TONGA RENEWABLE ENERGY PROJECT 2016 TO 2025

Lessons from BESS and SCADA implementation

Lachlan McKenna – September 2025

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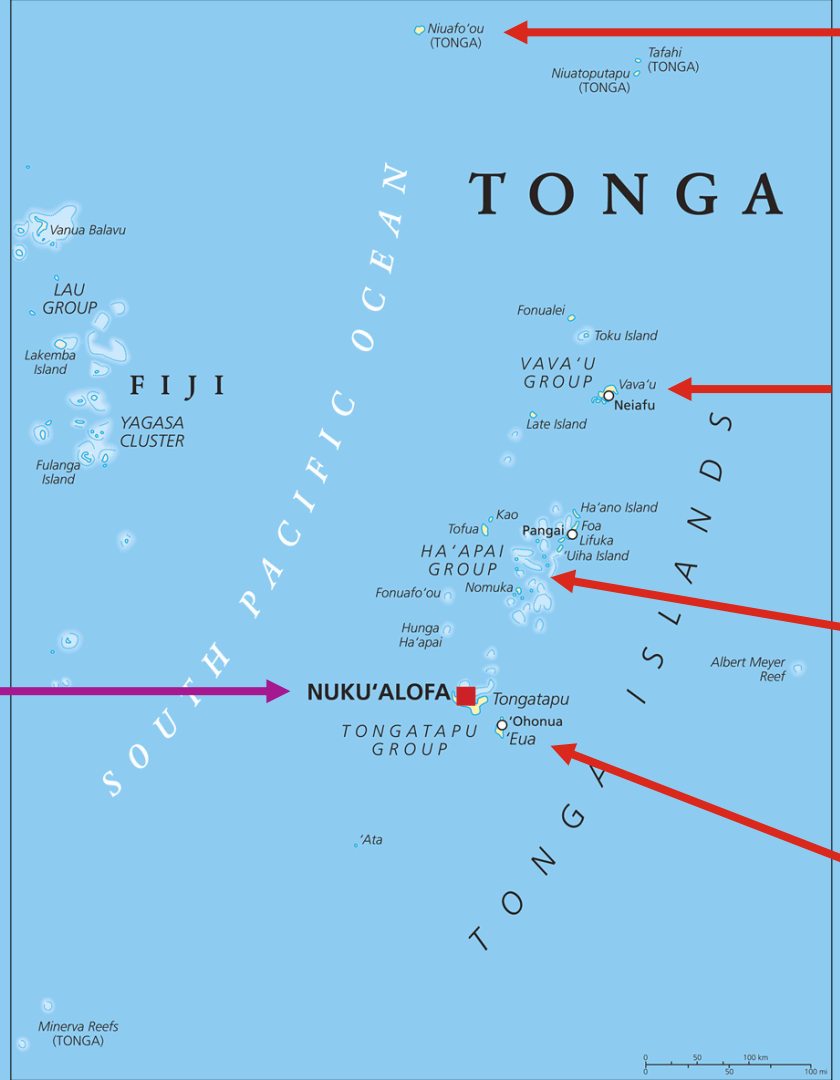
TREP sites
2016 – 2025



