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Wind variability: a manageable issue or fatal flaw?

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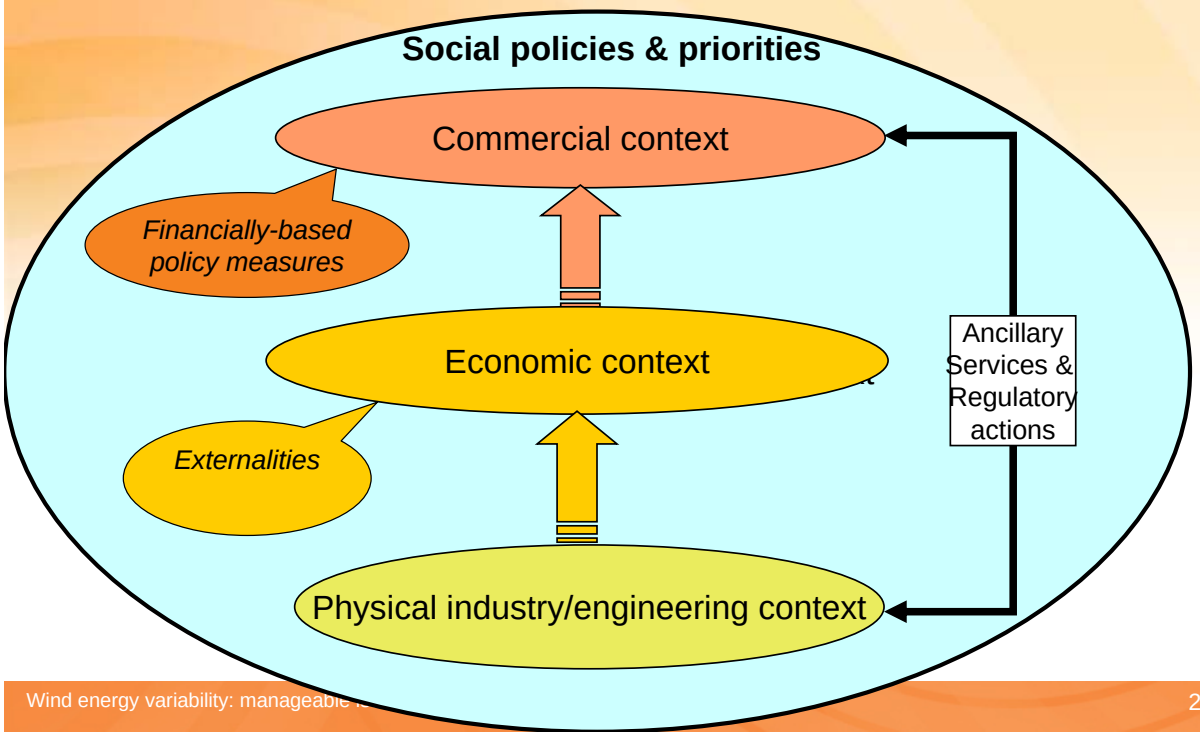
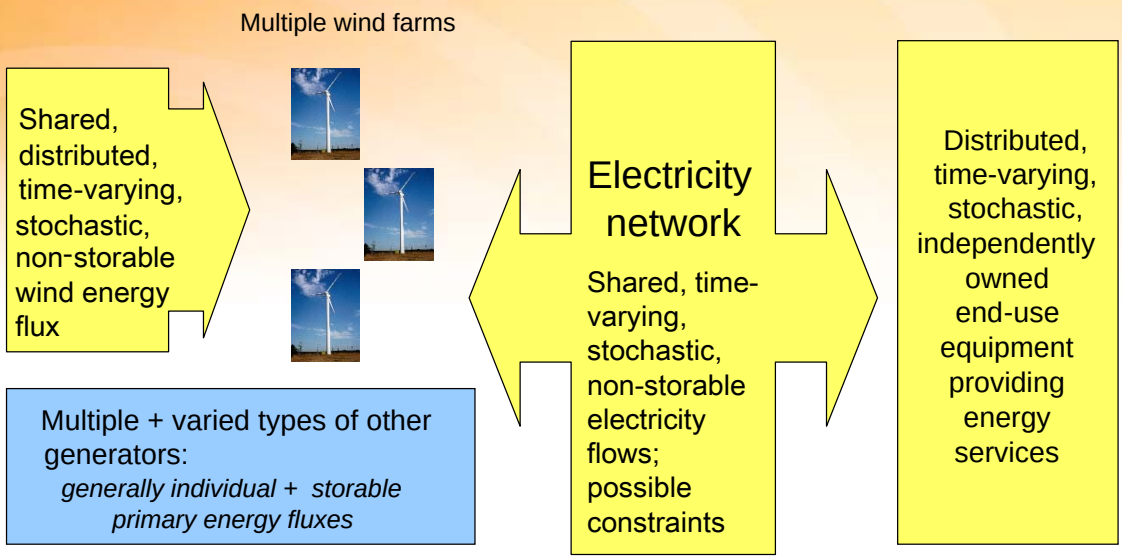
Various contexts of wind energy integration



