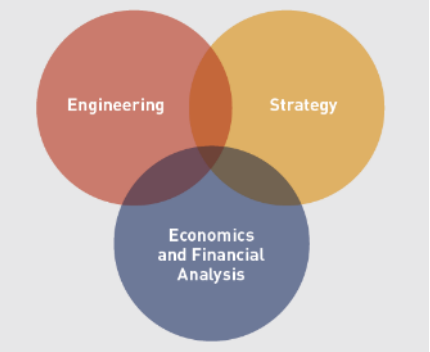
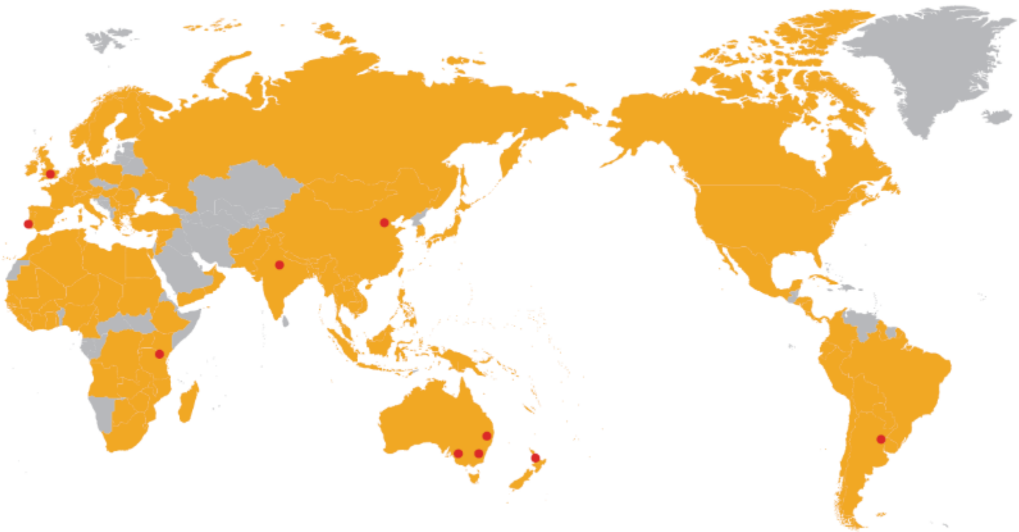
High Penetration Renewable Energy Access

Case study - Tuvalu

About ITP

- Specialist renewable energy consulting firm
- Over 35 years international experience and 1,500 projects
- Founded in the UK in 1981
- Major regional offices in UK, India, China and Australia
- Part of the ITPEnergised Group





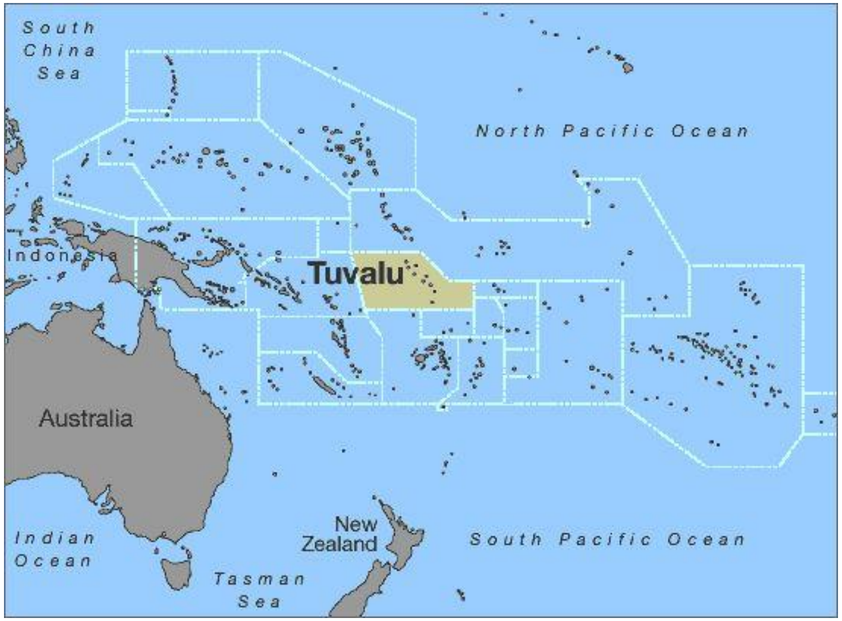
- Head office in Canberra, offices in SA, NSW and NZ
- Active in Australia and the Pacific region for over 10 years
- Involved in RE projects of all scales (1 kW to 50+ MW)
- Services
  - Engineering Consultancy
  - Project Engineering
  - Energy Markets and Advisory
  - International Aid and Development

