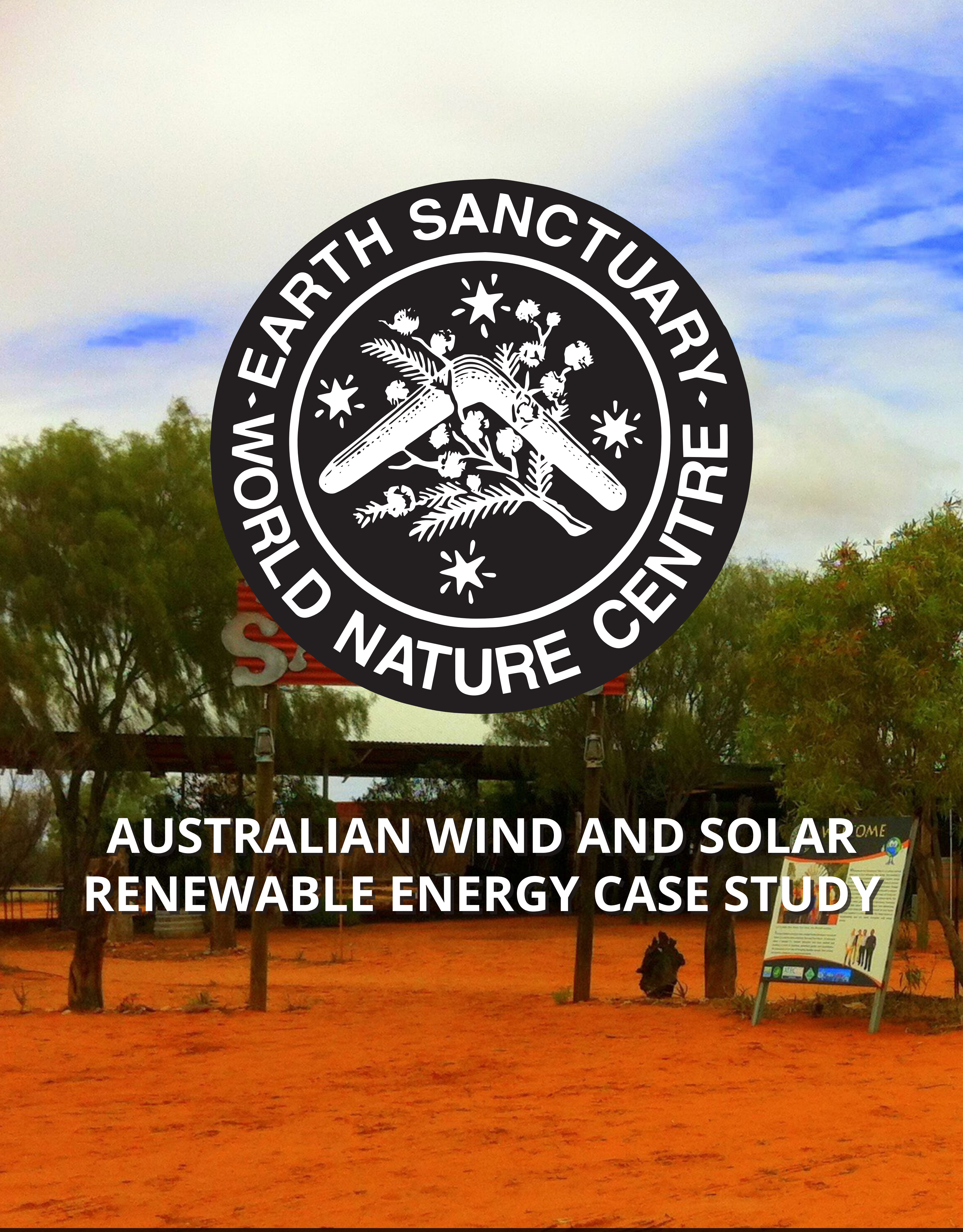

EARTH SANCTUARY · WORLD NATURE CENTRE ·

AUSTRALIAN WIND AND SOLAR RENEWABLE ENERGY CASE STUDY

AUSTRALIAN
WIND AND SOLAR

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1. Introduction

The Alice Springs Earth Sanctuary Project (ASESP) was a joint undertaking between Australian Wind and Solar and Earth Sanctuary World Nature Centre to greatly improve their renewable energy self sufficiency capabilities.

