Centre for Energy and Environmental Markets

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Experience with Market-Based Ancillary Services in the Australian National Electricity Market

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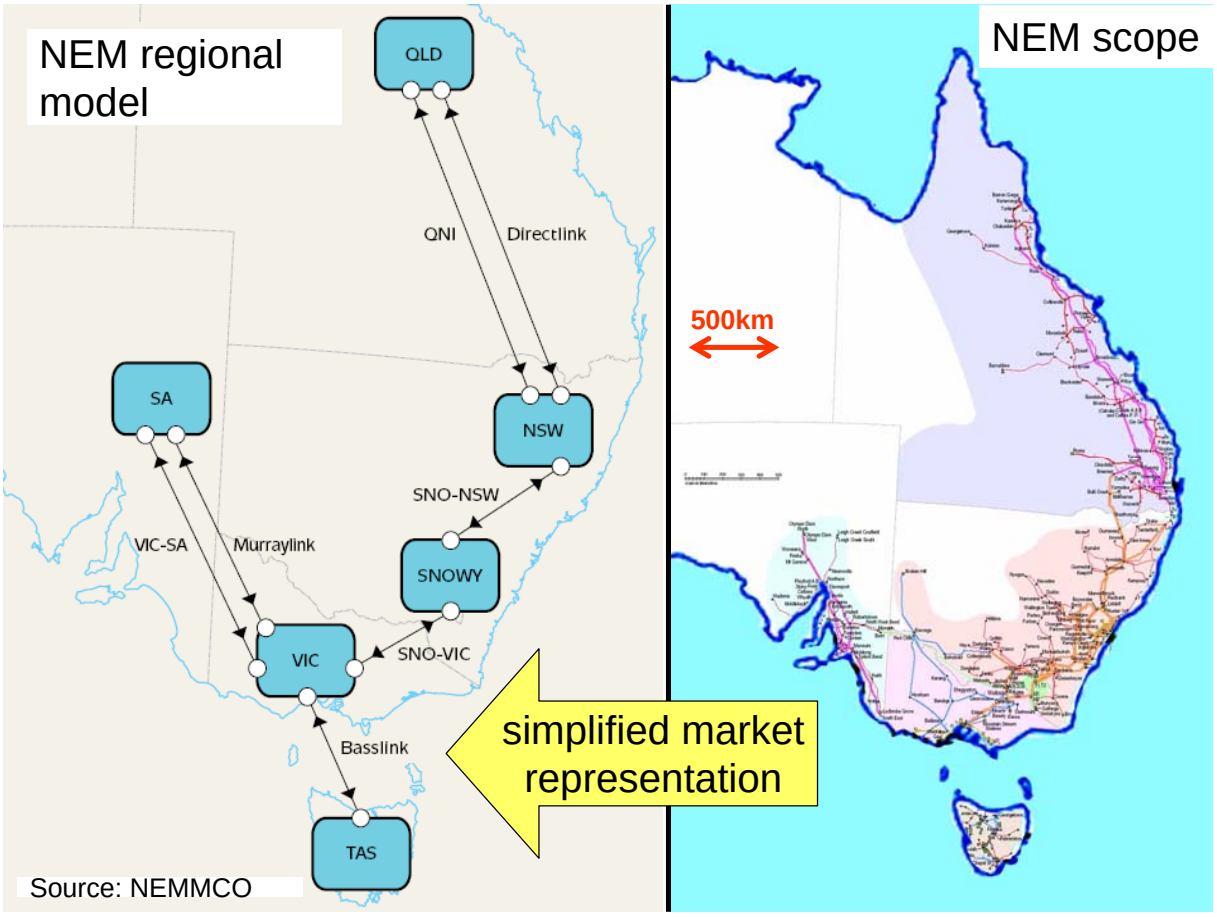
Outline

- brief overview of Australian National Electricity Market (NEM)
- key features & design choices of the NEM market-based ancillary service arrangements
- outcomes of the market-based ancillary services to date
- comment on strengths & weaknesses

Key Features of Australia's NEM

- regional market model covers south-eastern states
- compulsory participation for generators >= 30MW
- 5-min regional gross pool electricity spot market LP:
  - energy pricing & dispatch (based on generation offers, demand-side bids & load forecast)
  - market-based frequency control ancillary services are simultaneously priced and 'enabled' for 8 service types
  - many linear security constraints
- offers and bids for energy services and ancillary services can be revised as required (effectively no gate closure)
- all prices capped at $10,000/MWh
- inputs & outputs for all market processes including 5-minute spot market are published either immediately after calculation or the following day



Ancillary Services in the NEM

- Frequency Control Ancillary Services (FCAS)
  - maintain frequency close to 50Hz
  - market-based arrangements commenced Sept. 2001
- Network Control Ancillary Services (NCAS)
  - management of voltage magnitude & network power flows
  - non-market AS (long-term contracts)
- System Restart Ancillary Services (SRAS)
  - restart the system (or part thereof) following blackout
  - non-market AS (long-term contracts)

