Centre for Energy and Environmental Markets

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Wind generation and its potential impact on the NEM

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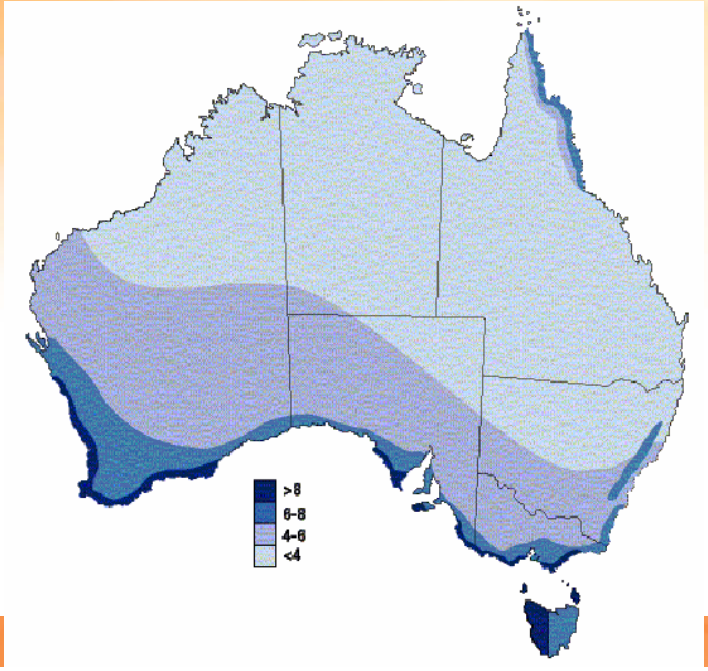
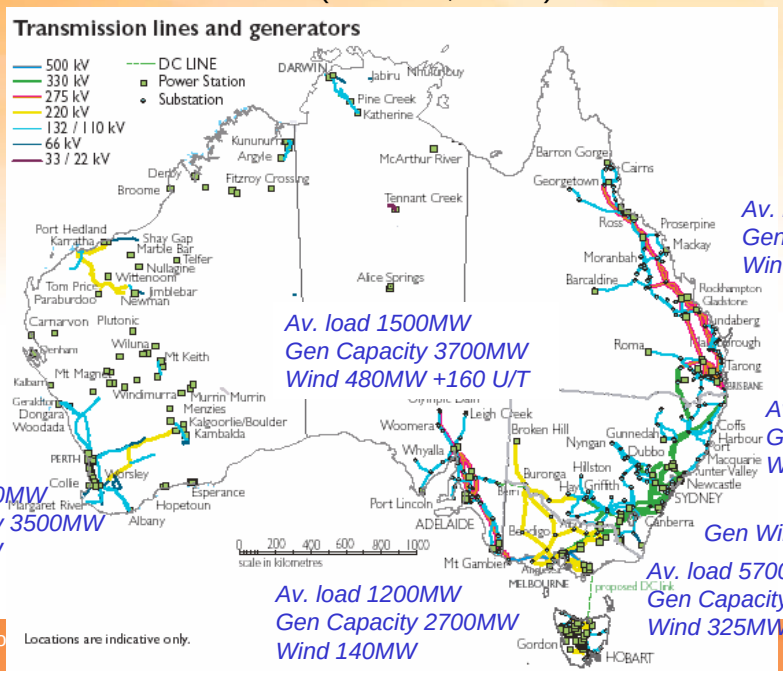
The Australian wind resource

(Simple estimates of background wind – Australian Greenhouse Office)



Current status of Australian wind generation

Estimated state average load, total installed generation capacity and wind installed or under construction (ausWEA, ESAA)



