Northpower

Off The Grid at Matakohe Limestone Island

The Solar Upgrade Project

Background

Matakohe Limestone Island is a predator-free scenic nature reserve in the Whangarei Harbour with an on-site Ranger. The Matakohe Limestone Island Solar Project was a collaboration between Northpower and Hubands to the upgrade of an existing off-grid system for the ranger hut. The previous system had grown in an ad hoc manner over the years but still frequently ran out of power.

Requirements

The new solar system needed to supply a modest ranger house, which homed a family of four at the time.

The new system was designed to be capable of supplying the following loads:

- Refrigeration
- Lighting
- Washing machine
- Water pump for domestic use
- Small electrical appliances e.g. TV, toaster, jug, computer equipment etc.

Other loads like the hot water, stove and space heating are provided by other energy sources (ie. gas).

Equipment Installed

Solar Panels

Photovoltic Canadian Solar Panels made up of 16 x 285 Watt polycrystalline panels configured in two string with 8 panels in each string. The total capacity is 4.56 kW.
Clenergy Solar Roof Mounting System

Solar Inverter

5 kW single phase Fronius Primo Selectronic Certified string inverter with MPPT (maximum power point tracking) to optimise solar panel output

Batteries

5 Powerplus 3.3 kWh, 48 Volt battery packs: total capacity 16.5 kWh. Battery type: lithium phosphate

Battery Inverter / Charger

5 kW Selectronic SP Pro single phase inverter / charger

Communication System

Selectronic SelectLIVE Communications Gateway

Back –up Generator

Honda EU70is 7kVa Auto Start Petrol Powered Inverter Generator
Fuel tank volume: 19.2 litres with a rated fuel consumption of 2.9 l/h giving an endurance of approximately 6.5 hours.

The total cost for this system was around $50,000.

Equipment Supplier and Installer

Hubands Energy

System Configuration

The system runs automatically apart from some relatively low maintenance. The power needed to supply the load comes from three sources; the solar panels, the batteries and the back-up generator.

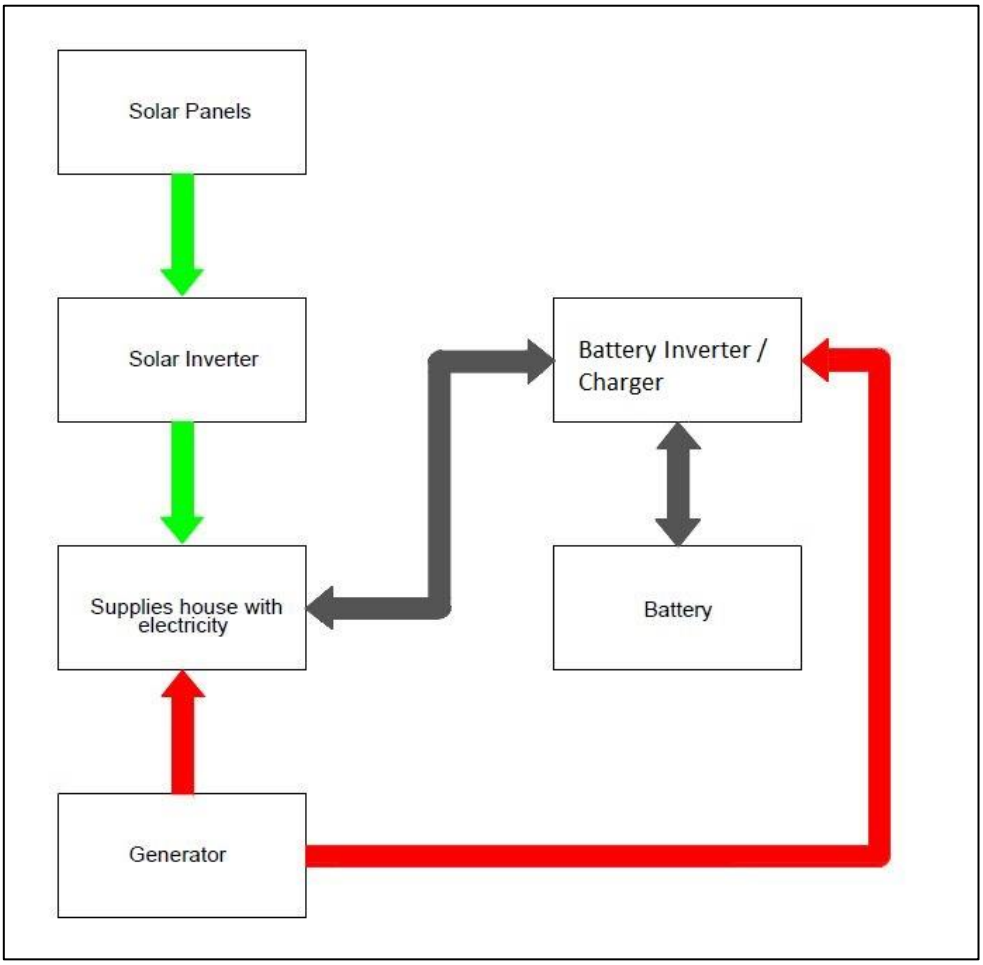


Illustration of energy flow

The solar panels are in two strings, each with eight panels, giving a total solar capacity of 4.56 kW connected to a 5kW inverter. The solar inverter connects the solar panel to the Low Voltage AC system and runs in parallel with the battery inverter/charger.