Tongatapu

BESS and SCADA

Niuafo'ou

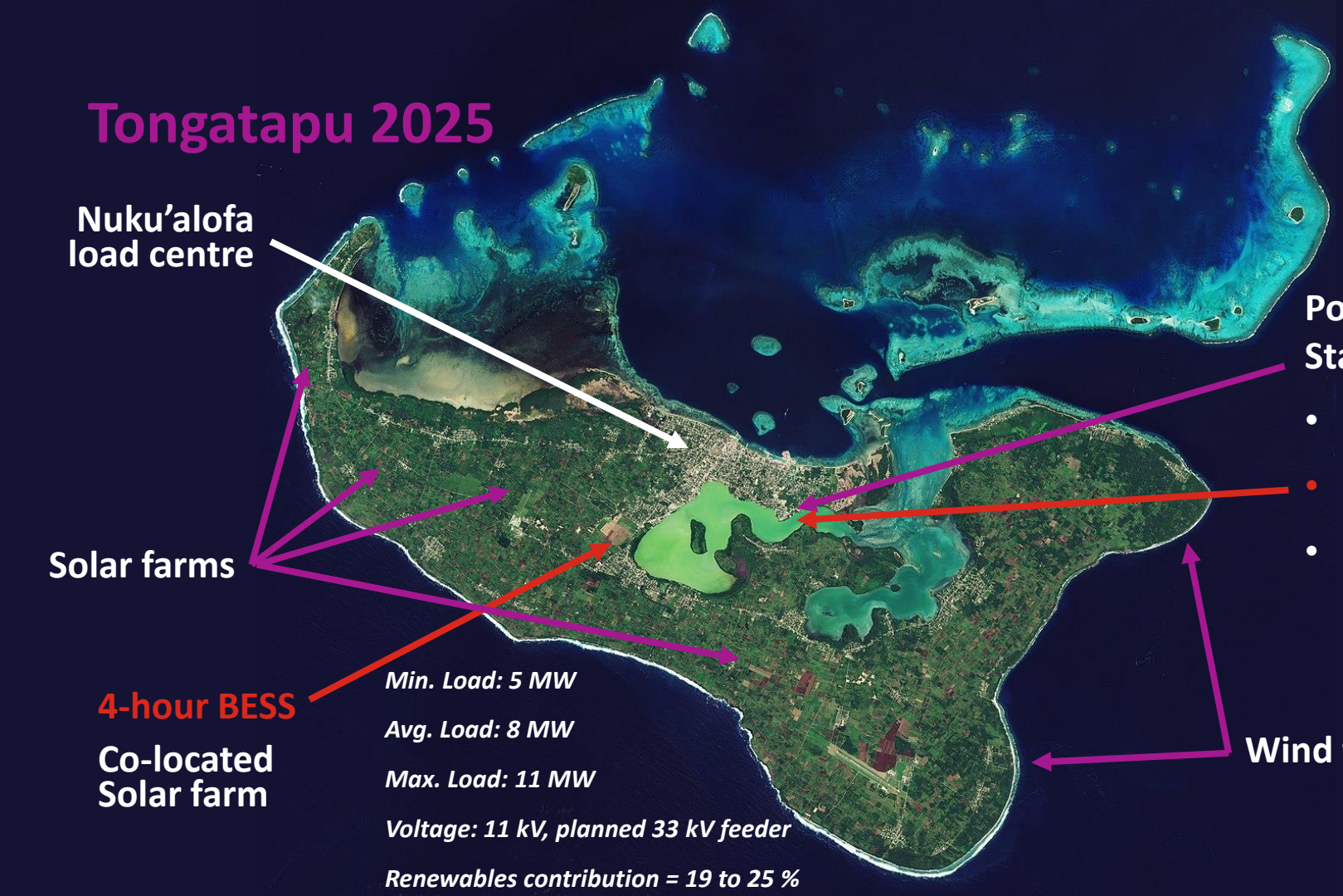
Vava'u main grid and outer islands

Contractor: CBS

Ha'apai outer islands

'Eua

Tongatapu 2025



Nuku'alofa load centre

Popua Power Station:

- Diesel units
- 30-min BESS
- Solar farm

Solar farms

4-hour BESS

Co-located Solar farm

Min. Load: 5 MW

Avg. Load: 8 MW

Max. Load: 11 MW

Voltage: 11 kV, planned 33 kV feeder

Renewables contribution = 19 to 25 %

Wind farms

2015

Min. Load: 3.5 MW

Avg. Load: 5.6 MW

Max. Load: 8.5 MW

Voltage: 11 kV

Renewables contribution = ~7 %

Tonga Energy Roadmap (TERM)

Policy objectives in the TERM (2010 – 2020):

1. Reduce vulnerability and exposure to globally volatile oil prices.
2. Increase quality access to modern energy services.
3. Follow a least-cost-approach.
4. **Renewable energy contribution of 50% by 2012.**
5. Increase energy efficiency.
6. Reduce transmission and distribution losses to below 9%.
7. Demand-side energy efficiency.

Updated 15-year TERM *PLUS* (2021 – 2035):

- Reduce diesel imports by 10%.
- **Renewable energy contribution of 70 to 100% by 2035.**

+ other objectives

2016 – 2018: Feasibility Study and Procurement

- Feasibility study objectives aligned with TERM.
- Significant solar variability due to cloud cover.
- High load growth of ~5% per annum.
- Rollout of distributed generation, traditionally centralised at Popua Power Station.

