SOMA Energy

System Design

Address: Palm Bay Resort
Great Barrier Reef Marine Park, Long Island **Coordinates:** -20.344460, 148.849593
Date: 27th April 2017

> **System Architecture**
> PV: 100kW
> Wind: 25.5kW
> Battery: 367.92kWh of useable storage at 70% DoD at C20

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1. Design Brief

This document is the product of results from several micro grid design simulations with the intent of identifying the most economically viable off grid energy system given the estimated energy demand for the resort. Price point of possible components, labour and the renewable energy resources at the given location was also included in this design. NASA satellite data is used in conjunction with BOM data to provide accurate readings of daily solar irradiation and daily average winds speeds.

This document has been prepared on the information and data available at this time (including, but not limited to appliance use, lifestyle choices, environmental factors of the site, etc.). Should any of these factors change, then AWS cannot guarantee the accuracy of the recommendations and/or estimated outcomes contained within this document. Annual barge freight of $39,843.75, annual maintenance cost of $14,500 and fuel rebate of $10,444 exclusive of GST were used to determine operating fuel costs of current generators (80kVA and 50kVA) as supplied by the client.

Figure 1: Aerial view of Palm Bay Resort

2. Power/Fuel Usage

2.1 Generator fuel consumption rates

Diesel Generator specifications used for analysis are shown below.

Generator Set Specifications

	Standby	Prime
Voltage regulation (no load to full load)	± 1%	
Steady-state voltage variation	± 1%	
Frequency regulation (no load to full load)	140%	
Steady-state frequency variation	±0.25%	
EMC compatibility	BS EN 61000-6-4 / BS EN 61000-6-2	
Fuel consumption, g/kw·h(L/hr)@100% load	210(23.4)	208(21.7)
Battery starting capacity, A/hr	100*2	
Total coolant capacity (with engine and water tank), L	34	
Base type fuel tank (Liters capacity)	250	

Figure 2: Cummins 80kVA Diesel generator set specifications used[1]

Approximate diesel fuel consumption data used to apply extrapolation points for Cummins 80kVA diesel generator as only fuel consumption at 100% load is given.

Generator Size	Approximate Diesel Fuel Consumption			
	¼ Load (litres/hr)	½ Load (litres/hr)	¾ Load (litres/hr)	Full Load (litres/hr)
8kW / 10kVA	0.9	1.2	1.7	2.1
10kW / 12kVA	1.0	1.4	2.1	2.6
12kW / 15kVA	1.3	1.8	2.6	3.2
16kW / 20kVA	1.7	2.4	3.5	4.3
20kW / 25kVA	2.1	3.0	4.3	5.4
24kW / 30kVA	2.6	3.6	5.2	6.4
32kW / 40kVA	3.4	4.8	7.0	8.6
40kW / 50kVA	4.3	6.0	8.6	10.7
60kW / 75kVA	6.4	9.0	12.7	16.1
80kW / 100kVA	8.3	11.9	16.1	21.4
120kW / 150kVA	10.9	17.3	24.1	32.1
160kW / 200kVA	14.1	22.9	32.7	42.8
200kW / 250kVA	17.4	28.6	40.8	53.5
280kW / 350kVA	23.7	39.3	56.0	74.9
400kW / 500kVA	33.3	55.6	79.6	107.0

Figure 3: Generic diesel generator fuel consumption[2]

Ratings	Standby				Prime			
	53 kVA		42 kW		48 kVA		38 kW	
Load	Full	3/4	1/2	1/4	Full	3/4	1/2	1/4
Consumption (L/hr)	13	10	8	5	11	9	7	5

Table 4: Cummins 53kVA Generator specs used for smaller genset.

The generator specifications used for this report are show below:

80kVA (64kW)			
Load capacity	Consumption (L/h)	Power output (kW)	Consumption (L/kWh)
0.25	9.30	16	0.5814
0.5	13.08	32	0.4088
0.75	18.46	48	0.3845
1	23.40	64	0.3656

Maximum fuel consumption in 24hr = 313.92 L at 50% load
Maximum fuel consumption in 24hr = 561.6 L at 100% load

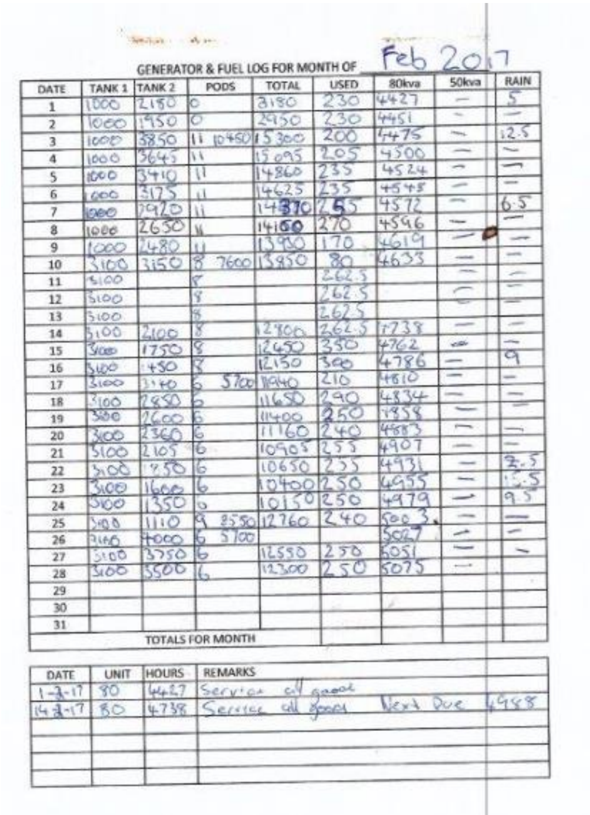
50kVA Gen			
Load capacity	Consumption (L/h)	Power output (kW)	Consumption (L/kWh)
0.25	5	10.5	0.48
0.5	8	21	0.38
0.75	10	31.5	0.32
1	13	42	0.31

Maximum fuel consumption in 24hr = 192 L at 50% load
Maximum fuel consumption in 24hr = 312 L at 100% load

Table 5: Diesel genset specifications used for report

2.2 Palm Bay resort energy use analysis

Diesel consumption figures for some months were given via daily log book scans. Appropriate months were selected where clear fuel usage data was given with months December, January, February, May, June, July and August being considered. This also gives a clear representation of fuel consumption during Summer and Winter.



GENERATOR & FUEL LOG FOR MONTH OF Feb 2017

DATE	TANK 1	TANK 2	PODS	TOTAL	USED	80kva	50kva	RAIN
1	1000	2180	0	3180	230	4427	–	5
2	1000	1950	0	2950	230	4451	–	–
3	1000	3850	11 10450	15300	200	4475	–	12.5
4	1000	3645	11	15095	205	4500	–	–
5	1000	3410	11	14860	235	4524	–	–
6	1000	3175	11	14625	235	4548	–	–
7	1000	2920	11	14370	255	4572	–	6.5
8	1000	2650	11	14100	270	4596	–	–
9	1000	2480	11	13930	170	4619	–	–
10	3100	3150	8 7600	13850	80	4633	–	–
11	3100		8		262.5		–	–
12	3100		8		262.5		–	–
13	3100		8		262.5		–	–
14	3100	2100	8	12800	262.5	4738	–	–
15	3100	1750	8	12450	350	4762	–	–
16	3100	1450	8	12150	300	4786	–	9
17	3100	3140	6 5700	11940	210	4810	–	–
18	3100	2850	6	11650	290	4834	–	–
19	3100	2600	6	11400	250	4858	–	
20	3100	2360	6	11160	240	4883	–	–
21	3100	2105	6	10905	255	4907	–	–
22	3100	1850	6	10650	255	4931	–	2.5
23	3100	1600	6	10400	250	4955	–	15.5
24	3100	1350	6	10150	250	4979	–	9.5
25	3100	1110	9 8550	12760	240	5003	–	–
26	3100	4000	6 5700			5027	–	–
27	3100	3750	6	12550	250	5051	–	–
28	3100	3500	6	12300	250	5075	–	
29								
30								
31								
TOTALS FOR MONTH								

DATE	UNIT	HOURS	REMARKS
1-2-17	80	4427	Service all good
14-2-17	80	4738	Service all good Next Due 4988

	Diesel usage (L/day) taken from log book scans					
Day	Dec-16	Jan-17	Feb-17	May-16	Jun-16	Jul-16
1	140	315	230	210	175	195
2	258	310	230	220	205	195
3	258	250	200	230	195	200
4	258	300	205	230	185	220
5	275	290	235	230	140	215
6	255	110	235	210	190	210
7	290	256	255	240	190	220
8	263	256	270	190	175	200
9	263	256	170	210	155	200
10	300	230	80	200	90	180
11	263	55	262.5	220	180	200
12	263	295	262.5	200	185	200
13	305	255	262.5	210	185	0
14	250	285	262.5	210	175	175
15	280	270	350	200	195	210
16	300	270	300	0	215	240
17	380	240	210	185	230	190
18	285	260	290	215	200	190
19	285	270	250	200	170	210
20	100	230	240	200	205	200
21	290	220	255	180	185	210
22	280	250	255	210	190	170
23	290	250	250	200	200	170
24	257	245	250	220	200	215
25	257	245	240	120	176	215
26	257	265	240	150	176	175
27	300	250	250	160	176	210
28	290	256	250	160	205	210
29	290	256	0	175	200	210
30	320	256	0	185	175	240
31	305	256	0	175	0	200
Total monthly consumption	8407	7752	6790	5945	5523	6075

Est. annual total fuel usage (L) averaged using 6 months
80984

From the above table of daily diesel consumption figures and specifications of consumption rates for the primary generator (80kVA), estimated daily fuel usage, average daily load and generator load capacity was determined for Summer and Winter months.

Consumption	Dec-16	Jan-17	Feb-17	May-16	Jun-16	Jul-16	Est. daily fuel usage (L)
Daily avg consumption (L)	271.19	250.06	242.50	191.77	184.10	195.83	221.87
Daily avg (kWh) @100% load	741.73	683.94	663.25	524.51	503.52	535.61	**Est. daily average load (kWh)**
Daily avg (kWh) @50% load	663.44	611.75	593.24	469.15	450.38	479.08	576.63
Max kWh @ 50% load	929.62	770.61	856.23	587.13	562.67	587.13	
Max daily consumption (L)	380	315	350	240	230	240	**Est. daily gen load (%)**
Daily avg. Gen Load (%)	48.29%	44.53%	43.18%	34.15%	32.78%	34.87%	39.63%

2.3 Cost of using Diesel generators

The annual average cost of diesel at the time of the report was taken to be $1.43/L. This figure coupled with annual barge freight, maintenance and fuel rebate costs were included to determine an overall cost of fuel. This is shown below.

