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Integrating Wind Energy into the Australian National Electricity Market

World Renewable Energy Congress IX
23 August 2006

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www.ceem.unsw.edu.au

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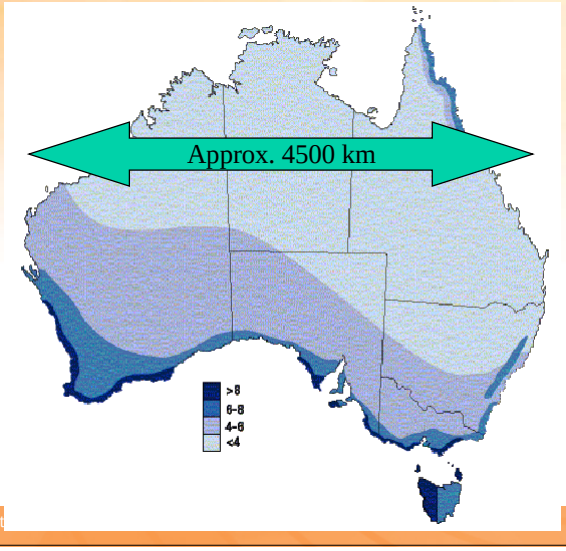
Australian wind resource

(Estimate of background wind (m/s) – Australian Greenhouse Office)



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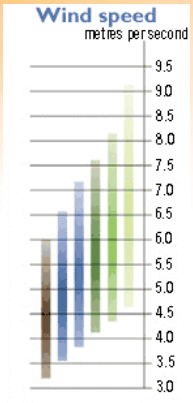
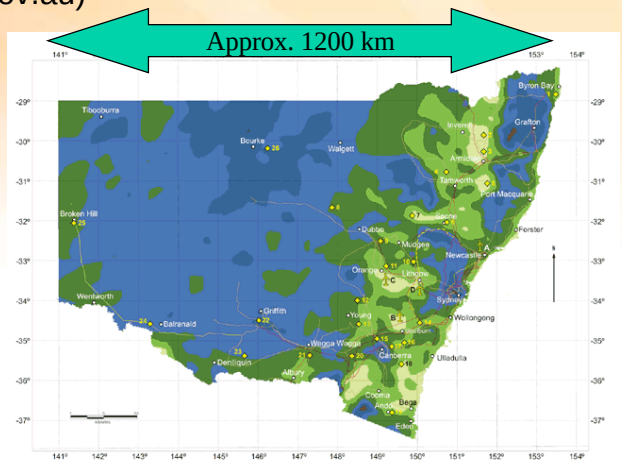
SEDA NSW Wind Atlas

(www.seda.nsw.gov.au)





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Wind energy characteristics

- Renewable energy fluxes are time-varying:
  - Solar, wind, hydro (tidal), biomass, geothermal, wave
- Wind & solar are non-storable:
  - Can be described as *intermittent energy resources*
- Electricity generation based on wind & solar energy can be described as intermittent generation
  - Electric power systems don't store electrical energy, hence intermittency reduces value of wind energy
  - Effective forecasts can reduce the loss of value

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Wind farms as “intermittent generation”

- Australian National Electricity Code (NER) definition of intermittent generation:
  - “A generating unit whose output is not readily predictable, including, without limitation, solar generators, wave turbine generators, wind turbine generators and hydro generators without any material storage capability”
- Issues identified by System & Market Operator (National Electricity Market Management Company - NEMMCO):
  - Forecasting; Frequency Control Ancillary Services (FCAS); voltage control; management of network flows

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Network issues for wind farms #1

- Networks are shared, centrally planned resources:
  - Must limit network disturbances caused by wind farms
  - Wind farms must survive disturbances from the network
- Renewable resources are often distributed differently from fossil fuel resources:
  - Weak network conditions likely to be more common in Australia & New Zealand than Europe or North America
- Network must be built to carry peak flows:
  - Want good estimates of aggregation & seasonal effects
- Benefits of staged development of wind resources:
  - Network savings; reduced voltage & frequency impacts