Earth Sanctuary World Nature Centre (ESWNC) is a family owned and run business which provide tours, events and functions focused on ecology, culture and sustainable living practices. Situated in Alice Springs, Central Australia, the Sanctuary has become a leader in the field of sustainability, education and eco-tourism. The team at ESWNC run programs such as the Earth's Cool initiative to aid kids in school to learn about sustainability. Day tours also run throughout the year based around the 'Spirit of the Outback' with night time astronomy lessions.



The team's dream merged with their passion and knowledge of local ecology, culture and astronomy to create a unique tourism focus where visitors can experience sustainable technoologies such as wind and solar energy. Earth Sanctuary's vision is to be Australia's leading provider of 100% carbon neutral education, tours and events. ESWNC has, since its inception, introduced over 17,000 visitors to sustainable technologies, practices and conecpts.

2. Analysis

The current grid supply for the ESWNC is known to have continuous outtages throughout the year, usually occuring during peak times around 6pm when functions are being held. When this occurs, operations such as cooking and lighting for guests become unavailable. Earth Sanctuary had previously invested in renewable energy infrastructure by installing solar, wind and battery systems, however, the incumbent infrastructure was not sufficient to mitigate the number of blackouts, brownouts and low quality power supplied from the grid. AWS and Earth Sanctuary utilized a high end energy software called HOMER to identify suitable renewable energy equipment.

AWS used the Meter Interval Data from the Earth Sanctuary to identify the load profile and existing energy rates to identify costs. Local solar and wind resource data along with NASA solar, wind and temperature data is used to model the performance of renewable energy and battery storage technology at the site.
AWS then analysed the available project budget, grid supply, renewable energy infrastructure, projected energy loads, energy costs and project lifetime to identify what system architecture would result in increased increase self sufficiency, backup power and carbon output reduction within project budget and timeline constraints.

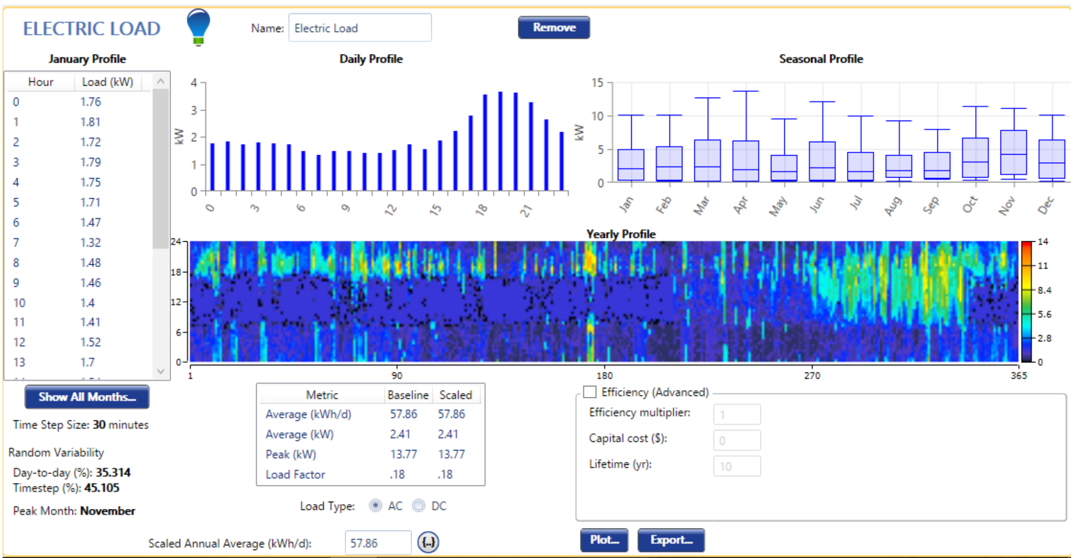

Figure 1: Electric load analysis

3. System optimization

AWS are proud to offer some of the highest level engineering and system design available. We utilize HOMER (Hybrid Optimization of Multiple Energy Resources), a high level micro grid design software that utilizes the sites' GPS location, NASA satellite data for wind speeds, solar resource and temperature data, yearly energy demand, equipment costs, fuel costs and equipment performance specifications in order to identify the best value for money system design possible.

12 months of meter interval data was supplied by ESWNC which was input into HOMER to produce a daily load profile with specifics such as peak load and daily energy usage in kWh.