The battery inverter/charger allows bi-directional power flow into and out of the battery bank. It has a 5kW capacity and is effectively the hub of the system. It:

- Regulates the battery charging and performs battery management system functions
- Can operate the system in AC bypass mode i.e. battery supply disconnected
- Delivers power to the installation when the solar output is insufficient to meet the load
- Control the back-up generation
- Reports system status and data
- Communicates the with solar inverter

The battery bank consists of five 3.3 kWh 48 Volt lithium ion battery pack giving a total 16.5 kWh of storage. The battery inverter/charger and the solar inverter/charger work together and communicate via a dedicated communication cable. When the batteries are fully charged, the solar inverter will regulate the solar output to match the load.

In addition to the solar panels, there is a 7kVA Honda petrol generator used as a back-up for extended periods of low production from the solar panels. The generator will automatically start when the battery charge drops below a pre-set level of 30% state of charge (SoC) and will stop when the batteries reach a pre-set level of 72% SoC. The generator can be manually started and stopped from the battery inverter/charger control panel. The generator has an endurance of 6.5 hours on a full tank of petrol. In the unlikely event that the back-up generator is unable to provide sufficient support to the system the inverter/charger will shut down at 10% SoC to preserve the batteries.

PV inverter

Battery and inverter panel

Operation and Monitoring

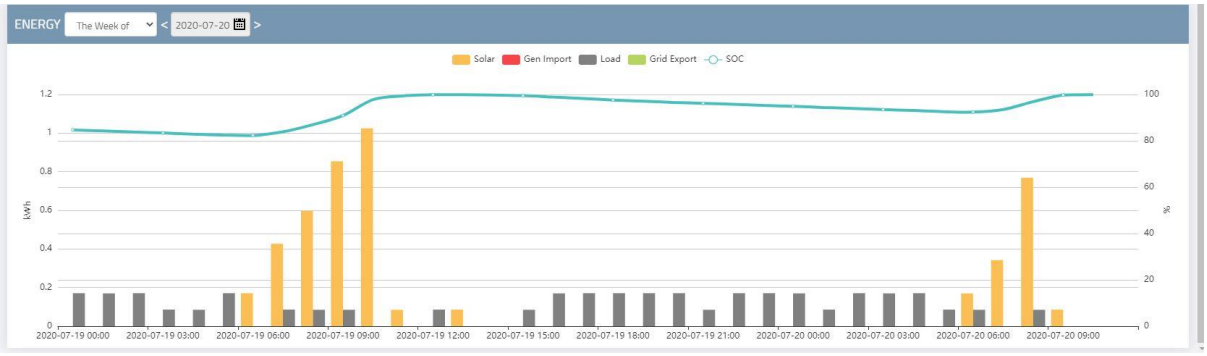
The local system monitoring displays are on the solar inverter and on the display panel of the battery inverter/charger. The solar inverter displays a range of electrical parameters that include:

- AC power output power
- AC power output current
- PV array current on each of the two string of solar panels
- PV array Voltage on each of the two string of solar panels
- System Voltage
- System frequency

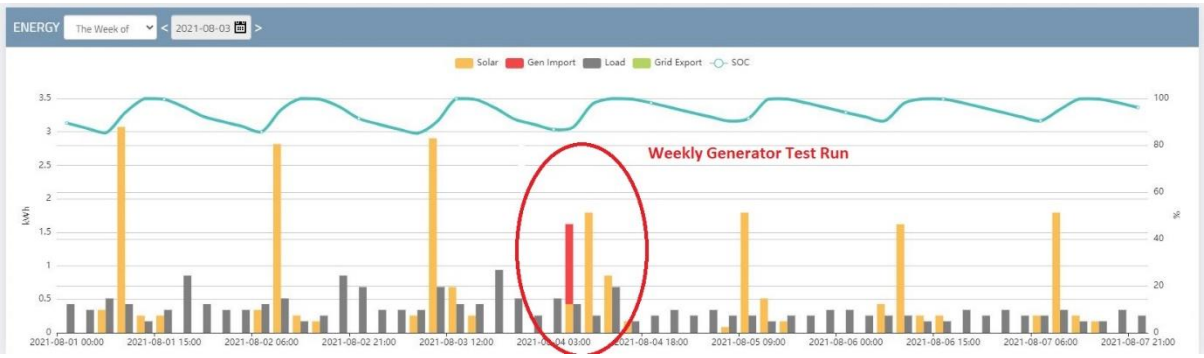
The battery inverter/charger (mounted in the battery cabinet) control panel displays:

- The system power flow
- Battery state of charge and status
- Battery charging mode
- Output mode status indication
- Alarms

Remote system monitoring via the internet is done through a portal on the battery inverter/charger manufacturer's web site. The portal allows real time monitoring of power generated from both solar panels and back-up generator, the flow into or out of the batteries, the load being drawn and the state of charge (SoC) of the batteries. There is also historical data available in graphical format.