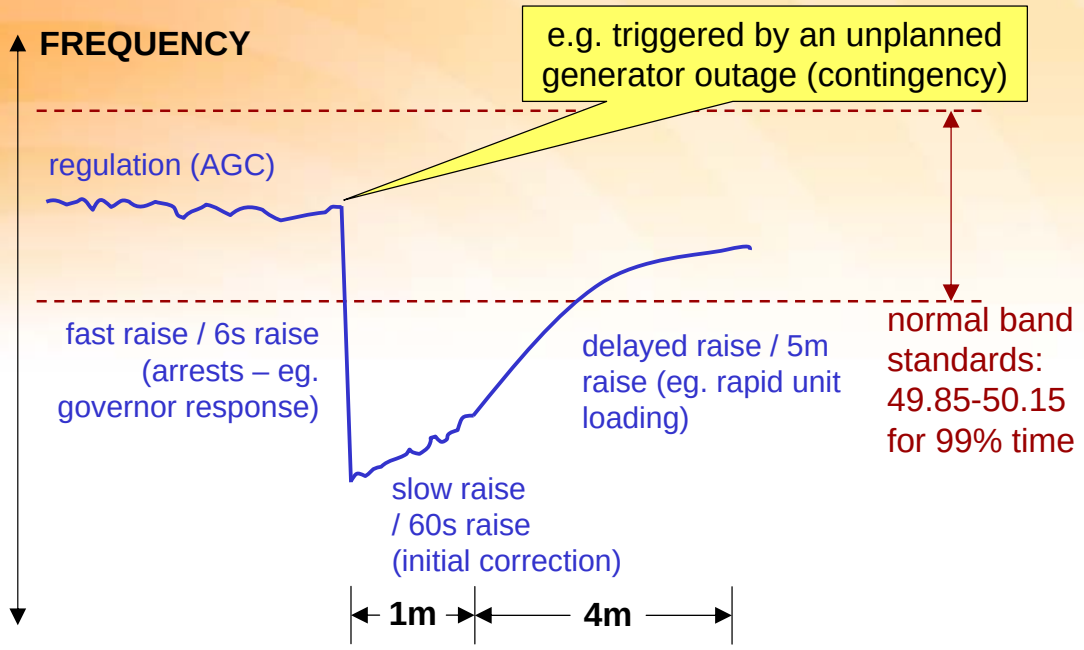
FCAS Responsibilities

- AEMC (Australian Energy Market Commission)
  - specifies power system frequency standards
  - assesses NEMMCO's performance in satisfying standards
- NEMMCO (Market & System Operator)
  - maintain secure power system
  - purchase sufficient ancillary services to achieve this
  - charge cost back to market participants
  - monitor system performance & verify service delivery
- Market participants
  - deliver ancillary services if required

8 Frequency Control AS Markets

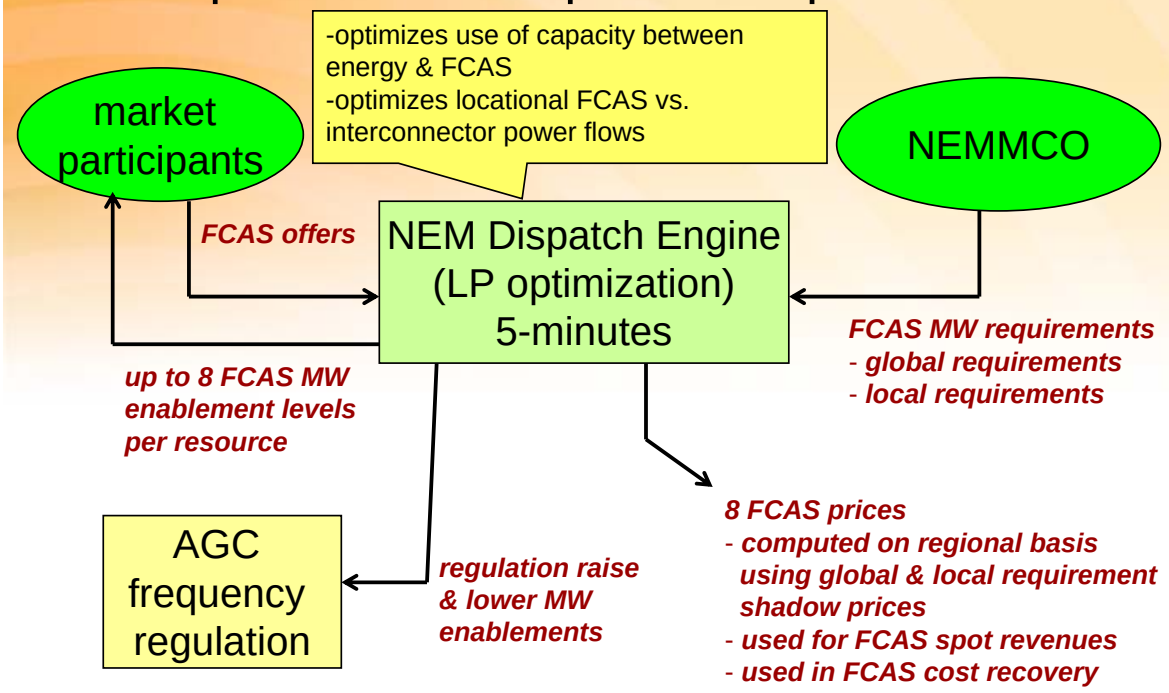
Service class	Service name	Description
regulation	regulation raise	continuous correction of small freq. deviations – AGC manages it
	regulation lower	
contingency	raise 6s (fast raise)	arrest a large frequency deviation – governor response & under-frequency load shedding
	lower 6s (fast lower)	
	raise 60s (slow raise)	stabilise and commence correction of frequency following large frequency deviation
	lower 60s (slow lower)	
	raise 5m (delayed)	response to return the system to the normal frequency band – rapid unit loading & unloading
	lower 5m (delayed)	

Defining Frequency Control Ancillary Services (FCAS)



