USAP, AntNZ, Meridian Energy, Powercorp, RPSC, DOE-NSF Collaboration & The Ross Island Wind Project

Owen Roberts

2012 Polar Technology Conference

with thanks to Scott Bennett, Meridian Power; Ian Miller and Johno Leitch, AntNZ;, Dick Armstrong, RSA Engineering; Ian Baring-Gould, NREL,

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC

Project Description

Strategy & Approach

Actively support the testing and deployment of energy efficiency, renewable energy and efficiency building designs into NSF facilities through coordinated technical assistance and demonstration projects.

Facilities at McMurdo range from the modern to amazingly old, with a huge range of need

Scope

- Support EE assessments, EERE data gathering and evaluation at NSF facilities
- Testing/demonstration of RE technologies at NSF facilities
- Technical support in the development of efficient building designs for new and older facilities at NSF sites
- Design and technical support on power systems and facilities
- Investigation of electric vehicles for transport and eventually grid stability
- Provide independent third party technical review and commissioning services in technology area where NSF has no intrinsic experience

Drivers for Ross Island Project

- The concept had been demonstrated
- Fuel Price Uncertainty – the cost of diesel taking a bigger chunk out of the AntNZ and NSF program budgets.
- Political drivers - All US government agencies have to produce some energy with renewable technology.
- Good for the environment and important for the Antarctic Treaty – Emissions reduced 1,243 t/CO_2 per yr.
- Energy Security – Project displaces 11% fuel used for generation at both stations improving diesel storage time.
- Demonstrates Environmental Sustainability/Leadership in accordance with Antarctic Treaty.

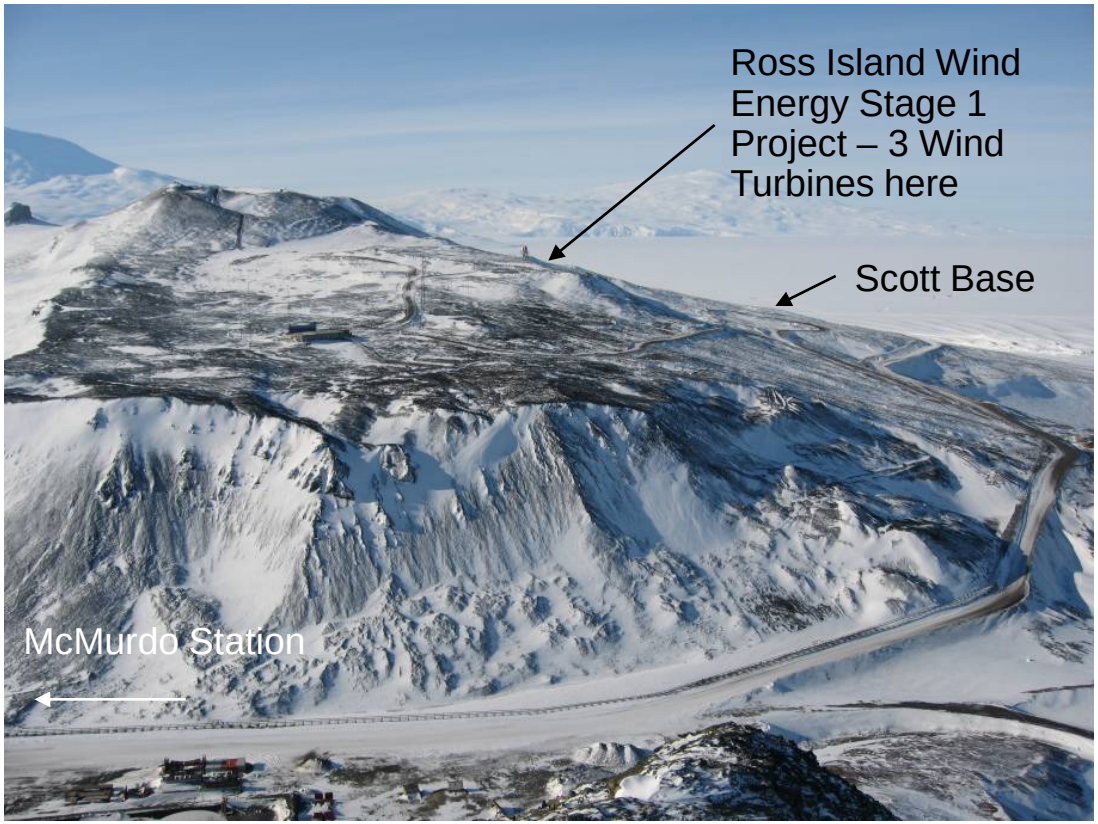
Leave no trace – but right now we leave about 10,000 tons of it each year

