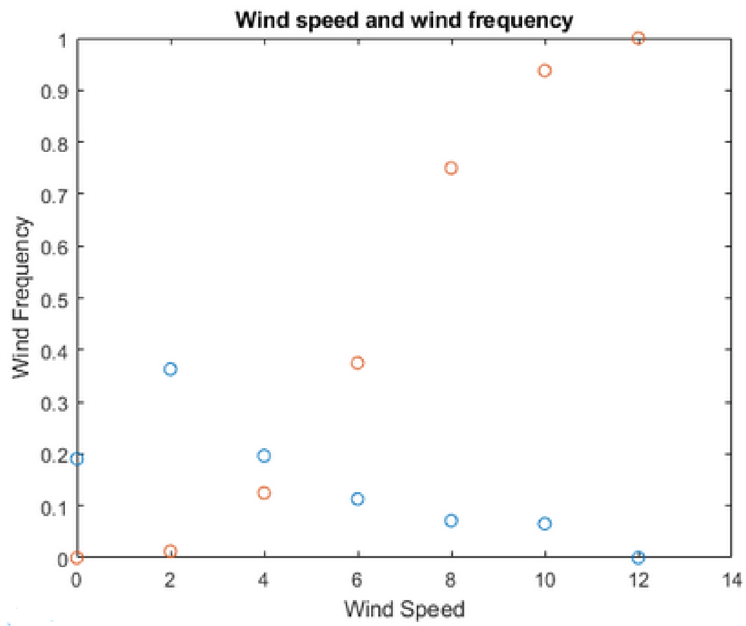


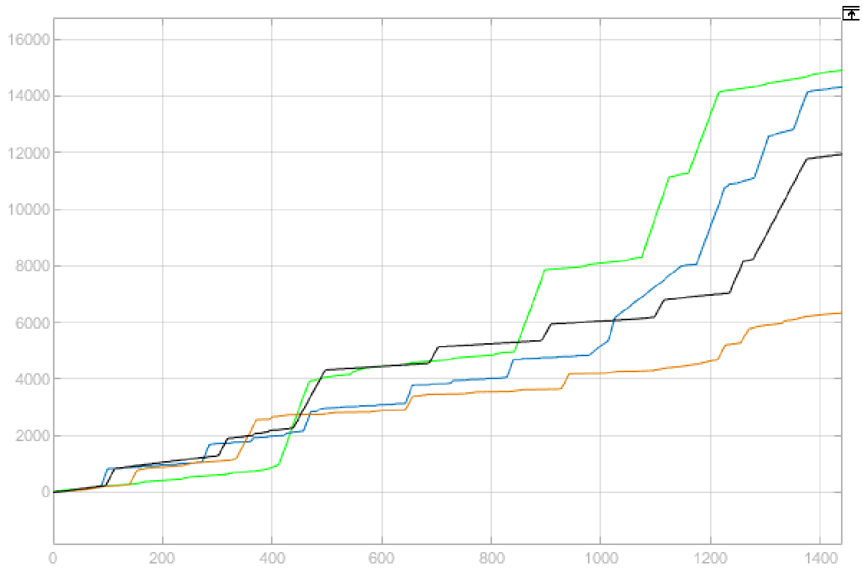
Figure 3: wind speed and wind frequency (e.g. 0.4 = 40% of the time) at that speed.

Load analysis

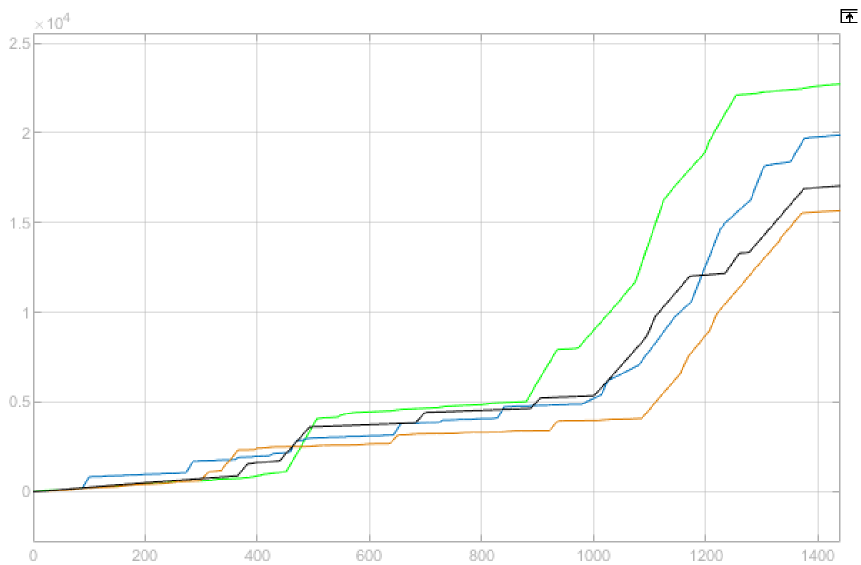
Nanogrid load analysis

To determine the load, a nanogrid will be considered as a **single house**'s load whereas a microgrid will be the load sum of **4 houses**. Both winter and summer loads will be explored to provide a feasible comparison between the 2 seasons. Additionally, both loads and instantaneous power will be observed.

To calculate the energy expenditure of a single nanogrid. The current draw of each unit will be calculated and multiplied by the national rated voltage (240 V). These sets of discrete values will be sampled for every minute of the day to provide a set of instantaneous power. Moreover, this dataset requires integrating to provide the load curve and thus the energy expenditure of the household. Both summer and winter load curves of all the nanogrids can be seen on Figure 4. Green being house 8, blue being house 3, black being house 9 and orange being house 4. The load will be serviced using AC current as a result an inverter is needed to support the nano-microgrid.



Summer load



Winter load

Figure 4: Daily seasonal load curves of the nanogrids

The nanogrids' energy expenditure for both summer and winter can be shown in Table 1, since the system has a minimum requirement of 95% of its load serviced, 100% of the energy expenditure will be considered as the excess that may be needed. These energy expenditures below will provide the sufficient energy required for component selection. It is expected that winter has higher energy demand than summer. As a result, all components selected for the nanogrid will be used to service its winter load. Additionally, the nanogrids energy expenditure can be totalled up to provide the energy expenditure for the microgrid. Instantaneous power determines the peak power drawn at any given time from the grid. This can be observed in Figure 5.1-4 where both summer and winter instantaneous power can be observed.