Cost (not inc. transport/maintenance)	Dec-16	Jan-17	Feb-17	May-16	Jun-16	Jul-16	
Diesel price ($/L)	1.43						Est. Annual fuel cost (no maint./transport) ($)
Monthly Total ($)	$12,022.01	$11,085.36	$9,709.70	$8,501.35	$7,897.89	$8,687.25	$115,807.12
Daily average ($)	$387.81	$357.59	$346.78	$274.24	$263.26	$280.23	
Daily max ($)	$543.40	$450.45	$500.50	$343.20	$328.90	$343.20	

Cost (incl. fuel transport and maintenance)							
Annual Barge freight ($)	$39,843.75						
Annual fuel Rebate ($)	-$10,444.00						
Annual maintenance cost ($)	$14,500.00						
Avg. daily fuel transport cost inc. rebate and maintenance	$120.27						
	Dec-16	Jan-17	Feb-17	May-16	Jun-16	Jul-16	
Avg. daily fuel cost ($)	$508.08	$477.87	$467.05	$394.51	$383.54	$400.51	Est. annual fuel cost ($/L) (incl. maint./transport)
Fuel cost ($/L)	$1.87	$1.91	$1.93	$2.06	$2.08	$2.05	$1.98
							Est. annual electricity cost @ 50% Gen load
Cost of electricity ($/kWh) at 50% load	$0.77	$0.78	$0.79	$0.84	$0.85	$0.84	$0.81

2.4 Electric Load profile

Data detailing the power usage of the resort was determined via generator fuel log book scans as no current monitoring of the generator output was available. Fuel consumption rates of the 2 generators (80kVA and 50kVA) at varying load capacities were used to estimate average generator power output figures. It was noted that warmer Summer months consumed the most fuel hence larger energy consumption, with figures dropping during winter. The daily average electricity consumption used to input into the simulation software was taken to be 600kWh/day, approximately 4% more than the estimated daily average noted earlier to allow for some deviations in energy consumption rates throughout the year at 50% load capacity. A synthetic load profile was created with seasonal changes as shown below. An annual average cost of Diesel fuel of $1.43/L was used (figure obtained as of April 2017).

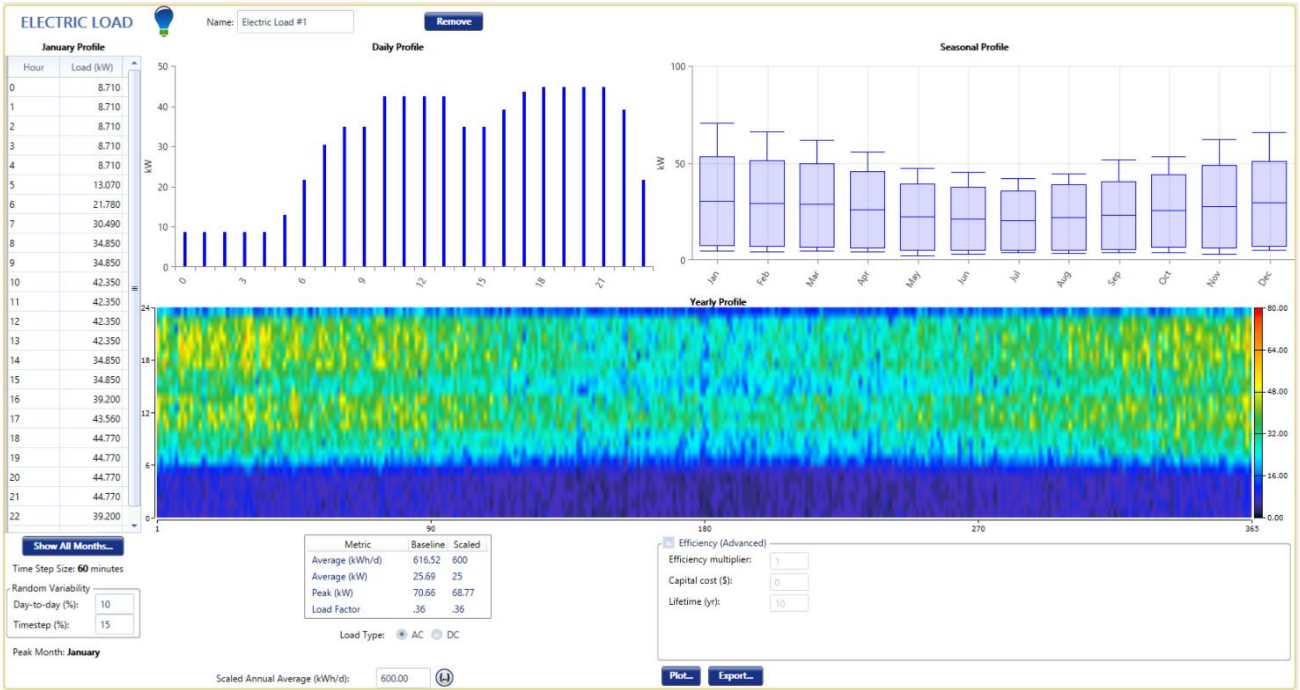


Figure 6: Daily, Seasonal and Yearly profile of Electric Load

2.5 Current Fuel usage

Via analysis of the fuel log book scans and averaged over 12months, it was noted that higher fuel consumption occurred during warmer summer months. This seasonal profile along with monthly fuel consumption figures and generator specification values were input into the software to simulate the current fuel consumption usage as shown below. The estimated fuel consumption figure of 214L/day via simulated consumption based on electric load and diesel consumption figures agreed well with the estimated daily average 221.87L/day from the spread sheet analysis.

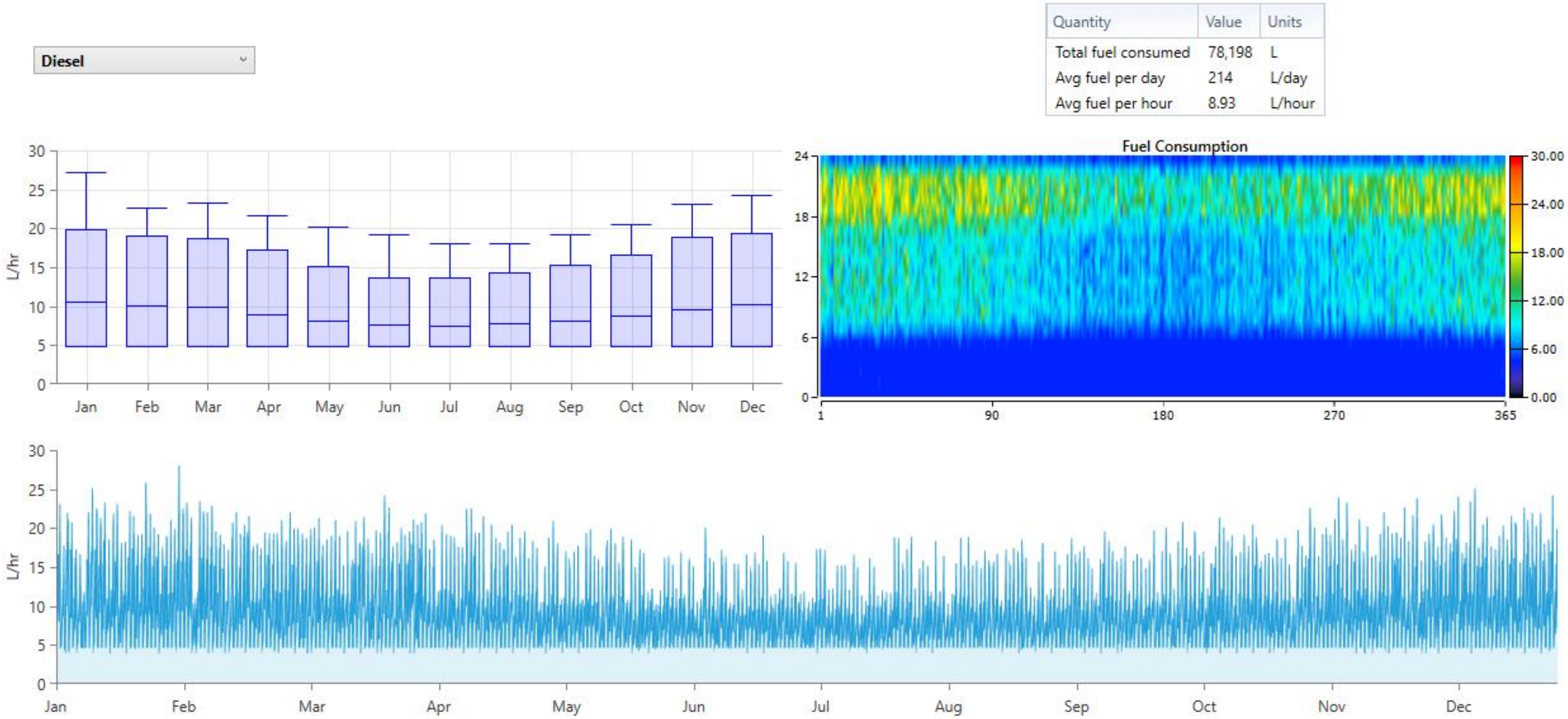


Figure 7: Current estimated total fuel consumption figures

2.2 Analysis

HOMER uses solar and temperature data sets combined with the demand profile compiled by the client and AWS and component pricing to identify the most cost effective energy system architecture. The components examined as part of this report are as follows. An auto sizing generator, AWS HC series wind turbine range and assortment of BAE battery storage is included in the simulation to find most optimum system.

Equipment	Parameter/Sizing
Solar	1kW – 100kW
Generator	80kVA + 50kVA
Wind Turbine	650W – 5.1kW
Battery storage	BAE 420 - 4940

Table 1: Equipment and parameters used for optimization of system

3. Solar and Wind Resource data

3.1 Solar Resource

Data over a 22-year period obtained from the NASA Surface meteorology and Solar Energy database has been used to identify the solar resource for your site.

