TONGA Renewable Hybrid Power System

International Seminar of Energy Security in the Pacific Island Countries

Presentation by Steven ‘Esau and Nikolasi Fonua

Presentation Overview

1. Introductions
2. An overview of the Pacific Islands
3. Tonga in General
4. National Energy Demand and Supply
5. Long Term Renewable Energy Strategy
6. Tonga Hybrid Micro Grid System
7. Present Situation of PV Development

Introductions

TONGA POWER LIMITED

- Pacific island countries –extreme weather volatilities & increasing energy & fuel costs
- PICs Energy Road Map Targets – 20% –100% renewable energy penetration targets.
- Few realised the complexity of these RE targets and the associated costs involves.
- High RE penetration to power grid – eg. Niue, Tuvalu, Samoa, & Fiji
- Tonga completed a study sponsored by the World Bank into how it will technically reached its 50% RE by 2020 using only solar and wind generation.
- Tonga has embraced the Renewable Energy Hybrid System shared by Japan (JICA).

1. PACIFIC FUEL PRICES AT A GLANCE

SPC CPS
SECRETARIAT OF THE PACIFIC COMMUNITY
SECRÉTARIAT GÉNÉRAL DE LA COMMUNAUTÉ DU PACIFIQUE

Figure 1: Regional retail prices including duty and taxes

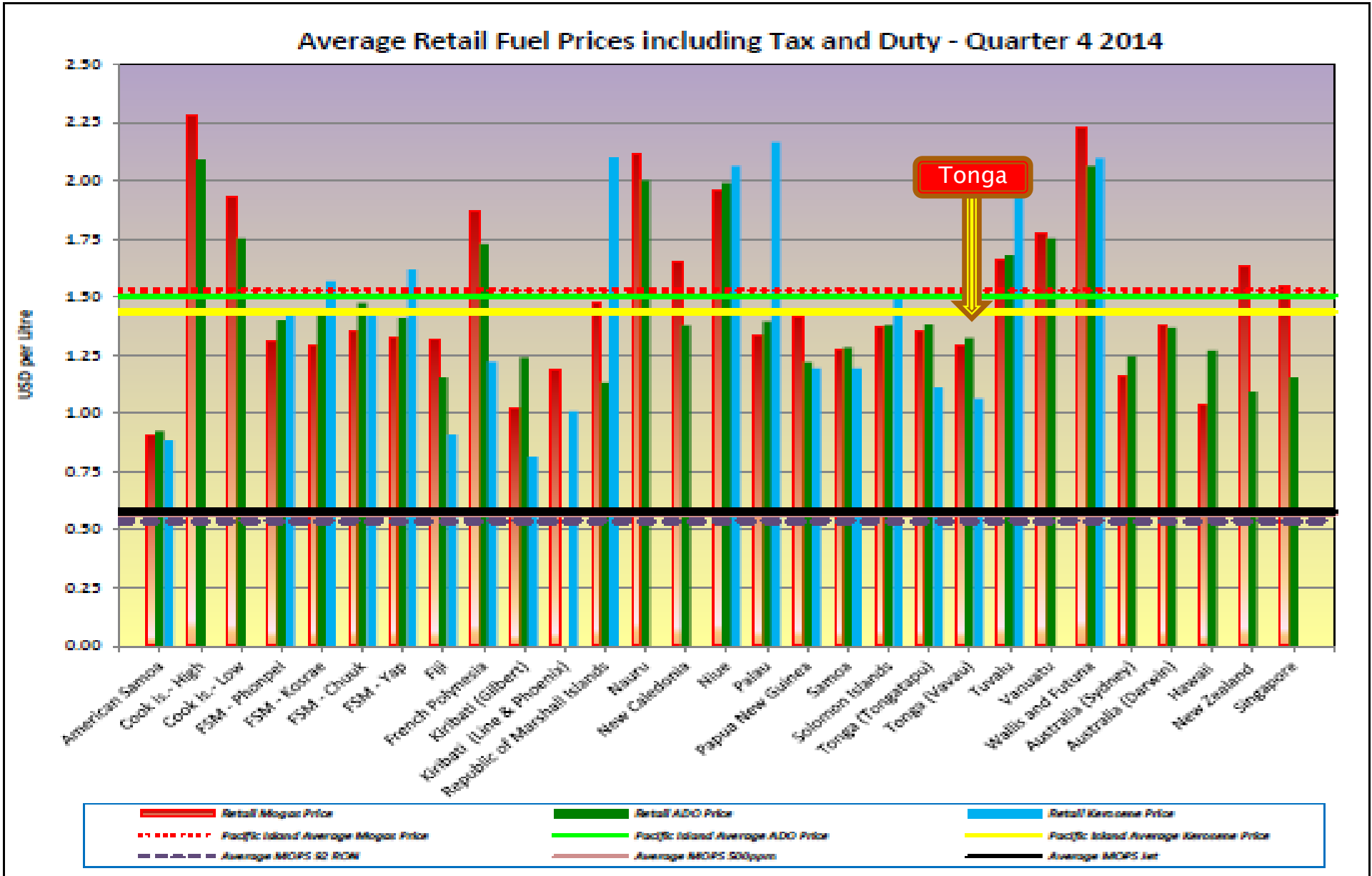
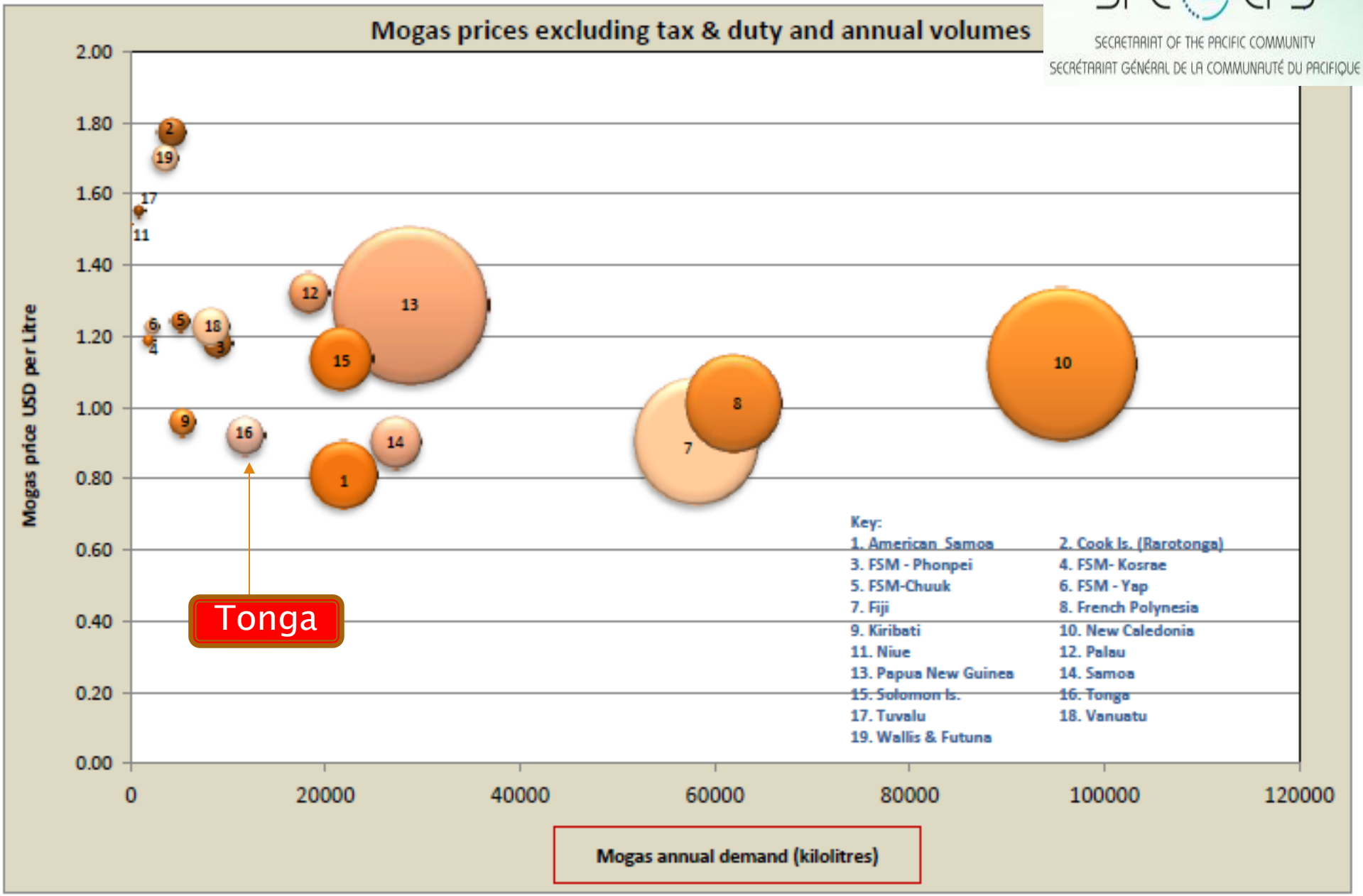