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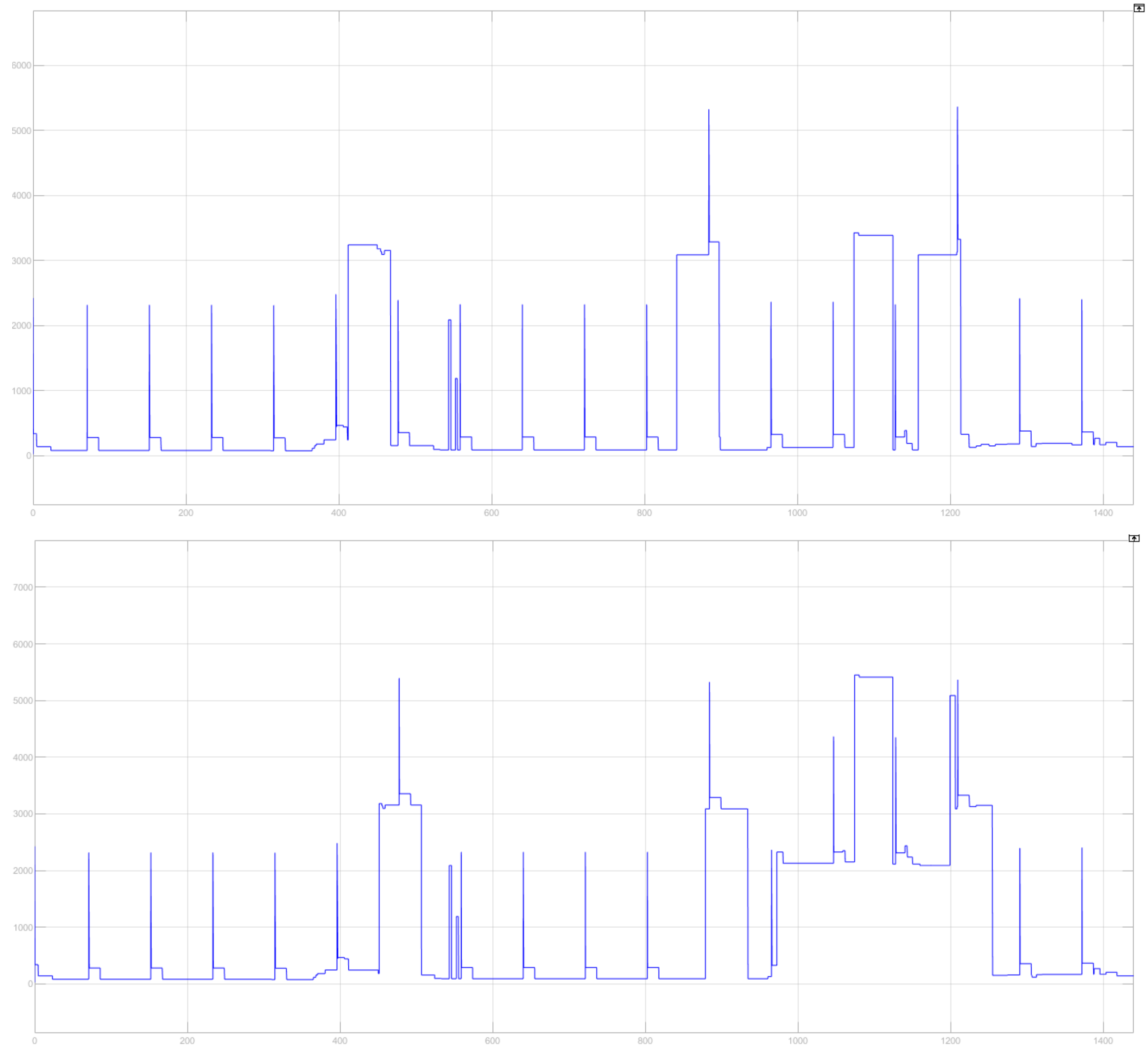

Figure 5.1:Daily instantaneous power draw of house 3. Top being summer, bottom being winter.

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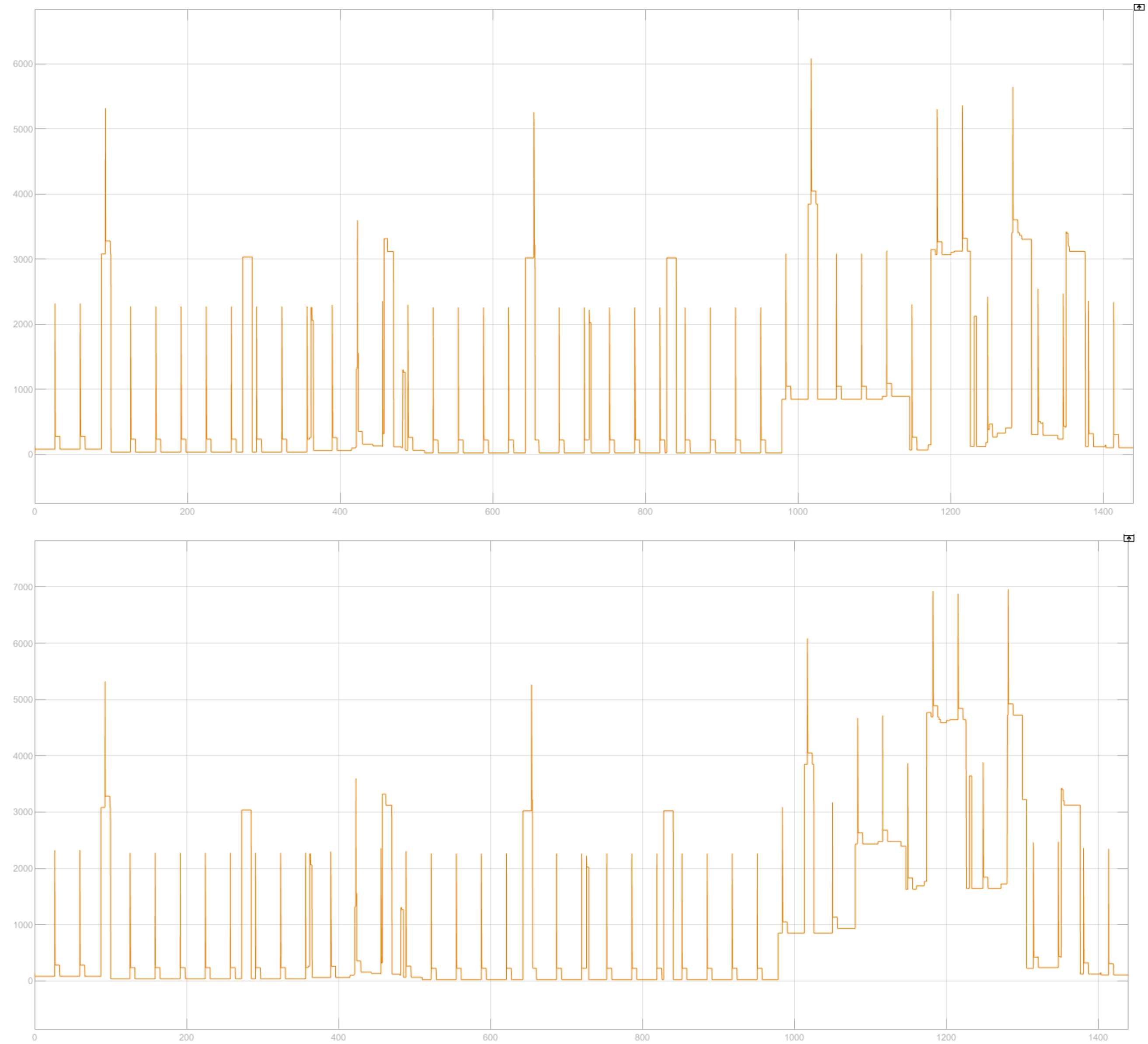

Figure 5.2: Daily instantaneous power draw of house 4. Top being summer, bottom being winter.

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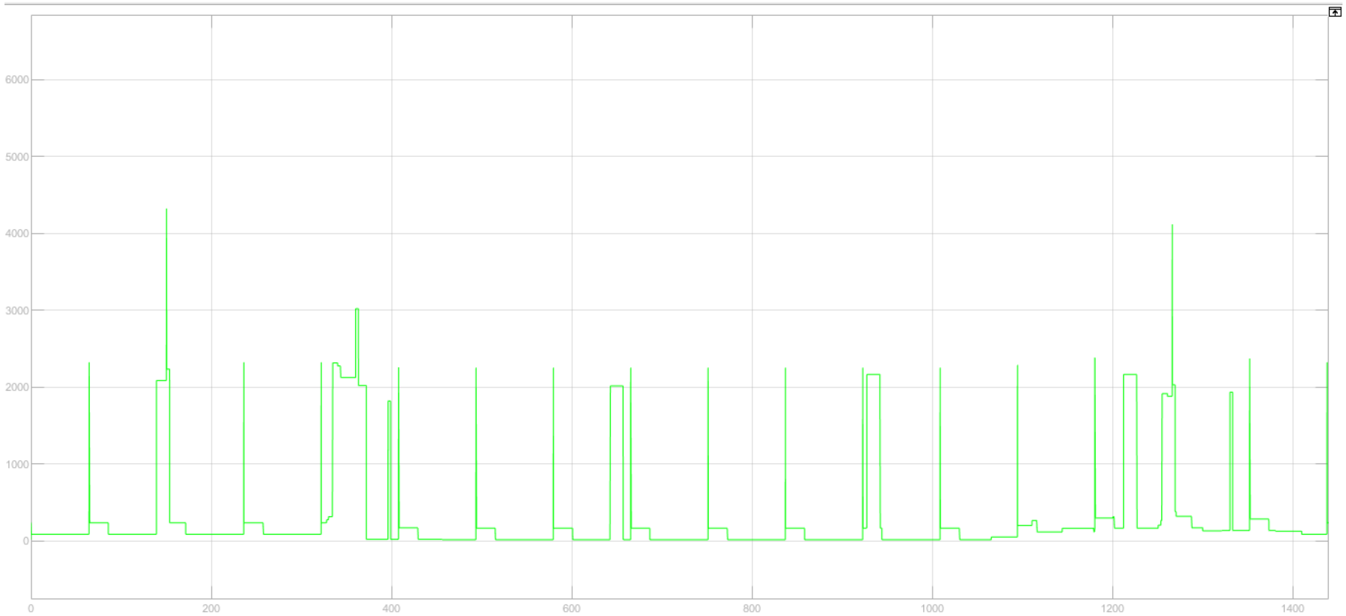

