EDGING TOWARD SUSTAINABILITY

Hybrid wind-diesel and wind-pumped-hydro-storage electricity systems for Stewart Island

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ACKNOWLEDGEMENTS

- Erik Barnes (SDC); Robin McNeill (Venture Southland); Chris Dillon (SIESA)
- Energy Engineering 2, class of 2012, Department of Civil and Natural Resources Engineering, University of Canterbury.

BACKGROUND

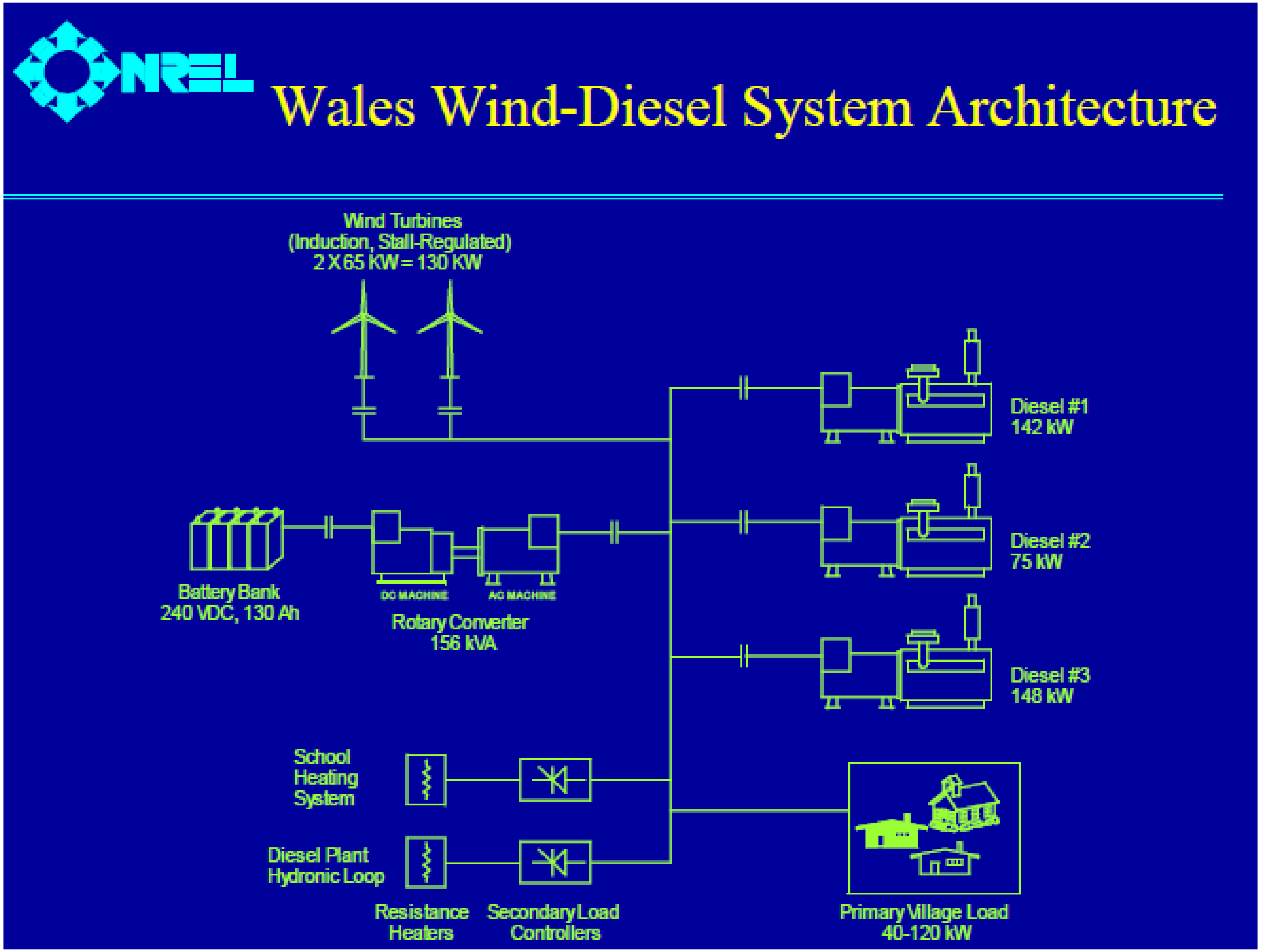
- Electricity supply from diesel generators
- Approximately 1,400,000 kWh per annum
- High cost: nearly 60c/kWh
- Environmental concerns; energy security
- Prior reports + Symposium February, 2012
- No detailed modelling