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

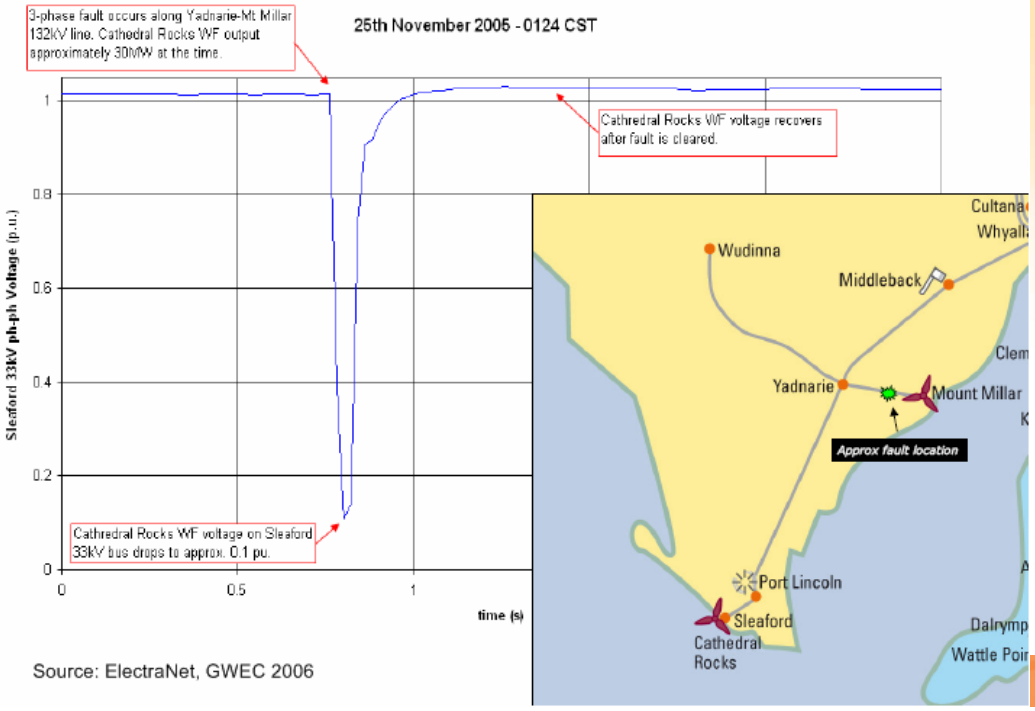
=> *Major value of electrical networks is in aggregation of diverse variable, uncertain generation and demand*

- **Wind:** reliable but highly variable energy flux, only somewhat (downwardly) controllable + somewhat unpredictable