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Network issues for wind farms #2

- Wind turbine starting & stopping transients:
  - Severity can be alleviated by soft-start & high wind-speed power-management
- Some wind turbine designs:
  - May cause voltage distortions:
    - Harmonics &/or transients
  - May have poor power factor, eg:
    - Uncompensated induction generator
  - May not ride-through system disturbances
    - Temporary voltage or frequency excursions
- Australian conditions favour large wind farms connected at high voltage

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SA wind regions with existing transmission access (green)

- Still potential impacts on existing generation & interconnector rating

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SA regions with limited transmission access (yellow)

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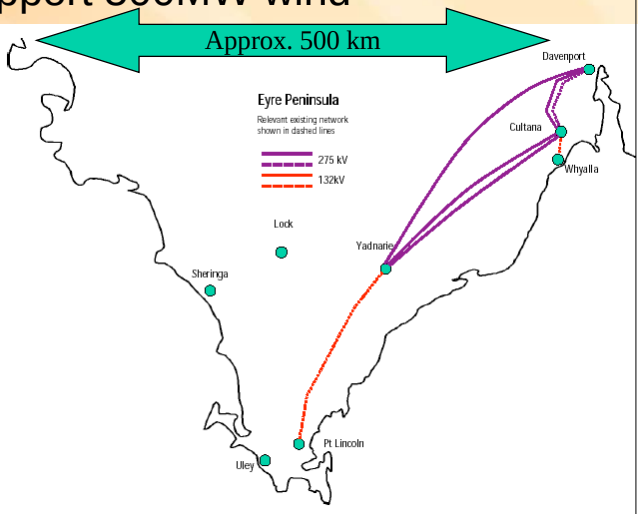
Eyre Peninsula Backbone network upgrade to support 500MW wind

Estimated cost of 275kV backbone upgrade: $140M or $280/MW assuming shared equally by 500MW of wind.

Wind may not have to pay full cost of backbone upgrade.



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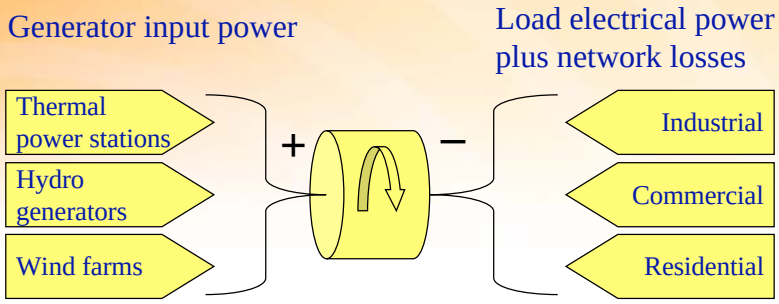
Managing supply-demand balance in the electricity industry



- Frequency is a measure of supply-demand balance:
  - always varying due to fluctuations in the power flows associated with particular devices
  - *Wind energy is only one of many fluctuating power flows*

