

DS3 Advisory Council Meeting Belfast

19/01/2017

EIRGRID GROUP

Agenda

Topic	Time	Speaker
Introduction	10.30	Jon O' Sullivan -EirGrid (5 mins)
Industry Perspective	10:35	Presentation: Mary Doorly - IWEA (15 mins) Presentation: Joe Duddy - RES (15 mins) Discussion: All (10 mins)
International Presentation	11:15	Presentation: Jenny Reisz - AEMO (25 mins) Discussion: (5 minutes)
DS3 Programme Status Update	11:45	Presentation: Jon O' Sullivan - EirGrid (20 mins) Discussion: All (10 mins)
Rate of Change of Frequency (RoCoF)	12:15	Presentation: David Cashman - EirGrid (10 mins) Presentation: Brendan McGrath - ESB Networks (5 mins) Update: Rodney Ballentine - NIE (5 mins) Discussion: All (5 mins)
Power Off and Save	12:40	Presentation: Conor Egan – EirGrid (5 mins)
System Services (General Update)	12:45	Presentation: Robert O' Rourke - CER (15 mins) Presentation: Jon O' Sullivan – QTP (5 Mins) Discussion: All (10 mins)
Lunch & Networking (13:15 – 14:00)		
Topic	**Time**	**Speaker**
Control Centre Tools	14:00	Presentation: Karen O'Doherty - EirGrid (15 mins) Discussion: (5 minutes)
Ramping Studies	14.20	Presentation: James Ryan - UCD (15 mins) Discussion: All (5 mins)
Closing Remarks and Actions	14:40	Jon O' Sullivan - EirGrid (10 mins)
Session Closed / Networking	14:50	

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Industry Perspective

DS3 Advisory Council Meeting 19/01/2017

10.35-11.15 am

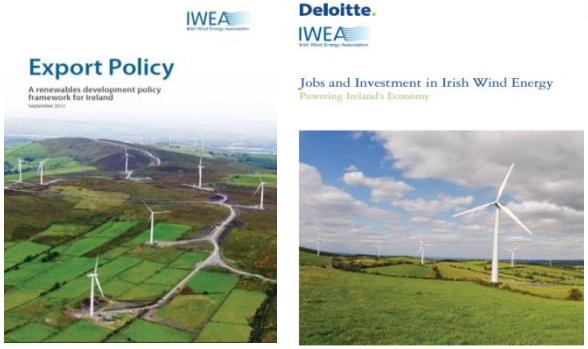
IWEA Perspective on the DS3 Programme

Mary Doorly

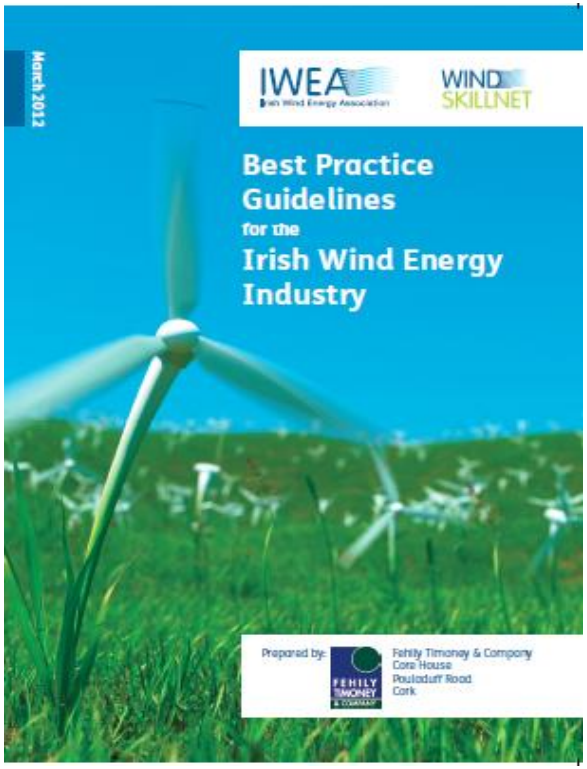
Thursday 19th January

IWEA Aims

- IWEA believes that Ireland can be a world leader in renewable energy
  - **Reduce** CO2 emissions
  - **Create** investment and jobs
  - **Increase** energy security
  - **Create** a thriving export industry



- IWEA is committed to responsible and sensitive wind energy development.



- IWEA promotes the development of onshore and offshore wind



- IWEA supports the development of other renewables particularly marine energy

IWEA Members

- Largest national network with members from various sectors
  - Wind farm developers
  - Turbine manufacturers
  - Construction companies
  - Supply companies
  - Accountants
  - Insurance
  - Consultancy
  - Legal firms
  - Banks
  - Small local businesses



IWEA 2017 Priority Policy Issues

Top 6 Issues

- I-SEM design
- Wind Farm Planning Guidelines and Legislative Requirements.
- Enduring Grid Connection Policy.
- Follow on support system to REFIT 2
- Route to market for wind energy projects in Northern Ireland
- **Reduction of Curtailment** through innovative use of Infrastructure, technology and operational practices including the DS3 Programme, Efficient Interconnection, and engaged consideration of any new alternatives.

Reduction of Curtailment

- While we are seeing increases in SNSP, curtailment mitigation remains a top priority for IWEA
- High build out in 2017/2018
  - ~1400MW in 2 years
  - Still assessing impact of REFIT 2 connection extension
- This will increase levels/forecasts of curtailment levels – in particular in advance of further SNSP increases
- REFIT revenues keep pressure on for early connections
  - Connection date has been extended but backstop date has not (remains at 2032)
- Removal of compensation for curtailment in 2018 is not appropriate

Reduction of Curtailment

- DS3 programme
  - System Services
  - RoCoF
  - Demand Side
  - Operational Tools
  - Frequency and Voltage Control

- More efficient Interconnection
- Increasing Demand
- New technologies
- Other considerations?

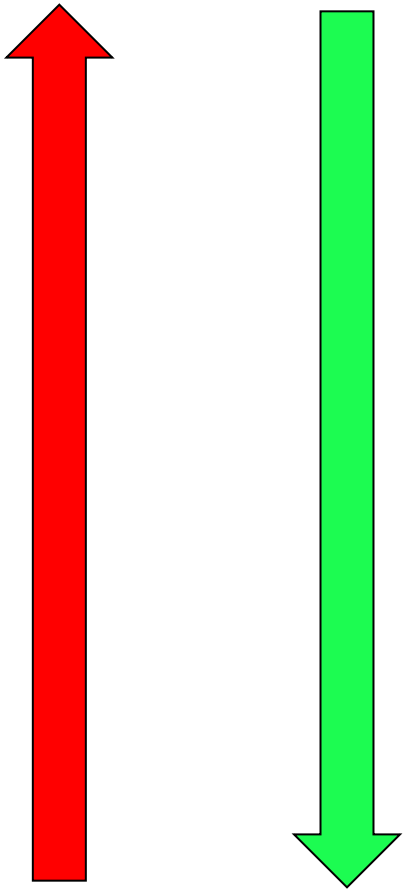
Factors Influencing Curtailment

Increased wind connections

SNSP limits

Operational Constraints

Minimum Generation Levels



Increasing SNSP limit

Improved exports – I-SEM and countertrading

System Services Interim & Enduring

Operational Tools

SNSP

- IWEA would like to commend the work to date carried out by EirGrid
- Timelines for SNSP increases are being progressed despite initial delays
- Acknowledge that SNSP might not remain the limiting factor as the system changes and other items may become binding

SNSP Level	2010 (PGOR's)	Apr-13	Apr-14	Jan-17
55%	2013	2014	Q4 2016	Q4 2015
60%	2013	2014	Q4 2017	Q4 2016
65%	2015	2015	Q4 2017	2017
70%	2017	2017	2019	2018
75%	2019	2019	2019	2019

  - How is the trial of 60% SNSP progressing?
  - Can we expect this to be policy in the near future?
  - What is required to move to 65%?

System Services

- Interim arrangements are a welcome development
  - Are expected benefits being delivered?
  - How much additional DS3 services are required from new connections?
- Clarity required in relation to Enduring Arrangements
  - Timelines and Volumes
- Results of Qualification Trials will be of interest to industry and provide clarity for wind

Interconnection

- EWIC back operational ahead of time – good news!
- Outage coincided with time of relatively low wind.
- But what it the likelihood of reoccurrence? What plans are in place?
- New wind limit December 23rd 11am – 2827MW All Island
- EWIC exports – important to ensure max export capacity of EWIC is available
  - Wind farms are undergoing changes to interface protections. Concerns remain over commercial implications, however benefit to curtailment has been acknowledged.
- I-SEM to deliver more efficient interconnection – signal to export at time of high wind
- Is there a need for further interconnection?

RoCoF

- Good progress being made in generator studies.
  - Some delays in high priority studies
  - Some delays in Northern Ireland
- IWEA has been engaging with windfarms re relay setting changes and will continue to do so
- What happens if a very small number of units do not / can not comply with 1.0 Hz/s?

Key Interactions

Going back to IWEA Top 6 Issues

- I-SEM design – essential to ensure efficient use of cross border interconnection so we can export at times of high wind
- Wind Farm Planning Guidelines and Legislative Requirements – no significant interactions for curtailment.
- Enduring Grid Connection Policy – needs to allow for efficient use of infrastructure, multiple owners behind connection points, storage/DS3 units co-located with wind, reduced costs.
- Follow on support system to REFIT 2 – lower curtailment levels will allow for more cost competitive projects under an auction based support scheme
- Route to market for wind energy projects in Northern Ireland – system service revenues could improve business case for wind in particular in NI where no clarity re future support.
- Reduction of Curtailment

Looking Beyond DS3

- Currently DS3 is focussed at allowing up to 75% SNSP
  - Can we get to 100% renewables?
  - What would be required?

- Influencing factors
  - 2030 Policy and beyond
  - Future connection policy – is it limited by the grid or does it drive the grid?
  - Market interactions
  - Maximise use of existing grid infrastructure
  - What are the roles for Storage, Further Interconnection, Solar etc.?
  - What new technologies are coming down the line?

Next steps

- Continued progress on DS3 programme as a whole
- Continued progress on increasing SNSP and assessment of appropriate metrics for system operation
- Implementation of Enduring Arrangements for System Services
- Implementation of RoCoF
- Reduction in no. of conventional units required on system
- Reduction in min gen of these units
- Continued reporting on curtailment
  - 2016 constraint and curtailment report
- Monitoring of curtailment and main drivers
- TSO countertrading to continue where required
- Assessment of need for further interconnection

Conclusion

- Reduction of Curtailment continues to be a priority issue for IWEA.
- Good work has been done on increasing SNSP
- Need certainty around system services enduring arrangements
- Timely access to information and Timely Decisions on Policy and Regulation needed
- The DS3 programme is extremely important to the wind industry and we are keen to continue to play an active role in whatever way we can to move this programme forward


www.iwea.com

Battery Energy Storage

Joe Duddy

19th January 2017



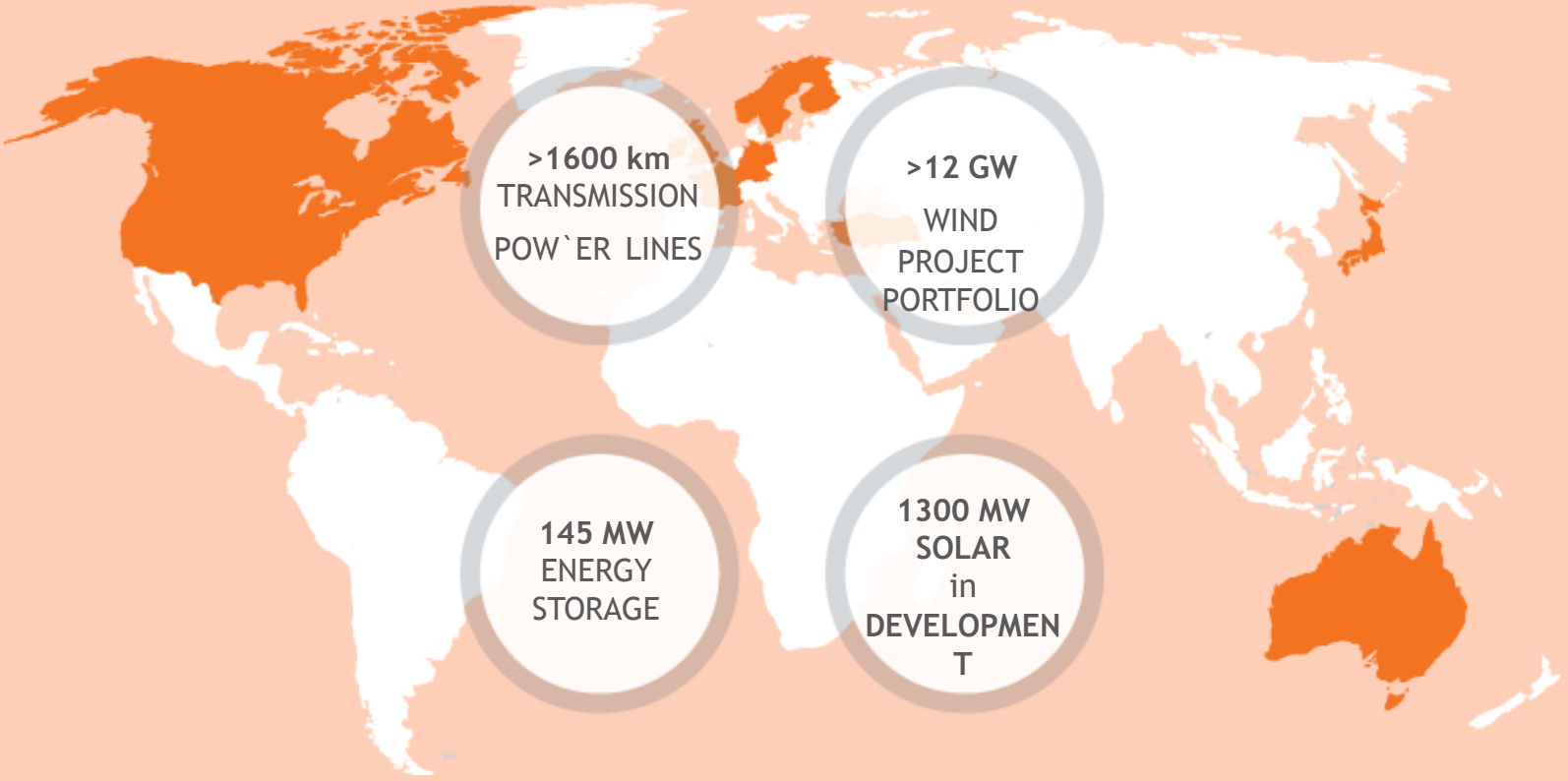
Today I'll aim to cover …

- Who is RES?
- What is battery energy storage?
- Why battery energy storage?
- What has RES done in energy storage so far?
- What lessons have we learned along the way across the portfolio?

About RES

RES operates across 4 continents
Headquarters in Hertfordshire, UK

Founded 1992



RES Capabilities



DEVELOPMENT

SOLAR



ENGINEERING

WIND

TRANSMISSION



CONSTRUCTION

STORAGE



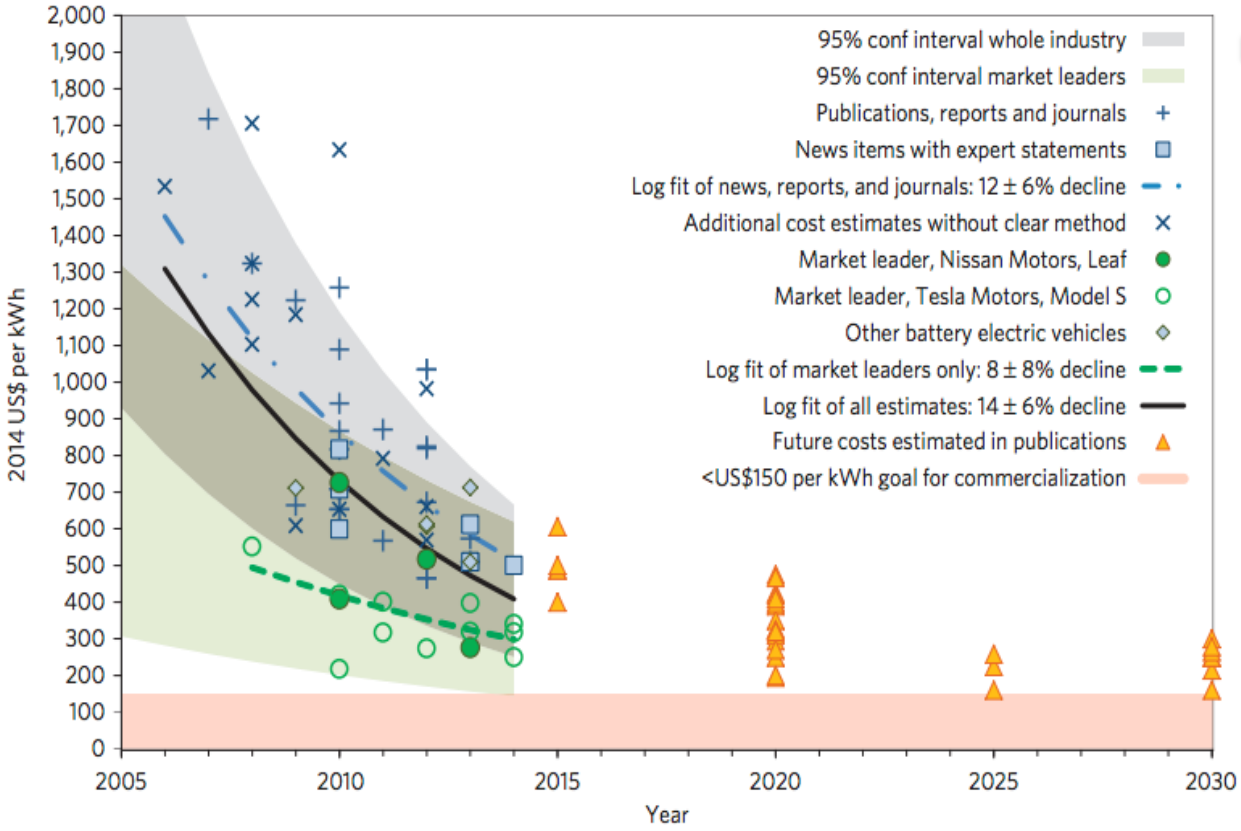
OPERATIONS

Why Battery Energy Storage?

- Complimentary to RES renewable energy business
- Essential to achieving very high levels of renewable energy penetration
- Flexible, modular and relocatable (compared to CAES and PHES)

Why Battery Energy Storage Now?

Costs are falling…Technology is improving…and Policy is changing

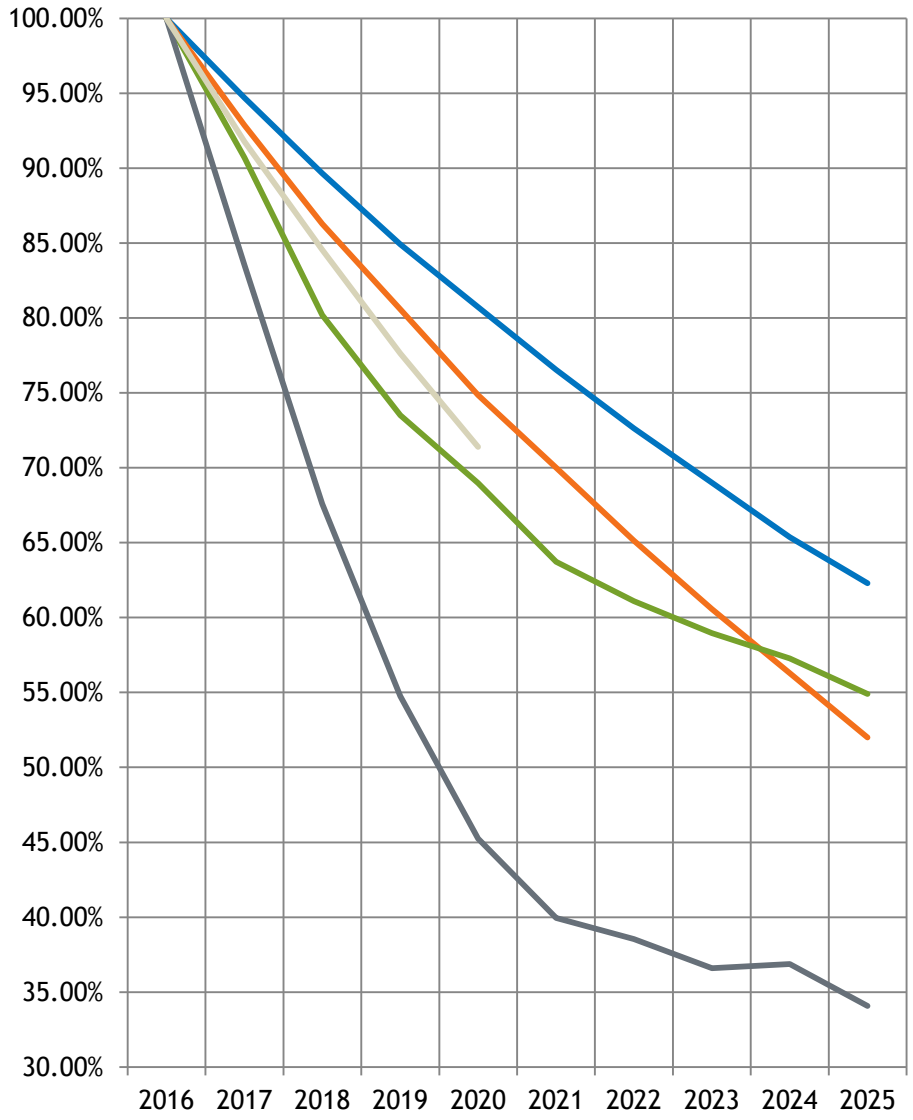


In the US, policy is opening storage markets

- California Distributed Resource Plans
- New York Reinventing the Energy Vision
- Massachusetts Energy Storage Initiative
- Hawaii Docket No 2014-0130 and 0192
- Texas DER Products
- Oregon Storage Procurement

Björn Nykvist and Måns Nilsson, “Rapidly falling costs of battery packs for electric vehicles”;, Nature Climate Change, March 2015

Lithium Battery Price Forecasts



All data was normalized to projected costs in 2016.

