

meridian



Major Environmental Impact Assessment

Popua 1MW Solar Farm

Report completed in cooperation with
Tonga Energy Road Map
Tonga Power Limited
Meridian Energy Limited

Project details

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Executive Summary

Meridian Energy Limited (Meridian) and Tonga Power Limited (Tonga Power) are proposing to build a 1 Megawatt AC photovoltaic solar farm at the Tonga Power generation facility in Popua, Tongatapu. The Popua Solar Farm will generate an estimated 1,700 – 1,900 Megawatt hours annually¹ and account for approximately 4% of the Tongatapu's electricity generation. The generated electricity will directly offset the burning of 250 litres of diesel per Megawatt hour, reducing Tonga Power's diesel consumption by approximately 425,000 – 475,000 litres and displace around 1,100 tonnes of CO₂ emissions annually.

The proposed solar farm will be constructed on land adjacent to the existing diesel generation facility and the Tonga Maritime Polytechnic Institute. There is no known endangered flora or fauna species occupying the land and it is understood that a large portion of the land has been previously reclaimed. The site has been modified, had several uses and is presently cleared, vegetated with grass and often mowed. It is proposed that the environmental impact of the facility will be minimal and greatly outweighed by the environmental benefits of less diesel burnt to produce electricity and the corresponding reduction of CO₂ emissions and other greenhouse gases associated with burning diesel.

The construction of a solar array will limit Tonga's exposure to the fluctuating price of diesel oil and be a flagship project for the Tonga Energy Roadmap, progressing the Government of Tonga's goal of 50% of electricity supplied through renewable energy.

Other project sites have been explored, but the land adjacent to the Tonga Power Generation facility is considered most appropriate for this first project because of the robust electrical connection and integration advantages, along with the proximity to Tonga Power's staff and facilities.

The Popua Solar Farm will have a positive and measurable impact on the Tongatapu environment and economy. These key attributes of the project are also expected to translate into social benefits for the people of Tongatapu.

¹ Final generation estimates and diesel displacement will be agreed with Tonga Power as a part of final PPA negotiations

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1. Introduction

Tonga Power produces all its electricity through diesel fired generators. Tonga Power, Meridian, the European Investment Bank and the governments of both New Zealand and Tonga are working together to develop a 1 Mega Watt (MW) AC photovoltaic (PV), solar array at the Tonga Power generation site in Popua, Tongatapu. The Popua Solar Farm is expected to generate approximately 1,700 – 1,900 Megawatt hours (MWh) of electricity per annum which is around 4% of Tongatapu's electricity demand. The solar array will offset approximately 425,000 – 475,000 litres of diesel and around 1,100 tonnes of CO₂ per annum.

Under Tonga's 2003 Environmental Impact Assessment Act and 2010 Environmental Impact Assessment Regulations the construction of a solar farm is labelled as a "major project" because it is an "electricity generating station" and Form 3: Major Environmental Impact Assessment applies to this Environmental Impact Assessment. This document is intended to provide the information required under the Act and Regulation.

Tonga Power is 100% Government owned and currently reticulates electricity across 4 islands with the main island, Tongatapu, accounting for 85% of the customers, assets and sales. The company has approximately 21,000 customers and produces 51 GWh of electricity annually (44 GWh on Tongatapu alone).

The Tonga Energy Road Map team is a Government organisation under the Prime Minister's office. Its focus is to reduce Tonga's vulnerability to oil price shocks and achieve an increase in quality access to modern energy services in an environmentally sustainable manner.

Meridian Energy is New Zealand's largest renewable energy generator, with hydro, wind and solar assets in New Zealand, Australia, Antarctica and the USA. Meridian is committed to renewable energy generation in New Zealand and throughout the world and is proud of its environmental and sustainability practices.

2. Project Description

Purpose and Direct Benefits

Tonga is highly dependent on imported fuels to meet its overall energy requirements. All grid-supplied electricity, which accounts for over 98% of electricity used in Tonga, is generated using imported diesel fuel. This has meant that the Tongan economy and electricity consumers have been exposed to high and volatile electricity prices linked to oil prices over the last ten years. Between 2001 and 2004, the average price of crude oil increased from around US\$25 per barrel to around US\$40 per barrel, an increase of 60%. In the next 4 years to 2008, the average price of crude more than doubled to a peak of around US\$100 per barrel. In late 2008, crude oil prices dropped and continued fall into early 2009 averaging around US\$62 per barrel during 2009. Diesel prices tracked the price of crude oil and led to Tongan electricity rates exceeding TOP1.00/kWh in late 2008. Crude oil price is expected to increase in the future based on projections from the United States Department of Energy.