Wind Project Evolution

- **2000 – 2005:** initial investigations of large wind applications at McMurdo station conducted by NREL and others.
- **2003:** Australia Antarctic puts in wind at Mawson Station
- **Early 2005:** UofC Scott Base energy review leads to Meridian wind energy potential discussion with AntNZ.
- **Feb 2005:** Meridian staff carry out assessment of wind farm sites & erect monitoring mast on Crater Hill.
- **June 2006:** 1+yrs of wind data analyzed and feasibility study conducted. Discussions held with NSF investigating wind energy at McMurdo Station.
- **Aug 2007:** Design proposal presented to AntNZ/NSF outlining technical/commercial concept for wind to supply both Scott Base and McMurdo Station.
- **2008-2010:** “Proof of Concept” project to be built using NSF/USAP and AntNZ support compact and existing alliance between Meridian and AntNZ.

The Site – Crater Hill

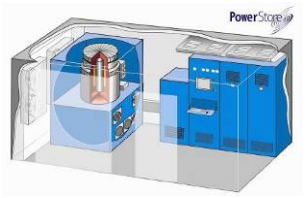
- Nearly halfway between both bases.
- Ice-free volcanic scoria with permafrost at depth 20-45cm.
- Good wind – average wind speed 7.9m/s (17.6 mile/hr or 15.3 knots), gust of 147.62 mile/hr.



- Minimum environmental issues as site already extensively altered.
- Existing road infrastructure.
- Good power interconnection options.

RIWF - Stage 1 Project Scheme

- Medium to High Penetration Wind-Diesel System
- Covers 22% of annual average electrical energy for combined station
- Electrically interconnect McMurdo and Scott Base



T1 T2 T3

CRATER HILL

PowerStore
(Flywheel system)

60Hz

Frequency
Converter

Fused
Disconnector
DS2706

A C E

60Hz B/D

Pole D36

50Hz

1 2 3 4 5 6

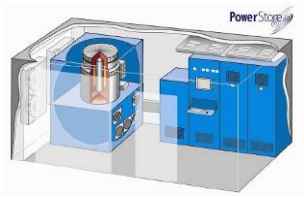
McMURDO STATION

1 2 3

SCOTT BASE

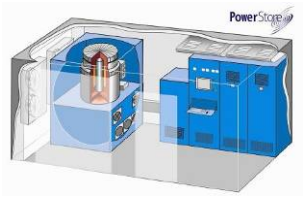
McMurdo Station Power Plant

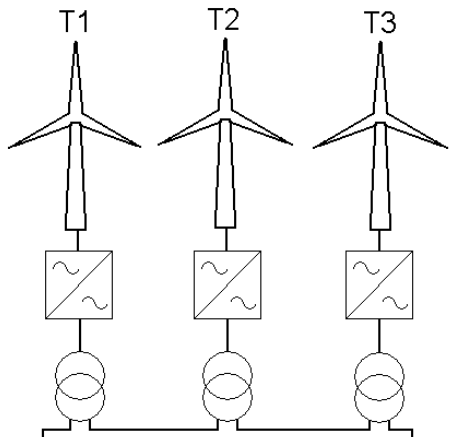
- Upgrade plant controls & monitoring
- As appropriate provide power to Scott Base when wind turbines are not producing enough power



Scott Base Power Plant

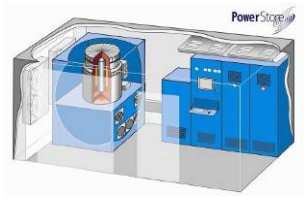
- Upgrade controls and monitoring
- Integrate frequency converter
- Expected to primarily receive power from the wind turbines or McMurdo diesel plant





Wind Turbines on Crater Hill

- 3 x 330 kW: Enercon GmbH, (Germany) turbines
- Wind turbines act as a negative load on the diesel grid, supplying power to Scott Base and McMurdo Station



