DS3 Advisory Council

Belfast

23rd May 2018

EIRGRID SONI

Agenda

Topic	Time	Speaker
Introduction & Welcome	10.30	Jon O'Sullivan , Eirgrid (5 mins)
Industry Perspective	10.35	Presentation: NIRIG (10 mins) Discussion: All (5 mins)
DS3 Programme Status Update (including System Services)	10.50	Presentation: Ian Connaughton, EirGrid (15 mins) Discussion: All (10 mins)
Rate of Change of Frequency (RoCoF)	11.15	Update: John Young , EirGrid (10 mins) Update: NIE Networks, ESB Networks (10 mins) Discussion: All (15 mins)
SNSP Re-planning	11.50	Presentation: Noel Cunniffe, EirGrid (5 mins)
Nodal Controller Project	11.55	Presentation: NIE Networks, ESB Networks (10 mins) Discussion: (10 mins)
Ramping Policy	12.15	Presentation: Noel Cunniffe, EirGrid (10 mins) Discussion: (5 mins)
Lunch & Networking (12.30 – 13.20)		

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Agenda

Topic	Time	Speaker
Oscillations	13.20	Presentation: Barry O'Connell, EirGrid (10 mins) Discussion: (15 mins)
Beyond 2020 - EU-SysFlex Literature Review	13.45	Presentation: Noel Cunniffe, EirGrid (10 mins) Discussion: (5 mins)
Closing Remarks and Actions	14.00	Jon O'Sullivan, EirGrid (10 mins)
Session Closed / Networking (14:10)		

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RENEWABLES INDUSTRY GROUP

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2020 to 2050 (via 2030)

DS3 Advisory Forum

23 May 2018

What is NIRIG?

NIRIG represents the views of the renewable electricity industry in Northern Ireland, providing a conduit for knowledge exchange, policy development, support and consensus on best practice between all stakeholders.

Committed to making a positive difference, we promote responsible development, support good community engagement and deliver low-cost electricity generation from sources such as onshore wind, tidal, solar and storage using our greatest natural resources.

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Perspectives on energy strategy NI

1. Existing strategy
2. Proposals for an Energy Strategy for NI
3. Additional analysis

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NI policy and strategy

Northern Ireland

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UK policy and strategy

STATUTORY INSTRUMENTS

2011 No. 1602

CLIMATE CHANGE

The Climate Change Act 2008 (Credit Limit) Order 2011

Made - - - - 29th June 2011

Coming into force in accordance with article 1

A draft of this instrument was laid before and approved by a resolution of each House of Parliament, in accordance with sections 11(6) and 91(1) of the Climate Change Act 2008 ("the Act")(a).

Before the draft was so laid, the Secretary of State –

(a) took into account the advice of the Committee on Climate Change under section 34(7)(b) in relation to the 2013-2017 budgetary period in accordance with section 11(7)(a) of the Act; and

(b) consulted the Scottish Ministers, the Welsh Ministers and the Department of the Environment in Northern Ireland in accordance with section 11(7)(b) of the Act(b).

Accordingly the Secretary of State, in exercise of the powers conferred by section 11(4) and (5) of the Act, makes the following Order:

Citation and coming into force

1. This Order may be cited as the Climate Change Act 2008 (Credit Limit) Order 2011 and comes into force on the day after the day on which it is made.

Interpretation

2. In this Order –

"the Emissions Trading Directive" means Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC(c); and

"the EU ETS" means the scheme for greenhouse gas allowance trading established under the Emissions Trading Directive as implemented by the Greenhouse Gas Emissions Trading Scheme Regulations 2005(d).

(a) 2008 c.27.
(b) See the definitions of "national authority" and "the relevant Northern Ireland department" in sections 91 and 96.
(c) O.J. No. L 275, 25.10.2003, p. 32, amended by Directive 2004/101/EC, O.J. No. L 338, 13.11.2004, p. 18, Directive 2008/101/EC, O.J. L 8, 13.1.2009, p. 3, and Directive 2009/29/EC, O.J. No. L 140, 5.6.2009, p. 63.
(d) S.I. 2005/925, as amended by S.I. 2005/2903, 2006/737, 2007/802, 2007/1094, 2007/3415, and 2007/3118.

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EU Policy and strategy

EUROPEAN COMMISSION

Brussels, 10.11.2010
COM(2010) 639 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Energy 2020
A strategy for competitive, sustainable and secure energy

{SEC(2010) 1346}

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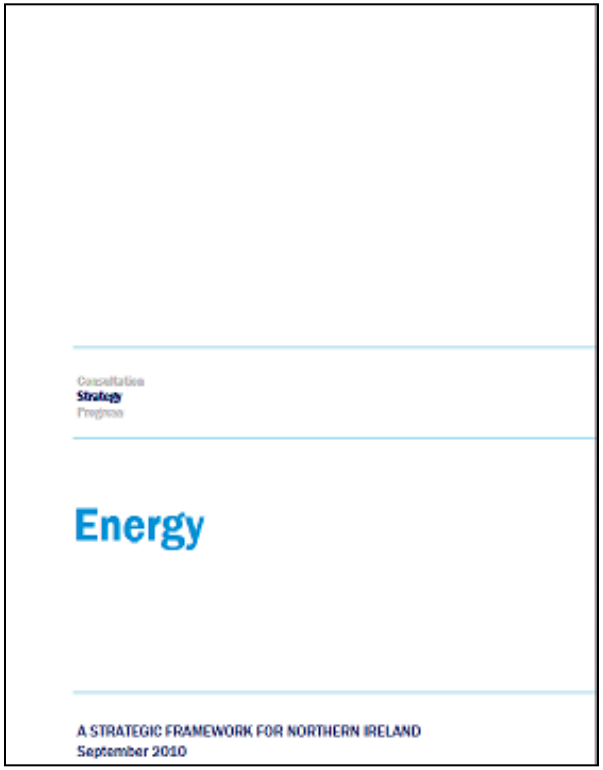
Strategic Energy Framework 2010-2020


Consultation
Strategy
Progress

Energy

A STRATEGIC FRAMEWORK FOR NORTHERN IRELAND
September 2010

4 goals

1. Building competitive markets
2. Ensuring security of supply
3. Enhancing sustainability
4. Developing our energy infrastructure

43 objectives

Goal 1: 9 objectives
Goal 2: 6 objectives
Goal 3: 20 objectives
Goal 4: 8 objectives

2 targets

40%
10%

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SEF - unmet objectives

SEF 20

Work with NIAUR to develop a cost-effective smart metering solution for Northern Ireland

SEF 24

Consult and if necessary legislate on DETI's and UR's statutory duties so that sustainability is given higher priority

SEF 39

Support construction and commissioning of the new North-South Interconnector by 2013-2014

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SEF – focus objectives 2018-2020

SEF 3

Promote the longer term integration of the Single Electricity Market within a British Isles and European wholesale electricity market

SEF 26

Work with developers, planners and those responsible for environmental consents to ensure that the need for renewable energy to address the environmental impacts of climate change is recognised, good quality applications are made and clear, consistent + proportionate procedures are in place for the consenting of renewable installations

SEF 36

Ensure that electricity grid development plans are future proofed to facilitate a more decarbonised energy mix beyond 2020

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2. Energy Strategy 2050

- Low-carbon energy is **delivering**
- Pathway for least-cost **decarbonisation of the energy sector up to 2050**

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Not overly ambitious

France Commits To Go Carbon Neutral By 2050

August 3, 2017

CARBON NEUTRALITY IN COSTA RICA BY 2021?

CHAPTER 10 / CLIMATE CHANGE, THE CLEAN DEVELOPMENT MECHANISM (CDM) AND CARBON CREDITS

Jacinda Ardern commits New Zealand to zero carbon by 2050

UK will legislate net-zero carbon emissions target, says minister

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Renewables already delivering

1550MW Renewable Generation	1193MW Wind	244MW PV
34.8% 2017	84.3% Wind	€34/MWh 2008 - 2012
49%	£1.2bn	24% 2004 - 2015

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Goals

A more diverse energy mix and increased integration provides adequate security of supply

Competitive and integrated markets deliver more efficient trading and lower wholesale electricity costs for homes and businesses

Low-carbon electricity delivers increasing amounts of energy needs in line with domestic and international climate change targets

- Security of supply focuses on integration and diversity
- Emphasis on ensuring markets deliver lower wholesale costs
- Electrification a key element of delivering climate change targets

Pillar 1

Long-term policy certainty and a whole-system view	• Confidence in policy direction and cooperation between policy-makers facilitates strategic, coordinated decision-making, allowing long-term planning and low financing costs • Political leadership provides a coherent message on the importance and value of decarbonisation • Accelerated growth in low-carbon electricity enables decarbonised electrification of heat and transport

Pillar 2

Cost-effective, efficient modernisation	• Our energy system is increasingly based on predictable and low cost energy sources • A future-proofed energy system and associated infrastructure reduces the likelihood of crisis interventions • Evidence-based decision-making is based on robust and comprehensive data collection, collation and synthesis

Pillar 3

Regional investment, skills and innovation	• Councils can attract inward investment and high skilled jobs • A robust and flexible electricity network enables efficient connection for all customers • Investment in skills drives high-value jobs and feeds the demand from growth industries. • Continued expertise in engineering and manufacturing ensures world-leading innovation

3. Other analysis

- "…think it is prudent to delay Network 25 until DETI **targets** are clear" (SONI, 2016)
- "convinced that the proposed scheme would make a considerable contribution to achieving government **targets** (PAC, 2016)
- "supportive of this proposal as it will contribute to the NI SEF **target** of 40%" (DETI, 2015)
- "investment case would be difficult to justify given…the lack of legislative backing (given that NI is on track to meet **targets** for renewable electricity consumption)" (NIE)
- "In carrying out our role, we work within the policy framework …of particular relevance is the NI Executive-endorsed **target** to have 40% of electricity consumption…" (NIAUR 2016)
- "NI is in a very positive position in terms of consented schemes and grid connection offers in moving towards the 2020 **target**. It is therefore not imperative that every wind farm scheme is approved to achieve this **target**" (Development Control Officer, 2013)

Stepping stones

Where to start?

DCCAE commissioned CEPA analysis on design options to compare the relative costs of different support schemes **and** analysed several scenarios with different RES-E Targets, mix and sensitivities

- **Did not quantify costs savings** to consumers derived from reduced electricity prices
- **Did not consider** battery storage or flexible demand
- **Used higher Levelised Cost of Energy (LCOE) assumptions** than currently benchmarked anywhere in Europe
- **Used simplified modelling - did not take into account flexibility provided by interconnection and pumped storage**

Association response

Targets

1

Fossil Fuels

No additional renewable electricity beyond 2020, so Ireland has 37% of renewable electricity by 2030

2

Renewable Energy

70% of electricity is met with renewables by 2030, primarily by wind and solar power

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Input assumptions – all-island

All Island Numbers	2020 Assumptions	Fossil Fuel 2030	Renewable Energy 2030
% RES-E	41%	37%	70%
Total Electricity Demand (TWh)	40.4	45.9	48.3
Wind Power (MW)	4800	4800	10,000
Solar Power (MW)	320	320	2900
Interconnection (MW)	580	580	2030
SNSP Limit	70%	70%	90%
Min Gen (MW)	1000	1000	700
Electric Vehicles (nr)	0	0	630,000 (ROI 426,000*)
Heat Pumps (nr)	0	0	396,000 (ROI 279,000*)
Small Scale Battery Storage (MW)	0	0	500
Large Scale Battery Storage (MW)	0	0	1200

Modelling approach

Model approach: day-ahead power

Baringa

We project spot wholesale electricity prices using our industry-leading pan-European hourly dispatch model, based on economic fundamentals and calibrated for the RAs

What questions does it answer?

- What will be the level and volatility of future day-ahead and intra-day power prices, and their sensitivity to different scenarios and outcomes?
- How will assets be dispatched in these timeframes on an hourly basis?
- What energy gross margins will be earned by different generation assets and technologies?
- What will the level of 'uplift' be, above short-run marginal costs?
- How will hourly price 'shape' change over time?

Key inputs

- Scenario inputs: fuel and carbon prices, demand (growth and shape), plant build, plant retirement
- Detailed pan-EU plant level database: installed capacity, efficiencies, operating costs, operating constraints
- Cross-border interconnector capacity
- Detailed hourly wind and solar profiles

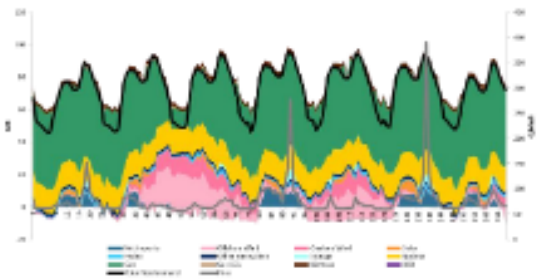
Model engine

- Hourly dispatch, least-cost optimisation framework using the PLEXOS platform
- Optimisation of operational constraints including start costs, ramp rates, heat rates
- Maintenance scheduling and unplanned outages

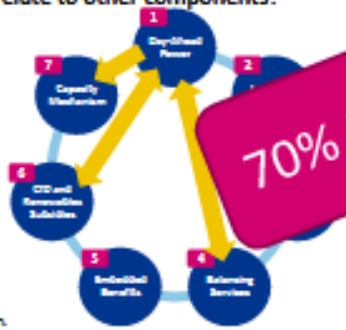
Key outputs

- Wholesale electricity prices
- Generation schedules
- Asset energy revenues and gross margins
- Emissions
- Dispatch costs
- Cross-border flows (imports / export

Illustrative schematic



How does it relate to other components?



70% RES-E Technically Possible!

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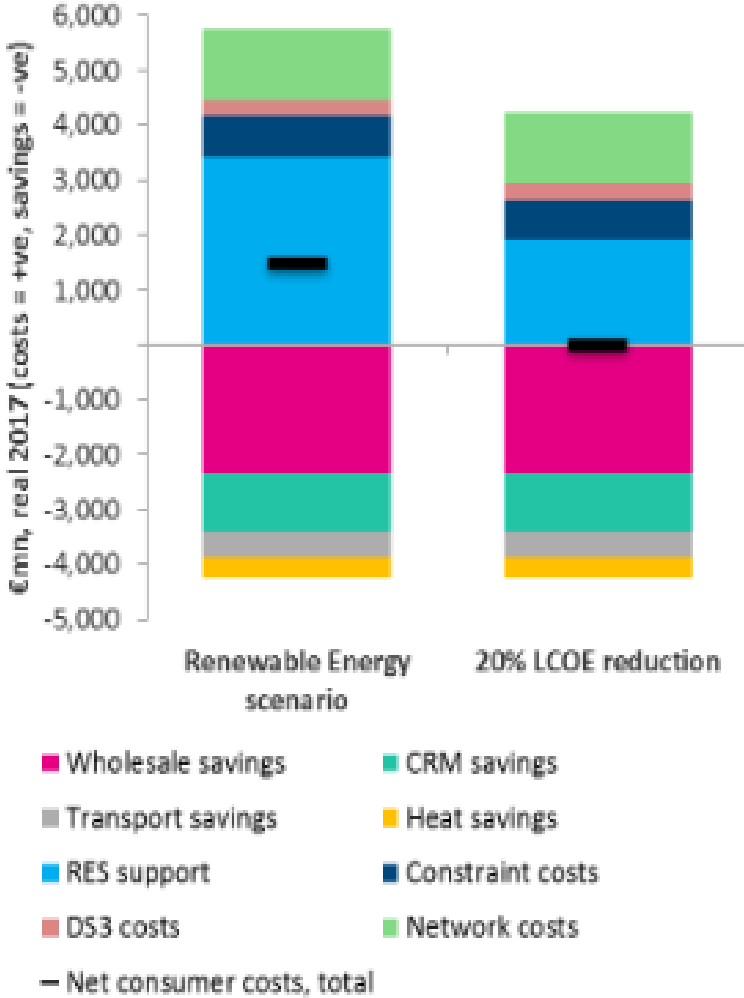
Headline results

Baringa's analysis indicates that a 2030 70% all-island RES-E scenario is cost neutral for end consumers with a 20% LCOE reduction

- For the Renewable Energy scenario, our analysis indicates a net consumer cost of around € 1.5 bn, with RES support, constraint costs, network costs and DS3 costs offset by:
  - Lower wholesale electricity prices, driven by the high RES-E deployment, leading to lower end consumer energy costs
  - CRM cost savings, as less conventional thermal new build is required
  - Transport and heat savings
- Our calculations show that a modest 20% reduction in LCOEs, equivalent to reducing the large onshore wind LCOE to €61/MWh, for the Renewable Energy scenario results in breakeven for the Irish consumers



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Summary

1. Renewables can go well beyond 40% renewable electricity
- High SNSP and Lower Minimum Generation
- More interconnection & batteries

2. Renewable electricity can also provide renewable heat & transport
- Electrification reduces energy demand
- Enables renewables to access all forms of energy storage

3. A 70% RES-E Scenario by 2030 is:
- Technically possible
- Cost-neutral for the consumer with conservative price forecasts

4. Policy support required to deliver cost-neutral 70% RES-E by 2030?

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Considerations

1. Assumptions have been based on existing information and scenarios, but need NI-specific research

2. What will the Clean Energy gap be, and what will fill it?

3. How do we address the potential for divergence?

4. Need to work with stakeholders to analyse in depth, once full technical report published

Thank you

Meabh Cormacain
ni-rig@ni-rig.org

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DS3 Programme Status Update – May 2018

Ian Connaughton

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DS3

Achievements	
The publication of the DS3 System Services Market Ruleset consultation.	15th of March
The publication of the Volume Capped procurement process consultation.	28th of March
The procurement of DS3 System Services Volume Uncapped Phase 2 Contracts for FFR.	5th of April
The power system moved to permanent system operation at 65% SNSP.	9th of April
A DS3 System Services Volume Uncapped Phase 2 Contracts Bidders conference.	18th of April
A DS3 System Services Volume Capped Consultation Industry Forum.	25th of April

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Key Operational Milestones

	2017	2018	2019	2020
SNSP	60% -> 65%	65% -> 70%	70% -> 75%	75%
RoCoF	0.5 Hz/s	0.5 -> 1 Hz/s	1 Hz/s	1 Hz/s
Inertia	23,000 MW.s	20,000 MW.s	17,500 MW.s	17,500 MW.s
Min Sets	8	8	7	7
Exports	300 -> 500 MW (interim)	500 MW (interim)	500 MW (interim -> enduring)	500 MW (enduring)
System Services	Current providers, 11 Services			14 Services

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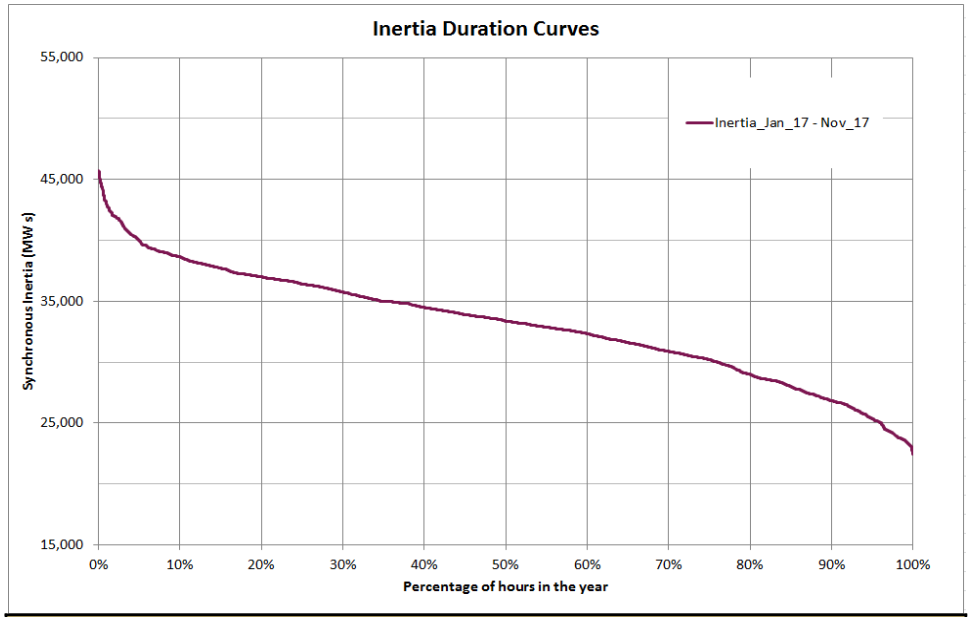
Inertia Floor 2017 Analysis

- System inertia floor was increased from 20,000 MWs to 23,000 MWs in November 2017 prior to the beginning of the 65% SNSP trial
- Inertia never reached 23,000 MWs in normal operation in 2017 due to 0.5 Hz/s RoCoF constraint and 8 minimum generation units online constraint
- Updated policy is more reflective of actual system operation and it is also acting as an interim mitigation to system oscillations (discussed later)



2017 Inertia Statistics (Pre-SNSP Trial)	
Maximum Inertia	45,750 MWs
Average Inertia	33,131 MWs
Minimum Inertia	22,050 MWs (post-trip event)
% > 23,000 MWs	99.74%

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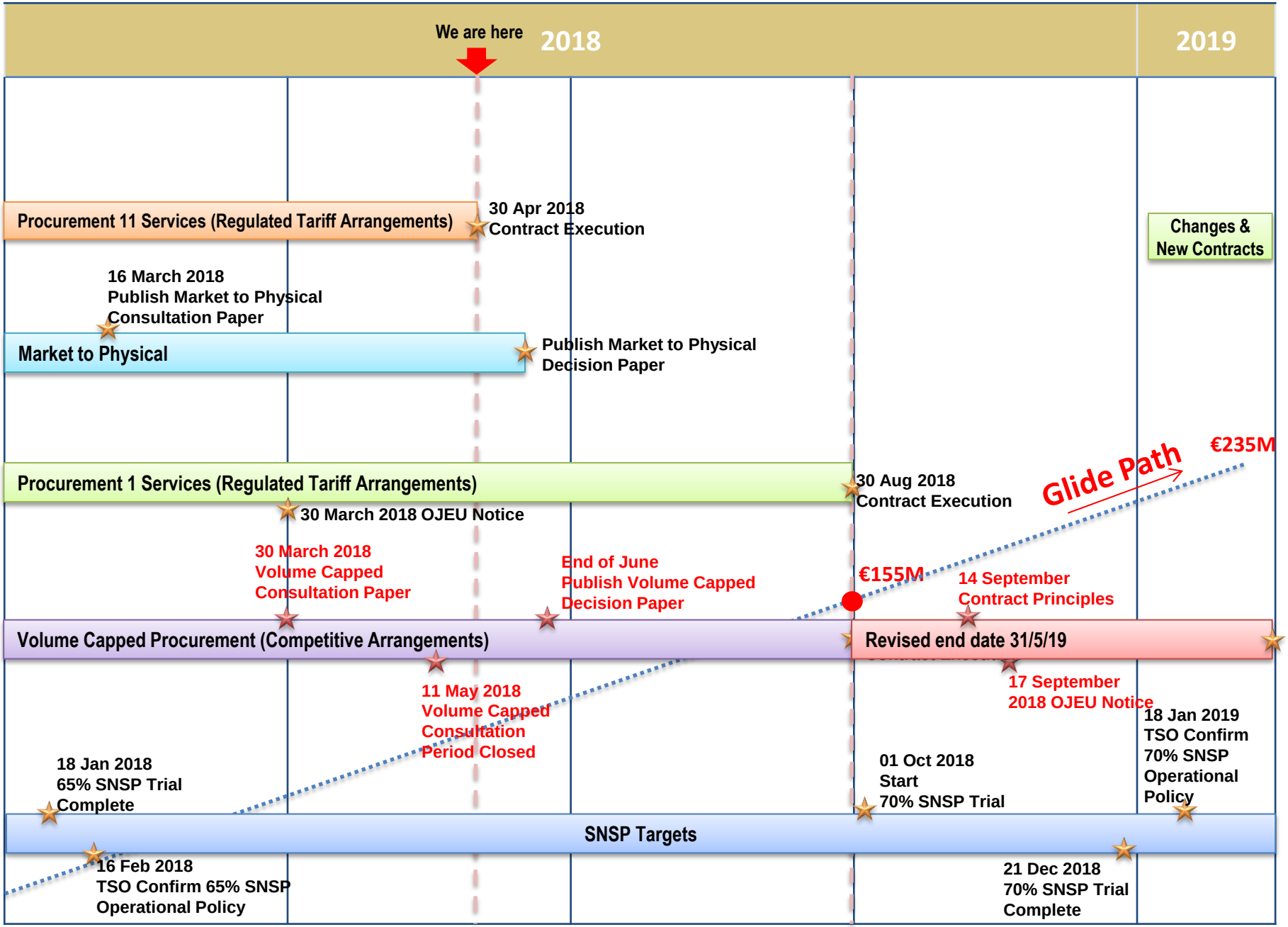
DS3 System Services 2018 - Milestone Plan



