DS3 Advisory Council Meeting

19th January 2016, Dublin

EIRGRID GROUP

Agenda

	Time	Speaker
Introduction	10.00	Louis Fisher (5 mins)
Industry Perspective	10:05	Presentation: Michael Conlon – DIT (10 mins) Presentation: Mick Hogan – ABB (10 mins) Presentation: Patrick Mohr – NTMA (10 mins) Presentation: Paddy Finn - Electricity Exchange (10min)
Actions from last meeting **DS3 Programme Status Update**	10:45	Presentation: Robbie Aherne (30 mins) Discussion: All (10 mins)
Rate of Change of Frequency (RoCoF) **(General Update)**	11:25	Presentation: David Cashman (10 mins) Presentation: ESB Networks (5 mins) Presentation: NIE (5 mins) Discussion: All (5 mins)
System Services **EirGrid (General Update)** **RA's (General update)**	11:50	Presentation: Eoin Kennedy (30 min) Presentation: RA's (15 min) Discussion: All (15 mins)
Lunch & Networking (12:50 – 13:50)		
SNSP Studies	13:50	Presentation: Ivan Dudurych (10 mins) Discussion: All (5 mins)
RoCoF Alternatives **(Technical Presentation)**	14:05	Presentation: Martin Eager (30 mins) Discussion: All (20 mins)
Closing Remarks and Actions	14:55	Louis Fisher (15 mins)
Session Closed / Networking	15:10	

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Industry Perspective

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Presentation to DS3 Advisory Council

19 January 2016

Prof Michael Conlon, Head of School

SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

DIT within the 3rd Level Sector

- **Provision of 3rd Level education from Level 6 to Level 10**
  - Broad scope of provision in terms of disciplines and levels
- **Student Numbers:**
  - 14, 297 undergraduate students (11,739 FT, 2,558 PT)
  - 2,396 postgraduate students (989 FT, 1,405 PT)
- **Undergoing significant change in the post-Hunt Report environment**
  - Merger with IT Tallaght and IT Blanchardstown in 2016/17
  - Application for Technological University in 2017
    - Technological Universities bill reached 2nd Stage in Dail Eireann in December 2015
  - Development of new DIT Campus in Grangegorman
    - 1000 students already located in Grangegorman since September 2014
    - New Greenway Hub will be occupied from February 2016
    - East and Central Quads to be occupied in September 2018 (10,000 students)

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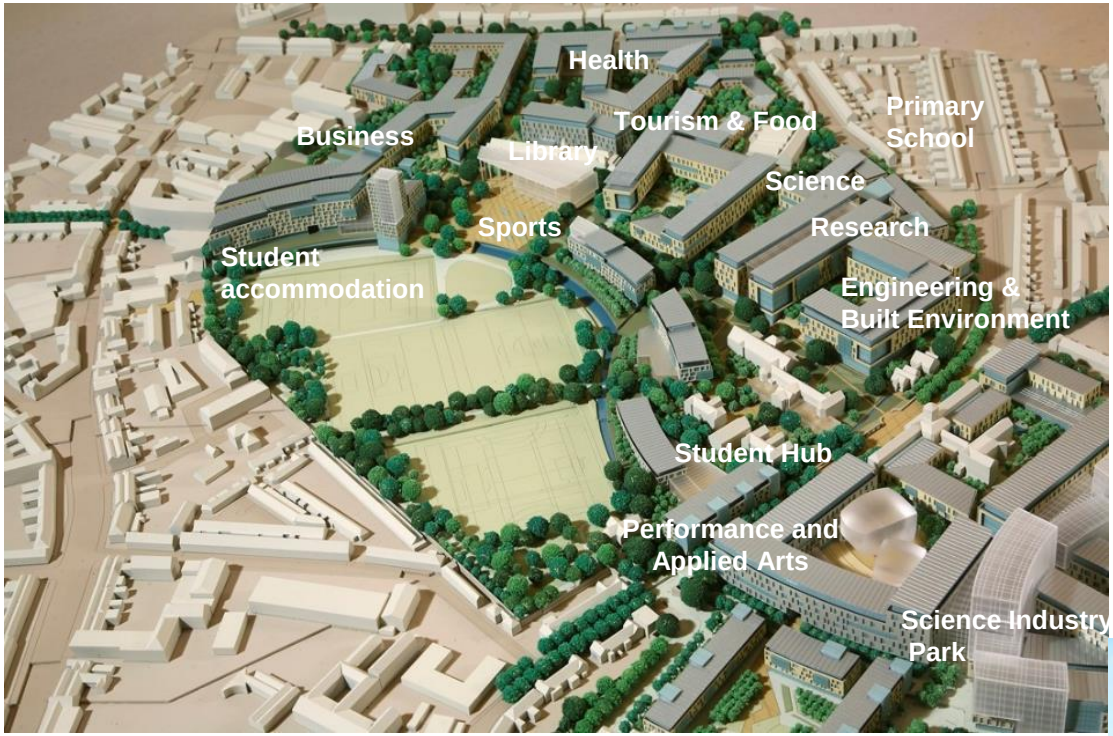
Grangegorman Campus



Greenway Hub:

- First new build on DIT Campus
- Environment, Sustainability and Health Institute
- DIT Technology Transfer/Hothouse
- Includes provision for Dublin Energy Lab (DEL)

SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

School and College

- **School of Electrical and Electronic Engineering**
  - One of 7 Schools in College of Engineering and Built Environment
- **Total of 100 staff, including 78 academic staff plus technical and administrative**
- **Core disciplines:**
  - Communications Engineering
  - Control Systems Engineering
  - Electronic Engineering
  - Electrical Power Engineering
  - Computer systems Engineering
  - Electrical Services Engineering
  - Energy Management
- **Engaged in all levels from Level 6 to Level 10**
  - MSc in Energy Management
  - ME in Sustainable Electrical Energy Systems

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Research Focus

Photonics Research Centre

Prof Gerald Farrell

- Optical sensors: Stress, temperature, humidity etc.
- Photonic device simulation
- Smart materials and structures
- Liquid Crystal Infiltrated Photonic Crystal Fibres
- Micro and nano photonics

Antennas and High Frequency Research Centre

Prof Max Ammann

- Small antennas
- Broad and Ultra-wide band antennas and EBG structures
- Antennas for Medical Applications
- Antennas for Solar Cell integration

Communication Networks Research Institute

Prof Mark Davis

- WLAN Radio Resource Management
- WLAN Mesh Networks
- Multi-Media over WLANs

Electrical Power Research Centre

Prof Michael Conlon

- Focus on integration of renewable energy and power quality
- Development of custom power electronic interfaces

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Electric Power and Energy Research

Both within EPRC and DEL

- EPRC: focus on electrical power engineering and power electronics
- DEL: DIT's interdisciplinary approach to energy research

Electrical Power Engineering:

- Integration of Renewable Energy in Electrical Networks
- Design and development of devices such as Active Power Filters and Unified Power Quality Conditioners
- Power Quality Monitoring - Analysis and Improvement
- Smart Grid and Microgrid Networks
- Electrical Networks for Wave Energy Systems
- Multi-Terminal High Voltage DC Systems
- Analysis and control of distribution networks

Dublin Energy Lab

- Encompasses energy research in Colleges of Engineering & Built Environment, Sciences & Health and Business
- Approximately 90 postgrads, postdocs and academic staff
- Applied research with a variety of companies

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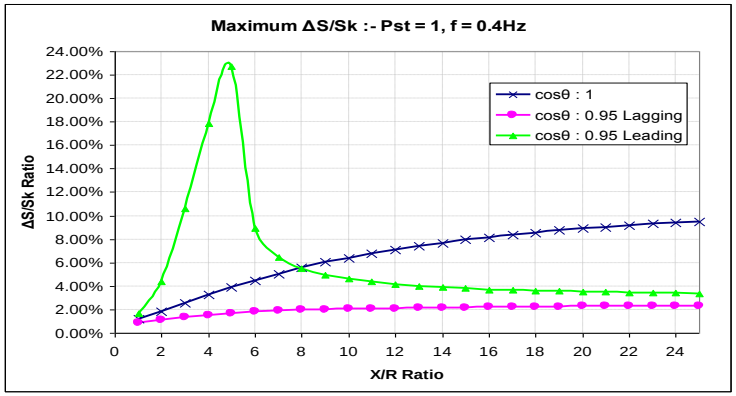
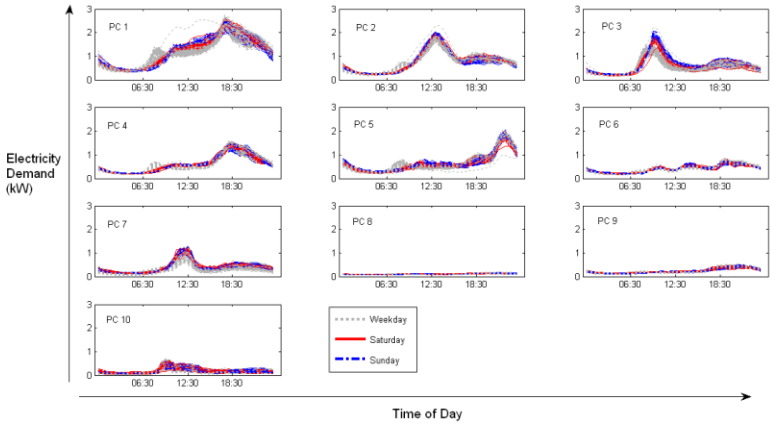
Electric Power and Energy Research - Projects

Fergus Sharkey, PhD, 2015: ***Offshore Electrical Networks and Grid Integration of Wave Energy Converter Arrays - Techno-economic Optimisation of Array Electrical Networks, Power Quality Assessment, and Irish Market Perspectives***



Fintan McLoughlin, PhD, 2013: ***Characterising Domestic Electricity Demand for Customer Load Profile Segmentation***



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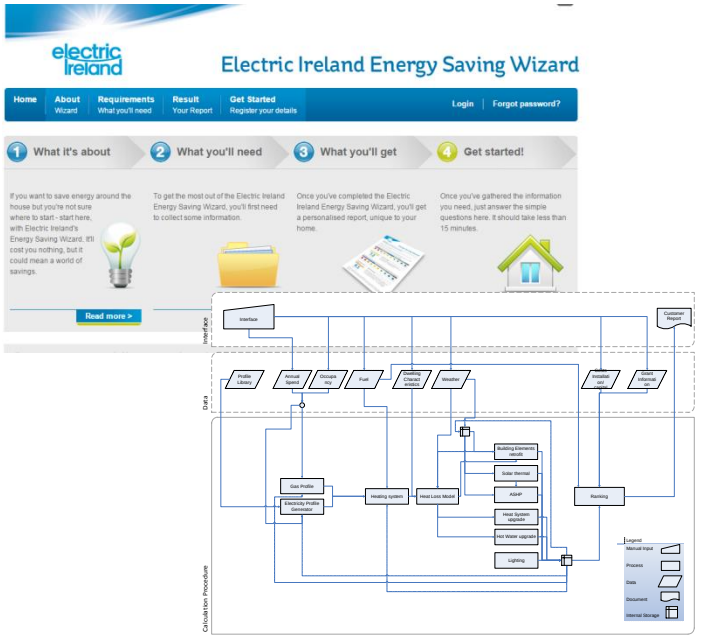
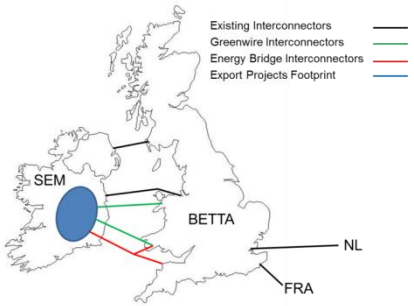
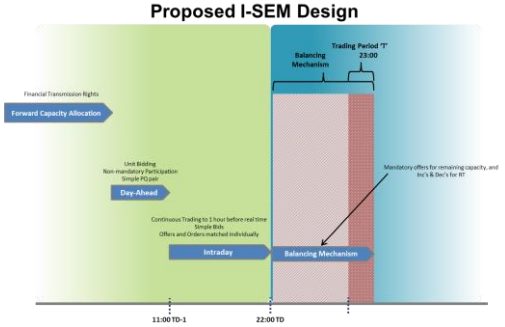
Electric Power and Energy Research - Projects

Daire Reilly, PhD, Current: ***Design and Development of Dwelling Energy Retrofit Assessment Tools for Irish Energy Consumers***



Brendan Cleary, PhD, Current: ***Evaluating the Future Economic Performance of Wind Generation in Conjunction with Compressed Air Energy Storage under Various Irish Electricity Market Conditions***





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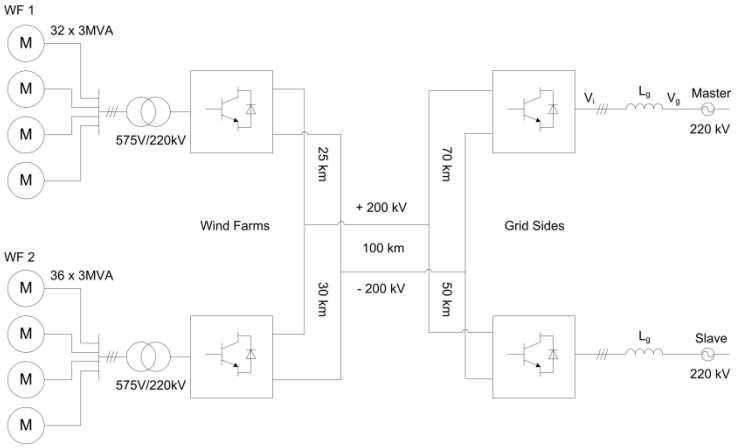
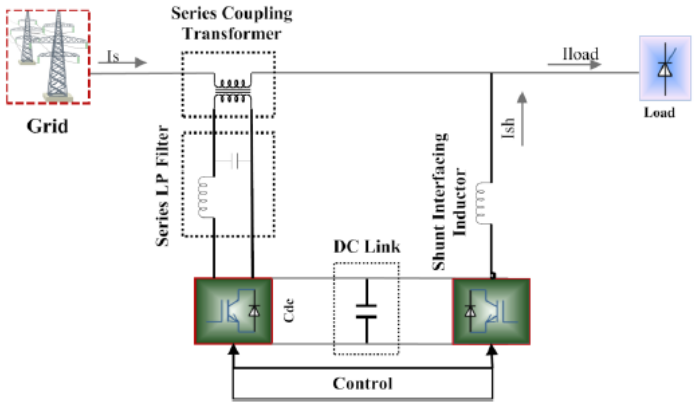
Electric Power and Energy Research - Projects

Roberto Sandano, PhD, Current: ***Performance and Operation of Multi-terminal HVDC Systems***



Shafiuzzaman Khan Khadem, PhD, 2013: ***Power Quality Improvement of Distributed Generation Integrated Network with Unified Power Quality Conditioner.***



www.arrow.dit.ie

Thank you

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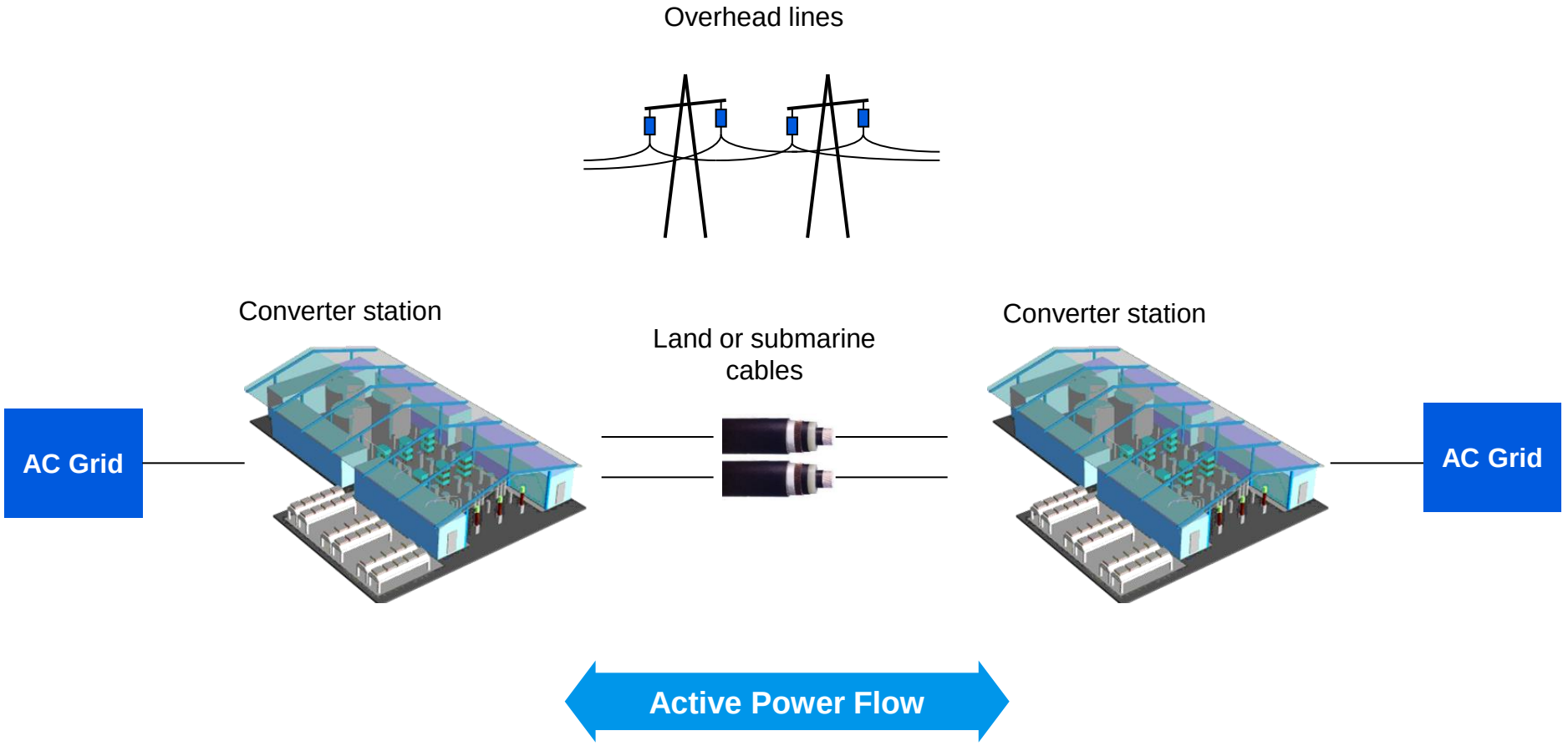
Mick Hogan, ABB Power Systems

Introduction to HVDC Technology

HVDC Transmission System



HVDC Technology

Two types of HVDC Technologies

- **LCC** - Line Commutated Converter

  High power capability – Thyristor based.

- **VSC** - Voltage Source Converter

  More controllable – IGBT based.

LCC (HVDC Classic)

Applications

- Interconnecting Grids
- Bulk Power Transmission / Connecting Remote Generation

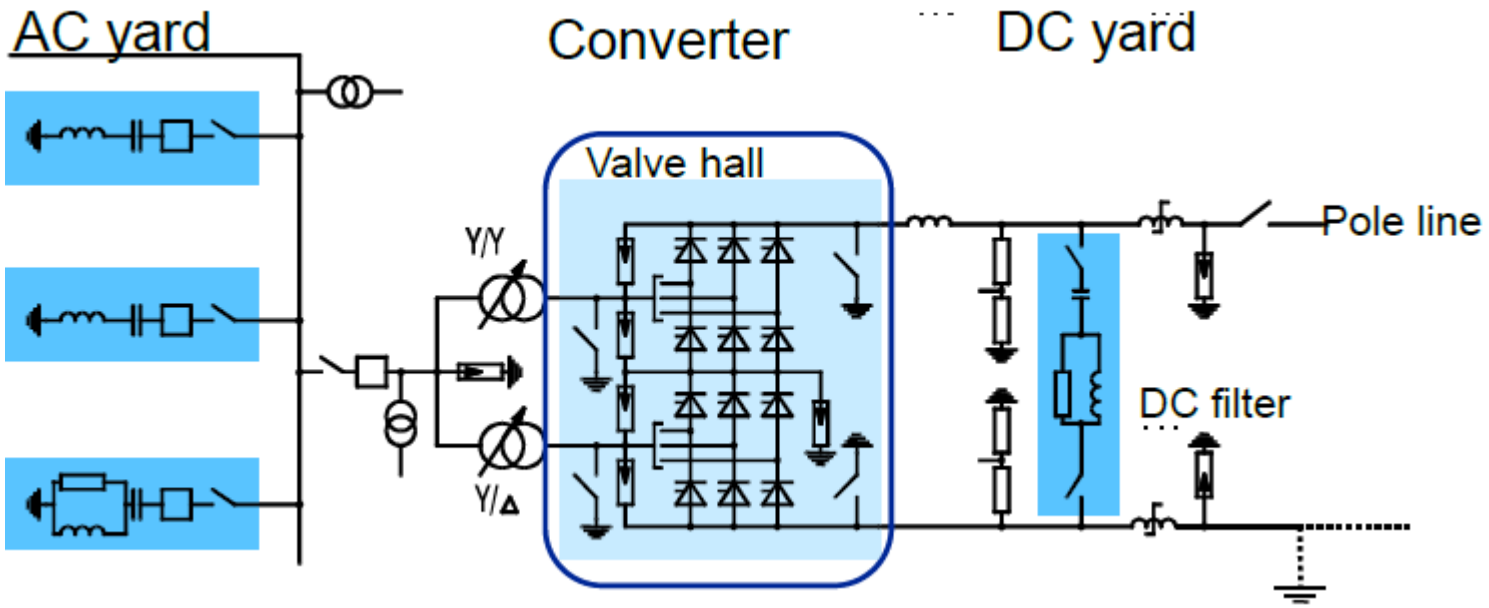
Ratings

- Up to 7,200 MW at ± 800kV

DC Transmission Link

- Overhead Lines
- MI Cables
- Back to Back

LCC Components



- Requires reactive power compensation
- Minimum short circuit capacity > 2x converter rating

LCC Example: Xiangjiaba – Shanghai

- Hydro Power 2,000 km from Load Center
- 7,200 MW
- ± 800kV DC
- Overhead Line

Xiangjiaba – Shanghai Converter Station

VSC (HVDC Light)

Applications

- Interconnecting Grids
- Offshore Wind Connections
- Power from Shore

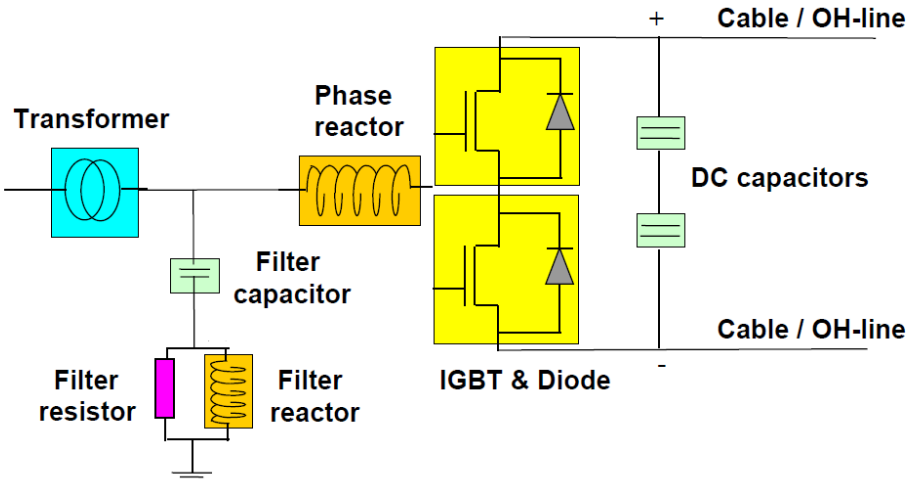
Ratings

- Up to 1,400 MW at ± 525kV

DC Transmission Link

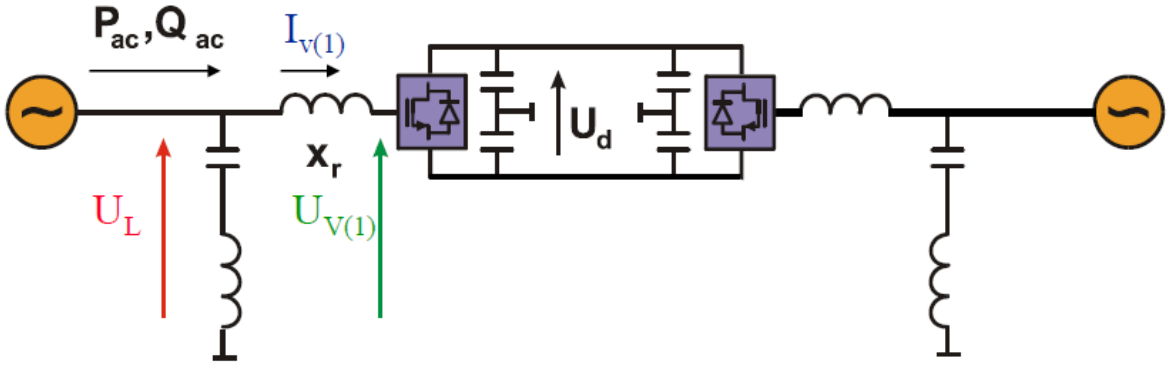
- Overhead Lines
- Extruded or MI Cables
- Back to Back

