Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA

auswind 2005

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Facilitating the uptake of stochastic renewable energy resources in the Australian NEM: *wind energy*

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CEEM established …

- *to formalise* growing interest + interactions between UNSW researchers in Engineering, Commerce + Economics, AGSM + more
- *through UNSW Centre* providing Australian research leadership in interdisciplinary design, analysis + assessment of energy + environmental markets, associated policy frameworks
- *in areas* of
  - Physical energy markets
  - Energy-related derivative markets
  - Environmental market-based approaches
  - Policy frameworks and instruments in energy and environment

- *'New' intermittent renewables raise interesting + important questions for both NEM and associated Aust. Env. markets – eg. MRET*
- *Wind power represents the frontier for integrating high penetrations of intermittent renewables into electricity industries worldwide*

Key issues for wind energy integration

- Physical complexity:
  - Shared, non-storable, time-varying wind energy flux
  - Shared, non-storable, time-varying electrical energy flow in network from combined behaviour of all generators, load and N/W elements
  - State-dependent network energy flow constraints
- Commercial complexity:
  - Electricity industry infused with short- to long-term risks that are difficult to commercialise (correctly allocate to industry participants)
- Institutional complexity:
  - Shared issues in 'new entrant' planning, grid connection + management of power system security, wider policy questions

➔ ***High wind penetrations tests adequacy of EI restructuring in its technical, commercial & regulatory aspects***

Understanding + managing wind integration

- Every country/network/region has different
  - Physical context – load + generation mix, network, wind resource
  - Commercial context – electricity industry arrangements
  - Institutional context – wider policy framework
- Growing international efforts
  - International Energy Agency (IEA, 2004; IEA, 2005), United Kingdom (UK SDI, 2005), Germany (DENA, 2005), New Zealand (EECA, 2005), United States (CEC, 2004) ….
- ..and within Australia
  - NEMMCO, MCE, ESIPC…
  - Australian Govt Wind Energy Forecasting Capability initiative (WEFC)
    - announced in June 2004 Energy White Paper
    - administered by the AGO with DITR support

CEEM research project

- 3 year research project with AGO support under WEFC
- to compliment work by AGO, NEMMCO, MCE + ESIPC with more specific goals
- beginning July 2005 + with
- 2 principle research strands:
  - **integration of wind energy**, focusing on the behaviour of wind resources and conversion systems with particular attention to the prediction and control of the power output of appropriately aggregated groups of wind farms, and
  - **electricity industry restructuring**, exploring the technical, commercial and regulatory issues associated with wind energy with particular attention to power system security, market design and readily acceptable levels of wind energy penetration.