Av. load 5600MW
Gen Capacity 11,300MW
Wind 12MW

Av. load 1500MW
Gen Capacity 3700MW
Wind 480MW +160 U/T

Av. load 8500MW
Gen Capacity 12,500MW
Wind 17MW

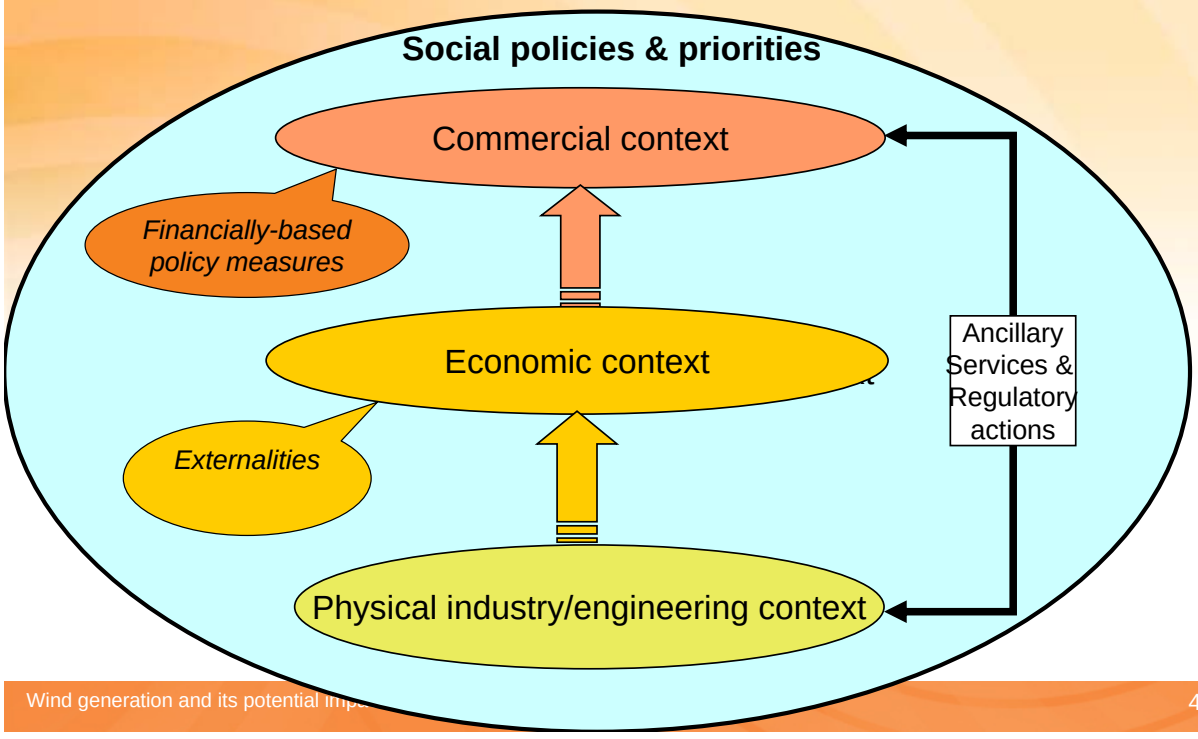
Av. load 1600MW
Gen Capacity 3500MW
Wind 200MW

Gen Wind 17MW

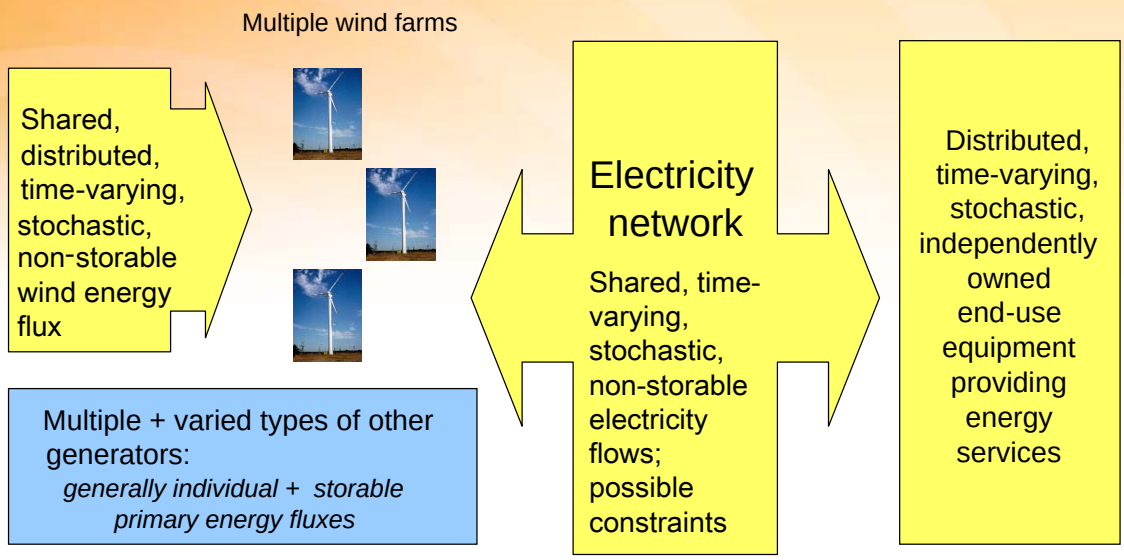
Av. load 5700MW
Gen Capacity 8800MW
Wind 325MW +165 U/T

