DS3 Advisory Council Meeting

24/05/2016

EIRGRID GROUP

Agenda

Topic	Time	Speaker
Introduction	10.30	Robin McCormick -EirGrid (5 mins)
Industry Perspective	10:35	Presentation: Graham Stein – National Grid (10 mins) Discussion: All (10 mins)
Actions from last meeting and Membership Discussion	11:05	Presentation: David Cashman -EirGrid (10 mins) Discussion: All (10 mins)
DS3 Programme Status Update	11:25	Presentation: Jon O' Sullivan - EirGrid (20 mins) Discussion: All (10 mins)
Rate of Change of Frequency (RoCoF)	11:55	Presentation: David Cashman - EirGrid (10 mins) Presentation: Tony Hearne - ESB Networks (5 mins) Update: Rodney Ballentine - NIE (5 mins) Discussion: All (5 mins)
System Services(General Update)	12:20	Presentation: Eoin Kennedy / Ian Connaughton - EirGrid (30 mins) Presentation: RA's (TBC) (15 mins) Discussion: All (15 mins)
Lunch & Networking (13:20 – 14:05)		
Topic	**Time**	**Speaker**
SMART Power Factor Study	14:05	Presentation: Eoin Sweeney - EirGrid (15 mins) Discussion: (5 minutes)
NIE Relays Detailed Presentation	14:25	Presentation: Rodney Ballentine - NIE (15 mins) Discussion: All (5 mins)
Impact of RoCoF for Demand Customers	14.45	Presentation: Willem Uijlings – DNV GL (10 mins) Discussion: All (5 mins)
Closing Remarks and Actions	15:00	Robin McCormick (10 mins)
Session Closed / Networking	15:10	-

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Industry Perspective

DS3 Advisory Council Meeting 24/05/2016

10.35-11.05 am

nationalgrid

Graham Stein

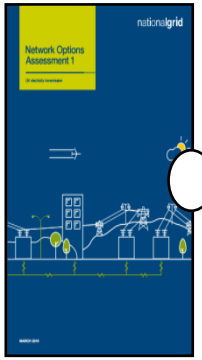
DS3 Advisory Council 24/05/2016

Background

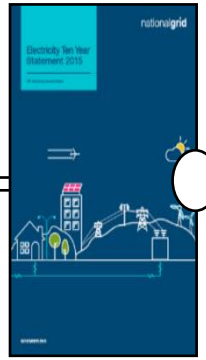
- System Performance Manager in National Grid, System Operator
- The System Performance Team is responsible for
  - System Operability Framework (SOF)
  - Enhanced Frequency Control Capability (EFCC) project

Planning in an Uncertain World

Electricity

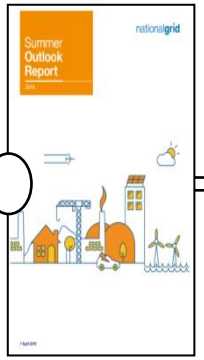


Network Options Assessment



Electricity Ten Year Statement

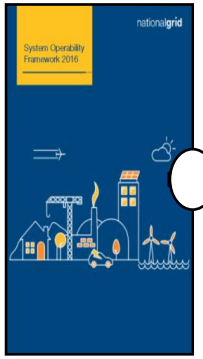
Electricity and Gas



Summer Outlook

Winter Outlook

Gas



System Operability Framework

Gas Ten Year Statement

SOF and the Future of Energy

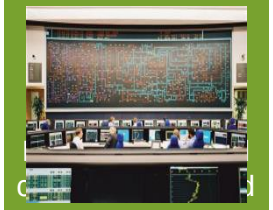
Operating Standards

- Maintain an operable system within frequency and voltage limits
- Minimise system constraints
- Facilitate the energy market

Operational Challenges

- Faster ramping and profile following
- Reductions in inertia and strength
- Frequency and voltage challenges
- Protection system event detection

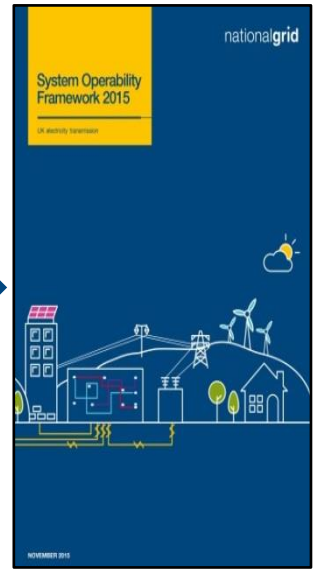
System Requirements



- Faster frequency response needed
- Dynamic voltage control required
- Coordinate across system boundaries
- New protection technical solutions

Solutions and Opportunities

- Flexible and low load operation of plant and networks
- Opportunities for demand side Participation
- Enhanced system control capabilities



