DS3 Advisory Council

Dublin

19th September 2018

EIRGRID SONI

Agenda - Morning

Topic	Time	Speaker
Introduction & Welcome	10.00	Jon O'Sullivan , Eirgrid (10 mins)
Industry Presentation	10.10	Presentation: Peter Kavanagh, ISEA (15 mins) Discussion: All (15 mins)
Dispatch and Balancing costs	10.40	Presentation: Peter Harte, Element Power (10 mins) Discussion: (10 mins)
DS3 Programme Status Update	11.00	Presentation: Ian Connaughton, EirGrid (10 mins) Discussion: All (10 mins)
DS3 Transitional Plan	11.20	Presentation: Karen O'Doherty, SONI (15 mins) Discussion: All (10 mins)
2018 QtP Trial	11.45	Presentation: Daniel Dixon, EirGrid (15 mins) Discussion: (15 mins)
Lunch & Networking (12.15 – 13.05)		

EIRGRID SONI

Agenda - Afternoon

Topic	Time	Speaker
RoCoF	13.05	Update: John Young , EirGrid (5 mins) Update: NIE Networks, ESB Networks (10 mins) Update: Noel Cunniffe, EirGrid (5 mins) Discussion: All (15 mins)
Oscillations	13.40	Presentation: Peter Wall, EirGrid (15 mins) Discussion: (15 mins)
Beyond 2020 - EU SysFlex scenarios & models	14.10	Presentation: Noel Cunniffe, EirGrid (15 mins) Discussion: (15 mins)
AOB	14.40	All (15 mins)
Closing Remarks and Actions	14.55	Jon O'Sullivan, EirGrid (10 mins)
Session Closed (15.05)		

EIRGRID SONI

Industry Presentation - ISEA

Peter Kavanagh

EIRGRID SONI

ISEA
Irish Solar Energy Association

ISEA view on RESS

Peter Kavanagh

18th September 2018

Photo: Solar Electric

Photo: Elgin Energy

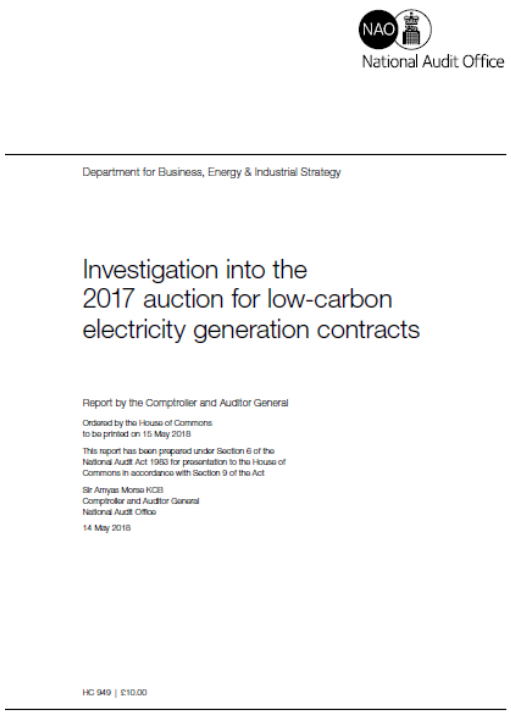
Photo: LIghtsource

Agenda

- Auction Structure
- Eligibility Criteria
- Delivery by 2020
- CfD Duration & Counterparty
- Community
- Bid Bonds
- Conclusion

Auction Structure

- Technology neutral auction is not appropriate in the absence of market specific price discovery
- ISEA called for technology specific auction to achieve diversification
- Rely on appropriate use of Intervention Levers
- Lessons learned from UK 2017 CfDs
- *"We found that the design changes enabled small fuelled-technology projects to raise the strike price of larger projects. This increased the cost to consumers by around £100 million each year, meaning a total additional cost of around £1.5 billion over the 15 year life of the contracts"*



NAO National Audit Office

Department for Business, Energy & Industrial Strategy

Investigation into the 2017 auction for low-carbon electricity generation contracts

Report by the Comptroller and Auditor General

Ordered by the House of Commons to be printed on 15 May 2018

This report has been prepared under Section 6 of the National Audit Act 1983 for presentation to the House of Commons in accordance with Section 9 of the Act

Sir Amyas Morse KCB
Comptroller and Auditor General
National Audit Office

14 May 2018

HC 949 | £10.00

Eligibility Criteria

- Low realisation rates are a key challenge for auctions ("winner's curse")
- Need to discourage speculation whilst avoiding excessive barriers to entry
- ISEA proposes the following criteria to participate in auction:
  - Evidence of Generator Land Rights
  - Final Grant of Generator Planning
  - Signed Grid Connection Agreement
  - Commitment to RESS community benefit obligations
  - Bid Bonds

Delivery by 2020

- Balance urgency of delivery with risk of delay
- Prevent hoarding of capacity
- Drop dead delivery dates can introduce risk weighting for capital and increase costs
- 3rd Party delays?
- Scale of shortfall means project delivery later is better than never
- ISEA recommend erosion of support rather than drop dead delivery date

CfD Duration & Counterparty

- Market is comfortable with 15 or 20 years duration
- Indexation is key to attracting low cost of capital
- CfD Contract Parties
- Double Benefits (GoOs, Capacity Revenues, DS3 Revenues, De Minimis Benefits)
- CRU PSO Forecasting risk
- Auction timing vs PSO timing

Community

- Developer Led Projects
  - Trusted Intermediary and compliance
  - Community Benefit
  - Community Ownership
  - Avoiding perverse incentives
  - Standardised offerings
- Community Led Projects
  - How to avoid gaming
  - Do we prioritise wholly owned community projects over 50% owned community projects?

Assessment of models to support community ownership of renewable energy in Ireland

Final report

Report for Sustainable Energy Authority of Ireland (SEAI)

Ricardo working with: bioXL

Bid Bonds

- Bid Bonds are appropriate to discourage delays and non-realisation of projects
- 2 stage bid bonds
  - Stage 1 to bid in auction & released upon CfD execution
  - Stage 2 to execute CfD & released if project connected within realisation period
- Bonds should be considered within wider context of delivery requirements

Conclusion

- Direction of travel is positive
- Time is of the essence
- Solar is part of the solution and sufficient volume of projects are available to support auctions
- ISEA is keen to engage constructively with stakeholders to enable industry move forward

Thanks for your attention

SOLAR IRELAND 18

- **27 - 28 November, Dublin, Ireland**
- https://www.solarireland2018.com/

elementpower

DS3 ADVISORY GROUP

Some thoughts on Dispatch and Balancing Costs

Peter Harte

September 2018

DISPATCH AND BALANCING COSTS

Illustrative trading period, cost of adding Operational Constraints to energy only dispatch (MW)

	Unconstrained Energy (Market Schedule)	Constrained (Dispatch Schedule)	Comment
Wind	3,100	2,560	18% curtailment
Conventionals	900 (2 units)	1,440 (8 units)	Min_gen of 40%
Demand	4,000	4,000	Fixed total

Forecast annual cost of dispatching away from energy only (€m/annum):

2020	2025	2030
75	98	199

(Baringa Plexos model, all Operational Constraints other than network. Actual DBC costs are higher, due to network constraints, e.g. €30m for N-S, but these should be temporary.).

DISPATCH AND BALANCING COSTS

Currently the budget cap on DS3 is €235m per annum. This is the wrong metric to seek to minimise. The true cost of maintaining ancillary services is sum of ***DS3 costs, curtailment costs and dispatch and balancing costs****.*

A wind fleet of 5000MW being curtailed 5% per annum in 2025 is around ***€46m*** *per annum. DBC costs from Baringa is* ***€100m*** *per annum. The right metric is the sum of these costs, i.e. €381m.*

Selection of which projects get DS3 tariffs or auctions should be made such that they reduce the true cost of ancillary services, not just the €235m budget cap figure. We should not be paying tariffs equally to projects that cause differing DBC or wind curtailment.

In fact we should be aiming to run a power system where the conventional plant only produces energy. There would then be ***no difference between the market schedule and the dispatch schedule****. (In I-SEM language, conventional plant would only experience energy balancing actions). There should be zero payments to conventional plant for ancillary services.*

This was the right answer even when there was no wind on the system, but its very economically attractive at RES-E of 40%, and its imperative if we're to go to 70%.
The only reason it hasn't been done to date is the "network device" technologies didn't exist until recently. These technologies include batteries (FFR-TOR2, SSRP, DRR), sync-comps (SIR, SSRP), DSM (FFR-TOR2) and interconnectors and STATCOMs/SVCs.

WHAT DOES SUCH A SYSTEM LOOK LIKE

Straw-man system for zero fuel cost ancillary services *:*	*Annnual cost (€m)*
- *400MW of batteries or DSM at 100k/MW/year*	*40m*
- *Lots of sync comps for inertia and*	*40m*
- *Interconnectors*	*10m*
- *Peaking plant for ramping*	*Cost covered by CRM*
- *STATCOMS*	*5m*

Such a system would enable the system to run with no conventionals at all, i.e. > 100% SNSP using exporting interconnectors.

2025 (€m)	Business as usual	Strawman zero fuel system
DS3	235	95
Curtailment	45	5
DBC Costs (fuel)	100	0
Total AS cost	375	100

DS3 Programme Status Update – September 2018

Ian Connaughton

EIRGRID SONI

DS3 Programme Key Achievements May – Sept 2018

1st May
System Services Regulated Arrangements
(11 services)
Go-live

31st May
System Services Regulated Arrangements FFR
Submission Tender Deadline

8th June
System Services Market Ruleset
Recommendation and Decision Papers published by TSOs and RA

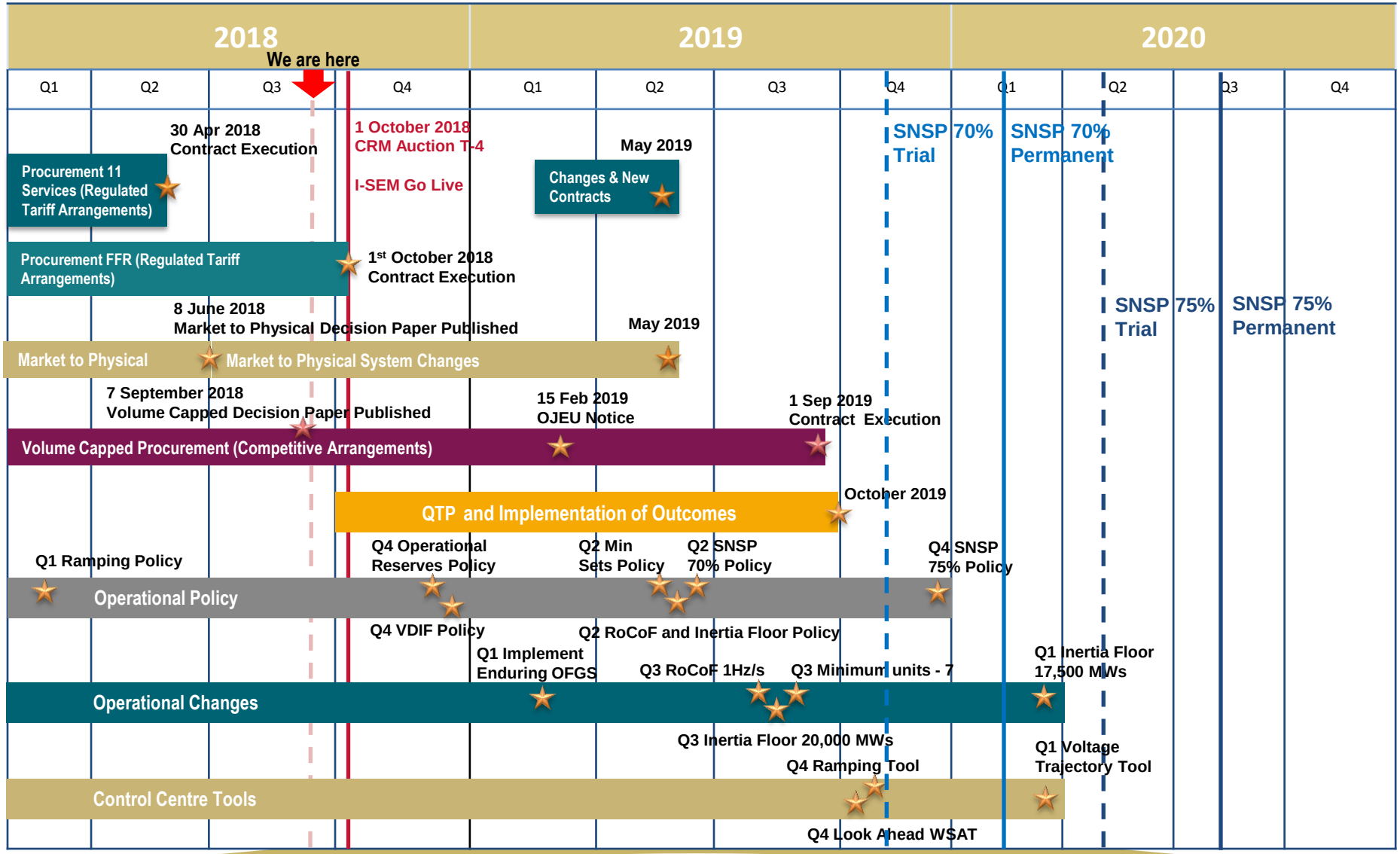
15th August
SNSP Replan
Revised dates for SNSP increases agreed with RAs

28th August
SNSP
Definition and Formulation document published

6th/7th September
System Services Volume Capped
Recommendation and Decision Papers published by TSOs and RAs

September
Oscillations and VDIF studies
Completion of initial assessments

EIRGRID GROUP



EIRGRID GROUP

DS3 Programme Deliverables

Review of Published 2017 Deliverables

EIRGRID GROUP

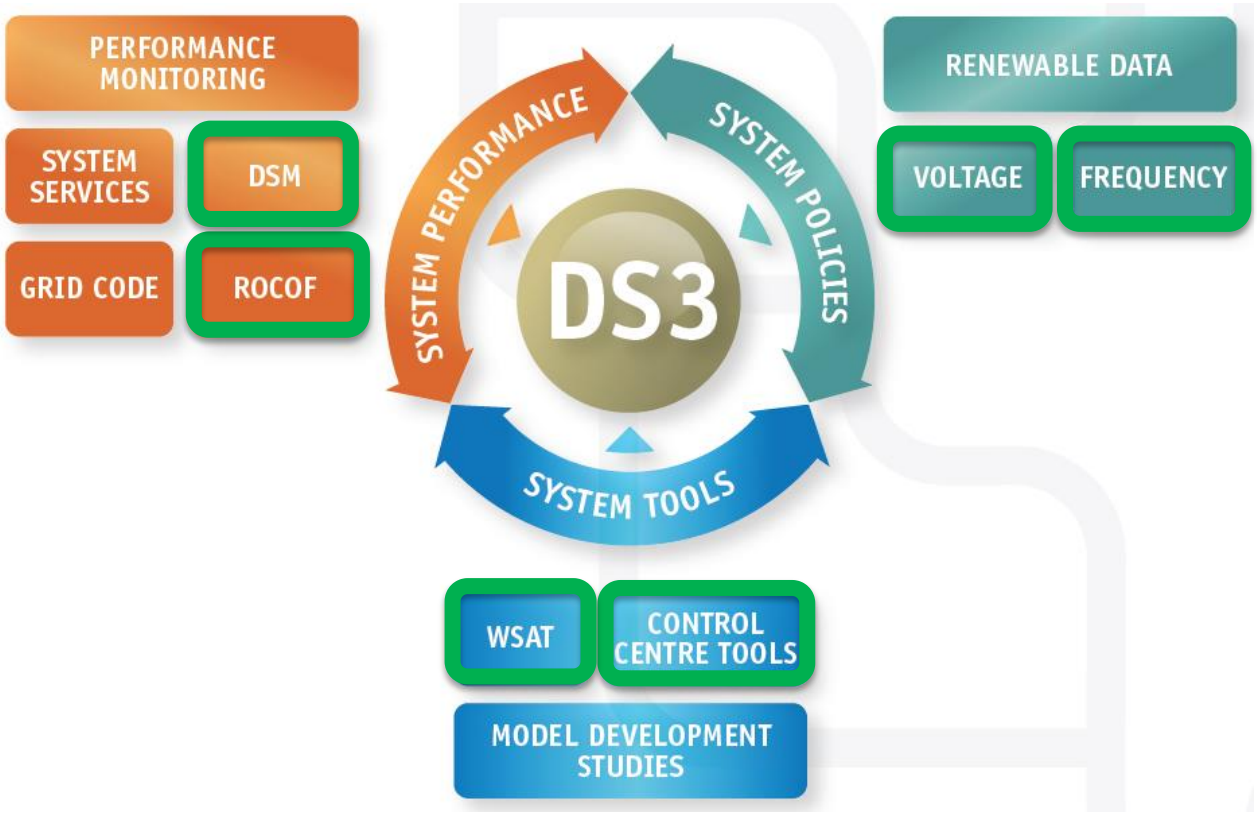
DS3 Programme Goals

- Meet the challenges of operating the electricity system in a secure manner while achieving the 2020 renewable targets
  - Ability to operate the system at 75% instantaneous penetration of non-synchronous generation (known as SNSP)
  - Keep curtailment at a level that is acceptable to industry to facilitate growth

EIRGRID GROUP

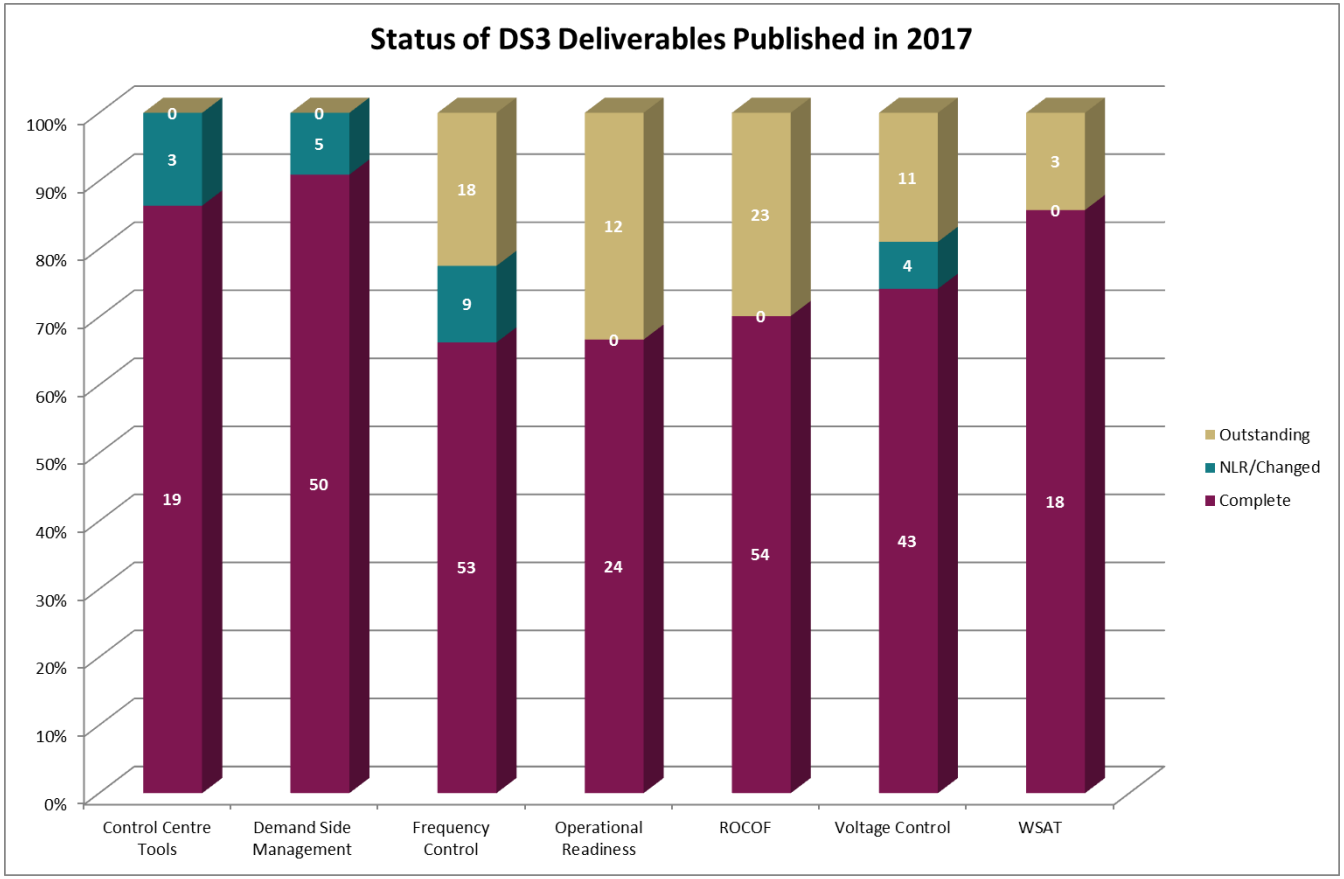
DS3 Programme Structure

Published 2017 Workstream Plans



EIRGRID GROUP

Review of 2017 Published Deliverables



EIRGRID GROUP

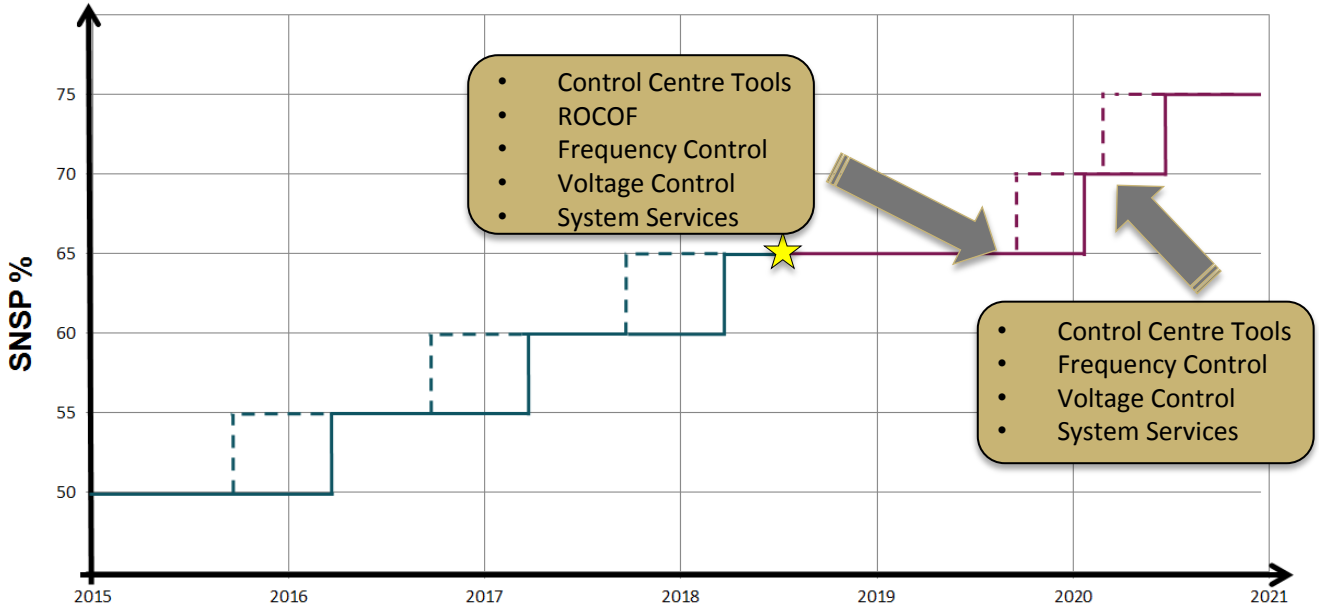
Review of 2017 Published Deliverables

- Not all deliverables are strictly DS3!
- Can be misleading – wording of deliverable means it is achieved, however work is ongoing and critical to DS3 Programme success i.e. Control Centre Tools
- Large number of outstanding actions to be completed may be outside the TSOs control i.e. ROCOF
- Deliverables cross several workstreams and are being double counted i.e. ROCOF and Nodal Controller