THIS STUDY

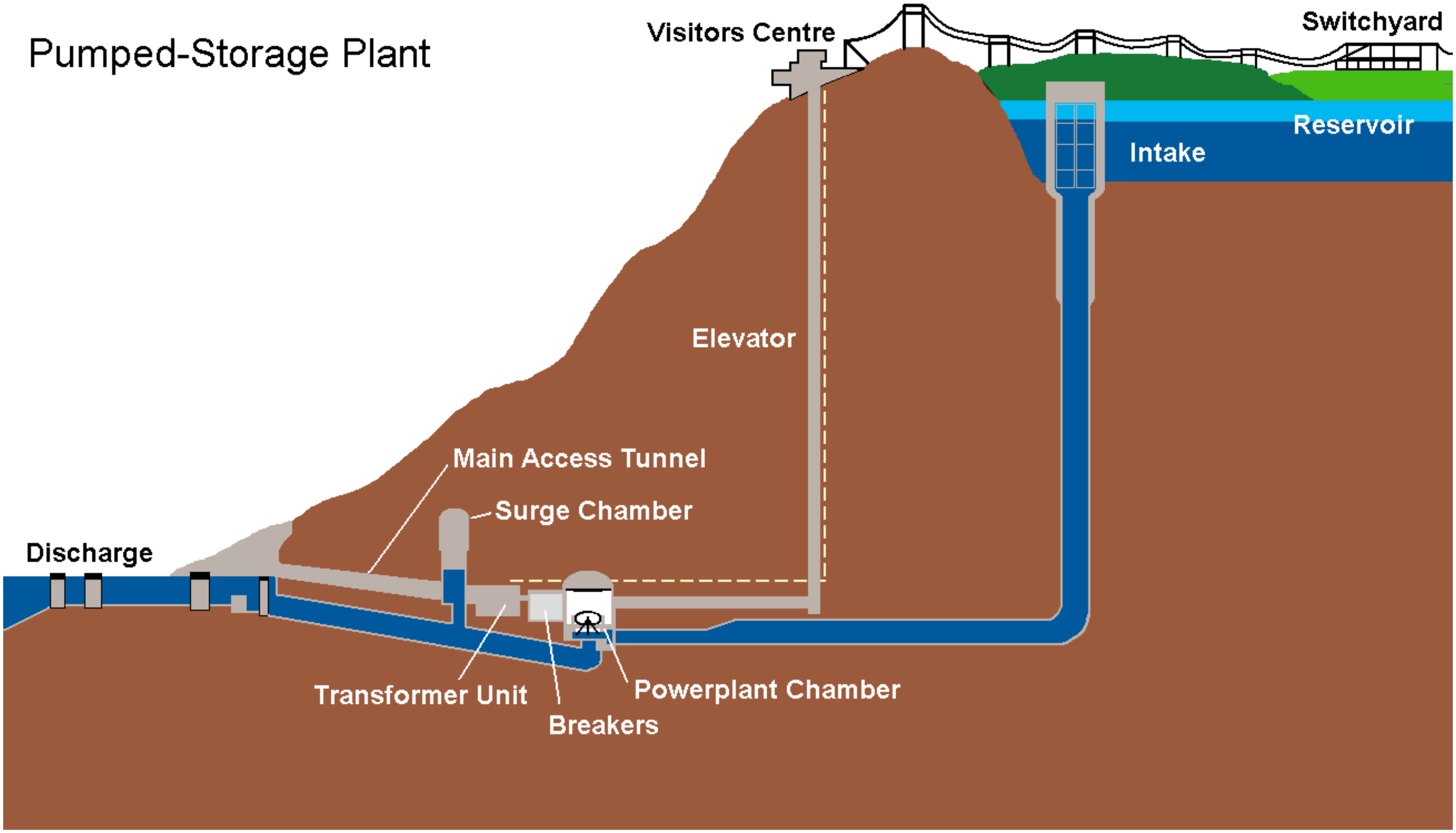
- Aim: to model a wind-diesel hybrid system and a wind-pumped-hydro-storage (PHES) system on a half-hourly basis
- Outputs include: a) wind turbine size; b) reduction in diesel usage, GHG emissions, costs; c) size of PHES system