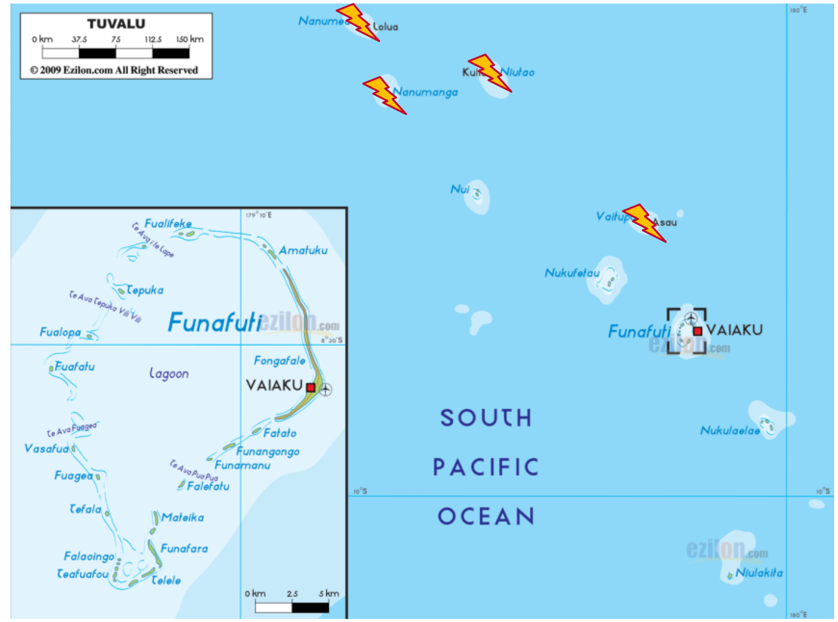
Mini-grid/Island Power System Planning

Context Island power:

- Vulnerability to severe weather events
- Energy access levels can be very low
- Energy security challenges (high price of fuel and supply chain)
- Renewable energy potential
- Solutions have to be locally appropriate

Case study – Tuvalu northern islands





- Total population approx. 10,000 (Outer Islands: 100 to 1,500)
- Outer islands only accessible by boat, typically 24hrs by boat to each island
- Irregular shipping (every 3-6 weeks), often disrupted

Case study – Tuvalu northern islands

- Existing low voltage AC electricity grids (diesel) since 2001
- Grids operated by electricity utility (Tuvalu Electricity Corporation)
- Local operators (TEC employees) deal with day to day running
- Technicians from the capital visit periodically or for repairs when required

Vulnerability to weather

Tuvalu northern islands- key issues

- Reliability
  - Only 12-18 hours of power per day normally (down to 2-4 hrs sometimes)
  - Frequent diesel shortages due to shipping unreliability
  - Generator breakdowns
  - Long delays for repairs (can take weeks to send a technician from Funafuti)

- Cost
  - Estimated ~$1.20 to $1.50/kWh cost of supplying energy (possibly more)
  - Vulnerable to diesel price changes
  - Vulnerable to utility cash flow issues
  - Tariffs ~25c/kWh – outer islands subsidised by main island and by government