EIRGRID GROUP

Proposed Restructure

- Remove workstream structure
- Link deliverables to programme milestones
- Clarity around responsibility for deliverable



Dashed line represents an SNSP trial

EIRGRID GROUP

Proposed Restructure

Workstream closeout statements to be issued:

- Performance Monitoring
- DSM
- Grid Code
- Renewable Data
- WSAT
- Model Development Studies

Workstreams to transition into new plan:

- ROCOF
- Voltage
- Frequency
- Control Centre Tools

EIRGRID GROUP

Restructure – 65% to 70% SNSP

Operational Change	*Expected Delivery*
RoCoF transition to 1Hz/s	Q3 2019
Inertia Floor – 20,000 MWs	Q3 2019
Operational Policy	
Ramping Policy	Q1 2018
SNSP 70% Policy	Q2 2019
Operational Reserves Policy	Q4 2018
RoCoF & Inertia Floor Policy	Q2 2019
Control Centre Tools	
Ramping Tool	Q4 2019
Look Ahead WSAT	Q4 2019
System Services	
11 existing services + FFR	Q3 2018

EIRGRID GROUP

Restructure – 70% to 75% SNSP

Operational Change	*Expected Delivery*
Implement OFGS enduring	Q1 2019
Inertia Floor – 17,500 MWs	Q1 2020
Minimum Units Online – 7	Q3 2019
Operational Policy	
Min Sets Policy (Voltage & Inertia)	Q2 2019
SNSP 75% Policy	Q4 2019
VDIF Policy	Q4 2018
Control Centre Tools	
Voltage Trajectory Tool	Q1 2020
System Services	
11 existing services + FFR + DRR + DPFAPR	Q3 2019

EIRGRID GROUP

Next Steps

- Draft plan and close out statements with RAs for review
- Plan and close out statements to be finalised and published
- Update to be communicated with wider industry

EIRGRID GROUP

System Services: Volume Capped Decision Paper

John Young

EIRGRID GROUP

Volume Capped – Overview

Recommendation Paper and Decision Paper published

- 24 responses to consultation with extensive stakeholder engagement undertaken
- Recommendation Paper and Decision Paper published 6th/7th September

Product Bundling

- FFR –TOR2 with asymmetrical over-frequency requirement

Product Characteristics

- Frequency threshold 49.8Hz with dynamic delivery

Availability

- 97% availability managed via scalars

Maximum Contract Size

- 50 MW per connection agreement, 91 – 140MW total

EIRGRID GROUP

Volume Capped – Next Steps

Finalisation and publication of Contract consultation

- October 2018, lasting for 6 weeks
- Contract structure similar to Uncapped arrangements

Stakeholder Engagement

- Stakeholder event to be held in support of contract consultation (November TBC)
- Subsequent event to be held in support of procurement

Procurement

- OJEU notice planned for February 2019
- Contract execution September 1st 2019

EIRGRID GROUP

Qualification Trial Process

Daniel Dixon

EIRGRID GROUP

Why do we need a Qualification Trial Process?

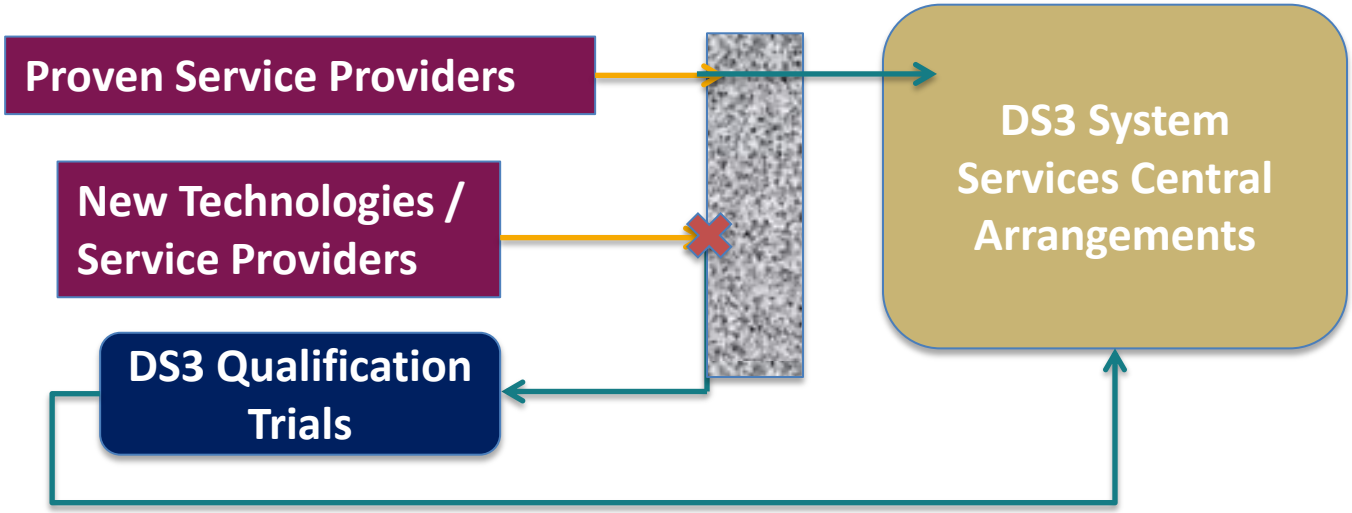
1. Gain an understanding of the capability of new & existing service providers to provide system services
   - Proof of reliable delivery of service
   - Proof of mechanism to monitor delivery of service

2. Identify the barriers to new technologies (technical/ commercial/ contractual) to System Service provision

3. Provide input to development of
   - Grid Codes for new technologies
   - Processes and procedures for commissioning and testing of new technologies
   - Design of the new System Services performance monitoring

EIRGRID GROUP

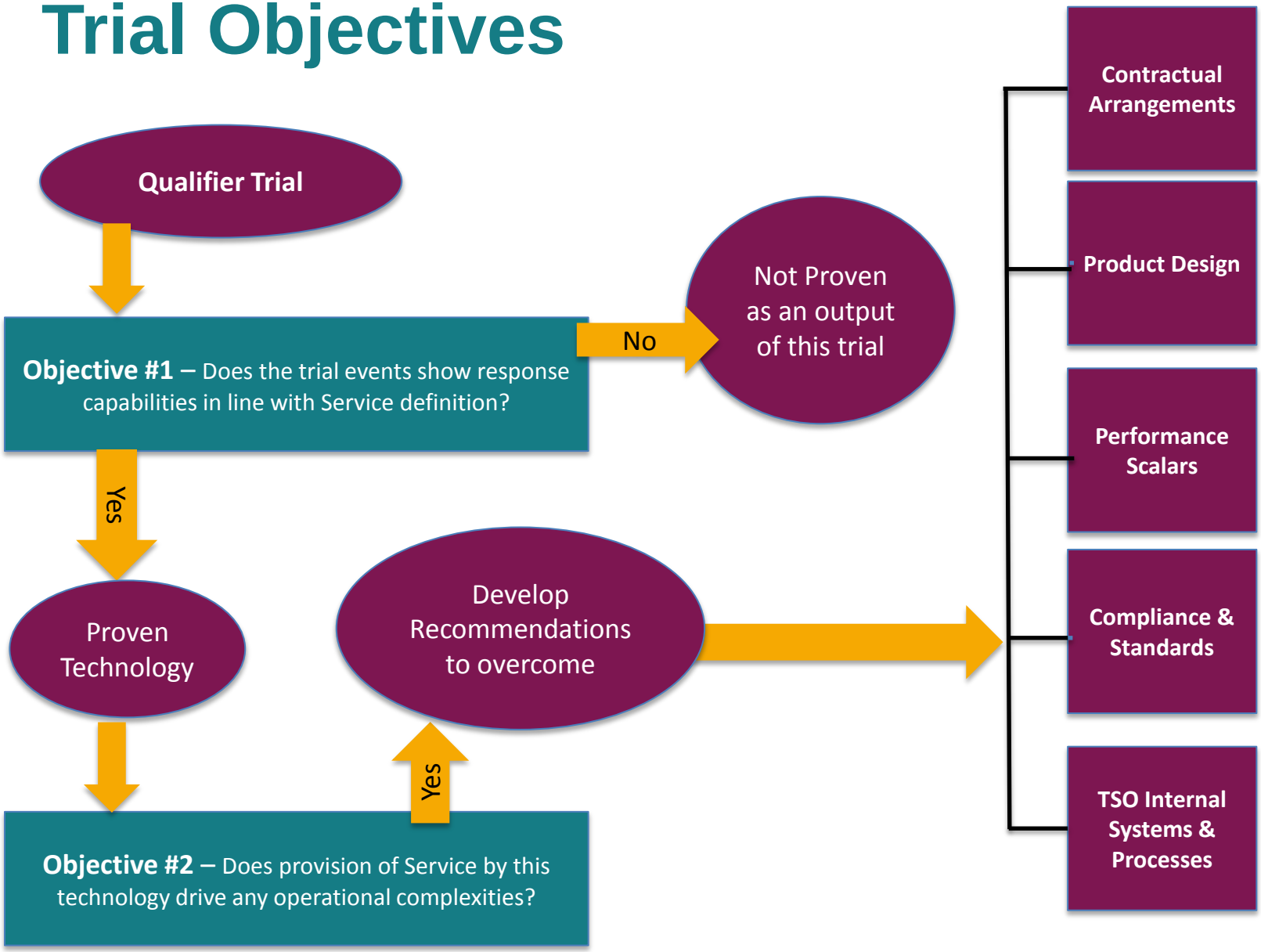
DS3 Qualification Trials



- Provides a mechanism to assess and identify the impacts of large scale deployment of new technologies / services on the system

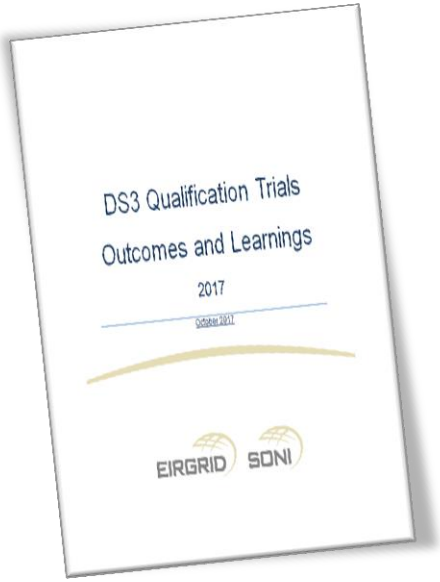
- QtP 2017 focused primarily on;
  1. Operating Reserve – Wind and Demand Side Response
  2. Fault Ride Through Services (Wind and Conventional)

Trial Objectives



DS3 Qualification Trials Outcomes

- Trials finished operationally on 1/9/2018
- Outcomes report published detailing the findings
- 26 Learning & Outcomes in total were published


DS3 Qualification Trials
Outcomes and Learnings
2017
October 2017
EIRGRID SONI

Qualification Trials Process Outcomes and Learnings 2017

EIRGRID GROUP

Objective #1 Outputs

Technology Class / Sub Class[1]	Services Applicable[2]
Wind - Wind Farm Control	FFR, POR, SOR,TOR1
Wind – Emulated Inertia	FFR,POR
Demand Side Management (DSM)	FFR,POR,SOR,TOR1
Synchronous Compensator and Flywheel Hybrid	FFR, POR,SOR,TOR1
Centrally Dispatched Generating Unit (CDGU)	FFR
HVDC Interconnectors	FFR

EIRGRID GROUP

Objective #2 Outputs

- 26 Learning & Outcomes identified in response to operational complexities

- Outputs fed into;
  - DS3 Procurement documentation
  - DS3 Contractual arrangements
  - DS3 Compliance and Testing procedures
  - DS3 Performance Monitoring processes
  - TSO Internal Systems

- Hence, although a technology class may be “Proven” they must still adhere to standards and requirements identified throughout the Qualification Trials in order to get a contract.

EIRGRID GROUP

Key Learnings on 2017 Trial Format

1. 2017 trial selection process was time consuming
2. Time between selection process and trial commencement was challenging
3. Applying standard time lines and format to all trials was not efficient
4. Industry requested additional time from contract execution to the provision of services. This limited the learning opportunities
5. Greater coordination and engagement with DSO / DNO would be beneficial.

EIRGRID GROUP

Feed into 2018 Trial Format

1. The Qualification trials are envisioned to run up to 2020/21 with a focus on Provenability and Operational Complexities
2. Greater coordination and engagement with DSO / DNO would be beneficial (In particular for future trials)
3. Likely that future years will more bespoke / embedded but also may require innovative methods to prove technology at scale.
4. Proposed each trial will have its own time lines end to end
    1. Small up to 6 months
    2. Medium up to 12 months
    3. Large up to 18 months
5. Volume of trials likely to be less but more detailed end to end trials.

EIRGRID GROUP

QtP 2018/19 Categories

- **Provenability Trials** – Any technology class not currently “Proven” as per a public list published on the website

- **Distribution Impacts Trials –** Focused on distribution technologies who have not qualified due to issues on the distribution network such as congestion management, protection issues or violation of operation protocols

- **Standards and Compliance Trials –** Focuses on currently proven technologies whom wish to provide the Service in a way which differs from the current standards set out in contracts. This could possibly be broken down into two sub-categories;
  - Visibility
  - Controllability

EIRGRID GROUP

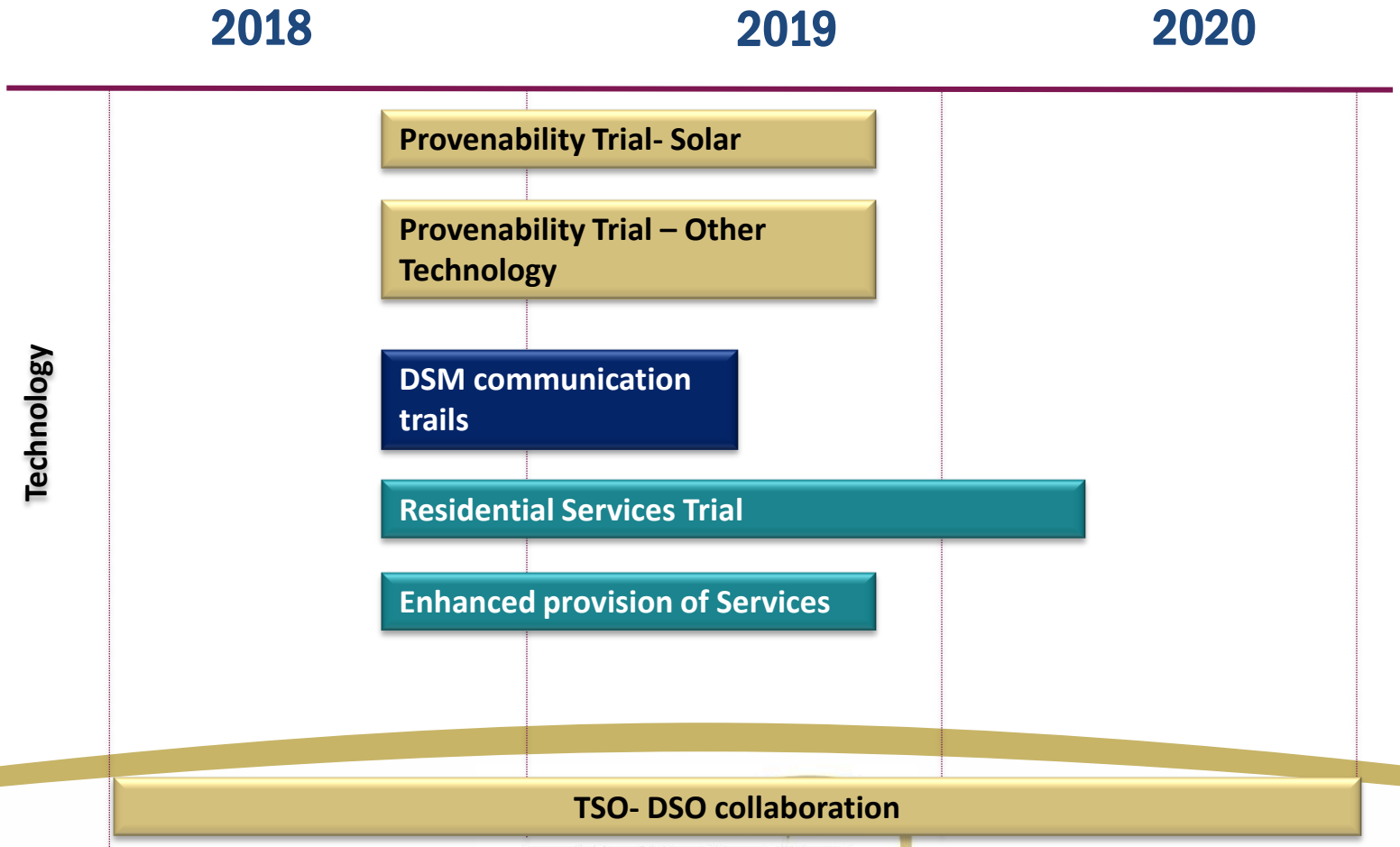
QtP 2018/19 Proposals

Provenability Trial Proposals

Lot	Category	Overview
1	Large	Provenability of Solar technology for the Provision of DS3 System Services.
2	Large	Residential trial focused on Services from large scale home appliances. The trial will investigate the capability to provide reserve and ramping services from immersions/storage and EV's
3	Medium	Provenability trial of new technology for the provision of DS3 System Services.
4	Small	Enhanced Technology Capability for the provision of DS3 System Services.
5	Small	Alternative communication approach for DSM providers at individual sites / aggregation acceptable for signals/performance monitoring purposes.

