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Hydro Review: Small Islands of Samoa Lead Renewable Energy Efforts

Two small hydro projects constructed in Samoa have increased electricity supply and helped boost hydro capacity to meet a goal of supplying 20% of the total demand of the islands via hydropower.

BY ANDREW BIRD AND ALFRED MATATIA

Halfway between Hawaii and New Zealand in the vast Pacific Ocean rests the island nation of Samoa. This nation is one of the first to feel the impacts of climate change, with warmer temperatures intensifying El Nino patterns and creating higher-intensity storm events. As a necessary result, Samoa is becoming a leader in renewable energy generation, spearheading the drive in the Pacific for 100% renewable energy to be achieved.

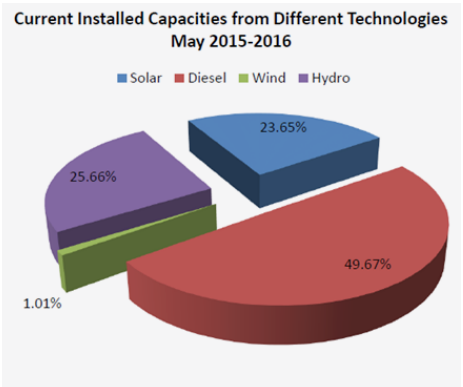
Most recently, renewable energy supply on the two islands that make up Samoa has increased by 34%, taking the total renewable energy contribution to 46,158 MWh. The increase is both from private development often via independent power producer (IPP) arrangements and from the various donor parties, including the New Zealand Government, European Union and Asian Development Bank (ADB).

In 2014, Samoa's Electric Power Corporation (EPC) secured grant funding from all three aforementioned donor parties for the "Power Sector Development and Rehabilitation Project." This grant included the rehabilitation of the Alaoa, Samasoni, and Fale-ole-Fe'e small hydro power stations, which were the three hydro stations that sustained the most damage during the flooding of Cyclone Evan in 2012. Also included in the project is the construction of the new Fausaga-Tafitoala, Faleata and Fuluasou hydro power stations. All told, this work would increase hydro capacity to meet 20% of the total demand of the islands, which to date is close to being achieved, with the last of the new stations to be commissioned in the final quarter of this year.

This article focuses on the new 600-kWW Fausaga-Tafitoala and 200-kW Faleata small hydro projects, which were commissioned and dedicated to the people of Samoa at the beginning of 2019.

Samoa's renewable energy goals

Until recently, Samoa's major form of electricity production was diesel generation. Diesel for electricity production forms 20% of Samoa's annual petroleum imports and 50% of the country's total installed electrical capacity. Hydropower, solar and wind generation contribute the other half of Samoa's installed capacity (see Figure below).



Samoa gets about half of its electricity generation capacity from diesel, with the other half coming from renewable sources.

While the country may have little impact on climate change, its is greatly affected by the consequences. Samoa is therefore taking a proactive approach to increasing its renewable energy generation and reducing its greenhouse gas emissions. Building new hydropower stations means Samoa is on track to greater energy independence and less reliance on costly diesel fuel oil.

EPC -- a state-owned enterprise that manages the generation, transmission, distribution and retail sale of electricity in Samoa -- ensures that these goals are met on various projects. To expedite the process, EPC has issued 13.48 MW of renewable generation licenses to IPPs (4.48 MW for biomass, 4 MW for solar and 4 MW for wind) to date. This new generation will offset close to 50% of the current diesel installed capacity. However, the inherent lower availability factors of such renewables means that a greater generation capacity is needed to fully account for the energy produced from the diesel generators.

The projects

The Tafitoala-Fausaga and Faleata hydropower plants were constructed on the islands of Upolu and Savai'i, respectively, in 2017 and 2018, with the primary objective to increase the deployment of renewable energy sources and boost the power sector's resilience to natural disasters.

The projects have a combined capital value of US$6.54 million, with a 70%/30% split between civil costs and mechanical and electrical costs. Both projects were implemented under a turnkey-type arrangement and took about 18 months to construct. The contract arrangement was driven predominately by the lenders' requirements, as development banks tend to steer away from multi-contract arrangements and the executing agency lacked the capacity to manage multiple contracts. Transmission works, which for both

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projects involved a short spur line of the existing transmission, were undertaken by EPC.

Due to lender and local requirements, both projects went through rigorous environmental and social safeguard checks, which were further enforced through the various contractual mechanisms and by EPCs safeguards team. Such requirements included employment of local villagers during construction, gender diversity, education and training.

Tafitoala-Fausaga

The run-of-river Tafitoala-Fausaga hydropower scheme is in the south of Upolu and upstream of the villages of Tafitoala and Fausaga. Integration of the scheme into the national grid has increased the renewable energy generation contribution by about 1,820 MWh annually and translates to a 2% increase in the hydropower contribution to the energy mix. The project has a gross head of 104 m and rated flow of 0.48 cubic meters per second. The powerhouse contains a four-jet vertical Pelton turbine.

Traditionally, the baseload for Samoa is provided by diesel power stations, with hydropower stations used as peaking stations to cater for the diurnal peak loads. Consequently, they continue to average capacity factors of no more than 35% due to lack of storage. The Tafitoala-Fausaga is a dual-intake scheme tapping into two tributaries of the same river basin. Both tributaries are perennial, with vast sub-catchment areas. Any one intake is able to sustain the plant for prolonged periods of time. This has contributed to the scheme's high annual generation, with a capacity factor to average 42% due to prolonged availability of water at rated flow. The scheme offsets 433,000 liters of diesel generation annually and has created greater access to electricity generated from hydropower.

