Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA



The Australian National Electricity Market

A model for Europe?

Dr Jenny Riesz

Improving European power market design: next steps

Stockholm – 7th July 2014

Who am I?

Powerlink Queensland

ASI Australian Solar Institute

AGL

Ausgrid

ElectraNet electricity transmission

westernpower

Clean Energy Council

origin

Australian Coal Association

imo Independent Market Operator

RioTinto

AEMC Australian Energy Market Commission

AEMO Australian Energy Market Operator

Delta electricity

The University of Queensland

ROAM CONSULTING ENERGY MODELLING EXPERTISE

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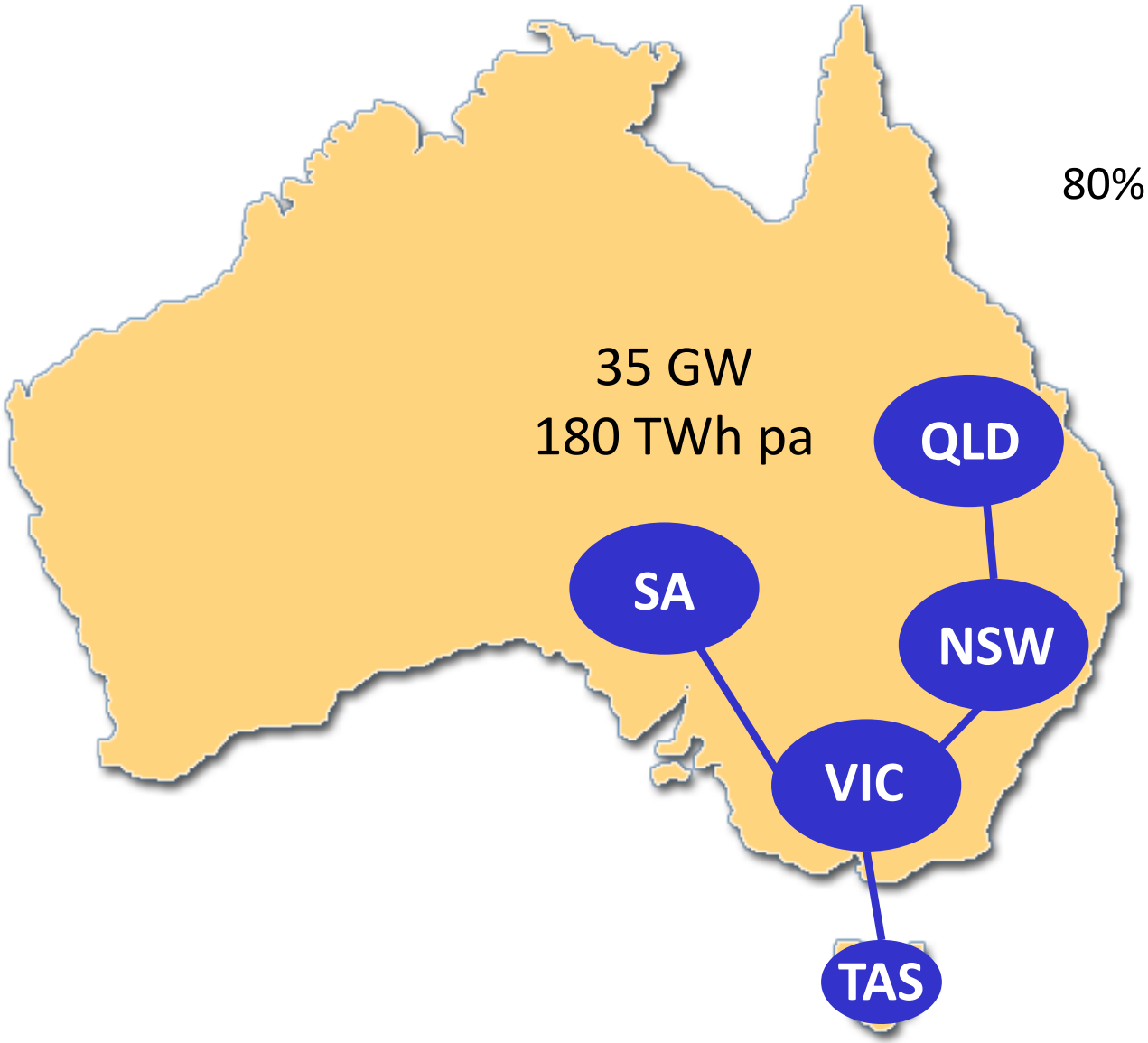
Overview

Introduction to the Australian NEM

Frequency Control Ancillary Services

Energy-only market with high renewables

Australian National Electricity Market (NEM)