EIRGRID GROUP

QtP Timeline for 2018 - 2020



EIRGRID GROUP

Lunch & Networking

12.15 – 13.05

EIRGRID GROUP

Agenda - Afternoon

Topic	Time	Speaker
RoCoF	13.05	Update: John Young , EirGrid (5 mins) Update: NIE Networks, ESB Networks (10 mins) Update: Noel Cunniffe, EirGrid (5 mins) Discussion: All (10 mins)
Oscillations	13.35	Presentation: Peter Wall, EirGrid (15 mins) Discussion: (10 mins)
Beyond 2020 - EU SysFlex scenarios & models	14.05	Presentation: Noel Cunniffe, EirGrid (15 mins) Discussion: (15 mins)
AOB	14.35	All (20 mins)
Closing Remarks and Actions	14.55	Jon O'Sullivan, EirGrid (10 mins)
Session Closed (15.05)		

EIRGRID GROUP

DS3 RoCoF Project

John Young

EIRGRID GROUP

RoCoF Status – September 2018

TOTAL (approx. 11,631 MW)

7,739 MW (67%) complete

Conventional Generation (8,550MW total)

5,274 MW (62%) complete

- Progress ongoing in Ireland and Northern Ireland
- Some high priority units undergoing testing currently
- 18 out of 24 high and mid-priority units compliant

IRE: 4,524/6,723 MW complete (68%)
NI: 750/1,827MW complete (41%)

Wind (2,223 MW total)

2,136 MW (96%) complete

IRE: 1,227/1,266 MW complete (97%)
NI: 909/957 MW complete (95%)

- Roll-out near completion in both jurisdictions
- Close-out of final MW expected by end of June 2018

Small-scale/embedded (approx. 770 MW total)

241 MW (31%) complete

- Roll-out in IRE making significant progress ahead of target
- Roll-out in NI targeting Sept 2019 completion – letters now sent to relevant units

IRE: 241/330 MW complete (73%)
NI: Roll-out recently begun

RoCoF 1Hz/s

EIRGRID SONI

ESB Networks – RoCoF Update
DS3 Advisory Council

Tony Hearne

19th September 2018

DSO RoCoF Project Wind Breakdown

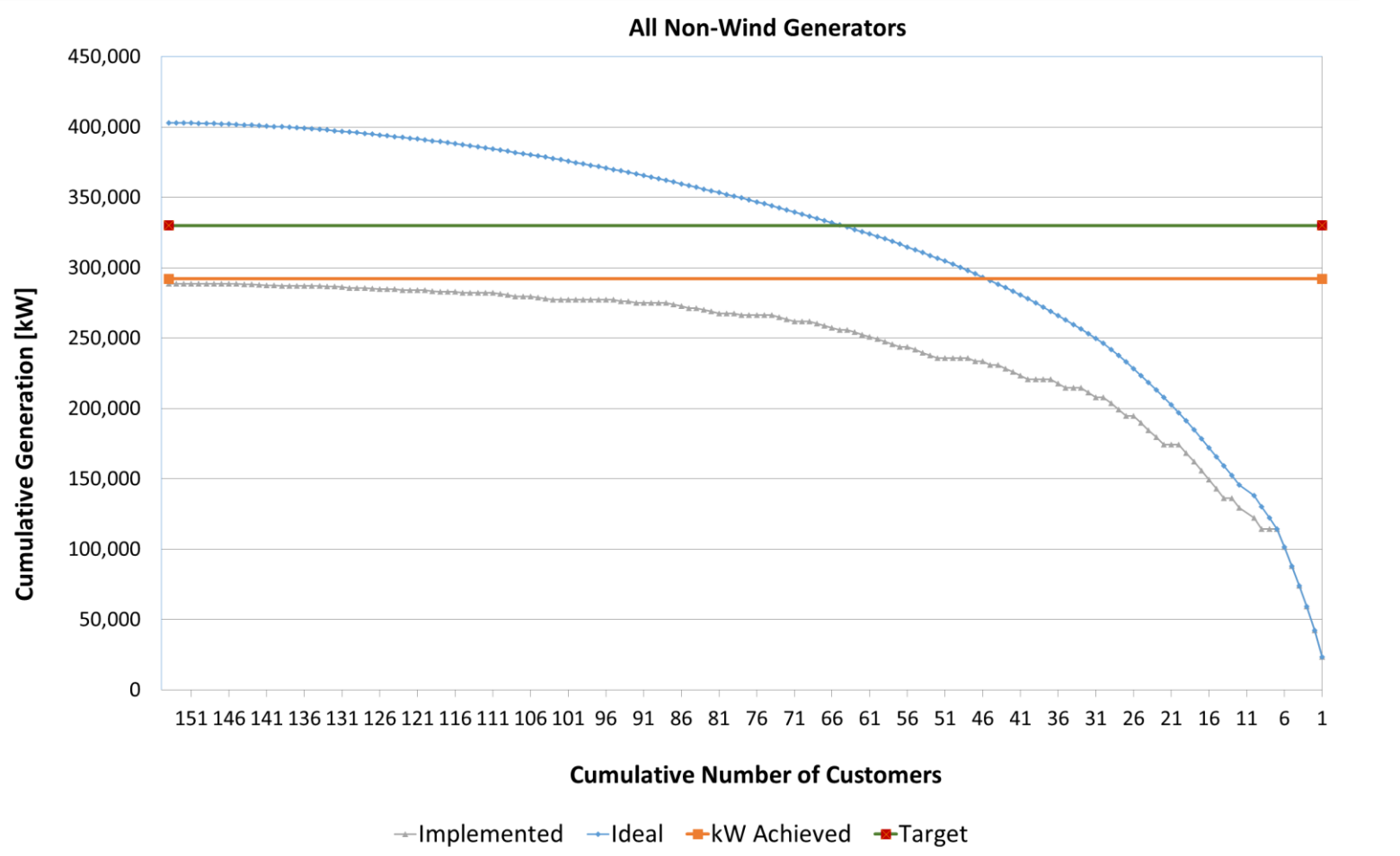
Wind Figures Breakdown	%
Confirmed Returns	96.94%
WFs to Confirm Completion	3.06 %
Likely to request a Derogation	0%

- **Loss of Mains relay installation is due to take place on remaining windfarm (38.9MW) on the 26th/27th September.**

Non Wind - 1

- Estimated total MW installed 410MW
- Agreed target 330MW of the total MW installed completed by Q4
- Completed to date 292MW
- Processing / Awaiting returns from Summer Shutdown activities
- Completed meaning either:
  - RoCoF settings changes made or
  - Confirmed as
    - being trickle-feed and interface circuit breaker trip or
    - Confirmed as being short term paralleling [peak lopping]

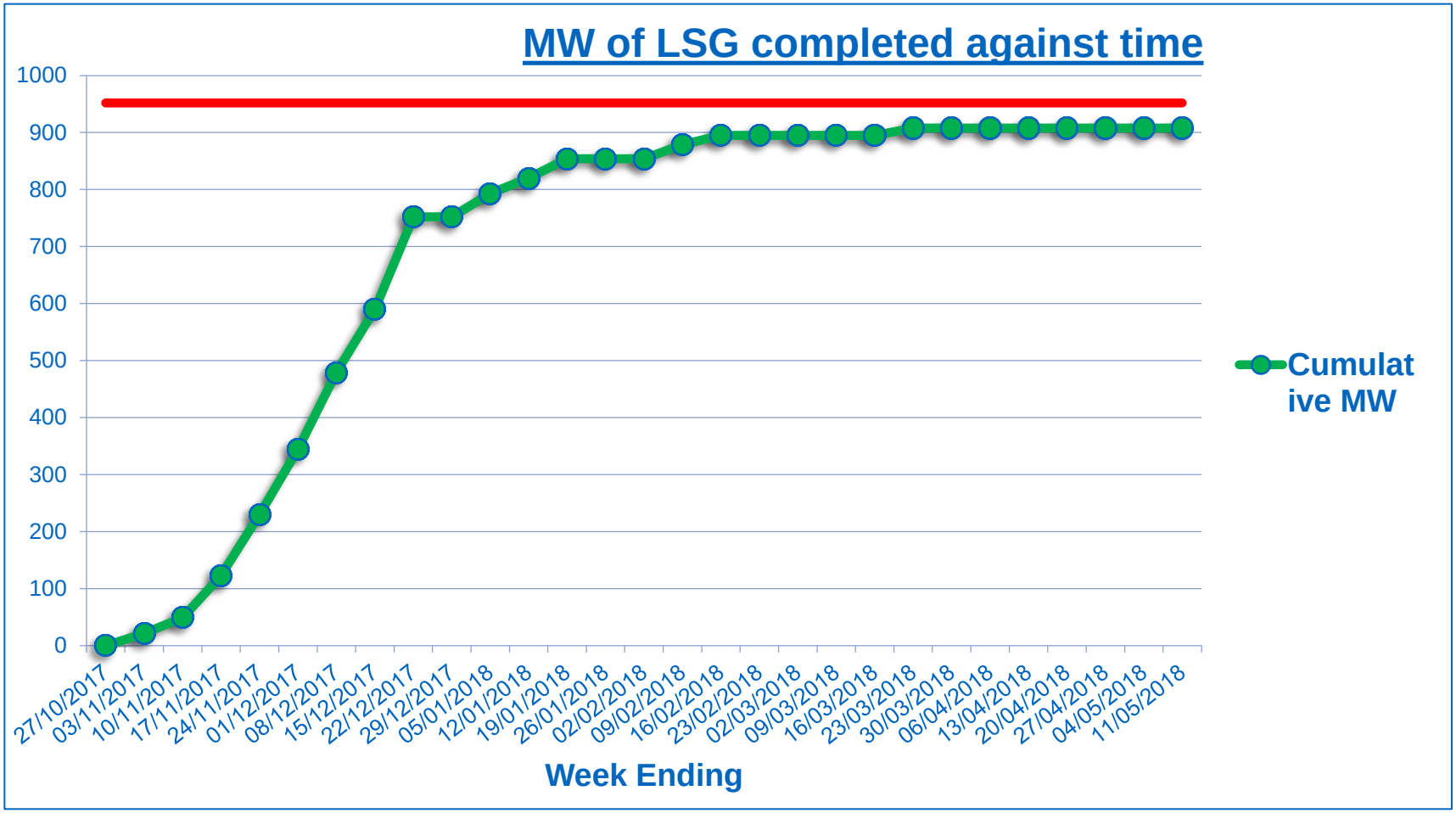
Non Wind – 2 How are we doing?



ROCOF

DS3 Advisory Council Update 19/09/18

LSG RoCoF Progress



LSG RoCoF Progress

- **To date 98% (1.1GW) of sites have changed to the new RoCof setting**
- **4 sites (25MW) still to change**
  - All remaining sites expected to test before end of October
  - All remaining sites date back to 1990's and require G59 relay changes
  - All owners are committed to making the changes
    - Delays due to equipment procurement and lack of protection panel drawings

SSG RoCoF Implementation

- **Letters requesting G59 changes sent out 01 June 2018**
- **SSG owners to acknowledge receipt by 29 June 2018**
  - Online or by return pre-paid envelope
- **For assurance purposes SSG owners to use G59 approved contractors**
  - List of approved contractors on NIE Networks website
- **G59 approved contractor list established following procurement exercise**
  - 19 contractors on list
- **SSG owners to make the changes by 30 September 2019**
- **Costs associated with making the changes borne by SSG owners**

SSG RoCoF Progress

- **G59 contractor technical workshop completed**
- **Briefing sessions held with interested parties, UFU, NIRIG, RGLG..**
- **c1500 letters sent to SSG owners**
  - SAE envelopes included for acknowledgement test results returns
- **G59 changes guidance note provided to SSG owners**
  - Gives the reasons and benefits for the changes and the technical detail of how to implement the changes

SSG RoCoF Progress

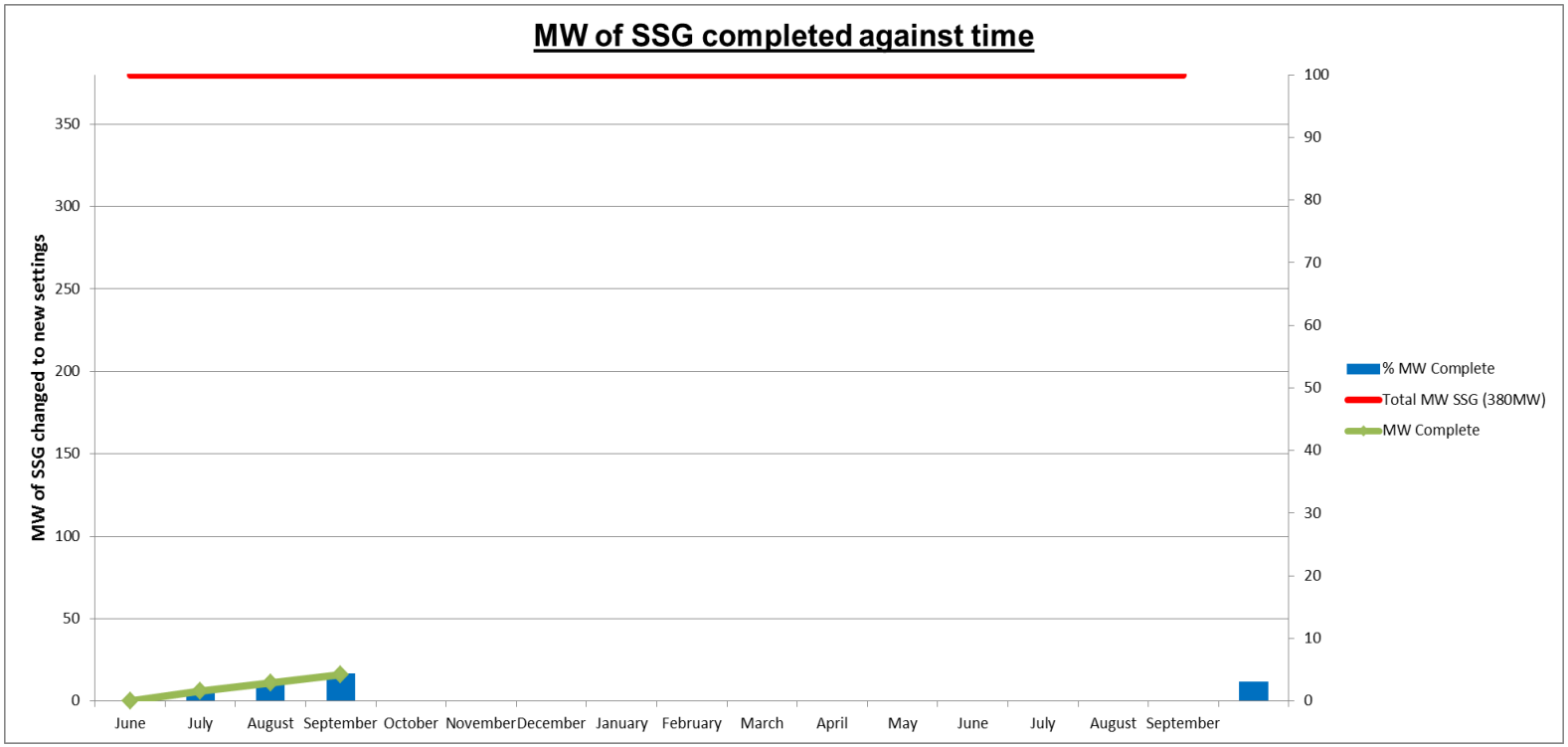
- The table below shows (1) the number of acknowledgment returns and the associated MWs, and (2) the number of sites and MWs complete.

Total Returns	Acknowledgement (MW)	Changes Complete (Number)	Changes Complete (MW)	Changes Complete (%)
976	301	59	22	5.9

- Next Steps
  - UR – SONI – NIE Networks progress review meetings.
  - Engagement with the approved G59 contractors to ensure effective programme delivery.
  - Consider further analysis of the 35% of SSG's who did not respond and determine if additional correspondence is required.

SSG RoCoF Progress

- The graph below shows the changes in MW made against a timeline out to September 2019.



RoCoF Analysis 2018-19

Noel Cunniffe

EIRGRID GROUP

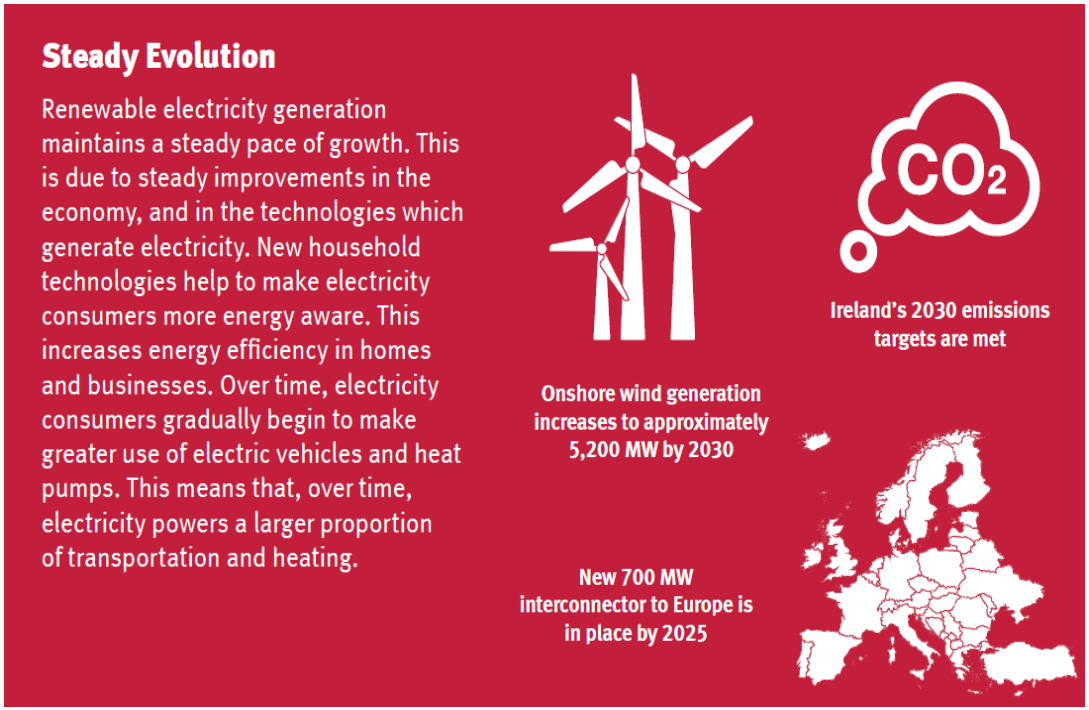
Overview

- Impact of Unmoved RoCoF on 2020
  - Summary of PLEXOS modelling carried out between May – August 2018
  - SNSP Impacts
  - RoCoF Impacts
  - Curtailment Impacts
- Assessing the impact of RoCoF tripping at less than 1 Hz/s

EIRGRID SONI

Impact of Unmoved RoCoF Study

- 2020 scenarios as per Generation Capacity Statement and Tomorrow's Energy Scenarios Steady Evolution
- Assess the impact of unmoved RoCoF on SNSP, RoCoF and Inertia levels
- Assess impact on Curtailment



EIRGRID SONI

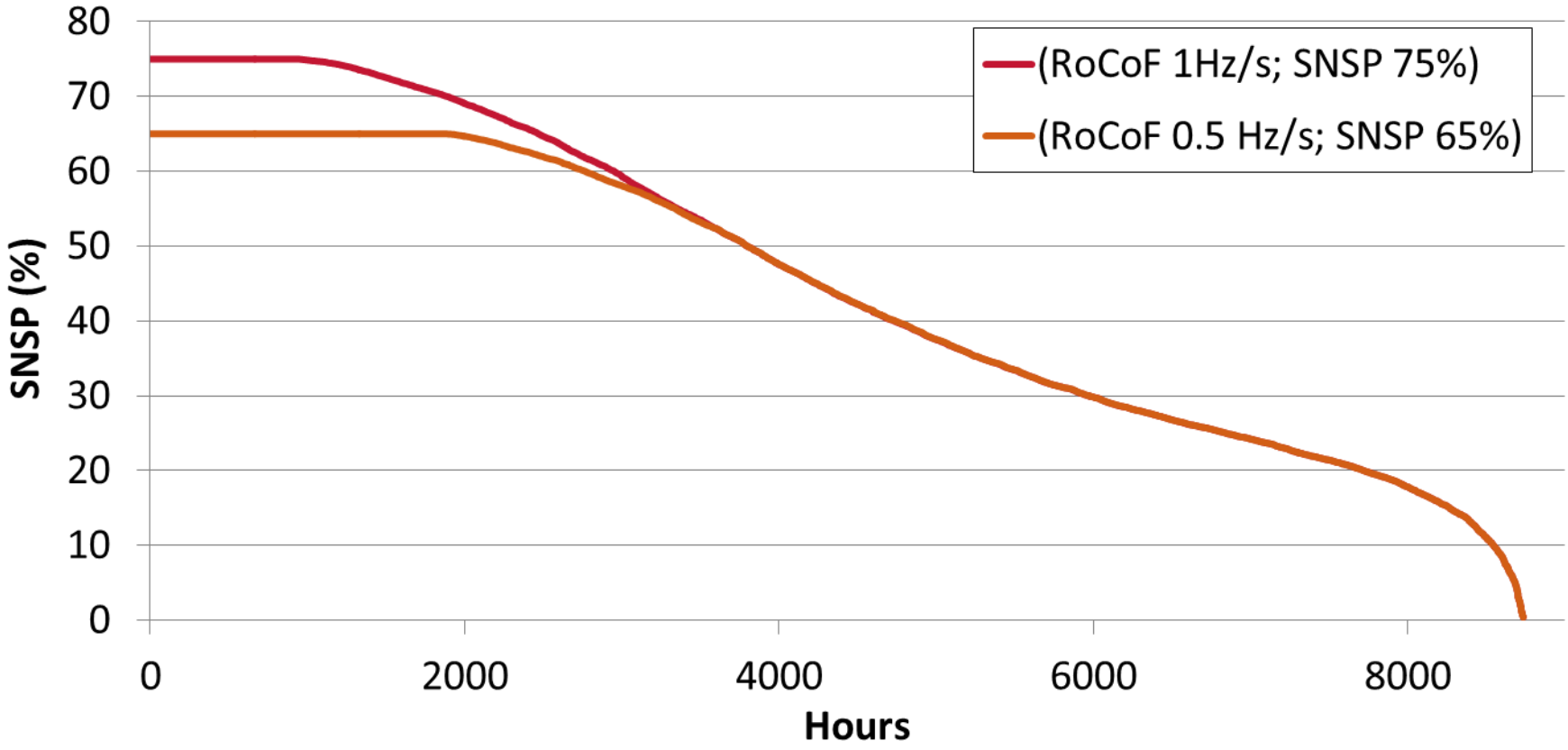
RES & Operational Constraint Summary

Steady Evolution 2020 RES Installed Capacities (MW)	All-Island
Wind	**5,350**
Hydro	**237**
Biomass (AI), LFG (AI), or Small Scale Hydro (NI)	**317**
Solar PV	**370**
Renewable Generation	**6,274**