In accordance with the Tongan Government's 10 year Energy Roadmap, the purpose of the Popua Solar Farm is to reduce Tongatapu's reliance on diesel-generated electricity by generating electricity directly from renewable energy resources. The Popua project is a key pilot for future solar and possibly wind generation projects in the Kingdom of Tonga, and an important first step in meeting the goal of the Government of Tonga to generate 50% of its electricity from renewables by 2012.

Implementing this solar project will reduce Tonga's exposure to the fluctuating price of diesel fuel, decrease its carbon footprint and place the Kingdom of Tonga as a leader in small-grid connected renewable solar generation. The direct benefits that Tongatapu will enjoy include:

- a reduction in the exposure of the electricity power price to diesel, with the solar facility reducing annual diesel requirements by approximately 425,000 – 475,000 litres per annum;
- employment opportunities, which could see up to 15 locally sourced positions during construction;
- up skilling of workforce in construction and operation of renewable energy technologies, and
- a regional showcase for renewable energy generation in the Pacific Islands.

Technology

Solar power generation is currently one of the fastest growing areas in renewable energy. Solar photovoltaic (PV) technology is well proven and solar panel manufacturers now provide 20-25 year production warranties with the panels themselves typically lasting up to 35-years. Compared to alternative renewable generation technologies such as wind turbines or biofuel generators, solar panels have no moving parts and very low maintenance requirements, making them particularly suited to Pacific islands.

The present solar array design will employ approximately 5,600 polysilicon PV modules with centrally located inverters and connection equipment located adjacent to Tonga Power's existing generation facility.

While the Popua Solar Farm will only generate power during the day, this will be a good fit with Tonga Power's load profile which is typically 0.5 to 1 MW higher during the day than at night.



Figure 1 – Meridian’s 5MW CaIRENEW-1 Solar Farm in Mendota, California

Location

The Popua Solar Farm project footprint will occupy approximately 2.5 hectares of land adjacent to the Tonga Power Generation facility in Popua, Tongatapu and includes a field behind the Maritime Polytechnic Institute. The land adjacent to the power station is leased by Tonga Power and has been previously cleared, predominantly grassed and mowed often.

The additional land behind the Maritime School will also be leased by Tonga Power and at present is unused by the school, in poor state and littered with a number of shipping containers around the outskirts. The project will establish a new security fence around the whole facility and a new access track around the southeast corner of the project for the School to access the lagoon wharf.