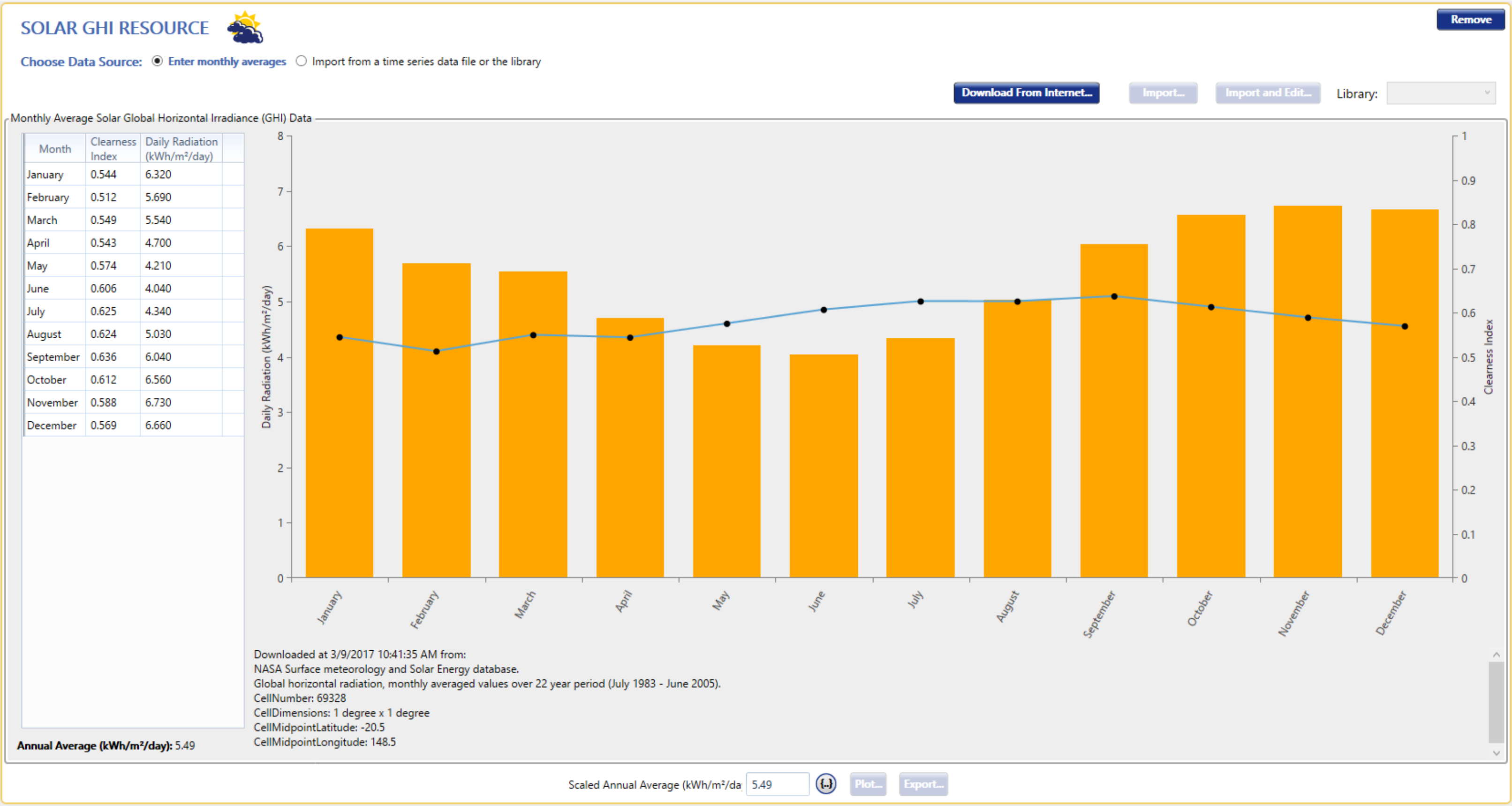


Figure 8: Solar GHI resource

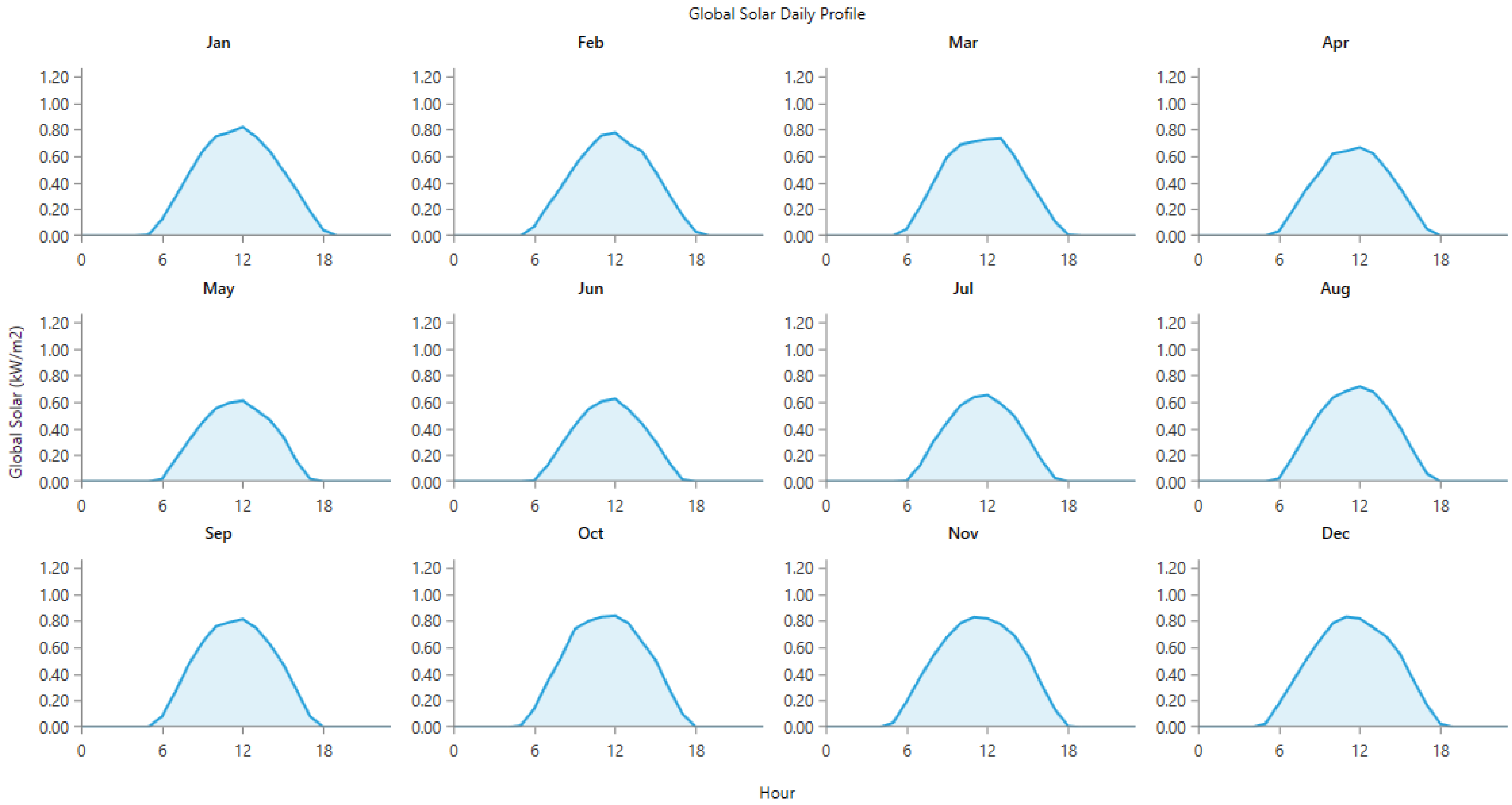


Figure 9: Average daily solar profile for months January to December

3.2 Wind Resource

Data over a 10-year period obtained from the NASA Surface meteorology and Solar Energy database was retrieved as shown below. This average data is taken over a large cell dimension of 1° x 1° (1° latitude is approximately 111km in radius).