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*

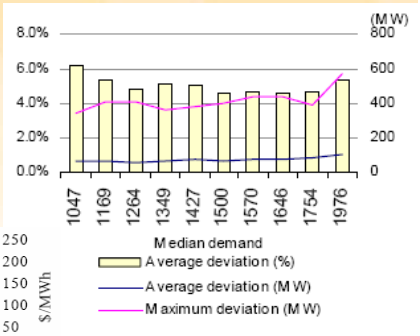
Technical performance requirements

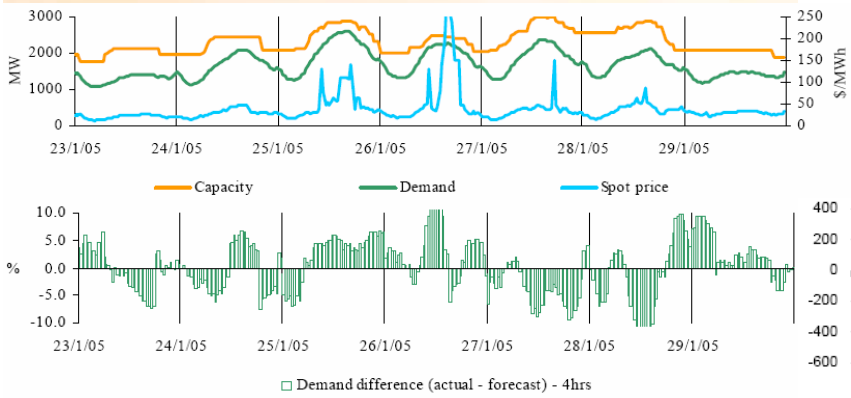


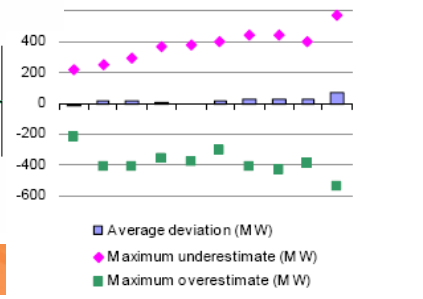
Source: ElectraNet, GWEC 2006

Load variability + unpredictability

- South Australia 4 hour ahead load forecasting challenges
  (NECA Market Analysis, 2005; Reliability Panel draft report, 2006)



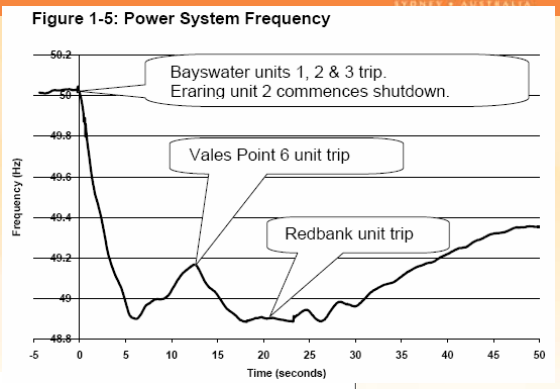


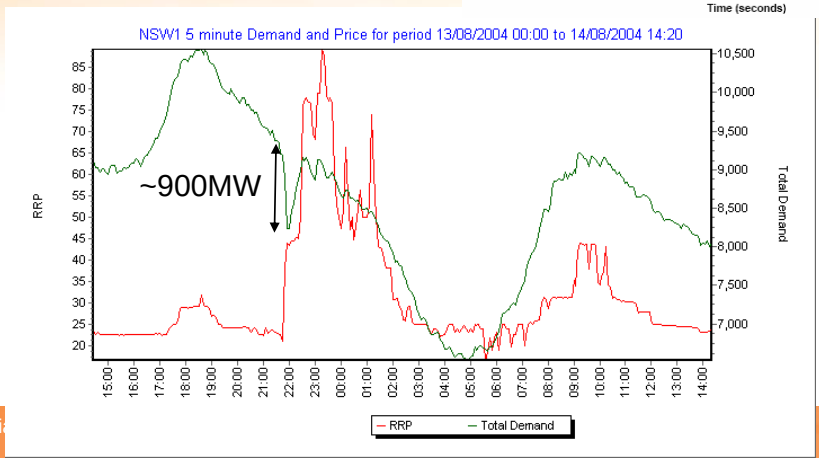


Wind energy variability: manageable issue or fatal flaw?