Result: Identified two BESS for ***Load Shifting/Solar Storage*** and ***System Stability/Power***.

4-hour 'Storage' BESS (6 MW / 20 MWh)
at a network feeder junction

30-minute 'Power' BESS (7 MW / 4 MWh)
at Popua Power Station

2019 – 2021: BESS construction and commissioning

- BESS factory acceptance testing was successful with connection to a load bank and diesel generator.
- Solar storage BESS operated as expected, but setpoints were manually scheduled.
- Grid-following BESS.

4-hour ‘Storage’ BESS (6 MW / 20 MWh)
at a network feeder junction and co-located solar farm

A comparison

Grid forming:

- ✓ **Can make its own sine wave, without a grid, or other synchronous generation.**
- ✓ **Can be capable of black starting a grid.**
- ✓ **Adds value during faults**, can assist *grid-following inverters* to ride through faults, or continue generation output during faults.
- ✓ **Regulates both its voltage and current outputs.**
- ✓ **All synchronous generation is grid forming** (diesels, gas, hydro, etc.)
- ✓ Electronics definition: **Voltage source device.**

Grid following:

- **Requires a voltage source to follow** and cannot create its own sine wave without this.
- If the voltage waveform starts to lose its shape, it will no longer be able to stay online.
- **Cannot assist during faults** – it can ride through faults but does not add value during a fault. Also does not come online immediately after a fault.
- Electronics definition: **Current source device.**

For extended technical definition, see:

2019 – 2021: BESS construction and commissioning

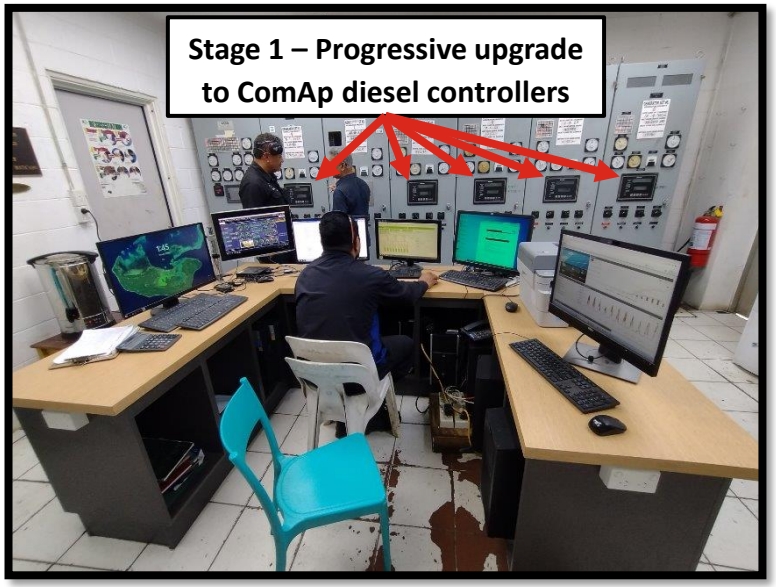
- ‘Power’ BESS acting disproportionately, causing instability.
- One of Entura’s first grid-forming BESS specifications.
- The supplier’s power system models (PowerFactory) were inaccurate compared with the real-world use.
- BESS settings had to be tuned, **but during the next phase of SCADA and control automation.**

30-minute ‘Power’ BESS (7 MW / 4 MWh)

