



# CEEM Specialised Training Program

## *El Restructuring in Australia*

# Ancillary services and power system security in the NEM

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Centre for Energy and Environmental Markets

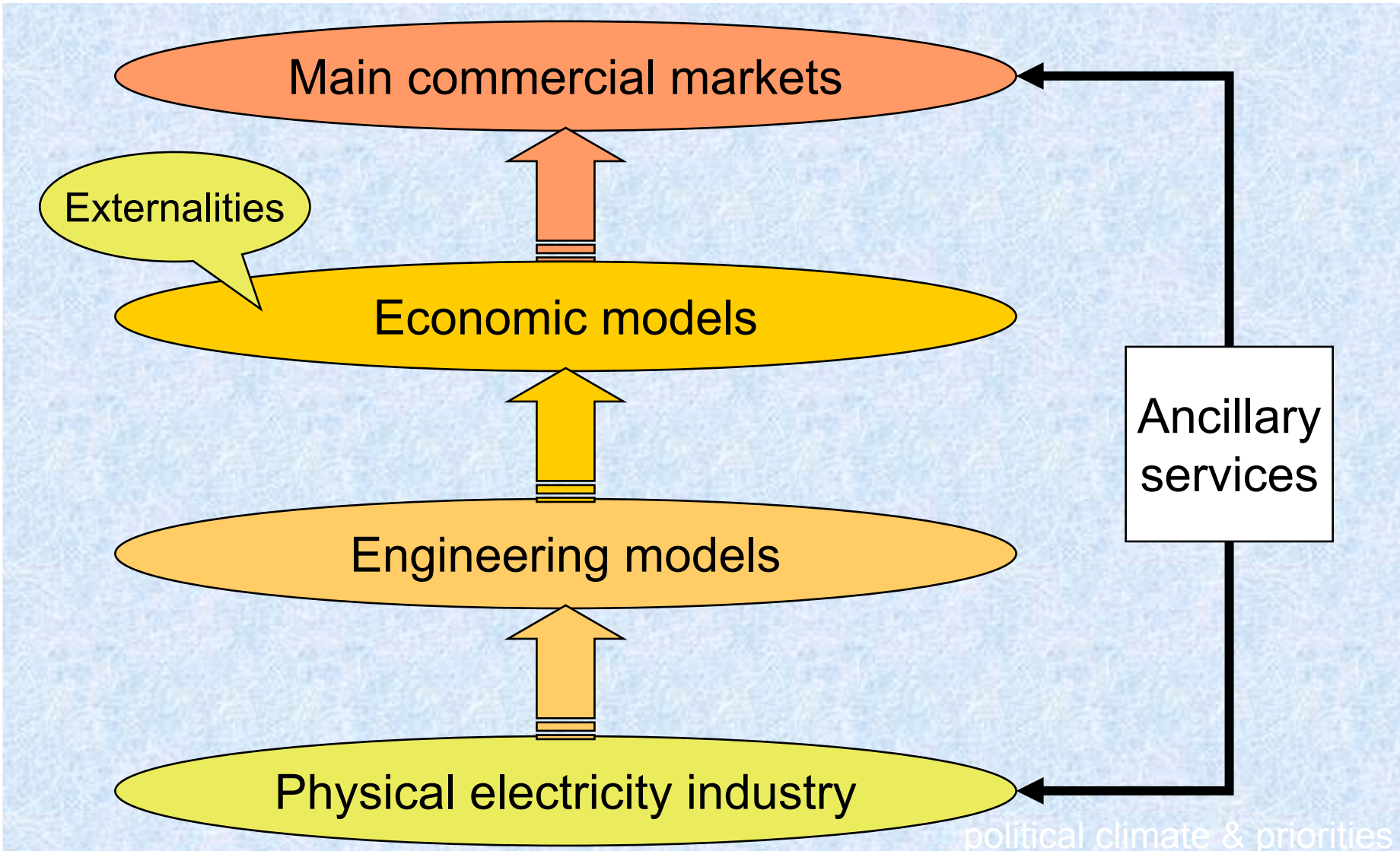
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# Ancillary services link commercial mkts with physical EI



# 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

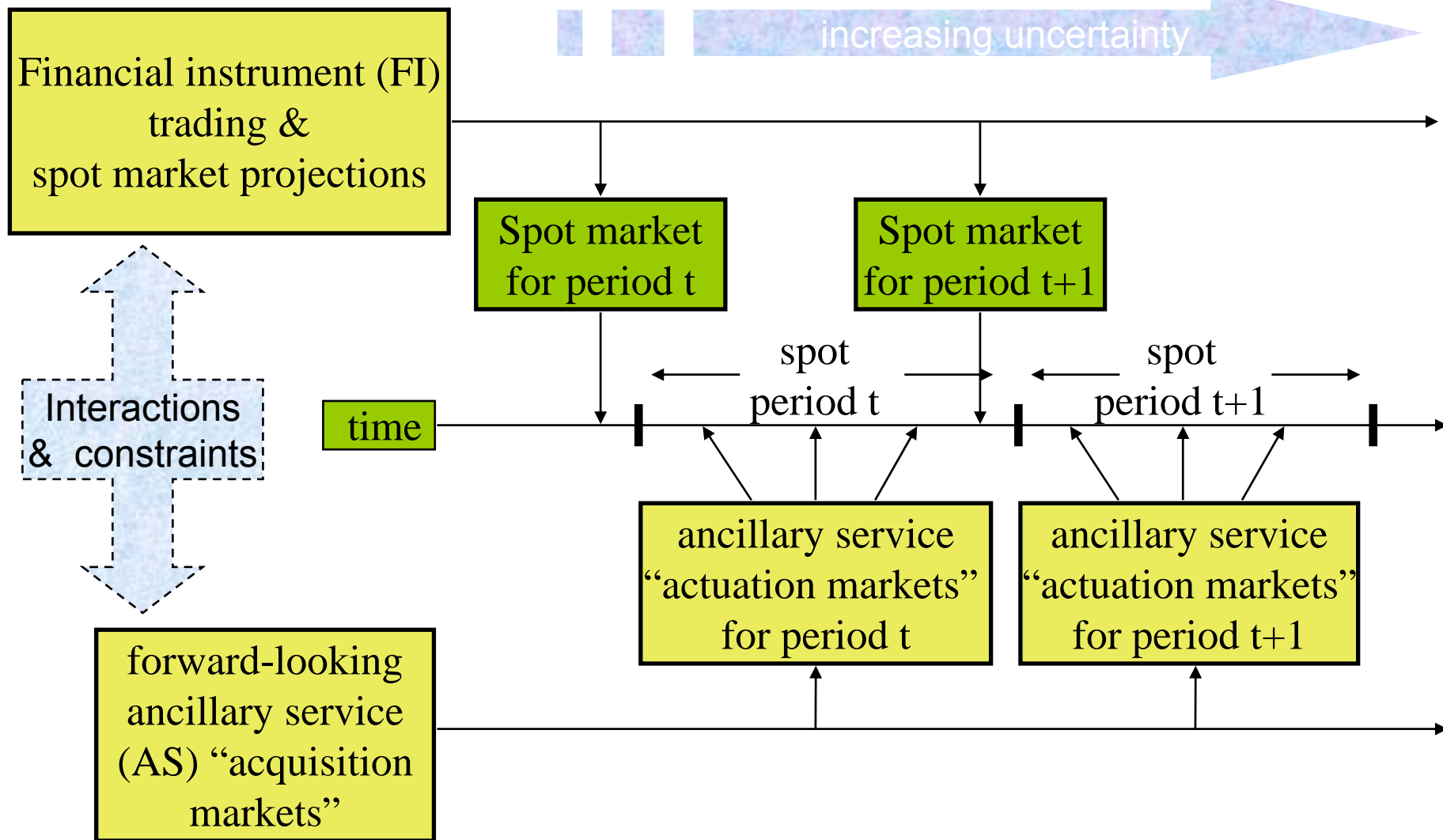
- ‘Quality of Supply’ (QOS) attributes:
  - Voltage, frequency, waveform purity, phase balance, supply availability *at each node*
- Managed by:
  - ‘Ancillary services’ (AS) in the short term:
    - Appropriate resources under automatic control
  - Projections of future supply-demand balance
  - Investments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

