ANTICIPATING AND ADDRESSING SECURITY CHALLENGES IN AN EVOLVING POWER SYSTEM

January 2017
AGENDA

1. Introduction to the NEM
2. Future Power System Security Program
3. Identifying & addressing future challenges
   • Frequency Control
     o RoCoF
     o Fast Frequency Response
     o Availability of regulation frequency control
   • System Strength
INTRODUCTION TO THE NEM

- ~85% of electrical load in Australia
SOUTH AUSTRALIA

<table>
<thead>
<tr>
<th>Area</th>
<th>Demand</th>
<th>Interconnections</th>
</tr>
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<tbody>
<tr>
<td>NEM</td>
<td>15 - 35 GW</td>
<td>None</td>
</tr>
<tr>
<td>South Australia</td>
<td>0.8 – 3.4 GW</td>
<td>1 x AC (650 MW) 1 x HVDC (220 MW)</td>
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42% non-synchronous generation
- 1.5 GW wind
- 600 MW rooftop PV
- Max instantaneous penetration: 119%
FUTURE POWER SYSTEM SECURITY

• The power system is changing

[Diagram showing installed capacity from 2016-17 to 2025-26 with labels for emissions reduction scenario, significant retirements, and distributed resources.]

SLIDE 5
Adapt AEMO’s functions and processes to deliver ongoing power system security and reliability

**Short-term**
To be transparent in how AEMO intends to meet its obligations

**Long-term**
To identify, rank and promote resolution of long-term technical challenges
TIMELINE

Dec 2015

Identify challenges

2016

Analysis to define operational bounds and risks

2017 →

Identify technical solutions

Develop solution frameworks

Other technical challenges
IDENTIFYING CHALLENGES

• Stakeholder consultation group
  o Formed a comprehensive list of challenges
  o Prioritised those requiring immediate focus
HIGH PRIORITY CHALLENGES

- Frequency control
- System strength
- Management of extreme power system conditions
- Visibility of the power system (information, data and models)
FREQUENCY CONTROL
FREQUENCY CONTROL ANCILLARY SERVICES (FCAS)

Raise and Lower services for each of:

<table>
<thead>
<tr>
<th>Control</th>
<th>Response time</th>
<th>Sustain time</th>
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</thead>
<tbody>
<tr>
<td>Regulation</td>
<td>AGC (Automatic Generation Control)</td>
<td>Responds every 4s</td>
</tr>
<tr>
<td>Contingency</td>
<td>Local frequency measurement</td>
<td>6s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5min</td>
</tr>
</tbody>
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- Nine separate real-time (5min) markets
  - 8xFCAS + Energy
FREQUENCY CONTROL CHALLENGES

High RoCoF

- If “Rate of change of Frequency” (RoCoF) is too high:
  - May not meet Frequency Operating Standards
  - Could result in cascading tripping
  - Emergency control schemes may not prevent system collapse

Insufficient FCAS

- “Frequency Control Ancillary Services” (FCAS)
  - Will there be sufficient services available in future?

![Graph showing RoCoF and Frequency (Hz) over time](image-url)
## ROCOF WORK PROGRAM

### International Review of Frequency Control Adaptation
- What other jurisdictions have encountered similar challenges, and what can we learn from them?

### RoCoF Screening
- What is the RoCoF exposure now, and in the future?

### Survey of System RoCoF Limits
- Survey of system elements sensitive to RoCoF
- Estimate of secure technical envelope for RoCoF

### RoCoF Withstand Capabilities of South Australian Generators
- PSSE modelling of RoCoF withstand capabilities of individual synchronous generators in South Australia

### Fast Frequency Response Specification
- Limitations and capabilities of technologies that can provide FFR
- Simple power system modelling to identify power system requirements
- Preliminary specification of FFR service
- Very few large jurisdictions experiencing RoCoF challenges
- Important exceptions:
  - EirGrid/SONI
  - National Grid
- Opportunities for collaboration
- FFR services are relatively novel
  - Very few practical examples of very fast frequency control
  - Real technical complexities
Exposure in SA upon “non-credible” loss of Heywood interconnector (double circuit)

AEMO has **no obligation or authority** to protect against loss of Heywood, unless reclassification of loss as “credible”

Rule change in progress to allow identification of “protected events”, for which AEMO would have some obligations and authority.
• UFLS
  o Issues above 3Hz/s
• Gas Turbines
• PSS/E modelling results:
  o Significant differences between synchronous units identified, some may be particularly vulnerable
  o RoCoF withstand capability depends upon many factors
    ➢ Individual unit (inertia?)
    ➢ Type of event (fault?)
    ➢ Operation of unit (power factor? Unit loading?)
    ➢ Network properties (local impedance?)
• Targeted testing, monitoring and verification required
NEM MAINLAND – CREDIBLE CONTINGENCIES

Exposure on NEM Mainland upon credible loss of largest unit

Potential challenges meeting Frequency Operating Standards above ~0.3 Hz/s

SLIDE 17
• New 0.5-2s FFR service?
• Sustain to 6s
• Wind recovery period?
• Hydro initial withdrawal?
• Proportional vs switched controls?
• Co-optimisation of FFR and inertia?

**FFR SPECIFICATION**

**Arrest (6s)**
(orderly transition to 60s service)

**Stabilise (60s)**
(orderly transition to 5min service)

**Recover (5min)**
(sustain until central dispatch takes over)

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![Active Power (% of response) vs Time (seconds)](chart)

**Fast**
**Slow**
**Delayed**
• Can FFR substitute for inertia?
  ○ Yes, within limits

232 MW contingency size
500ms FFR
IMPLEMENTATION FRAMEWORKS

Market operator

Collaborating (FFR / Inertia)

Rule maker
IMPLEMENTATION FRAMEWORKS

• **Options:**
  - Generator obligation
  - AEMO contract process
  - TNSP provision
  - Five-minute dispatch

• **Principles:**
  - Technology neutral
  - Competition & market signals
FUTURE FCAS NEEDS
Projecting FCAS supply-demand balance

- How much regulation FCAS will we need in future?

Removing barriers to FCAS participation

- Review of FCAS specifications
- Pilot projects for registration/demonstration of FCAS capabilities?
FUTURE REGULATION NEEDS

Estimated regulation requirement (MW) vs. Installed capacity (MW)

- Rooftop PV Data
- Utility PV Data
- Wind Data

Projected values for:
- Rooftop PV
- Utility PV
- Wind
SYSTEM STRENGTH PROJECTION

- Connection of 22GW large-scale wind & PV
- Reduction of ~15GW synchronous plant
- Trend towards reducing system strength
- Can be managed for new connections
- How to manage for retirements?
- Who has responsibility?

Weighted SCR for possible connections
Severe weather

Tornadoes (not anticipated in the forecast)

Loss of three transmission lines

Two tornadoes almost simultaneously damaged two 275kV lines, 170km apart

Multiple faults

Six voltage dips in 2mins

Wind farm protection triggered

• Almost all wind farms have protection against multiple faults
• AEMO was unaware of this protection (not included in models)

Loss of 456MW from nine wind farms in <7s

Significant increase in flow through AC Heywood Interconnector

600ms after reduction in output from last of wind farms

~890 MW contingency with ~3,000 MW.s inertia, UFLS cannot operate quickly enough

• Investigating System Protection Scheme (SPS) to initiate load shedding in response to excessive flows on Heywood, and prevent separation (or form a stable island)

• Assessing accuracy of power system models

• Assessing impact of credible faults (risk from transient reductions?)

System Black

RoCoF ~6Hz/s