FUTURE POWER SYSTEM SECURITY PROGRAM

WHAT IT MEANS FOR INDUSTRY AND CONSUMERS, WHAT WILL IT ACHIEVE.

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OBJECTIVES OF SESSION

- To give you an overview of the work that we have been doing in power system security.
- To give you an understanding of where we believe the immediate priorities are.
- To seek your thoughts and feedback on this work.

- We’re here to hear from you.

FUTURE POWER SYSTEM SECURITY

1. Context
2. What we have been doing
3. Immediate challenges
    1. Frequency control
    2. Management of extreme power system conditions
    3. System strength
    4. Visibility of the power system
4. Opportunities
5. Discussion

CONTEXT

FUTURE POWER SYSTEM SECURITY

- AEMO is responsible for overseeing power system security of the National Electricity Market (NEM).
  - From July 2016, that responsibility was extended to include the South West interconnected system (SWIS) in Western Australia.
- The electricity landscape is rapidly transforming.
  - Generation technology is changing.
  - Consumers are becoming more engaged in the way they manage their energy supply and consumption.

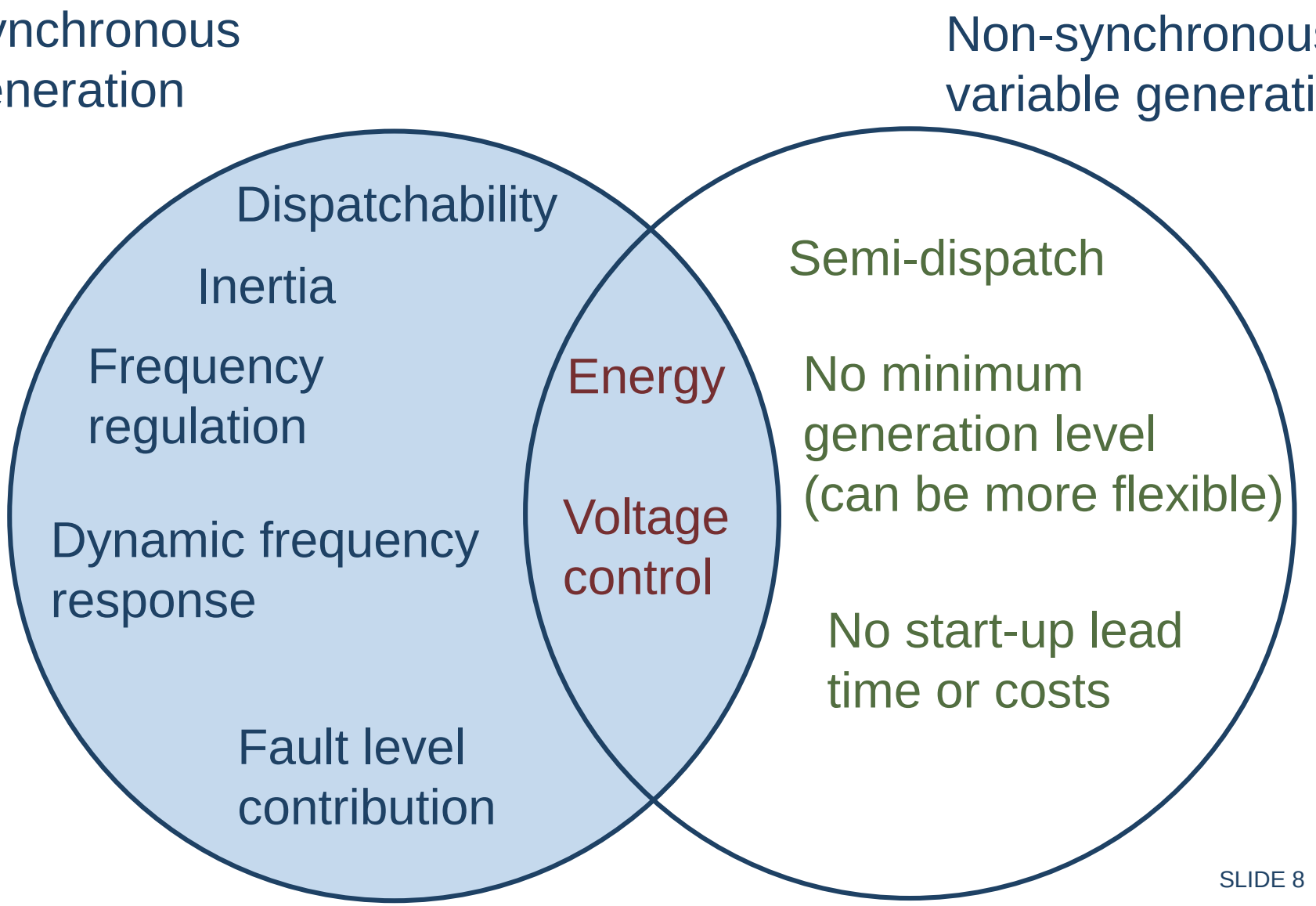
FUTURE POWER SYSTEM SECURITY

- We now have a strategic program of work underway to manage the challenges associated with these changes.
- In this we are reviewing how we will maintain power system security into the future.
- Initial focus has been on understanding the nature of potential challenges.
- It was critical to identify the right challenges and their relative priority before seeking to find solutions.

SOME OBSERVABLE TRENDS

Registered Generation	• Non-registered • Presence / characteristics could be unknown
Centrally Monitored Dispatched	• Distributed / embedded • Not individually monitored • Not centrally dispatched