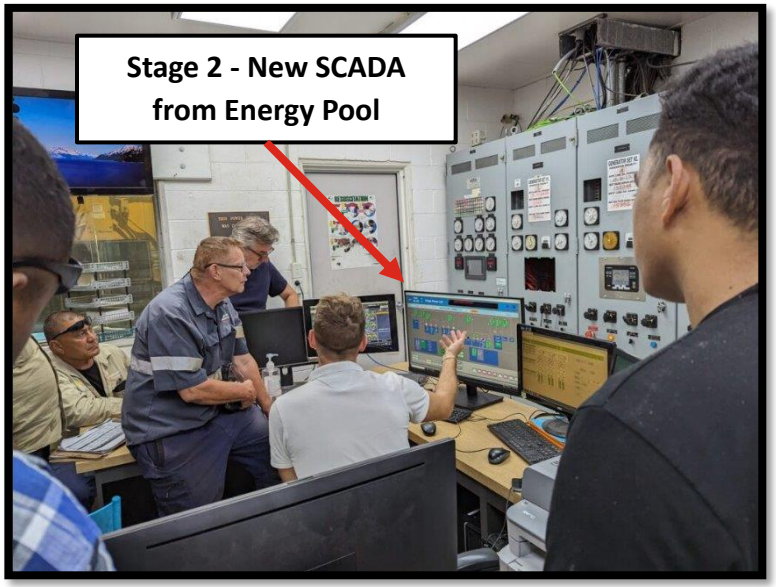
at Popua Power Station

2022 – 2025: New diesel controllers, upgraded SCADA, BESS tuning

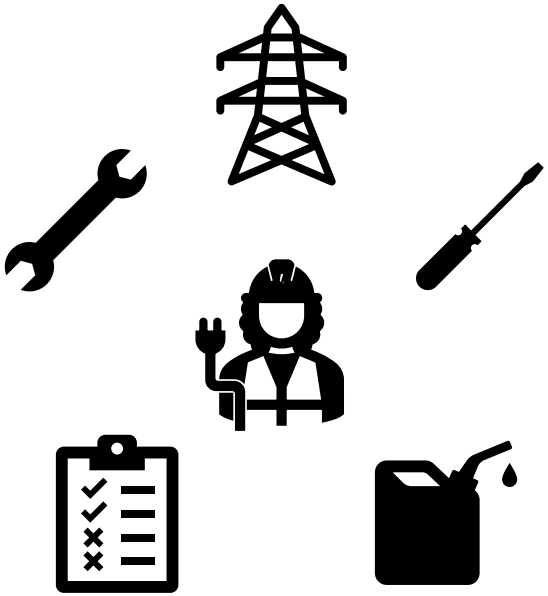
Popua Power Station Operations Room



Implementing automation, capacity building



From manual and diesel-based to automated and inverter-based



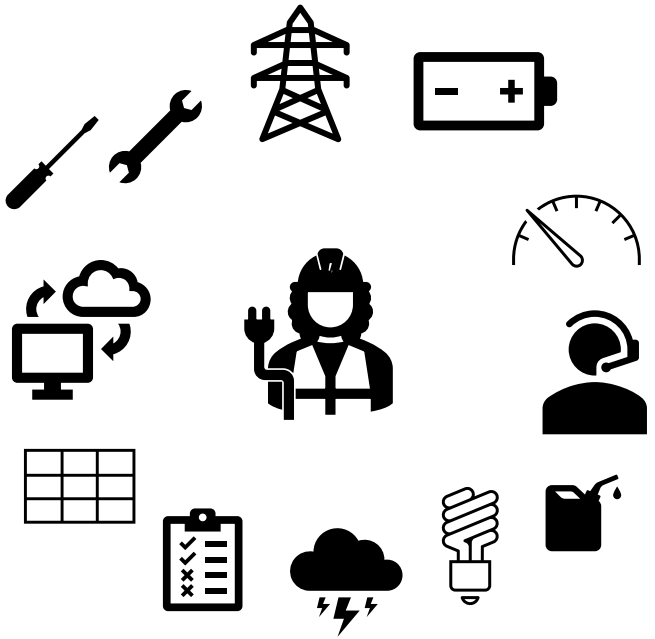
Smarter Grids