source: NEMMCO

NEM Spot Market – inputs & outputs for FCAS

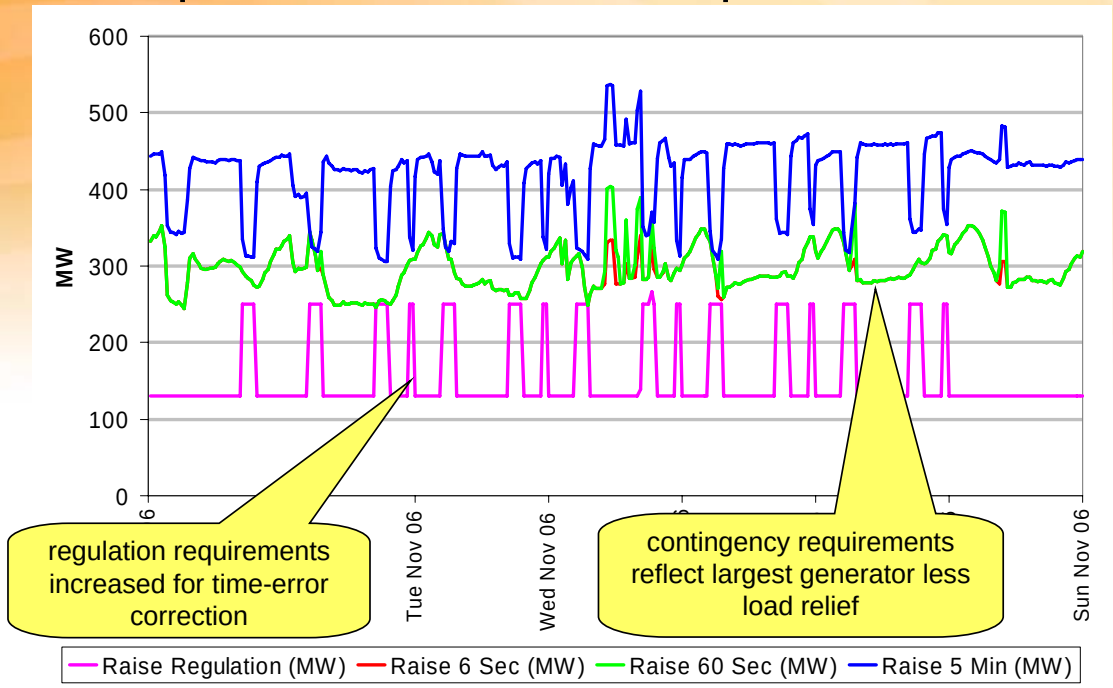


Setting FCAS Requirements

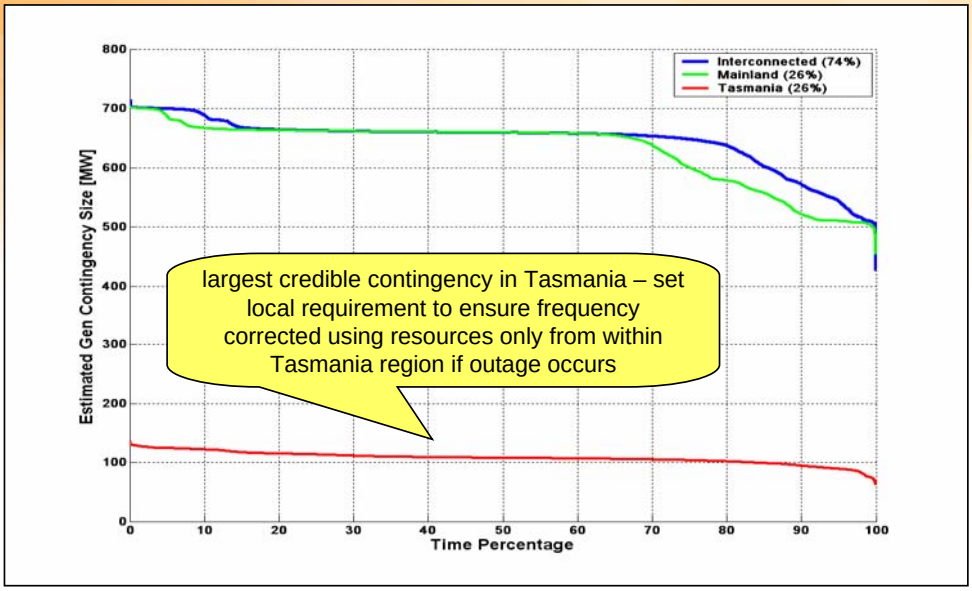
Service class	Service name	Requirement setting process
regulation	regulation raise & regulation lower	Set on a trial & error basis where each month the performance of the system is assessed and levels increased accordingly.
contingency	raise 6s, 60s, 5m	Based on the largest generator contingency less an allowance for load relief. For 5m trade-off between raise regulation.
	lower 6s, 60s, 5m	Based on the largest load block that could fail less an allowance for load relief. For 5m trade-off between lower regulation.