DS3 RoCoF Project

John Young

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RoCoF Status – May 2018

TOTAL (approx. 11,631 MW)

7,331 MW (63%) complete

Conventional Generation (8,638MW total)

4,954 MW (57%) complete

- Number of Cat 3 units have moved from study to test phase
- Progress made with several overdue high-priority units
- 17 out of 24 high and mid-priority units compliant

IRE: 4,612/6,811 MW complete (68%)
NI: 342/1,827MW complete (19%)

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 (full update in respective slides)
- Close-out of final MW expected by end of June 2018

Non-Wind Embedded (approx. 770 MW total)

241 MW (31%) complete

- Roll-out in IRE making significant progress ahead of October 2018 targets
- Roll-out in NI targeting Sept 2019 completion

IRE: 241/330 MW complete (73%)
NI: Roll-out not yet started

RoCoF 1Hz/s

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ESBN Update
DS3 Advisory Council
18/05/18

Padraig Lyons

Future Networks

ROCOF update

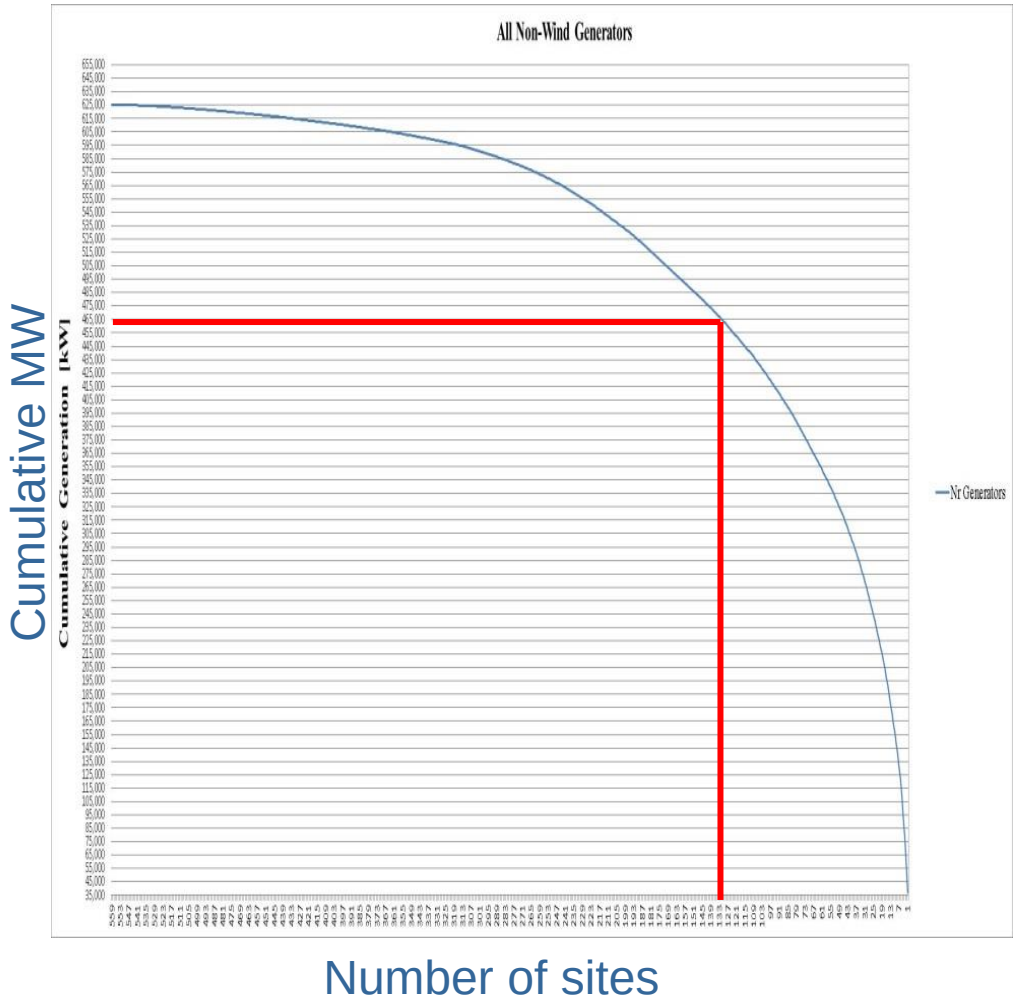
DSO RoCoF Project Wind Breakdown

Wind Figures Breakdown	%

Completed

- Sorne Hill (38.9MW) is the final wind farm to be upgraded. ABB has submitted a technical proposal for a Loss of Mains relay. Currently under review. Expected installation by end of May 2018.
- Bellacorick (6.45MW): Approval for derogation was granted by CRU on 30th April 2018.

Non Wind - 1

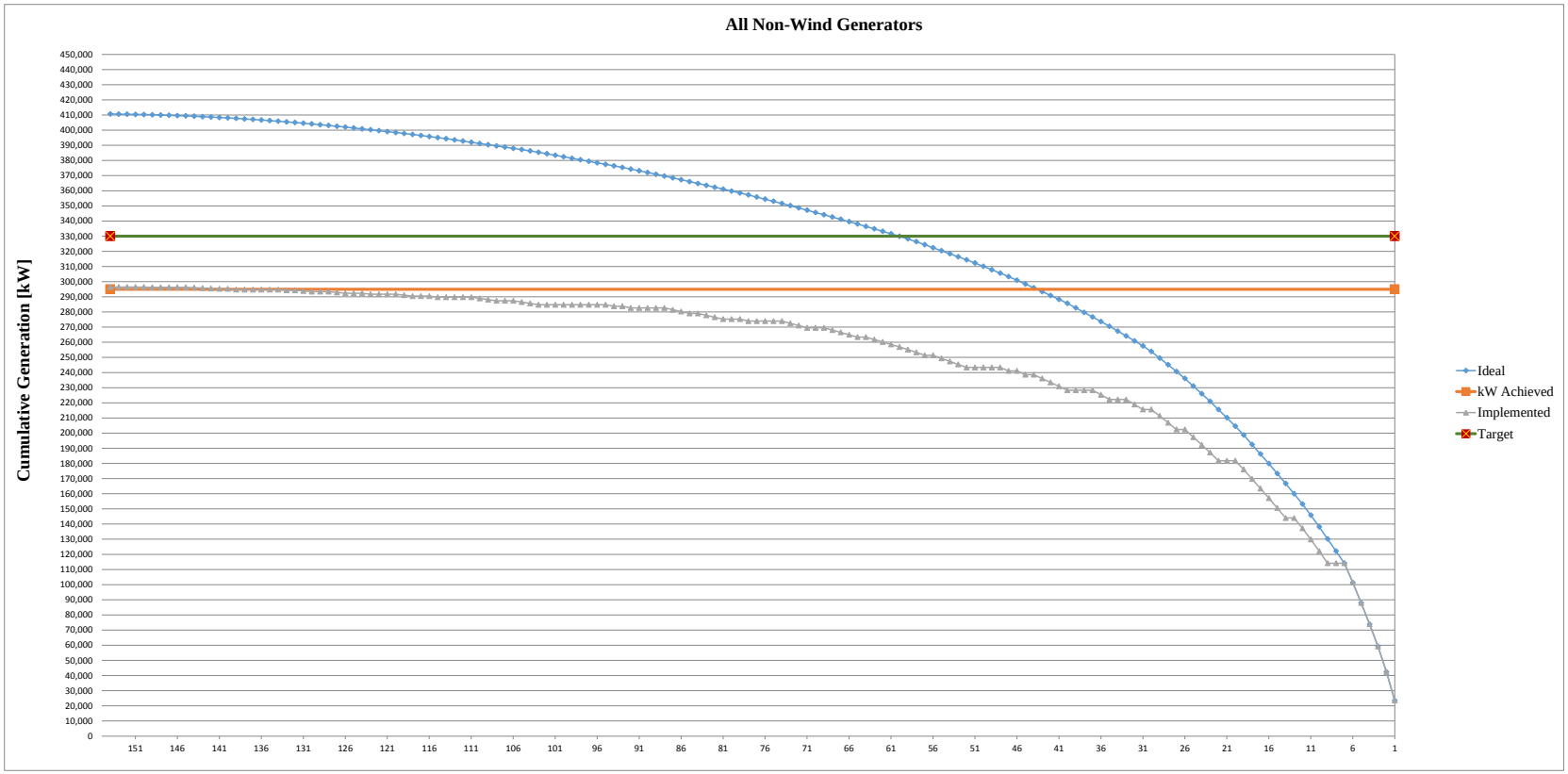


- Estimated Total MW Installed 410MW
- Agreed Target 330MW of the total MW installed completed[1] by November 2018

Completed meaning either:

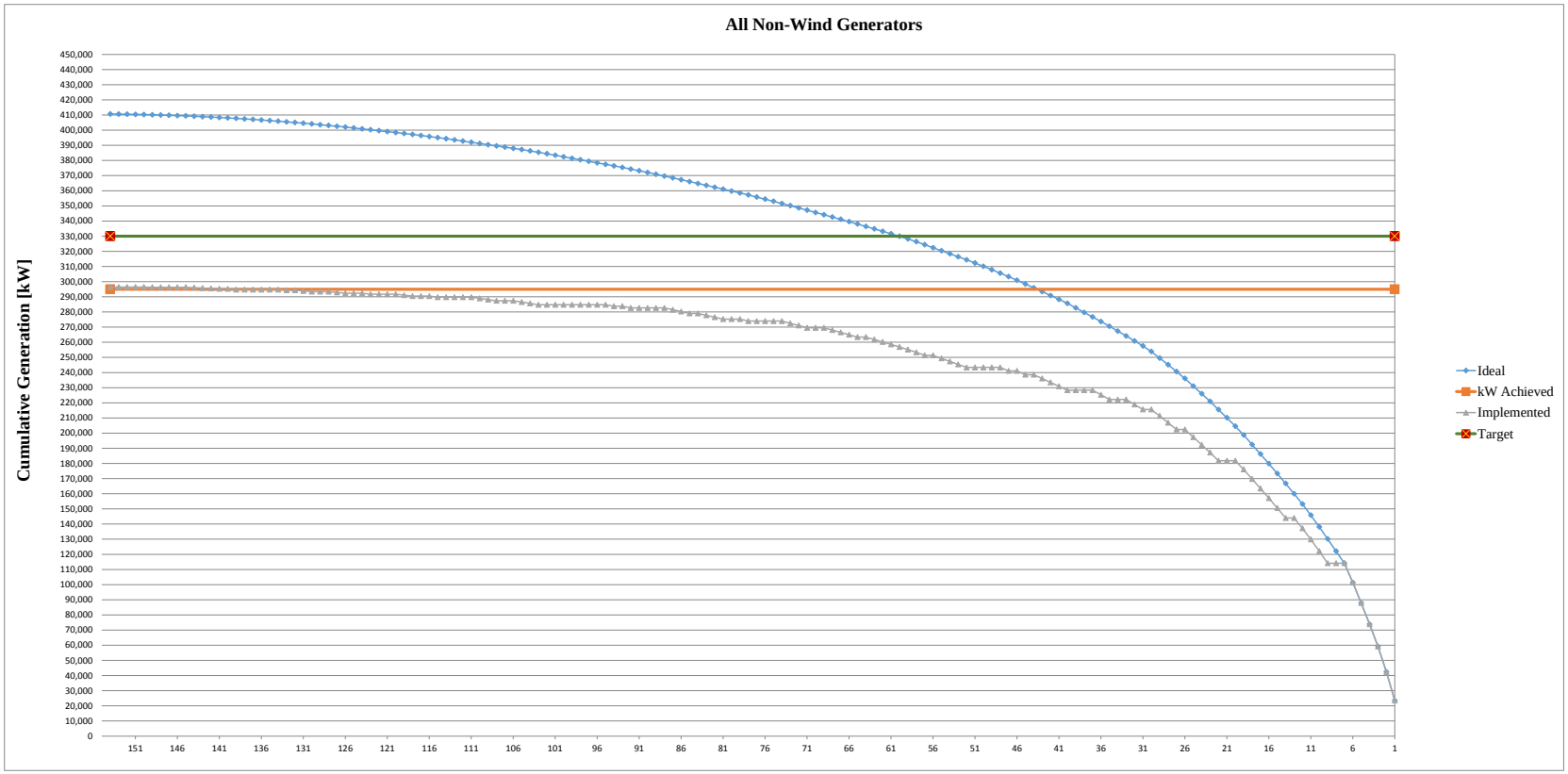
- ROCOF settings changes
- Confirmed as being trickle-feed and Interface CB trip
- Conformed as being short term paralleling [peak lopping]

Non Wind – 2 How are we doing?



- Target 330MW
- Completed to date 241MW
- Between completed and committed for June/July shut downs, on track for 295MW

Non Wind – 3 Risks

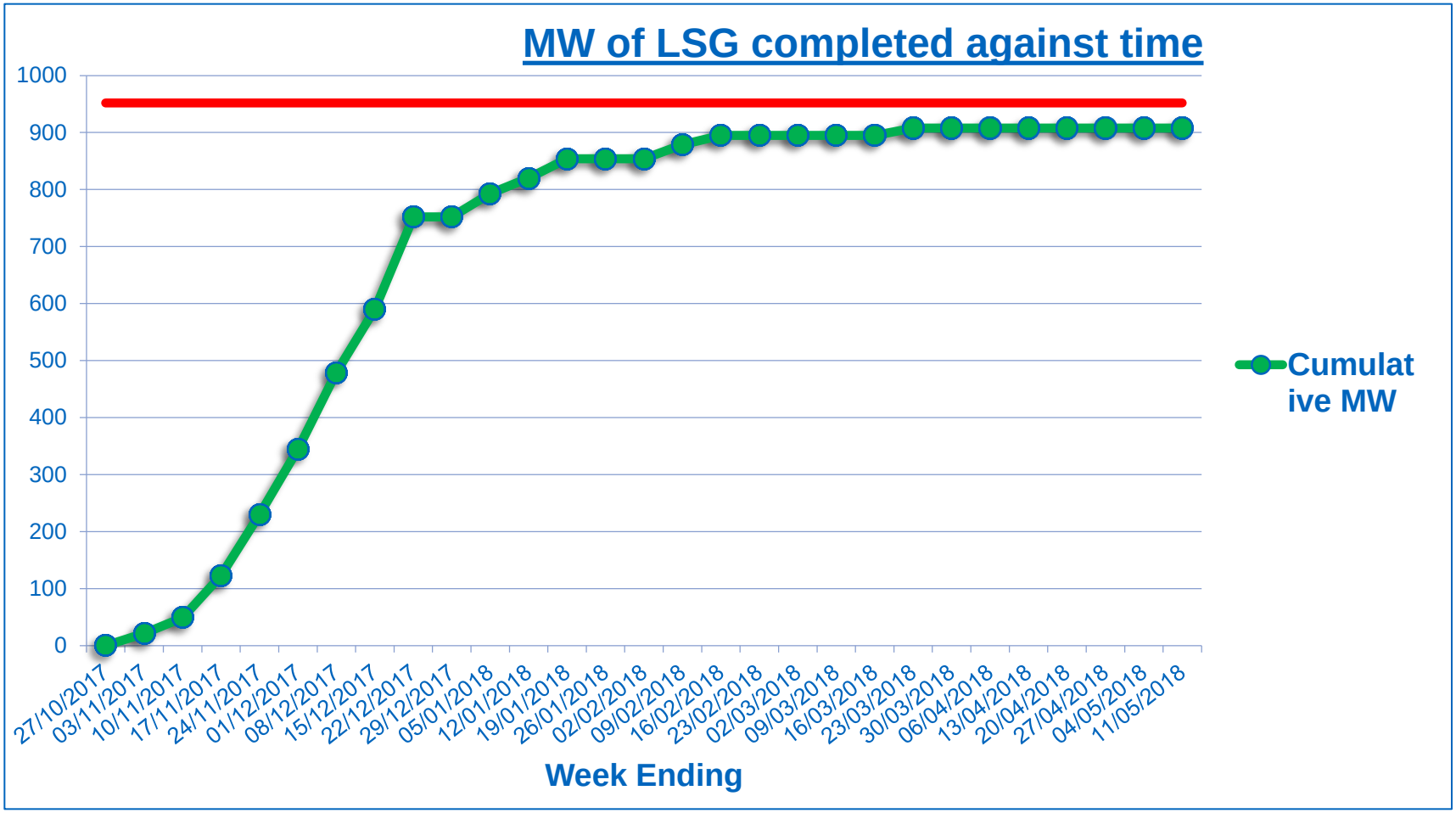


- Brendan McGrath promoted to new position outside Future Networks
- Process for replacement underway

DS3 – NIE NETWORKS UPDATE

DS3 ADVISORY COUNCIL – 23/05/18

LSG RoCoF Progress



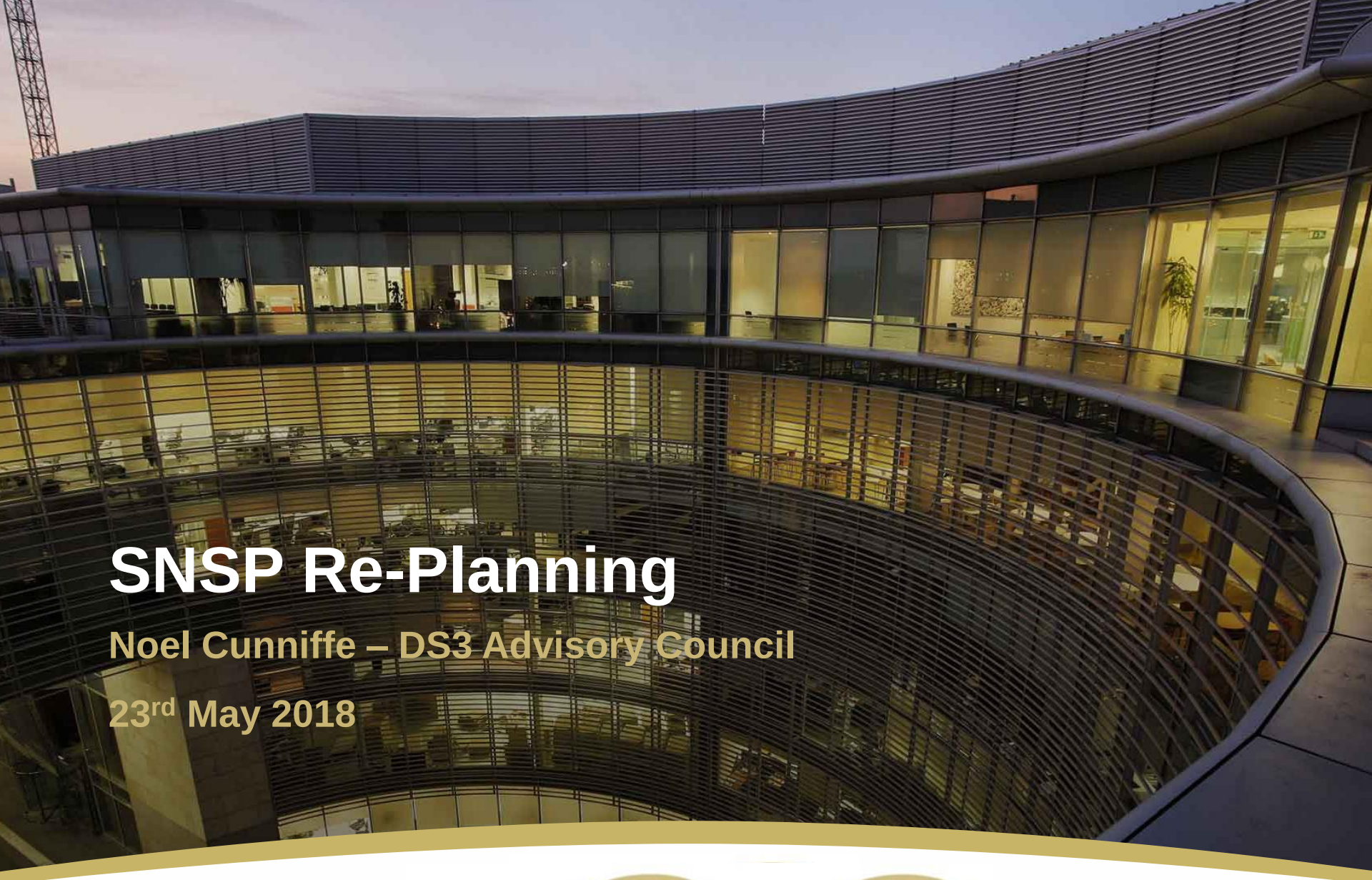
LSG RoCoF Progress

- **To date 95% (909MW) has been changed to new RoCoF setting**
- **Over 1GW of 1Hz/s RoCoF compliant generation (including sites that have connected since the programme started)**
- **6 LSG sites still to change**
  - 1 booked in for next week
  - 2 expected to test before end of May
  - 3 expected to test before end of June
  - All remaining sites date back to 1990s and require G59 relay changes
  - All owners are committed to making the changes

SSG RoCoF Progress

- **Consultation Response and implementation plan options submitted to UR in Feb 18**
- **Proposed that LoM (RoCoF) amended to 1.0Hz /second (with a 500ms time delay)**
- **D-Code amendments approved by UR and D-Code Issue 4 published 11 May 2018**
- **Implementation plan developed and agreed**
- **1500 SSG sites in scope**
  - Current plan is to send letters week beginning 21 May 2018
  - SSG changes to be completed by 30 September 2019
  - G59 approved contractor list established following procurement exercise
  - G59 contractor technical workshop completed
  - Briefing sessions held with interested parties, UFU, NIRIG, RGLG..
  - Further briefing sessions will be held with owners of multiple SSG sites

*Currently c1500 SSG sites, excluding micro generation
c400MW, excluding micro generation



SNSP Re-Planning

Noel Cunniffe – DS3 Advisory Council

23rd May 2018

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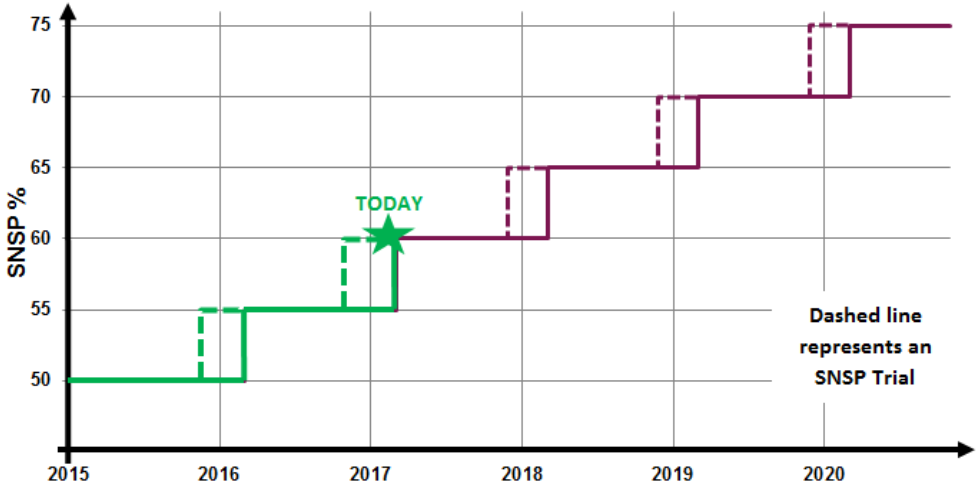
Existing SNSP Plan Overview

- Published SNSP Timelines*:
  - 2018 – 70% Trial
  - 2019 – 75% Trial



- Delays to areas in the DS3 Programme mean a re-plan of the programme is required out to 2020

- Re-planning SNSP is the first step in this process – input from the DS3 Advisory Council would be appreciated

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**Note: The graph shows published SNSP timelines as of early 2017. The current SNSP limit is 65%.*

65% to 70% SNSP – What is needed?