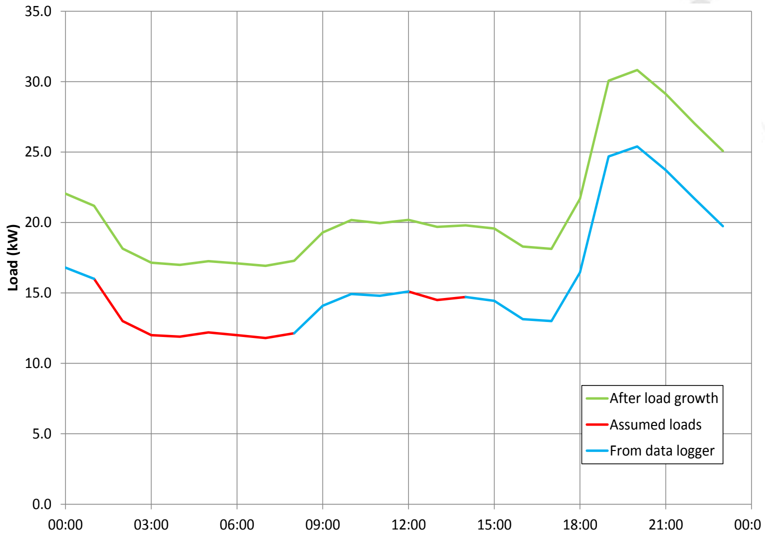
- Remote diesel grids were built as a service to the community, but are very expensive for the government

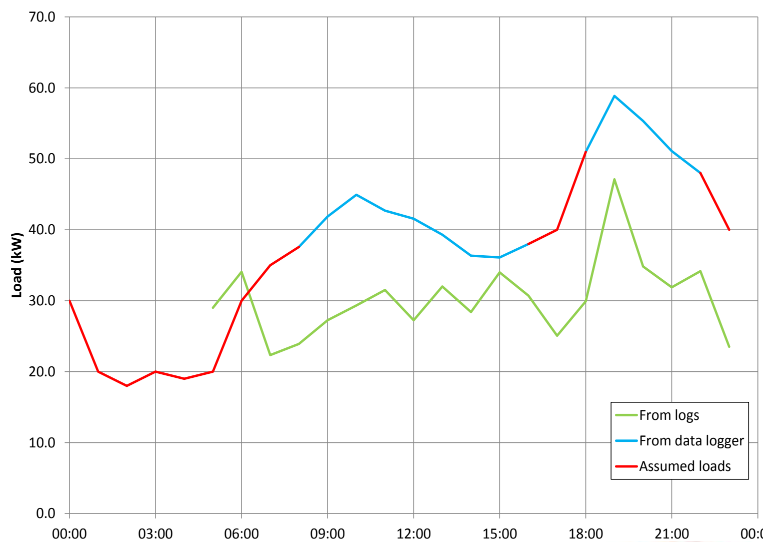
Aims of outer islands solar project

- Outer islands towards 100% renewable energy
- Energy Access: 24hr power
- System to last 20 years without need for major modification
- Reduce operating costs of outer islands power systems
- Improve power reliability (and availability during disasters)
- Eliminate need for aid fuel subsidies

Design

- Load curve – very important for design
- Inputs:
  - Data logging
  - Power station records
  - Try to estimate from diesel purchases
  - Appliance & equipment survey
- Estimation of missing data
- Load Growth (Historical and forecast)
- Usually a more reliable power supply leads to more people buying appliances