WIND-DIESEL HYBRID SYSTEM

Source: Drouilhet



PUMPED HYDRO



Pumped hydro storage using seawater in Okinawa

SOURCE: GOOGLE EARTH

DATA

- Demand data for 2011 obtained from SIESA (thanks Chris); kWh per half-hour
- Some rather large gaps – these were filled in using data from similar periods; slight over-estimate compared to reported sales
- Wind data for 2011obtained for Tiwai Point from NIWA (no usable data for SI); hourly average windspeed at 10 m elevation

WIND-DIESEL HYBRID

- Selected a Windflow 500 turbine; why?
- Calculated windspeeds and energy output for each half-hour of 2011;
- Calculated surplus and deficit energy for each half hour of 2011;
- Diesel used to supply the deficits; fuel usage, costs, emissions calculated

RESULTS: WIND-DIESEL

- Generate 100% demand: 1,580,972 kWh
- Wind turbines required: 1.5 (750 kW)
- Fuel savings: 38%; $195,980 p.a.
- Surplus energy: 984,954 kWh
- Generate 50% demand…
- Wind turbines required: 0.75 (375 kW)
- Fuel savings: 32%; $162,890 p.a.
- Surplus energy: 293,360 kWh

WIND-PHES

- All the surpluses used to pump water to a reservoir; head 100 m;
- All deficits met by running the stored water through a hydro generator

RESULTS: WIND-PHES

- Generate 100% demand: 1,580,972 kWh
- Wind turbines required: 1.7 (850 kW)
- Fuel savings: 100%; $515,305 p.a.
- Size of hydro generator: 300 kW
- Reservoir volume: 636,460 m3
- Reservoir dimensions: 6.4 ha; 10 m depth
- Surplus energy: 8513 kWh (stored water)
- Now let’s look at the model…