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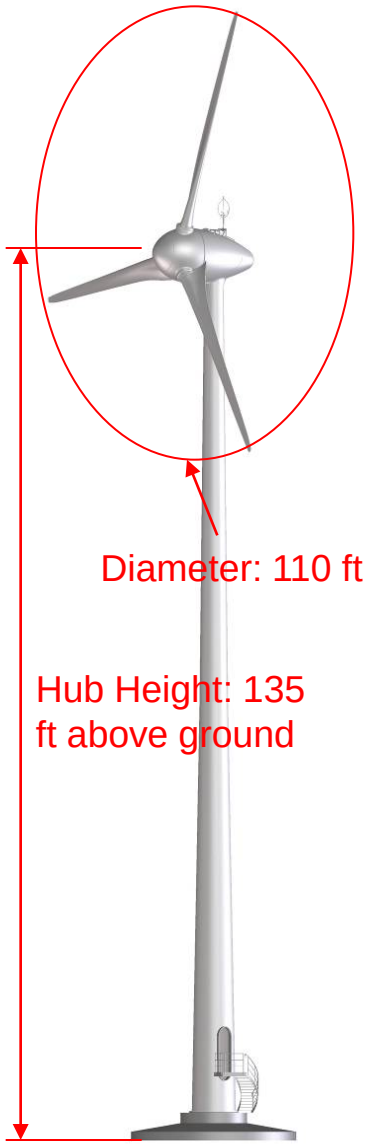
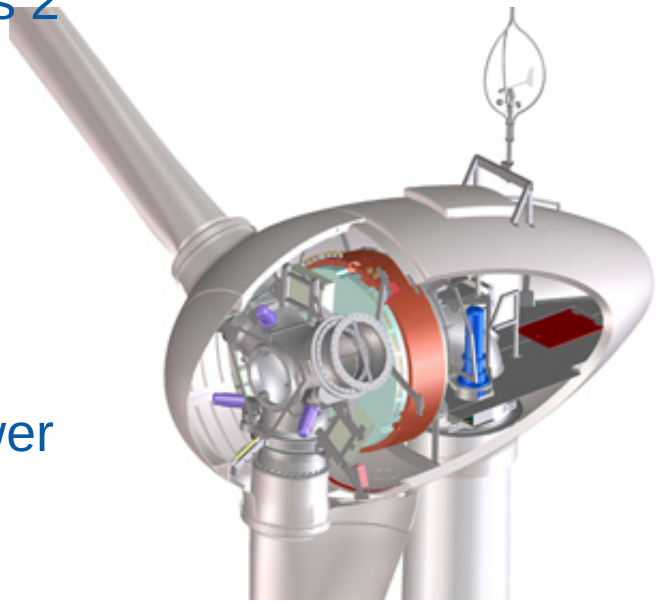
SCOTT BASE

Enercon E-33 Turbines



330 kW, variable speed, three bladed upwind turbine

- Direct drive generator eliminates gearbox & oil issues.
- Active Pitch gives high degree of turbine control
- Power electronic energy conversion highly flexible
- Control systems designed for wind diesel integration.
- Components fit into 40ft Containers – except blades.
- Proven in Antarctic Service, AAD Mawson Station has 2 x E-30s in service for 5 years.
- Major maintenance done once annually.
- 3.5 m/s (~7mph) cut in
- ~11 m/s (22mph) full power
- -40C min operating temp

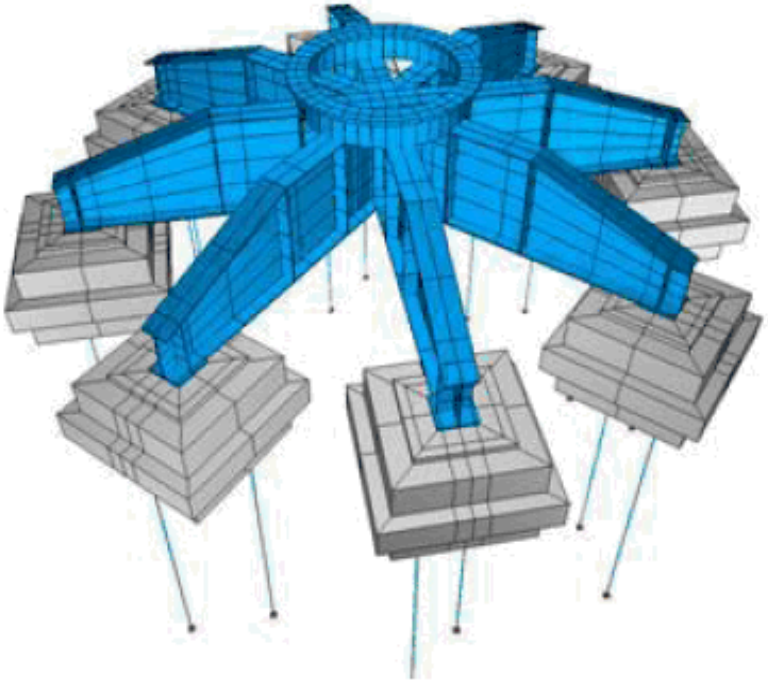


Turbine Foundations – Engineering Innovation - New use of old Design

Concrete gravity pads *not possible* due to temps, no batching plant, aggregate or fresh water.

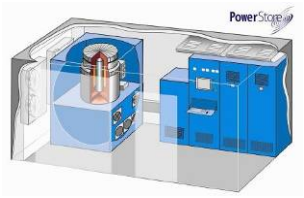
Solution is to pre-fabricate a transportable anchored structural steel foundation.