80% of the electrical load in Australia

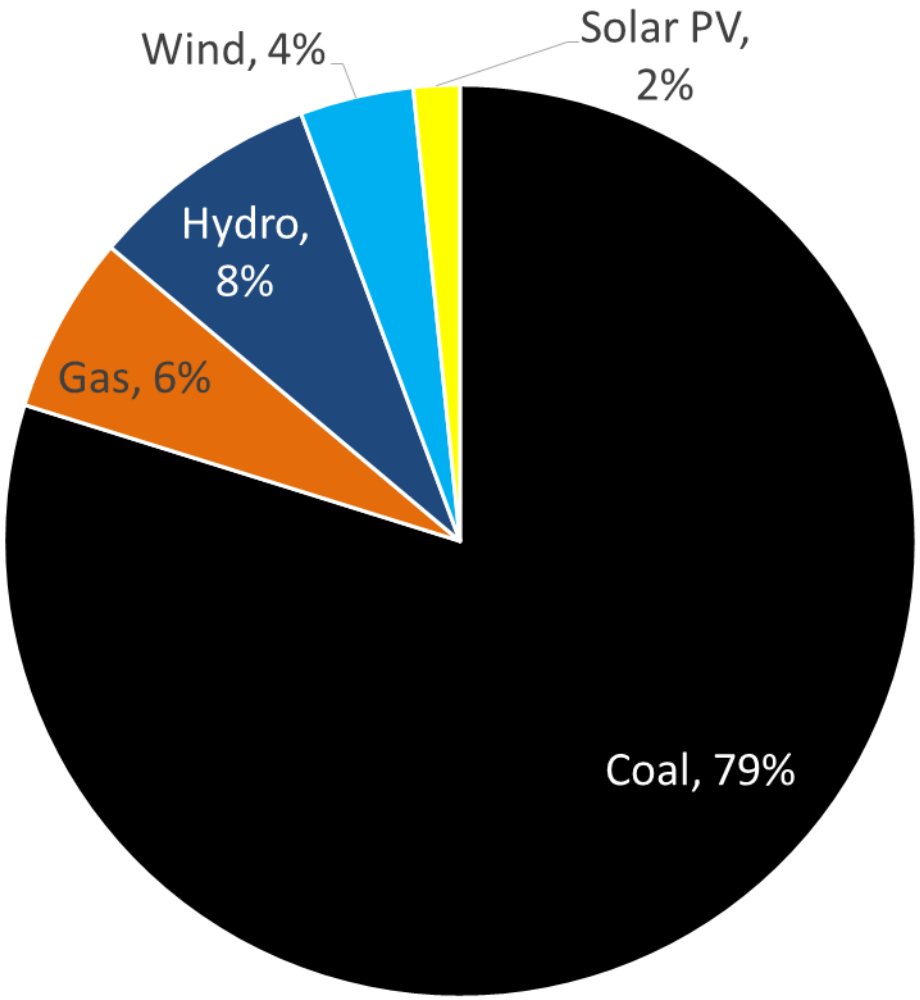
Australia – large and sparse

Consume less electricity than Spain

Electricity generation in the NEM (2013)

14% renewable energy

Target: 20% by 2020
(on track for ~25%)