VSC Components

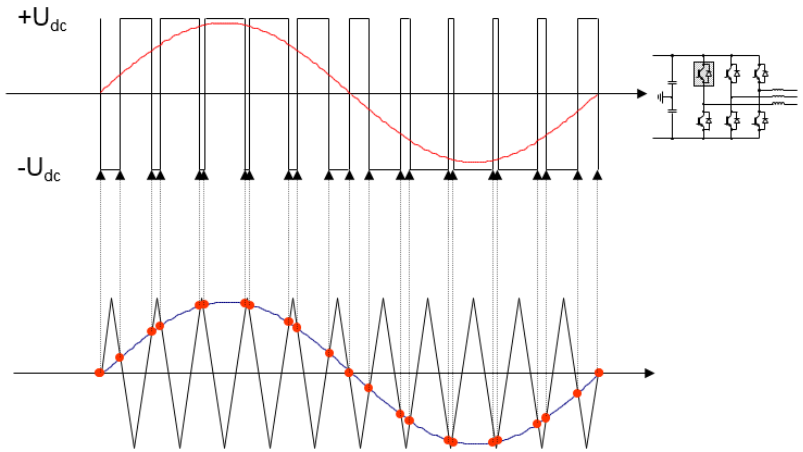


- Self-commutated IGBT valves (Allowing independent control of P & Q)
- Requires no reactive power compensation
- Can connect to a dead network

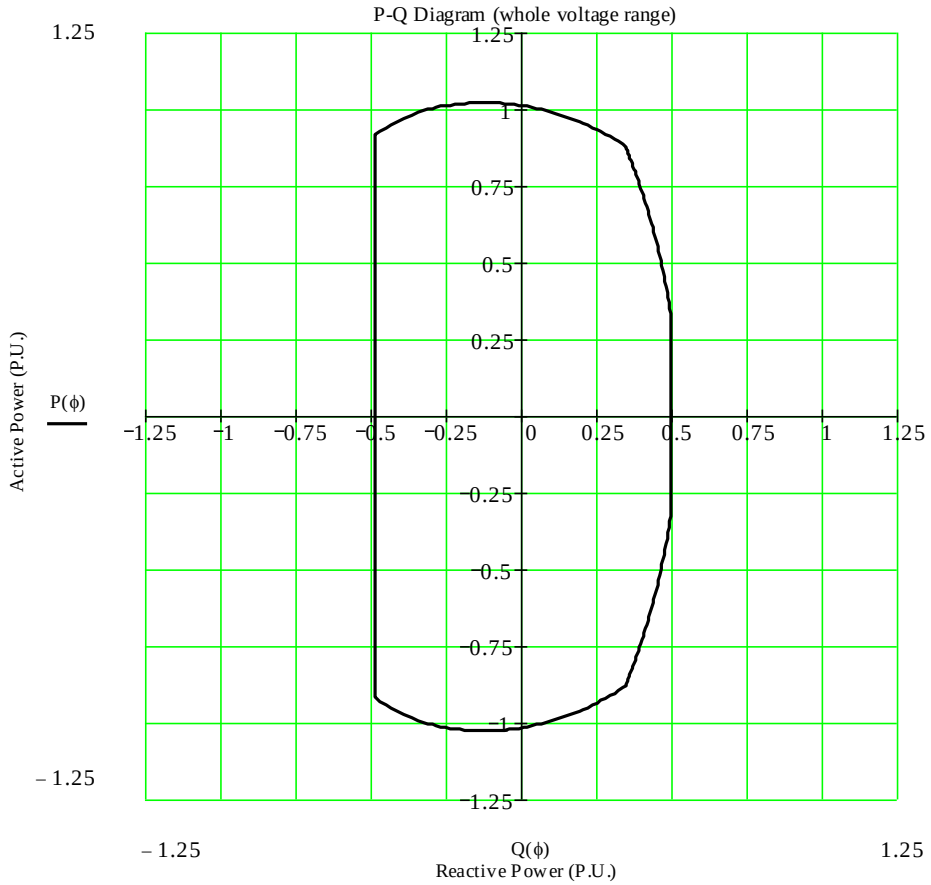
VSC Active and Reactive Power Control



Active and Reactive Power are controlled by the amplitude and phase of the Voltage UV(1) – using Pulse Width Modulation techniques.



VSC PQ Diagram



VSC Control Functions

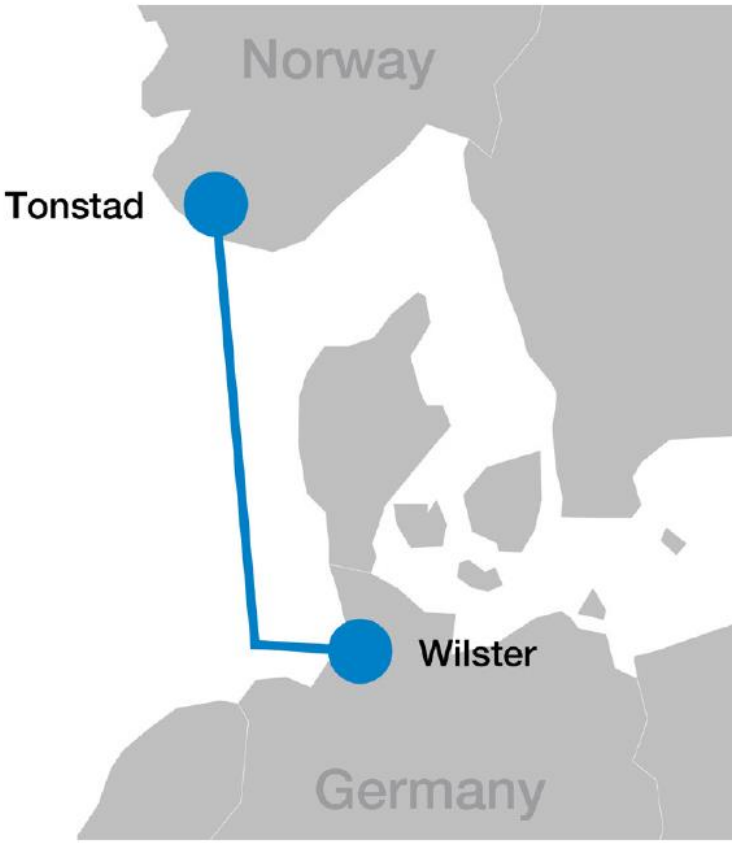
Basic Controls

- Active power control
- Reactive power control

Additional Controls

- Emergency power control
- Frequency control
- Blackstart

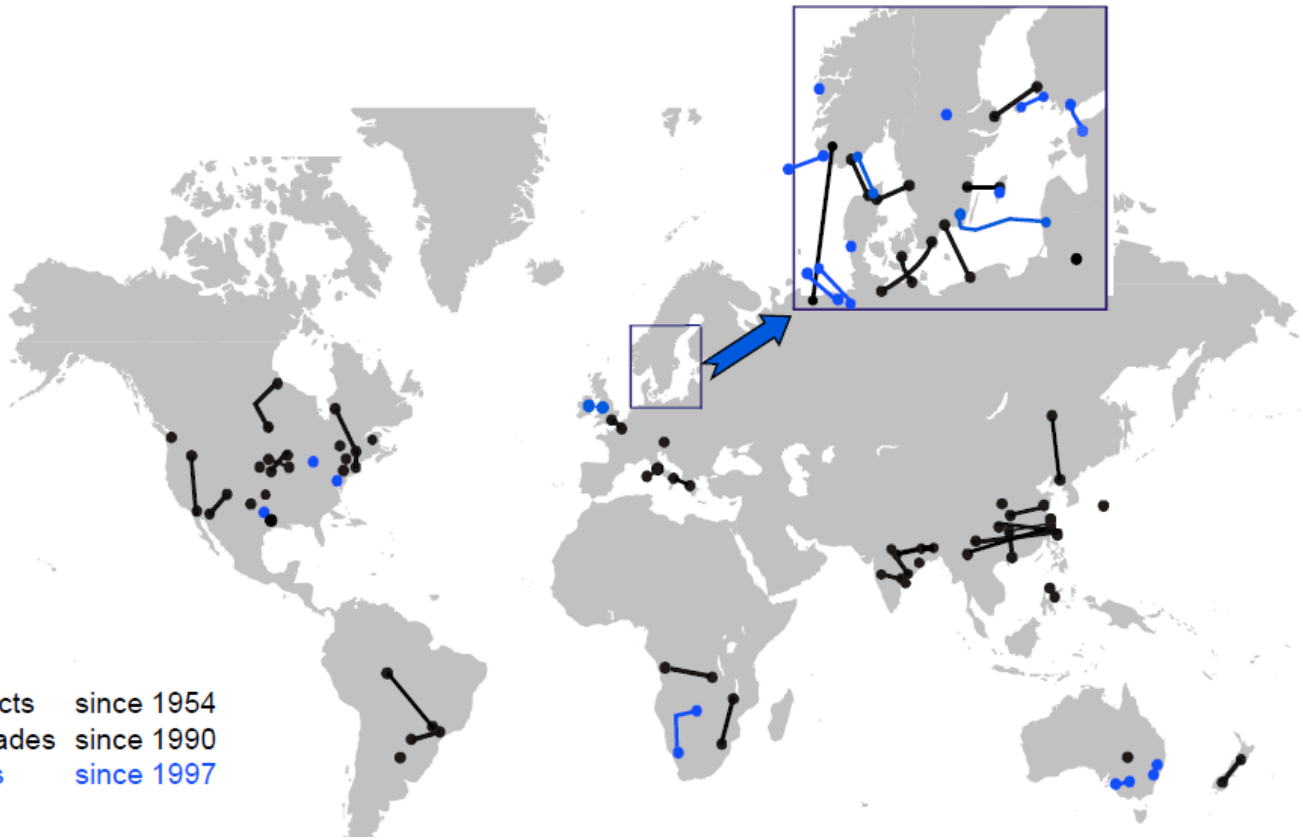
VSC Example - NordLink



- Commissioning Year 2020
- 1,400 MW
- ± 525 kV DC
- 623km – Land / Submarine Cable & OH Line.

NordLink Converter Station

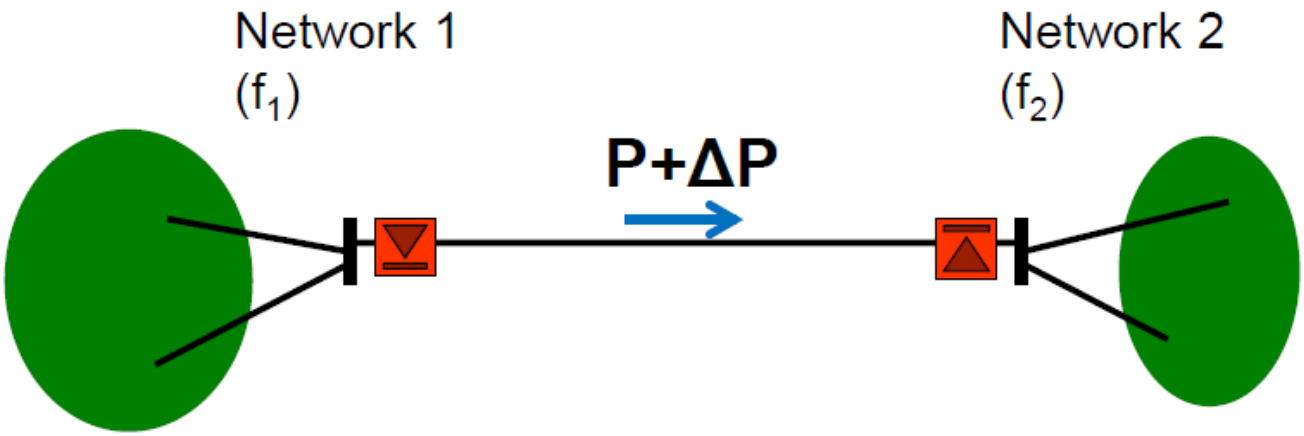
HVDC Projects Worldwide



60 HVDC Classic Projects since 1954
17 HVDC Classic Upgrades since 1990
20 HVDC Light Projects since 1997

http://new.abb.com/systems/hvdc

Relivance to DS3 - Frequency Control



- In the case of a loss of consumption / generation, HVDC can help with frequency stabilisation by active power modulation.
- Very fast increase / decrease of transmitted power using EPC.
- Dynamic Frequency Control using droop characteristic.

- Reactive Power Support

Power and productivity
for a better world™

Gníomhaireacht Bainistíochta an Chisteáin Náisiúnta
National Treasury Management Agency

Ciste Infheistíochta Straitéisí d'Éirinn
Ireland Strategic Investment Fund

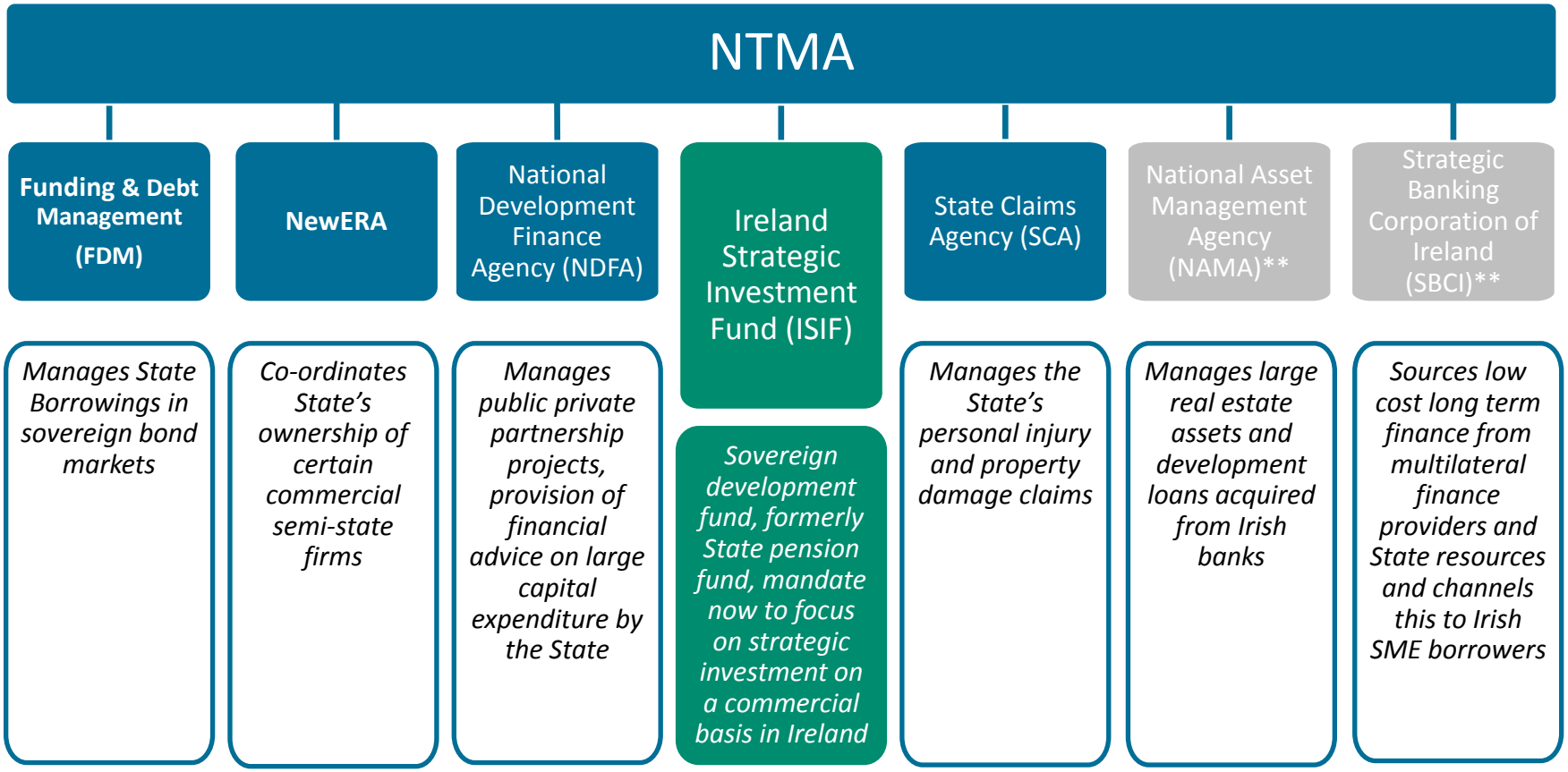
INVESTING IN THE FUTURE POWER SYSTEM

IRELAND STRATEGIC INVESTMENT FUND

PATRICK MOHR

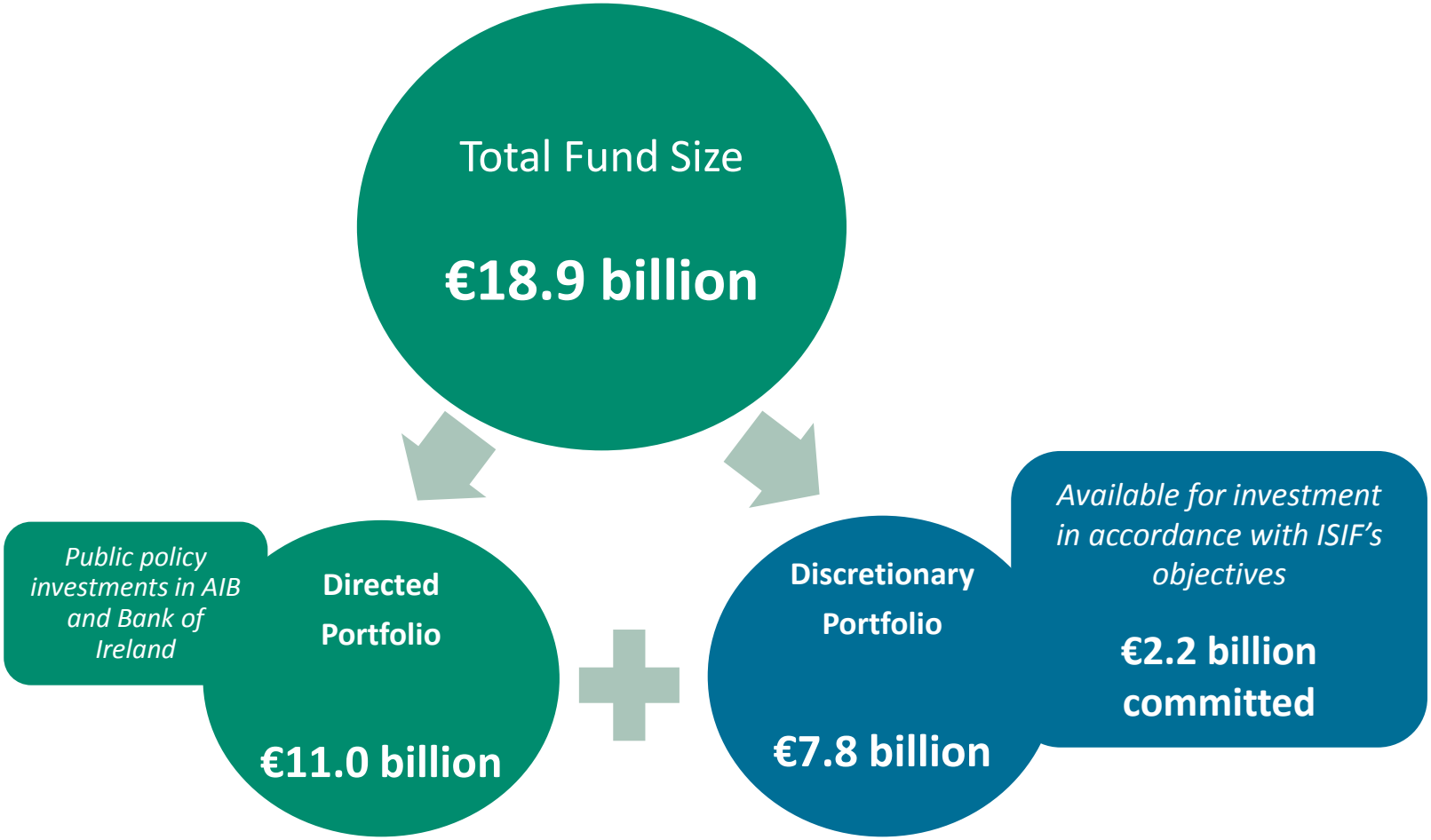
National Treasury Management Agency (NTMA)

The NTMA provides a range of asset and liability management services to the Government of Ireland and is the controller and manager of the Ireland Strategic Investment Fund



** Denotes businesses with separate boards staffed by NTMA

Fund Size and Structure



Gníomhaireacht Bainistíochta an Chisteáin Náisiúnta
National
Ciste Infheistiochta Straiteisi Eirinn
Ireland Strategic Investment Fund

Note: Figures are preliminary as at 31 Dec 2015, AIB valuation o/s

A Unique and Challenging Mandate

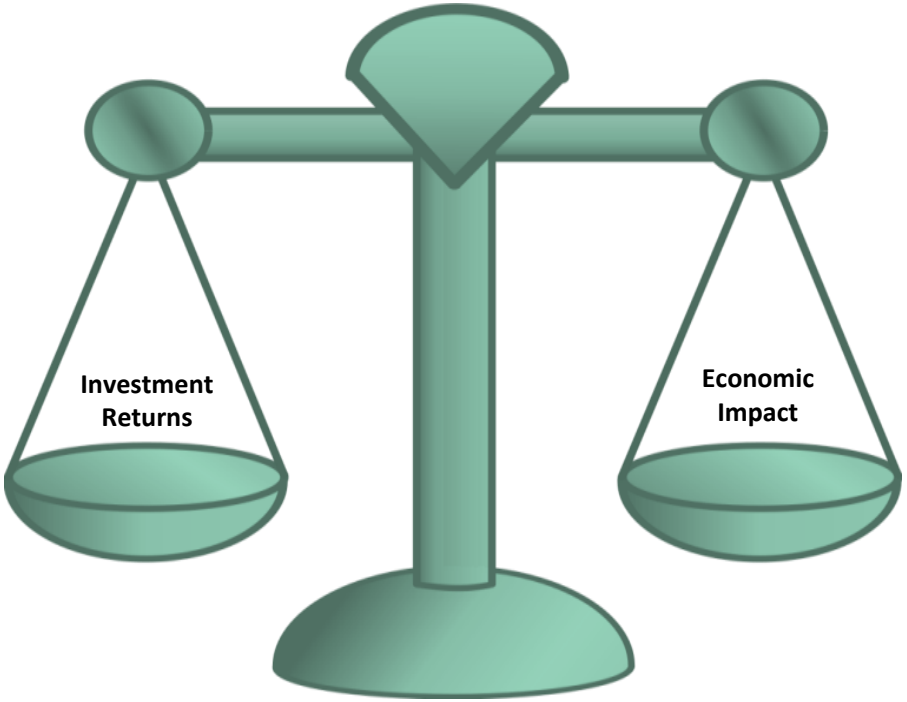
"invest on a commercial basis to support economic activity and employment in Ireland"

Double Bottom Line

Investment Returns

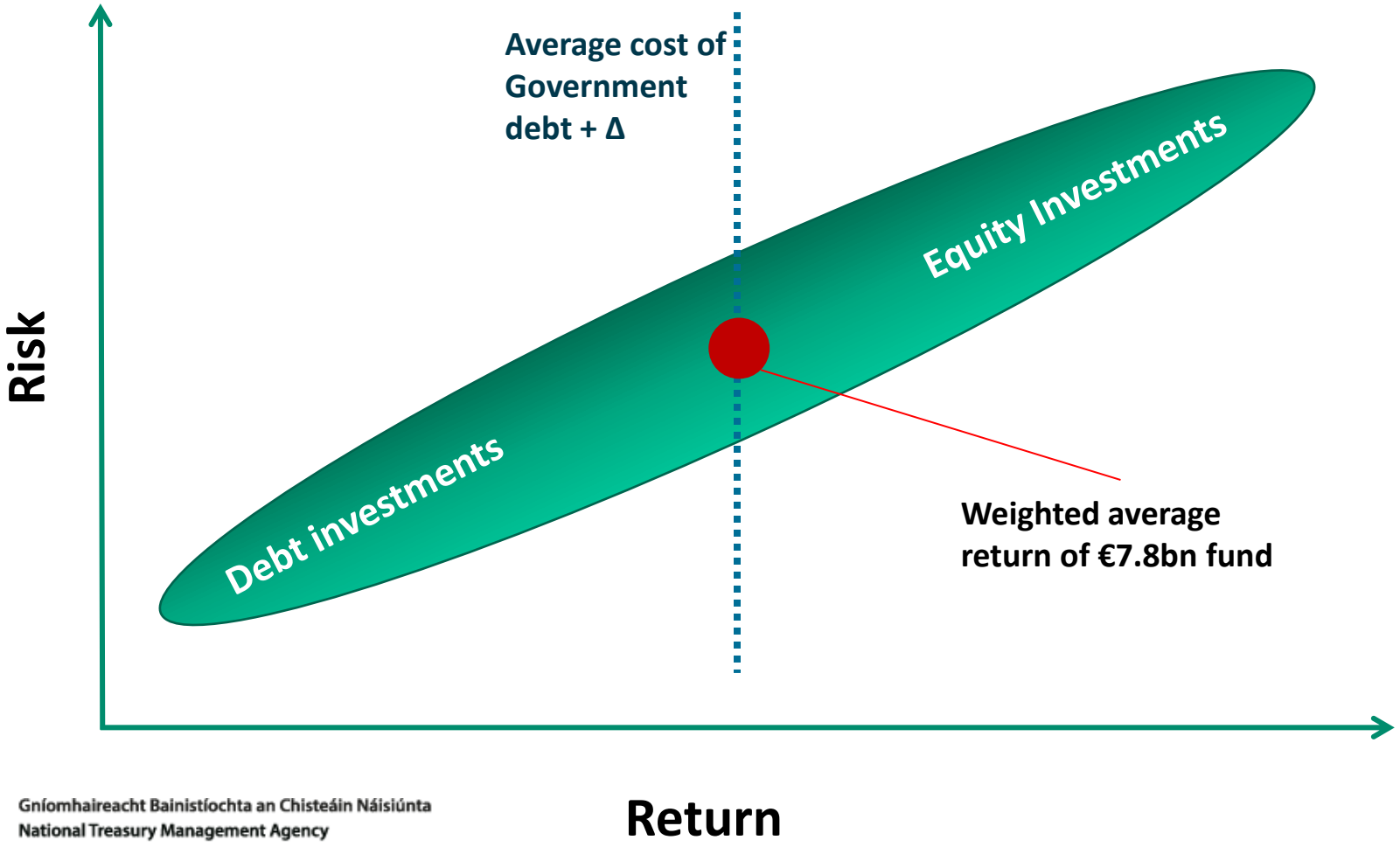
And

Economic Impact



Portfolio Construction: Target Return of 4%

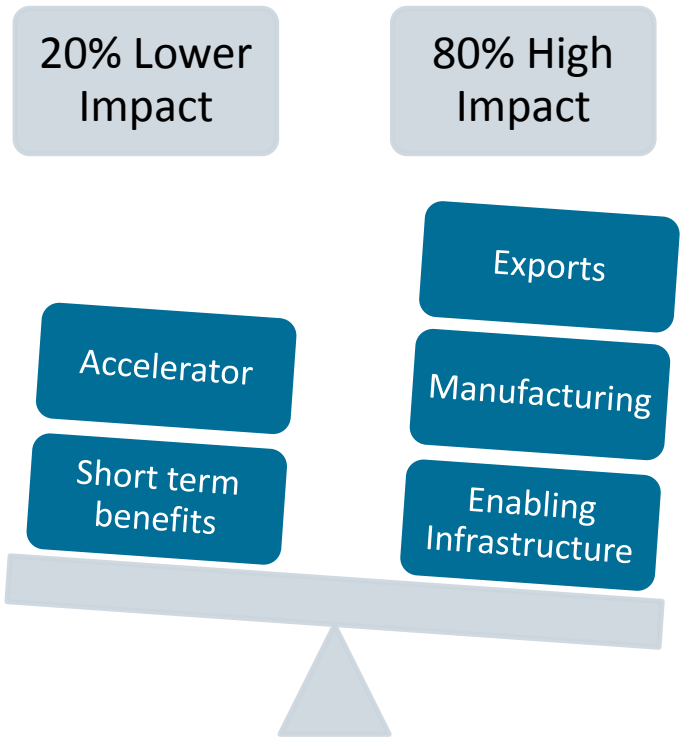
Portfolio approach - combination of low risk & return investments
<u>AND</u> higher risk & return investments



High Economic Impact Investments

Target 80% allocation to "High Economic Impact" investment opportunities

Fund Allocation



Economic Impact Framework - Key Concepts

Illustrative Portfolio - 2020

ISIF Illustrative Allocation			
Bucket	**Theme**	**€m**	**+/- range €m**
1	Water	700	+/- 100
2	Infrastructure	850	+/- 150
3	Energy	800	+/- 100
4	SMEs	900	+/- 200
5	Food & Agriculture	500	+/- 50
6	Real Estate Based Businesses	1,000	+/- 200
7	Venture	500	+/-50
8	Direct Private Equity	400	+/-40
9	Innovation / Big Idea	1,000	+/-200
10	Other	750	+/-50
	Total Fund Size	**7,400**	
	2x multiple	**14,800**	

Source: ISIF Investment Strategy (July 2015)

Commercial Investment Objectives

Return and Commerciality

- Risk adjusted Expected Return
- Third party investors validate commerciality
- No “Soft Money”

Debt and/or Equity

- Participate in all levels of capital structure: Equity, Mezzanine, Senior Debt etc.