Physical context for wind - power system integration

Shared, distributed, time-varying, non-storable wind energy flux

Multiple independently owned wind farms

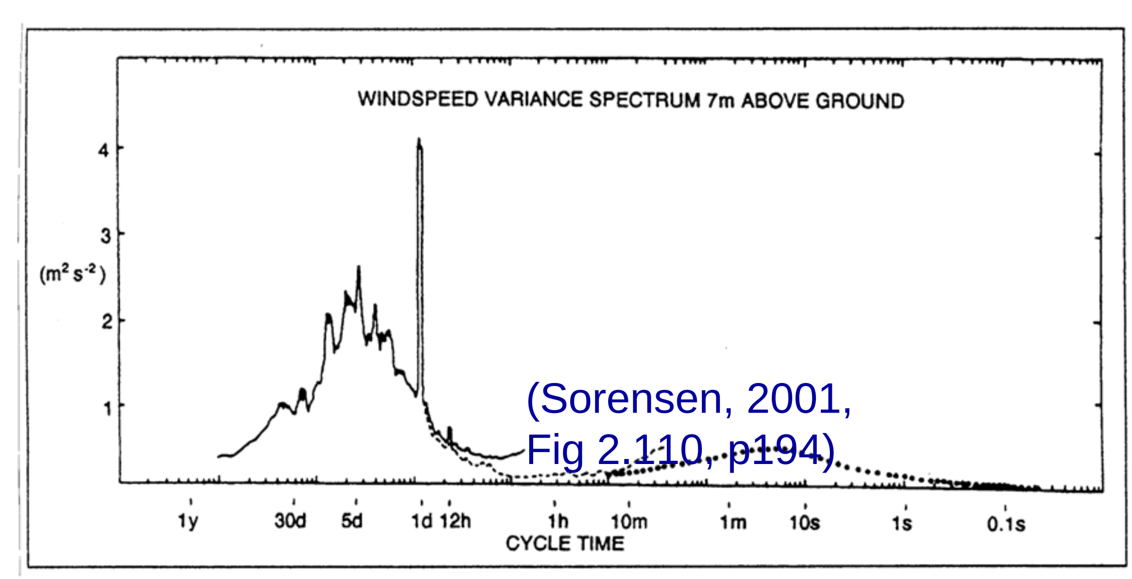
Shared electricity network

Multiple + varied types of independently owned end-use equipment providing energy services

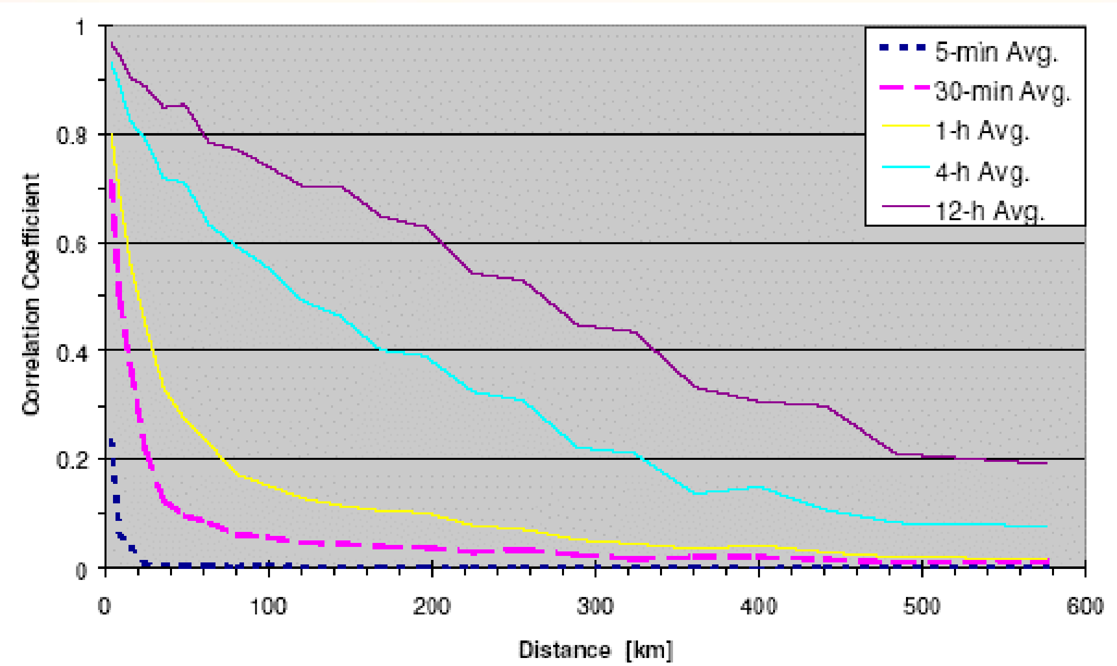
Multiple + varied types of other independently owned generators:
generally individual + storable primary energy fluxes