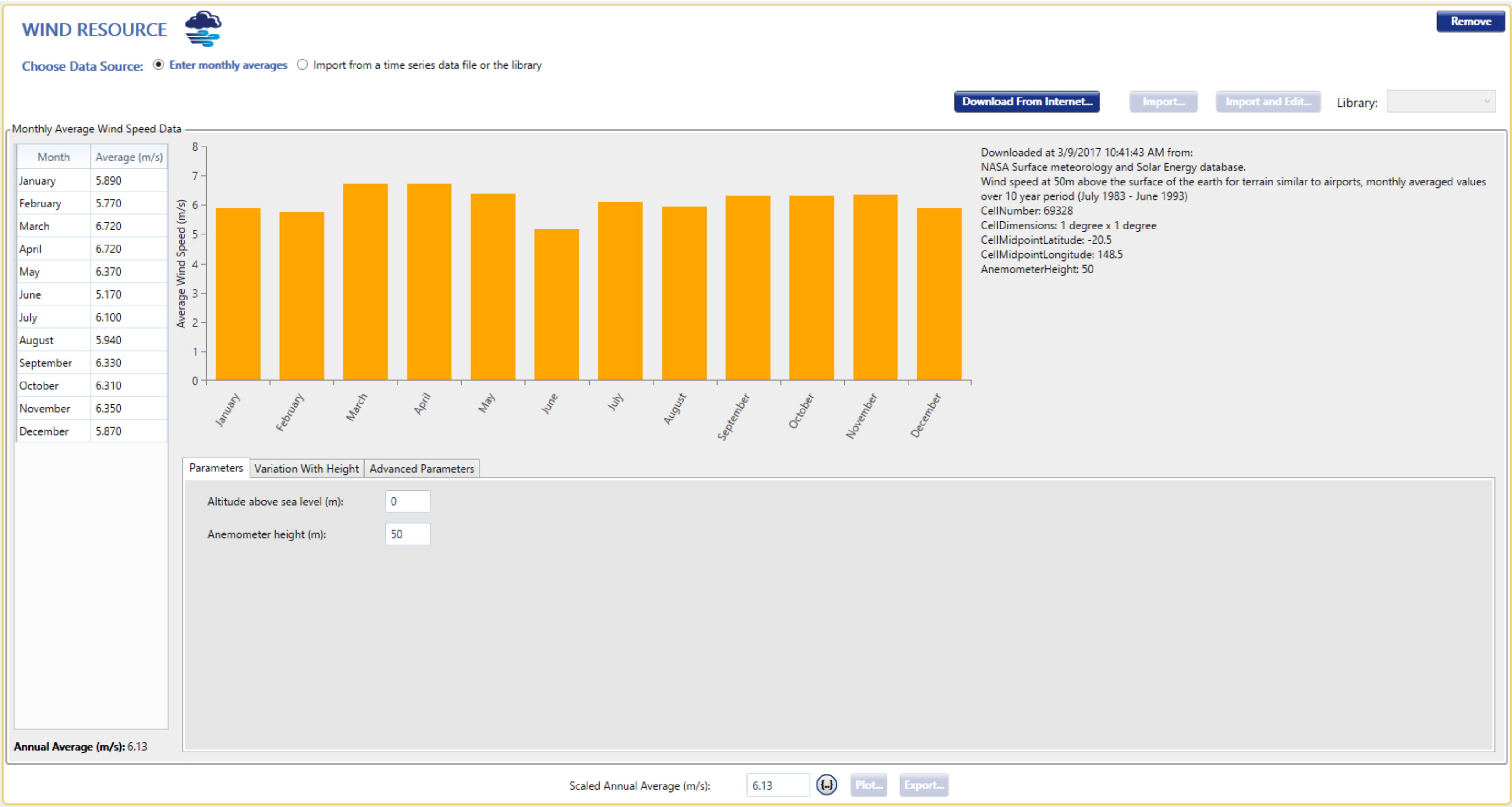


Figure 10: Monthly average wind speed at anemometer height of 50m

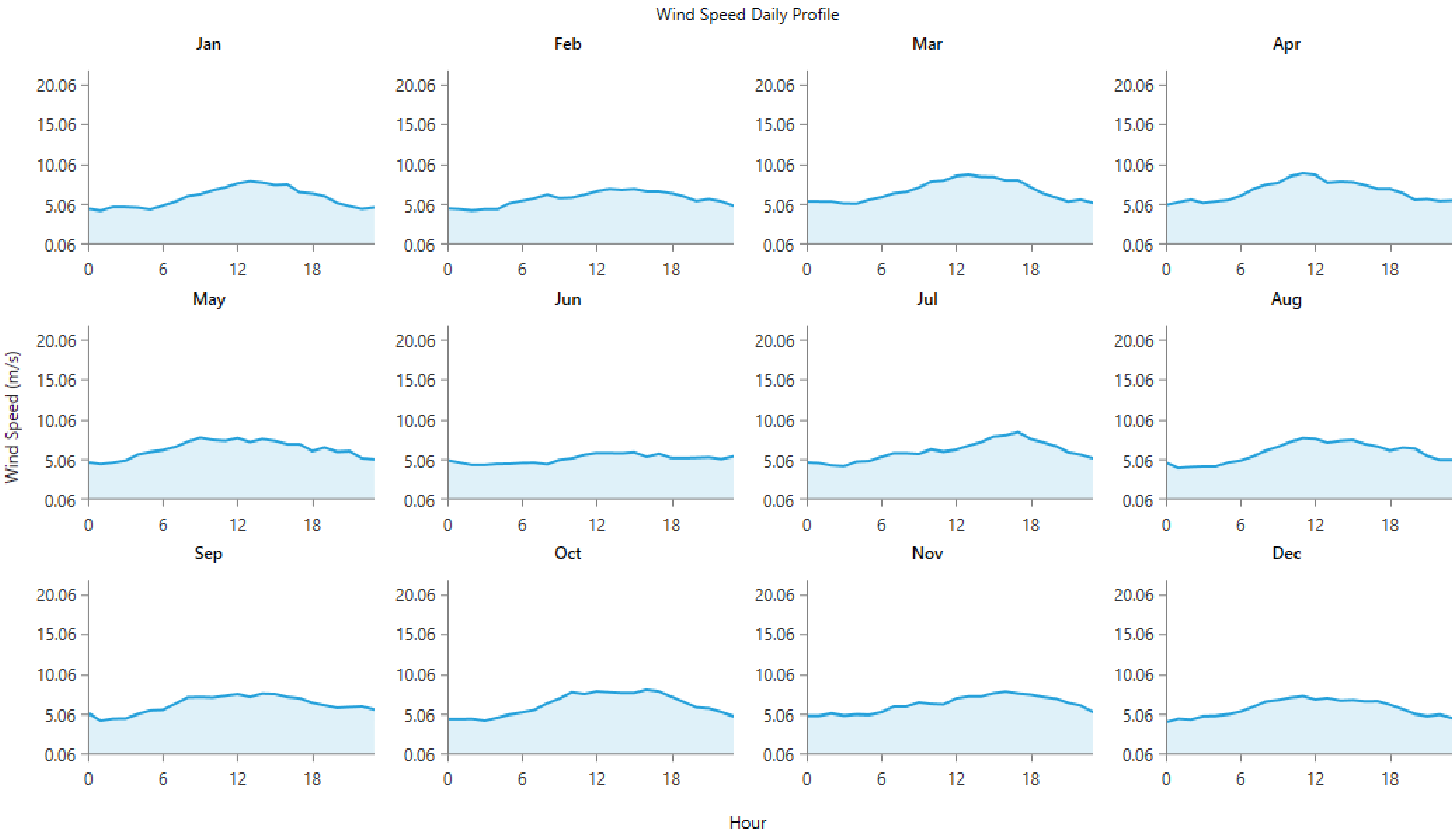


Figure 11: Monthly daily wind speed profiles

3.2.1 Comparison of Wind resource data

Since the NASA obtained data is averaged over such a large cell dimension, a comparison between Bureau of Meteorology (BOM) weather station data will be undertaken for more accurate results.

The nearest BOM long term weather station is located at Hamilton Island (20.35 ˚S, 148.95 ˚E), approximately 10.2km away where the mean monthly 9am and 3pm wind speeds are detailed below along with the wind resource data from NASA with applied wind shear at 10m for direct comparison.

NASA gives an annual wind speed estimate given the global position with estimates of wind speed but at a higher altitude, with the anemometer height at 50m. The data in table 3 is used for comparison with the NASA resource obtained shown in table 4 with applied wind shear at 10m. Wind velocity increases with altitude and wind moving across the Earth's surface is slowed down by obstructions like buildings, trees and similar. The wind shear exponent (α) varies with terrain as shown below. By viewing satellite imagery and supplied photos, the exponent used was 0.25 for heavy trees.

Table 2: Terrain features with corresponding wind shear exponent

Terrain	Wind Shear Exponent - α -
Open water	0.1
Smooth, level, grass-covered	0.15
Row crops	0.2
Low bushes with a few trees	0.2
Heavy trees	0.25
Several buildings	0.25
Hilly, mountainous terrain	0.25

Table 3: Table of monthly mean wind speed taken from Hamilton Island weather station at 10m above ground (Australian Bureau of Meteorology)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean 3pm wind speed (m/s) at 10m	6.44	6.61	7.36	7.36	6.94	6.81	6.22	6.33	6.50	6.33	6.47	6.58
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean 9am wind speed (m/s) at 10m	5.56	5.86	6.86	7.19	7.03	7.25	6.64	6.28	5.67	5.28	5.36	5.50

Table 4: Table of monthly mean wind speed taken from NASA database with applied wind shear at 10m.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NASA wind speed (m/s) at 10m	3.94	3.86	4.49	4.49	4.26	3.46	4.08	3.97	4.23	4.22	4.25	3.93

The NASA obtained data with applied wind shear at 10m, has an overall lower average wind speed than the BOM data with an average of the 2 resources taken for these simulations.

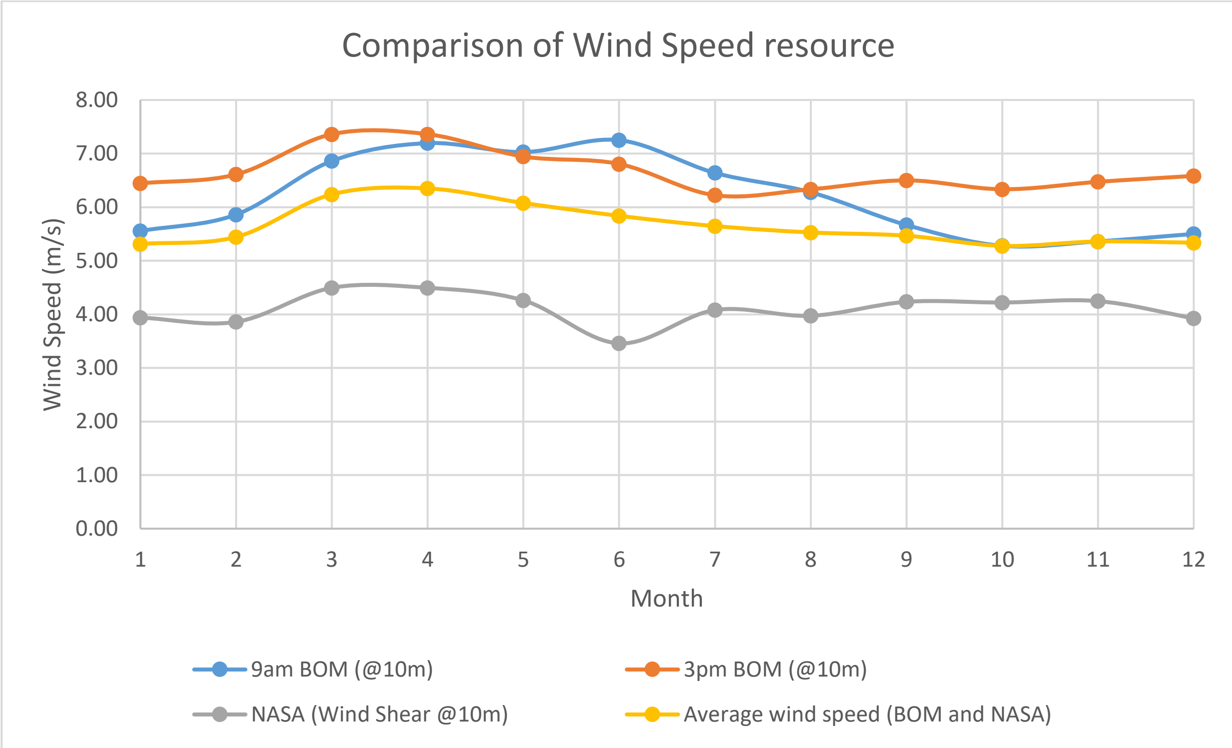


Figure 12: Comparison of wind speed resources

As shown above with the comparison of BOM and NASA resource wind data, they both follow a very similar trendline. The yellow trend line (Average Data) is the amalgamation of the BOM and NASA data which was used for this system design.

The wind rose below shows direction of prevailing winds for Hamilton Island, predominantly from the South and South east. These observations are considered when determining wind turbine placement/orientation.

