CASE STUDY

EU-GIZ ACSE

ADAPTING TO CLIMATE CHANGE AND SUSTAINABLE ENERGY

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SUPPLEMENTING A DIESEL-BASED POWER GRID WITH SOLAR ENERGY IN NEIAFU, TONGA

Tonga Power Ltd connected a 500 kW solar array onto the diesel grid in Neiafu, on the island of 'Utu Vava'u (the largest island in the Vava'u archipelago of Tonga) in November 2013. The system was required to supplement the existing diesel grid. The aim was to generate up to 70% of the island's maximum demand and up to 17% of the island's total energy consumption.

WHO FUNDED THE PROJECT?

The project was funded by the Abu Dhabi Fund for Development.

WHO MONITORS AND MAINTAINS THE SYSTEM?

The system is fully monitored in Tonga and Abu Dhabi, which allows remote diagnostics and ensures system performance is maintained. The Tonga Electric Power Board monitors the system with both on-line and on-site checks. Weekly, monthly and daily check sheet maintenance is undertaken on the system. There is a budget of TOP 20,000 for maintenance of the system, which is funded through customer revenue.

Quick Summary

- The solar system is working successfully, but could be improved by increasing battery storage
- The system has reduced fuel costs, which has lowered electricity prices in Tonga
- Solar penetration of 70% has proved viable, enhancing the business case for more integration of solar power for Tonga Power Limited energy.

WHAT SYSTEM IS USED?

The system, designed and installed by Ingenero Pty Ltd, is a hybrid PV farm with 1,680 PV 305 W Trina modules and 21 SMA Sunny Tripower 20 kW inverters. It is fully integrated into the existing diesel network. There is also a 240 kWh gel cell battery bank with SMA Sunny Island backup inverters in the system. It stores the excess power from day-time generation for use during the peak hours in the evening. The system is controlled using the SMA Fuel Save Controller, which maintains grid stability. Overall, the system saves about 170,000 liters of fuel per year, and reduces 500 Tonnes of CO2-equivalent greenhouse gas emissions. The solar power is centrally generated and is situated next to the power station to reduce the control cabling between the solar inverters and the generators.

HOW IS THE ENERGY STORED?

There is a small battery bank that is designed for peak lopping and smoothing and not long term energy storage. It uses 2V VRLA (dry lead acid) batteries which store energy from the solar array during the day and provides energy to the grid at night time. This allows the utility to use a smaller generator during the evenings which leads to fuel savings. The batteries also provide an immediate buffer during daytime periods, should the grid demand suddenly increase or the solar generation suddenly falls (for instance, during periods of fast-moving clouds).

HOW WELL DOES THE PROJECT WORK?

- The system is working reliably and is saving 170,000 litres of diesel and 500 tonnes of CO2-equivalent emissions per year, with pay back estimated at about five years for the fuel-saving system. It should be noted, however, that although there is substantial reduction of diesel usage, the efficiencies have dropped from 3.9 kWh/l to 3.8 kWh/l (2.5%) because the diesel generators are operating at lower loads.
- The system is credited with reducing the electricity tariffs across the whole of Tonga by 1%–1.5% (depending on diesel prices). Monthly generation figures vary between about 35,000 and 72,000 kWh, equating to about 870 MWh per year or 17% of the island's total energy consumption.
- With peak generation designed at 70%, there is little wastage of solar generation. Any higher penetration could give rise to 'wasted energy' without having a load to divert this surplus to.
- The project's unprecedented level of penetration (up to 70%) shows that the previously accepted penetration level of 20-30% can be improved, which improves the business case for further deployment.
- One distinct advantage to the Tonga Electric Power Board is that the generation can be monitored remotely from Tongatapu.
- Neiafu lies beside the port of Refuge, a deep-water harbour, so infrastructure is advanced and access is good.

HOW CAN THE SYSTEM BE IMPROVED?

The battery back-up system needs to be substantially increased in size. New battery (lithium ion or flow batteries) and inverter technology would have improved the situation but the technology is not ready to be applied at this size. Alternatives to batteries for helping with smoothing could be the use of flywheels or dynamic grid interfaces.

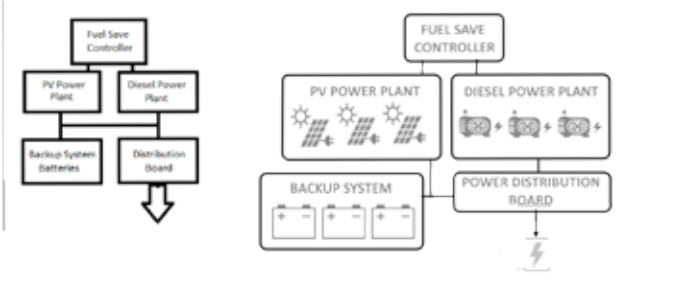
Increasing renewable energy provided to the system would require one of the following:

A. Getting it from a different source, such as wind, to increase the time-availability of renewable energy supply (as wind is capable of operating at night) adding more storage capacity to store the excess energy at peak generation;
B. Adding more storage capacity to store the excess energy at peak generation;
C. Installing a low load diesel generator to run at peak generation times to increase the acceptable penetration level to 90%;
D. Installing any new solar equipment facing east or west to increase morning or evening generation without adding too significantly to midday generation;
E. Accepting a greater wastage of energy at midday to improve the penetration levels through the rest of the day; and.
F. Shifting load to the midday peak generation period, thereby reducing the penetration level to allow for more generation.

Careful consideration would must be given to the cost benefit of these options.

CONCERNS

- Tonga is a tropical island nation with a hot climate, so corrosion is a major concern. Aluminium is used for all the framing to help slow the corrosion.
- One of the lessons learned was that it is important to include the electricity utility already in the early stages of the development of such projects to allow for all important design considerations to be taken into account.



Icons from: https://thenounproject.com/term/generator/24230/

REPLACEMENT COSTS

The power that is generated directly replaces electricity that would normally be generated from imported fossil fuels. Electricity tariff rates in Tonga are structured such that approximately half of it covers the cost of fuel and importing it, and the other half covers the cost of maintaining and running the electricity supply. Any fuel displacement reduces the portion of the tariff directly linked to the import of fuel only. The cost of maintaining and running the electricity supply also includes the cost of replacing and maintaining assets such as the solar farm, which adds to the 'non-fuel' portion of the tariff. If the asset is donated, as in this case, it is not immediately put on the books for replacement value, as this would cause the tariff to go up. Replacement costs are still being discussed, with the option of creating a 'sinking' fund being considered.

REFERENCES:

- A path to prosperity: Renewable energy of islands. 2014. IRENA
- SMA literature on Vava'u System at www.SMA.de/en/products/references.html
- Rojas AC, Case study: High Penetration Diesel Hybrid System in Vava'u Island Tonga. http://www.ppa.org.fj/wp-content/uploads/2015/08/PPA-Vol-23-Issue-2-Final.pdf
- Discussions with the Tonga Electric Power Board
- Discussions with SMA

The 35.5 million Euro regional European Union (EU) programme **Adapting to Climate Change and Sustainable Energy (ACSE)** is funded out of the 10th European Development Fund (EDF 10).

Under this regional programme, the EU-GIZ ACSE component is administered by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It aims to enhance sustainable livelihoods in fourteen Pacific Island countries and Timor Leste by strengthening the countries' capacities to adapt to the adverse effects of climate change and enhancing their energy security at the national, provincial and local/community levels.

EU-GIZ ACSE operates from the GIZ Pacific Office in Suva, Fiji.

DISCLAIMER

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