Operational Change	*Status (2018 Timeline)*	*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	🟢	Q4 2018
Operational Reserves Policy	🟢	Q3 2018
RoCoF & Inertia Floor Policy	🔴	Q2 2019
Control Centre Tools		
Ramping Tool	🟡	Q4 2018
Look Ahead WSAT	🟡	Q1 2019
System Services		
11 existing services + FFR	🟢	Q3 2018

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70% to 75% SNSP – What is needed?

Operational Change	*Status (2019 Timeline)*	*Expected Delivery*
Implement OFGS enduring	🟢	Q3 2018
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		
SNSP & Inertia Metrics display	🟢	Q2 2019
Voltage Trajectory Tool	🟢	Q2 2019
System Services		
11 existing services + FFR + DRR + DPFAPR	🟢	Q3 2019

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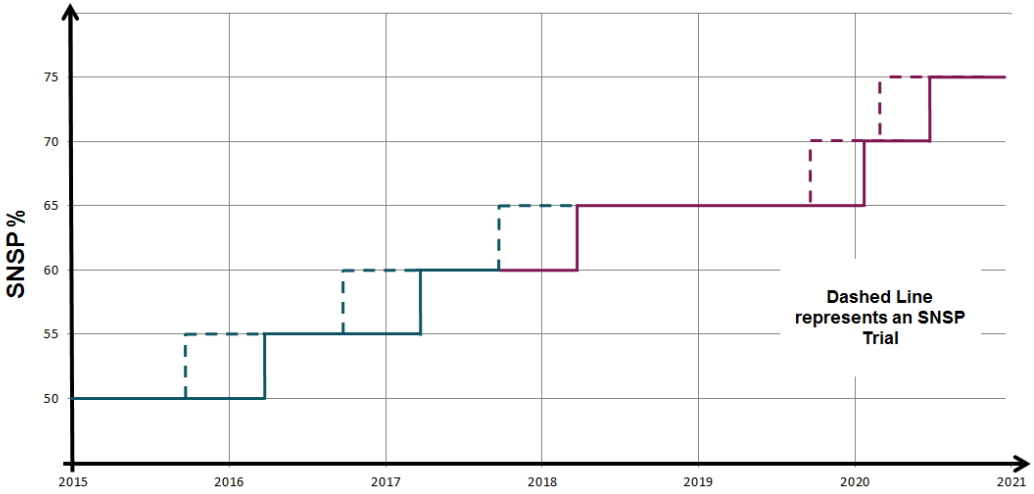
SNSP Re-Plan Overview

- Based on estimated delivery timelines, proposed new SNSP timelines:
  - Q4 2019 – 70% SNSP System Trial
  - Q1 2020 – 70% SNSP Permanent
  - Q1 2020 – 75% SNSP System Trial
  - Q2 2020 – 75% SNSP Permanent



- Suggestions on proposed SNSP Timeline welcome

- Full re-plan of the remaining DS3 Programme deliverables taking place in Summer 2018

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Nodal Controller

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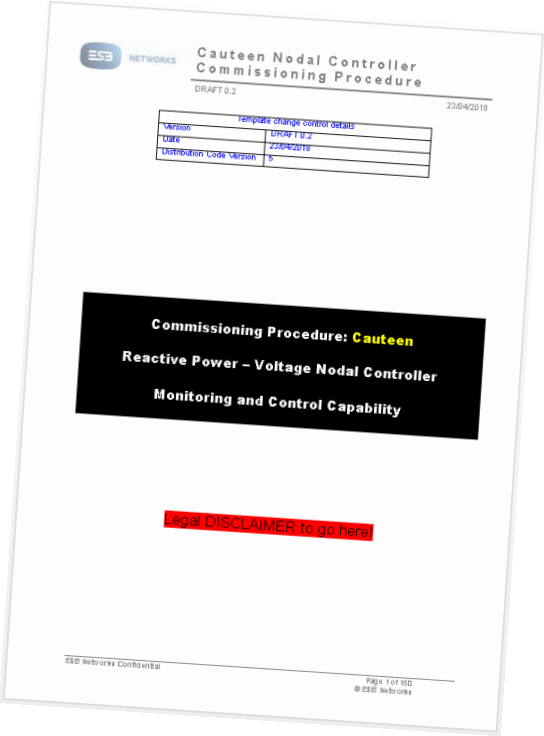
Nodal Controller update

Progress - 1

- **Detailed Commissioning procedure written**
  - Q – Q control mode
  - Q – V control mode
  - V – Q control mode
  - V – V control mode
- **Test with Glenough WF (±11 MVAr capability)**
- **Test with Glenough WF and Glencarbry WF (+22 / -11 MVAr capability)**
- **Alex Stefanov leading the commissioning work**



NETWORKS

Cauteen Nodal Controller
Commissioning Procedure

DRAFT 0.2

23/04/2019

Template change control details	
Version	DRAFT 0.2
Date	22/04/2019
Distribution Code Version	6

Commissioning Procedure: Cauteen

Reactive Power – Voltage Nodal Controller

Monitoring and Control Capability

Legal DISCLAIMER to go here!

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Page 1 of 160
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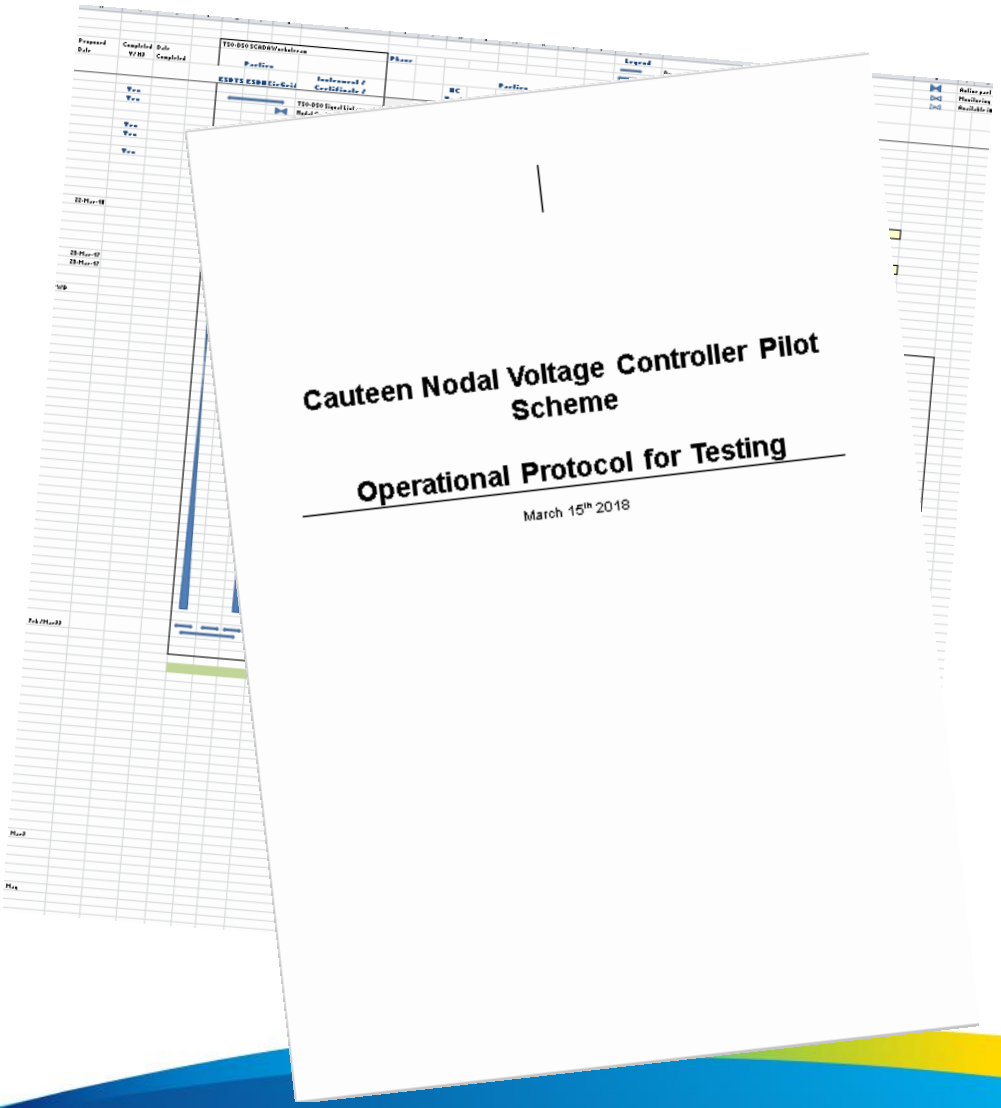
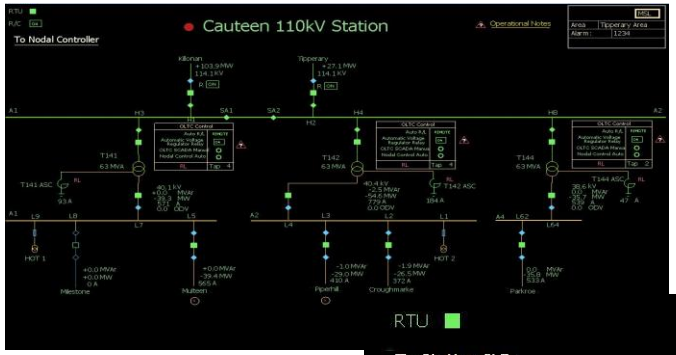
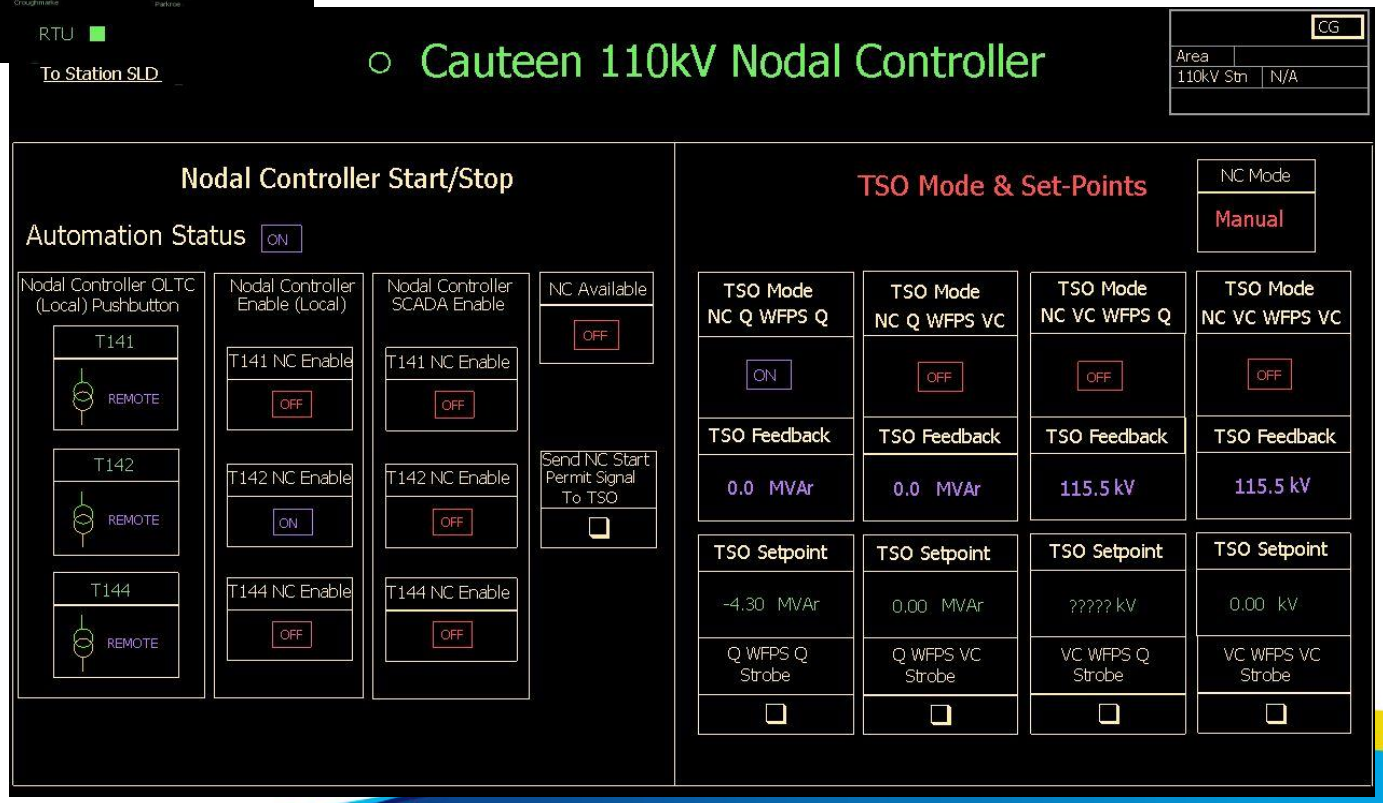
Progress - 2

- **Commissioning and Testing programme agreed between ESBN and EirGrid**
- **Operational Protocol agreed for conduct of testing**
- **Phase 1: ESBN Testing within agreed Q envelope with**
  - One windfarm
  - Two windfarms
  - All modes
- **Phase 2: NCC trial the device**
- **Phase 1 commenced April 2018**

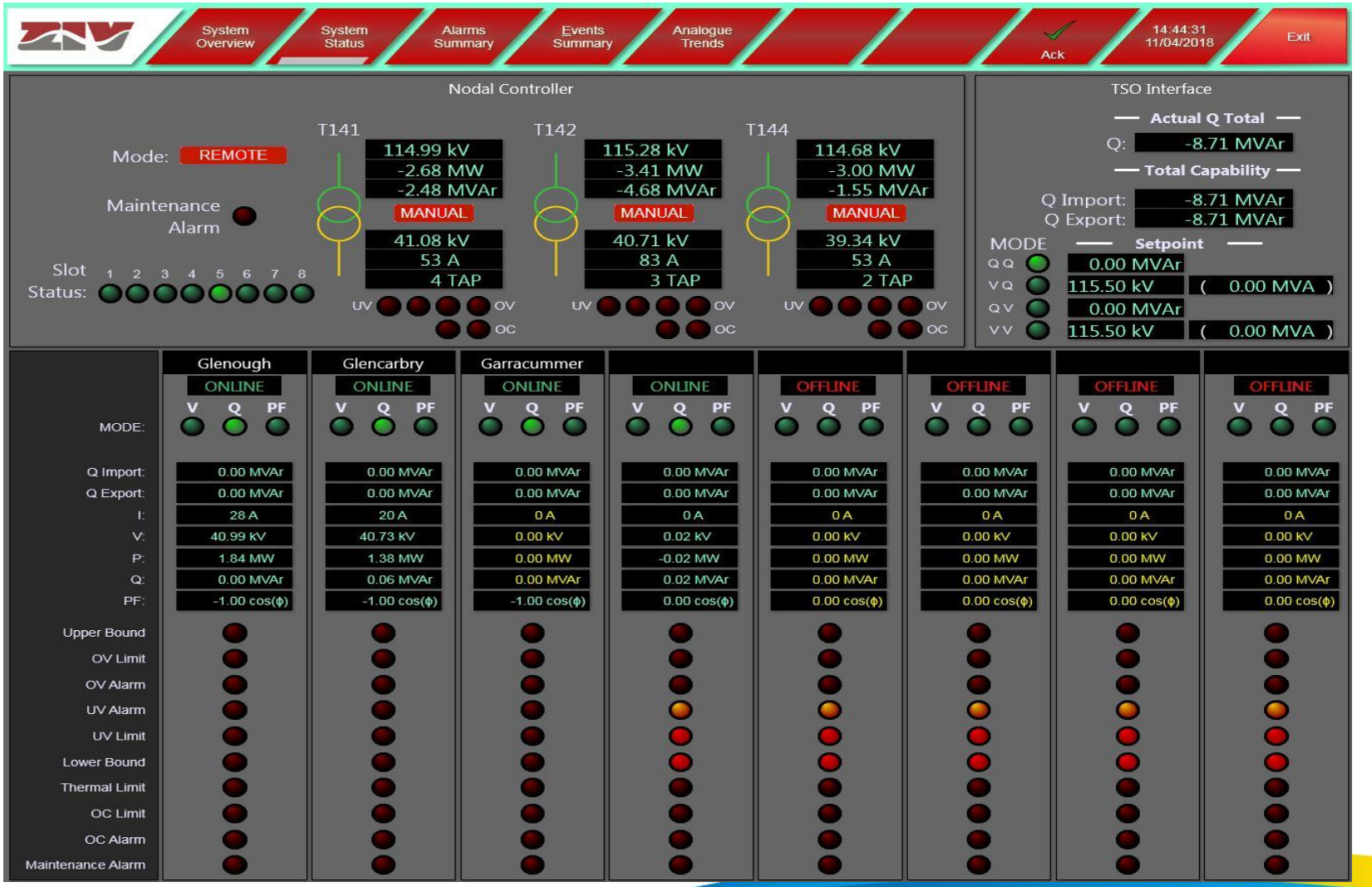


It does exist – really! ….SCADA Screens

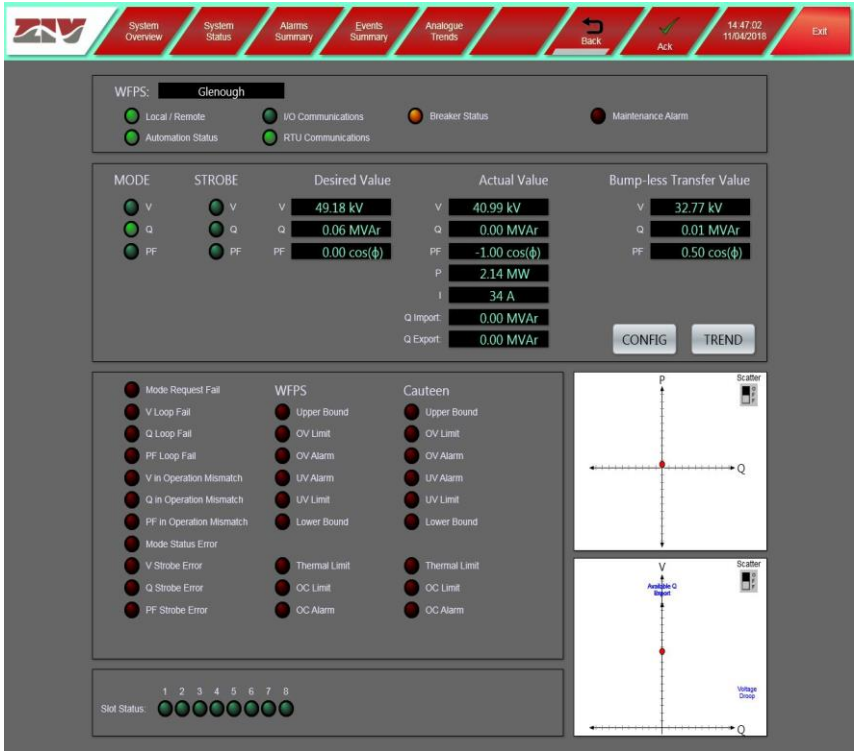




It does exist – really! ….HMI Screens - 1



It does exist – really! ….HMI Screens - 2



Where are we now?

- **Many technical issues encountered and now resolved**
- **Progress slower than expected due to:**
  - Lack of wind
  - Control Room resource challenges
  - Time taken to resolve technical issues

But..

- **Good that technical issues were exposed and resolved**
- **We believe [fingers crossed] there should be no more technical issues**
- **Renewed effort to complete phase 1 in coming weeks**

Questions?