Tenor

- Long term horizons
- No restrictions on tenor

Flexibility

- No set regulatory or return on capital requirements
- Ownership / Control not key driver
- Permanent / Patient Capital

Innovative

- Seek new ways to play a role in the market
- Work with public and private sector parties to develop financing solutions

Investments to Date

€2.2 billion committed to date

Bucket	Commitment
Water	€450 million
Infrastructure	€304 million
Energy	€44 million
SME Equity	€125 million
SME Credit	€200 million
Food & Agri	€30 million
Real Estate	€450 million
Venture	€414 million
Direct Equity	€56 million
Other	€92 million

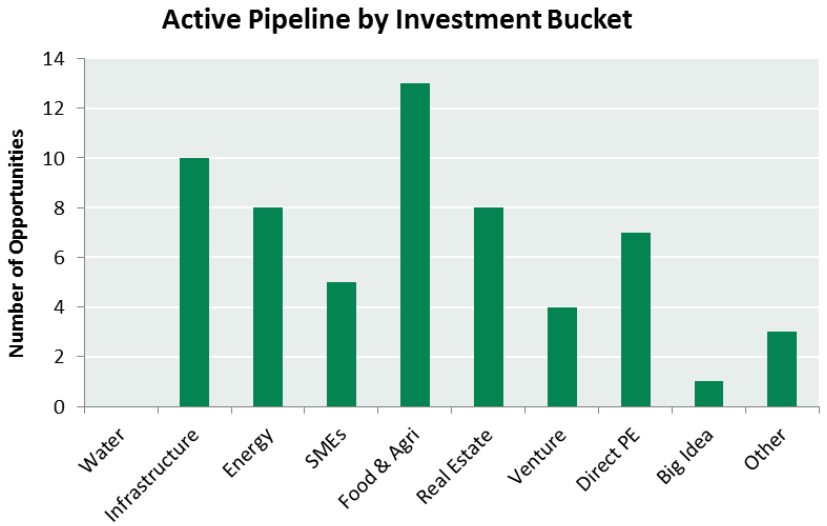
2015 Transaction Highlights

Malin PLC €50m	**Frontline €11m**	**AMCS €6m**	**Highland €10m**	**Student accommodation €54m**
Swrve €11m	**Irish Water €150m**	**Activate Capital €325m**	**Quadrant €50m**	**Sector investment fund €92m**

€759m committed year to date with continued strong pipeline

Strong Future Pipeline of Investment Opportunities

Status	Number of Opportunities
Investments Made	38
Initial Engagements	20
Active Pipeline	59
Dormant Opportunities	69
Lapsed Deals	52
Declined Opportunities	105
Total Engagements	**343**



- In excess of 340 engagements to date, with 79 current engagements
- The active pipeline consists of 59 opportunities across a diverse range of sectors
- Typically opportunities range in size between €10 million and €100 million

Flexible, long term, sovereign public investment partner

Engaging with ISIF

- **“Open for Business”**
  - Investment proposals welcome
  - No specific criteria, just commercial risk adjusted return and economic impact
  - Early stage proposals and ideas welcome as we can be constructive in shaping the transaction
  - Strong, supportive partner for corporate Ireland and international investment funds

ISIF - Current Renewable Energy Market

- ISIF targeting investment opportunities - providing ***additionality***

- Senior debt finance : high level of liquidity within funding markets for wind at present – so limited, if any, additionality;
- ISIF can fill gaps in the capital structure of wind projects:
  - Senior Debt / Mezz / Pref Equity / Traditional Equity
  - Form longer term strategic investor relationships for pipeline of projects
  - Supply chain constraints as REFIT 2 deadline approaches
- For smaller wind projects – ISIF exploring delivery channels to deal with scale / number of investments
- REFIT 3: Supporting a range of bioenergy projects

ISIF – Future Energy Market: Renewables

ISIF mandate enables a longer term view…..

- There will be an onshore wind market post 2017 (REFIT 2)
- ISIF looking to this period and how we may play a role
  - an evergreen fund;
  - patient, stable, long term
  - potentially non controlling capital
  - ability to explore innovative financing structures
- Future renewable support schemes (REFIT 4?)….
  - likely to allocate support through a more competitive process;
  - may make for more complex financing structures?
  - potential for lower debt / higher equity financing?
  - potential for higher level of pre-development financing?

ISIF – Future Energy Market: Enabling Infrastructure

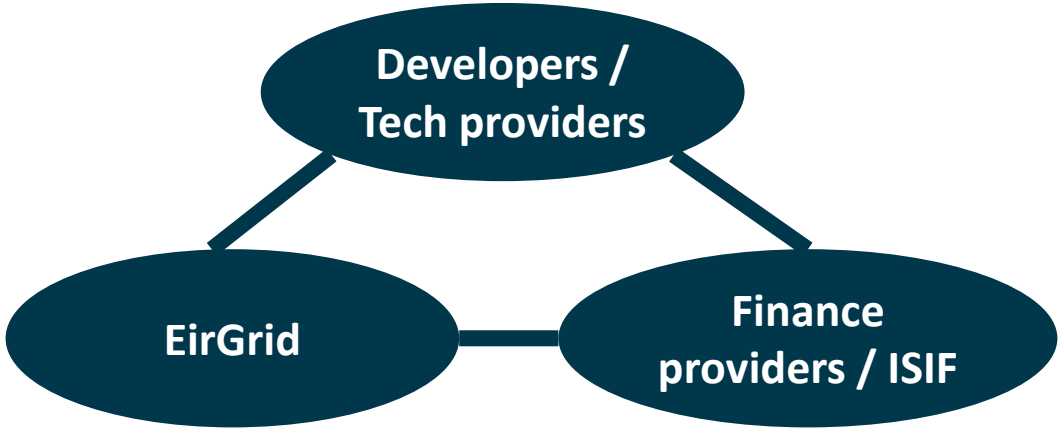
ISIF mandate enables a longer term view…..

- Higher penetration of intermittent renewables on the grid:
  - Can lead to higher levels of curtailment which cannibalises wind revenue and wastes low carbon, renewable energy (counter to government policy objective)
  - Increases the requirement for system services to maintain a balanced, stable and sustainable grid
- "Enabling infrastructure" – delivers system services to reduce impact of curtailment and enable higher penetration of renewables
- EirGrid's DS3 programme designed to incentive enabling infrastructure by increasing system service revenue
  - Annual payments increasing from €60m to € 235m under the DS3 program
  - Auction process where competition for services exists
  - Long term contracts through bilateral negotiation
- New technologies will compete with existing generation capacity for DS3 revenue
  - E.g. fly wheels, battery technologies, flexible gas generation, compressed air storage, pump storage, interconnection, and more……

ISIF – Future Energy Market: Enabling Infrastructure

- DS3 contracts awarded through auction need to reflect the scale of the infrastructure investment
  - Capex requirements
  - Opex requirements
  - Asset life
  - Investment payback period

- ISIF (and all financiers?) are technology neutral …. Need appropriate risk / return



ISIF Summary

- Open for investment in REFIT 2 wind projects where ISIF can provide ***additionality***
  - Strategic relationship
  - Gap in the financing structure
  - Supply chain constraints as REFIT 2 deadline approaches

- And for what comes next…ISIF is an evergreen fund with a long term mandate to provide economic benefit
  - Subsequent renewable support schemes to deliver renewable capacity in line with government policy
  - Enabling infrastructure to facilitate higher levels of renewable penetration

Contacts

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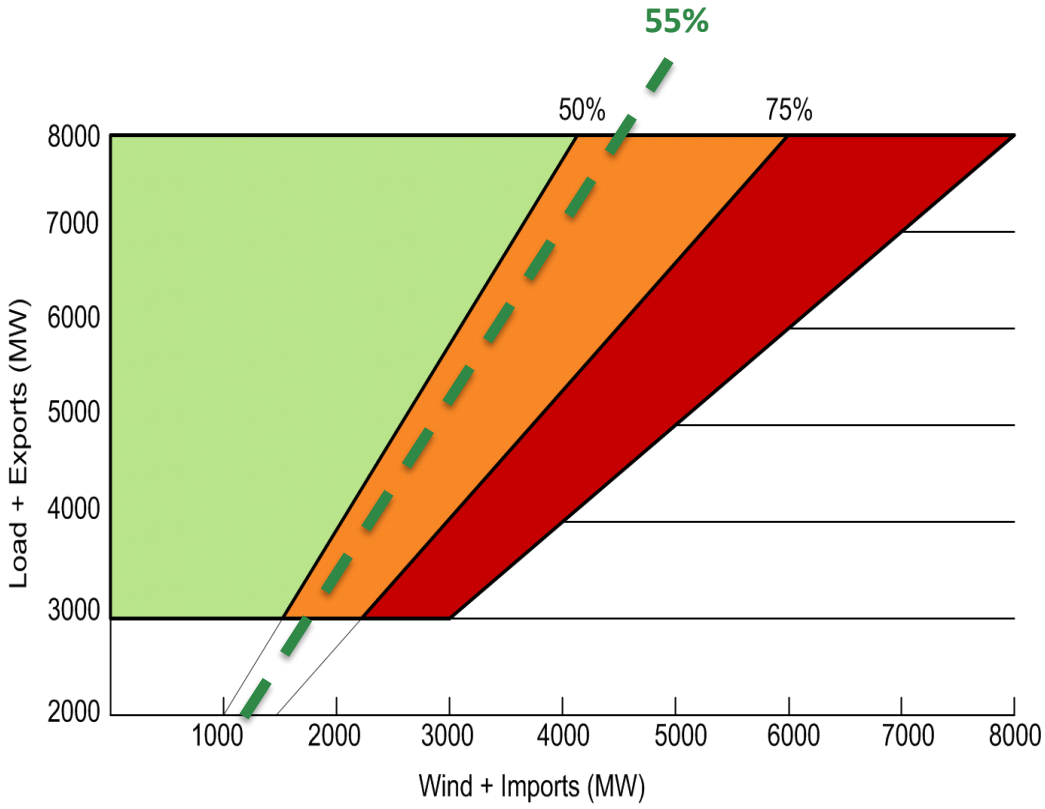
DS3 Programme Status Update

Robbie Aherne

EIRGRID GROUP

Increase of SNSP to 55% - System Trial

- Builds on the policies and tools brought through the OPR Committee
- Will inform future operational policy



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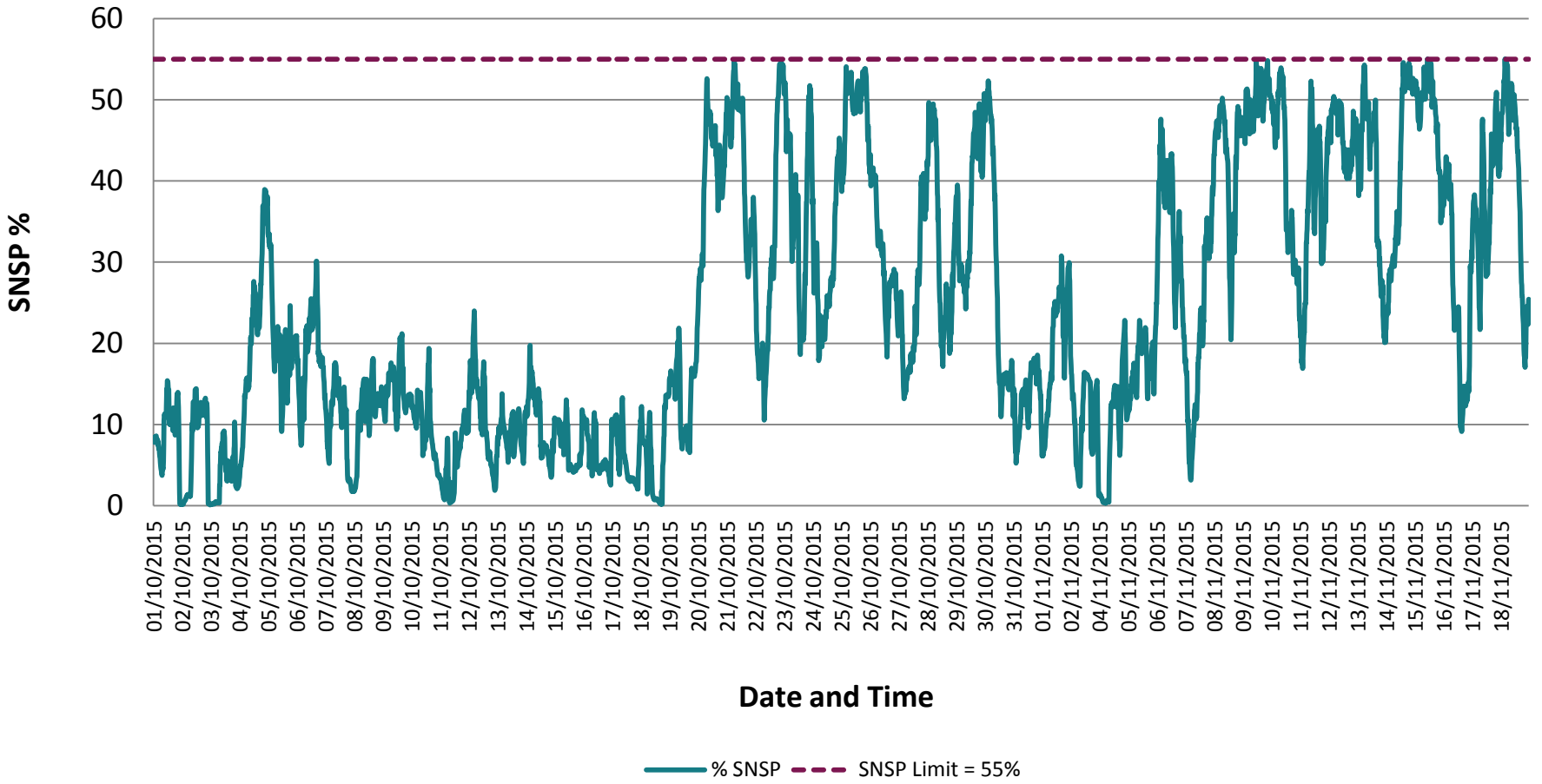
SNSP Trial – Real Time Experience



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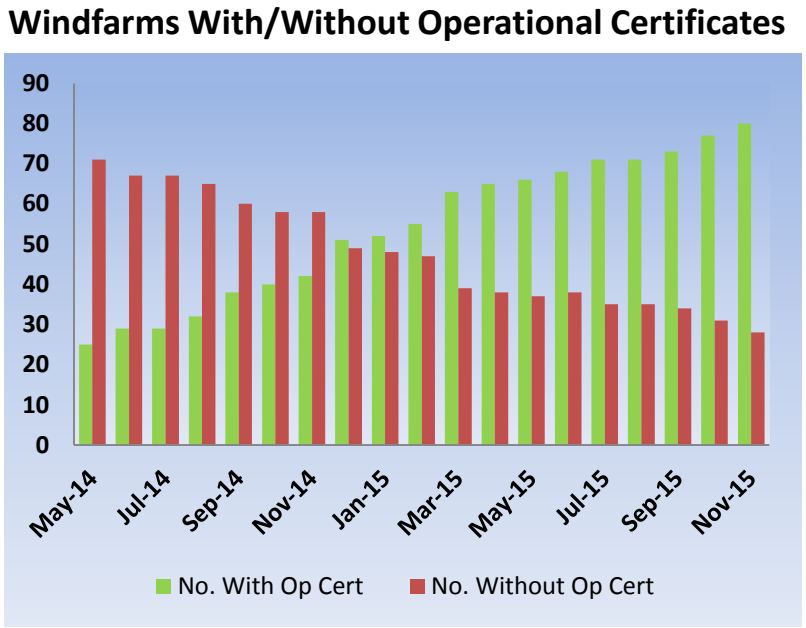
SNSP Trial - Enablers

- Ramping Tool
- Frequency Regulation
- RCUC – RoCoF/Inertia
- WSAT transfers
- High Frequency Analysis
- Etc.



Next steps:

- *Assessment of trial*
- *Focus on further changes to operational metrics*

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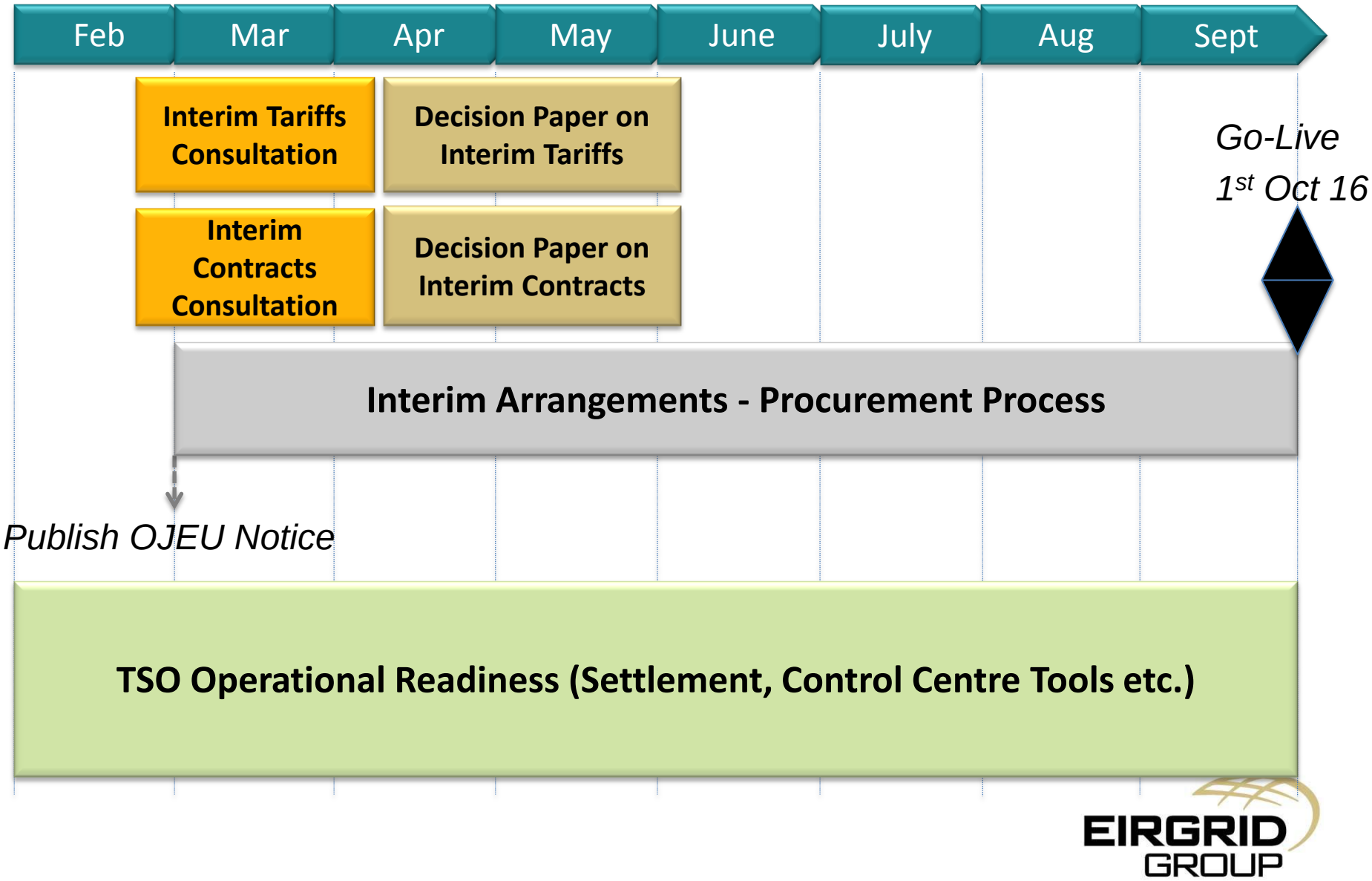
System Service – Interim



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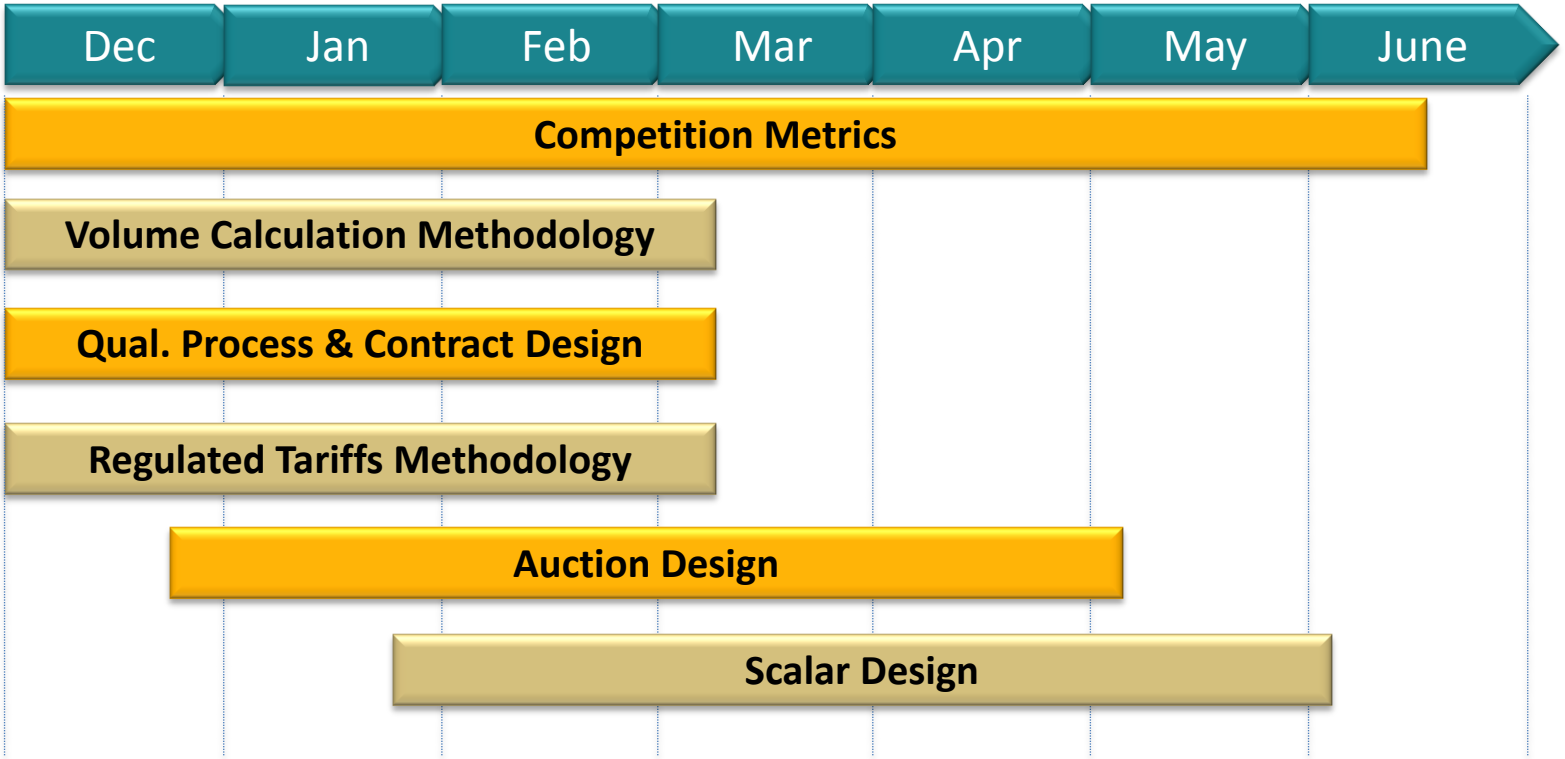
System Services – Enduring

