

SECTOR ASSESSMENT (SUMMARY): ENERGY

A. Sector Performance, Problems, and Opportunities

1. Tonga is a Pacific country of 177 islands with an estimated population of 103,000. Its main island groups are Tongatapu, Ha'apai, Vava'u, 'Eua, and Niuas group (comprising Niuatoputapu and Niuafu'ou). About 36 of the islands have permanent settlements, and more than 75% of the country's people live on Tongatapu, the main island and the location of the capital, Nuku'alofa. The electricity grids on seven of the outer islands that are involved in the overall Outer Island Renewable Energy Project—to be financed in part by the additional financing—are currently powered by diesel generators. On Niuas, scattered solar home systems and small diesel generators supply electricity to a limited number of households.

2. Tonga Power Limited (TPL) is solely responsible for providing grid-connected electricity services in Tonga. TPL is a vertically integrated public enterprise wholly owned by the government and under the oversight of the Ministry of Public Enterprises and the government's cabinet. It has concessions to operate four independent grids: the largest, which is on the main island of Tongatapu, and three smaller grids on the main islands of the 'Eua, Ha'apai, and Vava'u island groups. TPL generates, distributes, and sells electricity, and provides operation and maintenance (O&M) services.

3. Peak demand on the four TPL grids in 2016 was about 11.1 megawatts (MW), and demand for the year totaled about 55 gigawatt-hours. An estimated 13 million liters of diesel fuel were used to generate this electricity at a cost equivalent to about 10% of total gross domestic product and 15% of the value of total imports. It is expected that the peak capacity demand will increase to 17.2 MW by 2020 and that annual consumption will rise to 66 gigawatt-hours.¹

4. Petroleum dependency makes Tonga highly vulnerable to oil price changes and shocks, which affect the affordability of food, goods, electricity, and transport. More than 91% of Tonga's overall grid-connected electricity demand is supplied by generators fueled by imported diesel. This reliance on fossil fuels exposes the economy to high electricity tariffs because of volatility in oil prices. In addition, electricity tariffs are high in Tonga compared with those in other countries that import fossil fuel for power generation. This is because of its remote location and the high cost of transport.

5. On the TPL concession islands of Tongatapu, 'Eua, Ha'apai, and Vava'u, the electricity tariff in March / April 2018 was \$0.36 per kilowatt-hour (kWh). This comprised a base energy rate (or nonfuel component) of \$0.21 and a variable fuel surcharge component of US\$0.15. The electricity provider has rights under the concession contract to pass fuel costs on to consumers and charge an inflation-indexed nonfuel tariff. The nonfuel tariff covers operational costs, overhead expenses, interest payments, depreciation, and an allowed return on investment that provides retained earnings for future capital expenditure and dividend payments to shareholders. In the non-TPL, mini-grids, and off-grid outer islands of the Ha'apai and Niuas groups, the average cost of electricity has been conservatively calculated at about \$0.74 per kWh for the fuel

¹ TPL had a total installed grid connected power capacity in 2016 of about 20.827 MW. Ideally, a power generation utility is expected to have more capacity than demand. The exact ratio varies depending on the specifics of the market, but a rule of thumb is from 1.75 to 2.25. In a power system with high penetration of renewables, sufficient reserve capacity (e.g., spinning reserve) for the electricity supply is needed to compensate for a rapid, unexpected loss in generation resources in order to keep the system balanced.

component only. A nonfuel component (e.g. administration, asset management, and O&M records) has not been included. If a nonfuel component were to be included, the tariff would easily exceed \$1.00 per kWh.

6. The power distribution system is part of the electricity supply chain and requires considerable investment and O&M. Power distribution assets typically represent 20%–30% of the required power system investments in electricity industries worldwide, but this figure is about 42% for TPL. The standard losses in rural power distribution networks are generally about 7%, but the rate is about 13% in Tonga. Greater losses mean that more fuel is consumed in power generation, which makes improving the efficiency of the country's power system a matter of interest for both TPL and Tonga's consumers.

7. **Generation and distribution in Vava'u.** The Vava'u grid is served by the Taumu'aloto power station, which contains five diesel generator sets with a total installed capacity of about 1.9 MW, comprising two 186-kilowatt (kW) units, one 320 kW unit, and two 600 kW units. In 2010 TPL replaced two 300 kW units with the two 600kW units to maintain the N-1 reliability criteria.² Transmission is at 6.6 kilovolts (kV) and distribution at 415 volts (V). The number of customers served as of 2016 was 3,300.