Wind resource

- High temporal variabilty

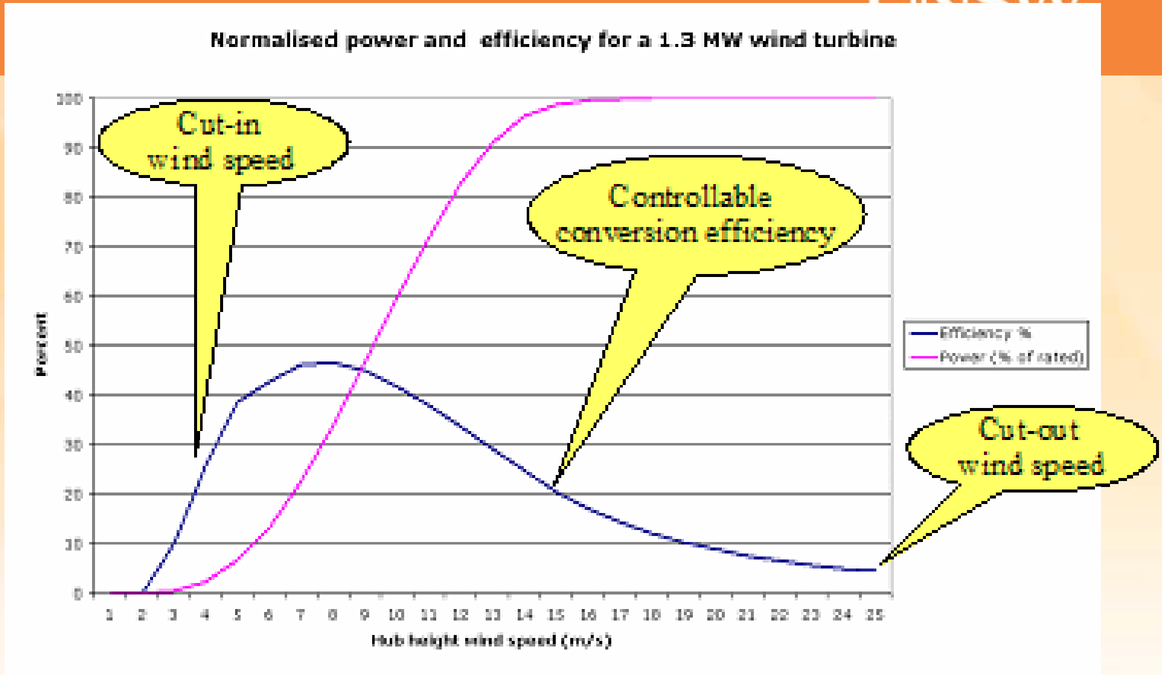


- whose correlation drops with distance, increases with time period

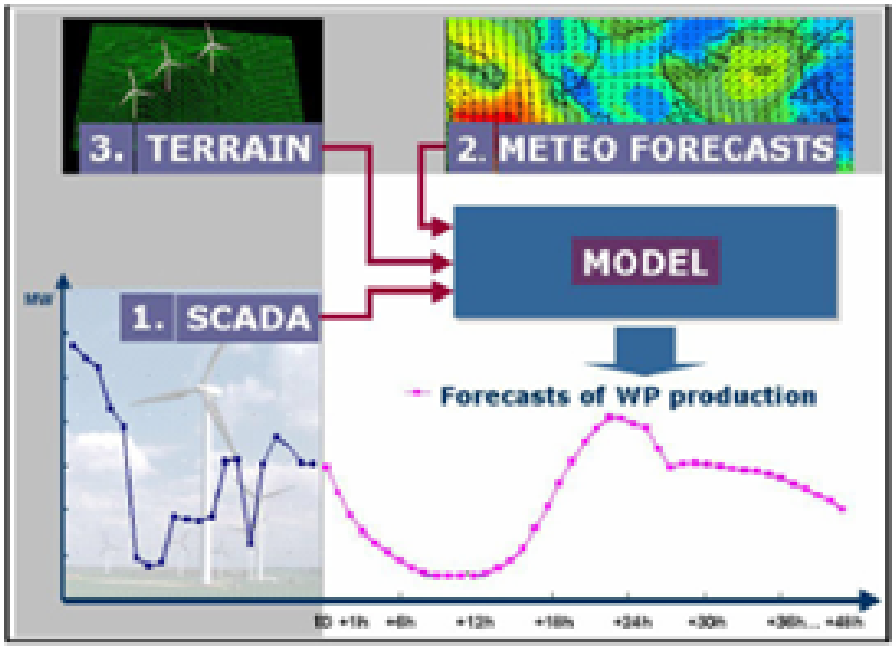