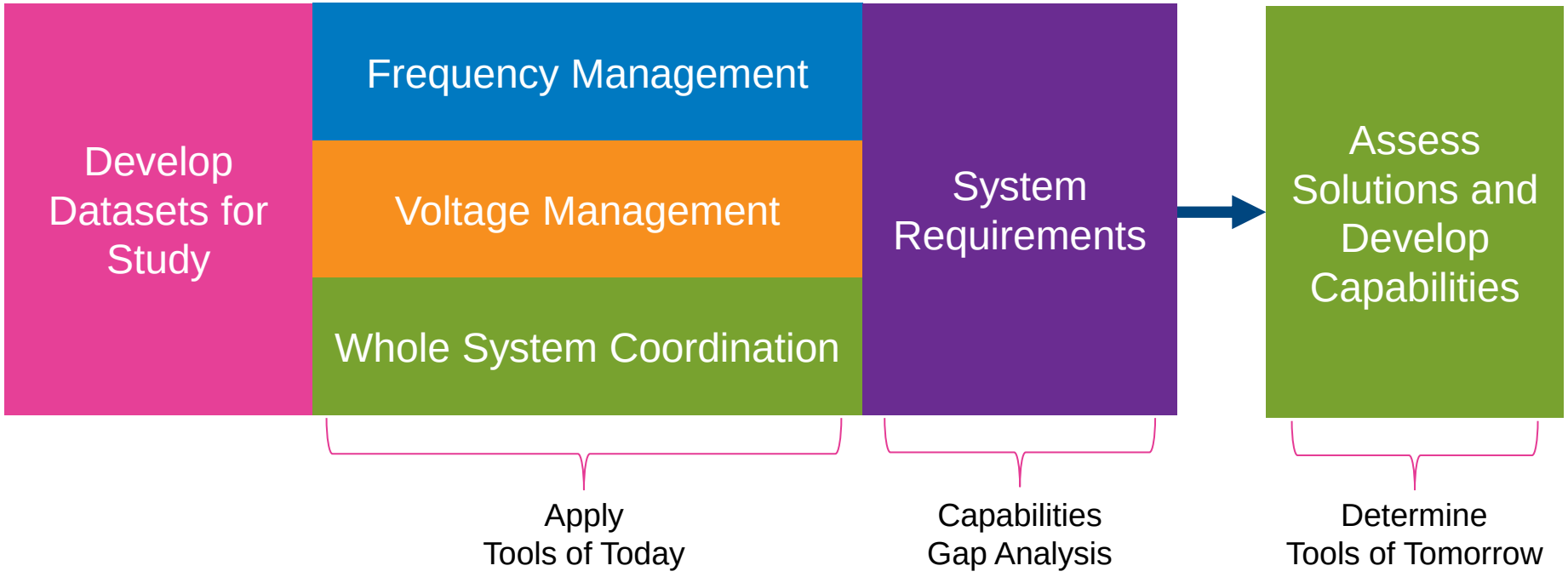
SOF 2016 Development

System Operability Framework

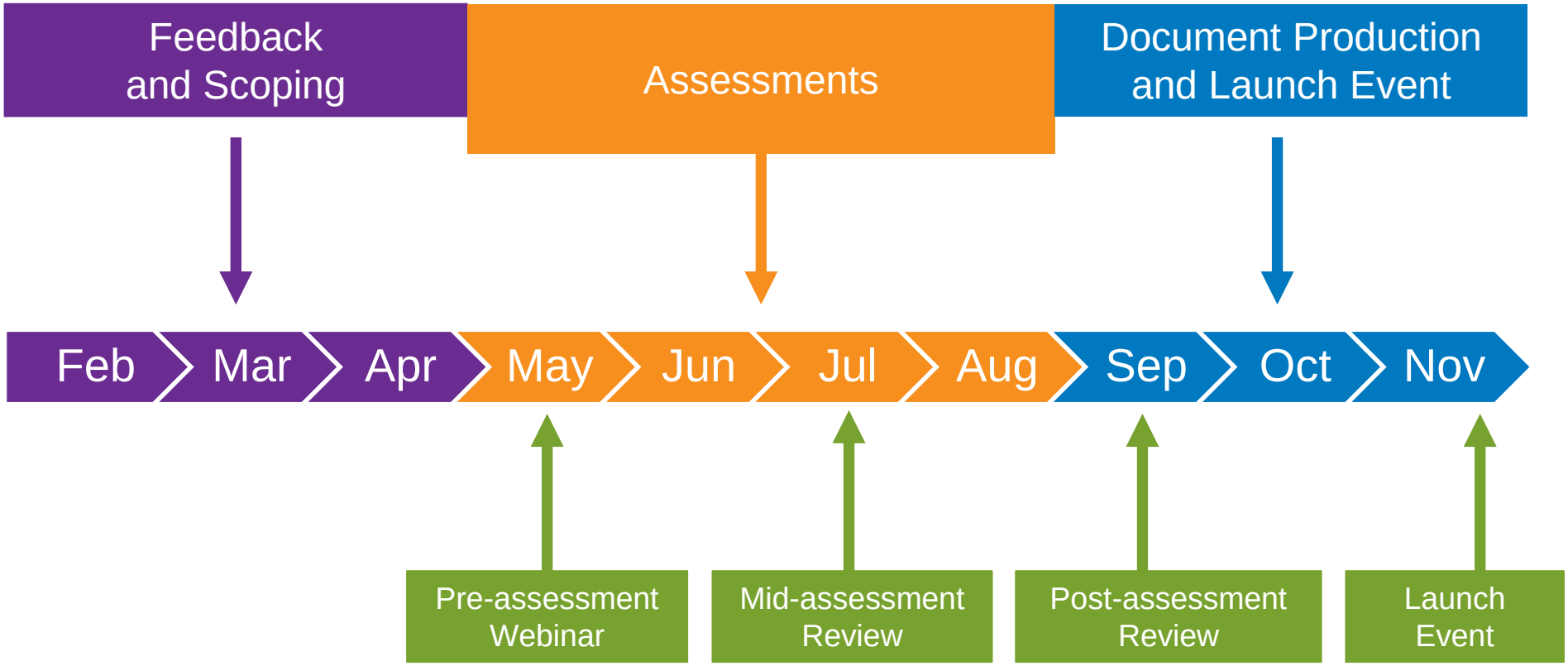
November 2016

Options Appraisal

Spring 2017

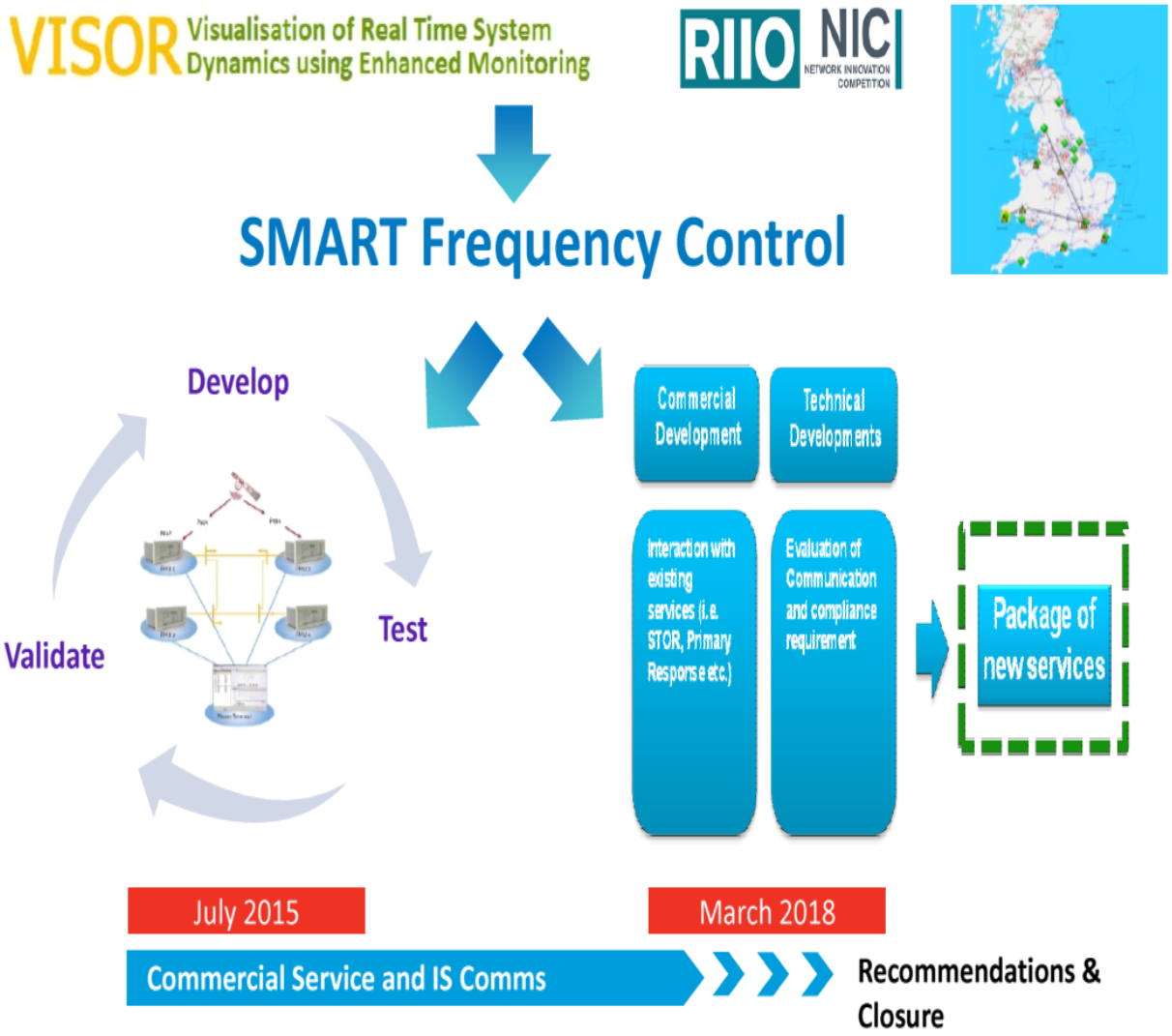


SOF 2016 Timeline



sof@nationalgrid.com
www.nationalgrid.com/sof

EFCC


VISOR Visualisation of Real Time System Dynamics using Enhanced Monitoring
RIIO NIC NETWORK INNOVATION COMPETITION
SMART Frequency Control
Develop
Test
Validate
Commercial Development
Technical Developments
Interaction with existing services (i.e. STOR, Primary Response etc.)
Evaluation of Communication and compliance requirement
Package of new services
July 2015
March 2018
Commercial Service and IS Comms
Recommendations & Closure

Thank You

Actions and Membership

DS3 Advisory Council Meeting 24/05/2016

11.05-11.25 am

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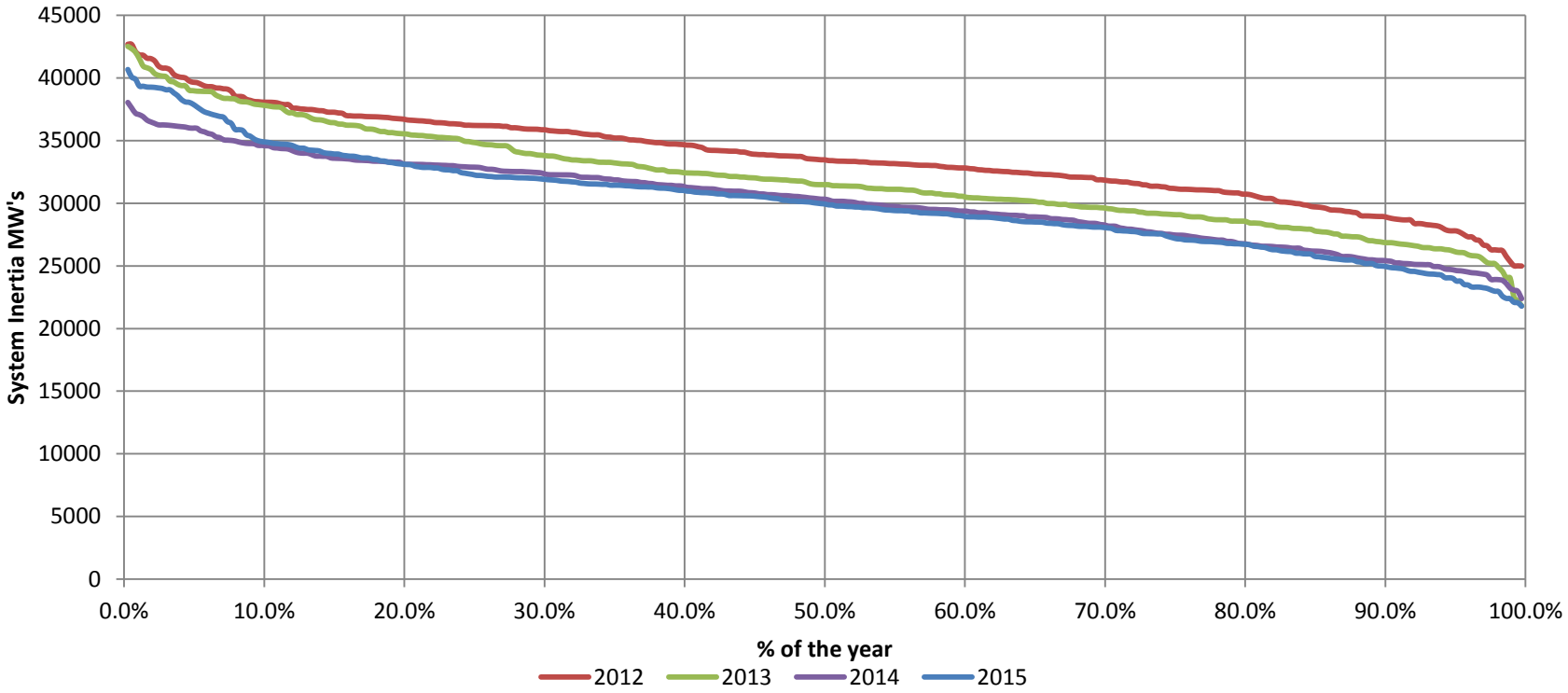
Actions

1. 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

2. TSOs to follow up with adding a new representative from National Grid and representatives from the conventional generation industry and the wind industry.