Figure 5: Mogas pre-tax retail prices 4Q-2014 compared by annual volume



*Note: For figure 6.0 total and mogas volume for New Caledonia is projected over 1995 data and it's an SPC estimate. The centre of the bubble represents the price.


©GraphicMaps.com
1400 mi
1400 km
Philippines
ASIA
Palau
Micronesia
Marshall Islands
Papua New Guinea
EQUATOR
0°
Nauru
Kiribati
Pacific Ocean
Indonesia
Tuvala
East Timor
Solomon Islands
Vanuatu
Tahiti (France)
Samoa
Fiji
Tonga
TROPIC OF CAPRICORN
23.5°
Australia
OCEANIA
Sydney
New Zealand
Tasmania (Australia)
Arctic
Pacific
Atlantic
Indian
Indian Ocean
180°

Tonga in General

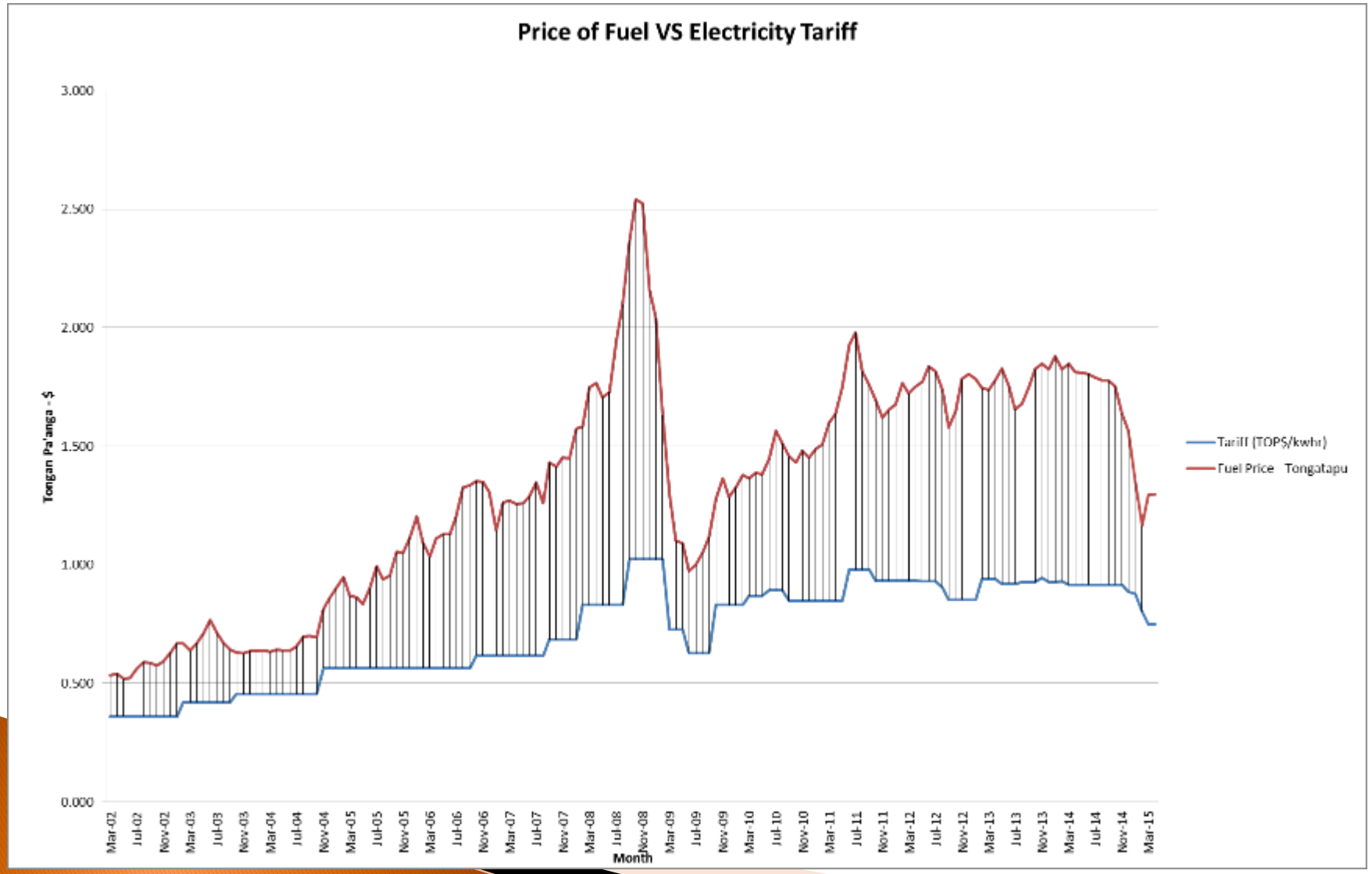
Population	103,252 (51,979 males and 51,273 females)
Area	720,000 km² land/sea 747 km² land 172 Islands
Language	Tongan, English
Religion	Christian 96%
Political System	Constitutional Monarchy
Major Industries	Agriculture, Fisheries, Tourism
GDP per capita (2014)	US$ 5,000
Major Exporting Products	Fish, Vanilla, Squash, root crops
Major Importing Products	Foodstuffs, machinery, transport equipment, fuel, chemicals

National Energy Supply and Demand

- Fossil Fuel Imports per annum total approx. 50m Litres
- 13m Litres per annum consumed for electricity generation
- Remaining fuel is consumed by transportation sector and other industries.
- There are 2 suppliers of fuel to the Kingdom of Tonga – 'Pacific Energy' and 'TOTAL'
- Managing Primary Energy procurement is the responsibility of the Government of Tonga through the competent authority.

