A Brief History of Islanded Systems using Renewable Energy

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Abstract

A review of Islanded Systems using renewable energy located in Antarctica, Alaska, Australia and the Azores including methods used and lessons learnt.

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What are we talking about?

Ross Island, Antarctica.

This talk is about:

- Isolated grids which supply utility grade power in the 200kW to 20MW range.
- History and deployed systems.

It is not about the *Big Grid*, IEEE Islanded Systems, or small house hold systems.

"There had been certain difficulties during the expedition and afterwards, There was no use denying it, I had simply told the story from my own point of view, as honestly as I could." – Tenzing Norgay.

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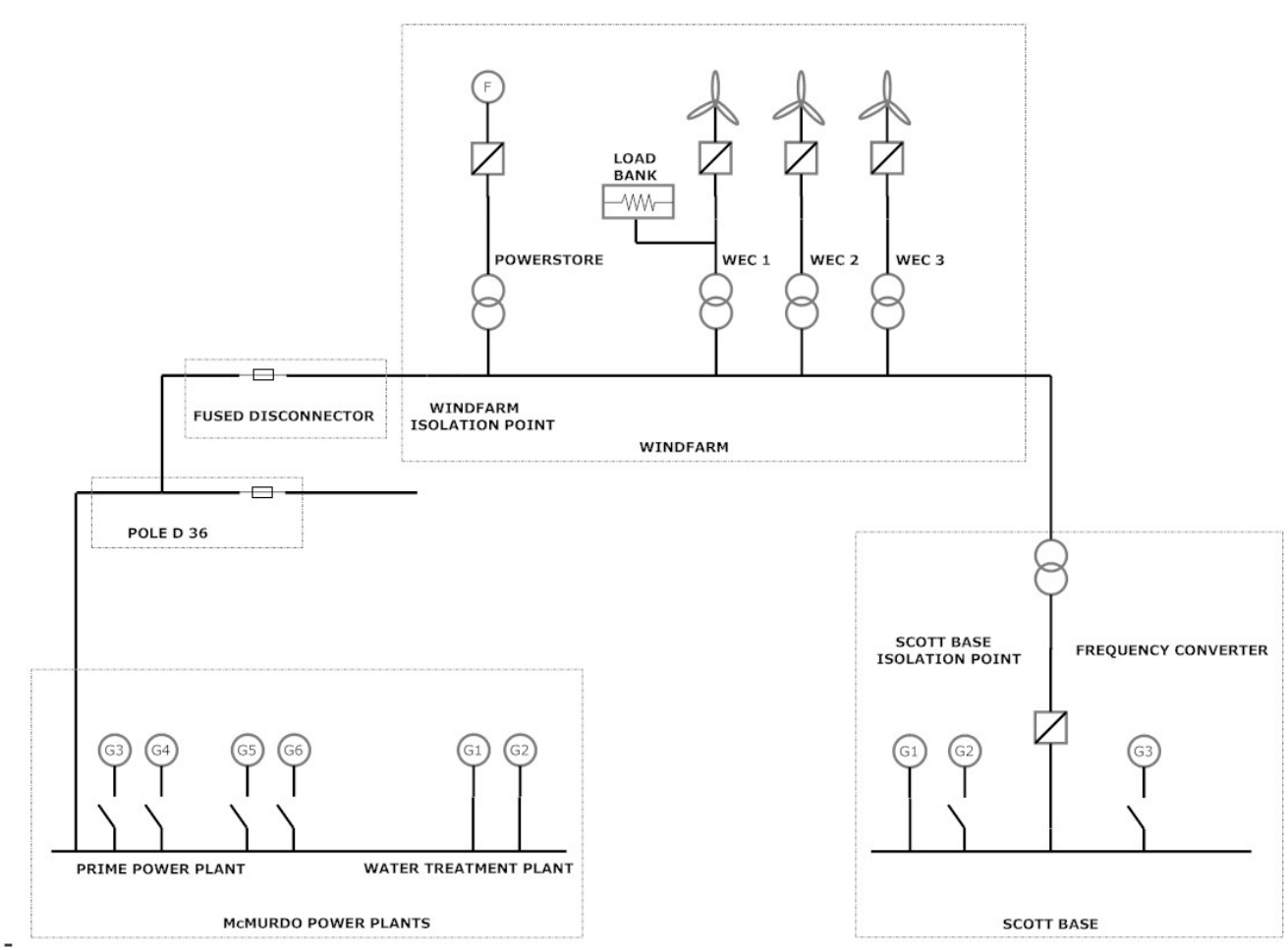
Example Ross Island Wind Energy