global requirements & local requirements

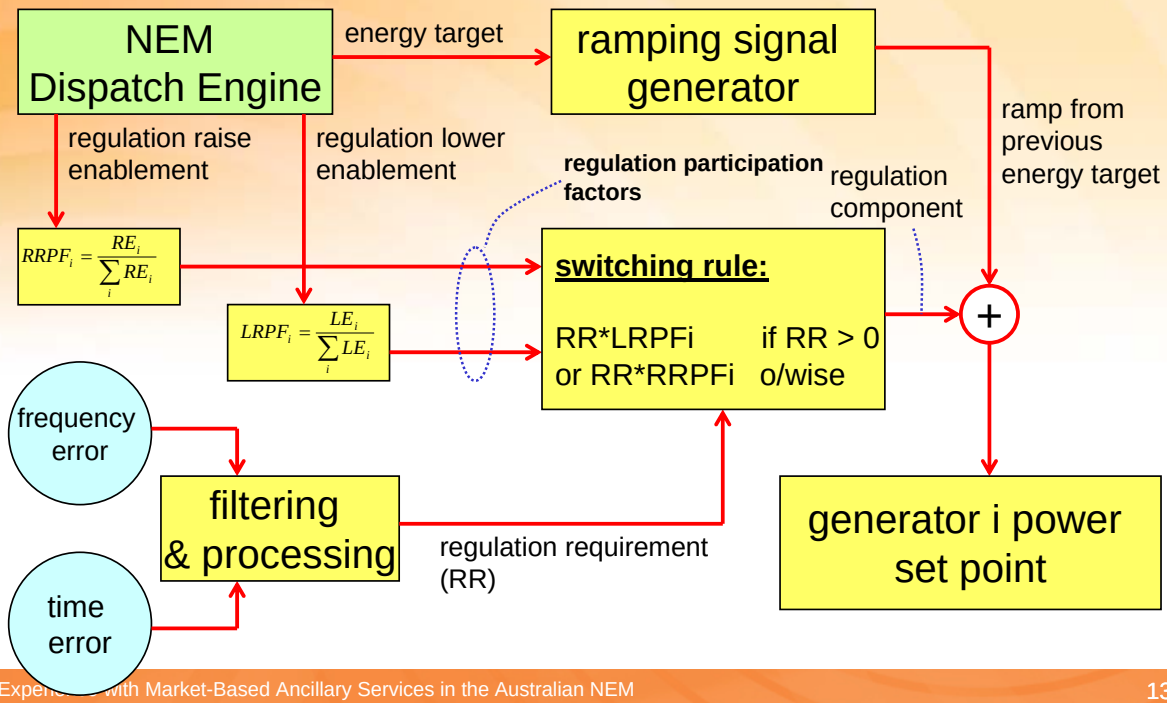
Example of Raise FCAS Requirements



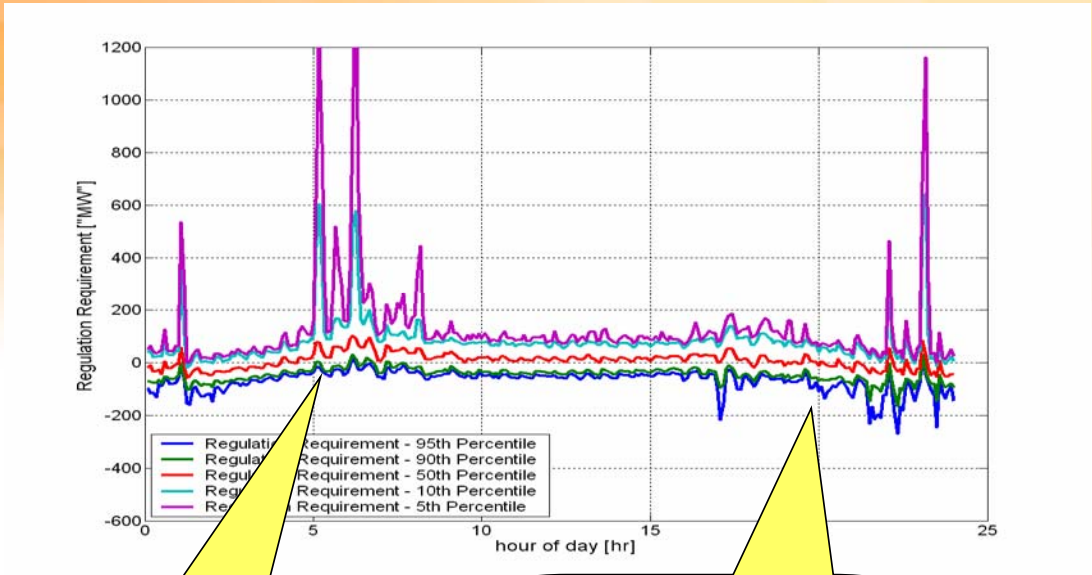
Largest Generator Contingency Duration Curves



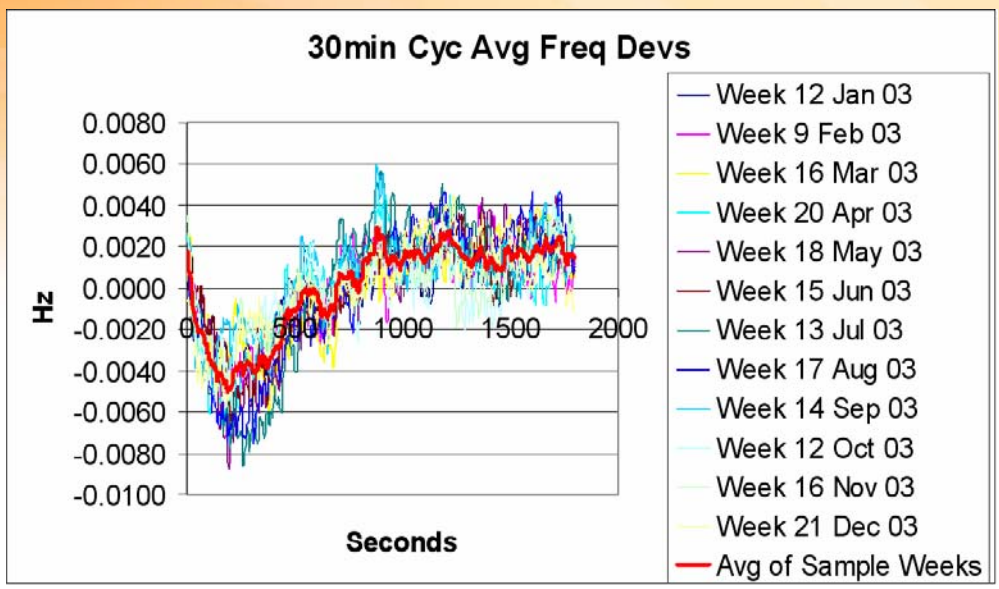
Interface between market & control systems



