His Majesty's Government of the Kingdom of Tonga

TONGA ENERGY ROAD MAP 2010 - 2020

A TEN YEAR ROAD MAP 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

FINAL REPORT

June 2010

TONGA ENERGY ROAD MAP (TERM) 2010-2020

A Ten Year Road Map to Reduce Tonga's Vulnerability to Oil Price Shocks
and to Achieve an Increase in Quality Access to Modern Energy Services
in an Environmentally Sustainable Manner

MAIN REPORT

Acronyms and Abbreviations

AC	alternating current
ADB	Asian Development Bank
ADO	Automotive diesel oil
ASTAE	Asia Alternative Energy Programme (Trust Fund managed by WB)
AusAID	Australian Agency for International Development
BAU	Business As Usual
BOO	Build Own Operate
BOT	Build-Operate-Transfer
CA	Concession Agreement
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Light
CNO	Coconut Oil
CPI	Consumer Price Index
CSCRE	Cabinet Sub-committee on Renewable Energy
DC	direct current
DSM	demand-side management
EC	European Commission
EC	Tonga Electricity Commission
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPU	Energy Planning Unit, Ministry of Lands, Survey and Natural Resources
EU	European Union
FOB	Freight On Board
GDP	Gross Domestic Product
IC	Internal Combustion (engine)
IRENA	International Renewable Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IUCN	International Union for Conservation of Nature
GHG	Green House Gas
GIS	Geographical Information Systems
GoT	Government of the Kingdom of Tonga
kV	Kilo Volts (thousands of volts)
kW	Kilowatt
kW-h	Kilowatt Hour
kWp	Kilowatt Hour peak for PV panels under standard conditions
LCT	local coastal tankers
LED	Light emitting diode (energy efficient light)
LPG	liquid petroleum gas
MoF	Ministry of Finance

MLA	Multilateral Lending Agency
MR	medium range (tanker)
MWh	Megawatt hour (1000 kW-h)
MAFFF	Ministry of Agriculture and Food, Forests and Fisheries
Nm^3	Normal Cubic metre
NZAID	New Zealand Agency for International Development
OI	Outer Islands in Tonga
O&M	Operation and maintenance
PEMM	Pacific Energy Ministers Meeting
PoC	Proof of Concept
PPA	Power Purchase Agreement
PRIF	Pacific Region Infrastructure Facility
PV	Photovoltaics
RAV	Regulated Asset Value
RE	renewable energy
REEEP	Renewable Energy and Energy Efficiency Partnership
RPM	Road Map Project Manager
SCADA	System Control and Data Acquisition
SME	Small and Medium Scale Enterprise
SPC/SOPAC	Pacific Community / Pacific Islands Applied Geoscience Commission
TERM	Tonga Energy Road Map (or "the Road Map")
TERM C	Tonga Energy Road Map Committee
TEPB	Tonga Electric Power Board
TGIF	Tonga Green Incentive Fund
TPL	Tonga Power Limited
TOP	Tonga Pa'anga
ToR	Terms of Reference
TOISEP	Tonga Outer Islands Solar Electrification Programme
UNDP	United Nations Development Programme
US$	United States Dollar
VCNO	Virgin Coconut Oil
WB	World Bank

Exchange Rate Used in this report:

1 TOP = 0.50US$

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Foreword

It is my pleasure to provide the forward for this, the first Report on the Tonga Energy Road Map 2010-20. The Report describes a work in progress and also describes a new and innovative approach to donor coordination, which has greatly assisted the Government of the Kingdom of Tonga, and our development partners, deliver an excellent outcome in record time. For the first time, a sector specific outcome has seen all major Development Partners; the Government; and Non-Government Organizations, including Private Sector Stakeholders, work together in a coordinated manner and contribute to solving the significant challenges of the Tongan energy sector in a programmed and planned approach.

From the Government's perspective the development of the Road map has required unprecedented access to Government Ministries and one of our State Owned Enterprises (Tonga Power Limited) by our Development Partners to enable them to clearly identify the underlying problems and therefore identify optimum and targeted solutions. This has not always been an easy process as it has stretched the resources and capacity of some of the Government entities. Hard questions have also had to be asked in relation to the adequacy of Government processes in areas of Governance, Effectiveness, Transparency and Accountability.

This report is unique for another reason: the model under which it has been developed is intended to be dynamic. While we expect that successiveGovernments over the next 10 years will use the Report as the sector Road Map, we also expect that it will be subject to ongoing review and, when necessary, change. Ongoing implementation must ensure that technological advance and the changing needs and requirements of the peoples of the Kingdom are taken into consideration.

Energy is a fundamental building block for the Kingdom in its social and economic development and in enhancing the livelihood and wellbeing of all Tongans. It affects all businesses and every household. Accessible, affordable and sustainable electricity that is environmentally responsible and commercially viable is a high priority. My Government recognized the importance of having dependable, accessible and reasonably priced power as a key catalyst for sustainable economic growth. Achievement of these goals is crucial to achieve the Government's primary target of "poverty alleviation" including100% accessibility to electricity.

With key Development Partners participating and supporting the development of this Road Map the Government's targets are now achievable. Some may now say that the "rest is history", but I say the rest is the future. With the on-going development and implementation of the Road Map Tonga will achieve its objective of reasonably priced, accessible and reliable power. That will lead to increased economic growth, which means more for all Tongans.

I am proud to bring this story to you and I commend this Report and the information contained to your attention. I look forward to successive Governments building on the start that is laid out in this Report to ensure that the work done to date lives on and provides the full benefits that this Report identifies.

'Ofa atu,

Hon. Dr. Fred Vaka'uta Sevele
Prime Minister of Tonga
April, 2010

EXECUTIVE SUMMARY

Tonga is highly dependent on imported fuels to meet its overall energy requirements. In 2000, when the last energy balance table for Tonga was compiled, imported petroleum products accounted for 75% of Tonga's energy supply, with 25% coming from biomass and off-grid solar PV. All grid-supplied electricity, which accounts for over 98% of electricity used in Tonga, is generated using imported diesel fuel.

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 averageprice 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/kW-h in late 2008. Crude oil price is expected to increase in the future based on projections from the United States Department of Energy.

The Tongan Government, in 2009, responded to the twin challenges of reducing the Tongan contribution to global Green House Gas (GHG) emissions and improving national energy security by approving a policy to supply 50% of electricity generation through renewable resources by 2012. While the target is ambitious, it represents a clear direction and indication from the Government that reducing the vulnerability of the country to future oil price shocks is a key objective, and that renewable energy is expected to be a major element of a strategy to enhance energy security for the Kingdom.

The Government recognises that the full benefits of investing in renewable energy can only be realised when it is a part of an overall plan for the energy sector. Such a plan will incorporate improvements in petroleum supply chain and consideration of price hedging instruments, increased efficiency both in electricity supply and use, improved access to quality electricity services in remote areas, reduced environmental impacts both locally and globally and enhanced energy security, while ensuring the sector remains financially viable in the long term. In April 2009, the Government embarked on a process to develop such an overall plan. This is the resulting document entitled the "*Tonga Energy Road Map 2010-2020: Ten Year Road Map 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*". Due to the length of the title it was agreed that it would be known as the Tonga Energy Road Map 2010 – 2020 (TERM).

The process to develop the Tonga Energy Road Map represents a joint effort among the Government of Tonga (GoT), Tonga Power Ltd. (TPL) and the development partners. The key analytical studies which form the inputs to the Road Map are financed by different agencies.

In addition to identifying a least cost program that will achieve the GoT objectives, the TERM also recommends a detailed program of actions with indicative funding sources and costs for each element.The TERM will serve as the guiding document for Government and TPL actions and development partner support. It covers a ten year time period. As technologies, costs, demand for electricity and sources of financing change over time, it is envisioned that the TERM will be periodically updated to take these factors into account.

Findings of the TERM

Institutional responsibility for the energy sector is fragmented. There is no GoT entity with the mandate and capacity to maintain a strategic overview of the electricity or petroleum sectors. A clear, effective institutional arrangement for the sector will be required for implementation of the TERM.

The TERM identifies gaps and overlaps in the existing policy, legislation and regulation for the energy sector. It is recommended that these issues be addressed during the initial phase of TERM implementation.

Significant data limitations were encountered during preparation of the TERM. Improving the data generation, analysis and record keeping is essential.

The Petroleum Sector and Recommendations for Improvements

Supply chain costs make up around 9% of the cost of delivered fuel. The base product cost represents 44% and Tonga wharfage, duty and consumption taxes 38%. The costs of wharfage in Tonga appear to be higher than elsewhere. The forthcoming Petroleum Supply Chain and Hedging Study is assessing the scope for price savings associated with the supply chain costs.

Significant benefits for Tonga could arise from implementing a financial risk management strategy that limits the effects of volatility in the base petroleum product price. The potential use of such financial instruments in Tonga is being examined as part of the study. The gradual introduction of financial hedging on some of the fuel volumes imported into Tonga would enable understanding of financial risk management to grow, together with an understanding of the costs, benefits and risks of various hedging strategies.

Significant data gaps limit understanding of actual operations, asset valuations, safety and environmental risk management and investment requirements which in turn limits the effectiveness of oversight and regulation. A formal data storage system should be established and maintained for future analysts.

An independent regulatory body has been established. However the regulatory process is generally characterized by a lack of transparency and availability of information, and there appear to be few people in the GoT who fully understand the methodologies applied. A review of the regulatory approach is recommended.

The Grid Electric Supply and Recommendations for Improvements

With respect to electricity demand growth, events over the most recent two years have seen a change that suggests that TPL should plan for lower rates of growth. In addition, these growth rates will be further reduced as programs to improve the supply efficiency and the efficiency of consumer use of electricity are implemented.

Based on available but insufficient data, the energy currently consumed is expected to be reduced initially by at least 10% in the two larger grids serving Tongatapu and Vava'u and by 5% on Ha'apai and 'Eua through targeted end-use efficiency programs. Further options for efficiency improvements will be assessed as improved data become available. The GoT should take a lead implementation role in the implementing end-use efficiency / DSM programmes.

TPL is experiencing relatively high losses between the energy generated and energy paid for. TPL has a program to invest in system upgrades and to upgrade the reticulation in villages across the system. These village upgrades will have multiple benefits including improving the safety of the electric supply, reducing technical losses and enhancing TPL's ability to manage customer connection and disconnection. The loss management program is expected to reduce the electricity generated by about 8% by 2020.

TPL has begun upgrading several of its management systems to mitigate limitations in the existing systems. Upgrades to the customer accounts system and replacing the failed SCADA system at Popua have been committed. It is recommended that TPL add SCADA on all grids extend and introduce an overall management information system to support both decision making and rapid, effective management intervention to resolve changing system performance.

The Off-Grid Supply and Recommendations for Improvements

It is recommended that a range of supply options be made available to the isolated communities to support both improved standard of living and economic activities where possible. The analysis identified a need to upgrade the database of the status of current systems and the developing needs of the communities using isolated supply systems.

The review of existing off-grid systems identified the need to adopt management systems that have proven most successful and sustainable in existing off-grid systems.

The recommendation is for an implementation agency under TPL (eg TPL Rural). The implementation agency would be a separate, stand-alone unit with its own accounts, finances and human resources.GoT establishes clear regulations for the development of fees and tariffs for outer island electricity supplies.The capacity both in manpower and in skill set of the government energy agency, the electricity provider and the private sector must be developed.

Opportunities for Renewable Energy Development.

All potential sources of renewable energy supply in Tonga were considered.Each option was evaluated against screening criteriaincluding maturity of technology,social and environmental showstoppers and levelized lifecycle cost. The options were considered in two categories: intermittent sources such as wind and solar PV which fluctuate with the resource availability, and firm capacity and energy which is available on a continuous basis.

Subject to verification of the resources, the least cost options are landfill gas and wind. The levelized cost estimates for solar PV without storage and substitution of coconut oil for diesel fuel in existing engines, were comparable given the uncertainties in the available data, and higher cost than landfill gas of wind. The most expensive option is intermittent (either solar or wind) with storage. The data available for landfill gas and wind will need to be firmed up to determine whether the resources are actually available and viable, before investment in these options is feasible. There is significant uncertainty regarding the coconut price and reliability of supply. Solar resource data are somewhat better, but further measurements would be required as a project proceeds to detailed design stage. All options will benefit from improved data on the resource and on the electric system to which they will be connected. Generating improved data is a high priority. Accordingly, the Indicative Implementation Plan described below sets out a program of actions that will allow decisions to implement the most economic and practical options to be made and the projects implemented as quickly as possible. Proof-of-concept projects are proposed to allow resolution of technical and management questions while the database for larger scale development can be built.

The Least Cost Implementation Action Plan

The implementation plan is based on a least-cost development with the target to reduce the use of imported oil in diesel-electric generation by 50% as quickly as possible. Impacts are measured against a "Business-as-Usual" scenario where existing conditions are allowed to continue.

Both supply-side and demand-side energy loss reduction and efficiency improvements are the least cost options to reduce electric energy generation. The actions are modular and each can be evaluated to demonstrate economic viability and avoid ineffective investments. Total impact will reduce energy generation by at least 18%.

Landfill gas, once proven, could be developed to provide energy at or below the alternative cost of imported oil fired diesel energy. This development would be a good option to be developed by the private sector and thereby provide valuable experience with IPP developments.

Until suitable sites for wind development have been proven, the next best renewable energy options are biomass using the existing surplus coconuts to make coconut oil (CNO) and solar PV without storage. For CNO, while the technology is proven, issues about the price and reliability of coconut supply, the collection and transportation remain to be resolved to ensure the long term success of such developments. A Proof-of-Concept development is proposed that would seek to identify how a larger development can be made economic and sustainable.

As solar energy can be developed across all parts of Tonga, it represents the most universally available renewable energy resource for the Kingdom. However, the energy yield is variable during each day and the integration of a large amount of solar energy into a grid supply system can be very difficult. A project to install and connect solar PV systems is proposed that would seek to answer questions about operation and maintenance. The recommended approach is to design a system with both centralized and distributed components and a Proof-of-Concept PV system with battery storage on one of the smaller grids.

Principles of the TERM

Flexibility to update and adjust the indicative implementation plan is needed to ensure the TERM remains relevant and responds to evolving circumstances. Recognizing the need for on-going adjustments, key principles of the TERM are set out. These will be adhered to as the specifics of the implementation plan are updated. The key principles are:

- least cost approach to meet the objective of reducing Tonga's vulnerability to oil price increases and shocks;

- managing risk including with respect to the sequencing and timing of new investments and to the extent feasible development of a portfolio of options to meet the demand for electricity;
- long term financial sustainability in the electricity sector;
- social and environmental sustainability; and
- clear, appropriate and effective definition of roles for government, TPL, and the private sector.

The Phased Action Plan

The Indicative Implementation Plan is divided into three phases. Phase 0 defines the most urgent steps that should be undertaken without delay including policy, institutional, legal, regulatory, capacity strengthening and data gathering actions as well as environmental and social strategic assessments and investments in improved efficiency of electricity supply, improved network safety and end-use efficiency. Phase 0 also includes the design and launch of a funding mechanism to allow flexibility in the use of grant funds to cover both upfront investment as well as on-going costs. This is needed to facilitate decision-making based on the least cost, rather than the financing structure of new investment. Design of such a fund would require the assistance of specialists and would involve a significant level of consultation with GoT and development partners who might contribute to the fund. The fund would be set up with independent management and with disbursement rules and regulations designed to ensure the requirements of all funding agencies are accommodated. Initiation of the off-grid programme is included in Phase 0. Phase 0 activities should be considered a priority in terms of allocating funding whether from Government, private sector, sector revenues or development partner support.

Phase 1, which can proceed in parallel with phase 0, includes works designed to implement the first set of Proof-of-concept renewable energy projects, including on-grid Solar PV supply and substitution of a portion of the fuel used in existing diesel engines with coconut oil. These projects will contribute to lowering diesel consumption for electricity generation and, very importantly, will generate sufficient information and experience about each possible option to allow decision making on subsequent investments. If the landfill gas resource is proven during Phase 0, development of a project could move forward on a commercial basis in Phase 1. Phase 1 will also include a scaling up of the end-use efficiency activities and review of initial experience with petroleum financial risk management and implementation of modifications as required.

Non-investment elements of Phases 0 and 1 could be completed within 18 months. All investments and new programs in Phases 0 and 1 should be launched in the same time frame. At least 12 months of operational data and experience generated from the Proof-of-Concept investments in Phase 1 would be recommended before embarking on Phase 2. The combination of Phase 0 and Phase 1 activities will result in a reduction of diesel use for generation, relative to the Do Nothing (no efficiency improvement) / Business As Usual (all diesel) scenario, of about 25% within 5 years.

Phase 2 will involve further efficiency and renewable energy investments and will be initiated when all policy, legal, regulatory and institutional adjustments have taken place and when data and experience from the phase 0 and phase 1 activities have been evaluated. Definition of the scope and sequencing of Phase 2 investments will be determined based on analysis of data and experience in earlier phases.

Conclusions

To implement the comprehensive set of actions laid out in the TERM the Government of Tonga will need to put in place a long-term institutional arrangement to provide strong leadership, coordination and oversight of the energy sector activities.

Petroleum price hedging may offer significant benefits in terms of smoothing out the price fluctuations. Efficiency gains in the supply chain could lead to cost reductions. Once the detailed study is completed, recommendations from the study should be considered by GoT, decisions made on implementation and initial activities launched as soon as possible.

Efficiency improvements in electricity supply and use are the least cost option for reducing dependence on imported petroleum and should be pursued aggressively.

Tonga has several potentially feasible options for domestic sources of electricity generation but existing data are insufficient to assess their viability. Steps should be taken to collect and interpret the information required, including through measurements to generate investment-grade wind resource data and through proof-of-concept projects.

To diversify away from nearly total dependence on diesel for power generation will require the development of domestic, renewable energy resources. To achieve a significant contribution of renewable energy for grid supply will likely require an element of subsidy to avoid raising tariffs. A new financing mechanism is needed that treats high capital cost projects, high operating cost projects and energy efficiency projects on an equal footing – assessing them all on the basis of their lifetime levelised cost.

Even with a subsidy contribution, a substantial amount of investment will be required to develop and operate new renewable energy systems. This implies that private sector participation will be an important element of achieving significant reduction in the use of diesel for power generation. The revised sector structure as defined in the policy, legal and regulatory instruments should facilitate and encourage private participation in the electricity sector.

Acknowledgements

Financial support towards the preparation of the Road Map, including the associated Technical Reports has been provided by ASTAE, IRENA, Pacific Region Infrastructure Facility partners (AusAID, NZAid, Asian Development Bank and World Bank) and the Government of Tonga. These agencies together with, SPREP, SPC, PIFS, PPA, EIB, EC, IUCN, JICA and REEEP have also provided technical review, input and active consultation. The enthusiastic participation of management and staff at TPL and Government has made this process possible.

1. INTRODUCTION

1.1 Tonga: Its People and Economy

Geography. The Kingdom of Tonga consists of 176 islands with a total area of 748 km^2 and an Exclusive Economic Zone (EEZ) of about 700,000 km^2. There are four groups of islands (Tongatapu, Ha'apai, Vava'u and Niuas) comprising 36 inhabited islands. The capital, Nuku'alofa, is located on the largest Island, Tongatapu. Most islands have a limestone base created from an uplifted coral formation. Some islands have limestone overlying a volcanic base and a few are purely volcanic in origin. The climate is tropical with warm-humid weather during December to May and cooler weather for the remaining months. Winds are seasonal with tropical cyclones most likely between November and March.

*The People of Tonga.*The total population of Tonga is 101,991[1],a 4.3% increase since 1996, when the population was 97,784[2]. This increase in population represents an average annual growth of 0.4%. Tongatapu is the most populous Island with 72,045, inhabitants, which represents 71% of the total Tongan population.The 2006 census recorded 17,462 private households comprising 101,144 household members. This represents an average of 5.8 people per household. The 2006 census data also shows a net flow of people from the "Outer Islands" of Vava'u, Ha'apai, and Niuas towards Tongatapu since the last census in 1996. However, during this period the larger migration has been to overseas destinations. There are now more Tongans living overseas than in Tonga, with around 40% of overseas Tongans living in New Zealand, 40% in the USA and 20% in Australia. These overseas Tongans send back "remittances" which equate to 31% of Tongan's annual GDP.

In 2006 98% ofall children in the compulsory school age group of 6-14 years were enrolled in schools. Tonga's population is highly educated. According to the 2006 census about one quarter had a primary education, more than 60% of the population 15 years and older had secondary education, and about 10% had tertiary education.

*The Economy.*Although a high percentage of the Tonga population was economically active (57%), only a relatively small proportion (37%) receives a regular paid income. Subsistence work is the main activity for 20% of the population. This proportion is much higher in rural areas (outer islands) than in urban areas. The unemployment rate for people actively seeking employment is around 1.1% of the total labour force. However, ifthose people who did not look for work and those who indicate that they were not available for work are included; the unemployment rate increases to 4.9%. More than half (53%) of all households receives remittances from overseas. Another 24% receives remittances from both overseas and Tongan sources.

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[1]Unless stated otherwise in this section the data used is taken from the 2006 Census
[2] 1996 census figures

*The role of energy in the economy.*Tonga is highly dependent on imported fuels to meet its overall energy requirements. In 2000, when the last energy balance table for Tonga was compiled, imported petroleum products accounted for 75% of Tonga's energy supply, with 25% coming from biomass (i.e. fuel wood and wood waste, coconut and palm oil residues) and off-grid solar PV. All grid-supplied electricity, which accounts for over 98% of electricity used in Tonga, is generated from diesel.

The main source for lighting is electricity supplied through the national grid, with 89% of all households being connected to the grid. In the Niuas and Ha'apai groups, about half of the households rely upon kerosene and the rest rely uponexisting solar power units as the main source of lighting. The main type of energy for cooking is gas, which is used by just over half of all households. The use of gas is more common in Tongatapu than in the outer islands where firewood is the main source of energy for cooking. A higher proportion of households in Tongatapu use items such as hot water systems, refrigerator, TV, computers, etc. and have internet at home than households on the outer islands. An important factor in this difference is access to affordable electricity.

Tonga's total fuel imports account for about25% of all imports and about 10% of GDP[3]. Hence changes in the price and amount of petroleum imports have a significant impact on Tonga's Balance of Payments situation. In particular, sudden price shocks can be difficult to absorb. Automotive Diesel Oil, ADO (i.e. "diesel")accounts for about 2/3 of petroleum imports (the rest is petrol and aviation fuel, with minimal LPG). About half of the ADO, i.e. about 1/3 of total petroleum imported, is used for electricity generation.

While fuel taxes and duties make up a significant share of government revenues, in 2008 these represented about 5%, Government revenues will not be significantly affected by actions to reduce the use of ADO at TPL diesel-generators because TPL is exempted from fuel duties and taxes.

1.2 History and Current Vision for the Electricity Sector

1.2.1 History of Electricity in Tonga

The first Tongan-owned reticulation system began operation in Nuku'alofa in 1950. The Nuku'alofa Electric Power Board provided electricity primarily for the port, commodities board, churches and government offices. As the Tongan economy grew during the copra and banana boom so did electricity demand and supply. The Nuku'alofa Electric Power Board became the Tonga Electric Power Board (TEPB) in the 1970's. The islands of Vava'u, Ha'apai and Eua obtain a regular electricity service beginning in 1982, as development began in the wake of Cyclone Isaac. In 1995 the TEPB achieved an important milestone when supply, for the first time, reached all communities on Tongatapu.