	Steady Evolution 2020 (Base)	Steady Evolution 2020 Unmoved RoCoF	Change
RoCoF Limit (Hz/s) (AI)	1	0.5	↓
SNSP Limit (%) (AI)	75	65	↓
Curtailment (%) (AI)	4.7%	10.7%	↑

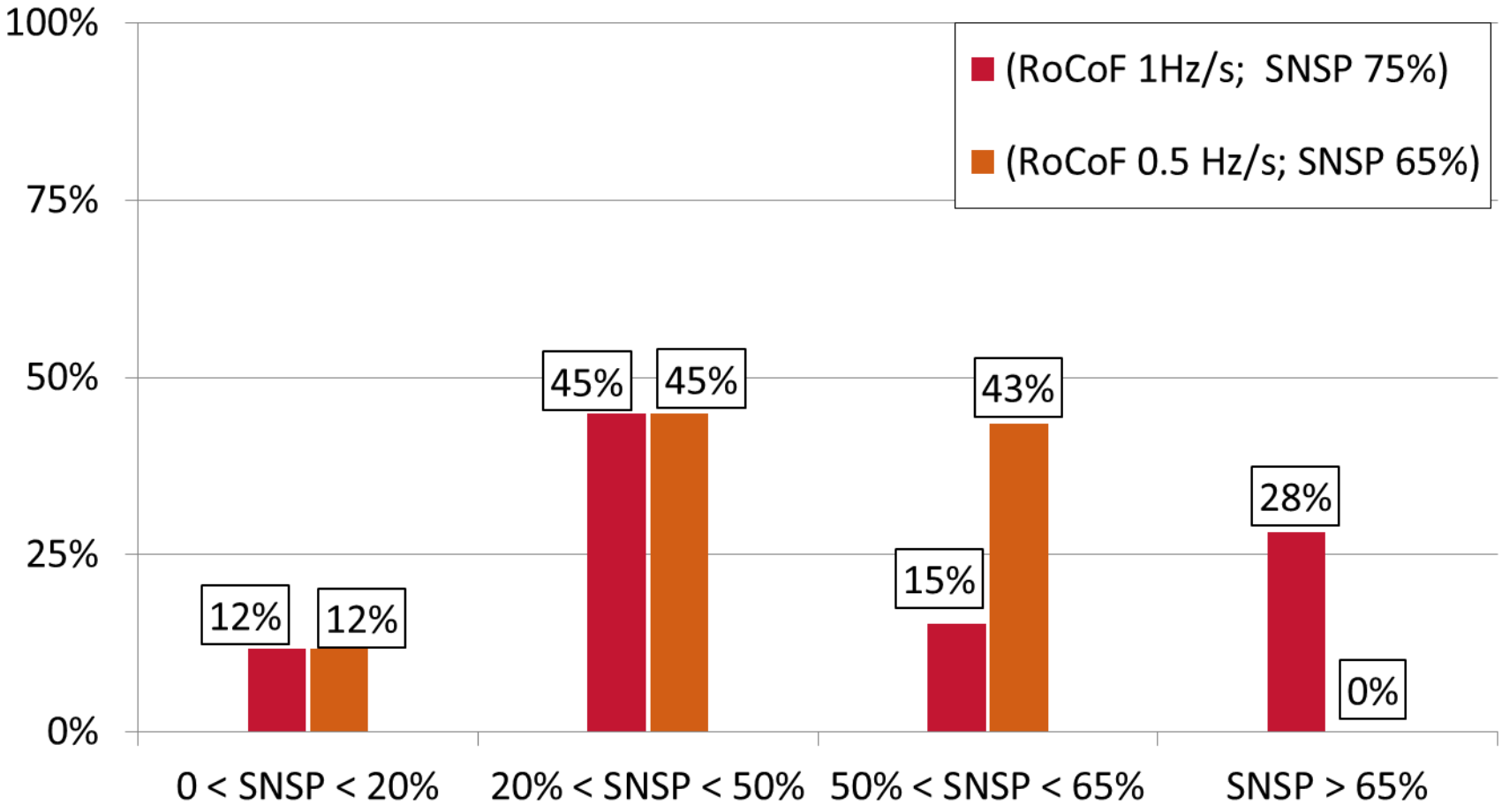
EIRGRID SONI

SNSP Duration Curve



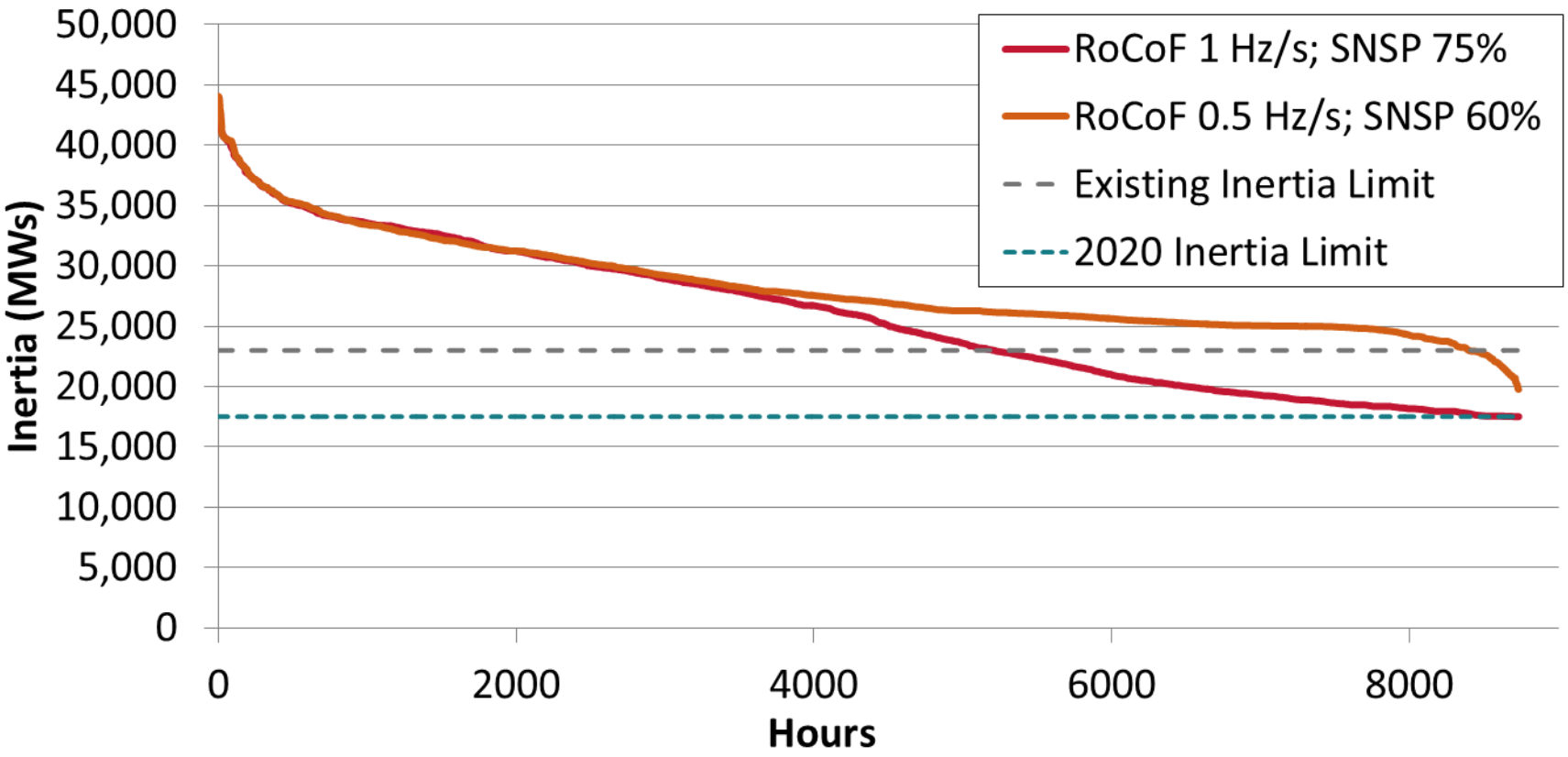
EIRGRID SONI

SNSP



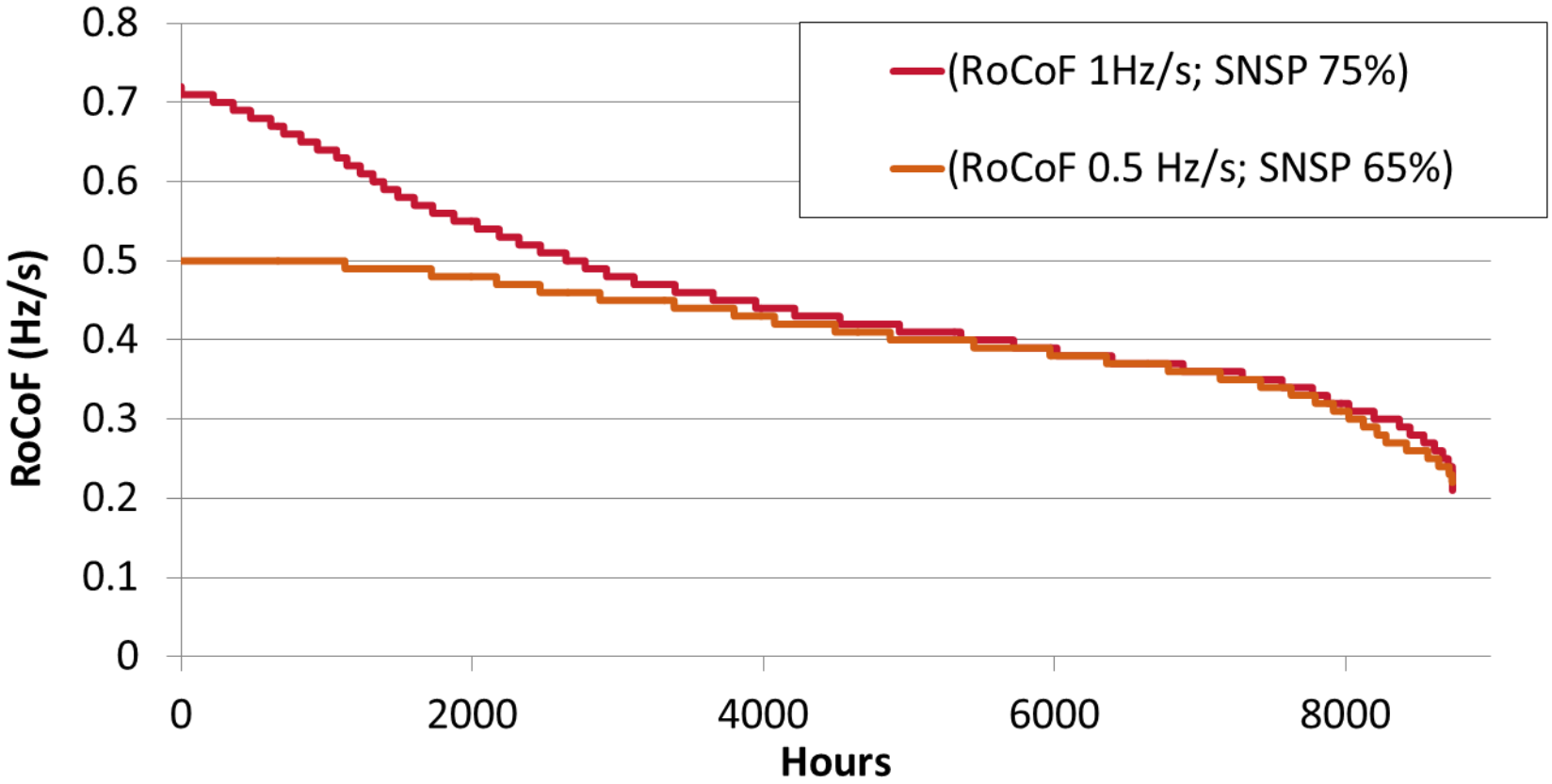
EIRGRID SONI

Inertia Duration Curve



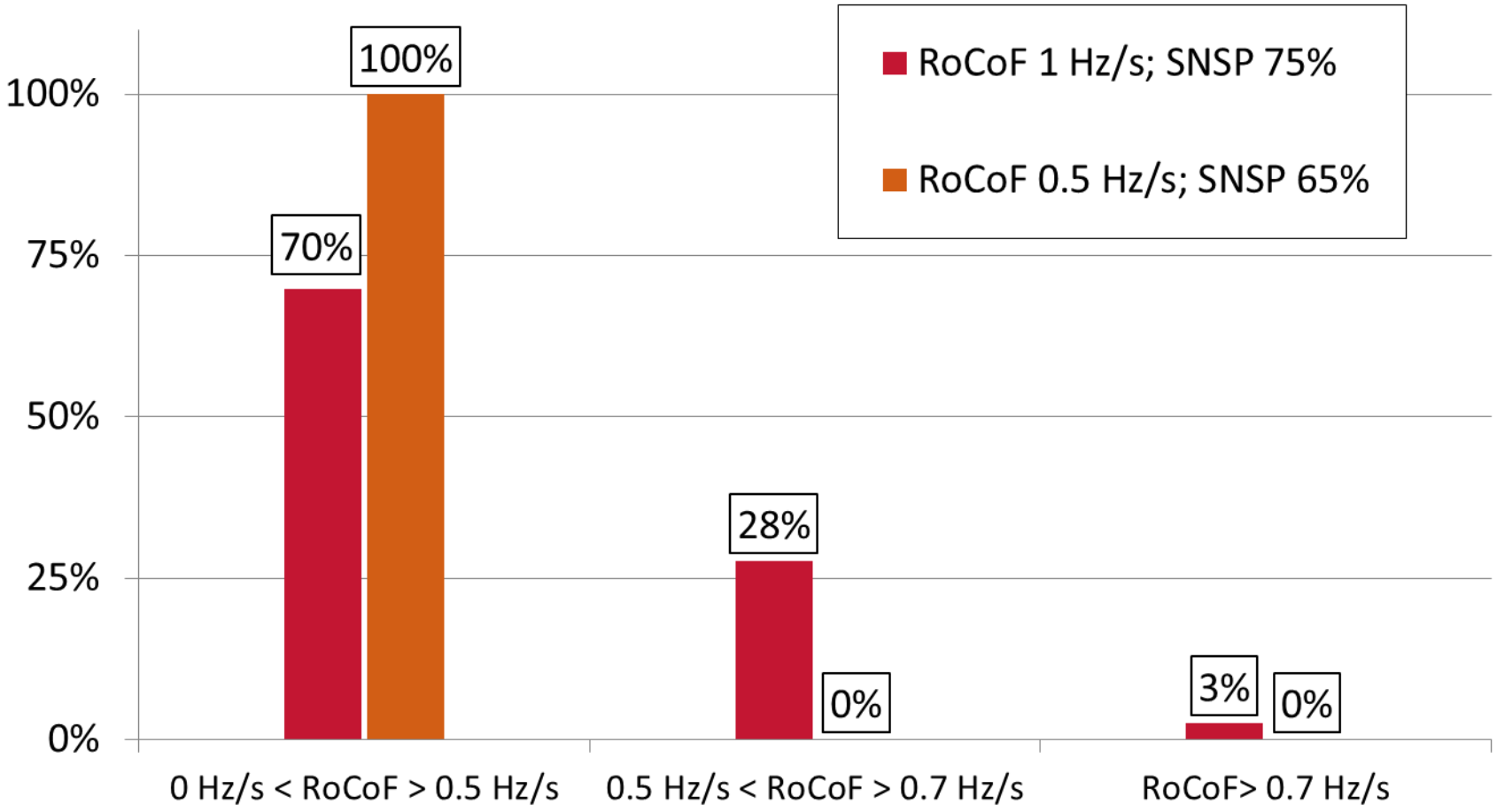
EIRGRID SONI

Potential RoCoF Duration Curve



EIRGRID SONI

Potential RoCoF



EIRGRID SONI

Next Steps – RoCoF Study

- Study focused on finding out the non-compliant MW tolerable

- **Analysis** – System analysis with updated operational policies and 2020 generation & demand portfolio
  - Q3 2018 – Q1 2019

- Updated and more detailed analysis than previous 2014 study

EIRGRID SONI

Oscillations

Peter Wall

EIRGRID GROUP

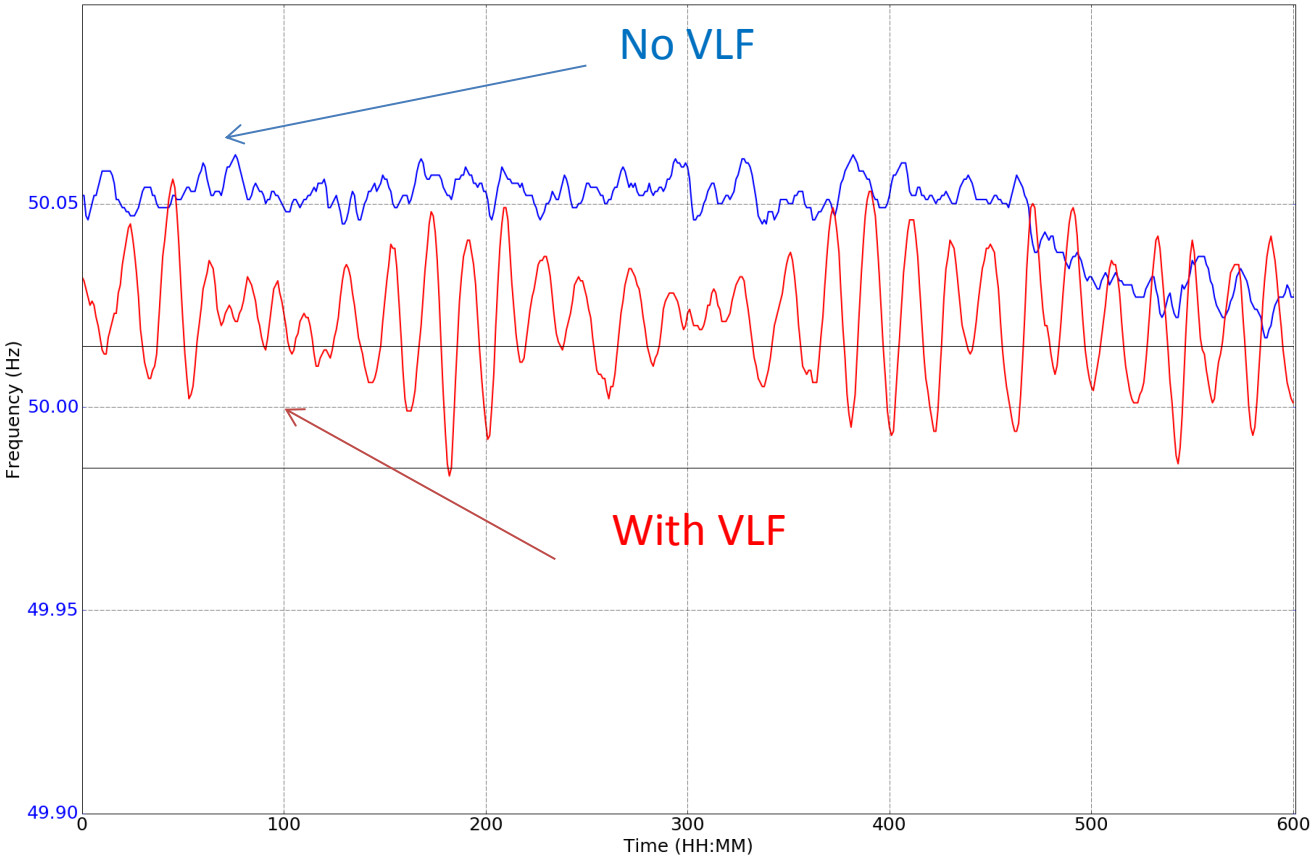
Outline

1. Introduction to VLF oscillations and a look at past events
2. APC and VLF damping from wind farms
3. Small signal stability of the mode
4. Correlation of VLF occurrence to system conditions
5. Conclusions and Conjecture