Regulation Requirement Profile



30-minute trading & observed frequency deviation pattern



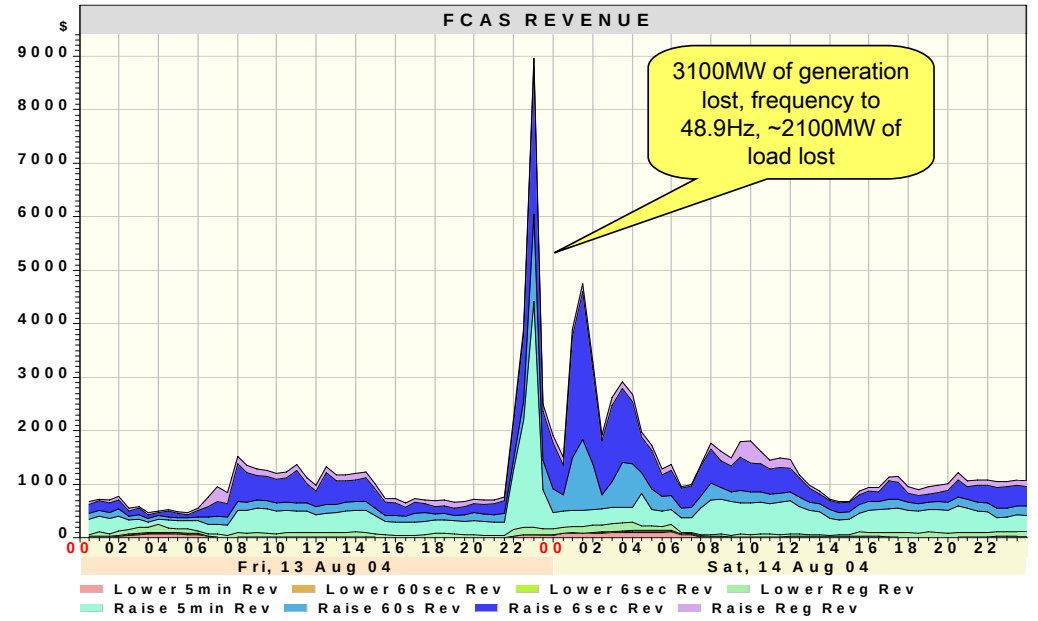
FCAS spot revenue

- FCAS service providers are only paid for enablement – no usage payments
- FCAS revenue is resolved on 5-minute basis:

$$\text{FCAS Revenue} = \frac{\text{FCAS Price} \times \text{FCAS Enablement}}{12}$$

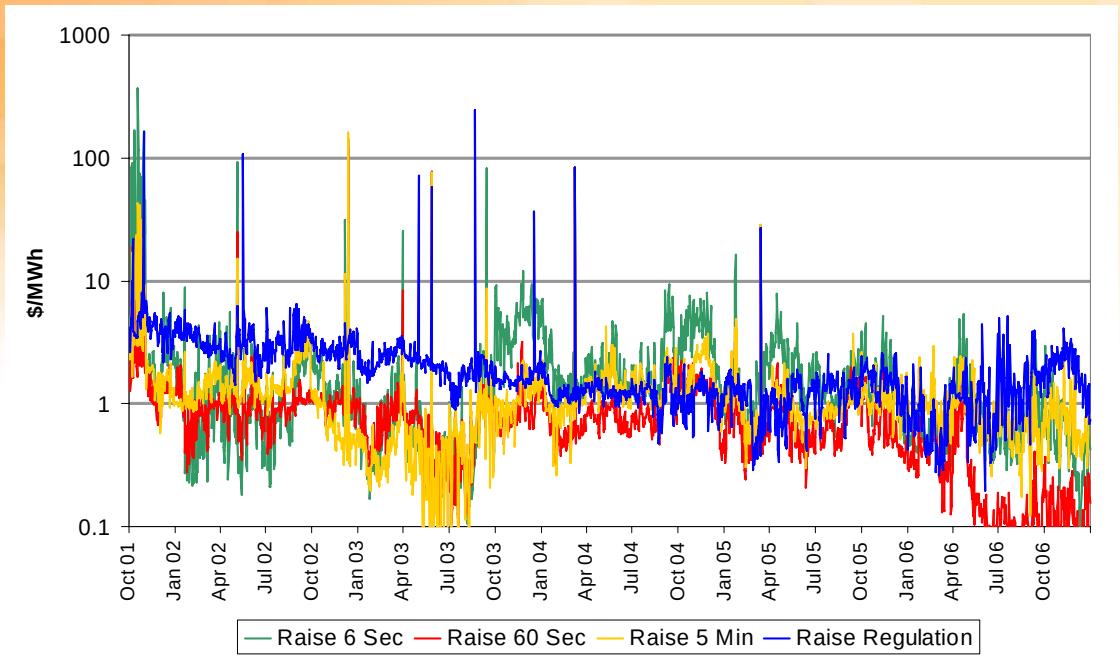
- FCAS costs recovered from NEM participants

FCAS revenue streams (13/8/04)

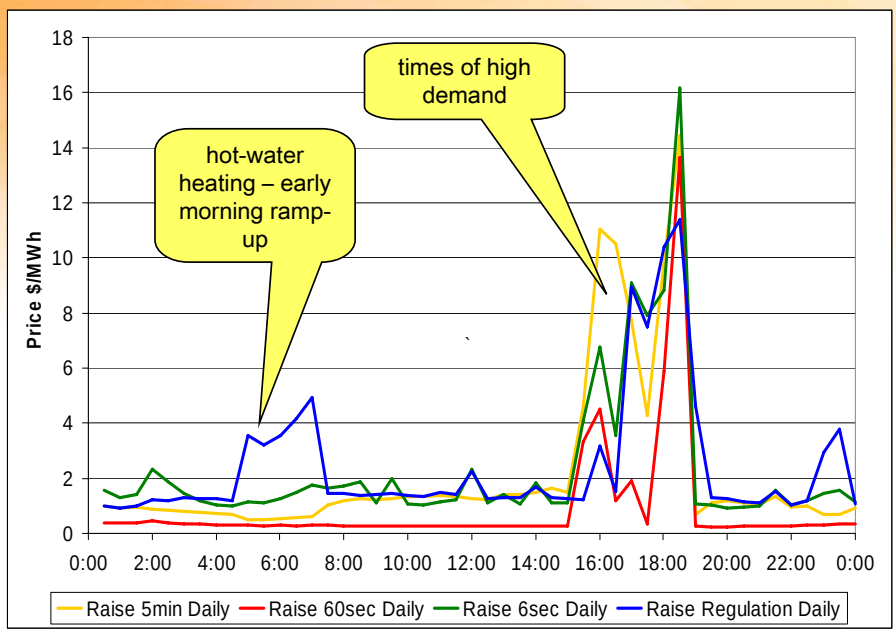


source: Intelligent Energy Systems

FCAS raise prices (daily-averages since '01)