Designed and built in Christchurch, NZ.



Scott Base Frequency Converter

- Allows the interconnection of the two bases by converting the 60 Hz (U.S.) frequency to 50 Hz used in New Zealand.



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McMURDO STATION

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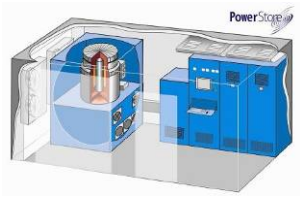
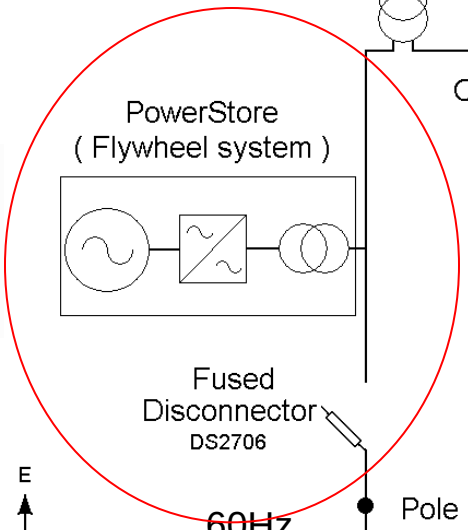
SCOTT BASE

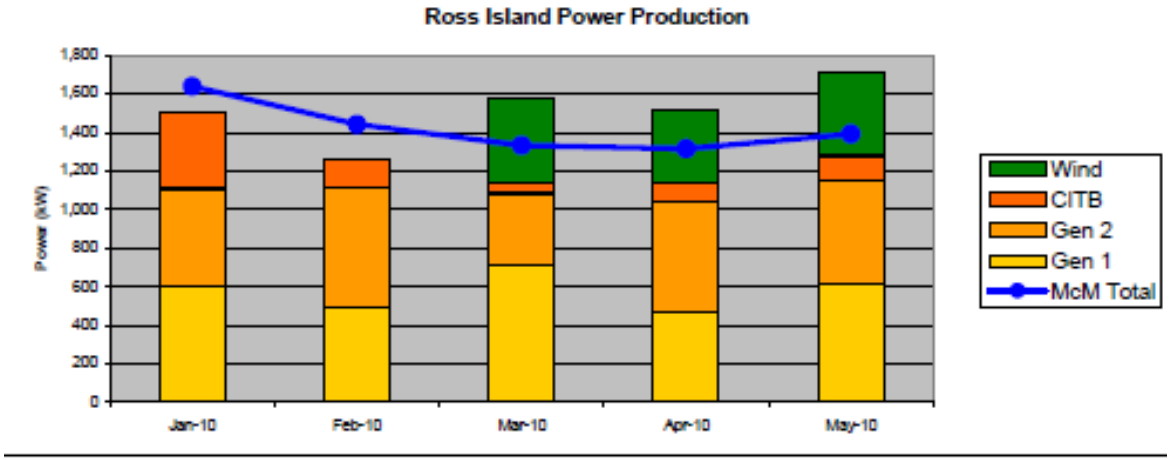
PowerStore Flywheel

- Provides grid stability (Frequency and Voltage)
- Helps the diesel plant in the event of the wind turbines disconnecting due to high wind speeds