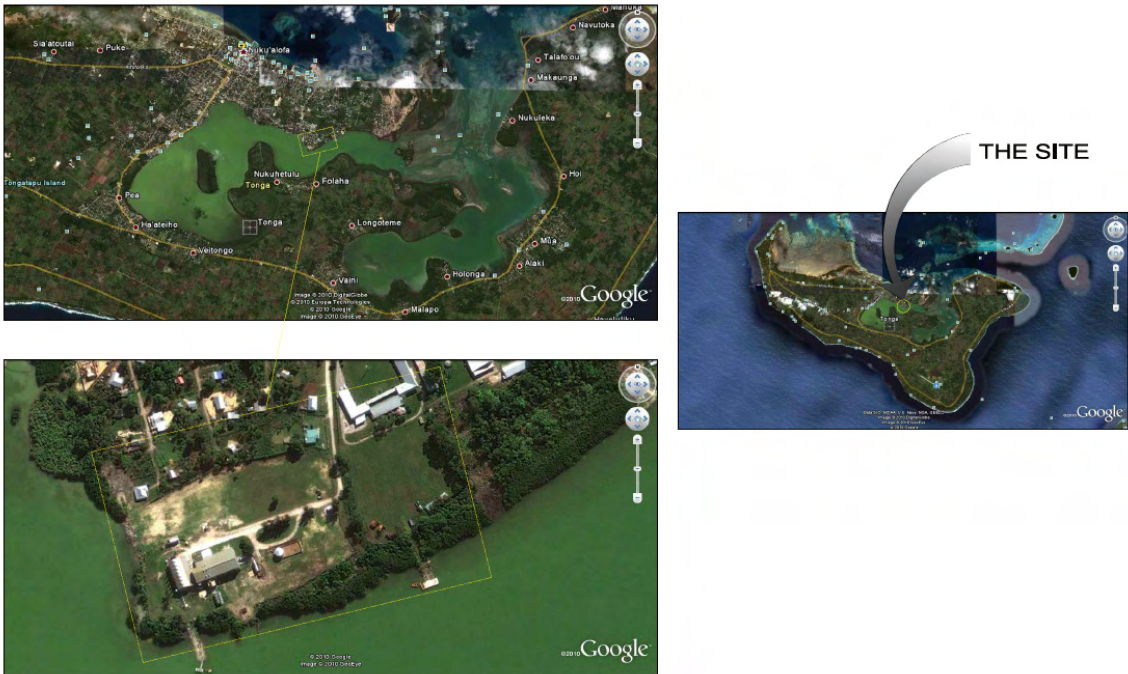


Figure 2 – Popua Solar Farm site location. Layout provided by ITS Pacific, Tongatapu

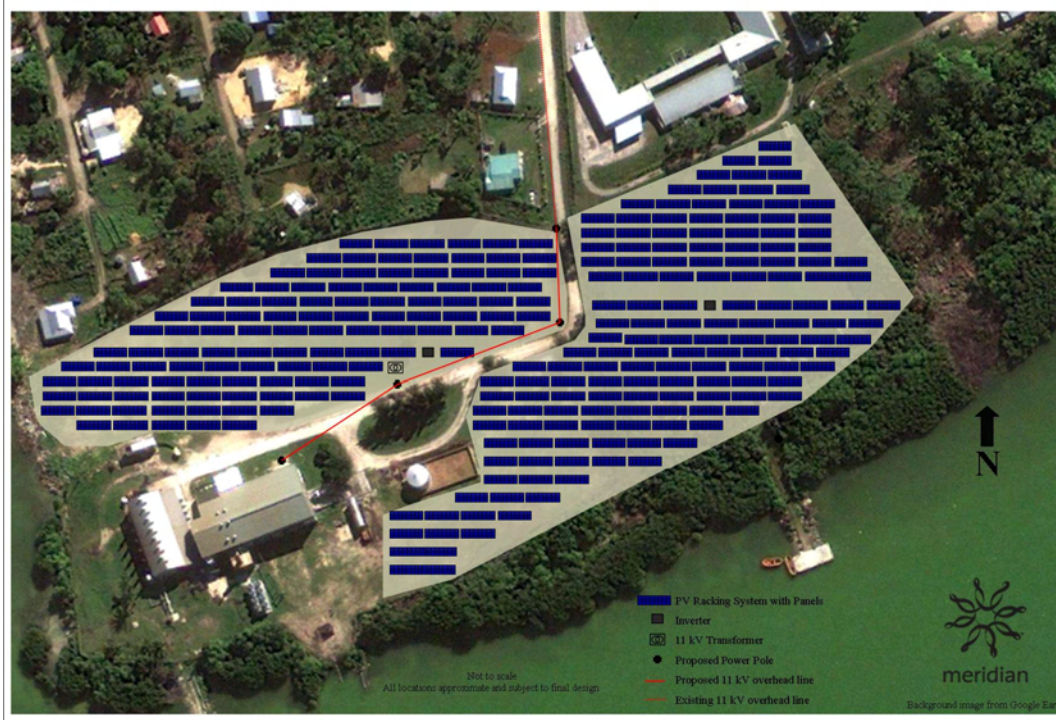


Figure 3 – Indicative Popua Solar Farm site layout

The proposed development site is on previously modified land and geotechnical investigations show some of the area is likely to be reclaimed land. Environmental impacts from the facility are expected to be minor, with clearance of scrub between the two fields and some trees around the outskirts of the northern and eastern site boundaries. Some of these trees are beyond the site boundary on residential land, Tonga Power will facilitate discussions with the effected parties to negotiate removal of these trees.