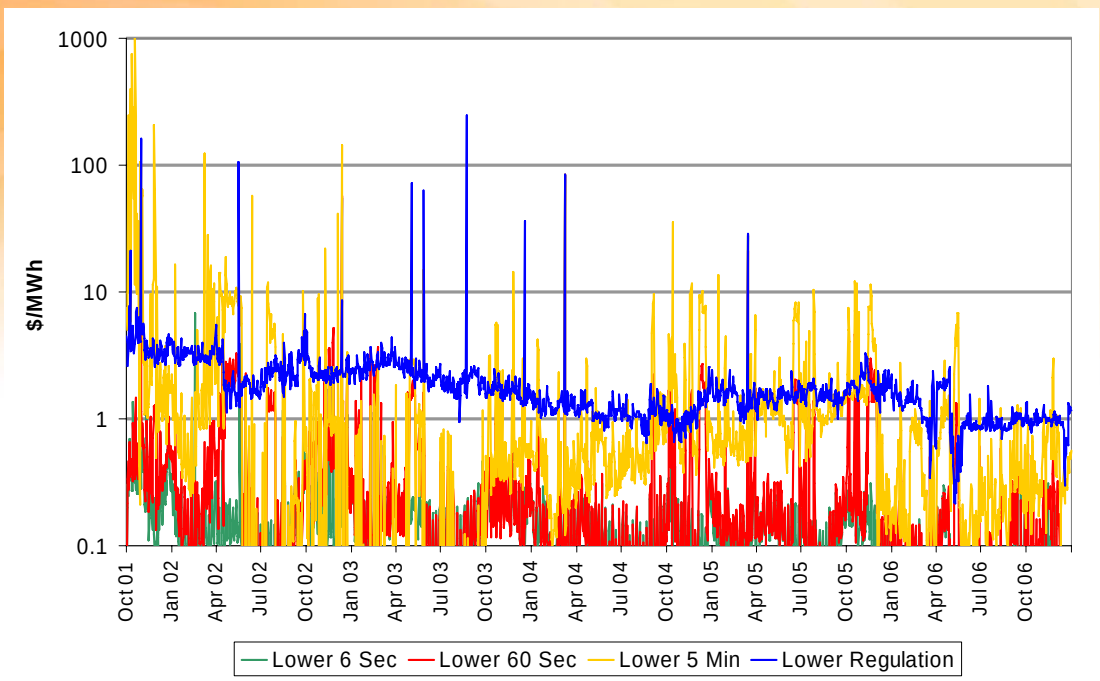


Raise FCAS average daily price profile

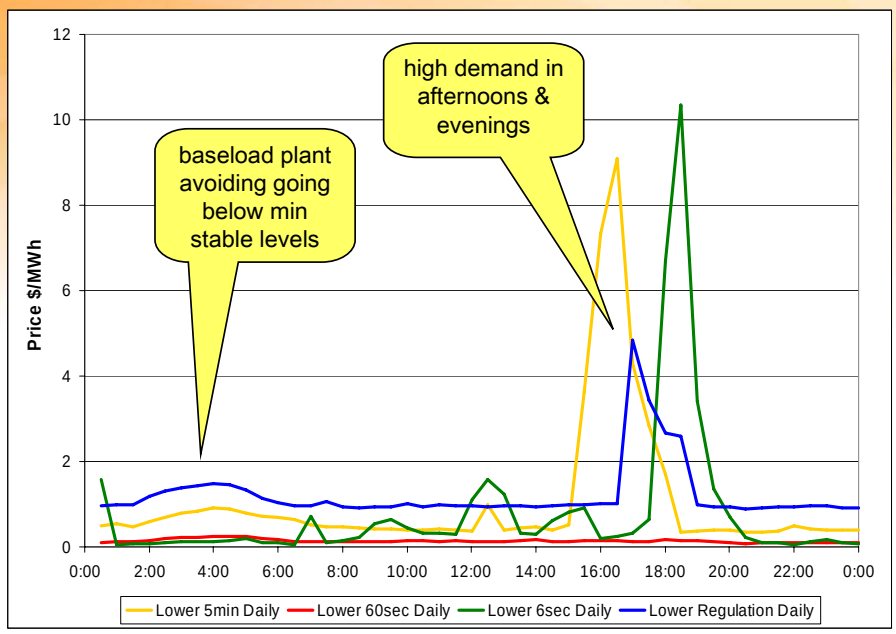


daily cyclic mean calculated for June 06 – June 07

FCAS lower prices (daily-averages since '01)