# Indicative control capabilities

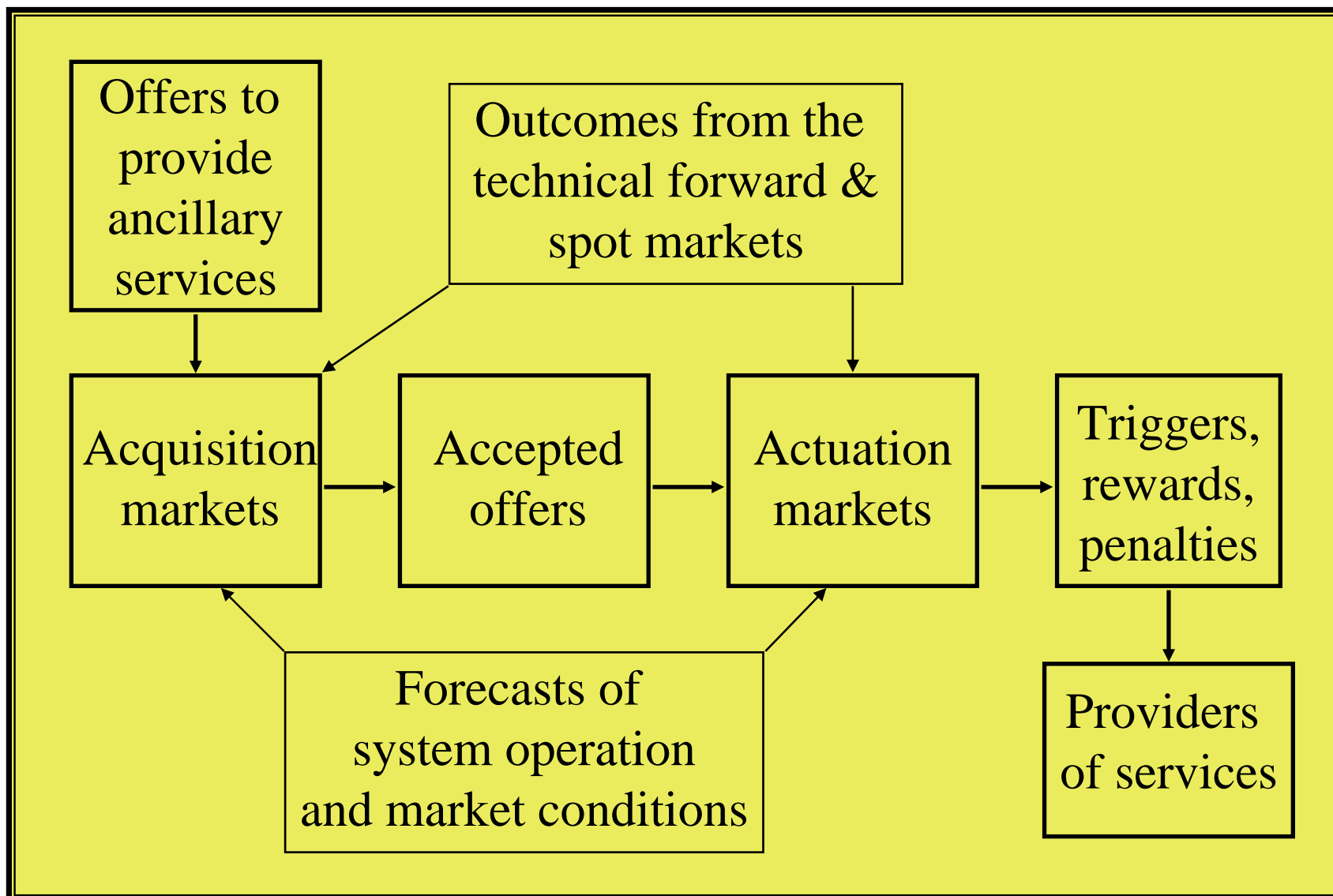
Technology	Controllable?	Start-up time	Ramp-rate limit
Steam cycle	Yes	5-24 h	+5%/min
CT	Yes	5 min	+20%/min
Hydro	Yes	1 min	+50%/min
Wind	No	-	-
Solar	No	-	-
Load	Yes	1sec	100%/sec

# 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

- Initialised by outcomes of AS acquisition & spot mkts:
  - Determine parameters & set points for control systems
- Acts mainly by automatic control functions, e.g :
  - Governor, voltage regulator, AGC, economic dispatch, transformer tap changers
- Same market interval as spot market
- Requirement det. by evolving system operation:
  - Notify market participants of evolving conditions in real time to enhance responsiveness

# Potential for commercial trading

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

# Power system security definitions

(National Electricity Code Chapter 4)

- Satisfactory operating state:
  - Frequency “normal” (49.9-50.1Hz), except for brief excursions within 49.75-50.25Hz
  - Voltage magnitudes within specified limits
  - All equipment operating within equipment rating
  - All plausible fault currents within breaker ratings
- Contingencies (equipment outages):
  - Credible, eg single generator or network element
  - Non-credible, eg multiple outages except in abnormal conditions, eg severe weather, bush fires