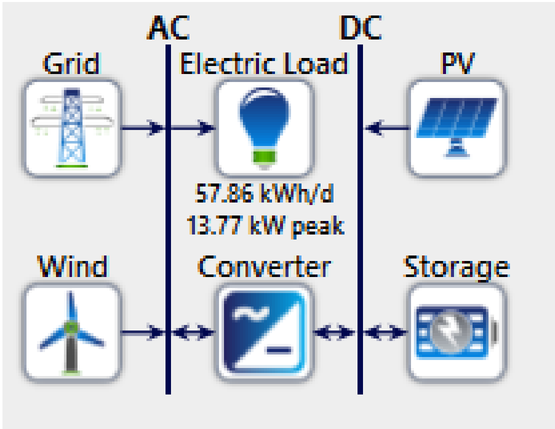

Figure 2: Renewable sizing search space for HOMER software

Due to the constant power outtages occuring on site, scheduled outages within the HOMER software were selected within the grid criteria to allow for optimal and correct sizing of batteries to allow for back up for 1 hour during several periods of the year as shown below.

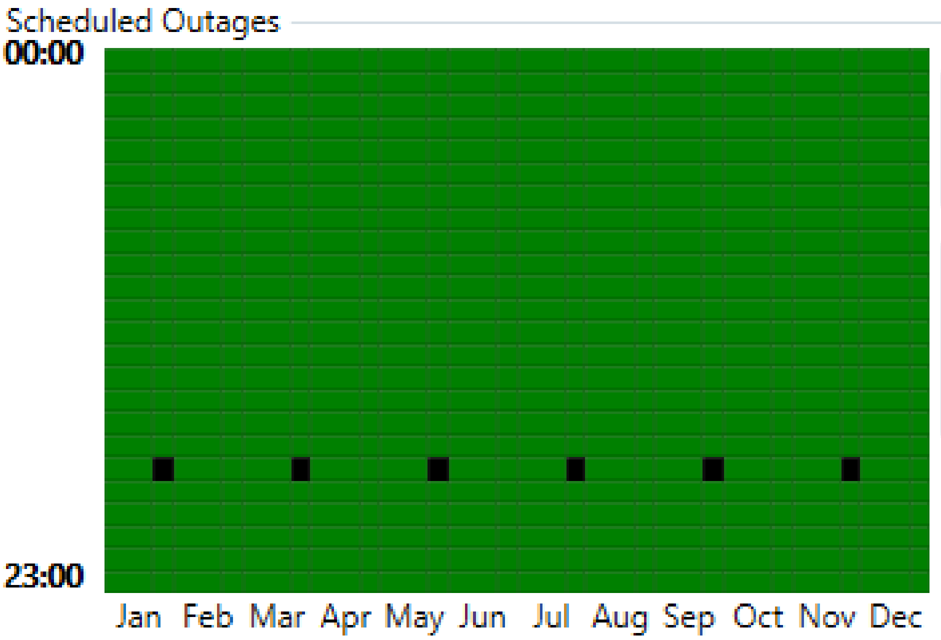

Figure 3: Scheduled outtages input into the system

4. Technical Configuration

4.1 System overview

Earth Sanctuary have a long history of investing in renewable energy technology and had already had solar and battery installed before Australian Wind and Solar were contracted to increase power capabilities. However, due to the success of earth sanctuary's programs/functions and the significant growth ESWNC had achieved, the existing battery system became obsolete.
AWS were contacted to identify and provide a cost effective energy system augmentation aimed at greatly reducing ESWNC's reliance on grid power and allowing for uninterrupted power during blackouts. This was achieved through the re configuration of existing micro wind turbines, the addition of increased solar PV capacity, the complete upgrade of battery systems using BAE batteries (24 x BAE 1200Ah 31kWh @ 70% DOD C10), and Selectronic inverter/chargers, providing a true three phase supply and backup.