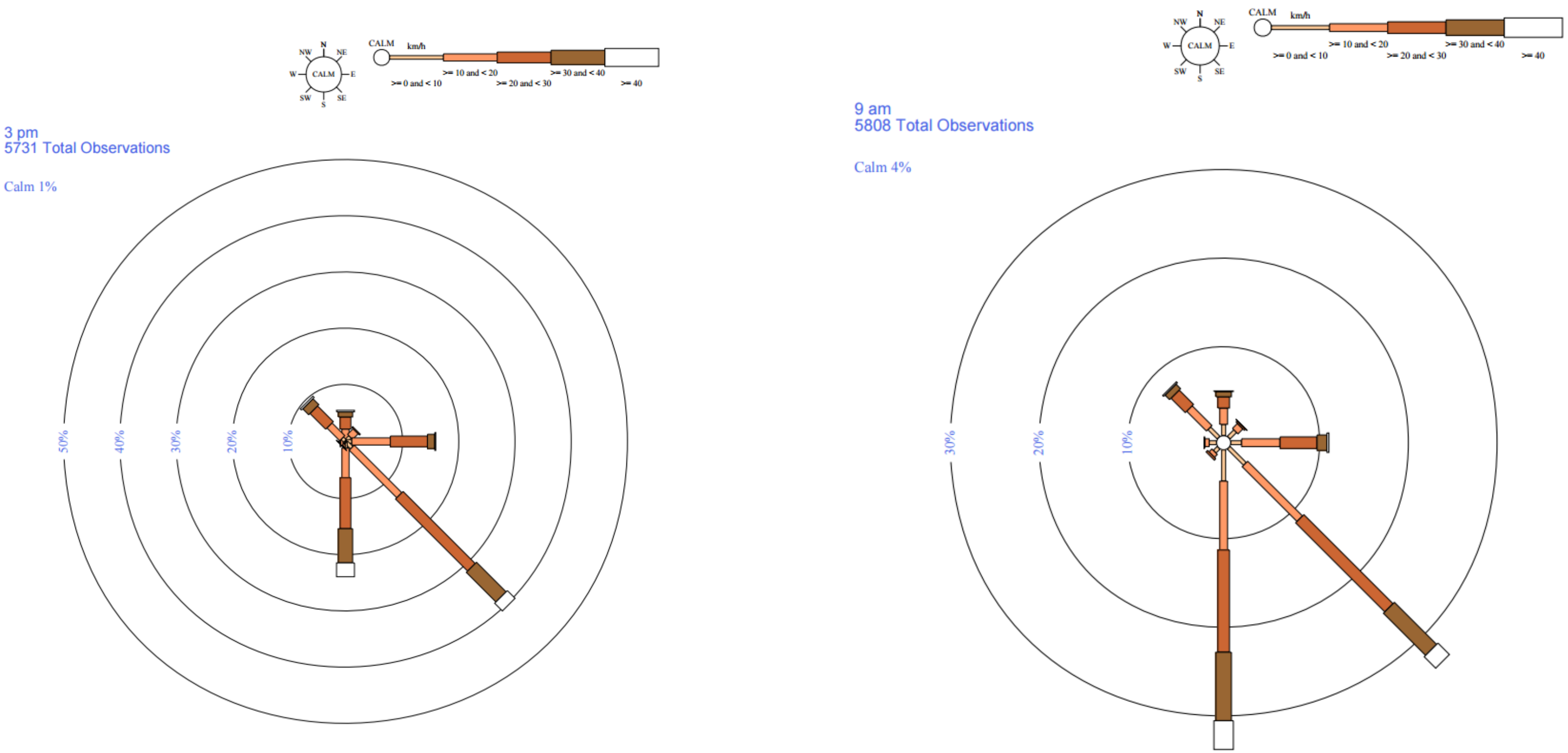


Figure 13: Annual wind rose showing prevailing winds at 9am and 3pm observations

4. System 1

This section details the design and costing that best suits the power requirements as prescribed by System 1.

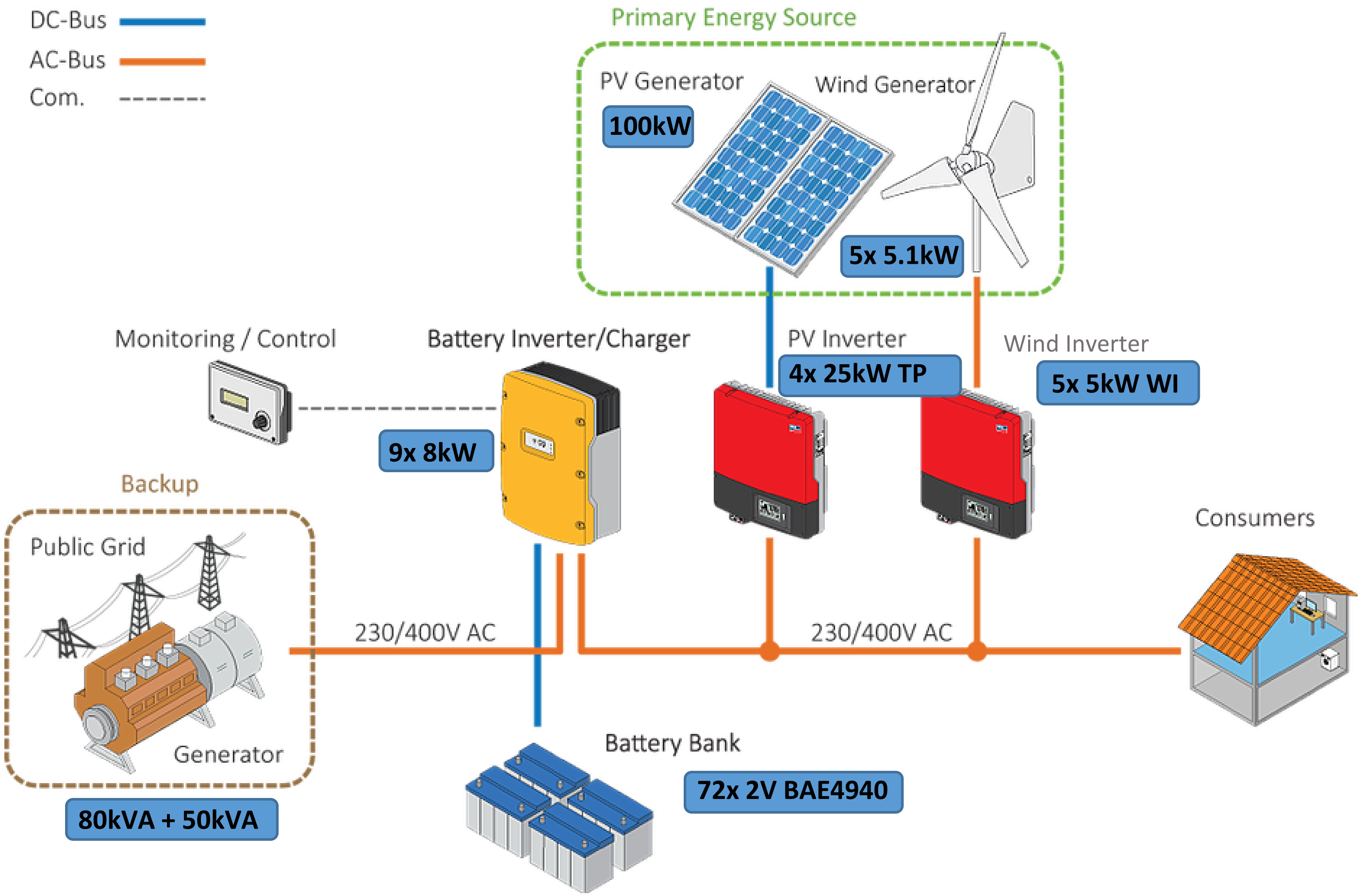


Figure 14: System 1 schematic

4.1 System 1 - Electrical Production

Production	kWh/yr	%
PV 3kW	3,985	1.69
PV 3kW (1)	4,278	1.81
PV 11kW	14,321	6.07
PV 11kW (1)	14,613	6.19
PV 11kW (2)	15,686	6.65
PV 6kW	8,556	3.62
PV 6kW (1)	7,812	3.31
PV 15kW	18,662	7.91
PV 22kW	28,950	12.26
PV 12kW	17,176	7.28
Gen80kVA	7,924	3.36
Gen50kVA	38,023	16.11
AWS HC 5.1kW Wind Turbine	56,065	23.75
Total	236,051	100.00

Consumption	kWh/yr	%
AC Primary Load	219,000	100.00
DC Primary Load	0	0.00
Total	219,000	100.00

Quantity	kWh/yr	%
Excess Electricity	1,172.2	0.5
Unmet Electric Load	0.0	0.0
Capacity Shortage	0.0	0.0

Quantity	Value
Renewable Fraction	79.0
Max. Renew. Penetration	925.6

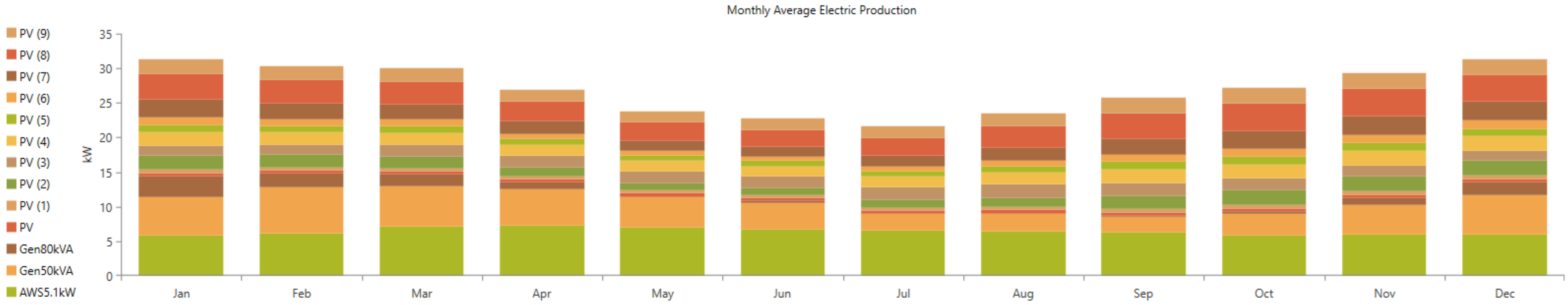


Figure 15: Breakdown of electrical generation for System

4.2 System 1 - Solar Panels

Simax Poly 250W polycrystalline panels were used for these simulations with the chosen sizing to be 100kW of Solar (400x 250W Panels over 12 arrays). 10 Arrays are mapped out here (2x2 arrays with identical azimuths and panel slopes were grouped to form 2 arrays, hence only 10 arrays shown below).