PRACTICAL DESIGNS

- Using a range of commercially available turbines
- Student results…

RANGE OF TURBINES

Source: various

Figure 7 - PS-600 turbine

SYSTEM CONFIGURATIONS

Source: Campbell, Maynard, Wang

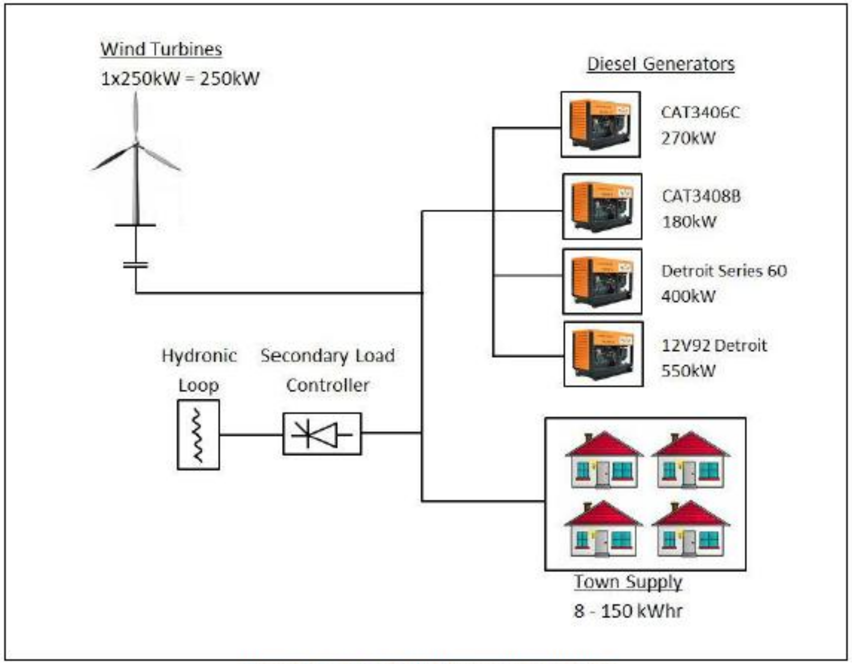


Figure 12. 50% installed capacity reduction

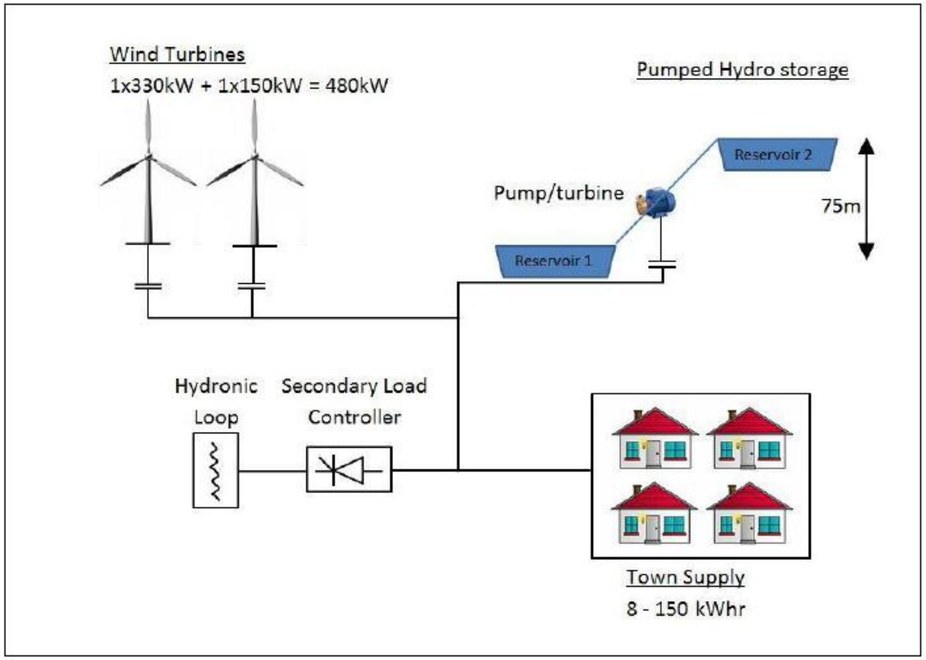


Figure 11. Schematic of wind turbine and pumped hydro energy storage (PHES) system.

