ECONOMIC ANALYSIS

A. Introduction

1. An economic analysis of the proposed third round of additional financing to the Tonga Outer Island Renewable Energy Project (OIREP), which includes a $2.6 million grant from the Global Environment Facility (GEF) and $0.74 million from the Australian Department of Foreign Affairs and Trade (DFAT)—to be administered by the Asian Development Bank (ADB)—and $5.5 million of ADF grant assistance, has been conducted in accordance with ADB's Guidelines for Economic Analysis of Projects (2017).

2. The original OIREP was approved in June 2013 to help reduce Tonga's dependence on imported fossil fuels and expand consumers' access to more affordable electricity through solar power generation.[1] The original project comprised a $2.0 million ADF grant a $4.5 million grant from the Government of Australia, administered by ADB. A first round of additional financing was approved in October 2015, which included a $1.4 million ADF grant and the administration of a $3.6 million equivalent grant from the European Union and a $0.75 million grant from the Second Danish Cooperation Fund for Renewable Energy and Efficiency for Rural Areas, and expanded the project's scope to include rehabilitation of the existing grid network near solar power generation systems in 'Eua and Vava'u.[2] A second additional financing ($2.5 million ADF loan and $2.5 million ADF grant) was approved in December 2016 to scale-up the grid rehabilitation component of the project.[3]

3. The proposed third round of additional financing will support (i) meeting cost overruns due to the higher bid price for the solar generation turnkey package to be implemented in the four Ha'apai outer islands ('Uiha, Nomuka, Ha'ano, and Ha'afeva) and Niuatoputapu; (ii) meeting financing gaps for building a mini-grid system in the island of Niuatoputapu and upgrading the existing electric service line in the four outer islands of Ha'apai;[4] (iii) meeting financing gaps caused by exchange rate fluctuations;[5] and (iv) meeting ongoing project management and technical advisory needs through to the end of the current project in 2019. Upgrades and rehabilitation of the Ha'apai power distribution system shall be financed by the $2.6 million grant from GEF, ADB resources amounting to $5.5 million in ADF grants, and $0.7 million in DFAT grants.

4. **Macroeconomic context**. Tonga has achieved high human development, ranking 101st of 188 countries (second only to Fiji among Pacific economies) as of the latest assessment, with per capita incomes at about $4,011 in FY2017 (ended 30 June 2017). Gross domestic product (GDP) growth averaged 2.9% from FY2014 to FY2017, with the economy buoyed by high public expenditure to finance reconstruction of damaged infrastructure and firmer private demand driven by recovery in remittances and private sector borrowing. The economy is projected to contract slightly in FY2018 due to the damage and losses from the impact of Cyclone Gita, which hit Tonga

[1] 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.
[2] 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.
[3] 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.
[4] The Government of Tonga was not able to timely confirm the funding contribution for this component.
[5] The applied foreign currency exchange rate is AUD1.00 = USD1.00 as per the original RRP. However, the average exchange rate from the effectiveness month (June 2014) of the original project until April 2018 is AUD1.00 = USD0.77.

in February 2018, before recovering to 1.9% growth in FY2019. However, the economy remains narrowly based and dependent on inflows of remittances and external assistance. Tonga is also highly vulnerable to disasters, as demonstrated by Cyclones Ian, Winston, and Gita all affecting the country just over the past 5 years. Expanding the use of renewable energy resources will lessen the economy's exposure to volatility in international prices for imported fuels.

B. Methodologies and Assumptions

5. As with the previous evaluation of current project components, economic analysis of this third round of additional financing is conducted on the basis of a world price numeraire. Costs of traded goods and services reflect economic prices as capital and operations and maintenance (O&M) expenditure for renewable subprojects are exempt from taxes and duties. Non-traded goods and service costs are adjusted to corresponding economic prices, using a standard conversion factor of 0.9 (implying a shadow exchange rate factor of 1.11). All costs and benefits are expressed in 2018 prices, and the analysis is conducted assuming a 1-year installation period and an economic lifespan of 25 years. The residual value at the end of the 25-year period is assumed to be small.

6. The economic feasibility itself was evaluated for the proposed additional financing component by comparing between the following without- and with-project scenarios. Under the baseline without-project scenario, electricity would be supplied through the existing inefficient power distribution networks in Ha'apai (as well as in 'Eua and Vava'u) with the corresponding high technical losses. In the with-project scenario, the existing power distribution networks will be rehabilitated with the proposed additional financing, and this is expected to bring down technical losses by about 5%.

C. Demand Analysis

7. Petroleum dependency makes Tonga highly vulnerable to oil price shocks, which affect the affordability of food, electricity, and transport. The peak demand of the four Tonga Power Limited (TPL) grids in 2016 is about 11.1 megawatts (MW), and the demand for the year was about 55 gigawatt-hours (GWh). It is expected that the peak capacity demand and annual consumption will increase to 17.2 MW and 66 GWh by 2020. In the outer islands of 'Eua, Vava'u, Ha'apai, and Niuas, total electricity demand is estimated at about 6.9 GWh as of 2017.