# Power system security definitions ctd

(National Electricity Code Chapter 4)

- Secure operating state:
  - Currently in a satisfactory operating state
  - Would return to a satisfactory operating state following any single credible contingency:
    - Non-credible contingencies can sometimes become credible, eg SA-Vic Heywood double circuit trip during lightning activity
- Technical envelope:
  - Boundary surface of secure operating states:
    - Which depends on load forecasts, equipment capabilities and their current operating constraints

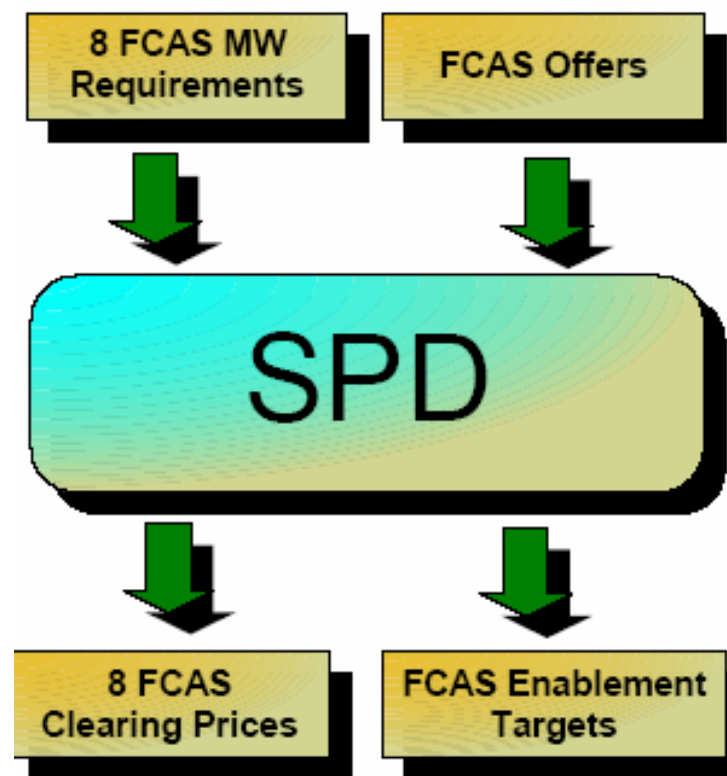
# Power system security tasks & states

(National Electricity Code Chapter 4)

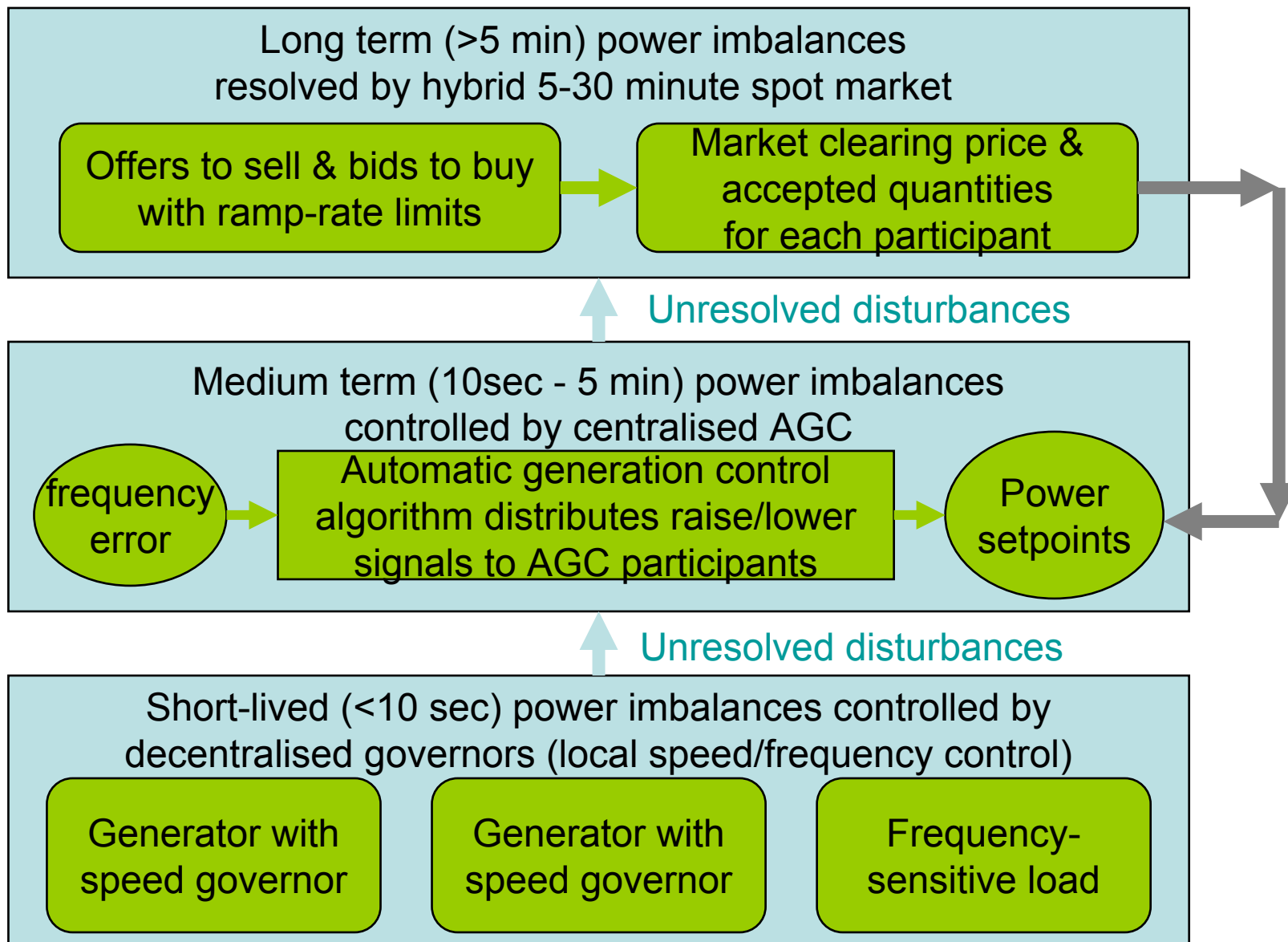
- Maintaining power system security:
  - Keep power system in a secure operating state
  - Return to a secure operating state as soon as possible following a non-credible contingency
  - If necessary to maintain security, shed load if frequency is outside the normal operating frequency excursion band (49.75-50.25Hz)
- Reliable operating state:
  - No load has been or is expected to be shed
  - Reserves adequate for at least next 12 weeks