WIND PENETRATION & SURPLUSES

Source: Payne, Pinfold

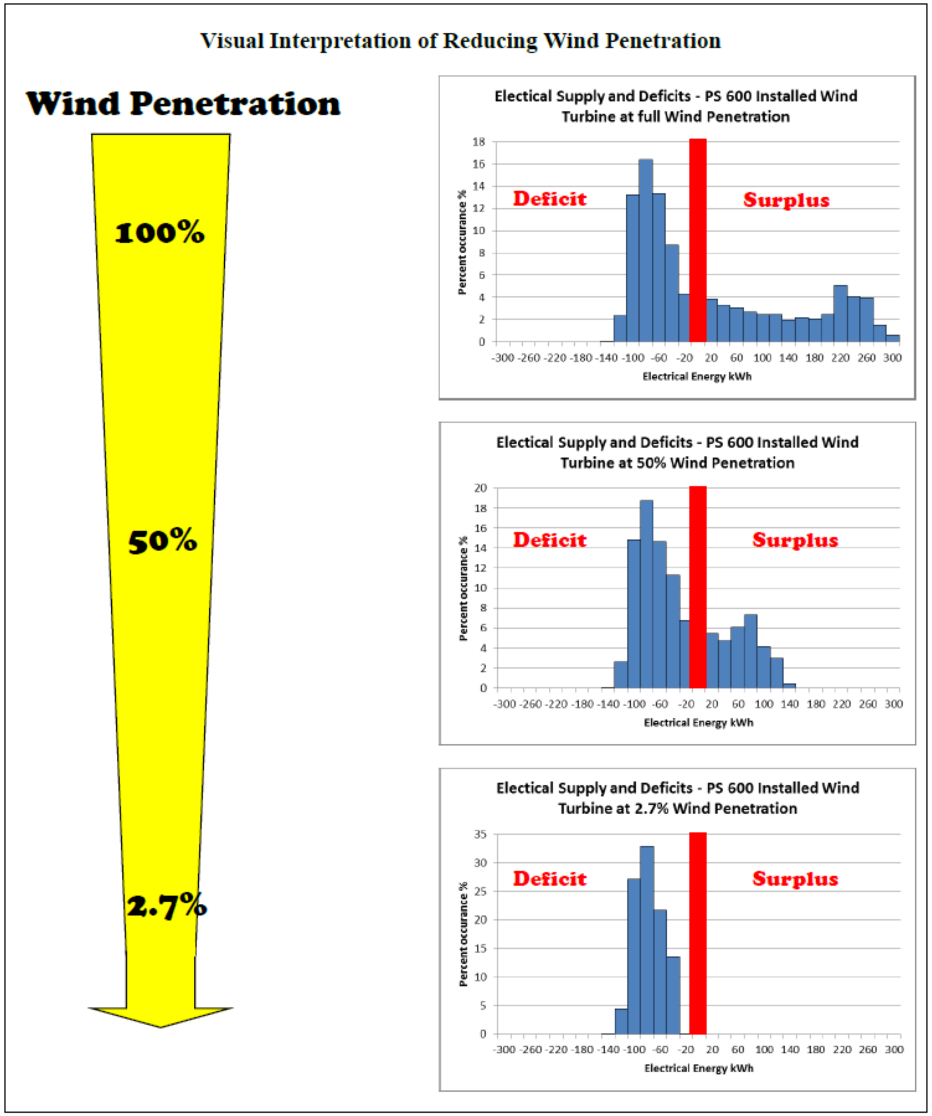


Figure 12.Effects of wind penetration on electrical supply

GHG, FUEL & COST SAVINGS

Source: Payne, Pinfold

Table 6. Diesel fuel consumption and emission savings for various installed capacities

Installed Capacity %	GHG savings	Fuel savings 1000 Liters	Fuel cost savings $1000
100	527	201	250
50	439	167	208
2.7	13	5	3
No turbines installed	0	0	0

