Variable speed wind generator control in Antarctica.

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EGU 2007

Small wind generators are the obvious choice for powering remote instrumentation in Antarctica – but there are few examples of their successful implementation: Antarctica is a very harsh place for wind generators.

Outline of talk

- Wind energy primer
- Modular system approach
- Our solution under development/test

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Describe some work at BAS to build a robust wind power system, I'll do this by giving an introduction to wind energy, espousing a modular approach and showing you something of our solution that we are developing.

(small) variable speed wind generators

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Small 100-200W

Antarctica

- Wind regime dominated by storms and katabatics.
- Many sites with average wind speeds of 10ms^{-1} or greater.
- Calms are rare – low windspeed and startup are unimportant.
- Survivability and MTBF is important.
- Roughness length over snow very low < 0.0002m

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Basic – but important

$E=\frac{1}{2}\ mv^2$

$m=\rho\pi r^2 v$

Therefore $P=\frac{1}{2}\ \rho\pi\ r^2\ v^3$

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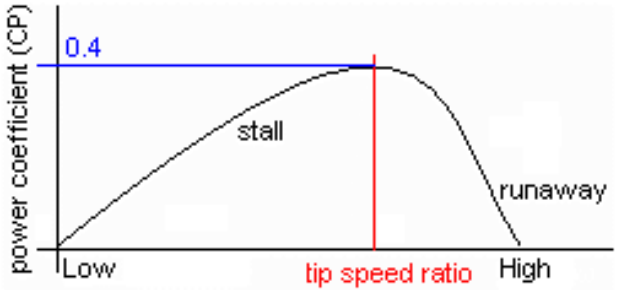
10w at 5ms-1 is 5KW at 40ms-1 10kW@50ms-1

Tip Speed Ratio - λ - tip speed /wind speed



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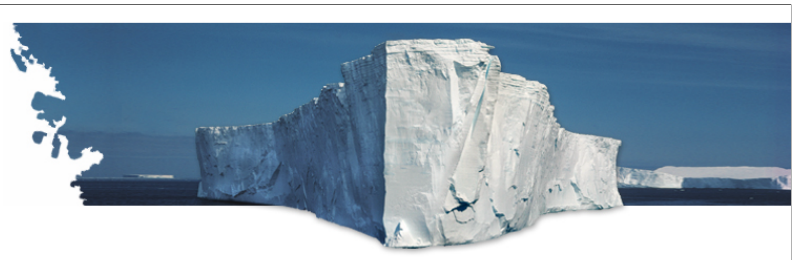
Tip speed ratio is speed of tip divided by speed of wind. At high or low values efficiency of generator is low.



Electrical Control methods

- Resistive load dumping
- Electro-dynamic braking

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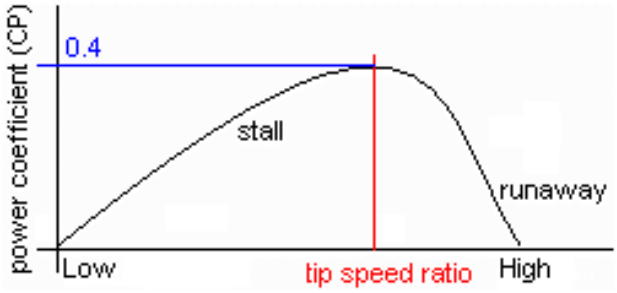
Generic control method that we could use for many different manufacturers wind generators.

Tip Speed Ratio - λ



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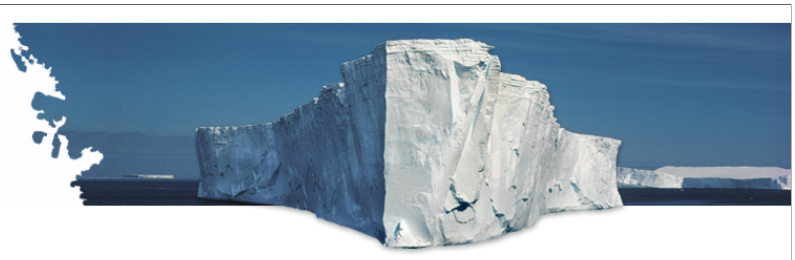
Disadvantage of resistive load dumping is that it needs to be tuned to a particular generator and simple implementations tend to be on/off and can move you into a more efficient area of the generators operation. A more difficult problem to overcome is that the generator is still absorbing power which needs to be dissipated somewhere.



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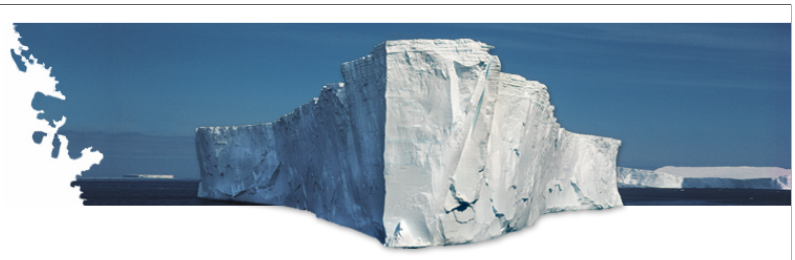
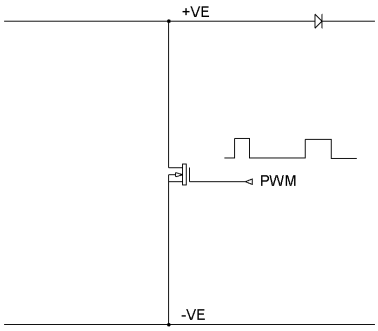
Electro-dynamic braking – an electronic way of braking the generators speed.