Ross Island Wind Energy System Components

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Where

Enercon E33 at Ross Island.

Antarctica: Mawson, Ross Island.
Australia: Bremer Bay, Cocos Island, Coral Bay, Denham, Esperance, Hopetoun, Rottnest Island, King Island, Thursday Island, Marble Bar, Nullagine
Atlantic: Flores, Graciosa, Bonaire, Cape Verde, St Helena, ..
Alaska: Kotzuebue, St Paul, Tin City, Savoonga, Nome, Hooper Bay.
Another place: Greece x 2, Norway x 2, Philipines, India, Kenya, Estonia, China, ...

See Wikipedia or Ackermann.

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1960's

WTG at South Pole

Early systems typically used small 0.1 to 10kW Wind Turbines to charge lead acid batteries and/or drive lights directly.

- Early lighting systems, e.g. on the Fram.
- Jacobs (US).
- Dunlite (AUS).
- Elektro (SWITZ).

A large number of systems were deployed, some which are still in use.

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1970's

Windmatic

- Windmatic, Bonus, Vestas (DEN) results in an 80kW modern tubular tower, 3 blade upwind design.
- Kenetech, etc (US) concentrate on high technology solutions.
- Interesting designs, e.g. MBB Monopterus.
- Explosion of EU machines in USA followed by collapse.
- Helgoland Island System with MAN and SMA.

Generally low penetration.

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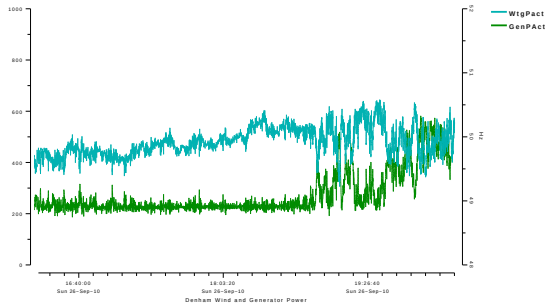
1980's

Mod 0 Wind Turbine.

- Cape Clear SMA and MAN.
- Ratlin Island.
- Outer Mongolia.
- Experimental Battery Systems, scaled up 12V systems using a mixture of droop and isochronous.
- Enercon Wind Energy Converters: E40 500kW.

1990's



Denham WTG and Gen Power.

- Denham (AUS): demonstration project using first 1, then 3 and 4 Enercon WTG reaching around 60% penetration. First attempt at Flywheel stabilisation of the grid.
- St Paul (US): using load dumps and synchronous compensators. Note that this system reaches 100% penetration.
- King Island (AUS): using a mixture of battery storage and load dumps.

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Now: Wind Diesel and PV Diesel Systems