WIND PENETRATION & FUEL

Source: Hildreth, Soulsby

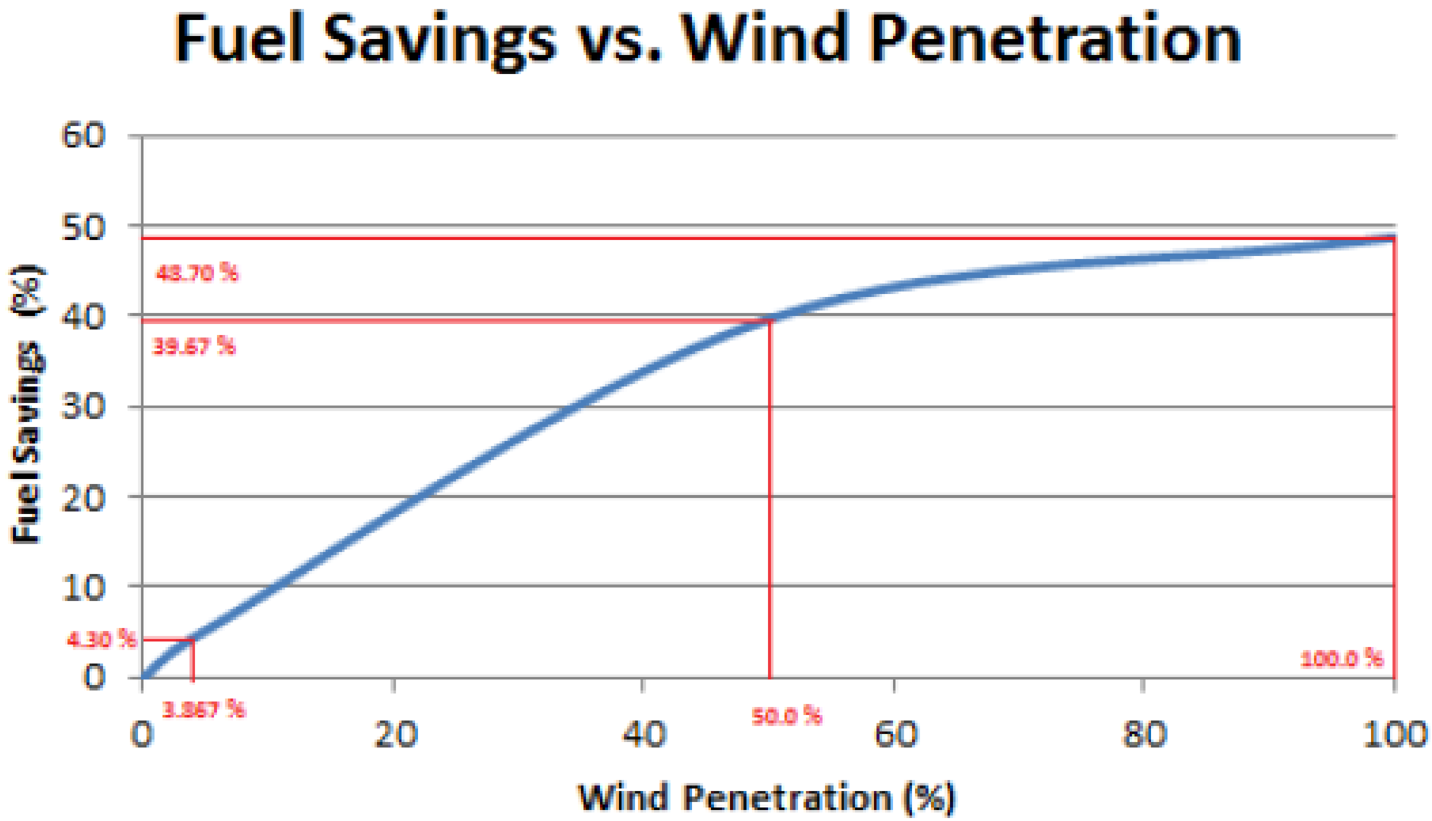


Figure 15: Quantifying cost savings on diesel fuel for various level of wind generation