National Energy Supply and Demand

- One tariff for all – 50/50 Fuel and Non-Fuel



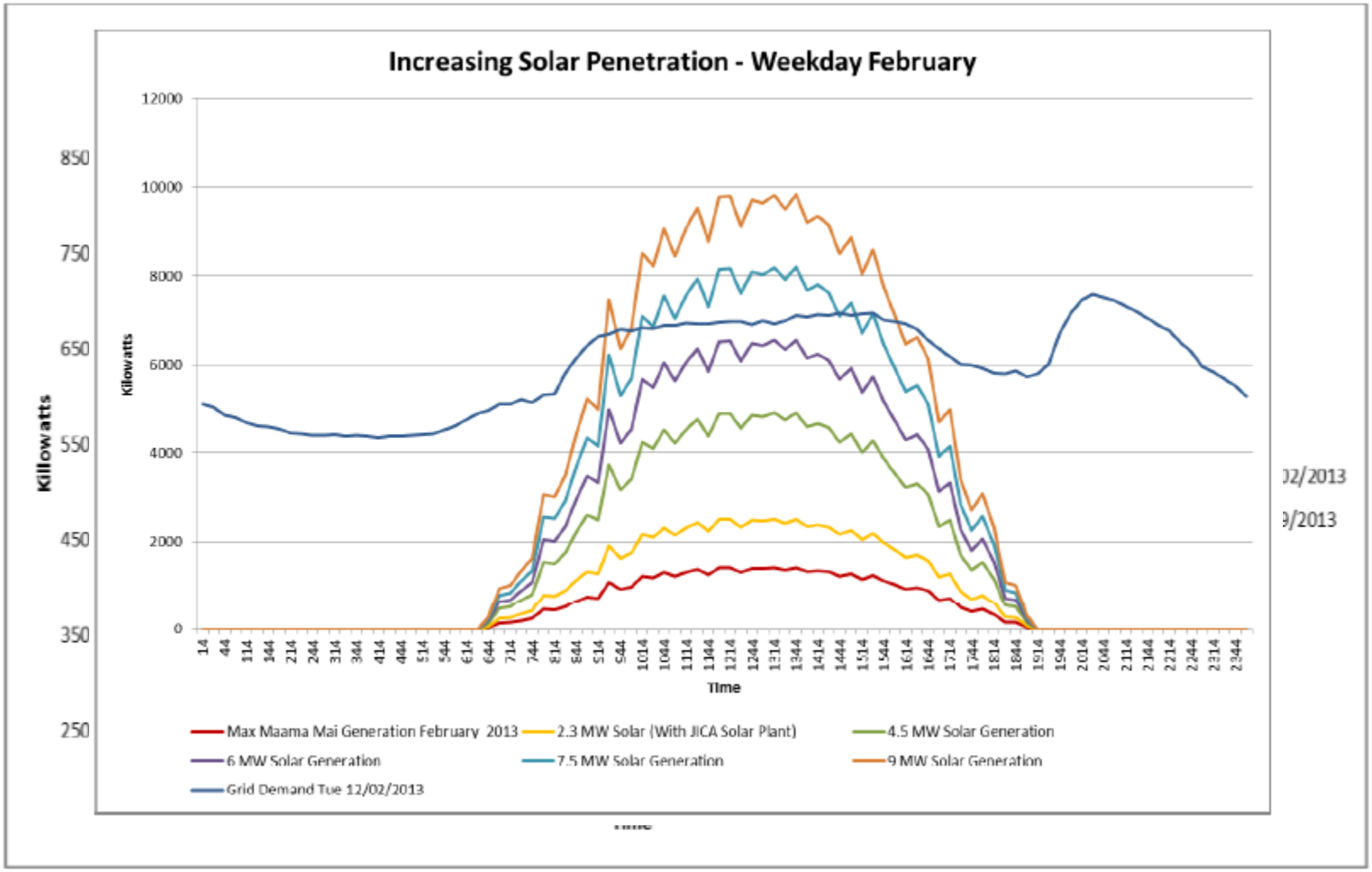
National Energy Supply and Demand

50% Renewable by 2020 = 50% of 54 GWh = 27 GWh from RE

- **Tongatapu** – 15,000 customers, 8.4 MW Peak Demand, 16.4 MW Installed Capacity (13.8 MW Diesel, 2.6 MW Solar PV)
  11,052,436 L/year p.a 47,138,891 kWh/year 4.26 kWh/L
- **Vava'u** – 3,000 customers, 1.2 MW Peak Demand, 2.372 MW Installed Capacity (1.872 MW Diesel, 0.5 MW Solar PV)
  1,137,333 L/year p.a 5,057,686 kWh/year 4.44 kWh/L
- **Ha'apai** – 1,000 customer, 350 kW Peak Demand, 400 kW Installed Capacity (100% Diesel)
  316,615 L/year p.a 1,202,045 kWh/year 3.79 kWh/L
- **'Eua** – 1,000 customers, 300 kW Peak Demand, 400 kW Installed Capacity (100% Diesel)
  318,399 L/year p.a 1,150,942 kWh/year 3.61 kWh/L

National Energy Supply and Demand

- Pattern of Demand and PV Penetration



Long Term Renewable Energy Strategy

- Tonga Energy Road Map – *'Reduce Tonga's vulnerability to oil price shocks, and achieve an increase in quality access to modern energy services in an environmentally sustainable manner'*
- Tonga Power Limited – *'To deliver nations core policy and remain financially sustainable. Safe, Reliable, Sustainable and Affordable Electricity'*
- Key Documents:- Electricity Act, Electricity Concession Contract

Long Term Renewable Energy Strategy

- Potential of Renewable Energy and Status of Development

Project	Funder	Capacity (MW)	Benefits (s/kWh)	Completion
Maama Mai	NZ	1.4	1.5	Aug 2012
3rd Party Solar	Private	0.2	0.2	July 2012
Pole-top Solar	TPL	0.0175	0.01	Ongoing
TPL Micro Solar	TPL/ECOCARE/Rotary	0.05	0.05	Feb 2013
TPL Micro Wind	TPL	0.011	0.04	May 2013
La'a Lahi	UAE	0.42	0.5	Nov 2013

Project	Funder	Capacity (MW)	Benefits (s/kWh)	Completion
Solar and Micro-controller Project	JICA	1	1.5	Feb 2015
Ha'apai Micro Turbine	TPL	0.011	0.04	June 2015
Outer Island Renewable Energy Project	ADB/DFAT	0.75	0.5	Mid 2016
TBU Wind	JICA/NZ	4.4	6.0	2017
Eua Biomass	TPL	0.25	0.15	2016 or 2017