8. No long-term load records are available for the Vava'u grid. As of 2017, the Vava'u system peak is 1.01 MW and that it has minimum loads of about 380 kW. Vava'u has customers in the tourism industry, and daily loads in the hot season are expected to increase. The system runs normally at a power factor above 0.9. The generator configuration in Vava'u allows flexibility in dispatch. No interruptible customers or dispatch loads have yet been identified in Vava'u.³

9. The Asian Development Bank (ADB) carried out a preliminary design of the project-funded 400 kilowatt-peak (kWp) solar power plant on Vava'u in 2012 under the current Outer Island Renewable Energy Project approved in 2013.⁴ However, a 420 kWp solar photovoltaic plant funded by the Abu Dhabi Fund for Development has been operating on Vava'u since November 2013. Throughout the course of the year, the 420 kWp solar plant meets approximately 20% of the Vava'u demand. This plant's storage system was undersized and does not contribute any significant amount of energy. Constructing additional photovoltaic and battery capacity is required if TPL is to meet its 50% renewable energy target by 2020. However, this would take a significant amount of funding. In an effort to enable the possible future enlargement of the existing solar generators, ADB aims to strengthen the Vava'u distribution network.

10. **Generation and distribution in Ha'apai.** The Ha'apai power station is located on the island of Lifuka and also serves the adjacent island of Foa through an 11 kV line. It is equipped with two diesel electric sets with a combined capacity of 372 kW. One of the generators provides base load while the second is switched on automatically when the load reaches 92% of the single unit's 186 kW capacity (i.e., 170 kW). When the load drops below 72% of the capacity of an individual unit (i.e., 140 kW) in the dual-generator operation, one generator is switched off.

² The N-1 criteria express the ability of the transmission system to lose a linkage without causing an overload failure elsewhere.

³ In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred.

⁴ ADB. 2013. *Report and Recommendation of the President to the Board of Directors: Proposed Grant and Administration of Grant to the Kingdom of Tonga for the Outer Island Renewable Energy Project*. Manila.

11. These current settings allow the units to operate below 40% of their rated capacity and to use fuel efficiently. In 2015, TPL reallocated a 300-kW diesel power generation unit from Vava'u. The Ha'apai system peaks at 310 kW, has minimum loads of 110 kW in the early morning hours, and runs at a power factor of 0.88–0.92. Transmission is at 6.6 kV and distribution at 415 V. Customers numbered 1,200 as of 2016. Under ADB's current project, a new 550 kWp solar photovoltaic plant coupled with large storage devices (batteries and battery inverters) is to be built. This will achieve the target of 50% renewable energy penetration on Ha'apai.⁵

12. **Generation and distribution in 'Eua.** The 'Eua power station consists of two containerized diesel electric sets with a combined capacity of 372 kW. One of the generators provides base load while the second is switched on automatically when the load reaches 90% of the first unit's 186 kW capacity (i.e., 167 kW). When the load drops below 80% of the individual capacity of a unit (i.e., below 149 kW) in dual generator operation, one generator is switched off. As in Ha'apai, this setting allows the units to operate below 40% of their rated capacity and to use fuel efficiently. The 'Eua power station has the lowest load factor and the lowest fuel efficiency of all the systems in Tonga. The 'Eua system operates at a power factor of approximately 0.85, which is acceptable in a rural network. Transmission is at 6.6 kV and distribution at 415 V. It served 1,108 customers as of 2016. Under ADB's current project, a 200 kWp solar photovoltaic plant is to be built on the island of 'Eua.

13. **Generation and distribution on the outer islands of Ha'apai.** The Nomuka island power station consists of two diesel electric sets. The combined capacity is 80 kW, and the power factor is about 0.8. The Ha'afeva, Ha'ano, and 'Uiha power stations each consist of two electric sets, with a combined capacity of 59.5 kW. The power factor is about 0.8. These islands are outside of TPL's concession contract area. ADB's current project will increase the capacity of the mini-grid system on 'Uiha (by 100 kWp) and Ha'afeva (by 150 kWp).

14. **Generation and distribution in the Niuas.** The two villages on the island of Niuatoputapu have about 155 households and an overall population of about 600. No electricity is available except at the local school and a church, which have their own diesel generator sets. Most households use candles or lamps run on kerosene or batteries for lighting. The 700 people in the 211 households on the island of Niuafou'ou, also in the Niuas group, live in eight villages. The households have individual solar home systems that were provided by the Government of New Zealand through the New Zealand Aid Programme in 2006 and are maintained by a social committee. However, these home solar systems are unable to take on the load of regular home appliances. The island has about 20 individually owned 5 kV-ampere diesel generator sets. Island residents often use car batteries and kerosene lamps for their additional power and lighting requirements. The social committee collects about T\$120 for each new solar home system connection and about T\$15 a month for O&M. Most of the replacement parts are purchased from Fiji. The Niuas group is outside TPL's concession contract area. Under ADB's current project, the off-grid solar home systems will be replaced on Niuafou'ou. A centralized solar power system will be constructed, which will be connected to a new mini-grid on Niuatoputapu.