# NEM frequency control ancillary services

Regulation	<i>Regulation Raise</i> <i>Regulation Lower</i>
Contingency	<i>Fast Raise and Fast Lower</i> (Six second response to arrest the immediate frequency deviation) <i>Slow Raise and Slow Lower</i> (Sixty second response to keep the frequency within the single contingency band) <i>Delayed Raise and Delayed Lower</i> (Five minute response to return the frequency to the Normal Operating Band)



# frequency control & NEM 5-30 minute spot market





# NEM frequency tolerance bands

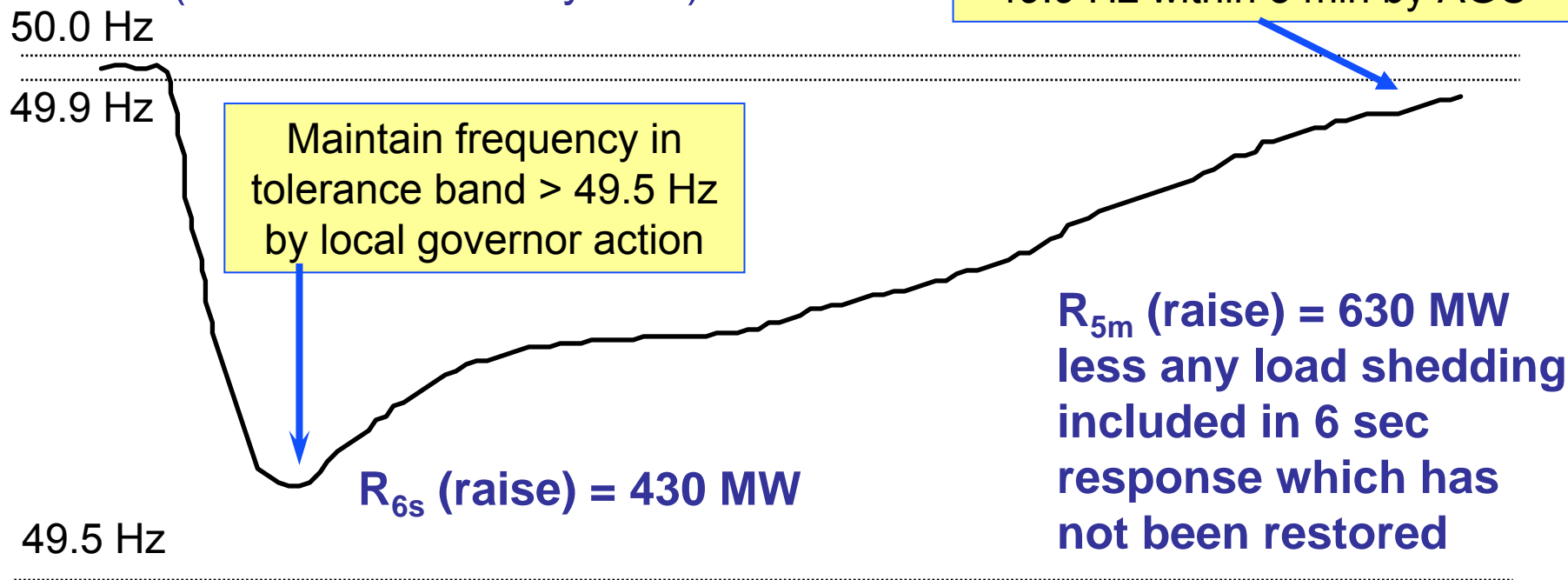
<b>State</b>	<b>Frequency band (Hz)</b>
Normal	49.85 Š 50.15 (99% of time) 49.75 Š 50.25 (1% of time)
Single generator contingency	49.5 Š 50.5
Other credible contingency	49.0 Š 51.0
Emergency	47.0 Š 52.0

# Large disturbance frequency control: loss of NSW 660 MW Generator

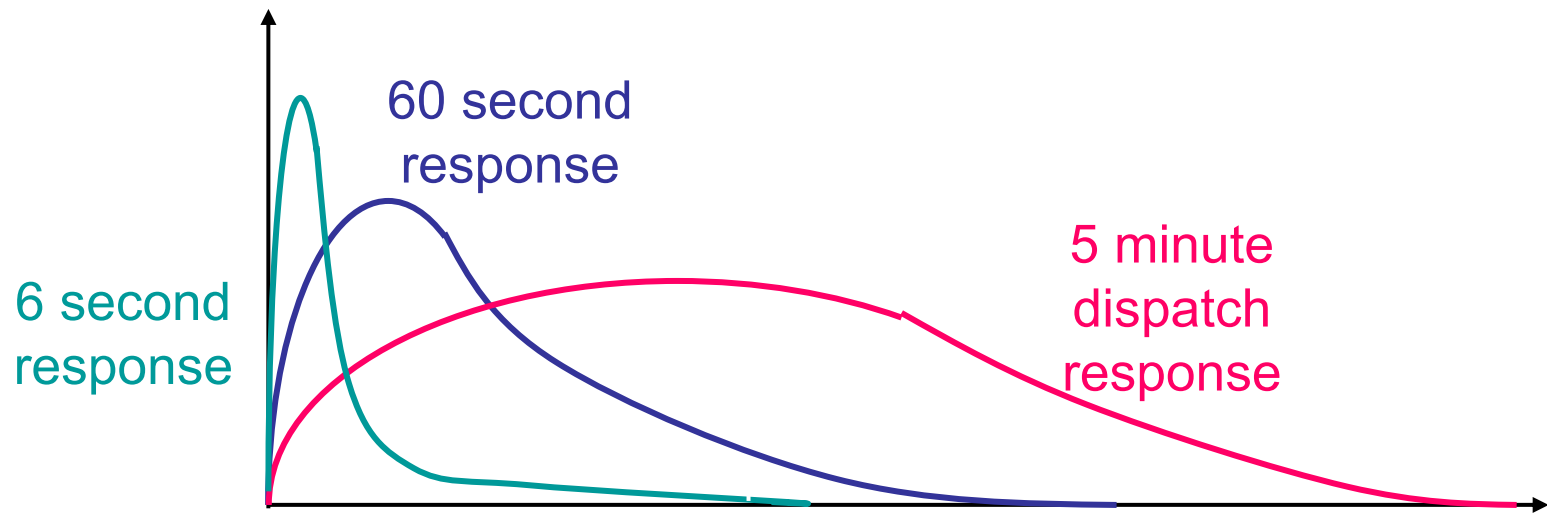
Frequency control capability requirement = R

Maximum Power Input = 630 MW  
(nett of unit auxiliary load)