DIESEL OPERATION

Source: Paton, Walls

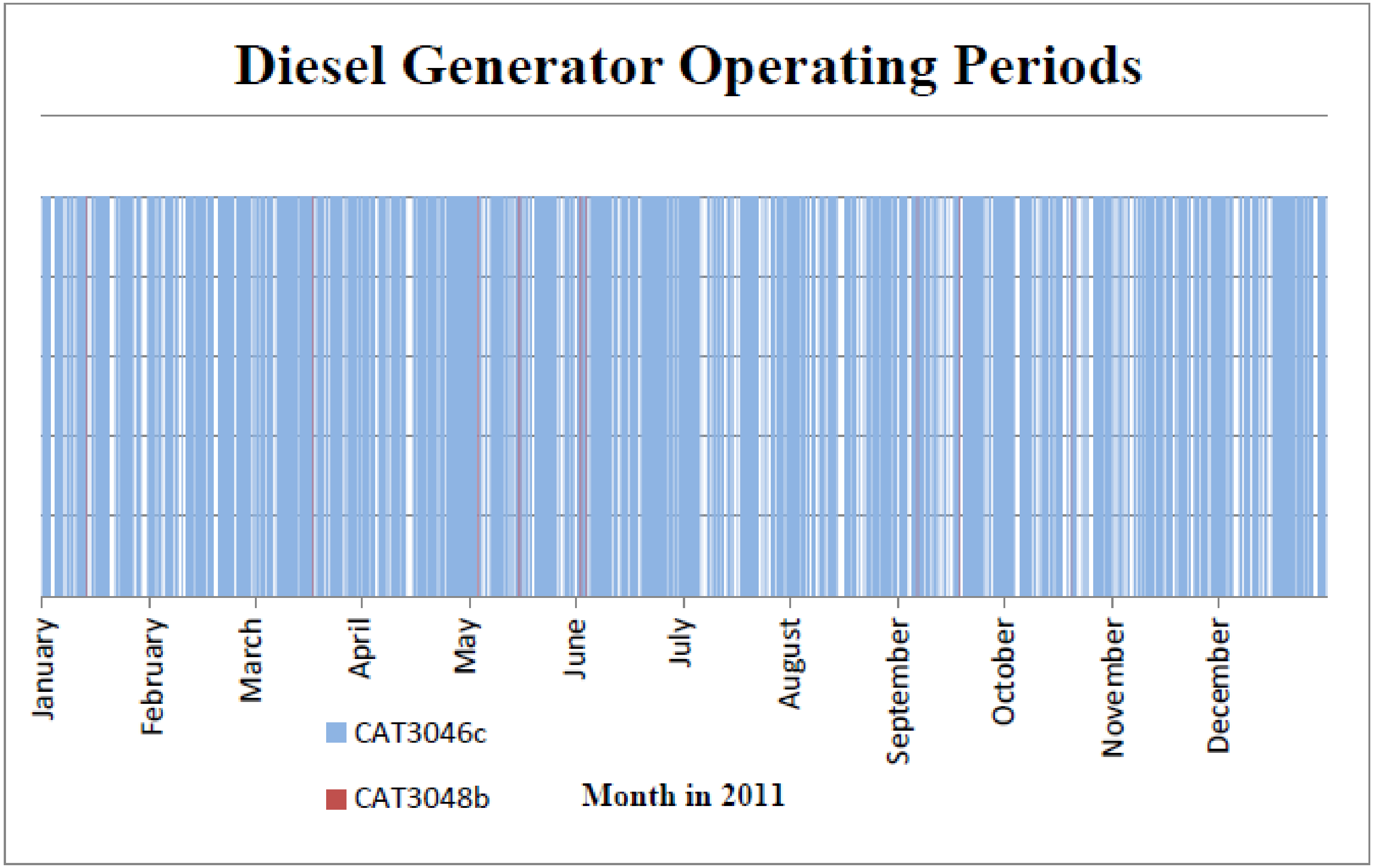


Figure 10. Operating Periods for each of the Diesel Generators.