Data from various industry analysts projections

RES approach

RES operates across the entire value chain except as the OEM



DEVELOPMENT



ENGINEERING

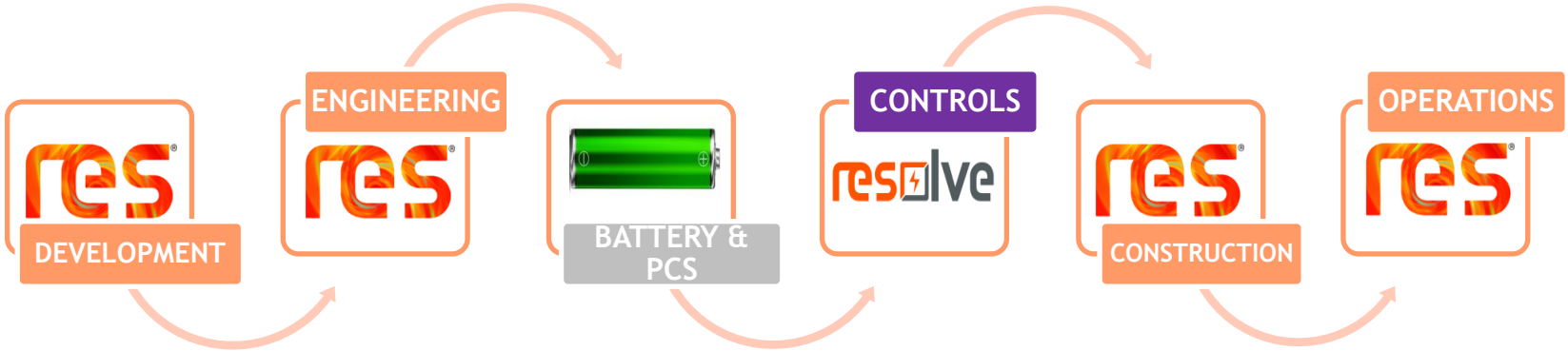


CONSTRUCTION



OPERATIONS

We select battery & PCS based on requirements, safety & value



RES Energy Storage Projects

Name	Function	Market	MW	MWh	Owner type	Role	COD
Ohio	Freq. Reg.	PJM	4.0	2.6	IPP	Dev, EPC, Asset Mgmt.	2014 Q1
Amphora	Freq. Reg.	IESO	4.0	2.6	IPP	Dev, EPC, Asset Mgmt.	2014 Q3
Jake	Freq. Reg.	PJM	19.8	7.9	IPP + Investor	Dev, EPC, Asset Mgmt.	2015 Q3
Elwood	Freq. Reg.	PJM	19.8	7.9	IPP + Investor	Dev, EPC, Asset Mgmt.	2015 Q4
Willey	Freq. Reg.	PJM	6.0	2.0	Investor	Dev, EPC, Asset Mgmt.	2015 Q4
McHenry	Freq. Reg.	PJM	19.8	7.9	IPP	EPC	2016 Q1
Glacier	Microgrid, freq. response, peaking	WECC	2.0	4.4	Utility	EPC	2016 Q1
New York	T&D Deferral	NYISO	2.0	12.0	Utility	EPC	2016 Q3
Clinton	Freq. Reg.	PJM	10.0	4.1	Investor	Dev, EPC, Asset Mgmt.	2016 Q3
Techno Centre	Multiple	Hydro-Québec	0.2	0.3	Research Centre	EPC	2016 Q4
Copley Wood	9 grid services	GB	0.3	0.6	Utility	EPC, Warranty Mgmt.	2016 Q3
M5Bat	Multiple	Germany	0.7	0.7	Research Centre	EPC	2016 Q2
UK ESS	Freq. Response	GB	20.0	TBC	TBC	Dev, EPC, Asset Mgmt.	2017 Q3
Port of Tyne	Freq. Response	GB	35.0	TBC	TBC	Dev, EPC, Asset Mgmt.	2018
Campo	Freq. Reg.	California	2.0	4.0	Utility	EPC	2017
TOTAL			145.6	>65.0			

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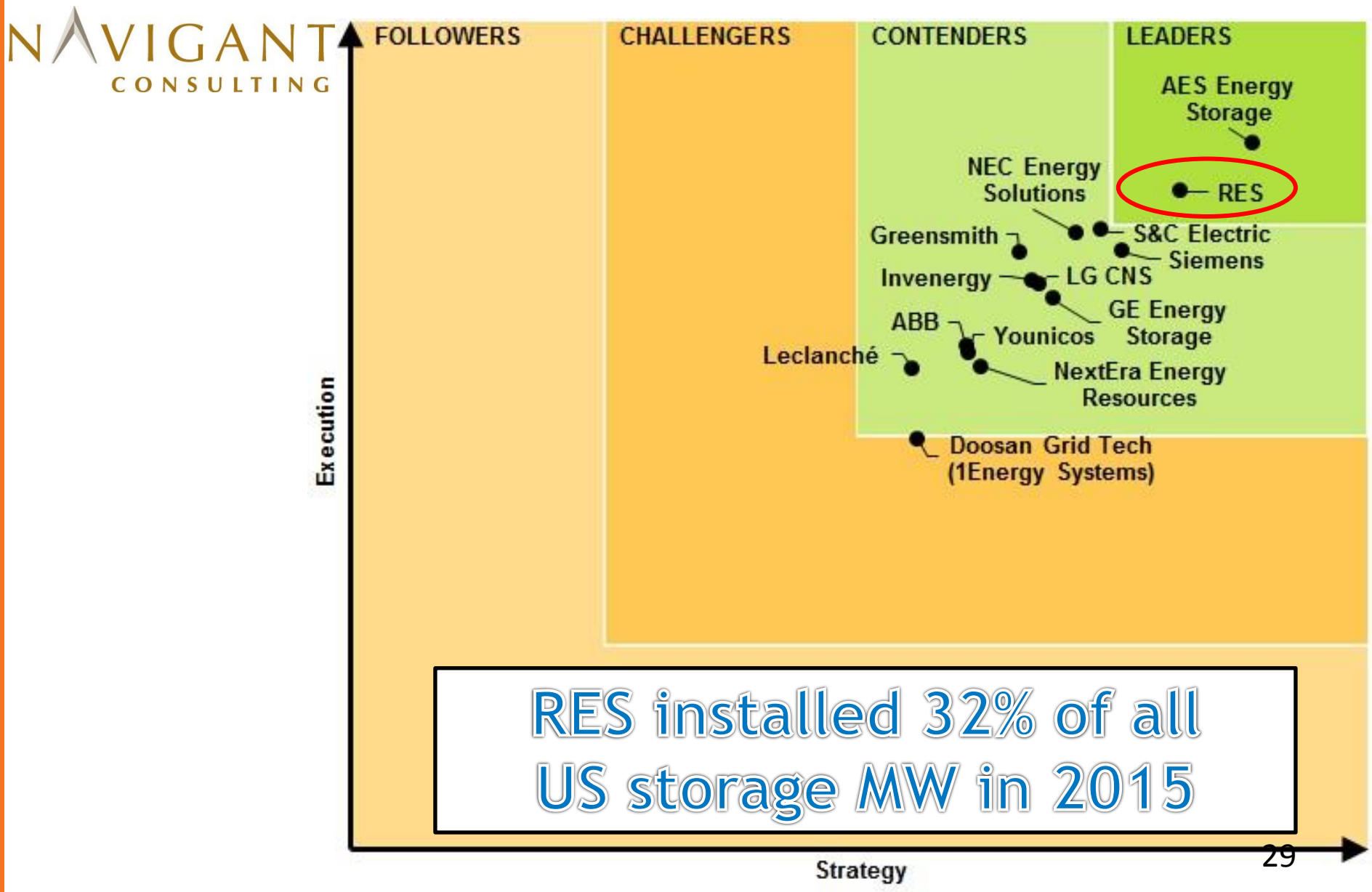
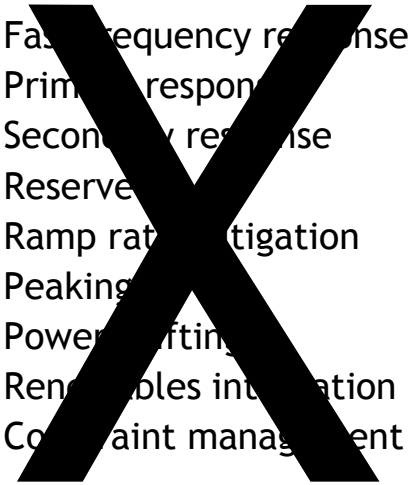
A Recognized Leader in Energy Storage



What does Energy storage do?

- **Confusion exists – so many products**



- Fast frequency response
- Primary response
- Secondary response
- Reserve
- Ramp rate mitigation
- Peaking
- Power shifting
- Renewables integration
- Constraint management

- **The value is simply in power injection or absorption <u>delivered at different response speeds</u> and <u>sustained over different timescales</u>**

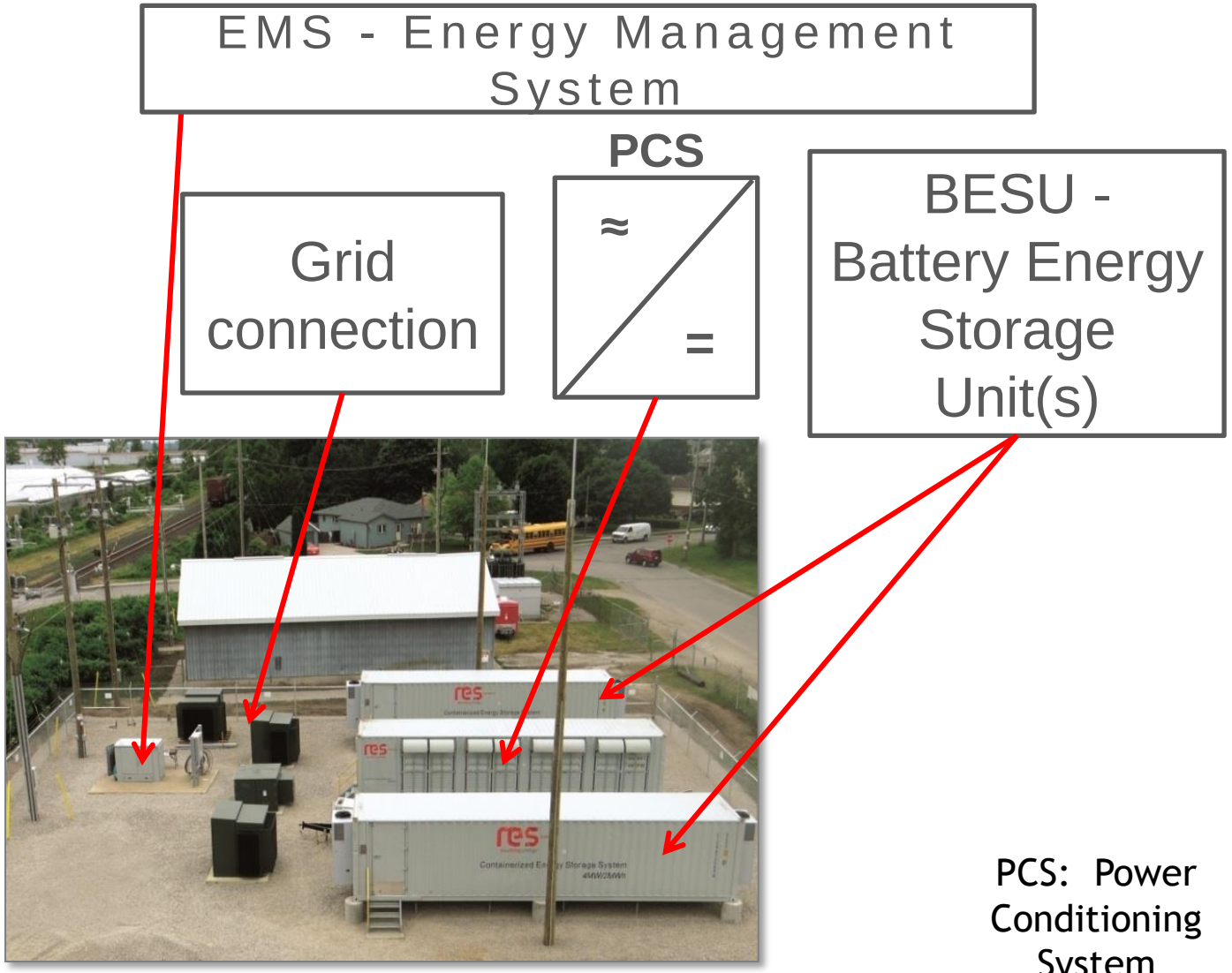
- **Real power (MW)**
  - For example, frequency response is injection/ absorption delivered quickly and sustained for a short time (low MWh:MW ratio). Energy storage does not 'generate frequency'. Frequency is just a measure of system balance. Energy storage either injects or absorbs real power in a way that helps keep frequency in balance

  - For example, reserve is injection of real power delivered within a few hours notice and sustained for multiple hours (high MWh:MW ratio)

- **Reactive power (Mvar)**
  - Voltage support for network stability

What does Energy storage do? (Anatomy of a BESS)

Delivers/absorbs power (MW_{AC}) for duration (hrs) ➔ MWh



PCS: Power Conditioning System

19.8MW / 7.8MWh battery storage project



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4MW / 2.6MWh battery storage project



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Main barriers to storage UK and Ireland

- GB regulations and market and network codes currently recognise three types of system user: demand, generation and interconnection.

- Given that the UK has historically had very few operational electricity storage sites, UK energy policy, market arrangements and network access and charging rules are not adequately designed for storage.

- This results in unintentional barriers to the uptake of electricity storage, and discriminatory treatment compared to other users.

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Main barriers to storage (cont.)

- Top three barriers:
  1. Market rules – e.g. charging of final consumption levies (GB)
  2. Network rules – charging does not reflect storage's impact on the system
  3. Service contract lengths – must be sufficient to finance project

- A key enabler to the removal of these barriers is the clarification of the status of storage in the UK licencing framework.

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Conclusions

- Conclusion – energy storage technology is ready for deployment at the MW/MWh ratios that create value for consumers over short to medium term. Battery technology is ready to supply. Providers are ready to build. Finance is ready.

- RES would encourage focus on bringing commercial solutions to market. This requires aligned policy making to
  - Create contracts of sufficient length to support new asset deployment
  - Enable layering of multiple value streams
  - Review and update grid connection access and charging methodologies

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powering change

ANTICIPATING AND ADDRESSING SECURITY CHALLENGES IN AN EVOLVING POWER SYSTEM

January 2017

PRESENTED BY JENNY RIESZ

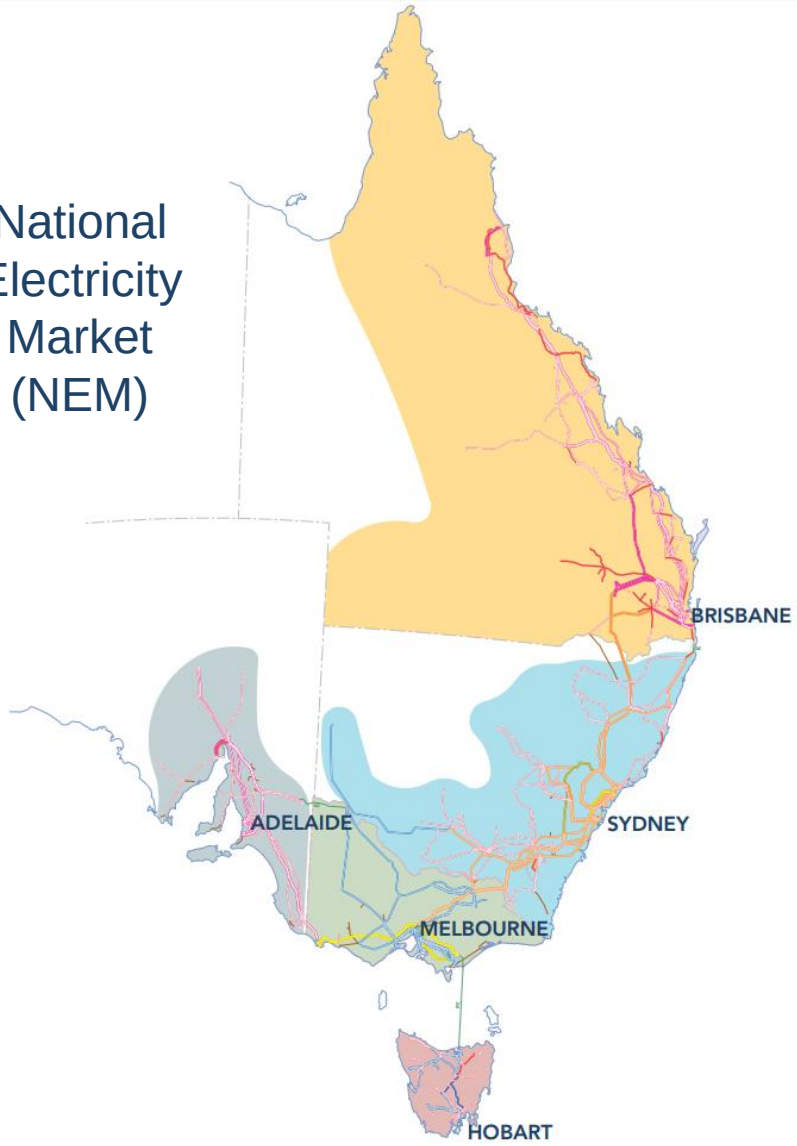
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

AGENDA

1. Introduction to the NEM
2. Future Power System Security Program
3. Identifying & addressing future challenges
   - Frequency Control
     - RoCoF
     - Fast Frequency Response
     - Availability of regulation frequency control
   - System Strength
4. Black system event – 28 Sept 2016

INTRODUCTION TO THE NEM

National Electricity Market (NEM)

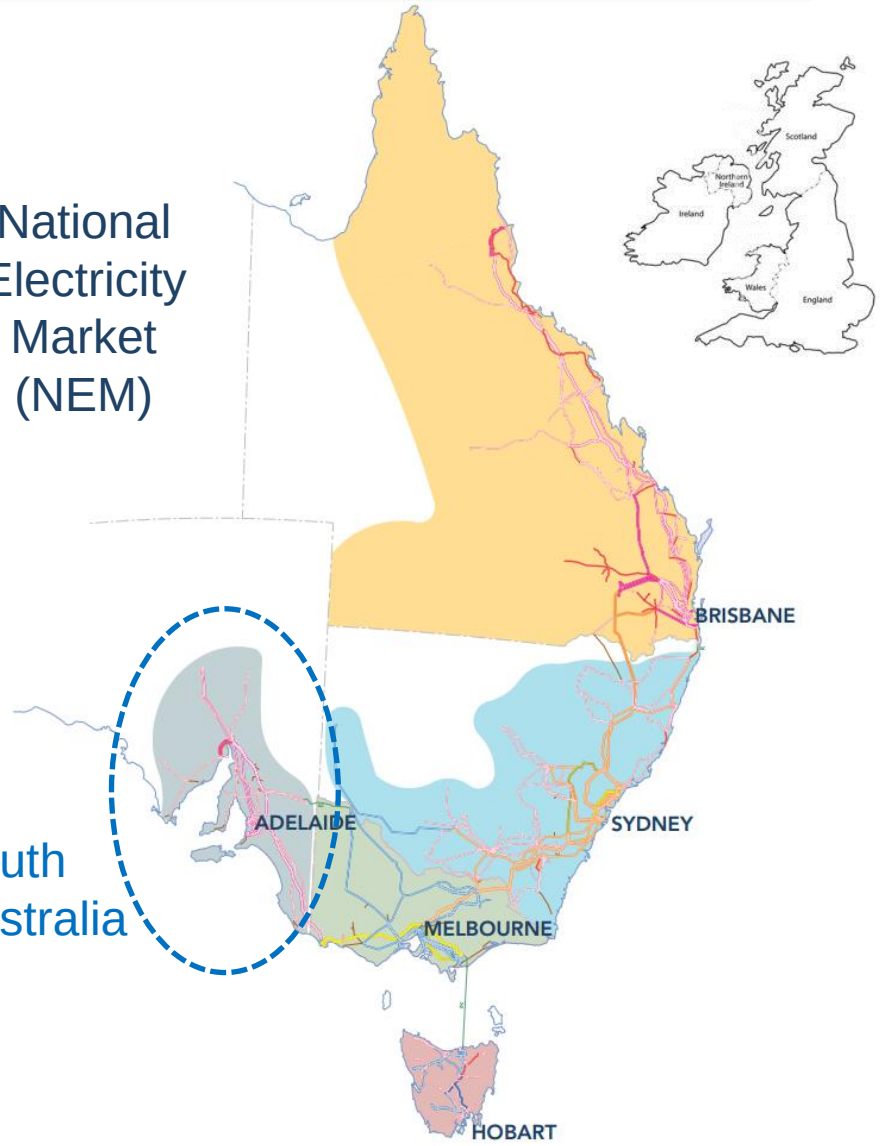


- ~80% of electrical load in Australia
- 5min spot market
- Regional pricing
- No day-ahead market
- Unit self-commitment

	Quantity
Energy	200 TWh pa
Demand	15 - 35 GW
Generating capacity	45 GW
Transmission lines	~5,000 km

SOUTH AUSTRALIA

National Electricity Market (NEM)