EIRGRID GROUP

VLF Oscillation

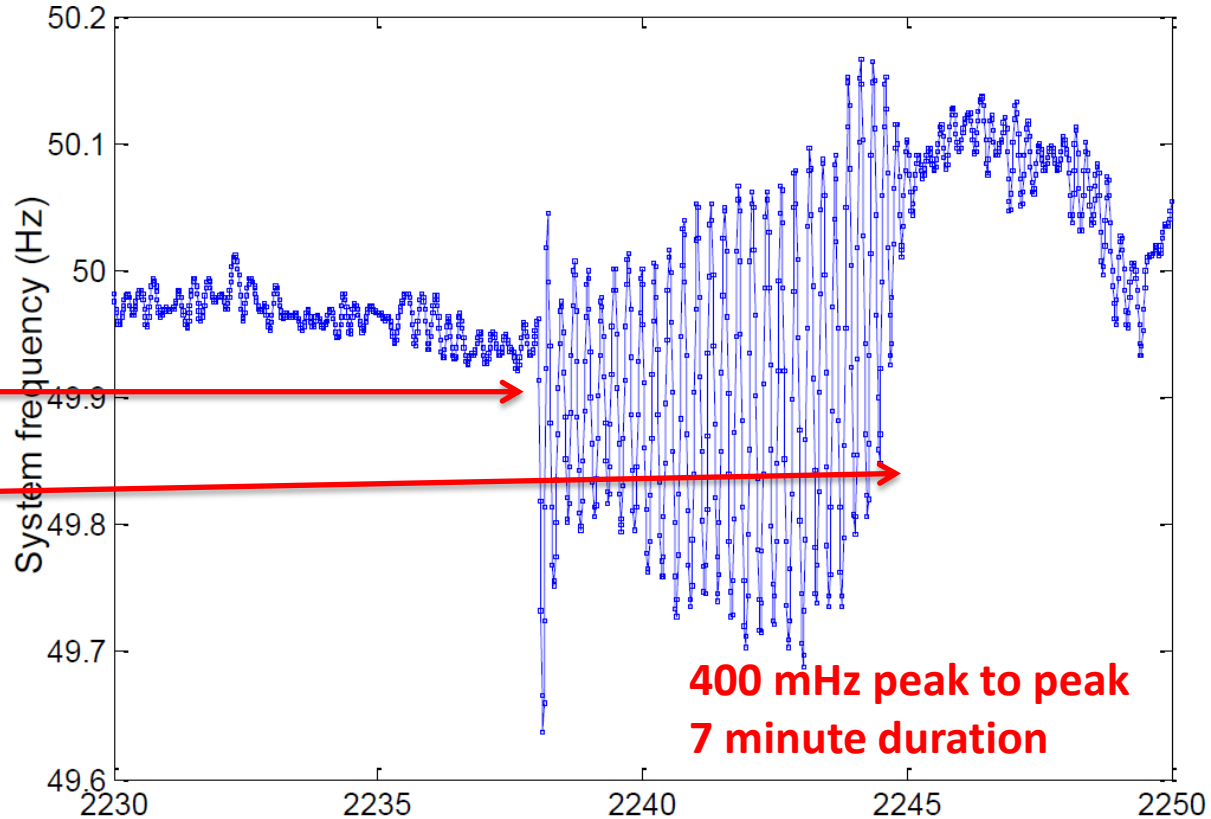
- Modulation of system frequency
- Usually has oscillatory frequency of approx. 0.05Hz



EIRGRID GROUP

VLF Oscillation

- Can result in significant events



EIRGRID GROUP

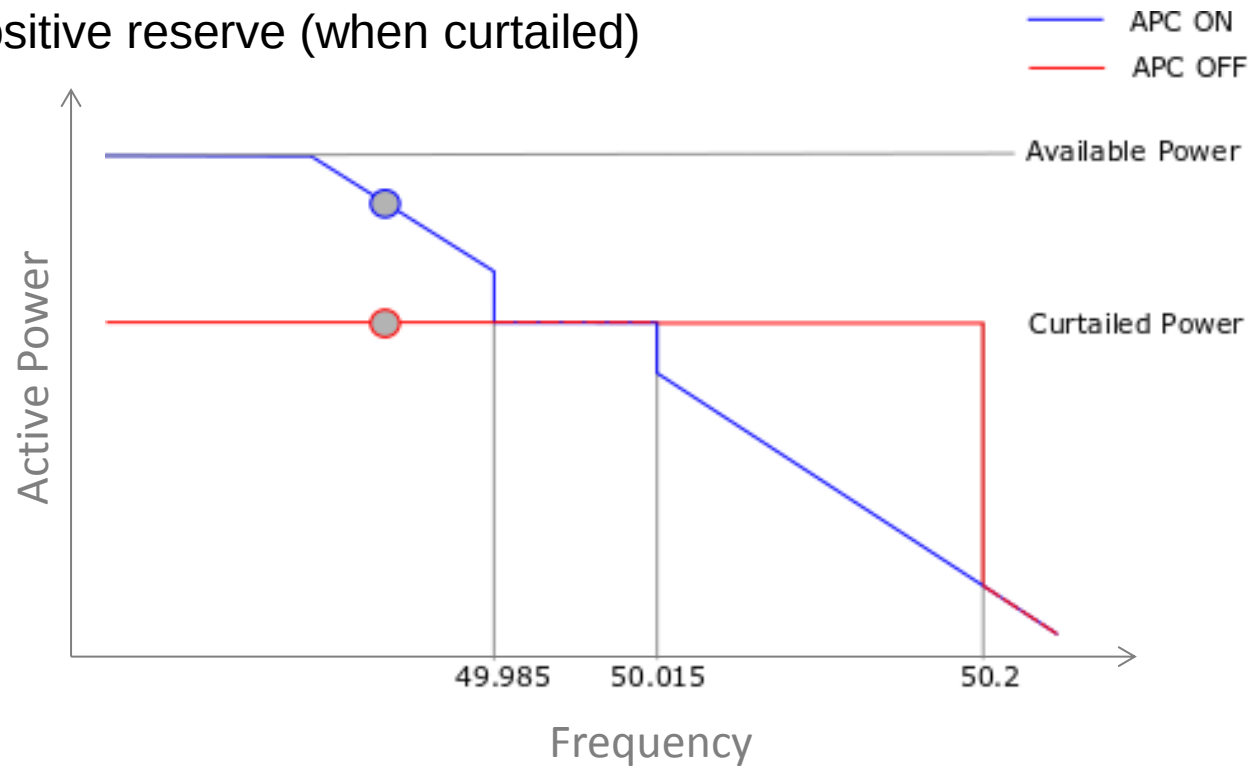
VLF Oscillation

- Can lead to significant events
- These events emerge from background oscillations
- Relationship to behaviour of specific thermal units
- This emergence was associated with a number of generation changes and governor tuning in late 2009
  - None of these clearly identified as a causal factor at the time.

EIRGRID GROUP

Active Power Control (APC)

- Normally, Wind Farm frequency response (FQR) is always enabled and on curve 1
- APC is a modified response curve that can be turned on:
  - Narrower dead band of +/- 0.015Hz
  - Positive reserve (when curtailed)

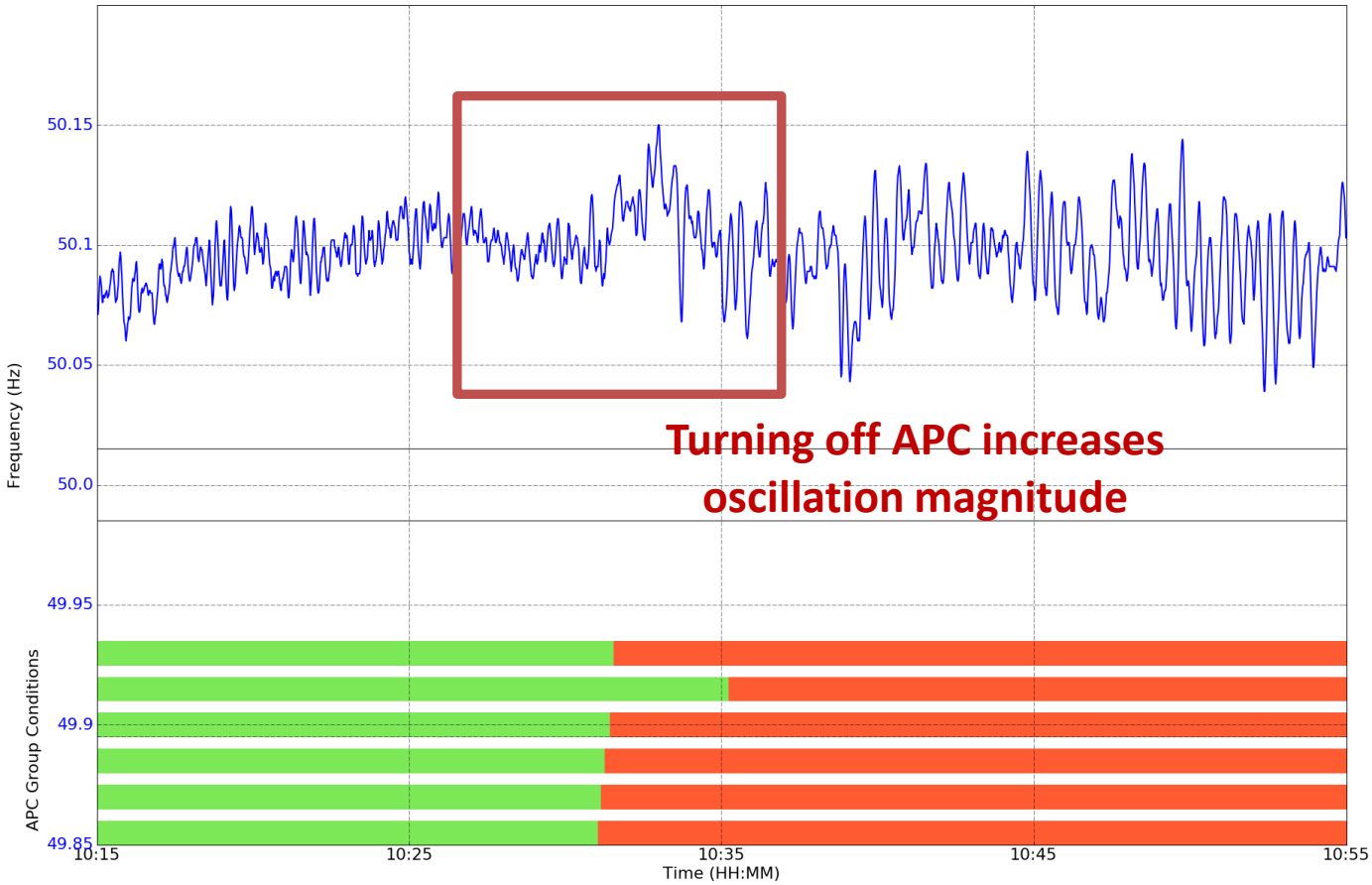


APC Damping VLF Oscillations

- APC damps VLF oscillation by providing active power response that is in antiphase to the frequency oscillation
  - Fast response of converter allows continuous antiphase response
- Further study required to:
  - Identify how many WFs provide this damping
  - Quantify sized of oscillation APC can suppress

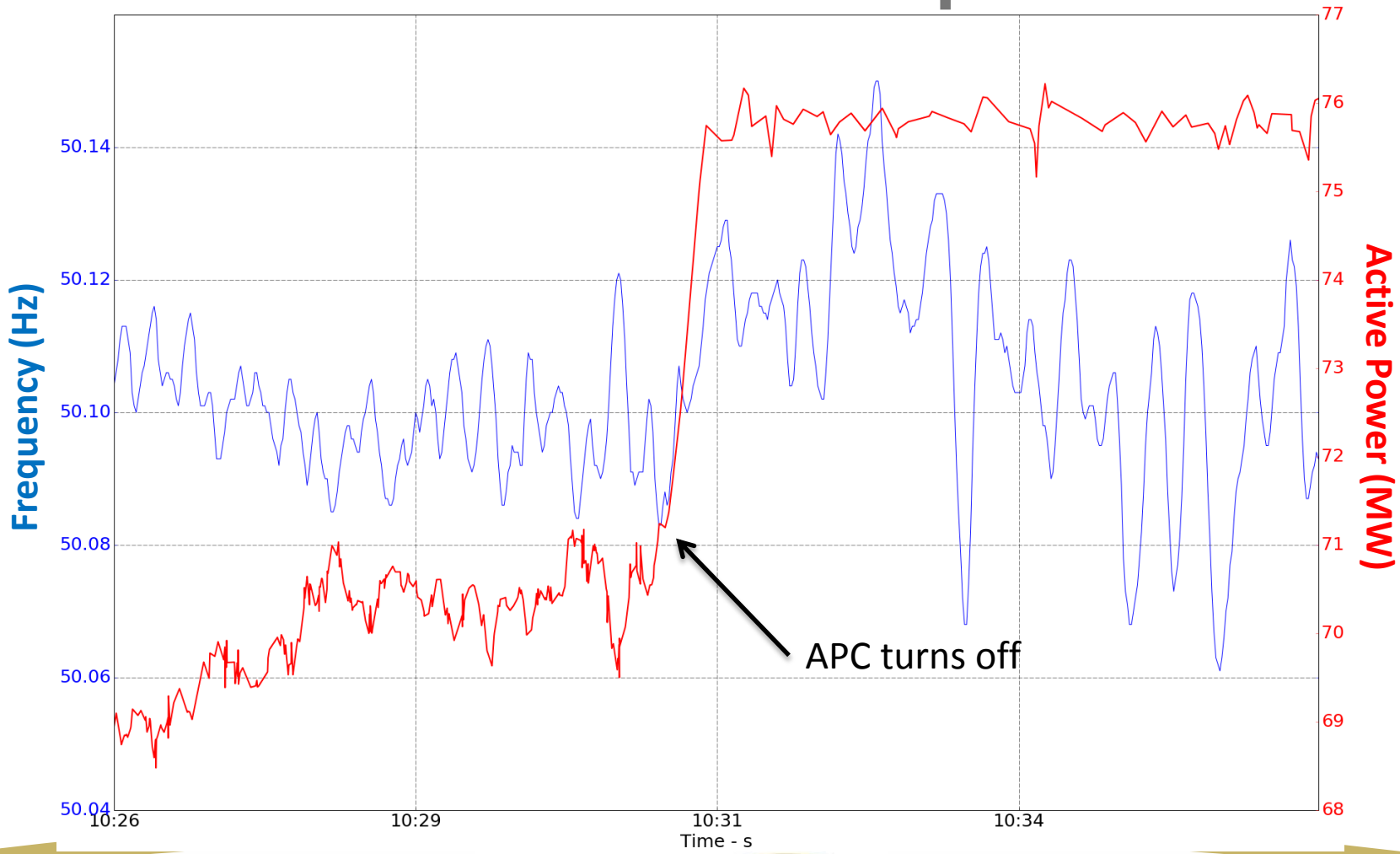
EIRGRID GROUP

Example of APC Damping VLF



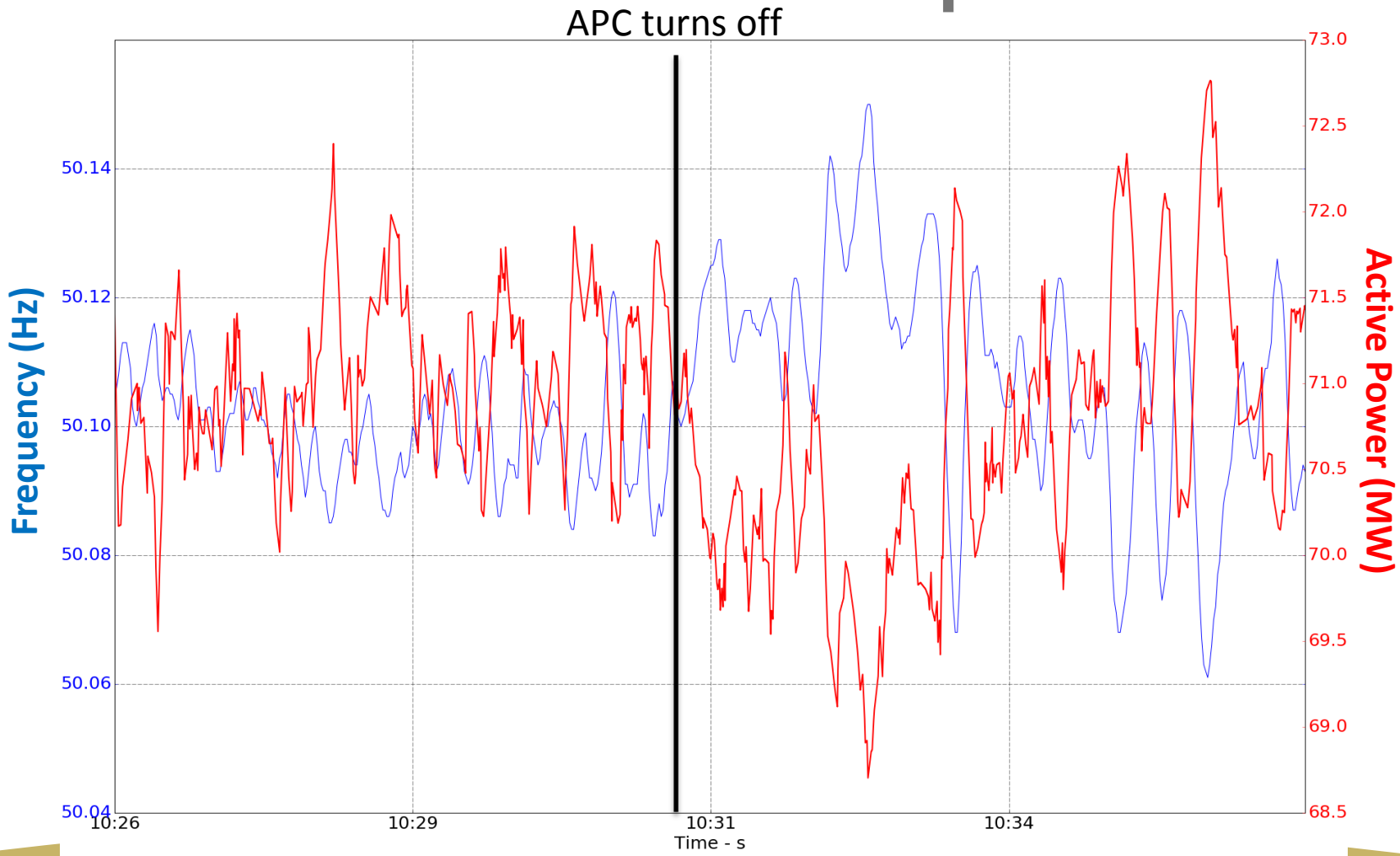
EIRGRID GROUP

Wind Farm A Output



EIRGRID GROUP

Wind Farm B Output



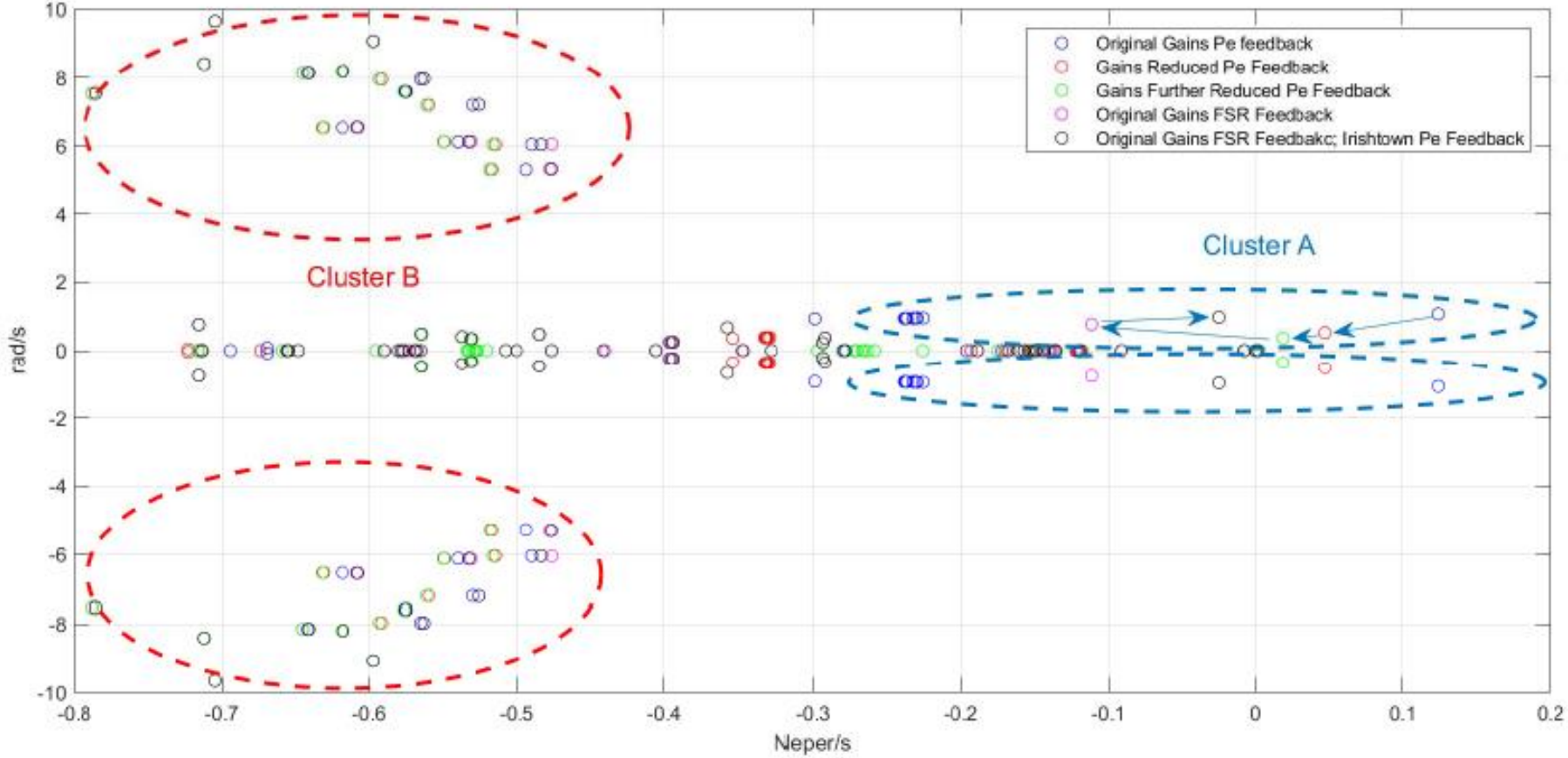
EIRGRID GROUP

Small Signal Stability Analysis

- Equivalent system modelled by consultants
  - 2017 topology
  - New models used for generators
  - Not accurate but effective representation
- Electrical power feedback on thermal turbine-governor controls shown to destabilise VLF mode
  - Swapping to fuel stroke reference for gas turbines resolves this or throttle valve position for steam turbines
  - Reducing gains also helps to stabilise mode
  - Increasing the number of governors in electrical power feedback reduces the stability margin accordingly