Renewable development – South Australia

27% wind
4% rooftop PV

More than 85% instantaneous penetration

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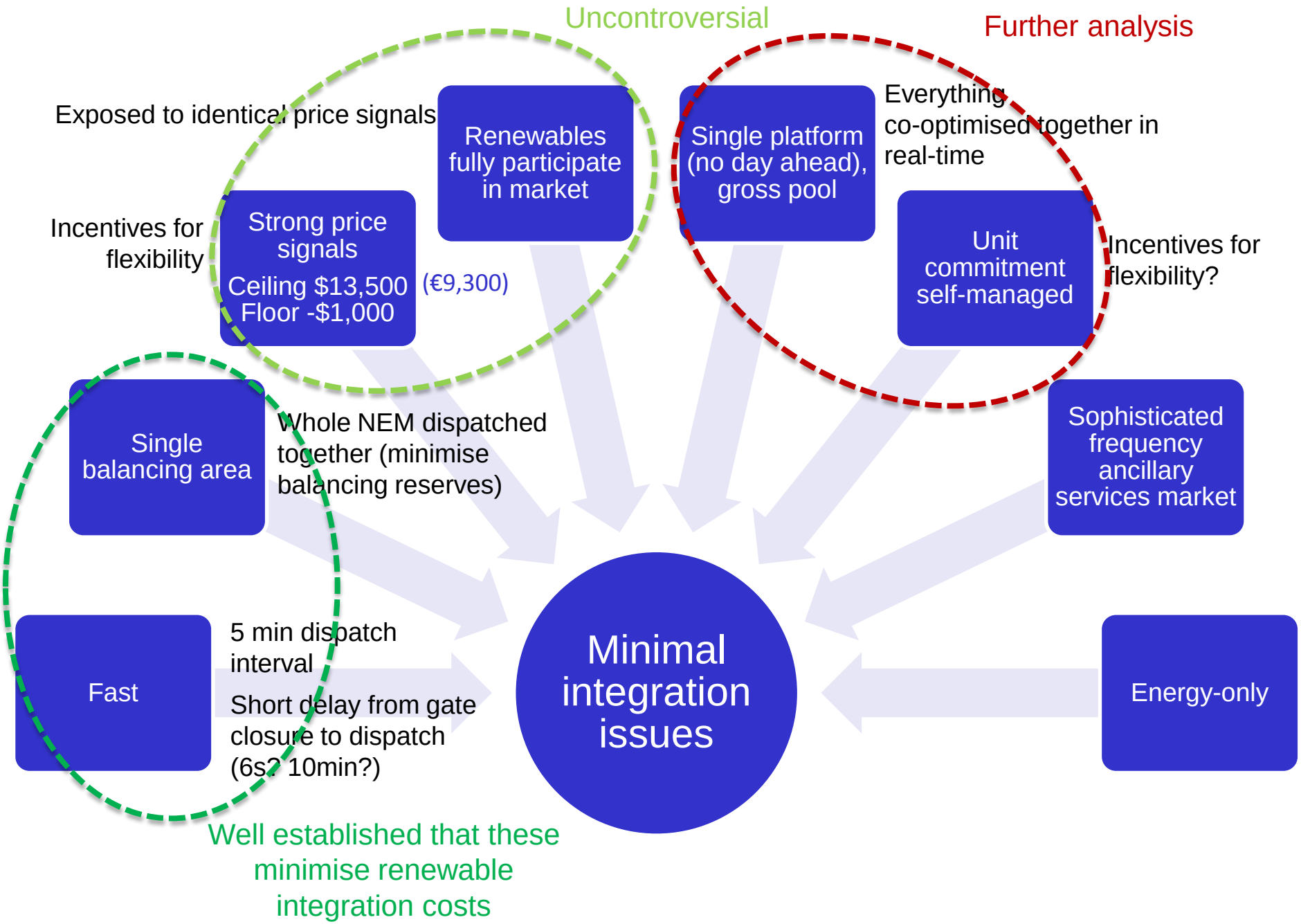
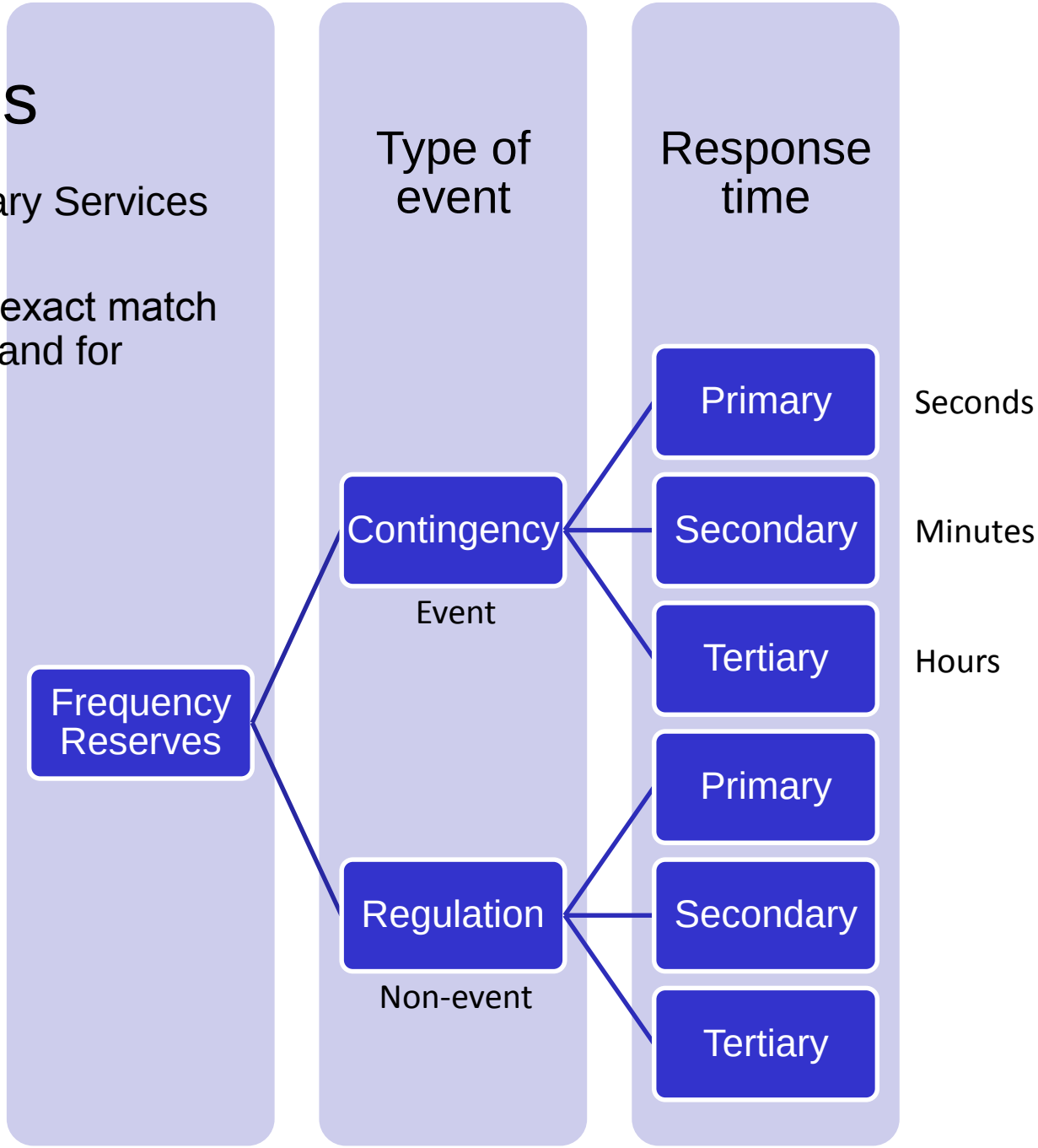