Wind generation

- Somewhat controllable



- ..and somewhat predictable



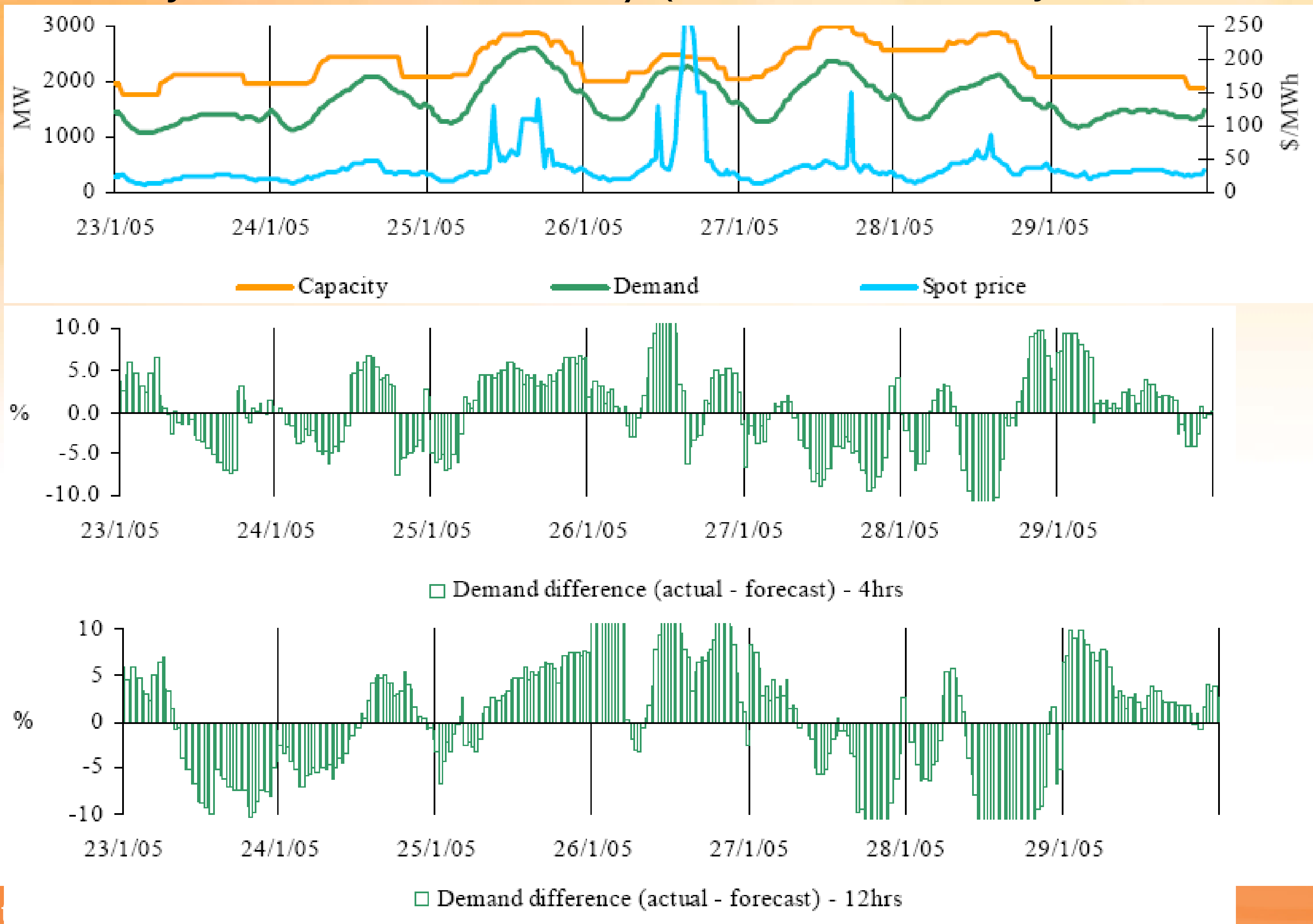
Integrating significant wind into power systems