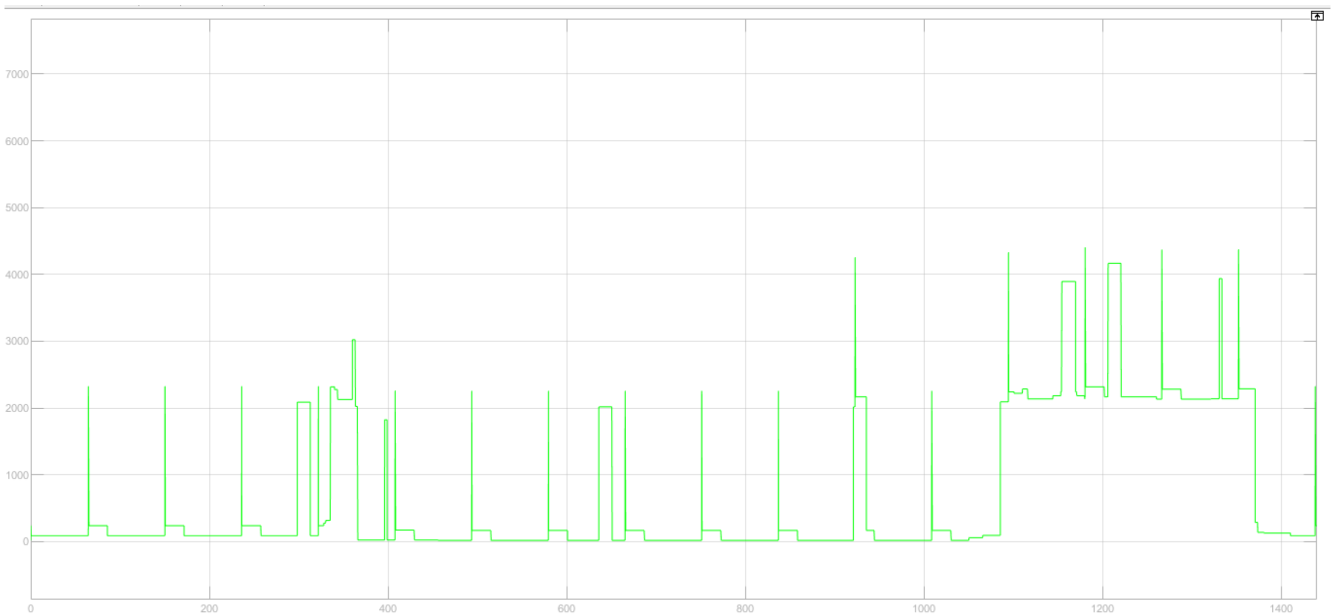

Figure 5.3 Daily instantaneous power draw of house 8. Top being summer, bottom being winter.

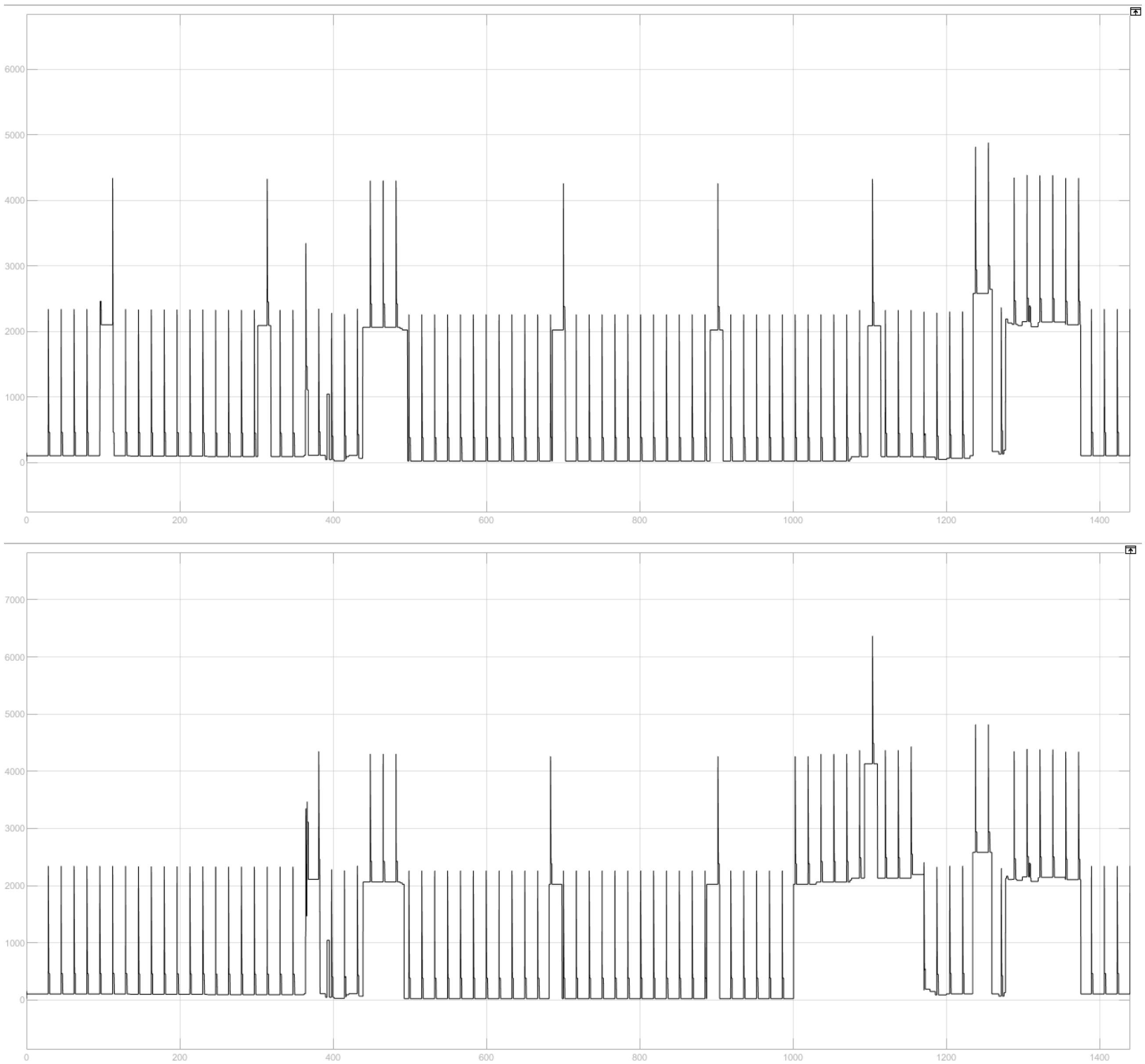

Figure 5.4: instantaneous power draw of house 9.Top being summer, bottom being winter.

These are the instantaneous power draw of each nanogrid. As shown in Figures 5.1-4, it is a recurring trait that all households tend to use more power during the evening. This makes sense as most people spend recreational time during the evening. E.g. watching TV, cooking. Unlike the daily energy expenditure the instantaneous power of each nanogrid is expected to be the same as most people would have the same routine year round.