Av. load 1200MW
Gen Capacity 2700MW
Wind 140MW

Various contexts of wind energy integration



Physical context for wind energy integration



Physical integration of significant wind

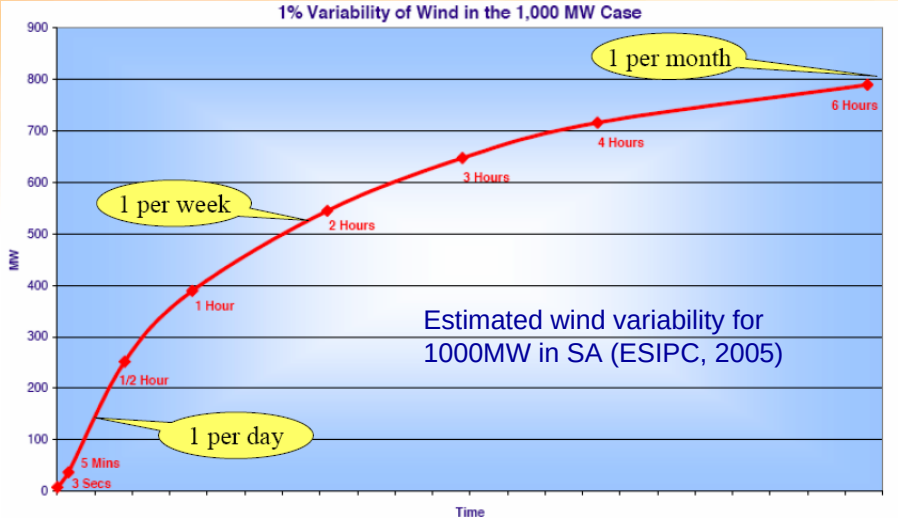
- All loads, generators + network elements have electrical flows that are variable, not completely controllable + somewhat unpredictable
- **Wind:** reliable but highly variable, only somewhat (downwardly) controllable + somewhat unpredictable
  - *Variability by some measures actually more predictable than base-load thermal plant where unexpected variations are forced outages*

The operational challenge for power systems

- Attempting to maintain continuous flow of end-user energy services
- Complex, stochastic, only partially predictable and time-critical systems: no cost-effective electricity storage
- manage small disturbances well but entire system put at risk by *large unexpected* changes:
  - failure of large centralised generation,Tx elements or loads
  - many strongly correlated small loads – eg. Air Conditioners
  - *significant wind generation experiencing shared extreme weather events*

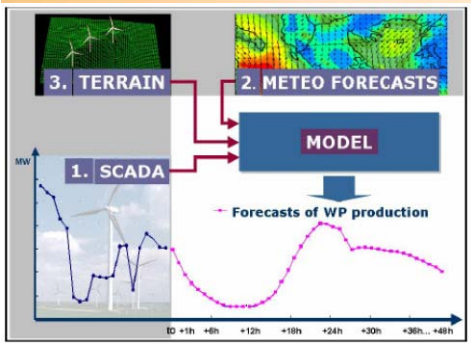
Wind generation variability

- Depends on context
  - Eg. Wind regime, geographical diversity..