Control method – PWM shunting.



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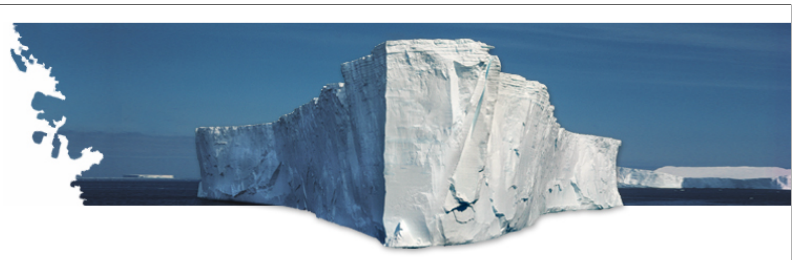

Control methods – PWM shunting.

- High frequency (2KHz) energy loss
- Removes energy from:
  - Stored in inductance of windings.
  - That being supplied by the wind.
  - Momentum of the blades etc.

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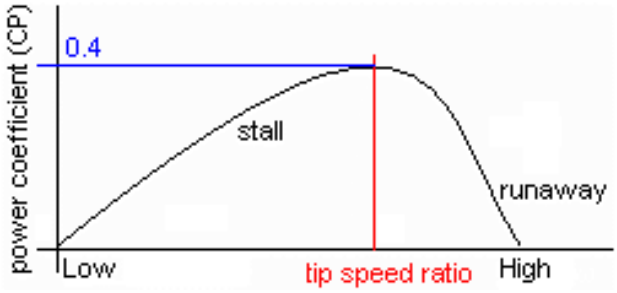
Tip Speed Ratio - λ



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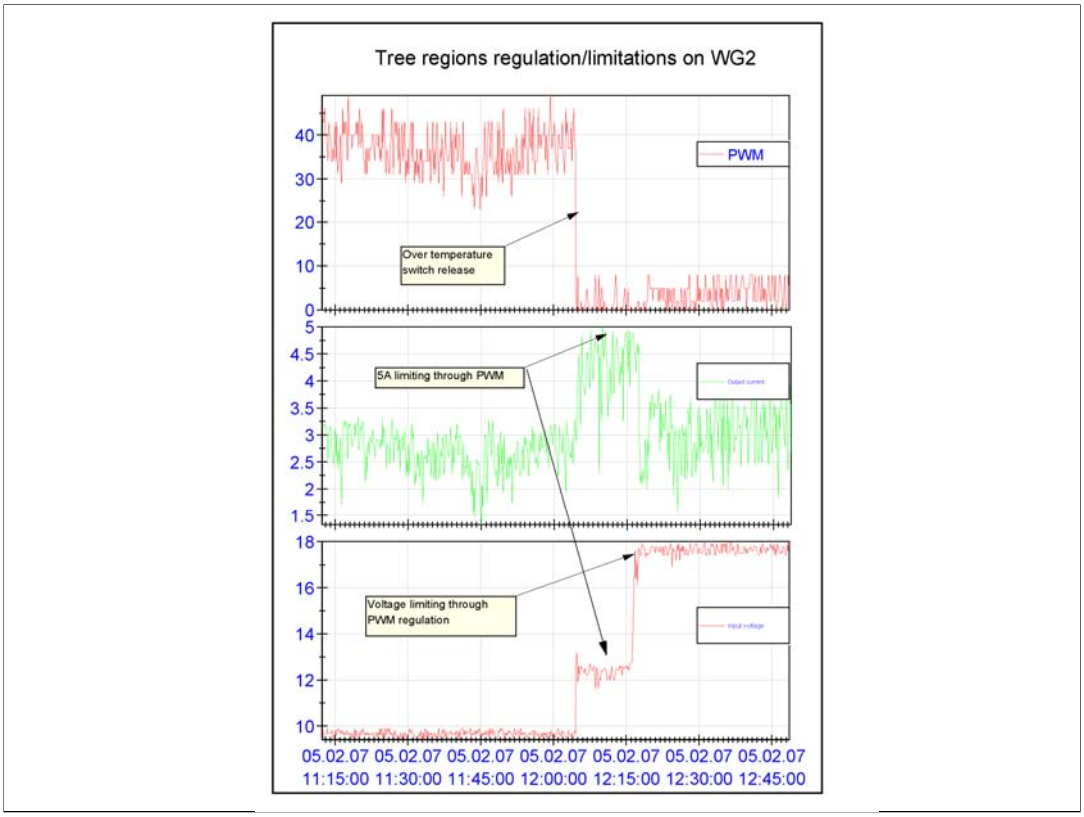
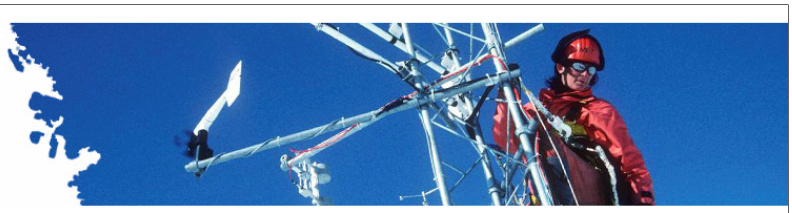