Digitalisation

Increasing grid visibility

Different skills

Different ways of working



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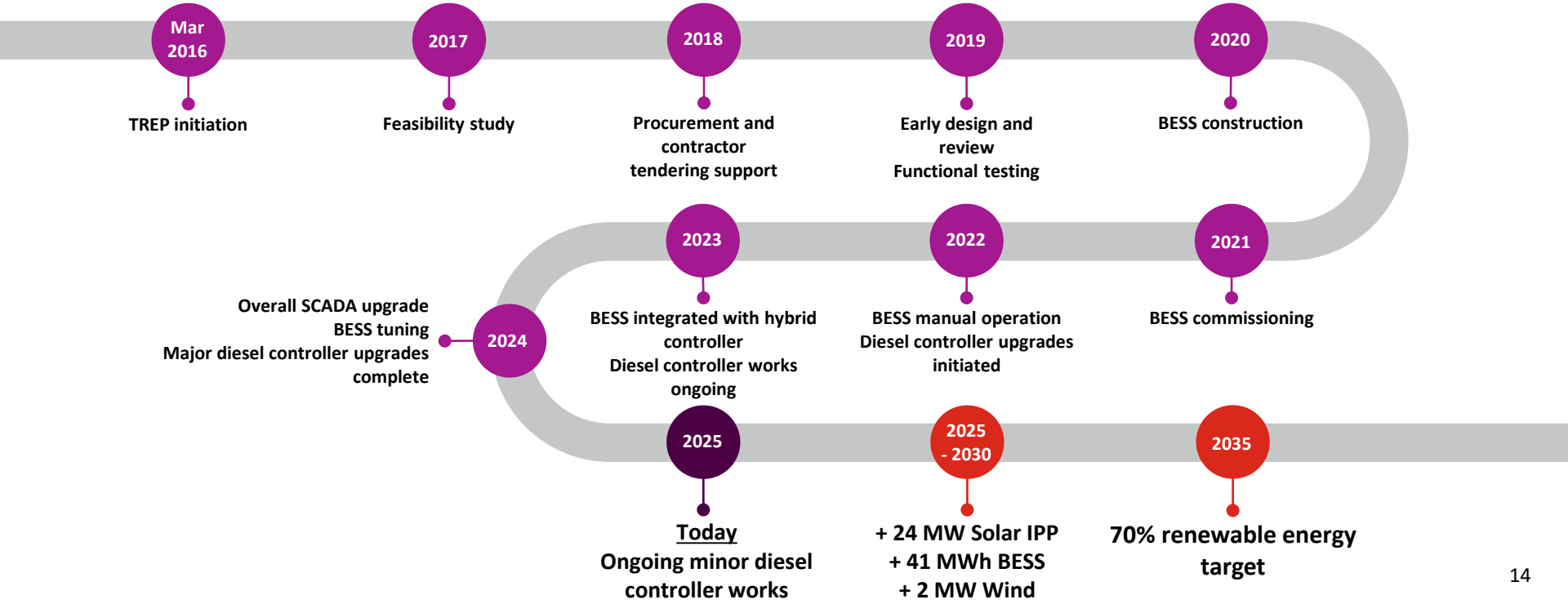
Beyond 2025: Ongoing works

1. Solar and wind generation sites need remote control functionality and SCADA upgrades.
2. Capacity building.
3. New physical communication fibre links.