WTG at Ross Island

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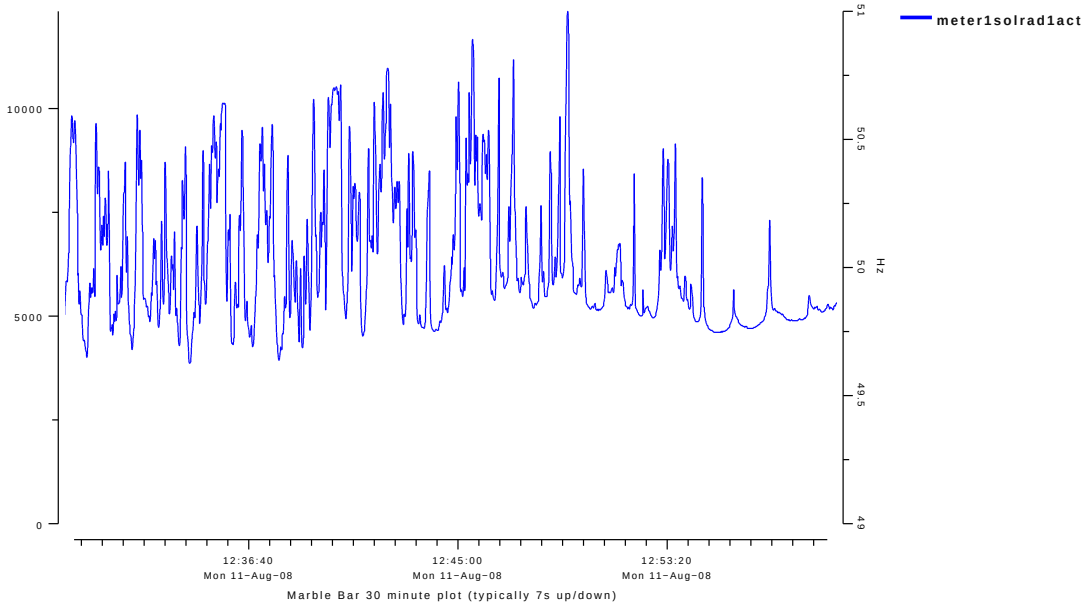
Variability

Renewable energy is highly variable, the rest of this talk deals with methods to manage that variability.



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Controlling Renewable Generation

Diesel and Wind Systems Low Load Diesel ™.

Control generation, e.g.

- Limit Penetration $\leq$ 20%.
- Limit the Renewables, e.g. Denham or Esperance in order to achieve 60% penetration. Note that Denham uses Inverter based WTG.
- Replace diesels with sets that can run at low load in order to achieved 93% penetration.

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Controlling the Load

Scott Base.

- Dump the excess power.
  - King Island
  - Bonaire.
- Use the excess power: e.g.
  - St Paul uses electrical heating.
  - Rottnest Island uses the desalination plant.
  - Mawson Stations uses the heat loop.
- Either switched, thyristor or inverter based control.

Storage

Small Vanadium Redox Battery.

Long Term:

- Batteries: King Island, Bonaire.
- Pumped Hydro: EU Grid.
- Hydrogen: Ramea, Froya.
- Compressed Air

Short Term:

- Flywheels: Marble Bar, Nullagine, Graciosa.
- Super capacitors.

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Stabilisation

Powerstore Flywheel at Coral Bay.

Bonaire, King Island, Mawson, Flores, Coral Bay, Rottnest Island, Kalbarrim St Paul.

Typically using a mix:

- High Speed Load Control.
- Flywheel Storage.
- Synchronous Compensators.

Note you need to consider both:

- Frequency (Hz) and Power (kW).
- Voltage (V) and Reactive Power (kvar).

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Alaska

St Paul, Wales:

- $\geq$ 100% Penetration using Synchronous Compensator to generate kvars.
- Load control using heat dumps.
- Typically not using inverter based wind turbines.

Ian Baring Gould at NREL has a number of papers summarising these systems.

King Island

King Island.

- Vanadium Redox Battery.
- Frequency Controlling Load Bank.
- Graphite Block Heat Storage.
- Both Wind and PV.
- 50% Average Penetration.

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Coral Bay

Vergnet WTG.

- 3 x Vergnet 225kW WTG which are induction machines!
- 4 x 320kW Low Load Diesels(tm).
- 18MWs at +/-500kW Powerstore which provides frequency and voltage stabilisation.

This results in 93% penetration.