Uncontroversial
Further analysis
Exposed to identical price signals
Renewables fully participate in market
Single platform (no day ahead), gross pool
Everything co-optimised together in real-time
Incentives for flexibility
Strong price signals
Ceiling $13,500
Floor -$1,000
(€9,300)
Unit commitment self-managed
Incentives for flexibility?
Single balancing area
Whole NEM dispatched together (minimise balancing reserves)
Sophisticated frequency ancillary services market
Fast
5 min dispatch interval
Short delay from gate closure to dispatch (6s? 10min?)
Minimal integration issues
Energy-only
Well established that these minimise renewable integration costs

FREQUENCY CONTROL ANCILLARY SERVICES

FCAS reserves

- Frequency Control Ancillary Services (FCAS)
- “Reserves” that maintain exact match between supply and demand for electricity at all times.



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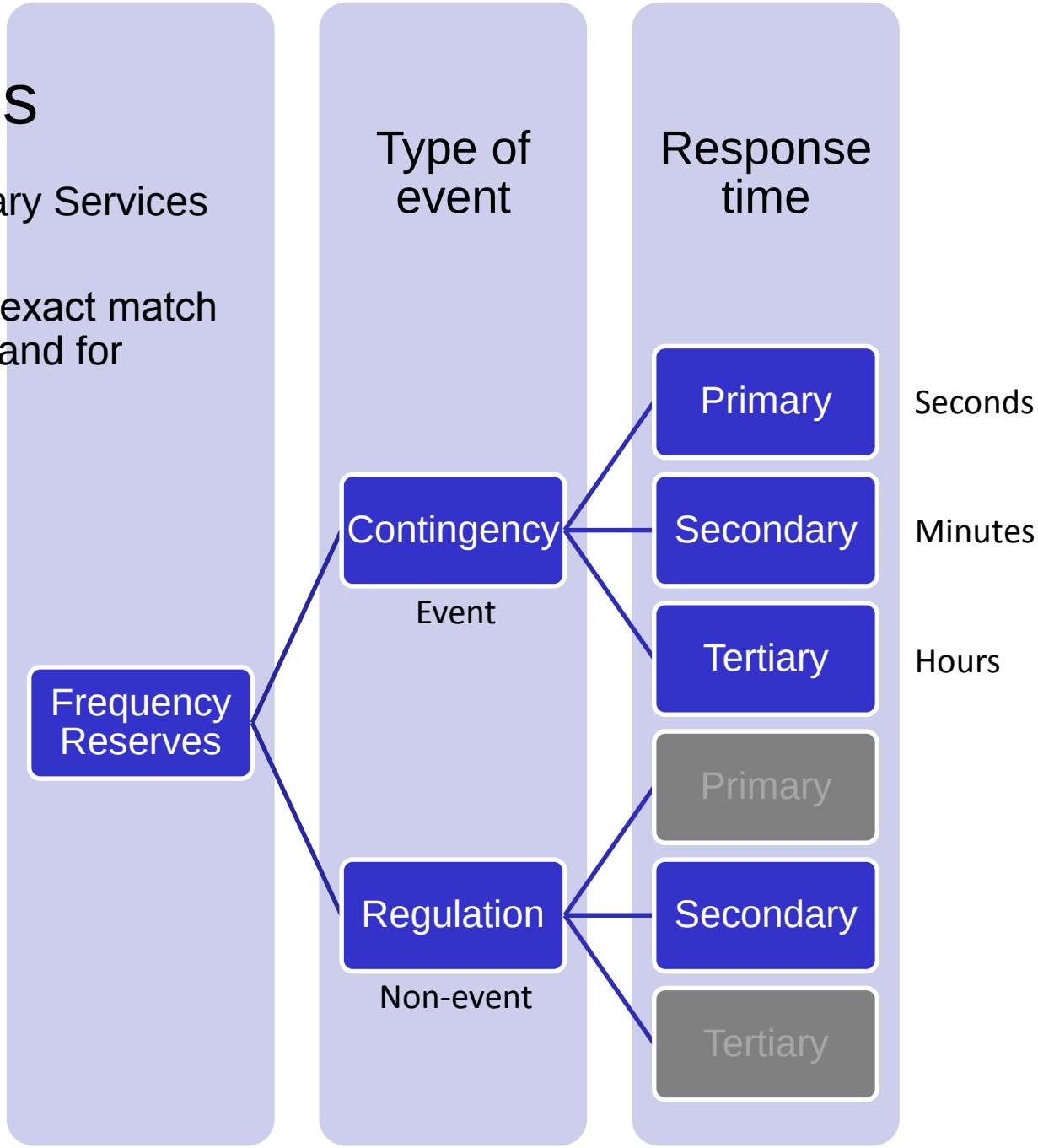