SEMC

TSOs



Note: Publication of the SEMC decision paper for the Competition Metrics consultation postponed to ensure there is opportunity to align with I-SEM market power considerations

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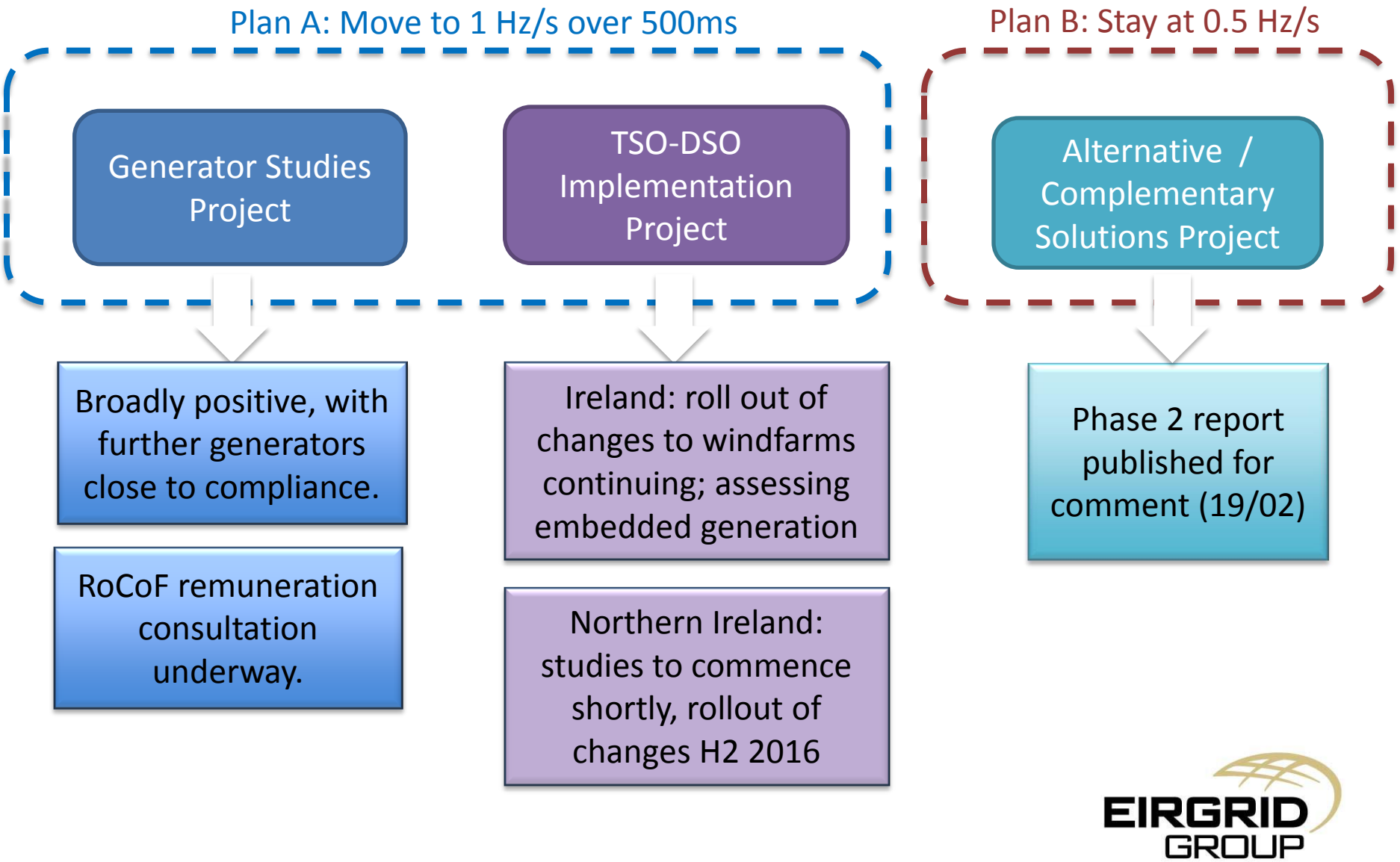
RoCoF Implementation Project



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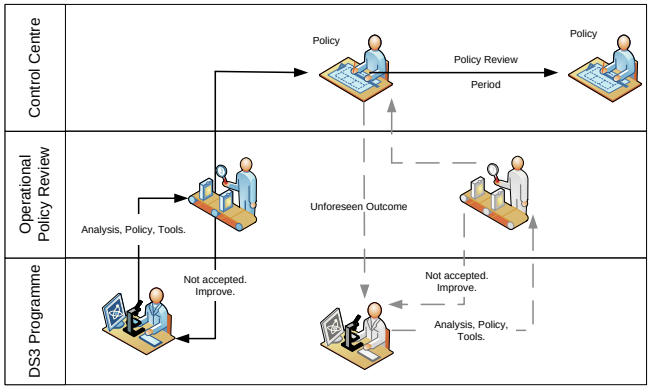
Operational Policies & Related Studies

- Voltage dip induced frequency dip (on-going)
- Voltage trajectory studies (on-going)
- Interim HVDC export limits analysis (on-going)
- Cauteen Nodal Voltage Control Pilot Project (on-going)
- Northern Ireland “smart” voltage control (almost complete)
- Quantitative frequency oscillation analysis (almost complete)
- Report on windfarm frequency response tests (almost complete)



Operational Policy Review Committee

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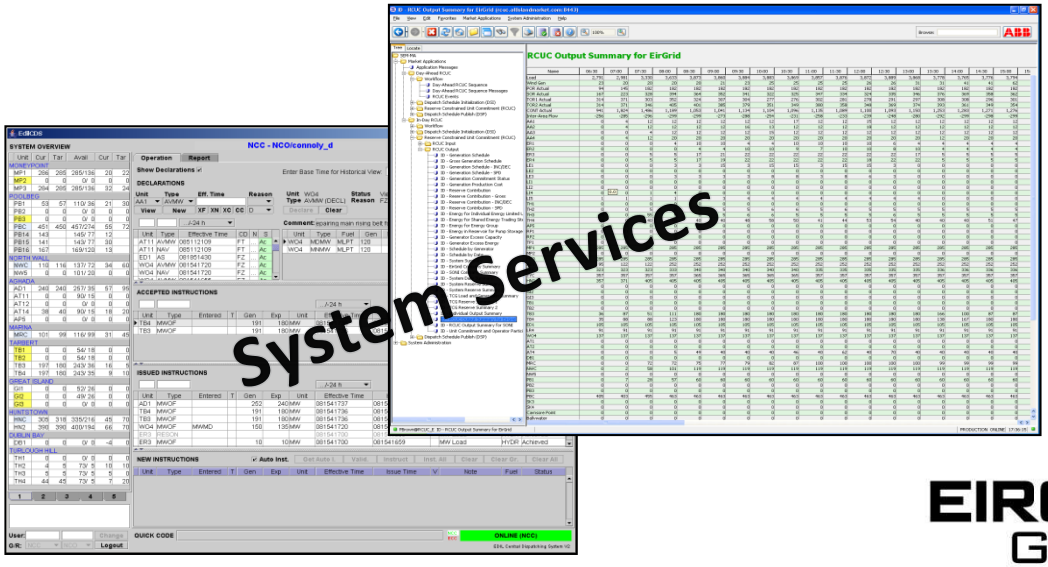
Control Centre Tools

Dublin

Belfast



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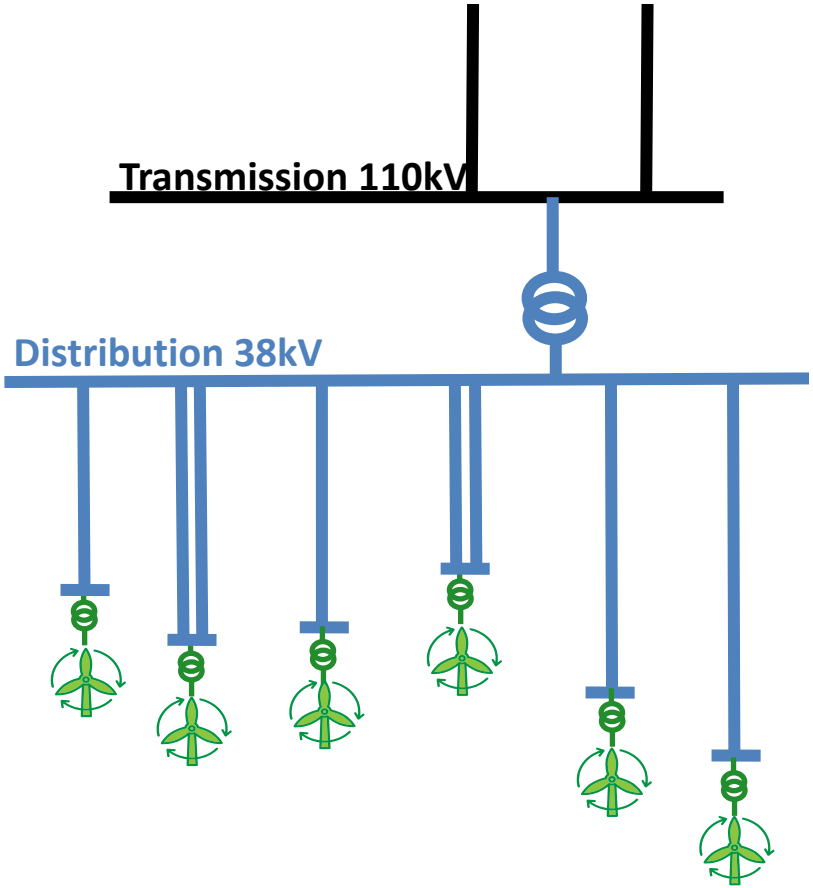
Smart Voltage Control



- Avoid transmission network reinforcement by realising potential of DSO generation
- IE: Progress continues to be made on the Cauteen Nodal Voltage Control Pilot Project
- NI: Study to investigate using smart power factor for embedded WFs near completion

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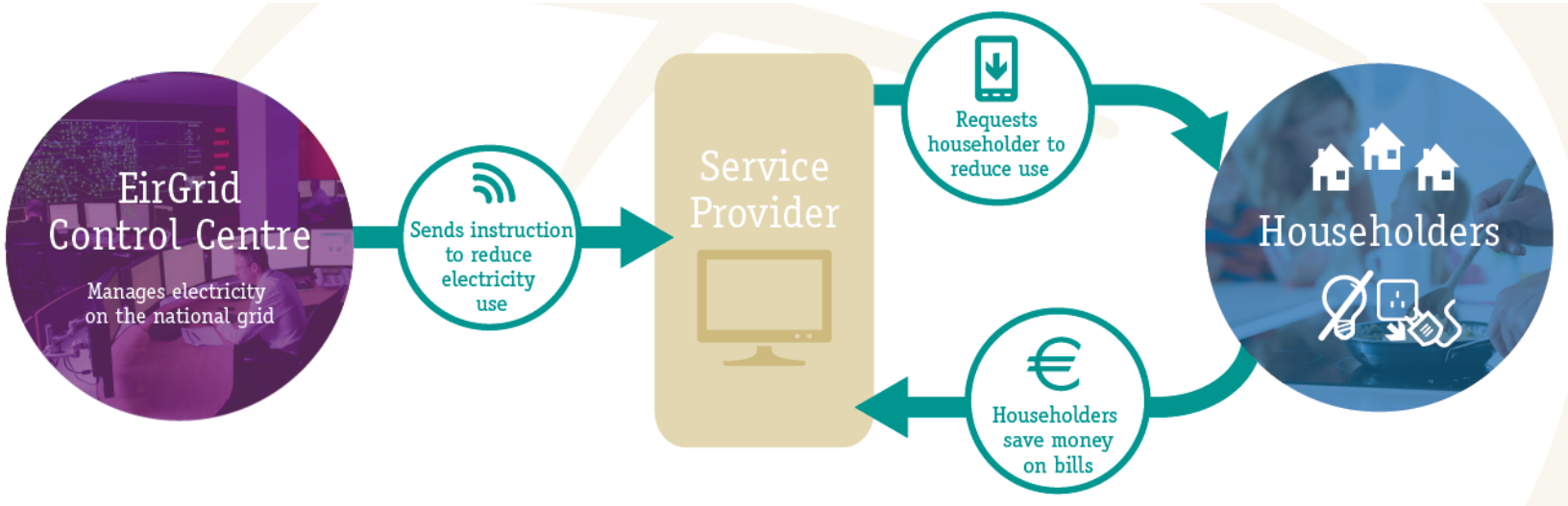
DSM – Residential DSM Scheme

Have a residential consumer based demand response project in operation in 2016



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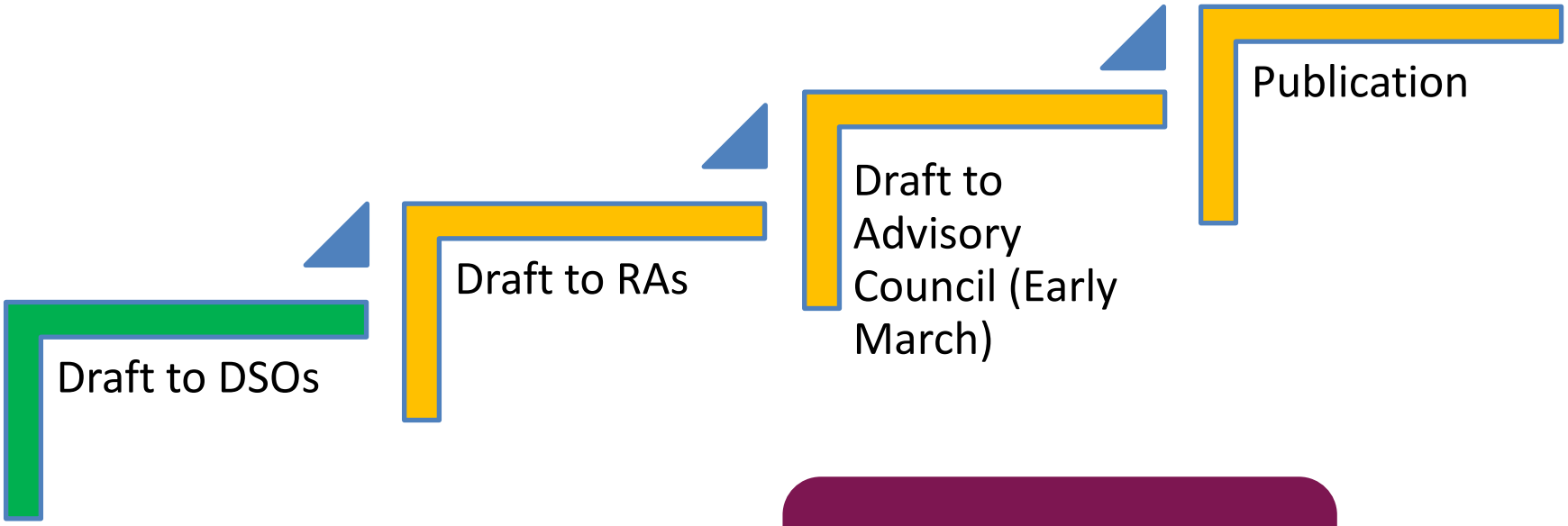
Workstream Plans – Annual Review



Revised "Operational Capability Outlook"

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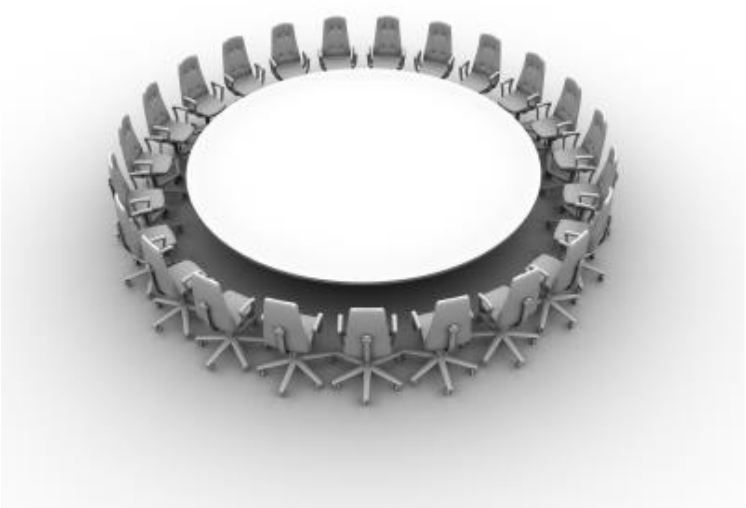
Advisory Council

- Membership
  - Generator
  - Transmission System Operator
  - Wind Industry



- RGI Award for Communication & Participation

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2016 Focus Areas

1. RoCoF Implementation Project

2. System Services Implementation Project
   - Interim Arrangements – Q4 2016
   - Enduring Arrangements – Q4 2017

3. Operational policy
   - Voltage dip induced frequency dips
   - Review of Grid Code derogations
   - Real time requirement for FFR
   - HWSSD (High Wind Speed Shut Down) review

4. Control Centre Tools
   - Tools for System Service Interim and Enduring Arrangements
   - Completion of EMS Integration Project
   - Implementation of off-line WSAT capability

5. Changes to operational metrics….as system performance evolves

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Actions

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Actions

- TSOs to investigate if regular data (e.g. hourly) for the total system inertia can be published on the EirGrid website in a similar manner to the frequency data (TSOs)
  - This matter was investigated in detail. However, to ensure confidential plant information is respected, it was decided not to publish the data. This reflects the relatively small number of generators in the SEM market and the potential to inadvertently reveal plant data

- TSOs to consider adding an agenda item for the next DS3 Advisory Council to discuss the impact Network Codes will have on the DS3 Programme. (TSOs)
  - EirGrid, as TSO, is closely monitoring the impact of the Network Codes on the future power system in Ireland and Northern Ireland – this includes DS3. For example, this could result in changes to current plant behaviour. This will continue to be monitored on an ongoing basis and will be discussed at current and future industry forums dedicated to the Network Codes.

- TSOs to publish industry responses to the Alternative / Complementary Solutions Phase 1 report if the appropriate permission was granted. (TSOs)
  - The industry responses to the Alternative Phase 1 report, were circulated to the members of the DS3 Advisory Council. The responses have also been uploaded to the https://eirgrid.app.box.com/ds3workshops page.

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RoCoF Project Overview

David Cashman

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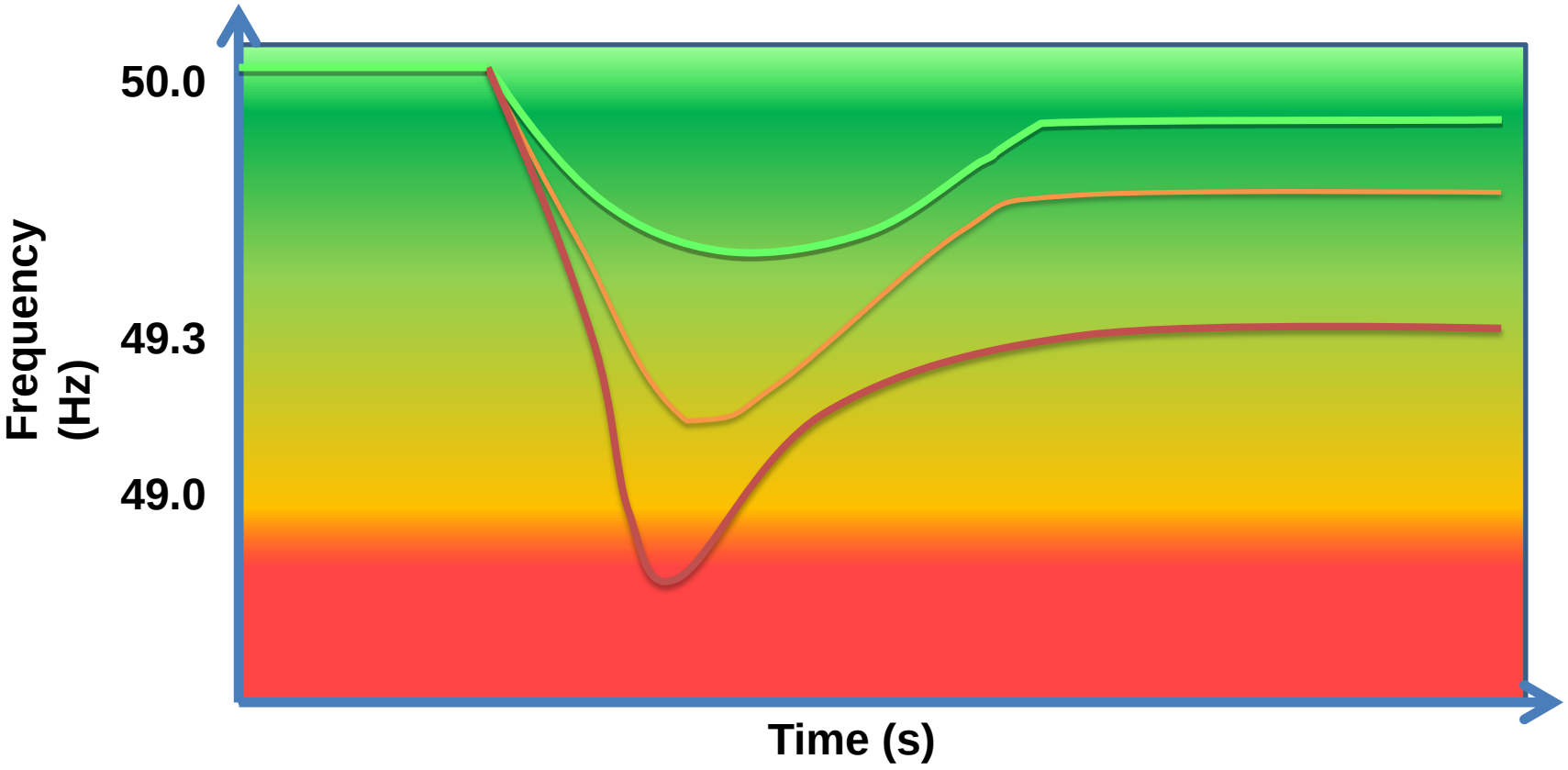
RoCoF Concept



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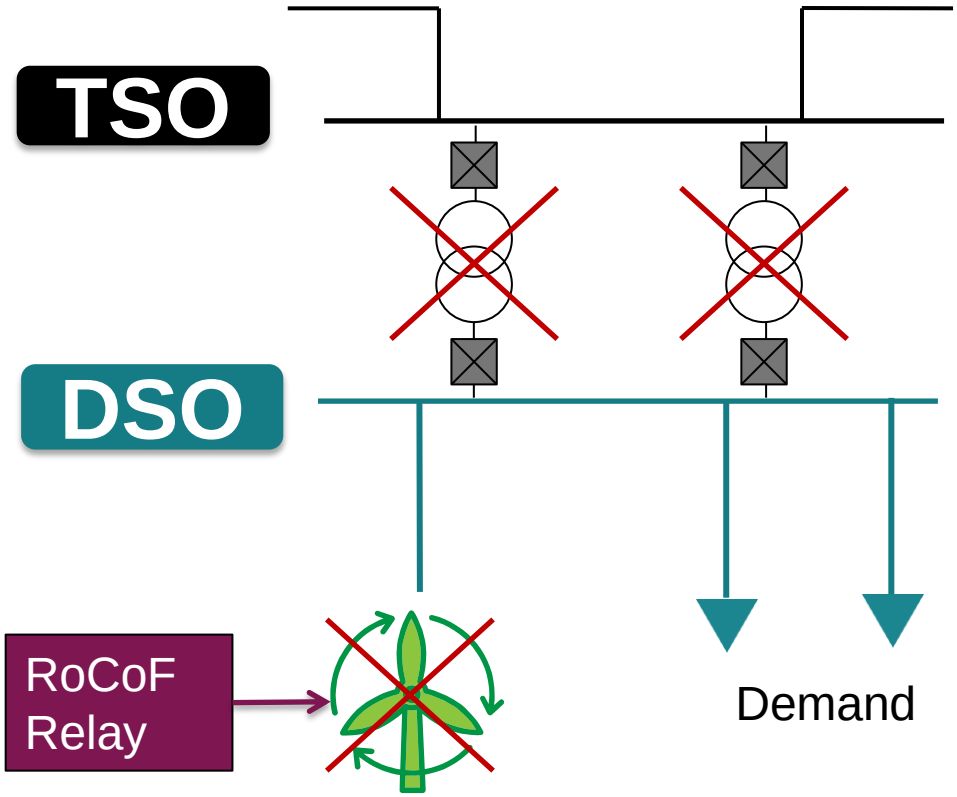
RoCoF TSO-DSO Project