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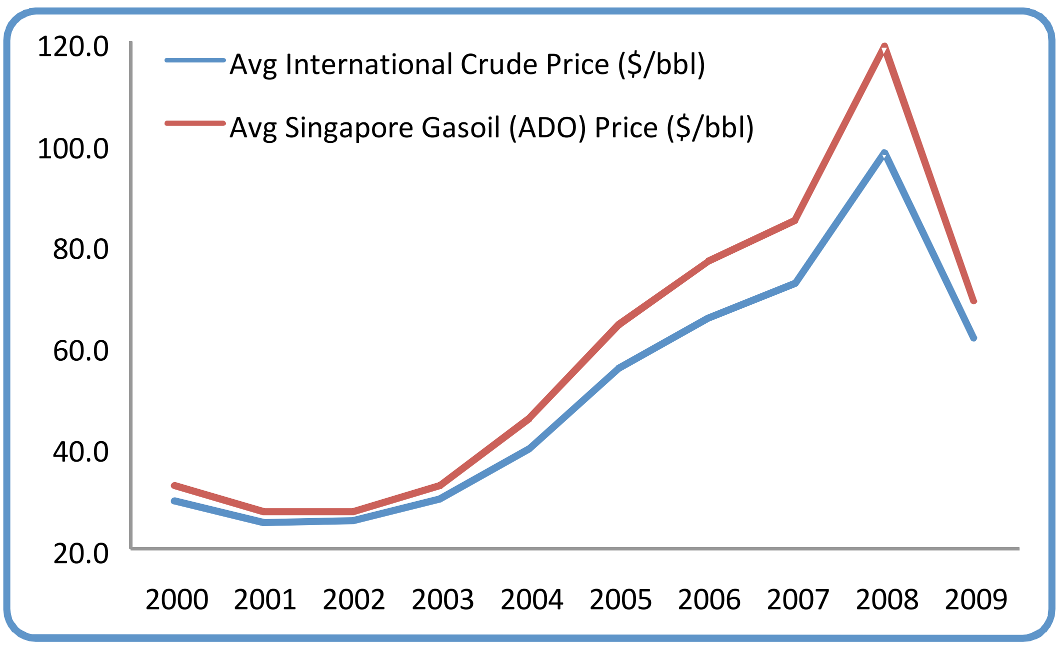
[3]Source: Tonga Statistics Department

In 1998 the TEPB was privatised, when the Shoreline Power Company leased the utility[4]. Shorelineinvested in upgradingthe grids and in new generation. In 2008 the government bought back the power assets owned by the Shoreline group and today the utility is run by Tonga Power Limited, which is a vertically-integrated, State Owned Enterprise.

1.2.2Government of Tonga Energy Sector Vision and Priorities

*Oil Price Volatility.*Oil prices over the last ten years illustrate the volatility to which the Tongan economy and electricity consumers are exposed. Between 2001 and 2004, the average price of crude oil (based on Brent and West Texas Intermediate spot prices) increased from around US$25 per barrel to around US$40 per barrel - a 60% increase. This was followed by a dramatic and continuous rise in crude oil prices between 2004 and 2008, where the average annual price of crude rose from US$40 per barrel to a peak of around US$100 per barrel (see Figure 1.1). In late 2008, there was a dramatic fall in crude oil prices that continued into 2009, with the average price in 2009 being around US$62 per barrel.Diesel prices tracked the price of crude oil.

Figure 1.1: Average annual crude oil and diesel prices, 2000-2009



Notes: a) Crude oil prices are an average of Brent Crude and West Texas Intermediate (WTI) spot prices; b)Diesel price is the annual average price in Singapore. ***Source***: US Energy Information Administration http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_a.htm)

The oil price volatility of 2008 led to the highest electricity tariffs the Kingdom has ever seen, with prices peaking at over TOP1.00 per kW-h (approximately 50USc/kW-h). This had a significant negative impact on economic activity and on the quality of life for all Tongans. The experience highlighted the risk to Tongan electricity consumers and the economy as a whole of

[4] The lease arrangement took place in two parts: first the generation assets and two years later the distribution system.

the combination of 100% dependency on imported petroleum for grid-based electricitygeneration together with essentially spot market pricing of all imported petroleum. The history of international oil prices demonstrates the price volatility and scenarios for future petroleum price trends suggest that on average, the price is expected to increase as the global financial situation normalizes. Acknowledging the prospect of increasing and volatile petroleum prices, the Government determined that it must, as a matter of priority, take measures to mitigate these risks in order to achieve an energy sector that supports, rather than constrains, economic growth and improved standards of living for the people of Tonga.

50% Renewable Energy Policy. The Tongan Government, in 2009, responded to the twin challenges of global Green House Gas (GHG) emissions reduction and its own energy security by approving a policy to supply 50% of electricity generation through renewable resources by 2012. While the target is ambitious, it represents a clear direction and indication from the Government that reducing the vulnerability of the country to future oil price shocks is a key objective, and that Government has identified a move to renewable energy as a major element of a strategy to provide enhanced energy security for the Kingdom and greater tariff stability.

Financial and Environmental Sustainability in the Energy Sector.The Government of Tonga recognises that the full benefits of investing in renewable energy can only be realised when it is a part of an overall plan for the energy sector. Such a plan will incorporate improvements in efficiency, reducing environmental impacts both locally and globally with respect to GHG emissions and enhancing energy security while ensuring the sector remains financially viable in the long term.

Steps toward Improved Coordination.Historically the funding available to the Tongan Government from its development partners for energy was mainly aimed at renewable energy sourcesand frequently limited to rural "off grid" communities. The availability and targeting of funds were in many cases driven more by the priorities of the external partners, which were often more relevant to other parts of the world[5], than by Tongan priorities, limiting the ability of Tongan authorities to match available support with areas of identified need such asactivities to reduce the risk associated with over-reliance on imported diesel for grid-based electricity generation. In addition, opportunities to benefit from a growing number of regional or global funds, in particular for renewable energy and energy efficiency activities, could easily be missed as they fell between different line Ministries and sub-regional programmes.The Tongan Government therefore established the Office of the Renewable Energy Coordinator in October 2008, accountable to the Prime Minister.

Shortly after Cabinet approved the 50% target the Prime Minister established a Cabinet Sub Committee on Renewable Energy (CSCRE), which he also chaired. The CSCRE was tasked with evaluating renewable options and to pursue possible funding sources with the country's development partners. The membership of the Committee comprised the Prime Minister (Chairman), Minister of Lands (responsible Minister for Energy), and the CEOs of the Ministries

[5] For example a focus on assistance to reach off-grid rural communities in Sub-Saharan Africa is well-justified by access rates which in many countries are still below 20%, but less appropriate for Tonga, where about 90% of the population is connected to grid-based electricity supply.

of Finance, Lands, and Environment, together with the Chairman of the Electricity Commission, the Prime Minister’s Economic Advisor and the Renewable Energy Coordinator.

2. EVOLUTION AND OBJECTIVES OF THE TONGA ENERGY ROAD MAP

2.1 Evolution of the Tonga Energy Road Map(TERM)

Pacific Energy Ministers Meeting April 2009. In April of 2009, the Kingdom of Tonga hosted the Pacific Energy Minister's Meeting (PEMM), which brought together most of the Government's development partners. This meeting was very timely and put renewable energy and energy efficiency at the forefront of regional issues and focused on the need for the Pacific to mobilise a model to implement energy efficiency and renewable energy options that would lay the foundation for improved energy security region wide.

The search for a holistic, achievable solution. The Prime Minister took the opportunity provided by the PEMM to meet with all Development Partners to set out the Government's objective of reducing the vulnerability of Tongan electricity consumers and the economy as a whole to oil price shocks. He emphasized the need for coordination and flexibility on the part of development partners while at the same time committing the Government to taking the needed actions, with development partner assistance, to achieve environmental and financial sustainability in the electricity sector. To do this, a joint Government-Development Partner plan would be needed – laying out institutional, policy, legal, and regulatory changes combined with a medium term investment plan.

*The Tonga Energy Road Map Concept.*Building on the strategic overview provided by the Prime Minister, the Development Partners and the Renewable Energy Coordinator engaged in a series of discussions to see how they could develop a programme that would have as its outcome a road map that would guide Tonga's investment in energy for at least the next ten years. The programme would be motivated by the 50% Renewable Energy policy. Recognizing that the underlying motivation for this policy is the need to reduce dependence on imported oil for electricity generation and to reduce the vulnerability of electricity consumers to oil price shocks, it was agreed that the Road Map would cover the full range of options to address the diesel vulnerability issue. Improved efficiency in supply and demand would play a major role, together with renewable energy options.

It became apparent very quickly that an assessment of the state of the existing energy sector would be required. This would need to look at the current infrastructure; projected demand growth, required upgrades; the institutional structures and participants; and policy and regulatory arrangements. The assessment would also need to look at any gaps in the sector and finally identify sources of potential funding. In order to undertake such an assessment two important principles were agreed upon at the inception:

- That the Government would coordinate all relevant stakeholders, and to facilitate the provision of an unprecedented level of accessibility for its development partners in the details of the Tongan energy sector, which to a large degree would rely upon the cooperation of Tonga Power Limited; and

- That the Development Partners, under the guidance of the World Bank, would coordinate and fund the technical assistance required to undertake the Energy Sector review, which would have as its output an assessment of and recommendations relating to the different options available to address Tonga's problem of high vulnerability to oil price rises and oil price shocks, while ensuring that other objectives, such as increasing good-quality access to electricity, are also achieved.

The Government agreed to prioritize its own resources to support implementation of the Road Map and take needed actions for implementation.The Government agreed that other resources available in the sector, e.g. internally generated revenues from Tonga Power Limited, would also be aligned to support implementation of the Road Map. Development Partners agreed to coordinate their funding to help develop and implement this Road Map.

A Minute of the meeting was agreed upon by the Development Partners, which was then endorsed by His Majesty's Cabinet at the end of April, 2009. The resulting document was entitled the "*Tonga Energy Road Map 2010-2020: Ten Year Road Map 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*". Due to the length of the title it was agreed that it would be known as the Tonga Energy Road Map 2010 – 2020.

Participation and Consensus-Building. The process to develop the Tonga Energy Road Map represents a joint effort among the Government of Tonga (GoT), Tonga Power Ltd. (TPL) and the development partners. The key analytical studies which form the inputs to the Road Map are financed by different agencies[6]. The World Bank assumed the responsibility of coordinating the studies and preparing the Tonga Energy Road Map based on these inputs. The process is intended to be open and consultative. In order to achieve the objective of aligning donor resources to support the implementation of the Road Map, it is important that all parties have the opportunity to comment on draft reports and have their views considered. The Scope and Objectives of the Tonga Energy Road Map were circulated and revised based on comments received. All draft reports have been circulated for comment.

2.2Objectivesand Implementation of the Tonga Energy Road Map

TERM Objective.The objective of the Tonga Energy Road Map is to lay out a least cost approach and implementation plan to reduce Tonga's vulnerability to oil price shocks and achieve an increase in quality access to modern energy services in a financially and environmentally sustainable manner. This TERM will serve as the guiding document for Government actions and development partner support. It covers a ten year time period. As technologies, costs, demand for electricity and sources of financing change over time, it is envisioned that the TERM will be periodically updated to take these factors into account.

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[6] The key background technical studies upon which this document's recommendations are based are listed in the Appendices.

While on-grid renewable energy will be a major component, it was agreed that there is a need to carefully assess the full range of opportunities and to determine the least cost combination of interventions to achieve the objective. These include:

- Improvements in Petroleum Supply chain to reduce the price and price fluctuation of imported petroleum products;
- Efficiency of conversion of petroleum to electricity (i.e. increases in efficiency and reduced losses at TPL);
- Efficiency of conversion of electricity into consumer electricity services (Demand Side Management measures);
- Replacing a portion of current or future grid-based generation with renewable energy.

In addition, in order to meet the objective of increasing access to good-quality electricity supply, the TERM includes recommendations for a new approach to meeting the needs of consumers too remote to be connected to a grid-based supply.

The Tonga Energy Road Map considers the full range of possible interventions and provides: (i) technical assessment, cost estimates and recommendations of the least cost approach to reducing the cost of petroleum, reducing Tonga's dependence on petroleum for power generation and increasing accessibility as fast as possible; (ii) actions in the policy, legal, regulatory and institutional areas necessary to implement the plan; (iii) sources of funding and financing strategy;and (iv) an indicative implementation plan.

*Looking forward: Implementation of the TERM and on-going partnerships.*The Tonga Energy Road Map 2010 – 2020 whilst having been compiled in just 12 months; draws on over 30 years of work and experiences the Development Partners have had with the Kingdom. The TERM is created through the technical expertise of the Development Partners and clearly establishes the options now before the Tongan Government. It also identifies funding options that will allow the Government to make the necessary adjustments to the energy sector, to put in place the arrangements and begin the investments to meet its ambitious 50% Renewable Energy Policy target.

The Tonga Energy Road Map 2010-2020 demonstrates clearly the benefits of a transparent, coordinated, programmed and planned approach to development. The TERM is built upon stakeholder participation, transparent public review and is created within an ethos of best practice and quality assurance. It is for this reason that the TERM will remain dynamic. The Tongan Government now must respond to the TERM by implementing necessary changes to the organisation of the Tongan Energy Sector and also the institutional and legislative issues indentified in the technical assessment. These changes will not be easy, but with the knowledge that they will lead to better energy security; greater tariff stability; improved affordability; and greater accessibility to electricity for the people of Tonga, the benefits far outweigh the cost and effort of overcoming the challenges.

3. OVERVIEW OF TONGA'S ENERGY SECTOR TODAY

3.1 Petroleum

3.1.1 Roles, Responsibilities, Policy, Legislation and Regulation

The three Tongan Acts affecting the pricing of petroleum products are:

- *Petroleum Act*;[7]
- *Prices and Wage Control Act*;[8] and
- *Customs and Excise Act*,[9] which provides for import duty exemptions on fuel imported for use in power generation and domestic airlines and shipping.

*Price regulation.*The Competent Authority is empowered to regulate petroleum prices under Section 5 of the *Price and Wage Control Act 1988*. The Tonga Competent Authority regulates the retail price of petroleum products, using a pricing template originally developed by the Pacific Islands Forum Secretariat. The pricing template builds up the retail prices by taking the Singapore price for fuel, then adding on shipping and storage fees and wholesale and retail markups. In effect, the average price for the next month is determined by fuel prices, shipping rates and margins two months prior.

The current process used to set monthly fuel prices is as follows:

- Every month, the fuel importers TOTAL and BP submit separate pricing templates for Tonga to an independent petroleum consultant.[10] These pricing templates reflect the costs paid for imports into Tonga. The submissions contain reference prices and costs in the previous month, including: fuel purchase costs in Singapore; shipping, storage and handling fees; and regulated mark-ups.
- The consultant reviews the pricing templates submitted by the oil companies against Singapore spot prices, published shipping rates, storage fees and regulated markups.
- The independent petroleum consultant prepares a report to Tonga's Competent Authority, containing suggested fuel prices that will apply in the following month. These prices are derived from volume weighting the results of the BP and TOTAL submissions.
- The Competent Authority considers the consultant's report and makes a decision on what prices are to be set for the following month.

In summary, the pricing philosophy seeks to build petroleum prices for Tonga that reflect the actual costs of buying fuels on the international market and the various costs of delivering that fuel to Tonga and then distributing it across the country. This petroleum pricing approach is

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[7] Available at http://www.paclii.org/to/legis/consol_act/pa137/

[8] Available athttp://www.paclii.org/to/legis/consol_act/pawca205/

[9] Available athttp://www.paclii.org/to/legis/consol_act/caea199/

[10] Since December 2008 the Tongan Ministry of Labour Commerce and Industry has engaged the services of consultancy firm Hale &Twomey Ltd to assist the Competent Authority in: a) carrying out the 2009 review of Tonga's fuel pricing template; and b) regular monthly fuel reviews of fuel prices using the new template. In addition, Hale and Twomey prepared a report to MLCI on the feasibility of having Medium Range Tankers ship larger volumes of fuel directly to Tonga, thereby bypassing Fiji (www.haletwomey.co.nz).

exactly the same as the 'import parity pricing', which is used in Australia and New Zealand, and is common across the petroleum industry.

The pricing methodology is subject to annual, triennial and ad-hoc reviews. Every year the pricing template is supposed to be reviewed, using a consultation process with the oil companies and other interested parties. However, there was no annual review in 2008. The 2009 annual review, completed in June 2009, was the first since May 2007.[11]. The 2009 review resulted in number of significant adjustments to some of the parameters used to build up fuel prices. Triennial reviews assess regional freight rate differentials, and the overall incentives for continued investment in petroleum supply, storage and distribution. Ad-hoc reviews of the pricing templates may be required to deal with issues such as changes in Duties, Taxes, or Wharfage costs.

Wholesale and retail fuel prices across Tonga vary, reflecting the higher transport costs to provinces distant from the main island, Tongatapu. However, in each province, a single price is set regardless of supplier. Retailers have a 7% mark-up on the wholesale price. The wholesale price incorporates a 15% return on investment for the oil companies. Retailers have expressed concern to the Competent Authority about the adequacy of the 7% retail margin.

*Safety regulation.*Both BP and TOTAL state that they operate under international standards for petroleum handling and storage and that their insurance companies require annual independent safety audits of their facilities and safety processes. Both companies claim that international standards are more stringent and specific than the very general safety requirements set out in Tonga's *Petroleum Act*.

In summary, the model for ensuring compliance with safety standards appears to be one of self-enforcement by the oil companies, under the oversight of internationally accredited and independent auditors.

3.1.2 Petroleum Supply

In 2009 petroleum was supplied to Tonga by two international oil companies -- BP and TOTAL - and a locally owned company, Uata Shipping, which supplied the Ha'apai group of islands. Both BP and TOTAL have onshore storage and distribution facilities on Tongatapu, while BP also owns the storage facilities on Vava'u. TOTAL bought Shell's assets in 2006 when Shell decided to exit the storage and distribution of fuel in Tonga and other South Pacific countries.

The bulk storage and distribution facilities on Ha'apai are owned by a local Tongan businessman. The Government of Tonga's own fuel storage facilities on Vava'u, which were leased to Shell, fell into disrepair and are now closed.

[11] Hale &Twoomey 2009*, Tonga Petroleum Pricing Annual Review*, prepared for the Tongan Competent Authority (TCA) & Pacific Islands Forum Secretariat, TCA, Nuku'alofa, June 2009.

BP and TOTAL are active in the Tongatapu ground product market (ADO, kerosene and gasoline), and BP is the sole supplier of aviation fuels across Tonga.

LPG is bulk supplied by Tonga Gas, (a subsidiary of Fiji Gas, 51% owned by Origin Energy, Australia), and marketed and distributed onshore by the GOT's Homegas Company.

Like other small Pacific Island countries, Tonga faces a long supplychain from the refinery source. Products are shipped from refineries in Singapore (or sometimes Australia) to bulk storage in Fiji via mediumrange (MR) tankers, based on TOTAL and BP's regional supply schedules, and thentrans-shipped to Tongatapu and Vava'u in local coastal tankers (LCT). Thus,landed costs of product in Tonga have a relatively high freight component.

The outer islands are supplied with products trans-shipped throughNuku'alofa. The Niua's and 'Eua islands are normally the only areas for whichmain products (gasoline, ADO, and kerosene) are supplied by drum. Lubricants and other minor products are all supplied by drums. Drum distribution is more expensive than bulkdistribution and costs are compounded by the fuel losses through evaporation,leakage and drum decanting which contribute up to 15% of total drum content.

3.2 Electricity

3.2.1 Roles and Responsibilities

*Current Institutional Arrangements.*For on-grid electricity services, Tonga Power Limited (TPL) has the concession and operates four independent grids in Tonga: the largest on Tongatapu, and three smaller grids on the main islands of the Vava'u, Ha'apai and Eua island groups. TPL is a public enterprise wholly owned by the Government of Tonga. Operation of TPL is regulated under a Concession Agreement between the GoT and TPL. The MoF is TPL's contractual partner in the Concession Agreement. In 2008, the Electricity Commission was established as the regulatory agency for grid-based electricity supply.

For off grid services,the Energy Planning Unit (EPU) of the Ministry of Lands, Survey and Natural Resources is the primary institutional unit. It also acts under policy and planning provided by the MoF and the Prime Minister's office.

Additionally, Ha'apai, Vava'u and the Niuas group each have individual off-grid project management structures that provide for day to day operations.

*Responsibility for Electricity Sector Policy and Planning.*Overall responsibility for on-grid electricity sector policy and planning is shared between the Prime Minister's Office and the Ministry of Finance and National Planning. The MoF's Policy and Planning Division assists other Government entities to formulate outcomes and outputs at operational levels and monitors progress on strategic policy objectives. The MoF is also TPL's contractual partner in the Concession Agreement that governs TPL's operation.

On-grid expansion planning is performed by TPL, the state-owned, vertically integrated utility. TPL prepares investment plans for the four TPL grids. Investment planning is scrutinized in a two step process: TPL's Board of Directors reviews the Investment Plans and requests amendments and modification as required. Subsequent to Board endorsement, investment plans are submitted to the Electricity Commission for review and final approval.

For off-grid electrification, the Energy Planning Office under the Ministry of Lands, Survey and Natural Resources has responsibility for electrifying the areas of Tonga not reached by a TPL grid. To date, this has been exclusively through solar home systems for individual households. Since off-grid household electrification efforts began in about 1985,almost all inhabited islands have been reached and a high percentage of off-grid households havereceived some type of individual system to supply basic needs such as lighting.Current records indicate that less than half of those solar home systems are now providing a reliable electricity supply.Off-grid expansion policy development, planning and donor project implementation is primarily performed by the EPU. The EPUhas not historically had any role in formulating policies or strategic plans for grid based electricity supply. The unit is not represented on TPL's board.

The Energy Road Map process has already stimulated a change in institutional arrangements. In November 2009, a high level 'Tonga Energy Road Map Committee' (TERM C) was established to oversee and govern the planning and implementation process of the Road Map. TERM C comprises Ministers from all key ministries including the Prime Minister's Office, Finance, Labor and Commerce, Lands, Survey and Natural Resources, Environment as well as representation from TPL. The members are expected to convene weekly in order to ensure consensus building and decision making related to Road Map issues. This has broadened the involvement of Ministries that have not previously been involved in on-grid electrification.

*Responsibility for Service Delivery.*The responsibility for on-grid service delivery rests solely with TPL which generates, distributes and retails electricity on the three major island groups of Tongatapu, Vava'u and Ha'apai and on 'Eua, an island close to Tongatapu. Responsibility for service delivery and ownership of electricity assets has changed twice in recent years. The first change was in 1998 when the national utility was bought by Shoreline Power, a private sector company, and more recently in mid 2008 when GoT bought the assets from Shoreline to create TPL as a state-owned enterprise. The sale of Shoreline Power was being planned in 2006before rioting in Nuku'alofa resulted in considerable damage to buildings in the downtown area. As well as destroying Shoreline Group records, the riots damaged international confidence in investment in Tonga and GoTdecided not to proceed with its preferred option of allowing the sale of the assets to private interests. In 2008, the Government concluded the agreement with the Shoreline Group[12] to purchase the utility and it is now government owned. The re-nationalization by the government of the power assets was as a result of pressure from the people at large who believed that these strategic assets needed to be in the hands of government until such time as the electricity sector was in a sound, sustainable, and stable state. There remains a strong interest to bring the private sector into the electricity generation and supply business as

[12] The Prince Regent was a major shareholder in the Shoreline Group and had expressed the desire to withdraw from commercial activities in the Kingdom prior to his coronation in late 2008.

evidenced by several regulatory policies, described in the following section, that are intended to ensure that the TPL remains financially interesting to private investors.

The Energy Planning Unit (EPU) of the Ministry of Lands, Survey and Natural Resources has taken on the responsibility for off-grid electrification, but to date has been given no mandate for other energy activities. The EPU has been almost exclusively focused on implementing donor provided solar projects in off-grid areas.A new Renewable Energy Authority within the Ministry of Lands, Survey and Natural Resources is mandated under the Renewable Energy Act approved in 2009, to deal with matters concerning renewable energy and to regulate all matters relating to renewable energies. However, reflecting the earlier paradigm in which Renewable Energy was considered almost exclusively for off-grid applications the Act, and consequently the mandate of the new Authority, only impacts off-grid installations.

Until the establishment of the Office of the Renewable Energy Advisor in the Prime Minister's Office, the EPU was the *de facto* government interface for international assistance on electricity matters.

3.2.2 Policy, Legislation and Regulation

*Policies relevant for the Electricity Sector.*In recent years there have been several policy and legislative initiatives in Tonga aimed at improving the legal framework for the electricity sector and the implementation of renewable energy projects.

The National Strategic Planning Framework provides the framework for improving electricity generation systems and their management in order to improve the living standards of all Tongans. The framework highlights a desire to both improve services, accountability, and appropriate revenue collection as well as improve the coordination of development partners. These are also core drivers behind the Energy Road Map approach.

*Legislation impacting the Electricity Sector.*The *Electricity Act 2007* provides the governance framework for the electricity sector in Tonga. It defines the role of the Electricity Commission in regulating the generation and selling of electricity, and establishes the role of the concession contract/agreement in producing and delivering electricity. In addition, the Act provides the Ministry of Finance (MOF) authority to be a party in the concession contract between the Commission and the Concessionaire and to establish regulations to ensure effective management of the electricity utility. The Concession agreement formed under the act states the utility's operations in comprehensive detail, including very specific details as to how the tariffs are calculated.

With regards to off-grid electrification, a Renewable Energy Bill was sponsored by the Energy Planning Unit of the Ministry of Lands, Survey and Natural Resources with support from SOPAC. The Bill was passed by parliament in 2009. The primary purpose of this Bill is to provide a legal framework to promote the utilization of renewable energy in Tonga through the creation of an enabling market environment. Since the bill relates only to direct current (DC) supply, such as comes from solar panels supplying households directly, the Bill does not affect any renewable energy supply to the four island grids. Grid-based renewable energy would fall under the Electricity Act. The Bill creates a Renewable Energy Authority within the Ministry of Lands, Survey and Natural Resources to deal with matters concerning renewable energy and regulate all matters relating to renewable energies but essentially off-grid only. In essence the Bill is a means to provide a legal basis and define operations for the Energy Planning Unit. In the past the EPU has been without a legal mandate or any well defined scope of operations.