PHES RESERVOIR SIZING

Source: Paton, Walls

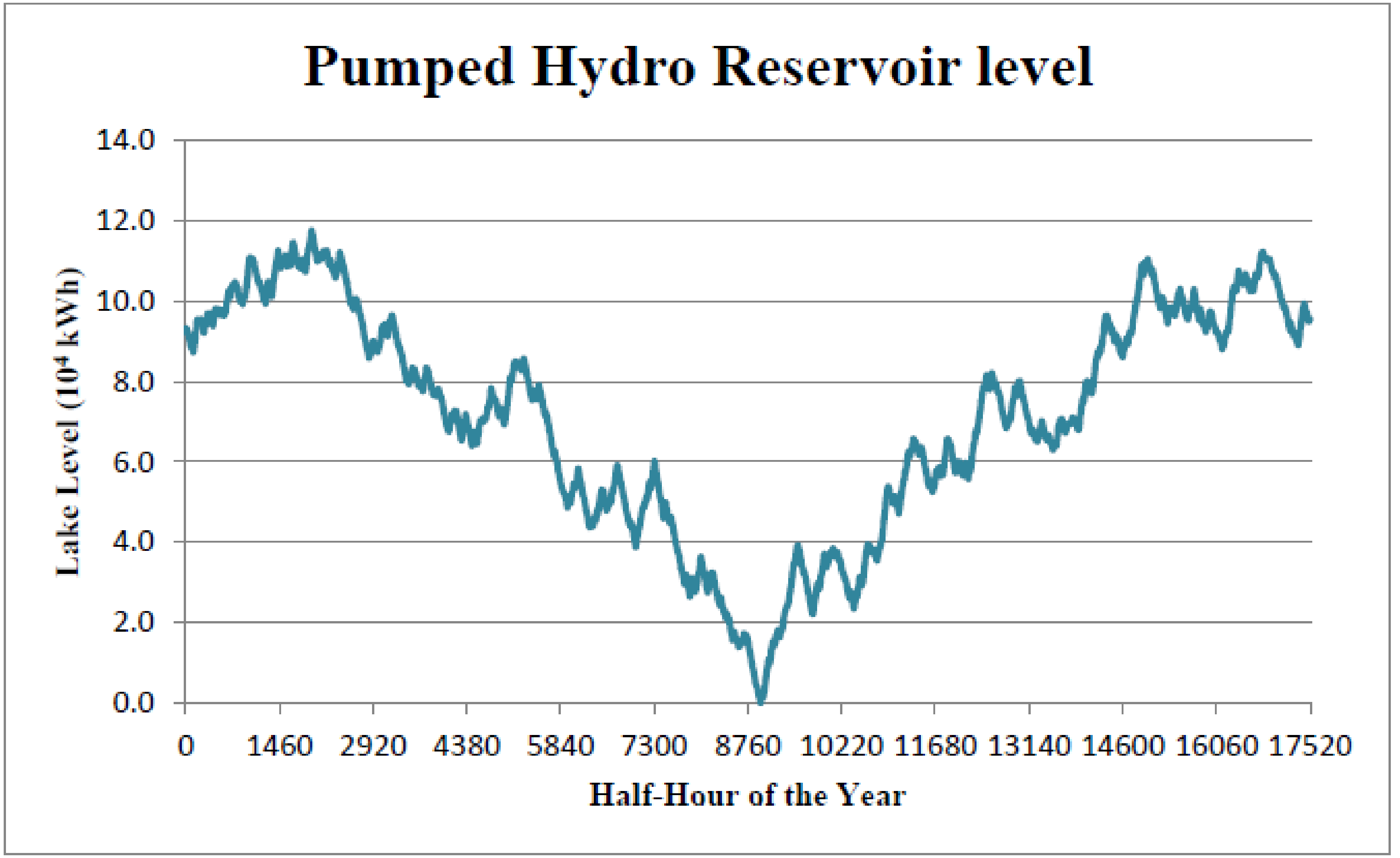


Figure 11. Half-Hourly Levels in the Upper Reservoir of a Pump Hydro Energy Storage System.

CONCLUSIONS

- Wind-diesel hybrid feasible; fuel cost savings: approx. $200,000-$250,000 p.a.
- Wind-PHES feasible: fuel cost savings: approx. $515,000 p.a.
- PHES reservoir 6.4 ha @ 10 m
- Limitations: incomplete demand data; use of Tiwai Point wind data.

RECOMMENDATIONS

- Wind study: data needed for best sites on Stewart Island; 1 year minimum
- Demand data: full uninterrupted data set needed; 1 year minimum
- Hydro study: runoff data; 1 year minimum
- Assess suppressed demand; secondary loads (pool; greenhouse…)
- Study tours: Australia, Alaska, Chathams
- Assess tourism potential…


A UK PERSPECTIVE

David Porter, Association of Electricity Suppliers, UK; April, 2012

- “A new electricity supply industry, shaped by tight constraints on carbon emissions and a desire to minimise fuel imports, presents a huge challenge and for many of the participants, a huge opportunity.
- In fact, the destination may be close to where we have to be when finite fossil fuels are in short supply. But, this is about a forced march to that place, rather than an evolutionary stroll.
- It is about pursuing vision, or anticipating events, rather than responding to them.”

RECOMMENDATIONS

- Now is the time

THANKS FOR LISTENING

Any questions

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