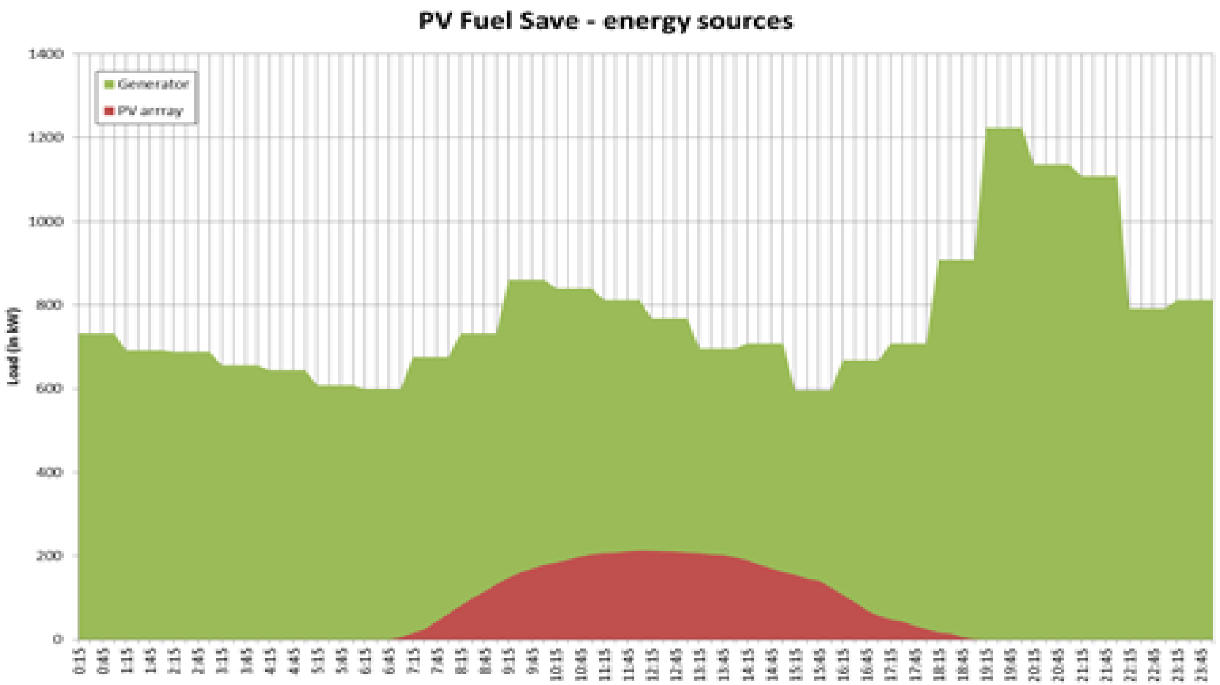




Integrating renewable energy

<u>Three broad diesel/PV hybrid design options:</u>

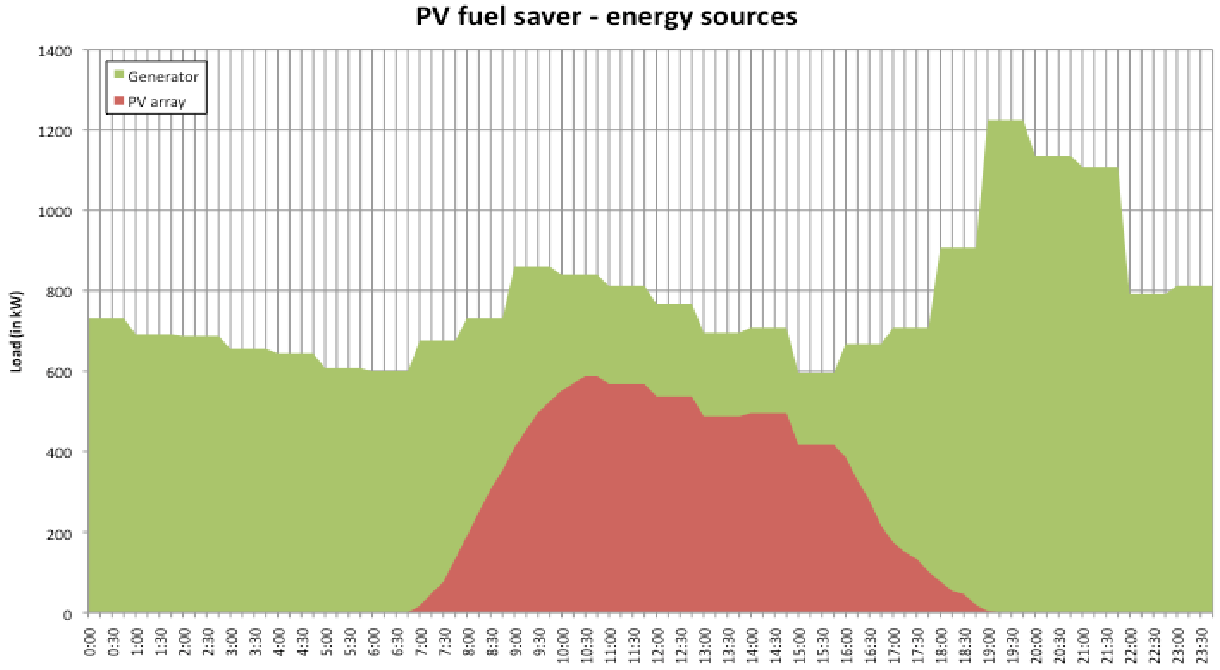
1. PV fuel-save (**no battery storage**, providing ~10-15% annual load contribution)