Return to normal frequency band  
>49.9 Hz within 5 min by AGC

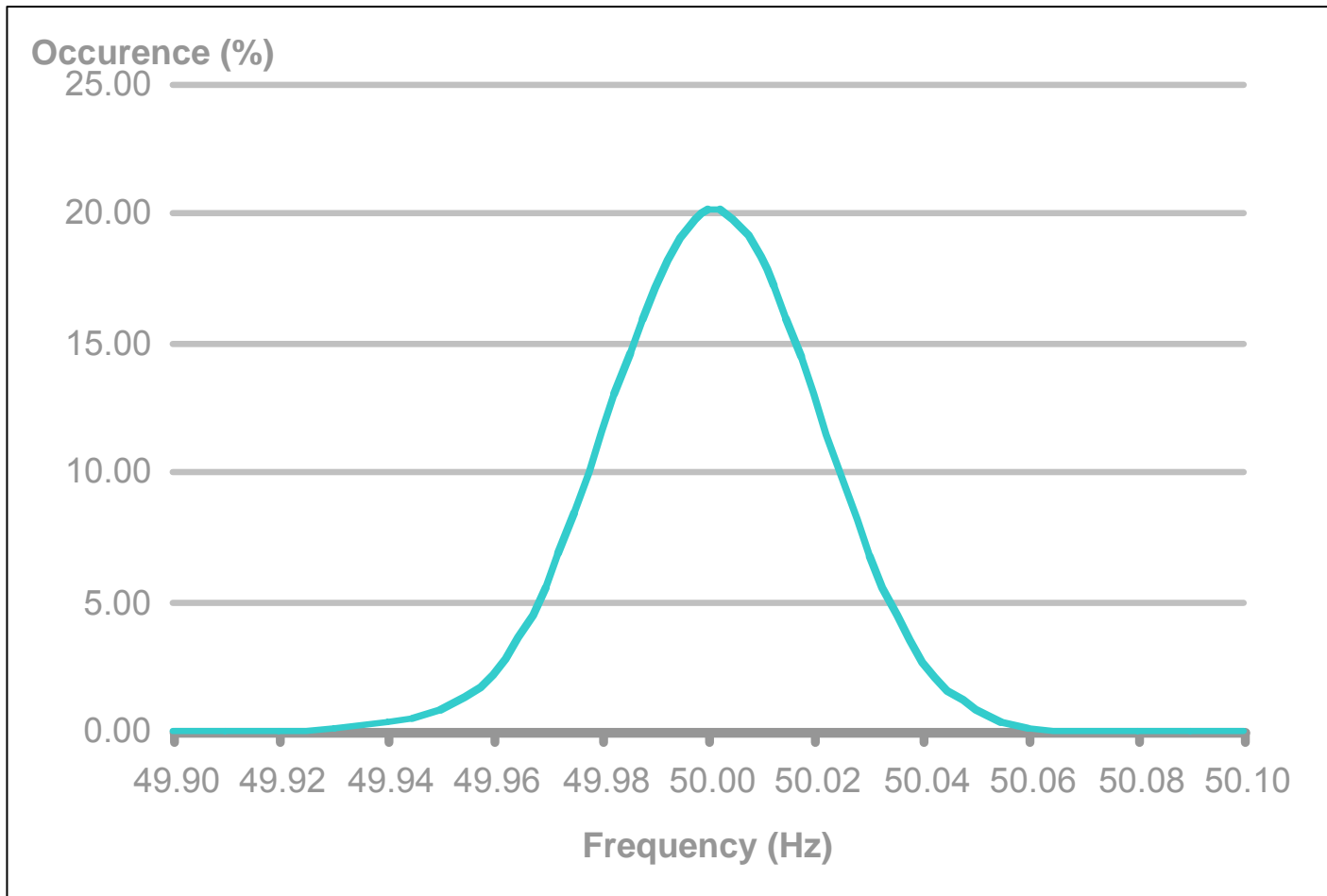


# Indicative AS response to a unit outage

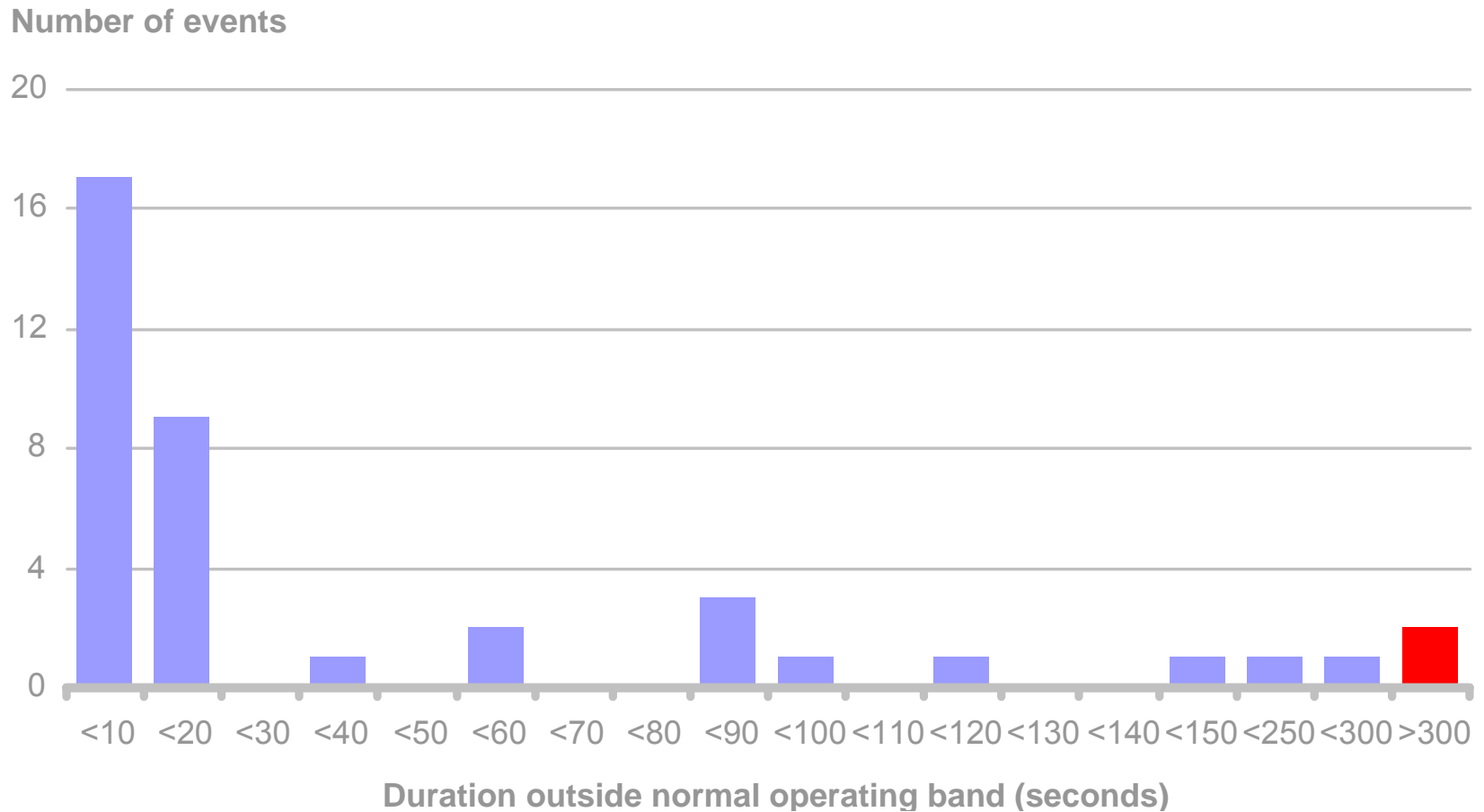




# Distribution of frequency in the NEM, June 2003 (Reliability Panel Annual Report, 2002-3)



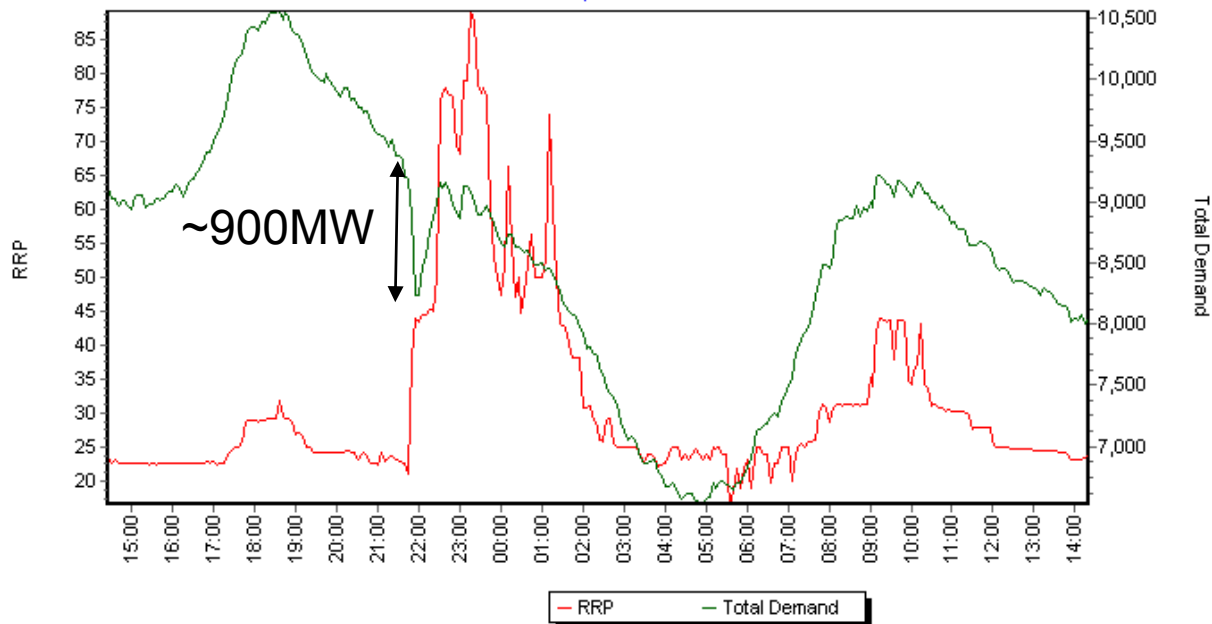