Controllable	• Intermittent generation • Reduction in frequency control capability under normal and extreme circumstances
Synchronous Generation	• Inverter connected and asynchronous generation • Low inertia and weak AC system

LARGE SCALE GENERATION – SOME IMPACTS OF THE CHANGES



WHAT WE HAVE BEEN DOING

ACTIONS SINCE LAST ROADSHOW

- Power Systems Issues Technology Advisory Group (PSI TAG):
  - Formed a comprehensive list of challenges.
  - Prioritised the challenges requiring immediate focus.
- Update to renewable energy integration in South Australia - Joint AEMO and ElectraNet report published.
- Response of Existing PV Inverters to Frequency Disturbances report published.
- Future Power System Security Program Progress report published.
- Advice given to Jurisdictions on related policies.

Reports available at http://www.aemo.com.au/Electricity/Market-Operations/Power-system-security

FUTURE POWER SYSTEM SECURITY PROGRAM OBJECTIVES

Adapt AEMO's functions and processes to deliver ongoing power system security and reliability

Short-term

To be transparent and clear in how AEMO intends to meet its obligations for system security and reliability as the generation mix changes.

Long-term

To identify, rank and promote resolution of long-term technical challenges of operating the power system to inform the potential need for policy, procedural or regulatory changes.

CHALLENGES NOT PROBLEMS

- We have identified challenges in maintaining system security:
  - Under some operating conditions,
  - Potential technical solutions abound.
- Delivery mechanisms for the solutions need to:
  - Be forward looking,
  - Provide a flexible market and regulatory environment,
  - Be fuel and technology neutral,
  - Use efficient markets or incentive regulation to drive optimal outcomes,
  - Incorporate regulatory arrangements that support innovation,
  - Be tested against National Electricity Objective.