Electricity Sector Regulation and Tariff Setting. A comprehensive Concession Agreement (CA) regulates TPL's operation in considerable detail. It includes tariff adjustments, service standards, penalties for breach of service standards, customer complaints, return on regulated assets and binding targets for fuel conversion efficiency and system losses. The first regulatory period of the CA ends 30 June 2015 and thereafter each subsequent regulatory period shall be for a period of seven years. The existing regulation did not foresee significant on-grid renewable energy investment. As noted in the following paragraphs, there are a number of areas where the current sector regulation would need to be updated in this regard[13].

The electricity provider has legal rights under the CA to pass through to consumers the actual fuel costs and to charge a non-fuel tariff, but the calculation of those costs must meet specified criteria. The non-fuel tariff covers agreed operational costs, business overheads, depreciation and an allowed return on investment to provide retained earnings for future capital expenditure, interest and shareholder dividend payment. The tariff structure is designed to ensure that the TPL operates using full commercial standards in order to make the company more attractive for future sale to private interests.

The CA distinguishes fuel and non-fuel components of TPL's tariff and the Commission hired an independent consultant to review the non-fuel tariff. This review has to be repeated in each seven year regulatory period. Although the CA allows TPL to treat the four island grids individually, TPL has chosen to standardize tariffs across all grids and consumer classes. Tariffs are allowed to be adjusted every three months. The non-fuel tariff component follows the CPI, while the fuel tariff component of the regulated tariff is adjusted so that the Concessionaire recovers the permitted fuel costs. To calculate the permitted fuel cost in a given month, the demand for electricity is estimated. Target system losses are then used to calculate the amount of generation that should be required at the supply efficiency target. From this level of generation and permitted fuel conversion efficiency the litres of fuel that should be required under those target conditions is calculated. Litres of fuel, multiplied by the fuel price, equates to the permitted fuel costs. This adjustment mechanism is designed to provide a strong incentive for the Concessionaire to work to meet the CA mandated targets of fuel and system efficiency.

The concession contract defines the mechanism for adjusting the elements that make up the tariff. The regulator is charged with reviewing whether TPL has correctly applied the provisions of the CA and, if so, confirms the adjusted tariff. An additional benefit is that the contractually-binding tariff calculation becomes difficult to reinterpret to accommodate political interest. While the CA achieves the foregoing objectives, it has resulted in a complex agreement that is difficult for those outside of the energy sector to understand. Nevertheless, the CA is a public

[13] These topics are covered in the subsequent section on Implementation Plan and Recommendations.

document and the tariff reset hearings by the regulator are held in public so anyone can examine exactly how the tariffs are determined.

Relevant for the introduction of renewable energy into TPL's generation mix is the 'extraordinary event' adjustments of tariffs. An extraordinary event includes:

- a material change in the definition of any of the indices used in adjusting the non-fuel component;
- more than 3 % deviation between forecast generation and actual generation;
- any *Force Majeure* event;
- the regulatory risk where there is any discriminatory treatment by GoT or its agencies which reduces the revenues or increases cost of the concessionaire over any 12 month period;
- any change in the tax rate applicable to the concessionaire greater than three percentage points; and / or
- any other event, which is not reasonably foreseeable, not reasonably under the control of either party, and which neither party was required or reasonably expected to provide against, that changes the revenues of the concessionaire or the non-fuel cost of service over any 12 month period.

TPL is required to submit capital expenditure plans to the Commission for approval and the Regulator can deny approval of a capital expenditure that is not in line with a least-cost supply strategy. On the other hand, there is no provision in the concession that covers the procurement of a Power Purchase Agreement (PPA) or other form of supply from an Independent Power producer (IPP), nor is there any specific provision for how the introduction of renewable energy is treated.

The determination of efficiency standards under the CA requires that the long-term benefit to customers of improving efficiency standards must be greater than the long-term costs to customers, though the definition of "long term" is not clearly defined.

The CA states that TPL is required to earn a rate of return (currently set at 12.9 %) of its Regulated Asset Value (RAV). The RAV was set at TOP 30.3 million when TPL took over the operation and, as a result of an assets revaluation process during 2009, the RAV no longer reflects the value of TPL's net fixed assets in service. Due to the nature of RE investment typically involving significant up-front capital investment, this requirement could force TPL to adjust its revenue upwards in order to reflect the increases in capital value even if that value has been grant funded. Noting this, GoT has advised that the RAV provision of the CA could be waived or amended in order to allow large scale, donor funded investment in renewable energy to be made without forcing TPL to fully depreciate these 'special' assets or including them in the calculation of rate of return on investment.

Along with the change in ownership in 2008, a new regulatory environment was introduced reflecting international practices and in preparation for a possible future sale of the GoT interest in TPL. These reforms balance the interests of consumers, as far as tariff and service standards are concerned, against the need for investors to have a reasonable expectation about earning a fair return on their investment. The reforms also recognize that investors need appropriate incentives for them to invest in maintaining and upgrading the network.

In the off-grid sector no regulations have been issued effectively allowing each project to operateunder its own rules. Each project has different operating structures though in recent years there has been some standardization of the general structure for project operations based on the PREFACE project structure for Ha'apai set in 2002.

3.2.3 The Grid Systems

*Operational and Financial Situation at Tonga Power Limited (TPL).*The value of TPL assets when the company was established in mid 2008 was approximately TOP48.5 million (US$24.25 mil.)[14]but, as noted, TPL has revalued its assets based on depreciated replacement costs for network assets and on depreciated historic costs for other assets. TPL obtained a US$6 million loan from the Westpac Bank for operating capital. This is scheduled to be repaid over 5 years so that it will have been fully paid by the end of 2013, coinciding with the first year when TPL is expected to start paying dividends. In addition, Caterpillar Financial Services Corporation assigned the balance of a loan provided to finance the MaK diesel-generator.

The non-fuel component of the current tariff was established following hearings with the regulator in early 2009 and is very close to the rate applied for by TPL management (38.69 vs. 40 seniti per kW-h, US$0.193-0.20). Regulated performance targets such as system loss rates and fuel efficiency rates are incorporated in the fuel component of the tariff.

The cost of ADO, the fuel used in all of TPL's diesel generator sets, has varied widely during recent years. In Table 3.1, the total energy generated, the fuel used and the total cost of that fuel is shown for calendar years 2005 through 2008. Although annual electric demand grew by just over 10% in the 4 years, the annual fuel cost increased close to 120% in the same period.

Table 3.1- Recent Fuel Use and Costfor Electricity Generation[15]

Year	Energy, kW-h	ADO, Litres	Fuel Cost, TOP Millions	Fuel Cost, US$ millions
2005	51,557,573	13,132,596	13,015,693	6,671,978
2006	55,281,157	13,921,617	17,006,525	8,198,466
2007	56,434,346	14,115,388	19,527,073	9,411,998
2008	56,777,701	14,186,248	28,527,236	13,750,053
% increase from '05-'08	10%	8%	119%	106%

Source: TPL Records

[14] Data provided by TPL as input to the financial modeling carried out by consultants examining options for on-grid renewable energy.

[15]The cost of shipping fuel to the grids on Vava'u, Ha'apia and 'Eua has not been included here.

Based on data provided by TPL which covered about 85% of their customer accounts, their accounts receivable were less than 11 days[16] as of September 30 2009. This is about one half of the levels reported during late 2008. While these figures do not include all of the billed energy, it is reasonable to assume comparable accounts receivable performance on the balance of the billed energy.

TPL advise that their supply reliability performance has been good since mid-2008 and that the majority of supply failures may be traced to network and distribution faults. TPL changed its inventory policy to ensure appropriate levels of replacement poles and other network repair supplies are on hand so that repairs were made and supply restored quickly following weather emergencies such as the April 2009 cyclone. Overall technical and non-technical losses have been high in recent years and TPL management has committed to reduce these as quickly as practical. On the Tongatapu grid where approximately 85% of all of the grid-supplied energy is consumed, total losses represented just over 17.5% of the energy generated at the engine-generators in 2009 while on the remaining grids, recent total losses have been between 12.5% and over 20.0% of generated energy.

Demand Forecast.[17]Forecasts are frequently founded on history. Historical records of electricity generation each month are available from April 1998 for Tongatapu and from January 2004 for each of the other grid systems. Tongatapu accounts for about 85% of the total electricity consumed in Tonga. The records are discontinuous but generally include the energy generated, the energy sent out to each network, the fuel used and the energy billed. A less complete record of the peak and minimum hourly demand each month is also available. TPL provided a partial record of customer monthly billing records for the Tongatapu system from January 2004 to late 2009.

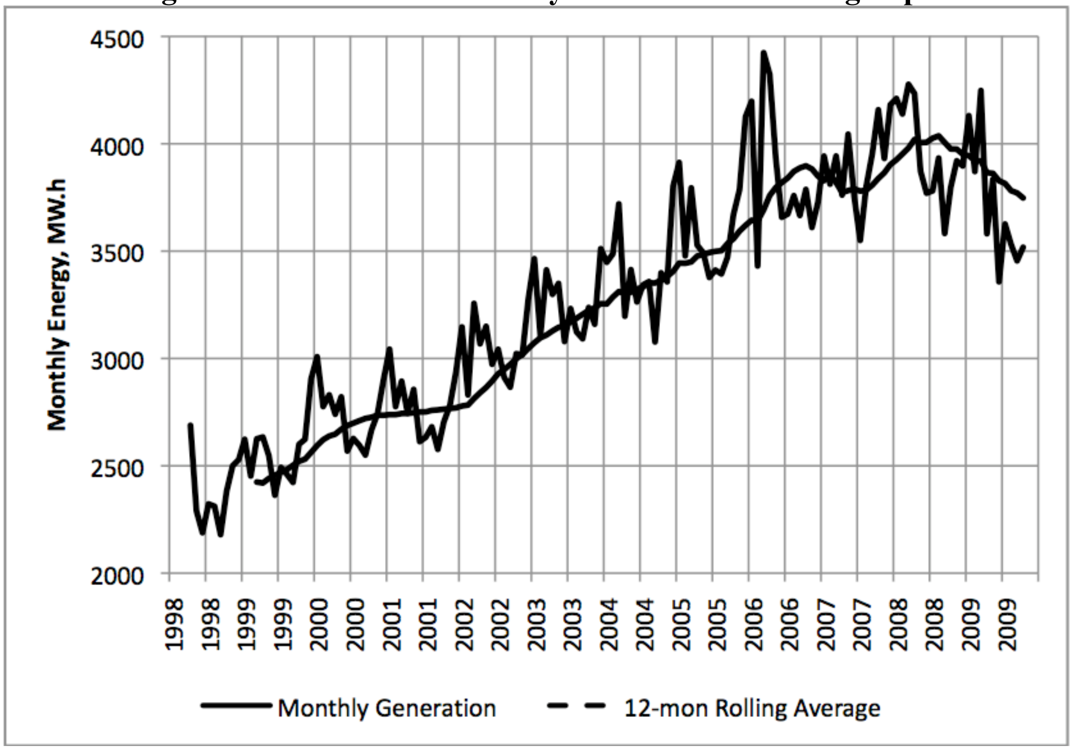
Electricity consumption is usually linked to national economic performance and change in the number of consumers. Growth in numbers of electricity consumers has been less than 0.7% annually since 2005 because all consumers within reach of the grid have been connected. Hence, changes in numbers of users have not been a major factor in demand growth. As noted herein, the Tongan domestic economy is driven by farming and fishing. Data[18] shows that these activities have risen and fallen as regional and broader international markets have changed. In addition, records indicate that most Tongan families receive remittances from relatives who work abroad. Electricity consumption is also affected by the cost of the energy and the tariff rose to an all-time high during the latter half of 2008, primarily because electricity is generated almost exclusively from imported diesel fuel.

The electric demand on Tongatapu grew from 1998 to 2008 at an average rate of 5.5% annually until August 2008 when the growth faltered and the demand has since declined. The gross peak demand[19] reached almost 8,400kW during the summer of 2007/08 and has since declined to less than 8,200kW during the summer of 2008/09. The 12-month average annual energy delivered

[16] Calculated as the accounts receivable of more than one month divided by the average daily billing.
[17] Appendix 1: Report on Tonga Electricity Supply System presents the full details of the demand forecast.
[18] Economic performance data was taken from the National Reserve Bank of Tonga Quarterly Reports.
[19]The gross peak demand is the maximum power generated by diesel sets during a calendar month and includes whatever the station service was at the time.

from the Popua power station, net of station service, reached just over 48.2GWh during the winter of 2008 but started to decline in late 2008. By October 2009, the average annual energy sent out had declined to about 42.2GWh. This pattern may be seen in Figure 3.1 which shows the monthly energy sent out and the 12-month rolling average monthly energy sent out for the period 1998 to October 2009.

Figure 3.1 Historical Electricity Generations on Tongatapu



Source: TPL Records

Efforts were made to establish a statistical link between the level of remittances, the tariffs and the consumption of electricity in order to identify important electric consumption drivers. Although a weak statistical link was observed between remittances and electric use, no correlation was identified between tariffs and consumption. Accordingly, the forecasts were made based on recent consumption patterns together with broad economic expectations reflected in the Tonga Reserve Bank reports. Near-term economic growth expectations for OECD countries are generally pessimistic and opinions on Tongan economic growth are similar.

An initial set of forecasts for the period 2010 through 2020 were prepared in May-June 2009 but as the demand unexpectedly continued to decline quite sharply through late 2009, these early forecasts were revised. To build forecasts for each grid, the energy billed by TPL was projected and the gross energy generated was determined by adding the three types of losses; the estimated energy lost in transmission, the energy used at the generating stations and an allowance for non-technical losses being the energy that is unaccounted for because of faulty meters, inaccurate meter reading, accounting errors and theft. Median forecasts were prepared for each grid system as well as high and low projections.

Two key assumptions were introduced in all forecasts to evaluate the impact of system efficiency improvements. The first of these two scenarios is described as the "Do Nothing" case where no changes in the system losses or end-use efficiency are made. In the second, the "Efficient Supply & Demand" case, TPL implements a loss reduction programme and a DSM[20]programme is implemented with the GoT. Table 3.2 summarizes the median energy and peak demand forecasts for each of the four grids under the "Efficient Supply & Demand" case. Figure 3.2 shows the sum of the median, high and low energy forecasts for the entire TPL supply system under the "Efficient Supply & Demand" case and for the "Do Nothing" median forecast. The forecast energy in the "Efficient Supply & Demand" case is 17.7% less than the "Do Nothing" case.

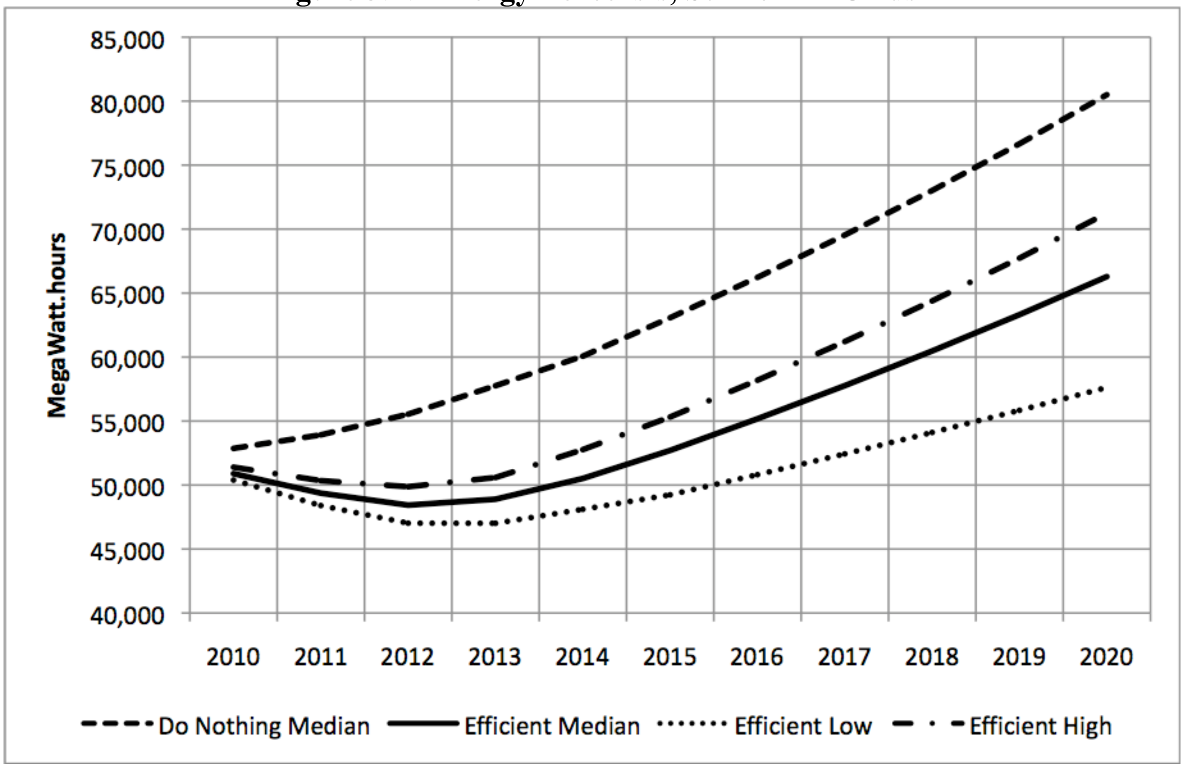
Table3.2: Median Forecasts – "Efficient Supply & Demand" Case

	2010	2011	2012	2013	2014	2015	2020
Tongatapu Grid	MegaWatt.hours						
Billed Energy	36,759.0	36,223.3	36,001.0	36,760.1	38,230.6	40,142.1	51,232.6
Total Losses	6,856.3	6,019.6	5,391.4	4,987.6	4,899.1	4,845.6	5,284.3
Total Generation	43,615.3	42,242.9	41,392.3	41,747.7	43,129.6	44,987.7	56,516.9
Loss as % of Gen.	15.72%	14.25%	13.03%	11.95%	11.36%	10.77%	9.35%
Peak Demand, MW	7.903	7.654	7.500	7.565	7.815	8.152	10.241
Vava'u Grid	MegaWatt.hours						
Billed Energy	4,037.0	3,978.1	3,953.7	4,037.1	4,198.6	4,408.5	5,626.5
Total Losses	756.6	666.8	600.5	570.3	557.1	560.2	663.2
Total Generation	4,793.6	4,645.0	4,554.2	4,607.4	4,755.6	4,968.7	6,289.7
Loss as % of Gen.	15.78%	14.36%	13.19%	12.38%	11.71%	11.28%	10.54%
Peak Demand, MW	1.021	0.989	0.970	0.981	1.013	1.058	1.340
Ha'apia Grid	MegaWatt.hours						
Billed Energy	1,236.5	1,240.0	1,255.4	1,294.2	1,346.0	1,413.3	1,803.8
Total Losses	168.4	165.4	160.4	162.4	168.8	175.5	217.5
Total Generation	1,404.9	1,405.4	1,415.7	1,456.6	1,514.8	1,588.8	2,021.2
Loss as % of Gen.	11.99%	11.77%	11.33%	11.15%	11.14%	11.05%	10.76%
Peak Demand, MW	0.300	0.300	0.304	0.313	0.325	0.341	0.432
'Eua Grid	MegaWatt.hours						
Billed Energy	882.1	884.6	895.6	923.3	960.2	1,008.2	1,286.8
Total Losses	194.1	182.0	162.6	146.2	142.8	140.3	163.0
Total Generation	1,076.2	1,066.6	1,058.2	1,069.5	1,103.0	1,148.5	1,449.8
Loss as % of Gen.	18.04%	17.07%	15.37%	13.67%	12.94%	12.22%	11.25%
Peak Demand, MW	0.229	0.227	0.225	0.228	0.235	0.245	0.309
Total, All Grids	MegaWatt.hours						
Billed Energy	42,914.5	42,326.0	42,105.6	43,014.7	44,735.3	46,972.1	59,949.6
Total Losses	7,975.4	7,033.8	6,314.8	5,866.5	5,767.7	5,721.7	6,328.0
Total Generation	50,889.9	49,359.8	48,420.4	48,881.2	50,503.0	52,693.8	66,277.6
Loss as % of Gen.	15.67%	14.25%	13.04%	12.00%	11.42%	10.86%	9.55%

By M.C. Swales

[20] In the regional study "Promoting Energy Efficiency in the Pacific" by Econoler International for the ADB, 2009, the Consultant found that energy use could be reduced by at least 10% on Tongatapu through efficiency improvements by consumers. DSM programs are part of the "Efficient" case that will reduce demand by 10% on Tongatapu and Vava'u and by 5% on Ha'apia and 'Eua by the end of 2014.

Figure 3.2: Energy Forecasts, Sum of All Grids



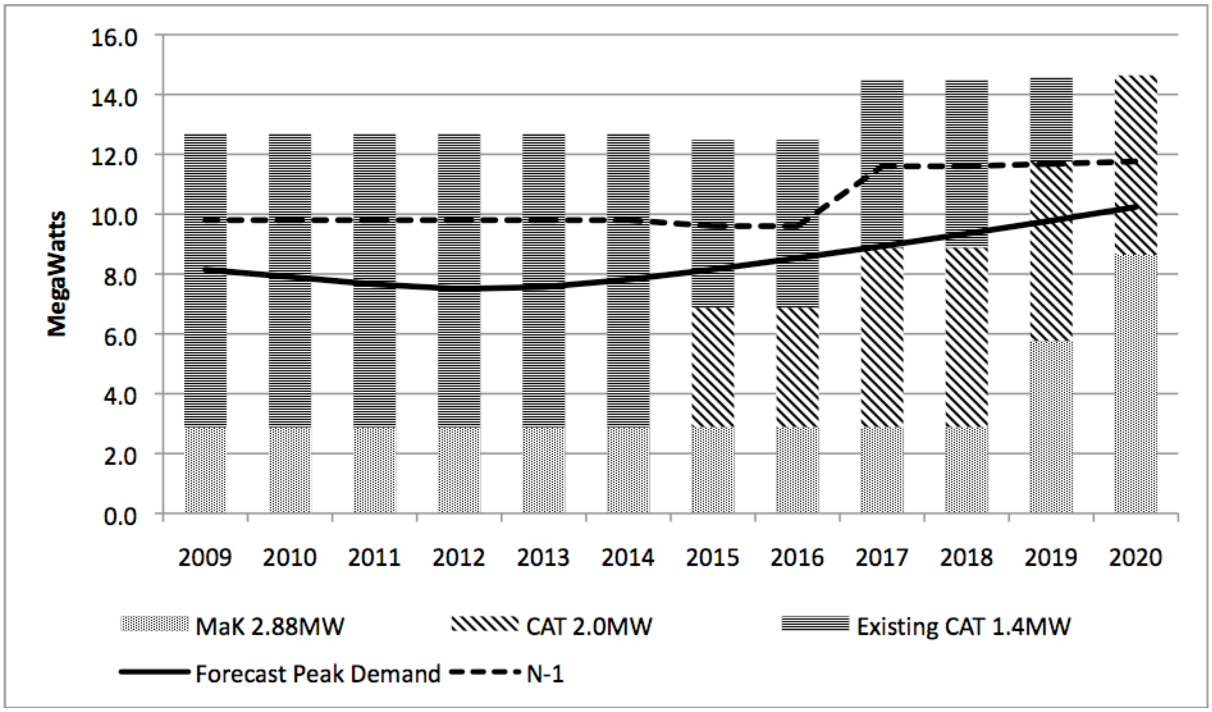
By M. C. Swales

*Diesel Fuel Requirements.*As a reference for the analysis of ways to reduce the use of imported diesel fuel, a projection of the fuel oil required if all future energy continues to be generated by diesel engine-generators has been prepared. In this scenario, referred to as "business-as-usual" or BAU, new diesel engine-generators will be needed to replace some existing units that have reached the end of their useful economic lives and to supply load growth. TPL has adopted an "N-1" capacity reliability criterion[21] and this has been used to guide the timing of new additions. Figure 3.3 illustrates the schedule of retiring units and new units together with the peak demand and N-1 capacity each year for the median forecast on Tongatapu. Similar schedules for new generation on the other grids are presented in the Annexes.

The schedule of new units shown in Figure 3.3 has been prepared to ensure that the capacity reliability criterion is met on the Tongatapu system. TPL may determine that advancing the commissioning of one or more new units may be justified based on the value of fuel savings. However, such analyses will be appropriate once the schedule of new renewable energy projects has been selected.