South Australia

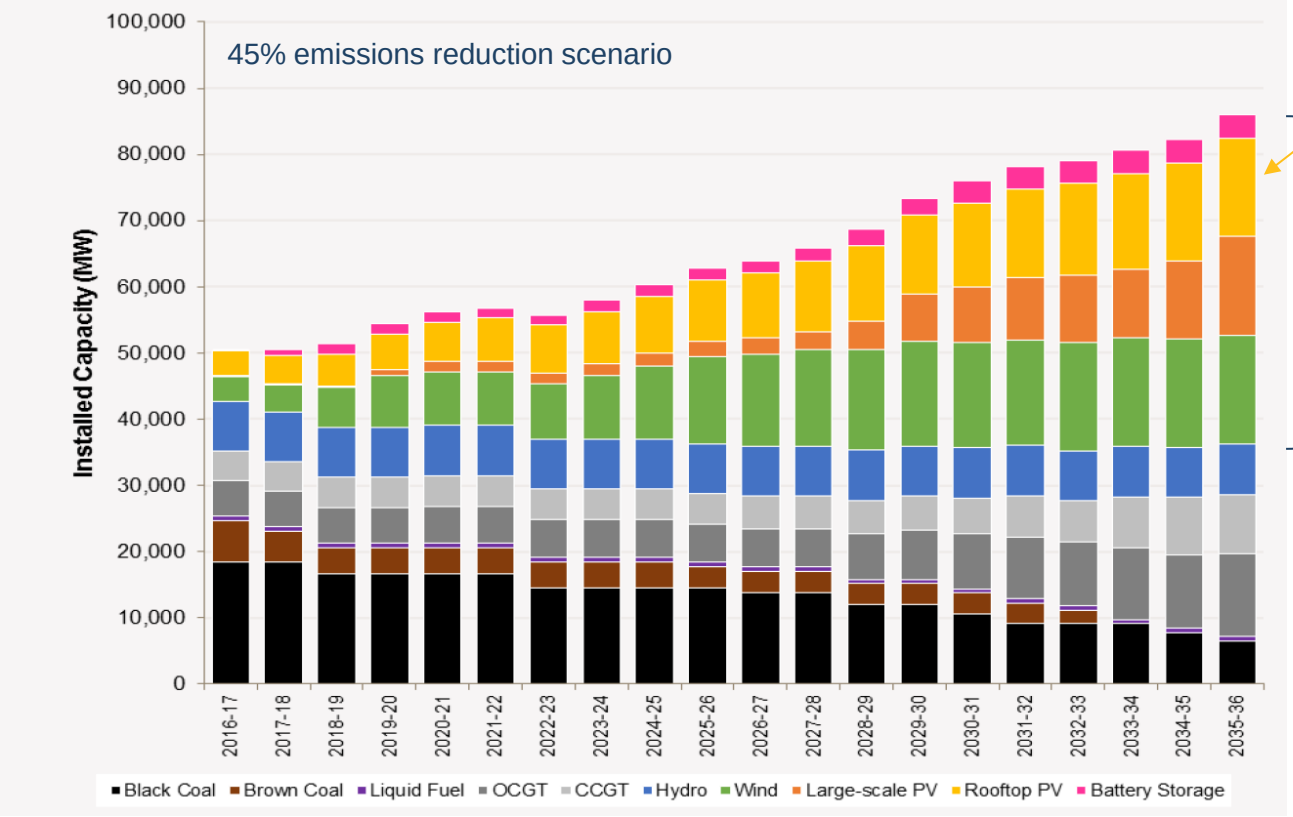
Area	Demand	Interconnections
Ireland	2.3 - 6.8 GW	2 x HVDC
Great Britain	17 - 50 GW	3 x HVDC
NEM	15 - 35 GW	None
South Australia	**1 – 3.4 GW**	**1 x AC (650 MW) 1 x HVDC (220 MW)**

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



Distributed resources

Variable & Non-synchronous

Significant retirements

- What challenges will we encounter?
- How do we maintain power system security?

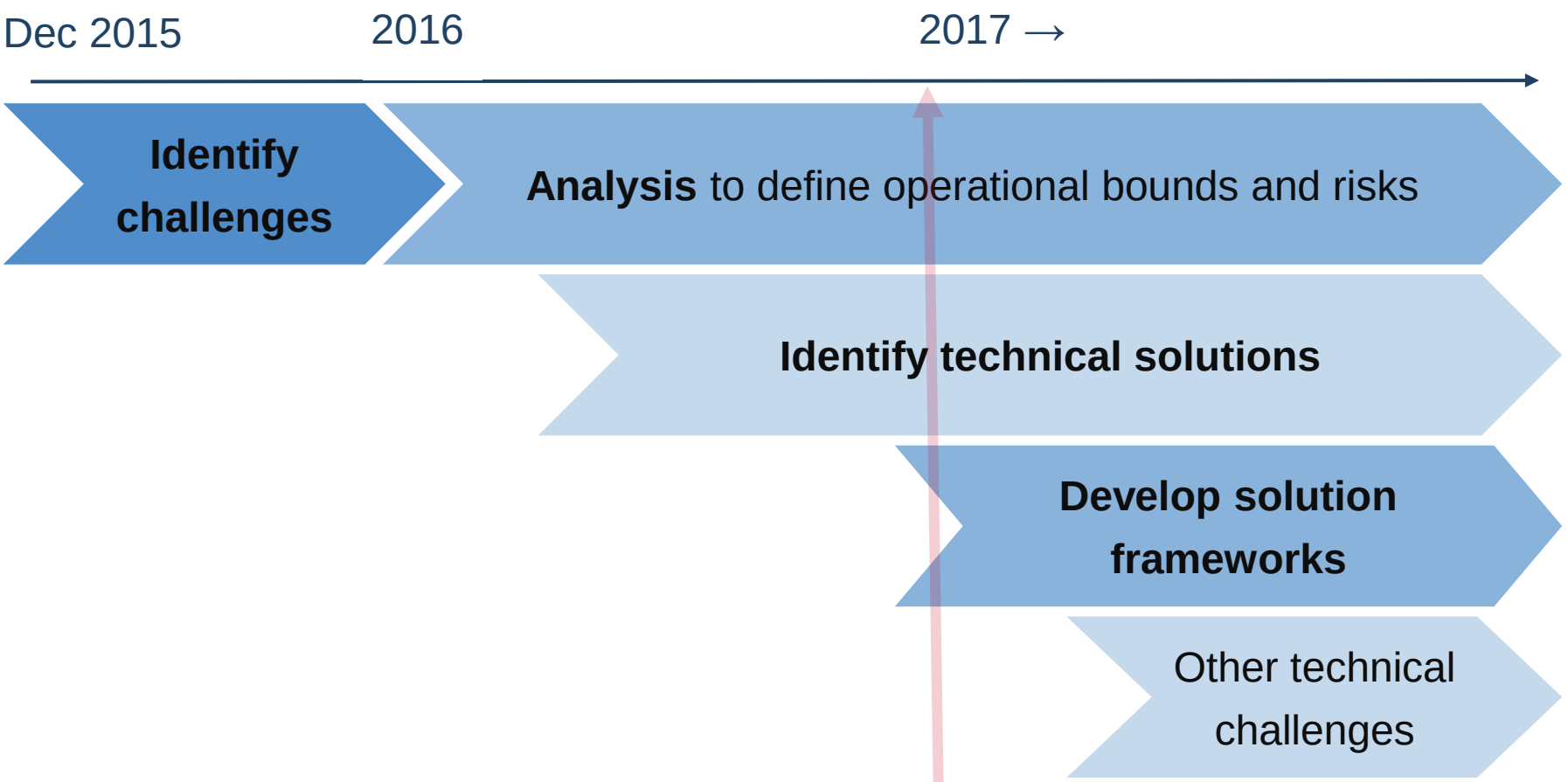
FUTURE POWER SYSTEM SECURITY (FPSS) PROGRAM

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



Where are we at now?

- Identified challenges
- Finalising first round of quantitative analysis, further identified
- Analysing technical solutions
- Commencing work on implementation frameworks

IDENTIFYING CHALLENGES

- Power Systems Issues Technology Advisory Group (PSI-TAG)
  - Stakeholder consultation group
  - Formed a comprehensive list of challenges
  - Prioritised the challenges 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:

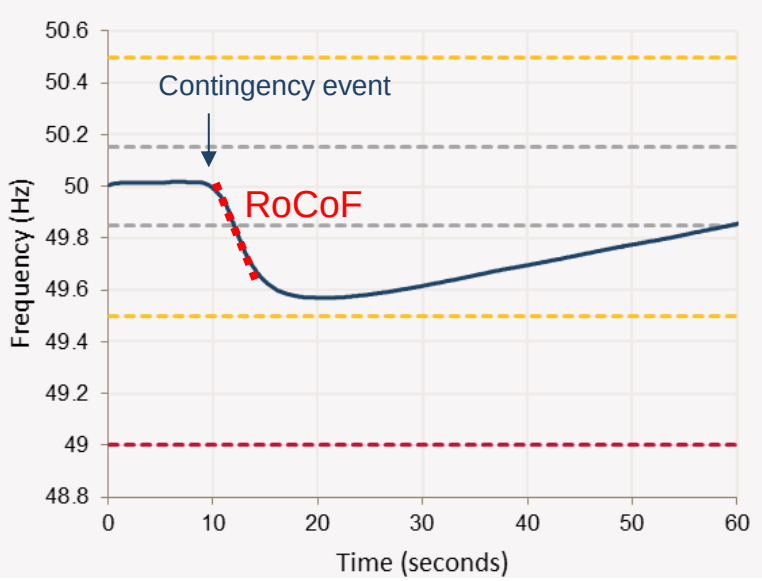
	Control	Response time	Sustain time
Regulation	AGC (Automatic Generation Control)	Responds every 4s	Enabled each five minutes
Contingency	Local frequency measurement	6s	60s
		60s	5min
		5min	~10min

- Nine separate real-time (5min) markets
  - 8xFCAS + Energy
- Regulation FCAS:
  - **Quantity:** Minimum values, increased in response to time error (dynamic)
  - **Cost recovery:** Causer-pays mechanism - Units that deviate from dispatch targets pay a larger proportion (4s assessment)

FREQUENCY CONTROL CHALLENGES

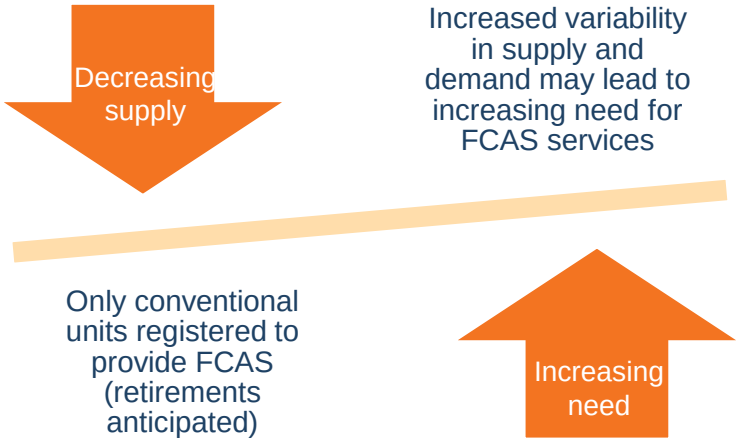
High RoCoF

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



Insufficient FCAS

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



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

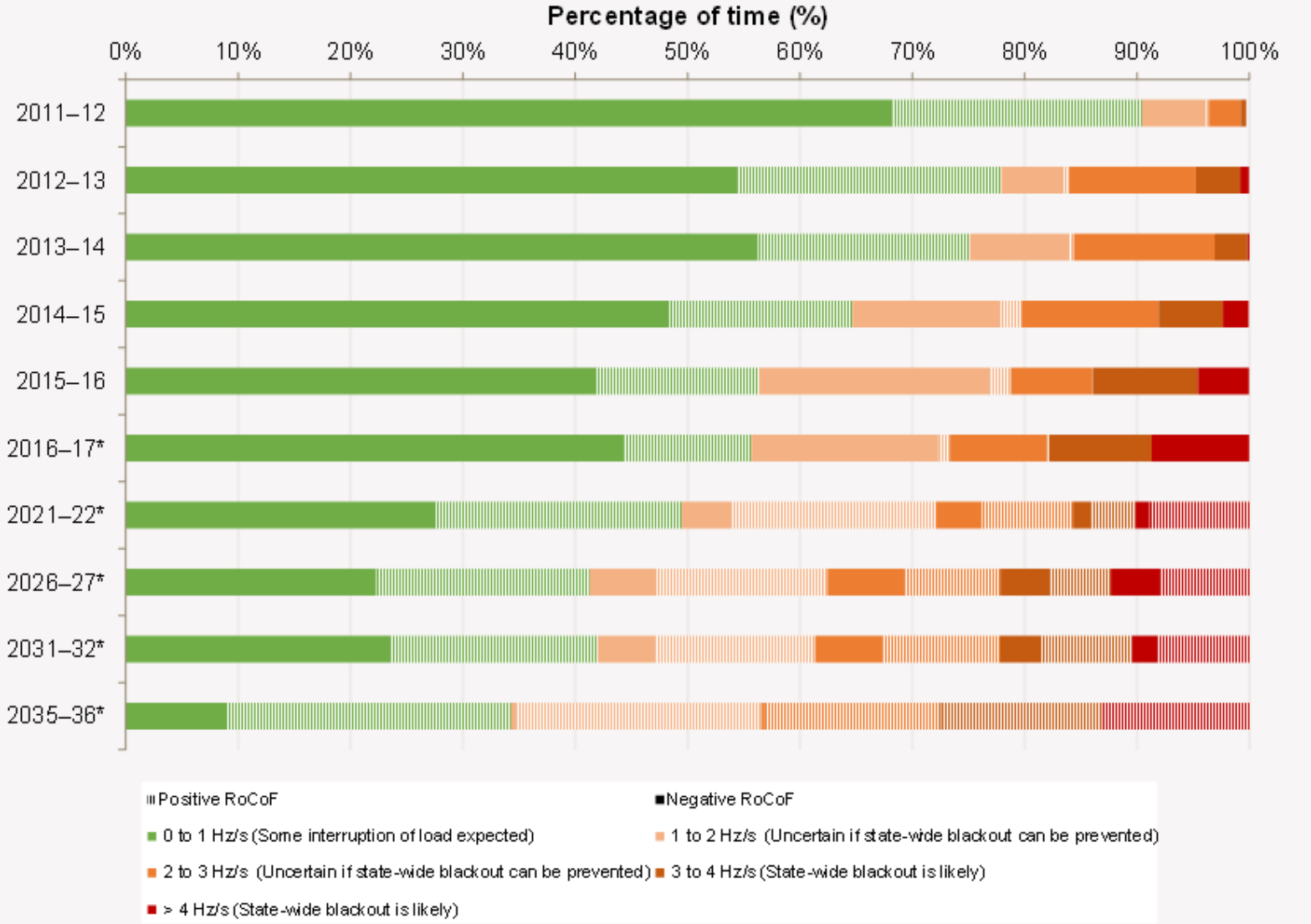
- Limitations and capabilities of technologies that can provide FFR
- Simple power system modelling to identify power system requirements
- Preliminary specification of FFR service

INTERNATIONAL REVIEW

- Very few large jurisdictions experiencing RoCoF challenges
- Important exceptions:
  - EirGrid/SONI
  - National Grid
- Opportunities for collaboration
  - At the forefront of managing these challenges
  - Important to share learning and experiences
- FFR services are relatively novel
  - Very few practical examples of very fast frequency control
  - Real technical complexities



ROCOF EXPOSURE IN SOUTH AUSTRALIA



Exposure in SA upon "non-credible" loss of Heywood interconnector (double circuit)

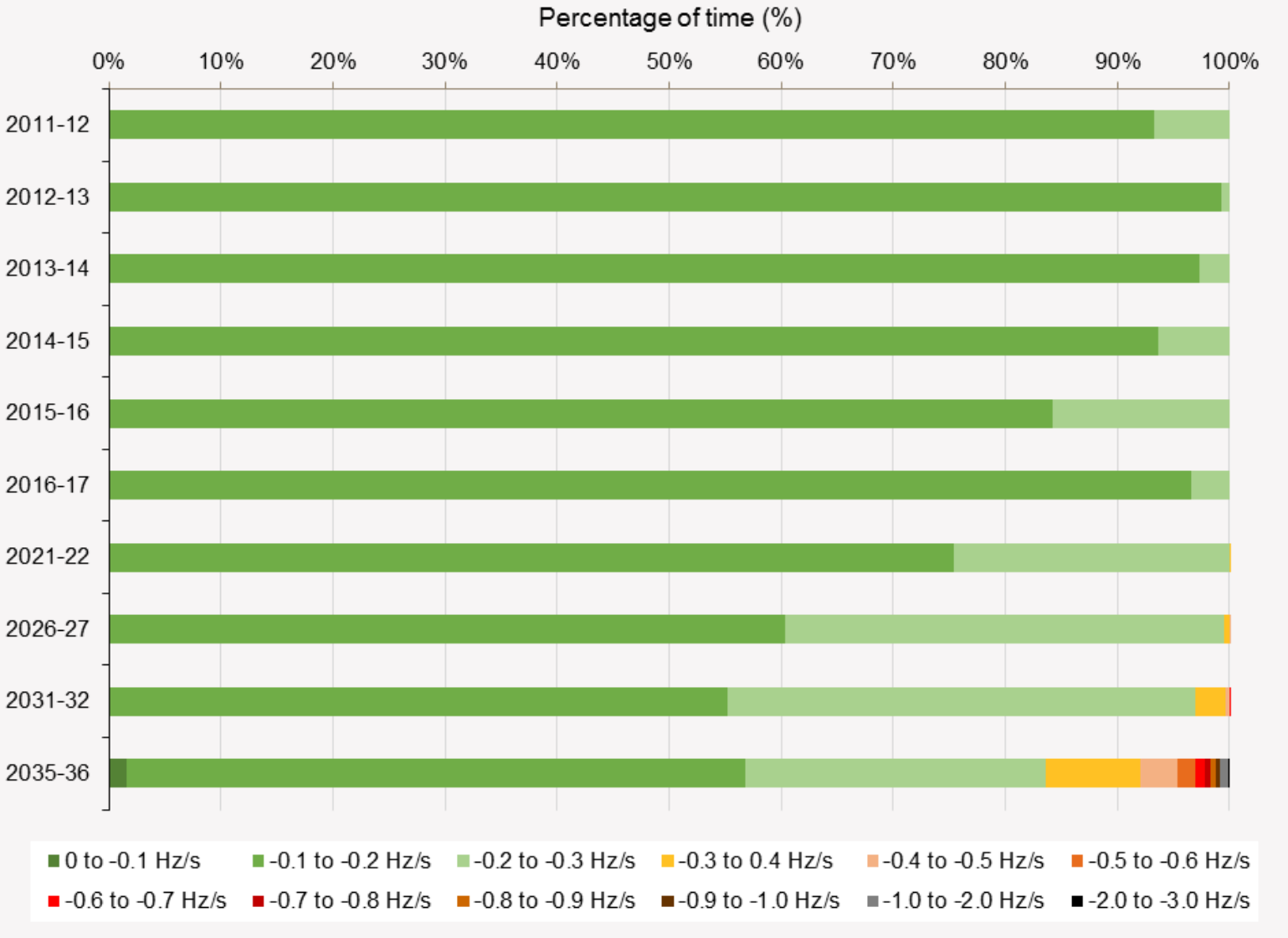
AEMO has **no obligation or authority** to protect against loss of Heywood, unless reclassification of loss as "credible"

Rule change in progress to allow identification of "protected events", for which AEMO would have some obligations and authority.