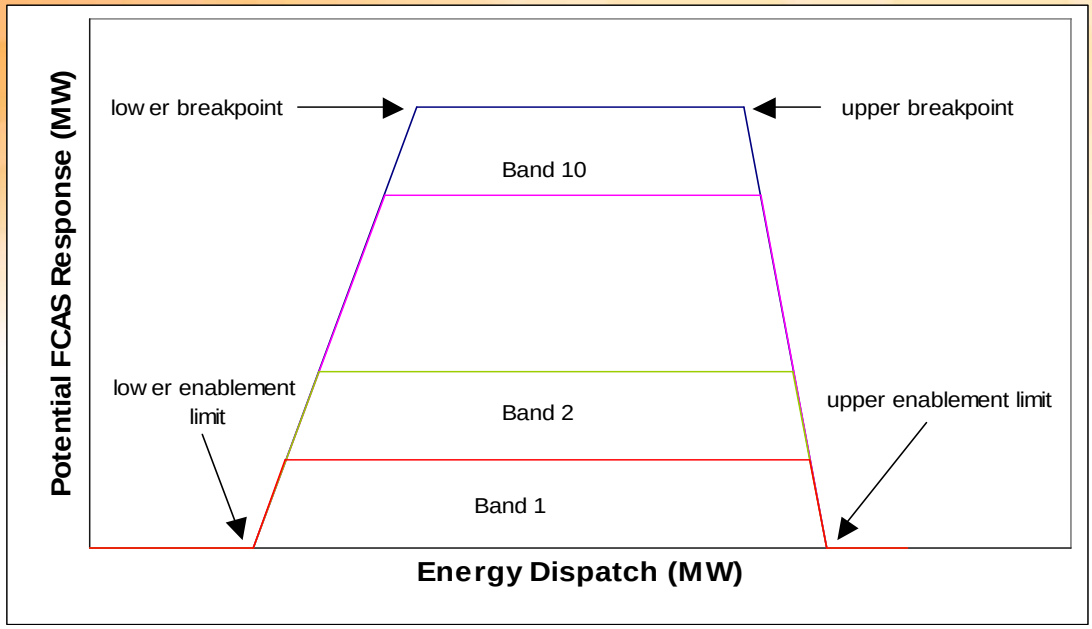


Lower FCAS average daily price profile



daily cyclic mean calculated for June 06 – June 07

Market interface for FCAS providers



source: Intelligent Energy Systems

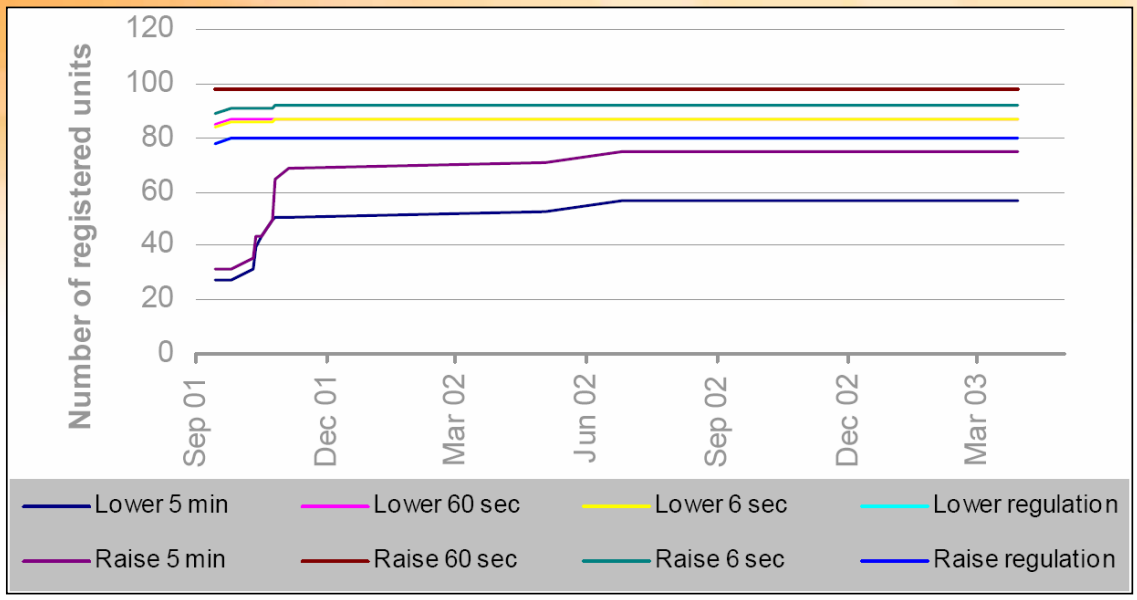
FCAS participation

- generally more participants have installed necessary control systems & entered into the FCAS markets
- rebidding in FCAS occurs frequently – gaming vs. management of technical issues?

Fuel source	Raise regulation average enablement (%)	Lower regulation average enablement (%)	Raise contingency average enablement (%)	Lower contingency average enablement (%)
Black Coal	45%	38%	43%	43%
Brown Coal	19%	9%	16%	16%
Hydro	31%	45%	36%	36%
Gas / Oil	5%	8%	6%	6%