[21] This criterion requires that there be sufficient generating capacity to allow TPL to meet the forecast peak demand while the largest single generating unit is out of service.

Figure 3.3: Installed Capacity on Tongatapu Required for the Median Forecast BAU Scenario



From TPL Data, adjusted by M. C. Swales

The energy expected to be generated by each unit has been calculated using a model incorporating a probabilistic representation of the generating units and an annual load pattern derived from a sample of hourly records provided by TPL. This model allows the energy output constraints caused by equipment availability and varying energy demand to be accounted for. The most efficient units are dispatched first with the balance of the demand being supplied with progressively less efficient units. The expected volume of fuel required is calculated from the energy production of each unit. Table 3.3summarizes the fuel that would be needed under the BAU Scenario and compares the two cases, “Do Nothing” and “Efficient Supply & Demand”. The total diesel fuel used during 2009 was approximately 13.27 million litres.

Table 3.3: Estimated Annual Diesel Fuel Requirements, All Grids, BAU Scenario Thousands of Litres

Case	2010	2011	2012	2013	2014	2015	2020
Do Nothing	13,268	13,440	13,860	14,438	14,981	15,009	18,852
Efficient Supply & Demand	12,753	12,146	11,906	12,027	12,400	12,494	15,472
Reduction in Fuel Use	515	1,294	1,954	2,411	2,581	2,514	3,380
Percent Saving	3.88%	9.63%	14.10%	16.70%	17.23%	16.75%	17.93%

By M.C. Swales

3.2.4 Off-grid Electricity Supply

The ‘Outer Islands’ (OI’s) of Tonga are a group of 26 islands scattered throughout the three primary island groups of Tonga. The total population of the OI’s is approximately 6,001 people, with 5,300 of these living on islands without reticulated diesel generated electricity. This section of the TERM while providing almost 100% renewable energy generation will only impact 6% of the total population and will have no impact on reducing diesel use.

Projects to provide basic electricity to communities on the Outer Islands have been operating since 1988 with varying levels of success. While the technical options on the outer islands revolve primarily around solar PV generation which has proven to be the most cost effective option, clear and repeatedly reported issues still exist concerning institutional, financial and technical support sustainability.

Providing reliable and adequate electricity supply to the remote, declining and dispersed population of the outer islands (Table 3.4) is a major challenge and requires an entirely different strategy than that for the urban island of Tongatapu.

Table 3.4: Population of Tonga, 1996-2006

Island or Group	Population (2006)	% of total	% increase (1996-2006)	Annual growth
Tongatapu	72,045	71%	7.6%	0.7
Eua	5,206	5%	5.5%	0.5
Ha’apai	7,570	7%	-7.0%	-0.7
Vava’u	15,506	15%	-1.3%	-0.1
Niuas	1,665	2%	-17.5%	-1.9
Total	101,991	100%	4.3%	0.4

Beginning in 1988, GoT has, with the assistance of various international agencies and donors, implemented a number of outer island electricity supply models with varying levels of success. The focus has mainly been on solar energy, but projects utilizing diesel generationhave also been undertaken.

3.3 Observations on Cross-Cutting Energy Sector Issuesto be addressed in the TERM

Compared to many Pacific Island Countries Tonga has a relatively well-functioning energy sector. However, the Government recognizes that significant adjustments are needed to move the sector to a more secure and sustainable footing. The review of the current situation has highlighted a number of cross-cutting issues that will need to be addressed at an early stage in the plan to improve the energy security while achieving environmental and financial sustainability. These issues and recommended actions to address them are picked up in Section 5.

3.3.1 Data limitations

Several broad areas of data limitations were encountered during the preparation of the TERM:

- petroleum product supply, costs and uses;
- TPL Utility Database and customers use profiles;
- Reliable, comprehensive indigenous energy resource information;
- Current status of existing off-grid systems and future demand in remote areas.

Specific regulatory recommendations and assessment of financial tools to limit the volatility of imported petroleum prices require detailed information on the existing supply and cost by sector and over time. Given petroleum's current and ongoing importance in meeting Tonga's energy needs, and the risks to Tonga arising from supply interruptions or oil price spikes, greater emphasis is required by government in collecting, storing and analyzing the petroleum sector and the costs of supplying fuel to Tonga.

*Petroleum product supply, costs and usage.*At present, there are significant shortcomings in the government's retention and analysis of petroleum data. Accurate information on petroleum product supply and usage by sector and by customer type would assist policy makers in: a) assessing the overall vulnerability of the economy to oil price shocks; b) identifying energy intensive sectors that are vulnerable to fuel price shocks; c) understanding the impacts of fuel price rises on households, particularly low income households.

*Energy Use Database.*To determine the full extent of possible DSM programmesand end-use efficiency options, a better understanding of how customers are currently using electricity is needed. This will require targeted end-use data collection activities to be undertaken across all major consumer categories. For TPL to implement a cost-effective loss reduction programme, a sound database of their existing system and its recent performance is important. Data defining the indigenous resource available to meet the future electricity needs of the country is key to implementing a least-cost investment programme. An assessment of the cost and details of the implementation arrangements of the recommended off-grid approach cannot be finalized until further information is available regarding the current status of existing systems in remote areas and the projected growth in demand.

To meet the objectives of the TERM, significant effort will be targeted to improving the generation, collection and availability of energy sector data. Detailed design of sub-components of the TERM and many investment decisions cannot be undertaken without improved data. Examples of the gaps and the impact on decision-making are given below.

TPL Utility Database and customer use profiles. TPL inherited its database and data management systems from its predecessor. Although much important data was lost during the 2006 civil disturbance, the previous owners were apparently reluctant to share information outside the organisation and the data collection systems reflect this attitude. Typically, electric utilities will maintain System Control and Data Acquisition (SCADA) systems to electronically collect a wide range of system performance data and so provide management with the information needed to keep their operations efficient. There was a SCADA at the Popua power station that automated data collection on the generating units but the system failed and has not yet been replaced. There are no comparable systems at power stations supplying the other three grids and there are no systems to automatically monitor the performance of key sections of any of the grid networks. Hence there is no record of the hourly load demand, a key requirement in any planning activity. The billing database system is over 15 years old, it has certain limitation and TPL only has consumption data by customer back to when it acquired the business[22]. TPL did not purchase the accounts receivable records from the previous owner. With information on customer electricity use, TPL will be better able to monitor a wide range of customers as well as the important large consumers for their development plans that affect future electric consumption. Such information will be essential to tailor DSM programmes across the system.

Renewable Energy Resources Database.In general, the data record for possible RE sources isinsufficient for investment-grade project feasibility assessment. Further resource assessment is needed to formulate projects that are financially viable and potentially attractive for private sector participation. Neither TPL nor GoT ministries have much data on the renewable energy potential of the country. Solar and wind records are available in a very limited number of locations and the data series are often discontinuous. There is even less reliable information on the biomass that might be available as energy feedstock. The combination of limited electric system data together with poor resource data introduces a considerable degree of uncertainty into any project assessment. While the resource and integration[23] risks are lowest for solar PV, even for this technology, a prerequisite for a large investment should be the acquisition of accurate resource data. One of the most important first steps in the implementation of the TERM, described further in Section 5, must be to collect and analyzerelevant resource, power system and petroleum data.

3.3.2 Distributed Institutional Responsibility for the Energy Sector

As described in Section 3.1, in the petroleum sector different Government entities are responsible for almost every aspect of the petroleum supply arrangements, planning, monitoring and regulation. There appears to be little interaction among these entities in terms of data sharing or cross-checking, with the result that it is very difficult to create the accurate picture of the sector needed to regulate the sector effectively and understand the opportunities for improvement.

As described in Section 3.2, the situation is similar in the electricity sector. There is no GoT entity with the mandate and capacity to maintain a strategic overview of the electricity sector including on- and off-grid, renewable and conventional energy and energy efficiency and issues of quality, cost and energy security. To some extent the Office of the Renewable Energy Coordinator has taken on this role in the electricity sector as the Road Map process has progressed. However the current arrangement is a temporary one.

3.3.3 Transparency and Simplification of Regulatory and Oversight Processes

In both the petroleum and electricity sectors, independent regulatory bodies have been established. However in both sectors the regulatory process is generally characterized by a lack

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[22] The same metering and billing database is used to manage the meter readings of customers on the other grids.
[23] Electricity from renewable energy sources is intermittent and must be backed up with "spinning reserves" or capacity at a fully controllable generating plant that is able to respond quickly to changes in system demands.

of transparency and availability of information, and there appear to be few if any people in the GoT who fully understand the methodologies applied. Added to that, in the electricity sector, the existing regulatory arrangements do not address a situation where a significant amount of the grid-based electricity supply is generated from renewable energy sources. The significant data gaps noted above would make it difficultto effectively regulate either sector.

Price regulation of petroleum sector. Tonga's current approach to petroleum price regulation could be strengthened by subjecting key petroleum company cost drivers to greater scrutiny. Under present arrangements, it appears as if it may be difficult for the petroleum regulator to:

- Validate operational and distribution costs as quoted by suppliers (which risks suppliers padding costs out);
- Form views on actual capital cost requirements or the validity of asset valuations;
- Understand the potential financial impacts arising from an environment or safety event and who bears the risks arising from such an event;
- Assess performance and reward efficiency.

Together these limit understanding of actual operations, asset valuations, safety and environmental risk management and investment requirements. This limited understanding could pose a number of financial risks, including:

- higher fuel prices than would otherwise be the case if accurate asset values were used; either through:
  - inefficient investment to increase the value of the regulated asset base (i.e. 'gold plating' of assets);
  - overstatement of asset values;
- under-investment or insufficient maintenance (i.e. running down assets);
- cost padding of capital and/or operating expenditures; and
- the regulator setting rates of return that are too low for sustainable business operations, given the financial, environmental and safety risks and the costs of capital associated with petroleum supply, storage and distribution.

3.3.4 Gaps and Inconsistencies in the Policy and Legal Framework

The existing policy and legal framework for the electricity sector has gaps or inconsistencies in the areas relating to procuring electricity through a Power Purchase Agreement (PPA) from an Independent Power Provider (IPP); treatment of investment in renewable energy systems with a significant grant contribution; provision of private sector incentives for renewable energy investment or for the long term finance of consumer owned renewable energy installations; consumer owned installations of renewable energy; off-grid electricity supply from sources other than solar; and jurisdictional distinction between direct current (DC) and alternating current (AC) electricity operations.

The existing policy and legal framework for the petroleum sector has gaps or inconsistencies in the areas relating to energy security, mitigating financial risks arising from oil price volatility, petroleum safety and environmental protection, the degree of independent scrutiny in the fuel the price regulation process.

*Petroleum, energy security risks and their mitigation.*Tonga's high dependency on imported petroleum products to meet its energy demands makes Tonga highly vulnerable to two types of risks: 1) Oil price shocks; and 2) Interruptions in the delivery of fuel. An improved understanding of these risks is required by government, together with greater policy direction on how to mitigate risks arising from supply interruptions (e.g. increasing the level of storage in Tonga or storing fuel offshore), oil price spikes (e.g. financial hedging); or catastrophic events (e.g. enforcing stringent safety standards and developing contingency plans for major fuel leaks or fires).

Environmental and safety risks. Tonga's current approach to petroleum safety relies on fuel companies managing the safety and environmental risks of their own facilities without a great deal of regulatory oversight. This lack of scrutiny has a number of safety, environmental and financial impacts. Petroleum storage facilities face very high impacts from disaster, even in highly regulated and controlled environments (e.g. Coode Island disaster in Australia in 1991;Longford gas plant in Australia, 1997; West Atlas oil rig fire in Australia in 2009; Major US refineries after cyclone Katrina in 2005). In Tonga's case, loss of the country's main storage facilities through fire or a tsunami would result in severe transport and electricity supply disruptions, with consequential impacts on the economy, communications, and public health and safety. These negative impacts could last for months, until such time as the facilities could be brought back into service. A major fuel spill could have adverse impacts on fisheries, the tourism industry, or public health. Fuel leaking into the water table from underground fuel storage tanks poses public health and safety risks. Improvements in Tonga's petroleum safety and environmental laws, regulations, licensing and regulatory arrangements would contribute to the understanding of and mitigation of these environmental and safety risks. It would also affect the pricing of petroleum, by giving greater comfort that adequate investments and maintenance of fuel storage and distribution facilities are carried out to international standards; done efficiently; and the costs of this are accurately reflected in the asset values, capital expenditure, and operational expenditures of fuel companies.

4. ANALYSIS OF TECHNICAL OPTIONS

4.1 Improved Efficiency in Petroleum Supply Chain

Options for improvement in efficiency of the supply chain of petroleum products to Tonga are aligned with the various stages of the supply chain:

- Oil Sourcing Location. Exploring efficiencies in sourcing refined product from the current locations, Singapore (fuels other than LPG) and Australia (LPG), or from other refineries.
- Transport to Tonga.
    i) Bypassing Fiji by having a Medium Range Tanker (MRT) steam to Tonga directly from Singapore
    ii) Merged supplier shipping
- Storage & Safety Stock. Establish a strategic reserve Off shore or In Tonga
- Local Distribution.

These options are being assessed as part of the petroleum supply chain study, which is still underway.

There has recently been a study on the option of by-passing Fiji by having a Medium Range Tanker (MRT) steam to Tonga directly from Singapore.[24] An MRT to Tonga would enable larger volumes to be shipped than at present using LCTs, and avoid the storage fees and port charges associated with shipping via Fiji. However, an MRT would require significant investment in port and fuel storage infrastructure in Nuku'alofa and LCTs would still be required to supply Vava'u.

It is important to note that supply chain costs make up around 9% of delivered fuel costs (see Figure 4.1), with the largest cost components being the base product cost (44%) and Tonga wharfage, duty and consumption taxes (38%). While savings brought about by supply chain efficiencies may be significant in reducing fuel prices and price volatility, reducing the volatility of the price of the base product is critical. The costs of wharfage in Tonga appear to be higher than elsewhere, and this is an area which should be reviewed by the Government of Tonga. Duties and taxes have a compounding effect on any increases in the base product cost, as the level of fuel taxes also needs to be considered in discussions concerning the impact of fuel price rises.

The estimated savings from using a Medium Range Tanker to deliver diesel fuel directly to Tongatapu from Singapore are 7.7 seniti per litre (or around 4 US cents per litre), which is a 3.5% saving -- see Table 4.1. The study did not examine any cost savings or additions relating to fuel distribution within Tonga.

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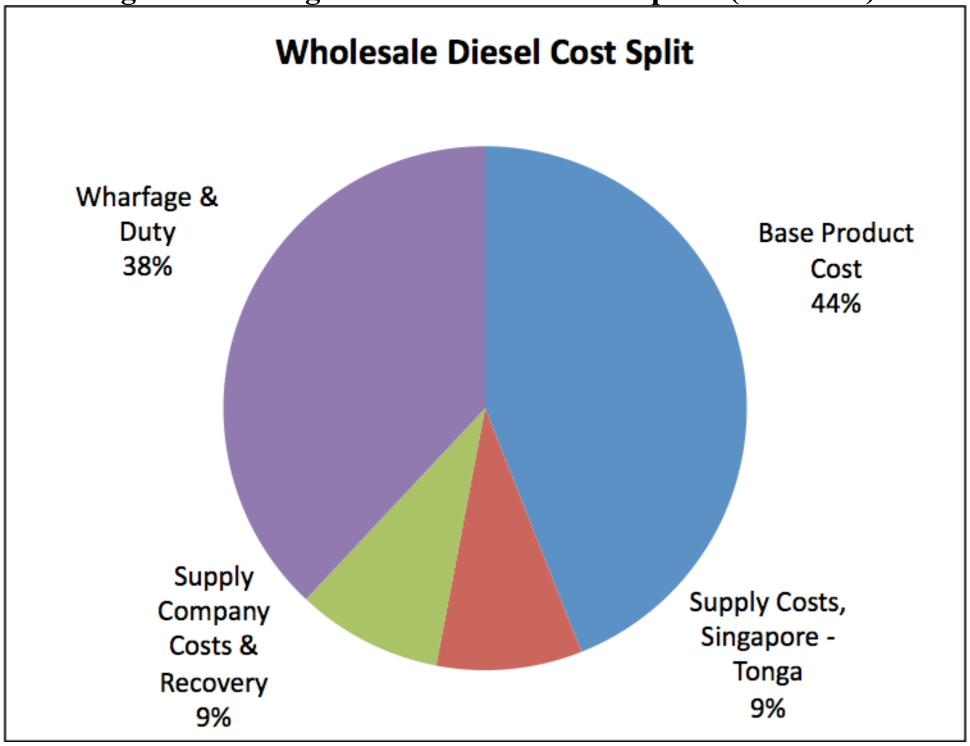
[24] Hale &Twomey and Aurecon 2010, *Tonga MR Tanker Port Feasibility Study*, prepared for Ministry of Labour, Commerce and Industies, Tonga, January 2010.

Figure 4.1: Tonga's wholesale diesel fuel price (Nov 2009)



Source: Hale &Twomey and Aurecon 2010, *Tonga MR Tanker Port Feasibility Study*, p.3.

Table 4.1 Estimated supply chain savings from Medium Range Tanker, Diesel fuel, November 2009 prices (Tongan senitiper litre)

Cost component	*Current supply via Fiji* (Seniti per litre)	*Direct imports using Medium Range Tanker* (Seniti per litre)
Singapore base price + quality premiums	96.1	96.1
Freight from Singapore (incl. insurance and loss)	5.9	7.6
Fiji landing cost and storage and holding	1.9	0.0
Freight from Fiji to Tonga	11.8	0.0
Tonga demurrage	0.0	0.2
New wharf/terminal return	0.0	5.1
Possible wharf investment	0.0	1.0
Tonga wharfage	3.4	3.4
Tonga Duty	50.0	50.0
Local operating costs	9.2	9.2
Oil company return on investment	11.5	10.6
Consumption tax	28.5	27.5
TOTAL	**218.3**	**210.6**

Source: Hale &Twomey and Aurecon 2010, *Tonga MR Tanker Port Feasibility Study*, p.19.

While the supply chain efficiency savings may be relatively small, they are significant. More significant benefits for Tonga could arise from implementing a financial risk management strategy that limits the effects of volatility in the base product price. As noted herein, ADO used by TPL for generation is exempted from duty and consumption tax.

*Financial hedging and risk management.*Financial hedging is one way of managing price volatility risks and generating price stability. There are a range of financial instruments that can provide a buyer with greater certainty about the final price that will paid for petroleum products. There are a few important points to note:

- Price stability comes at a cost - an "insurance" premium is paid against the risk of potential future price fluctuations
- The greater levels of price stability come at higher costs/premiums
- Users of Risk Management products have to decide what percentage of their purchased product risk is to be managed (i.e. hedged)
- Risk Management is NOT speculation. Speculation occurs when risk management tools are used with no relation or regard to the objectives of price stability or the underlying physical volumes that will be consumed.

The financial instruments -- oil futures and options -- are traded in commodity markets around the world, including Singapore, New York Mercantile Exchange (NYMEX), and London. These products are traded either via exchanges, bilaterally between parties, or in Over the Counter (OTC) markets. The simplest financial hedge products are swaps, caps, and collars.

Major energy users, such as power companies, transport companies and airlines often use financial hedge products to manage the commercial risks to their business arising from fluctuations in the price of their energy inputs.

The potential use of such financial instruments in Tonga is being examined as part of the forthcoming petroleum supply chain and hedging study that will form part of the final Road Map. The gradual introduction of financial hedging on some of the fuel volumes imported into Tonga (such as those used for power generation) would enable understanding of financial risk management to grow; together with an understanding of the costs, benefits and risks of various hedging strategies. At present, Tonga is entirely exposed to fluctuations in fuel prices, with significant risks arising from fuel price spikes. That is, there is no effective financial risk management in place, just hoping for stable and low prices or in the event of price spikes passing those costs on in ways that can be debilitating to the economy, businesses and consumers. A shift towards financial risk management on fuel purchases offers a way of reducing the vulnerability of Tonga to such fuel price volatility.

4.2 Reduced dependence on fossil fuels

4.2.1 Options Available to Reduce Imported Fuel Use

*Efficiency Improvements.*As highlighted in several places in this report, energy efficiency has been identified as the least cost option for reducing diesel fuel usage in Tonga's electricity system and is an area where urgent and immediate action is needed. During the preparation of this draft report the identification of the full suite of potential cost effective energy efficiency measures was constrained by lack of consumer energy use and capital stock data. The limited range of energy efficiency options identified below reflects the data constraints encountered but a range of immediate follow-up actions are recommended. These will enable a more complete assessment of the energy efficiency potential available in Tonga. It is expected that substantial cost effective energy efficiency activities remain to be identified.

Energy efficiency measures can be divided into two main sub-categories, namely, supply side measures (delivering more energy to end-use consumers per unit of fuel consumed, for example through reducing system distribution losses) and demand side measures that reduce the consumption of energy at the end use per unit of end-use service (for example replacing and inefficient incandescent light bulb with a more efficient CFL bulb).

The economic benefits of energy efficiency measures need to be viewed in a national economic context rather than merely the explicit benefits to the power utility. While the electric power utility can achieve significant technical and economic gains from implementing energy efficiency measures there are a wide range of measures they may not be in the direct interest if the utility to implement, especially where such measures could reduce their revenue base. The TERM approaches energy efficiency from the broader national perspective. In theory energy efficiency measures should continued to be implemented up to the point where the full life cycle costs equal the benefits of the measure. More specifically energy efficiency should be implemented up to the marginal cost of the next unit of supply. In the situation where the next unit of supply was wind generator producing at a delivered system cost of 50 cents/kW-h then the cost of the avoided unit to which efficiency measures should be introduced is 50c per unit. In reality this is rarely achieved due to a range of market and non–market barriers, especially information constraints and transaction costs.

Supply Side Efficiency. Options to improve the efficiency with which fuel is converted to electricity and electricity transported to consumers include reducing energy used in power stations (station service), improving overall station efficiency by removing operating limitations, improving the maintenance schedule timing to maximize fuel efficiency, potentially installing new units to improve station efficiency, reducing network technical losses through upgrading lines, insulators, transformers, adding new circuits, adding metering and central monitoring to improve operations and the network performance database. A further option may be to consider recovering the waste (exhaust) heat from the diesel engines and utilizing this for additional electricity generation, once the system at relevant scales in similar contexts has been demonstrated. The variable loading of the TPL diesel engines may pose challenges that would need to be carefully evaluated. Initial estimates suggest that supply side efficiency improvements could result in a reduction of diesel fuel use relative to the "Do-Nothing" approach[25] of 7-8%. If recovery of the waste heat is determined to be feasible, larger reductions would be possible.

[25] The "Do Nothing" case is defined in Section 2 and represents a situation where there is no reduction in TPL losses over time compared to the current levels, and no Demand Side Management efforts.

Improving the supply efficiency has the benefit of being made up of very many separate investments which may be implemented, or not, depending on how economically viable each is. Each element of technical loss can be identified, for example, a circuit with too small a conductor, the cost of the upgrading the conductor determined and the loss reduction assessed. Only those elements that meet the threshold criteria will be implemented ensuring the overall component remains least cost. Assessments of all opportunities for efficiency improvements should be undertaken to firm up the scope and cost of other supply side efficiency options. Generally such improvements are considered commercially viable and are financed from a utility's internally generated revenues and commercial borrowing. In the case of TPL, acknowledging the deficit in regular maintenance under the previous owner, there may be justification for extending concessional credit and grant funding to the utility to accelerate the implementation of measures to improve safety and efficiency.

One upgrade project that cannot be financed from tariffs is the upgrade of the supply networks in most villages supplied from a grid. The essential investment to make these village networks safe, efficient and reliable has been deemed to be a legacy cost that should not be passed to current electric consumers. TPL is in the final stages of a study to identify the scope and cost of upgrading the village distribution networks, which would result in improved safety of the system and also a reduction in losses. The plan calls for replacing the entire network in the selected villages so that all parts of the electric systems would meet international standards. As a separate element, TPL plan to self-finance and install more sophisticated metering so that the risk of tampering would be reduced and meter reading would be simplified. The village upgrade would also include new street lights with low-power LED bulbs and TPL have proposed that the Government would fund this component. In the implementation, TPL have identified a two-part programme in which the first part would be a pilot scheme to upgrade the systems in 18 villages with 1,700 households at an estimated cost of TOP6.86 million (US$3.43 million). Meters funded by TPL would add TOP0.68 million (US$0.34 million) and streetlights would add a further TOP1.9 million (US$0.95 million). In total, the pilot scheme if fully implemented would cost TOP9.44 million (US$18.88 million), aboutTOP5,550(US$2,780) per household. The second part would complete the upgrade of another 52 villages and 5,950 households at a project cost of TOP23.9 million (US$11.95 million), not including meters and street lights. Additional details of the scope of work and cost estimate is included as Appendix 6.