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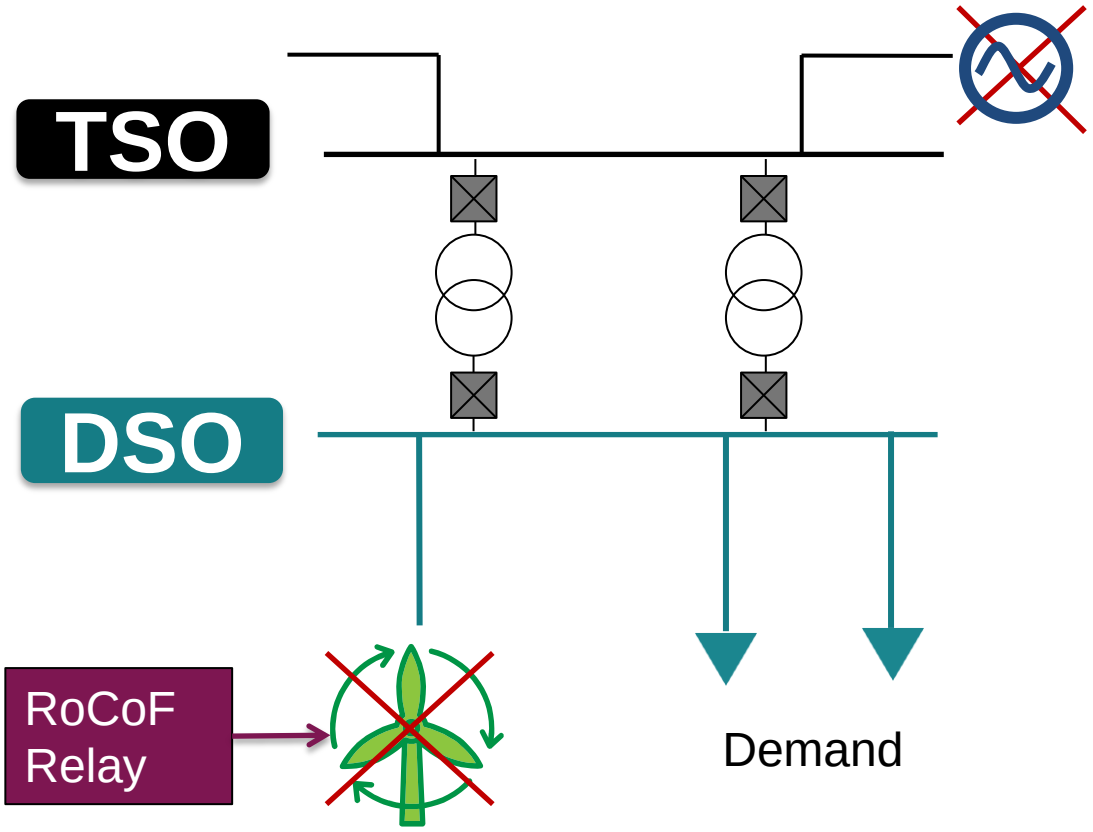
RoCoF TSO-DSO Project



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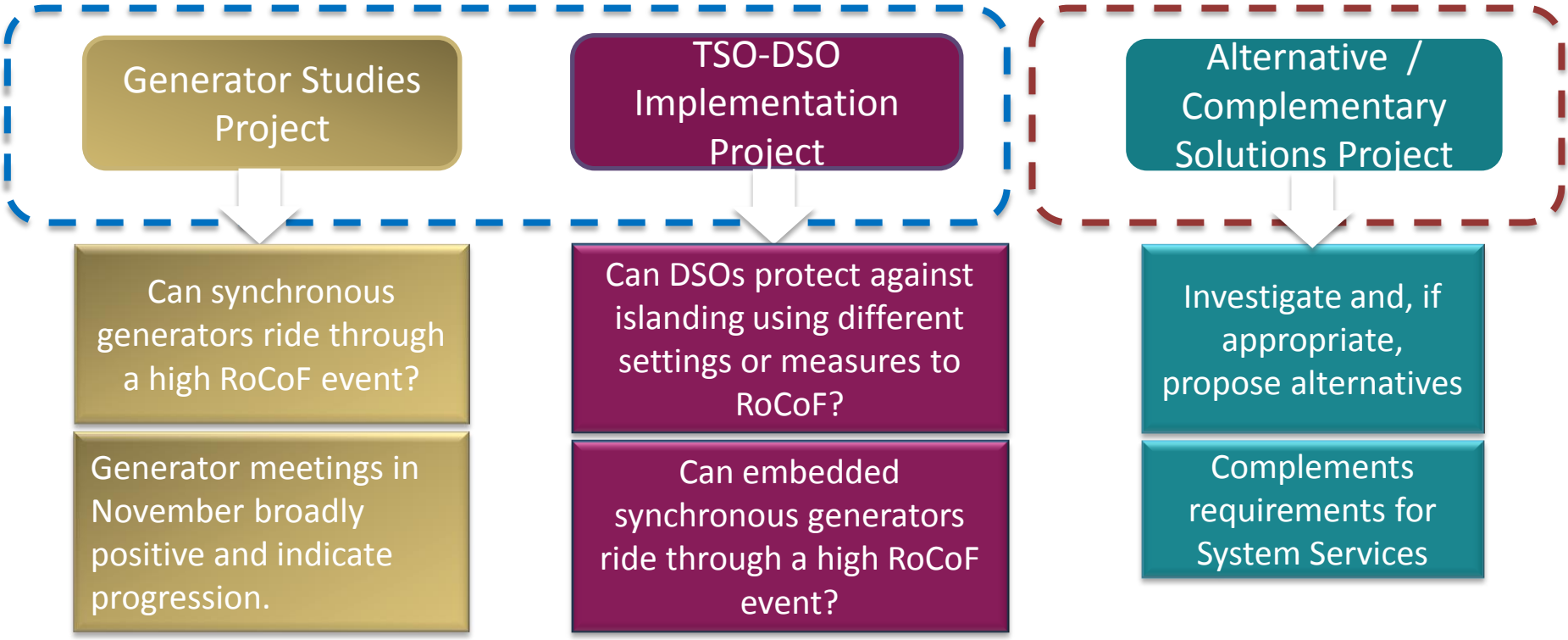
RoCoF Implementation Project



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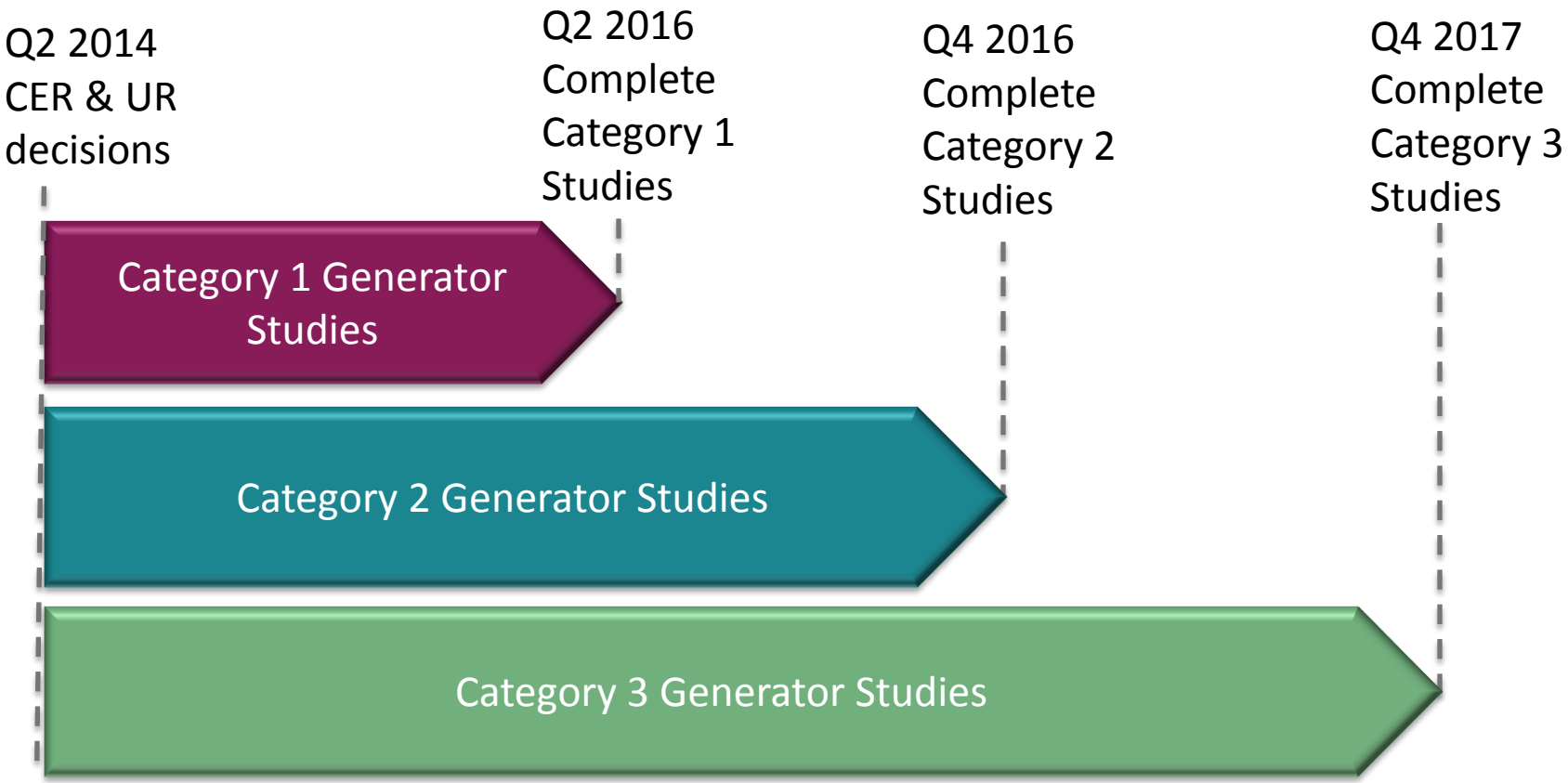
Generator Studies Timelines



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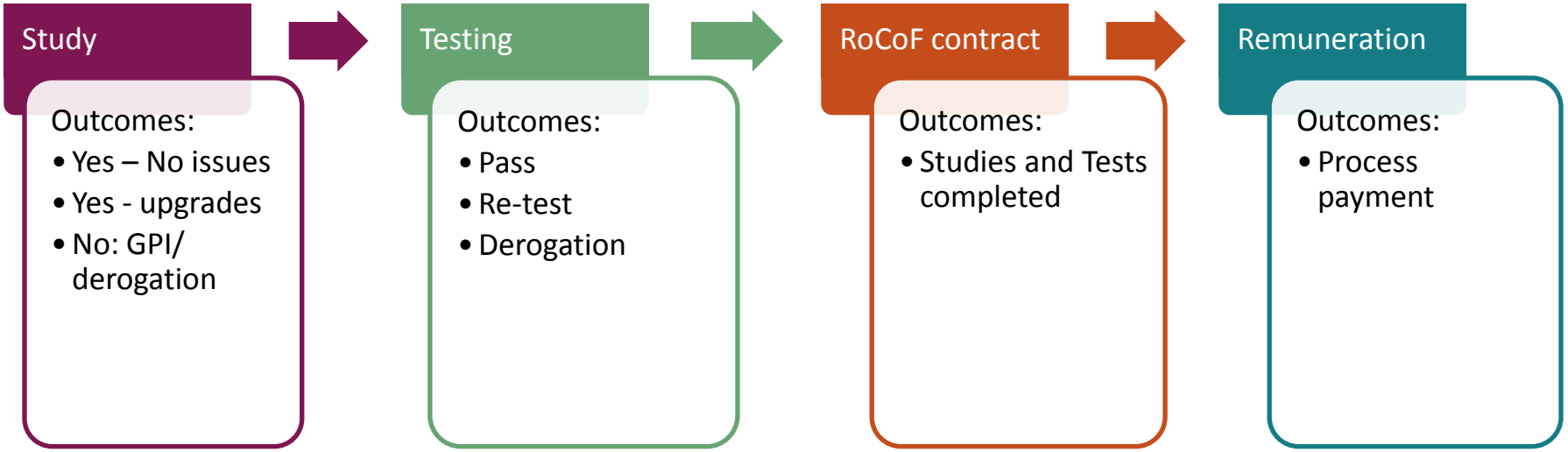
RoCoF Remuneration Method



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Next Steps

- 6-week consultation on Remuneration paper currently in progress
- DS3 Industry Forum on February 1st
- Industry comments up to February 8th
- TSO recommendation paper to SEM-C March 2016
- SEMC review March/April
- Remuneration Mechanism to apply from June 1st 2016
- Payments back-dated to March 2016 for early submissions

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TSO-DSO Project: Ireland

DSO Wind

- Requests for protection settings changes issued
- Roll-out of changes on wind farms is continuing
- DSO have provided database of settings to TSO

Embedded non-wind generation

- D-code modification tabled and agreed in principle
- Meetings with representatives to assess impact on existing fleet
- DSO have provided indicative volumes of generation to TSO
- TSO to perform impact assessment studies based on these volumes

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TSO-DSO Project: Northern Ireland

Large-scale generation

- Studies to be completed by Q2 with NIE review by Q3 2016
- Commence Roll-out of LoM protection settings Q3 2016
- All large-scale generators have new settings Q3 2017

Small-scale generation

- D-code modification consulted on and currently under review
- Studies to commence Q2 2016
- Commence Roll-out of LoM protection settings Q4 2016
- All small-scale generators have new settings Q3 2017

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DS3 Advisory Council
ESBN ROCOF Update

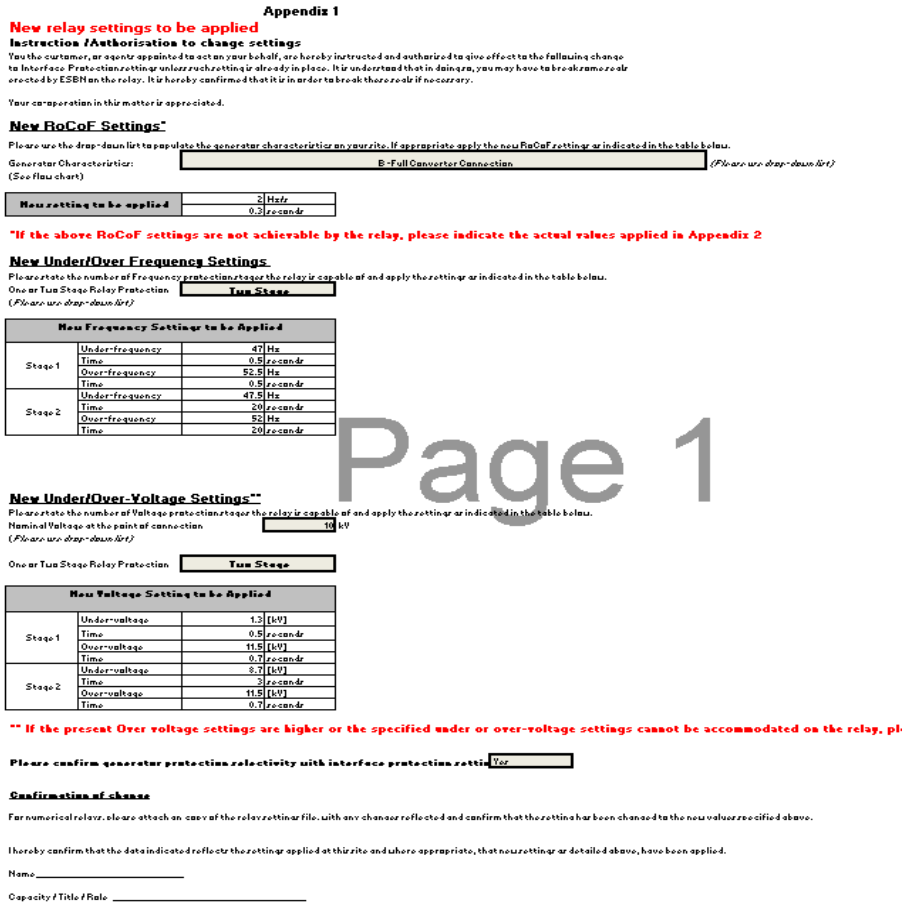
Tony Hearne

19th January 2016

Questionnaire and Settings Change

Wind Generators

- Wind Farm setting changes on-going
- Significant engagement in recent months from most IPPs
- Little engagement from some IPPs
- Approximately 40% of MW outstanding



Appendix 1

New relay settings to be applied

Instruction / Authorisation to change settings

You the customer, or agent appointed to act on your behalf, are hereby instructed and authorised to give effect to the following change to Interface Protection settings unless such setting is already in place. It is understood that in doing so, you may have to break seals erected by ESBN on the relay. It is hereby confirmed that it is in order to break these seals if necessary.

Your co-operation in this matter is appreciated.

New RoCoF Settings*

Please use the drop-down list to populate the generator characteristics on your site. If appropriate apply the new RoCoF settings as indicated in the table below.

Generator Characteristics: (See flow chart) — E - Full Converter Connection (Please use drop-down list)

New setting to be applied		
	2	Hz/s
	0.3	seconds

*If the above RoCoF settings are not achievable by the relay, please indicate the actual values applied in Appendix 2

New Under/Over Frequency Settings

Please state the number of Frequency protection stages the relay is capable of and apply the settings as indicated in the table below.

One or Two Stage Relay Protection: Two Stage (Please use drop-down list)

New Frequency Settings to be Applied			
Stage 1	Under-frequency	47	Hz
	Time	0.5	seconds
	Over-frequency	52.5	Hz
	Time	0.5	seconds
Stage 2	Under-frequency	47.5	Hz
	Time	20	seconds
	Over-frequency	52	Hz
	Time	20	seconds

Page 1

New Under/Over-Voltage Settings**

Please state the number of Voltage protection stages the relay is capable of and apply the settings as indicated in the table below.

Nominal Voltage at the point of connection: 10 kV (Please use drop-down list)

One or Two Stage Relay Protection: Two Stage

New Voltage Setting to be Applied			
Stage 1	Under-voltage	1.3	[kV]
	Time	0.5	seconds
	Over-voltage	11.5	[kV]
	Time	0.7	seconds
Stage 2	Under-voltage	8.7	[kV]
	Time	3	seconds
	Over-voltage	11.5	[kV]
	Time	0.7	seconds

** If the present Over voltage settings are higher or the specified under or over-voltage settings cannot be accommodated on the relay, pl

Please confirm generator protection selectivity with interface protection settin: Yes

Confirmation of change

For numerical relays, please attach an copy of the relay settings file, with any changes reflected and confirm that the settings have been changed to the new values specified above.

I hereby confirm that the data indicated reflects the settings applied at this site and where appropriate, that new settings as detailed above, have been applied.

Name _____

Capacity / Title / Role _____

Non-Wind Generation & D-Code Mod

- **Very little response from non-wind generators on request to change interface settings**
- **Discussions on going with non-wind embedded generator representative**
- **Indication of quantum of connected non-wind, non exporting distribution connected generation supplied to EirGrid**
- **Next step to evaluate CHP and Diesel generator operating regimes and topologies to determine overall impact**
- **Distribution Code Modifications agreed for all generators in relation to;**

1. Voltage FRT
2. Frequency withstand
3. RoCoF

NIE NETWORKS' ROCOF PROJECT UPDATE

DS3 Advisory Council – 19th January 2016

Introduction

- **Requested to amend the current LoM protection settings to ensure that Distributed Generation (DG) remains stable for RoCoF events up to 2Hz/s measured over 500ms.**

- **Before any generation amendments can be made a full and comprehensive quantification of increased stability vs increased risk must be carried out.**

- **It was decided to follow the same process carried out by the GB DNOs.**

- **Strathclyde University were appointed to carry out this research using the same proven methodology as used in GB.**

Project Overview

- **Research is broken into 4 work packages:**
  - WP1 – Analysis of the DG connection registers to establish dominant generating technologies and generation mixes in the identified islanding scenarios.
    - A forecast DG register will also be examined to ensure that the proposed settings are appropriate for future DG scenarios.
    - DG forecast is based on research carried out by Element Energy on behalf of NIE Networks.
  - WP2 –Investigation of the LOM protection stability under critical system events.
    - G59 stability investigated using a combination of a validated software RoCoF relay package and laboratory injection testing.
  - WP3/WP4 – Investigation and quantification of the risks associated with the relaxation of the LoM settings for generation with registered capacity greater than 5MW and smaller than 5MW respectively.
    - Four generation types are modelled: Synchronous; Induction; DFIG and Fully Converted.
    - Generators are modelled with voltage control turned on.
    - Studies to examine the impact of frequency control mode.
- **3 Technical reports will be produced with key findings published.**
- **Engagement with Health and Safety Executive for Northern Ireland (HSENI) to determine if the increased risk is acceptable.**
- **Send out letters requesting generators to amend their G59 settings based on their generator technology.**

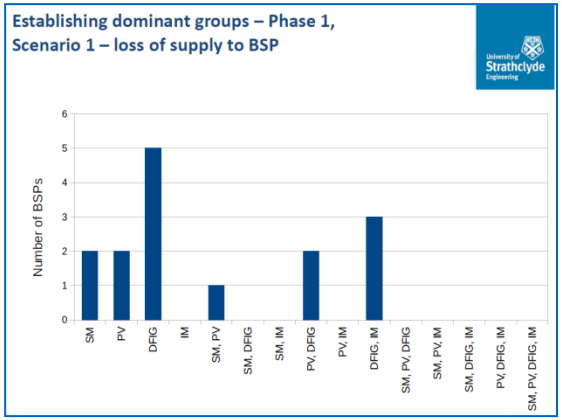
Data Capture

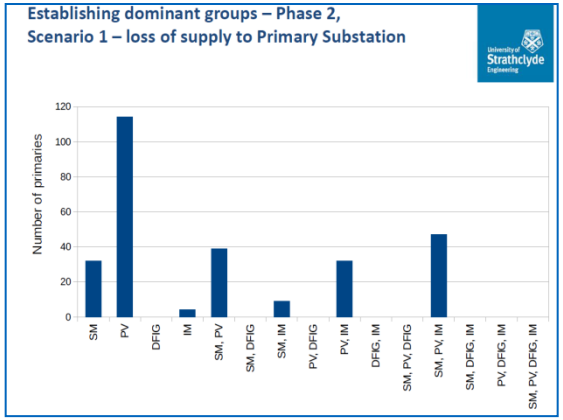
- **Large volumes of data required:**
  - High resolution, long duration generator profiles.
  - High resolution, long duration substation and feeder profiles.
  - Records of severe system events.
  - Accurate generation connection register (down to G83 level).
  - Forecast generation connection data.
  - Network fault statistics, including short term interruptions.
  - Generator performance data i.e. voltage control performance.
  - Generator protection data.
  - Generator type and H-constant.