# Frequency events outside the normal operating band in the NEM due to contingencies, 2002-03



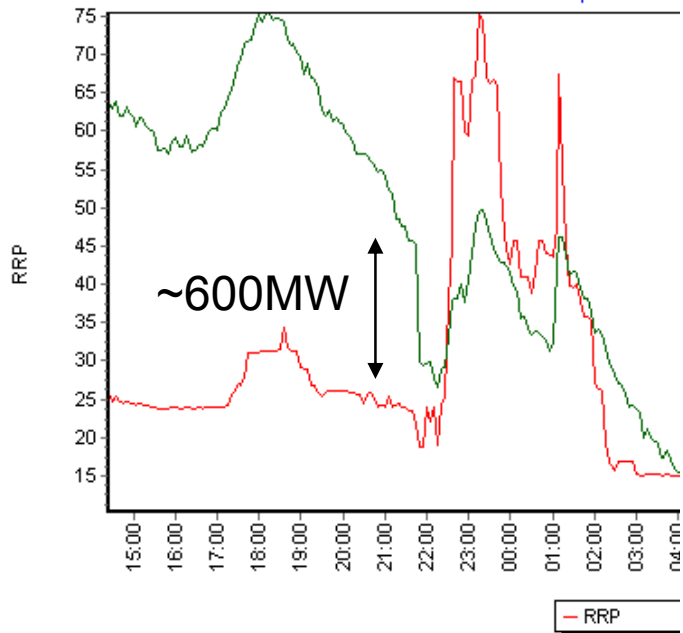


Transgrid transformer failure at 2142, 13/8/04 causes 5 generators to trip: frequency fell to 48.9Hz, ~2100 MW load shed in NSW, Qld & Vic (also some in SA) ([www.nemmco.com.au](http://www.nemmco.com.au))