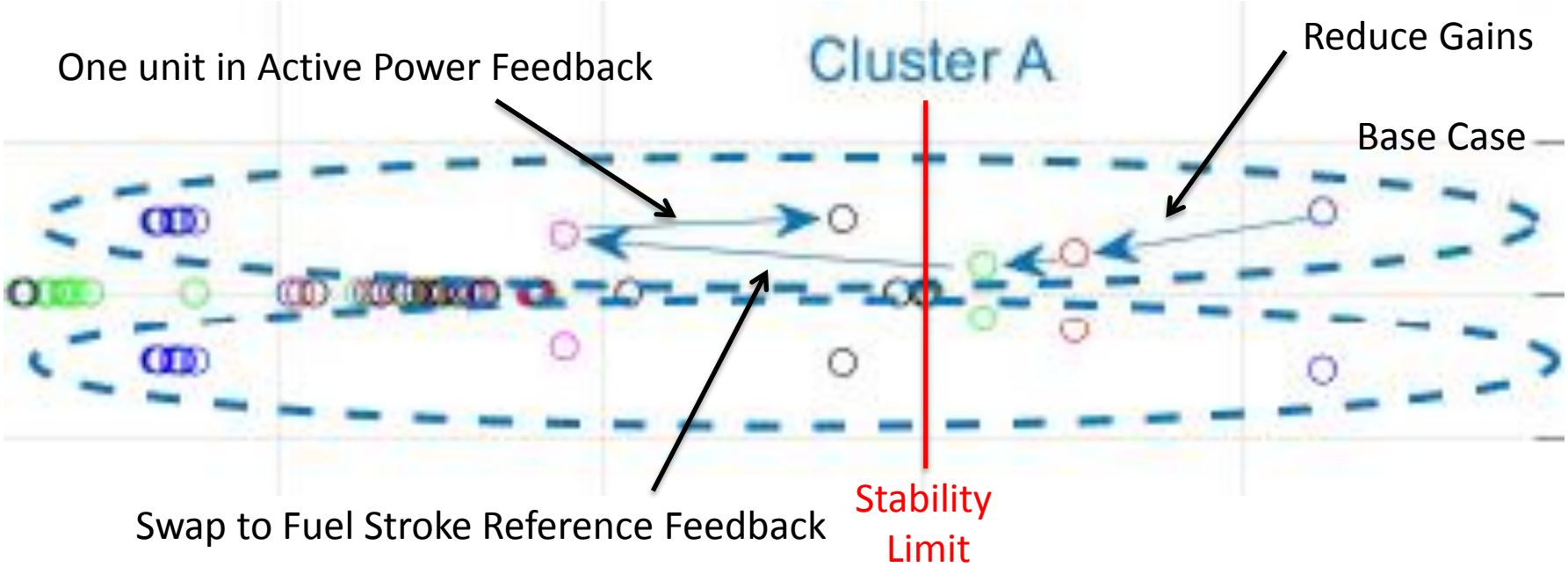
EIRGRID GROUP

VLF mode stability – Modal Analysis



VLF mode stability – Sensitivity governor

- Changing governors moves VLF mode
  - One governor in active power feedback can have large impact



EIRGRID GROUP

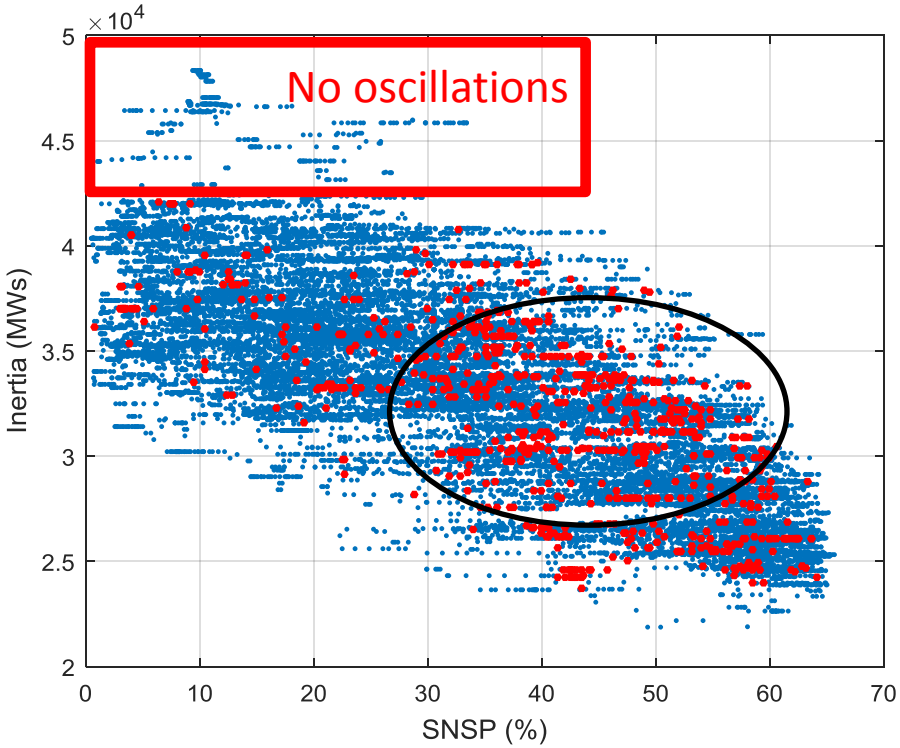
System Level Correlations

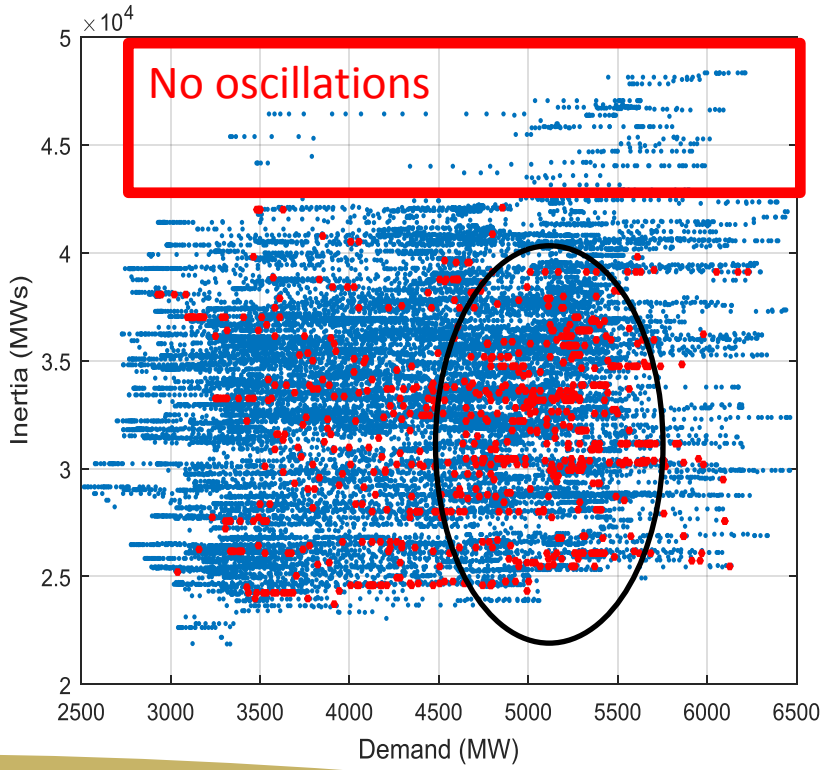
- Studied background oscillation events Jan – May 2018
  - Identified using Fast Fourier Transform of 1Hz frequency data
  - Oscillation above study threshold 3.35% of the time
- System level measures studied:
  - Demand, Inertia, Wind, SNSP, time, frequency
- Few significant correlations observed
  - No oscillations observed when inertia above 42200 MVAs
  - Disproportionate number of events are observed for moderately high SNSP/demand and moderately low inertia
- Oscillation occurs for most system conditions
- Root cause not observed in any system level measure

EIRGRID GROUP

Correlations

- Event Windows (red dots) occur for most system conditions (blue dots)





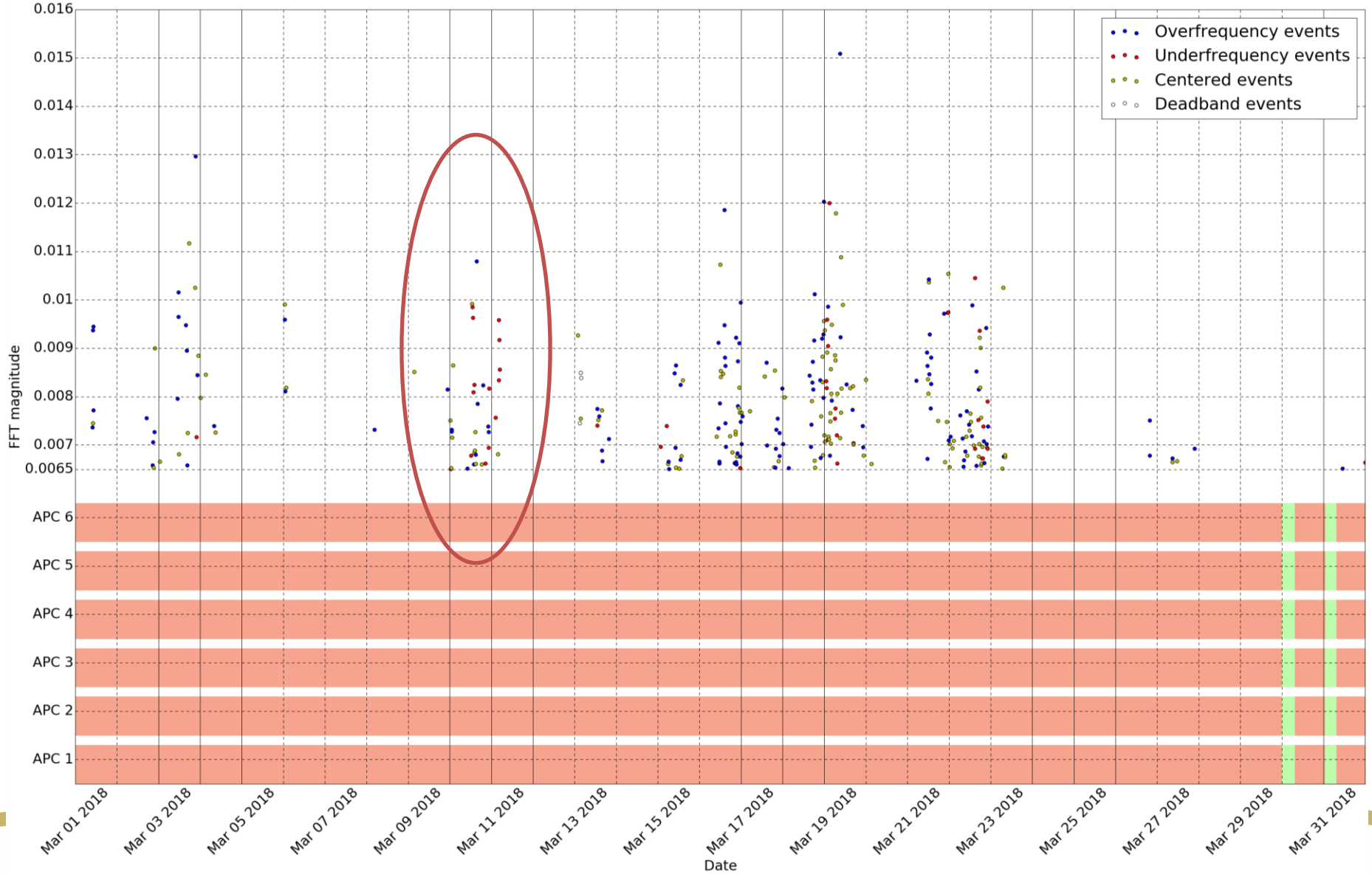
EIRGRID GROUP

Sensitised Periods

- System experiences sustained 24-48Hr periods of oscillation
  - System sensitised to oscillations for days at a time
  - Low magnitude oscillations but potential vulnerability if a large system event were to coincide with one
- No apparent pattern to when these periods occur
  - Expectation is that unit level study would reveal a pattern
- APC suppresses oscillations during these periods
  - How large and oscillation can APC suppress?

EIRGRID GROUP

Events distributed against time - March



EIRGRID GROUP

Conclusions

- APC enables certain windfarms to damp VLF oscillations
  - This damping is effective
  - Which windfarms do provide this damping is not known
  - Severity of oscillation that can be suppressed is not known
- Electrical power feedback on thermal governors reduces stability of VLF mode
  - Existing models are inadequate to study this
- No significant system level correlation
- 24-48 Hr periods where VLF oscillations occur frequently
  - These sensitised periods may create vulnerability

EIRGRID GROUP

Conjecture

- Oscillations are linked to specific unit commitments and dispatches
  - i.e. if certain combinations of units are on and running in a certain way then oscillations will occur
  - Some of these will give rise to more severe oscillations than others
  - Likely that there are units that help supress the oscillation
- The severity of any oscillation is a combination of
  - The severity of the root cause conditions (mode stability margin)
  - The size of any system event (excitation)
  - The amount of inertia and regulation on the system (mitigation)

EIRGRID GROUP

Recommendations

- Prioritise use of APC when VLF oscillations observed
- Establish ongoing monitoring process to find baseline background events
- Assess damping provided by each windfarm when event data is available
- Issue survey to thermal plant owners with the purpose of identifying their turbine-governor controls
- Investigate root cause at a generator level by studying unit commitment and dispatch for background events

EIRGRID GROUP

Questions?

EIRGRID GROUP

EU-SysFlex

WP2 – SCENARIOS, MODELS AND DRAFT RESULTS

Noel Cunniffe

19th September 2018

Work Package 2 Overview

- Identify the **technical shortfalls** of the pan-European system with **high RES-E** and **high levels of electrification**
- Assess **technical characteristics** such as synchronous inertia, synchronising torque, fault ride-through capability, electromagnetism, reserves provision, reactive power, short circuit levels, black start, and network congestion
- Perform **cost-benefit analysis** for investment and operation optimisation to find where **gaps arise** – i.e. **value service provision** to operate at high RES-E
- Validate the ability of **improved market designs** and **technical flexibilities** from **demonstration projects** to reduce or remove the technical shortfalls and improve the **resilience and stability** of the system through innovative services

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Work Package 2 Tasks & Deliverables

FASTTRACK → WP3

2.1 - Augmented literature review and state-of-the-art review across Europe

Review of literature, grid codes, European projects, existing models and studies for scenarios for EU, NI-IRE, Baltic states, UK

→ WP 3

Imperial College London — Nov 17 – Apr 18

LONGTRACK → WP3

2.2 - Definitions of the EU-SysFlex scenarios and hypotheses

Scenarios HiRes and LoRes with electrification of heat and transport, with at least 50% RES-E

MS1 M4

→ WP 3,6,7,8,9

EirGrid — Nov 17 – Oct 18

2.3 - Setting up detailed models to simulate technical shortfalls on EU system

New models to simulate production cost, steady-state, transient/dynamic and small signal studies in EU system, European subnetwork and NI-IRE power system as well as interaction TSO/DSO

MS2 M6

→ WP 4

EDF — Nov 17 – Oct 18

2.4 - Determining technical shortfalls from detailed simulations on EU system

Technical issues arising from frequency, voltage and general disturbances on the EU system, European subnetwork and NI-IRE and proposed solutions

EirGrid — Jul 18 – Oct 19

2.5 - Financial & economical analysis of scenarios

Financial gaps to identify where market incentives appear to be insufficient

EirGrid — Oct 18 – Oct 19

2.6 - Demonstration and market modelling validation

Integration of demonstrators and market modelling into European wide simulations

← WP 3,6,7,8,9

EirGrid — Oct 19 – Apr 21

→ WP 10

Multiple Scenarios and Sensitivities

Core Scenarios

- Generation portfolios, demand, IC, storage etc.
- **Based on EU Ref Scenario 2016**
- Pan-European to ensure consistency
- 2011 climate year

Network Sensitivities

- **Sensitivities of the core scenarios**
- Scenarios to **further test IE and NI system**
- TES 2017 & TYNDP (IE and NI)
- 2015 climate year

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

EU-SysFlex Core Scenarios

- Two Core Scenarios based on **EU Reference Scenarios 2016**
  - Baseline Scenario = 50% RES-E for Europe in 2030
  - Ambitious Scenario = 63% RES-E for Europe in 2030

Baseline Scenario

Ambitious Scenario

0% 71%

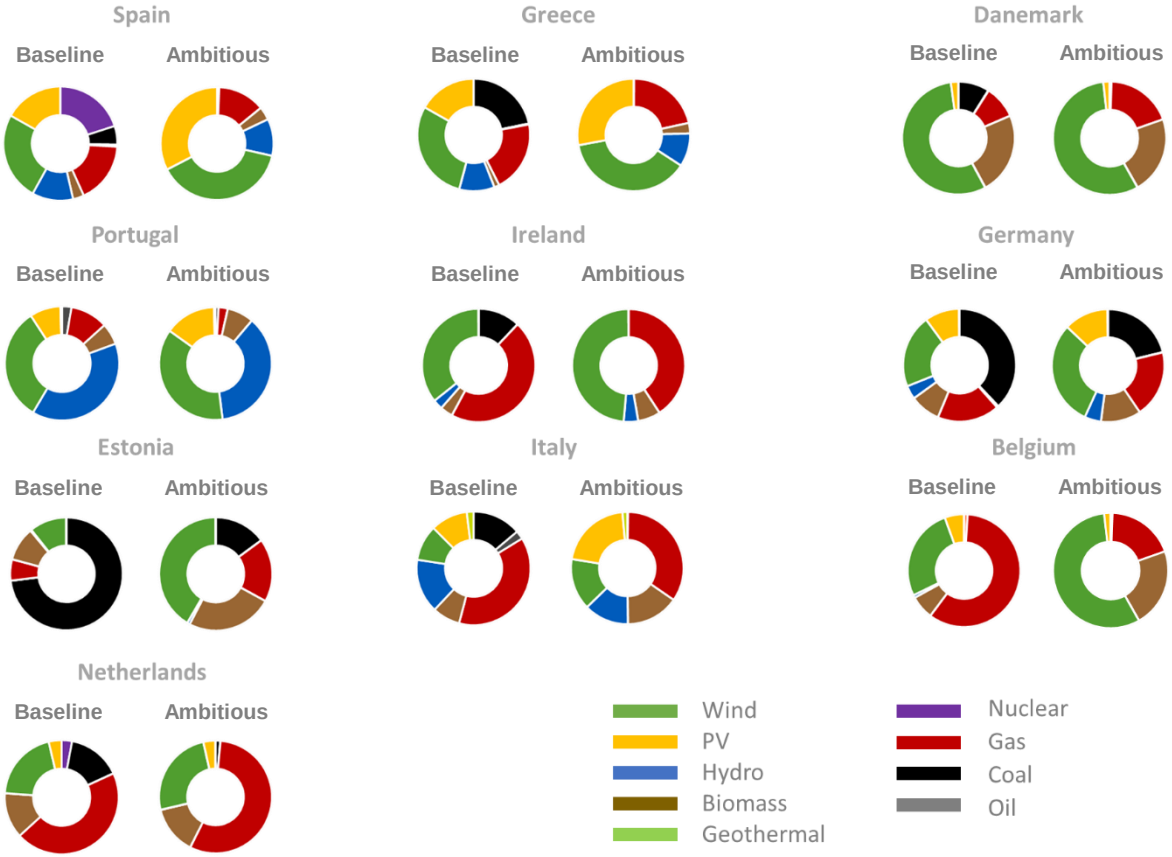
% of Non-Synchronous RES Output

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

EU-SysFlex Core Scenarios

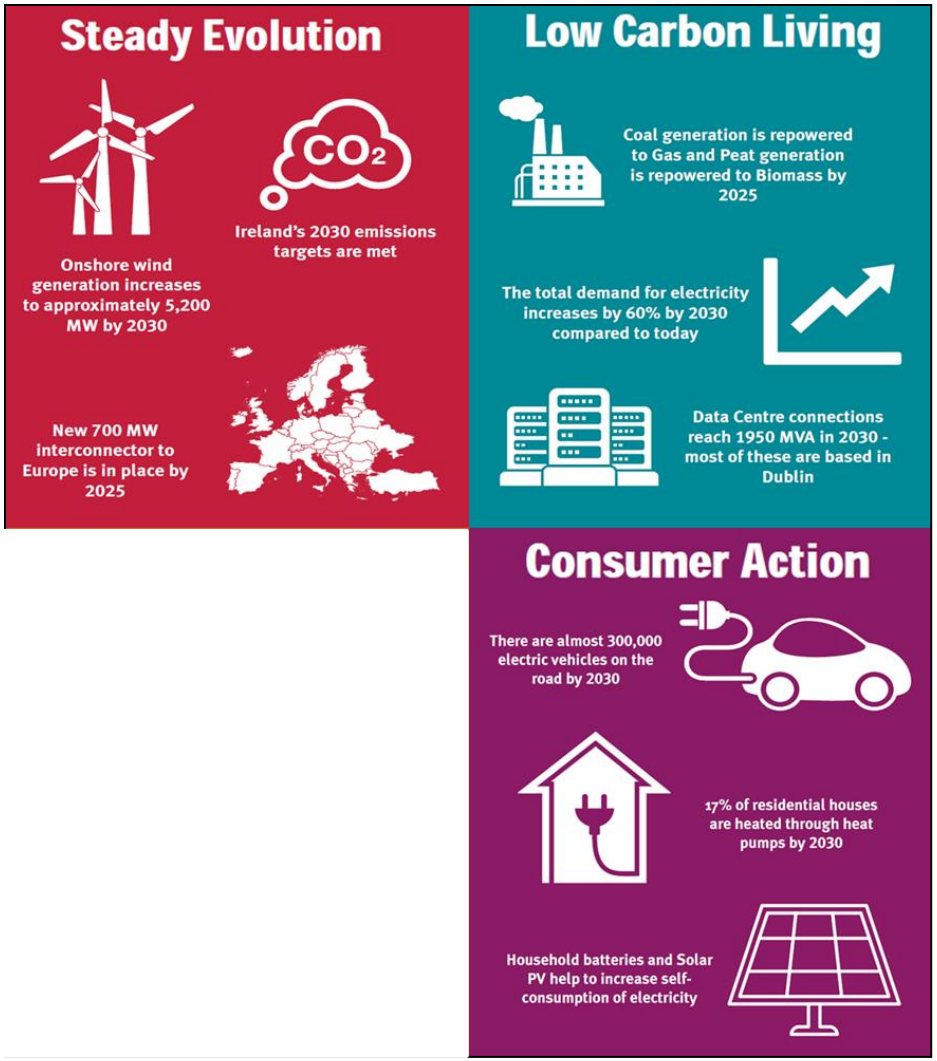
- Overview of countries predominantly relying on non-synchronous renewable generation



Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Development of Network Sensitivities for IE



- Tomorrow's Energy Scenarios published July 2017
- Sets out four scenarios from 2020 – 2040
- Each has its own story in terms of economic, policy, technology and consumer developments
- Each scenario has an associated "portfolio" with different quantities and types of generation and demand technologies
- The **three most ambitious scenarios in terms of RES-E will be used for the network sensitivities.**

EU-SysFlex

Development of Network Sensitivities for NI

- Tomorrow's Energy Scenarios for IE only

- Development of scenarios for NI are based on the ENTSO-E **Ten Year Network Development Plan 2018** scenarios

- Mapping of Tomorrow's Energy Scenarios and associated assumptions with TYNDP 2018
  - Steady Evolution = Sustainable Transition
  - Consumer Action = Distributed Consumer Participation
  - Low Carbon Living = Sustainable Transition

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Summary of the Scenarios

Installed Capacity by Fuel Type (MW_e)	EU-SysFlex Core Scenarios		IE and NI Network Sensitivities		
	Base Scenario	Ambitious Scenario	Steady Evolution	Low Carbon Living	Consumer Action
	All-Island	All-Island	All-Island	All-Island	All-Island
Conventional Fuel Generation	**5562**	**5826**	**6096**	**5530**	**5980**
Wind (Onshore)	5650	7268	6678	7040	6922
Wind (Offshore)	25	25	700	3000	1000
Wind-Total	5675	7293	7378	10040	7922
Hydro	237	237	237	237	237
Biomass	287	310	487	847	528
Solar PV	369	420	900	3916	2916
Ocean (Wave/Tidal)	-	-	50	98	73
Renewable Generation	**6568**	**8260**	**9052**	**15188**	**11725**

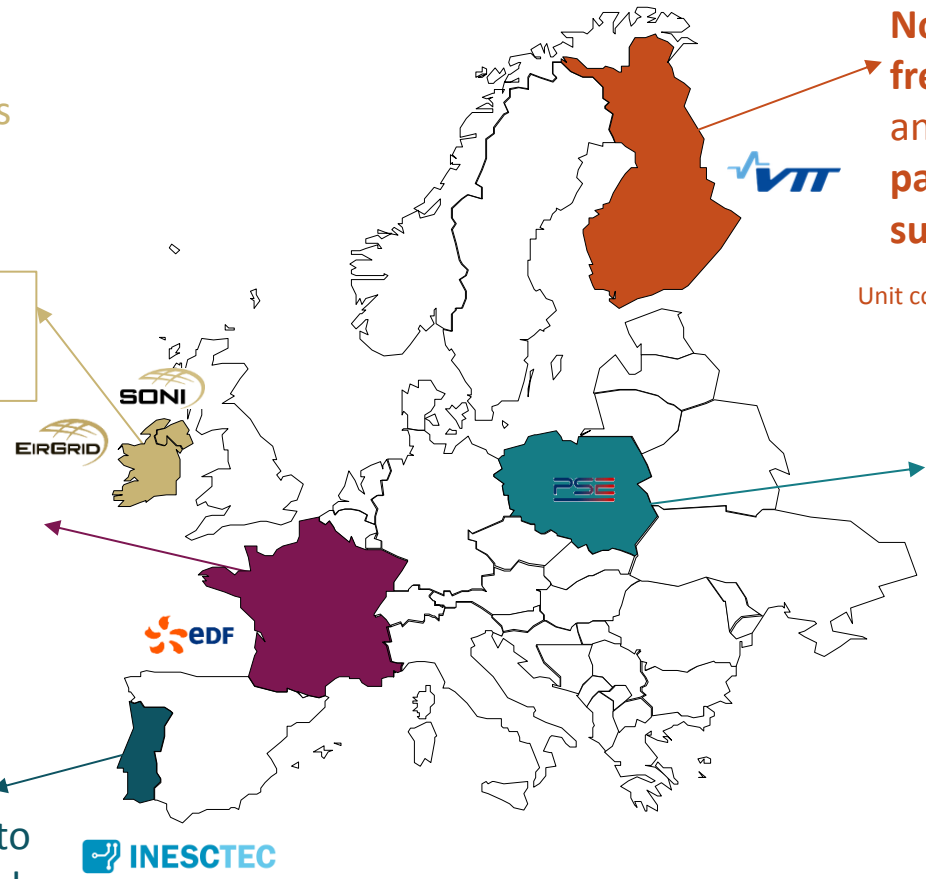
Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Model Development for EU-SysFlex Studies

NI-IE real-time detailed representation of power system with instantaneous RES-E penetration reaching up to **100%**

Synchronous inertia	Reactive Power
Reserve Provision	Short Circuit Levels
Synchronising Torque	Black-Start
Fault Ride-Through	



Nordic System frequency stability analysis inputting to **pan-European** and **sub-network** models

Unit commitment
Synchronous inertia
Reserve

European sub-network dynamic representation with detailed **network**

Dynamic stability
Voltage stability

Pan-European frequency and **dynamic** model (Continental + Paladyn)

Unit commitment
Synchronous inertia
Reserve

Bulk modelling of **Distribution System demand side resources** into Transmission System models

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Model Development for Ireland and Northern Ireland

- Network infrastructure update – 2030 model developed
- Re-calibration of load models to reflect load changes (e.g. Data Centre inclusion & electrification of heat and transport)
- Wind farm type 3 and type 4 models update – move to WECC2 from WECC1 – ability to simulate frequency control and emulated inertial response
- Large scale battery energy storage models developed
- Large scale solar PV plant models developed
- STATCOM and Synchronous Condenser models developed
- Small Scale Generation included

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

DRAFT – Initial Simulation Results

- Initial outputs from Ireland and Northern Ireland network sensitivities – these will be used in detailed network analysis

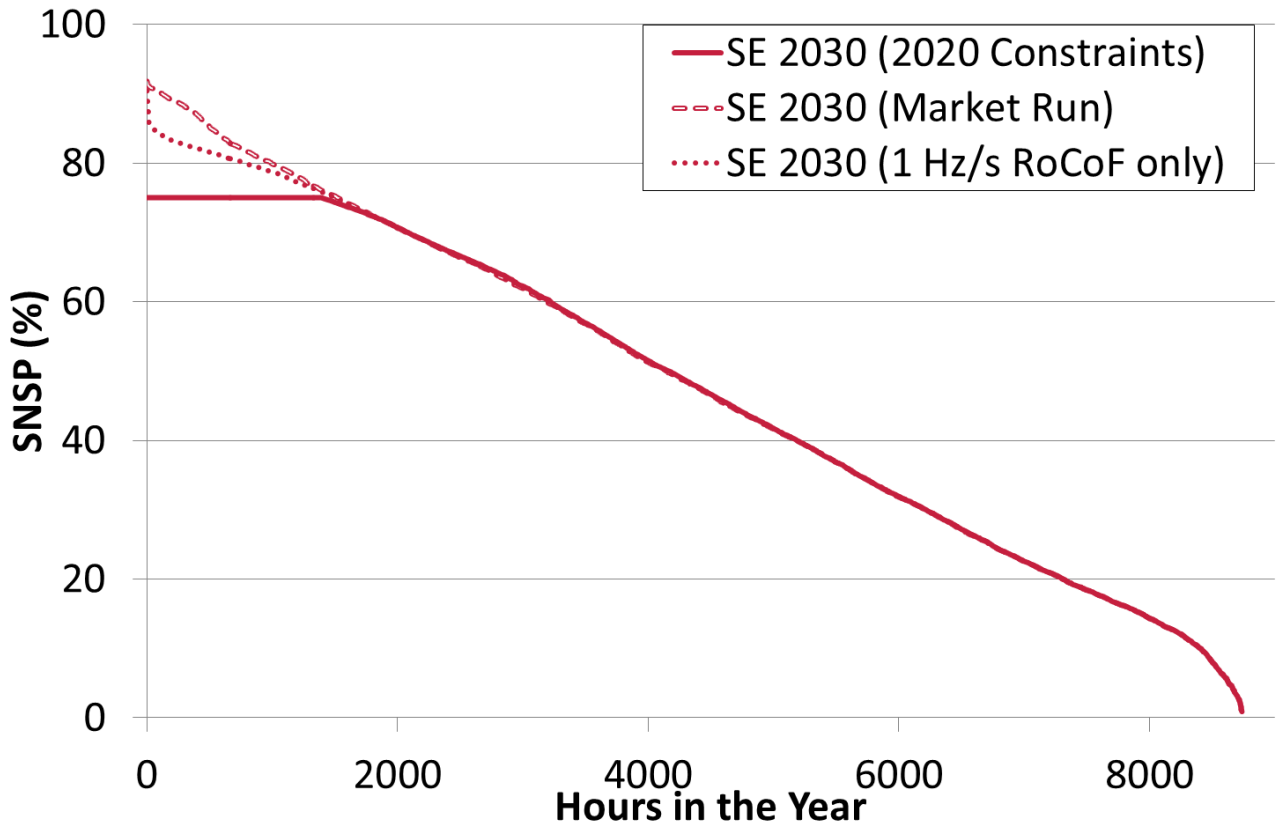
- Three cases assessed:
  - **2020 Constraints** – 2020 RoCoF, Inertia and SNSP constraints
  - **Market Run** – No operational constraints
  - **1 Hz/s RoCoF** – RoCoF constraint only

- These results are still being validated and will not be officially published until Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