Wind generation predictability

- Also depends on context
  - Prediction objectives? Expected value or extreme events
  - Scale – windfarm, region, NEM-wide



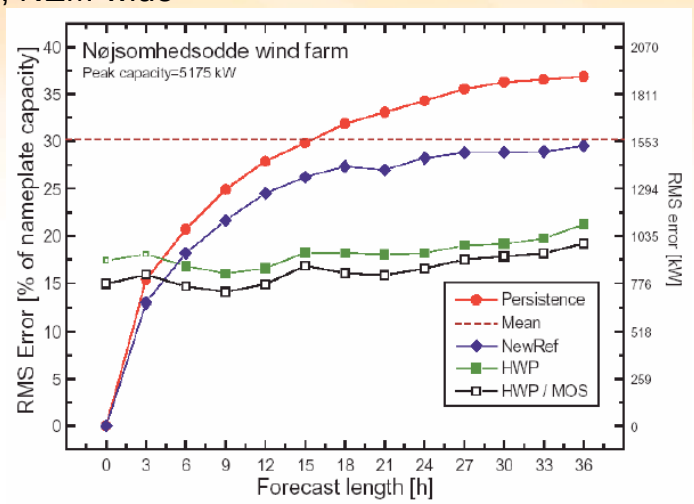


Figure 9 Root Mean Square (RMS) error for different forecast lengths and different prediction methods. Upper curves are statistically based systems, lower curves are weather forecast-based systems, from Giebel et al. (2003).

Economic context for wind energy integration

Free if uncertain wind energy flux but relatively expensive + only moderate possible cap. factor plant

Multiple + varied types of other generators:
Mix of plant with different fuel + capital costs, associated uncertainties

Electricity network
Significant, location dependent, capital costs; rel. low operating costs

End-users
Value of energy services varies stochastically by user, quantity, time, location

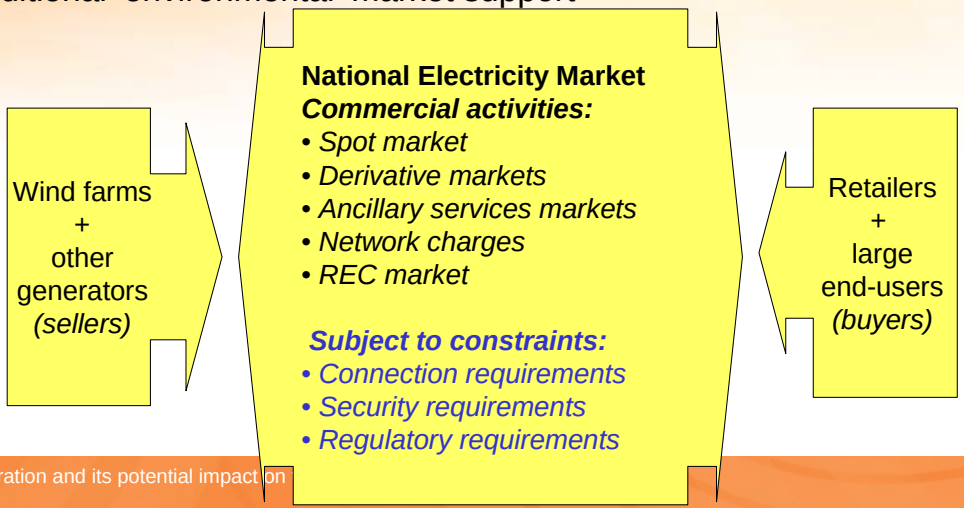
Range of externalities

Commercial context for wind energy integration

- Electricity markets are 'designer' markets
- Key design challenges
  - Embracing + hence better managing inherent uncertainties within EI
    - allocate risk to those responsible + best placed to manage
    - *EI infused with risks that are difficult to commercialise (allocate to players)*
  - Allocation, as best possible, of costs + benefits to participants wrt costs + benefits they each provide to the industry,
  - Establish level playing field that doesn't favour incumbent technologies + participants against 'new entrants' –*key part of competition*
  - Commercialise externalities as best possible
  - Appropriate centralised decision making where required
    - Short-term security, longer-term policy
- High wind penetrations
  - Worldwide, one of the first generation technologies to emerge within restructured industry context
  - *will test adequacy of electricity industry restructuring*

Commercial context for wind integration in NEM

- Wind classified in NEL as 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"
- Currently classified as non-scheduled, can be market or non-market
- Additional 'environmental' market support