Annual System Inertia 2012 -2015



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Annual System Inertia 2012 -2015

Key	Range
	0 MW's - 4 MW's
	5 MW's - 9 MW's
	10 MW's - 14 MW's
	15 MW's - 19 MW's
	20 MW's - 24 MW's
	25 MW's - 29 MW's
	30 MW's - 34 MW's
	35 MW's - 39 MW's
	40 MW's - 44 MW's

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Membership

Category	Current Membership	Actual Members
IE & NI Renewables	4	3
IE & NI Conventional	4	1
IE & NI New Tech	2	2
OEMs	2	2
DSOs	2	2
Academia	2	2
Regulators	2	2
Departments	2	2
SEAI	1	1
DSM	1	1
Interconnection	1	1
Finance	1	1
External TSO	1	1
Total	25	21

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DS3 Programme Status Update

DS3 Advisory Council Meeting 24/05/2016

11.25-11.55 am

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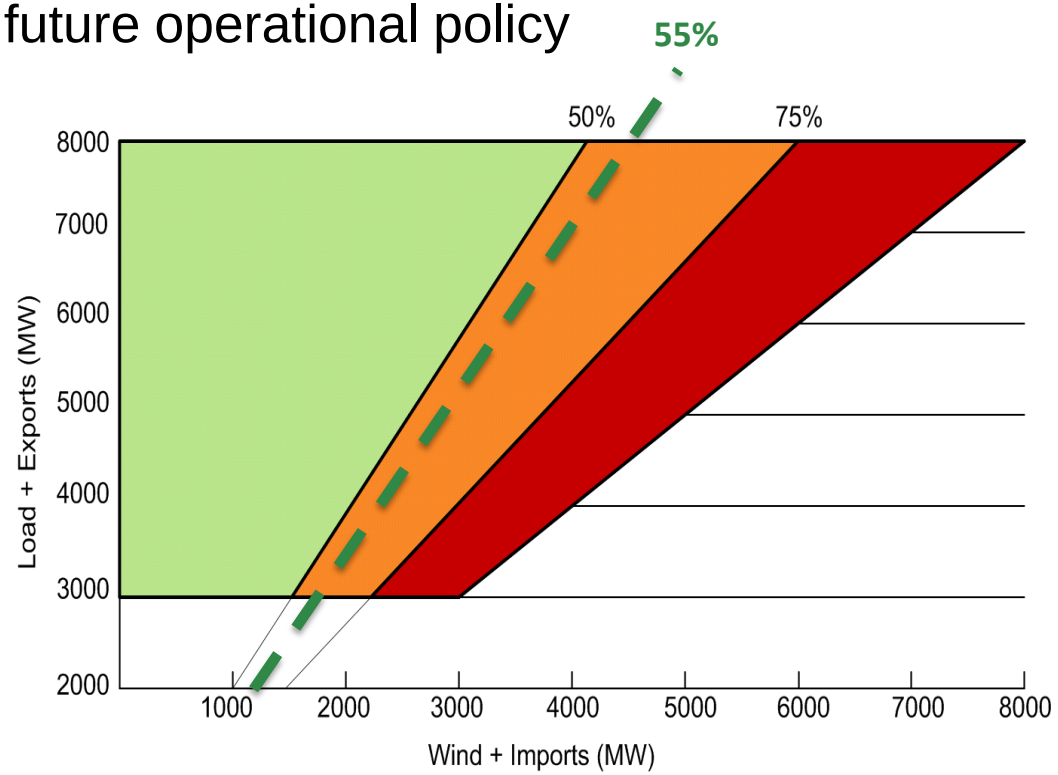
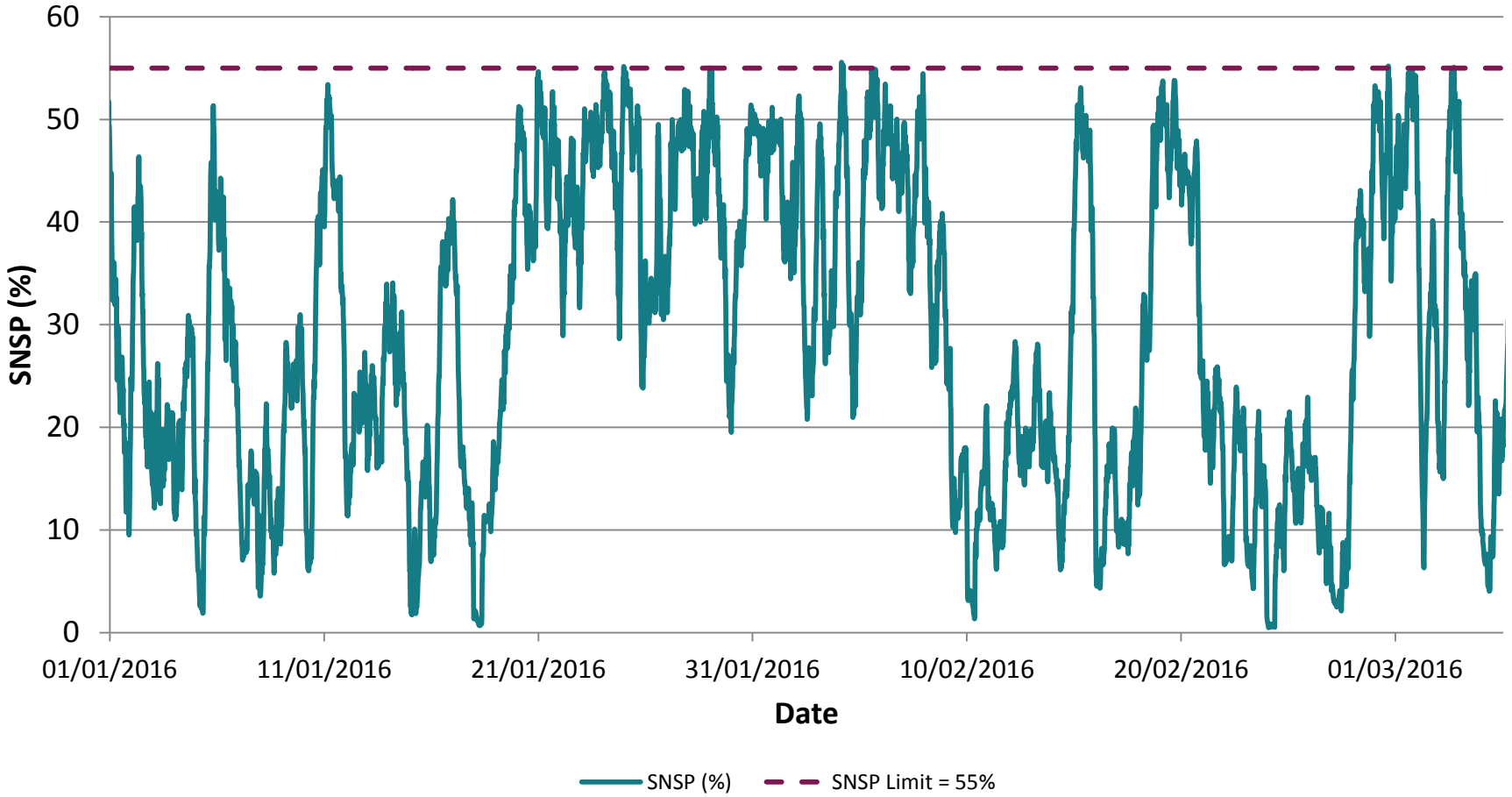
Increase of SNSP to 55%

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



SNSP Trial – Real Time Experience



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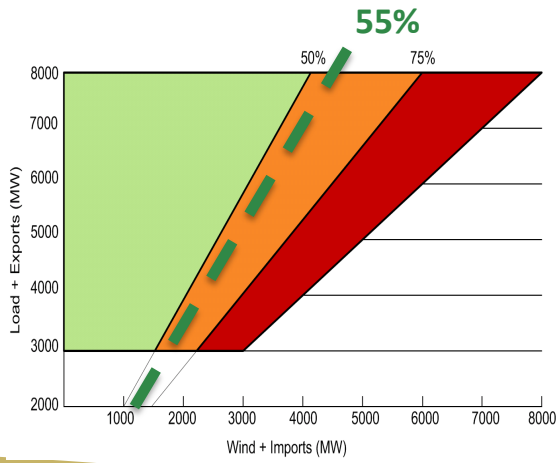
Observations and Next Steps

- SNSP above 50% for 10% of the time
- No observed differences in system behavior at 50%<SNSP<55%
- Detailed analysis of events in this period has been conducted
- OPR have approved Operational limit of SNSP at 55% from March 1st
- Official Operational policy moved to 55% SNSP from March 1st



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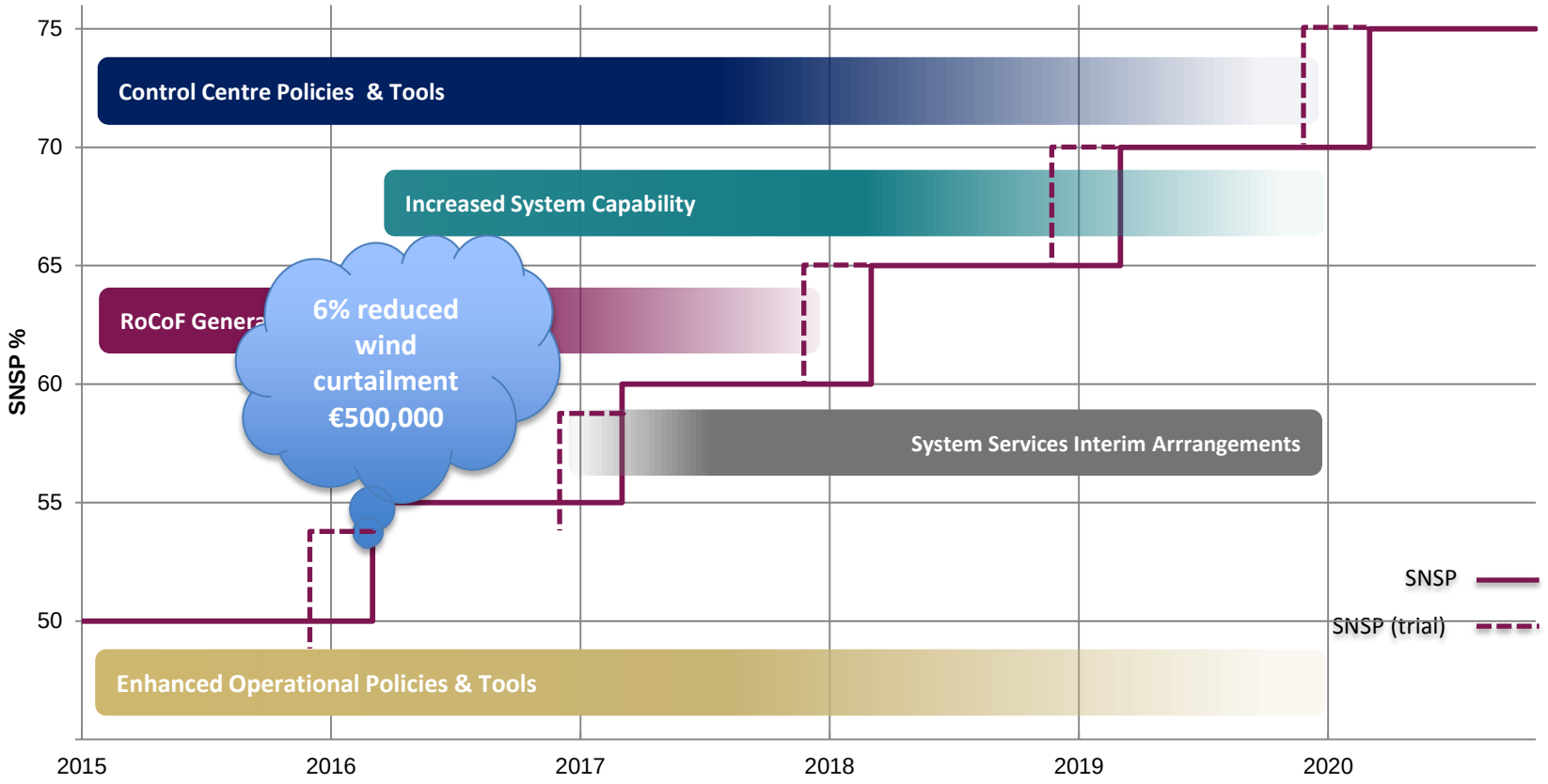
Operational Capability Outlook 2016



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But what are we trying to change..