The gravity based design of the foundations will comprise of concrete blocks placed on the surface of the site. Concrete will be sourced from local contractors and the construction operator will employ a small local labour force (approximately 15 personnel). The solar modules, racking system, electrical inverters, transformers and electric cabling will be sourced from overseas. The solar manufacturers enforce strict environmental standards during manufacturing. The solar farm components are composed of non-toxic materials and are easily removed after the life of the project.



Figure 4 – Proposed solar farm site looking southwest towards Popua Diesel Generation facility



Figure 5 – Proposed solar farm site looking northeast towards security hut and Maritime School



Figure 6 – Proposed solar farm site behind Maritime School – looking northeast



Figure 7 – Proposed solar farm site looking north towards Maritime School buildings

Local Infrastructure Requirements

The project construction phase is expected to be completed in four to five months from commencement. The effect on local infrastructure will be additional heavy vehicle and construction worker traffic to and from site as well as additional wharf activity. The site access road is currently regularly used by heavy vehicles accessing the diesel generation facility, including daily fuel deliveries to the onsite diesel storage tank.

Although the existing Tonga Power generation facility is operational 24 hours a day, it is not expected that the solar farm construction team will need to operate outside of normal daytime work hours.

The Popua Solar Farm will be connected into the main generation switchboard at the existing Popua diesel generation facility, with transmission cabling contained within the facility.

A new security fence will be constructed to encapsulate the whole diesel and solar generation facility with the security hut moved to a new access gate at the end of the access road. A new access way will be constructed around the southeast boundary to enable the Maritime School unimpeded access to the lagoon wharf.

Capital and Resource Inputs

The Popua Solar Farm project is expected to cost approximately \$US 6.5m (excluding Tonga Power costs to secure land), with funding provided by the New Zealand Aid Programme, European Investment Bank and Meridian Energy. Tonga Power will also be a key partner in the project, sub-leasing the land to the project, providing the transmission connection point and operational support. After 20 years, full ownership of the facility will transfer to Tonga Power with an anticipated 15 years remaining life.

While the construction management and equipment supply will be provided from offshore companies, it is expected that local contractors and labourers will also be employed during this infrastructure development project.

Tonga Power employees will also have the opportunity to increase their knowledge of solar technology and be involved in the renewable integration aspects of the project. Tonga Power employees are also likely to be involved in the ongoing operation and maintenance.

Once operational the facility will have minimal natural resource requirements, other than occasional washing of panels to remove dust and saline residue.

Construction Period and Operating Life

The facility is expected to be commissioned by 1st November 2011. The main solar facility construction period will be approximately three months, however site preparation work will commence prior to this and could begin as early as May 2011.

The asset life of the solar panels is expected to be 35 years. Most top tier solar module manufacturers now provide a 5 year product warranty and a 20-25 year production warranty that guarantees module output to approximately 80% of nameplate output. The balance of plant would generally have a design life of around 20 to 25 years and may require refurbishment to match the useful life of the solar modules. In the case of inverters, a refurbishment would likely require replacement of some of the inverter components. In regards to the module mounting system, a refurbishment could range from minor structural repairs through to replacement of the entire mounting system (or a significant portion of it). The concrete foundations will be expected to comfortably meet the module asset life of 35 years. Once module life has been reached, re-powering with new solar modules could be an option depending on the integrity of the mounting system.

At the physical end of the asset life, solar modules (mainly glass, aluminium & silicon) can be fully recycled either locally (if an appropriate recycling facility is available) or overseas. The aluminium racking system could also be fully recycled.

3. Development Activity Justification and Impact

Benefits of the Project

The proposed Popua Solar Farm will have a positive environmental and economic effect on Tongatapu.

The key environmental benefits will be the reduction of diesel consumed by the existing generation facility, with the consequential reduction of CO₂ and other greenhouse emissions from the diesel generators.

The key economic benefits include a generated power price from the solar facility that is independent from the price of diesel, the up-skilling of the Tongan labour force and the contracting of a local civil construction company and labourers.