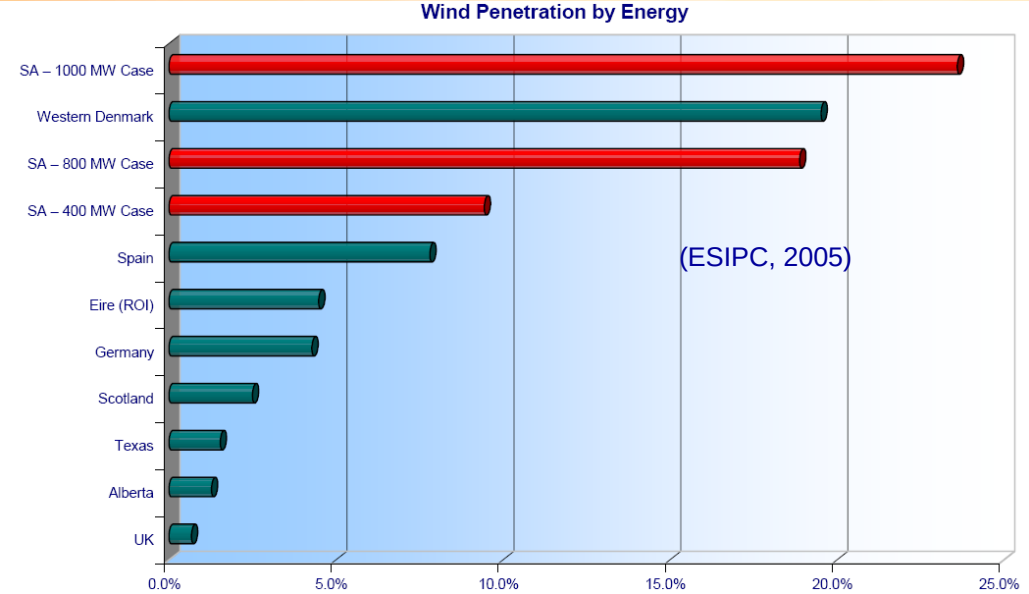


Growing interest in potential wind impacts…

- NEMMCO (2003) …. ongoing work
  - Network management: V regulation, sub-5min flows
  - Increased FCAS requirements
  - Forecasting challenges – price + reserves
- MCE (WETAG) (2005) ….
  - Technical standards
  - Network flows
  - Wind farm modelling
  - Information disclosure
  - Cost recovery for FCAS
- ESIPC South Australia (2003 onwards..)
  - Technical standards, scheduled operation, forecasting

Wind penetrations

- Current Australian wind generation ~ 1% penetration
- Victorian 10% target might see ~5% Victorian penetration