Impacts of variable renewables on FCAS

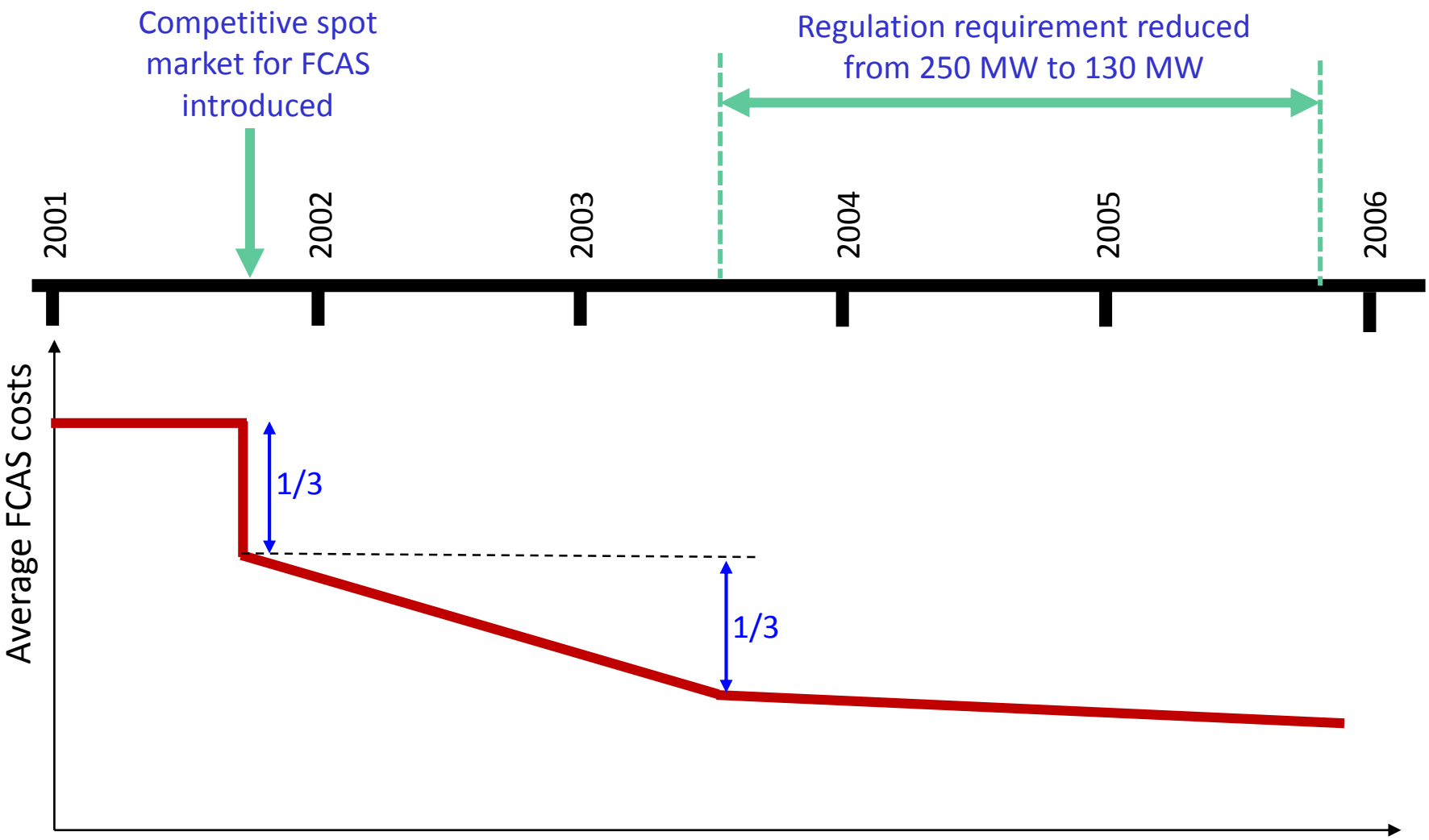
FCAS incorporates much of the 'system integration' costs & challenges of wind and solar