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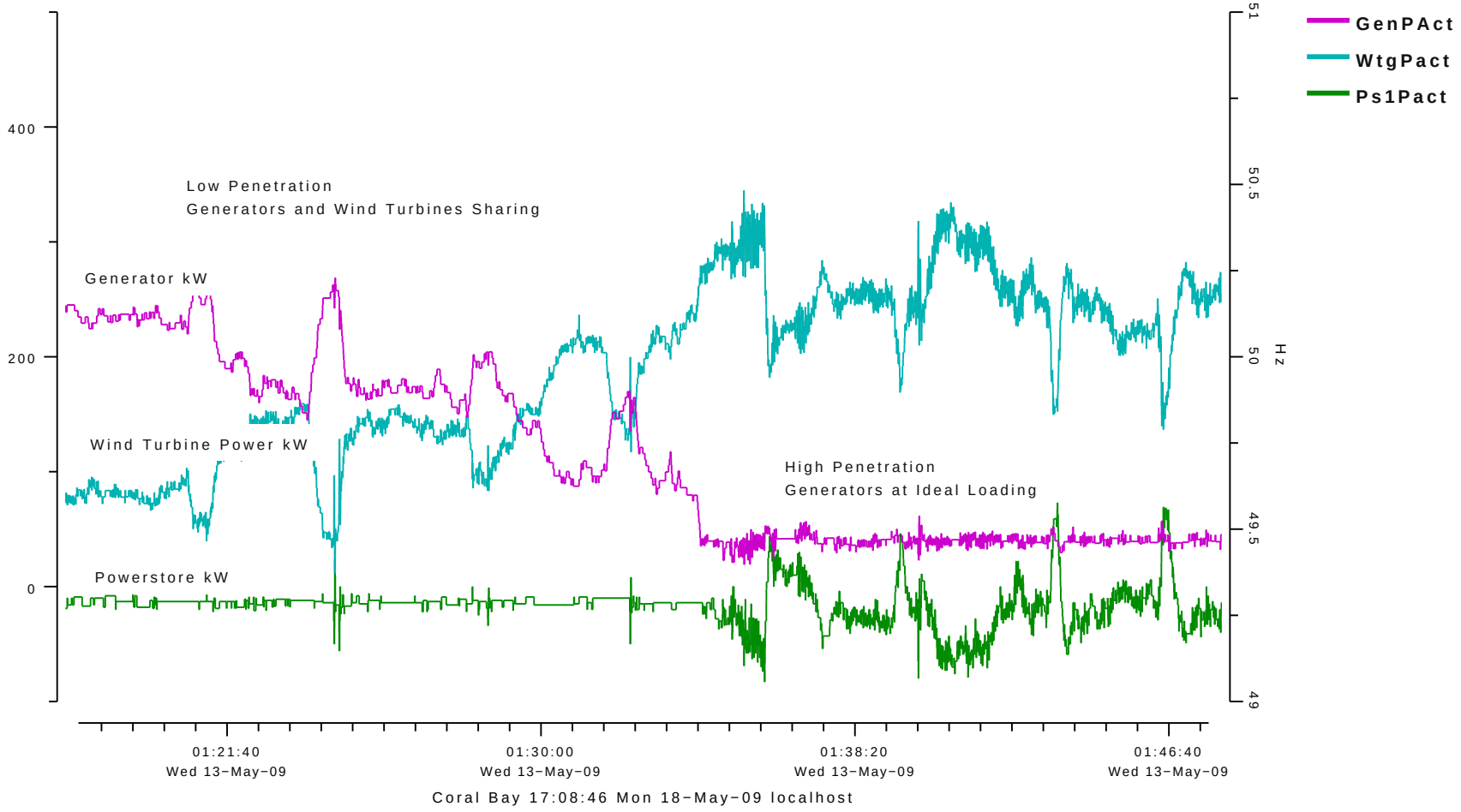
Coral Bay



Coral Bay Performance: 93% Penetration with Stabilisation

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Conclusion

- High Penetration Renewable Systems have been commercially demonstrated.
  This is not research anymore.
- One part of the Smart Grid is best demonstrated on remote systems now.
- The big grid can get to a high penetration of renewables using the methods described. (Can someone tell Radio National please).

"To know a thing well, know its limits.
Only when pushed beyond its tolerances will its true nature be seen" – The Amtal Rule.

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