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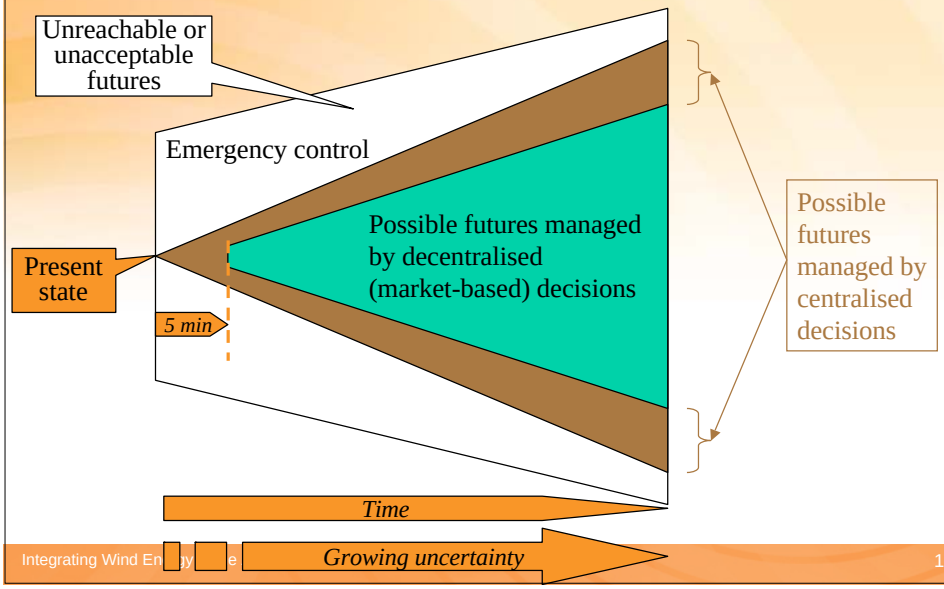
Managing system security in the NEM



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NEMMCO concerns about wind energy

(NEMMCO, 2003)

- Frequency control in normal operation:
  - Frequency regulating service costs ~5 $/MWH
- Security control - largest single contingency
  - Will wind farms ride-through disturbances?
- Interconnection flow fluctuations:
  - Exceeding flow limit may cause high spot price
- Forecast errors due to wind resource uncertainty:
  - Five minute dispatch forecast (spot price)
  - Pre-dispatch & longer term (PASA & SOO) forecasts

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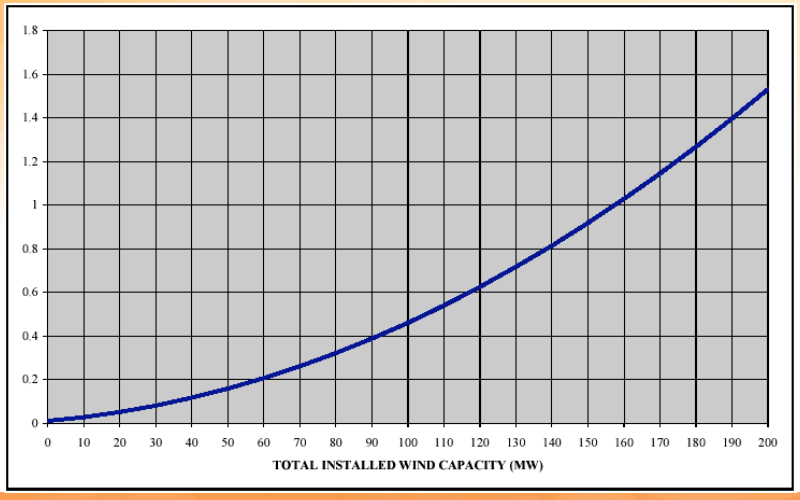
Western Power's wind penalty charge (c/kWh) (Western Power, 2002)



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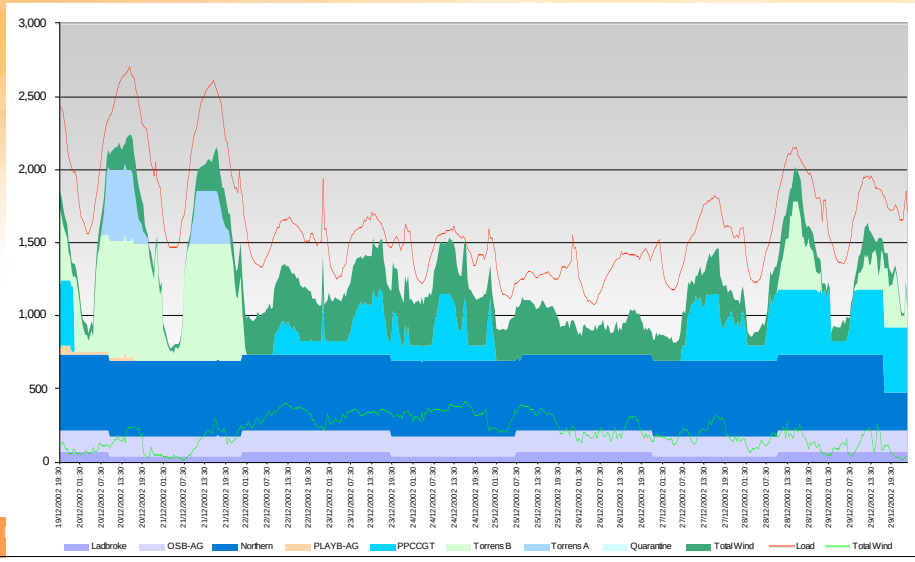
Simulated dispatch with 500MW wind in SA