Nanogrid	Summer daily energy expenditure	Peak instantaneous summer load	Winter daily energy expenditure	Peak instantaneous winter load
House 3	14.3 kWh	6 kW	19.8 kWh	7 kW
House 4	6.4 kWh	4.3 kW	16.0 kWh	4.5 kW
House 8	15.0 kWh	5.4 kW	23.2 kWh	5.5 kW
House 9	12.0 kWh	5 kW	17.7 kWh	5.4 kW

Table 1: seasonal energy expenditure of all nanogrids.

Microgrid load analysis

As shown in Figure 6.1, the summer microgrid daily energy expenditure is approximately 48 kWh. Whereas, the winter microgrid daily energy expenditure is approximately 77 kWh. As a result, winter energy expenditure will be considered when considering the capacity of battery, capacity of inverter, quantity of PVs and wind turbines selected.

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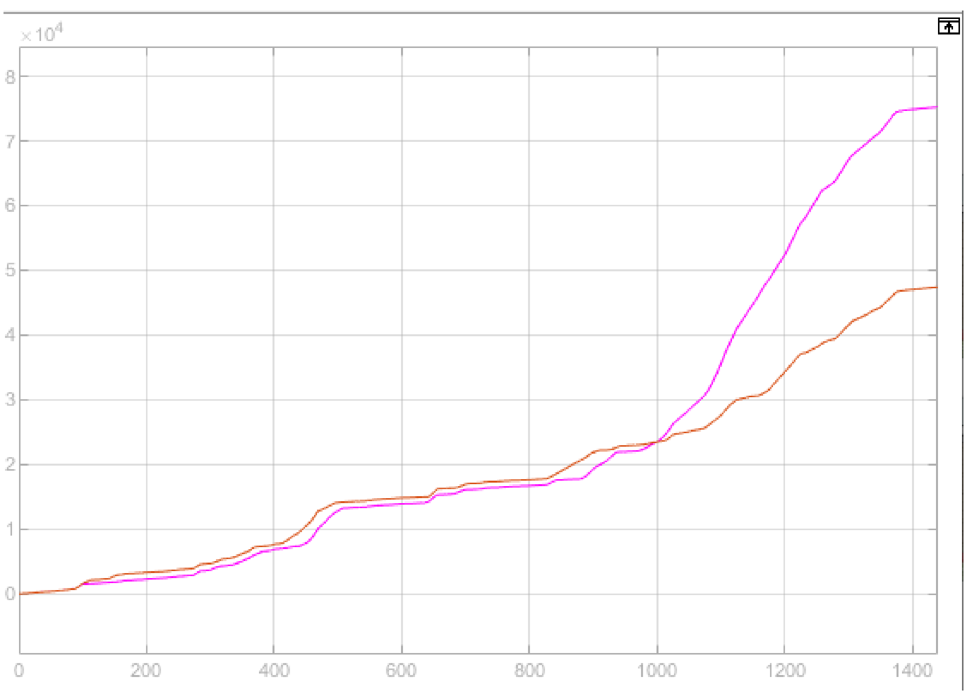

Figure 6.1: Microgrid daily energy expenditure for summer and winter.
Purple = Winter, Orange = Summer

All wind turbines connected to the battery must first be converted to DC to allow the battery to charge. However, the PVs would not need any conversion to allow the battery to charge as its generated via DC current.

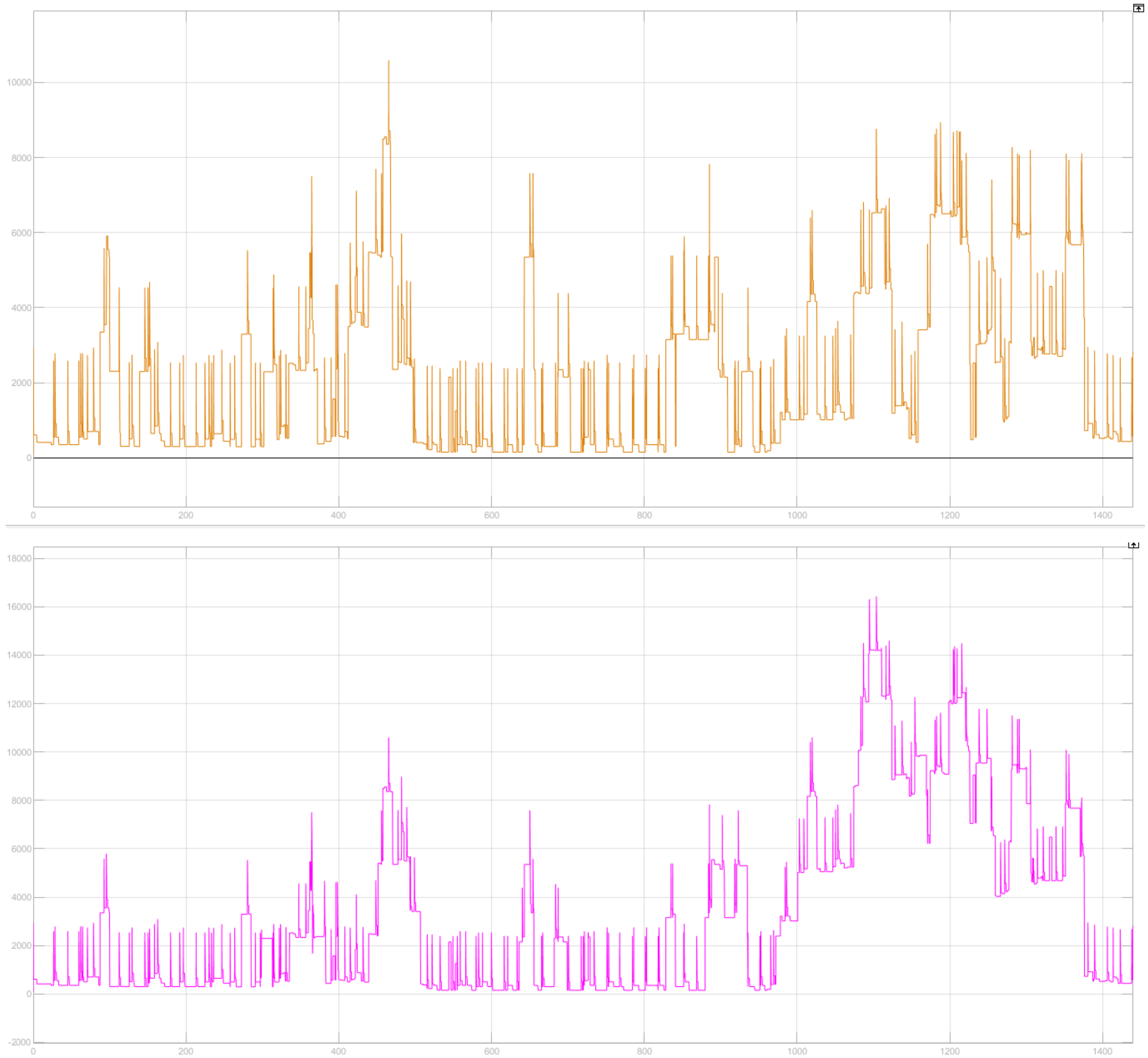

Figure 6.2: Microgrid instantaneous power draw. Top being summer, bottom being winter.

Unlike the nanogrid, microgrids have a higher instantaneous power draw during winter compared to its summer power draw. This is the cause of high power demands from all the households at once.

Microgrid	Summer daily energy expenditure	Peak instantaneous summer load	Winter daily energy expenditure	Peak instantaneous winter load
Microgrid	48 kWh	10.5 kW	77 kWh	16 kW

Table 2: seasonal energy expenditure of all microgrids

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Component Selection

component	Capital cost (per unit)	O&M cost	Replacement time
PV	$750 /kW	$1 /280W /year	25 year
Wind	$1460 /kW	$146 / 500W /year	20 year
Battery	$110 /kW	$11 /kWh /year	10 year
Inverter	$364 /kW	0.0026 /kW /year	10 year

Table 3: component cost of the project in USD

PVs, wind turbines and battery selection will be based on the winter energy expenditure as it has a higher load curve compared to summer's energy expenditure. Components selected from Table 3 must accommodate for the loads in Table 1. In addition, this allows us to compare the financial benefits of microgrid and nanogrid when their loads are high. For a self-sustaining community, it is more important to have an energy surplus than a deficit since to accommodate for later use. As a result, both solar panels and wind turbines calculated in Table 4 must be rounded up to ensure an energy surplus. Additionally, all calculations below will be done in USD before converting to NZD.