- All loads and generators have electrical flows that are
  - Variable over time
  - Never more than partially controllable
  - Somewhat unpredictable
  - **Wind:** reliable but highly variable, limited control + somewhat unpredictable
    - *More predictable than thermal plant where unexpected variations are forced outages*
- Major part of network value arises b/c enables diversification
  - help manage variability and stochasticity of all power system resources (load, generation and network elements)
- *The operational challenge*
  - complex and time-critical systems – no cost-effective electricity storage
  - manage small disturbances but sensitive to large unexpected changes
    - Failure of large centralised generation or Tx elements
    - strong correlation between behaviour of many small generators or loads; eg. air conditioners on a hot day

      or wind farms upon arrival of storm front.

Load variability and unpredictability

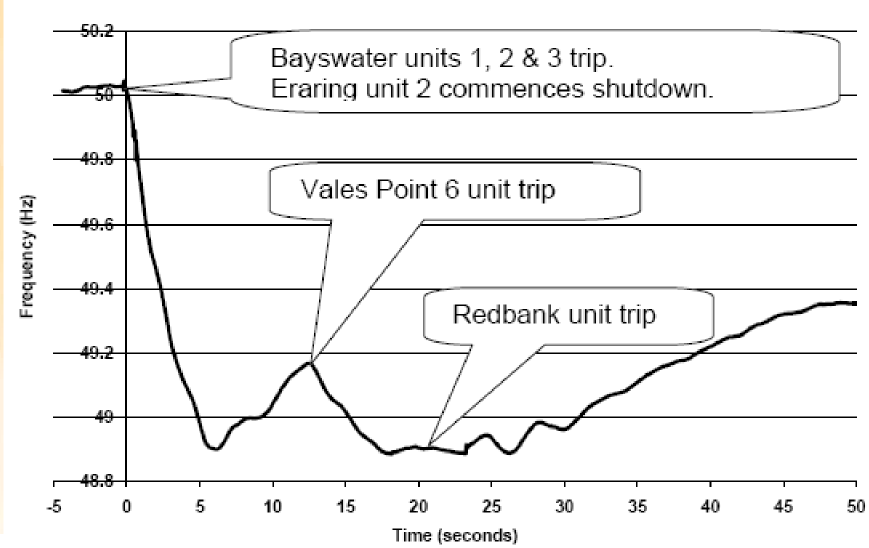
SA electricity demand cf forecasts, (NECA, Market Analysis 23-29 January, 2005)