Long Term Renewable Energy Strategy

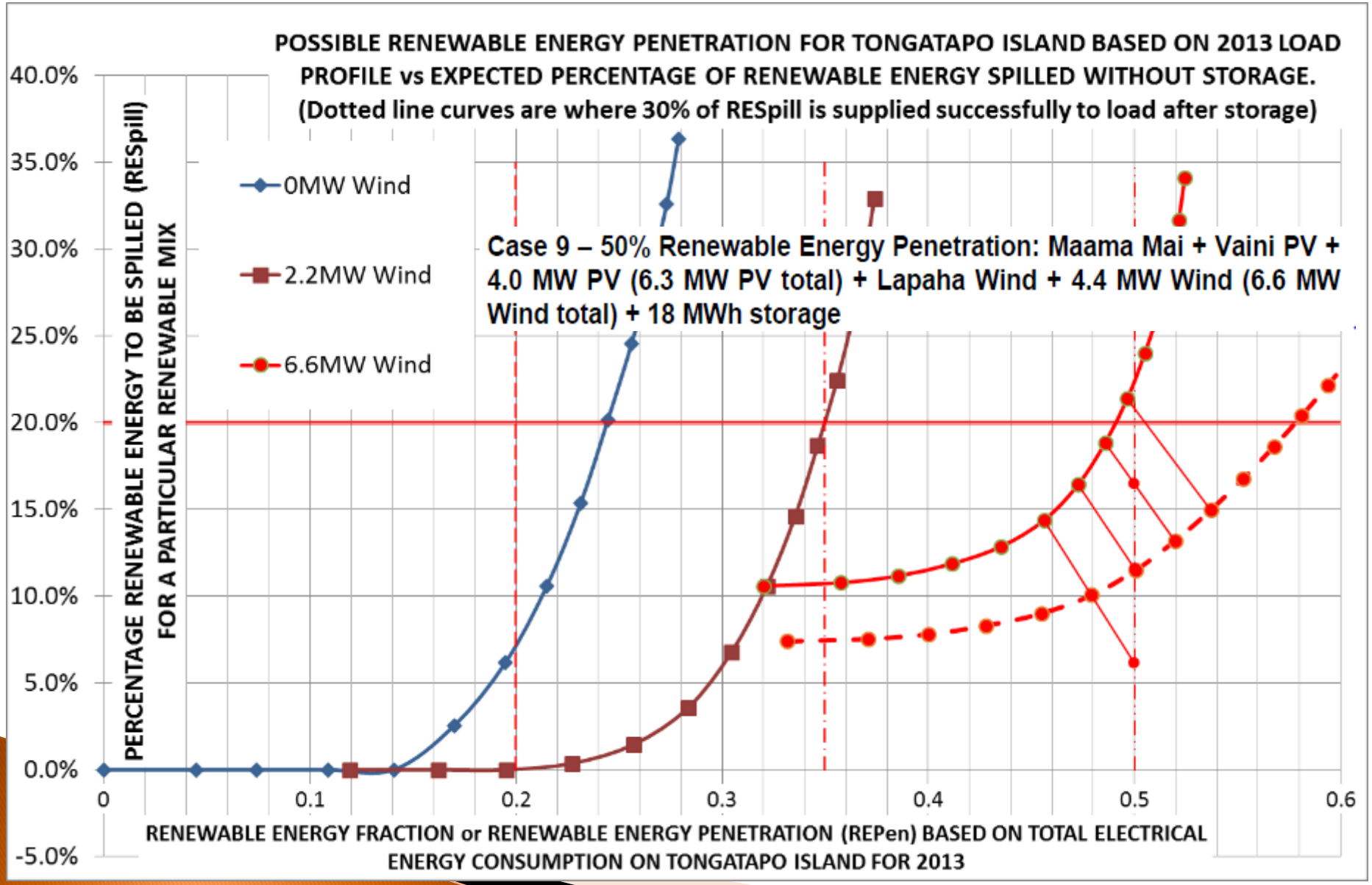
- Basic Data and Information
- Wind

Hub height [m]	Lapaha wind speed [m/s]	Niutoua wind speed [m/s]
55	6.89	7.45
45	6.50	6.72
38	6.19	6.16

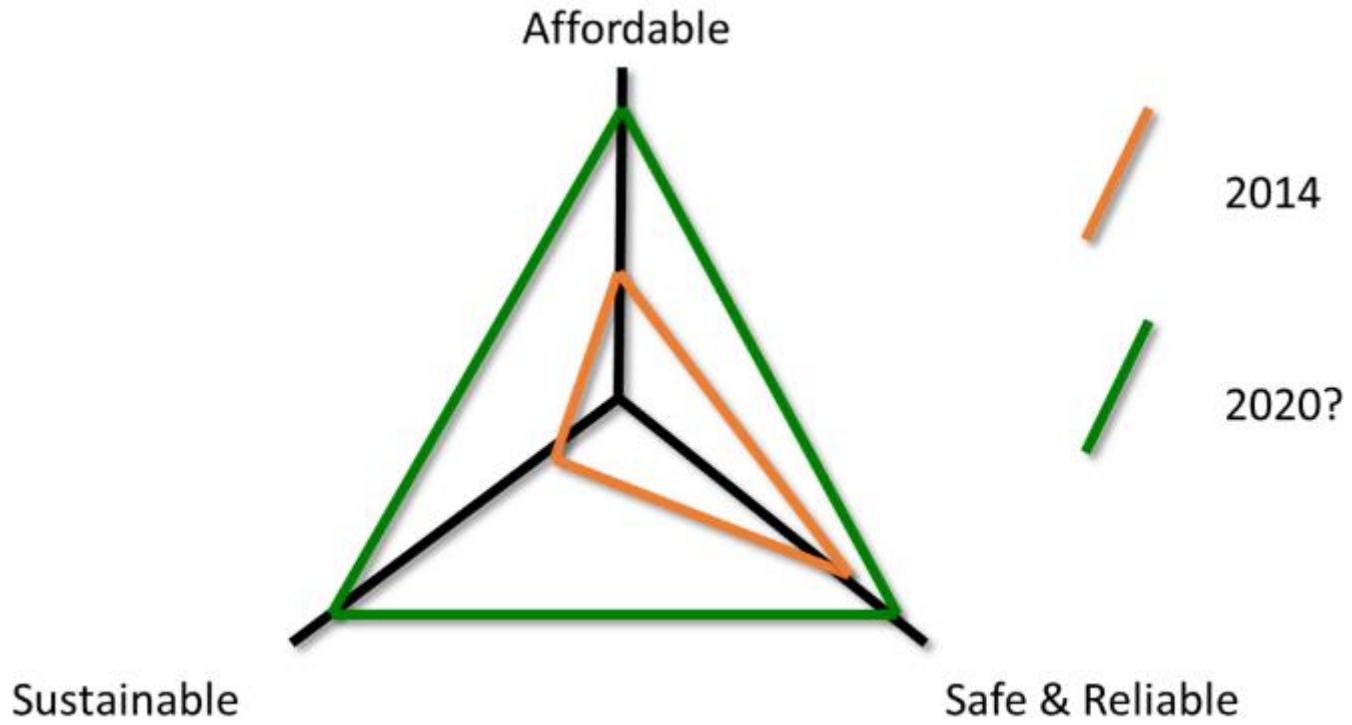
- Solar

Island system	*Optimal tilt*	*Irradiation on the tilted plane kWh/m²*
Eua	*22° N*	1.878
Ha Apai	*20° N*	1.882
Vava u	*19° N*	1.876
Niuas	*17° N*	1.856