Economic Benefits

Presently, Tonga Power produces electricity entirely from diesel. The solar farm will generate approximately 1,700 – 1,900 MWh of electricity annually or 4% of Tongatapu's annual electricity demand. This solar generation will offset approximately 425,000 – 475,000 litres of diesel and around 1,100 tonnes of CO₂ per annum.

Based on reported figures in the Tonga Energy Road Map, Tonga Power's diesel fuel cost increased from an average \$US80/barrel in 2005 to an average \$US154/barrel in 2008. These coincided with crude oil prices averaging \$US50/barrel in 2005, and \$US91.5/barrel respectively. While crude oil prices fell back to 2005 levels after the global financial crisis, they have steadily increased back up to \$US90/barrel levels by the start of 2011 and some have predicted it to rise to over \$US105/barrel by the end of the year. This would result in delivered diesel prices in Tonga of between \$US150-180/barrel during 2011.

At these crude oil prices, the solar farm would directly reduce Tonga Power's annual diesel purchases by \$US 400,000 to \$US 530,000 per annum.

In addition to smoothing out the cost of 4% of Tongatapu's electricity generation, the project financing structure will result in the ownership of the Popua Solar Farm transferring to Tonga Power at minimal cost after 20 years, with another 15 years of production life still possible at low cost.

Employment Benefits

During the four to five month construction period there may be a number of local contractors and labourers employed by the head contractor. The proposed concrete footings for the solar arrays are expected to be sourced from concrete production facilities in Tongatapu.

Tonga Power employees will be trained on the maintenance and operation of the solar facility, and those who worked during the construction phase will have skill applicable to additional solar projects throughout the region.

Political and Social Benefits

The Popua Solar Farm will be the second largest in Oceania², and larger than any existing solar project in New Zealand or Australia. The solar farm will receive media coverage throughout the region and will illustrate Tonga's commitment to renewable energy generation, as well as being a flagship project for the Tonga Energy Roadmap. The project is supported and funded by New Zealand Aid Programme, a division of the Ministry of Foreign Affairs and Trade. Successful completion of the project will illustrate to the NZ Aid agency the benefit of working with corporate entities to develop infrastructure projects in Tonga.

The success of this project will raise confidence for investors and aid agencies to develop further solar and other renewable projects in Tonga. Ultimately this will increase the proportion of renewable energy generated indigenously and significantly reduce the dependence on imported fuel. The flow on effects for the consumer will be lower and more stabilised long run electricity prices than would otherwise have been seen.

Environmental Impacts from Construction

The Popua Solar Farm will be located on 2.5 hectares of land that has been previously modified and is now a grassed clearing with several rusting containers and broken concrete blocks in the southeast corner. The land is mowed often and does not harbour any known endangered species of flora or fauna. A detailed geotechnical underground report has been conducted on the site. It determined that the land is composed predominantly of sands and crushed coral with an organic layer below a high water table. It also determined a portion of the land was likely to have been reclaimed.

In terms of foundation design, the current preferred option (given the high water table) is to place concrete blocks 1.4m wide x 0.25m high x 3.0 m long on the ground surface and attach the racking system to the concrete blocks. This method will have minimal environmental impact, and is easily removable after the life of the project.

The greatest environmental impact will be during site preparation, which will include the removal of scrub and a small number of trees that have shading implications for the site. A portion of the ground will be cleared of its topsoil and replaced by locally sourced crushed coral aggregate. This aggregate will be placed to reduce ground settlement, limit flooding during a rain event and ensure the ground is level for the concrete block placement. The removed topsoil will be placed as a wind protection bund on the southeast section of the property and will not be removed from site.

The project footprint will not impact the lagoon or shoreline mangroves. Some coconut trees on the northern boundary of the site may need to be cut down to prevent shading of solar panels, and reduce the likelihood of branches or coconuts dropping onto panels and damaging them.

² The 2.1MW "Helios Bay" solar farm was commissioned in New Caledonia in 2010 and is the largest PV solar farm in the Pacific region

Another impact during the construction of the Popua Solar Farm will be the increased traffic to and from the site as well as additional wharf activity. The modules, racking system, inverters, transformers and cabling will arrive in Tonga via shipping container. The shipping containers will be transported to the Popua site by truck and unloaded. This increased traffic may cause delays for the local residents. Umusi Road, adjacent to the Tonga Power access road, has recently been maintained and can accommodate the required shipments.