VARIABLE	→ Increase variability of net demand	→ Increase requirement for regulation reserves
NON-SYNCHRONOUS	→ Displace synchronous plant	→ Reduce system inertia and automatic governor response

Effective market design can minimise the FCAS reserves required, eg:

- Short dispatch intervals
- Short delay from gate closure to dispatch
- Large balancing areas

FCAS market experience in the NEM



New Zealand Electricity Commission, Frequency Regulation Market Development, Appendix E: Preliminary Cost-Benefit Assessments

Unique aspects of FCAS in the NEM

Primary frequency response market

- Fast primary frequency response market requiring full response within six seconds

Dynamic reserve setting

- Fully dynamic determination of regulation reserves based upon real-time measurement of time error

Causer pays payment recovery

- Sophisticated ‘causer pays’ mechanism for recovery of regulation payments

Fast 6 second response time

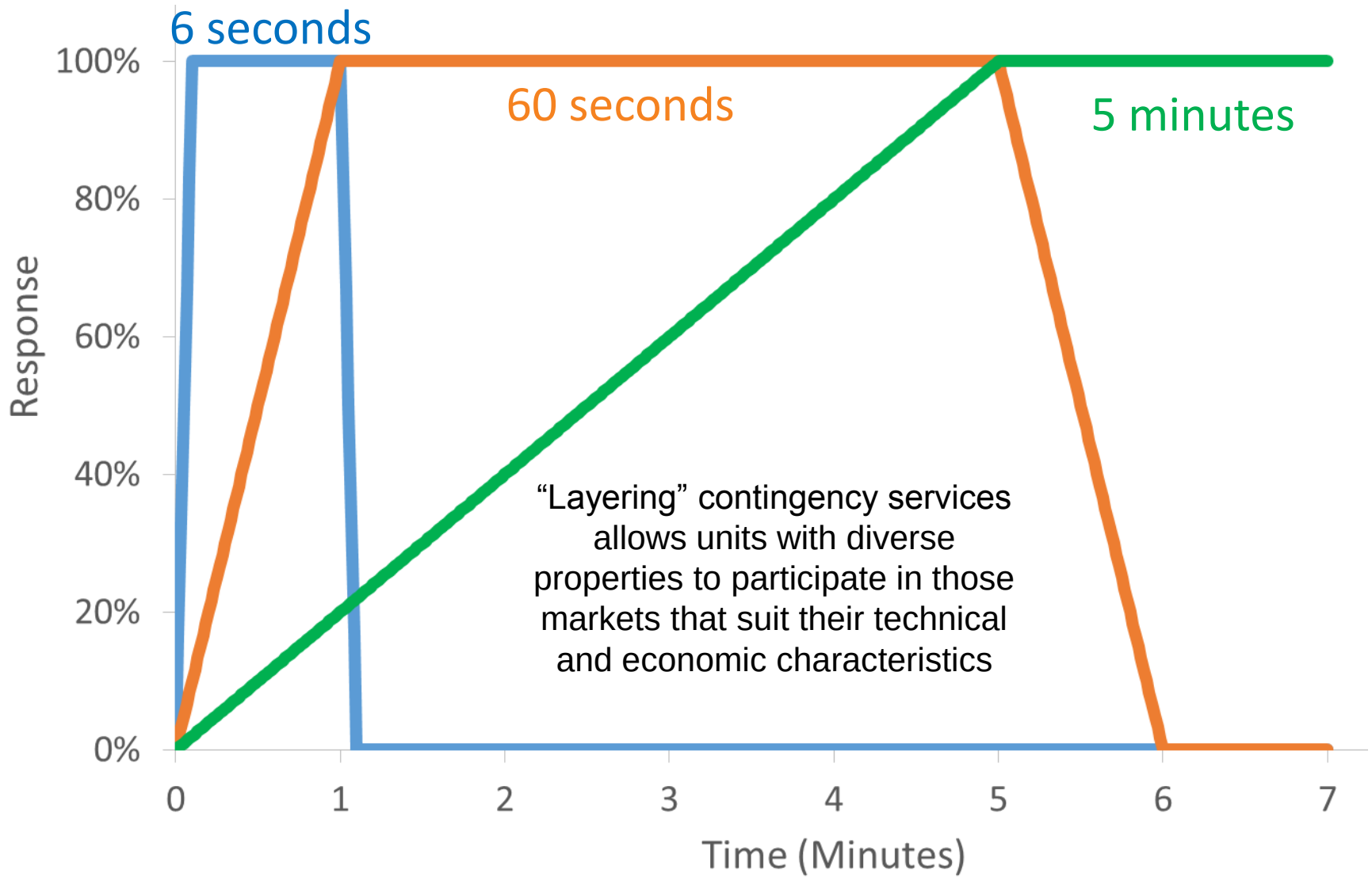
PRIMARY FREQUENCY RESPONSE MARKET

Primary frequency response

- Autonomous response triggered by frequency drop
  - Very rapid response following contingency (deployed in first 5-10 seconds)
  - Very few markets have an explicit market for a service this fast