Demand Side Management (DSM). DSM measures are designed to improve the efficiency of converting electricity into useful services without loss of benefits from the point of view of the consumer. The changes are modular so that the value of each change, upgrade and investment to increase the efficiency of energy use can be evaluated and implemented if it meets the threshold criteria. Although significant data constraints were encountered it was possible to identify several initial energy efficiency measuresfor implementation. These are:

- Upgrading of streetlights to use either LED or incorporate dimming (voltage reduction) technology,
- Reducing the demand in large Government buildings through modifications to the cooling and ventilation systems, changing lighting and upgrading other equipment, and
- Reducing lighting demand in the residential, commercial and religious sectors by replacing incandescent bulbs with compact fluorescent lights (CFLs).

The combined annual energy savingsof these measures is estimated to be some 6% of the generation forecast for all grids together in 2012. A summary of the indicative costs for three possible measures is shown in the Table 4.2.

Table 4.2: Energy Efficiency Impact for Three Identified DSM Programmes

Programmes	Measures	Electricity saving (kW-h)	Load Reduction (kW)	Investment Cost (US$)	Annual Savings (US$)	Pay Back Period (Years)	TCO^2 Savings
LED fixtures for Street Lighting	3,208 Lamps changed	697,200	196	1,200,000	802,000	4.1	541
EE in Public Buildings	Various ECM	380,000	NA	346,500	130,000	3	295
CFL Programme	20,000 IBs replaced	942,000	780	95,000	97,050	1.2	731
TOTAL		**2,019,200**	**976**	**1,641,500**	**1,029,000**	**1.6**	**2,000**

At least three additional areas should to be evaluated as data become available: the energy use in the public water supply systems; the improvement of load factors at large consumers; and broad efficiency improvements in the industrial, commercial, religious and Tourismsectors. Based on experience elsewhere, it is anticipated that cost effective end-use energy efficiency measures in these areas may contribute upto 30% reduction in energy. Further details are available in Appendix 3.

To enable a full assessment of the potential for cost effective energy efficiency investment opportunities in Tonga, Phase 0 activities should include:

- Implementing a comprehensive energy use survey across all major consumer categories to provide sufficient information on end-use consumption and capital stock characteristics (for example, appliances, air conditioning and motors);
- Implementing an energy audit programme for Tonga's 50-100 largest energy consumers to identify cost effective energy efficiency investments and assess the opportunities for on-going sub-sector energy efficiency audit support programme (for example in the Tourism sector).
- Assessing the current fiscal and regulatory settings (for example, import duties and taxes) to determine whether they create a disincentive for investing in high efficiency equipment and appliances. Also identify whether opportunities exist to establish incentives to drive energy efficiency (for example exempting high efficiency appliances from taxes and duties;
- Investigate the benefits of introducing regulatory arrangements to exclude low efficiency equipment and appliances from the market through the introduction of

mandatory minimum energy performance standards (similar to those recently introduced by Fiji) or other equivalent regulatory mechanisms

- Develop and implement a public awareness and information programme for consumers as means of increasing their awareness of the economic benefits of energy efficiency and the options available to them to capture these benefits.

Existing regional activities be undertaken by the SPC Regional Energy Programme, REEEP and others could assist with the design and implementation of some of these measures, particularly energy data collection and analysis, and the application of minimum energy performance standards. These measures will require donor support but will also require the commitment from the Tongan Government to coordinate and contribute to the implementation and management of these activities.

Following the collection of sufficient data to enable meaningful analysis of energy sector during Phase 0, a range of innovative follow-on activities in Phase 1 and Phase 2 could be identified and implemented. For example the establishment of the TGIF could provide low or no interest loans up to 5 years to finance the purchase (on a exchange and scrap basis) energy efficient appliances (5 star or better) or the implementation of an energy efficiency investment portfolio identified through energy audits. Opportunities may also exist to tender for an energy service company to manage and implement an energy efficiency portfolio serving a range of large energy consumers.

*On-grid renewable energy options.*All potential sources of renewable energy supply in Tonga were considered. A summary of the options together with the potential benefits and limitations is included in Annex 3. Further detailed assessment is presented in the report provided in Appendix 2.

Each option was evaluated against the following screening criteria:

- *Maturity of Technology*. Only mature technologies are considered options for inclusion in the Road Map[26]. A technology is considered mature when the equipment is commercially available and there are reference projects where the technology has performed satisfactorily.
- *Social or Environmental Showstoppers*. Showstoppers would include serious environmental impacts that cannot be mitigated, or major social hurdles, for example related to land use and ownership, that cannot be overcome within the timeframe of the Road Map. If a showstopper is identified, the option is not considered as part of the scenarios modeled.
- *Lifecycle Cost*. The most important criteria to determine a least cost development path for grid connected RE is levelized lifecycle cost for the various options. These costs, expressed in US$/kW-h, are the sum of the discounted annual expenditures (investment and operation) divided by the sum of the discounted annual energy production, all at the same 5% real discount rate.

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[26] However it is recommended that as the Roadmap is periodically reviewed and updated, promising technologies which are currently not considered mature should be re-evaluated as experience is gained elsewhere.

The options can be separated into two categories:

- *Intermittent energy supply*[27]: Solar and wind, without storage, are intermittent and variable sources of supply, i.e. they generate electricity only when the sun is shining or the wind blowing. Each time a cloud passes or the wind dies down, an alternative source of power generation (e.g. diesel generation) has to quickly be brought on line in order to meet customer electricity demand. The potential contribution of these sources of energy on a grid system is limited because above a certain level, their contributions can be very disruptive to the grid service. In some cases, electricity generated from win or solar sources must be "dumped" – i.e. not used, because of difficulties in quickly reducing diesel output to match a sudden increase from this generation. Solar and wind generation can reduce the fuel used in the diesel engines, but because a firm source of supply (e.g. diesel generation) must be ready to replacethis variable electricity supply, intermittent energy cannot displace capital investment in firm capacity. In essence, the full cost (capital and O&M) of electricity from an intermittent source is compared only to the cost of fuel displaced.

  Since both wind and solar are intermittent sources, production from one will limit the amount of the other that can be supplied to the grid without negative consequences. Initial modeling suggests that no more than 2.4 MW of PV alone, or 1.4MW of wind alone or a combined 2.1MW of solar and 1MW of wind, can be connected on Tongatapu without causing problems in grid operation and supply quality. This level of intermittent generation would supply between 7% and 11% of the annual electric energy generated in 2009. These numbers should be considered preliminary due to data limitations.

- *Firm capacity and energy supply*: Firm capacity and energy is available on a continuous basis (subject to normal maintenance outages). The electricity generated can be fully used to supply the electric grid demands. Limits to the energy contribution are related to the resource availability, the development size and available funding. Of the options available in Tonga, there are four sources of firm energy that could potentially be considered: landfill gas; Coconut Oil (CNO) blended with or replacing diesel in existing or slightly modified engines; and intermittent (solar or wind)-with-storage projects[28]. The cost of firm renewable energy options would be compared to the full cost of generation (capital, O&M including fuel) from diesel-fired generation.

Table 4.3 below ranks the levelized unit costs for the options which meet the first two screening criteria. With respect to each resource (excluding landfill gas which potentially available only on Tongatapu), different sizes and configurations of development could be considered to meet the specific requirements of each of the separate grids. The levelized cost estimates for solar

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[27]In common use, the term intermittent indicates something that is either on or off. For wind and solar generation, the situation is more complex because, while the generation is indeed intermittent - calm winds and night times for solar - it is also variable. The use of intermittent is to distinguish between energy resources that can be managed to supply electricity as needed versus energy that is only available according to natural events.

[28] The use of gasifiers to use some of the coconut waste has been considered but rejected in part because the CNO plant needs process steam which would be provided by a boiler fired with much of the coconut husks and shells and in part because of the high proportion of failed installations in PICs.

without storage and CNO, given the uncertainties in the available data. Subject to verification of the resources, the least cost options are landfill gas and wind, and the most expensive option is intermittent (either solar or wind) with storage. A summary of the inputs to the levelized cost calculations is presented in Annex 1. Further detail is provided in Appendix 2.

The data available for landfill gas and wind will need to be firmed up to determine whether the resource is actually available and viable, before significant investment in any of these options is feasible. A proof-of-concept scale coconut-to-electricity project may be needed to address the uncertainties around the coconut supply issues. Solar resource data are somewhat better, but further measurements would be required as a project proceeds to detailed design stage. All options will benefit from improved data on the resource and on the electric system to which they will be connected. Accordingly, the Indicative Implementation Plan described in Section 5 sets out a programme of actions that will allow decisions to implement the most economic and practical options to be made and the projects implemented as quickly as possible.

Table 4.3: Renewable Energy Unit Energy Costs[29]

Renewable Resource	Potential Annual Yield, kW-h	Unit Cost US$/kW-h	Unit Cost TOP/kW-h	Notes
Intermittent Energy				
1MW Wind* (size could vary up to max. noted above)	1,927,000	0.177	0.354	Investment-grade wind data not currently available; limited contribution possible without storage system.
1MW Solar (size could vary up to max. noted above)	1,577,000	0.346	0.692	Additional resource data is needed to firm up levelized cost estimates; limited installation possible before a storage system needed; only available during daylight hours; potential for distributed generation.
Firm Capacity and Energy				
Landfill Gas	675,000	0.178	0.356	Resource unproven. Small low-cost option on Tongatapu only; capacity could be potentially doubled when second, new landfill yields gas.
Coconut Oil (CNO) used to displace ADO in diesel generators.	2,585,000 – prototype 15,505,000 - full scale	0.357 0.341	0.714 0.682	Size and cost of the resource to be confirmed; requires involvement of land holders to ensure an adequate supply of coconuts. Husks and shells used for process heat in the CNO plant but some electricity may be available from any surplus process heat.
15MW of solar PV + Battery storage	21,024,000	0.754	1.508	Larger and smaller installations possible to match each grid system requirements; batteries need replacement approximately every 10 years.

*Wind resources are site-specific. If a wind resource is proven, wind turbines would be located where wind resources permit. This may imply investment to connect the generation site to the grid, or to strengthen the grid where the wind generation is supplied. This cost can be substantial but cannot be included due to a lack of information. Each wind prospect would need to be evaluated individually.

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[29] The unit energy costs are the levelised cost of energy calculated including capital, interim replacement and O&M and discounted using a real rate of 5%.

4.2.2 Summary of the Least-Cost Ordering of Options to Reduce Diesel Use for Electricity Generation

*Supply and Demand Efficiency Improvements.*Supply and demand efficiency measures will be the least cost interventions to reduce the use of diesel for power generation. A combination of these measures could result in a reduction of up to 18% in diesel use relative to projected diesel use without efficiency improvements ("Do Nothing" case). Grant or concessional financing, including for institutional support, would accelerate the pace of implementation of these programmes.

*Landfill Gas Development.*One landfill site on Tongatapu has been closed and could potentially be tapped to produce methane immediately. The estimated potential yield is equivalent to 675,000kW-h per year, equivalent to 1.5% of the electricity currently generated by TPL on Tongatapu. There may be additional potential from the new landfill in about 10 years. If the volume and quality of the gas at the old landfill site on Tongatapu is confirmed, the expected cost of electricity from this renewable energy resource is sufficiently low that implementation on a fully commercial basis could be possible without requiring a tariff increase.

Wind Turbines without Storage. Two or more wind turbines, up to a maximum of about 1.4MWcould be accommodated on the Tongatapu grid, potentially yielding 2,700,000kW-hof electricity annually – equivalent to 6% of the electricity currently generated by TPL on Tongatapu. These findings are preliminary as site-specific wind records are not available. If a suitable site with high enough average wind speeds can be found, the unit electricity cost from a small wind project without storage is similar to the estimated unit cost of electricity generated from landfill gas. Costs of connecting to the grid would need to be factored into the calculations once a specific site has been identified.

Subject to confirmation of landfill gas and wind resources, these projects would be commercially viable without increasing the cost of electricity relative to continued diesel-based generation. Investments from this point onward would lead to an increase in the cost of electricity generation relative to diesel, unless a subsidy is provided. Given thecurrent uncertainties in data, the coconut and solar PV options are considered roughly comparable on a unit cost basis. However electricity supplied from CNO would be firm and therefore more attractive both from a cost point of view (displacing energy and capacity, as opposed to energy only). The last option (solar PV with storage) is clearly the most expensive, even considering the data uncertainties.

Coconut Oil. Notwithstanding an inadequate database describing the full extent of the coconut resource in Tonga, the analysis to date suggests that coconut oil will provide the lowest cost source of firm renewable energy for Tonga with the potential for significant impact on diesel usage. A proof of concept installation for Tongatapu would require 5 million nuts per year or 20% of the estimated available (unused) nuts on Tongatapu. Such a facility could produce 660,000 litres of coconut oil equivalent to approximately 600,000 litres of diesel or 10% of the annual fuel consumption of TPL's MaK generator[30].

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[30] The MaK diesel generator is a medium speed engine that can burn CNO with minimum modifications. All other TPL diesel generators are high speed engines that cannot be converted to burn CNO.

Subject to verification of the resource estimates and supply response, CNO could produce up to about30% of the current Tongatapu grid electricity requirements without requiring new area of coconut plantation. Some upgrade and maintenance of existing plantations would be needed. Theoretically, CNO could also be used to fuel the three smaller island grids. The existing generators would however, have to be modified or replaced by units with CNO capability.

Solar PV without storage. Installations of solar PV, up to a maximum of about 2.4MW[31]could be installed on Tongatapu. On average, solar PV will generate electricity equivalent to about 3.5 hours per day at full output. An installation of 2.4MW would yield about 3,784,000kW-h of electricity per year – equivalent to 8.4% of the electricity currently generated by TPL on Tongatapu. A 1MW installation would supply about 3.5%. One way to enhance the value of solar technology is to disperse the energy generation by installing smaller arrays on Government buildings and other institutional buildings across Tonga. A programme could also be designed to encourage individuals and private sector to install PV systems on their premises and sell excess capacity to the grid. Use of existing structures would reduce the installation cost compared to larger, centralized solar power stations. Also the energy would be fed into the electricity network at many dispersed locations, reducing the loading of the network and contributing to reduced losses.

Solar PV with Storage. Any larger installation of solar PV (or wind, if the resource is proven viable) would require significant storage to both smooth the very short term variations in power delivered from these systems and to provide energy when the PV system is not generating due to low or zero solar insolation (or calm weather in the case of wind). The only practical storage option for Tonga today is batteries, a system that requires careful management in order to extend the useful life to about 10 years. Initial modeling indicates that to approach the energy yield needed to meet the Government target of 50% renewable energy, the cost of solar PV with battery storage would be about TOP 1.40-1.60 per kW-h (US$0.60-0.70) or over twice the estimated unit cost of generating electricity from coconut products. Further modeling of a possible large scale wind – storage system is not considered useful until improved wind resource data and improved data about TPL's current grid operations are available. Once further data are available including on the load profile and operation diesel generation with the first on-grid renewable energy supplies, further detailed modeling is recommended with respect to possible storage option. More detailed modeling to optimize the use of PV (or wind) plus storage using active load balancing approaches now being used in Europe and elsewhere will likely show reduced storage requirements, and hence lower cost, compared to the initial modeling based on limited information.

4.2.3 Indicative Tariff Impacts

The current tariffs (early 2010) are 44.45 seniti per kW-h for the fuel component and 38.69 per kW-h for the non-fuel component (US$0.222 and 0.193 respectively). The fuel component is sufficient to cover TPL's fuel costs but is set so that there will be little or no surplus revenues

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[31] If the wind resource is proven viable, it is likely to be lower cost than solar PV which would imply a level of solar PV well below this maximum to accommodate lower cost wind generation.

that may be used by TPL for other expenses. Based on current world oil price projections, the fuel component is unlikely to fall below about 40 seniti/kW-h in the foreseeable future. The non-fuel component has been established to provide just sufficient cash to allow TPL to achieve the programmes of new generation and network upgrades as planned in early 2009, and meet the return on assets specified in the CA, when the hearings with the Electricity Commission concluded. Based on the current tariff structure and level, there will be no unallocated revenues to be applied to significant new investments for renewable energy resource development. With this background, it is possible to indicate how investments in efficiency and renewable energy would impact tariff levels.

Supply and Demand Side Efficiency Improvements. All of the loss reduction and efficiency improvement opportunities can be deemed neutral, that is having no impact on the tariffs or marginally reducing them. As noted, the work will involve very many small projects and each can be evaluated to ensure the investment will be cost effective. Any project that cannot justify the investment because the savings are too small would not be undertaken. It may be necessary for the Government to become involved in some of these decisions as an investment may not be determined to be cost effective when evaluated from the perspective of TPL but may be effective from a national perspective. For example, some of the DSM opportunities will reduce the total energy sales by TPL and the value of such reductions from TPL's perspective is only the fuel savings. Nationally, the full value of the tariff is saved. Grant or concessional funding could be justified to ensure that the beneficial externalities (from TPL's point of view) are achieved.

Landfill Gas and Wind without storage. If the landfill gas or wind resource is proven, the costs are expected to allow a private developer to implement and operate a power plant to deliver electric power and energy at a rate that is at or below the cost of the alternative cost of ADO-fuel diesel generation. Hence, these options would not increase the tariff and may even reduce it.

CNO. The development of this renewable energy resource will have a relatively low capital investment and a relatively high operating cost due to the cost of coconuts. It is estimated that the capital component of the CNO option will represent between 10% and 15% of the levelized cost per litre of CNO. The operating cost of a CNO plant is made up of the cost of feedstock (coconuts) and plant O&M. Plant O&M represent about 28% of the total operating costs and the remaining 72% is the cost of buying and transporting coconuts to the plant. Relative to the equivalent ADO fuel costs, CNO could be up to twice as expensive during early operating years but the difference might decline as world oil prices rise. A subsidy equivalent to between 25 and 33 seniti per kW-h (US$0.125-0.165) of electricity produced from CNO would be required to avoid increasing the tariff.

*Solar PV without storage.*Solar PV is expensive to install but has low operating costs. For small installations that do not need a battery system to facilitate integration of the intermittent energy into the grid, between 20 and 40% of the capital cost (depending on the financial terms for the balance of financing) would need to be provided as grant for the cost of energy to be the same as the price as from diesel. This assumes that the greater of the commercially-funded portion of the asset value or 50% of the project cost would be depreciated over the lifetime of the equipment[32]. For a 1MW solar installation, the capital grant would need to be between TOP 2.75 and 5.5 million (US$1.35-2.75 million) in order to avoid raising the tariff.Details of the cost assumptions are provided in Appendix 2. Information from recent large-scale Solar PV projects suggests a declining price. The prices yielded from the first on-grid Solar PV project in Tonga will provide a good basis for updating cost assumptions for subsequent investments under the TERM.

Solar PV with Storage. For the larger solar installations that would include a large battery storage system, a very significant capital subsidy would be needed to ensure tariffs can remain the same as energy produced using ADO fuel. However, these large systems with storage would be able to deliver some firm capacity and energy so the capital costs equivalent to the cost of new diesel generationcould be credited to them. For 15MW of solar panels and 2-day battery storage system[33], the value of alternative firm capacity would be between TOP10.6 and 15 million (US$5.3-7.5 million) depending on the firm capacity[34] of the solar-battery system. A 15MW system would supply 21,024,000kW-h annually or about 46% of the forecast electric demand on Tongatapu in 2015. The total capital cost would be TOP294 million (US$147 million) of which TOP52.5 million (US26.25 million) would be for the battery storage. It is important to note that even with careful management the batteries are expected to need full replacement by year 10 of operations.

The annual value of the energy supplied by this large solar-battery system would increase from about TOP11.3 million in 2015 to some TOP11.5 million by 2020 (US$5.6-5.8 million) based on an increasing value of ADO. The value of the capacity is between 7 and 10% of the capital cost. A capital subsidy equivalent to TOP200-220 million or 4 to 5 times the current value of all assets held by TPL would be needed to ensure Tonga electric consumers pay no more than the BAU tariffs. Alternatively, the subsidy per unit of electricity produced needed to keep the tariff unchanged would be about TOP0.99 (US$0.50).

Table 4.4summarizes the subsidy needed to deliver electricity at tariffs no higher than electricity from ADO-fuelled diesel generation.

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[32] The depreciation assumption is set to improve the probability that the sector will be financially viable when the renewable energy developments must be replaced at the end of their economic lives.
[33] Refer to Appendix 2 for details.
[34] Additional data is needed about the performance of the TPL system into which the large solar systems would be integrated. Firm capacity and energy can be defined once that data has been collected and analysed.

Table 4.4:Approximate Levels of Subsidy by Renewable Energy Development

Renewable Energy Option	Unit Subsidy per kW-h	Alternative Capital Subsidy
Landfill Gas and Small Wind	None	None
Small Solar PV	TOP 0.20 – 0.40 US$0.10 - 0.20	TOP 2.75 and 5.5 million US$ 1.38 – 2.75 million
Full Scale CNO Project	TOP 0.25 – 0.33 US$0.125 – 0.165	Not practical/effective due to high O&M costs
15MW Solar + 2-day Battery Storage System	TOP 0.99 - 1.04 US$0.495 - .52	TOP 200 – 220 million US$ 100 – 110 million

Several important points emerge from the tariff impact assessment and are illustrated in the above table:

- Of the two options for achieving significant level of renewable energy in the grid supply (i.e. from coconuts and from solar PV with storage), based on currently available data the coconut option would require a much smaller subsidy contribution per unit of electricity generated to compete with diesel-fired generation than would be required by the storage option;
- Because of the structure of the cost of generation from coconut products (relatively low up front capital, relatively high on-going fuel cost),a subsidy mechanism that could be paid out over time would be needed.
- Even with the significant level of subsidy required to bring the costs in line with electricity generation from diesel, a substantial amount of investment will be required to develop and operate new renewable energy systems. This implies that private sector participation will be an important element of achieving significant reduction in the use of diesel for power generation.

4.3 Expanding Access to All Tongans

4.3.1 Overview of Off-grid Situation and Lessons Learned

Projects to provide basic electricity in communities on the outer islands of Tonga have been operating since 1985 with varying levels of success. Clear and repeatedly reported issues exist with institutional arrangements, financial sustainability and technical support capability across the 26 islands with SHS or diesel mini-grid electrification.

Lessons learned from the existing Off-grid systems include:

- *That service quality is priority:* A quality electricity service requires reliable hardware, a responsible organization, sound finance for operation, maintenance and spares, and appropriate knowledge. Users were found to be willing to pay more than conventional willingness to pay surveys predict. However, payment is critically dependant on service meeting quality expectations.
- *That the design must fit needs:* One size does not fit all. That can mean while basic electrification is accessible, it also 'locks in' whole communities to low level lighting-

only systems without making accessible electricity options for potential economic activity. Consumers demand is varied and detailed design of supply options that cater for simple lighting to AC-quality is essential as over sizing can be as detrimental as under sizing.

- *That the solution must be attractive*: Like any other business, this far-reaching endeavour can only be sustainable if it offers opportunities and benefits for all participants, from implementers to recipients.For users, energy has to open better life opportunities and allow for possible economic activity.
- *That the institutional framework must function*: The current institutional framework governing energy in Tonga must be upgraded to cope with development in the sector. Policy and regulation should be separated from administration and planning. Project implementation and management should be separate from planning.

4.3.2 Tonga Off-Grid Initiative

A JICA funded project is currently underway that aims at providing 501 SHS-Basic systems to Vava'u and two islands off Tongatapu which would leave only Lofanga and Niuatoputapu remaining as islands yet to receive an electrification project[35]. The Tonga Off-Grid Inititiative is designed assuming that that the JICA project has been implemented.

The overall objective of the Tonga Off-Grid Initiative is to provide Off-Grid communities[36] with access to electricity options from renewable sources that are sustainable and also provide for their varied power needs. It is the potential for the enhancement of the quality of life and potential to increase economic activity of the outer islands communities that the Tonga Off-Grid Initiative aims to ultimately cultivate.

In-order to achieve this, lessons learned must be acted upon and the strengths of previous projects built on while their weaknesses are avoided.

*The Institutional framework.*The GoT must clearly define the separate responsibilities and functional bodies for policy and regulation, administration and planning, and project implementation, service provision, and programme management.

The roles of both the TPL and the EPU must be clarified to accelerate renewable energy use for rural electrificationin the outer islands. A current recommendation is for an implementation agency to be set up under TPL (e.g. TPL Rural).This implementation agency must be a separate, stand-alone unit with its own accounts, finances and human resources. A well controlled and clear transition must occur between the previous ISM model run by village committees and the tiered approach. It will be critical for the GoT toestablish clear regulations for the fees and tariffs for outer island electricity supplies. The regulations must also establish the mechanism by which

[35] Although the majority of Tonga's outer islands have been exposed to an electrification project of some kind there is a very low percentage of actual and existing electrification that is sustainable or that reaches the designed lifespan.