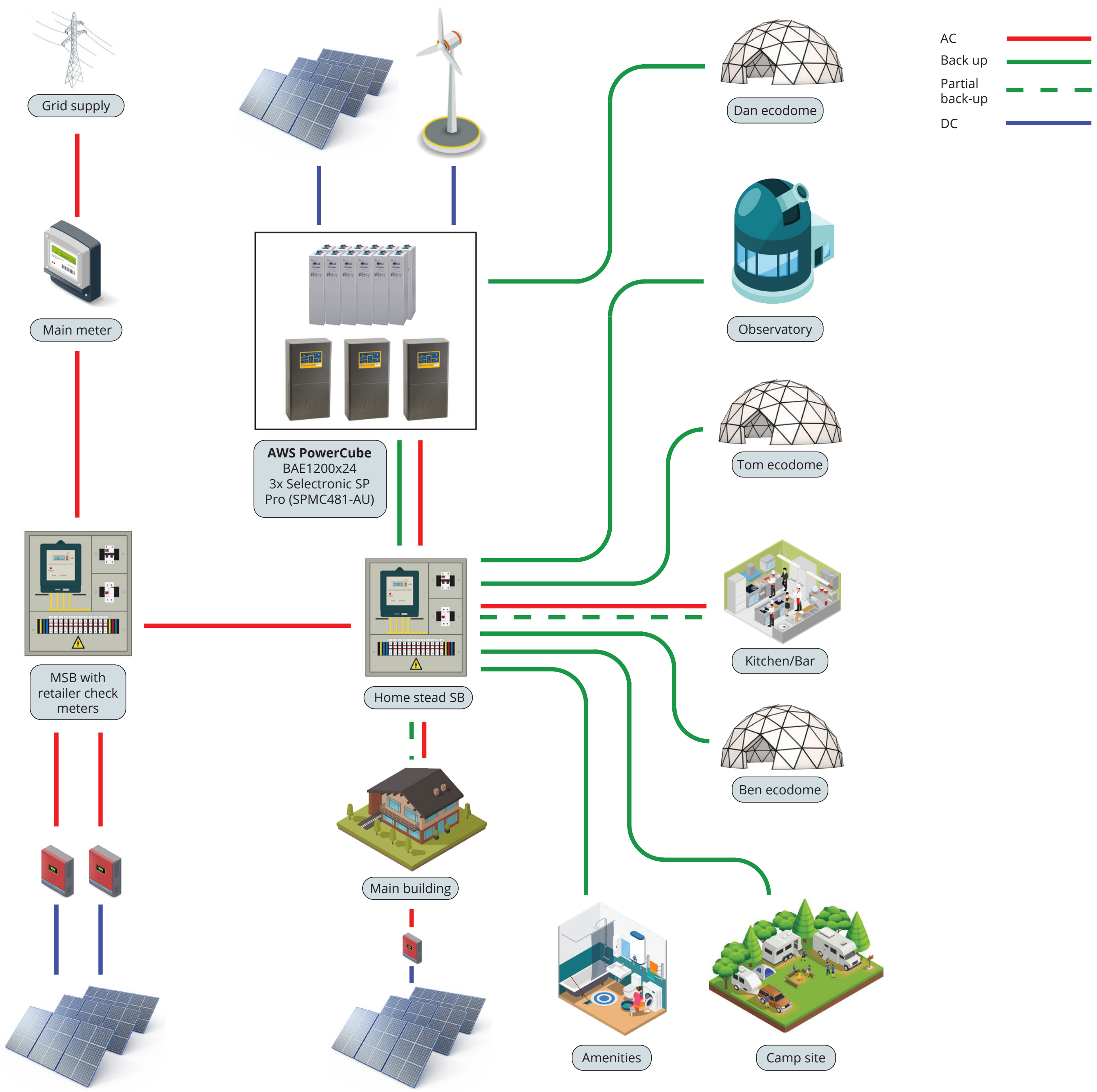

Figure 4: Schematic of Power generation at ESWNC.

4.2 Selectronic SP Pro series

The Selectronic SP PRO AU series of multi-mode inverter/chargers used in this project control and manage the renewable energy supply and incoming grid supply and are labelled as the ‘brains’ of the system. The reason this product was selected was due to their outstanding and proven track record for managing power systems across Australia. They are designed and manufactured in Melbourne to withstand Australia’s harsh climate conditions, making it an essential pick considering the desert surroundings of Alice Springs.
The SP PROs range of varying voltages and its ability to be configurable for 3 phase power supply for AC coupling allowed for seamless integration with the energy system at ESWNC.

Three SP Pro 5kW multi-mode inverter/chargers were chosen for this system to allow renewable system management and control between existing grid supply, ensuring peak loads are meant over 3 phases via 3 phase balancing.

4.3 BAE Valve Regulated Lead Acid batteries

The recommended batteries for this project are German made, BAE Valve Regulated Lead Acid batteries (VRLA). The cells are very robust and have been on the Australian market for over 10 years without a single warranty claim. BAE as a German producer of lead acid batteries for automotive and industrial applications and have operated 1899. This long proven track record for producing quality products is one of the reason why this battery technology and company were chosen. 24x BAE 1200 2V cells were chosen for this system to allow for adequate storage.