ROCOF VULNERABILITY

- UFLS
  - Will not operate successfully above 3Hz/s
- Gas Turbines
  - Particularly vulnerable
- PSS/E modelling results:
  - Significant differences between synchronous units identified, some may be particularly vulnerable
  - 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?)
- No other major vulnerabilities identified
  - But targeted testing, monitoring and verification required
- Secure technical envelope for RoCoF?
  - Remains uncertain
  - Cost-risk trade-off

NEM MAINLAND – CREDIBLE CONTINGENCIES

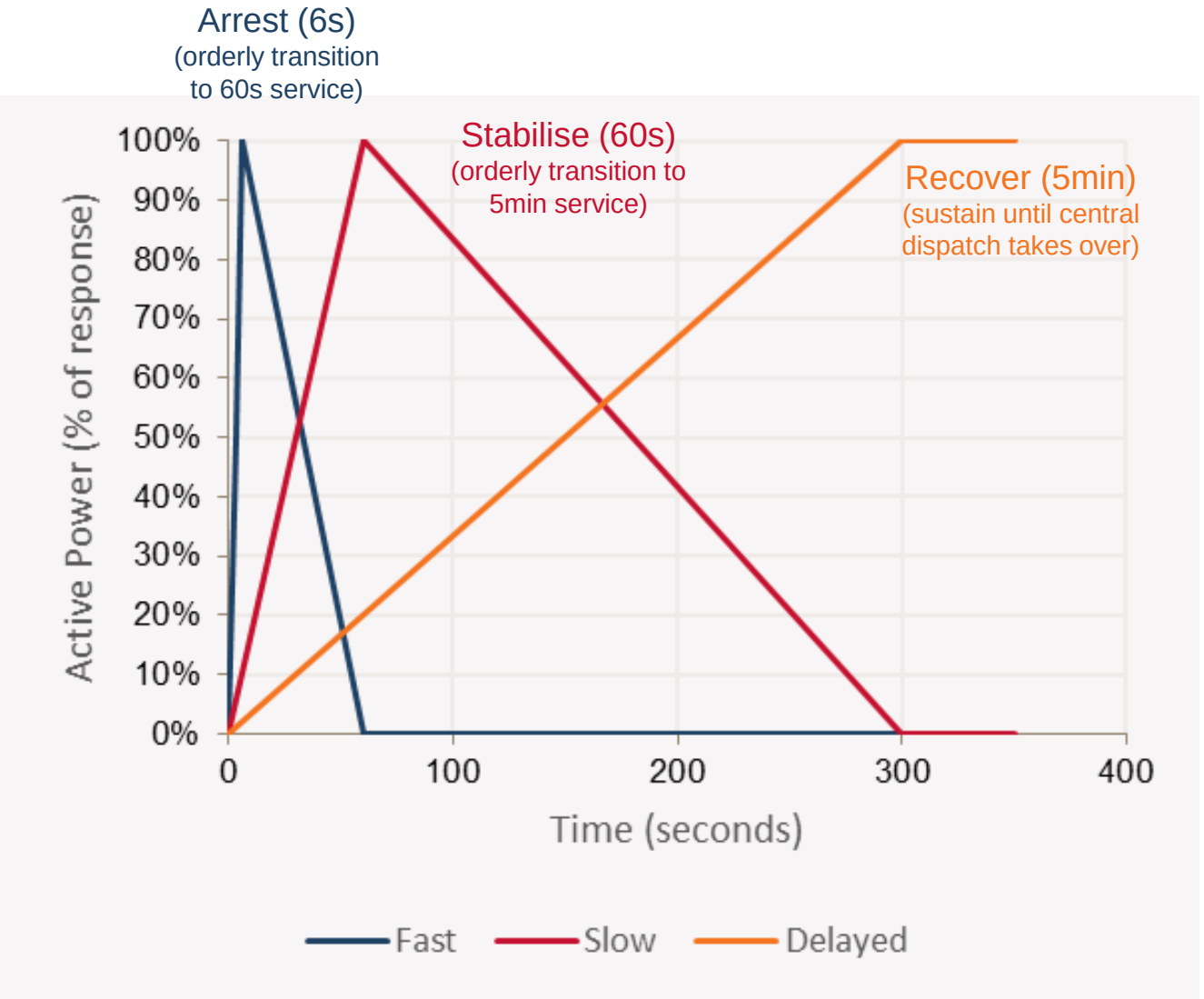


Exposure on NEM Mainland upon credible loss of largest unit

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

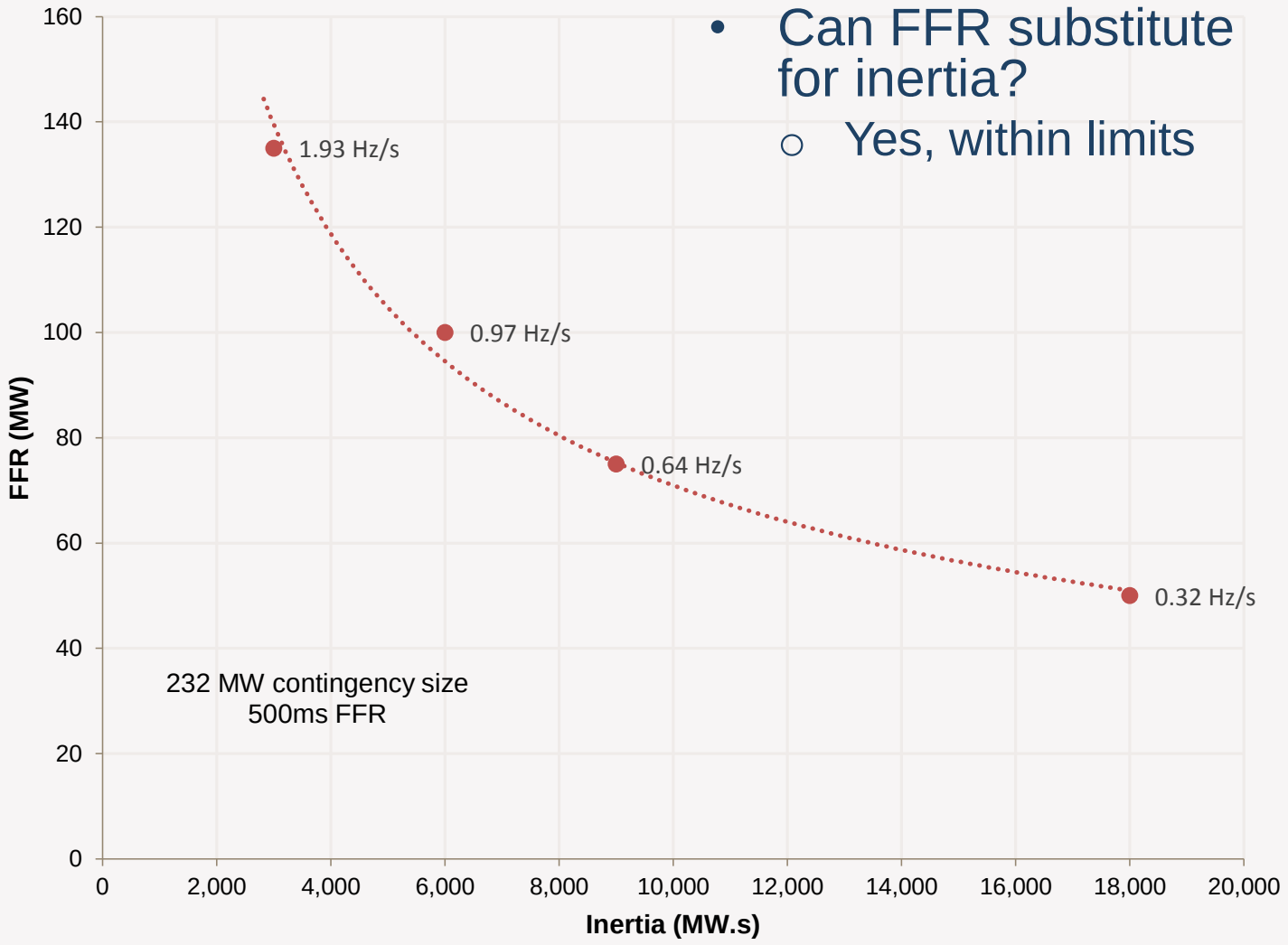
FFR SPECIFICATION – PRELIMINARY IDEAS

- 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

- Can FFR substitute for inertia?
  - Yes, within limits

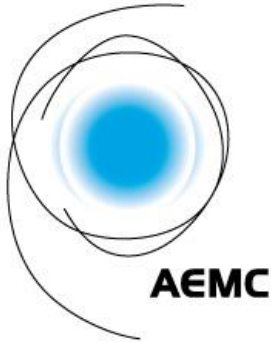


IMPLEMENTATION FRAMEWORKS



Market operator

Collaborating
(FFR / Inertia)



Rule maker

IMPLEMENTATION FRAMEWORKS

- Options:
  - Generator obligation
  - AEMO contract process
  - TNSP provision
  - Five-minute dispatch
- Principles:
  - Certainty vs flexibility
  - Technology neutral
  - Competition & market signals

FUTURE FCAS NEEDS

AVAILABILITY OF FCAS

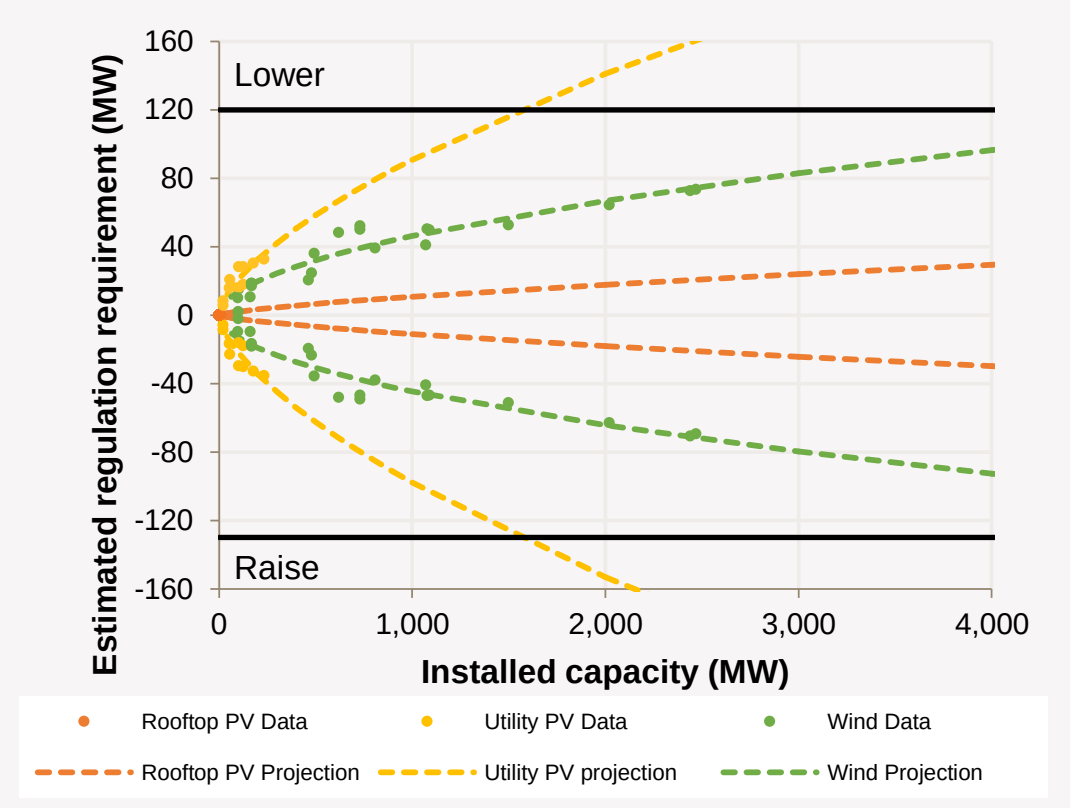
Projecting FCAS supply-demand balance

- 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



- Utility-scale PV is a significant driver of regulation FCAS requirements (1-2 GW exceeds present requirements)
- Rooftop PV is relatively insignificant (30GW required to exceed present requirements)
- Moderate increase in requirements is likely in the coming decades
- Intervention in dispatch likely to be increasingly required, unless new entrants provide regulation
- Priority to promote regulation provision from wind/PV

SYSTEM STRENGTH

- System strength is a measure of power system stability, associated with low fault currents
- Operational challenges:

Voltage instability
- Voltage management challenges

Power-electronic interfaced generation
- Inability of power-electronic interfaced generation to operate properly

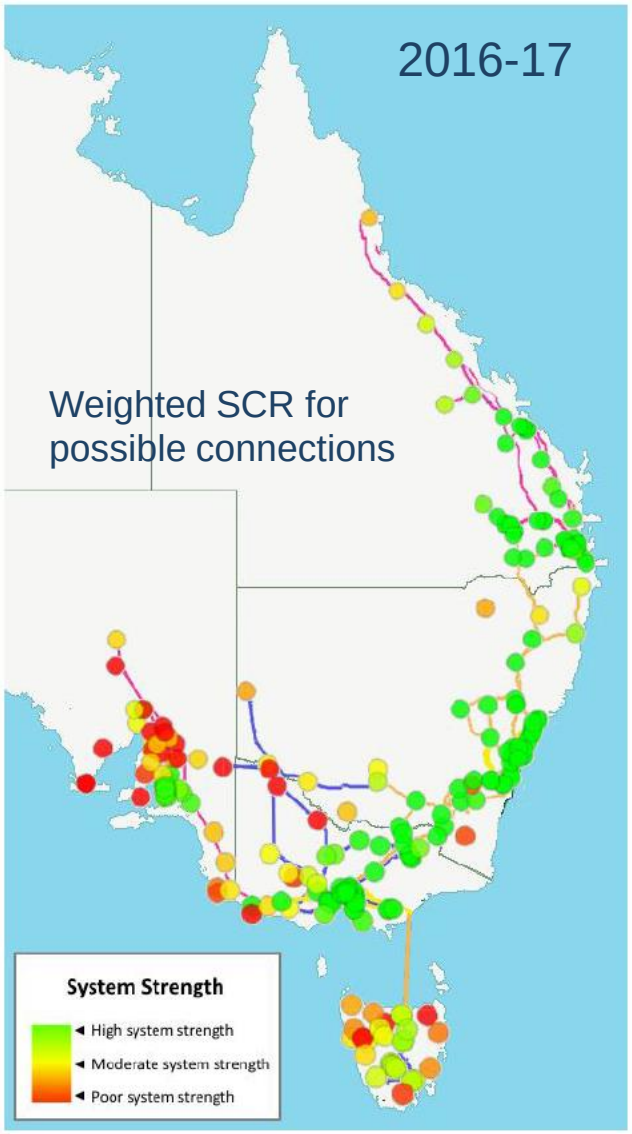
Protection systems
- Failure of protection systems to operate properly

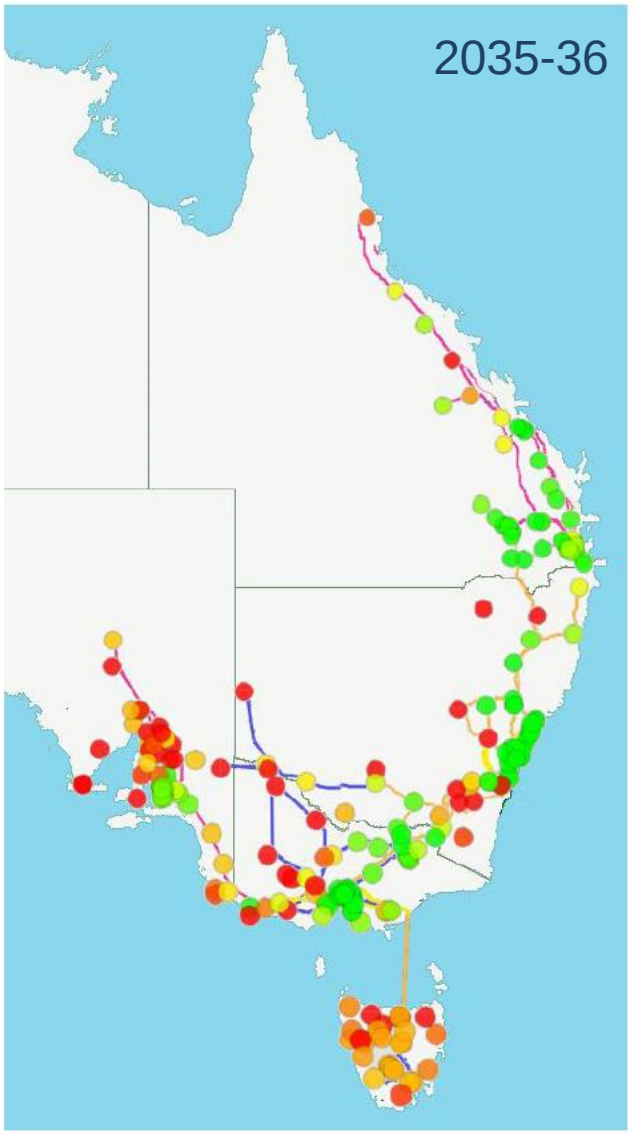
Slower recovery of active power following faults
- Implications for frequency control

HVDC links
- Commutation failure challenges

Modelling
- Increased challenges in accurate power system modelling

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?

BLACK SYSTEM – 28 SEPT 2016

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

Loss of synchronism on AC interconnector — 600ms after reduction in output from last of wind farms

RoCoF ~6Hz/s — ~890 MW contingency with ~3,000 MW.s inertia, UFLS cannot operate quickly enough

System Black

- 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?)
- Impacts of **system strength**?

DISCUSSION – RELEVANT INSIGHTS FROM IRELAND/NI?

- RoCoF vulnerability
  - Any other power system elements that are likely to be sensitive to RoCoF?
- RoCoF generator testing program
  - Key lessons & findings?
- System Services, particularly **FFR**, **inertia** and **Fast Post-Fault Active Power Recovery**
  - Why were they specified in the manner implemented?
  - Intentions to evolve in future?
- Managing transient active power reductions following faults
  - The most difficult challenge?
- Other concerns/challenges?
- Contact:
  - Jenny.riesz@aemo.com.au

DS3 Project Progress

DS3 Advisory Council Meeting 19/01/2017

11:45-12:15 p.m.

Jon O’ Sullivan

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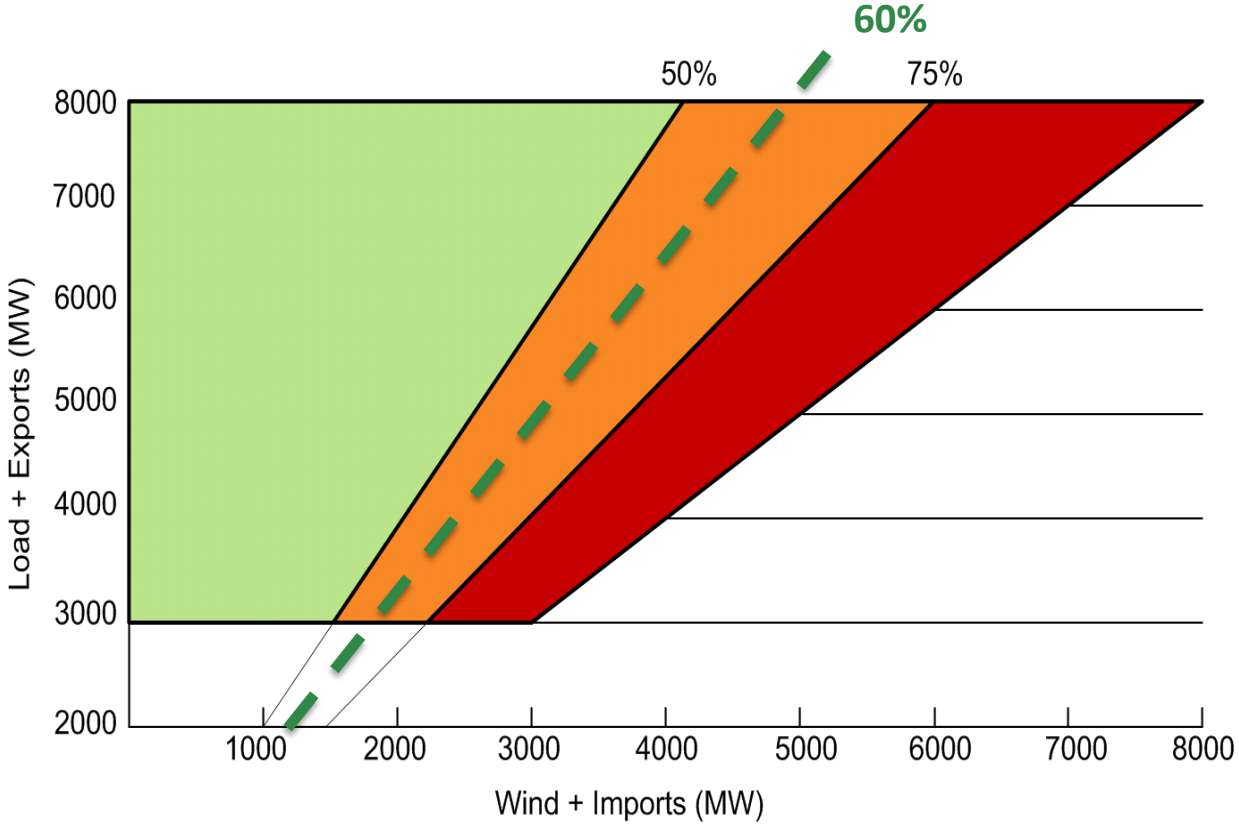
SNSP trial latest developments...

- In November increased SNSP limit to 60% on trial basis



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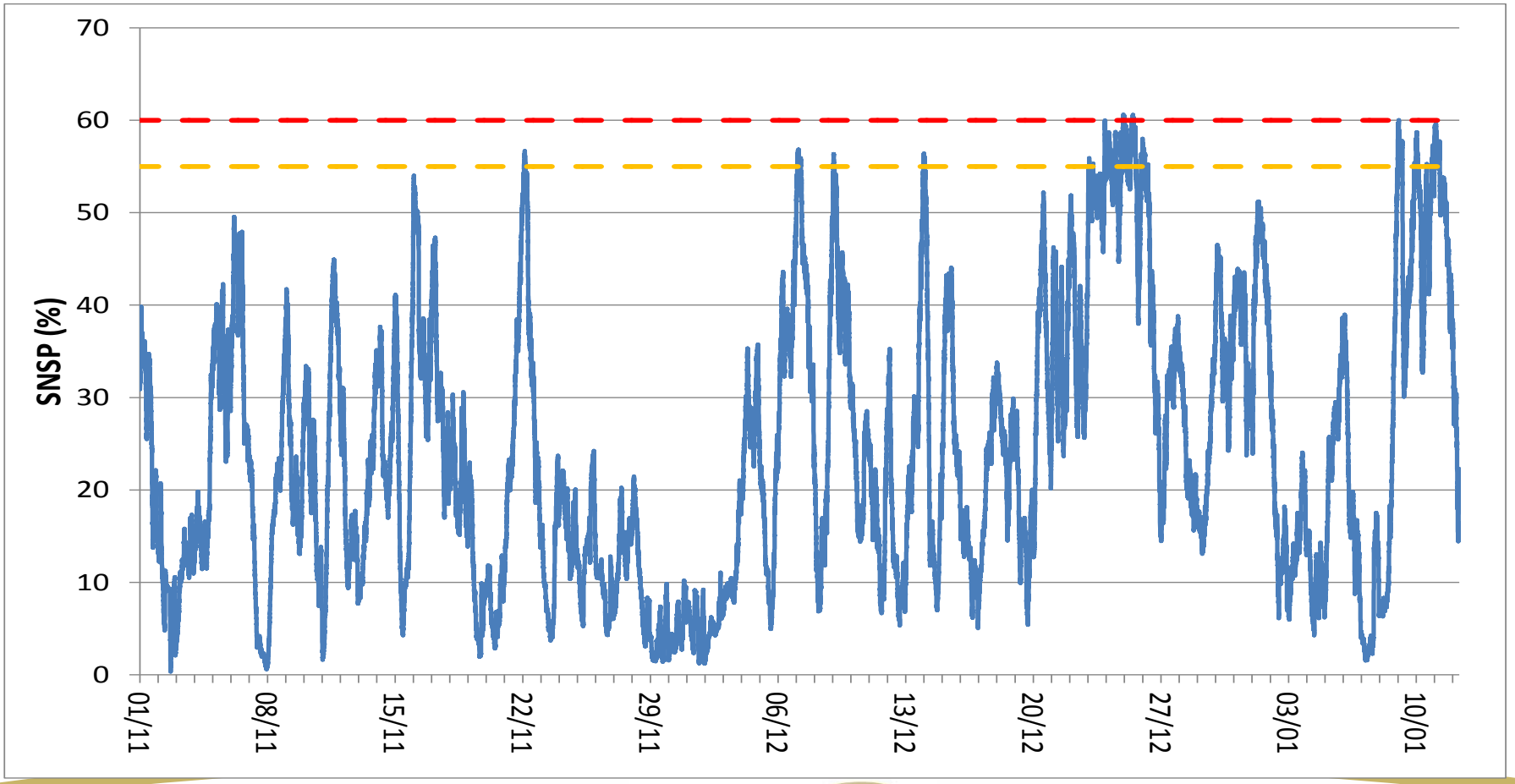
SNSP Trial – Real Time Experience



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SNSP Trial – statistics to date

Summary Statistics

- **Max SNSP reached = 60%**
- **Max wind = 2815 MW**
- **48 Hrs above 55%**
- **Real time monitoring – 5 Minute WSAT**
- **Off-line studies on-going – ‘Stress tests’ of system conditions**

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SNSP Studies

- Offline studies currently being conducted:
  - Voltage Stability: Wider limits to extend VSAT transfers
  - Transient stability: Critical Clearance Time analysis
  - Frequency Stability: Loss of Largest Infeed & System Separation
  - Sensitivity analysis
    - Load frequency response modified
    - Complex load models
    - Modified governor droop response
- To date no major issues identified for operating above 55% - Analysis is ongoing.