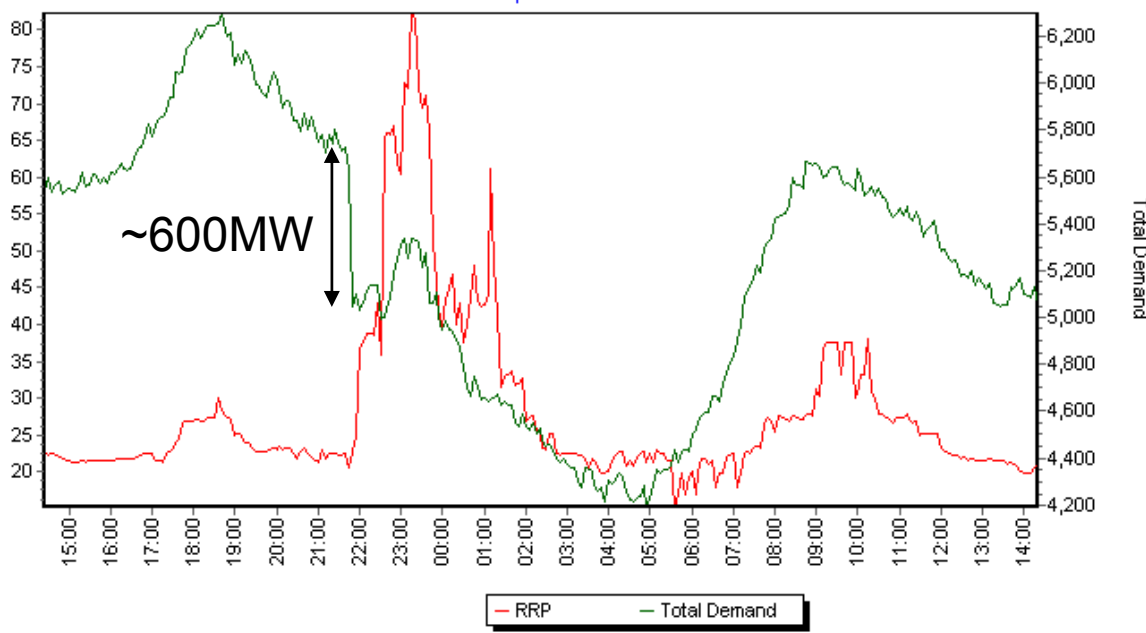
NSW1 5 minute Demand and Price for period 13/08/2004 00:00 to 14/08/2004 14:20



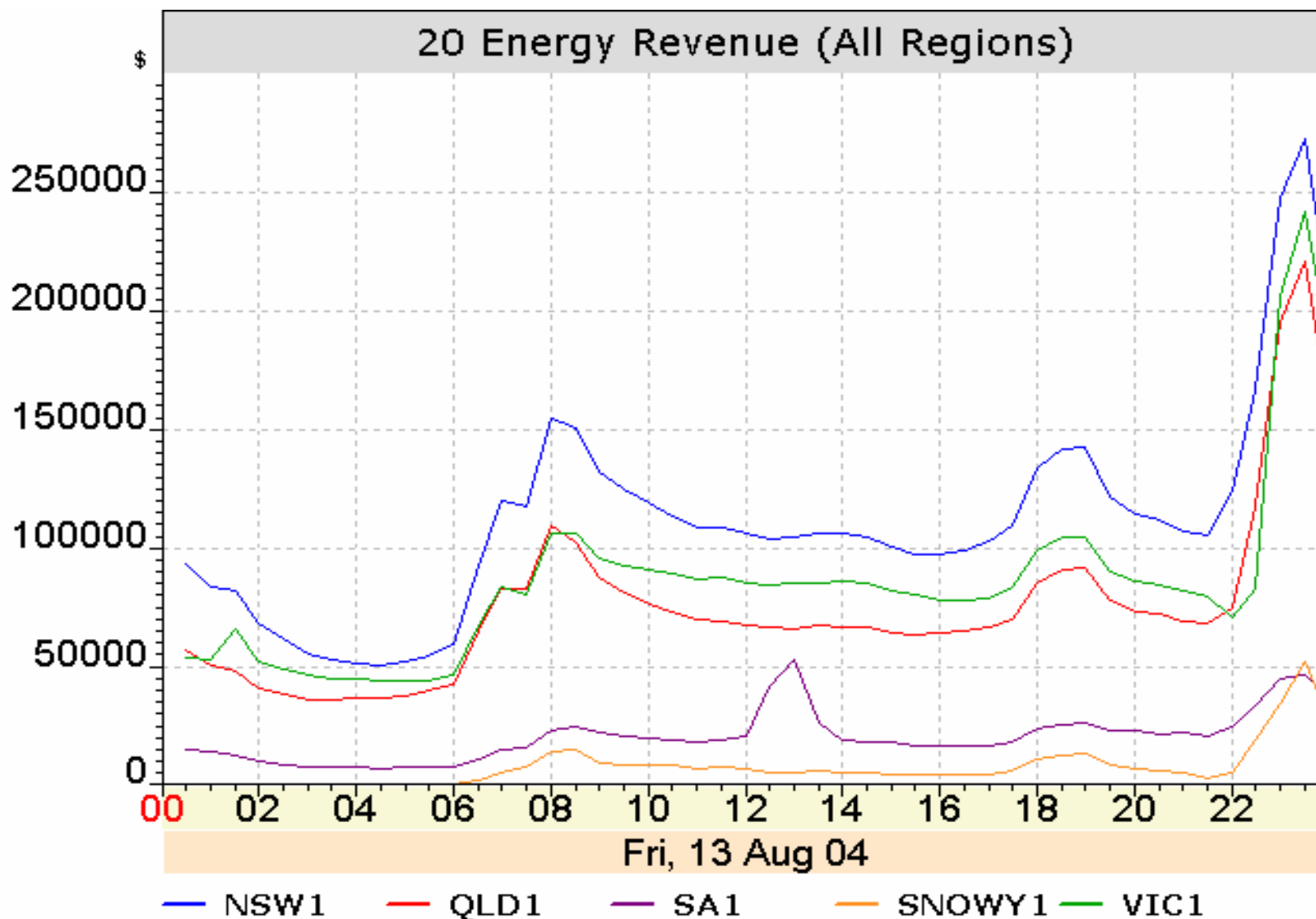
VIC1 5 minute Demand and Price for period 13/08/2004 00:00 to 14/08/2004 14:20