SNSP

- But made up of multiple issues
- 60% - Q4 2016
- 65% - Q4 2017

RoCoF

- Generator studies + testing
- DSO LOM settings
- Alternative solutions

Operational Policy

- Higher SNSP
- Lower inertia?
- Lower min sets?
- Ramping policy?
- Reactive control

Reactive control

- Synchronising torque
- Falling short circuit levels
- Co-ordinated TSO-DSO action
- Optimising 3rd party capability
- Complementary Network investment

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And how are we going to do that..

OF/UF settings

- Long term linked to RoCoF
- Interim bespoke TX wind farms

3rd party

- Investment in complementary capability
- Adherence to standards
- Evolving for the long term

Control centre tools

- WSAT
- PMU/Event/Oscillations
- Ramping tool
- Reactive control decision support tool

TSO-DSO collaboration

- DSM, Solar, Storage
- Coordinated voltage control
- RoCoF LOM
- System Services

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Rate of Change of Frequency (RoCoF)

DS3 Advisory Council Meeting 24/05/2016

11.55-12.20 pm

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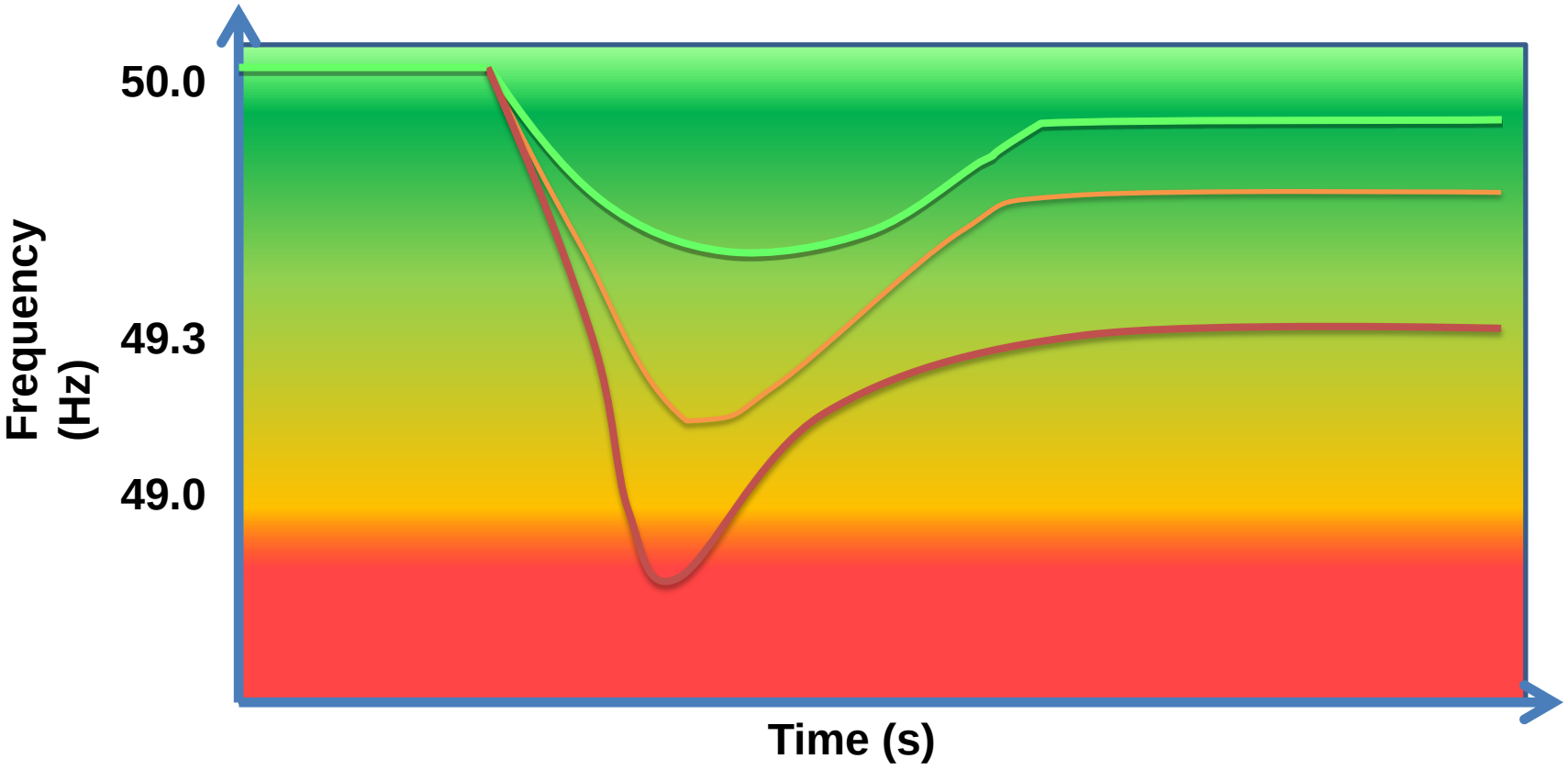
RoCoF Concept



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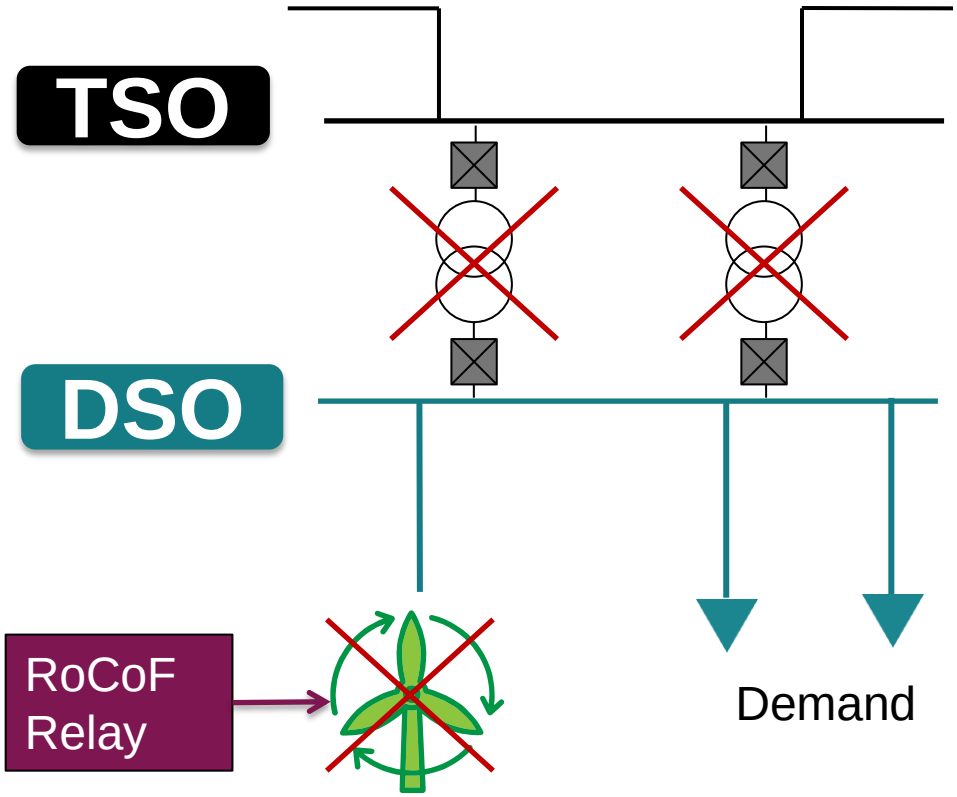
RoCoF TSO-DSO Project



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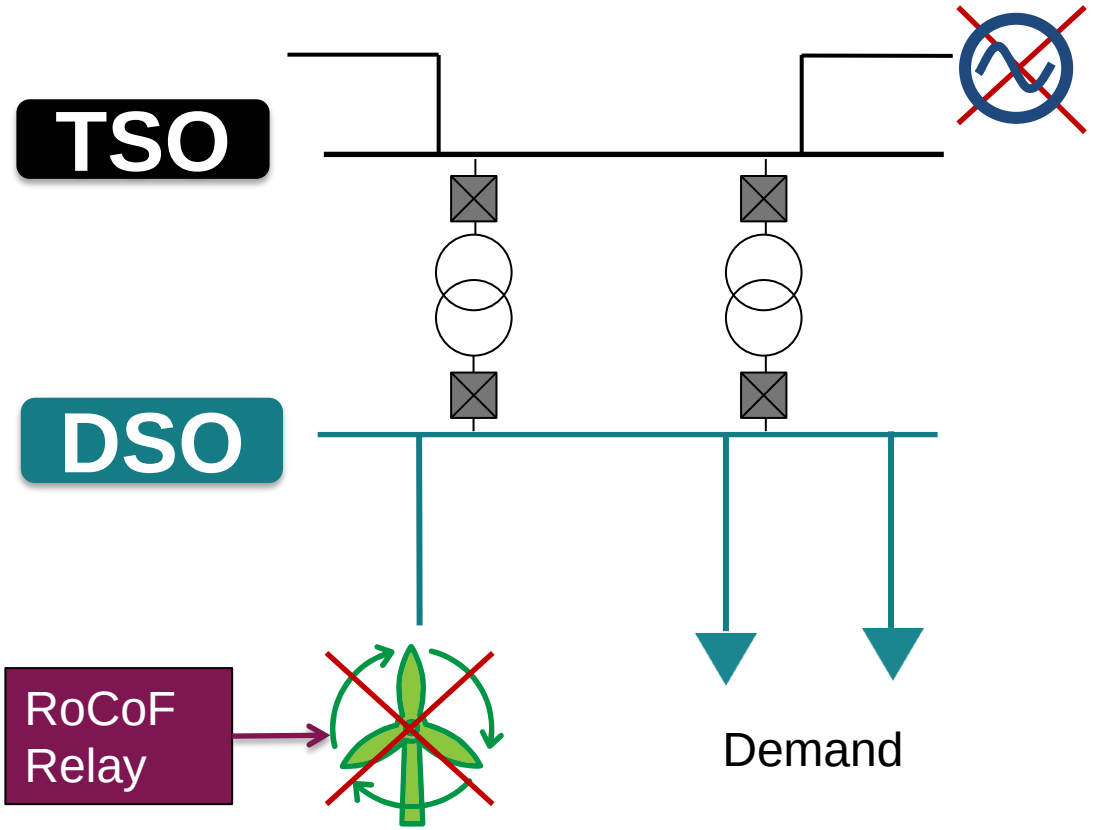
RoCoF TSO-DSO Project