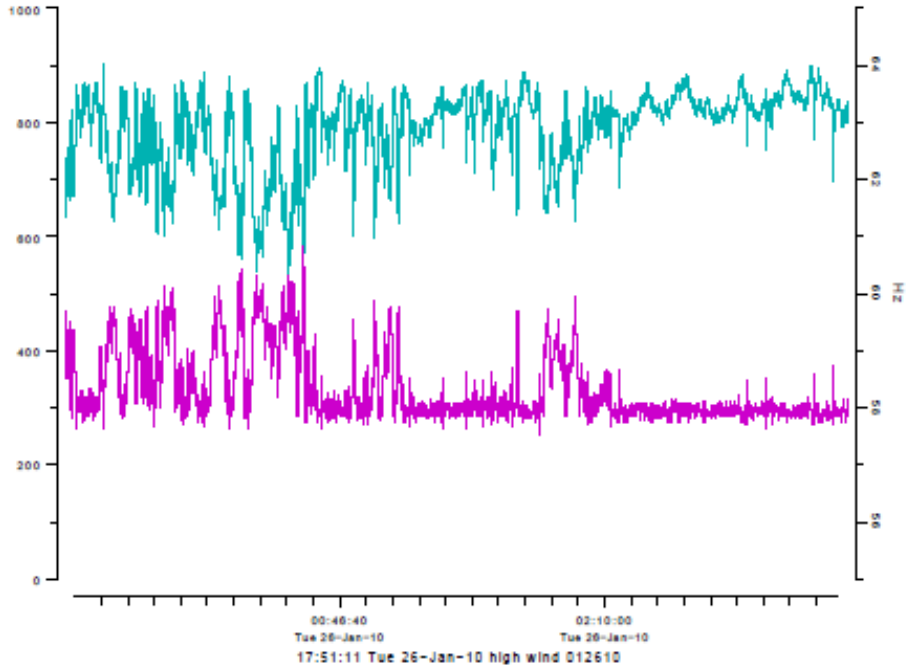


Operation … it does



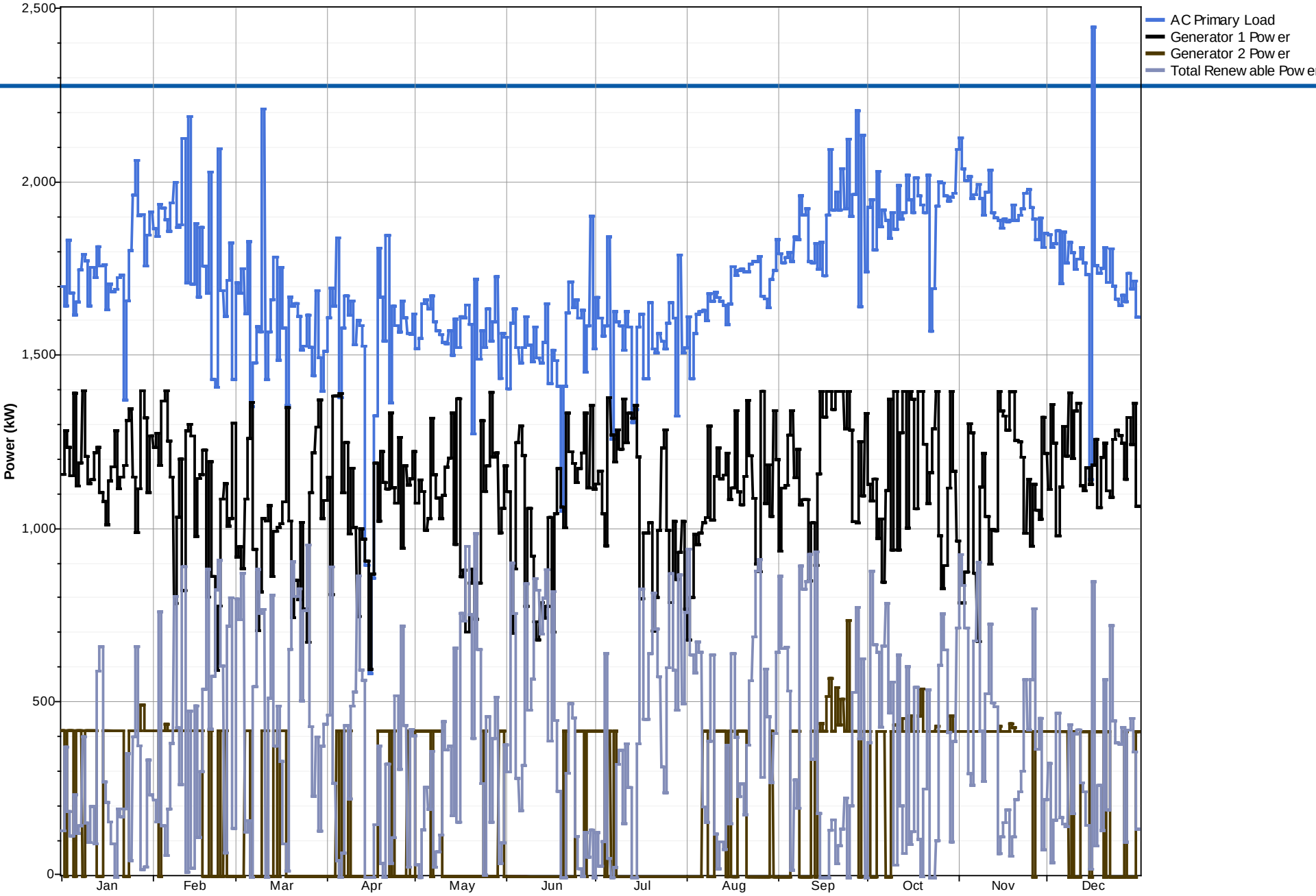
Screen capture from the McMurdo power house over two days –showing wind (green) producing ~ 50% of the electrical energy needs of Ross Island