Typical daily energy pattern



Typical weekly energy pattern

Maintenance

Solar Panels

The solar panels are generally low maintenance with the occasional cleaning of the glass surface to remove dirt and grime.

Solar Inverters

No maintenance is required except checking that cover remains weather proof and free of any dirt and grime.

Battery Cabinet

Checking the ventilation fan located on the top left hand side of cabinet is clean and working prior to the warmer summer period is recommended. The fan is thermostatically controlled and can be checked by temporarily adjusting the thermostat and observing the temperature it starts and stops at. It should be set close to the ambient temperature of the inside of cabinet. The normal setting is around 25°C. Checks for any infestation of insects, dirt and grime build on the equipment is advisable.

Back – Up Generator

In addition to keeping the generator fuelled, general maintenance includes:

- Checking the oil level and topping it up if required
- Engine maintenance as per the manufacturer's recommendation. This would typically include;
    - Changing the oil, recommended oil grade SAE 10W-30
    - Cleaning the air filter
    - Changing the spark plug
- Checking the starting battery and replacing as required

The generator is connected via an umbilical cable that allows it to be moved out from the shed to allow routine maintenance to be carried out.

It is desirable to regularly test and exercise the generator to ensure that the starting battery stays charged. For this reason, the battery inverter/charger is programmed to carryout a test run for 15 minutes every Wednesday.

Back up petrol generator

Additional Load Potential

Current Requirements

Currently the solar PV system provides power to the ranger hut for refrigeration, lighting, a domestic water pump, washing machine and other small appliances. Other energy sources power the hot water, space heating and the stove.

System Efficiency

The efficiency of the system is 85-89% (energy used divided by energy generated, including the weekly test run of the back-up generator). The system is more efficient in winter when the energy generated is closer to the energy used, rather than in summer when the generation is higher.

Spare Capacity

The winter spare capacity is approximately 5kWh per day and in summer is 9kWh. This is an average daily spare capacity over a weeklong period. The system is currently generating more energy than required by the load, or that can be stored in the battery, as they get full.

Battery Endurance with No Solar Generation

If there were a period of days with no generation, the battery would provide enough electricity to power the ranger's house for a few days, depending on the season. In winter, it would last around 4.5 days before the generator kicked in. In summer, it would last roughly 3.2 days. Long periods of zero generation are rare though, because even on cloudy or rainy days the panels would produce at 5-20% of their full normal output.

Adding a Hot Water Load

In theory, there is enough capacity to have an electric hot water system assuming a relatively small heating element was fitted. However, the system's back-up generator will be needed when there are consecutive days of poor solar production, particularly in winter. A heat pump electric hot water system would be preferable over a traditional electric hot water cylinder, as it is more energy efficient and would reduce the dependence on the back-up generator.

There is the option of increasing the battery storage to ride through consecutive poor solar days without the use or limited use of the back-up generator. The battery cabinet at Matakohe Limestone Island has room to host more batteries, but the batteries are relatively expensive. While we have not priced additional batteries, you could be looking $4,000 - $6,000 for a modest increase in battery capacity.

Adding a Conventional Electric Stove

For an electric stove, there is both the additional energy consumption and peak demand to consider. An electric stove has a significant peak demand depending on what, when and how you are cooking. To ensure that an electric stove can be fully utilised as you would in a grid connected house, you would need to double the system capacity. So a $50,000 system would be become $100,000 system. However, the present system could accommodate a single element induction hob and a microwave.

More Detail

On the Northpower website, you can find a detailed case study report on the current Matakohe Limestone Island system and what capacity it has to introduce extra load, compiled by our Northpower engineering interns. This report contains a list of common household appliances and the typical daily consumption, what impact they would have on the current system, as well as the potential increase in storage or capacity you would need to power a fully electric house (ie. water, cooking, heating included). It also details any system upgrades that would be required.

Learnings from the Matakohe Limestone Island Solar Project

- ✓ When designing a solar system, it is a good idea to understand the load and lifestyle requirements for the household or business and keep in mind any possible future requirements. Each household or business uses electricity differently and may have alternative energy solutions for things like cooking or hot water. Therefore, any solar system should be bespoke and unique to the household or business.
- ✓ If there is an existing system, you need to understand what the inadequacies or issues are so they can be remedied when installing a new system.
- ✓ An off grid system for modest home is likely to cost at least $50,000.
- ✓ The operation and maintenance manual should be written specifically for the owner/occupier so it works into their lifestyle.
- ✓ Being able to monitor the system can give valuable insights into its use, where there is spare capacity, showing how full the batteries are at any point and to make sure the system is performing to its potential.

Your Own Off-Grid System

We hope this gives you some ideas if you are considering powering your own home or business fully off the grid. We always encourage that any system you do choose be tailored and designed specifically for your home and your needs and that you use a trusted and reliable installer. For more information, please visit northpower.com.