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Control Centre developments…

I-SEM Changes

DS3 Changes

Increased RES

Smart Grids

Operational Policy Changes

Control Centre Tools





Safe, Secure Operations

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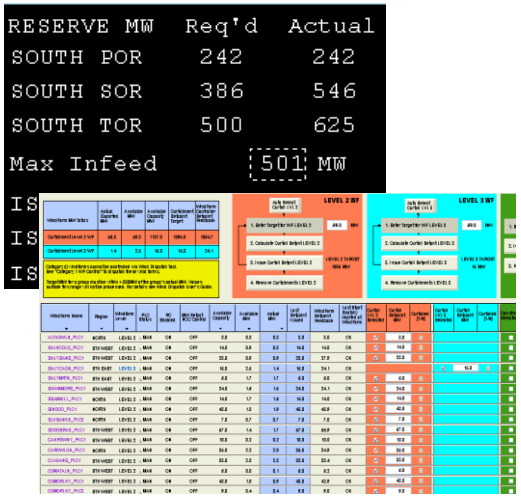
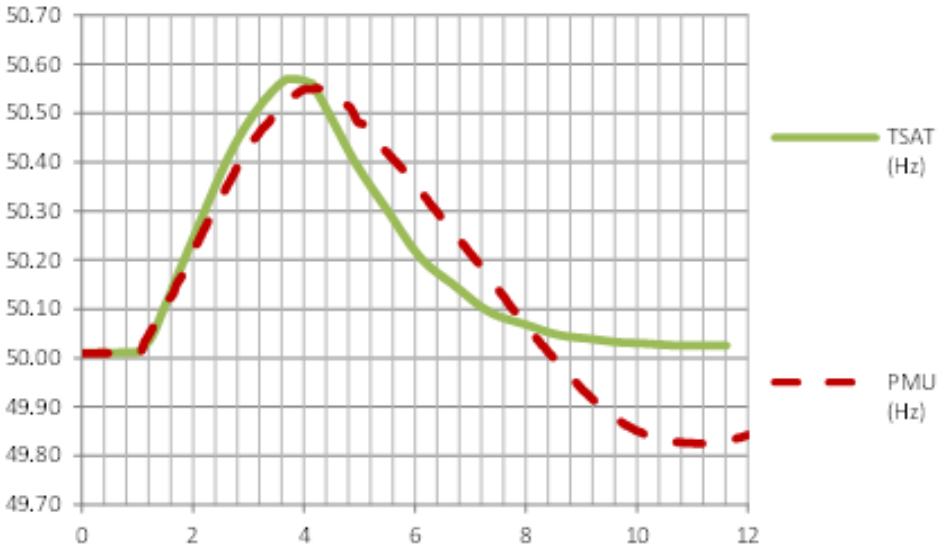
What's been happening…

- EDIL release for System Services
- 5 minute WSAT launched
- WSAT modelling enhancements
- Wind Dispatch Tool developments



High-Frequency Mitigation Scheme

- Trip of IC could result in exceptional HF
- Studies and system testing carried out to develop an operational strategy
- EWIC System testing took place in August



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High Frequency Mitigation Scheme

Interim mitigation plan is to be rolled out

- Extensive model validation
- Enhanced control centre tools
- Modify HF triggers on Moyle and EWIC
- Wind Farm Grid Interface Protection settings
- Runback schemes

EWIC operations

- Returned to service December 23rd
- Trial of exports at 500 MW when wind < 1000 MW
- Upgrades to wind dispatch tool currently being investigated.

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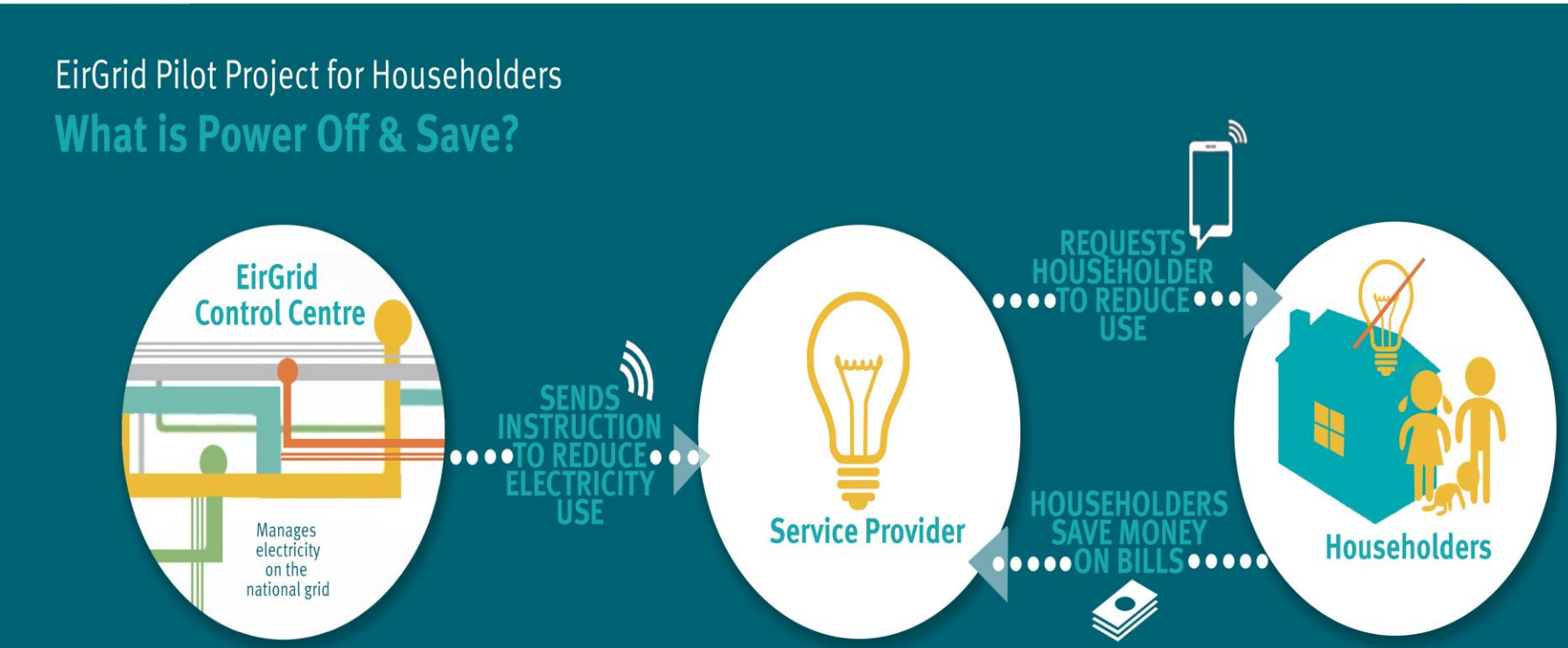
We are trialling residential services…



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The current. The future.

So what are the plans for DS3?

Task	2016	2017	2018	2019	2020
SNSP Limit	55% -> 60%	60% -> 65%	65% -> 70%	70% -> 75%	75%
Studies	Future Ops Policy/ Curl. 60% Study	Ramping V. Trajectory Inertia Floor Solar + DSM	Revised VDIFD Freq. Regulation	VDIFD? New Tech. Reserves	New Tech. Solar & DSM dispatch
Policies	Cat 1&2 Gen Studies	RoCoF -> 1 Hz/s	1 Hz/s Min sets: 7 17,500 MW.s	New Tech Dispatch Policy	Revised FFR, POR policies Min sets: 6?
Control Centre Tools	5 min WSAT SS Tools FFR monitor	Robust WSAT Ramping Nodal Controller	Look Ahead WSAT RES Dispatch	Voltage Trajectory	New Tech. Solar & DSM dispatch
Performance	Interim OFGS	New Tech. Trials LoM settings	Enduring OFGS	Renewables Variation	Reserves from New Tech

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So what are we doing about these…

Future system study

- Increase DSM, Solar
- Wind
- Interconnection
- Increased data centres
- Operational perspective of Advanced scenario planning

New technology

- Working group DSM
- DS3 SS Qualifier trials
- Expand membership of DS3 Advisory Council?
- Solar – Batteries - Storage

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Rate of Change of Frequency (RoCoF) Update

DS3 Advisory Council Meeting 19/01/2017

12:15-12:40 p.m.

David Cashman

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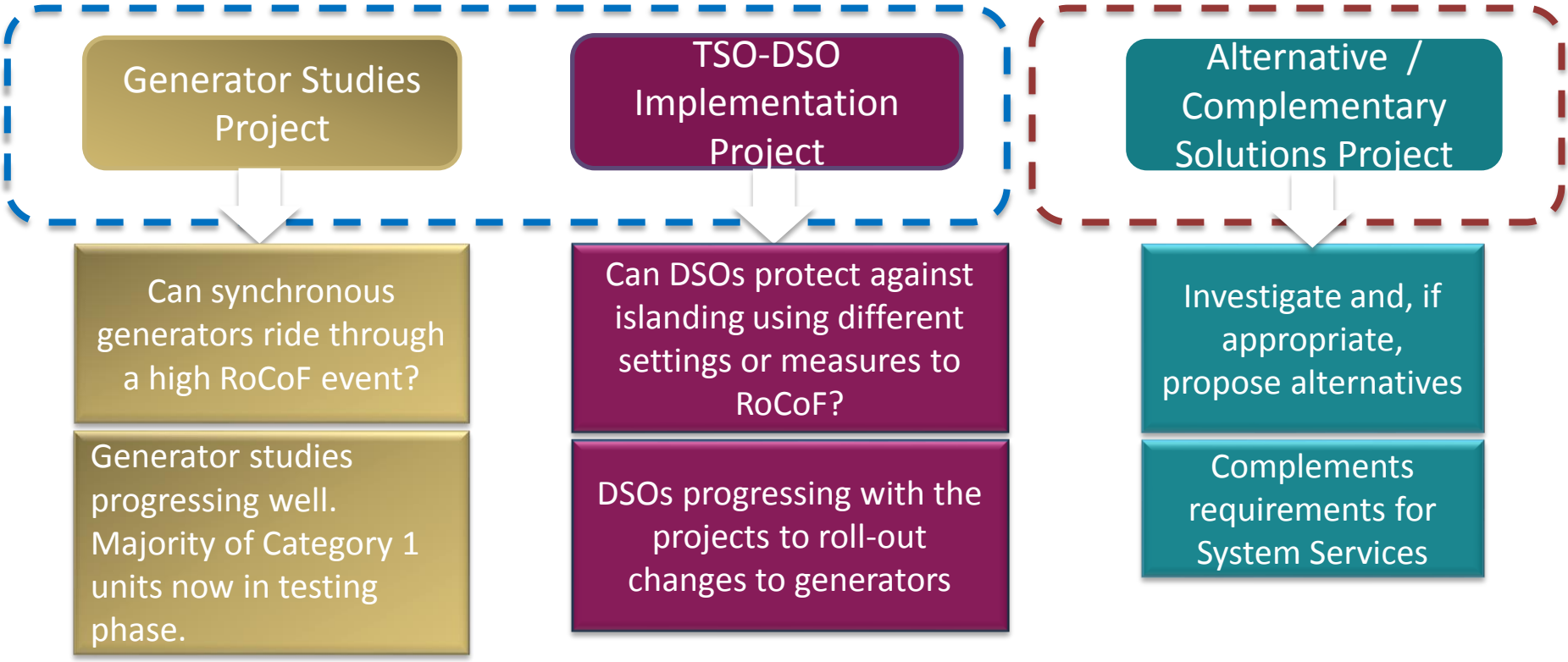
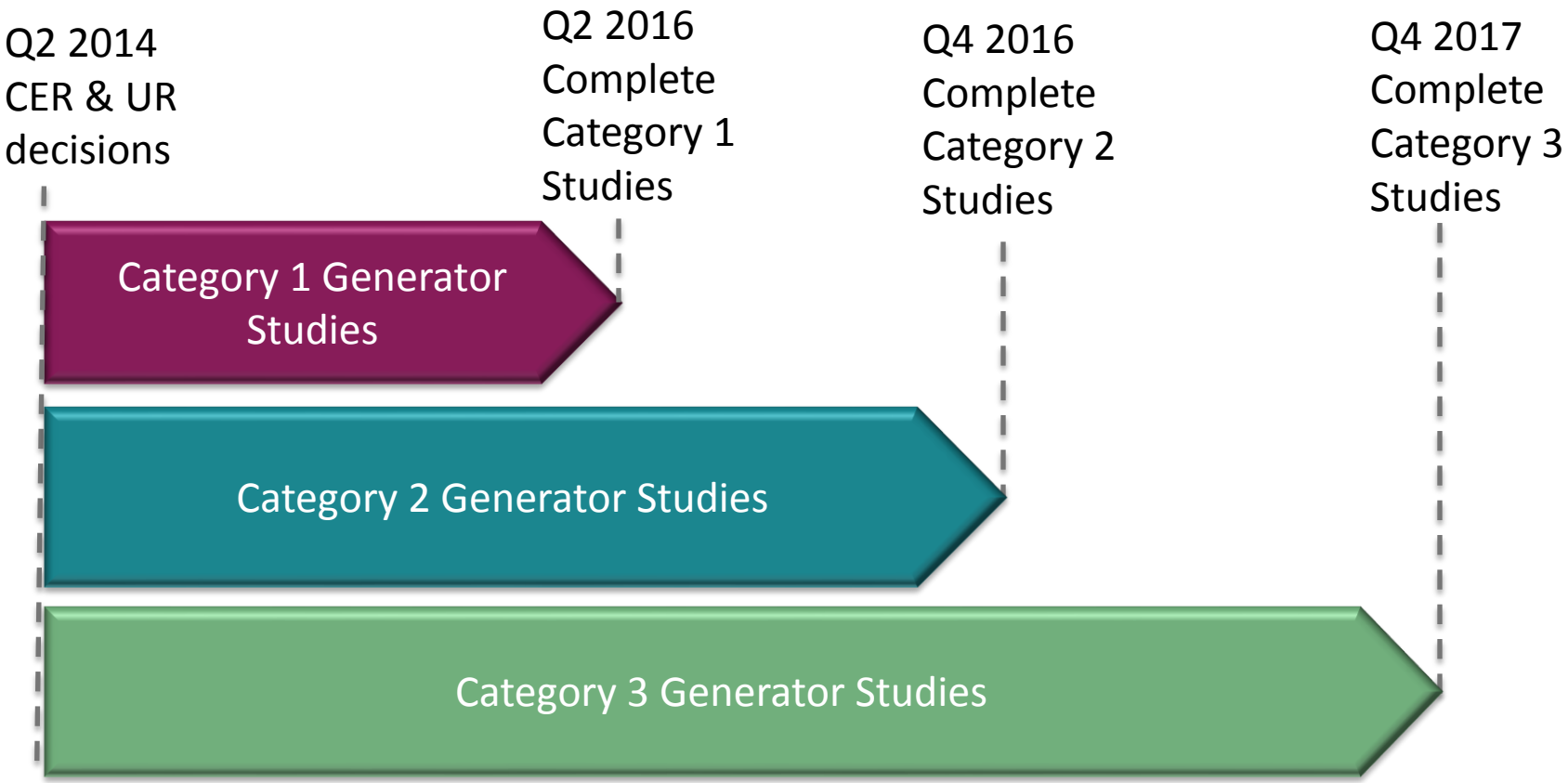
RoCoF Implementation Project



Generator Studies Timelines



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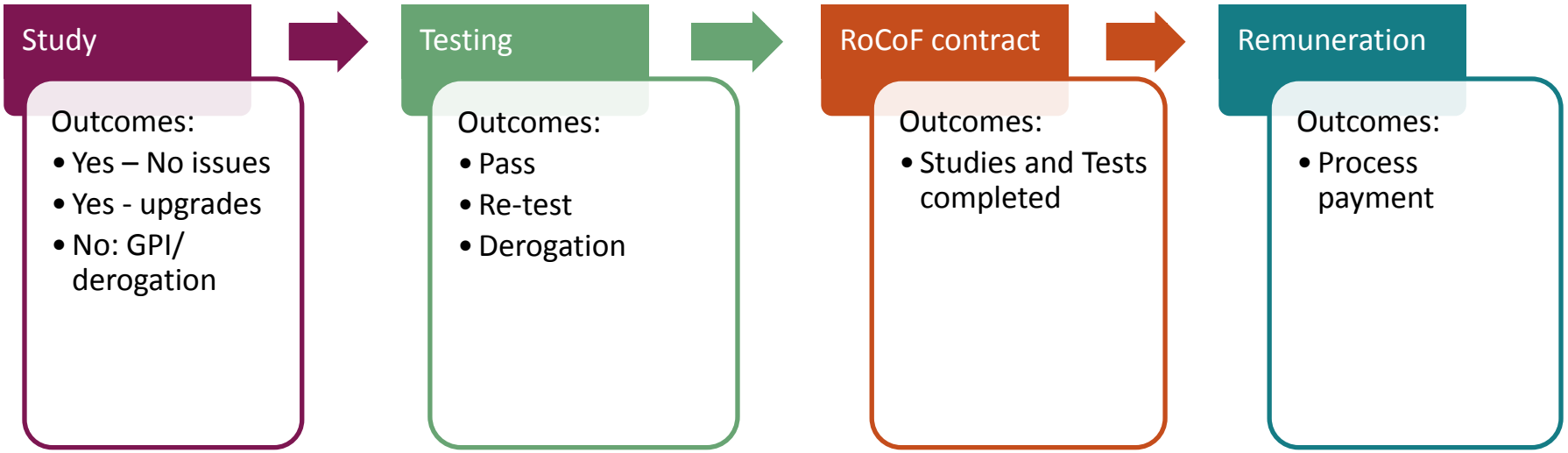
RoCoF Remuneration Method



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Generator Testing

- 22 generators due to be tested by March 2017
- 7 units have completed testing and another 6 have arranged test dates in coming weeks
- Testing documents available on TSO websites
  - RoCoF Test Procedure Template
  - RoCoF Test Report Template
  - RoCoF Test Report Workbook

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Next Steps

- Several category 1 and 2 study reports outstanding which need to be processed
- Generator testing team are engaging with units to prepare testing timelines
- Engage with generators that require remedial works to meet standard

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TSO-DSO Project

Ireland

- Requests for settings changes issued and roll-out is continuing
- Settings changes on >70% of wind farm sites completed
- Engagement with non-wind embedded generators ongoing

Northern Ireland

- University of Strathclyde WP1-3 studies for Large scale generation have been completed
- NIE N consultation on cost recovery for changes
- Roll-out of settings to commence following consultation

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DS3 Advisory Council
ESBN Update

Brendan McGrath, IVADN Team

19th January 2017

TSO-DSO ROCOF Workstream

Wind Generators – Protection Settings Update

67% confirmed returns.

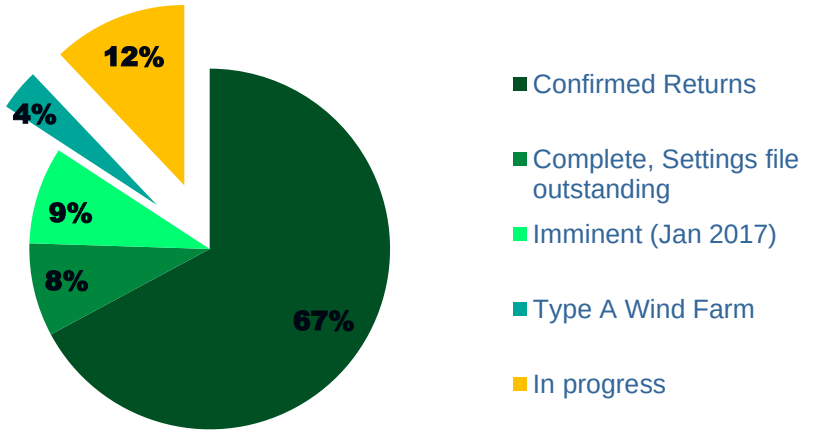
8.3% complete but setting still to be transferred to ESBN.

8.7% either upgraded or due to be upgraded this month (Jan 2017).

3.7% Type A Wind Farm

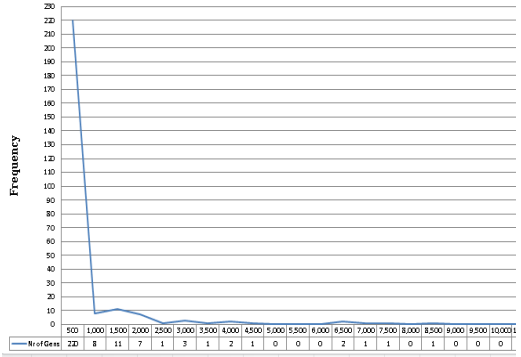
12% at various stages of progress.