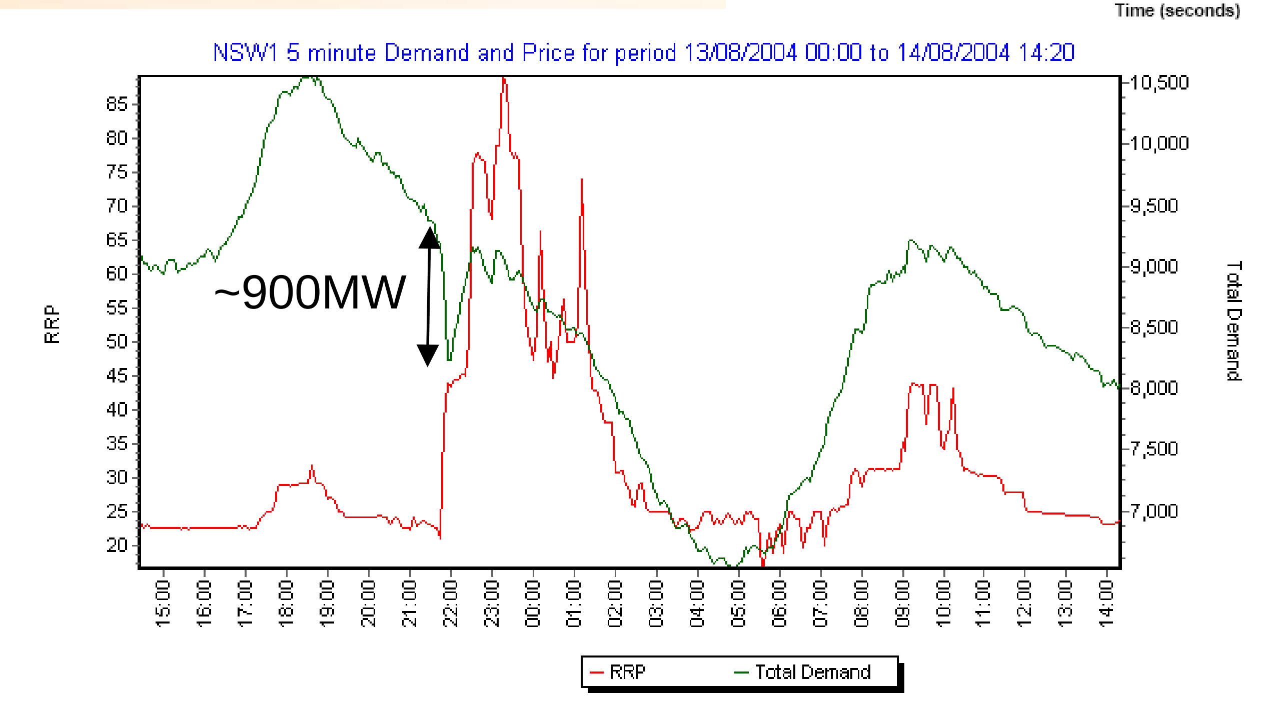


Gen variability + unpredictability

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)

Figure 1-5: Power System Frequency





Electricity industry restructuring

- Last 2 decades has seen worldwide efforts in restructuring EIs
  - structural disaggregation from monopoly (typically government owned) utilities to mix of competing firms in generation + retail markets, monopoly NSPs + centralised market and system operators
  - More decentralised commercial (market price based) decision making
  - *Outcomes to date mixed + too soon to declare success or failure*
- Some principles of good market design:
  - focus on embracing + hence better managing inherent uncertainties within EI: *uncertainty drives competition*
  - 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*
  - support for innovation to meet emerging challenges + change
  - **Markets need information: individual + centralised forecasting roles**

Commercial context for wind integration in Australia's National Electricity Market