An additional social impact is the lease for a portion of the adjacent Maritime Polytechnic Institute land has been transferred to Tonga Power for the construction of the Popua Solar Farm. An access way will be constructed between the Maritime School and the wharf for pedestrian access around the south east corner of the site.

The current understanding of the Popua site is that it is of no significant historical or archaeological significance.

Environmental Impacts from Operations

After construction, the project impacts will diminish. After construction, traffic to and from the Tonga Power site will reduce to present levels. The solar facilities contribution to noise in the vicinity will be undetectable and definitely insignificant compared to that of the adjacent diesel generators. In fact, it is feasible that the solar array may act as a partial noise barrier between the diesel generators and the neighbouring residential area.

There will be some visual impact with the addition of the solar panel arrays on the site, including the possibility of some glare from the panels, even though they are designed to absorb the incident solar radiation. The arrays will be less than 3m high at their peak, and will be on a fixed 20 degree angle facing due north.

However, the proposed sites for the arrays are currently bounded by dense vegetation to the southeast and southwest between the land and the lagoon. A number of properties, including the Maritime school are located to the northwest of the project site. Many of these have their own bushes and trees along the fence line. Given the flatness of the land, the existing vegetation, diesel tank and generation building, neighbours to the northwest of the site have no "view" of the lagoon that can be impacted by the solar arrays and visual impact from the Popua Solar Farm will be low.

The foundations and racking system will be designed to withstand powerful cyclones, which will limit the probability of generation unavailability as well as reducing any potential hazard of panels being lifted up and blown onto adjacent properties.

Net Benefit

In short, while there will be short term additional noise, dust and traffic at the site during construction, the long-term environmental impacts of building a solar farm at the site will be negligible. The long-term operational and economic effects of the Popua Solar Farm will be positive and outweigh any impacts during construction and operation.

4. Mitigation Measures

The major adverse effects of construction are increased traffic and ground disturbance. The environmental effects during operation are minor. If the increased traffic causes an issue with local residents, a scheduled time for shipments to and from the wharf can be created. The preferred foundation design of floating concrete pads is being proposed because it uses local materials and limits the ground disturbance.

The clearing of the top soil and placement of crushed coral aggregate will have a definite impact on the grassed site in appearance and habitat. This crushed coral aggregate is required in some areas of the

solar farm because of the potential for liquefaction and settling. Geotechnical studies indicate that the land is composed of loose sands, crushed coral layered below and above the organic matter. The geotechnical engineers believe the upper material may have been placed during a land reclamation project. The placement of additional crushed coral material for the solar farm will repeat a similar process carried out at an earlier date. Meridian will attempt to limit the amount of organic material removed from the site and the amount of crushed coral aggregate layered and compacted on the site, limiting the construction environmental impact. Any organic material removed from the surface will remain on site and be placed in the southeast corner of the property.

5. Alternatives to the Project

Solar Generation

Alternative sites were considered, but the Tonga Power Generation site in Popua was considered the best location for the solar farm as:

- It provides the most robust electrical connection - the Popua Solar Farm will connect directly to the main generation busbar, alongside the diesel generators. This connection point simplifies the electrical integration of the variable solar generation into the Tongatapu network;
- It is a brownfields site, providing existing facilities, security and operational workforce that will reduce capital and operating costs;
- The land has low agricultural, environmental or residential value, given the existing power generation operations and leases in place.

A potential solar generation site has been identified by Tonga Power on Taufa'ahau Road and discussions are under way with its owner. Investigations need to be undertaken on its suitability for a solar facility. It is almost certain that it will be more challenging and costly to develop than Popua as it is further away from transmission and is a greenfields site. It is not considered a suitable alternative to Popua as a pilot site for solar generation, but it has potential to be the next best site for solar generation once the Popua Solar Farm has been successfully developed. Lessons learned from the Popua site will be directly applicable to the future development of the Taufa'ahau site.

Development of the Popua Solar Farm will be a key enabler for future solar farms in Tonga.