Market	Fully activated within…	Notes
USA	-	Not explicitly included in any USA market
Europe	30 seconds	Start within a few seconds, at least 50% deployed within 15 seconds (ENTSO-E requirement)
New Zealand	1 second	Sustained for 60 seconds
Australian NEM	6 seconds	Sustained for 60 seconds

Contingency Reserves Response Times



FCAS in the NEM

FCAS (8 markets)				
Regulation		**Contingency**		
Raise	Lower	6 second (R/L)	60 second (R/L)	5 minute (R/L)
AGC	AGC	Governor	Governor	Rapid Gen

AGC: Automatic Generation Control signal from AEMO

Generator responds to locally sensed frequency

CIGRE Technical Brochure 435 – Ancillary Services : an overview of international practices. Oct 2010.

Regulation Reserve

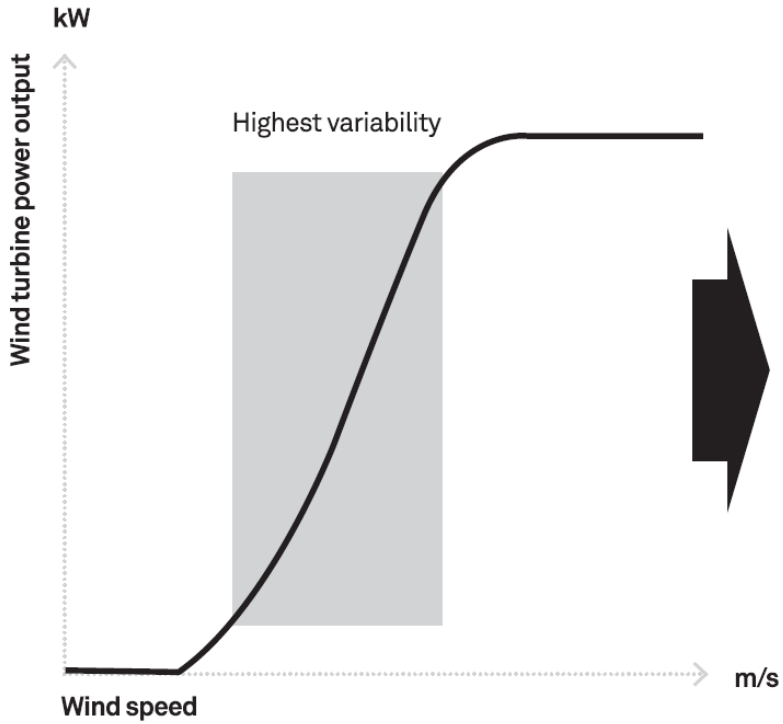
DYNAMIC RESERVE SETTING

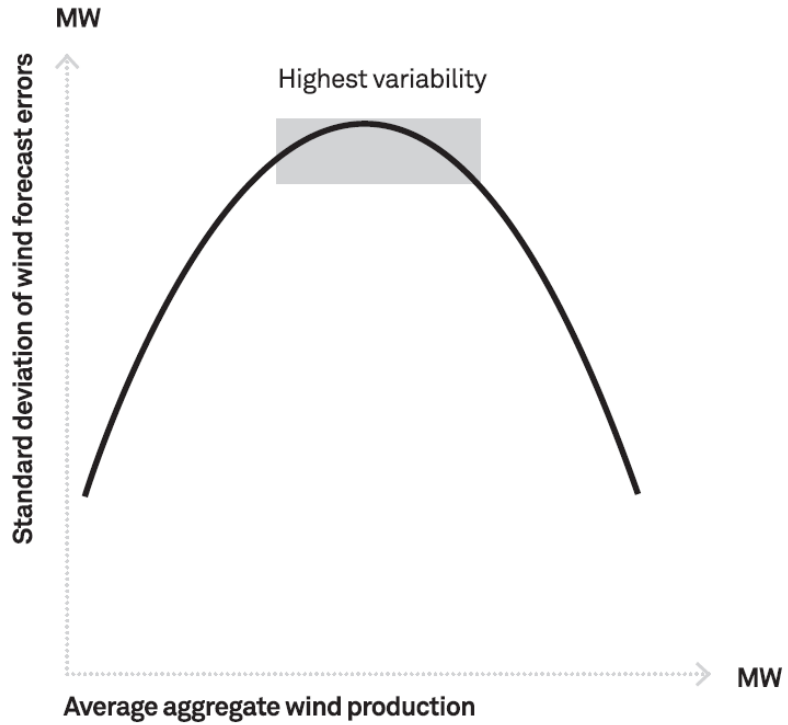
Static regulation reserve requirements

Region	Separate/ Combined	Rule
PJM	Combined	Based on 1% of the peak load during peak hours and 1% of the valley peak during off-peak hours.
NYISO	Combined	Set requirement based on weekday or weekend, hour of day, and season.
ERCOT	Separate	Based on 98.8th percentile of regulation utilized in previous 30 days of same month of previous year and adjusted by installed wind capacity.
CAISO	Separate	Use a requirement floor of 350-MW up and down regulating reserves which can be adjusted based on load forecast, must-run instructions, previous CPS performance, and interchange and generation schedule changes.
MISO	Combined	Requirement made once a day based on conditions and before the day-ahead market closes.
ISO NE	Combined	Based on month, hour of day, weekday/sat/sun.

NREL, E. Ela et al, 2011, Effective Ancillary Services market Designs on High Wind Power Penetration Systems

Dynamic regulation reserve





Wind turbine power curve – highest variability in the central region

Wind likely to be most variable when operating in the central range

Set reserves dynamically to reduce costs

NREL, Enernex Corporation, Eastern Wind Integration and Transmission Study, 2011

Regulation reserve setting in the NEM

- Set dynamically by the “time error”
  - Accumulated deviation of frequency over time from 50Hz
  - Will schedule more reserves if frequency deviates a lot, or for a long time

Default:

130 MW raise
120 MW lower

Time error exceeds ±1.5 seconds?

Add 60 MW regulation per 1 second deviation

Upper limit 250 MW

Only carry required reserves, automatically adjusts to wind variability, demand variability, inertia, etc

Scope for fine tuning

- In reality, the implementation is relatively coarse
  - Regulation reserves typically at the default, rarely adjusted
- Could be fine tuned to improve efficiency
- Could be warranted with higher renewable levels

Is time error the ideal measure?

- Time error itself isn't problematic
  - Used as a proxy for sustained frequency deviation
- Potential issues?
  - Need to operate over-frequency to correct a sustained period of under-frequency?
  - Over-frequency and under-frequency events in the same five minute dispatch interval could cancel out, suggesting that regulation reserves were sufficient when in fact frequency may be deviating significantly.