(Oakeshott, 2005)



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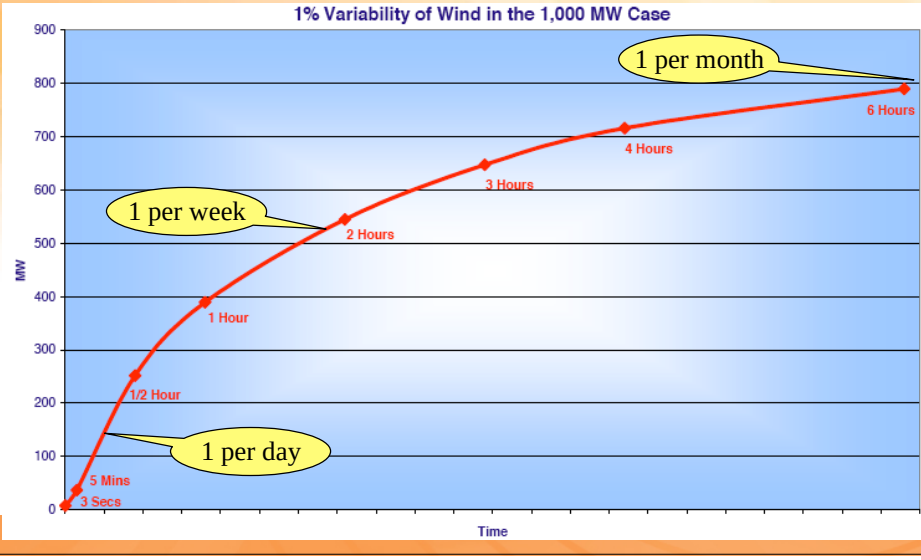
1000 MW wind, SA: 1% likelihood variation

(ESIPC, 2005)



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Forecasting the output of wind farms for system security assessment

- Groups of wind farms rather than single wind farms
- 30 minute horizon (FCAS & spot market):
  - Turbulence spectrum - likely to be uncorrelated for turbines spaced > 20 km:
    - Then % power fluctuations ~ $N^{-0.5}$
- 30 minutes to ~3 hours:
  - ARMA model best predictor of future output
- > 3 hours - NWP model may be a better predictor:
  - Direct weather observations may contain additional information about large changes

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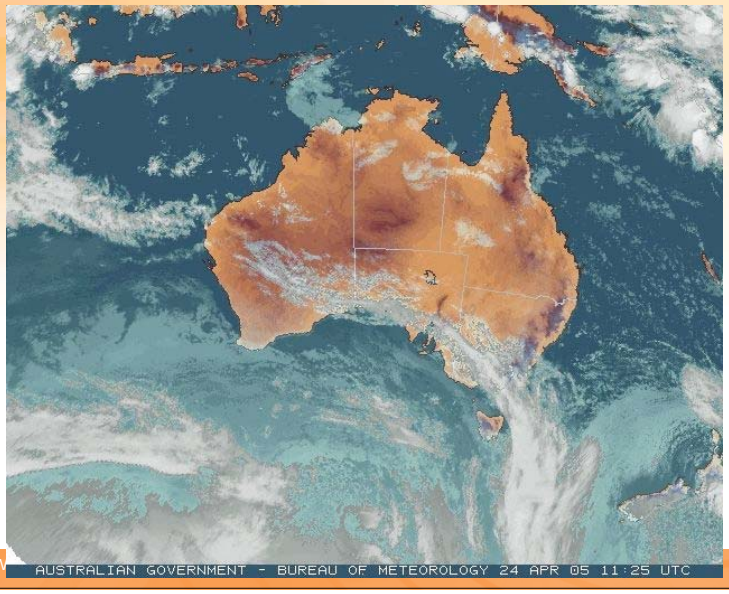
S1: Infra-red satellite map (BoM Aust,1125 UTC 24/4/05)