NIE NETWORKS' NODAL CONTROLLER PROJECT

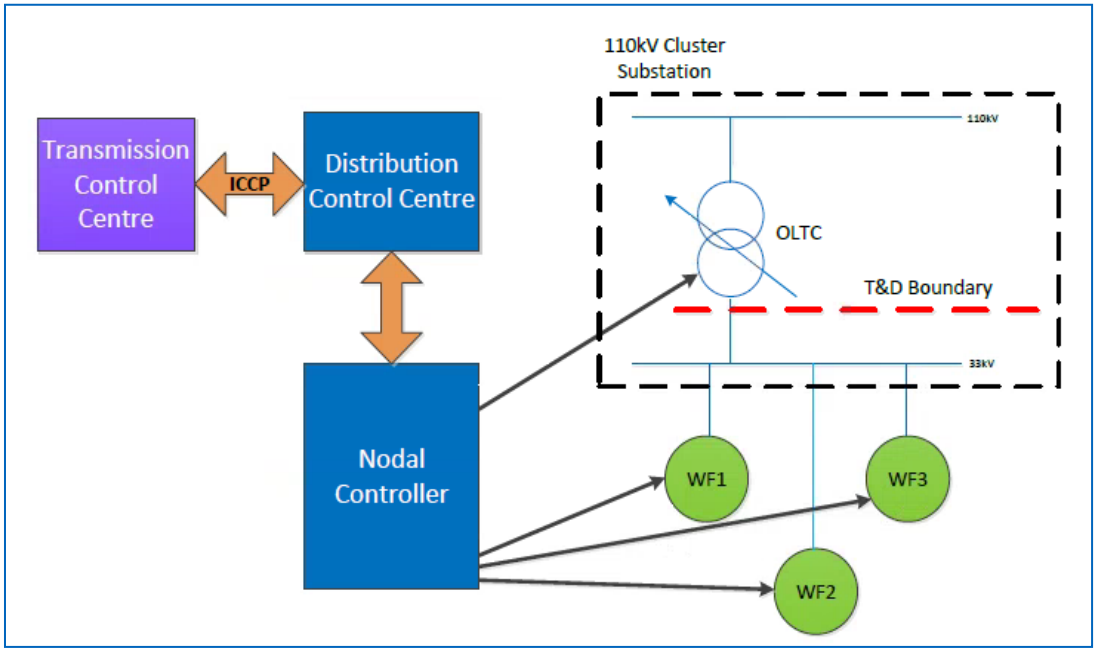
DS3 Advisory Council - 23/05/18

What is the Northern Ireland Nodal Controller

- Controller which regulates the reactive power of downstream generators to deliver a constant:
  - Power Factor
  - Reactive Power; or
  - Voltage

  set point at an upstream node.

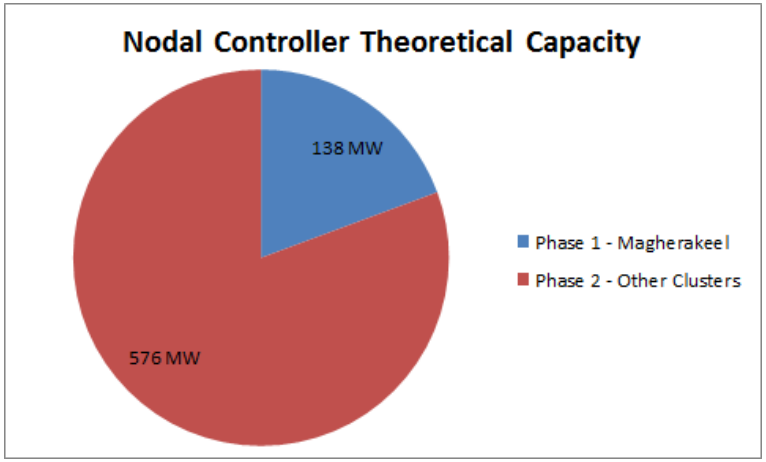
- Required to:
  - Ensure stable operation (no hunting from occurring).
  - Protect the distribution and transmission system from voltage and thermal violations.
  - Enable consistent Principles of Access to be applied.
  - Ensure efficient use of the system i.e. reduced OLTC operations.



NIE Networks Nodal Controller Strategy

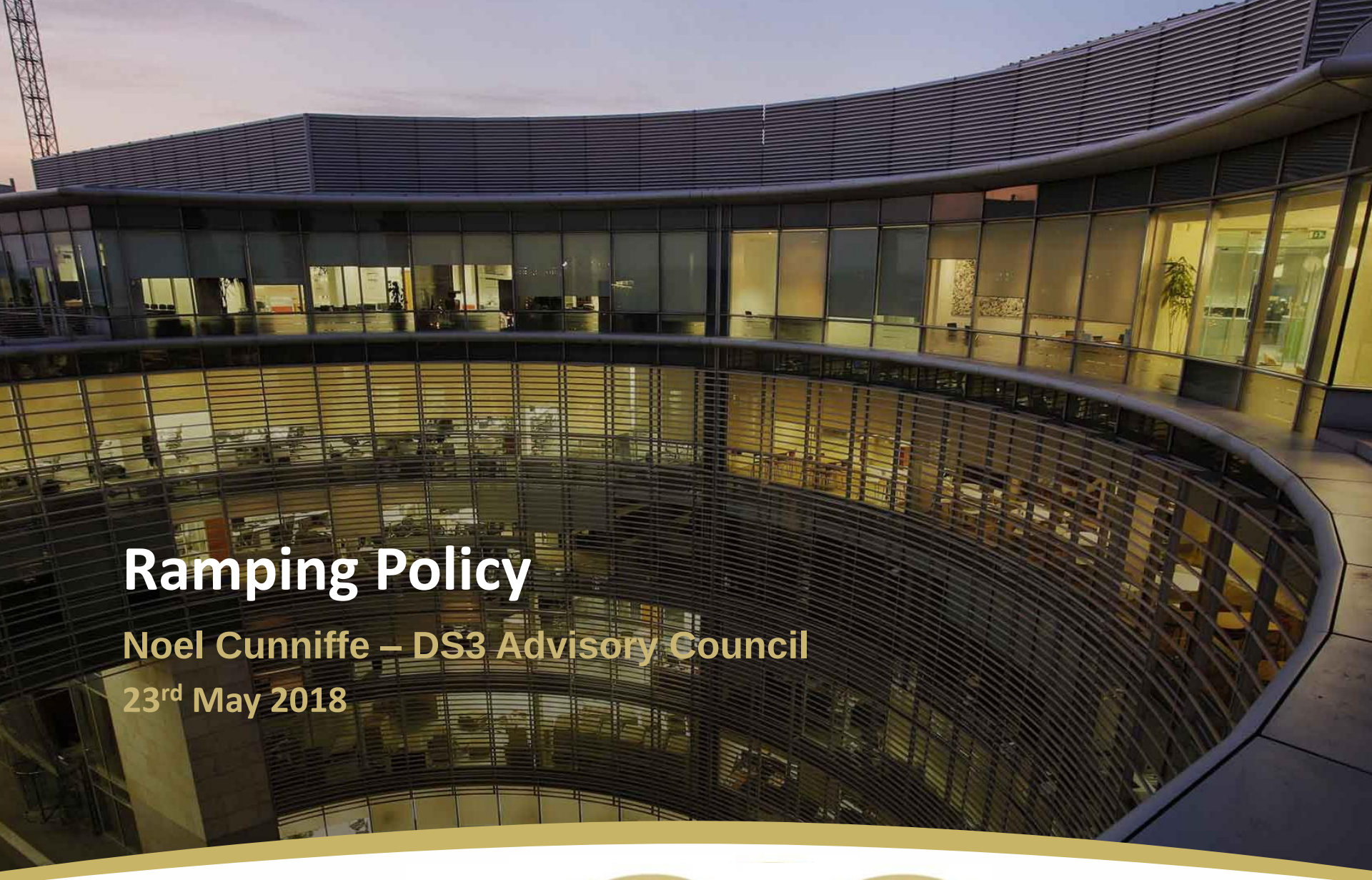
- Phase 1: Nodal Controller Trial at Magherakeel cluster substation.

- Phase 2: If Phase 1 is successful, roll out of Nodal Controllers at other cluster substations. Subject to a positive CBA outcome for each site.



Phase	Stage	Timeline
1	Integration into SCADA system	Q2 2018
	Algorithm Development	Q2 2018
	Trial Live	Q3 2018
	Decision on Nodal Controller success	Q3 2019
2	Begin project to roll out Nodal Controllers at remaining cluster substations. Will require decision on funding mechanism.	Q3 2019

QUESTIONS?



Ramping Policy

Noel Cunniffe – DS3 Advisory Council

23rd May 2018

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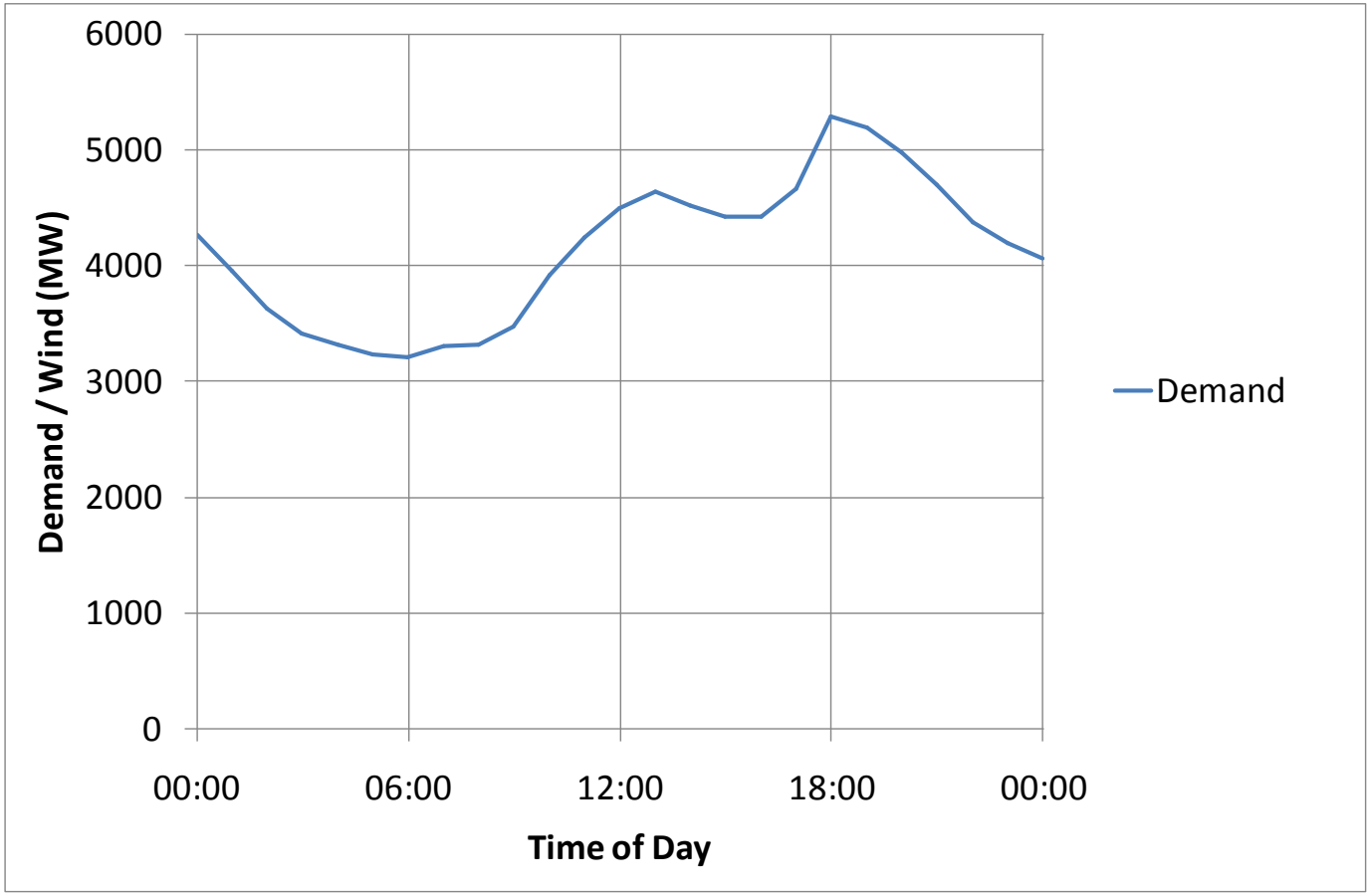
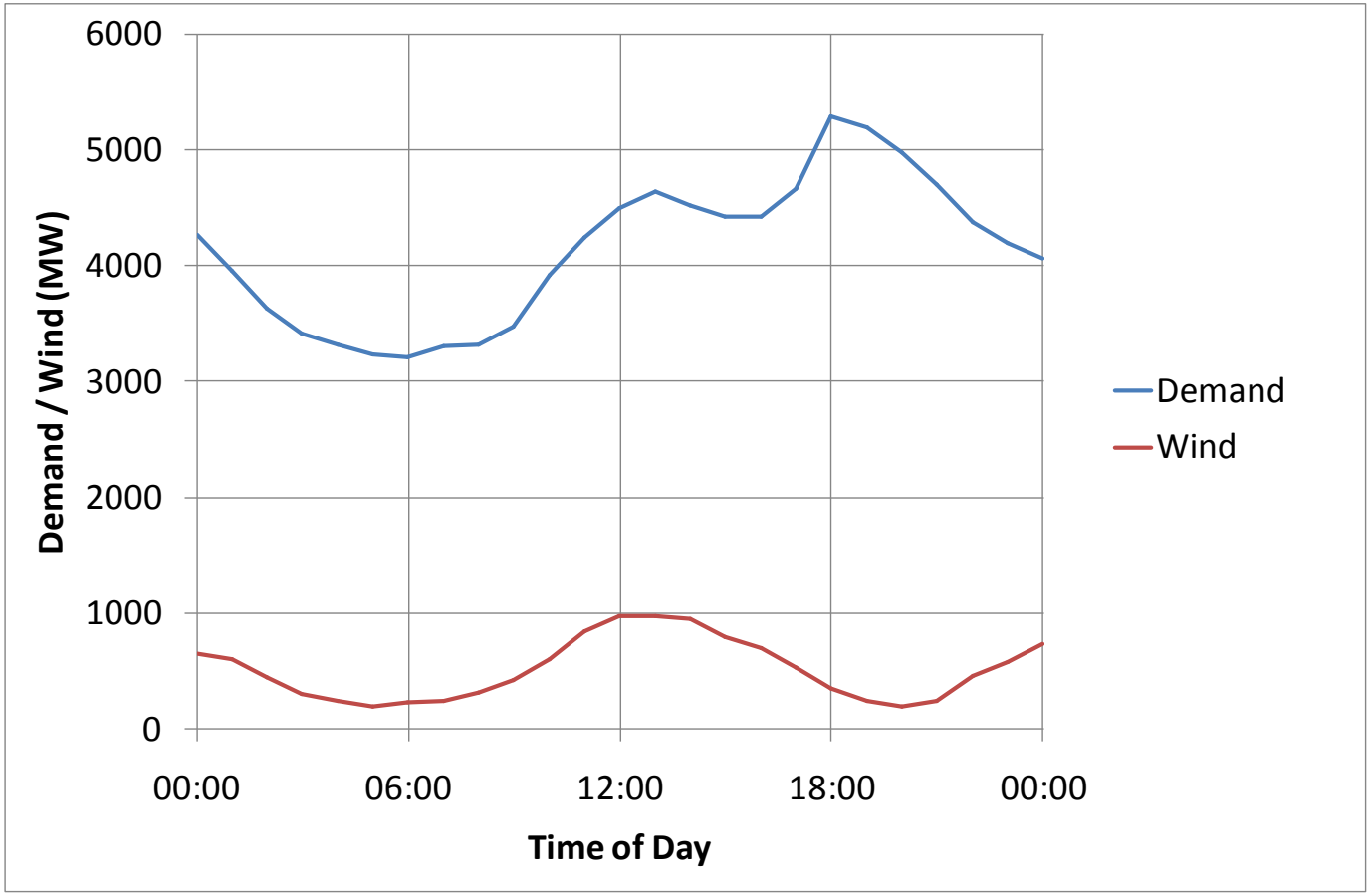
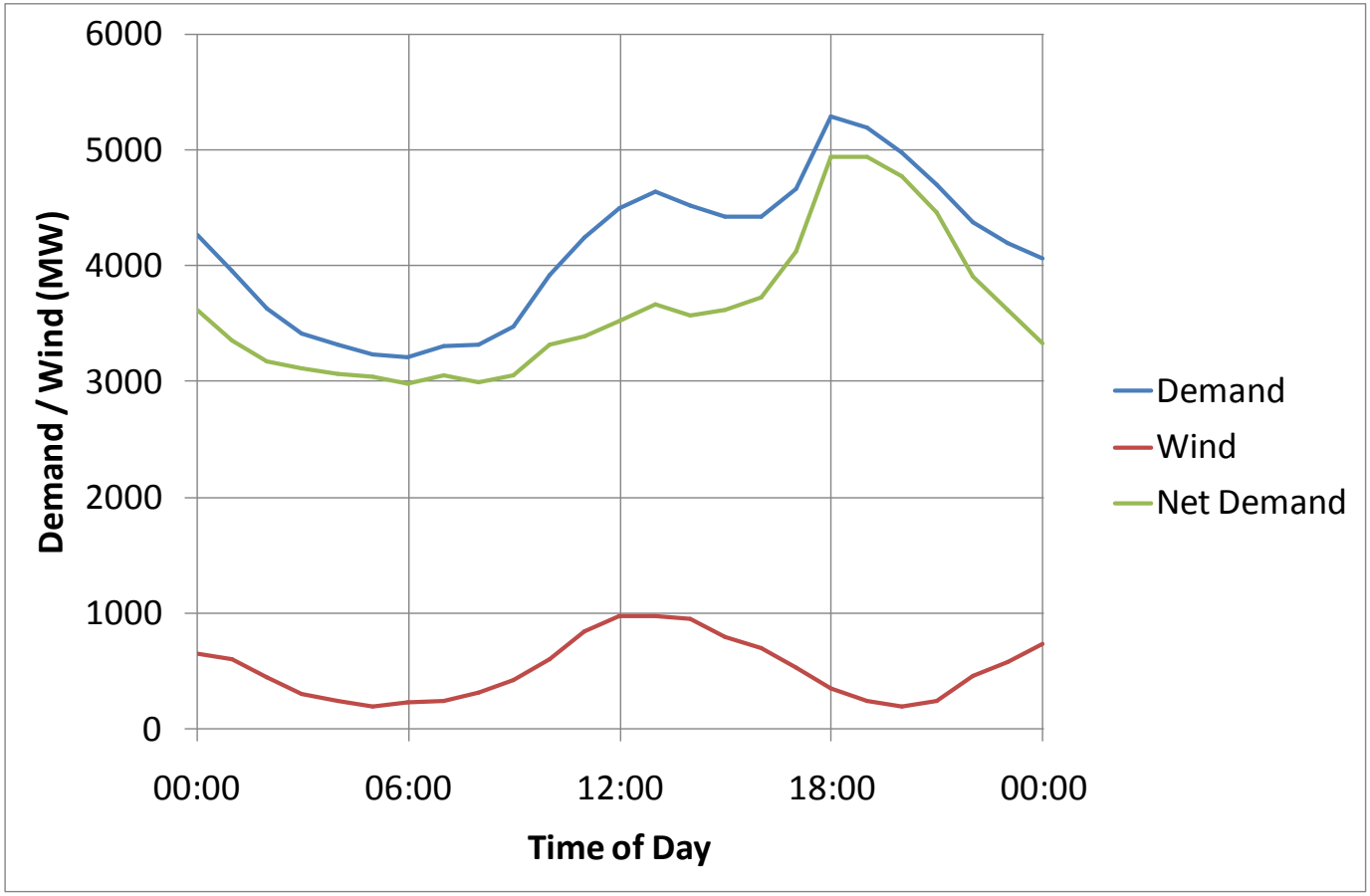
Ramping Concept