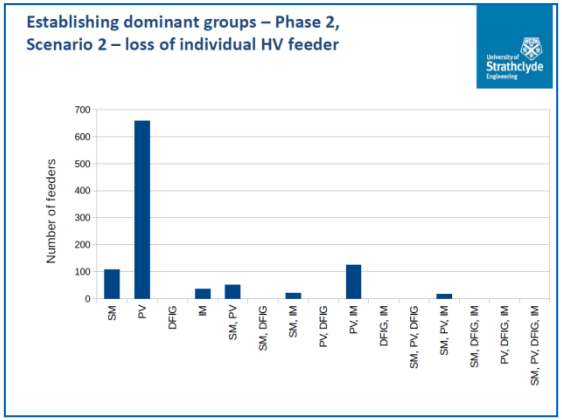
- **Due to the quantity and quality of data provided Strathclyde University are confident that the results will contain high statistical robustness.**

Initial Findings - WP1: DG registers

- **4 islanding groups identified:**
  - The loss of a Bulk Supply Point (BSP).
  - The opening of a 33kV circuit breaker with generation and/or load connected downstream.
  - The loss of a Primary Substation.
  - The opening of an 11kV circuit breaker with generation and/or load connected downstream.
- **The graphs below illustrate the generation mixes for the various islanding groups.**



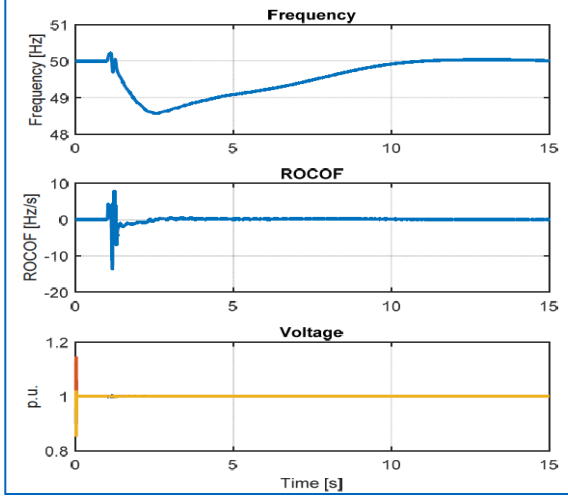




Initial Findings – WP2: LoM stability

- **Stability of G59 protection relays were assessed for 13 modelled critical system events. The current G59 settings were used:**
  - Under-Voltage/Over-Voltage = - / +10%
  - Under-Frequency/Over-Frequency = -4% / +1%
  - RoCoF = 0.4Hz/s
- **Results below show the RoCoF settings required to ensure stability for the most critical system event.**

ROCOF relay response to simulated voltage records

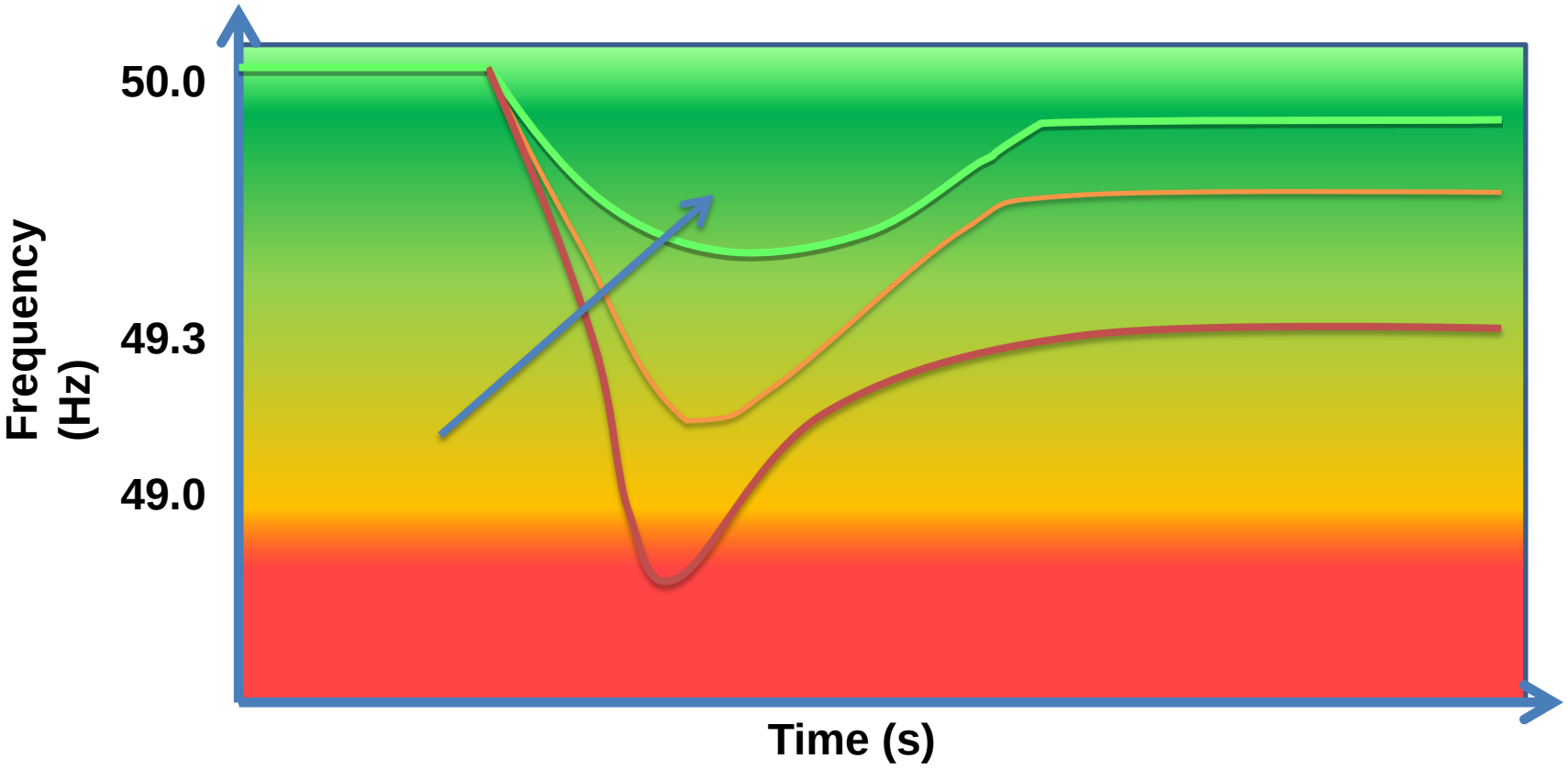


- Case: **NI System Separation (Low)**
- Setting of 2.9Hz/s would stabilise ROCOF relay or 1.03Hz/s with 0.5s delay

Protective Function	Status	Operation Time [s]
Under-Voltage	0	99.000
Over-Voltage	0	99.000
Under-Frequency	0	99.000
Over-Frequency	0	99.000
ROCOF	1	1.079
Relay Output	1	1.079

Questions?

RoCoF Alternatives Objective



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Phase 1 Review

Highlights

- Both Synchronous and synthetic inertia can provide solutions to RoCoF
- Weighted Scoring Matrix did not favour any specific solution
- Event Detection essential for synthetic devices
- A combination of devices may be required to resolve RoCoF

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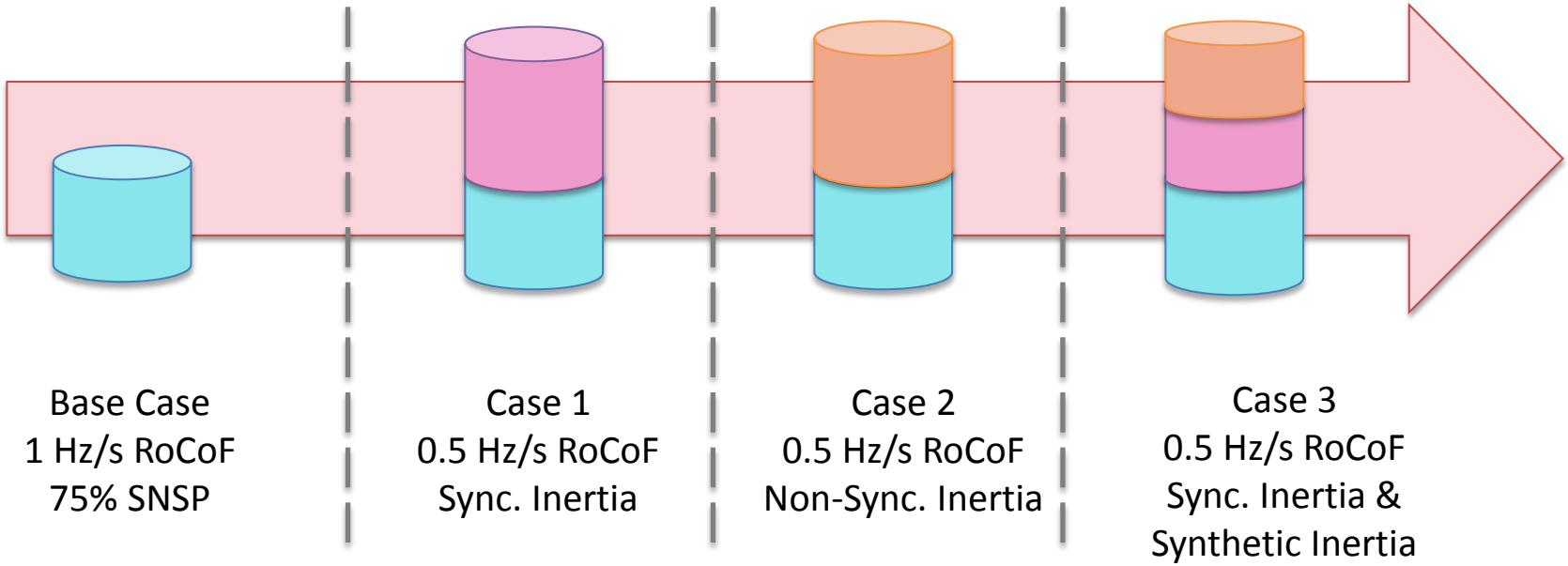
Phase 2 outline

- Determine extra volume of sync. and/or synthetic inertia to maintain RoCoF from 0.5Hz/s and allow 75% SNSP
- 3 Cases investigated:



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Phase 2 Overview

Synchronous Inertia

- 20,000 MW.s required to maintain RoCoF

Synthetic Inertia

- Begin to respond within 100 ms
- Ramp to full output in 200 ms
- Control for recovery
- +/- 360 MW

Combination

- Sensitive to synthetic device performance
- Would require TSO lead project to implement

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Study Conclusions

- Alternative Solutions are available for the RoCoF issue
- Further analysis required to implement alternatives project
- RoCoF Alternatives Solutions is ‘back-up’ to primary RoCoF Project and not a procurement exercise
- Generator Studies and TSO-DSO projects progressing
- TSOs welcome feedback on report from industry

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Timelines

Dec. 2015	• RoCoF Alternatives Phase 2 Report
1st Feb 2016	• DS3 Industry Forum
19th February 2016	• Submission of industry comments
End March 2016	• Publication of Final Report

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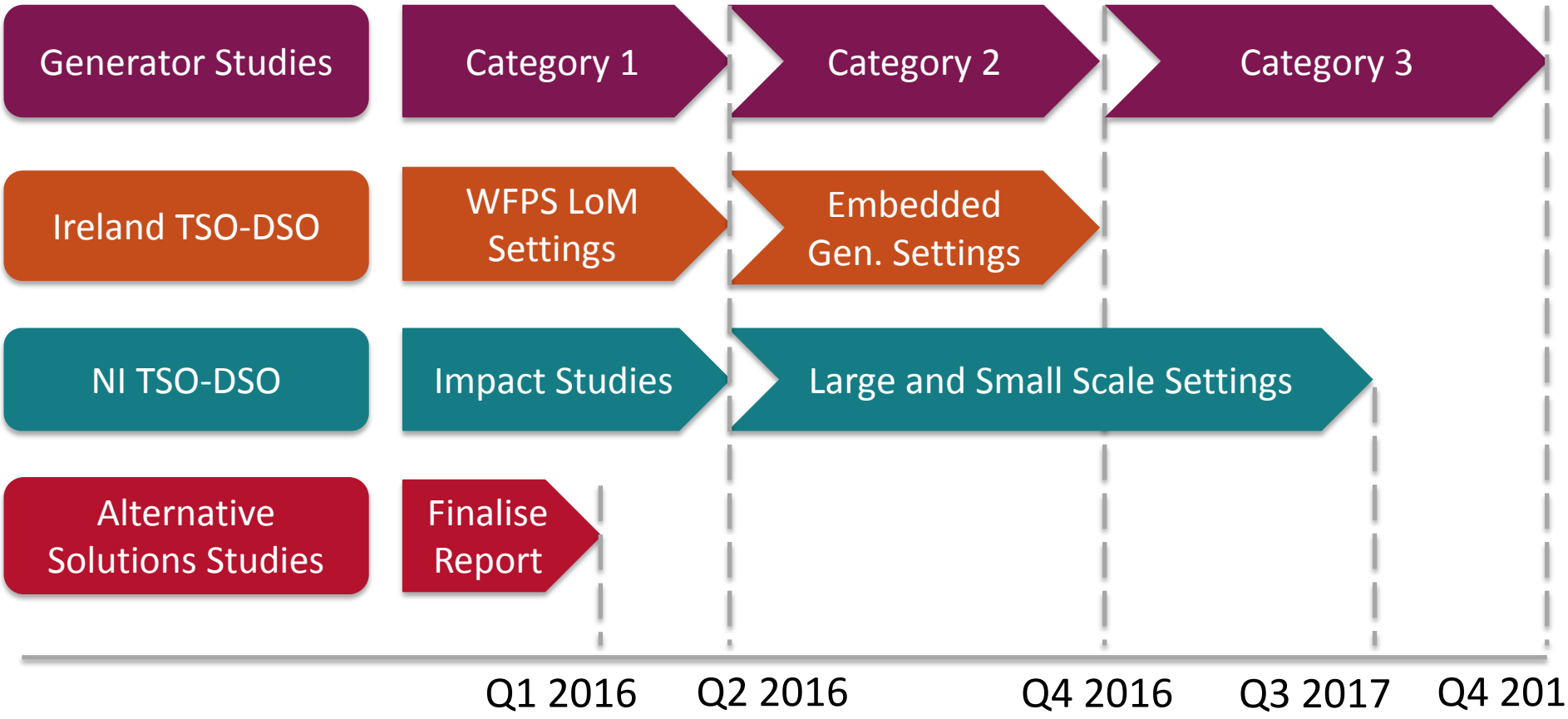
RoCoF Project Summary



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DS3 System Services Implementation Project

Eoin Kennedy

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Agenda

- Background
- Project Plan
  - Interim Arrangements
  - Enduring Arrangements
- Design Principles and Methodologies
- Stakeholder Engagement
- Next Steps

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Background

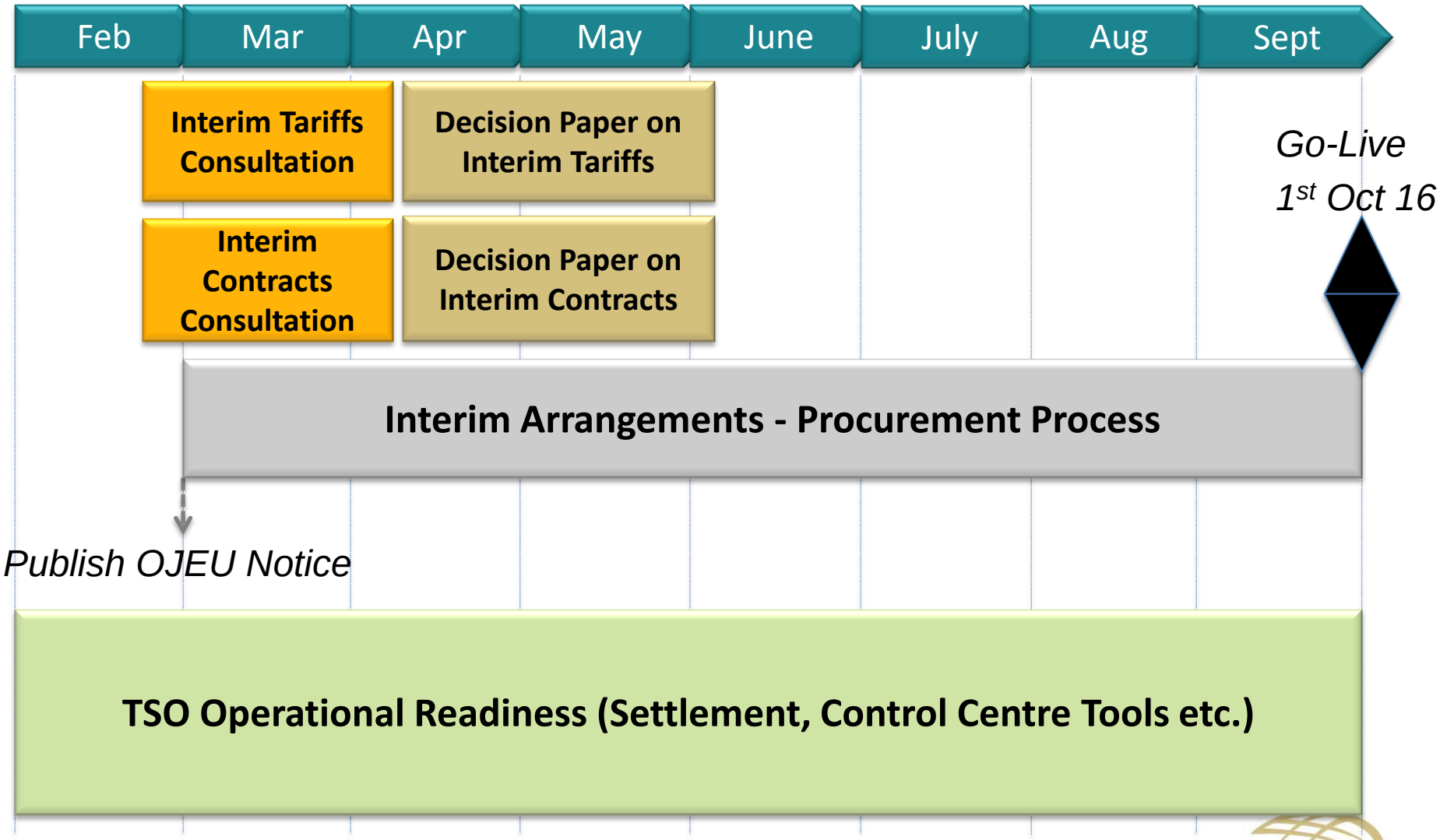
DS3 System Services Decision

- Regulated tariffs paid for all 14 services for one year only

- Auction for services deemed competitive
- Regulated tariffs for others

Project Plan

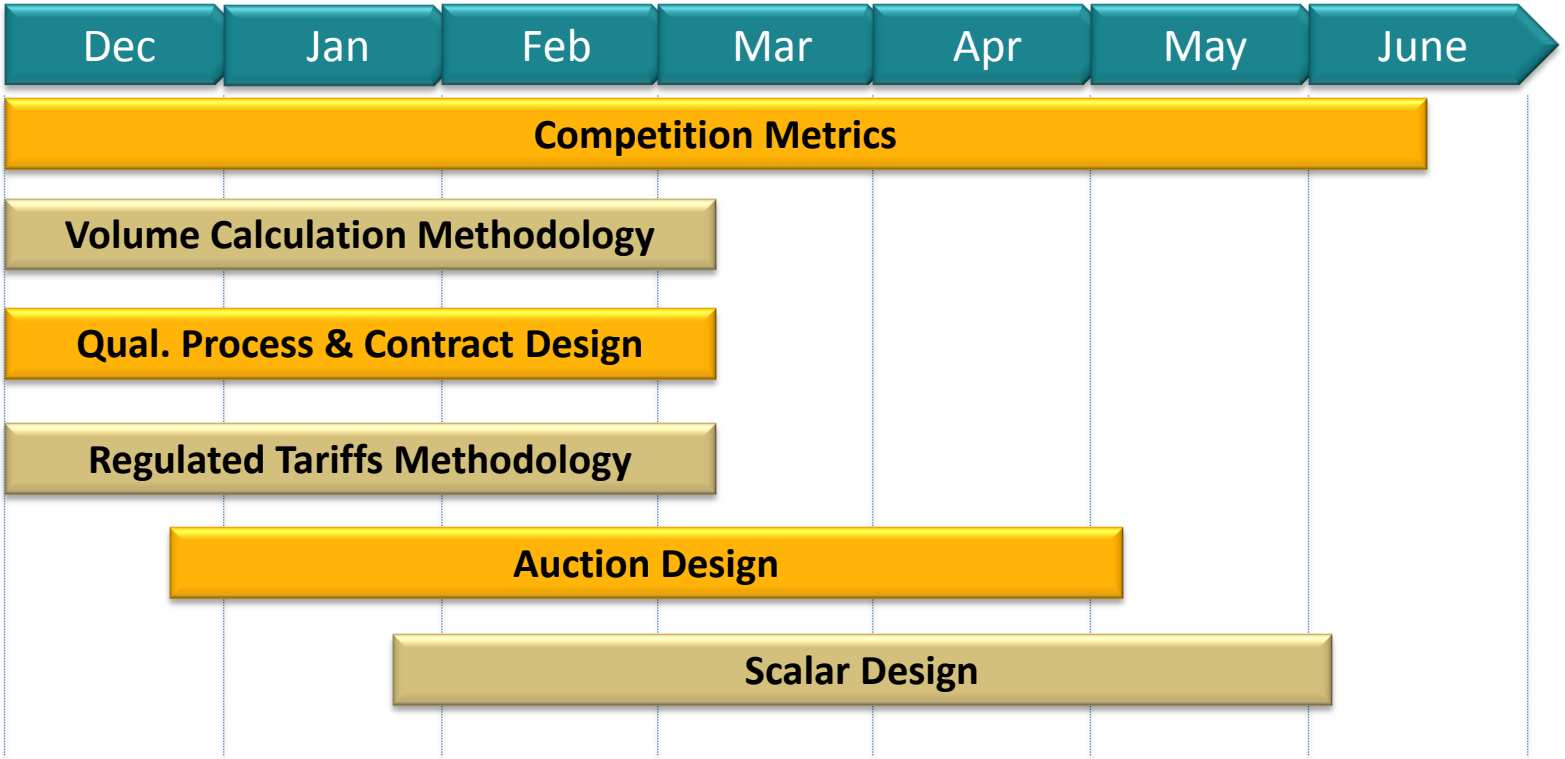
Interim Arrangements – Timelines



Enduring Arrangements Timelines to June 2016

SEMC

TSOs



Note: Publication of the SEMC decision paper for the Competition Metrics consultation postponed to ensure there is opportunity to align with I-SEM market power considerations

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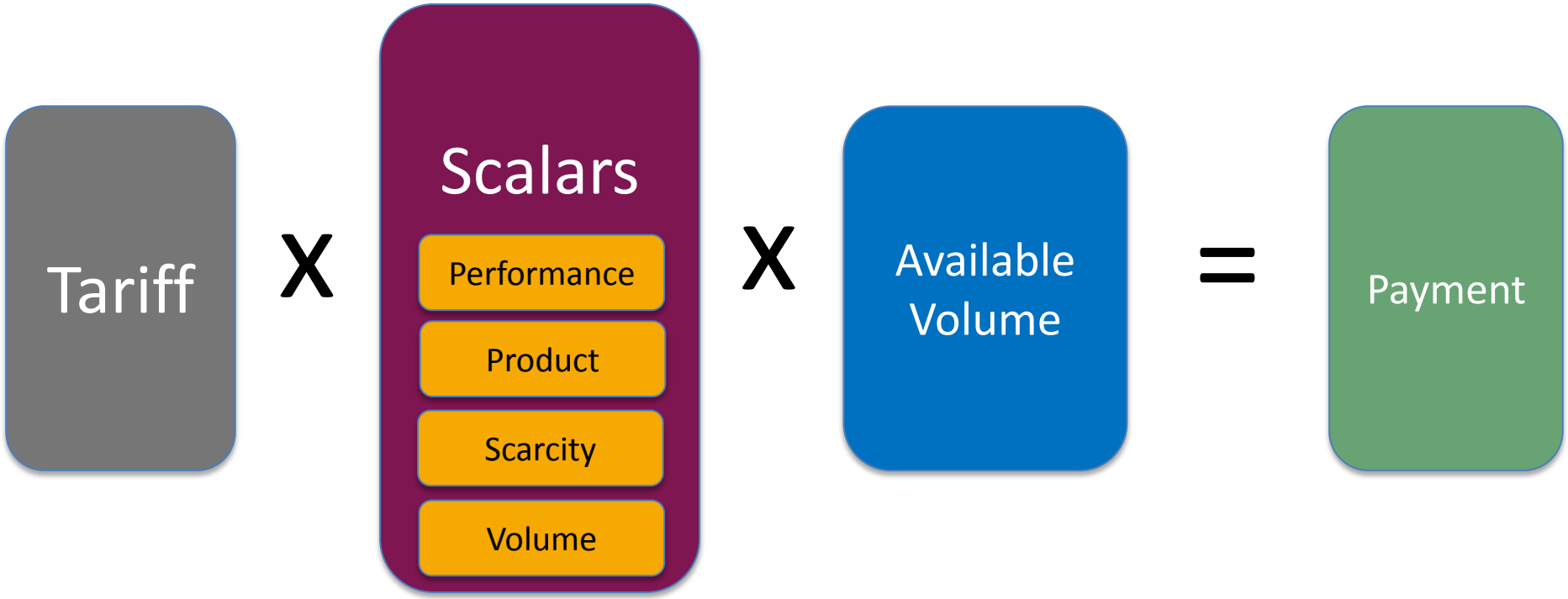
Design Principles and Methodologies

Holistic Design

- Holistic approach to design of Regulated Tariff, Scalars and Volumes needed



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Volumes and Tariff Consultations

- Volume Calculation Methodology - 17 responses
- Regulated Tariff Calculation Methodology – 18 responses
- Many detailed comments included in consultation responses

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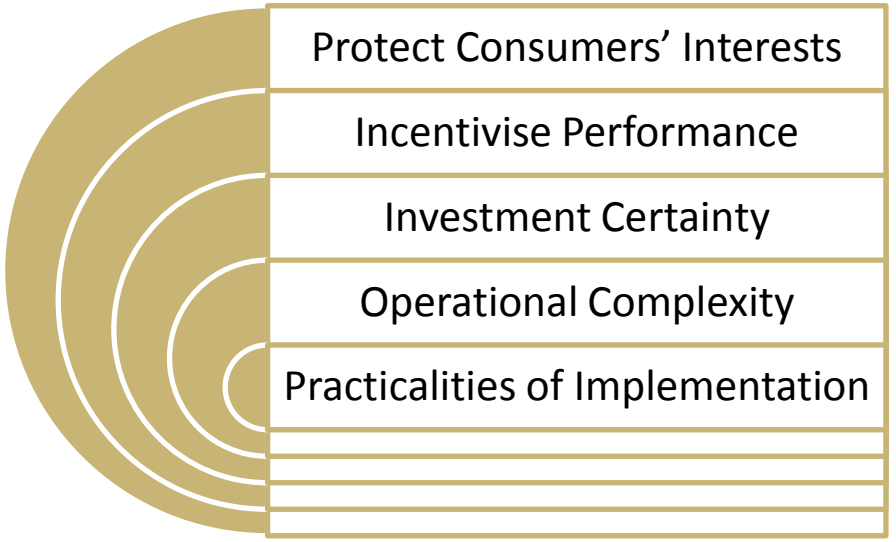
Scalars - Design Considerations

- Seeking to balance incentivisation benefits from use of scalars with downsides of implementation complexity and impact on investment certainty
- Consultation due to issue End Jan 2016



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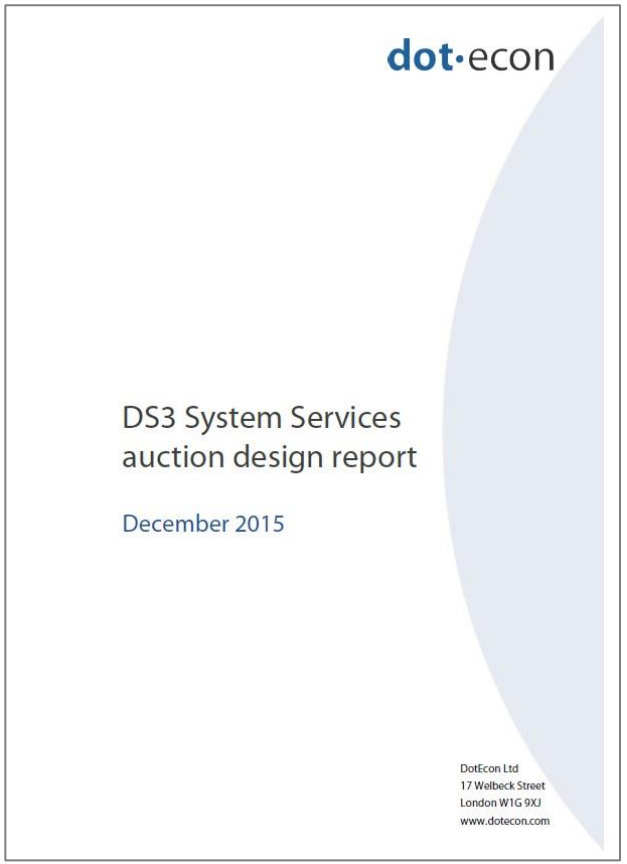
Auction Design



- *DotEcon auction design report provided to the RAs in December 2015*
- *SEMC Consultation issued on 22nd December – closes 12th Feb*

Stakeholder Engagement

Stakeholder Engagement

- Stakeholder workshop held in Dundalk on 12th Nov
- 15 separate TSO-RA-Stakeholder trilateral meetings held in Nov / Dec
- Workshop confirmed for 1st Feb – focus on auction and scalar designs
- Further workshop planned for early March – focus on:
  - Procurement Process
  - Interim Contract
  - Settlement Calculations
  - Interim Tariff

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Next Steps

Next Steps

- Finalise and publish consultation papers
- Continued focus on timely delivery of the interim and enduring arrangements
- Hold stakeholder workshops – next workshop scheduled for 1st Feb in Dublin

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Questions?