SNSP Duration Curve

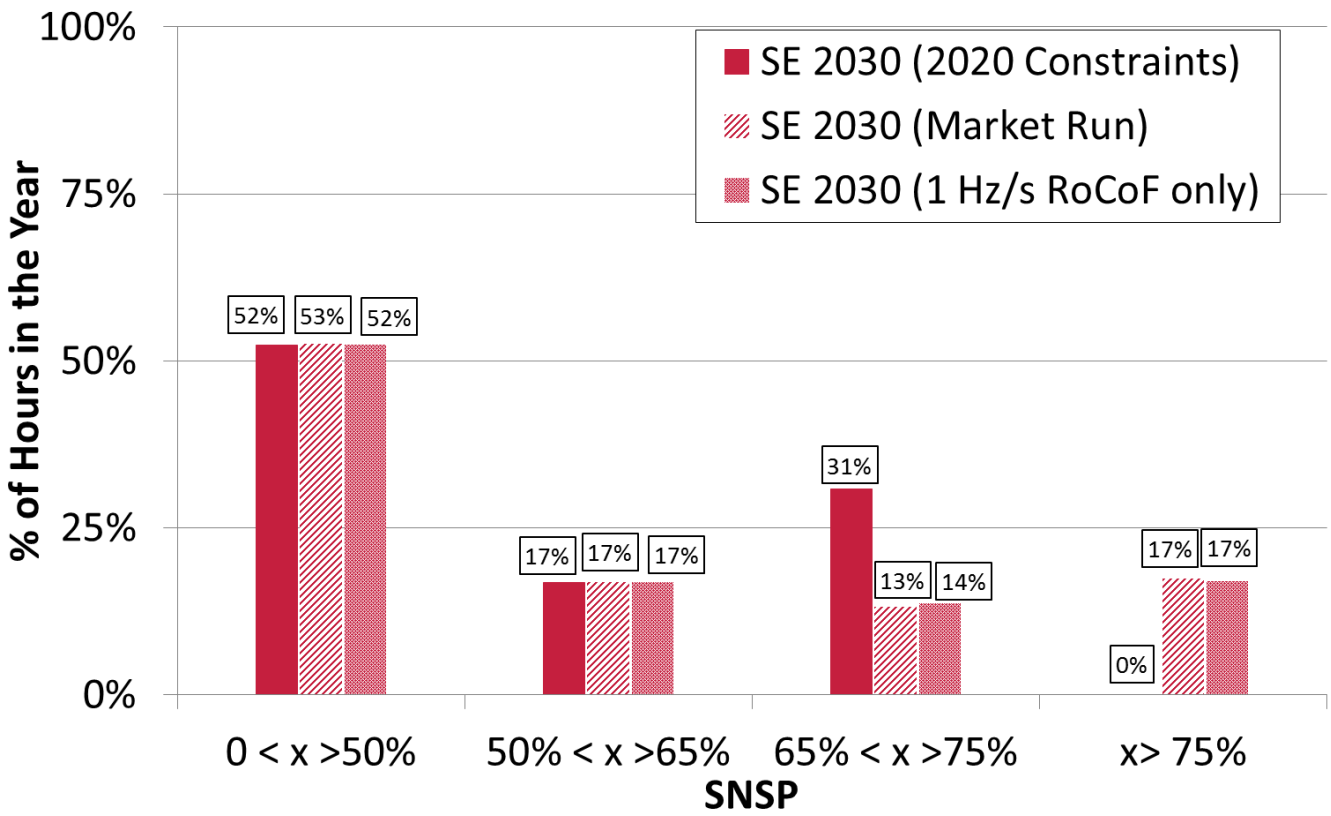


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

SNSP Histogram

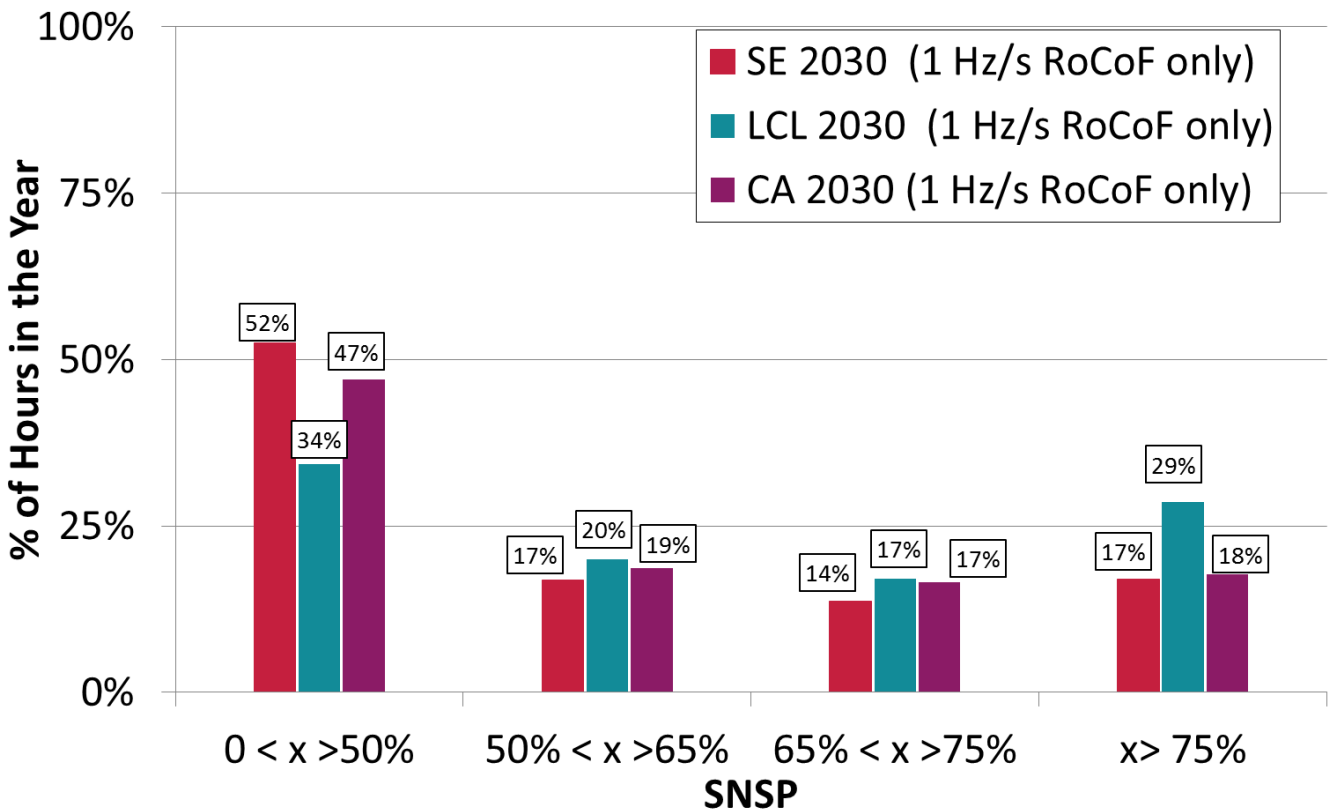


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

SNSP Histogram – All Scenarios

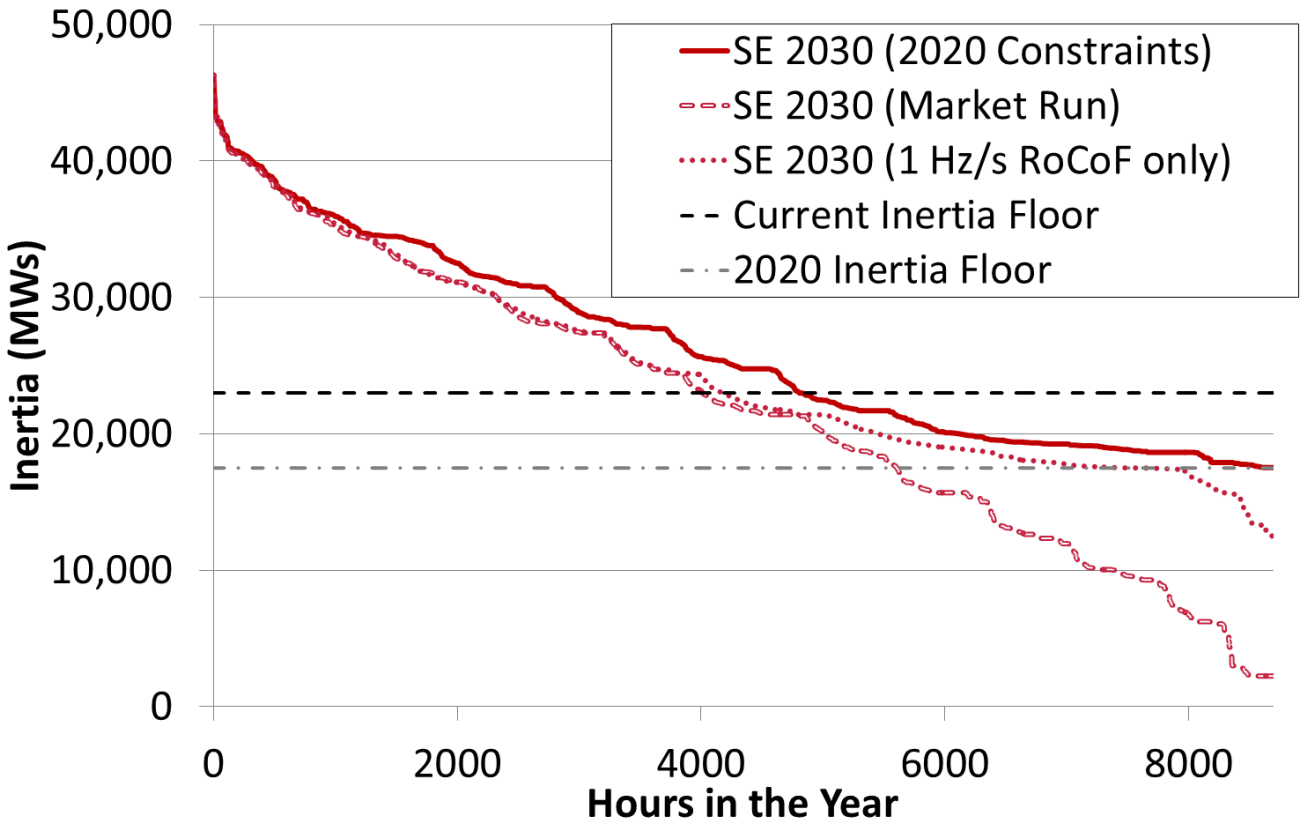


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Inertia Duration Curve

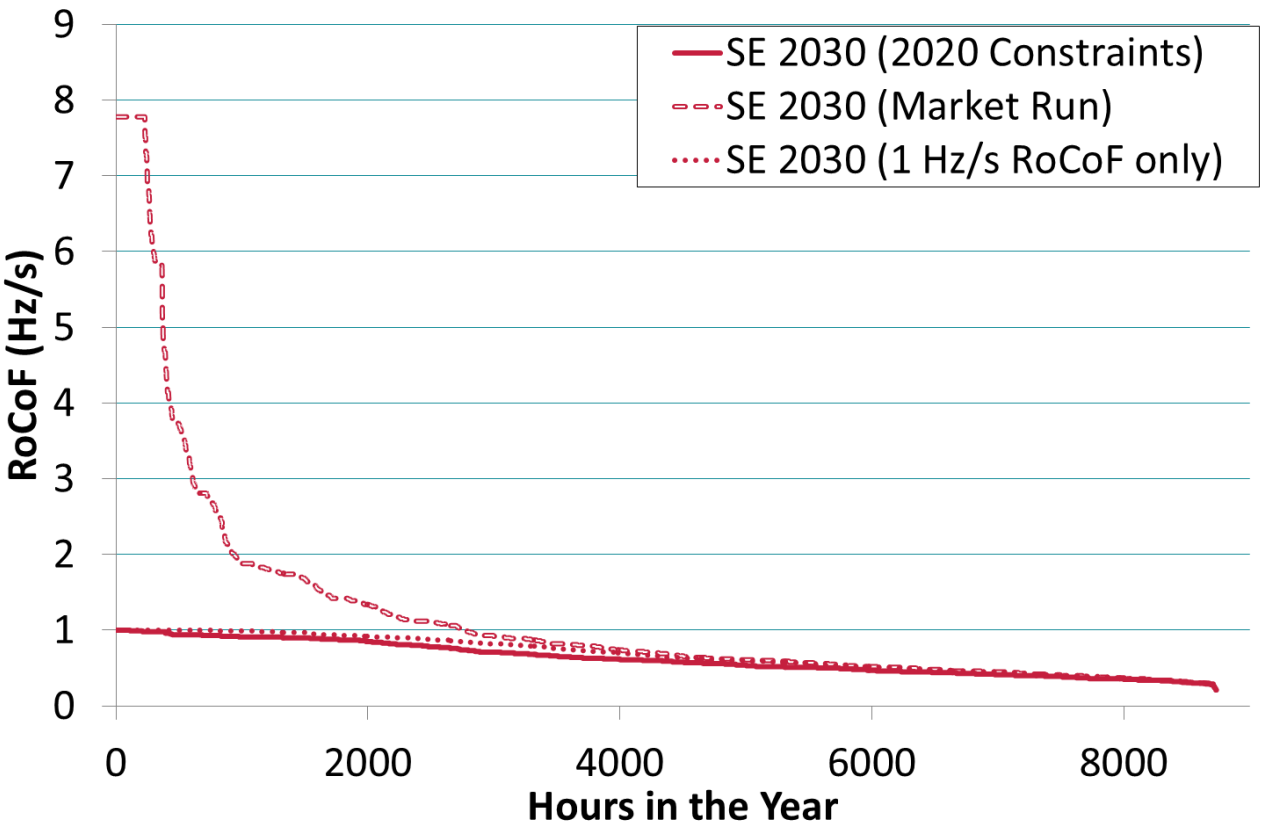


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Maximum Potential RoCoF Duration Curve

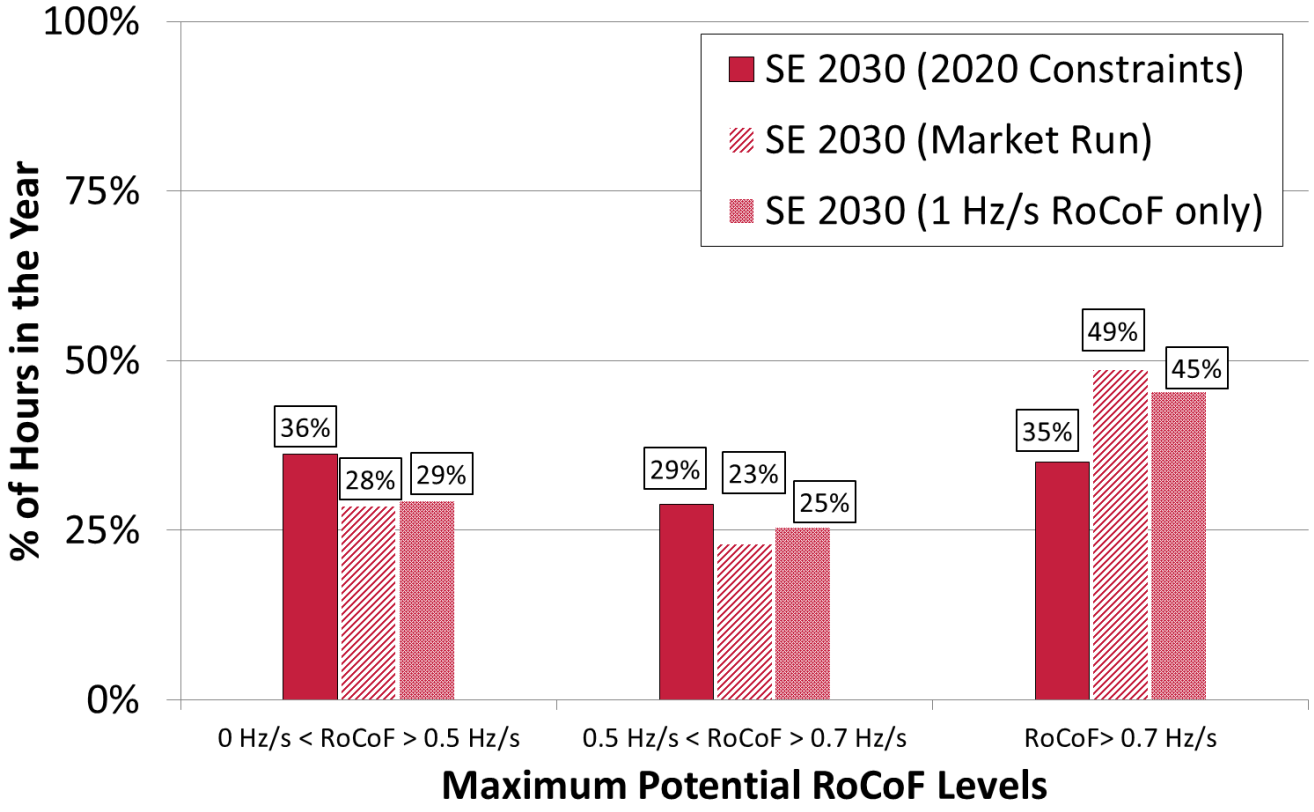


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Maximum Potential RoCoF Histogram

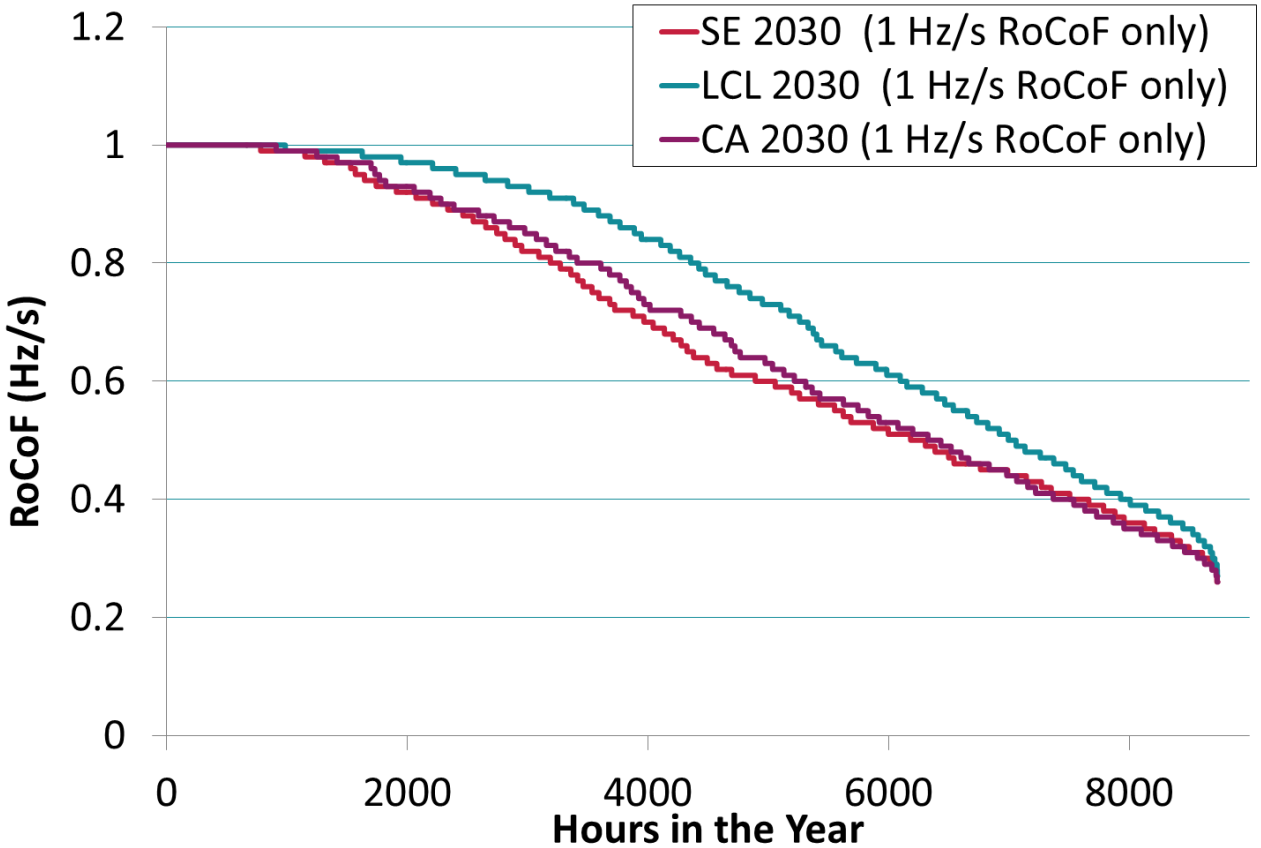


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

RoCoF Comparison – All Scenarios

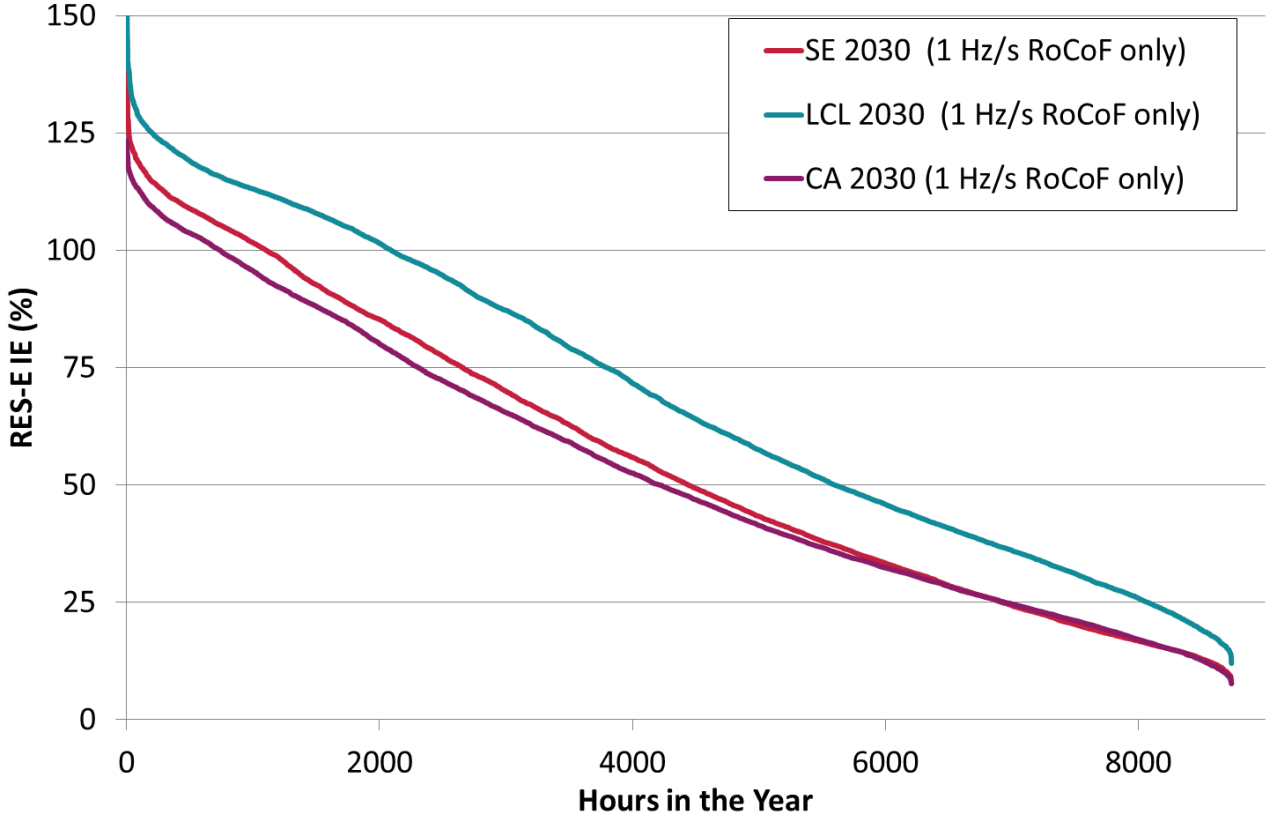


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

IE RES-E Comparison – All Scenarios

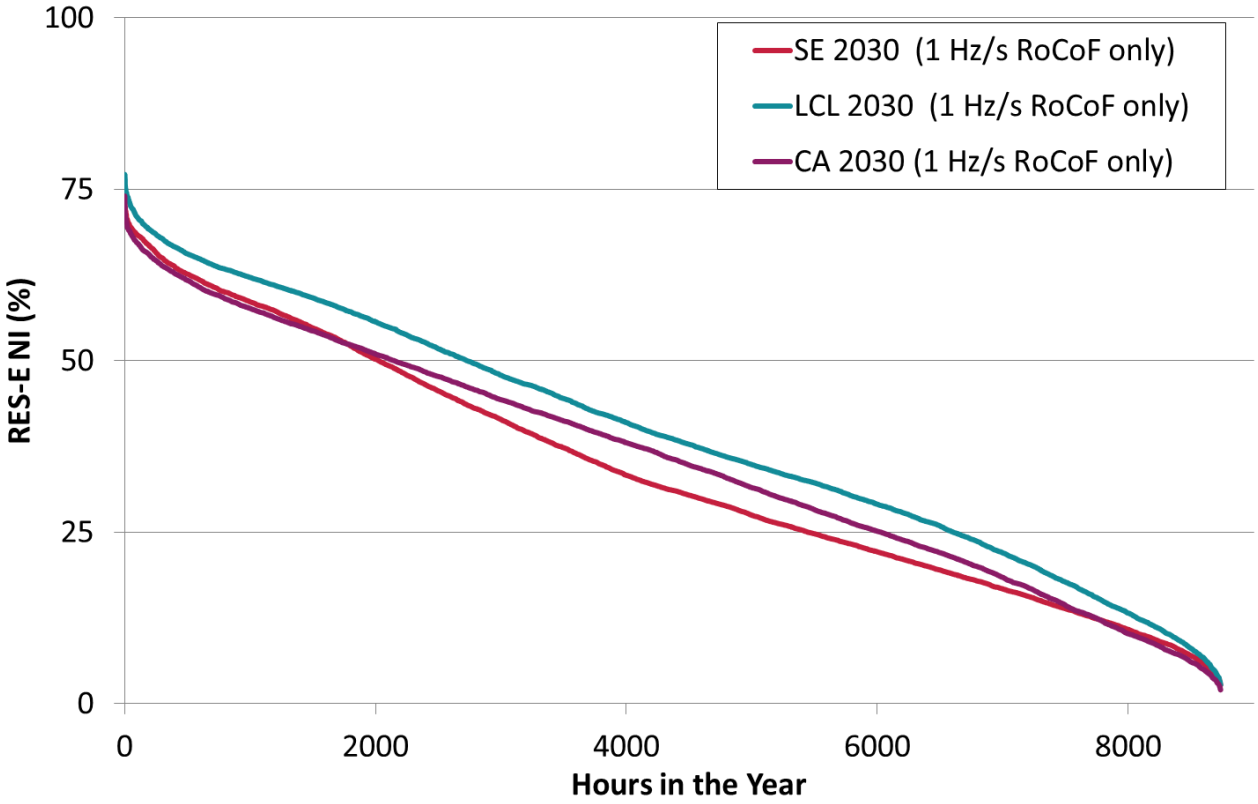


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

NI RES-E Comparison – All Scenarios

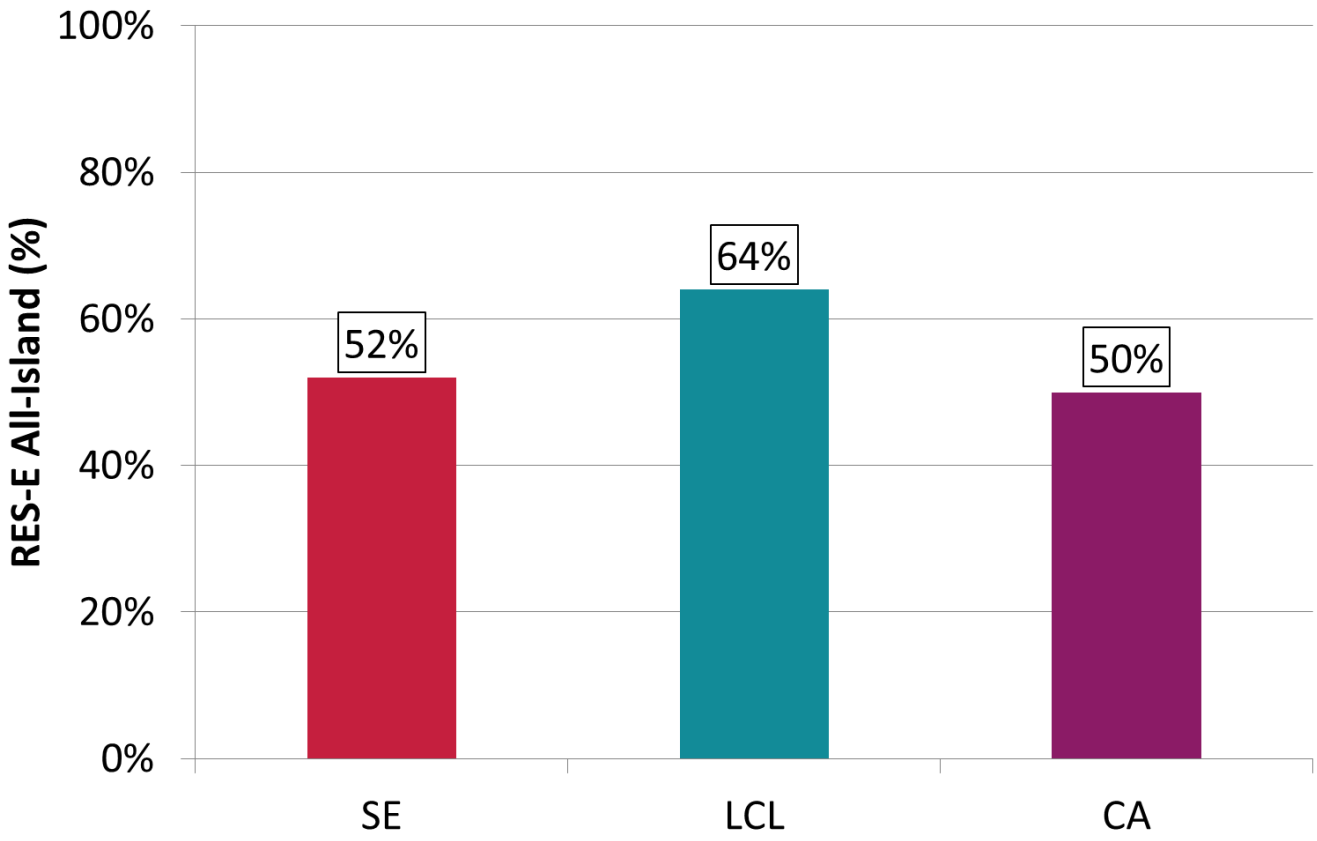


DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

All-Island Annual RES-E Comparison – 1 Hz/s RoCoF



DRAFT – Final version in Q4 2019

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

Conclusion and Next Steps

- These outputs represent the first study results following **10 months** of **literature reviews**, **scenario** and **model development** across multiple platforms
- Detailed **network 2030 analysis** will begin in the coming months to identify **technical scarcities** in the 2030 system
- Detailed **market modelling** will begin later in the year to assess the **value of System Services** to the system in **2030**
- This will look at a range **considerations** including **production costs modelling**, **CO2 pricing**, **societal benefits** to meeting **2030 targets** and benefits to **network optimisation**
- Primary outputs to be completed in **Q4 2019**

Disclaimer: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773505.

EU-SysFlex

AOB

EIRGRID SONI