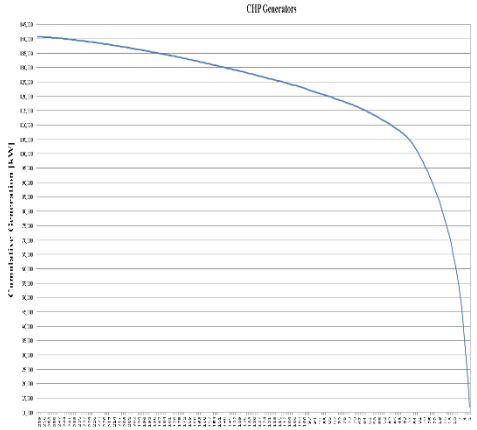
DSO RoCoF Project - Wind



Non-wind Generation

- Meeting with OEMS / Agents held on 13th October 2016
- As previously presented, nature of fleet characterised by a very small number of large sites and an extremely large number of small sites.
- Hence need to focus on efficiency of effort
- Subsequent meetings held with two specific OEM/Agents, who collectively account for 52% of the non-wind fleet.
- Some particular issues dealt with and path forward agreed
- Five step process proposed by Tony Hearne





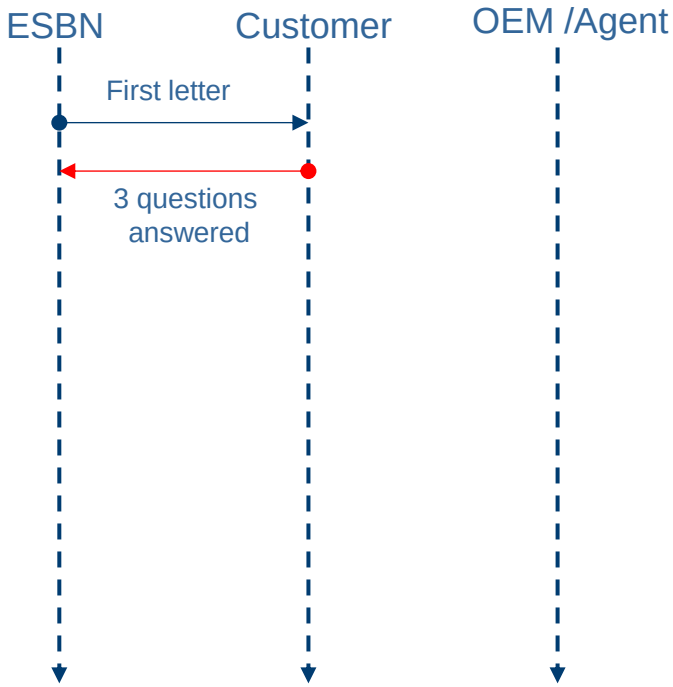
Proposed five step process

Step 1: First direct approach to customers

For the non-wind cohort, a formal written approach will still have to be made to each customer that ESBN has on record, starting with the largest and working down. The proposal is for a simplified document containing the following;

- Brief, non-technical explanation of the background to the issue.
- Three simple questions to ascertain;
  - If they have a generator on the site?

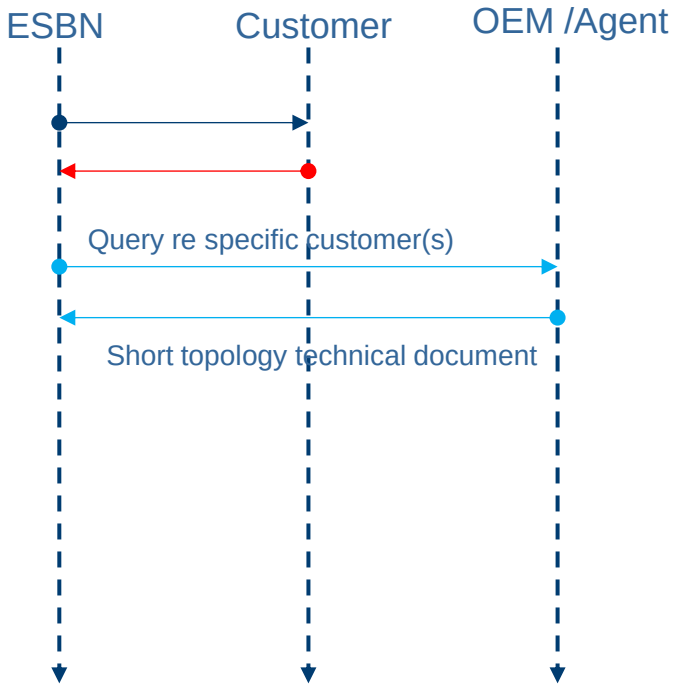
  If yes,
  - If they look after the maintenance of it themselves or contract it out?
  - If the latter, who their OEM-agent is?
    - Carefully crafted wording outlining the consequences of non-action



Step 2: ESBN contact OEM / Agent

Engagement with the OEM-agents identified through step 1 using a revised shorter *topology* questionnaire to identify further relevant detail such as

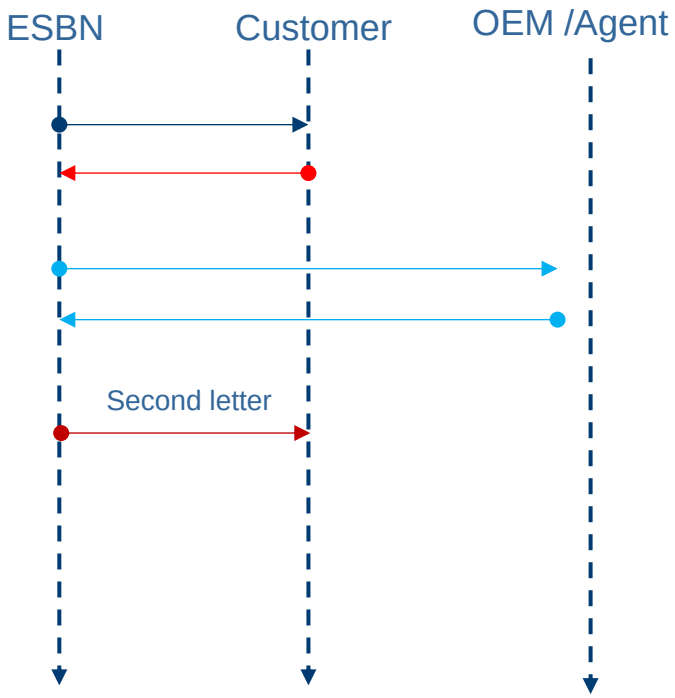
- presence of the trickle topology
- Presence of Megacon KCG 592 relay



Step 3: Second ESBN approach to customer

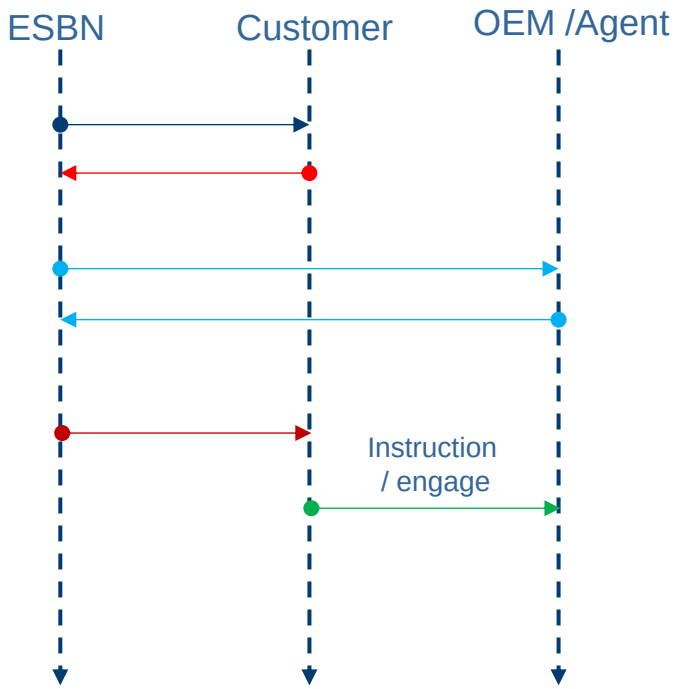
A second written communication to customers, selected on the basis of the previous step, backed up by follow up phone calls containing;

- Brief, non-technical re-cap of the background to the issue
- ESB Instructs Customer to engage the identified OEM-agent, to implement the changes
- Any relevant information captured in step 2 may be referred to e.g.
  - Megacon relays if present
  - For Trickle Topologies, ROCOF setting to be left as is.
- Carefully crafted wording re-stating, in slightly stronger terms, the consequences of non-action



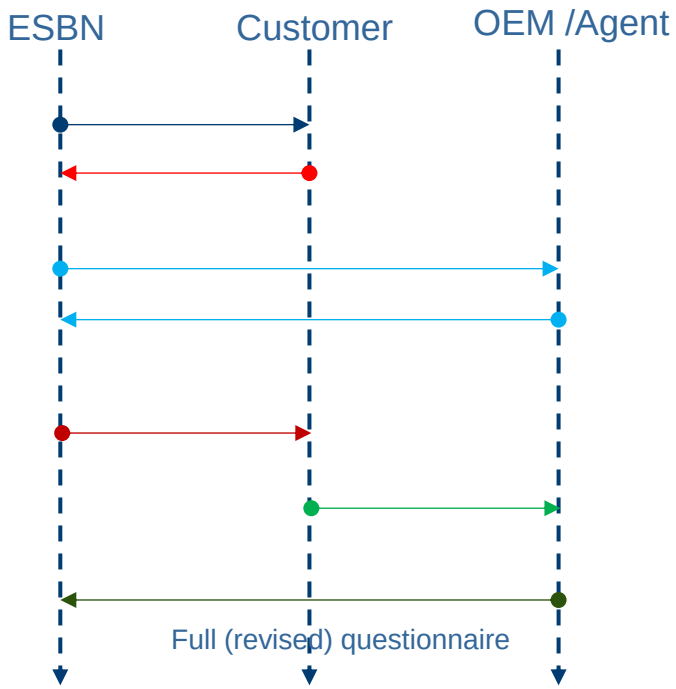
Step 4: Customer engages OEM /Agent

Customer engages generator OEM / Agent to make changes



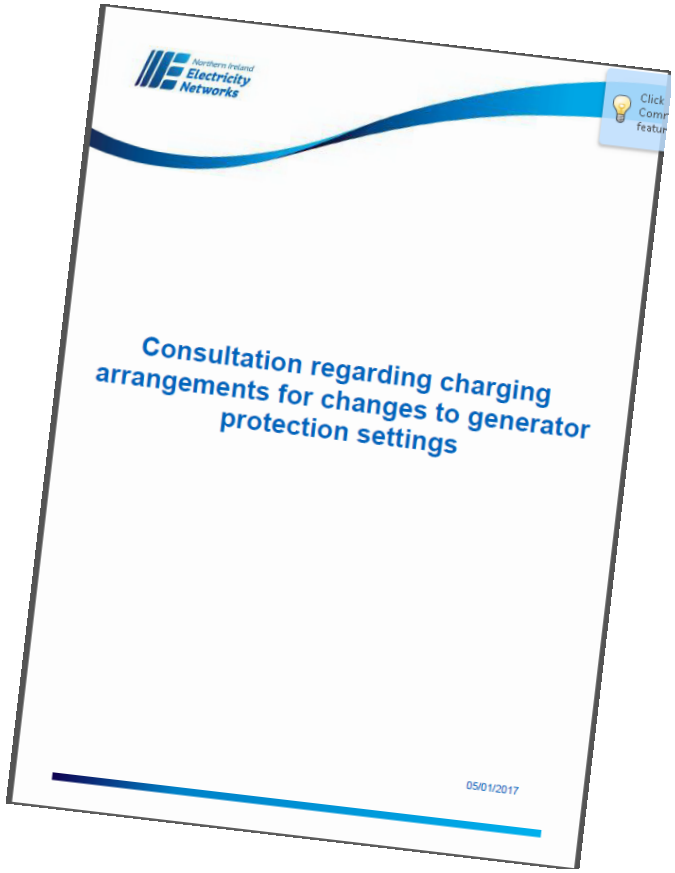
Step 5: OEM / Agent returns [revised] long questionnaire

- **Completed questionnaire returned to ESBN by generator OEM / Agent**



TSO-DSO ROCOF Workstream Conclusion

- Efforts continuing on TSO-DSO ROCOF workstream
- Good progress on wind cohort
- Basis for good engagement with non-wind cohort now in place
- Concern re NIE consultation on funding implementation of ROCOF standard in Northern Ireland
- Has potential to undermine messaging in RoI approach
- Otherwise intention remains to close out TSO-DSO ROCOF workstream by end of 2017



Voltage Control /Reactive Power Workstream

Cauteen Trial

- **Work progressing on coding of algorithm onto Master RTU**
- **Design for "NC (Nodal Controller) Ready OLTC panel" approved**
- **Good engagement with participating windfarms**
  - Post-energisation end-to-end SCADA testing completed on one participating WF in December 2016
  - Full compliance testing scheduled for February 2017
  - Another new build windfarm due to begin testing in March 2017
  - Two remaining windfarms due to be ready for testing in Q3 2017



Cauteen Trial cont'd

- For one pipeline windfarm project, an NC-ready OLTC panel will be installed
- Need for outage of existing trafos to facilitate replacement of OLTC panels
- Some emerging issues on timing of Cauteen works
- Outage and general co-ordination with other ongoing works at Cauteen, i.e. new WF connection, third 110kV transformer, double 110kV installation busbar – is challenging
- All other work in previous slide can proceed in parallel …. But
- Possibility that trial proper cannot begin until Summer 2017



ESBN DS3 System Services interactions

Work to date

- ESBN engaging with QTP (Qualifying Trial Process)
- Potential for fast products to compromise operation of some protection relays
- Form of Consent letter agreed
- Communications ongoing with distribution connected applicants
- Consent letter issued to anyone who requested it, by the QTP deadline of 20th January



ESB Networks Limited Confirmation:

Proposed Customer Participation in DS3 Qualifying Trial Process

ESB Networks Limited, in its capacity as the Distribution System Operator ("DSO"), has been informed of an intention by the DSO customer named below (the "customer"), to participate, under contract with EirGrid Plc in its capacity as the Transmission System Operator ("TSO"), in the DS3 System Services Qualification Trial Process ("QTP") which will involve the trialling of the provision by the Customer of certain DS3 System servkes, including:

- Measurability trials for fast DS3 System Servkes (e.g. FFR, FPFAPR and DRR) and;
- Provenability trials (reserve and ramping) for new system service (SS) technologies e.g. wind, DSU, storage, flywheels etc.

As part of its tender submission to the TSO to participate in the QTP we understand that the customer has been asked to confirm that, as a DSO customer, "appropriate protocols are in place" for the provision by the customer of the DS3 System Services.

As at the date hereof, and given the novel nature of the DS3 System Servkes, there are no specific protocols or procedures for advance testing of distribution connected facilities, or tools to quantify potential adverse network impact.

However, recognising the importance to the overall electricity system of the need to develop and trial the functionality of the DS3 System Servkes, the DSO has agreed with the TSO that the following form of confirmation shall suffice for the purposes of the QTP process.

To the extent that it is possible to do so, given the limitation outlined above and on the basis of a preliminary desktop review, the DSO confirms that at the time of writing, no immediate issues are seen to arise from the customer's participation in the QTP. Accordingly, as at the date hereof, the DSO confirms that it does not object to the Customer participating in the QTP to trial the provision of the Permitted DS3 System Services specified in the table below for the Effective Period identified below, subject to Customer's acknowledgement of the following:

(i) Given the novel nature of the Permitted DS3 System Servkes, procedures for advance testing of distribution connected facilities, or means to quantify impacts, may not yet be available, or have not yet been implemented by the DSO. In the event of any adverse impact or reasonable threat of any adverse impact on the Distribution System becoming apparent, which is attributable to the dispatch, activation or operation of any such service or services by the

Conclusion

- **Work generally on track for ESBN DS3 workstreams**

TSO-DSO ROCOF workstream

- **Serious intent to close out by end 2017**
- **NIE consultation non allocation of costs may undermine RoI messaging**

Nodal Controller / Voltage Control Workstream

- **Majority of strands progressing well**
- **Engagement with and testing of IPPs due to progress through 2017**
- **Co-ordination with other works at Cauteen may delay start of trial to Summer**

ESBN QTP engagements

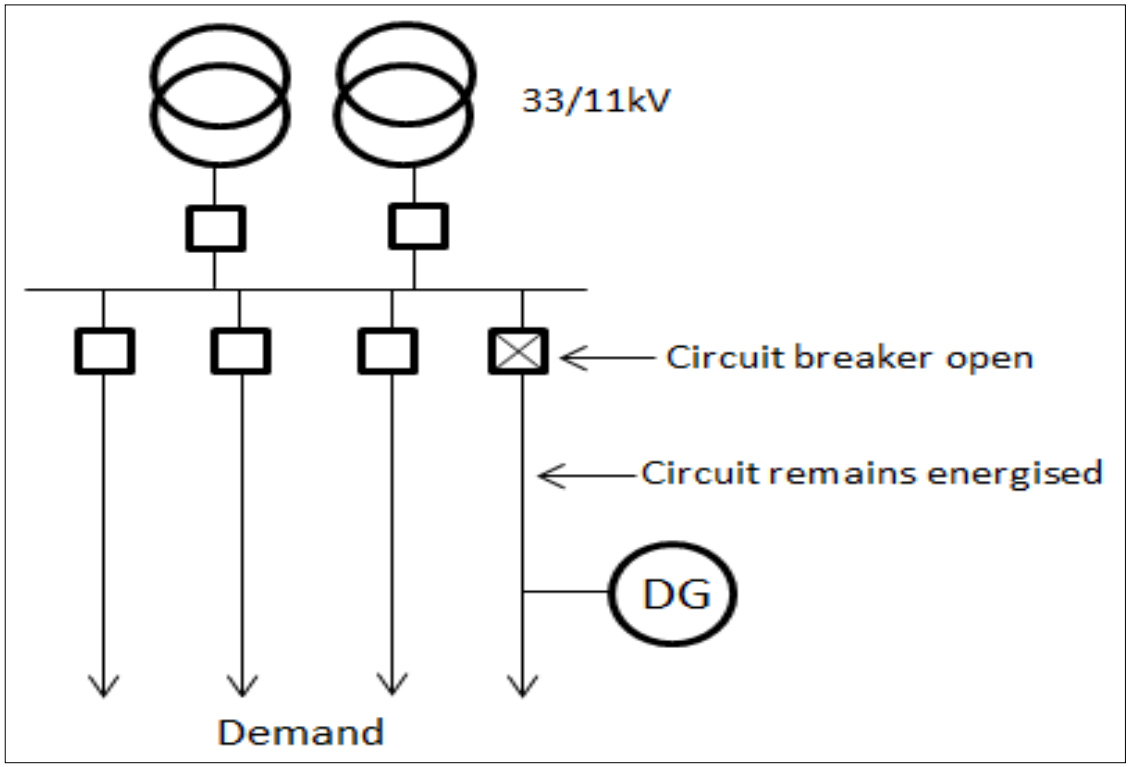
- **Potential disruption to protection from fast products**
- **Consent letter issued to all requested**

DS3 - NIE NETWORKS' ROCOF IMPLEMENTATION PROJECT

DS3 ADVISORY COUNCIL 19/01/17

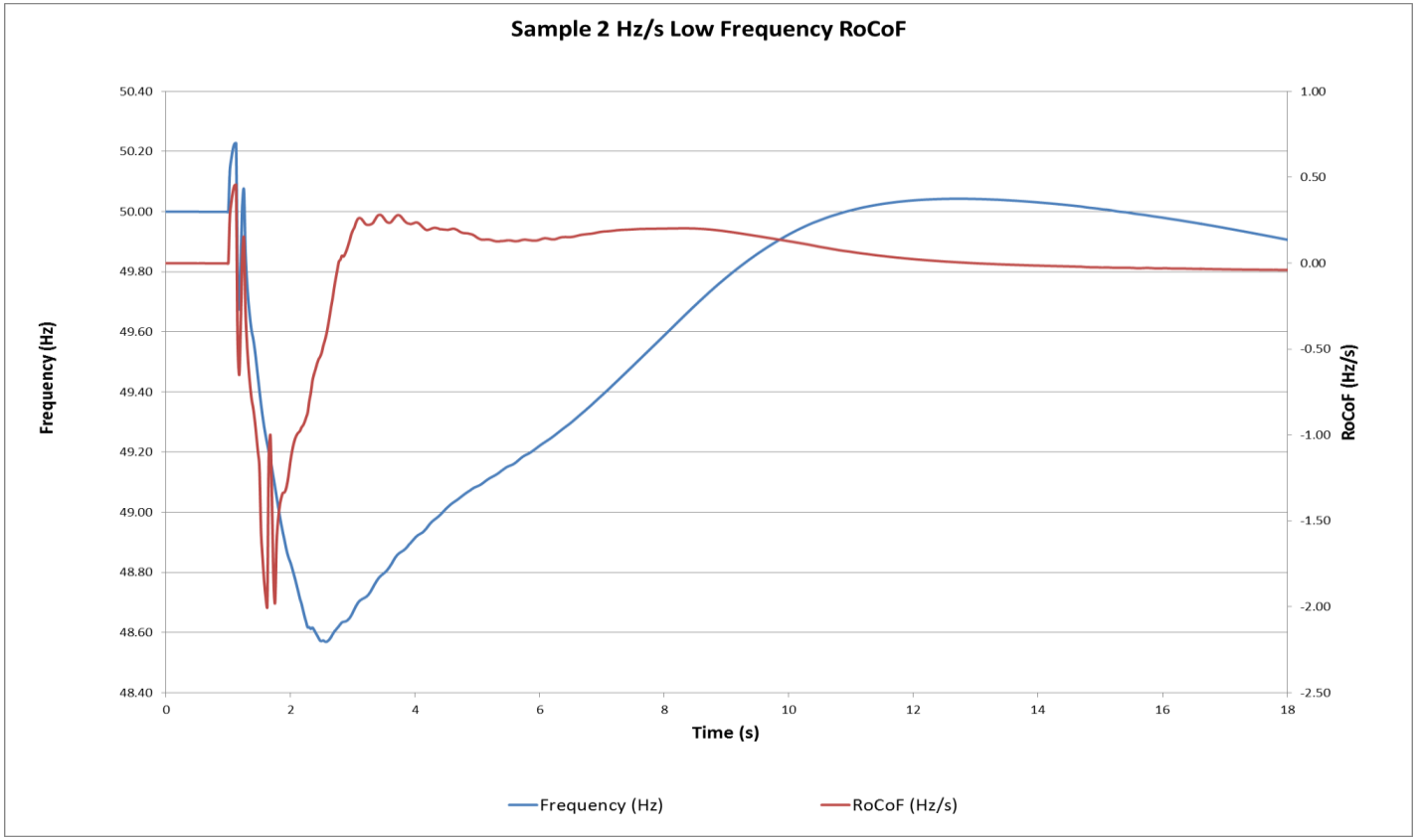
Interface Protection

Purpose – To prevent electrical Islanding!