Quantity	Value	Units
Rated Capacity	3.00	kW
Mean Output	0.45	kW
Mean Output	10.92	kWh/d
Capacity Factor	15.16	%
Total Production	3,985.30	kWh/yr

Quantity	Value	Units
Rated Capacity	3.00	kW
Mean Output	0.49	kW
Mean Output	11.72	kWh/d
Capacity Factor	16.28	%
Total Production	4,278.03	kWh/yr

Quantity	Value	Units
Rated Capacity	11.00	kW
Mean Output	1.63	kW
Mean Output	39.24	kWh/d
Capacity Factor	14.86	%
Total Production	14,321.30	kWh/yr

Quantity	Value	Units
Rated Capacity	11.00	kW
Mean Output	1.67	kW
Mean Output	40.04	kWh/d
Capacity Factor	15.16	%
Total Production	14,612.78	kWh/yr

Quantity	Value	Units
Rated Capacity	11.00	kW
Mean Output	1.79	kW
Mean Output	42.98	kWh/d
Capacity Factor	16.28	%
Total Production	15,686.11	kWh/yr

Quantity	Value	Units
Rated Capacity	6.00	kW
Mean Output	0.98	kW
Mean Output	23.44	kWh/d
Capacity Factor	16.28	%
Total Production	8,556.06	kWh/yr

Quantity	Value	Units
Rated Capacity	6.00	kW
Mean Output	0.89	kW
Mean Output	21.40	kWh/d
Capacity Factor	14.86	%
Total Production	7,811.62	kWh/yr

Quantity	Value	Units
Rated Capacity	15.00	kW
Mean Output	2.13	kW
Mean Output	51.13	kWh/d
Capacity Factor	14.20	%
Total Production	18,661.83	kWh/yr

Quantity	Value	Units
Rated Capacity	22.00	kW
Mean Output	3.30	kW
Mean Output	79.32	kWh/d
Capacity Factor	15.02	%
Total Production	28,950.17	kWh/yr

Quantity	Value	Units
Rated Capacity	12.00	kW
Mean Output	1.96	kW
Mean Output	47.06	kWh/d
Capacity Factor	16.34	%
Total Production	17,175.77	kWh/yr

Figure 16: PV output data for 100kW of solar show via individual solar arrays

Size (kW)	Panels	Orientation (°Degrees East from North)	Panel slope (°)
3	12	12	45
3	12	12	10
11	44	192	10
11	44	12	45
11	44	12	10
6	24	12	10
6	24	192	10
9	36	102	30
12	48	282	30
6	24	102	30
10	40	282	30
12	48	12	12

Table 2: Arrangement of 400 panels (100kW) with corresponding orientations and slope angles

Using the Solar path finder shown below, efficiency losses due to shading on the roofs contributed to 9.75%. This figure was subtracted off the standard derating factor of 75% giving a working derating factor of 65.25% for the Solar arrays used in this analysis.

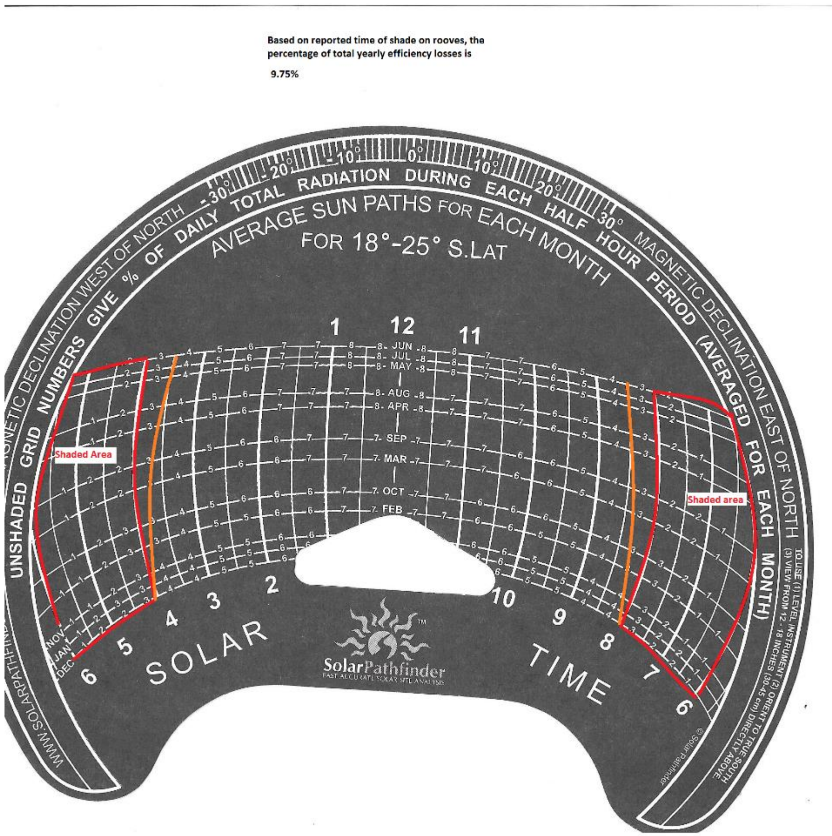


Figure 17: Solar path finder with shaded regions showing efficiency losses

4.3 System 1 – Wind Turbine

The recommended turbine for this system configuration was the AWS 5.1kW HC (x5). The wind turbines, along with 50m of trenching done for the cable run from the property, 12m free standing tower, GL 5kW inverter and AWS wind controller with dump load is included in the installation costing.

Quantity	Value	Units
Total Rated Capacity	25.50	kW
Mean Output	6.40	kW
Capacity Factor	25.10	%
Total Production	56,065.50	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	30.98	kW
Wind Penetration	26.95	%
Hours of Operation	7498	hrs/yr
Levelized Cost	0.3109	$/kWh

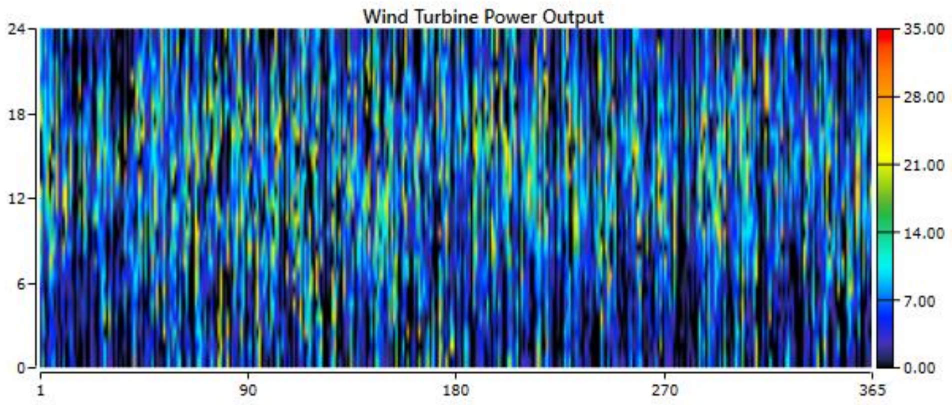


Figure 18: Wind Turbine power output data

4.4 System 1 - Batteries

9x 8kW rated inverter chargers was chosen to ensure the batteries are discharged safely to ensure the peak loads of the system are met. AWS set the minimum state of charge to 30% of their total capacity (70% depth of discharge) allowing for 1800 cycles before they are downgraded to 70% of their original capacity. 72x 2V BAE4940 in parallel (48V) batteries selected for this system can provide 367.92kWh of useable storage and, if fully charged, 14.72 hours of autonomy at 70% depth of discharge (DOD).

From these estimates the expected life of the batteries is **14.50 years.**

Quantity	Value	Units
Batteries	72.00	
String Size	24.00	
Strings in Parallel	3.00	
Bus Voltage	48.00	

Quantity	Value	Units
Autonomy	14.72	hr
Storage Wear Cost	0.10	$/kWh
Nominal Capacity	525.60	kWh
Usable Nominal Capacity	367.92	kWh
Lifetime Throughput	809,424.00	kWh
Expected Life	14.50	yr

Quantity	Value	Units
Average Energy Cost	0.00	$/kWh
Energy In	60,149.10	kWh/yr
Energy Out	51,465.94	kWh/yr
Storage Depletion	367.92	kWh/yr
Losses	8,315.24	kWh/yr
Annual Throughput	55,822.65	kWh/yr

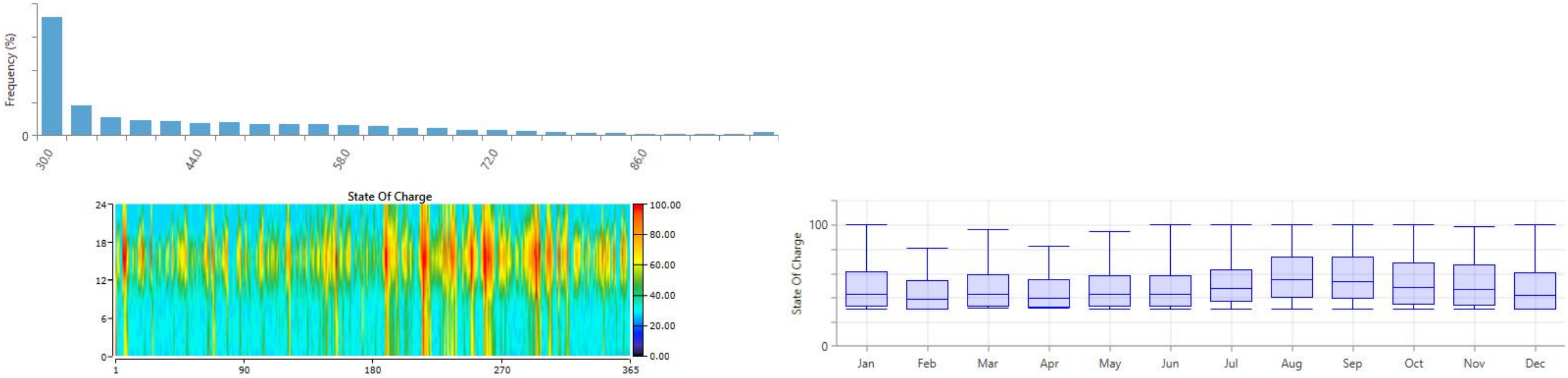


Figure 19: Battery analysis

4.5 System 1 - Generator

Both 50kVA and 80kVA generators with their respective fuel consumption rates were input into the software to simulate their current functioning capacity. In these simulations, the software opted to run the 50kVA as the primary generator where in reality the 80kVA generator is currently being used as the primary.