Method of energy harvesting

The method of energy harvesting will determine how the nanogrid will be powered. The method of harvesting would be PVs (solar energy) and/or wind turbines. To determine how many PVs and turbines required, the daily energy expenditure will be divided by the energy output of the system. Additionally, the initial cost will consider the required quantity of PVs and wind turbines, the rated power output and the initial cost of the equipment. Finally, the operation and maintenance cost (O&M cost) will consider the quantity of equipment and the annual operation and maintenance cost.

$$required\ quantity\ of\ equipment\ =\ Daily\ energy\ expenditure\ \div (power\ output\ *\ functional\ hours)$$
$$initial\ cost\ =\ power\ output\ of\ the\ equipment\ *\ required\ quantity\ of\ equipment\ *\ cost\ of\ equipment$$
$$OM\ cost\ =\ O\&M\ cost\ per\ year\ for\ the\ equipment\ *\ required\ quantity\ of\ equipment$$

Nanogrid	Daily energy expenditure	Required PVs (280 W)	Initial cost	O&M cost per year
House 3	19.8 kWh	23	$4830	$23
House 4	16.0 kWh	19	$3990	$19
House 8	23.2 kWh	27	$5670	$27
House 9	17.7 kWh	21	$4410	$21

Nanogrid	Daily energy expenditure	Required wind turbines (500 W)	Initial cost	O&M cost per year
House 3	19.8 kWh	9	$6570	$1314
House 4	16.0 kWh	8	$5840	$1168
House 8	23.2 kWh	11	$8030	$1606
House 9	17.7 kWh	8	$5840	$1168

Table 4: PVs and wind turbines required quantity and costs for nanogrids

As shown in Table 4, although solar panels may be more cost effective in general. Solar panels are made redundant if there's low sun exposure as well as only effective for 3.107 hours of the day. However, this can be made negligible by allowing a greater battery capacity. Wind turbines have a high upkeep cost and initial cost as a result, will not be considered when sizing the nanogrid. Additionally, it may require a voltage rectifier to charge the battery as the battery charges in DC.

Battery management system

Battery management system must be able to supply enough energy to the nanogrids until the next morning. Additionally, the battery management system must be doubled to accommodate for the days when power can not be generated as well as supporting the nanogrid during down time. This will lower the chances that the battery will go below 50% on cloudiest days during winter which may result in battery damage.

Nanogrid	Daily energy expenditure	Battery capacity	Initial cost	O&M cost per year	After replacement cost
House 3	19.8 kWh	39.6 kWh	$4356	$435.60	$8712
House 4	16.0 kWh	32 kWh	$3520	$352	$7040
House 8	23.2 kWh	46.4 kWh	$5104	$510.4	$10208
House 9	17.7 kWh	35.4 kWh	$3894	$389.4	$7788

Table 5: Battery capacity and costs for nanogrids

The cost stated in Table 5 was doubled to compensate for the replacement cost. This was the result of the battery lifespan being 10 years where this project span is 20 years.

Inverters

The purpose of the inverter is to provide sufficient AC power to the nanogrid. This AC power must accommodate for the peak instantaneous load as that's the maximum load required to accommodate at any time. There must be extra capacity to prevent overloading. To accommodate for this safety measure, the inverter capacity will be 50% greater than the peak instantaneous power of the nanogrid when determining inverter capacity.

Nanogrid	Peak instantaneous power in winter (kW)	Inverter capacity	Initial cost	OM cost per year	After replacement cost
House 3	7 kW	10.5 kW	$3,822	$0.03	$7,644
House 4	4.5 kW	6.75 kW	$2,457	$0.02	$4,914
House 8	5.5 kW	8.25 kW	$3,003	$0.03	$6,006
House 9	5.4 kW	8.1 kW	$2,948.4	$0.03	$5,897

Table 6: Inverter capacity and costs for nanogrids

The cost stated in Table 6 was doubled to compensate for the replacement cost. This was the result of the inverter lifespan being 10 years where this project span is 20 years. There were some abnormalities since house 9 has a greater peak instantaneous power compared to house 4, this was a result of high power draw at a given time.

Nanogrid costs in NZD

Nanogrid	PVs cost + annual O&M cost	Wind turbines cost + annual O&M cost	Inverter cost + annual O&M cost	Battery cost + annual O&M cost
House 3	$6,955 + $33	$9,461 + $1,892	$11,007 + $0.04	$12,545 + $627.26
House 4	$5,746 + $27	$8,410 + $1,682	$7,076 + $0.03	$10,138 + $507
House 8	$8,165 + $39	$11,563 + $2,313	$8,649 + $0.04	$14,700 + $734.98
House 9	$6,350 + $30	$8,410 + $1,682	$8,492 + $0.04	$11,215 + $560.74

Table 7: Total cost of the components for nanogrids

Table 7 summarises the cost of each component from Tables 4 to 6 with its annual operating and maintenance cost in NZD (appended with an + sign). This will provide a better insight to the total cost of the nanogrid projects as the system is hosted in the NZ setting. As the initial and upkeep cost of wind is less cost effective than solar, wind power will not be used when sizing a nanogrid. However, it will be included in the economic analysis to provide an economical comparison.

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Microgrid costs

All the calculations in Table 8 were done in USD to prevent miscalculations. As the energy expenditure of each nanogrid totals up to provide the microgrid's energy expenditure, the total cost of PVs/wind and battery in the nanogrids can be totalled up to provide its respective cost for the microgrid.

Microgrid	Daily energy expenditure	Required PVs (280 W)	Initial cost	OM cost per year
Microgrid	77 kWh	90	$18900	$90

Microgrid	Daily energy expenditure	Required wind turbines (500 W)	Initial cost	OM cost per year
Microgrid	77 kWh	36	$26,280	$5256

Microgrid	Daily energy expenditure	Required battery capacity	Initial cost	OM cost per year	After replacement cost
Microgrid	77 kWh	153.4 kWh	$16,874	$1,687	$33,748

Microgrid	Peak instantaneous power in winter (kW)	Inverter capacity	Initial cost	OM cost per year	After replacement cost
Microgrid	16 kW	24 kW	$8,736	$0.06	$17,472

Table 8: Inverter capacity and costs for nanogrids

As shown in Table 2. The peak instantaneous power drawn for the microgrid is 16 kW. This allows the microgrid to cut costs for the inverter as it only requires 24 kW instead of the sum of the peak power drawn for the nanogrids.

Microgrid cost in NZD

Microgrid	PVs cost + annual O&M cost	Wind turbines cost + annual O&M cost	Inverter cost + annual O&M cost	Battery cost + annual O&M cost
Microgrid	$27,216 + $130	$37,843 + $7,569	$25,159.68 + $0.09	$48,597 + $2,429.86

Table 9: Total cost of the components for nanogrids

Table 9 summarises the cost of the components in Table 8 along with its annual operating and maintenance cost in NZD (appended with an + sign). This will provide a better insight to the total cost of the microgrid project. As the initial and upkeep cost of wind is less cost effective than solar, wind power will not be used when sizing a microgrid. However, it will be included in the economic analysis to provide an economical comparison.

Nanogrid technical considerations

Technical considerations include making sure that all the inductive and capacitive loads have phase correction units so that it may not cause disturbance elsewhere in the house. In the nanogrid, software may be needed to optimise power usage, such as allowing charging to happen simultaneously with discharging. During the summer, when the PVs are more efficient, bus load may be a concern. It may be recommended that PVs operate during some of the daytime hours to avoid bus overload. All buses must be low resistance to prevent voltage curtailing.