Wind Generation

The potential for wind generation is currently being investigated by the Tonga Energy Road Map team – but this form of generation is highly dependent on long term wind monitoring to be undertaken prior to planning the project. The TERM team are planning to install a number of masts around Tongatapu to begin assessing wind resource. It is yet to be determined whether wind generation technology will be viable in Tonga – however, given the different nature of the wind resource to solar- the two technologies will be complementary from a grid integration perspective.

Wave Generation

The TERM team are also investigating the potential for wave generation on Tongatapu. Wave power technologies are in their infancy worldwide and it may be a number of years before this technology is suitable for deployment. As with wind, wave power would be complementary to solar.

6. Implications of Not Implementing the Project

The Popua Solar Farm will be a key pilot to the future development of other solar and alternative renewable projects in Tongatapu and Vava'u. Future solar projects will benefit from the learnings from the construction and operation of the site, and other renewable projects will benefit from the project development and financing structures that have been developed by the parties. A failure to implement this project would result in a loss of confidence by developers and likely set back other renewable development opportunities in Tonga by a number of years.

Presently, Tongatapu's peak electricity demand is 7.8 MW, down from 8.5 MW in 2007. This electricity demand is expected to rise by 2 to 3 MW (25-40%) over the next 5 years³ as the CBD reconstruction is completed. The Popua Solar Farm will generate around 4% of the island's annual electricity usage, and is a major step in integrating intermittent renewable energy to Tongatapu's grid. As stated earlier, the 1,700 – 1,900 MWh of electricity generated annually by the proposed solar facility will displace approximately 425,000 – 475,000 litres of diesel and around 1,100 tonnes of CO₂. Electricity will continue to be used by Tongan consumers whether the solar farm is built or not. If the solar farm is built, less diesel will be imported and burned on Tongatapu.

7. Cumulative Effects of the Solar Farm

The Popua Solar Farm will be located adjacent to the existing Popua diesel generation facility which consists of two large buildings housing the diesel generation and a diesel storage tank. While the facility will result in a large number of new solar array structures, these will be no higher than 3m and visual impact on neighbouring properties will be limited by existing vegetation along their boundaries.

Presently, there is no scope for additional solar generation near the Popua site. A potential solar farm site has been identified on Taufua'ahau Road. Because of the spatial distance, there will be no negative cumulative environmental effects of constructing an additional solar farm.

8. Public Involvement

Given the Popua site's existing use for electricity generation and the small number of residences adjoining the facility, the social impact of the facility is expected to be quite limited. Meridian and Tonga Power will need to engage with the local Town Officer and neighbours to the site who may be directly affected by the development of the facility – most notably if any trees on their property need to be removed to prevent shading or potential damage to solar panels.

The Ministry of Environment and Climate Change has provided a "Development Application – Site Notice" to be erected in a prominent position at the Popua site. This notice will remain in position for 20 days and will direct the public to the MECC office to view site plans and project information and to make any appropriate submissions.

9. Correlation with the Government of Tonga Development Plan

The Tongan Government in 2009 approved a policy to supply 50% of electricity generation through renewable resources by 2012. This ambitious target represents a clear direction from the Tongan Government that reducing the country's vulnerability to future oil price shocks is a key objective, and renewable solar energy may be a major element of its strategy. The Tonga Energy Road Map was published in April 2010 and its focus is to maintain social and environmental sustainability and develop least cost projects to meet Tonga's renewable energy needs.

The Tonga Energy Road Map considered all potential sources of renewable energy, with wind, bio diesel from coconut oil and solar the more viable options. The study found that:

³ Tonga Power Limited, CBD Load Estimation, 9th August 2010

- Wind energy requires comprehensive data and precise location planning in order to be cost effective and viable. Wind also requires extensive ongoing maintenance.
- There is significant uncertainty in the coconut oil supply and reliability, and logistical and economic challenges associated with collecting the biomass.
- Solar energy is the most universally available renewable energy resource in the Kingdom, and although it requires a large capital investment, its annual maintenance costs are minimal, and over time with comprehensive data collection the annual generation of solar can be accurately predicted.

The proposed Popua Solar Farm is in accordance with the Government of Tonga's energy and environmental sustainability programmes. It is supported and funded by the New Zealand Ministry of Foreign Affairs and Trade, will reduce Tonga's diesel consumption and carbon footprint and place Tonga as a leader in renewable energy in Oceania.