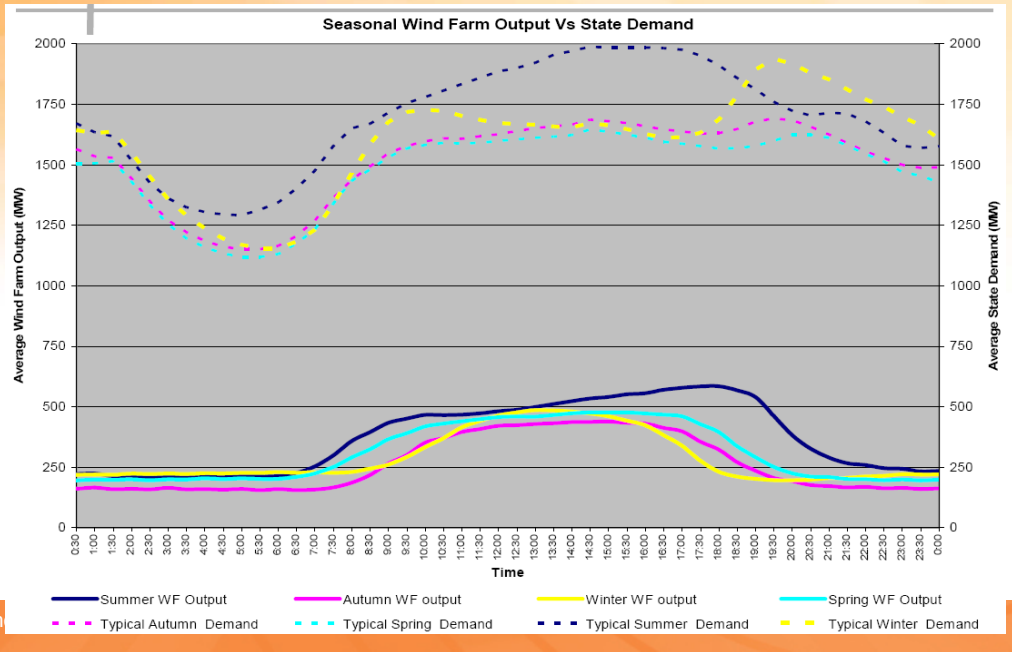


Wind in the NEM spot market

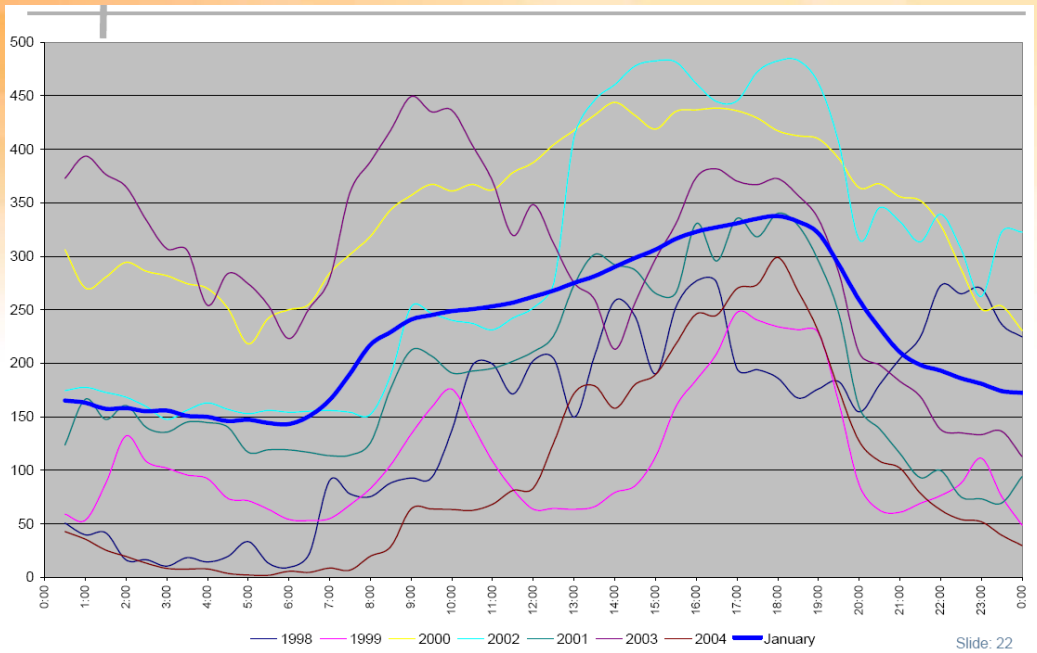
- Wind currently non-scheduled
  - Generate whenever wind is blowing (possibly s.t. to N/W constraints)
  - Wind farms (or local retailer) operate as “price takers” although high penetrations will impact spot market prices – *difficult to estimate*
  - Value of wind energy in the spot market depends on how regularly wind farms are producing when spot prices are high
    can be reasonably good correlation seasonally and daily cycle
- Wind farm developers see locational price signals
- Load will remain major source of variability + unpredictability until we see considerably higher wind penetrations (SA an exception)
  - **NEMMCO has interim + progressing major NEM wind forecasting sys**
- Considerable transparency
  - NEMMCO provide historical generation, now also non-scheduled generation forecast in pre-dispatch + PASA
- Coming changes to wind non-scheduled status
  - **Semi-dispatch:** Wind farms can be given downward dispatch targets when network constraints (NEMMCO is progressing)
  - **Scheduled generation:** Licensing requirement by ESCOSA.

Wind and demand variability

- eg. SA modelling (Oakeshott: ESIPC, 2006)



…but note variability



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Wind in derivative markets

- Wind farms may wish to participate in derivative markets:
  - Variable + somewhat unpredictable energy will normally have lower value that energy from other generators
  - Important to have good forecasts of average production plus seasonal & diurnal patterns
  - 'Smoothing/firming' contracts between wind + other generators are possible
- All market participants will be interested in predicting future wind power at local, regional + system-wide scale:
  - Important to develop high quality forecasting techniques available to all market participants

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Wind in ancillary services markets