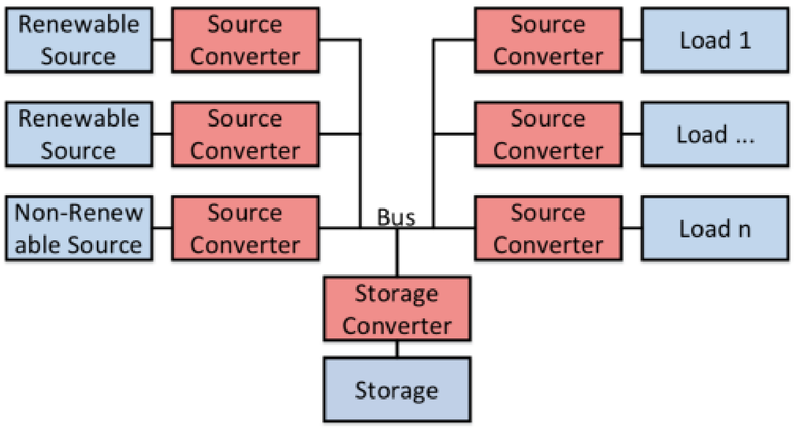

Figure 7: example of a bus load

Microgrid technical considerations

Microgrids will likely use more wiring and buses than the nanogrids. Additionally, the microgrid may need some protective brakes/relays to prevent any faults from affecting other houses. Furthermore, there may be an increase in bus load as the microgrid connects to each household thus, additional phase protection may need to be implemented to accommodate load growth. Single phase lines will be required to deliver power to each of the houses.

Microgrids will also require a more complex software to optimise the load demands of each household. This software may be used inside the central processing unit of the microgrid to accommodate for the load curves and bus load of the system. Furthermore, there will be additional costs associated with this software.

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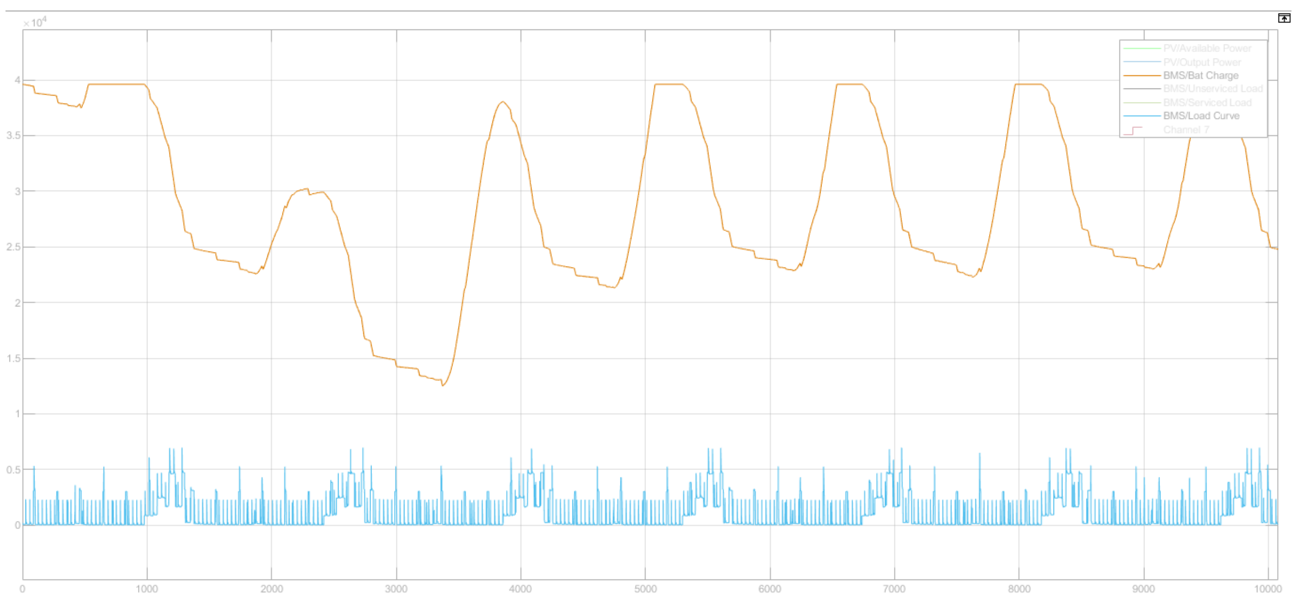
Nanogrid PVs system simulation model

To provide a realistic simulation of the nanogrids in simulink a week of tilted solar irradiance was picked. The week of the winter solstice was picked to provide the sunlight hours 21st of June 2021 to 27th of June 2021 [2]. This week was to showcase how the nanogrids would perform in the least optimal winter conditions. This week has a mean of 4.031 peak hours a week. As shown in the Figures below the nanogrids required to draw some energy out of the energy reserve to sustain the house. This was a result of a lack of solar irradiance during the day. The orange line represents the energy usage of the battery management system and the blue line represents the instantaneous power throughout the day. It can be observed in Figures 8.1-4 that all nanogrids have shown to be able to sustain the load demand of its household with a slight drop below 50% battery capacity. We can conclude that the components selected for the nanogrids are viable.