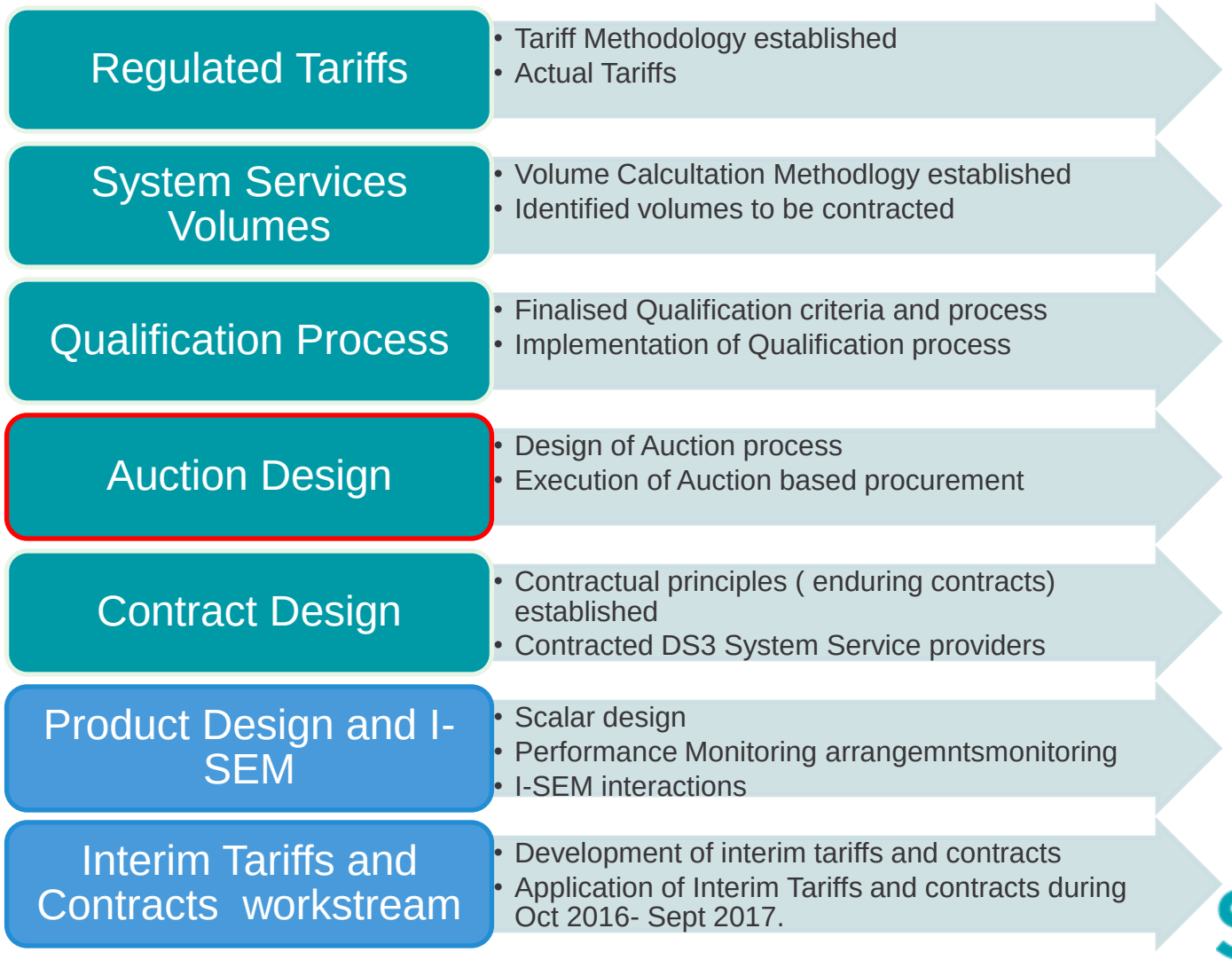
DS3 System Services Auction Design Consultation

DS3 Advisory Council

19th January 2016

SEM committee

Auction Design – System Services Design Workstream

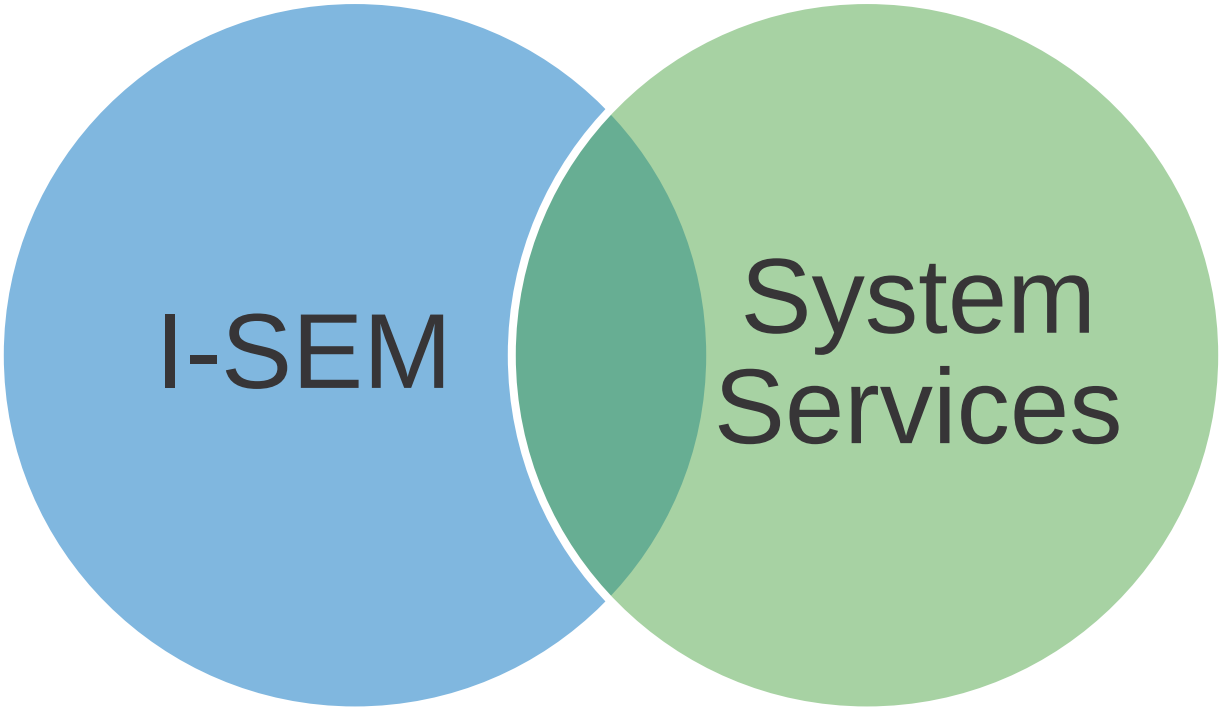


SEM committee

Auction Design – Combined lead workstream

SEM committee

System Services / I-SEM Interaction



System Services / I-SEM Interaction

SEMC have recognised there is a requirement to achieve a level of consistency regarding the procurement of capacity and DS3 System Services where possible.

- Develop, where possible, a consistent DS3 and Capacity Implementation Agreement (recognising specific differences of each). The second CRM consultation paper will consult on the Implementation agreement. We will look at how this can be applicable to DS3 in the coming months.
- Develop, where possible, a consistent DS3 and Capacity qualification process (recognising specific differences of each)
- Develop DS3 auction platform to accommodate an extra (Capacity) product
- Separately develop Capacity only auction in parallel

Auction Design report –thorough examination of options with clear proposals

Commitment model

- No commitment
- Full commitment
- Contingent commitment

Auctions for long and short term contracts

- Separate Auctions - long and short term contracts
- One Auction- assessment and award of long term contracts to new only

Auction pricing

- Availability considerations
- Winners and losers
- Price determination
- Treatment of Interconnectors

I-SEM Interaction

- Interaction with Balancing market
- Assessment of risk to auction of providers' dependency on SS and CRM revenue

SEM committee

Auction Design report –emerging proposals

Separate Auctions

- Assess plant that are eligible for long term contracts together - different lead times
- Assess plant that are 1 year term contracts together
- Will require specific volume considerations for each type

One Auction

- Aligned with SEMC decision in Initial High level Design
- Requires assesment of different contract lengths to establish clearing price

Consultation paper

Discussion and Development of key aspects within Dot-Econ report

- No decisions made on commitment model, and an alternative commitment model proposed
- Recognition of interaction with I-SEM and the need to ensure alignment where possible
- Consideration of Auction proposals for contracts of different lengths, in addition to possible CRM auction alignment

Consultation paper

Discussion and Development of key aspects within Dot-Econ report

- Consideration of Availability proposals, winner/price determination
- Consideration of proposals to offer strictly lower payments to providers who are unsuccessful in auctions but who are required to provide services by the TSO through non-energy actions
- Consideration of requirement for potential new entrant providers to successfully qualify for SS and CRM revenue before development can proceed

Conclusion

Consultation closes 12th Feb 2016.

Industry workshop – 1st Feb to concentrate on Auction Design and Scalars

Questions

DS3 Advisory Council

19th January 2016

SEM committee

55% SNSP Trial Analysis

Ivan Dudurych

EIRGRID GROUP

55% SNSP Trial

- The trial started on the 16th October 2015
- Builds on the Developments of Policies and Tools over the last 4 years
- System closely monitored in real-time and off-line
- No adverse system behavior observed

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Advances in the System Tools

- Monitoring tools
  - Inertia monitor (>20,000 MWs)
  - RoCoF monitor (<0.5 Hz/s)
- Enhanced WSAT
  - Frequency, Transient and Voltage Security
  - Frequency nadir/zenith (49Hz<F<51Hz)
- Phasor Measurement Unit system
  - Oscillation monitoring

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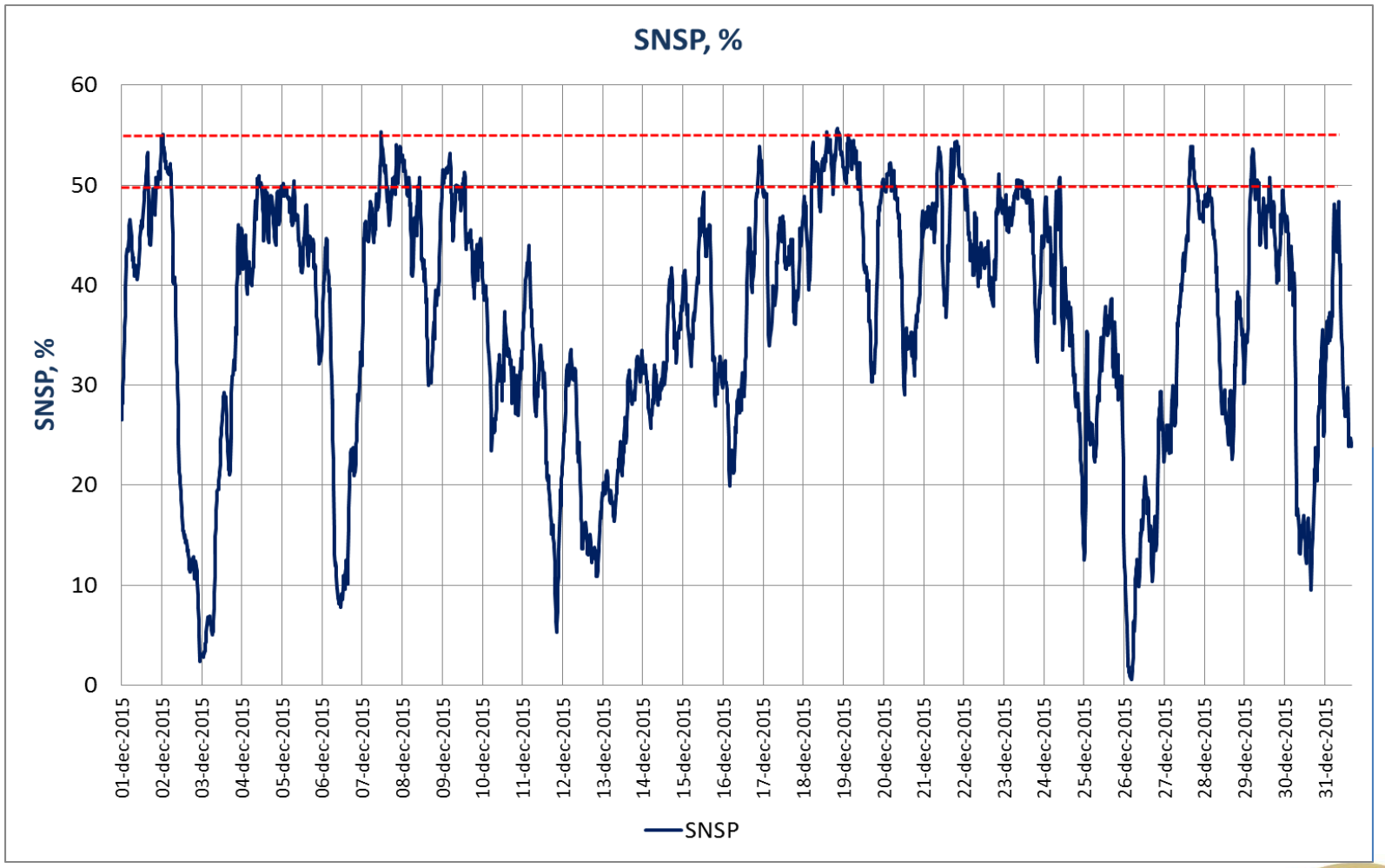
SNSP



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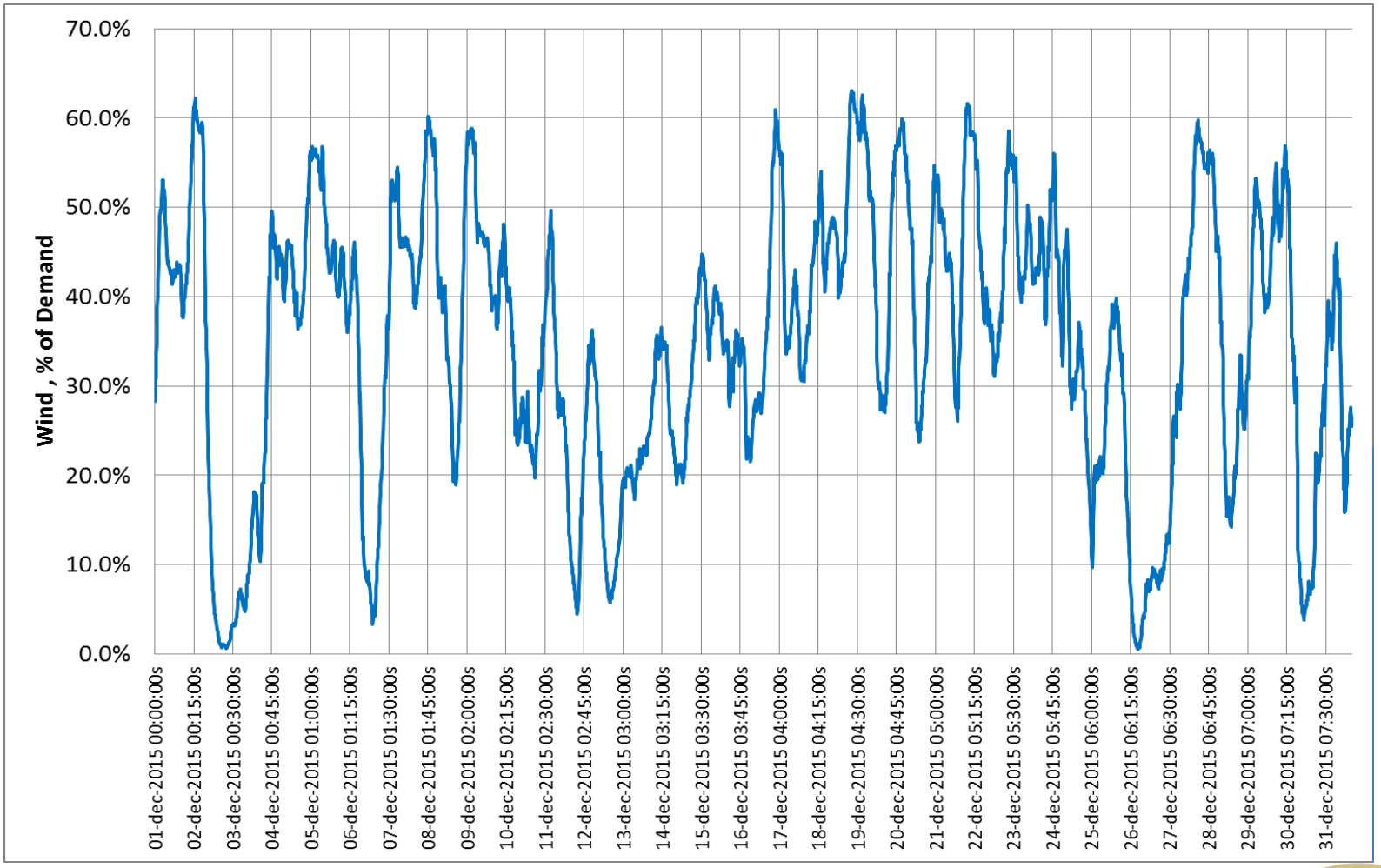
Wind, % of Demand



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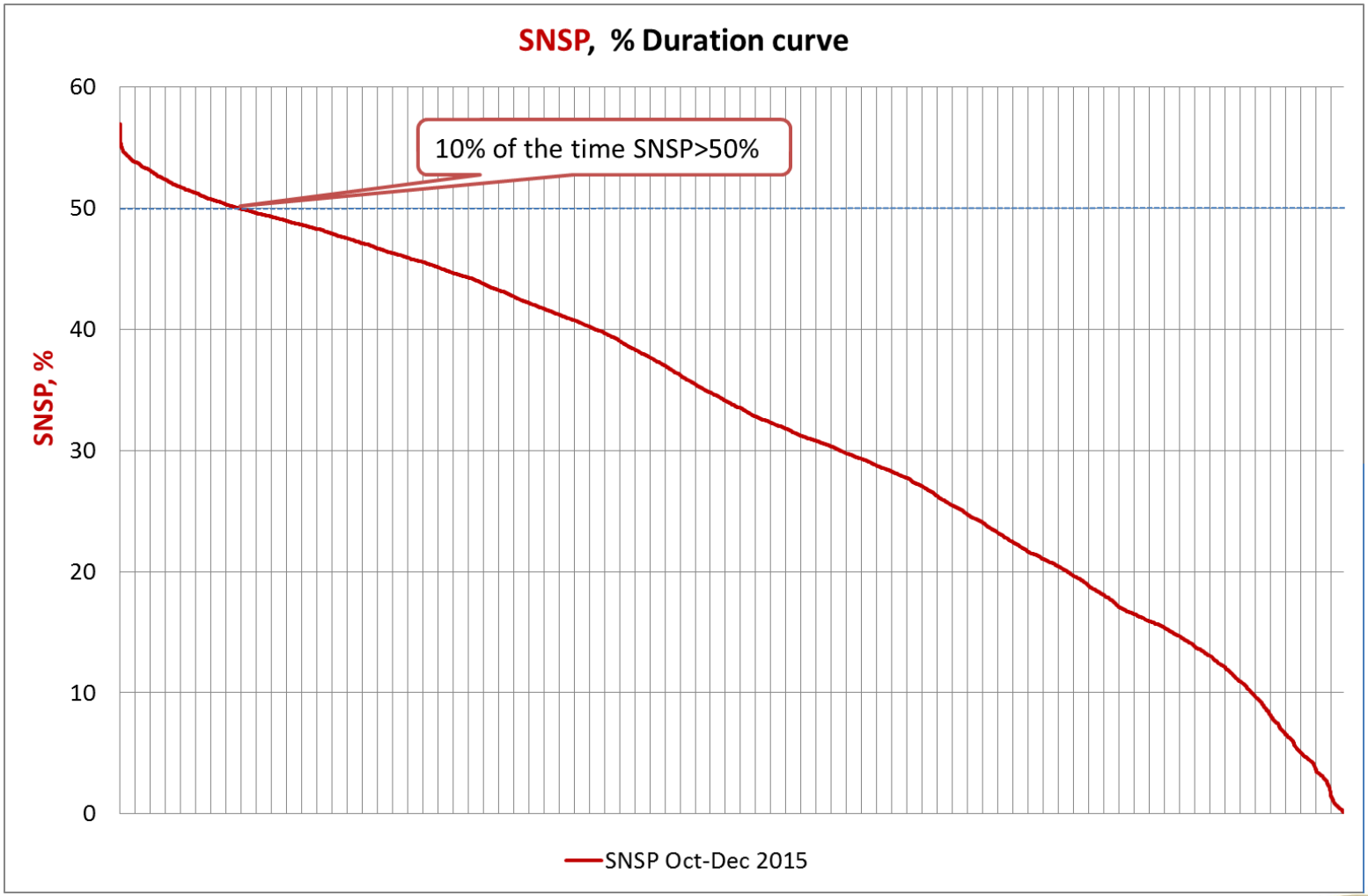
SNSP Duration Curves



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Assessment Criteria

Monitored and Assessed Issues	Result
Inertia	✓
RoCoF	✓
Frequency Regulation	✓
Voltage Stability	✓
Transient Stability	✓
Frequency Stability	✓
Sensitivities	✓

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Conclusions

- From 16 October to 8 January the SNSP was over 50% for 10% of the time
- There is no fundamental difference in system behavior at 50%<SNSP<55% and at other high SNSP levels
- Operating the system with SNSP up to 55% will reduce curtailment
- Trial is expected to end Q1 2016

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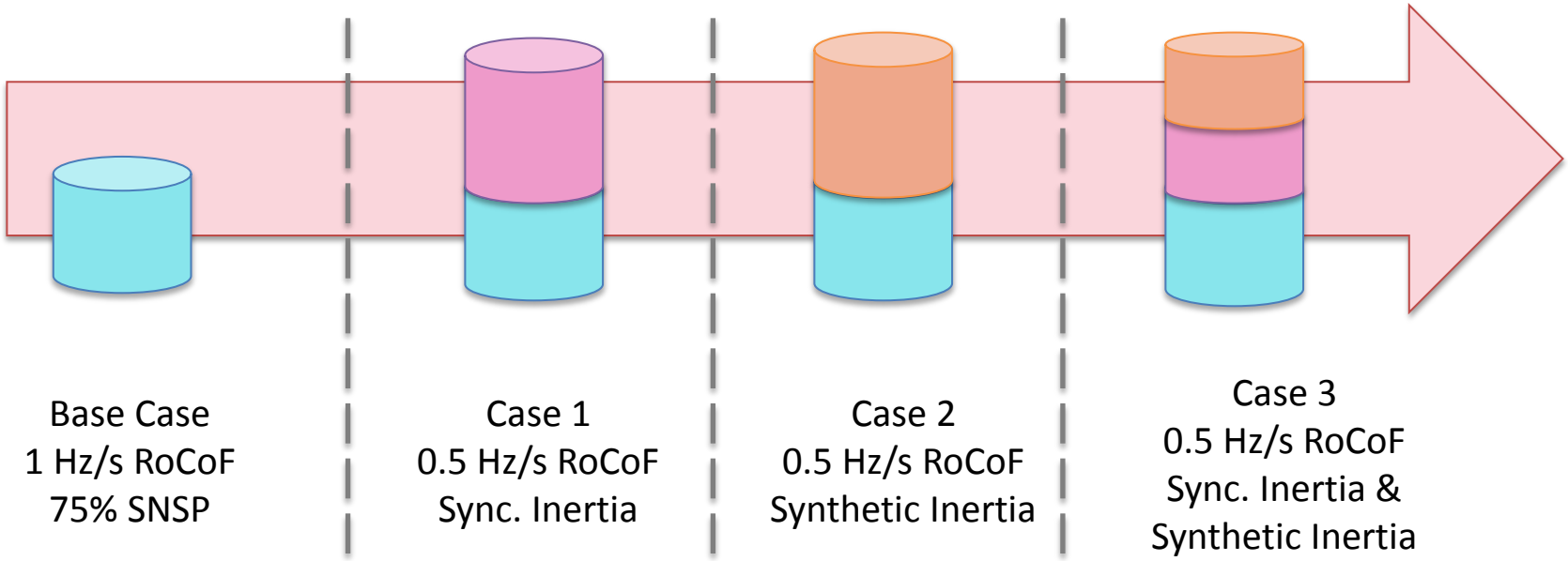
RoCoF Alternative & Complementary Solutions Phase 2 Study

Martin Eager

EIRGRID GROUP

RoCoF Phase 2 Outline

- Determine the extra volume of synchronous and/or synthetic inertia to maintain RoCoF within 0.5Hz/s and allow 75% SNSP
- 3 Cases investigated:



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Base Case Generation

Property	Value
SNSP	75 %
RoCoF	1.0 Hz/s
Moyle Interconnector	Import 450 MW / Export 80 MW
East-West Interconnector	Import 500 MW / Export 500 MW
Installed Large Scale Wind Capacity	4732 MW
Number of Must Run Units	Existing constraint disabled
Second North-South Line	In service
Frequency Reserve	Existing constraints disabled

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Acceptance criteria

- A scenario is deemed acceptable if:
  - RoCoF is within ±0.5 Hz/s (measured over 500 ms) in 99% of the solved cases following an N-1 event.