D. Cost–Benefit Analysis

8. The overall project will replace a total of 2.1 GWh per annum of existing diesel generation in the outer islands with solar power. Through the project, a hybrid system will be in place in each of the target outer islands, with diesel generation supplying the balance of electricity requirements, including backup, for each system. As with the ongoing project, this round of additional financing is expected to generate the following non-incremental economic benefits:

(i) **Fuel cost savings.** Diesel consumption will be reduced with the partial switch to solar, and since the rehabilitation of the existing power distribution networks under the new component of the overall project will reduce technical losses. The diesel saving benefit was derived by multiplying the amount of avoided diesel consumption by the unit economic cost of diesel—$0.70 per liter.[6] The volume of

[6] This is the average diesel price in Tongatapu for the year 2017 ($1.10 per liter) less excise taxes of 65 seniti per liter and a consumption tax rate of 15%.

net diesel savings is estimated by multiplying the electricity produced by diesel generators that will be replaced by solar in kilowatt-hours (kWh) by the unit volume of diesel required to produce 1 kWh of electricity. Transport costs from the main island to outer islands were also considered. The economic benefits from a net reduction in diesel consumption (i.e., for generation and transport) with the switch from the current full diesel generation system to a solar-diesel hybrid system is considered in the analysis.

(ii) **Distribution operation and maintenance cost saving.** The rehabilitation of existing power distribution networks is expected to reduce distribution O&M expenses of TPL by about 25%.[7]

(iii) **Energy and environmental benefits**. The environmental benefit of reduced diesel consumption and grid losses was quantified by accounting for the value of avoided carbon emissions. The economic cost of carbon is much higher than the existing carbon markets prices as the price of carbon should ideally equal the social cost. The social cost of carbon emissions is assumed to have a unit value of $36.3 per ton of carbon emissions or its equivalent as of 2016, as specified in ADB's Guidelines for the Economic Analysis of Projects. This increases by 2% annually in real terms reflecting the rising marginal damage of global warming over time.

9. The overall project, including the proposed additional financing components, also involves the following unquantified benefits, which are excluded in the economic internal rate of return (EIRR) calculation, because these benefits are hard to quantify although they are expected to exceed unvalued costs.

(i) **Climate resilience benefits.** The Government of Tonga requested ADB's support to rehabilitate TPL's grids following the devastation caused when Cyclone Ian passed directly over the northeast islands of Ha'apai in January 2014.[8] Both the ongoing grid rehabilitation work, which is being implemented under the current project,[9] and the additional rehabilitation work to be funded by the proposed additional financing will improve the climate resilience feature of TPL's grids.

(ii) **Gender and other social benefits.** Under the current project, 8 women out of 15 trained workers brought into the project by TPL, have previously completed similar tasks under the Cyclone Ian Recovery Project. TPL's effort may create a long-term employment opportunity for these female workers. The proposed additional financing will allow TPL to train those female field workers and create more opportunities for them.

[7] Based on TPL's experience in similar projects in other islands.

[8] Cyclone Ian was a category 5 system, with winds of more than 200 kilometers per hour (km/h) and gusts of about 300 km/h. About 5,000 people were directly affected—66% of Ha'apai's population. According to TPL, the cyclone damaged 90% of the Ha'apai power network's distribution lines, 40% of the high-voltage poles, 70% of the low-voltage poles, 65% of the transformers, 90% of the transformer structures, one of the two generators, and 95% of the streetlights. The grid reconstruction works were completed under the Cyclone Ian Recovery Project: ADB. 2014. *Report and Recommendation of the President to the Board of Directors: Proposed Grant and Administration of Grant to the Kingdom of Tonga Cyclone Ian Recovery Project.* Manila. Overall progress of rehabilitating the electricity network on Ha'apai has been satisfactory.

[9] ADB. 2015. *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 (Additional Financing)*. Manila. It is to rehabilitate 80% and 20% of existing grid networks on 'Eua and Vava'u.

E. Results of the Economic Evaluation

10. Recall that, inclusive of the first two rounds of additional financing, the current project yields an estimated EIRR of 12.3%.[10] Adding the costs of upgrading and rehabilitating power distribution systems on the four outer islands of Ha'apai—estimated at $6.2 million in economic terms ($6.9 million in financial terms)—reduces the overall project's EIRR to 7.7%. This remains above the economic opportunity cost of capital (EOCC) for social sector projects of 6%.[11] The overall project's economic net present value (ENPV) therefore remains positive at $2.5 million.[12] These results confirm that, under the baseline scenario, the proposed third round of additional financing still allows for the OIREP taken as a whole to maintain economic viability.

11. **Sensitivity analyses**. To gauge the impact of unfavorable developments, and to test the robustness of the overall project's economic viability, sensitivity was tested for each of the following scenarios: (i) a 10% increase in capital costs; (ii) a 10% increase in O&M costs; and (iii) a 10% reduction in benefits, for example through declines in diesel prices (and therefore lower savings) and reduced solar generation, respectively. Results are summarized in Table 1 below.