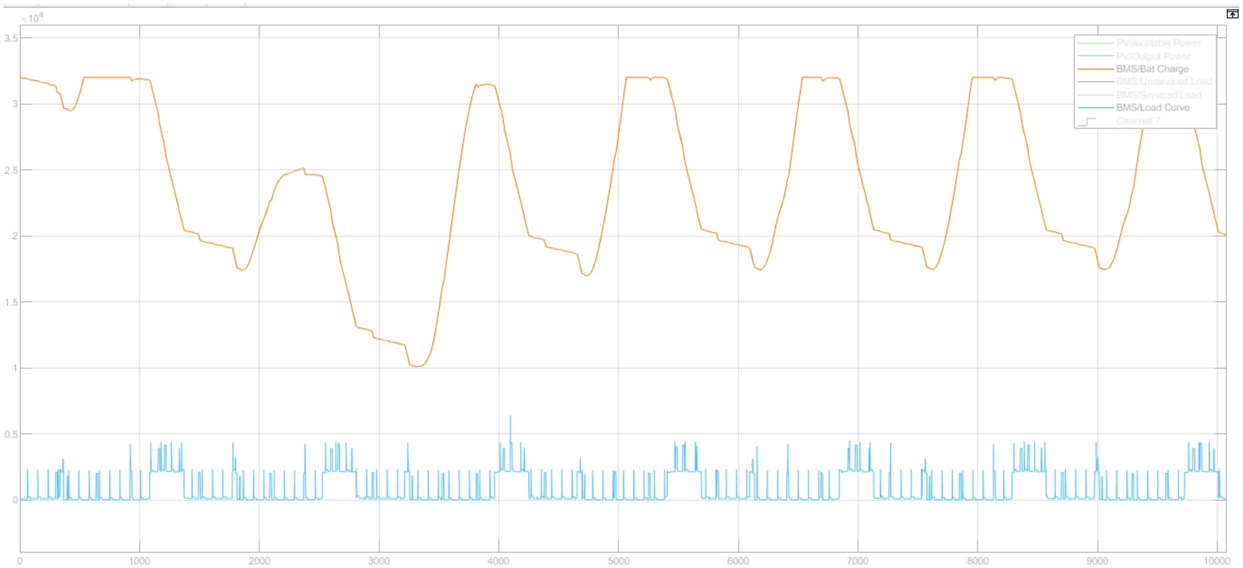
House 3



PVs capacity	Battery capacity	Inverter capacity
6.44 kW	39.6 kWh	10.5 kWh

Figure 8.1: house 3 battery management system and instantaneous power demand

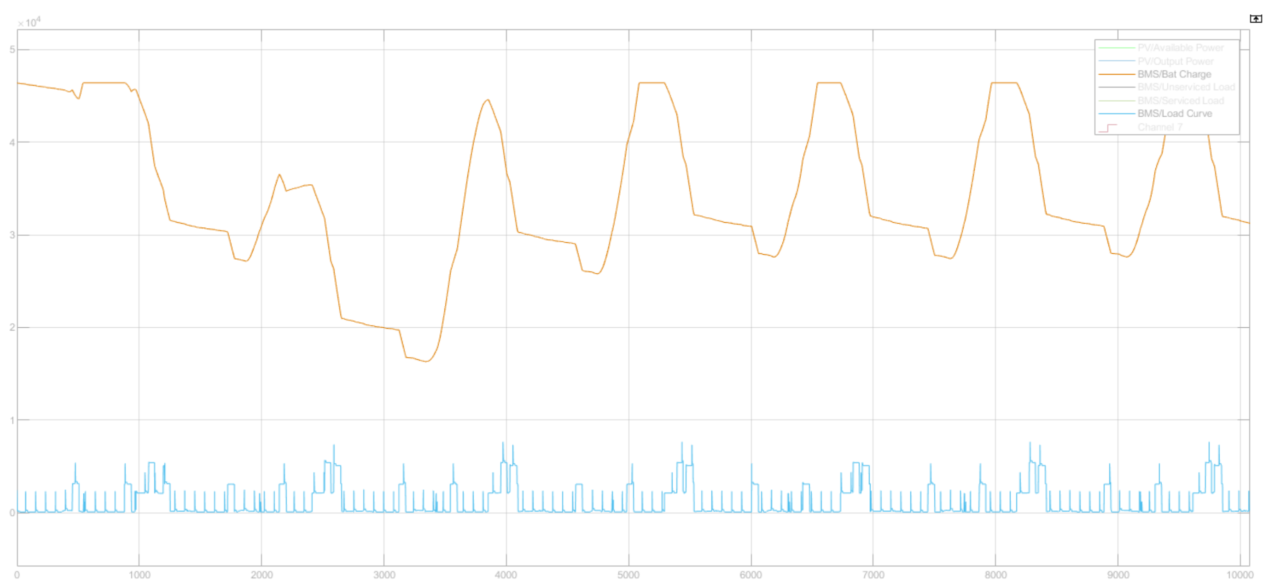
House 4



PVs capacity	Battery capacity	Inverter capacity
5.32 kW	32 kWh	6.75 kWh

Figure 8.2: house 4 battery management system and instantaneous power demand

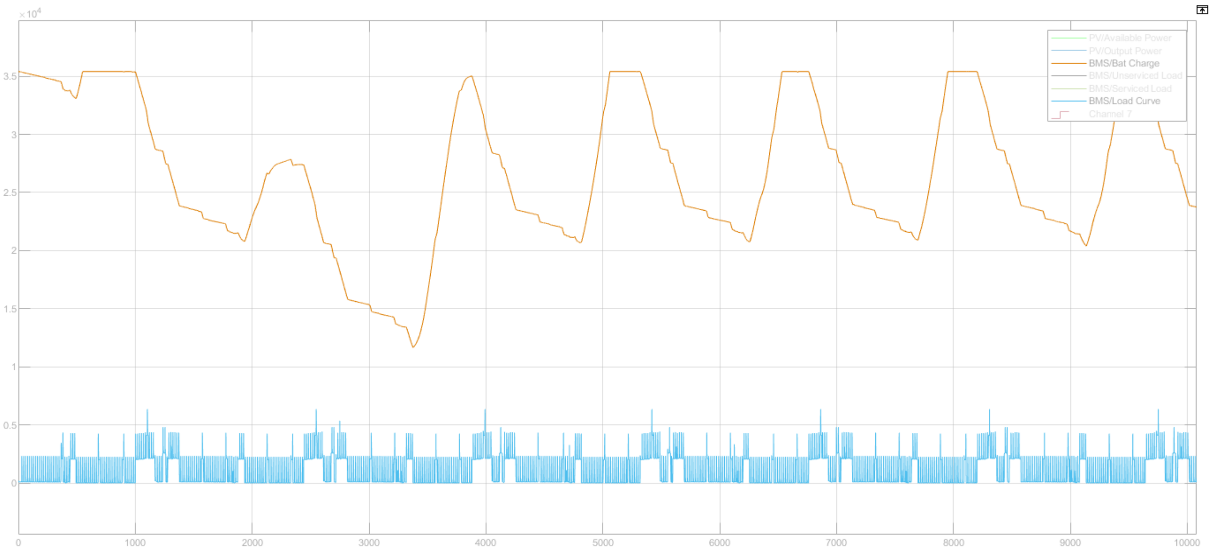
House 8



PVs capacity	Battery capacity	Inverter capacity
7.56 kW	46.4 kWh	8.1 kWh

Figure 8.3: house 8 battery management system and instantaneous power demand

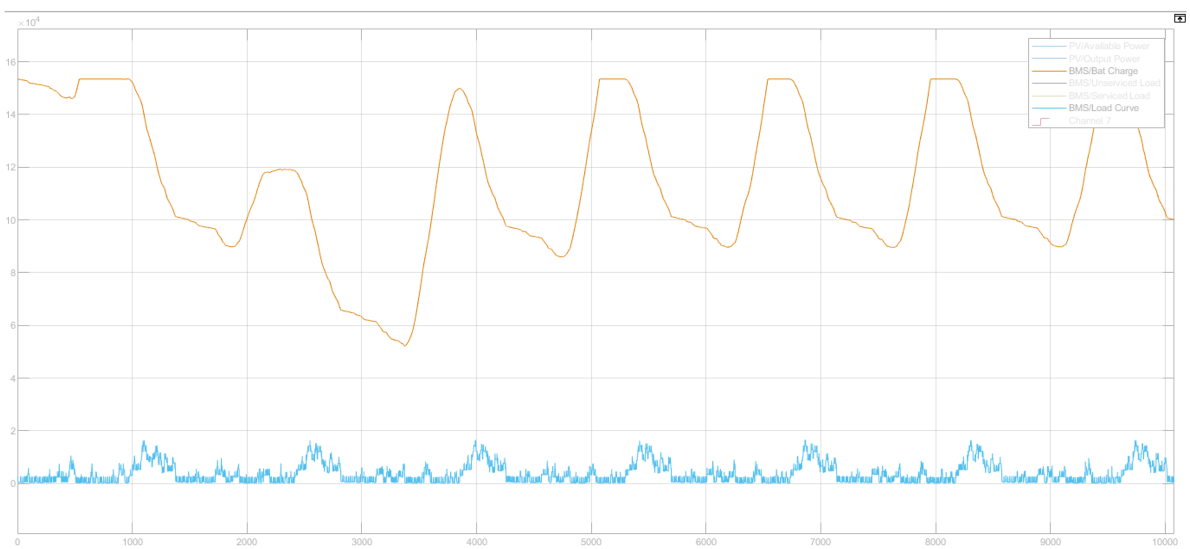
House 9



PVs capacity	Battery capacity	Inverter capacity
5.88 kW	35.4 kWh	8.25 kWh

Figure 8.4: house 9 battery management system and instantaneous power demand

Microgrid PVs system simulation model



PVs capacity	Battery capacity	Inverter capacity
25.2 kW	153.4 kWh	24 kW

Figure 9: Microgrid battery management system and instantaneous power demand

The same process of exposing the microgrid with the same sunlight hours as the nanogrid provided a fair comparison of how each system would fare in the same weather conditions. In Figure 9, the orange line represents the energy usage of the battery and the blue line represents the instantaneous power drawn for the system. It can be observed that the battery was enough to sustain the load demand of the microgrid. As a result we conclude that the component selected would make this microgrid viable.

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Nanogrid economical analysis

To determine the economical feasibility of the nanogrids, Simple Payback, Net Present Value and Levelised Cost of Energy (LCOE) will be used as a metric of comparison. The grid price per kwh ($0.29 NZD to $0.2 USD) will also be considered as well as rebates to determine the Simple Payback. Additionally, the PVs based system will only consider the cost of the battery, inverter and PVs whereas the wind based system will only consider the cost of the battery, inverter and PVs. The calculations will all be conducted in USD before converting to NZD to prevent miscalculations. NZD to USD conversion is assumed at $1.44 NZD to $1 USD.

$$Net\ Annual\ energy\ saving\ (\$/year)\ =\ [AOE\ (kWh/year)\ *\ Price\ (\$/kWh)]\ -\ O\&M\ (\$/year)$$

Nanogrid	Annual energy output (AOE)	PVs Net Annual Energy Savings (NZD)	Wind Net Annual Energy Savings (NZD)
House 3	7227 kWh	$ 1,420.95	-$ 438.09
House 4	5840 kWh	$ 1,147.65	-$ 506.91
House 8	8468 kWh	$ 1,664.90	-$ 608.86
House 9	6460.5 kWh	$ 1,269.62	-$ 382.06

Table 10: Annual energy output and Net Annual Energy Savings of PVs and wind nanogrids

As each nanogrid will not be using all its produced power throughout the year. The annual energy output (AOE) can be considered using the energy production during winter multiplied by the number of days in the year. As observed in Table 10 the Net Annual Energy Savings is higher for PVs.