Tonga Power Ltd Hybrid System Plan to reach 50% Renewable Penetration by 2020



Hybrid Power Generation Drivers



Hybrid System Plan to reach 50% Renewable Penetration by 2020

Grid Stabilizer (Micro Grid Controller)
(Battery, SCADA, Ring Topology)

Wind
6.6 MW

+

Solar PV
6.3 MW

+

Diesel & Biomass & Biofuels

+

Storage
2.3MW
(18 MWH)

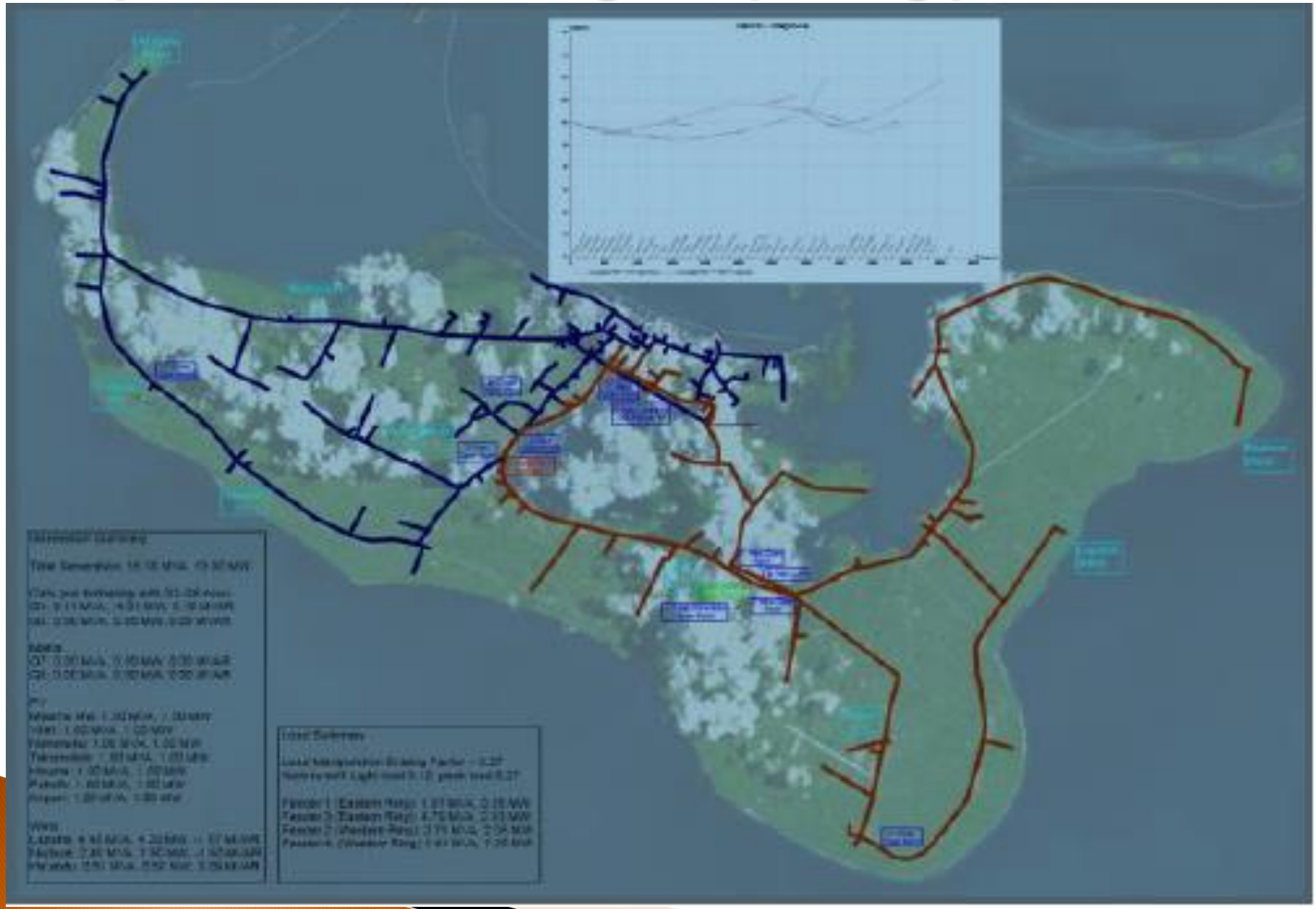
=

50% RE – SAFE, RELIABLE, SUSTAINABLE, AFFORDABLE Electricity for the people of Tonga

