The Australian National Electricity Market

A model for Europe?

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Improving European power market design: next steps

Stockholm – 7th July 2014
Overview

Introduction to the Australian NEM

Frequency Control Ancillary Services

Energy-only market with high renewables
Australian National Electricity Market (NEM)

35 GW
180 TWh pa

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
Minimal integration issues

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

Uncontroversial

Further analysis

Everything co-optimised together in real-time

Incentives for flexibility?
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.
FCAS reserves

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

NON-SYNCHRONOUS

Displace synchronous plant

Increase requirement for regulation reserves

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

Competitive spot market for FCAS introduced

Regulation requirement reduced from 250 MW to 130 MW

Average FCAS costs

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

<table>
<thead>
<tr>
<th>Market</th>
<th>Fully activated within…</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>-</td>
<td>Not explicitly included in any USA market</td>
</tr>
<tr>
<td>Europe</td>
<td>30 seconds</td>
<td>Start within a few seconds, at least 50% deployed within 15 seconds (ENTSO-E requirement)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1 second</td>
<td>Sustained for 60 seconds</td>
</tr>
<tr>
<td>Australian NEM</td>
<td>6 seconds</td>
<td>Sustained for 60 seconds</td>
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</table>
“Layering” contingency services allows units with diverse properties to participate in those markets that suit their technical and economic characteristics.
FCAS in the NEM

**FCAS** (8 markets)

**Regulation**
- Raise
- Lower
- AGC
- AGC

**Contingency**
- 6 second (R/L)
- 60 second (R/L)
- 5 minute (R/L)
- Governor
- Governor
- Rapid Gen

AGC: Automatic Generation Control signal from AEMO

Generator responds to locally sensed frequency

Regulation Reserve

DYNAMIC RESERVE SETTING
# Static regulation reserve requirements

<table>
<thead>
<tr>
<th>Region</th>
<th>Separate/Combined</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJM</td>
<td>Combined</td>
<td>Based on 1% of the peak load during peak hours and 1% of the valley peak during off-peak hours.</td>
</tr>
<tr>
<td>NYISO</td>
<td>Combined</td>
<td>Set requirement based on weekday or weekend, hour of day, and season.</td>
</tr>
<tr>
<td>ERCOT</td>
<td>Separate</td>
<td>Based on 98.8th percentile of regulation utilized in previous 30 days of same month of previous year and adjusted by installed wind capacity.</td>
</tr>
<tr>
<td>CAISO</td>
<td>Separate</td>
<td>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.</td>
</tr>
<tr>
<td>MISO</td>
<td>Combined</td>
<td>Requirement made once a day based on conditions and before the day-ahead market closes.</td>
</tr>
<tr>
<td>ISO NE</td>
<td>Combined</td>
<td>Based on month, hour of day, weekday/sat/sun.</td>
</tr>
</tbody>
</table>

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
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:

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

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

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

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**Paid for by:**
- Generators
- Loads
- Causer Pays
Causer Pays

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)

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

- No barriers to provision by renewables, as long as they meet the technical requirements

Single platform market

- 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**
  - Revise 6s, 60s, 5min response times to new technology capabilities?

- **Inertia**
  - Market for inertia?
  - Very fast FCAS service?

- **Following service / Flexibility Market**
  - Tertiary regulation service?
Can the NEM provide an effective model for other markets?

<table>
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<tr>
<th>Well established to minimise renewable integration costs</th>
<th>Uncontroversial?</th>
<th>Need further analysis</th>
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<tr>
<td>• Fast&lt;br&gt; • Large</td>
<td>• Strong price signals (high price ceiling, low price floor)&lt;br&gt; • Renewables fully participate in the market</td>
<td>• Single platform (no day-ahead)&lt;br&gt; • Gross pool&lt;br&gt; • Unit self-commitment</td>
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**Frequency Control Ancillary Services**

• Primary frequency response market
• Dynamic reserve setting
• Causer pays payment recovery
Thank you

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