Gen variability + unpredictability

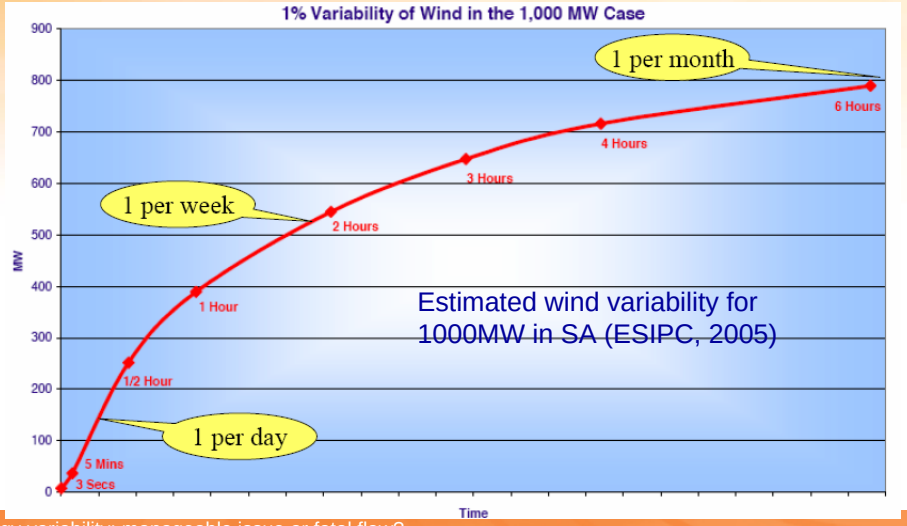
Transformer failure on Friday 13/8/04 causes 6 coal-fired NSW generators to trip totalling 3100MW:
Approx. 2100 MW load shed in NSW, Qld & Vic (also SA) (www.nemmco.com.au)



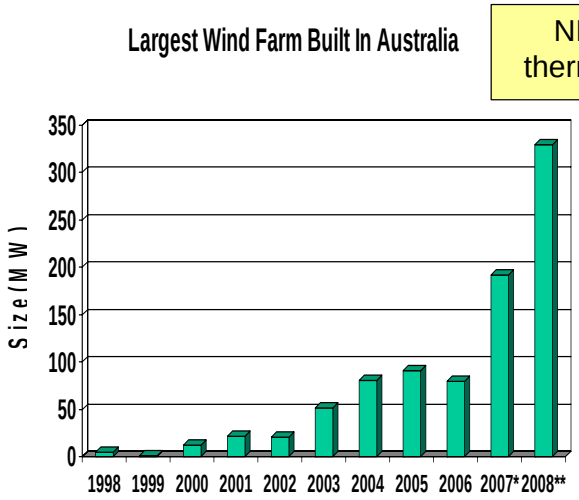


Wind generation variability

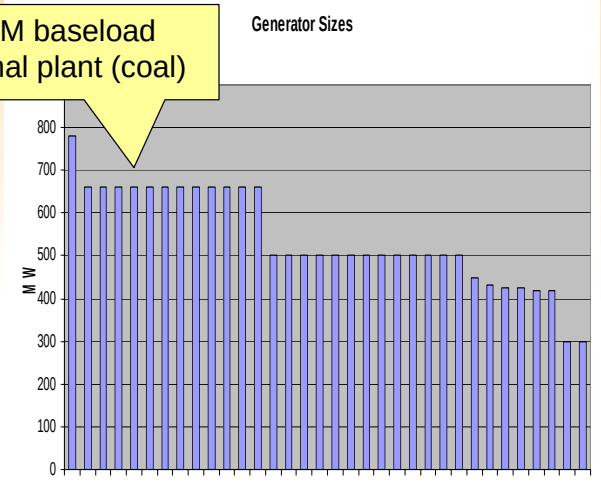
- Depends on context
  - Eg. Wind regime, geographical diversity, windfarm control strategies....