4.4 AWS HC Wind Turbine

AWS HC are the next evolution in Horizontal Wind Turbines. AWS HC Wind Turbines have the lowest start-up speed in their class, highest efficiency, superior build quality, including cast body, carbon-fibre blades and revolutionary full body passive pitch control. AWS HC Wind Turbines can operate at full capacity in all wind conditions whilst protecting itself in extreme weather conditions. AWS HC Wind Turbines have a minimum 20 year life expectancy. AWS HC Wind Controller is available in 12V, 24V, 48V or High Voltage Grid Connect. It offers superior performance with absolute Wind Turbine protection. It includes power smoothing and surge protection.

There are a range of sizes available: 650W, 1.5kW, 1.8kW, 3.3kW, 4.2kW, 5.1kW.

Figure 5: AWS HC 650W turbine

The 650W machine was selected for this project with the aim of reducing the drain on batteries during night time and overcast times. The turbine is a fantastic addition allowing for increased battery life and self sufficiency.
As wind resources commonly compliment solar resources, during periods of rain or at night, the installation of a turbines allows for for an increased renewable energy percentage year round.

4.5 PV System

Solar PV prices have plummeted over the past 15 years making PV one of the cheapest available energy technologies. As can be seen from figure 5.1, PV represents the work horse of the energy system, providing an average of 80% of the sites power needs. Due to the cost effective nature or solar PV and the amazing solar resource year round at Eath sanctuary, Photovoltaics are a cost effective, reliable and carbon negative solution.

Figure 6: Ground mount PV at Earth Sanctuary

5. System Performance

Simulated perfomance analysis on the Solar, battery and wind turbine energy systems are shown below.

Production	kWh/yr	%
SIMAX POLY 156 250W	20,747	75.0
AWS HC 650W Wind Turbine	1,255	4.53
Grid Purchases	5,679	20.5
Total	27,681	100

Consumption	kWh/yr	%
AC Primary Load	21,105	83.1
DC Primary Load	0	0
Grid Sales	4,289	16.9
Total	25,394	100

Quantity	kWh/yr	%
Excess Electricity	0	0
Unmet Electric Load	15.4	0.0731
Capacity Shortage	17.7	0.0839

Quantity	Value
Renewable Fraction	77.6
Max. Renew. Penetration	4,586

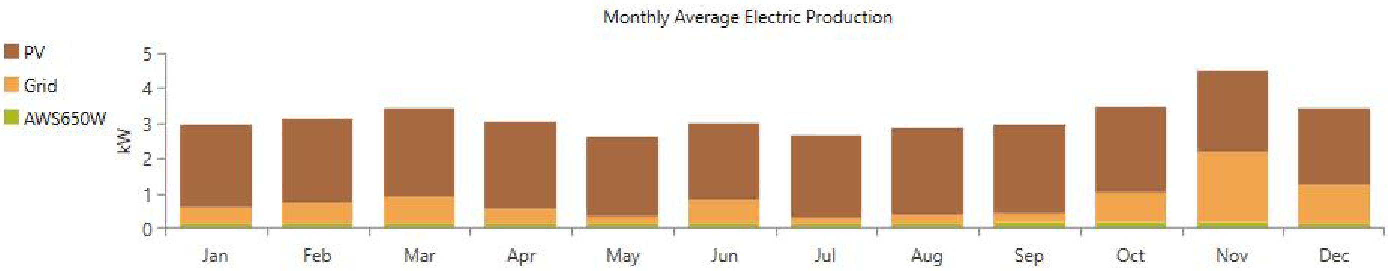

Figure 7: Monthly average electric production

Quantity	Value	Units
Rated Capacity	10.5	kW
Mean Output	2.37	kW
Mean Output	56.8	kWh/d
Capacity Factor	22.6	%
Total Production	20,747	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	11.3	kW
PV Penetration	98.2	%
Hours of Operation	4,361	hrs/yr
Levelized Cost	0.0626	$/kWh