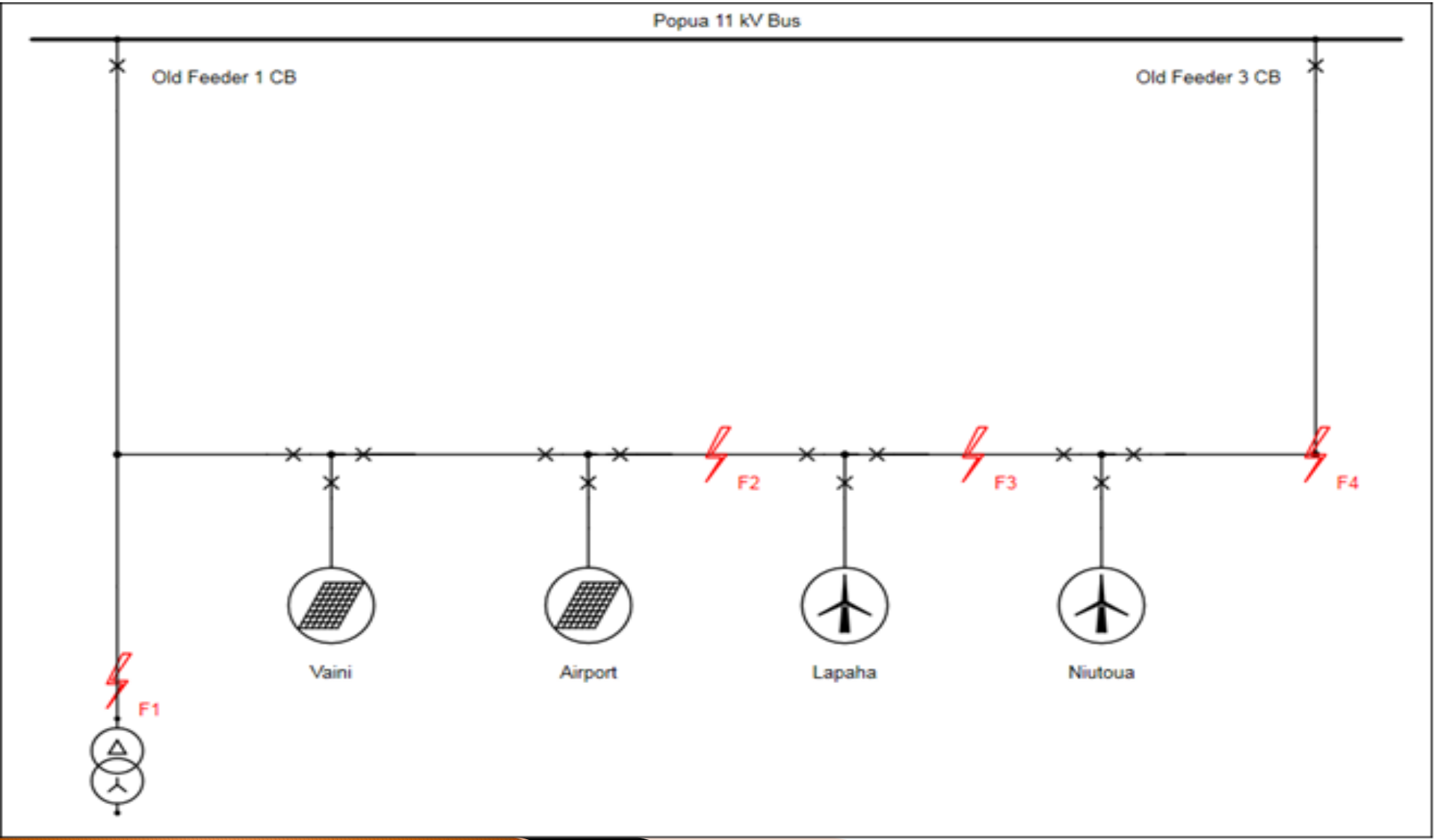
Size of spill (12% to 22%) is dictated by the: size of battery and fluctuation suppression