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Comparing AusWEA forecast (www.auswea.com.au) & readily acceptable (RA) wind capacity for Australia

(Outhred, 2004)

	Qld	NSW	Vic	SA	Tas	WA	Aus
Inst MW	13	17	92	400	67	29	*610*
App MW	0	62	207	800	220	67	1320
Total MW	*13*	*80*	*300*	***1200***	*280*	*100*	*1930*
RA MW	2100	3100	2200	500	500	500	8900

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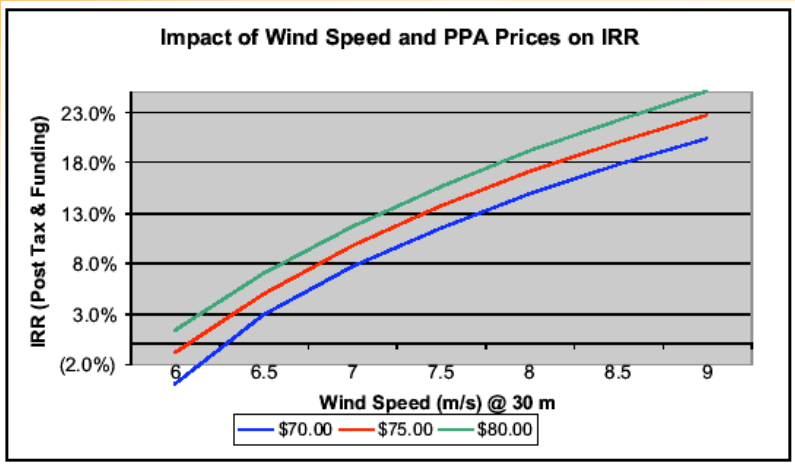
Wind farms marginal at $70/MWH

(PWC, 2002)



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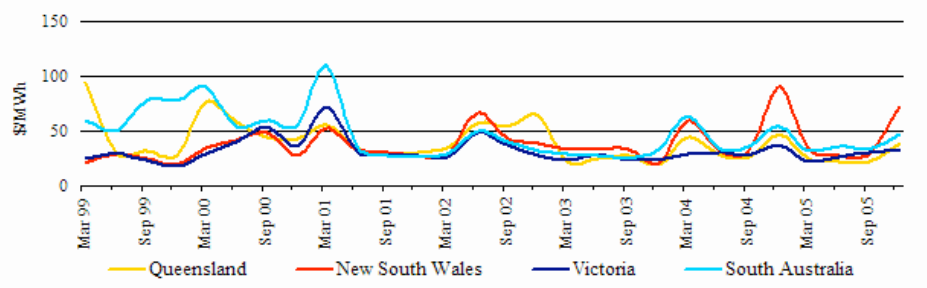
Average NEM spot prices since market inception (12/98 to 12/05) (AER long term analysis)



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Conclusions on wind energy in the NEM

- Brings new challenges for electricity industry restructuring (technical, market design, regulation)
- Network connection issues:
  - Wind energy distributed differently from fossil fuels
- Planning issues - visual & bird impacts:
  - Regional, rather than project specific
- Forecasting & system security issues:
  - Regional, rather than project specific
- Wind not competitive on NEM electricity price:
  - Requires additional income from selling Renewable Energy Certificates (RECs) but now fully subscribed