Not only can you see it from anywhere in McMurdo and or at Scott Base – it actually works and is reducing fuel consumption with winter hourly average penetrations into the 70's regularly (wind data only collected from March 2010)



Issues reported to date:

- Pitch motors causing shutdown at -35'C
- Oversight computer issues (does not impact operation)


AC Primary Load
Generator 1 Power
Generator 2 Power
Total Renewable Power
Power (kW)
2,500
2,000
1,500
1,000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Fuel Savings and Turbine Performance

- ~15 MkWh/yr Total McMurdo Electrical Load

- ~37-40% capacity factor for Wind Turbines ~3.5 MkWh/yr
- 6.8 MkWh total electrical production Jan ‘10-Feb ’12
- Average ~95% availability, some months ~25% (ice, cold)

- Offsets ~270,000 gal/yr NOT including offset waste heat
  - Summer still venting waste heat to atmosphere, need to expand waste heat loop
  - Winter utilizes all waste heat, gen electrical efficiency decreases, waste heat per unit fuel increases but system not optimized for matching flow rates
  - New data of mass flow and delta T measurements in/out gens and buildings

Additional Savings and Issues

- Single gen operation 25.6% in 2011, saved ~4000 operating hours on gens if no wind contribution
- Average loading on gens ~53% annual average (reduced efficiency), need load reduction, peaking smaller generator, or more deferrable loads (temporal limitations)

RIWE System Performance, Single Diesel Explanation (next slide)

