



REDUCING DIESEL COST WITH SOLAR HYBRID MINI-GRIDS IN TOKELAU

The Tokelau Renewable Energy Project was launched in 2010 and culminated in the installation of a photovoltaic-diesel hybrid system with battery storage on each of Tokelau's three atolls; Fakaofu, Nukunonu and Atafu. The new solar power systems replaced the existing diesel systems and were designed to provide at least 90% of the islands' electricity needs, saving roughly NZD 900,000 per year in diesel costs. In fact, expectation has been exceeded and Tokelau is the first country to have almost all its electricity needs met by solar power.

WHO FUNDED THE PROJECT?

The project was funded by the Government of New Zealand, who provided approximately NZD 8.5 million as a four-year advance in the aid money given to Tokelau. Maintenance and project works are funded by the Government of Tokelau.

HOW ARE THE FEES COLLECTED?

The village councils collect the revenue from energy users, which is used for buying the diesel for back-up generation and paying the villagers who maintain the system. Power is sold using pre-pay meters that are installed and maintained by the Tokelau Energy Department. Typical loads on the island include fridges, freezers, fluorescent lighting, fans, microwaves and washing machines. Electric ovens, water heaters and air-conditioning units are banned on the atolls.

Short Summary

- The solar hybrid system was designed to provide 90% of the electrical needs of Tokelau.
- The reduction in diesel costs from pre-solar days has dropped by 84%. If there are seven hours of bright sunlight there is no need for back-up generation
- The availability of 24/7 power has provided vast improvement to the quality of life in the atolls, allowing the use of most modern amenities

CONSTRAINTS

The atolls are difficult to access as there is no port and all equipment has to be taken onto the islands by barge. The size and weight of the equipment is limited to what can be fitted on the barge and lifted by the crane.

The heat and humidity of the atolls posed concerns in the installation process. To help slow corrosion, the solar cables were all run in an aluminium channel and UV stabilised conduit, and everything was manufactured from either 316 stainless steel or anodised aluminium; and to keep the battery and inverter rooms cool, care was taken to ensure that they were well ventilated with passive heat controls. These included lining roofs with

foil, keeping a roof space to keep hot air away from the rooms, building verandas to keep direct sunlight off the rooms, and making judicious use of windows and doors to stimulate good air flows.

WHAT SYSTEM IS USED?

The system chosen is the standard mini-grid system used by the New Zealand Ministry of Foreign Affairs and Trade, and consists of multi-cluster SMA Sunny Island inverters with battery back-up, and both Sunny Island MPPT regulators and Sunny Boy inverters feeding both the AC and DC buses. Village men's groups built the PV array foundation and battery buildings, and the systems were installed by a New Zealand Company, PowerSmart. Solar power is centrally generated in a single large solar array with inverter and battery room. The batteries used are 2 Volt flooded lead acid batteries giving autonomy of 1.6 days to a 50% depth of discharge.

DIESEL-POWER BACK-UP

The generators that were once the sole source of electricity on the atolls are now used as back-up for the solar power system. The SMA inverters have the capability of starting the generator automatically if the load exceeds the inverters' capability or if the batteries drop to a predefined state of charge. However, Tokelau has decided to start the generators manually if required for three key reasons: (i) so that the operators get to know and understand the system; (ii) to prevent automatic generator starts from masking a fault in the system; (iii) to bring human intelligence to bear when deciding whether to start the system, i.e. if the sun is about to come out then it is worth delaying a generator start, as it may not be needed. The danger in this system is human failure; if inaction were to allow the battery state of charge to drop too far, it would cause damage to the batteries.

HOW IS THE SYSTEM MAINTAINED AND MONITORED?

The system is fully monitored using the SMA Sunny Portal that allows remote diagnostics to ensure system performance is maintained and to help with any fault diagnosis under a three-year contract with the installer.

On the atolls, basic maintenance tasks are simple and cost very little. However, they are crucial to the long-term success of the project, and must be carried out regularly and thoroughly (especially the battery maintenance procedures, as batteries are sensitive to neglect). Routine maintenance includes topping up batteries and downloading data from the inverters to send to the monitoring teams. This scheduled maintenance



Landing on Tokelau

requires semi-skilled staff and utility technicians were given training in the regular operation and maintenance of the PV system's components, and of troubleshooting procedures and solutions. Unplanned problems are addressed as required by Tokelau Energy Department staff; if the monitoring contractor finds a problem, he or she will contact the relevant station supervisor by phone, skype or email.

HOW WELL HAS THE PROJECT WORKED?

On the social side, uninterrupted power has brought huge benefits to the village quality of life, as has the use of most modern technology. It has allowed for the introduction and availability to everybody of satellite television and digital communication, including the internet. Most appliances and power tools can be used, including commercial freezers and welders; all night street-lighting, and hospital and school facilities are improved. The availability to all residential customers of uninterrupted electricity is now reliable and expected.

In terms of finance, there is now only an average of 6200 litres of fuel used per month, a saving of about 82% in fuel usage from prior to the project's installations. There is, however, insufficient solar generation, as consumption has climbed and there has been increasing cloud cover over the last two and a half years. Programmes have been instigated to educate consumers on how to save power and money and encourage them to purchase more efficient white goods and to use energy-saving lighting. These programmes have already started to reduce consumption. If the demand fails to reduce to a sustainable level, then the cost per unit of electricity will have to be increased to force consumers to use less.

Obtaining urgent parts can be a problem. Down time usually depends on the availability of spare parts or



Nukononu batteries

equipment and can be anywhere between two hours and one month. Power black-outs are generally rectified within two hours with the use of portable generators that can supply full village load until the fault is repaired.

HOW CAN THE SYSTEM BE IMPROVED?

The increasing demand is working the batteries too hard so, in order to maintain a healthy State of Charge at sunrise, there are plans to install a further 33 kW of PV and one 48 v bank of batteries at each station. There is also a wind trial planned which, if successful, will create a hybrid system that should reduce the load on the batteries considerably. Increasing the cost per unit may reduce the increased demand and help fund future replacements.

POSSIBILITIES

Bio-fuel from coconuts has been considered as a replacement to reduce the amount of diesel oil used in the standby generators. Tokelau coconut plantations are, however, mostly old and the nuts produce little oil. Landowner issues and high labour costs also inhibit sustainable production. Using pure coconut oil and a blend of diesel and coconut oil were considered but the cost of setting up the processing plant locally was not viable compared to importing ready blended oil. Gasification is another possibility, using coconut by-products and wood and requires further exploration.

LESSONS LEARNED

It was learned that it is important to ensure that the back-up generation is adequate to supply demand and boost charges for the batteries. Further, it is important that building design is efficient for tropical weather conditions, and that the design has sufficient capacity for an increase in future demand.

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