= 50% RE Penetration by 2020

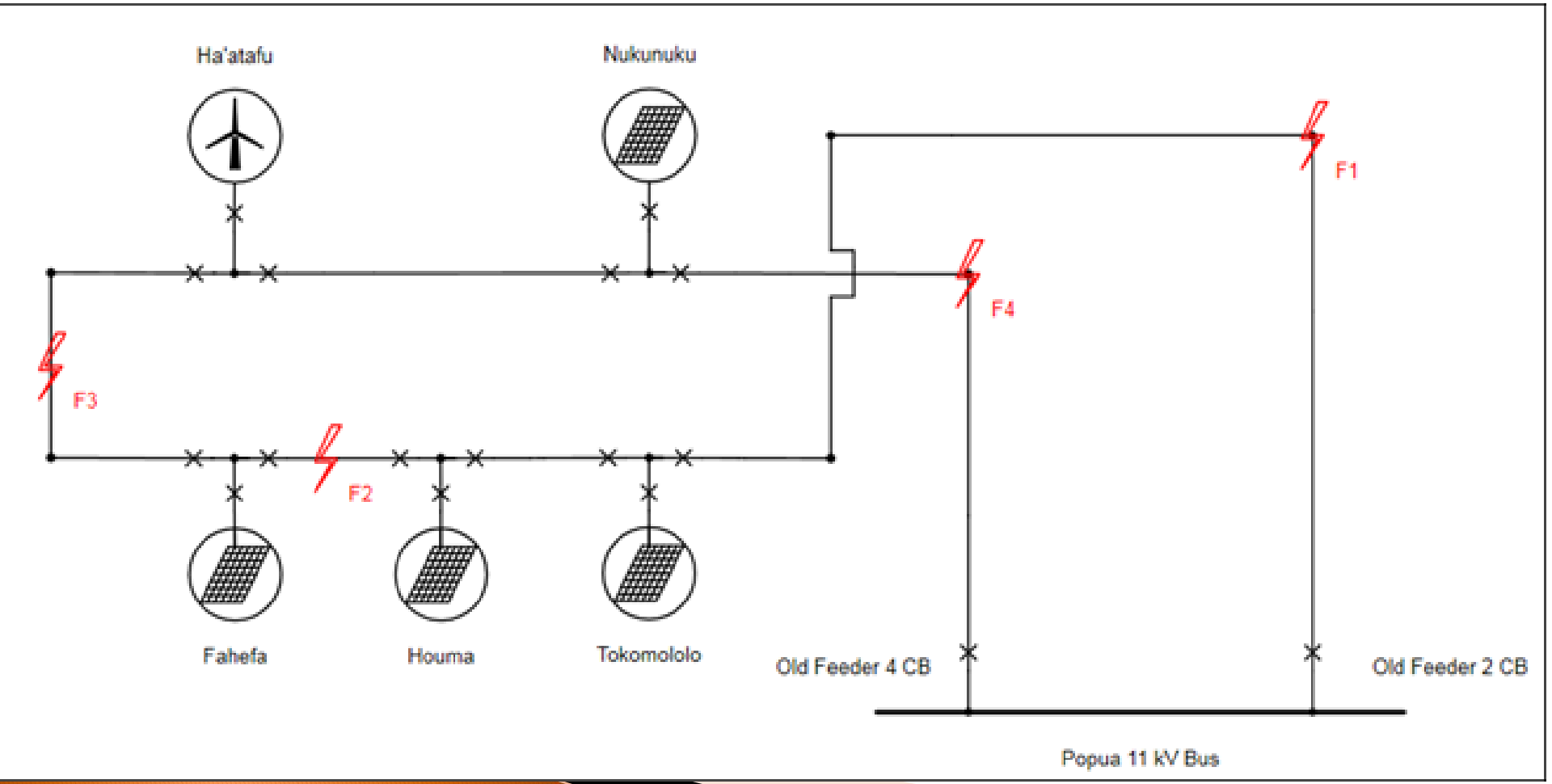
Hybrid Grid Ring Topology



Hybrid Grid Ring Topology – Eastern

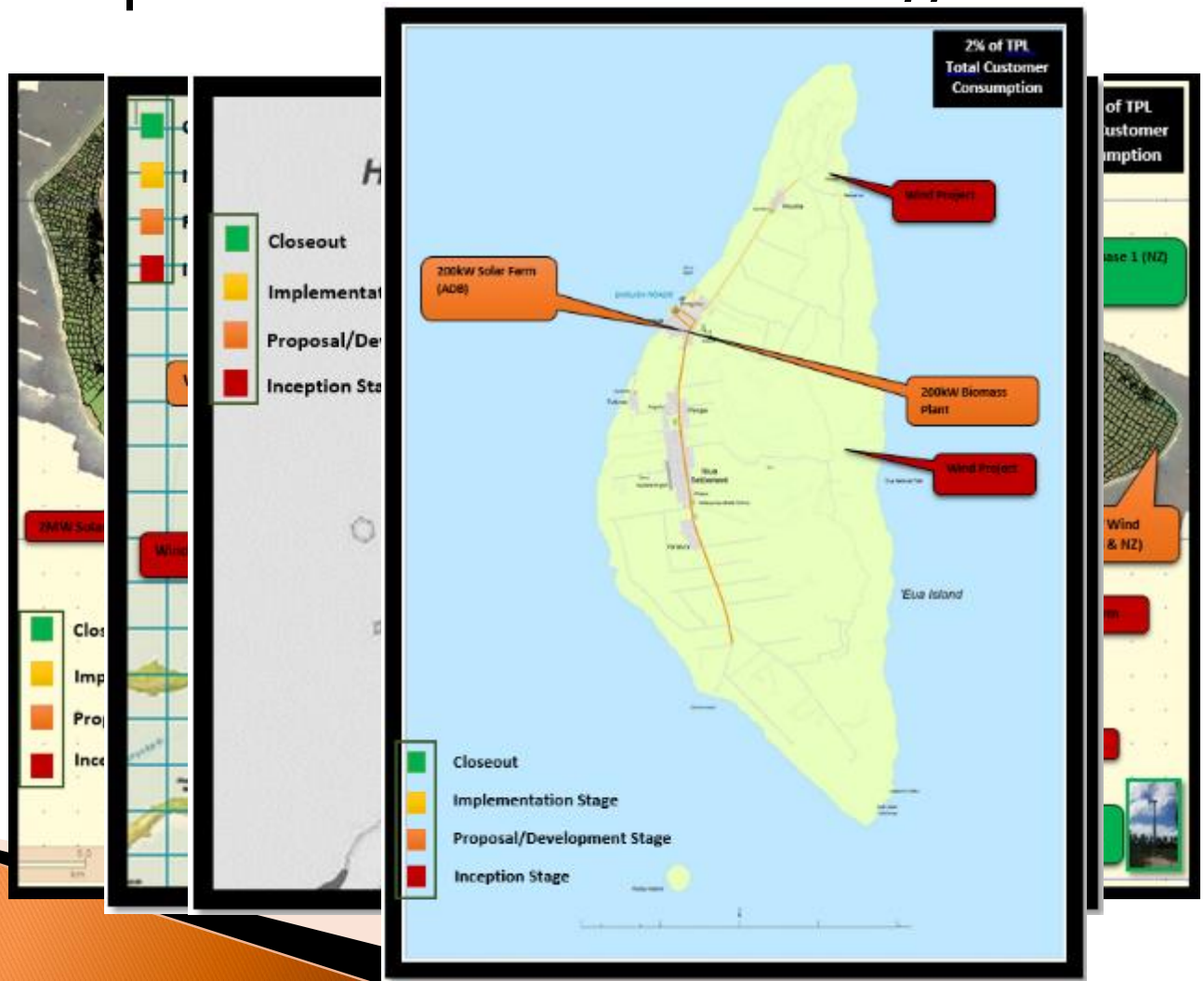


Hybrid Grid Ring Topology – Western



Long Term Renewable Energy Strategy

- Future plan of Renewable Energy Installation



Conclusion

- Pacific Island Countries are susceptible to climate change due to lack of disaster resilience infrastructure with high energy costs
- HOMER Modelling shows it is possible for Tonga to reach 50% REpen by 2020 – Hybrid Renewable Generation System
- Combination of 6.6MW Wind Turbine (Retractable WT of PEC) and 6.3MW Solar PV with Micro Grid Stabiliser (Storage 2.3MW(18MWh)) = 50% RE
- Tonga to be a model Hybrid RE-Island in the pacific with the help of Development Partners like JICA & IRENA

Arigato gozaimasu.