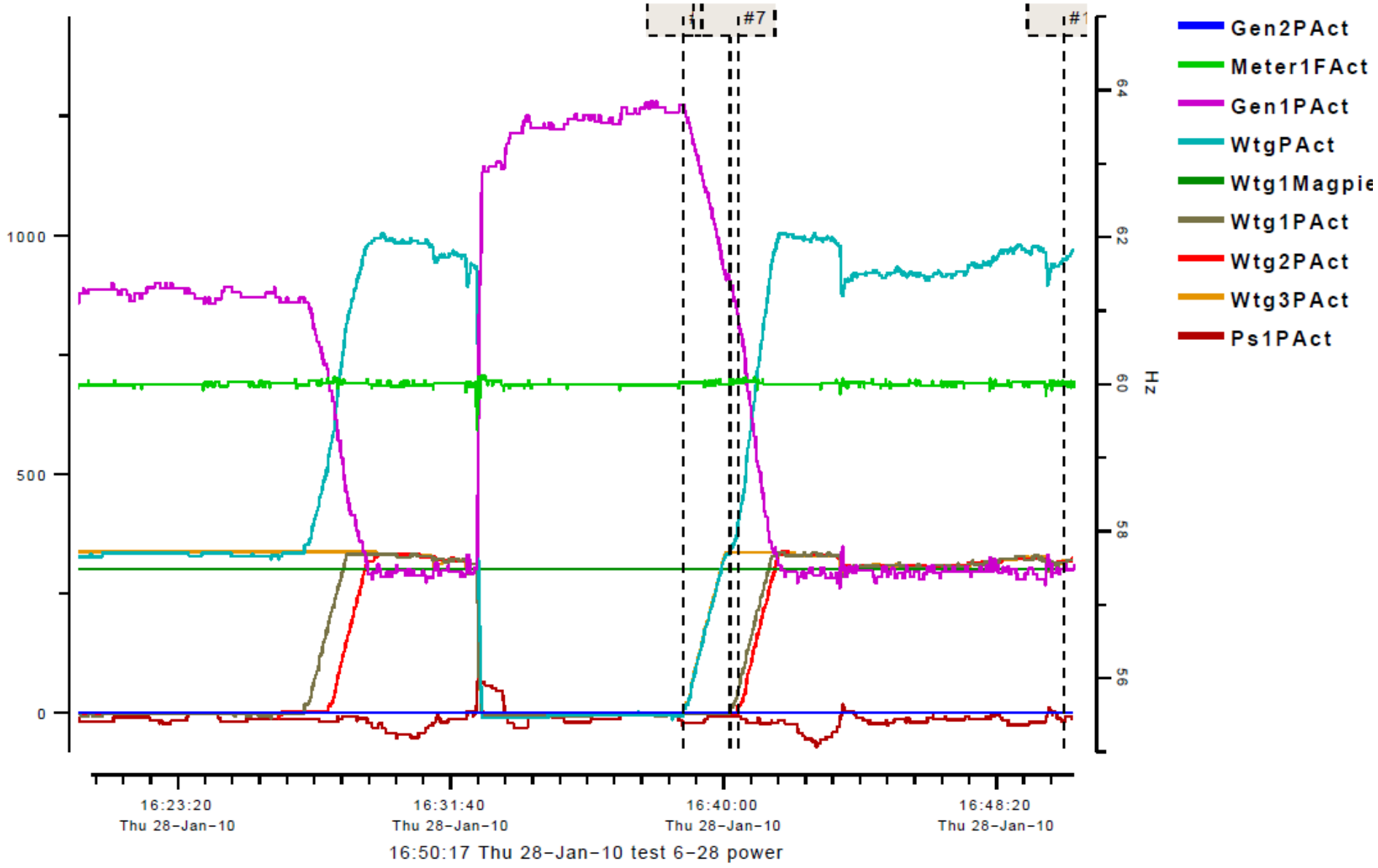
Three turbine trip and restart

Turbine3 starts the test operating then the next two turbines start, with one generator operating.

At 16:32 all three turbines are tripped off in less than two seconds. The powerstore comes on line (Brown) and the diesel (pink) chugs up. After about 10 minutes the three turbines are then restarted (put in auto mode and they start up) and the system goes back to full operation with the wind covering 2/3 of the load.

Note: Frequency +- <0.5HZ

RIWE System Performance, Single Diesel



RIWE System Performance, Dual Diesel Explanation (next slide)

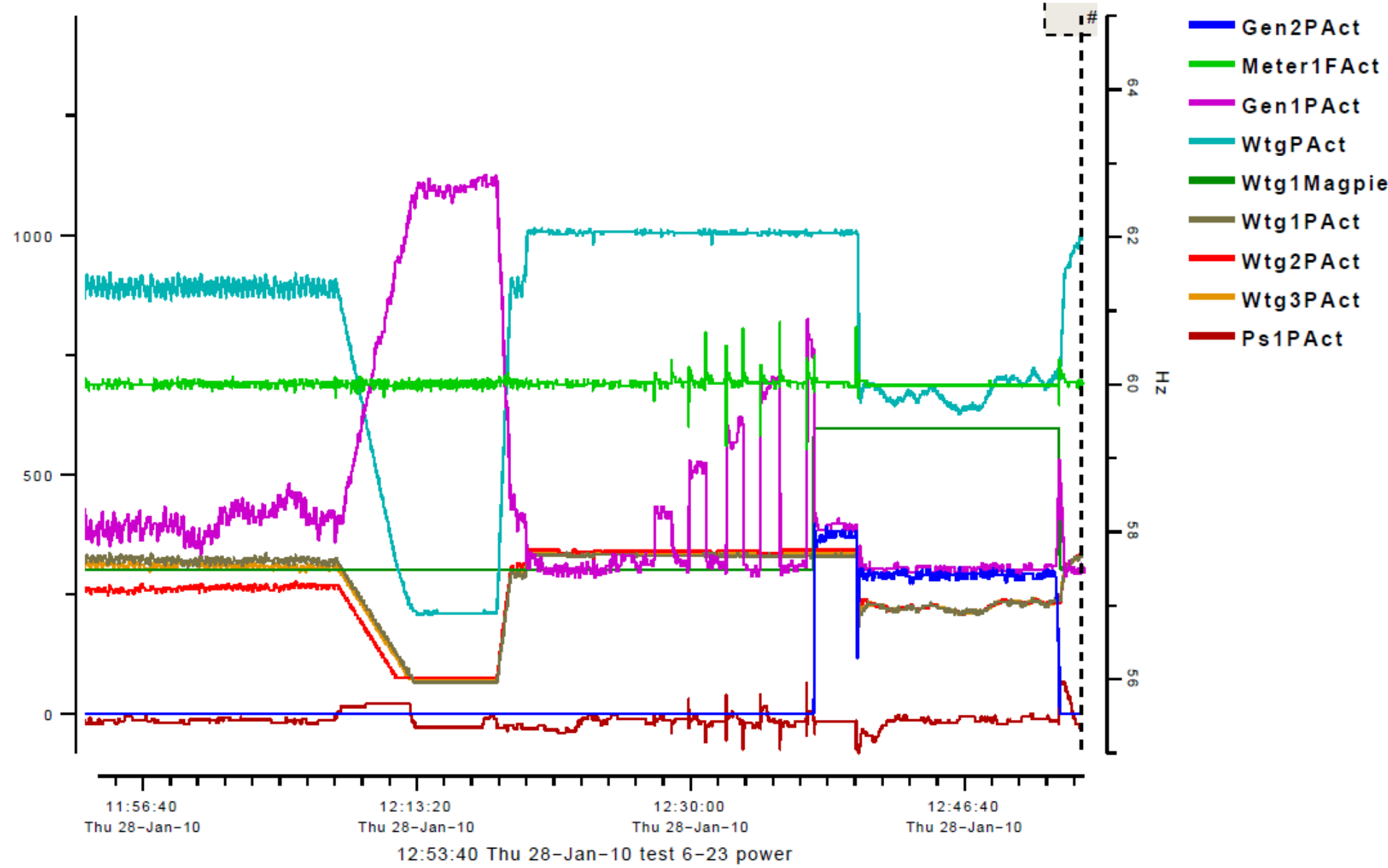
High wind with one diesel operating – wind covering 2/3 of the load about.