The Problem

Moving towards 75% SNSP will result in higher system RoCoFs!



Academic Research – Stability Analysis

	Current	New	
	Setting	Setting	Time Delay
RoCoF	0.125Hz/s – 0.4Hz/s	1.5Hz/s	300ms
VS	6^0 - 12^0	12^0	0s
Over Frequency	50.5Hz	Staged up to 52Hz as per Over Frequency Shedding Schedule. Specific setting for generator will be stated in letter.	1s
Under Frequency	48Hz	48Hz	500ms
Over Voltage	1.1pu	1.1pu	500ms
Under Voltage	0.9pu	Stage 1: 0.85pu Stage 2: 0.6pu	Stage 1: 3s Stage 2: 2s

Academic Research – Sensitivity Analysis

Large Scale Generation

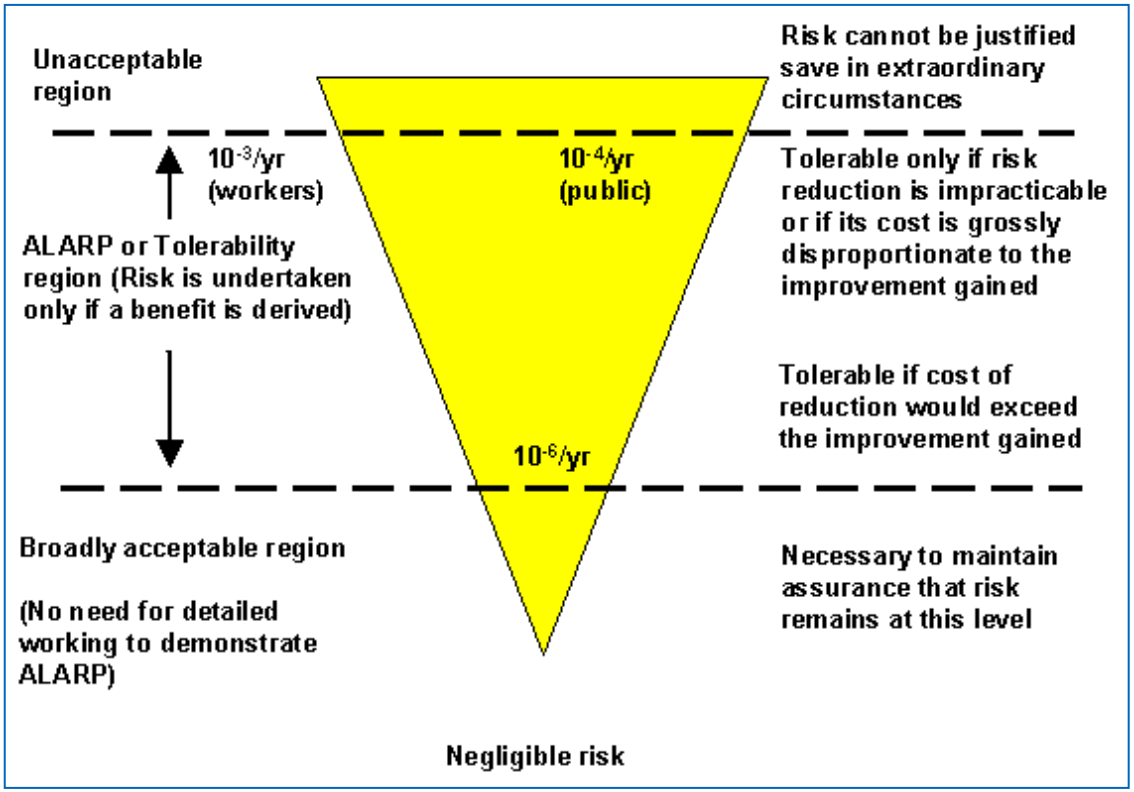
	Current Settings		Proposed Settings	
	Fatality	Out-of-Phase Reclosure	Fatality	Out-of-Phase Reclosure
Risk	4.16 x10-6	6.63 x 10-3	7.59 x10-6	1.21x10-2
Occurrence (Years)	240k	151	132k	83

- Incremental risk of Fatality = 3.43 x10-6
- Incremental risk of Out-of-Phase Reclosure = 5.47 x10-3
- Neutral Voltage Displacement (NVD) protection will significantly reduce risk

Small Scale Generation

- Draft studies completed
- NIE Networks currently developing position on SSG

Assessment of Risk



http://www.hse.gov.uk/comah/assessexplosives/step5.htm

- With NVD protection, the risk of fatality for LSG will be reduced further, possibly moving it into the “Broadly acceptable region”
- Each generator should assess and determine if their risk of out-of-phase reclosure is acceptable

Costs and Benefits

Benefits

- The implementation of the new RoCoF standard will reduce SEM production costs by €13m/annum
- 4.4% reduction in wind curtailment levels
- 1.5% increase towards 40% renewables target

Costs

- Implementation costs are estimated at £498,750 for both LSG and SSG.
- Consultation currently live on “charging arrangements regarding changes to generator protection settings”. Closes on 3rd Feb.

Consultation

Options	Funding Proposal	
	LSG Costs	**SSG Costs**
1	LSG Pay for individual costs	SSG Pay for individual costs
2	LSG pay for their individual costs and cover SSG costs	
3	LSG Pay for individual costs	Northern Ireland customer pays for SSG costs
4	Northern Ireland customer pays for all implementation costs	
5	Alternative proposal	

http://www.nienetworks.co.uk/documents/D-code/RoCoF-consultation-on-funding-mechanism.aspx

Timelines / Next Steps

Activity	Due Date	Status
Work Package 1	Q4 2015	Complete
Work Package 2	Q1 2016	Complete
Work Package 3	Q3 2016	Complete
Work Package 4	Q4 2016	Draft Complete
Engagement with HSENI	Q4 2016	Complete
Consultation on “who pays”	Q1 2016	On Schedule
Consultation on D-Code Amendments	Q1 2017	On Schedule
LSG G59 amendments complete	Q3 2017	On Schedule
SSG G59 amendments complete	Q3 2017	On Schedule

- Generator Interface Protection settings to be included in D-Code



Power Off and Save Update

Conor Egan, Project Engineer,
Operations Planning and Innovation, EirGrid

19/01/2017

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Customer Breakdown

Smart Energy Control (SEC)	**Smart Pay as You Go (SPAYG)**
Smart Hot Water Controller (SHW)	**Other Technologies (MicroGen, EV's …)**

- Customers recruited to Date:
  - 389 SEC customers
  - 432 SPAYG customers

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Two events to date

- *Event 1:*
  - Thursday 3rd of November 2016 19:30 – 20:00.
  - Total participant Demand Reduction of 93.4 kW. (17% of participant total Demand)
  - 634 Participants
- *Event 2:*
  - Monday 5th of December 2016 18:30 – 19:00.
  - Total participant Demand Reduction of 119 kW. (14% of participant total Demand)
  - 785 Participants

*Note: Reductions in Demand are measured against a five week historical average

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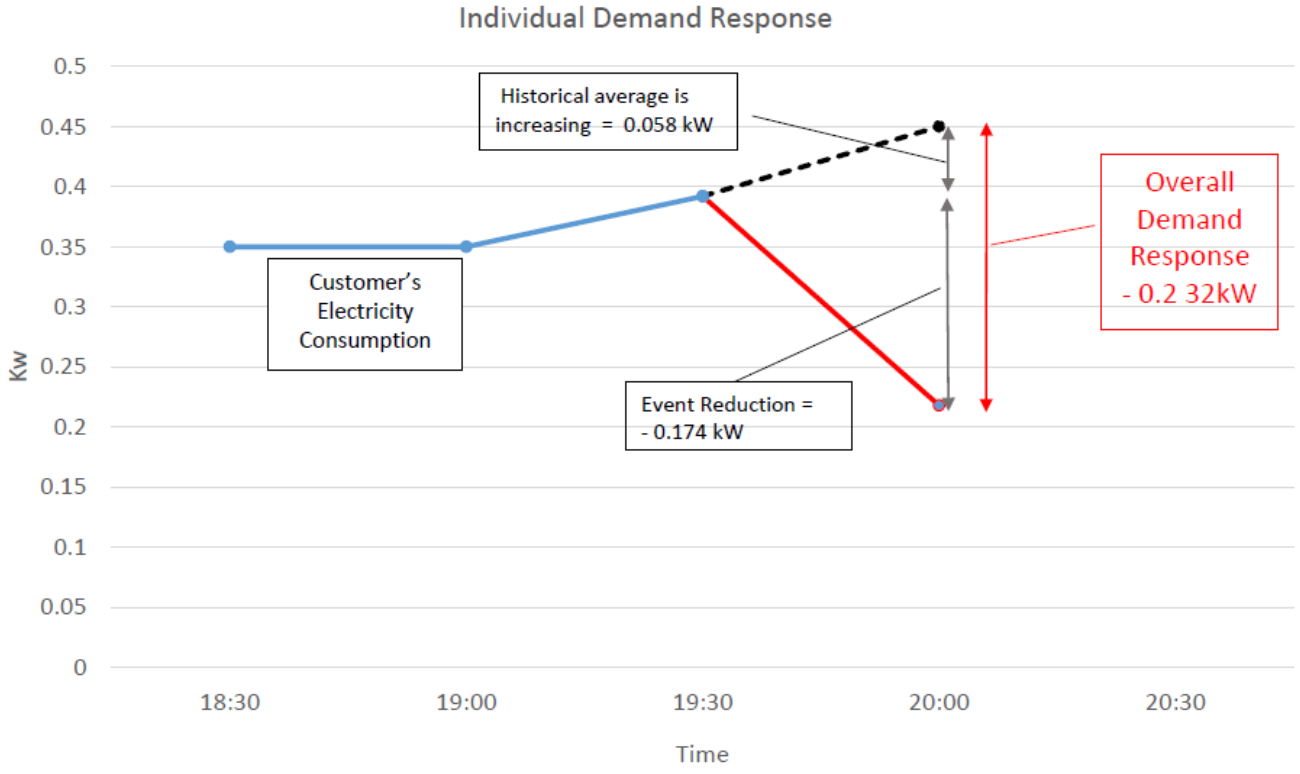
Example Customer Demand Response

- Below is an example individual customer demand response - compared to the customers historical response.



What we have learnt so far…

- Consumer Motivations
- Communication issues affect on customer availability
- SEC data insights to date

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System Services Update

DS3 Advisory Council Meeting 19/01/2017

Jon O' Sullivan

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Qualifier Trials

DS3 Advisory Council

Operations Planning and Innovation

19 January 2017

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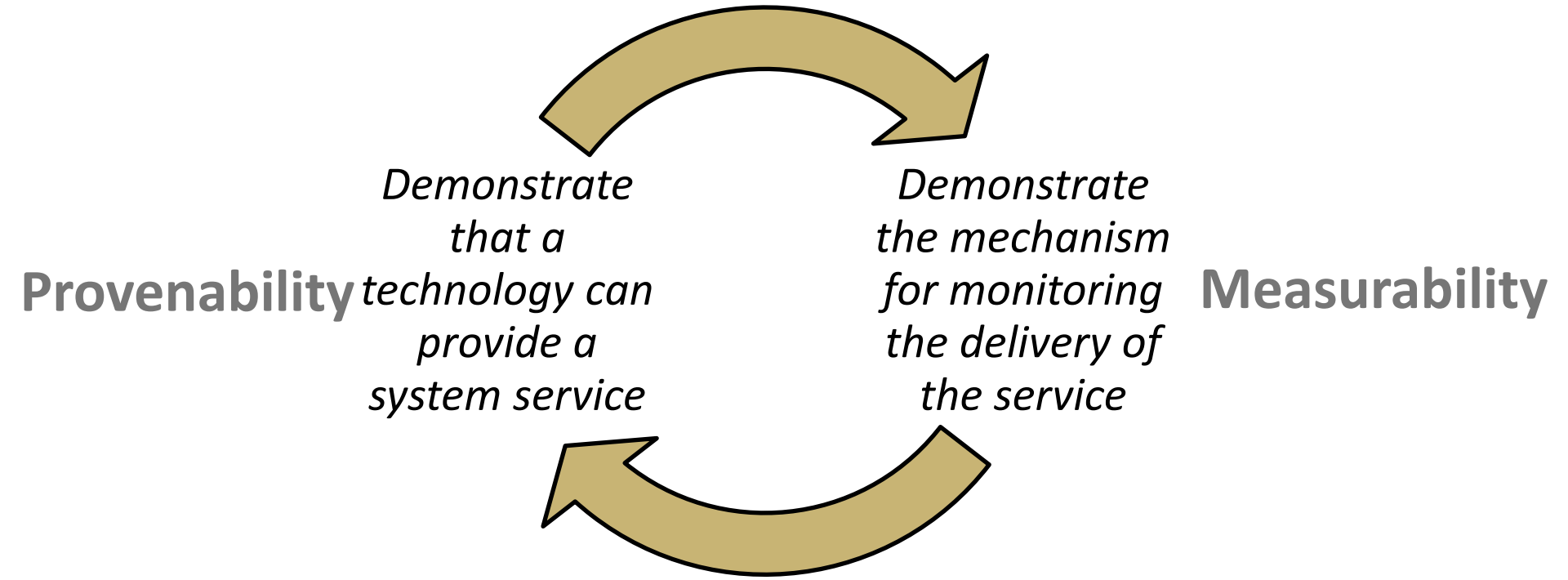
Qualification Process Objectives



Trial Format

Provenability

Services to be proven	*Technology*	*Max #*
POR, RM3	Wind	4
POR	DSM	4
POR, RM3	Other Technologies	4

Measurability

Services to be measured	*Technology*	*Max #*
FFR	Conventional Generators	2
	Wind	1
	Other Technologies	2
	DSM	1
FPFAPR, DRR	Conventional Generators	1
	Other Technologies	1
	Wind	1

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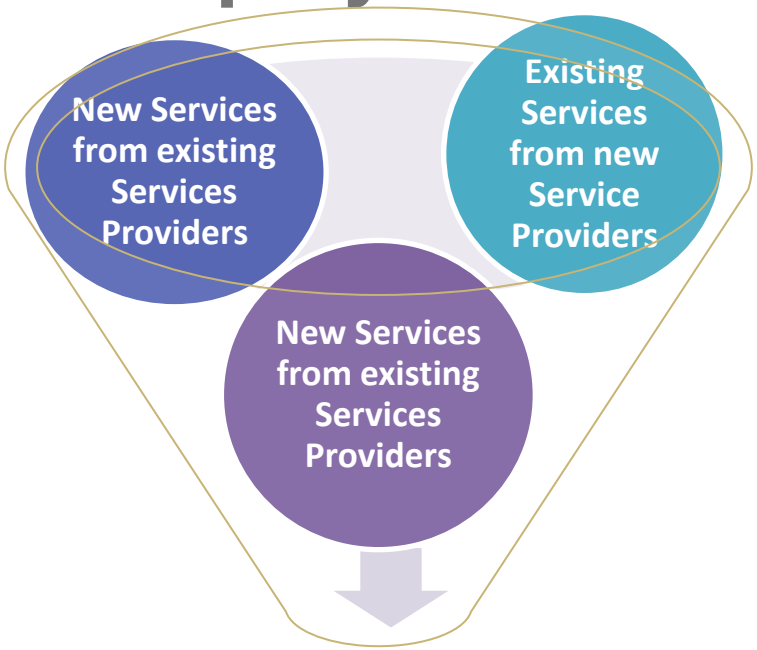
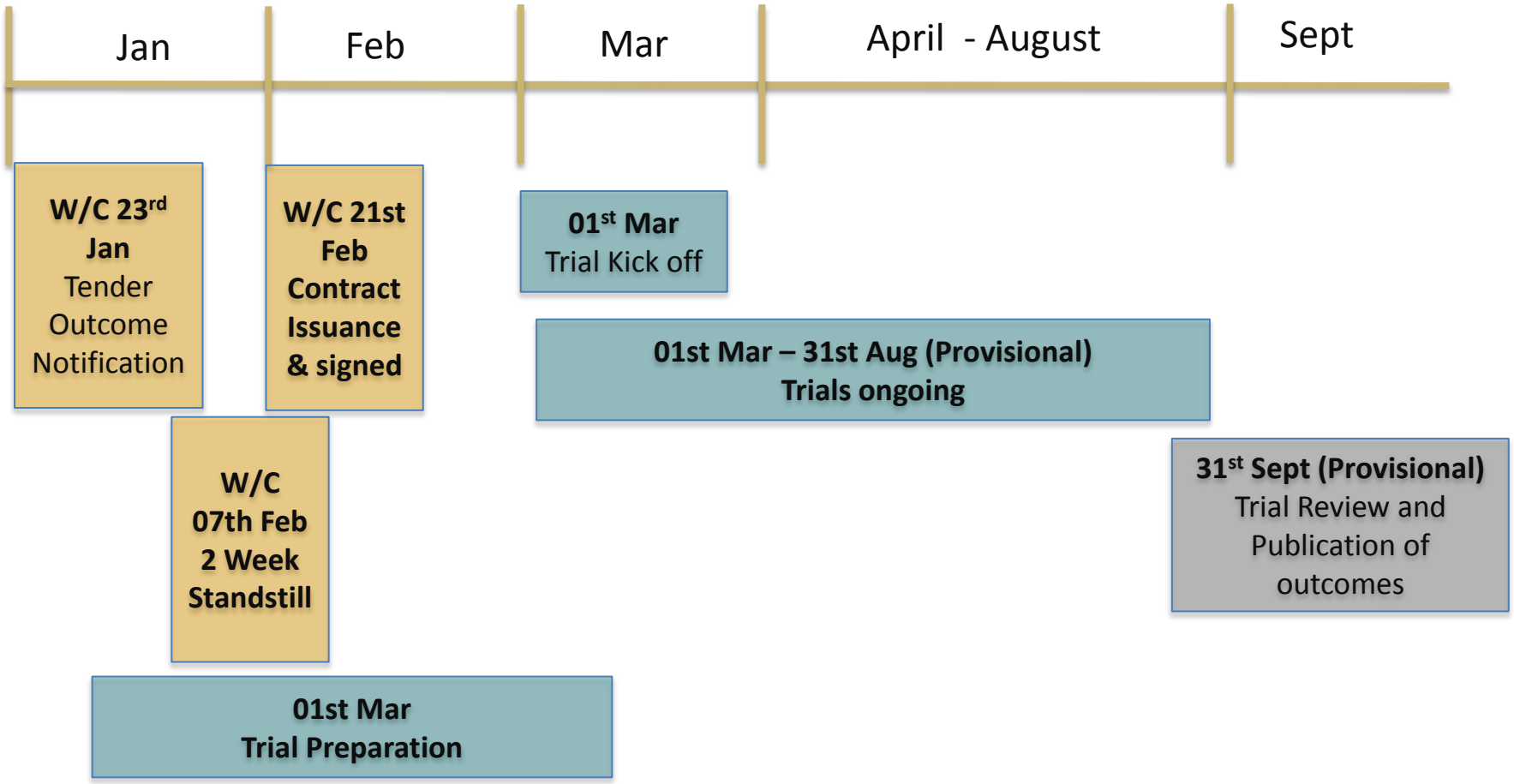
What's needed for prudent large scale deployment?