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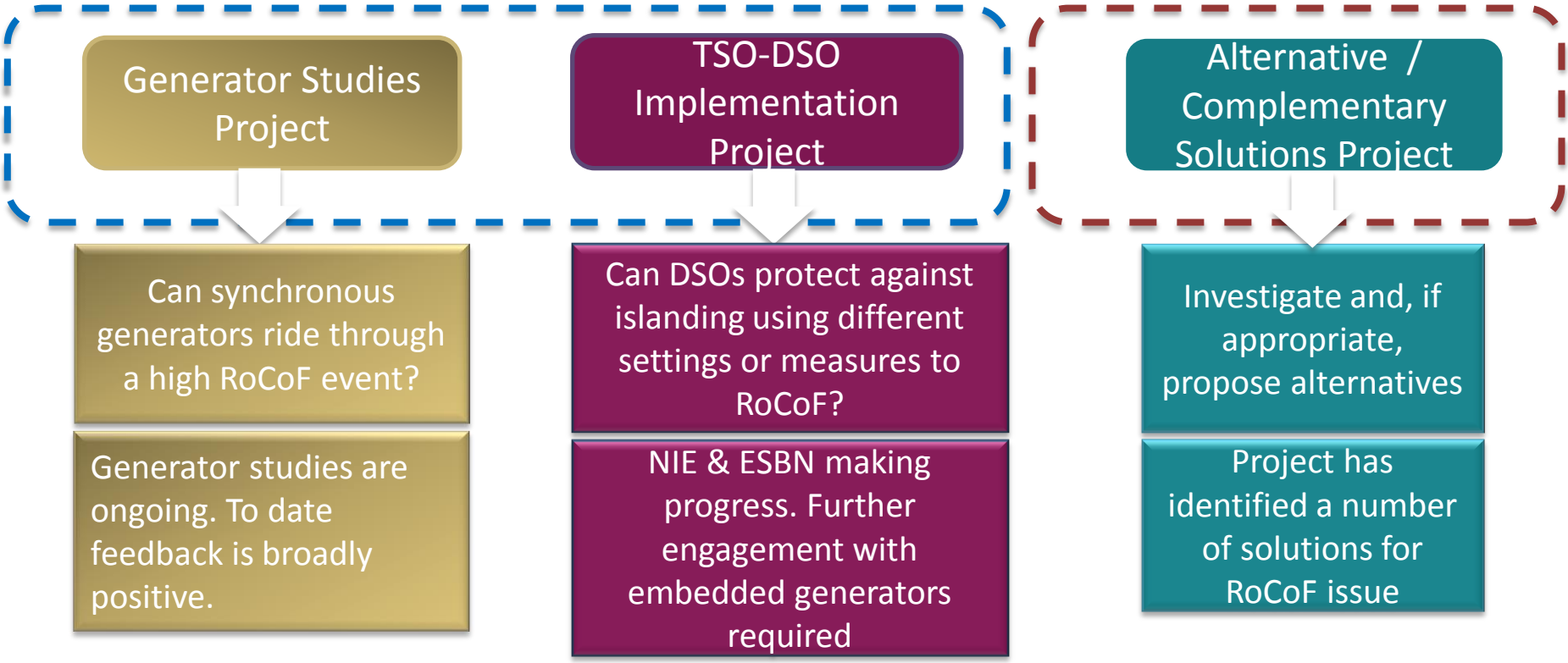
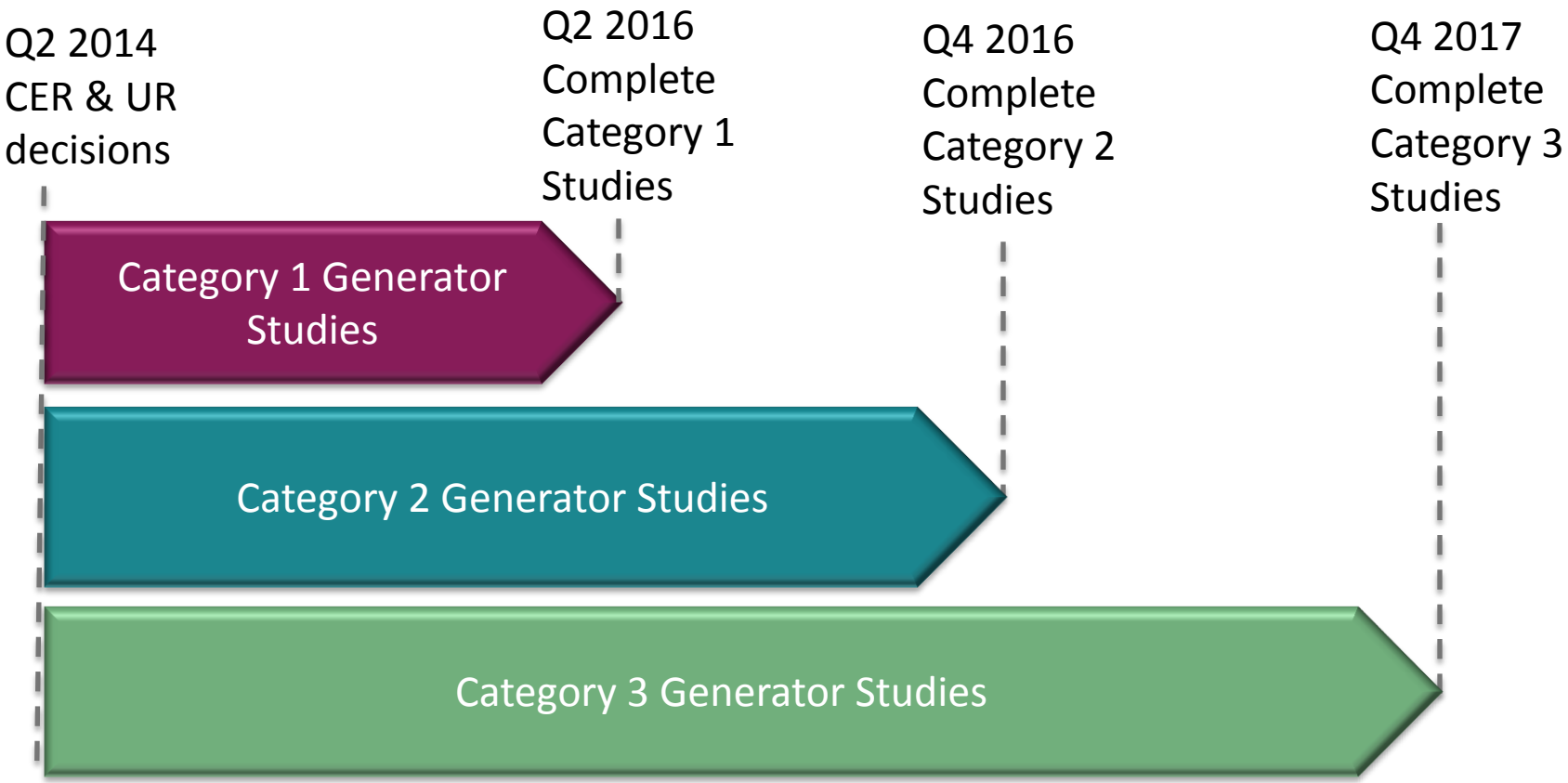
RoCoF Implementation Project