Faleata

The run-of-river Faleata hydropower scheme increased the renewable energy generation contribution by about 790 MWh annually and translates to a 14% increase in the hydropower contribution to the energy mix of Savai'i. Prior to the commissioning of the hydropower facility, 96% of that island's energy mix came from diesel generation.

The project has a gross head of 83 m and rated flow of 0.3 cubic meters per second. The powerhouse contains a four-jet vertical Pelton turbine.

The intake for the Faleata Scheme was constructed alongside an existing Samoa Water Authority (SWA) intake. Detailed planning was undertaken to ensure that water security to the SWA plant was not compromised during construction of the Faleata Scheme. The SWA plant is now primarily supplied from the tailrace of the Faleata Scheme. The old connection can be used as a system redundancy in event of a Faleata Scheme shutdown.

Challenges of working in the Islands

The logistical planning that is required on small island projects significantly increases for unique developments such as hydropower construction. All supplies into Samoa must be carefully planned and coordinated with shipping schedules, which are fortnightly and subject to regular delays due to bad weather. A minimum of three days is typically required to get specialist and not "off the shelf" items to project sites and means using commercial flights from New Zealand, Australia or Fiji.

A majority of materials were imported for both projects. Reinforced steel, for example, which is seismic-compliant and not available in Samoa, was imported from New Zealand. Likewise, all glass-reinforced plastic (GRP) pipes used for this project were supplied through New Zealand but manufactured in Turkey. All generation equipment was supplied through a New Zealand company but manufactured in Europe.

Sitting as it does in the Pacific "rim of fire," Samoa is regularly subject to cyclones, earthquakes and flooding. A key criterion for the

Most of the GRP used for the two schemes was placed underground, except in areas where a trench could not be dug.

design and construction of the projects was their resilience to natural disasters and climate change.

For resilience to natural disasters, the 3.5-km-long penstock for the Tafitoala-Fausaga scheme was placed below ground and the powerhouse was waterproofed up to 1 m from its finished floor level. Much of the decision to integrate such measures in the design for the Tafitoala-Fausaga scheme were direct results of lessons learnt from the damages caused by Cyclone Evan in 2012, whereby the damage to EPC's hydropower infrastructure was concentrated on its aboveground steel penstock pipes and direct flooding of the powerhouse.

In addition, turbine runner erosion due to sedimentation is an ongoing issue in Samoa. Traditionally, sedimentation has been removed from water via large desanding basins, which require constant maintenance through flushing and can be costly. As an alternative, 1-mm Coanda screens were used for these new schemes. This alternative approach allowed for the screening of sediments at the intake, reducing the risk to the turbines and the need for constant operation and maintenance. To our knowledge, the use of these types of screens was a Pacific first. Since going into commission, the intakes are achieving their design objective.

Considering the pipeline for small hydro can account for between 40% and 60% of the overall capital cost, GRP is a very cost-effective solution for small hydropower. The key to success is having the skills and resources to install the pipe. In addition, there are advantages to a coupler-type arrangement over other alternatives, such as welding, which require strict quality assurance. The joint venture team of Pernix and MAP brought their previous experience of working with GRP in New Zealand to the Samoan projects, which was critical to achieving successful testing.

While it was desirable to place most of the pipes underground, it was not possible on every occasion. The Faleata scheme could only be accessed via a walkway up the river, making machine access to the intake and initial section of pipeline impossible. Thus, construction of a trench was out of the question. The Pernix/MAP JV team developed an innovative technique of manually handling and installing pipes up to the Faleata intake using a trolley system, before lifting the pipes into place.

Capacity building

The transfer of best practices, tools and procedures was top priority for all parties involved. Capacity building and knowledge transfer was achieved through a number of avenues, including:

- Training local subcontractors in GRP pipeline installation
- On-the-job training with local subcontractors on hydropower installation and commissioning
- Implementation of higher levels and health and safety management and associated training, with benefits to the project and the people working on them
- Training on quality assurance and quality control requirements.
- Hydropower operation and maintenance training for EPC staff.

The Tafitoala-Fausaga and Faleata hydropower plants should allow future small hydropower projects to be maintained locally in Samoa. By participating in these projects, consultants are provided insights into the constraints faced by local partners, which otherwise might not be obvious. Simultaneously, local partners benefit by learning from participating and then honing their skills by performing alongside us. Should EPC wish to develop and construct additional projects, local contractors with the relevant skills and experience are now available.

Why small hydropower

The increased penetration of utility-scale solar PV systems that feed directly into the national grid has proven to be problematic for EPC in the context of reliability. The variability of solar resources during diurnal peaks has often resulted in brown-outs and in the worst cases total system failure, with system frequency going well below safety levels. As a countermeasure, EPC is forced to run its expensive medium-speed diesel generator to provide spinning reserves during the diurnal peak hours.

Building these new hydropower schemes will allow EPC to manage their grid better. In addition, the flexibility of storage on a number of the schemes has allowed EPC to use solar PV during the day and hydropower at peak times (typically first thing in the morning and early evening) when solar PV is not available.

The Samoa success story

Samoa's renewable energy success is the result of a strategy that includes numerous projects both at a government level (with aid funding) and through private developers. Even with the increase in solar PV, small hydropower has been an essential ingredient in the renewable energy mix and will continue to serve Samoa with clean and reliable renewable energy.

Resilience is key to future projects. This is even more important across the Pacific where dramatic climate impacts are being felt. Projects must be resilient to both natural disasters and climate change and be easy to maintain and operate so as not to lead to the build-neglect-rebuild paradigm. Not addressing these issues can create legacies that could cripple a country should they become overdependent on them.

Acknowledgments

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