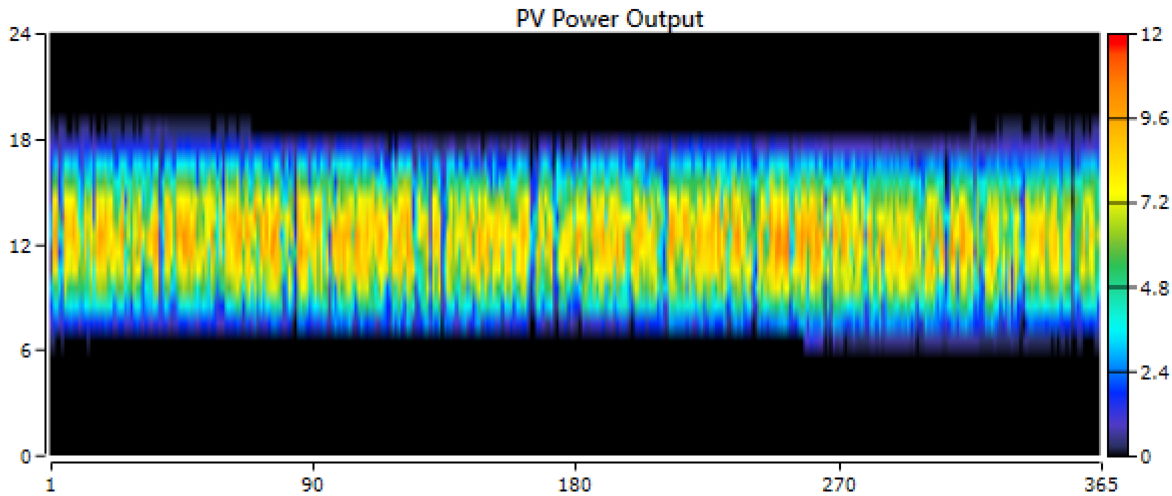

Figure 8: PV output

Quantity	Value	Units
Batteries	24.0	qty.
String Size	24.0	batteries
Strings in Parallel	1.00	strings
Bus Voltage	48.0	V

Quantity	Value	Units
Autonomy	13.5	hr
Storage Wear Cost	0.225	$/kWh
Nominal Capacity	46.6	kWh
Usable Nominal Capacity	32.6	kWh
Lifetime Throughput	71,702	kWh
Expected Life	8.80	yr

Quantity	Value	Units
Average Energy Cost	0	$/kWh
Energy In	8,826	kWh/yr
Energy Out	7,511	kWh/yr
Storage Depletion	9.20	kWh/yr
Losses	1,325	kWh/yr
Annual Throughput	8,147	kWh/yr

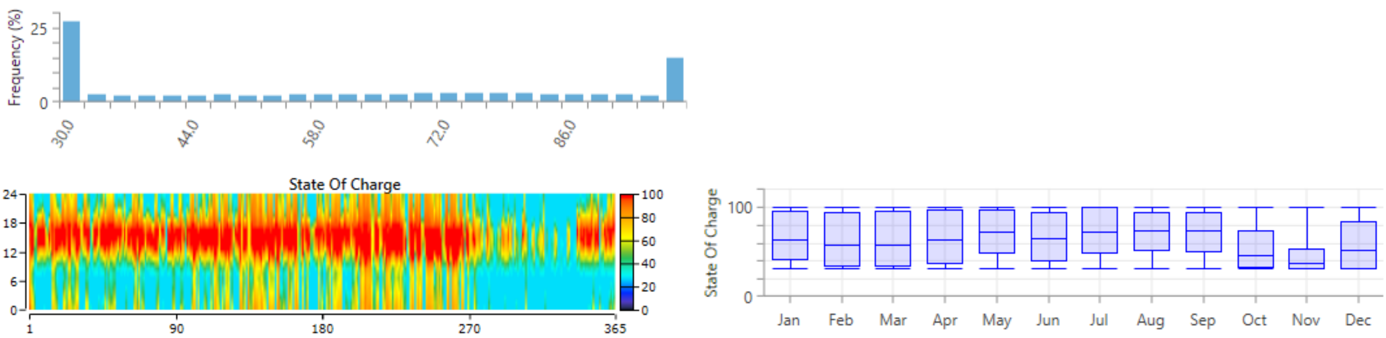

Figure 9: Battery analysis

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. 24x BAE1200 (48V) batteries selected for this system can provide 32.6kWh of useable storage and, if fully charged, 13.5 hours of autonomy at 70% depth of discharge (DOD). From these estimates the expected life of the batteries is 8.8 years.