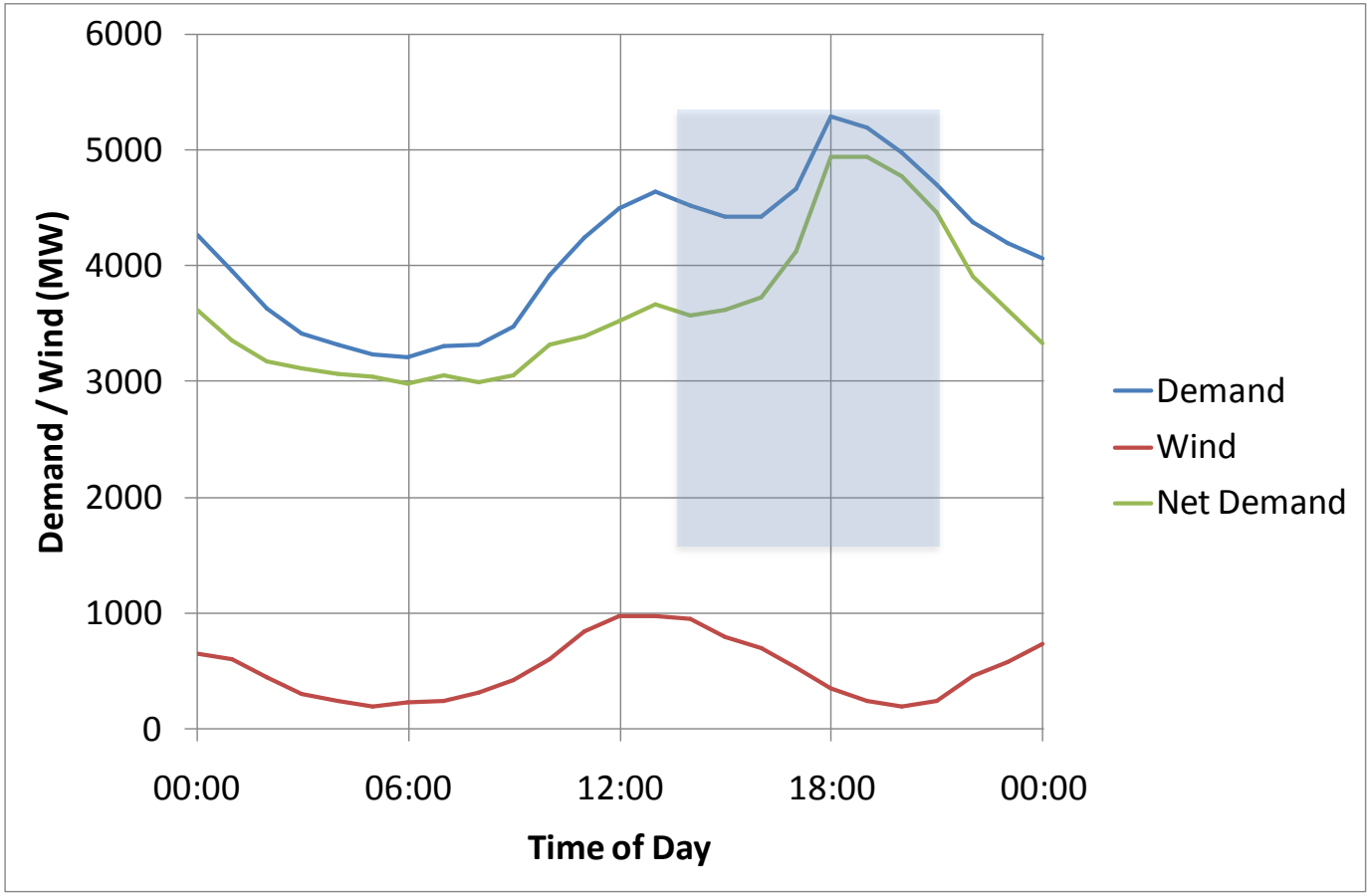
Ramping Concept



Ramping Concept



Ramping Concept



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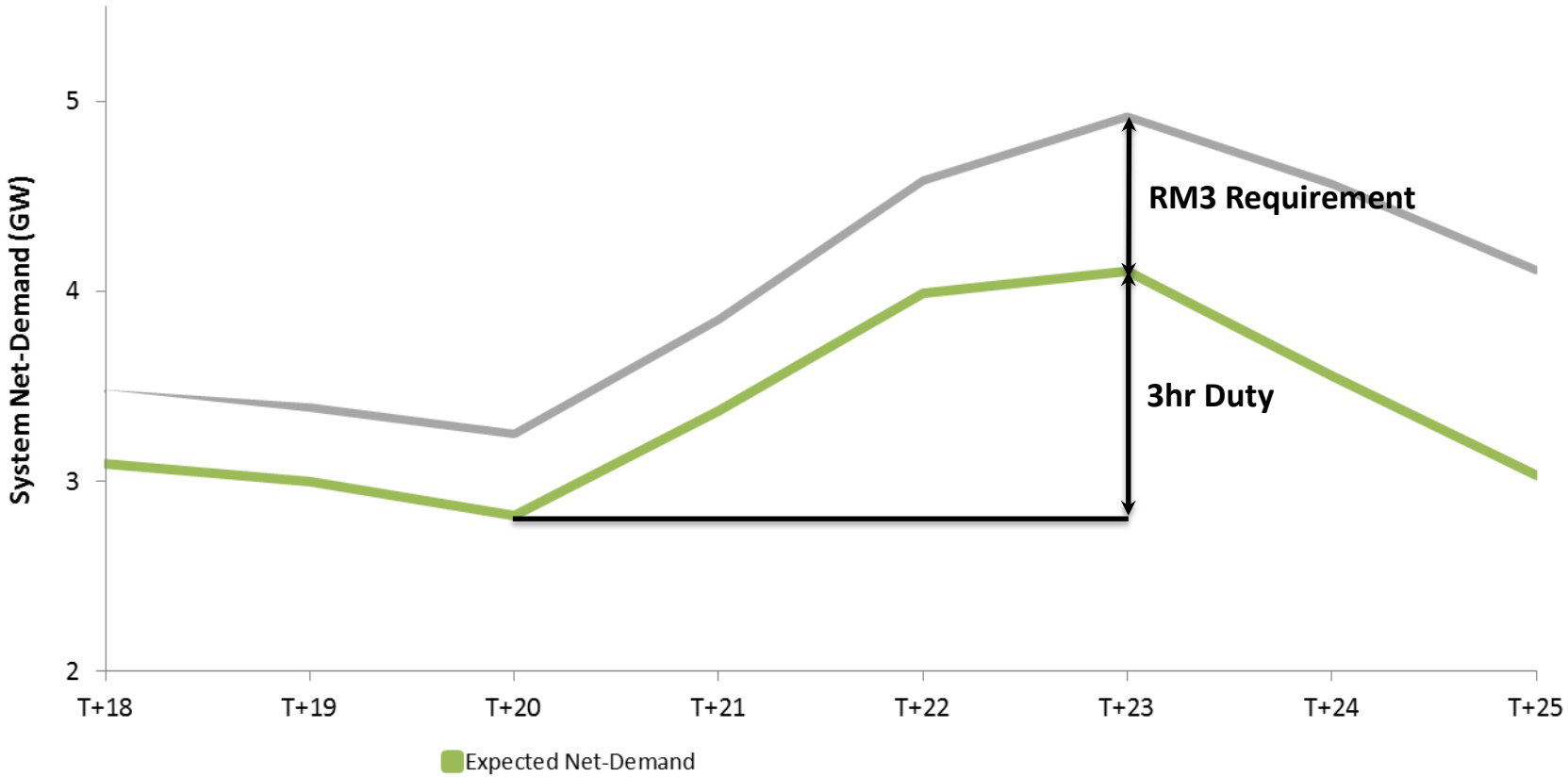
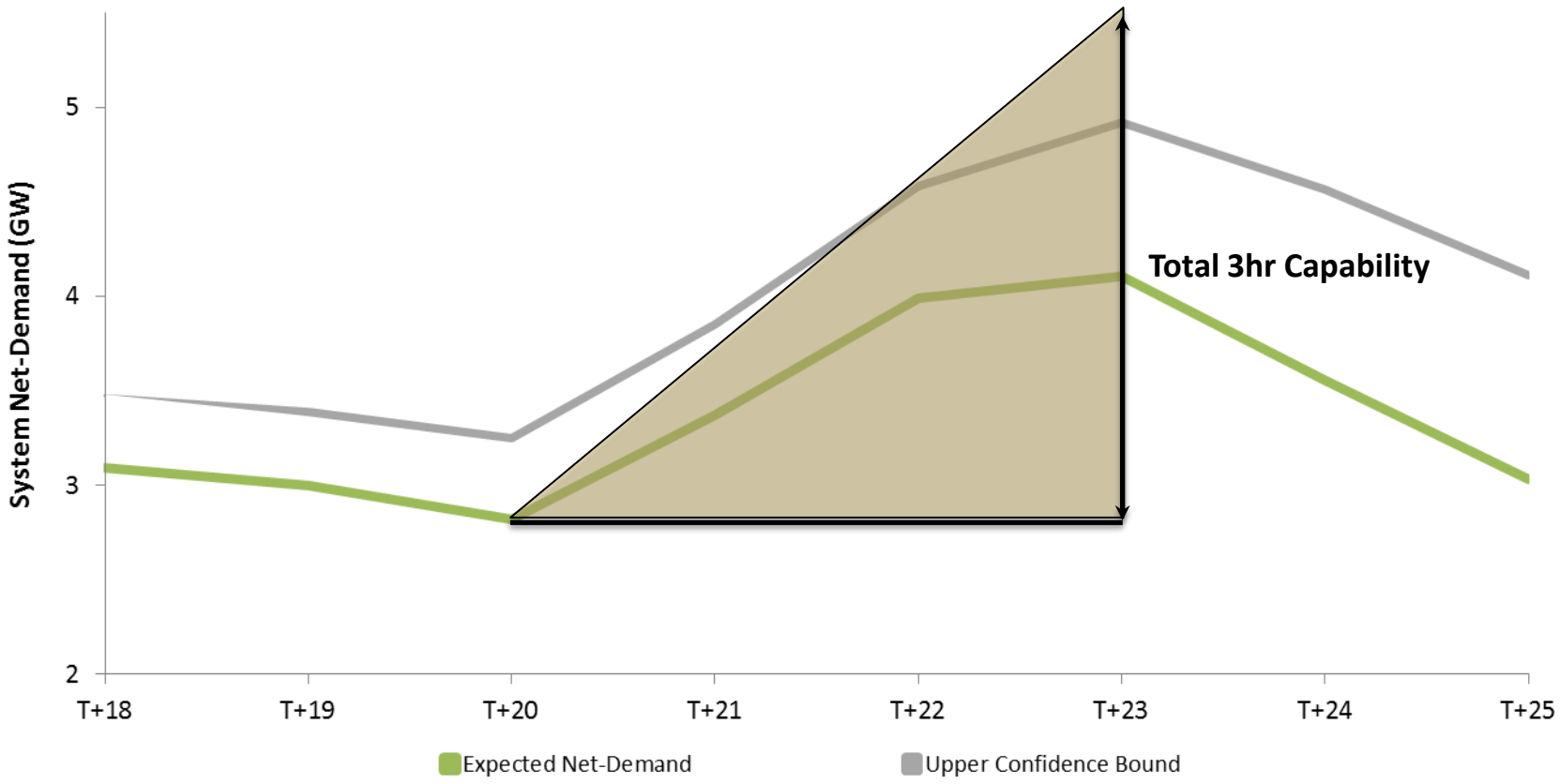
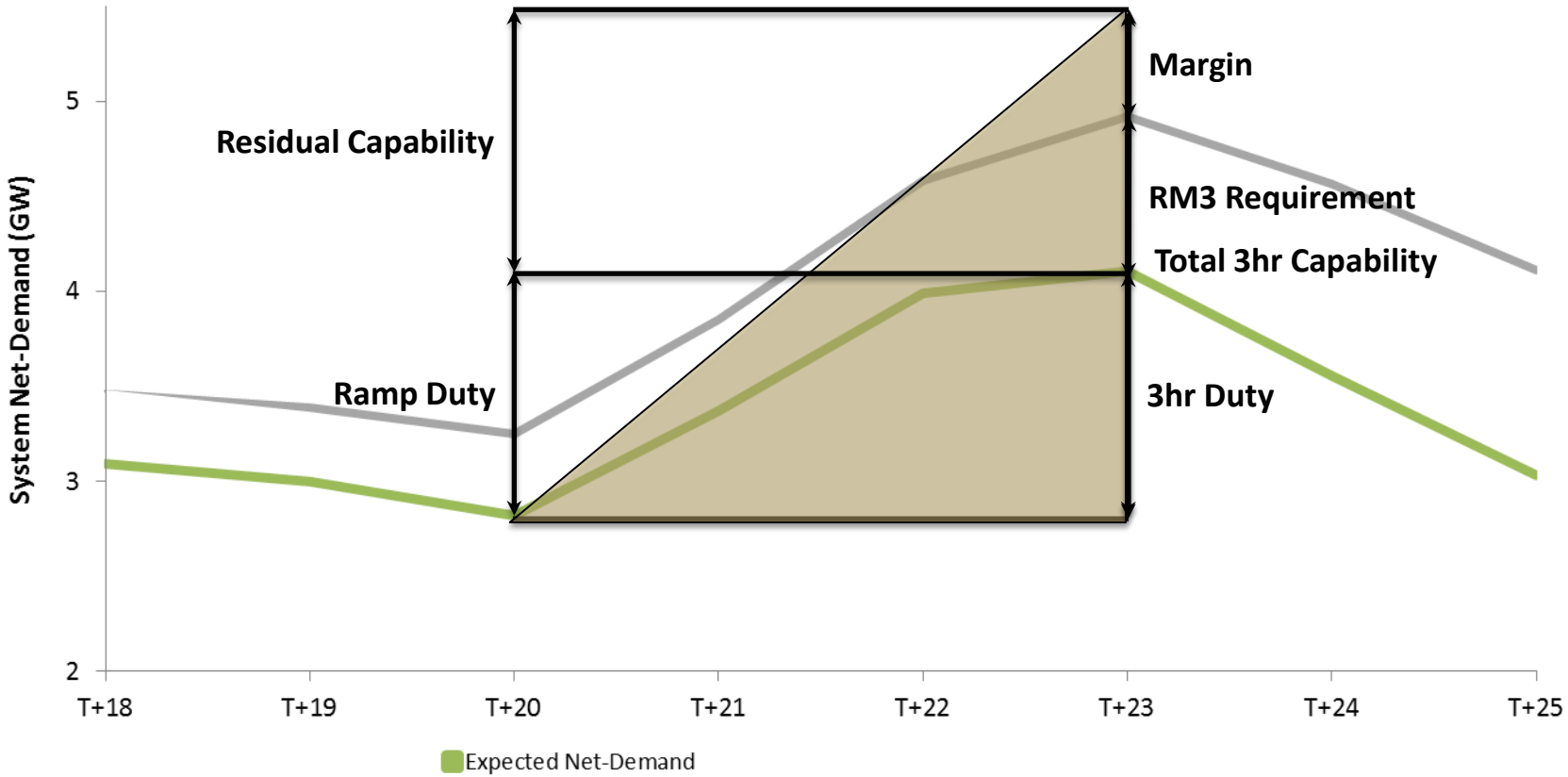
System Ramping Terminology