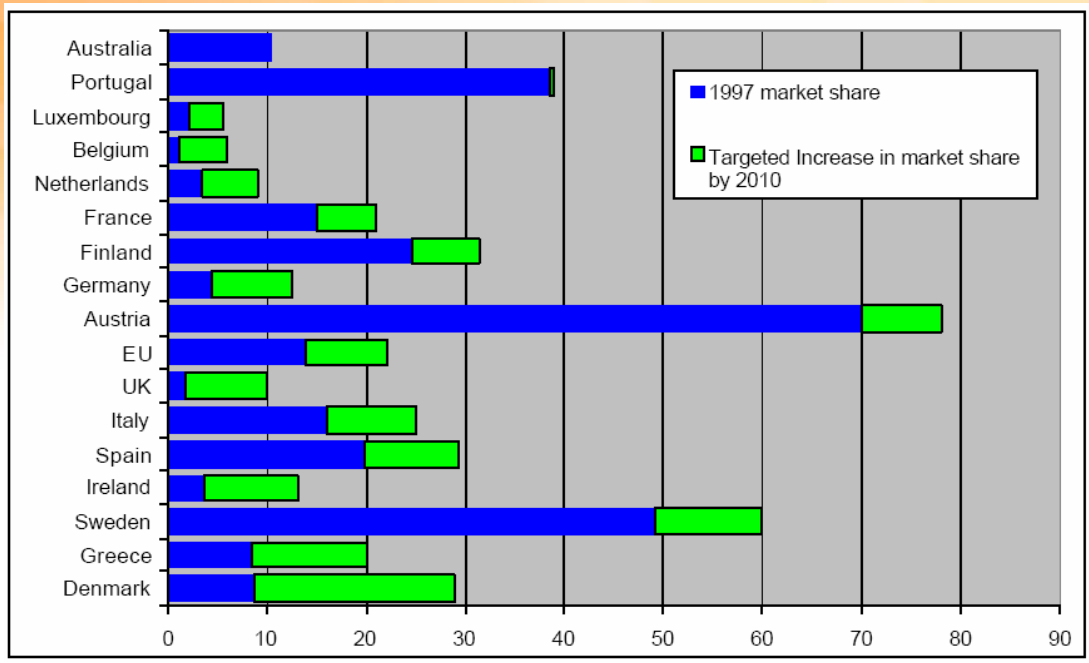
Wind currently doesn't participate

- NEMMCO progressing non-scheduled generator contribution to FCAS costs
- Wind farms will be buyers but could also be sellers in FCAS markets
- Australian power systems are technically challenging:
  - Wind farm installers should be choosing Best Available Technology for both turbines & wind farm control schemes

Wind in energy-related environmental markets

- Range of markets
  - Federal MRET
    - Wind expected to meet around 35% of RECs to 2020 (BCSE, 2006) or around 1000MW capacity
    - Targets to 2020 already nearly filled, will be insufficient to drive significant future investment. REC prices now falling markedly.
  - Victorian scheme (VRET)
    - Estimated around 1000MW of wind to 2016
  - SA exploring options
- Interactions with energy markets
  - Existing wind farms
    - Typically approx. half revenue from energy market, half from RECs
    - Limited exposure to changing energy market conditions
      - Effectively worth generating in spot market at –ve REC price
  - Wind farm investment
    - Energy market signals significant wrt location; potentially significant wrt chosen turbine technology, windfarm layout, control systems

Some international renewable electricity targets



Conclusions

- NEM
  - Infused with uncertainty – *a key to driving competition*
    - Generators can rebid with 5 min notice, don't know dispatch beyond 5 min
  - Some success in commercialising costs + benefits
    - Spot/forward markets price current/future uncertainty for all generators
    - FCAS markets set frequency ancillary services costs
    - Principle of 'causer pays' although difficult in practice
  - Formal objectives of equal treatment… although difficult in practice
- Wind
  - Currently unscheduled generation + outside many NEM processes
    - NEMMCO has very limited opportunities to direct behaviour yet remains accountable for maintaining system security
  - Already 'sees' many of NEM's commercial signals; reasonable that they 'see' more of costs + benefits they bring to NEM + society
  - Wider environmental + industry development value needs to be recognised with greater 'external' policy support
  - **Adds new challenges to risk management for NEM participants**

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Thank you… and questions

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Many of our publications are available at:
www.ceem.unsw.edu.au