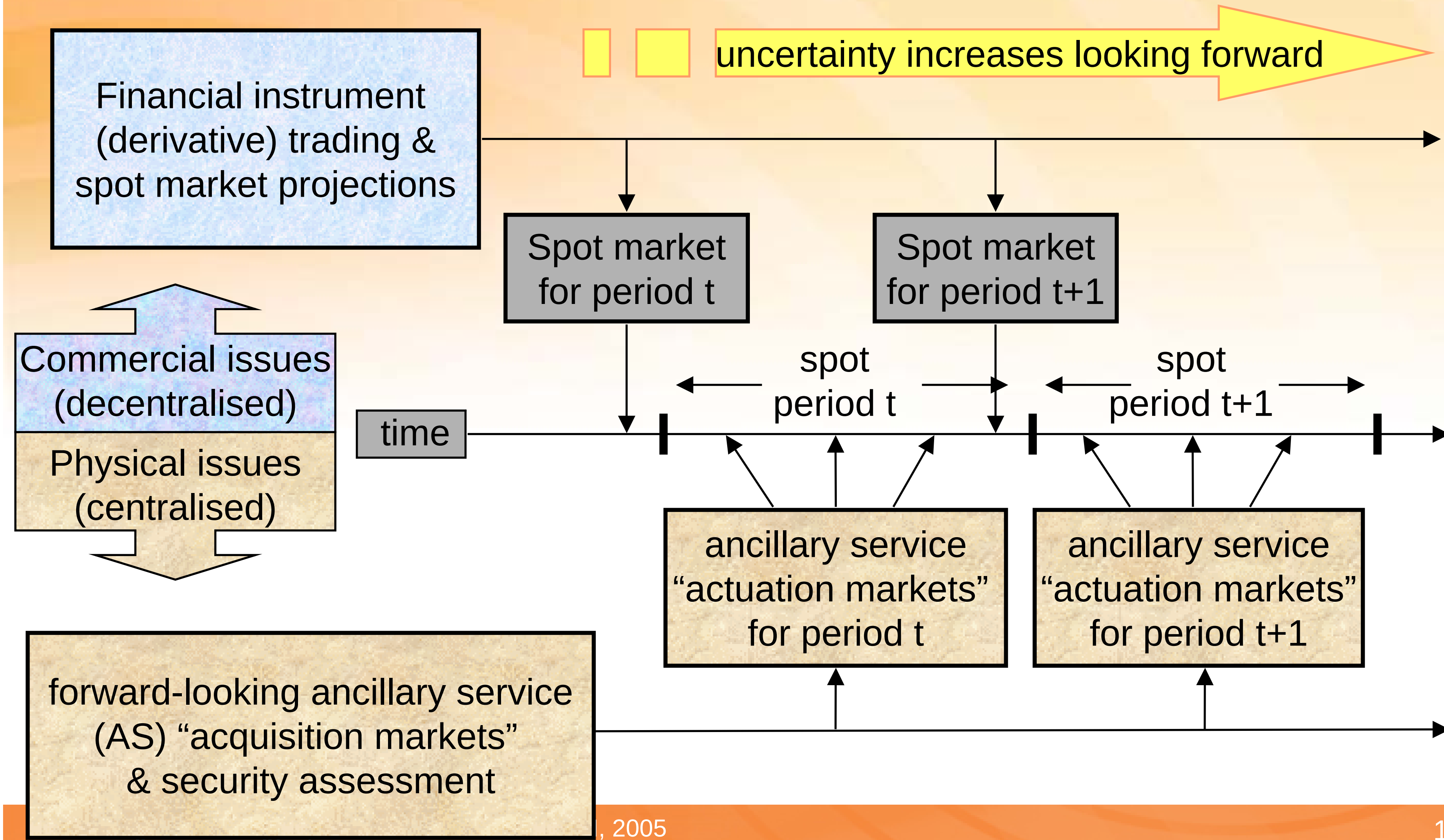
Wind farms
+
other
generators
(sellers)

National Electricity Market
Commercial activities:
- *Spot market*
- *Derivative markets*
- *Ancillary services markets*
- *Network charges*
- *REC market*

Subject to constraints:
- *Connection requirements*
- *Security requirements*
- *Regulatory requirements*