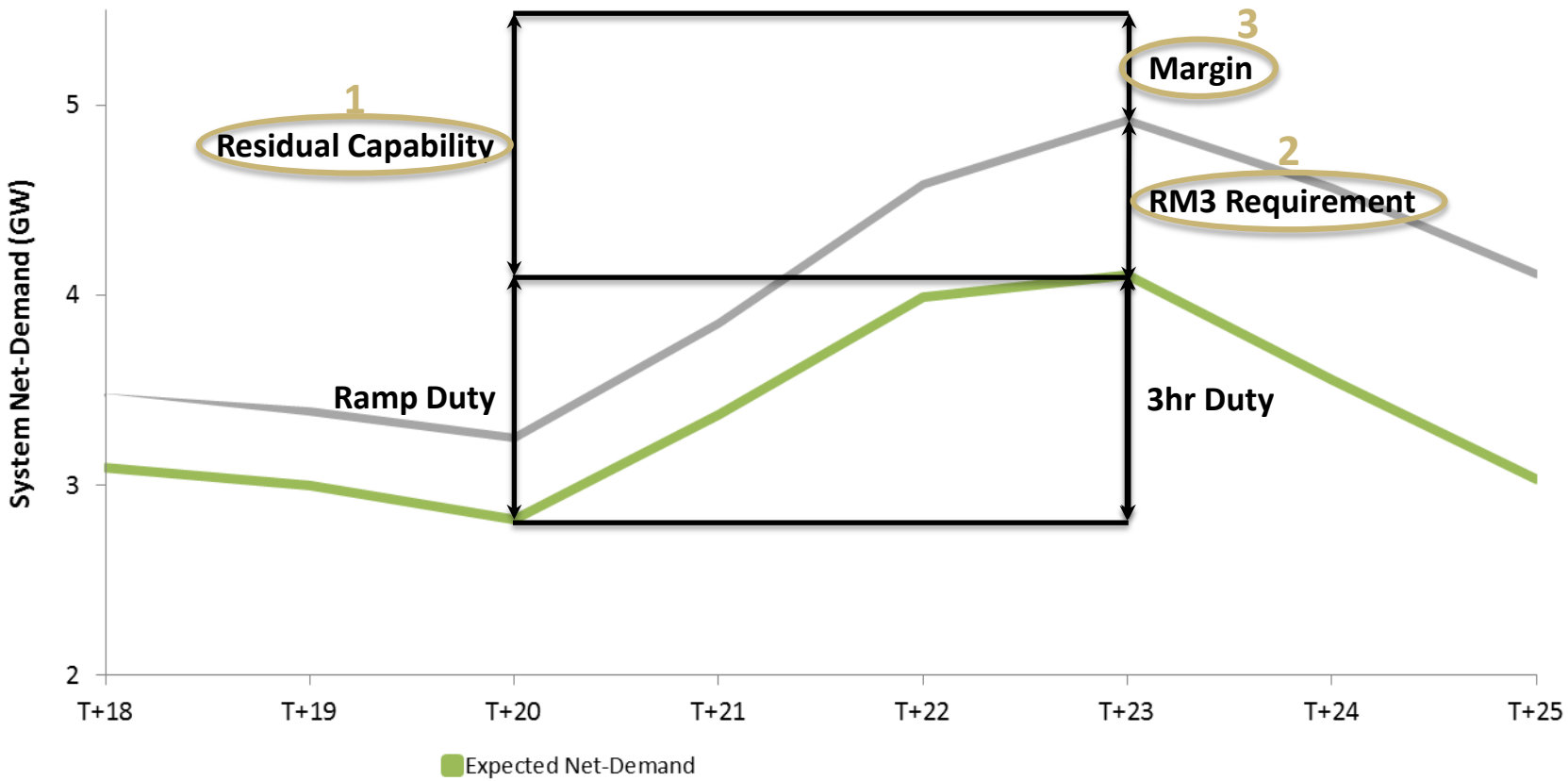
System Ramping Terminology



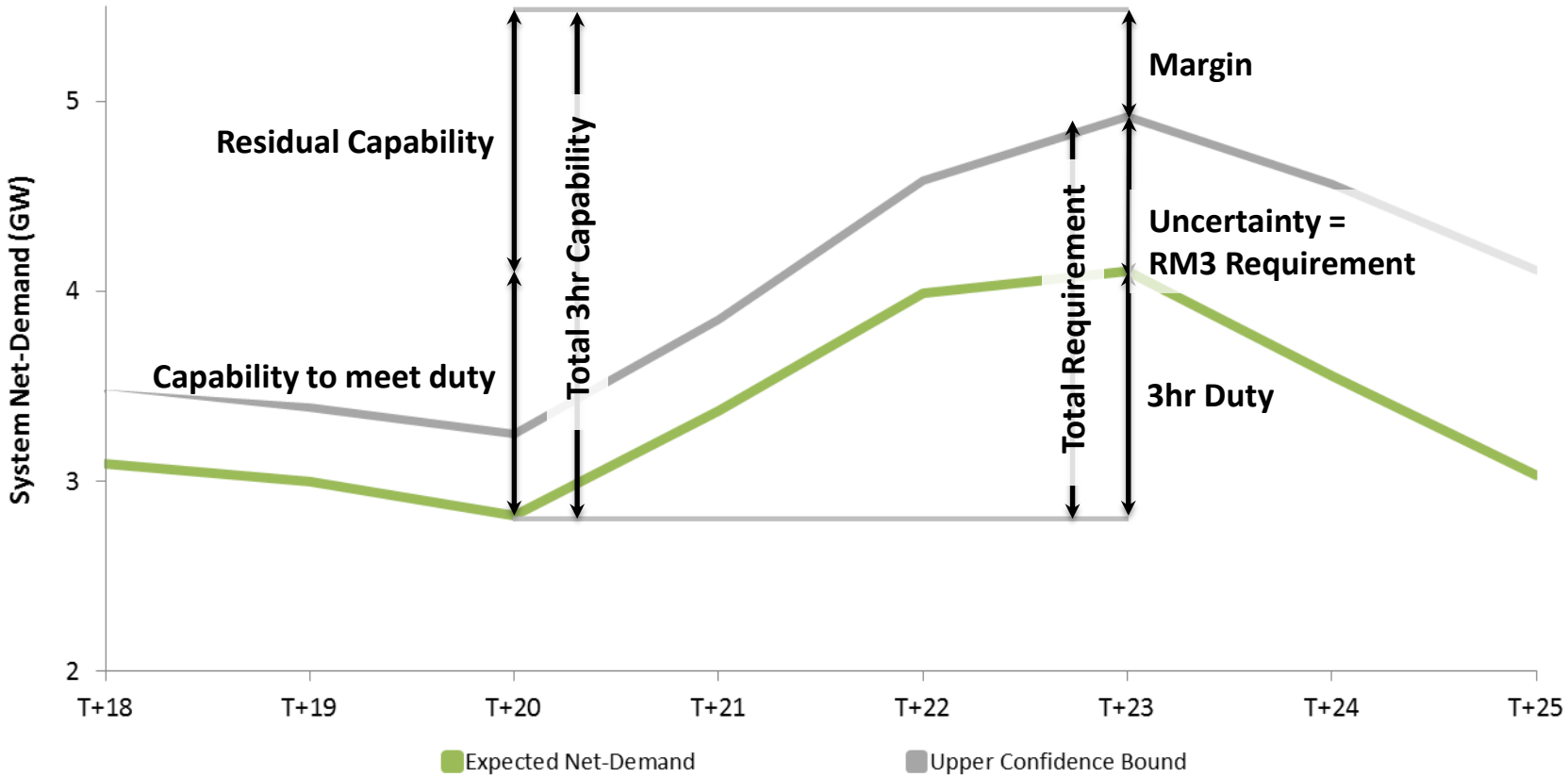
System Ramping Terminology



System Ramping Terminology



System Ramping Terminology



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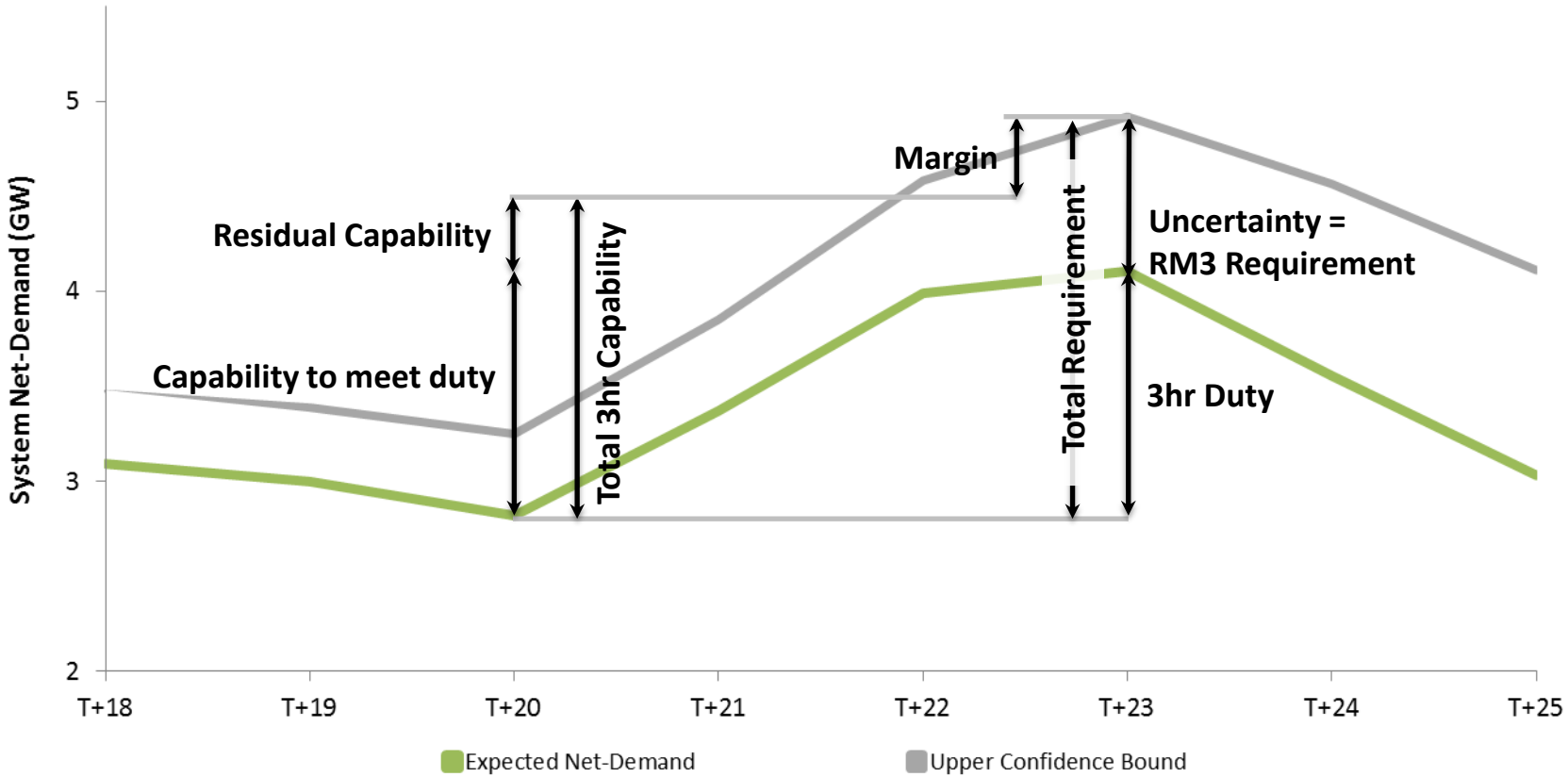
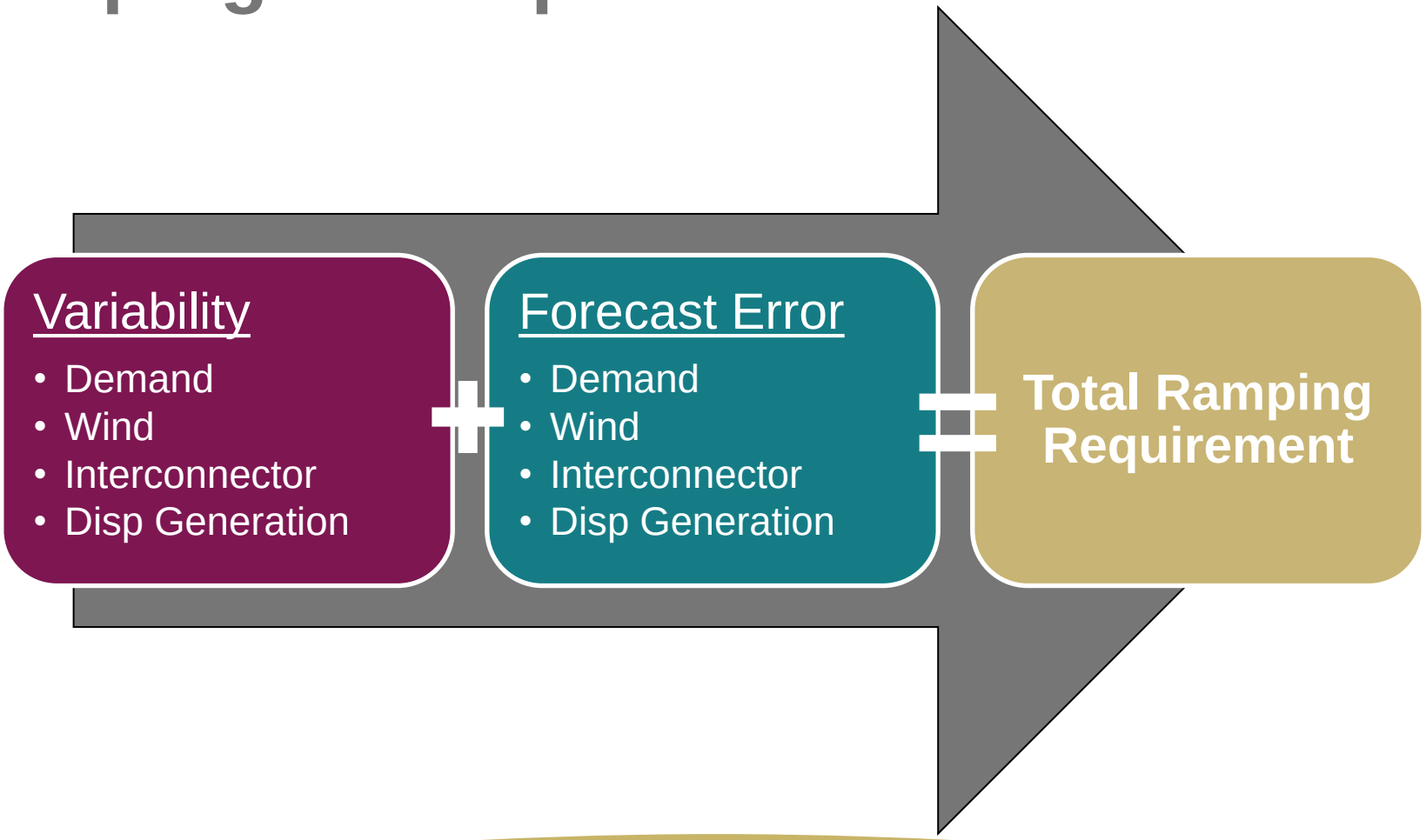
System Ramping Terminology



Ramping Concept



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Ramping Concept

Ramping Duty +

Forecast Error

- Demand
- Wind
- Interconnector
- Disp Generation

= **Total Ramping Requirement**

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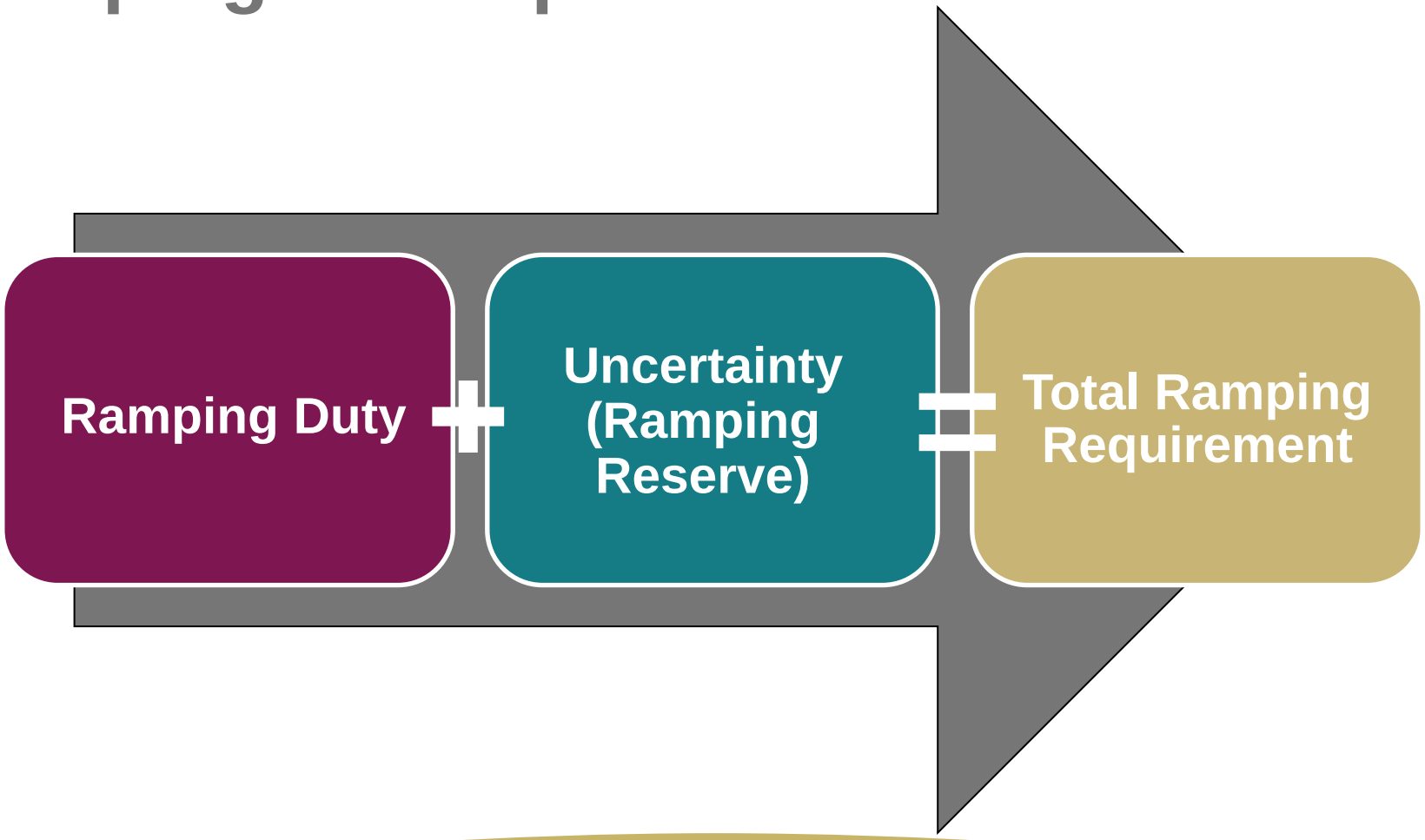
Ramping Concept



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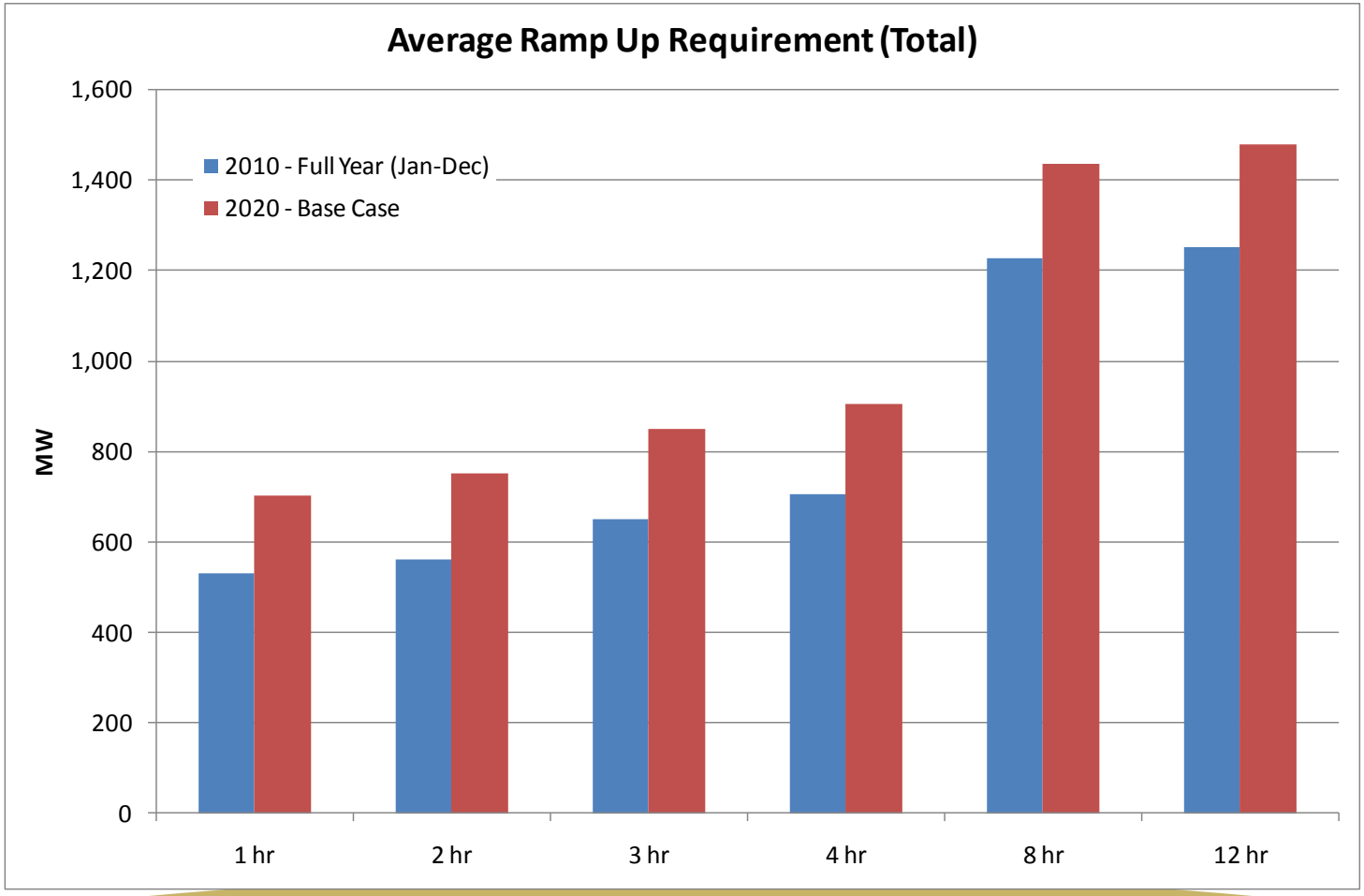
DS3 – Ramping Requirement Study (2011)



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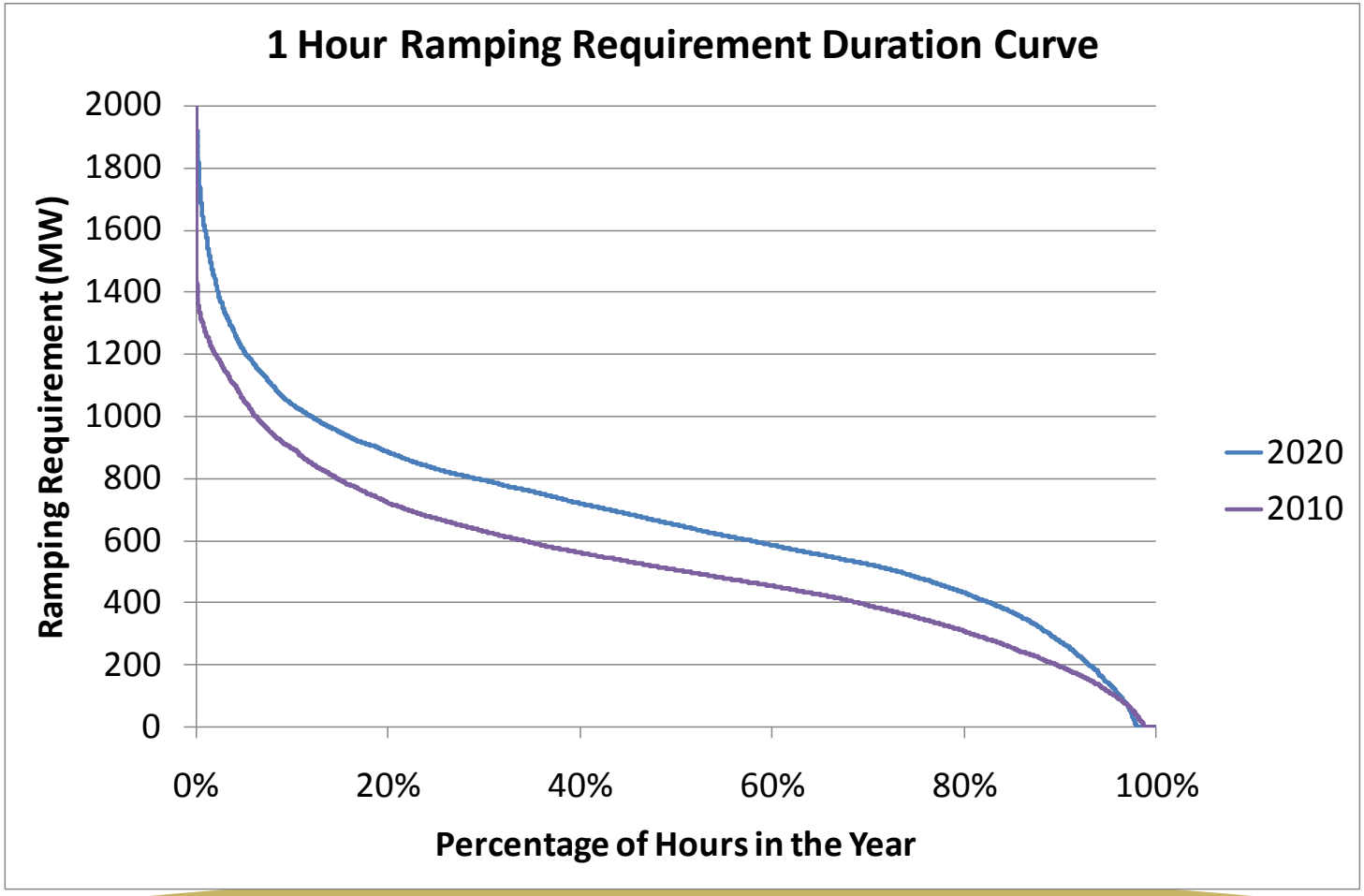
DS3 – Ramping Requirement Study (2011)



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Basis for Ramping Reserve Requirement

- Ramping Reserve Requirement needs to account for:

1. Load Forecast Risk

2. Production Schedule Risk
   - Loss of Largest Single Infeed
   - Wind Forecast Error

3. Reserve Supply Risk

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Basis for Ramping Reserve Requirement

$$\boldsymbol{Primary\ Operating\ Reserve\ Requirment}$$
$$= 75\%\ Largest\ Single\ Infeed$$

$$\boldsymbol{Ramping\ Reserve\ Requirmentt}$$

$$= 1\%\ Load\ Forecast_t$$
$$+ \max(\ Largest\ Single\ Infeed_t \boldsymbol{\ or\ } fn(Wind\ Forecast_t)$$
$$+ Largest\ offline\ reserve\ resource_t$$

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Wind Forecast Error

- As the capacity of wind generation increases on the system, the importance of accurate forecasts increases
- Similarly, the impact of incorrect forecasting can have a large impact on system operation
- An increased number of wind generators leads to an increased forecast error possibility for the same power output due to geographical spread

	2013	2015	2018
Installed Wind Generation Capacity	2.1 GW	2.5 GW	4 GW
Wind Generation Forecast	1.5 GW	1.5 GW	1.5 GW
97th Percentile Wind Forecast Error	500 MW	650 MW	850 MW

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Ramping Reserve Requirements Example

Characteristic	Starting Point (t=0)	1 Hour Horizon (RM1)	3 Hour Horizon (RM3)	8 Hour Horizon (RM8)
System Demand (MW)	3,500	3,750	4,250	5,600
Largest Single Infeed (MW)	450	450	475	500
97th Percentile Wind Forecast Error (MW)	-	100	450	720
Largest Offline Reserve Resource (MW)	-	150	225	400

$$\boldsymbol{RM1\ Ramping\ Reserve\ Requirement} =$$
$$(3{,}750\ x\ 1\%) + \max(\ 450\ \boldsymbol{or}\ 100) + 150 = 37.5 + 450 + 150 = 637.5\ MW$$

$$\boldsymbol{RM3\ Ramping\ Reserve\ Requirement} =$$
$$(4{,}250\ x\ 1\%) + \max(\ 475\ \boldsymbol{or}\ 450) + 225 = 42.5 + 475 + 225 = 742.5\ MW$$

$$\boldsymbol{RM8\ Ramping\ Reserve\ Requirement} =$$
$$(5{,}600\ x\ 1\%) + \max(\ 500\ \boldsymbol{or}\ 720) + 400 = 56 + 720 + 400 = 1{,}176\ MW$$

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Conclusions & Next Steps

- Ramping capability on the system is a function of:
  - Scheduling process: foresight, operational constraints
  - Demand and wind forecasts

- Ramping risk will soon be dominated by average wind forecast error
  - Improved forecasting techniques, use of real-time error estimation help
  - However – growth of largest ramp unavoidable

- Negative ramping margins probable without dedicated ramping products

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Conclusions & Next Steps

- Define Ramping Policy

  Q1 2018

- Scope, Develop and Procure Ramping Tool for integration into Control Centre

  Q2-Q3 2018

- Trial Ramping Tool in Control Centre and train operators

  Q1-Q2 2019

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Lunch

12:40 – 13:20

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Oscillations

Barry O'Connell

EIRGRID SONI

Overview

- System Events
- Response to Events
  - Phasor Monitoring System
  - Operational Protocol
- Current Analysis
  - Plant tuning
  - System damping
- Future Work

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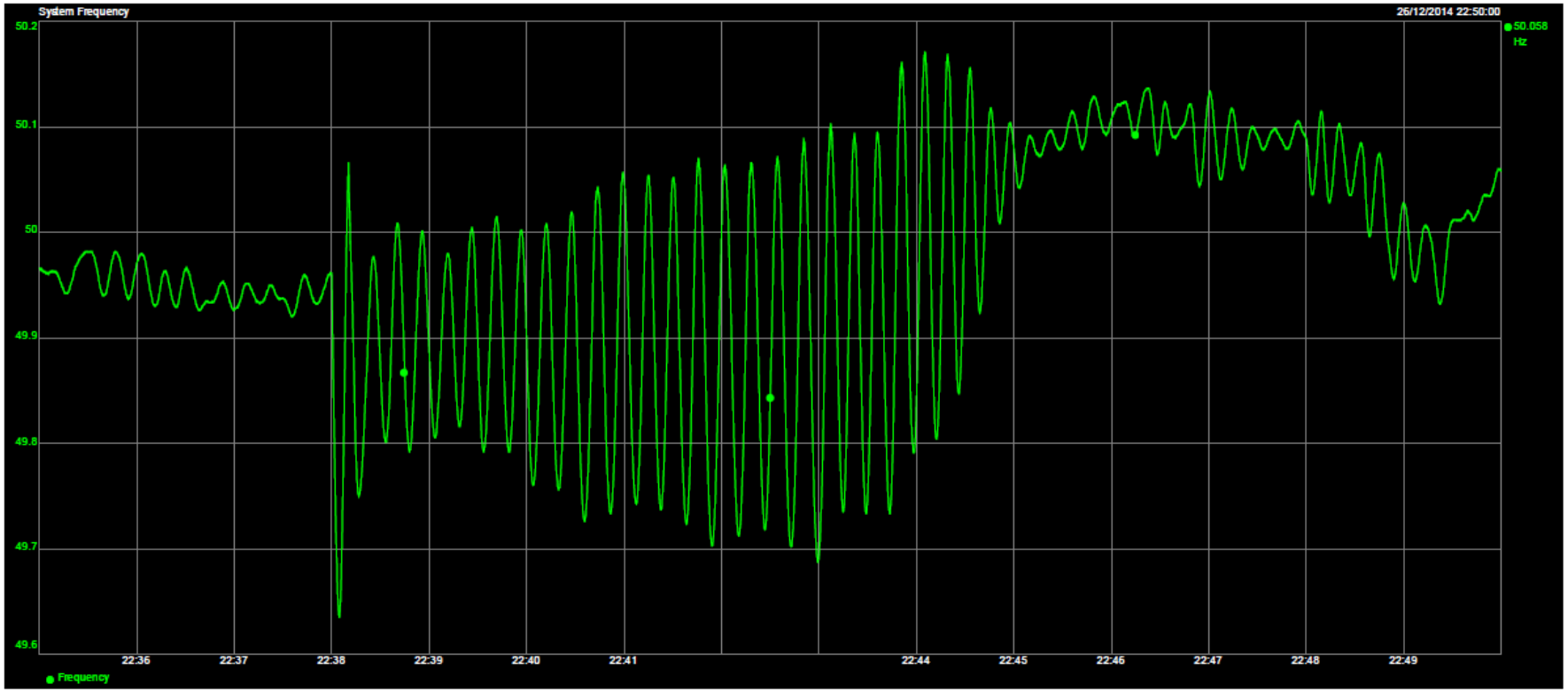
2014 Oscillation Event

Date: 26/12/2014 22:38

Details:

Duration:	7mins approx.
Max Pk-Pk Amplitude:	484 mHz
Frequency/Mode:	0.06 Hz

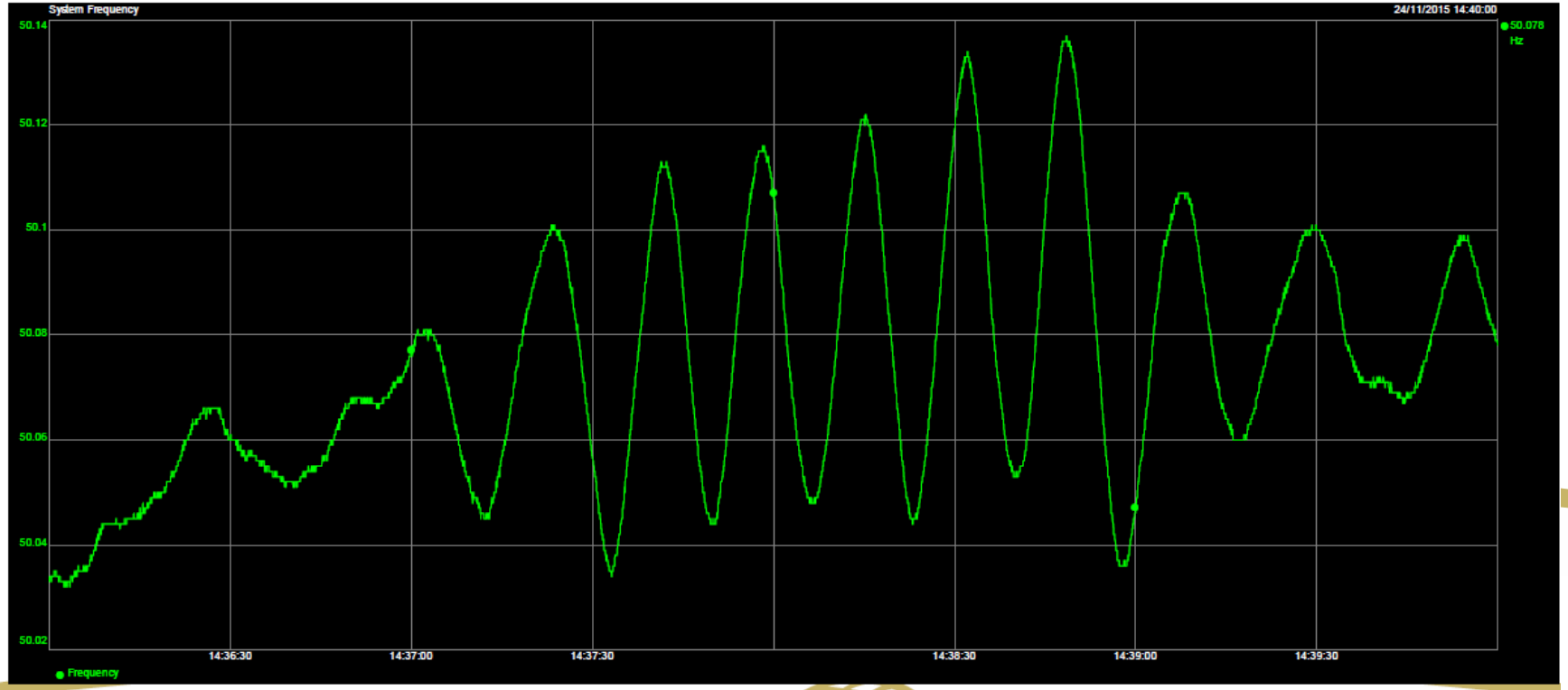


2015 Oscillation Event

Date: 24/11/2015 14:36

Details:

Duration:	2mins approx.
Max Pk-Pk Amplitude:	100 mHz
Frequency/Mode:	0.06 Hz

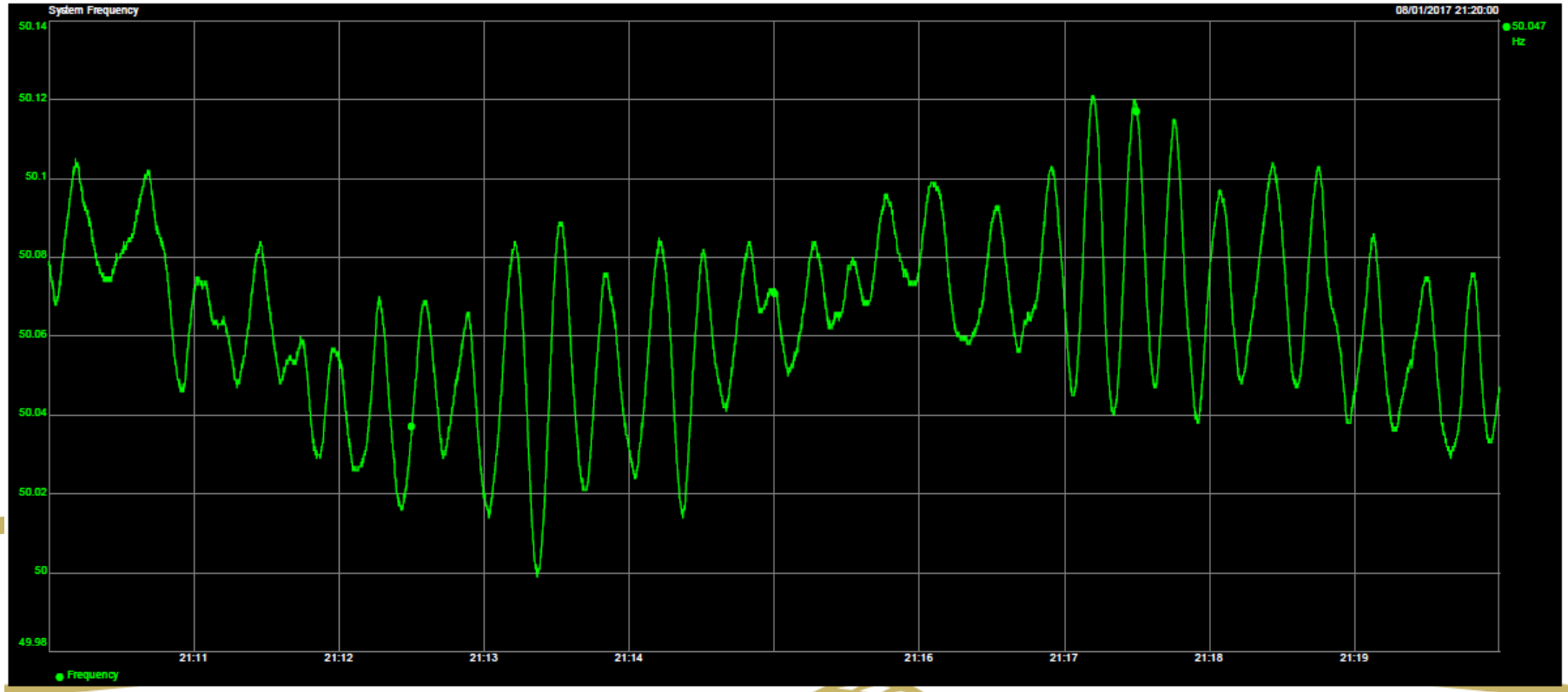


2017 Oscillation Event

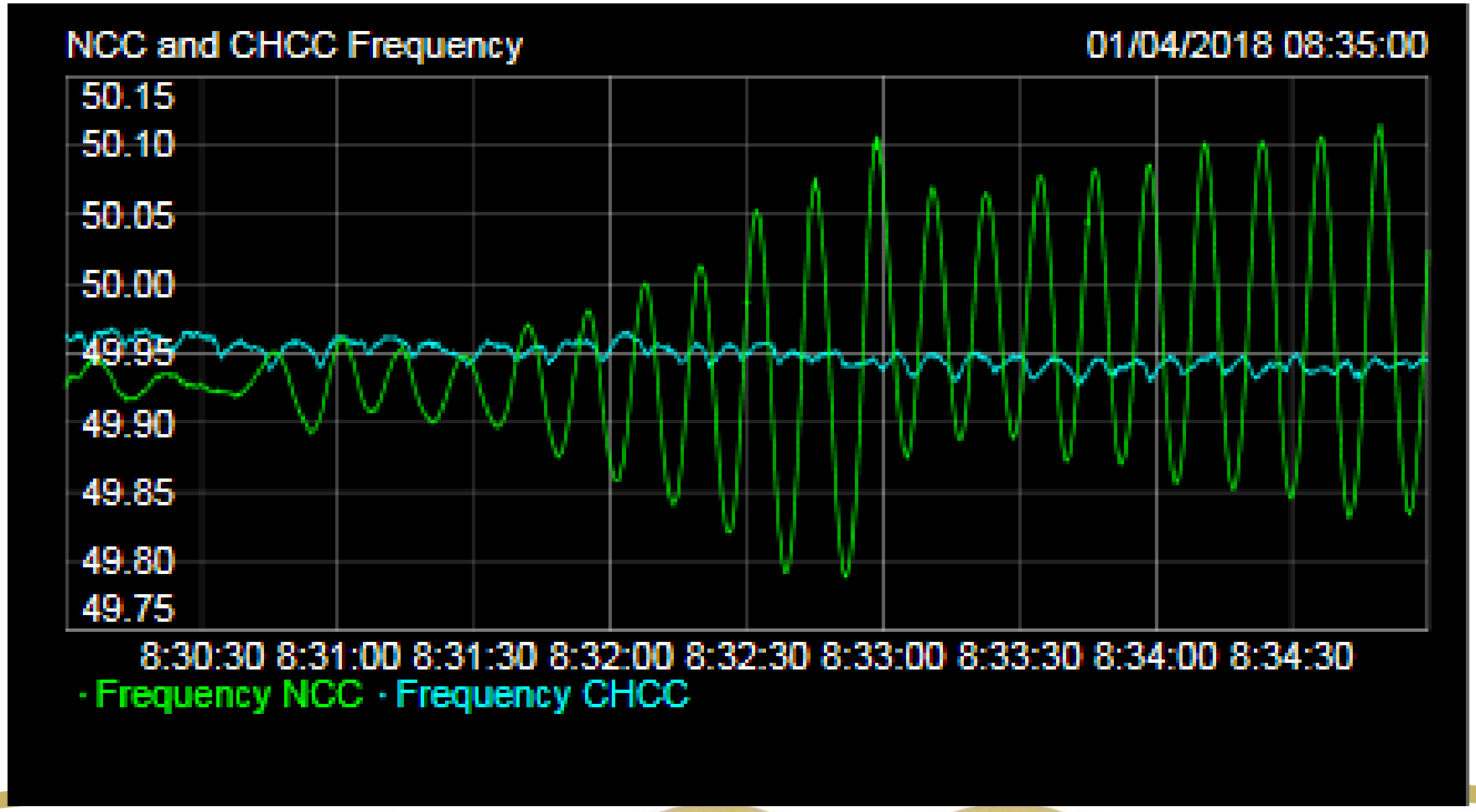
Date: 08/01/2017 21:10 – 21:20

Details:

Max Pk-Pk Amplitude:	85mHz
Frequency/Mode:	0.05 Hz



2018 Oscillation Event



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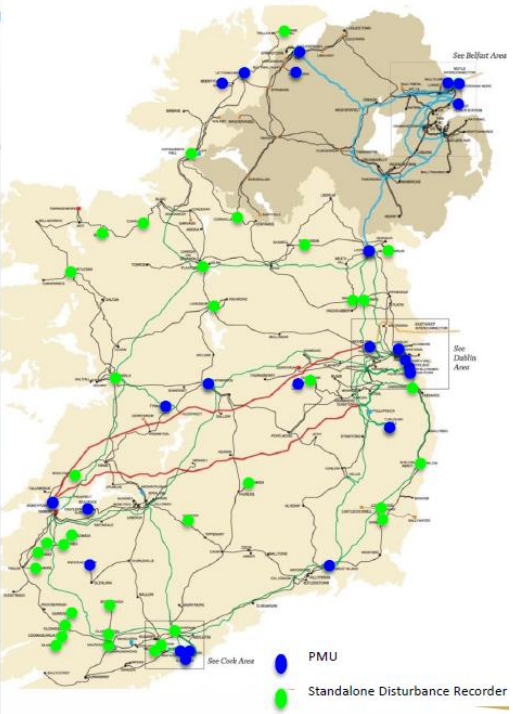
PMU Device and Locations

- 2/2 HVDC Interconnectors
- 14/15 Gas CCGTs
- 5/9 Coal Units
- 3/4 IE-NI Tie Lines
- 3/8 Priority Dispatch Units
- 2/17 GT/Peaking Units
- 4/36 TSO connected windfarms
- 2/4 Pumped Storage Units
- 0/15 Hydro Units



- Installed at larger gen units first and areas where comms was readily available
- Devices installed on ~ 85% of remaining units

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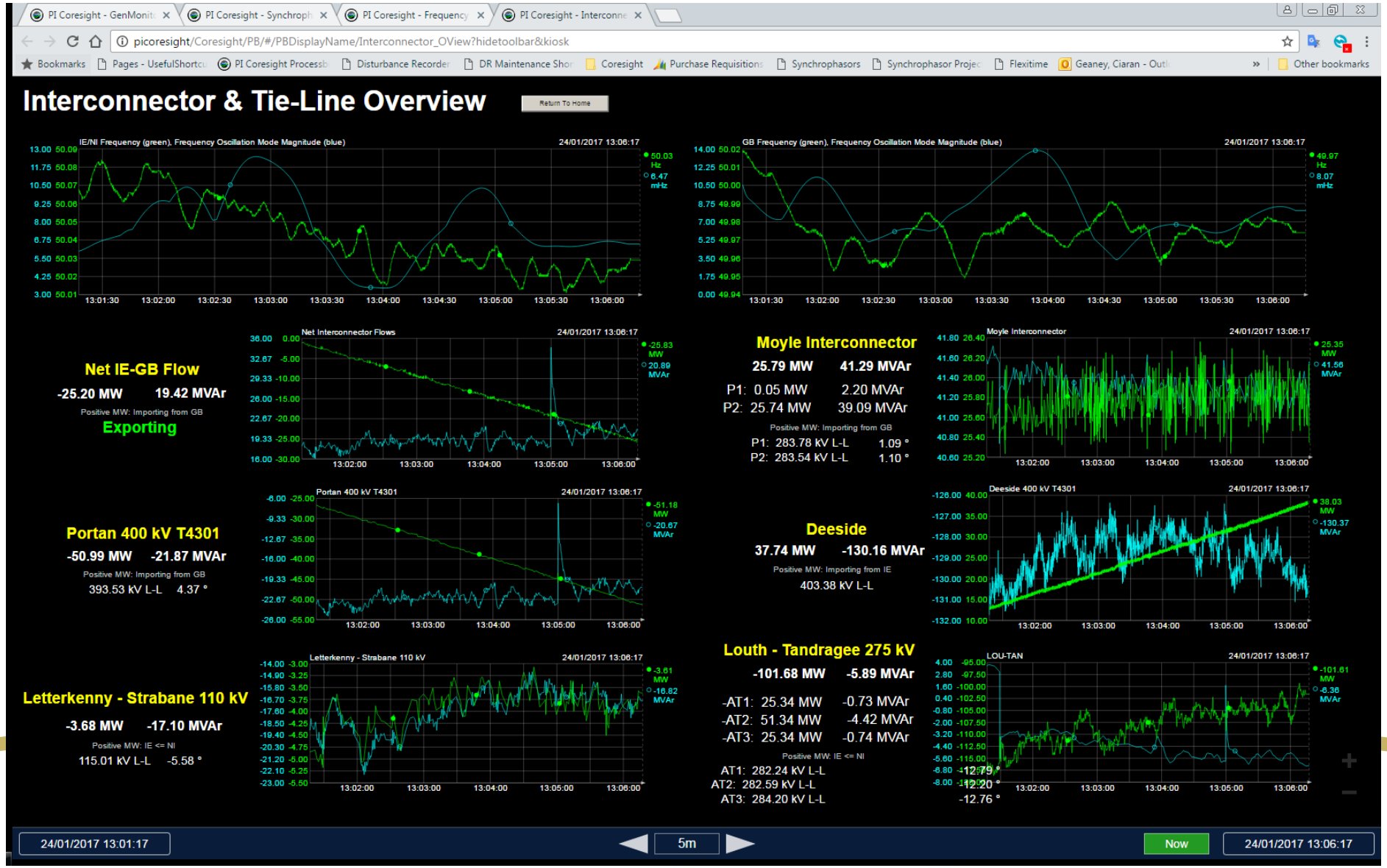
PI System


PI Coresight - GenMonit
PI Coresight - Synchroph
PI Coresight - Frequency
PI Coresight - Interconne
picoresight/Coresight/PB/#/PBDisplayName/Interconnector_OView?hidetoolbar&kiosk
Bookmarks
Pages - UsefulShortcu
PI Coresight Processb
Disturbance Recorder
DR Maintenance Shor
Coresight
Purchase Requisitions
Synchrophasors
Synchrophasor Projec
Flexitime
Geaney, Ciaran - Outlo
Other bookmarks
Interconnector & Tie-Line Overview
Return To Home
IE/NI Frequency (green), Frequency Oscillation Mode Magnitude (blue)
24/01/2017 13:06:17
50.03 Hz
6.47 mHz
GB Frequency (green), Frequency Oscillation Mode Magnitude (blue)
24/01/2017 13:06:17
49.97 Hz
8.07 mHz
Net IE-GB Flow
-25.20 MW 19.42 MVAr
Positive MW: Importing from GB
Exporting
Net Interconnector Flows
24/01/2017 13:06:17
-25.83 MW
20.89 MVAr
Moyle Interconnector
25.79 MW 41.29 MVAr
P1: 0.05 MW 2.20 MVAr
P2: 25.74 MW 39.09 MVAr
Positive MW: Importing from GB
P1: 283.78 kV L-L 1.09 °
P2: 283.54 kV L-L 1.10 °
Moyle Interconnector
24/01/2017 13:06:17
25.35 MW
41.56 MVAr
Portan 400 kV T4301
-50.99 MW -21.87 MVAr
Positive MW: Importing from GB
393.53 kV L-L 4.37 °
Portan 400 kV T4301
24/01/2017 13:06:17
-51.18 MW
-20.67 MVAr
Deeside
37.74 MW -130.16 MVAr
Positive MW: Importing from IE
403.38 kV L-L
Deeside 400 kV T4301
24/01/2017 13:06:17
38.03 MW
-130.37 MVAr
Letterkenny - Strabane 110 kV
-3.68 MW -17.10 MVAr
Positive MW: IE <= NI
115.01 kV L-L -5.58 °
Letterkenny - Strabane 110 kV
24/01/2017 13:06:17
-3.61 MW
-16.82 MVAr
Louth - Tandragee 275 kV
-101.68 MW -5.89 MVAr
-AT1: 25.34 MW -0.73 MVAr
-AT2: 51.34 MW -4.42 MVAr
-AT3: 25.34 MW -0.74 MVAr
Positive MW: IE <= NI
AT1: 282.24 kV L-L
AT2: 282.59 kV L-L
AT3: 284.20 kV L-L
LOU-TAN
24/01/2017 13:06:17
-101.61 MW
-6.36 MVAr
-12.79 °
-12.20 °
-12.76 °
24/01/2017 13:01:17
5m
Now
24/01/2017 13:06:17

Oscillation NCC Protocol Summary

- Frequency Response is ON for all conventional
- Move suspected primary driver of an oscillation to a different set-point (20 MW steps)
- Redistribute downward and upward regulation over a number units IE and NI; this includes:
  - Move units above their min load
  - Move units below their full load
- Start GTs to provide more regulation / inertia
- Curtail wind by up to 5%
- Enable Active Power Control (APC) and Frequency Response (FQR) for windfarms which provide enhanced frequency response.
- Switch Frequency response OFF on suspected driver of the oscillation;

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International Experience

Individual Plant Tuning

- New Zealand
  - Hydro unit mechanical oscillation
- Nordic
  - Tune hydro governors to stabilise mode

System Tuning

- Australia
  - Inter-Area damped using AVR tuning
- Canada
  - New PSS to dampen modes
- New England ISO
  - SVC tuning