B. Government's Sector Strategy

15. The government has been attempting to reduce the cost of electricity supply and Tonga's vulnerability to oil price increases since 2008, when it approved a renewable energy act as a

⁵ The minor change in scope was approved on 5 June 2015.

regulatory instrument to promote the use of renewable energy technologies.⁶ In recognition of the sector's vulnerability to oil price rises, in 2009 the government set a target under its Strategic Development Framework, 2015–2025 to generate 50% of grid-based electricity from renewable energy resources and achieve a 50% reduction in diesel consumption by 2020.⁷ The Tonga Energy Road Map, 2010–2020 is the government's development, reform, and improvement plan for the energy sector.⁸ The road map was drafted in close coordination with development partners and pursues (i) enhancement of the petroleum supply chain, (ii) deployment of renewable energy technologies, and (iii) improvement of energy efficiency on both the supply and demand sides.

16. Overall responsibility for electricity sector policy and planning is shared by the Prime Minister's Office and the Ministry of Finance and National Planning (MFNP). The MFNP's policy and planning division helps other government entities formulate outcomes and outputs at operational levels, and monitors progress on strategic policy objectives. The MFNP is also TPL's contractual partner in the concession agreement that governs the state-owned, vertically integrated power utility's operations. TPL undertakes the expansion and investment planning for the four grids under its concession contract in the 'Eua, Ha'apai, Tongatapu, and Vava'u islands. Investment planning is scrutinized in a two-step process. TPL's board of director's reviews investment plans and requests any amendments and modifications required. After the board's endorsement, investment plans are submitted to the Electricity Commission for review and final approval.

17. The Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change, and Communications is responsible for mini-grid and off-grid (i.e., non-TPL grid) rural electrification planning and has not had a role in formulating policies or strategic plans for grid-based electricity supply. The Energy Department is not represented on TPL's board. Tariff setting is regulated by the Electricity Commission on the four main islands covered by TPL's concession. However, in the Niua and on the four outer islands of Ha'apai (Ha'afeva, Ha'ano, Nomuka, and 'Uiha), the electricity tariff is not regulated by the government and neither are the local electricity cooperative societies and management committees that manage the electricity systems on these islands.

C. ADB Sector Experience and Assistance Program

18. The original Outer Island Renewable Energy Project was approved on 27 June 2013 and became effective on 9 June 2014. To address the dual challenges of reducing high technical losses and incorporating climate resilience features for the grids on the outer islands of Tonga, ADB approved the two additional financings in 2015 and 2016.⁹ The current project includes the

⁶ Government of Tonga. 2008. *Renewable Energy Bill 2008*. Nuku'alofa.

⁷ Government of Tonga. 2010. *Tonga Strategic Development Framework, 2015–2025*. Nuku'alofa.

⁸ Government of Tonga. 2010. *Tonga Energy Road Map, 2010–2020*. Nuku'alofa.

⁹ (i) ADB. 2015. *Report and Recommendation of the President to the Board of Directors: Proposed Grant and Administration of Grants for Additional Financing to the Kingdom of Tonga for the Outer Island Renewable Energy Project*. Manila. ADB and the Second Danish Cooperation Fund for Renewable Energy and Energy Efficiency for Rural Areas provided \$2.19 million and the European Union provided €3.00 million, all on a grant basis. TPL will provide \$0.67 million as an in-kind contribution. The first additional financing was approved on 20 October 2015 and became effective on 30 November 2015. (ii) ADB. 2016. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Grant for Additional Financing to the Kingdom of Tonga for the Outer Island Renewable Energy Project*. Manila. ADB provided a loan of \$2.5 million equivalent and a grant of \$2.5 million from ADB's Special Funds resources as well as an additional contribution from TPL of \$0.60 million. The second additional financing was approved on 14 December 2016 and became effective on 28 March 2017.

original project and the two additional financings.¹⁰ ADB has been implementing emergency assistance for reconstructing and climate- and disaster-proofing the electricity network and school facilities in the Ha'apai islands since January 2014.¹¹ The proposed additional financing project is in line with ADB's country operations business plan for Tonga, 2017–2019, which makes the deployment of renewable energy sources a priority area of support.¹²

¹⁰ All grants and the loan are administered by ADB.

¹¹ ADB. 2014. *Report and Recommendation of the President to the Board of Directors: Proposed Grant and Administration of Grant to the Kingdom of Tonga for the Cyclone Ian Recovery Project*. Manila.

¹² ADB. 2016. *Country Operations Business Plan: Tonga, 2017–2019*. Manila.

Problem Tree for Energy