Simple Paybacks

To calculate the Simple Paybacks (years) the total installed cost is calculated by summing the cost of the PVs/wind turbines, battery cost and inverter cost. This payback will provide an insight as to when the cost of the project would break even. As observed in Table 11, PVs can break even during the span of the project but not wind turbines.

$$Paybacks\ (year)\ =\ \frac{installed\ cost(\$)\ -Rebates(\$)}{Net\ Annual\ Energy\ Savings\ (\$/year)}$$

Nanogrid	PVs Simple Payback (years)	Wind turbines Simple Payback (years)
House 3	20.1	70.8
House 4	18.3	46.6
House 8	17.7	54.1
House 9	18.9	68.4

Table 11: Simple Payback for PVs and wind nanogrids

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Discounted Net Annual Savings

Using Figure 10, we select a discount rate of 2% as well as consider the project span of 20 years. This provided a PVAF of **16.35**. This can be used to calculate the Discounted Net Annual Savings in the Table below. The Net Present Value will consider all costs and savings for the lifetime of the project. Furthermore, the Net Present Value (NPV) can be calculated by subtracting the Discounted Net Annual Savings from the Initial Cost and the Rebates. Rebates are used as part of the initial cost as the government issues out financial incentives for the construction of nanogrids ($1389 USD).

Discount Rate (sidebar 1)	Useful Life (years)				
	10	15	20	25	30
2%	8.98	12.85	16.35	19.52	22.40
3%	8.53	11.94	14.88	17.41	19.60
4%	8.11	11.12	13.59	15.62	17.29
5%	7.72	10.38	12.46	14.09	15.37
6%	7.36	9.71	11.47	12.78	13.76
7%	7.02	9.11	10.59	11.65	12.41

Figure 10: PVAF

$$Discounted\ Net\ Annual\ Savings\ (\$)\ =\ Net\ Annual\ Energy\ Savings\ (\$/year)\ *\ PVAF$$

$$Net\ Present\ Value\ (NPV)\ (\$)\ =\ Discounted\ Net\ Annual\ Savings\ (\$)\ -\ (installed\ cost(\$)\ -\ Rebates(\$))$$

Nanogrid	PVs Discounted Net Annual Savings (NZD)	Wind turbines Discounted Net Annual Savings (NZD)	PVs Net Present Value (NPV) (NZD)	Wind Net Present Value (NPV) (NZD)
House 3	$ 23,232.57	-$7,162.73	-$5,275.11	-$38,176.01
House 4	$ 18,764.15	-$8,287.91	-$2,209.45	-$31,911.11
House 8	$ 27,221.07	-$9,954.91	-$2,291.73	-$42,866.11
House 9	$ 20,758.25	-$6,246.72	-$3,298.10	-$32,362.27

Table 12: Discounted Net Annual Savings and Net Present Value of PVs and wind turbines for nanogrids

As observed in Table 12 all the NPVs for all nanogrids are negative, the nanogrid project will most likely lose money. As a result, this system is not economically viable. However, if a system must be built, the most economically viable ones would be the PVs as it has the highest NPVs values, specifically house 4 as it has the highest Discounted Net Annual Savings and NPV.

Levelised Cost of Energy

The Levelised Cost of Energy (LCOE) represents the discounted price that the system provides to breakeven over the project lifespan [3]. The nanogrids would be economically feasible if the LCOE is less than the grid price per kWh since it would be more cost effective to use the generated electricity than import power from the grid.

$$LCOE\ (\$/kWh) \ = \ \frac{Initial\ cost\ (\$) + O\&M\ (\$/year) * PVAF}{Annual\ Energy\ Output\ (kWh/year) * PVAF}$$

Nanogrid	PVs LCOE (NZD)	Wind turbines LCOE (NZD)
House 3	$ 0.33	$ 0.60
House 4	$ 0.30	$ 0.62
House 8	$ 0.30	$ 0.60
House 9	$ 0.32	$ 0.59

Table 13: LCOE of PVs / Wind nanogrids

As shown on the Table above, the LCOE is more than the price per kWh ($0.29) as a result not economically viable. However, there can be additional benefits such as being robust against outages. Outages can happen when there’s a sudden power demand in a more densely populated area and the grid will redirect power to accommodate the demand. Furthermore, the LCOE of the PVs system can be lowered there’s an increase in energy expenditure. This may indicate that an internal load growth may decrease the Levelised Cost of Energy.

Microgrid economical analysis

Using the same formulas and principles conducted on the nanogrids. We can obtain the Net Annual Energy Savings, Simple Paybacks, Net Present Value and Levelised Cost of Energy for the microgrid. These figures will help determine whether a microgrid project is economically viable.

Microgrid	Annual energy output (AOE)	PVs Net Annual Energy Savings (NZD)	Wind turbines Net Annual Energy Savings (NZD)
Microgrid	28105 kWh	$ 5,590.90	-$ 1,848.14

Table 14: Annual energy output and Net Annual Energy Savings of PVs and wind microgrid

Microgrid	PVs Simple Payback (years)	Wind Simple Payback (years)
Microgrid	17.7	59.3

Table 15: Simple Payback for PVs and wind microgrid

Microgrid	PVs Discounted Net Annual Savings (NZD)	Wind Discounted Net Annual Savings (NZD)	PVs Net Present Value (NPV) (NZD)	Wind Net Present Value (NPV) (NZD)
Microgrid	$ 91,411.28	-$ 30,217.02	-$ 7,561.52	-$ 139,817.02

Table 16: Discounted Net Annual Savings and Net Present Value of PVs and wind turbines for microgrid

Microgrid	PVs LCOE (NZD)	Wind turbines LCOE (NZD)
Microgrid	$ 0.31	$ 0.59

Table 17: LCOE of PVs / Wind nanogrids for microgrid

In terms of NPV, Net Annual Energy Savings and Discounted Net Annual Savings, it has shown to be a similar value to the sum of the nanogrids as observed in Tables 14-17. However, the Simple Payback and LCOE indicates that the microgrid is slightly more economically viable than the nanogrid. This was a result of the lower cost spent on the inverter.

Conclusion and Recommendations

The location for this project may be improved to Whakatane as it's a sunnier location. This would result in higher peak sunlight hours and require less PVs to support the microgrid. This would result in an overall lower cost to the project and would increase the Discounted Net Annual Savings of the project and decrease the LCOE. Additionally, an improvement in PV technology would also make microgrids more economically viable in the future. Furthemore, an Maximum Power Point Tracking (MPPT) could be implemented to maximise power output resulting in a more cost effective system.

We can also conclude that the PVs system was more economically feasible than the wind turbine. However, a hybrid system where both wind turbines and PVs are employed may be a viable solution. An example of the hybrid system would be the nanogrid on the Laby Building of Victoria University of Wellington [4].

Comparing the cost of having 4 nanogrid against the microgrid. The Microgrid has shown to be more economically viable due to the instantaneous power drawn. This resulted in lower cost spent in the inverter making it more cost effective. Having a microgrid system will lower the demand of fossil fuel used in NZ as a result will assist in reaching carbon emission goals.

The microgrid may be profitable if the inverter was connected to the grid for power export. There may be short term costs associated with power export; standard regulations (AS4777.2 2020) [5]. Furthemore, power export may come with additional tax if being sold back to the grid. To make the microgrid more profitable, the project must span longer than 20 years. There may be network congestion in the summer due to high energy output from PVs. This may be resolved if a dynamic export limiter was implemented to the microgrid [6].

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