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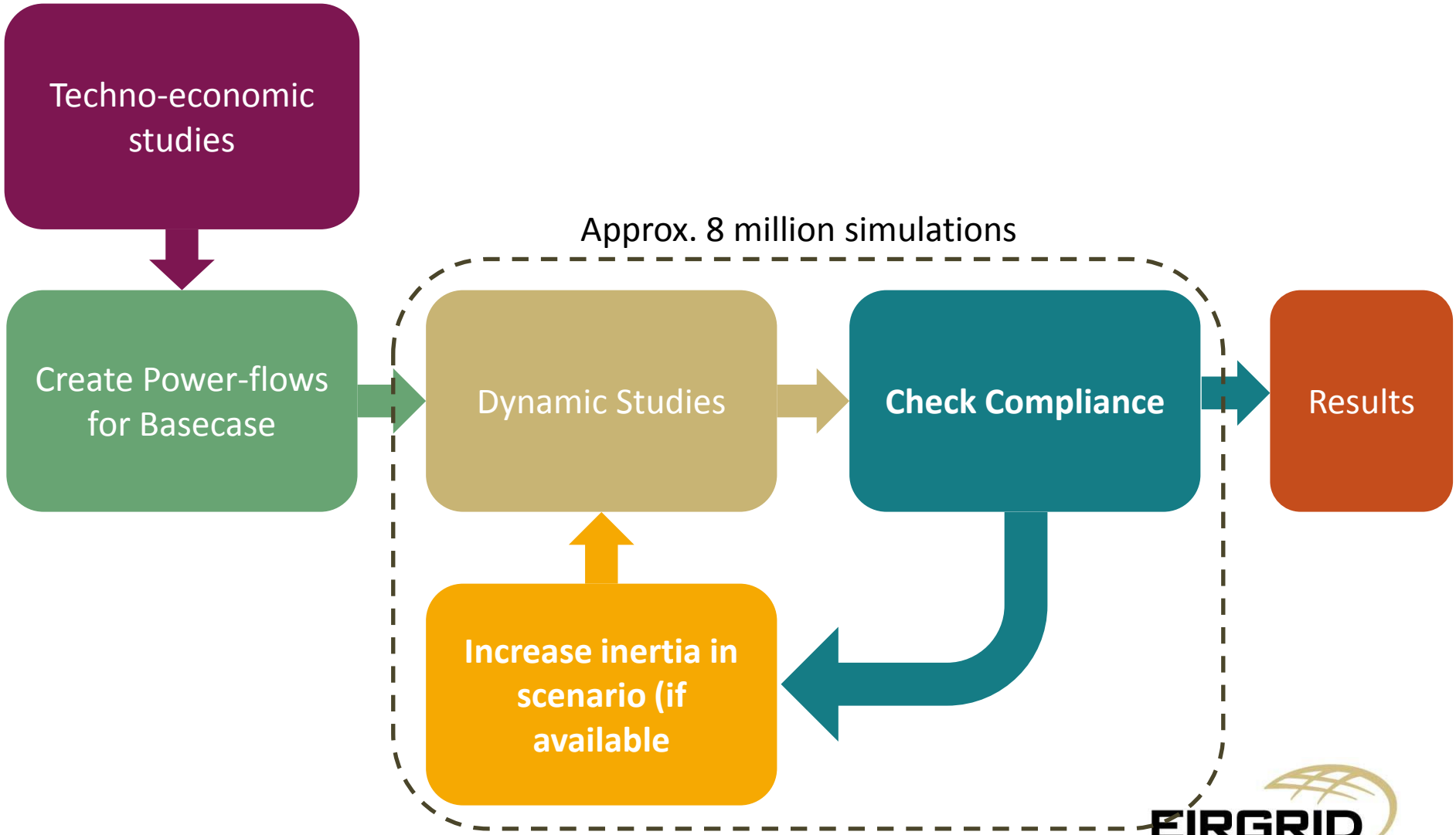
Study Process Flow



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Techno Economic Studies

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Techno Economic Studies – Constraints

Techno-economic scenario	Constraints			
	SNSP (%)	RoCoF (Hz/s)	P Min (%)	POR / SOR (% of LSI)
A	75	0.5	Existing limit	-
B			35	-
C			Existing limit	75
D			35	75
E		1	Existing limit	-
F			35	-
G			Existing limit	75
H			35	75

0.5 Hz/s constraint ⇨

System inertia > 20,000MW.s for most the year

Pmin at 35% ⇨

No material impact on the no. of large units dispatched

Reserve constraint ⇨

Equivalent to adding another large unit

Technical simulations will be based on Case E

Base Case Studies

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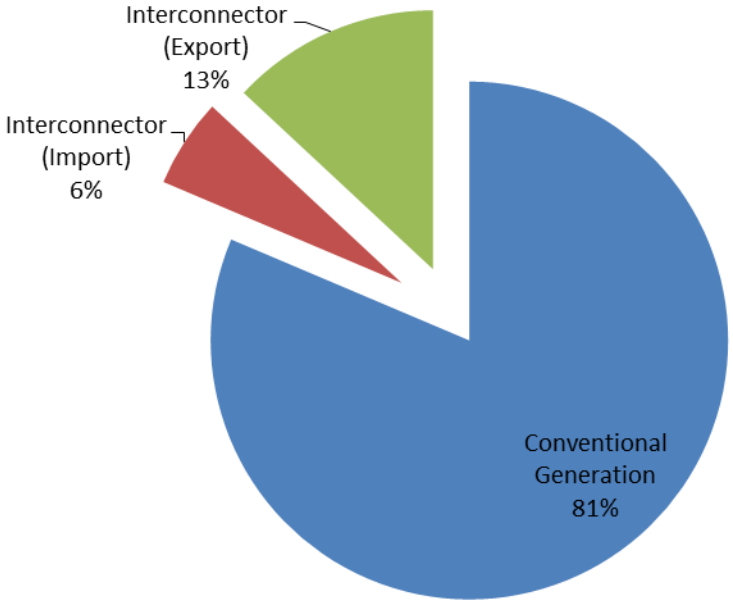
Base Case Studies

Approximately 60% of the hours of the year require supplementary inertia within 200ms – 500ms.



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Synchronous Inertia Studies

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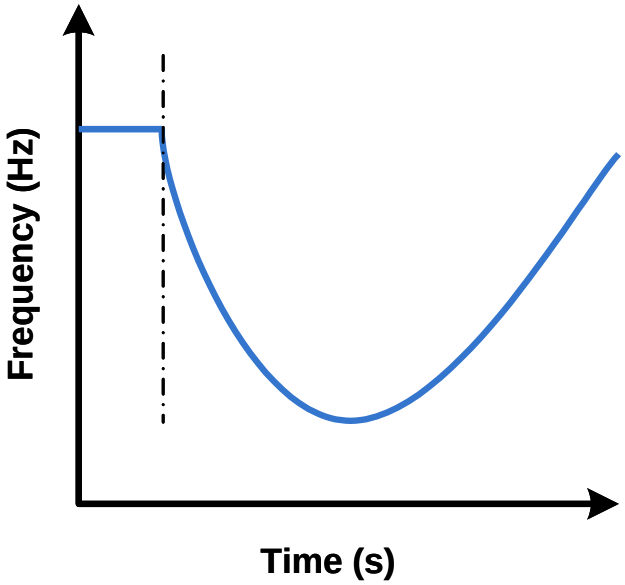
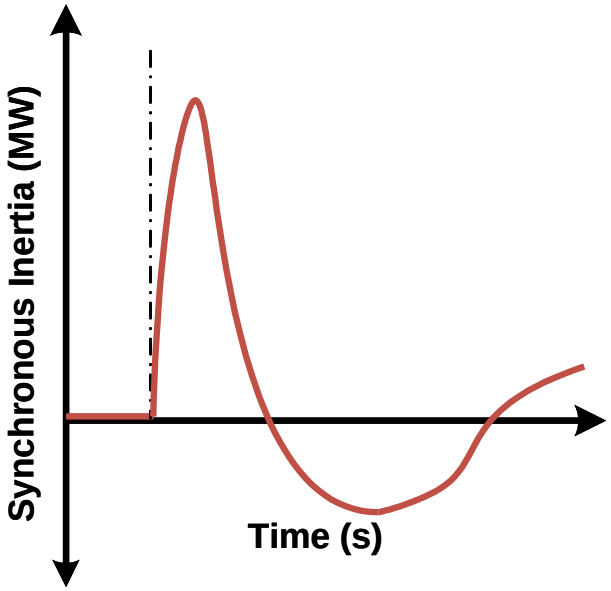
Synchronous Inertia Model





20,000MW.s of system inertia required to maintain RoCoF.

Approx. 12,000 MWs of supplementary synchronous inertia is required by the Base Case to met the acceptance criteria.

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Synthetic Inertia Studies

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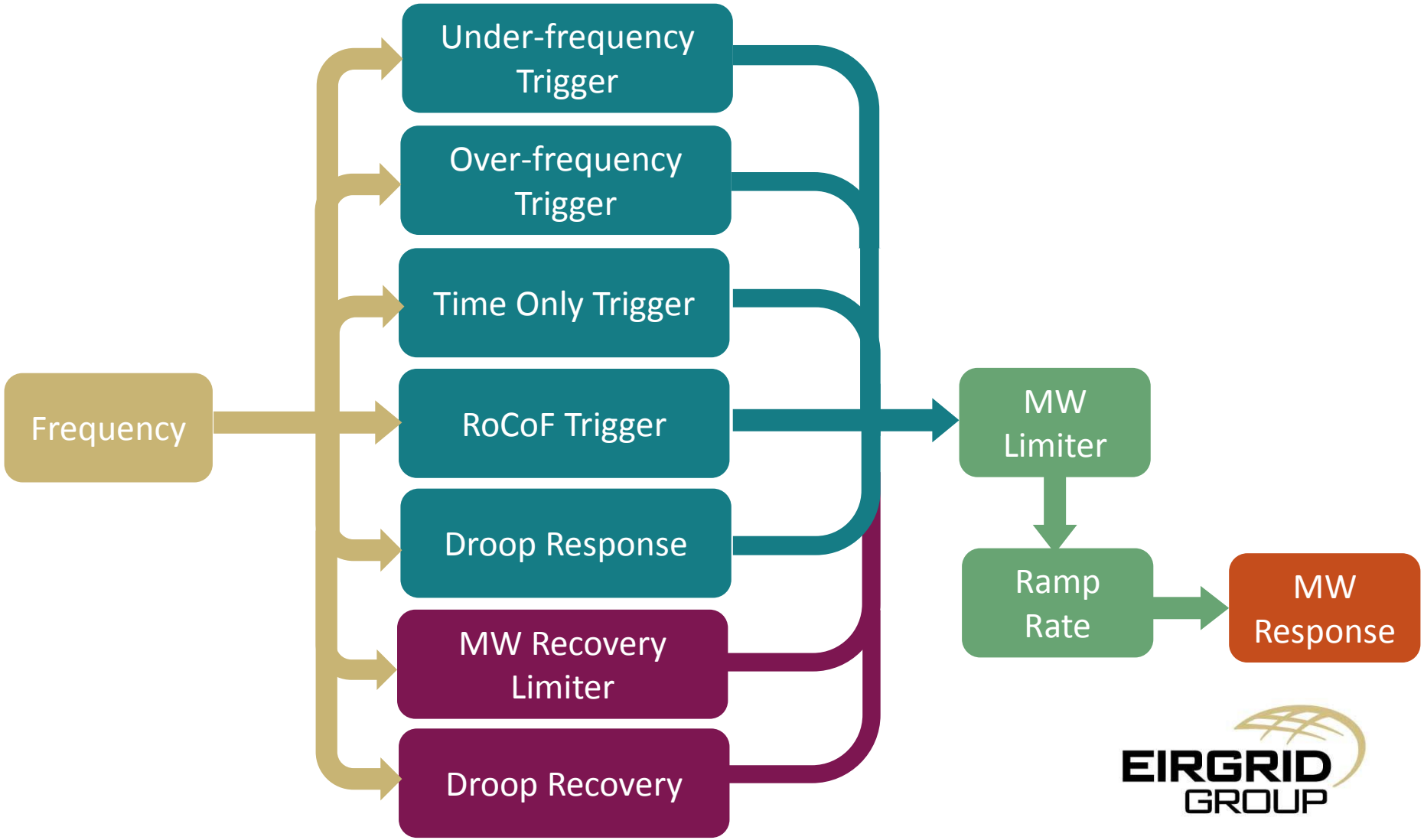
Synthetic Inertia Model



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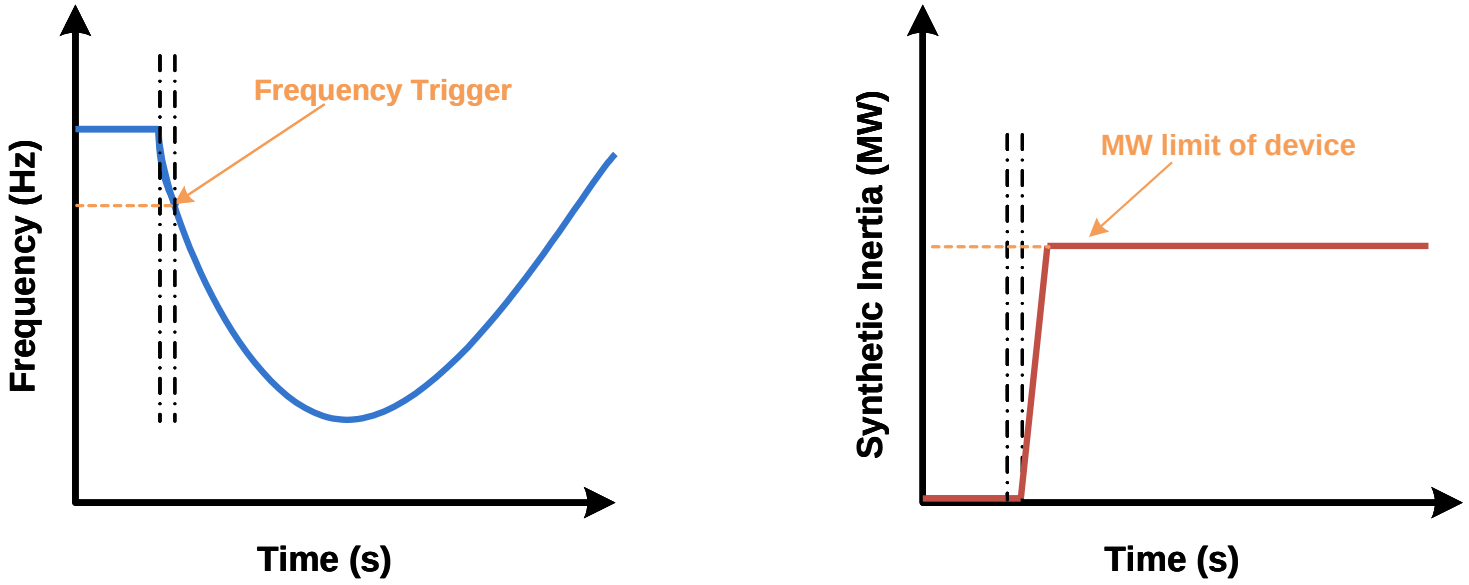
Synthetic Inertia Model

Frequency triggered – Step response

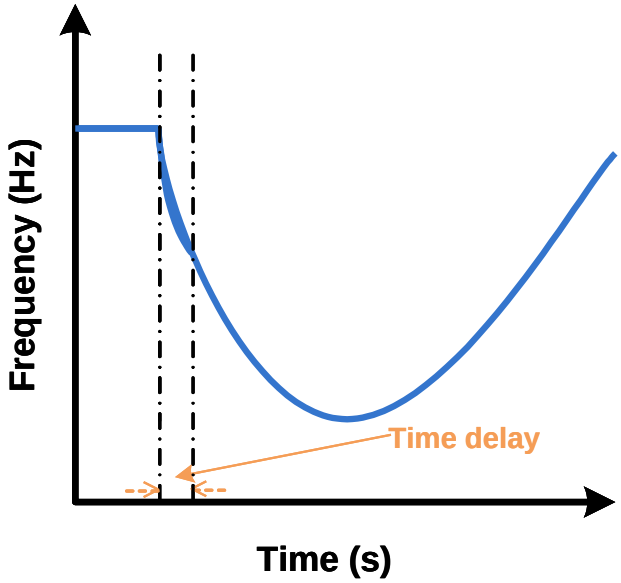


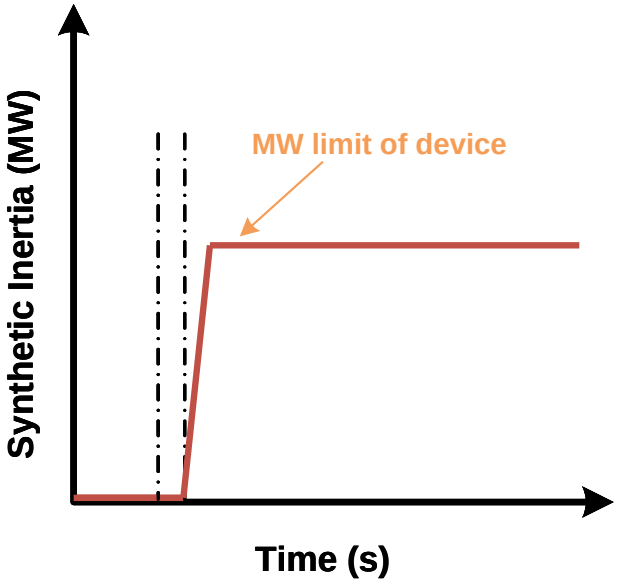
A trigger of 49.8Hz does not met the acceptance criteria.

A trigger of 49.9Hz with a step injection of 360MW may meet the criteria but would lead to over-providing active power following small frequency excursions.

Synthetic Inertia Model

Time triggered – Step response





To met the acceptance criteria synthetic devices should respond within 100 ms of the event and ramp to full output in 200 ms of the initial device response.

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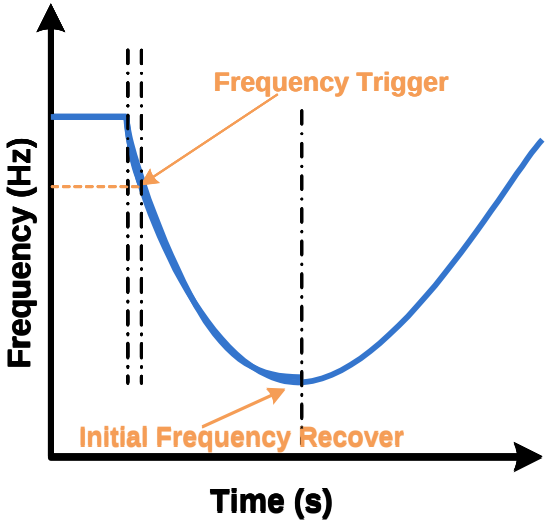
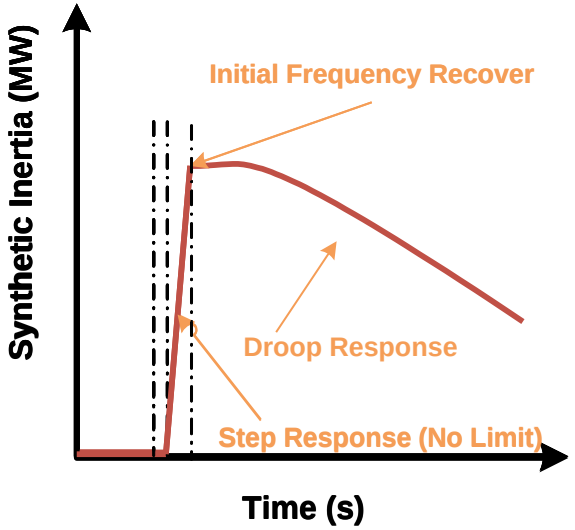
Synthetic Inertia Model

Step triggered at 49.8Hz followed by droop controlled recovery





A fast initial response maintains initial RoCoF within 0.5Hz/s, while a droop controlled recovery resolves unintended frequency recovery issues.

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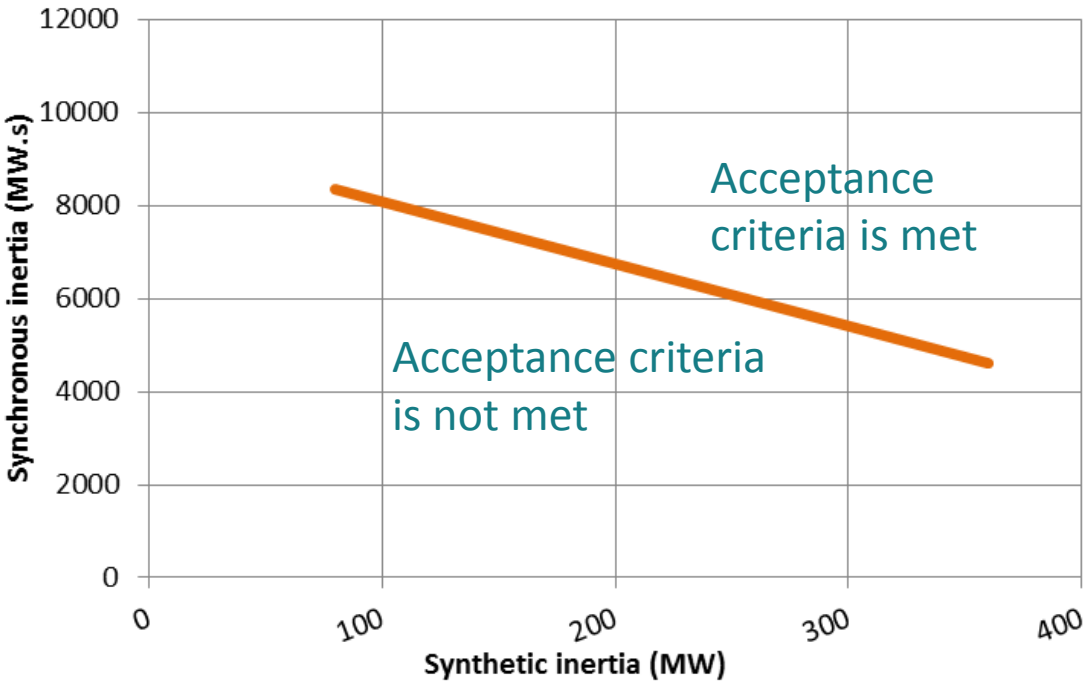
Combined sync. & synthetic inertia

Synthetic inertia injects a step response at 49.8Hz



The combination results are found to deliver a solution where the different devices responses can complement each other.

Results are highly depend on the synthetic inertia characteristics.

Key Findings

Synchronous Inertia

- 20,000 MW.s required to maintain RoCoF
- 12,000 MW.s was added to Base Case

Synthetic Inertia

- Begin to respond within 100 ms
- Ramp to full output in 200 ms
- Control for recovery
- +/- 360 MW

Combination

- Sensitive to synthetic device performance
- Would require TSO lead project to implement

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Closing Remarks and Actions

Louis Fisher

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