[36] Communities which are not currently supplied with electricity from TPL

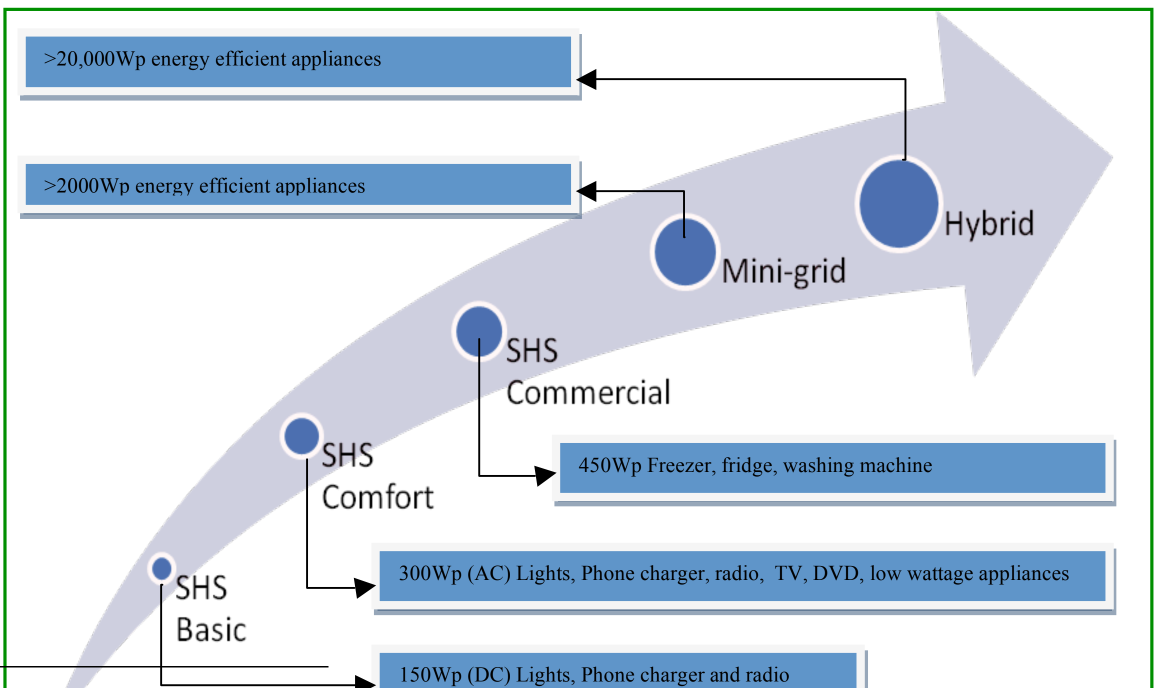
these fees and tariffs are adjusted in the future. The capacity both in manpower and in skill set of the government energy agency, the electricity provider and the private sector must be developed.

System Configuration: The Tiered Approach. Based on the lessons learned, it is important to consider the wide variation of energy demand and development opportunities as well as the economic abilities throughout the islands and to match the supply concepts to match energy demands. Figure 4.2 illustrates the concept of the tiered approach.

- The model remains based on the concepts of a SHS, starting with the current design level of 150W_p. For greater demand additional 150Wp units may be added. Also, AC appliances may be added using appliance based dedicated inverters.
- For commercial installations an all-AC supply can be provided using the SHS components with a single larger inverter.
- Between these tiers, the user can opt to upgrade (or downgrade) according to means and needs.
- At sufficient density of demand, the expansion to mini-grids will be an option.
- Only existing diesel based small grids will be considered for the PV-Diesel hybridoption[37].

It should be noted that some distant villages currently on one of the existing grid systems may be candidates for transferring off the main grid to be served by an isolated mini-grid as proposed in the tiered system.

Figure 4.2: The Tiered Approach for Off-Grid Electricity Supply



[37]This was suggested in the final report (page 42) of the AusAid Ha'apai Outer Islands Electrification Project Data Collection and Analysis Mission, September 2007.

The Financial Cost. Using estimates based on surveys from proxy data available from Fiji and also by using relative prosperity ratings, an estimate can be made on the level ofthe 'take-up' of the various tiers. A high to low envelope of between TOP4.0-10.0 million ($US2.5-5 million) is estimated. However a detailed survey of the island communities to see what systems they are able to afford and wish to operate is necessary for accurate demand assessment.

5. THE TONGAN ENERGY ROAD MAP (TERM)

The Government of Tonga target of achieving 50% of grid-based electricity supply from renewable energy within 3 years is recognized as setting a clear direction and indication from the Government that reducing the vulnerability of the country to future oil price shocks is a key objective and that consideration of renewable energy should be a significant element of the solution. It is also recognized that other factors such as petroleum supply chain efficiencies and improved efficiency both in electricity supply and use will make important contributions to achieving the goal of reduced vulnerability to high and variable petroleum prices. Hence the Indicative Implementation Plan for the TERM aims to achieve a 50% reduction in petroleum use relative to a business-as-usual scenario.

5.1 Principles Underpinning the TERM

As noted in earlier sections, further information with respect to utility, customer and resource data is needed to improve the understanding of the energy efficiency and renewable energy options available in Tonga. Many other factors that impact investment decisions also change over time. Flexibility to update and adjust the implementation plan is needed to ensure the TERM remains relevant and responds to evolving circumstances. Recognizing the need for on-going adjustments, it is useful to set out the key principles that will be adhered to, as the specifics of the implementation plan are updated.

The key principles of the TERM are set out below.

*Least Cost Approach to Meet the Objectiveof reducing Tonga's vulnerability to oil price increases and shocks.*To identify the least cost approach, the full range of options must be considered and evaluated relative to one another rather than being considered in isolation. These include improvements in the petroleum supply chain efficiency; supply and demand side efficiency improvements; and options for non-diesel power generation for both grid and off-grid electricity supply. The selection of each new investment will be based on the principle of the lowest lifecycle cost among the technically feasible alternatives.

Managing Risk. The introduction and implementation of new technical and institutional approacheswill be designed and managed to avoid inadvertently increasing interruption risks in the effort to address price risk issues. The sequencing and timing of adjustments will allow sufficient time to undertake the detailed work and get in place the required specialist expertise.An important element of managing risk is to develop a portfolio of options to meet the demand for electricity. The value of establishing a portfolio of supply sources will be considered when evaluating alternatives with comparable cost characteristics.

*Financial Sustainability.*In this context "financial sustainability" means thatthe cost of operating the energy sector, including regulatory, operations, maintenance, fuel and financing costs are recovered through the tariff. While the provision of a subsidy for a particular investment is not incompatible with the concept of financial viability, it should be applied in cases where there are specific objectives outside the normal commercial operation. For example to address specific social or equity objectives related to providing electricity services in remote areas, to address specific negative externalities including funds aimed at supporting a transition to renewable energy to reduce GHG emissions, or to support gaining experience with technologies that may be expected to become more cost effective over time. The essential feature is that the source of any subsidy required to keep the sector financially viable must be secure. Continued dependence on significant injection of subsidy to meet the cost of normal operations and expansion would not be considered a financially sustainable situation.Investment options must be evaluated considering the cost implications over the investment lifetime, to avoid substituting short term price relief for continuing high prices in the medium to long term.

Social and Environmental Sustainability. Environmental and Social sustainability encompasses both minimizing local negative social and physical environmental impacts of the energy sector, as well as aligning with global goals with respect to minimizing impact on climate change where possible. New energy investments under the TERM would be subject to Environmental and Social Impact Assessments and Mitigation Plans as necessary, as per international practice. Special consideration will be given to those groups with specific needs including youth, women, religious groups and those with special needs.Investments that have major negative environmental or social impacts or constraints that cannot be mitigated or solvedwill be avoided. As one of the group of countries which has contributed least to global climate change, yet stands to be severely impacted, Tonga is committed to setting an example for larger countries with respect to responsibly and sustainably reducing GHG emissions. Social sustainability also incorporates an element of equity. Hence the scope of the TERM includes the provision of sustainable, affordable electricity supply that meets the needs of people living in remote areas.

Clear, appropriate and effective definition of roles for Government, TPL, and the Private Sector. GoTis responsible for strategic direction in the energy sector (policy and legal framework), sector oversight (regulation),creating an enabling environment and monitoringof progress to achieve the strategic goals, and facilitating where possible the direction of financial assistance to the sector in accordance with the principles listed above. This implies a strong role in supervising the implementation of the TERM and actions to revise policy, legal and regulatory arrangements.For projects and investments that have as a major goal the testing and gaining experience with technologies new to Tonga, to the extent that public sector funding is available ownership should remain with Government, possibly but not necessarily through TPL.

TPL will be an important implementing agency for the early TERM activities, including in improved network and efficiency,and implementation of the off grid programme. TPL will also have responsibility of maintaining supply of electricity to customers on the four grids. TPL is a key source of technical expertise in the energy sector and this role will be strengthened through training as part of the implementation of the TERM. TPL's role will focus increasingly on the network and supply aspects of the electricity sector. TPL will participate as a developer of new generation projects only to the extent that there are clear benefits and whenprivate sector options have been demonstrated to be technically or financially unworkable.

For new proof-of-concept generation projects, the construction and operation and maintenance will be contracted out to the private sector with explicit provision for training of TPL staff and other Tongan technicians in the private sector. Generation projects, for which data are sufficient to fully define and objectively evaluate bids, should be private sector-ledwith selection followinga competitive and transparent approach. Private sector competition for new generation will play a key role in maintaining downward pressure on prices and limiting the commercial and operational risk borne by electricity consumers. As described in the Indicative Implementation Plan below, a mechanism will be developed – the Tonga Green Incentive Fund - to facilitate the contribution of public sector (including grant) funding to "buy down" the cost of the best proposal to any given renewable energy IPP tender,to a level where the cost is attractive compared to a Business As Usual (all diesel) approach.

By maintaining a financially sustainable energy sector and maintaining TPL as a financially viable company, the option of privatizing or concessioning TPL in the future remains open.

5.2Policy, Legal, Regulatory, Institutional Adjustments in the TERM

As set out in the Indicative Implementation Plan below, an early action is to fully review and update policy, legal, regulatory and institutional arrangements as required to implement the sector structure and investments indicated in the TERM including appropriate financing resources allocated through normal Government budgetary process. The key areas to be specifically addressed in the review and updating process are set out below.

5.2.1 Primary areas for policy revision

Policy revision areas relevant to the petroleum sector include energy security and risk management (financial, environmental and safety)

Independent Power Production. Policies need to be developed, emphasizing competition and transparency, for the process for procuring electricity through a Power Purchase Agreement (PPA) from an Independent Power Provider (IPP). With the need to raise substantial capital to incorporate renewable energy into the existing grid, an important option for mobilizing private capital is through the formation of IPPs and the purchase of energy from them through PPAs. These processes must be clarified before large scale private investment in renewable energy can occur and achieve the desired efficiencies and risk transfers.

Treatment of Grant-funded Renewable Energy Investments. Specific policies need to be in place regarding the treatment of investment in renewable energy systems that are paid for by grant. The Concession Agreement under which TPL operates requires a return on regulated assets of 12.9%. It is understood that an exemption from considering donor-funded renewable energy investment when calculating return on investment apparently can be secured, but there is no clear policy in place. There is no policy covering a situation where the investments are owned by an entity other than TPL.

Subsidy Mechanism to Support Private Sector Investment in Renewable Energy. There are currently no viable options for the provision of private sector incentives for renewable energy investment or for the long term finance of consumer owned renewable energy installations. To help reduce these problems, a dedicated fund – the Tonga Green Incentive Fund (TGIF) - could be included in the energy policy. A leveraged use of donor funding could result in far more investment in renewable energy than using the same amount of donor money for direct grants for installations. Most development partners are well positioned to fund capital works but few have systems established to support ongoing operating costs. A mechanism to allow flexibility in the use of grant funds to cover on-going costs, as opposed to only upfront capital costs will be needed to allow decisions to be made based on the least cost, rather than the financing structure. There are some precedents for such an arrangement e.g. carbon financing mechanisms. Further consideration of such a Tonga Green Incentive Fund is presented in the Indicative Implementation Plan and in Annex 2. Design of such a fund would require the assistance of financial specialists and would involve several rounds of consultations with GoT and development partners who might contribute to the fund. Initial consultations would identify key features of the fund that would make it attractive to GOT and development partners as a secure financing mechanism. Subsequent consultations would take place based on a proposed design, with ample opportunity to development partners and Go to review and indicate revisions that would be needed to facilitate their participation. The design would incorporate policy and regulatory oversight mechanisms as well as the required characteristics of the fund manager.

Consumer-owned Renewable Energy Systems. In many countries, consumer-owned renewable energy systems are an important part of the renewable energy based electricity supply system. For substantial consumer investment to take place in Tonga, clear policies need to be promulgated relating to consumer owned installations of renewable energy primarily for use at the consumer's own premises and with any surplus generation feeding in power to the grid.

Off-grid electricity supply. Off grid policy needs to be extended to renewable resource use other than solar. In particular the use of CNO, other biomass and wind energy based generation needs to be addressed. Policies relating to the use of renewable energy powered mini-grids or other forms of combined DC/AC systems need to be developed since mini-grid and DC/AC type installations are likely to be of increasing interest for outer-island electrification.

Development and maintenance of renewable energy resources database. Renewable energy projects will need to be retired in due course and replaced with other energy options. It is a reasonable expectation that future renewable energy projects will be greater in number and variety and that they will be built using more cost effective technology. However, fundamental databases on potential resources will need to continuously maintained and expanded so that the challenges that faced the current TERM analysts will be substantially reduced. The need for such a system and mechanisms to continuously fund itshouldbe recognized in the policy.

Energy Efficiency Standards and Regulations. Energy conservation and efficiency improvements remain the highest priority for reducing electricity sector petroleum consumption. Appropriate, cost-effective end-use equipment energy efficiency programmes are crucial in overcoming existing market barriers such as high initial investment costs, split incentives, lack of information, as well as the ingrained habits of producers and consumers.

*Integrating livelihoods, biodiversity and environmental considerations in the energy policy framework.*The TERM is promoting the widespread use of low carbon energy systems particularly the use of renewable energy sources. It is important that the impacts of these systems on the environment are well understood. Equally important is a thorough understanding of the changing climate conditions and the impacts on the environment and how they can affect the sustainability of the energy systems of their choice. Review of policies, laws and regulations should include consideration of the importance of conserving the integrity and diversity of nature and to ensure that any use of natural resources is equitable, efficient and ecologically sustainable.

5.2.2 Primary legal revision areas

Explicit recognition of private sector participation in electricity supply to the grid. Under the existing legislative structures IPPs and consumer-owned, grid connected renewable energy installations can be utilized. However an amendment to the Electricity Act that specifically covers the competitive and transparent participation of private sector in electricity generation and sale into the grid, for example through power purchase agreements, can be important in providing investors with a stronger sense of stability and reduced risk of policy changes causing problems in the future.

Establishment of a Mechanism to use Subsidy in support of private sector provision of electricity from renewable sources. In line with the policy adjustment to support a Tonga Green Incentive Fund proposed above, legislation would be required to establish such a fund. There are currently no viable options for the provision of private sector incentives for renewable energy investment or for the long term finance of consumer owned renewable energy installations. For large scale consumer investment in renewable energy to occur, incentives are likely to be required and the regulatory and appropriate tariff structures for consumer owned, grid connected renewable energy installations have to be clearly defined through legislation.

The Renewable Energy Act. The Acthas several areas that are not clear and require further development. The Act should be reviewed in the light of the approach to off-grid electrification planned in the TERM, and revisions made that help facilitate the application of renewable energy in off-grid areas. In particular, there is a jurisdictional distinction made in the Act between direct current (DC) and alternating current (AC) electricity operations. That distinction was reasonable a decade ago but today many modern renewable energy systems generate with DC but then often provide AC to the consumer. Clearly these DC/AC off-grid installations do not fall under the Electricity Act but the AC components of the off-grid installations do not fall under the Renewable Energy Act either. In particular renewable energy by CNO or biomass mini-grids not operated by TPL would most likely be entirely AC but would not come under either the Renewable Energy Act or the Electricity Act.Notwithstanding, any private developer that wishes to supply energy from any generating project to a TPL grid will have to reach an agreement with TPL for that supply.

In the petroleum sector, legal revisions should be examined in the areas of acts relating to petroleum licensing, safety and environmental laws, and taxation of fuels.

5.2.3 Primary regulatory revision areas

As described in Section 3, in both the petroleum and electricity sectors, the regulatory process is generally characterized by a lack of transparency and availability of information. The cost of regulation, at least in the electricity sector, would also benefit from review. Tariff structure and level will also need to be revised is the sector is to accommodate alternatives to diesel-fired generation and emphasize efficiency in supply and use of electricity. Internationally, it is considered good practice to undertake a review of a new energy regulatory entity a few years after the start of operation, to ensure that the design, resources and mandate are able to deliver the intended oversight. A recommended early action in the TERM implementation is a review of the regulatory processes in both the petroleum and electricity subsectors.

As part of this review, the following electricity sector issues should be explicitly considered:

- Regulations relating to both technical and non-technical components for IPPs selling power to the TPL need to be developed and put into place. Technical components include such things as quality of power, the specific interface components to be used, the quantity of power that can be accepted under different service conditions and any other issues that relate to the technical design of an installation of an IPP generation system. Non-technical issues include the how regulatory decisions on the pass-through of power purchase costs will be made (e.g. through specifying competitive process of selection), the methodology used for the payment for purchased power, provision for penalties should an IPP fail to provide the agreed upon level of energy, verification of energy provision by the IPP, etc.

- For on-grid installations, regulations relating to grid connected, consumer owned renewable energy systems must be promulgated. These need to regulate both the technical and non-technical aspects of these installations. In the technical area components of the installation – in particular the components that comprise the interface between the renewable energy installation and the grid – must comply with international standards for such equipment and provide for the safety and quality of power of the grid system. For the non-technical component, the structuring of feed-in tariffs must be clearly defined as well as any requirements for licensing, inspections or other interactions between the consumer and the TPL[38].

Areas for petroleum sector regulatory review are discussed in Section 3.

5.2.4 Primary Institutional revision areas

As described in Section 3, in the petroleum and electricity sectors different Government entities are responsible for almost every aspect of the petroleum and electricity supply, planning, monitoring and regulation. There appears to be little interaction among these entities in terms of data sharing or cross-checking, with the result that it is very difficult to create the accurate picture of the sector needed to regulate the sector effectively and understand the opportunities for improvement.In order to implement the TERM and achieve and maintain an efficient, secure and sustainable energy sector, it will be important that GoT puts in place a long term arrangement to consolidate responsibility for maintaining strategic overview of both the petroleum and electricity sectors, possibly under a single entity, including addressing the current division of

[38] TPL has implanted a Distributed Generation Policy facilitating purchase of surplus energy from grid connected consumer owned renewable energy systems.

responsibility for on-grid and off-grid components, in order to manage and monitor the implementation of the TERM.

As described in Section 4, a new institutional arrangement is required for managing and monitoring the off-grid programme.

5.3 Indicative TERM Implementation Plan

The Indicative Implementation Plan is consistent with the key principles set out above. Other factors considered in the selection and sequencing of investments include:

- Prioritize actions and direct resources to implement the most urgent and cost-effective steps first;
- Use commercial technology;
- Consistency with other national policies such asthe Tonga National Action Plan on Climate Change Adaptation and Disaster Risk Management 2010 - 2015 **-** whereenergy initiatives will be consistent with, and supportive of, national efforts to address and respond to climate change, environmental issues and natural disasters.
- Tonga is, relative to other PICs, quite constrained in terms of options for renewable sources for electricity generation. Nevertheless there are several technically feasible options. The Indicative Implementation Plan seeks to develop potentially feasible options to a level which will provide Tonga the flexibility to quickly adjust to developments in the energy sector occurring at both the international and national levels. This portfolio approach implies that where existing information or experience is inadequate for firm decision making, steps are taken to collect and interpret the information required, including through proof-of-concept projects.
- In the case of IPP projects for which the project sponsor is seeking a price and risk allocation competitive with current variable cost of diesel generation, and for which no subsidy or GoT guarantee is required, a process of a negotiated power purchase agreement may be appropriate. TPL would need to seek the approval of the Electricity Regulator to pass through the cost of power purchases to consumers through the retail tariff. A level of transparency can be achieved through the regulatory review process.

The Indicative Implementation Plan is designed to fast-track those components of the TERM for which sufficient data are available, to accelerate data collection for those components that cannot be implemented without some upgraded information and to implement demonstration or "Proof of Concept" renewable energy plants to facilitate the work out of unknown and potential full-scale implementation constraints.

5.3.1 Activities and Responsibilities

TheIndicative Implementation Plan is divided into three phases. Phase 0 defines the most urgent steps that should be undertaken without delay, including policy, institutional, legal,data gathering actions as well as some investments.Phase 0 activities should be considered a priority in terms of allocating funding whether from Government, private sector, sector revenues or development partner support. Phase 1, which can proceed in parallel with phase 0, includes works designed to gather sufficient information and experience about each possible option to allow subsequent firm decision making. Phase 2 will be initiated when all policy, legal, regulatory and institutional adjustments have taken place and when data and experience from the phase 0 and phase 1 activities is sufficient to define the full-scale developments of renewable energy and other actions to reduce the use of imported fuel are implemented.

Non-investment elements of Phases 0 and 1 could be completed within 18 months. All investments and new programmes in Phases 0 and 1 should be launched in the same time frame. At least 12 months of operational data and experience generated from the Proof-of-Concept investments would be recommended before embarking on Phase 2. The combination of Phase 0 and Phase 1 activities will result in a reduction of diesel use for generation, relative to the Do Nothing (no efficiency improvement) / Business As Usual (all diesel) scenario, of about 25%.

The "proof of concept" projects – i.e. the first solar PV and the first CNO project – would be considered eligible for subsidy in the form of grant financing because a significant element in the project motivation and design is related to learning and data gathering with the objective of understanding the constraints and opportunities for future scaled-up application with commercial financing contribution as expected in Phase 2. Ownership of the proof of concept projects would remain with Government. However private sector would be contracted to provide operation, maintenance and training in the initial years.

The items noted in the following sections represent the core activities for implementation of the TERM. As each activity is further defined there will undoubtedly be many additional related activities that will be important in maximizing the benefits of the TERM. For example as a result of the Off-grid programme, DSM programme, a consumer-owned generation programme (if that is determined to be feasible), and a range of other activities, there will be many opportunities for Tongan private sector entities to participate in the implementation. Some of these will lend themselves to support mechanisms via targeted funding, or though regional entities.

Phase 0

The key activities for Phase 0 are:

- Recommendations from the Petroleum Supply Chain Study are considered by GoT and decisions made on implementation; initial activities launched;
- Institutional, legal, policy and regulatory updates for petroleum and electricity implemented;
- Data gathering activities and data collection and monitoring system in place;
- Environmental screening of the TERM to identify environmental considerations of the planned activities in the TERM
- Analysis of environmental change impact on Tonga to identify any risks to long term safety and security of energy infrastructure;

- Initial end use efficiency / DSM programme launched and development of data and analysis to design and implement more extensive end use efficiency programme underway
- Off-grid programme launched;
- Necessary TPL investments for safety, data acquisition and improved efficiency launched;
- Tonga Green Incentive Fund launched (refer to Annex 2).

GoT Actions and Responsibilities. A permanent institutional arrangement will be established to manage, coordinate, monitor and report on the TERM implementation.Coordination of the various components of the TERM will require frequent interaction among the various agencies planning and implementing policy, legal and regulatory changes and projects. .. As an example, a project monitoring and coordinating committee (PMCC) will be designated. This will be the recently-created Tonga Energy Road Map Committee (mentioned in Section 2), with expanded participation. The committee will be Chaired by the Head of the Civil Service, and include all CEO's of the GoT agencies that will be impacted by the TERM (electricity and petroleum) and TPL. The TERM-C will meet monthly with a six-monthlymechanism to involve development partners and other interested entities.