Overall fuel consumption analysis for both generators agreed well with the fuel log book scan analysis.

The generators currently in use will be integrated into the system controller and will be used to ensure the maximum life of the batteries will be achieved.

Quantity	Value	Units
Hours of Operation	2,597	hrs/yr
Number of Starts	673	starts/yr
Operational Life	5.78	yr
Capacity Factor	10.3	%
Fixed Generation Cost	5.45	$/hr
Marginal Generation Cost	0.448	$/kWh

Quantity	Value	Units
Electrical Production	3.8E+04	kWh/yr
Mean Electrical Output	14.6	kW
Minimum Electrical Output	10.5	kW
Maximum Electrical Output	42	kW

Quantity	Value	Units
Fuel Consumption	1.49E+04	L
Specific Fuel Consumption	0.391	L/kWh
Fuel Energy Input	1.46E+05	kWh/yr
Mean Electrical Efficiency	26	%

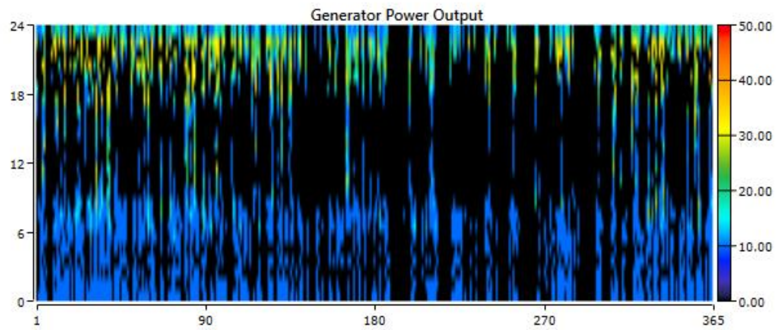


Figure 20: 50kVA Generator usage patterns

Quantity	Value	Units
Hours of Operation	194	hrs/yr
Number of Starts	106	starts/yr
Operational Life	77.3	yr
Capacity Factor	1.41	%
Fixed Generation Cost	6.45	$/hr
Marginal Generation Cost	0.539	$/kWh

Quantity	Value	Units
Electrical Production	7.92E+03	kWh/yr
Mean Electrical Output	40.8	kW
Minimum Electrical Output	16.6	kW
Maximum Electrical Output	55.9	kW

Quantity	Value	Units
Fuel Consumption	2.88E+03	L
Specific Fuel Consumption	0.363	L/kWh
Fuel Energy Input	2.83E+04	kWh/yr
Mean Electrical Efficiency	28	%

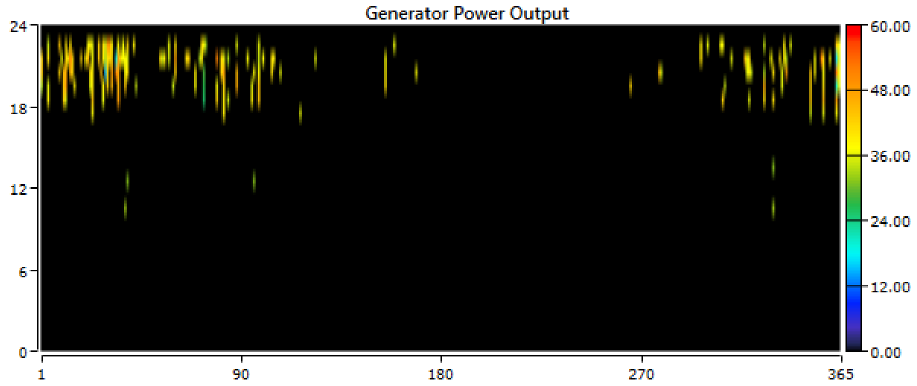


Figure 21: 80kVA Generator usage patterns

With the inclusion of System 1, fuel consumption from generators was estimated to be reduced dramatically to an average of 48.6 L/day, a 77.3% reduction from the business as usual case of 214L/day.

Quantity	Value	Units
Total fuel consumed	17,744	L
Avg fuel per day	48.6	L/day
Avg fuel per hour	2.03	L/hour

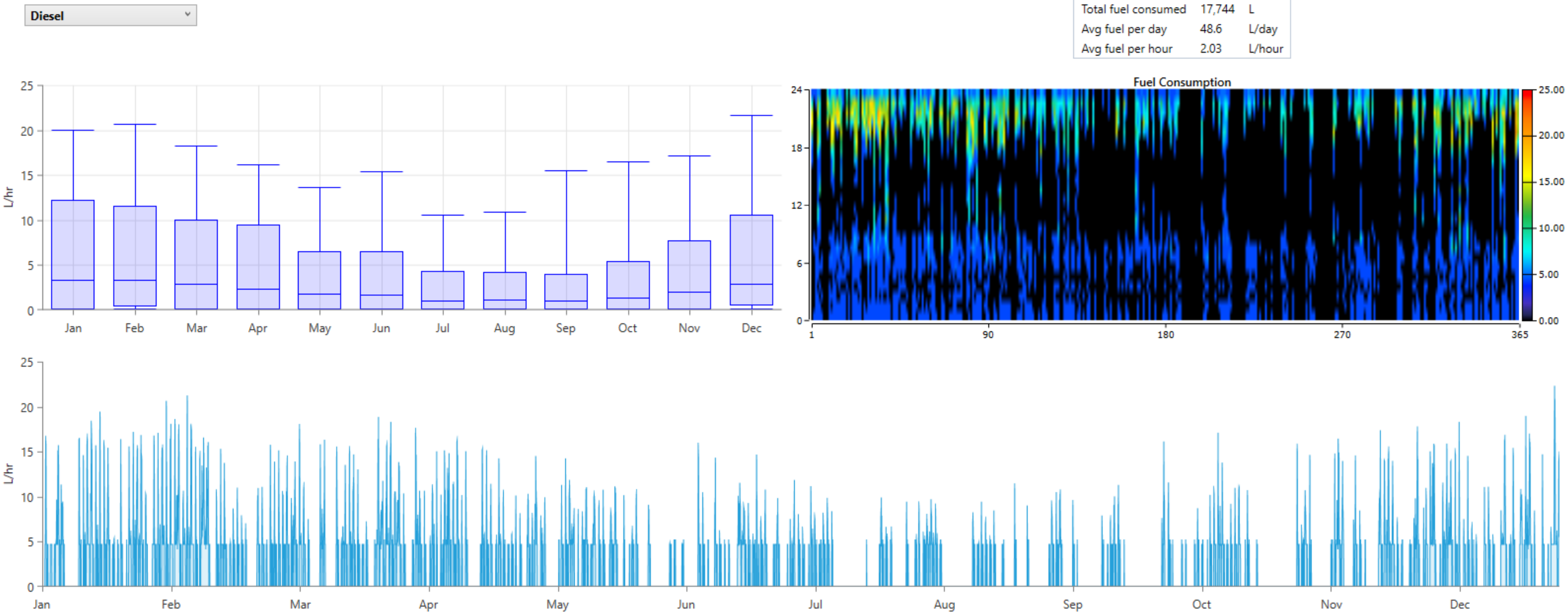


Figure 22: New fuel consumption analysis

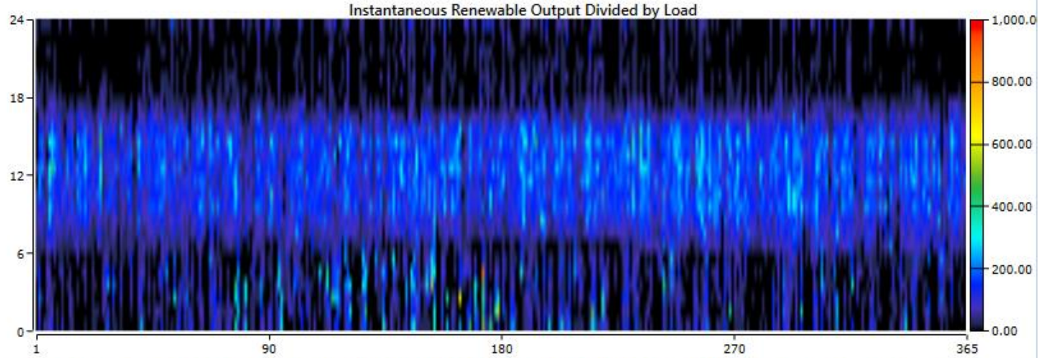
4.6 System 1 - Renewable fraction

The inclusion of an 100kW PV System, 367.92kWh of usable storage and a 5x 5.1kW Wind Turbines garnered a renewable fraction of 80.54%, meaning the generators would account for an estimated 19.46% of the power supplied to the property.

Capacity-based metrics	Value	Units
Nominal renewable capacity divided by total nominal capacity	54.21	%
Usable renewable capacity divided by total capacity	40.24	%

Energy-based metrics	Value	Units
Total renewable production divided by load	86.81	%
Total renewable production divided by generation	80.54	%
One minus total nonrenewable production divided by load	100.00	%

Peak values	Value	Units
Renewable output divided by load (HOMER standard)	925.58	%
Renewable output divided by total generation	100.00	%
One minus nonrenewable output divided by total load	100.00	%



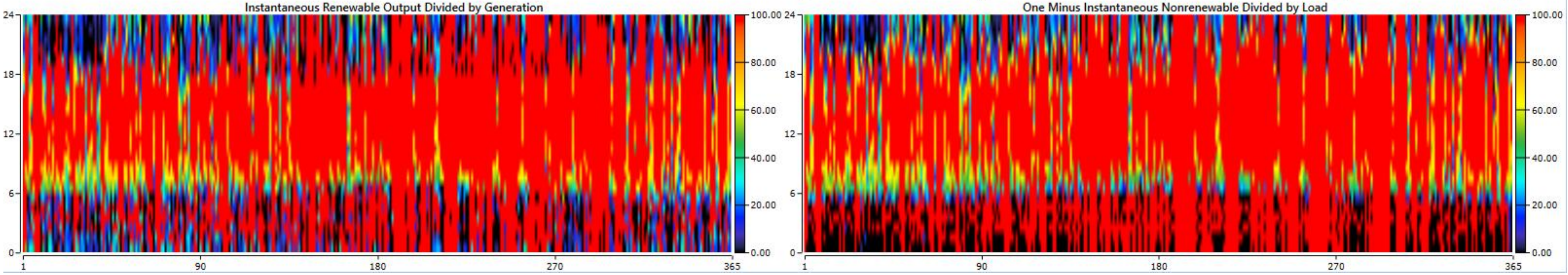


Figure 23: Renewable penetration for system

4.7 Indicative finance (with tax rebate of 29.5% taken of repayments)

With a 29.5% tax rebate taken off the yearly repayment figure, the following figures show a **net cash positive position** from year one.