Tonga Renewable Energy Project (TREP) timeline and Entura's engagement



New radio links providing backup to fibre communications network

TPL's continued rollout of smart meters

Key lessons from the Tonga Renewable Energy Project for the Pacific

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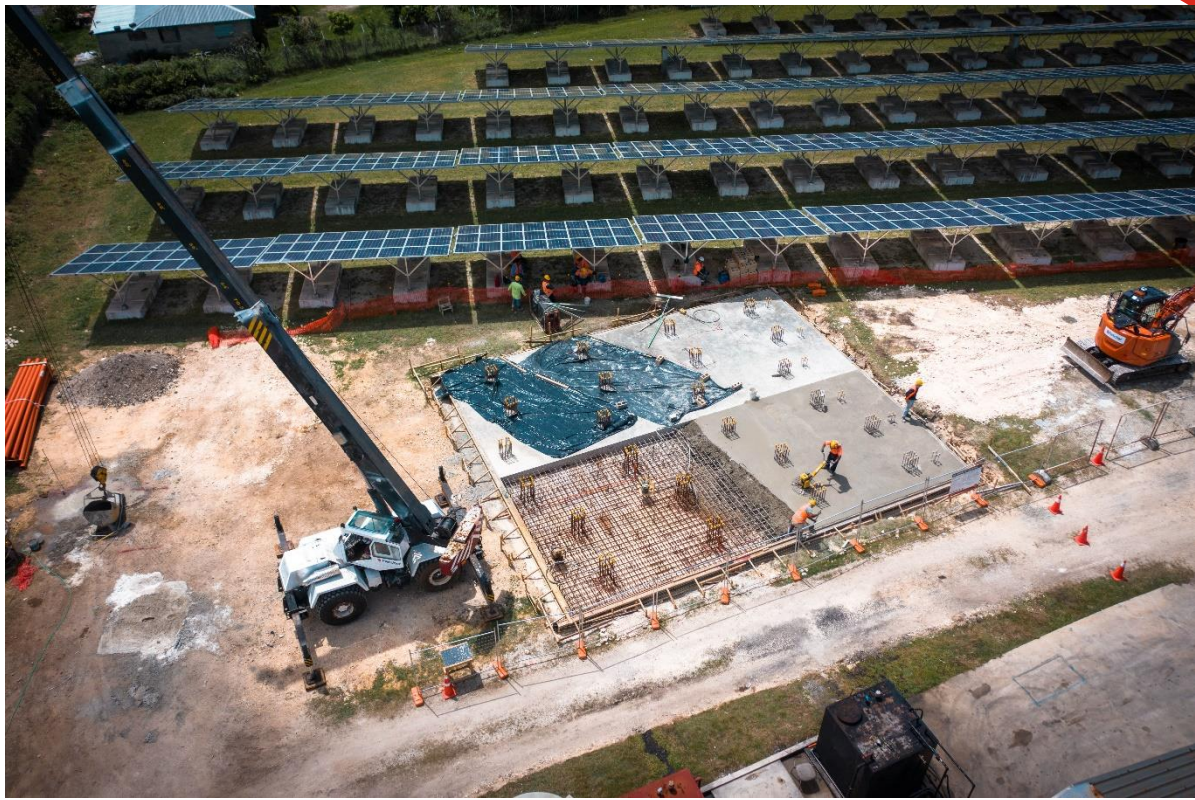
Lesson 1

Modernised SCADA and control systems are critical when renewable energy contribution approaches 30%.



Lesson 2

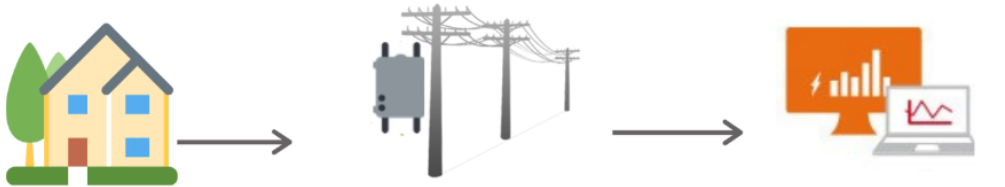
There’s an increasing need to install and establish a new SCADA and controls system prior to any new generation or storage.

Lesson 3

BESS offer reliability and security improvements - SCADA and controls are the backbone.

Lesson 4

Distributed smart metering = better visibility, reduced fault-finding time, outage minimisation, dynamic control through inverter reactive power injection.



Your smart meter measures and records electricity usage.

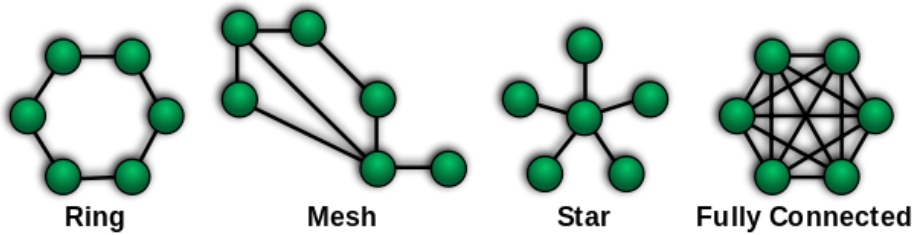
Smart Meter Data is transmitted through to our CGR transmittor which transmits usable data for TPL.

Tonga Power Limited make consumption data available to you via your electricity bill

Image Source: Smart Meter Project | Tonga Power Limited

Lesson 5

Different network design = different ways to enhance visibility and security.



Lesson 6

Advanced SCADA and smart metering may be able to be brought forward alongside incentives for consumer-led rooftop solar.

Lesson 7

Adequate SCADA more critical for remote resources like outer island systems.

Construction monitoring for TREP in Ha’apai outer islands (September 2024)

Entura at 32nd PPA Conference, Palau

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