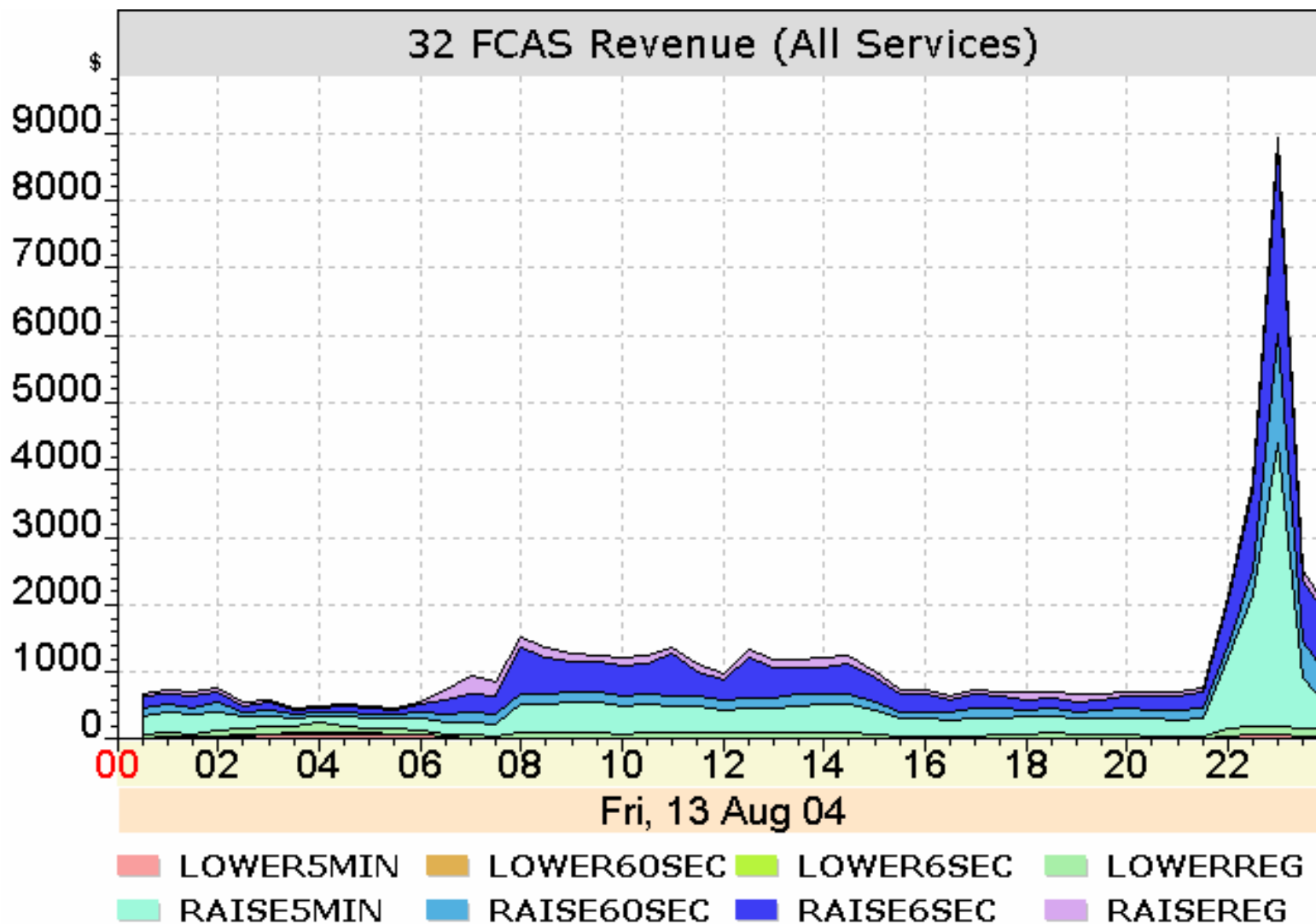
QLD1 5 minute Demand and Price for period 13/08/2004 00:00 to 14/08/2004 14:20



# NEM energy revenue, 13/8/04



# NEM FCAS revenue 13/8/04





# 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

# Power system security projections

(National Electricity Code Chapter 4)

- NEMMCO demand forecasts (indicative):
  - Daily forecasts to one week in 30 min intervals
  - Weekly forecasts to 2 years with daily profile
  - 10% probability of exceedence forecasts to be used for assessing reserve requirements
- Projected assessment of system adequacy:
  - Demand & supply-side forecasts:
    - Daily projection to one week (STPASA)
    - Weekly projection to two years (MTPASA)

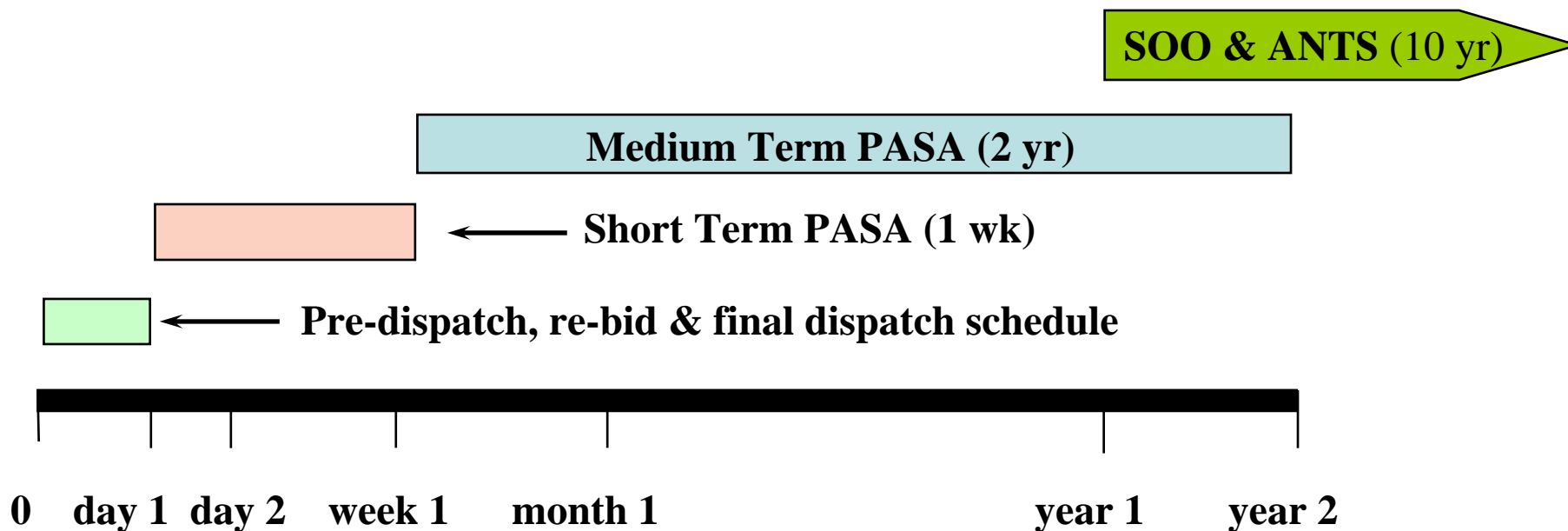
# Power system security projections ctd

(National Electricity Code Chapter 4)

- Statement of opportunities (SOO):
  - Prepared annually by NEMMCO to assess future need for additional generation, demand management or network augmentation
- Annual National Transmission Statement:
  - Identifies major transmission flow paths
  - Projects pattern of generation & demand
  - Assesses adequacy of transmission capacity

# Dispatch, Pre-dispatch, PASA, SOO & ANTS

(source: NEMMCO)



Statement of Opportunities (SOO) & Annual National Transmission Statement (ANTS) are intended to inform generation, demand & network investment decisions (10 year horizon, yearly update)

MT Projection of System Adequacy (PASA) is intended to inform near-term reliability assessment and reserve trader processes (2 year horizon, weekly update)