Monthly repayment: $8,205.97
Yearly repayment: $98,471.58

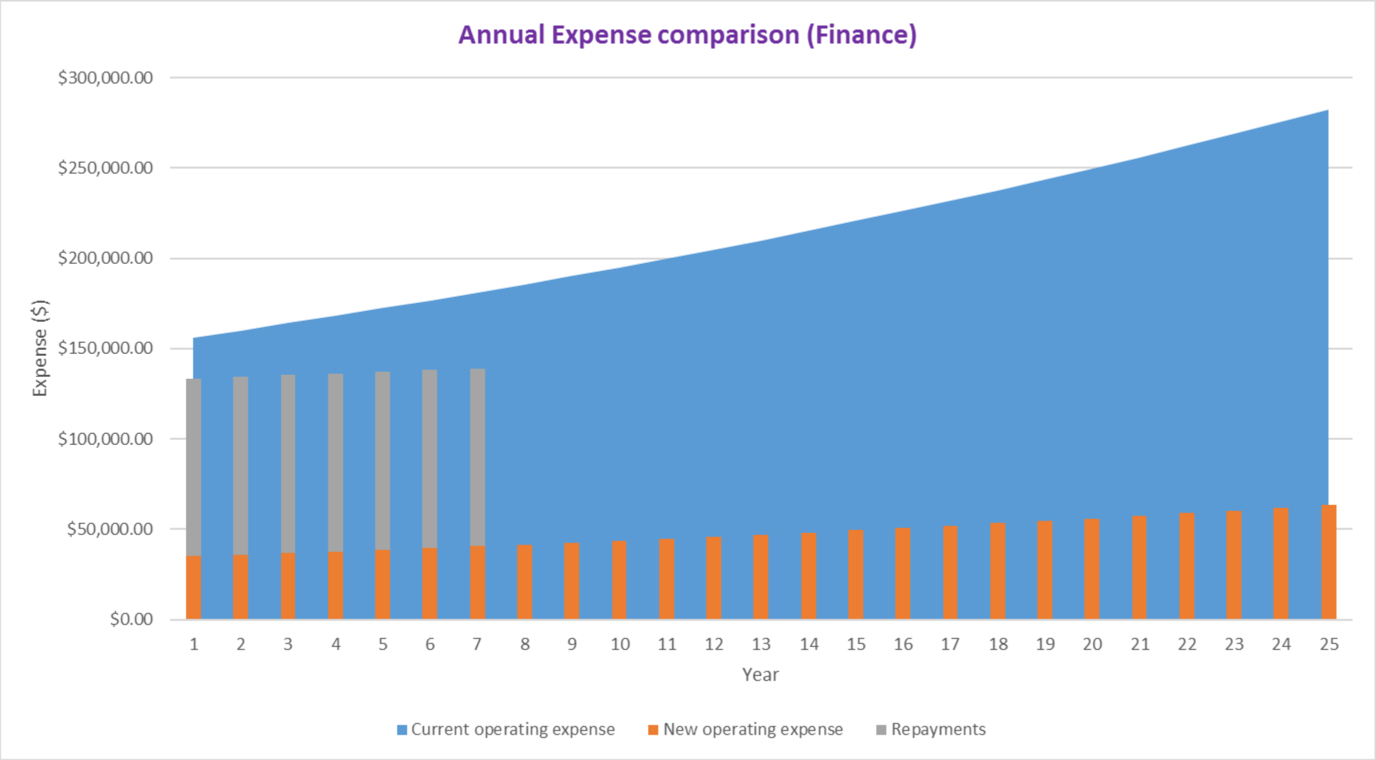


Figure 25: Finance analysis with tax rebate applied

4.7.1 System 1 - Indicative Finance

An indicative finance option is listed below showing that even with a 0% deposit on the energy system at a fixed interest rate of 5.51% over 7 years. This includes capital cost of system, set up and valuation fees.

Monthly repayment: $11,639.67

Yearly repayment: $139,676

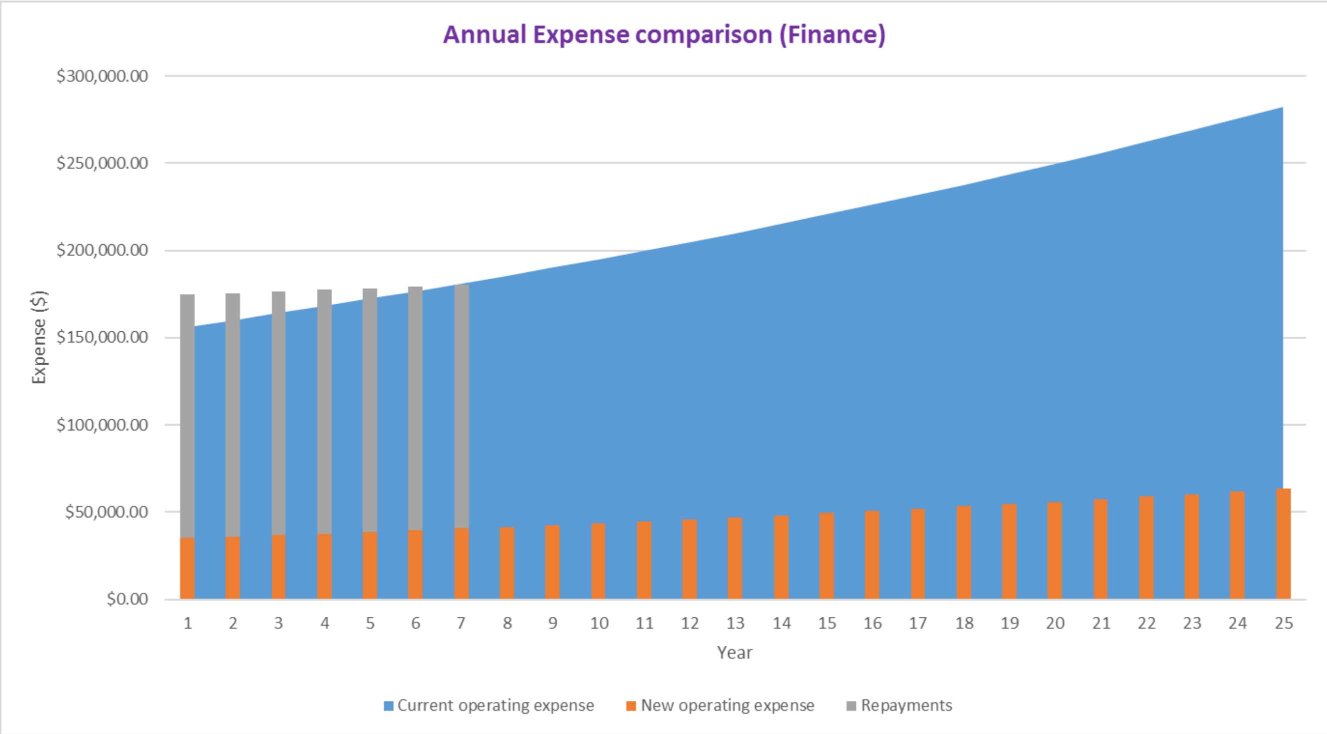


Figure 24: Finance analysis

5. Savings

With the inclusion of the tax rebate with the annual repayment figures, overall savings figures are shown below (includes new operating cost of generator usage)

These figures are the result of: (Business as usual case operating cost – New system operating cost – Repayment cost)

Year 1: $22,656.42

Year 7: $224,901.12

Year 10: $667,742.17

Annual expense calcs for Finance comparison					
Year	**Old Annual Expense**	**New Annual Expense**	**Savings**	**Repayments**	**Overall savings**
0	$0.00		$0.00		
1	$156,159.00	$35,031.00	$121,128.00	98,471.58	$22,656.42
2	$160,062.98	$35,906.78	$124,156.20	98,471.58	$25,684.62
3	$164,064.55	$36,804.44	$127,260.11	98,471.58	$28,788.53
4	$168,166.16	$37,724.56	$130,441.61	98,471.58	$31,970.03
5	$172,370.32	$38,667.67	$133,702.65	98,471.58	$35,231.07
6	$176,679.58	$39,634.36	$137,045.21	98,471.58	$38,573.63
7	$181,096.56	$40,625.22	$140,471.34	98,471.58	$41,999.76
8	$185,623.98	$41,640.85	$143,983.13		$143,983.13
9	$190,264.58	$42,681.87	$147,582.71		$147,582.71
10	$195,021.19	$43,748.92	$151,272.27		$151,272.27

6. Conclusion

System 1

It was determined from the information provided and system design that a 100kW solar array installed with 5x 5.1kW HC wind turbines along with 72x BAE4940 in (3 parallel strings) batteries for a usable storage capacity of 367.92kWh at 70% DoD can is a viable option to provide an ample source of power for the energy demand supplied and significantly reduce the fuel consumption of the already existing generator system. The battery control system will automatically start and synchronise the generator to the power supply for a seamless power transition in the event of low battery status and will maintain all system parameters including health of the system.
A major positive aspect of the solar system design and inclusion of wind generation gives an estimated lifetime of the battery system of **14.5 years.**
The estimated first year expenses without renewables is $156,159, compared to $35,031 per year with System 1. First year savings is estimated to be $121,128.
With the 29.5% tax rebate applied to the repayment figures, a **net cash positive outcome** occurs from year one with overall savings of $22,656.42.

System Architecture and Cost:

PV	400x Simax 250W Polycrystalline Panels (100kW) on 4x 25kW PV Inverters
Batteries	72x BAE4940 (48V in parallel) VRLA Gel. 367.92kWh of usable storage at 70% DoD with 15.49 hours of capable autonomy **(estimated 14.5 year battery life time)**
Inverter/Charger	9x 8kW Inverter chargers for the battery storage and 1x MC12
Wind Turbine	5x 5.1kW AWS HC Wind Turbines (incl. 12m tower, GL 5kW inverter, AWS wind controller and dump load)

Estimated first year expenses (without renewables):	**$156,159**
Estimated first year expenses (with renewables):	**$35,031**
Estimated first year savings:	**$121,128**
Annual repayments with tax rebate applied:	**$98,471.58**
Overall savings (incl. first year expenses with renewables including repayments with tax rebate):	**$22,656.42**

Please contact us to follow up any questions or revisions you may have regarding the suggested systems presented.

References:

1. www.cumminspower.com

2. https://www.ablesales.com.au/blog/diesel-generator-fuel-consumption-chart-in-litres.html