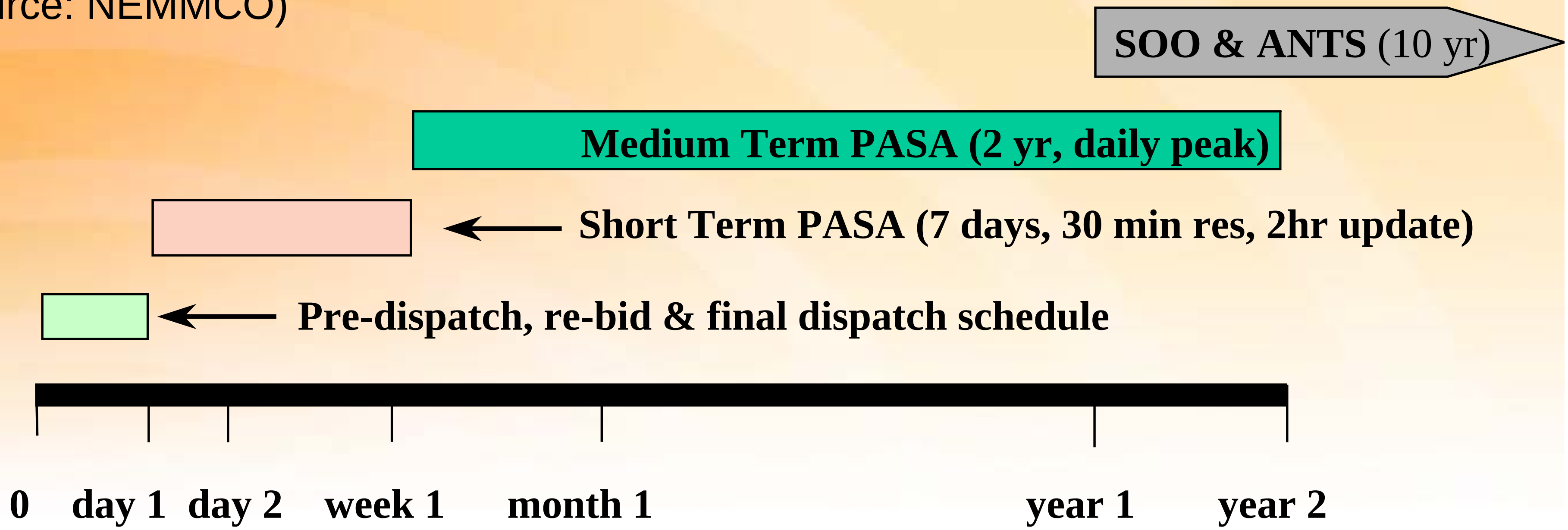
Retailers
+
large
end-users
(buyers)

Timeline for electricity trading in NEM



Dispatch, Pre-dispatch, PASA, SOO & ANTS

(source: NEMMCO)



- ST & MT Projected Assessment of System Adequacy support security assessment + participant operating decisions. ST PASA projects region demand & reserve for 7 days @ 30 min resolution, updated every 2 hours. MT PASA projects region daily peak demand & reserve for 2 yrs, updated weekly.
- Statement of Opportunities (SOO) & Annual National Transmission Statement (ANTS) support generation, demand & network investment decisions
  10 year horizon, issued annually

Decision-making frameworks to address uncertainty

Time scale	Issues	Mechanisms
< 30 minutes	• Fluctuations in generator & load power, network outages	• Security, ancillary services, spot market
30 minutes to several days	• Fluctuations in generator & load power, network outages • Inter-temporal links	• Security, ancillary services, spot & derivative markets

Weeks to years - *operation*	• Inter-temporal links, eg
	  • Retail tariff setting
	  • Hydro scheduling
		• Derivative markets supported by projections & security assessment

Weeks to years – *investment*	• Optimal investment decisions	• Derivative markets supported by projections • Policy framework

- Most disturbances >5 min left to the market to resolve
  - commercial opportunities for participants who can help manage them

Integrating wind into NEM arrangements

- NEM
  - Infused with uncertainty – *a key to competition*
    - Generators can rebid with 5 min notice, don't know dispatch beyond 5 min
  - Some success in commercialising costs + benefits
    - Forward mkts price future uncertainty for all generators + loads
    - FCAS mkts set ancillary services costs rather than monopoly utility
    - 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' some of NEM's commercial signals – eg. forward prices
  - Reasonable that they 'see' more of costs + benefits they bring to NEM
  - Good reasons to support strategic investment that supports innovation
  - **Excellent pot'l for improved wind forecasting to enhance its value**

Conclusions

- High penetration of wind energy in NEM raises many complex issues
- Improved wind generation forecasting has a vital role to play in managing these + maximising value of wind

- UNSW project will address these in two streams:
  - Integration of wind energy (prediction & control)
  - Electricity industry restructuring (to facilitate uptake)

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Thank you… and questions

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Many of our publications are available at:

www.ceem.unsw.edu.au