Example of controller in operation. Panels are PWM %, current, voltage.



Modular system considerations

- Multiple manufacturers - redundancy
- Scaleable – more generators, more batteries
- Standard controllers in system – one per generator
- Maintenance – data log history of performance

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Batteries

- Most practical technology is AGM lead acid.
- Severe temperature effects on charge and discharge.
- Heat is as important as charge.
- Need to control the charge, discharge, and the temperature of the batteries.
- Modular daisy chaining battery boxes requires series regulators in each box.

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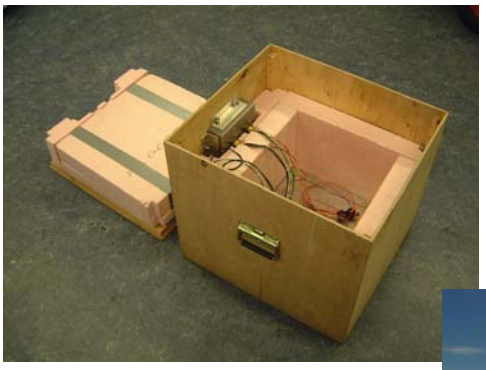

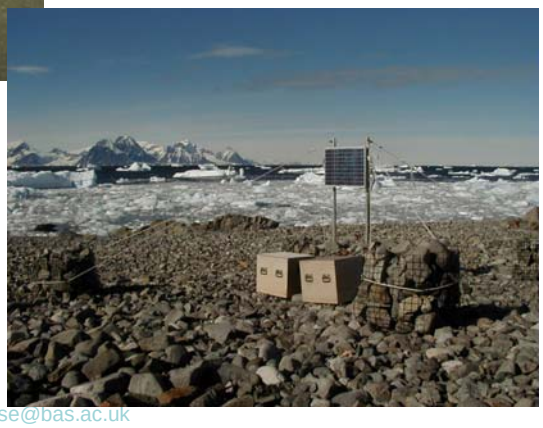

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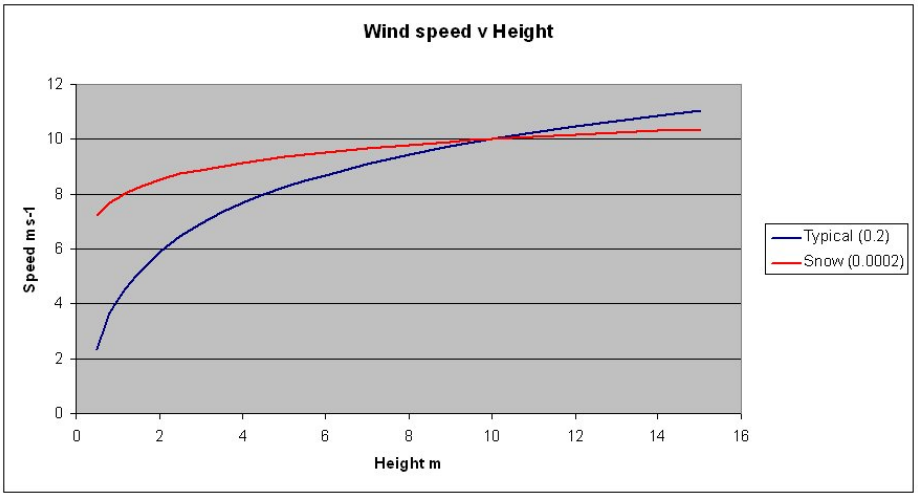
Roughness length implications



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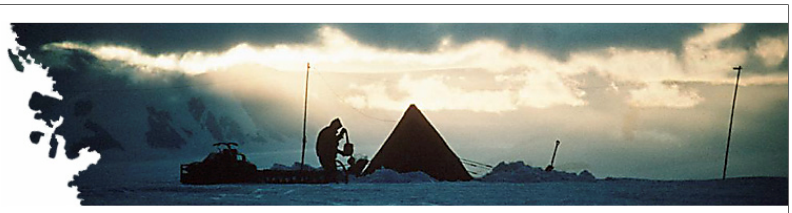

Conclusions:

- PWM shunt controllers – one per generator.
- Complex control strategies possible.
- Multiple generators for robustness.
- Insulated, daisy chained battery boxes.
- Data logging for maintenance and performance info.
- Low towers and masts.

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Questions ?

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