Quantity	Value	Units
Total Rated Capacity	0.650	kW
Mean Output	0.143	kW
Capacity Factor	22.0	%
Total Production	1,255	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	1.14	kW
Wind Penetration	5.94	%
Hours of Operation	7,342	hrs/yr
Levelized Cost	0.616	$/kWh

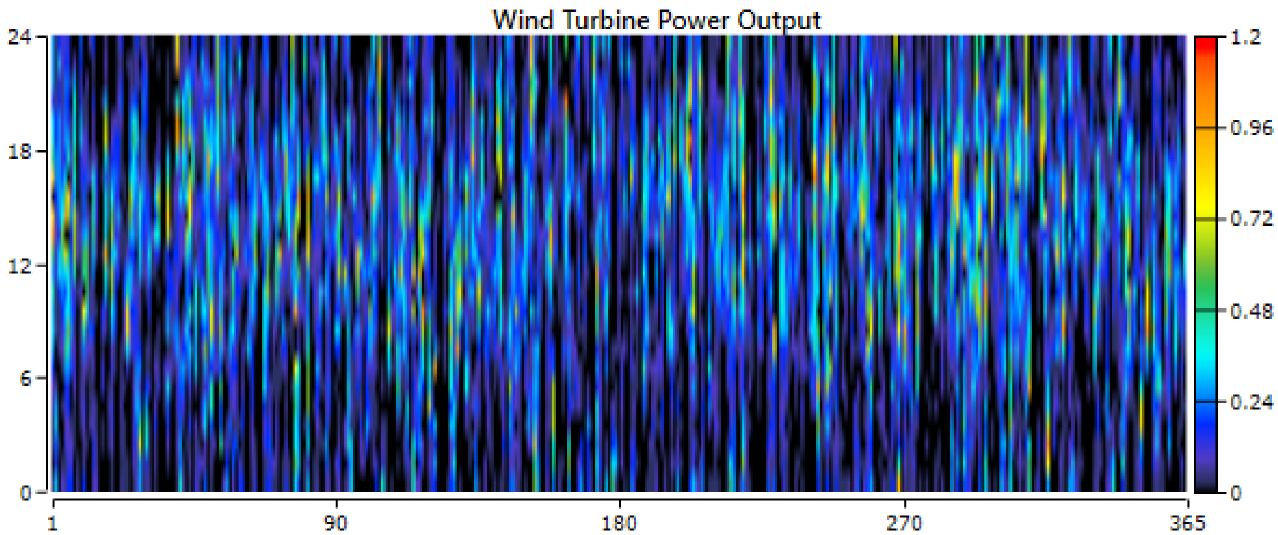

Figure 10: Wind turbine output

6. Benefit Analysis

Upon the completion of this project, Earth Sanctuary were able to significantly improve the utilization of renewable energy while also providing seamless power supply during blackout and brownout events. Selectronic SP Pro inverter/chargers maintain the correct phase angle, so even when operating in backup mode, three phase loads such as motors and pumps have no issue operating efficiently.

Earth Sanctuary had issues with unbalanced loads (depending on the event on site), if loads were slightly unbalanced even by a small margin, phase voltage was measured to drop dramatically under 200V. This would caused damage to machinery around site during these periods. An unexpected benefit from the Selectronic Sp Pro system and batteries was the observation that the system was able to balance the line side even if the load side wasn't balanced. This offered greater grid stability and mitigated machinery issues.

Figure 11: Channel 7 crew filming for the AFL event

Earth Sanctuary have reported "Fantastic performance" from the system since what they call their "Pinnacle system upgrade". During this summer, Earth Sanctuary reported a significant reduction in power bills equating to around a 75% reduction in operating costs for the summer period. Earth Sanctuary also reported that since the completion of this upgrade they have experienced no power failures, even during large functions. Such a reliable power supply has seen a larger intake of events and bookings made with patrons knowing that their night won't be cut short due to intermittent grid failures.

The Earth Sanctuary recently hosted two AFL teams in an AFL and Channel 7 sanctioned event 'Evening Under the Stars' in May 2018. Guests included AFL CEO Gillon McLachlan, Federal Sports Minister Senator The Hon. Bridget McKenzie alongside Channel 7 greats Bruce McAveney and Footy legends Brian Taylor, Daisy Pearce and Campbell Brown. The renewable energy system was able to handle the full grunt of this large event allowing for no power interruptions throughout the evening.

This was welcome news for the AWS team, who designed the system specifically to increase the utilization of renewables, reduce operating costs and mitigate the weekly blackouts experienced at Earth Sanctuary.

Tom Falzon, the Managing Director of Earth sanctuary, stated that now that the system is installed, it practically runs it's self and no attention is needed, even during large events. Tom commended the AWS team for their ongoing technical/servicing support and follow ups.