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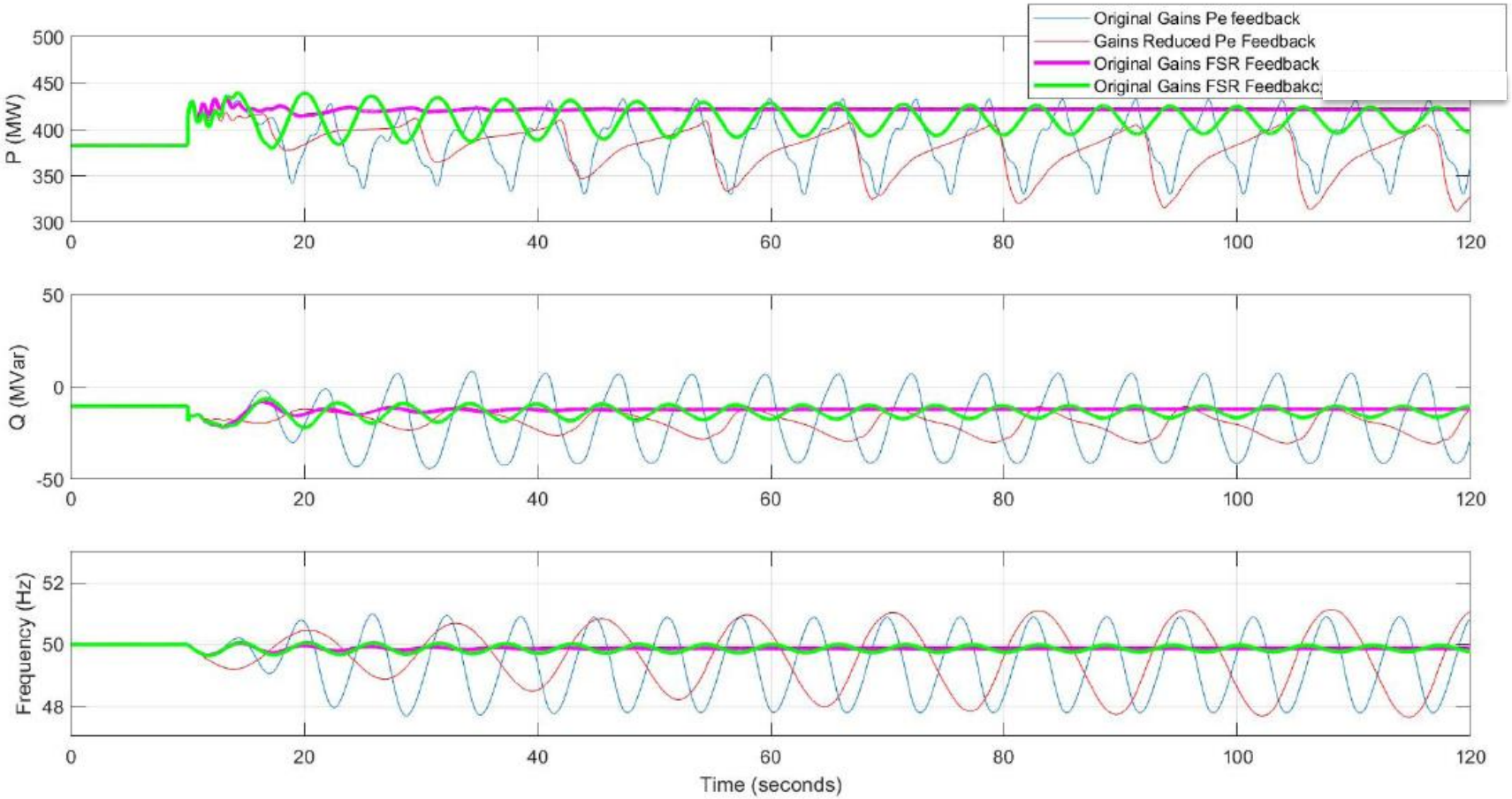
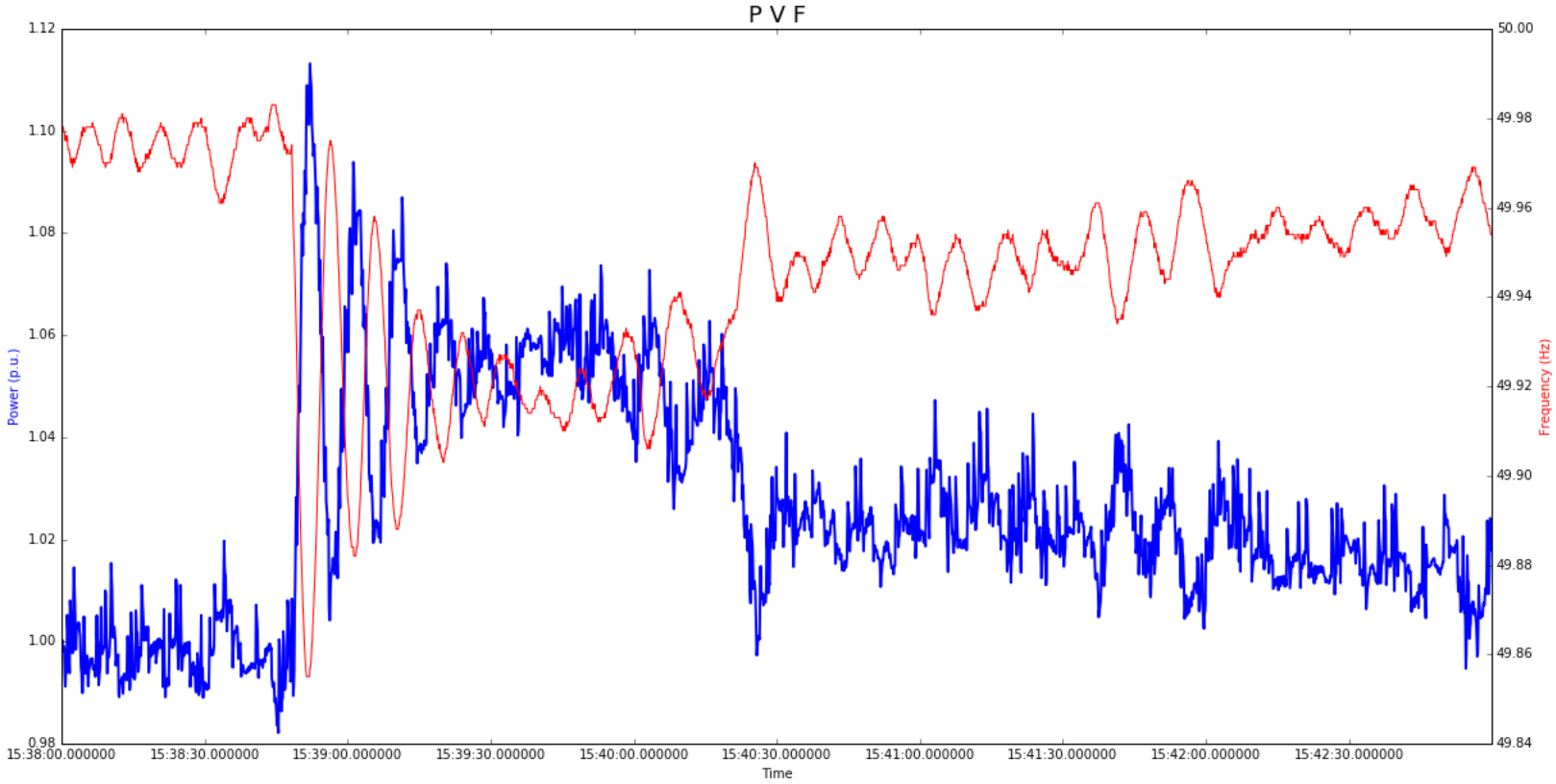
Individual Tuning



Other Technologies - Wind



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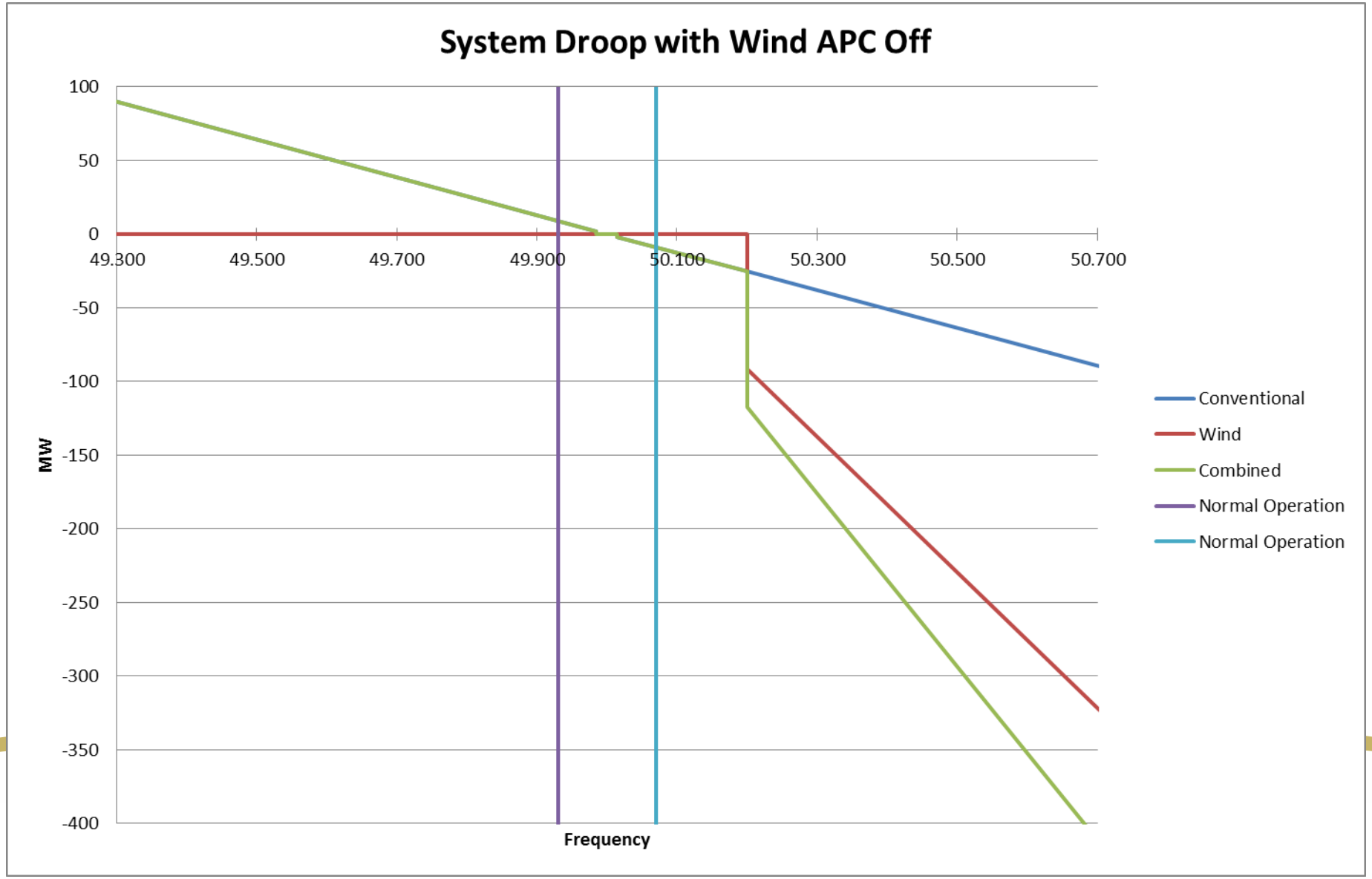
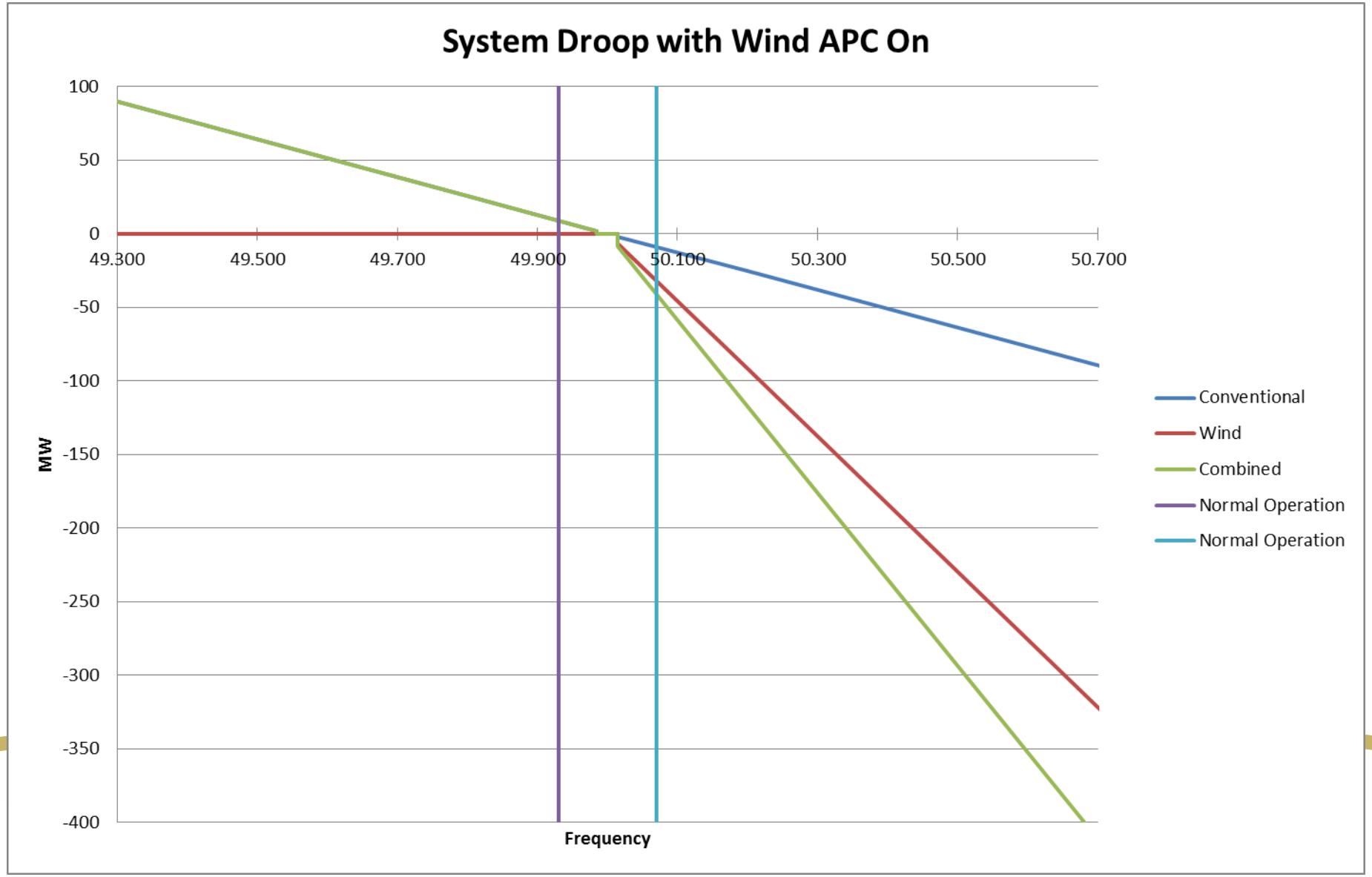
System Droop



System Droop



Summary

- Oscillation Events
- Installed Sychrophasor System
- NCC Protocol
- Analysis of control system of existing plant
- Investigating new ways to add more damping to the system

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Questions

?

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EU-SysFlex

DELIVERABLE 2.1 OVERVIEW

Noel Cunniffe

23rd May 2017

Deliverable 2.1 – State of the Art Literature Review

- **Review covering**: 28 RES integration studies, projects and grid codes
  - Focus on European power systems with inputs from US and Australia
- **Initial conclusions**
  - Several technical scarcities showing technical issues of high levels of non-synchronous renewable generation and need for system flexibility
- **Scarcities identified**
  - **Lack of frequency control** – Inertia, Operating Reserves, Ramping Capability
  - **Lack of voltage control** – Steady-state & Dynamic Control, Short Circuit Power
  - **Rotor angle instability** – Small-signal Stability, Large-disturbance Stability
  - **Network congestion** – Hosting Capacity, RES Curtailment, Capacity Allocation
  - **Need for improved system restoration** – Black-start Capability, Network Configuration, Load Restoration
  - **Degradation of system adequacy** – Variable RES Uncertainty, System Interdependencies

Final report submitted at the end of April 2018

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

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Deliverable 2.1 – Technical Studies and Projects Reviewed

Projects reviewed in Task 2.1	
1. Delivering Secure Sustainable Electricity System (DS3) (Ireland & N. Ireland)	15.GridTECH (EU)
2.All Island Grid study (Ireland & N. Ireland)	16.RAO Tool
3.Facilitation of Renewables study (Ireland & N. Ireland)	17.UMBRELLA
4.Massive Integration of Renewable Energy (MIGRATE) project (EU)	18.CIGRE – Innovation in the power system industry, Volume 5, June 2016, pp. 119-125
5.System Operability Framework (UK)	19.Coordinating cross-country congestion management
6.Technical and Economic Analysis of the European Electricity Power System with 60% Renewable Energy Sources (France)	20.Future system inertia 2 (Nordic countries)
7.PROMOTioN (EU)	21.Future Power System Security Program (FPSS) (Australia)
8.Challenges and Opportunities for the Nordic power system (Nordic countries)	22.Western Wind and Solar Integration Study (WWSIS)
9.100% RES in Baltic sea countries (Nordic countries)	23.Eastern Renewable Generation Integration Study (ERGIS)
10.e-Highway 2050 (EU)	24.Mid-Term Adequacy Forecast (MAF) 2017
11.MARKET4RES (EU)	25. ENTSO-E TYNDP 2018 - System Needs 2040 Report (EU)
12.NORTHSEAGRID (EU)	26.ENTSO-E 'Requirements for Generators' (EU)
13.GRID4EU (EU)	27.ENTSO-E 'Network Code on HVDC Connections' (EU)
14.REserviceS (EU)	28.ENTSO-E 'Demand Connection Code' (EU)

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Deliverable 2.1 – Technical Scarcities – Frequency Control

- **Continued decrease in system inertia**
  - This issue has been identified by numerous studies (Ireland, GB, Continental Europe, Nordic) for increasing penetration of non-synchronous renewable generation
- **The reduction in system inertia can potentially lead to the following major impacts on system operation:**
  - Excessive frequency excursions (following an energy imbalance): problematic if under or over-frequency relay settings for both generation and demand have been tuned for systems with higher inertia
  - Excessive rate of change of frequency (RoCoF) can lead to the operation of Loss of Mains protection on the distribution system (EirGrid, National Grid) leading to further generation loss or wide-are frequency instability on transmission level
  - Market solutions with new products for faster response : IE/NI, GB, Nordic

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Deliverable 2.1 – Technical Scarcities – Frequency Control

- **Decreasing operating reserves** and the **need for faster response times**
  - Ireland/GB, Nordic, continental Europe: Faster reserve response is crucial to mitigate excessively low frequency nadirs and Voltage Dip Induced Frequency Deviations (VDIFD)
  - Ireland: high penetrations of wind generation led to considering VDIFD as an alternative to the loss of the largest single infeed as a worse case event inducing to a need for operating reserves
- **Geographical location of reserve providers**
  - Nordic system: geographically unbalanced volumes of primary reserves can lead to the inability to balance active power in the timeframes required – i.e. reserve is situated all in one country
- **Flexible ramping**
  - IE/NI system has identified a need for increased flexible ramping services over a 1 – 12 hour time period
- **Solutions Market based and technology**
  - New products: sub 5 second products in place: IE/NI, GB, Nordic system
  - Non-synchronous generation (wind and solar) have proven their ability to provide reserve services and are being used or considered in several systems

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Deliverable 2.1 – Technical Scarcities – Voltage Control

- **Reduction of short-circuit power** (National Grid, AEMO, MIGRATE, e-highways2050)
  - Short circuit power provides an indication of the local dynamic performance of the system and behaviours in response to a voltage disturbance
- **Reduction in steady-state and dynamic voltage control capability**
  - Due to the displacement of transmission-connected conventional generation by distributed non-synchronous generation
- **Technical impacts**
  - Leading to a larger propagation of voltage dips caused by short-circuit events. This can negatively impact protection schemes and needs to be assessed and addressed in future – some systems actively addressing low Short Circuit Ratio (IE/NI, GB)
- **Market and technical solutions**
  - The need for non-synchronous generation to provide voltage support to the transmission system (EirGrid and SONI, National Grid, GRID4EU, PROMOTioN, REserviceS)
  - Development of synchronous compensators in Denmark

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Deliverable 2.1 – Technical Scarcities – Rotor Angle Stability

- Rotor angle stability has been identified as a concern for future systems with high non-synchronous generation levels (e-highways2050)
  - refers to 'the ability of synchronous machines of a power system to remain in synchronism after being subjected to a disturbance' and includes : small-signal and transient stability
- **Technical impacts**
- Lack of synchronising torque results in non-oscillatory instability, and lack damping torque leads to oscillatory instability => due to the reduction in synchronous plant
  - Oscillations of a group of generators maintaining synchronism in one area swinging against another group in another area; these are inter-area modes or inter-area oscillations
  - Inability of a power system to maintain synchronism after a severe disturbance and has been observed as a critical issue in areas with very high levels of non-synchronous generation (EirGrid and SONI, MIGRATE)
- **Technical solutions**
  - To monitor Critical Clearance Time (CCT) following a fault at high RES periods since this is a key indicator for this phenomenon and take preventive re-dispatch measures

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Deliverable 2.1 – Technical Scarcities – Congestion Mgt.

- Increased renewable generation has increased power flows from areas with abundance of natural resources, which have resulted in network congestion
- **Technical and economic impacts**
  - Congestion can lead to RES curtailment and/or limit the ability to connect new RES and is one of the main obstacles to achieve full benefits from the regional energy market.
  - Several projects have identified the need for increasing network hosting capacity in order relieve network congestion (UMBRELLA, GRID4EU,GridTECH, Nordic TSO Analysis Group)
- **Technical and organizational solutions**
  - Active management of network congestions through smart control devices to increase grid hosting capability (UMBRELLA, GRID4EU,GridTECH, Nordic TSO Analysis Group)
  - Flexibility demonstration projects and innovative solutions achieve this through demand side management, energy storage, smart location of reserve services, on-load tap changers and grid reconfiguration
  - Control and smart application of RES Curtailment
  - Enhance cross-border interconnection and evolve markets mechanisms (cost sharing, information sharing)

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Deliverable 2.1 – Technical Scarcities – System restoration

- **Technical impacts**
  - Large-scale synchronous generation has traditionally provided system restoration. As these generators are being displaced, new restoration strategies shall be developed to enable non-synchronous generators to provide it.
- **Market and technical solutions:**
  - Modern technologies enable converter-fed variable generation to provide both frequency and voltage control dynamically, as required by black-start generators
  - This suggests that system restoration could be realized in a bottom-up way enabling renewable generation to participate in such restoration procedures
  - Strong TSO-DSO coordination would be required for this to become a reality
  - An appropriate market mechanism could be established to remunerate the capabilities of non-synchronous generators able to provide restoration services (e.g. incorporation of black-start services in capacity market)

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Deliverable 2.1 – Technical Scarcities – System adequacy

- **Technical impacts**
  - Continued decommissioning of thermal plants will cause capacity margins to become tighter
- **Market and technical solutions:**
  - Cross-border coordination appears to be a key enabler of system adequacy in a European-wide scale, as interconnectors can enable countries to share capacity leading to a pro-EU approach rather than a member state centric one
  - This approach could reduce the requirement for additional generation capacity
  - Suitable capacity markets should also be in place to create a level playing field between traditional generation and distributed energy resources

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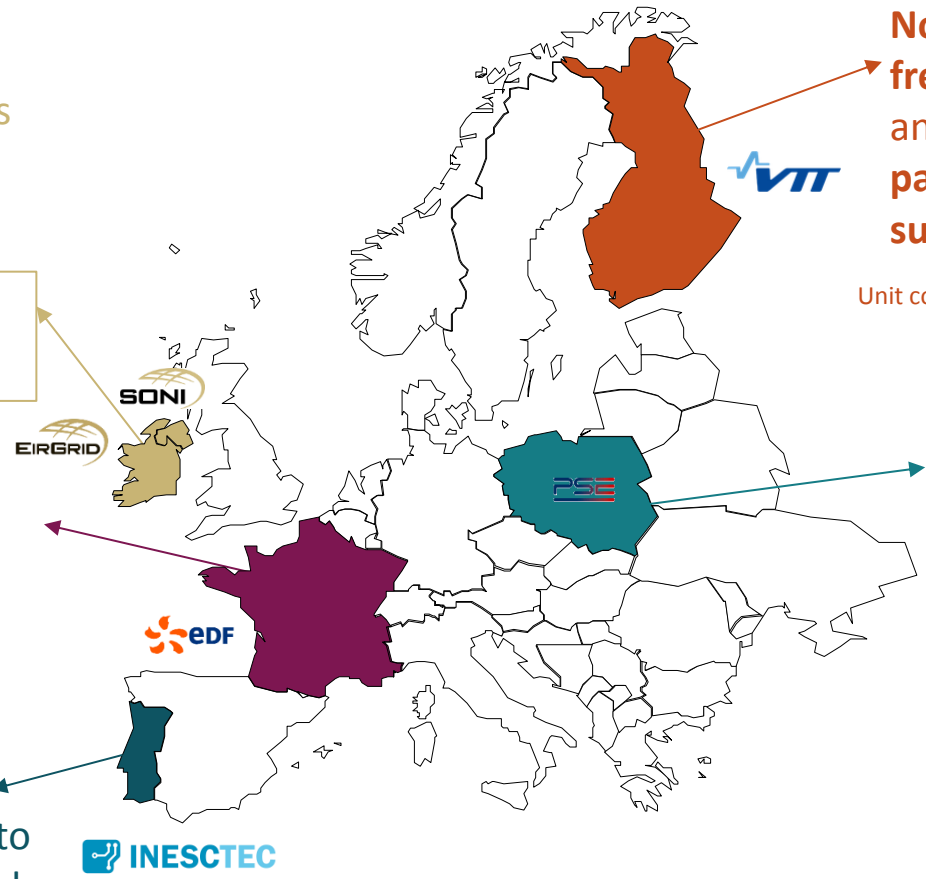
Work Package 2 – Future work on System Studies

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

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EIRGRID SONI