Generator Studies Timelines



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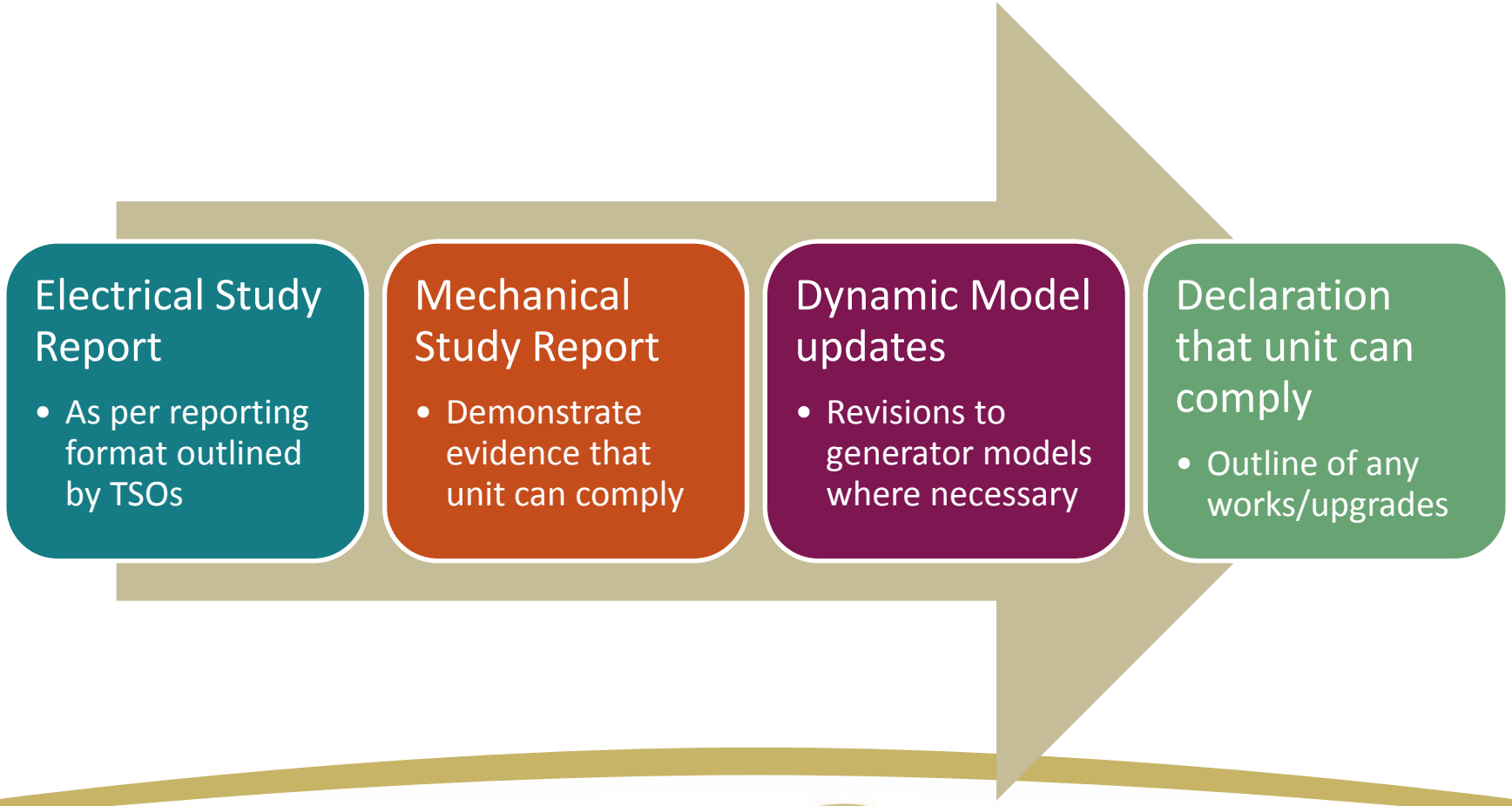
Generator Study Submission



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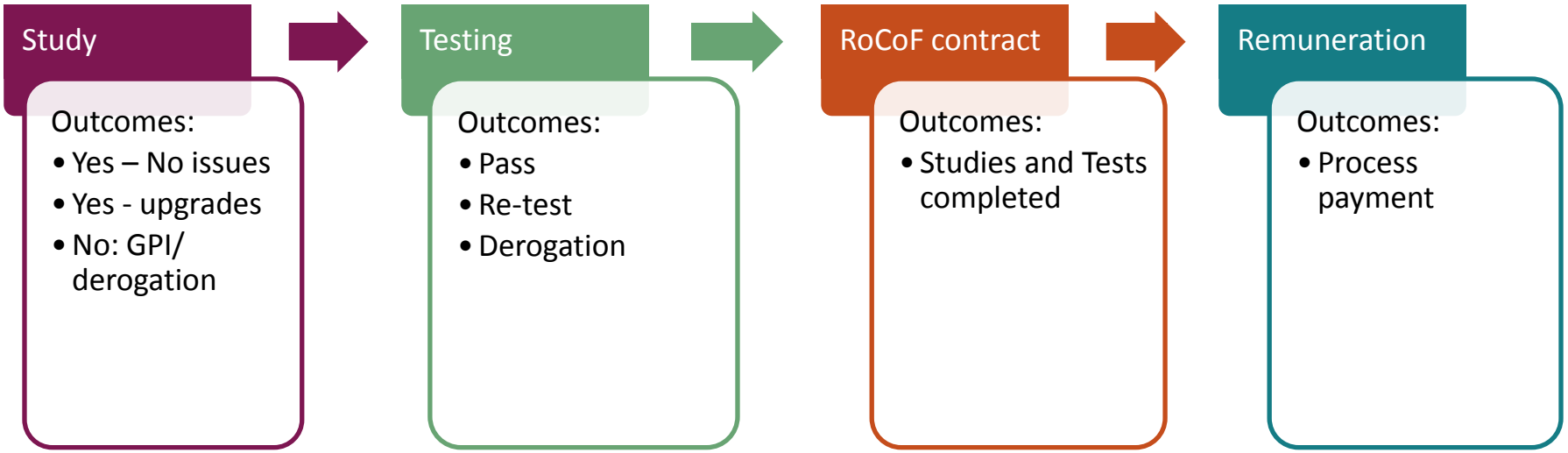
RoCoF Remuneration Method



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Next Steps

- Several reports submitted in recent weeks
- Expecting reports from majority of Category 1 units
- Settlement systems for GPI and remuneration mechanism being finalised
- Generator testing programme currently being developed

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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 assessing potential system impact based on these volumes

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TSO-DSO Project: Northern Ireland

Large-scale generation

- First set of studies completed and under review by NIE
- 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 has been approved by UR
- 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

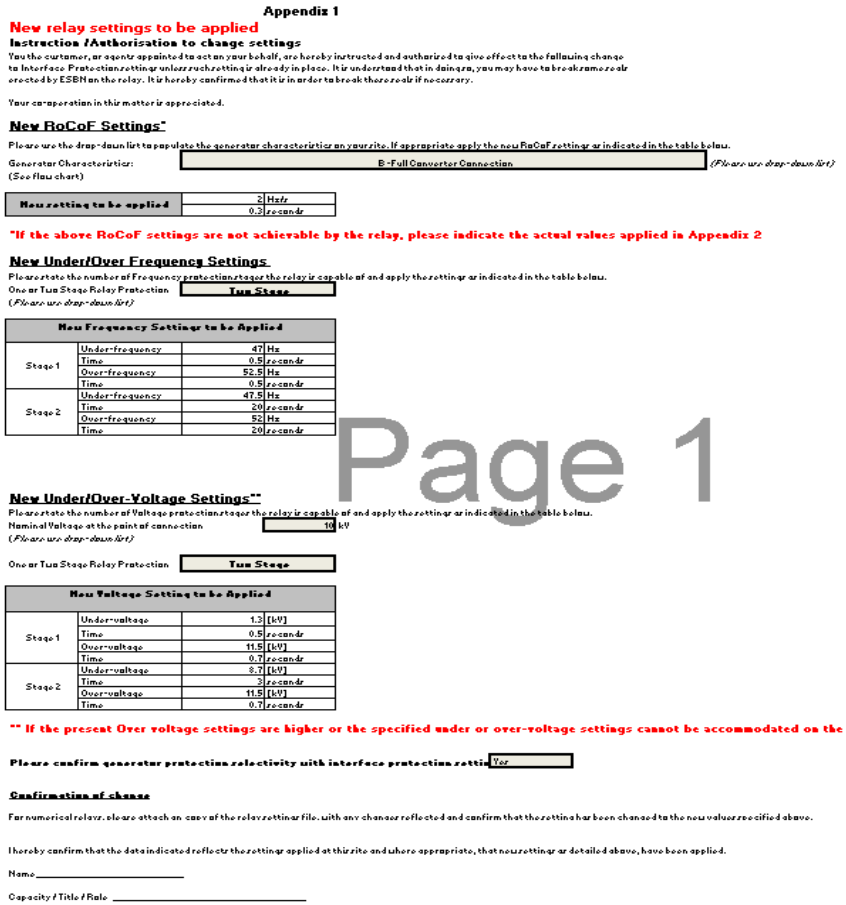
Tony Hearne

24th May 2016

Questionnaire and Settings Change

Wind Generators

- Wind Farm setting changes on-going
- Little engagement from some windfarms
- Approximately 40% of MW outstanding



Appendix 1

New relay settings to be applied

Instruction / Authorisation to change settings

You the customer, or agents 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 setting file, with any changes reflected and confirm that the setting has 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 _____