Growing size of wind farms vs. thermal generator unit sizes



NEM baseload thermal plant (coal)

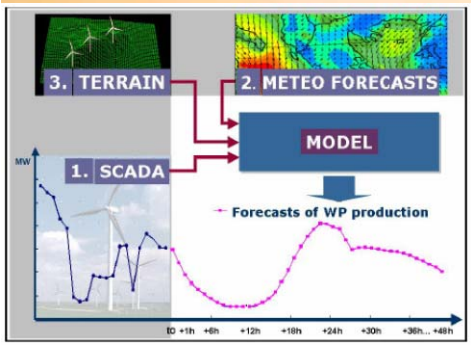


Largest generators in the NEM

* Under construction ** Planning Approved

Wind generation predictability

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



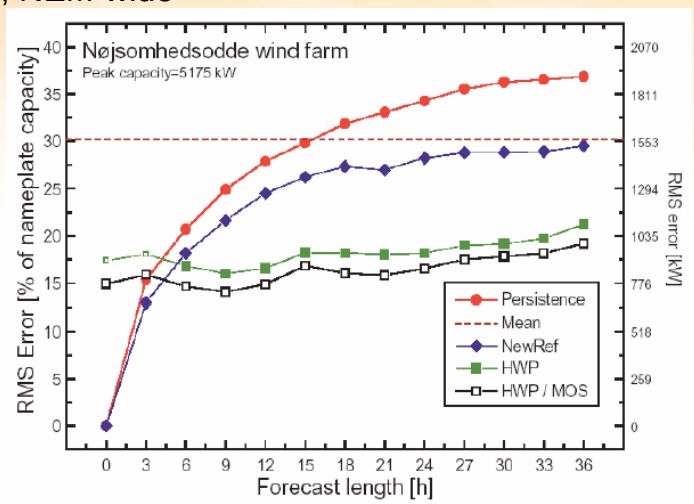


Figure 9 Root Mean Square (RMS) error for different forecast lengths and different prediction methods. Upper curves are statistically based systems, lower curves are weather forecast-based systems, from Giebel et al. (2003).

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

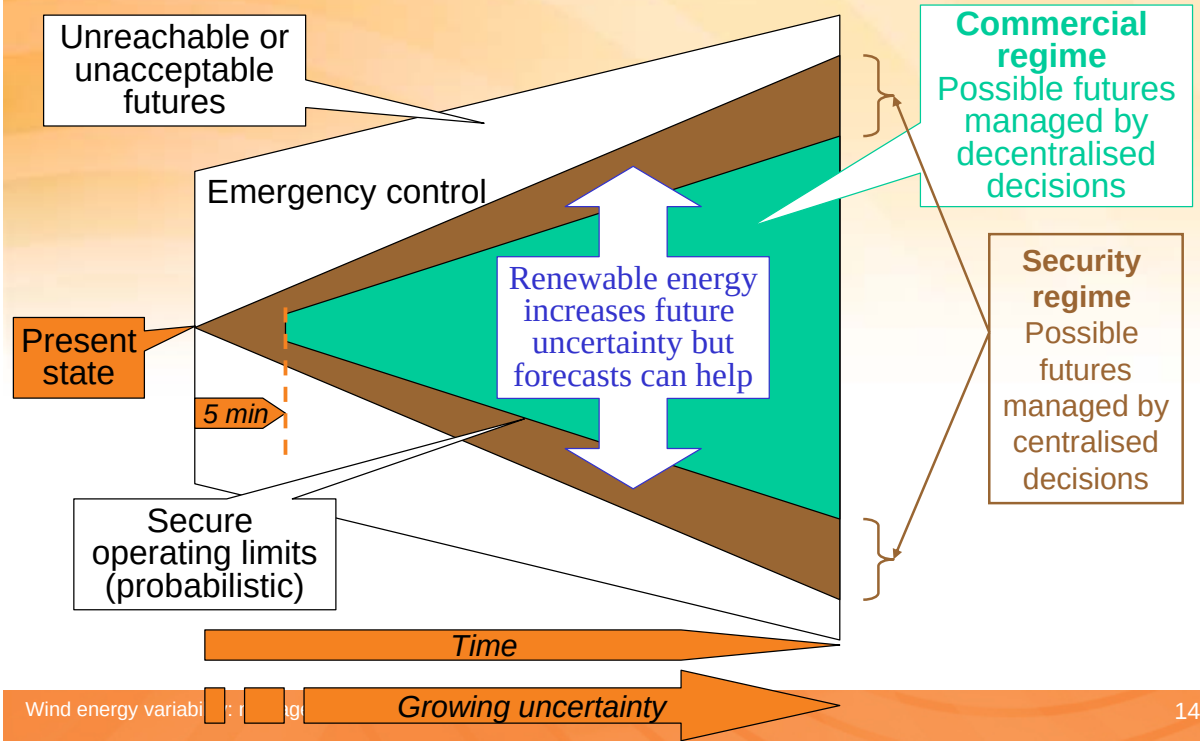
Economic integration of significant wind