  - Probably rare and not exacerbated significantly by variable renewables
- Consider alternative measures
  - Mean absolute error in the frequency over a period of time?

Regulation Reserve

CAUSER PAYS PAYMENT RECOVERY

Cost recovery

- In most systems all FCAS costs are allocated to loads
- Removes price signals for market participants to manage variability and uncertainty they add to the system

NEM – Payment for FCAS:

Paid for by:

Contingency Raise → Generators

- Need is caused by generators
- Pro-rata by energy generated in that trading interval

Contingency Lower → Loads

- Need is caused by loads
- Pro-rata by energy consumption in that trading interval

Regulation → Causer Pays

- Paid for by loads/generators whose variability contributes to system frequency deviations

Causer Pays

Contribution factors:
Deviation from expected dispatch
Positive – Assisting in correcting system frequency
Negative – Causing deviations in system frequency

Attribution of regulation costs:

Calculate "**contribution factors**" for each load/generator every 4 seconds

Generators/Loads with negative contribution factors pay relative proportion of FCAS cost (aggregated over 1 month)

Aggregated by portfolio (beneficial operation of one unit can correct for deviations in another)

Benefits of causer pays methodology

More cost reflective signals

- To wind farms (and other generators)

Incentives to manage variability & uncertainty

- Select less variable sites or technologies?
- Self-imposed occasional curtailment to limit unanticipated ramps?

Incentives scale with costs

- Stronger incentives to reduce variability when regulation is expensive to provide

Technology neutral

- Eg. Biomass and landfill gas observed to be significant contributors to variability, pay their share of regulation costs
- Variable loads pay more

Other beneficial aspects of the NEM

Technology neutral approach to provision of FCAS	Single platform market
• No barriers to provision by renewables, as long as they meet the technical requirements	• No day-ahead market (real-time only) • FCAS reserves set dynamically in real time, based upon latest information

Adjustments that may be required in the NEM FCAS market

Optimise contingency response times	Inertia	Following service / Flexibility Market
• Revise 6s, 60s, 5min response times to new technology capabilities?	• Market for inertia? • Very fast FCAS service?	• Tertiary regulation service?

Can the NEM provide an effective model for other markets?

Well established to minimise renewable integration costs	Uncontroversial?	Need further analysis
• Fast • Large	• Strong price signals (high price ceiling, low price floor) • Renewables fully participate in the market	• Single platform (no day-ahead) • Gross pool • Unit self-commitment

Frequency Control Ancillary Services

- Primary frequency response market
- Dynamic reserve setting
- Causer pays payment recovery

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Thank you

ceem.unsw.edu.au
jenny.riesz.com.au