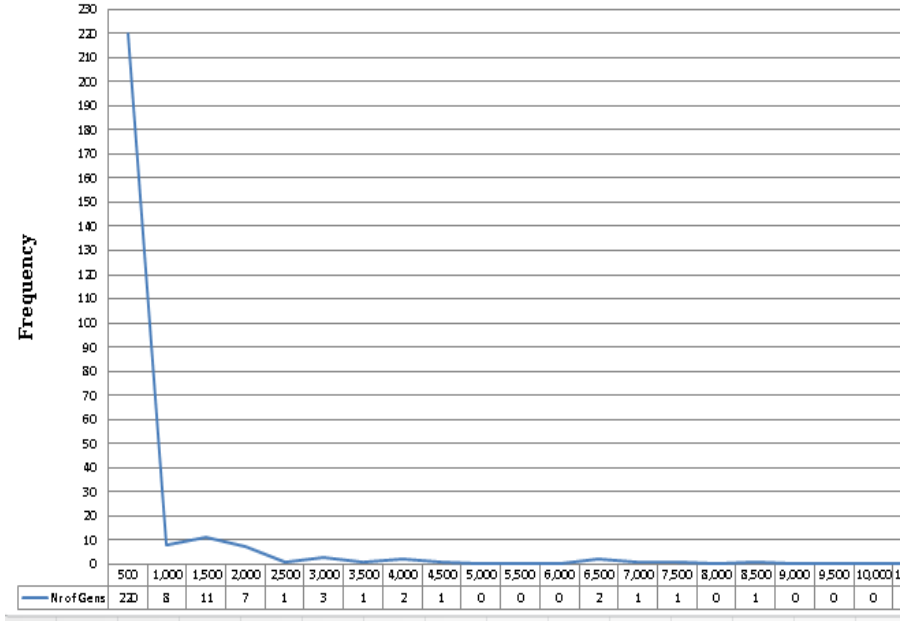
Capacity / Title / Role _____

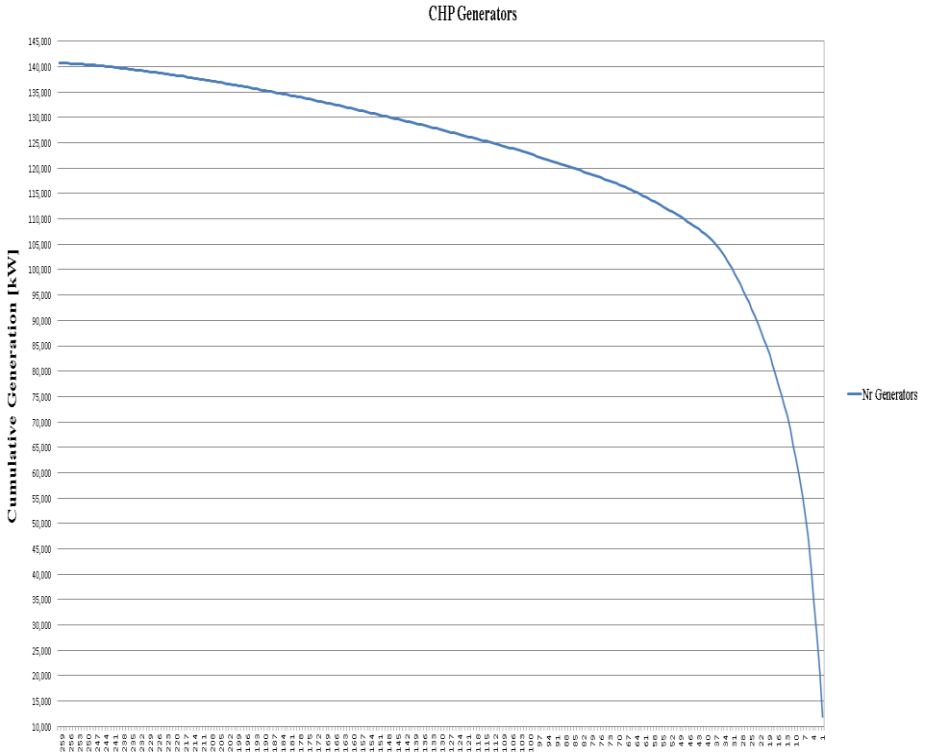
Non-Wind Generation

- **Very little response from non-wind generators on request to change interface settings**
- **Meeting with non-wind generator OEMs and agents planned for 30th May in Portlaoise**
- **Work ongoing by both ESBN and EirGrid to understand and quantify the impact of these generators, taking into account;**
  - Installed capacity
  - Which CB is tripped
  - Operating regimes
  - Spread of generator sizes in distribution connected fleet

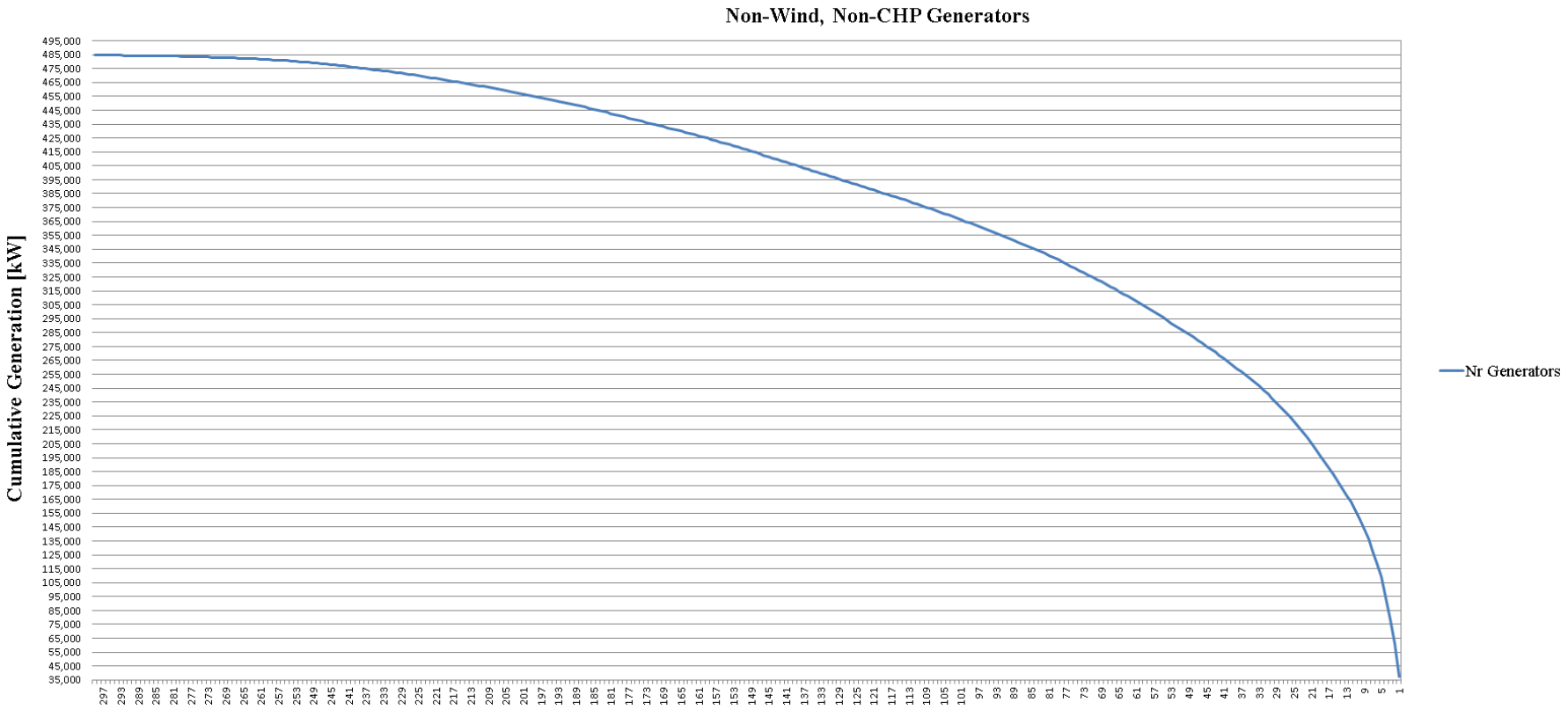
Efficiency of effort

Will need to target quick wins





Efficiency of effort



Conclusion

- **Efforts continuing on TSO-DSO ROCOF workstream**
- **Wind community needs to get over the line with their settings changes**
- **Challenge to get engagement on non-wind cohort**
- **Intention to close out analysis phase in near future and move to a focussed implementation phase**

DS3 System Services (General Update)

DS3 Advisory Council Meeting 24/05/2016

12.20-13.20 pm

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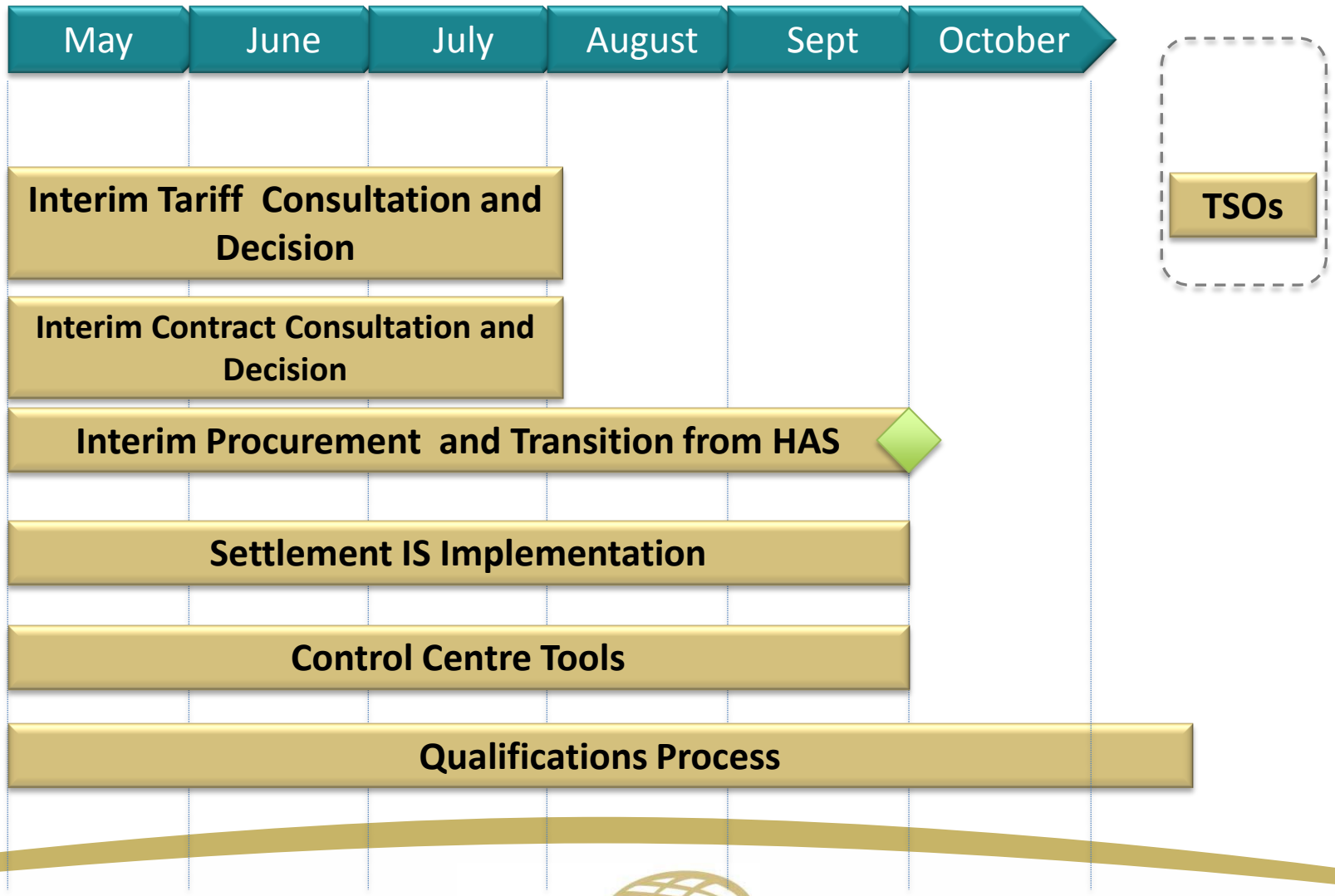
Interim Arrangements



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Interim Arrangements Key Updates

- Industry Forum Held – 11th April
- Bidders Conference Held – 27th April 2016
- Interim Tariffs Consultation Closed –20th May
- OJEU Procurement Notice Issued –Tenders due by 25th May
- Interim Contracts Consultation Open – Responses due by 3rd June
- Qualification Trials Consultation (Aim to publish W/C 23rd May)
- Interim Arrangements Go Live – 1st Oct 2016