- All generation and loads have particular economic characteristics for integration
  - eg. large inflexible thermal plant imposes significant integration costs, as well as 'intermittent' renewables
- Objective is to maximise the value of wind
  - Energy value: temporal, locational & contingency dependencies wrt rest of generation, network + loads
  - Environmental values
  - Other possible values… eg. industry development etc.

Commercial context for wind energy integration

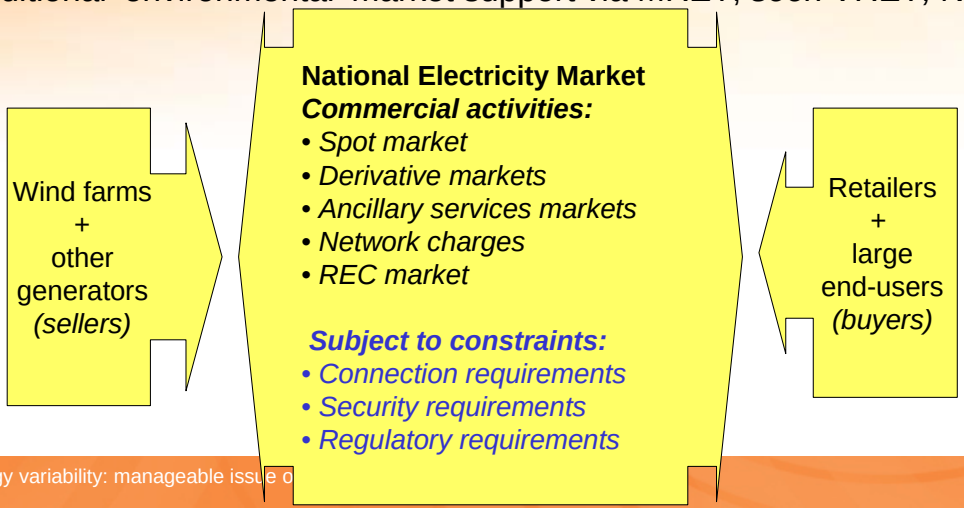
- Electricity markets are 'designer' markets
- Key design challenges
  - Embracing + hence better managing inherent uncertainties within EI
    - allocate risk to those responsible + best placed to manage, however *EI infused with risks that are difficult to commercialise (allocate to players)*
  - Establish 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
  - *now testing adequacy of electricity industry restructuring*

Security & commercial regimes (global & local)



Commercial context for wind integration in NEM

- Wind currently 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 via MRET, *soon VRET, NRET?*



Wind in the NEM spot market

- Wind currently non-scheduled
  - Generate whenever wind is blowing (possibly s.t. to N/W constraints under NSP connection agreements)
  - Wind farms operate as "price takers" although high penetrations will impact spot market prices – *difficult to estimate*
  - Wind energy value in spot market depends on how regularly wind farms are producing when spot prices are high - *can be reasonably good correlation*
- Load will remain major source of variability + unpredictability until considerably higher wind penetrations (SA an exception)
  - NEMMCO has interim + progressing major wind forecasting sys
  - Other changes in progress….