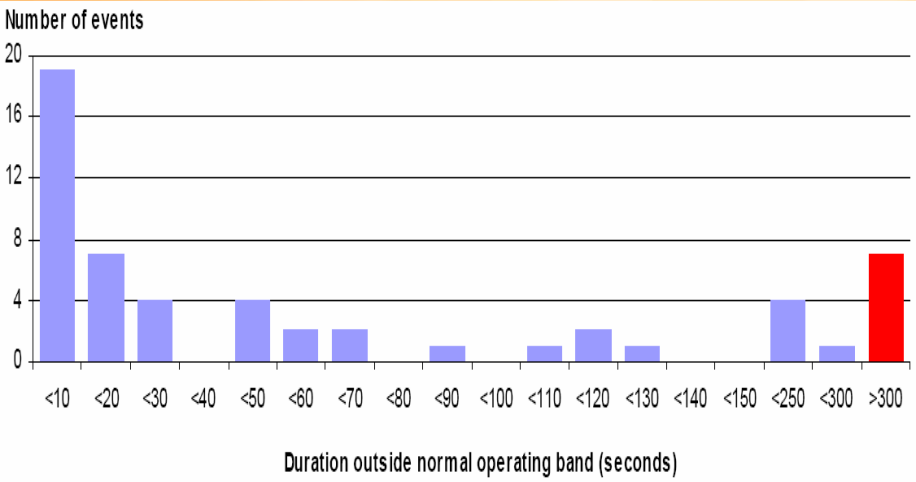
calculated for calendar year 2006

Entry into FCAS markets up to '03



source: NECA

Number & duration of Frequency Events FY 04/05



- Outworking of AEMC reliability / security monitoring process

source: AEMC

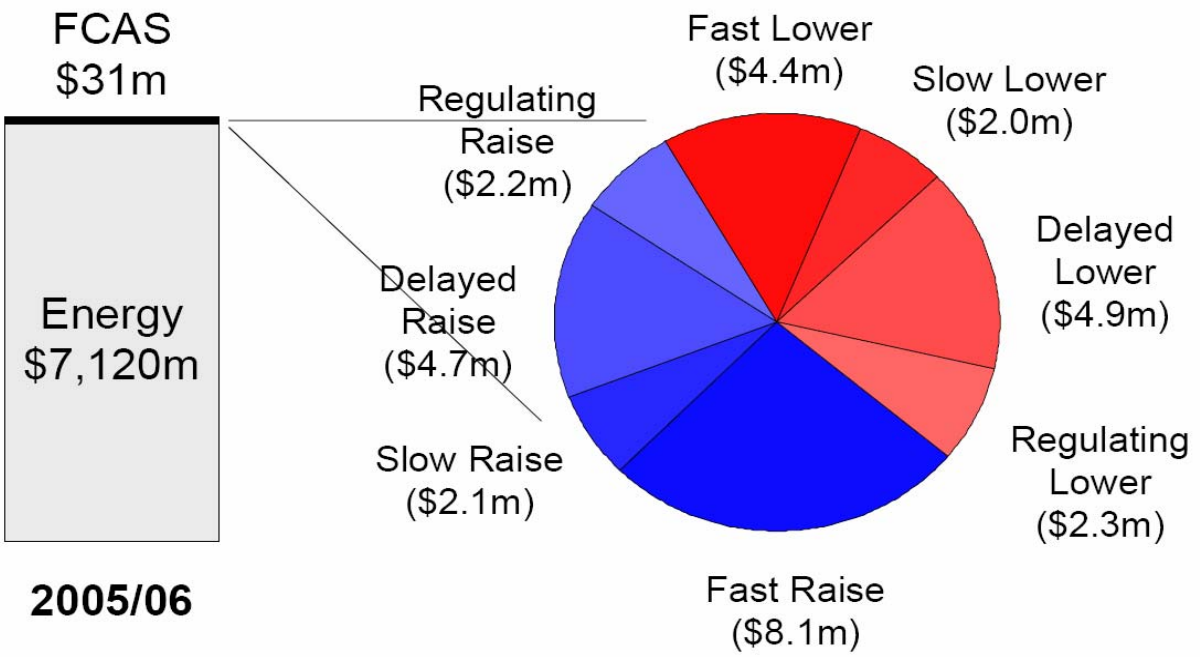
FCAS cost Recovery

- Raise contingency services
  - cost of 3 raise contingency services split between generators based on metered energy
- Lower contingency services
  - cost of 3 lower contingency services split between loads based on metered energy
- Regulation service costs
  - split between generators & loads based on ‘causer-pays’
  - 4s SCADA data processed to identify generators & loads that gave rise to need for frequency regulation
  - fraction of cost calculated using correlations between deviations from spot market targets (or lines of best fit) & regulation control signal

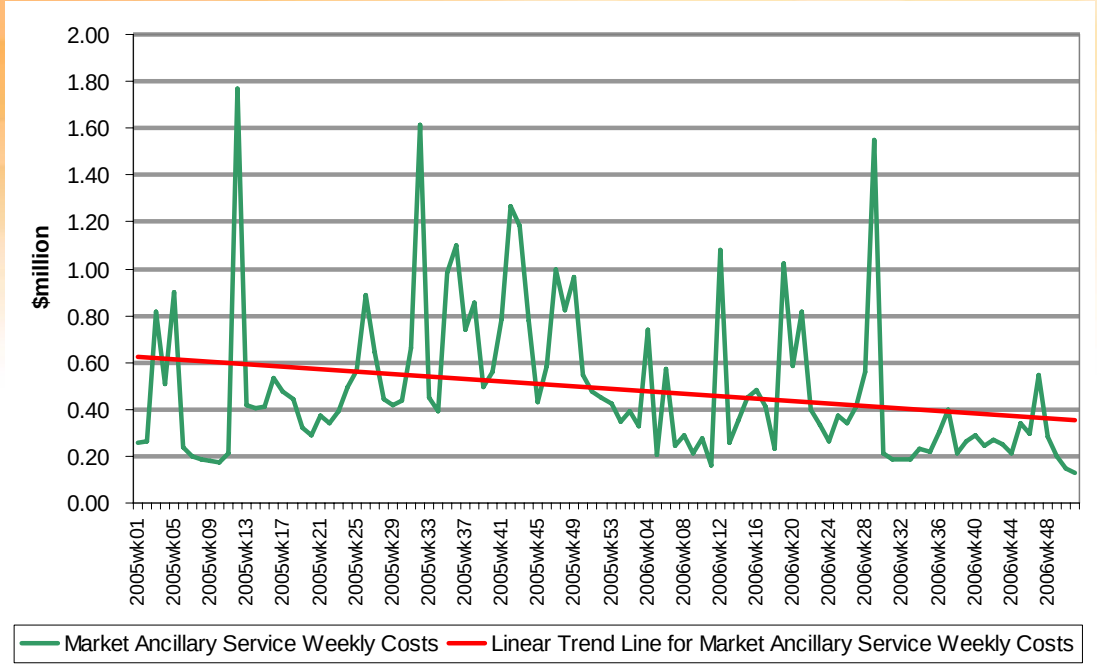
Observations of FCAS costs

- very low ~ 0.4% of market turnover
- significant part of costs associated with rare-events where prices increase dramatically due to network outages requiring local sourcing of service providers (smaller pool of resources)
- generally declined over time, numerous factors:
  - NEMMCO has refined algorithm with time which has generally increased level of co-optimization
  - increased number of service providers
  - increased interconnection in the NEM (QLD & TAS regions) increased pool of providers
  - participants better able to manage trade-offs between FCAS & energy

FCAS Costs for FY 05/06



Market Ancillary Service Costs since '05



Strengths

- arrangements have resulted in very low FCAS costs
- very few incidents where frequency standards have been breached
- generally a robust set of arrangements that have worked during large disturbances (e.g. Jan 16 '07)
- clear assignment of roles, responsibilities & principles
- processes in place to improve efficiency of existing arrangements where possible
- services offered by broad different types of generators (hydro, gas-fired, coal-fired)

Weaknesses

- only market-based arrangements exist for frequency control (e.g. voltage & other ancillary service markets could be envisaged)
- arrangements have increased complexity of spot market trading
- mismatch between FCAS model & physical reality
- boundary issues between services & market vs. AS
- minimal demand-side participation & generators connected to the LV portion of grid
- lack of hedging instruments for FCAS

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S. R. Thorncraft, H. R. Outhred, "Experience with Market-Based Ancillary Services in the Australian National Electricity Market", Proceedings of the IEEE PES General Meeting Tampa Florida, USA, June 24-28 2007, available: www.ceem.unsw.edu.au.

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