A full-time Road Map Coordinator will be retained and will head an Implementation Unit (IU) that will also provide secretariat services to the TERM-C, with additional specialist support as needed, for a period not less than five years. The IU will be funded externally of GoT through one of the GoT Development Partners and remain politically independent The Road Map Coordinator will undertake the day-to-day management of all aspects of the TERM, reporting on a monthly basis to the TERM-C. The IU would need to carry out, *inter alia*:

- Selection and supervision of specialist consultants to undertake the reviews of policy, regulatory and legal issues precipitated by the TERM; management of outreach and consensus-building to institute essential changes with relevant ministries and agencies.
- Assisting of the establishment of the Government of Tonga institutional arrangements and processes that allow for ongoing GoT institutional support for TERM implementation, beyond the IU's anticipated five year period.
- Coordination of the establishment of a network of weather stations to collect solar and wind data in sufficient detail to support future development of these resources. Management of the installation of one and possibly two towers to monitor wind at least 40m above the ground, including moving towers to increase coverage of the wind records as needed. Adaptation as needed of the existing weather data monitoring systems to ensure data quality for the TERM.
- Coordination of the upgrading of the Tonga biomass resources database in support of the CNO project.
- Coordination of the assessment of the Landfill Gas Resource.

- Coordination with TPL on all loss reduction programmes and facilitation of the involvement of the Government and financing sources when national priorities supersede TPLs' perspective on specific loss reduction projects.
- Establishment of institutional arrangements and launch the implementation of the DSM programme, including essential funding mechanisms.
- Establishment of all reporting systems and protocols including the project management systems to ensure a real-time understanding of all activities.
- Coordination of the creation of a database of data to support the TERM including the collection, maintenance and analysis of data, the design of a widely accessible computerized system with graduated access to allow for limiting access to sensitive information.
- Ensure any major development complies with the Environmental Impact Assessment Act 2003. Additionally, coordinate an assessment of the vulnerability of Tonga's energy infrastructure, with attention paid to the impact of environmental change. With the goal of ensuring that design and implementation will limit disruptions and ensure a safe supply, the analysis will include, for example, the effects of coastal erosion, flooding, and potential increased storm activity on energy system components such as transmission, storage facilities and generation sites. To understand the cost/benefits of 'environment proofing' infrastructure, an assessment of the economic cost of projected disruptions will be included. This study can be facilitated by the Ministry of Environment and Climate Change, though the findings would be implemented through the TERM.
- Coordination with Department of Environment to undertake environmental screening of the projects proposed under the TERM
- Selection and supervision of specialist consultants to design the mechanism for the Tonga Green Incentive Fund, coordinate consensus-building among potential funding agencies, identify and recommend a Fund Manager, work out mechanisms to access existing carbon financing / CDM for energy efficiency, consumer-owned RE, grid RE, TPL efficiency improvements beyond regulated ones. This is an essential step in preparation of Phase 2 projects.
- Coordination of the establishment of the Government-owned entity that would own renewable energy projects and establish the interaction between the entity and TPL.
- Provision of top-level management to establish the implementation arrangements for the off-grid electric systems upgrade and extension project.
- Maximize the value of the work to Tongan staff through the provision of seminars, training programmes and the counterpart involvement of individuals throughout the assignment.
- Liaise directly with the Development Partners and provide updates and reports on the implementation of the TERM.

TPL Actions and Responsibilities. TPL will be a major partner in most parts of the TERM. TPL will be responsible for the essential loss reduction programme on the TPL grids and, as the off-grid system manager,for launching and operating the new off-grid programme. A full-time TPL Road Map Project Manager (RPM) will be retained. The position is expected to be for three years and the individual would work inside TPL. The individual might best be contracted from an engineering firm that would also provide additional *ad-hoc*support from specialiststo advise and assist with certain renewable technologies, the preparation of bid specifications, requests for proposals, bid evaluation and other time-critical activities. The RPM would assist TPL with an efficiency audit and procedure review, the selection and installation of SCADA on all four grids, the addition of associated new meter systems and the protocols for data collection and data management. To the extent needed, TPL might call on this support to assist in the management of the village reticulation upgrade project and some of the loss reduction projects.

In order to retain the maximum benefit from the RPM, TPL should work with the RPM and his/her specialist support team to provide training for TPL staff at all stages. TPL should also arrange for key staff to be given extended training in all aspects of project and contractor management.

Phase 1

Key activities for Phase 1 are:

- Implementation of second-generation end-use efficiency / DSM measures;
- Implementation of up to 1 MW on-grid solar PV on Tongatapu and at least one other island grid, including components covering centralized, decentralized and battery storage. Operation, maintenance and training contract in place.
- Implementation of a Proof of Concept Coconut Oil (660,000l/yr) Project. Operation, maintenance and training contract in place.
- Implementation of Landfill Gas IPP (if resource proved in Phase 0)
- Review of initial experience with petroleum financial risk management and implementation of modifications as required.
- Transaction advisor for Phase 2 projects selected.

Phase 1 SolarPV Project. While detailed design will require more detailed solar insolation data, the data currently available are sufficient to confirm the feasibility of solar PV in Tonga. As the possibility of alternatives (e.g. wind, CNO) remains open and will be explored in Phases 0 and 1, the first solar PV project should be sized to gain real benefits in terms of experience and early displacement of diesel, but not so large that it excludes the possibility of alternatives, particularly wind as a “competing” intermittent source, should these prove viable and more cost-effective. The objectives of this project would be to (i) gain experience with an intermittent energy supply on the main grid(s), (ii) gain experience with both centralized and decentralized intermittent input to the grid, (iii) gain experience with solar PV-battery storage combination at the utility level. The installation will generate up to about1,577,000kW-hannually, displacing approximately 3.5% of projected diesel usage for 2010.

To achieve these objectives, the concept involvesthree sub-projects:

i) installation of some centralized solar PV on at least two of the TPL grids,

ii) installation of several solar panel arrays in decentralized locations, e.g. on existing government buildings and

iii) implementation of a centralised sub-project with a battery storage component.

It is expected that the decentralizedsub-project would be on Tongatapu and the centralised plant with storage would be on either Ha'apia or 'Eua. Full feasibility, design studies, and environmental and social impact assessments will be conducted. The whole process from design through contracting, commissioning, operation and maintenance will be designed to maximize the learning at TPL.The implementation would be supervised by TPL with assistance from the RPM.The Road Map Coordinator will monitor the progress.

*Phase 1 Coconut OilProject.*The objectives of this project are to

i) generate real data regarding the price at which coconuts will be supplied reliably for electricity generation; and

ii) gain experience with the coconut supply chain and integrated CNO processing system.

The proof-of-concept installation for Tongatapu would based on about 20% of the estimated available (unused) nuts already produced annually on Tongatapu. The facility would produce 660,000 litres of coconut oil equivalent to approximately 600,000 litres of diesel or 10% of the forecasted fuel consumption of TPL's MaK generator. The meal (press cake) produced possibly has a market value as animal fodder which could be determined as part of the project.The implementation (i.e. the feasibility and design studies, and environmental and social impact assessments and the tender process) would be managed by TPL with assistance from the RPM. The Road Map Coordinator would provide oversight and monitor the progress.

*Landfill Gas Project*This project will proceed only if the resources is verified in Phase 0. If the gas is deemed adequate, feasibility, engineering and environmental and social impact assessmentsstudies will be undertaken. The objective of this project would be to

i) provide an alternative, lower cost source of fuel to displace diesel use in power generation (up to about 300kW installed; 680kW-h displacing approximately 1.6% of projected diesel usage for 2010); and

ii) to demonstrate the process of a transparent, competitive IPP tender process.

As the technology is well understood and the estimated costs of this project suggest that it would compete with diesel-fired generation without any subsidy, this project could be a good candidate for an initial IPP supplying either base-load or peaking power to TPL. Depending on the implementation mechanism selected, the Road Map Coordinator and RPM would coordinate the implementation through to commissioning. They would also be responsible to identify and undertake such work as may be needed to ensure a landfill gas can be undertaken at the new Tapuhia landfill sites with minimum investment.

Operation and Maintenance Contracts. The solar PV and coconut projects will be owned by Tonga. The Road Map Coordinator and / or the RPM would be responsible to design and prepare specifications and manage the process of getting in place anO&M contractor for at least three years. The contract would include the obligation of the contractor to provide fully trained Tongan operating staff by the end of the contract.

Phase 2 Transaction Advisors. Towards the end of phase 1 as the experience and data gathering from measurements and data gathering equipment makes it possible to define the first Phase 2 project, the Road Map Coordinator, with assistance from the RPM, would be responsible to prepare TOR and select transaction advisors to assist the Government in managing the first Phase 2 IPP process.

If a suitable wind resource is proven during Phase 0, it is recommended that wind-based generation project be delayed until at least 6 months of operating experience of the grid-connected solar PV intermittent electricity supply be fully evaluated before another project supplying intermittent energy is launched.

Phase 2

The specific investment projects for Phase 2 will be defined based on the data and experience gathered during Phases 0 and 1. Phase 2 actions will include:

- A formal analysis of the data and findings from the Phase 1 projects. In particular, the success of the loss-reduction programmes and the DSM programmes should be assessed to identify shortfalls on target energy reductions. The recent load demands should be assessed by the side of the then-current load forecast and new forecast prepared to drive the needs and timing of ongoing sector development. The successes and problems with each of the Proof-of-Concept project will need to be carefully evaluated to determine if the problems are determined to be too difficult to resolve or some design change or other modification in the process will overcome them. New grid system performance data will need analysis to confirm what measures need to be taken and new technology added to ensure that the most practical renewable energy alternative can be successful integrated. Any promising (but not yet commercial) technologies that have generated a track record in Tonga or elsewhere during the Phase 0 and 1 implementation period, could be evaluated at this point and considered for inclusion in Phase 2.
- A very important activity during Phase 2 will be to "institutionalize" the data collection systems set up during Phase 1. The value of databases is often to be found in their longevity and continuity so as the Tonga economy and energy systems develop, the best data on what can be expected in weather, ocean regimes and electric system performance will ensure that Tonga's continuing efforts to use its' indigenous energy resources can progress in as timely a manner as possible.
- A full-scale development of renewable energy projects on an IPP basis, utilizing the Tonga Green Initiative Fund discussed in section 4 and in Annex 2 and designed and established in Phase 0. Selection of the sequencing of the Phase 2 projects will be determined based on the key principles of the TERM, set out at the beginning of this section. Depending on the experience with the decentralized PV sub-project, and the improved assessments of the cost of wind and coconut-based electricity generation, phase 2 could include a programme of consumer-owned, decentralized PV generation.

Development partner involvement at the design stage of the tender process for each Phase 2 project will be needed to confirm the level of subsidy available through the Tonga Green Incentive Fund, which in turn will influence the size of the installation specified in the tender. All reasonable preparations regarding financing modalities and implementation, feasibility and environmental and social impact studies, will have been pushed as far as possible during Phase 1 so that the first IPP tender in Phase 2 can commence as quickly as possible.

5.3.2 Indicative Costs, Sources of Funding, Key Indicators

The following table provides an initial indication of the anticipated sources of financing for the key TERM activities. All financing would be subject to the normal project preparation and due diligence activities of the funding agencies. Amounts of available funding are still under discussion and inclusion in the table does not imply that the indicated funding sources are committing to cover the full estimated cost of the activity.

Table 5.1: Indicative Costs, Sources of Funding, Key Indicators

Activity	Estimated Cost (US$)	Source of Financing	Key Indicators
PHASE 0			
Creation of GoT Institutional Arrangements	tbd	GoT	Institutions in place and operational.
GoT role in leading TERM implementation	tbd	GoT, bi-lateral	TERM implementation on track.
Technical assistance for policy, legal, regulatory adjustments; establishment of TGIF, data gathering, resource assessments and technical studies[39].	2.5 million	IDA / PRIF Partners* / IRENA / REEEP/ SPREP-PIGGAREP	Policy, legal, regulatory reviews completed and recommendations implemented. TGIF launched. Data gathering mechanisms in place and functioning.
Technical assistance for Environmental screening, assessment of impact of environmental change on energy infrastructure	60,000	GoT / IUCN	Environmental screening and environmental change impact report. Findings to be incorporated as projects are planned and implemented.
Strategic Environmental Impact Assessment			
End-use efficiency and DSM Programme (note this continues through Phase 1 and 2)	2.0 million (Phase 0 only)	ADB, EC, REEEP, IUCN, private sector	DSM programme launched. Reduction in demand relative to “Do nothing”

[39] Specific activities that qualify for specific funding under other agencies or programs can be split out.

			scenario:9% within 3 years, 30% within 5 years.
Off-grid Programme (additional to JICA project)	3.0 – 5.0 million (Additional to JICA $US5.9 million)	EC, Japan, IUCN, private sector	Off-grid programme launched. Number of households benefiting from programme on annual basis. Financial sustainability mechanism functioning.
TPL village upgrade project to improve efficiency and ensure safe supply to 70 small and medium villages	US$15.4 million	Concessional financing possible: NZAID; EIB, PRIF Partners, EC, bi-laterals to accelerate implementation.	Reduction in line losses to less than 11% and network safe by recognized international standards.
TPL investments on safety, data acquisition and management and efficiency improvements	tbd	Primarily internally-generated revenues; Concessional financing possible: NZAID; EIB, PRIF to accelerate implementation.	Specific targets tbd. Contributes to 11% target above.TPL infrastructure meets international standards of safety.
Evaluate the studies and implement improvements in the Petroleum Supply chain including financial risk management.	tbd	GoT, TPL, private sector.	Supply chain efficiency improvements, consequential cost savings.[40] Improvements in price certainty at a cost.
PHASE 1			
Landfill Gas Project commissioned (only if resource is proven in Phase 0)	0.2million 1.0 million	PRIF Partners Private sector	Advisors in place. Plant commissioned.
First solar PV project	8.0 million	UAE, EC	Project design covers learning areas. Plant(s) commissioned. Annual kW-h of displaced diesel generation. Tongan technicians fully capable of PV plant O&M and management of TPL grid with intermittent and

[40]If MRX implemented: Reductions in the freight cost by up to 30%.

			decentralized energy supply.
First CNO project	1.5 million	Bi-lateral funds	Project design covers learning areas. Plant commissioned. Annual kW-h of avoided diesel generation. Tongan technicians fully capable of O&M.
PHASE 2			
Evaluation of Phase 0 and Phase 1 data	0.2 million	IDA / PRIF Partners / IRENA	Evaluation report completed and discussed with Tongan stakeholders, development partners, other interested parties.
Phase 2 transaction advisors	0.7million	PRIF Partners	Advisors in place.
Tonga Green Incentive Fund funded for first set of Phase 2 projects.	tbd	bi-laterals and multi-laterals	Dev. Partner commitments made.
First major Renewable Energy IPP project. Second major Renewable Energy IPP project.	tbd tbd	Private sector equity, Commercial lending, Tonga Green Incentive Fund, Electricity sector revenues.	Tender proceeds according to agreed TGIF agreed rules; Financial close on first project; Plant commissioning.

*PRIF Partners includes AusAID, NZAID, the Asian Development Bank and the World Bank. Decisions on investments are subject to PRIF decision-making processes.

Potential additional sources of funding are presented in Annex 4.

6. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Findings

Tonga is highly vulnerable to external shocks in the energy sector, both from the point of view of Balance of Payments and from the point of view of the cost of electricity to businesses, households and other consumers.Tonga's total fuel imports account for about25% of all imports and about 10% of GDP. Changes in the price and amount of petroleum imports have a significant impact on Tonga’s Balance of Payments situation. In particular, sudden price shocks can be difficult to absorb. Electricity generation accounts for about one third of petroleum imports. Almost 100% of electricity in Tonga is generated from diesel. Fuel imported to Tonga is purchased at spot market prices. Under the current electricity regulatory structure the cost of fuel is essentially passed through to electricity consumers. Electricity consumers are fully exposed to oil price rises and fluctuations.

For both electricity and petroleum, there are a number of policy, legal, regulatory and institutional updates required to put in place a sector structure which would reducethis vulnerability. Key areas for review and adjustment are identified in this report.

There are significant data gaps in most aspects of the energy sector. More detailed analysis will only be possible when improved data are available. Analysis based on the currently-available information indicates the following:

- Efficiency improvements in electricity supply and on the demand side, could significantly reduce the use of diesel (by up to 18% or more relative to a situation with no efficiency improvements) in the electricity sector and lower the cost of electricity supply to be passed through in lower tariffs.

- Electricity generated from landfill gas and wind may be the least cost options for grid-based renewable energy supply on a life cycle basis, but the resources must first be proven. Landfill gas could supply firm energy but the maximum potential remains small because of the relatively small amount of gas potentially available. The contribution of wind will be limited by the level of intermittent energy that can be accommodated without negatively impacting operation of the grid.

- The onlyrenewable energy option for grid supply with sufficient resource data to determine viability and launch an investment project in the near term is solar PV.

- The two options for achieving a significant level – i.e. above about 10% of energy generation - of renewable energy in the grid supply, are electricity generated from coconut products (CNO) or from an intermittent (e.g. solar or wind) source combined with battery storage. Insufficient data are available to assess the cost of a wind-battery storage combination. Based on currently available data, the PV-storage option would be significantly more expensive on a life-cycle cost basis than electricity produced from coconut products. Both would likely require some form of subsidy to compete with electricity from diesel generation.

Much useful experience has been gained in Tonga in supply to electricity to remote locations.An approach based on the principle of “one size fits all” can mean that while basic electrification is accessible, whole communities are “locked in” to low level lighting-only systems without affordable options for electricity to support potential economic activity. A revised approach to off-grid electricity supply must offerchoices and opportunities for all participants, from implementers to service to users. The current institutional framework governing energy in Tonga must be upgraded to cope with development in the sector.

Conclusions

To implement the comprehensive set of actionslaid out in the TERM, including in policy, legal and regulatory aspects, the Government of Tonga will need to put in place a long-term institutional arrangement to provide strong leadership, coordination and oversight of the energy sector activities.

Petroleum price hedging may offer significant benefits in terms of smoothing out the price fluctuations. Options should be investigated further.

Efficiency improvements are the least cost option for reducing dependence on imported petroleum and should be pursued aggressively.

Tonga has several potentially feasible options for domestic sources of electricity generation but existing data are insufficient to assess their viability. Adopting a portfolio approach will help provide Tonga with the flexibility to quickly adjust to developments in the energy sector occurring at both the international and national levels. This implies that where existing information or experience is inadequate for firm decision making, steps should be taken to collect and interpret the information required, including through proof-of-concept projects.

To diversify away from nearly total dependence on diesel for power generation will require the development of domestic, renewable energy resources. To achieve a significant contribution of renewable energy for grid supply will likely require an element of subsidy to avoid raising tariffs relative to projected average costs estimated for continued diesel-based electricity supply. The different options have very different cost structures. A new financing mechanism is needed – the proposed Tonga Green Incentive Fund - to channel available grant funding for renewable energy to the most cost effective investments and to provide flexibility to use available grant funding either for up-front capital subsidy or as an on-going subsidy to “buy down” the on-going costs of electricity generated from renewable energy sources (or saved by energy efficiency investments).

Even with a subsidy contribution, a substantial amount of investment will be required to develop and operate new renewable energy systems. This implies that private sector participation will be an important element of achieving significant reduction in the use of diesel for power generation. The sector structure as defined in the policy, legal and regulatory instruments should facilitate and encourage private participation in the electricity sector.

Recommendations

Recommendations regarding the principles to be followed to improve the performance, sustainability and security of the energy sector are set out in Section 5.1. These include focusing on a least cost approach, managing risks, financial sustainability, social and environmental sustainability and clear, appropriate and effective definition of roles for Government, TPL and private sector. Recommendations regarding specific actions are set out in section 5.3: the Indicative TERM Implementation Plan. The most urgent actions, described in Phase 0 of the Indicative Implementation Plan, should be initiated as a matter of priority.

Annex 1: Data used in calculating lifecycle costs

Table A1.A

Small Solar Photovoltaic System	**Characteristics**	**Plant Cost**
Data Collection, Feasibility Study Costs	US$120,000 (TOP 240,000)	US$120,000 (TOP 240,000)
Duration of Data Collection & Studies	9 months	
Capacity	1,000 kW	
Annual Energy Yield (18% Plant Factor)	1,577,000 kW-h	
Rate of Decline of Annual Yield	0.5%	
Economic Life of Panels	25 years	
Unit Cost, per kW installed	US$ 6,900 /kW (TOP13,800)	US$6,900,000 (TOP13,800,000)
PV Operating and Maintenance Costs	US$ 0.0075 /kW-h	US$11,826
Battery Storage included	0.0 kW-h	
Time to Commissioning	6 months from Contract award	

Table A1.B

Large Solar Photovoltaic System	**Characteristics**	**Plant Cost**
Data Collection, Feasibility Study Costs	US$400,000 (TOP800,000)	US$400,000 (TOP800,000)
Duration of Data Collection & Studies	24 months	
Capacity	15,000 kW	
Annual Energy Yield (16% Plant Factor)	21,024,000 kW-h	
Rate of Decline of Annual Yield	0.5%	
Economic Life of Panels	25 years	
Unit Cost, per kW installed	US$ 6,300 /kW (TOP12,600)	US$94,500,000 (TOP189,000,000)
PV Operating and Maintenance Costs	US$ 0.0075 /kW-h	US$157,680
Battery Storage included	26,250 kW-h	
Economic Life of Batteries	10 years	
Battery Storage Costs	US$2,000 /kW-h (TOP4,000)	US$52,500,000 (TOP105,000,000)
Battery Operating and Maintenance Costs	US$0.005 /kW-h (TOP0.01)	US$131 (TOP262)
Time to Commissioning	24 months from Contract award	

Table A1.C

Landfill Gas System	Characteristics	Plant Cost
Data Collection, Feasibility Study Costs	US$160,000 (TOP 320,000)	US$160,000 (TOP 320,000)
Duration of Data Collection & Studies	21 months	
Capacity	300 kW	
Annual Energy Yield	675,400 kW-h	
Rate of Decline of Annual Yield	0%	
Economic Life of Equipment	20 years	
Unit Cost, per kW installed	US$ 3,240 /kW (TOP6,480)	US$972,000 (TOP1,944,000)
Operating and Maintenance Costs	US$ 0.035 /kW-h	US$23,639
Time to Commissioning	9 months after contract award	

Table A1.D

Small Wind System	Characteristics	Plant Cost
Data Collection, Feasibility Study Costs	US$120,000 (TOP 240,000)	US$120,000 (TOP 240,000)
Duration of Data Collection & Studies	30 months	
Capacity	1,000 kW	
Annual Energy Yield	1,577,000 kW-h	
Rate of Decline of Annual Yield	0%	
Economic Life of Equipment	25 years	
Unit Cost, per kW installed	US$ 6,900 /kW (TOP13,800)	US$6,900,000 (TOP13,800,000)
PV Operating and Maintenance Costs	US$ 0.0075 /kW-h	US$11,826
Battery Storage included	0.0 kW-h	
Time to Commissioning	12 months after Contract award	

Table A1.E

Small Coconut Oil (CNO) Extraction	**Characteristics**	**Plant Cost**
Data Collection, Feasibility Study Costs	US$100,000 (TOP 200,000)	US$100,000 (TOP 200,000)
Duration of Data Collection & Studies	16 months	
Capacity, CNO	660,000 l/year	
Annual Energy Yield	2,584,000 kW-h	
Rate of Decline of Annual Yield	0%	
Economic Life of CNO Equipment	10 years	
Cost of CNO Plant		US$646,000 (TOP1,920,000)
Interim Replacement Costs of CNO Plant		US$296,400 (TOP592,800)
Plant Operating and Maintenance Costs	~US$ 0.09 /kW-h	US$232,500 (TOP465,000)
Capital Cost of Coconut Transport Trucks		US$120,000 (TOP240,000)
Economic Life of Trucks	10 years	
Interim Replacement Costs of Trucks		US$120,000 (TOP230,000)
Coconut Transport O&M costs		US$51,488 /kW-h (TOP102,976)
Annual Coconut Costs		US$554,500 (TOP1,109,000)
Total Annual O&M costs, Plant + Coconuts		US$838,488 (TOP1,676,976)
Time to Commissioning	8 months after contract award	

Table A1.F

Full Scale CNO Extraction Plant	Characteristics	Plant Cost
Data Collection, Feasibility Study Costs	US$100,000 (TOP 200,000)	US$100,000 (TOP 200,000)
Duration of Data Collection & Studies	Determined by PoC operation findings, 6-9 months after decision to implement	
Capacity, CNO	4,000,000 l/year	
Annual Energy Yield	15,505,200 kW-h	
Rate of Decline of Annual Yield	0%	
Economic Life of CNO Equipment	10 years	
Cost of CNO Plant		US$3,042,000 (TOP6,084,000)
Interim Replacement Costs of CNO Plant		US$2,052,000 (TOP4,104,000)
Plant Operating and Maintenance Costs	~US$ 0.075 /kW-h	US$1,162,500 (TOP2,325,000)
Capital Cost of Coconut Transport Trucks		US$720,000 (TOP1,440,000)
Economic Life of Trucks	10 years	
Interim Replacement Costs of Trucks		US$720,000 (TOP1,440,000)
Coconut Transport O&M costs		US$353,475 /kW-h (TOP706,950)
Annual Coconut Costs		US$3,267,000 (TOP6,534,000)
Total Annual O&M costs, Plant + Coconuts		US$4,782,975 (TOP9,565,950)
Time to Commissioning	24 months after contract award	

Annex 2: A preliminary Outline forTonga Green Incentive Fund (TGIF)

Objectives:

- Channel grant funding available for energy efficiency and renewable energy to the most cost effective investments.
- Provide flexibility to use available grant funding either for up-front capital subsidy or as an on-going subsidy to "buy down" the on-going costs of electricity generated from renewable energy sources (or saved by energy efficiency investments).