Integrating renewable energy

Three broad diesel/PV hybrid design options:

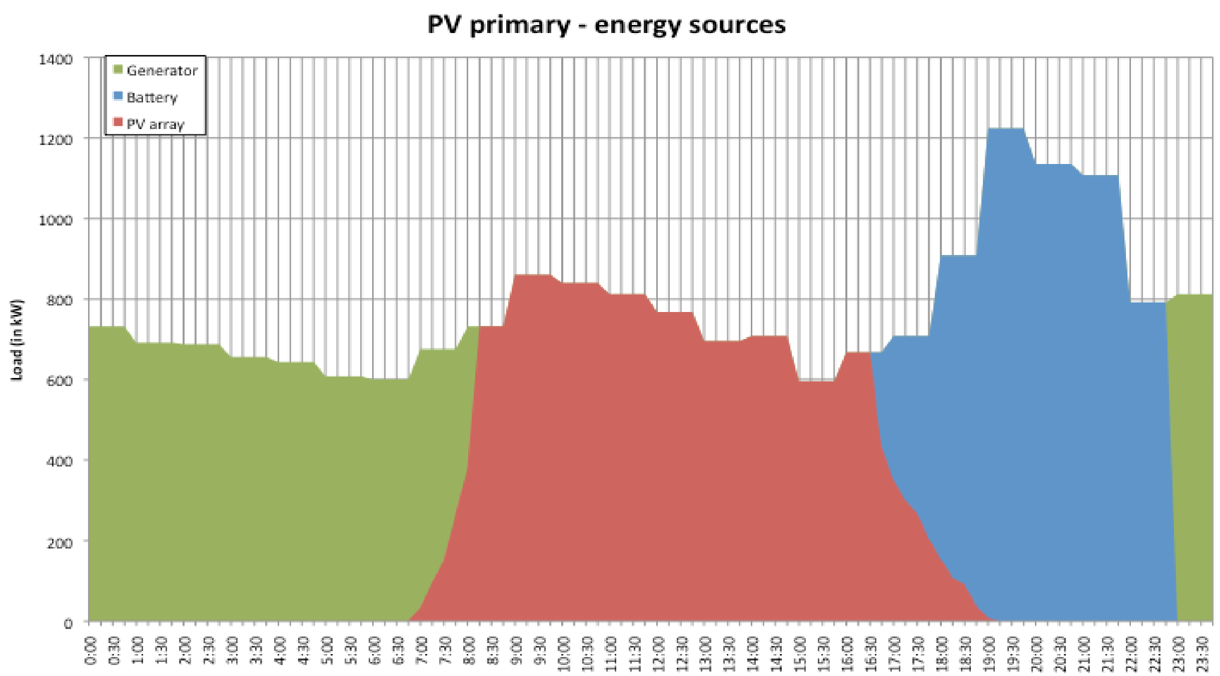
2. PV fuel-save plus (sometimes utilising a small amount of battery storage, providing up to 30% annual load contribution)