FPSS PROGRAM PROCESS

→ Dec 2015 | May 2016 | Dec 2016 | 2017 →

Identify challenges

Analysis to define operational bounds and risks

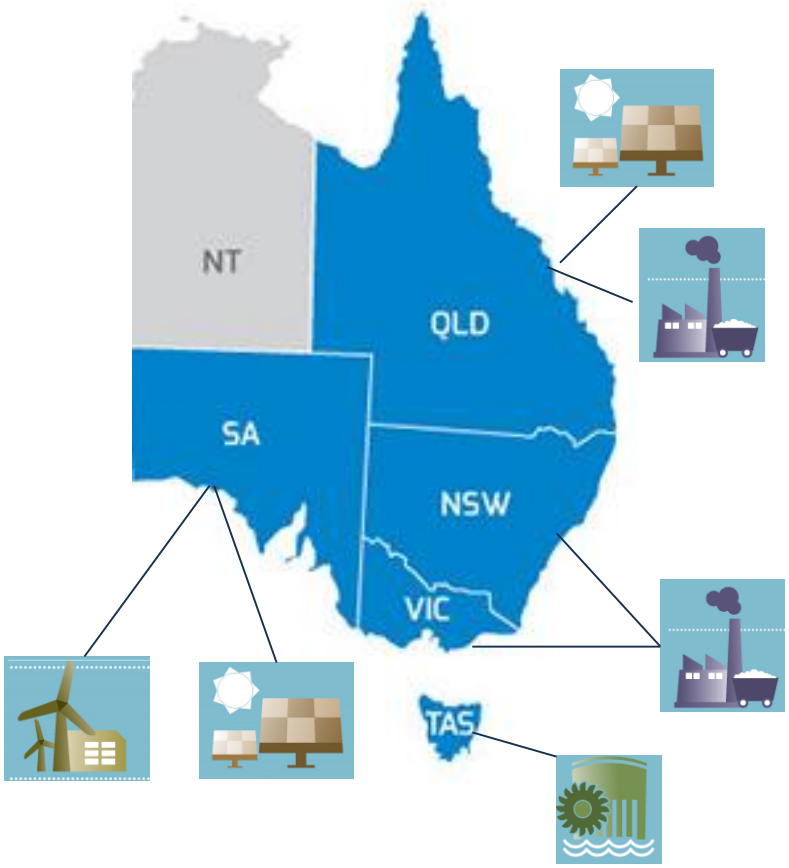
Identify technical solutions

Develop solution frameworks

Analysis of other technical challenges

Address short-term challenges using existing market and regulatory frameworks

OVERALL FINDINGS TO DATE



- Clear that there are technical challenges under some conditions
- Generally not expected when the NEM is intact – except some local issues that cannot be managed globally
- Some technical challenges can arise at the same time
- Need for visibility of widespread embedded devices

IMMEDIATE CHALLENGES

WHAT ARE THE IMMEDIATE CHALLENGES?

Frequency control

Management of extreme power system conditions

System strength

Visibility of the power system
(information, data and models)

Frequency control

Management of extreme power system conditions

System strength

Visibility of the power system
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FREQUENCY CONTROL

Challenges:

- Managing high RoCoF when inertia is low.
- Reducing FCAS supply as synchronous generation withdraws.
- Possible increasing FCAS requirements from variability of supply and demand.
- Can under-frequency load shedding (UFLS) schemes react fast enough?
- Are over-frequency generation shedding (OFGS) schemes needed?

Where challenges might arise:

- Not expected to be NEM-wide challenges in the near term.
- May be challenges in regions that can separate from the NEM.

Frequency control

Management of extreme power system conditions

System strength

Visibility of the power system
(information, data and models)

MANAGING EXTREME POWER SYSTEM CONDITIONS

Challenges:

- We have limited powers to act pre-emptively to manage a non-credible contingency event.

Where will the challenges arise:

- Initial challenge is to manage risks of non-credible loss of Heywood Interconnector

Interim solutions:

- We are:
  - Redesigning the current UFLS,
  - Designing an OFGS,
  - Reviewing procedures to operate SA as an island,
  - Assessing the need to clarify expectations, roles and responsibilities in relation to particular system events.

Frequency control

Management of extreme power system conditions

System strength

Visibility of the power system
(information, data and models)

SYSTEM STRENGTH

Challenges:

- System strength is reducing.
- Can be challenging to model.
- Impacting on new connections.
- Can compromise:
  - Effectiveness of protection systems to detect and clear electrical faults,
  - Ability of non-synchronous generation to operate as required in performance standards,
  - Voltages stability leading to potential voltage collapse.

Where challenges might arise:

- Can arise in even in an intact NEM
- In areas remote from synchronous generation.

Frequency control

Management of extreme power system conditions

System strength

Visibility of the power system (information, data and models)

VISIBILITY OF THE POWER SYSTEM (INFORMATION, DATA AND MODELS)

Challenges:

- Visibility of distributed energy resources (DER).
- Dynamic load behaviour is not effectively modelled.
- In the future, models of physical plant and modelling tools currently used may not be capable of providing accurate system state information.

Where challenges might arise:

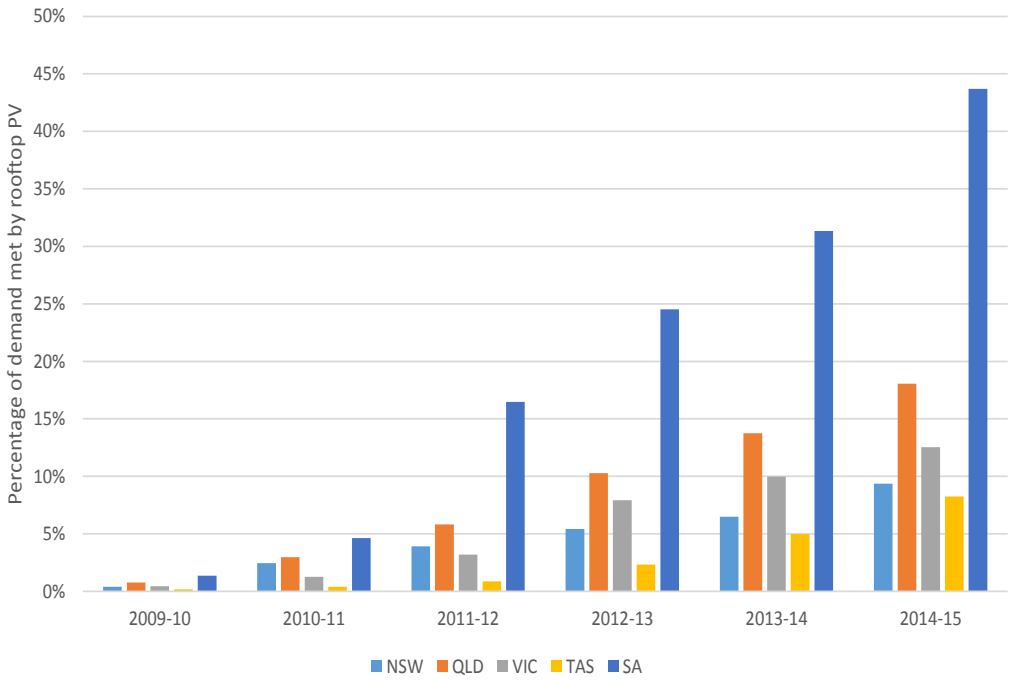
- The challenges will arise in all NEM regions.
- There will be greater uncertainty in operational demand forecasts.
- Future limitations in determining system security limitations.
- The process of assessing and reviewing models and modelling tools is expected to be a longer-term challenge.

VISIBILITY OF THE POWER SYSTEM (INFORMATION, DATA AND MODELS)

DISTRIBUTED ENERGY RESOURCES
A MAJOR BLIND SPOT

- Over 4 GW of rooftop PV systems are installed in NEM
- Individually small but in aggregate LARGE
- What If the Clean Energy Regulator didn't collect details?

- DER displaces scheduled generation.
- We lose some levers to maintain system security.
- Visibility becomes even more important at these times to maintain normal operating conditions.

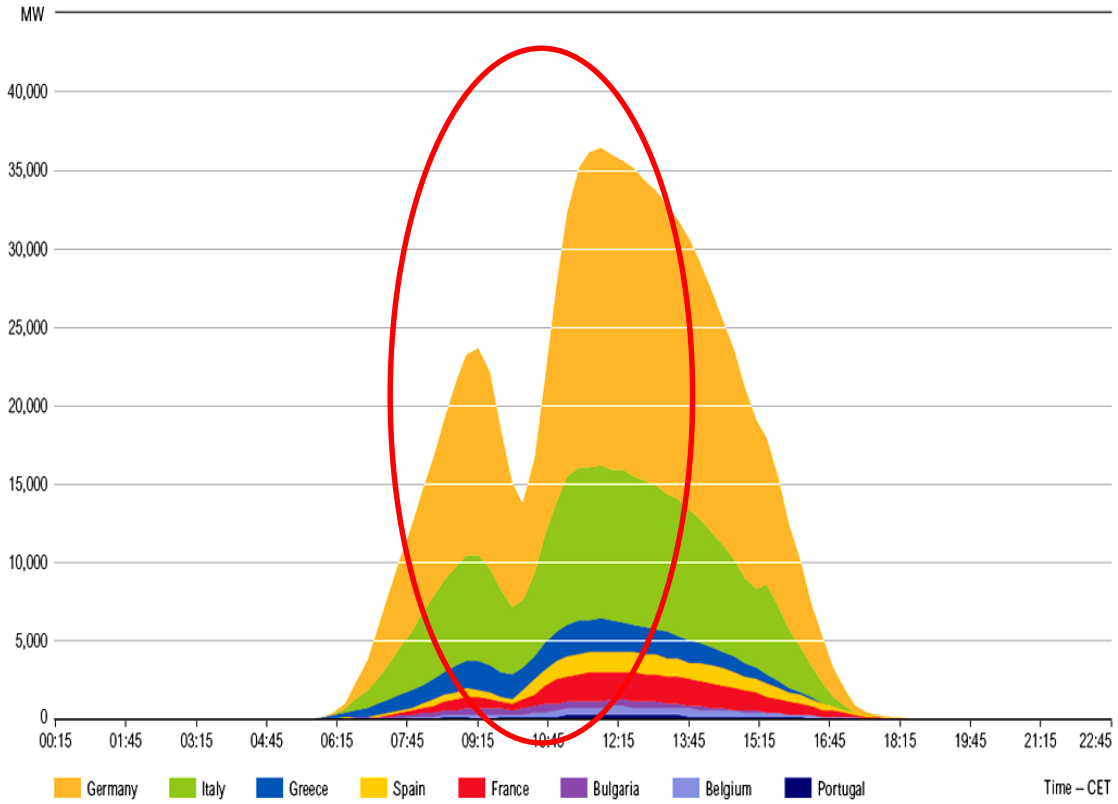


CASE STUDY:
MARCH 2015 EUROPEAN SOLAR ECLIPSE

- 6 months planning across 23 countries with 89 GW solar.
- Decrease in forecast PV output of 20 GW at start of eclipse.
- Increase by ~40 GW at end.
- Power system remained secure because operators had:

"A clear description of the installed PV capacity and their capabilities… [and] real time measurement of the dispersed PV generation… key for adapting the operational strategy in real-time"*

*ENTSOE, Solar Eclipse: The successful stress test of Europe's power grid, 2015. https://docs.entsoe.eu/dataset/solar-eclipse-the-successful-stress-test-of-europe-s-power-grid-more-ahead



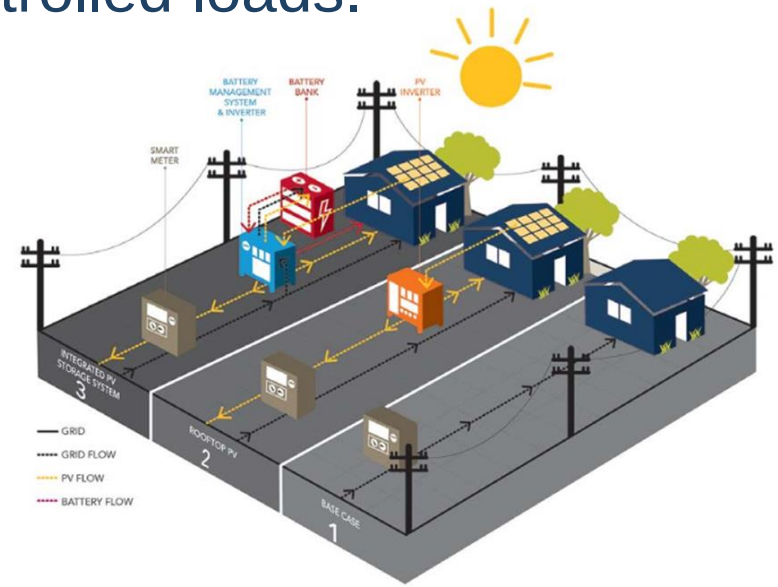
NOT JUST ABOUT DER

- DER is biggest gap but not the only one.
- Generator performance standards changed in 2007 to include information of RoCoF settings, etc.
  - Settings for older generating units are not all known.
- As the generation mix changes, system strength is changing,
  - Can affect the performance of some generating units and other network elements,
  - Need greater level of information about generating units to understand performance under changing system.

OPPORTUNITIES TO ADDRESS THE CHALLENGES

OPPORTUNITIES – CONSUMER SIDE

- Enhanced retail market offerings and rollout of advanced meters.
- Home automation and the Internet of everything.
- Smart, controlled loads and embedded generation.
- Smart, controlled embedded storage.
- Frequency controlled loads.



OPPORTUNITIES – UTILITY SIDE

- New or upgraded AC or DC interconnectors.
- Deployment of synchronous condensers.
- Advanced protection systems and dynamic UFLS.
- Synthetic inertia / fast frequency response.
- Wider range of technologies providing:
  - Frequency control,
  - System restart.

BY-NC-SA

OPPORTUNITIES – DELIVERY FRAMEWORKS

- Revised markets to encourage the economic delivery of required services.
- Revised technical standards requiring new plant to provide additional services.
- Changed Australian standards for appliances, embedded generation and storage.
- New regulatory arrangements.

NEXT STEPS

FPSS PROGRAM PROCESS

→ Dec 2015 | May 2016 | Dec 2016 | 2017 →

Identify challenges

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FUTURE POWER SYSTEM SECURITY

- With challenges identified, our focus is now on:
  - Specifying the technical parameters required by the system, and
  - Assessing the technical capability of various potential technology solutions.
- Feedback
  - We welcome feedback on progress report.
  - Encourage written submissions by 16 September 2016:
    - **StakeholderRelations@aemo.com.au**

- Discussion
  - Have we identified the most immediate challenges?
  - What else should we be considering?
  - What is the range of potential technical solutions?

DISCUSSION

Have we identified the most immediate challenges?

What else should we be considering?

What is the range of potential technical solutions?