Wind turbines are told to ramp down, single diesel picks it up. At 12:20 wind turbines released and peg at full power (1000 kW) with the diesels down at ~350 kW.

Add load in steps starting at about 12:28 getting up to 500 kW at which point the system pulls on another diesel (dsl2) and they load share. We then drop the 500 kW load and the diesels drop to their minimum load threshold of 300kW and the turbines spill energy to maintain the diesels at minimum loading. At the very end of the test ds2 goes off line after reaching its minimum run time and the wind turbine again go up to full power.

Note: Frequency+-1 Hz

RIWE System Performance, Dual Diesel



End Result – a Project to be Proud of

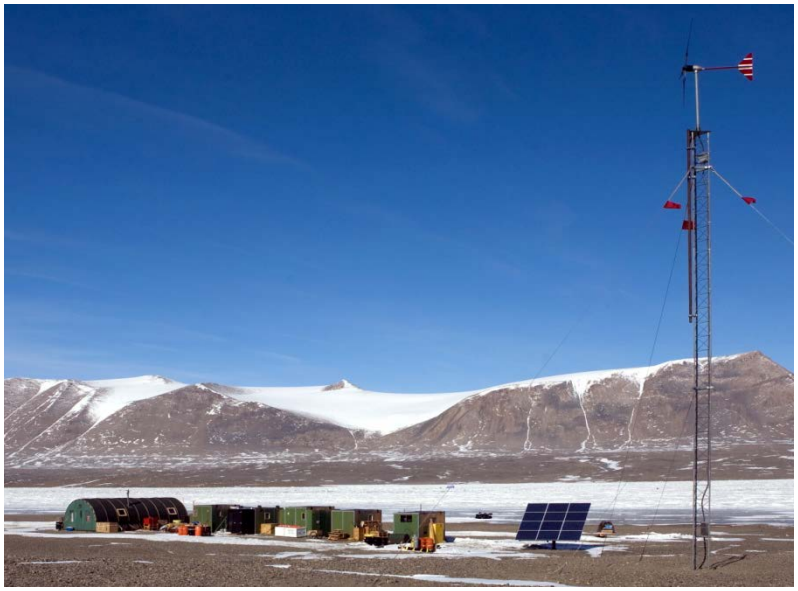
Represents the most southern wind farm in the world and the largest demonstration of renewable technologies in Antarctica.

- it will allow Antarctic science to proceed with a greatly reduced carbon footprint using wind energy.
- it will demonstrate New Zealand & U.S. leadership in following the principles of the Antarctic Treaty.
- a project that demonstrates & expands the ties between USAP & ANZ

Next Steps

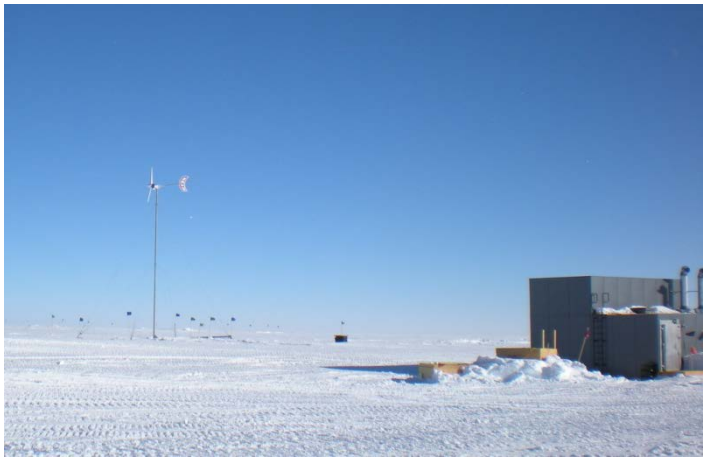
- Phase II possible, currently studying locations, number of turbines, spinning reserve requirements

Other renewable projects



Lake Fryxell Renewable Power System – Brian C. and Tony B.

Just one of many RE projects…



Summer Camp PV & turbine testing – Laura R. and Joe C.

Black Island System Redevelopment – Tony M. & David H.

National Renewable Energy Laboratory
Innovation for Our Energy Future

Carpe Ventum

Joseph “Owen” Roberts

303-384-7151

joseph.roberts@nrel.gov

National Wind Technology Center

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