Integrating renewable energy

<u>Three broad diesel/PV hybrid design options:</u>

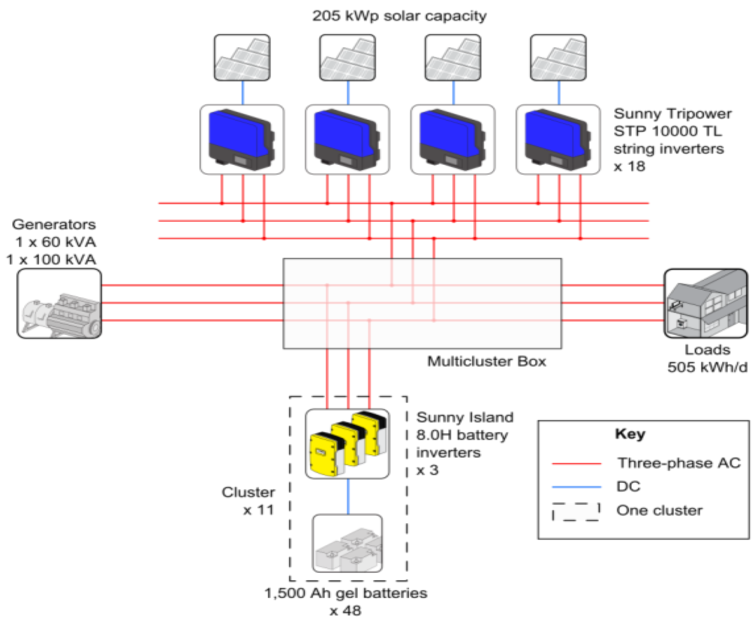
3. PV primary (utilising a large amount battery storage, providing >50% annual load contribution).



Transportation

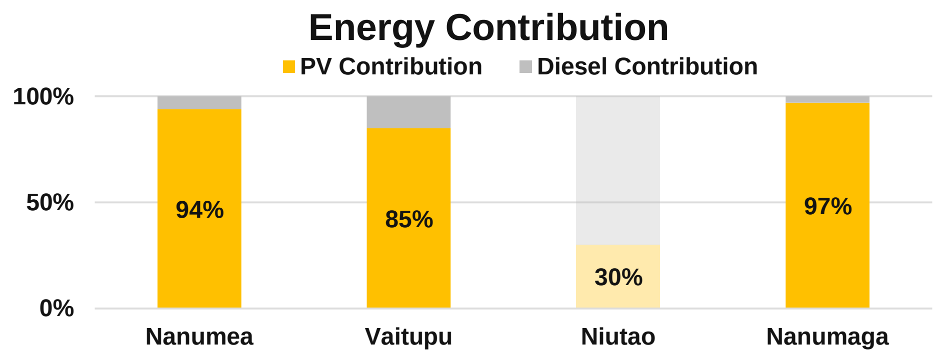
System sizing and Design overview

- 33,000 Ah battery bank (sealed lead acid batteries)
- 200 kW solar PV array
- SMA modular inverter/charger units
- Diesel generator to be switched off normally.



Completed system

Performance Results



- ¾ Systems very large for current loads
- Batteries drop to 80% SOC overnight, 100% by midday if sunny
- 5 days of cloudy weather without generator
- 1 inverter failure – local operator successfully replaced it and sent it back for warranty claim
- Effective cost of energy supply reduced to about \$0.55/kWh (from over \$1, though tariff ~ \$0.25/kWh)

Conclusion: Lessons for Planning

- Local operators involved Day 1 & preach understanding
- Complementary activities add significant value and critical for sustainability (billing/pre-payment, EE, AMPs, tariff settings)
- Community Engagement Critical: e.g social problems with 24hr power (e.g. loud music at night)
- Training throughout construction, troubleshooting & follow up – also risk if systems becoming too reliable (operators stop maintaining generators totally/ get lazy)
- Logistics can be very complicated (never underestimate!)
- Getting accurate data and information is difficult (e.g. powerhouse data, shipping schedules)
- Knowledge sharing on what works and what doesn’t.

Thankyou

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