Figure 12: AFL event 'Evening under the Stars'

To date, an 80% energy cost reduction has been reported by Earth Sanctuary. If this trend continues, then annual savings are estimated to reach $5,864 by the end of year one. This increase in savings would result in a return on investment for this significant energy storage asset of less than 10 years. Additional economic windfalls seen are the increase in bookings due to increased power reliability and increase in school groups interested in learning about renewable micro grid technology.

Figure 13: Dinner eating area, one of the many parts of Earth Sanctuary benefiting from back up power and renewables.

Month	Energy Purchased (kWh)	Energy Sold (kWh)	Net Energy Purchased (kWh)	Peak Demand (kW)	Energy Charge ($)	Demand Charge ($)
January	1,636	0	1,636	10	$486.25	$0
February	1,604	0	1,604	10	$476.69	$0
March	1,909	0	1,909	12	$567.34	$0
April	1,536	0	1,536	13	$456.53	$0
May	1,226	0	1,226	9	$364.39	$0
June	1,584	0	1,584	12	$470.67	$0
July	1,239	0	1,239	10	$368.30	$0
August	1,368	0	1,368	9	$406.56	$0
September	1,301	0	1,301	8	$386.51	$0
October	2,398	0	2,398	11	$712.83	$0
November	3,106	0	3,106	11	$923.03	$0
December	2,214	0	2,214	10	$657.91	$0
Annual	21,121	0	21,121	13	$6,277.02	$0

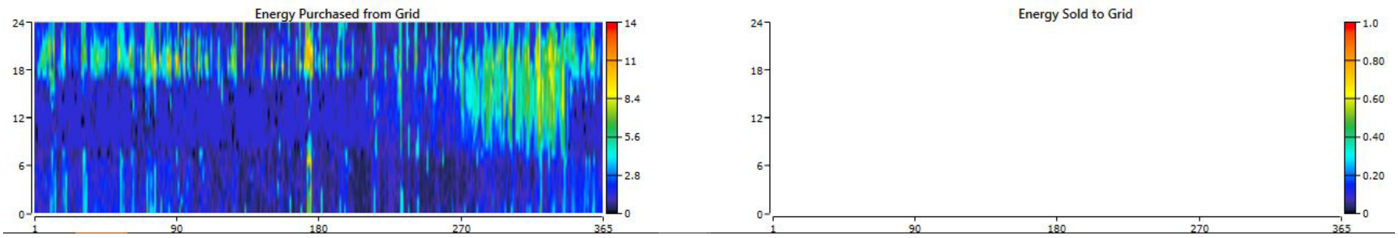

Figure 14: Grid analysis pre energy system

Month	Energy Purchased (kWh)	Energy Sold (kWh)	Net Energy Purchased (kWh)	Peak Demand (kW)	Energy Charge ($)	Demand Charge ($)
January	346	375	-29	8	-$8.66	$0
February	402	290	111	6	$33.10	$0
March	577	385	192	11	$56.98	$0
April	305	436	-131	10	-$39.03	$0
May	144	509	-365	9	-$108.42	$0
June	489	392	97	11	$28.80	$0
July	128	507	-379	6	-$112.73	$0
August	181	597	-416	6	-$123.73	$0
September	177	651	-474	7	-$140.83	$0
October	657	24	632	8	$187.93	$0
November	1,464	1	1,463	10	$434.84	$0
December	809	120	689	9	$204.91	$0
Annual	5,679	4,289	1,390	11	$413.17	$0

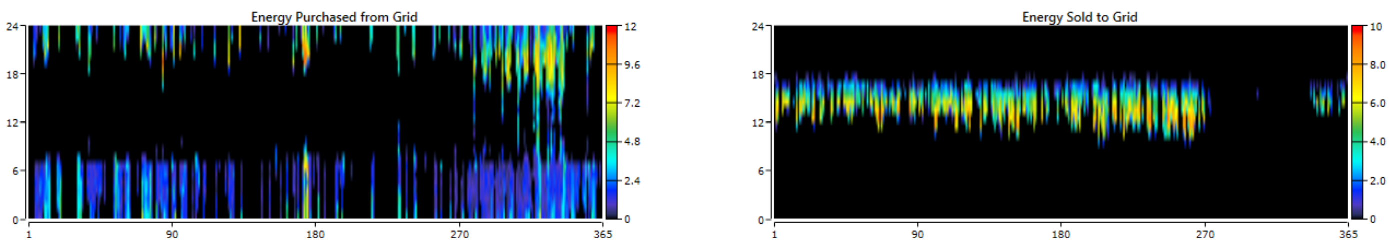

Figure 15: Grid analysis post energy system

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