Grid Codes & Standards	Capabilities of new tech at scale	Performance Mechanisms	Payment Mechanisms	Comms. & Protocols	Schedule & Dispatch

QTP Timeline





DS3 Advisory Council Control Centre Tools

Karen O'Doherty

19 January 2017

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Our most Strategic Asset

I-SEM Changes

DS3 Changes

Increased RES

Smart Grids

Operational Policy Changes

Control Centre Tools





Safe, Secure Operations

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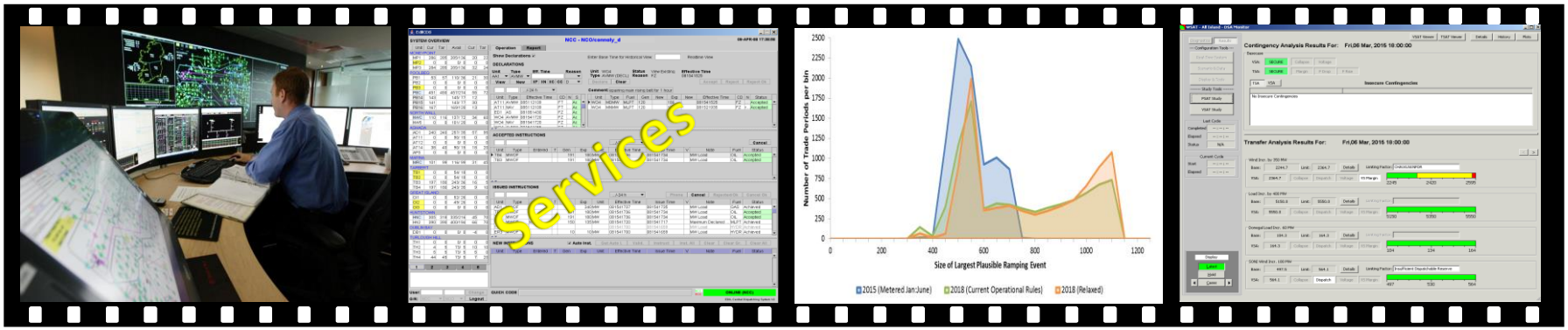
Future Tools

- Nodal Controller
- Ramping
- Voltage Trajectory
- System Services Dispatch Tool(s)
- WSAT Enhancements



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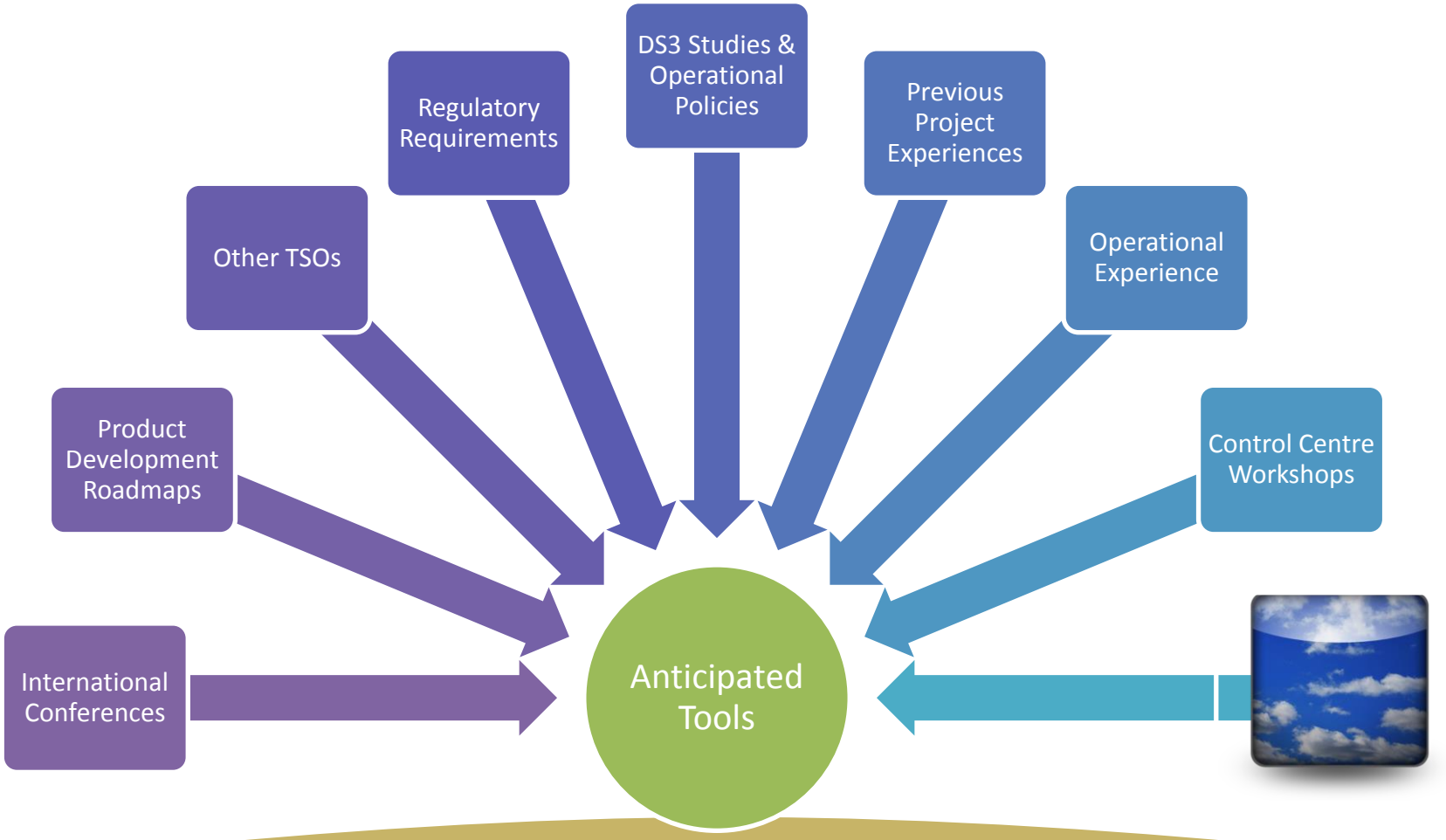
Future Tool Requirements



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What's been happening…

- EDIL release for System Services
- 5 minute WSAT launched
- WSAT modelling enhancements
- Progressing with nodal controller
- Wind Dispatch Tool developments

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Wind Dispatch Tool

- Interaction between frequency response (DS3 Grid Code modifications) and wind dispatch setpoints

- During times of dispatch down and sustained high system frequency, wind farms with frequency response will experience greater levels of dispatch down that those wind farms without frequency response

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WDT – What's the problem?

	Reg Cap	Availability	Setpoint #1	Output #1	Setpoint #2
WF A	10	10	8	8	6.9
WF B	10	10	8	8	6.9
WF C	10	10	8	6	5.2
Totals			24	22	19

- Setpoint #1 is calculated pro rata across all WF
- WF C is providing frequency response (Output #1 < Setpoint #1)
- Setpoint 2 is calculated pro rata based on Output 1
- WF C is issued a lower Setpoint 2 than A&B which are not providing frequency response

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WDT - Progress

- Communications issued (Nov & Dec 2016)
- Initially frequency response was disabled for impacted sites. Developments have been made to enable frequency response to be enabled during times of no curtailment/constraint
- Analysis completed to identify a potential solution
- Engagement with WDT vendor is ongoing

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Ramping Studies

DS3 Advisory Council Meeting 19/01/2017

James Ryan

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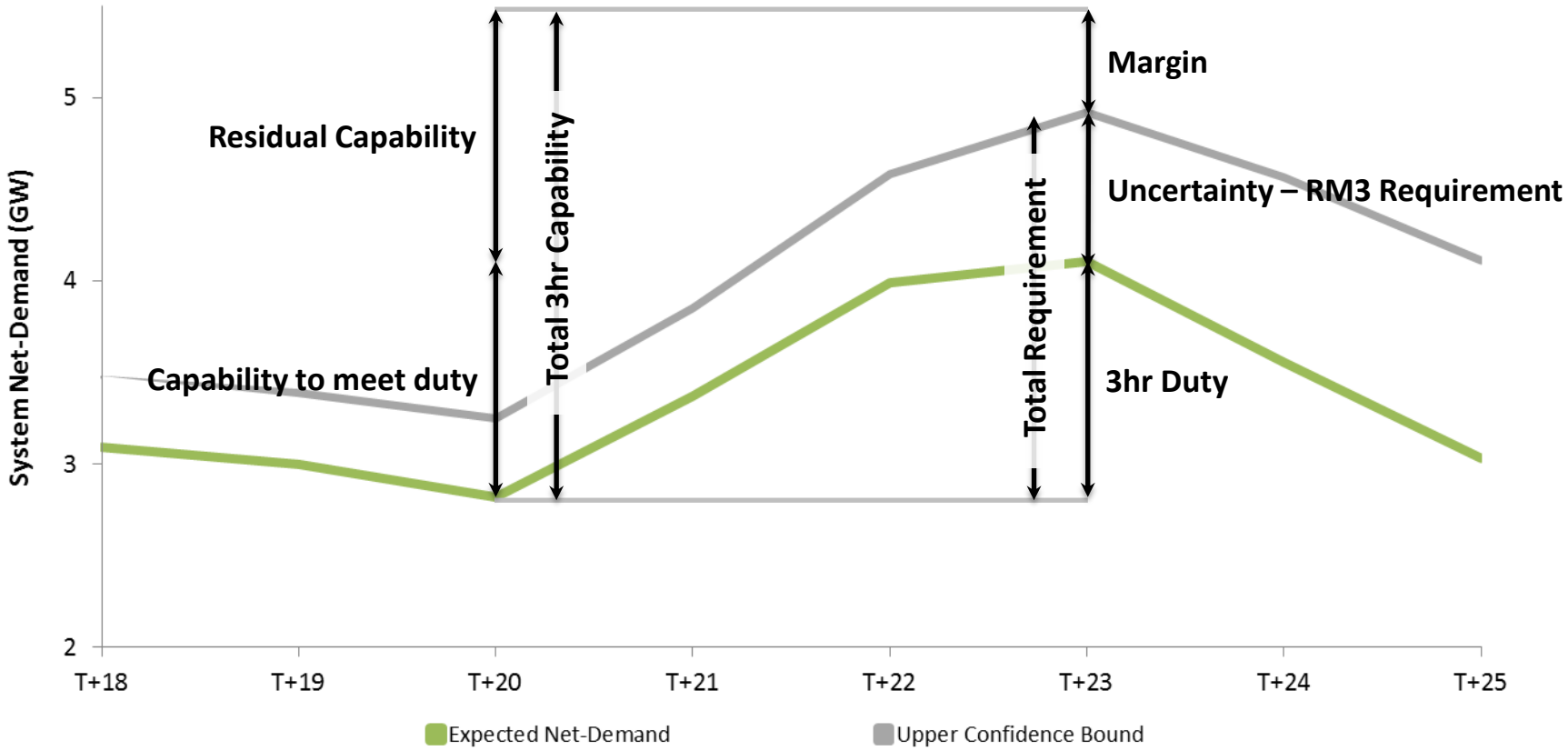
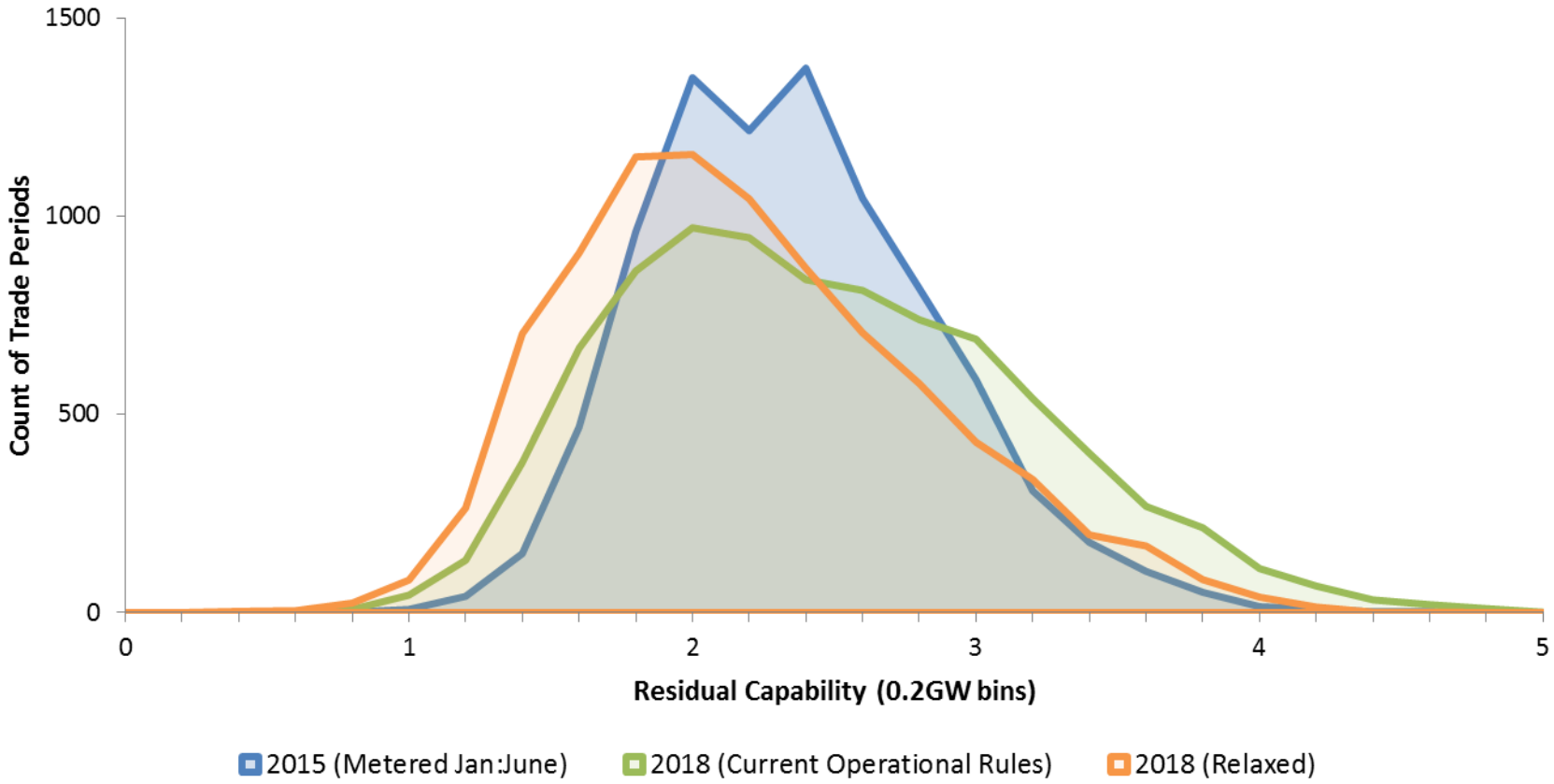
System Ramping Terminology



Residual 3hr Ramping Capability



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Basis for Reserve Requirement

Primary Operating Reserve Requirment

$$= 75\%\ Largest\ Single\ Infeed$$

Possible Ramping Reserve Requirment

$$= \gamma \times Max \begin{cases} Largest\ Single\ Infeed \\ Largest\ Ramp\ Resource \\ Wind\ Forecast\ Error\ Criteria \end{cases}$$
$$+ 1\%\ Forecast\ Demand$$
$$+ Fail\ to\ sync\ of\ largest\ ramping\ resource$$

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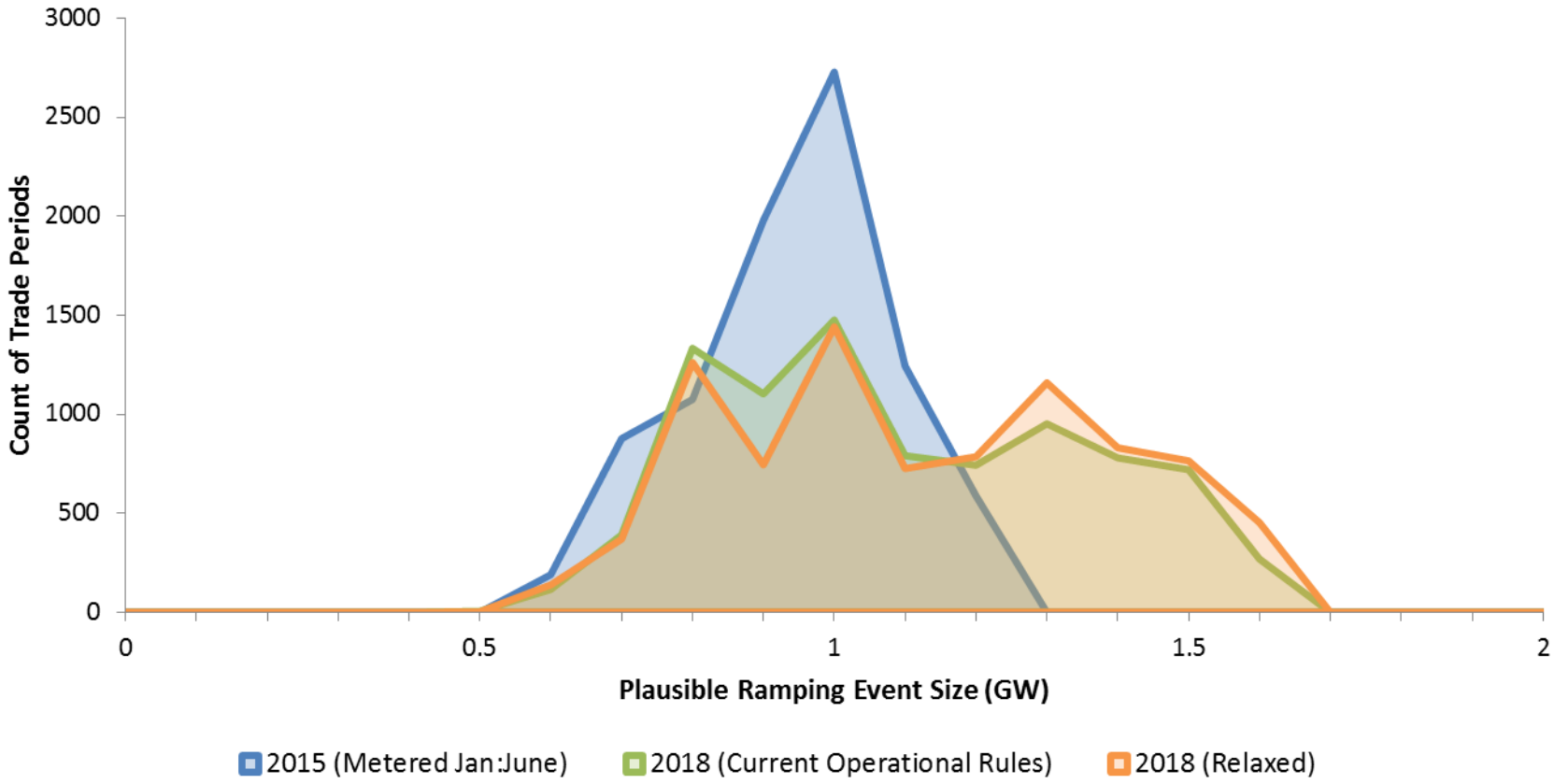
RM3 Requirement



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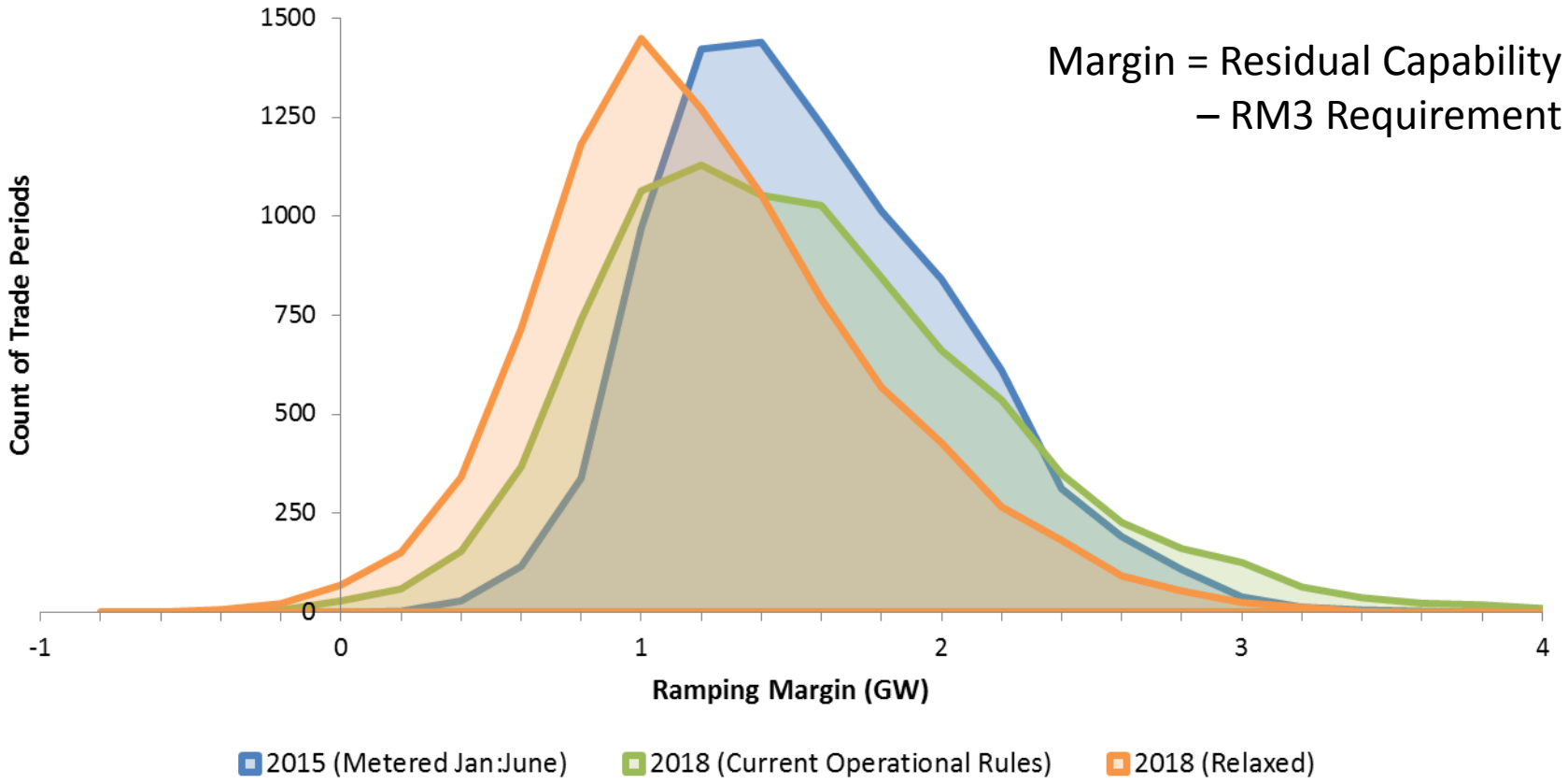
Ramping Margin



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Conclusions + Future Work

- Residual ramping capability is a function of:
  - Scheduling process: foresight, operational constraints
  - Demand and wind time series inputs
- Ramping risk will soon be dominated by average wind forecast error
  - Improved forecasting techniques, use of real-time error estimation can help….. But….
  - Growth of largest ramp unavoidable
- Further studies required
  - Add ramp product requirements to Plexos
  - Assess the reliability impacts

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Closing Remarks

DS3 Advisory Council 19/01/2017

14.40-15.00pm

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