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# Ancillary services & their treatment in the NEM

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### UNSW THE UNIVERSITY OF NEW SOUTH WALES • SYDNEY • AUSTRALIA Trading in electricity:an abstraction from reality



### A model of electricity trading

- Spot market energy traded as a commodity:
  - Energy (that meets QOS criteria) traded during each (short) spot market interval
- Financial instruments:
  - Related to future spot market prices:
    - Convey expectations of future spot market behaviour
    - Allow risk management
- Ancillary services:

- To manage availability & quality of supply

# Managing quality of supply

- 'Quality of Supply' (QOS) attributes:
  - Voltage, frequency, waveform purity, phase balance, supply availability at each node
- Managed by:
  - 'Ancillary services' (AS) in the short term:
    - Appropriate resources under automatic control
  - Projections of future supply-demand balance
  - Investments in new resources as required
- Via appropriate commercial arrangements

#### UNSW THE UNIVERSITY OF NEW SOUTH WALES · SYDNEY · AUSTRALIA Timeline for electricity trading (requires active demand-side participation)



### AS acquisition & actuation markets



### AS Acquisition market design

- Offer to provide a service:
  - Capability statement, e.g:
    - max, min & rate of change limits
    - required lead time (starting time)
    - Minimum running time
    - dependence on acceptance of spot offer
  - 'Willingness to provide' functions:
    - for readiness
    - for actuation
  - Valid time period of offer

### AS Actuation market design

- Mainly by automatic control functions, e.g :
  - Governor, voltage regulator, AGC, economic dispatch, transformer tap changers
- Same market interval as spot market
- Requirement determined by evolving system operation:
  - Notify market participants of evolving conditions in real time to enhance responsiveness

### AS Actuation market design

- Initialised by outcomes of AS acquisition & spot markets:
  - Determine parameters & set points for control systems
  - Accepted spot market quantities provide a basis for assessing participants' AS activity
- Financial outcome resolved after the relevant spot market closes

## Potential for commercial trading

- Voltage, frequency, short term availability:
  - √ Competition to provide services (technical efficiency)
  - $\sqrt{\text{Willingness to pay for services}}$  (allocative efficiency)
  - $\sqrt{\text{Transition to a spot market solution if need is prolonged}}$
- Power system security:
   ? Market valuation of security
  - ? Competition to provide services

### Potential for commercial trading

- Waveform purity & phase balance:
  - Potential for competition in provision in service
  - Standards likely to define target outcome
  - Payment likely to be by regulated cost allocation
- Potential reduction in QOS requirements:
  - Short-term QOS excursions often acceptable:
    - 1% voltage reduction causes ~ 1% load reduction
    - 1% frequency reduction causes ~ 2% load reduction
  - Consumers may find cost effective alternatives:
    - uninterruptible power supplies, insurance

## Physical vs financial risk management

- Ancillary services are physical means for risk
  management
- 'Financial instrument' alternatives, e.g:
  - Insurance against damage caused by loss of QOS
  - Call options used to finance rapid start generators:
    - could operate in both spot & ancillary service markets
- Such alternatives enhance contestability in the provision of ancillary services

## NEM definition of ancillary services

(a wholesale market approach)

- Those services that provide for:
  - Power system security
  - Quality of supply
  - Enhanced spot trading benefits:
    - Where not provided on the basis of spot prices alone
- NEM categories of ancillary service:
  - Frequency control ancillary services (FCAS)
  - Network control ancillary services (NCAS)
  - System restart ancillary services (SRAS)

### Network Control Ancillary Services (NCAS)

- Voltage control continuous:
   NEC requires tap changers
- Voltage control contingency:
  - Reactive power resources for planned worst case conditions
  - Emergency schemes for plausible multiple contingencies
- Stability control
  - NEC requires generators to install stabilisers
    - To enhance small & large disturbance stability

### Network Control Ancillary Services (continued)

- Network loading contingency control:
  - To control transmission line flows
  - To permit full utilisation of transmission lines

# System Re-start Ancillary Services

- Power station self-start capability
- Early restoration of supply to major cities

## NEM frequency control ancillary services

- Frequency management small deviations:
  - Maintain frequency within normal band & control time error
  - Two markets (raise & lower regulation) from 10/01
- Frequency management large deviations:
  - Large step changes in demand
  - Loss of largest single generator
  - Multiple contingencies
  - Six markets from 10/01: 6 sec; 60 sec; 5 min raise
     & lower

# FCAS cost comparison before & after 10/01 (Performance of the ancillary service markets, NECA May 2003)



#### FCAS ancillary services around 50% of total AS cost since 10/01

FCAS cost 10/01-3/03: sourced globally (top) & by region (bottom) (Performance of the ancillary service markets, NECA May 2003)



### Current situation with NEM FCAS

- ACCC determination on Regional Pricing of Ancillary Services, 17/9/03:
  - Participants in each region will bear costs when prices set by region
  - NECA to undertake a broader review
- Theoretical underpinnings of current FCAS
   arrangements appear to be weak

#### Relationship between main commercial markets & physical reality Main commercial markets Spot & FI markets: Set commodity targets Commercial for ancillary services disturbances Manage persistent physical disturbances Manage commercial disturbances Projected Spot market cost of Unresolved energy physical meeting targets disturbances future targets **Physical reality** Ancillary services: Physical Direct physical behaviour disturbances towards future energy targets

- Reject physical disturbances
- Sufficient for expected tasks

### frequency control & NEM 5-30 minute spot market



# A generator responding to dispatch & small disturbance frequency control



# A generator tracking five-minute dispatch targets with AGC raise/lower bounds

bayswater 1



#### UNSW THE UNIVERSITY OF NEW SOUTH WALES • SYDNEY • AUSTRALIA Finite horizon ramping control example (S Samuelsen, 2001)

Spot market target & produced power for The Total, G1, G2, G3 and G4 (MW)



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### Large disturance frequency control: loss of NSW 660 MW Generator (source: NEMMCO)

Frequency control capability requirement = R



typical minimum load of 10 GW

### Indicative AS response to a unit outage



### NEM frequency tolerance bands

State	Frequency band (Hz)
Normal	49.85 Ğ 50.15(99% of time) 49.75 Ğ 50.25(1% of time)
Single generator contingency	49.5 Ğ 50.5
Other credible contingency	49.0 Ğ 51.0
Emergency	47.0 Ğ 52.0

### Distribution of frequency in the NEM, June 2003 (Reliability Panel Annual Report, 2002-3)



#### UNSW THE UNIVERSITY OF NEW SOUTH WALES • SYDNEY • AUSTRALIA Frequency events outside the normal operating band in the NEM due to contingencies, 2002-03 (Reliability Panel Annual Report, 2002-03)



Duration outside normal operating band (seconds)

### Projected surplus reserves NEM states

(Medium growth + extreme (10% POE) weather, NEMMCO SOO, July 03)



Advanced or publicly announced generation projects by fuel type & compared to expected reserve deficit in 2008/09



### Conclusions

- Ancillary services are an essential part of a competitive electricity industry:
  - Required to maintain availability & quality of supply
  - Critical in determining the need for investment
- AS most important at consumer nodes:
  - Primarily distribution rather than transmission issue
  - AS presently dealt with at the wholesale level:
    - Bias towards large participants
- Australian approach to AS is still evolving:
  - Unresolved issues include boundary problems