Implementation Timing:

- The TGIF would be designed during phase 0 and piloted (e.g. for energy efficiency) during phase 1. It would be one of the mechanisms for grant funding support for phase 2 onwards.
- The TGIF Manager would be a commercial financial institution with no linkages to GOT – it could be off-shore. It would manage and release the funds in accordance with the rules set up on establishment of the fund.

Principles:

- The fund will be designed so that it treats high capital cost projects, high operating cost projects and energy efficiency projects on an equal footing – assessing them all on the basis of their levelised cost of energy generated (or saved) over the standardized design life of the project.
- To minimize market distortions the single buyer (TPL) would pay generators or implementers of energy efficiency programmestheunsubsidized market price for the electricity generated from renewable energy sources, or saved by efficiency programmes. A pre-specified level of subsidy would be available from the TGIF for each unit of diesel displaced through efficiency or RE measures.
- The level of subsidy could be set on a tender-by-tender basis at the start of each Phase 2 tender. That is TPL would seek by international tender bids for projects to provide a specified quantity of renewable energy (or improvement in energy efficiency) and the proposals would be assessed on the basis of the levelised cost of energy (or energy saved) that met TPL requirements over the specified design life of the project.
- As part of the process of designing and establishing the TGIF, certain rules would be set out governing the situations in which subsidy from the TGIF would be made available to TPL. For example, rules would be agreed regarding i) Selection of each project to be tendered (i.e that the selection of each Phase 2 project is in accordance with the key principles set out in the TERM); (ii) The tendering process (to ensure it is competitive and transparent to provide comfort that the best deal has been achieved). The TGIF Manager would confirm that the tender was in accordance with the rules.
- The size of the plant in the tender would be set so that the funds already committed or already in the TGIF are sufficient to provide the expected level of subsidy over the lifetime of the project. This would ensure the "sustainability" of any on-going subsidy,

i.e. funds would be committed upfront as if for capital investment although the funds could be released from the TGIF to TPL as an on-going subsidy.

- For small scale consumer owned suppliers an annual per kW-hsubsidy price would be determined based on the average kW-hr subsidy the fund was paying for RE and energy efficiency energy.

Possible Approach for New Generation in Phase 2:

- TPL / GoT, with the assistance of Transaction Advisors, would launch a tender for an IPP to supply a certain capacity and energy from renewable sources. The tender documents would include a draft Power Purchase Agreement (PPA). The experience gained from Phase 1 demonstration projects will improve the quality of the tender documents and also allow TPL/GoT to have a good estimate of the price at which an IPP could sell electricity.
- Before a tender, TPL would approach donors for contributions. Donors would already be aware of the TGIF mechanism and the tender rules etc. so they would be comfortable committing to a certain maximum funding level once the tender process was completed and approved. From the donor point of view, funds for the lifetime of the project tendered would be disbursed to the clean energy fund immediately after the tender was awarded.
- Upon award of the tender the TGIF would then disburse either (i) upfront capital subsidy or (ii) annual or monthly payments, or (iii) some combination depending on the agreement with the IPP.
- In response to the tender, IPPs would submit bids which are evaluated on the lowest levelized cost of electricity supply backed up by a credible financing plan.
- The winning bidder would raise financing for the project on the basis of a PPA with TPL. Before signing the PPA, TPL would have a back-to-back agreement in place with the TGIF, based on the amounts of energy to be supplied as per the PPA and the allowable level of subsidy (specified in the rules for the TGIF). The IPP sponsor would be able to take this agreement to commercial (and other) financiers to demonstrate the creditworthiness of TPL as an off-taker.
- A parallel process could be used to seek bids for energy efficiency proposals.
- The IPP would be able to seek concessional financing (e.g. from EIB and other sources). There would be some equity and probably some commercial borrowing.

Annex 3: Summary of On-Grid Renewable Energy Options Considered

In the following table, a summary of the potential and outstanding issues associated with the several ways in which Tonga' dependence on imported fuel oil can be reduced. All unit costs take into account capital, O&M and fuel costs, the lifetime of the assets and have been levelized using a 5% real discount rate.

<table>
<tr><th colspan="2">Generation and Supply Efficiency Improvements</th></tr>
<tr><td>Potential:

Reduce energy used in power stations (station service), improve overall station efficiency by removing operating limitations, improving the maintenance schedule timing to maximize fuel efficiency, install new units to improve station efficiency, etc.

Reduce network technical losses, upgrade lines, insulators, and transformers, add new circuits, add metering and central monitoring to improve operations and the network performance database. Will reduce both energy and demand.

Consider options for recovering the waste heat from the diesel engines and utilizing this for additional electricity generation.</td><td>Limitations:

Insufficient data, metering, fuel use by unit, etc. limits capacity to evaluate costs and benefits of power station and network upgrades

Some financial limitations exist if TPL is required to accelerate investments in loss reduction relative to the timing that can be achieved from financing through the tariffs</td></tr>
<tr><td colspan="2">Benefits:

There is a potential to reduce the energy generated by TPL on all four grids by about 7% by the middle of the decade and by up to 9% in total by the end the decade. If recovery of waste heat is determined to be feasible, further reduction in diesel use would be possible.</td></tr>
<tr><th colspan="2">Demand Side Management (DSM)</th></tr>
<tr><td>Potential:

Preliminary studies have identified several specific investments that will improve the efficiency of electricity use and other opportunities will be identified once energy use inventories are completed. Can reduce both energy and peak demands</td><td>Limitations:

Data on how customers use electricity is limited, funding will be needed for investments in new equipment required to achieve the higher energy use efficiency</td></tr>
<tr><td colspan="2">Benefits:

There is a potential to reduce the energy used by consumers by at least 9% in total on all four grids by the middle of the decade.</td></tr>
</table>

Landfill Gas	
Potential; One landfill site on Tongatapu has been closed and might be tapped to produce methane immediately, potential yield estimated to be equivalent to 675,000kW-h per year, unit energy cost estimated at 35.6 Seniti/kW-h (US$0.178), additional potential from the new landfill in about 10 years. Can provide both firm capacity and energy	*Limitations*: Unknown gas yield, quantity and quality of gas needed to confirm potential, no evidence of useable landfills on other islands
Benefits: An energy resource that would otherwise leak into the atmosphere and contribute to green house gases. Total energy represents about 1.5% of generation on Tongatapu.	

Coconut Oil (CNO)	
Potential: Manufacture substitute fuel oil from an indigenous renewable resource for use in the existing diesel engines, could substitute for more than 50% of imported fuel oil used in the MaK unit at Popua, could be implemented on other grid systems, expected unit cost of between 68 &72 seniti/kW-h (US$0.34-0.36) for annual energy yields of between 2,580,000kW-h and 15,500,000kW-h. Alternative fuel for existing medium-speed diesel engines	*Limitations:* The size of the resource is estimated from out of date statistics, needs involvement of land holders to ensure an adequate supply of coconuts, price needed by landholders to ensure supply not known, will be key to economic viability of option, reasons for failures of previous CNO operations to be overcome/avoided
Benefits: Would substitute imported oil with indigenous, renewable energy with a potential of supplying over 50% of the current fuel oil used in the four grids	

Small Solar Energy usingPhotovoltaics	
Potential: Sufficient resource. Can be installed in single arrays, centrally located, or dispersed using existing buildings on which to install various size arrays. Already widely used for small isolated supply. Annual yield about 1,570,000 kW-h per kW installed (18% plant factor). Unit cost for solar alone, circa 70 seniti/kW-h (US$0.35) for non firm energy only	*Limitations:* Weather records are not sufficient for reliable estimates of expected annual energy yields and inadequate to determine the probability distributions of energy available during short periods (minutes). Only a limited capacity can be integrated into a grid supply system unless some storage is included with the installation to compensate for short term solar output fluctuations. Only available during daylight hours.
Benefits: With very low maintenance, the cost of this renewable energy is directly related to the capital cost of the installation.	

Wind Energy	
Potential: Considerable but with today's technology, minimum wind conditions of speed and duration at the height of the turbine towers is sought to produce economically viable electric energy. Energy available when the wind blows, annual yield expected to be 1,927,000kW-h per kW installed (22% plant factor) Unit cost circa 35 seniti/kW-h (US$0.177) to provide non-firm energy	*Limitations:* Wind records are very limited making it infeasible to identify viable sites and assess likely energy yields, wind turbines are located where wind conditions are favorable so transmission to interconnect to the grid is often needed, is liable to damage during extreme weather events Only a limited capacity can be integrated into a grid supply system unless storage is included with the installation.
Benefits: Energy at relatively low operating cost, intermittent renewable energy available at all times of the day and night	

<table>
<tr><th colspan="2">Solar PV with Storage</th></tr>
<tr><td>Potential:

Can be installed in large arrays, centrally located, or dispersed using existing buildings on which to install various size arrays. The capacity of the required battery storage is estimated to be equal to the annual yield of the intermittent energy resource.

Unit cost with large storage, circa 1.51 seniti/kW-h (US$0.75) - Provides both energy and capacity</td><td>Limitations:

Neither wind nor solar records are sufficient to support a full feasibility analysis of this energy option.

Current batteries must be carefully managed in order to extend their useful lives to about 10 years, to be financially viable, budgets must account for full battery storage replacement every 10 years whereas the solar or wind systems will last over 20 years.</td></tr>
<tr><td colspan="2">Benefits:

Renewable energy and some capacity can be provided with these systems. Can replace some diesel capacity to support intermittent energy without storage.</td></tr>
</table>

<table>
<tr><th colspan="2">Coconut Waste Energy through Gasifiers</th></tr>
<tr><td>Potential:

The husks and shells from a CNO plant can be used in a gasifier where combustible gas is generated and subsequently burned in a gas-engine generator. Low energy costs if the gasifier is located close to the CNO plant. These gasifiers can supply energy to meet electric system needs. Annual yield linked to the CNO project size and would be between 917,000kW-h at the POC plant and 5,506,000kW-h at the full scale plant

Unit cost would be between 26 & 31 seniti/kW-h (US$0.13-0.16)</td><td>Limitations:

Similar to the CNO option.

Cannot be considered without a CNO plant</td></tr>
<tr><td colspan="2">Benefits:

Would improve the overall cost effectiveness of a coconut oil renewable energy plant, could add dispatchable renewable energy to a TPL grid at costs comparable to imported fuel oil</td></tr>
</table>

Other Biomass	
Potential: There is considerable potential for using existing biomass for either direct combustion in a steam-turbine-generator or in gasifiers where combustible gas is generated and subsequently burned in a gas-engine generator. Unit costs will be affected strongly by material handling and transport to a plant. This option can supply energy as needed to meet electric system needs at all times. Dedicated biomass harvesting is possible and needs a relatively large, preferably contiguous area for dedicated cropping.	*Limitations:* Data base on existing biomass is dated so the potential for biomass to be used as feedstock is very uncertain. Some feedstock might be available from harvesting senile coconut trees. Experience elsewhere suggests that such projects are most cost effective where feedstock is available as a waste product from other agricultural or related biomass developments. Existing land use practice is expected to limit options to develop dedicated energy cropping schemes.
Benefits: Could provide firm energy and capacity from a renewable energy resource to a TPL grid	

Ocean Technologies	
Potential: Potential to exploit the kinetic energy of waves and currents, and the thermal energy of the oceans is limited because these technologies are at a pre-commercial stage. Local conditions preclude tidal energy development.	*Limitations:* The database of ocean conditions is limited but the greater limitation is technological development. Annual yields unknown.
Benefits: Could provide energy throughout the Tongan archipelago when proven, cost-effective technology becomes available	

Wind-Hydrogen Systems	
Potential: This and similar hybrid systems seek to use intermittent renewable energy to manufacture hydrogen gas that can be stored and subsequently used to create electricity.[41] Can provide firm capacity and energy	*Limitations:* Currently unproven systems, significant time needed to demonstrate their reliability under a wide range environments before widespread adoption can be considered
Benefits: When the systems have been proven, they will be able to supply energy throughout Tonga	

[41] Tonga has signed an MOU to allow a US-based developer to test a wind-hydrogen system offshore an island in Tonga to demonstrate the specific system.

Annex 4: Additional Sources of Funding Available

A4.1 Regional Organizations

Secretariat of the Pacific Community

The core functions of the SPC regional energy programme are:

i. *Regional coordination* – more specifically as the lead regional energy agency that will complement the technical service delivery role and capacity currently vested in SPREP, PPA, PIFS, USP and other regional agencies and stakeholders delivering solutions in the energy sector.

ii. *Capacity building* – focusing on developing human resources through training and associated measures including other interventions such as advising on implementation and application of sustainable policies and procedures at legislative, regulatory and operational levels.

iii. *Capacity supplementation* – supplement national capacities by directly providing or facilitating access to specialised expertise at regional or international levels.

The following summarises how the SPC regional energy programme can assist in the implementation of the TERM over the next 18 months.

- *Capacity supplementation* – provide technical assistance for policy reviews and study on MEPS; and, advisory services on petroleum issues. Additionally, SPC will share the currently available energy data-sets that will provide the baselines upon which additional work will be required for updating.
- *Capacity building* – training on energy auditing (to be carried out with the MEPS study)

These activities [and possibly others] are subject to the availability and confirmation of funding.

The Government of Tonga and SPC Joint Country Strategy approved in 2009, outlines SPC assistance to Tonga. Through the review process of the JCS, SPC support to the TERM shall be more clearly articulated and crystallised through this "whole of SPC" approach.

Forum Secretariat -PECFund

Forum Leaders at their at their 40th meeting in Cairns, Australia, last year agreed to a new development compact (the Cairns Compact) that:

- Recognises the sovereignty of national governments to determine their own development plans and priorities;
- Calls for properly coordinated efforts by Forum island countries (FICs) and development partners in working together to improve current performance and to ensure effectiveness and coordination of development resources and aid practices;
- Draws on and to enhance national systems and processes in accordance with international and regional best practice in the Compacts' implementation

The concept presented by the Tonga Energy Road Map proposes a new way of doing business verymuch in line with the objectives of the Compact. The Government of Tonga and its development partners have committed to develop and collectively implement this strategic approach to overcoming a major vulnerability which Tonga, like other FICs, faces in its energy sector and which ultimately underpins its development aspirations. In this vein, the Pacific Islands Forum Secretariat is pleased to associate itself as a supportive partner in the development and implementation of the Tonga Energy Road Map.

PIFS is responsible for managing the Pacific Environment Community Fund (PEC Fund) provided by the government of Japan under its PALM5 Commitments. This Fund is for the implementation of Climate Change initiatives with a focus on solar power generation systems and desalination plants. Under this fund, member countries including Tonga will be eligible to seek resources for the procurement of solar power generation systems. Management modalities around this fund are in the process of being finalised, which includes the basis for the allocation of funds. The Secretariat will establish a PEC Fund Management Unit which will be supported by a Technical Advisory Group (TAG). The TAG will provide technical appraisals on the project proposals submitted for funding. Japan has specified that technology procured through the utilisation of this fund must be from Japan or Forum Island Countries. There is no timeline to the implementation of the fund, to this end the PEC Fund will conclude when the fund is fully expended.

The Secretariat of the Pacific Regional Environment Programme(SPREP)

SPREP is providing technical assistance to its member countries, Tonga included, to address the environment-related issues in the energy sector. This is in terms of climate change mitigation and adaptation, pollution, wastes and biodiversity. It is presently providing assistance to member countries on renewable energy with funds from the GEF, Japan, Taiwan and FAO. SPREP has available up to US$120,000 which could contribute to fund Phase 0 activities of the Tonga Road Map such as the TGIF an assessment of the landfill gas resource, up to a total of US$ 120,000.

IUCN – The World Conservation Union – Regional Office for Oceania

Pacific Island Countries are working on strengthening their national energy systems based on a mix of alternative sources of energy, innovative distribution systems, and different consumption patterns. They are making decisions about their energy futures, that focuses on reducing their reliance on fossil fuel and an increase in the use of renewable energy technologies. IUCN Oceania acts to accelerate the transition to energy systems that are ecologically efficient, sustainable and socially equitable. IUCN is promoting a rapid transition to sustainable energy sources by providing knowledge about the impacts of different energy alternatives on nature and biodiversity and how to limit these impacts. Achieving better understanding of the relationships between energy systems and natural systems and the impacts each has on the other is vital.

The following summarizes how IUCN – Oceania Regional Office can contribute to the TERM over the next 12 months:

- Provide support to the Government of Tonga to undertake environmental screening of the TERM

- Review the lessons learnt from the solar home electrification in Ha'apai villages to contribute the lessons learnt to the process of development of the TERM
- Provide support to integrate climate change into the planning for the implementation of the TERM

A4.2 Clean Development Mechanism / Carbon Financing

Clean Development Mechanism (CDM) of the Kyoto Protocol of the United Nations, allows emission reduction projects, that assist developing countries in achieving sustainable development and that generate 'certified emission reductions' (CER), to be used by the investing countries or companies toward meeting their CO2 emission reduction targets. Solar, wind and landfill gas projects all qualify for CDM and projects in Tonga could therefore generate an additional revenue stream from the trade of certified emission reductions. As the baseline is 100% diesel, calculating emission reductions from renewable energy contribution is straight forward. The UNEP CDM guidebook suggests an emission co-efficient for small diesel grids of 0.8 kg CO_2/kW-h generated by renewables.

Biofuel crop plantations are now eligible for carbon credits under the CDM, following approval of a new methodology in August 2009. However, conditions are restrictive and it is not clear if the use of coconuts for energy purposes would qualify under the new rules. This would require further investigation.

The methodology – ACM0017 – covers the production of biodiesel for use as a fuel, both in generators and vehicles, but only if used in the country of origin. A CNO project in Tonga would fulfill this criterion. The biofuel will only be eligible for carbon credits if it is produced from waste oil or fat, or vegetable oil that is "produced with oil seeds from plants that are cultivated on dedicated plantations established on lands that are degraded or degrading at the start of the project activity". The application of this condition is not clear-cut in the case of the recommended biofuel project for Tonga. While the oil contained in coconuts that rot on the ground could be considered as waste oil (and would thus be eligible for CDM), eligibility needs to be confirmed. The establishment of new plantings, however, would have a high chance of qualifying for CDM.

It is recommended that eligibility be assessed, through the development and submission of a Project Identification Note (PIN) to UNFCCC, as soon as a developer for such as project has been identified. Based on this PIN, a dialogue with potential carbon financing organizations can be started.

In addition to CER, trading is undertaken in so-called "verified emission reductions" (VERs) in what is commonly referred to as the voluntary carbon market. VERs are not a standardized commodity. While they may eventually become CERs, there is a risk that this may not happen and therefore buyers tend to pay a discounted price for VERs, which takes the inherent regulatory risks into account. Such opportunities may also be explored.

In order to participate in the CDM, Tonga will be required to establish a Designated National Authority (DNA). This will require technical assistance to establish the operational structure and resource requirements, develop working guidelines and procedures for the DNA, provide capacity building and hands-on training for stakeholders and DNA staff in procedural requirements and raise public awareness on the role, functions, and requirements of the DNA. Such TA could be combined with TA to establish the Tonga Green Incentive Fund.

A4.3 The Secretariat of the Pacific Regional Environment Programme (SPREP)

The Secretariat of the Pacific Regional Environment Programme (SPREP) is providing technical assistance to its member countries including Tonga addressing the environment-related issues in the energy sector. This is in terms of climate change mitigation and adaptation, pollution, wastes and biodiversity. It is presently providing assistance to member countries on renewable energy with funds from the GEF, Japan, Taiwan and FAO. SPREP has expressed interest in funding some Phase 0 activities of the Tonga Road Map.

A4.4 ACP-EU Energy Facility

The Energy Facility is a co-financing instrument initially established in 2005 in order to support projects on increasing access to sustainable and affordable energy services for the poor living in rural and peri-urban areas in African, Caribbean and Pacific (ACP) countries.

The European Commission established the ACP-EU Energy Facility within the EU Energy Initiative for Poverty Eradication and Sustainable Development (EUIE). The EUEI was launched by the European Union in 2002 during the World Summit on Sustainable Development in order to confirm its commitment to the achievement of the Millennium Development Goals in terms of poverty alleviation and eradication.

A second Energy Facility (EFII), with a total budget of €200 million, has been established under the 10th European Development Fund for the period 2009-2013.The second Energy Facility will be implemented through two calls of proposals. The first €100 million call was launched on the 30th November 2009. This new Facility will also include new co-financing instruments namely a financial support to energy governance through the EUEI-Partnership Dialogue Facility and a pooling mechanism which involves European financing institutions (like the EIB) and the private sector.

More information may be found under:
http://ec.europa.eu/europeaid/where/acp/regional-cooperation/energy/second-energy-facility_en/index_en.htm

Annex 5: Academic Linkages

A5.1 Overview

It is recommended that academic linkages be established to document, and contribute to, the TERM. The linkage would then use the knowledge and skills developed through TERM to establish courses, trainingprogrammes and seminars in a range of related sectors, including energy technologies, financial mechanisms, adaptation, mitigation and public policy. Once expertise is in place, establish an associated but independent think tank looking at related issues from national, regional and international perspectives.

This initiative could establish Tonga as a globally-important, living laboratory and an example of realistic, size, social and economy appropriate, renewable energy systems and policy innovations.

A5.2 The Concept

As the Road Map has demonstrated, it can be a time-consuming process to assess appropriate technologies and policies for achieving affordable, environmentally sound, energy sustainability. Rather than have other nations/regions continuously reinvent the wheel, TERM could establish an academic linkage with the goal of developing courses/training/seminars in relevant sectors.

The advantage Tonga has in being an important leader in this area is that, as the Road Map is implemented, Tonga will be in the interesting position of quickly having in place multiple new renewable energy systems, policies and efficiencies. This gives students/seminar participants valuable opportunities for real world research projects and site visits (for many, seeing an energy system in operation is infinitely more effective for understanding than reading a technical document).

As the educational component grows, and more come to Tonga to see what is possible, Tonga can become one of the key places for private sector and university-based testing/demonstration of new and appropriate techniques and technologies. Tonga can become a place to ‘be seen’ for energy sector innovation -- a one-stop shopping location for small scale and off-grid renewable and efficiencies.

This can also result in the increased attractiveness of Tonga as a preferred destination for conferences related to energy/climate issues as well as a unique ‘green/innovative/guilt free’ tourism destination.

Those wishing to set up demonstration sites and test technologies would be required to include students in the projects in order to build local/regional expertise. As expertise develops in Tonga, the academic component could also form a leading, regional, independent think tank that would allow ‘safe space’ for the open discussions on relevant issues.

A5.3 The Academic Linkage

A first place to look for linkage would be the University of the South Pacific, with the possibility of turning the Tonga campus in to the regional hub for TERM-related topics. Once the academic component has a permanent physical home, it becomes a natural location for a related think tank.

As USP itself is linked to the University Consortium of Small Island States, collation, testing and dissemination of research could potentially have a global reach. It is also possible that strategic partnerships could be developed with specific universities in New Zealand, Australia, China, Canada, the UK, India and elsewhere that offer relevant courses.

Courses, seminars and training programmes might follow two tracks, longer core development courses and shorter specialist courses.

A5.3.1 Example of longer core development courses

In the first instance, perhaps a one-year diploma course could be developed in energy systems and policies. Closely following the experiences of the development of TERM, it could be divided into two sections.

- The first half-year could look at TERM and its results as a totality, with student projects designed to support TERM work (data collection, technical assessments, site work, periodic review of TERM, community outreach, etc.);
- For the second half year, the student group could split in two, with half focusing more in depth on policy issues, and the other half on technical issues.

Graduates will develop the capacity to assess appropriate technologies from a technical, social, financial and policy perspective and would then be well placed to improve and disseminate the TERM approach both in Tonga and abroad.

Eventually, as appropriate staff/structures grow, longer undergraduate and graduate level courses can be developed on energy technologies, financial mechanisms, environmental change adaptation, mitigation and public policy.

A5.3.2 Example of shorter specialist courses

Shorter (one/two week) seminars can be offered for mid-career professionals on specific aspects of TERM-related work. These would be complementary to the work being done by regional organisations.

For example:

- Appropriate energy technologies for small island states;
- Energy/environmental policies of donor nations;
- Assessment of environmental change impacts on regional energy infrastructure;
- Assessments of regional energy supply chain/procurement cooperation.