Semi-Scheduled generation

- Scheduled
  - Submission of dispatch offers
  - Compliance with targets
  - Causer-pay for ancillary services
  - Ability to offer ancillary services
  - Publication of individual outputs:- forecast, offered & actual
  - Comply with technical standards
- Semi-Scheduled
  - Submission of dispatch offers
  - Causer-pay for ancillary services
  - Ability to offer ancillary services
  - Are treated as positive supply
- If involved in a constraint
  - Compliance with targets if less than forecast
- Publication of data
  - Not finalised yet
- Non-scheduled
  - Are treated as negative demand
  - Can only be curtailed (by NEMMCO) if system security is at risk

NEW

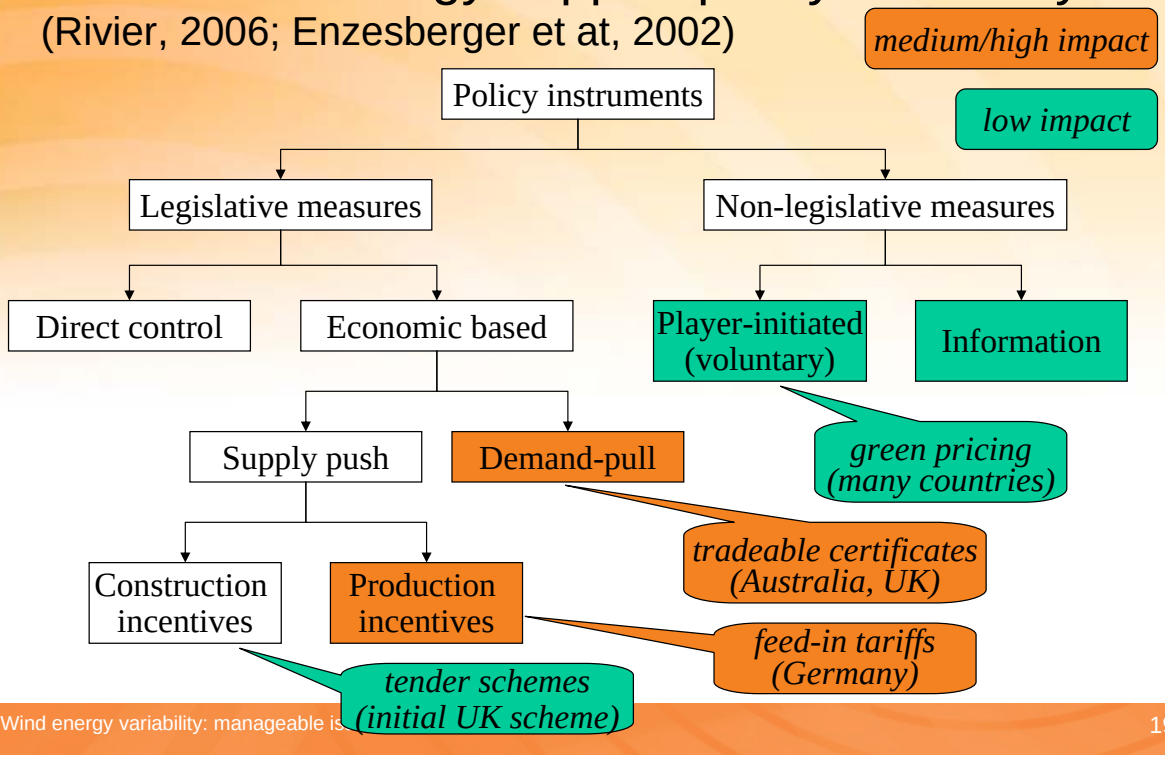
  - Publication of grouped outputs forecast and real
  - New Technical Standards

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

Renewable energy support policy taxonomy

(Rivier, 2006; Enzesberger et at, 2002)



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 volatile.
  - Victorian scheme (VRET)
    - Estimated around 1000MW of wind to 2016
      - NSW has committed to having scheme, 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

Conclusions – wind management in the NEM

- 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 – **this is now changing**
    - NEMMCO requires ability to direct behaviour of significant wind penetration 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

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Thank you… and questions

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www.ceem.unsw.edu.au