Table 1: Sensitivity Analyses Results

Variables	Change	ENPV ($ million)	EIRR (%)	Switching value
Base case		2.5	7.7%	
Capital cost overrun	10%	0.8	6.5%	14.6%
O&M costs increase	10%	2.1	7.5%	63.6%
Benefits decline (e.g., lower diesel savings, reduced solar generation)	–10%	0.1	6.1%	–10.6%

EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operations and maintenance.

12. The overall project's EIRR remains above the EOCC of 6% in all 3 scenarios considered. The largest potential reduction in economic viability occurs in the 10% decline in benefits scenario, for which an EIRR of 6.1% is estimated. This indicates that the OIREP's overall economic viability is highly sensitive to reductions in expected project benefits, most notably through lower fuel prices that can substantially cut savings or avoided costs from imported diesel. With fuel prices already rising from recent lows, and a conservative assumption of only 2.2% annual average increases in oil prices in real terms, the risk of diesel prices drastically falling well below baseline scenario levels can be considered relatively low.

13. A scenario with a 10% capital cost overrun reduces the overall project's EIRR to 6.5%. The corresponding switching value confirms that capital costs can increase by up to 14% and the EIRR would remain above the EOCC. However, with installed costs and levelized costs of solar power generation steadily falling, the risk of this scenario being realized is also likely to be very

[10] See Linked Document 9 (LD9 Economic Analysis) of 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.

[11] Recall that the lower minimum required EIRR for social sector projects of 10% was already applied in economic analysis of the second additional financing for OIREP (footnote 10). Under the revised guidelines, the corresponding minimum required EIRR for such projects has been reduced to 6%.

[12] No additional benefits are considered in this analysis as full cost savings and environmental benefits were already accounted for in previous rounds of additional financing, which assumed that distribution grid upgrading and rehabilitation would have been undertaken in parallel using Government of Tonga resources.

low.[13] As annual O&M costs for solar PV generation are low, a scenario with 10% higher O&M costs only results in a marginal reduction in the overall project's EIRR to 7.5%. In view of unquantified benefits outlined above, it can be concluded that the OIREP, inclusive of the proposed third round of additional financing, remains economically viable even under adverse scenarios considered.

F. Distribution Analysis

14. To gauge the project's impact on various stakeholders, distribution analysis was undertaken by comparing financial flows with broader economic benefits. Table 2 summarizes estimated financial versus economic net present values of project flows on consumers, labor, and the overall economy.[14] As would be expected, the results confirm that the bulk of economic benefits accrue to consumers in remote outer island communities targeted by OIREP investments. The overall economy, and labor employed by the project, also register net positive gains.

Table 2: Distribution of Project Impacts

	Project financial and economic net benefits			Distribution of net project benefits among stakeholders			
Project Costs and Benefits	**FNPV**	**ENPV**	**ENPV – FNPV**	**Consumers**	**Labor**	**Government / Economy**	**Total**
Output benefits	3.8	24.0	20.2	20.2			20.2
Capital costs	(18.3)	(15.7)	2.6			2.6	2.6
O&M costs	(4.0)	(3.6)	0.4			0.4	0.4
Labor costs	(2.5)	(2.1)	0.3		0.3		0.3
Project effects	(21.0)	2.5	23.5	20.2	0.3	3.0	23.5
Net financial benefits	(21.0)					(21.0)	(21.0)
Net economic benefits		2.5		20.2	0.3	(18.0)	2.5
Proportion of poor in stakeholder group				27.1%	27.1%	22.1%	
Benefits to poor stakeholders				5.5	0.1	-4.0	1.6
Poverty Impact Ratio (Benefits to poor / net economic effects)							**0.62**

( ) = negative, ENPV = economic net present value, FNPV, financial net present value, O&M = operations and maintenance.
Source: ADB estimates.

15. **Poverty impact ratio (PIR).** Latest available estimates place the proportion of Tonga's population living below the basic needs poverty line at 22.1% as of 2015.[15] No poverty estimates by island group are available, but under a reasonable assumption that poverty in the outer islands is about 5 percentage points higher than the national average, OIREP's PIR is estimated at 0.62. Under an even more conservative scenario where outer island poverty is only 2.5 percentage points higher, the PIR is reduced to a still high 0.42. These results confirm that OIREP investments can have outsize impacts on Tonga's poor and vulnerable, and could at least indirectly contribute to ongoing poverty alleviation efforts by government and development partners.

[13] Installed and levelized costs of solar PV are expected to continue declining globally for the foreseeable future due to expanded manufacturing capacity.
[14] For comparability, financial net present values (FNPV) are calculated using a discount rate of 6%, which is the same as the economic opportunity cost of capital used to derive the economic net present values. Thus, FNPVs differ from those reported in LD9. Financial Analysis.
[15] ADB. 2017. *Key Indicators for Asia and the Pacific 2017*. Manila.