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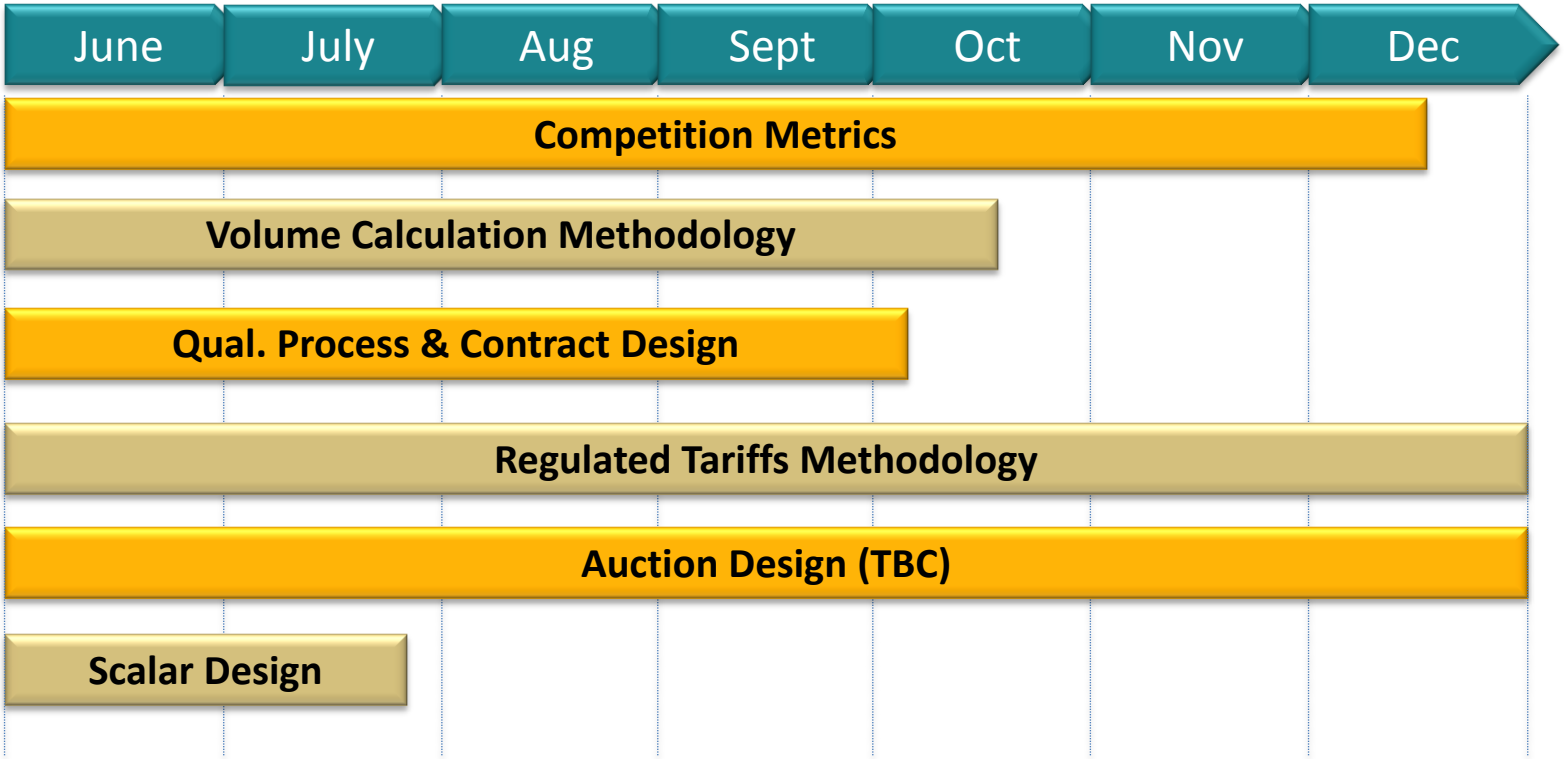
Enduring Arrangements Timelines to Dec 2016

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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Enduring Arrangements Key Dates

- Consultation on Scalar Design – Closed 29th April
  - 24 Responses Received
- Consultation Paper on Volumes Calculations – Due End of May
- Enduring Arrangements Go Live – 1st Oct 2017
- Decision on Auction Design Pending

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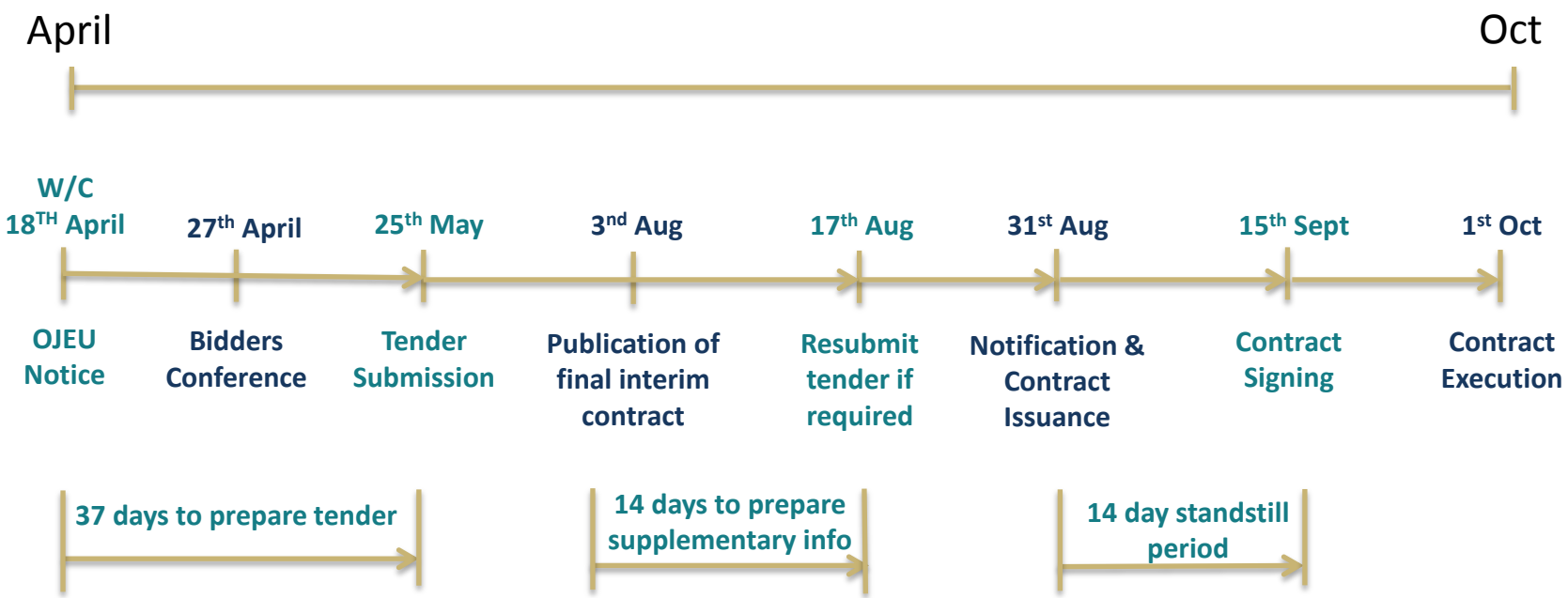
Procurement Timelines



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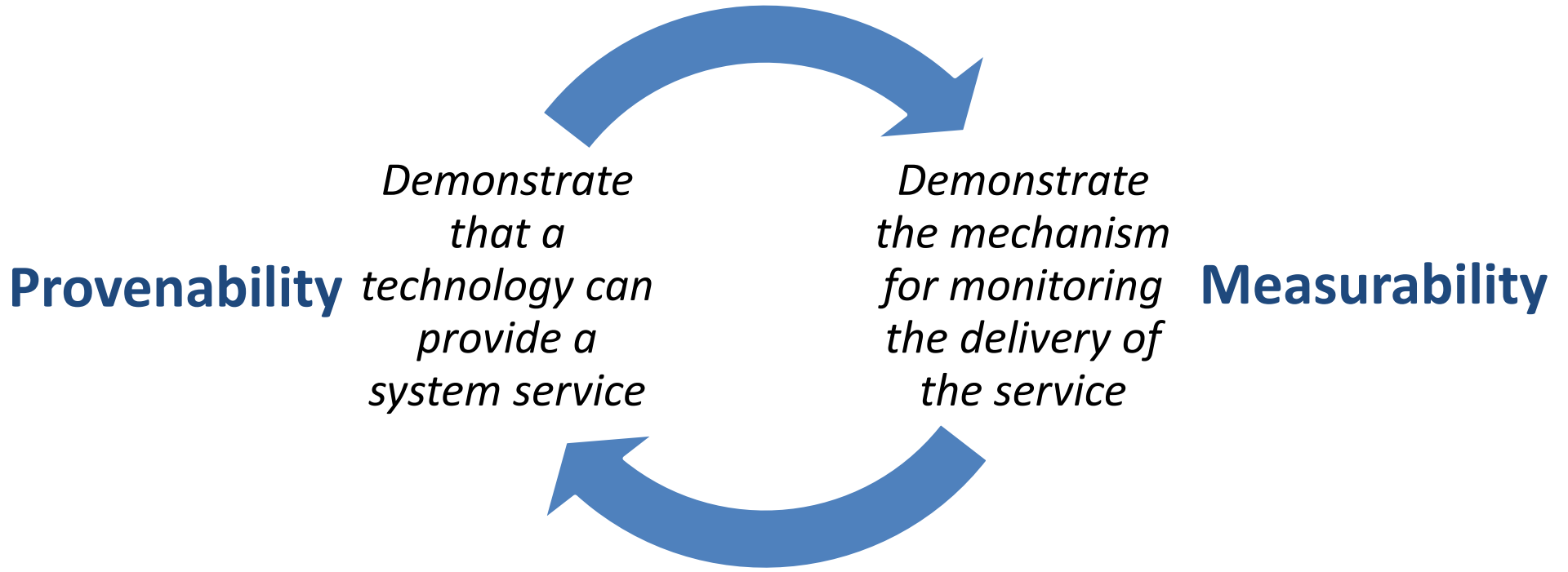
Qualification Process Objectives



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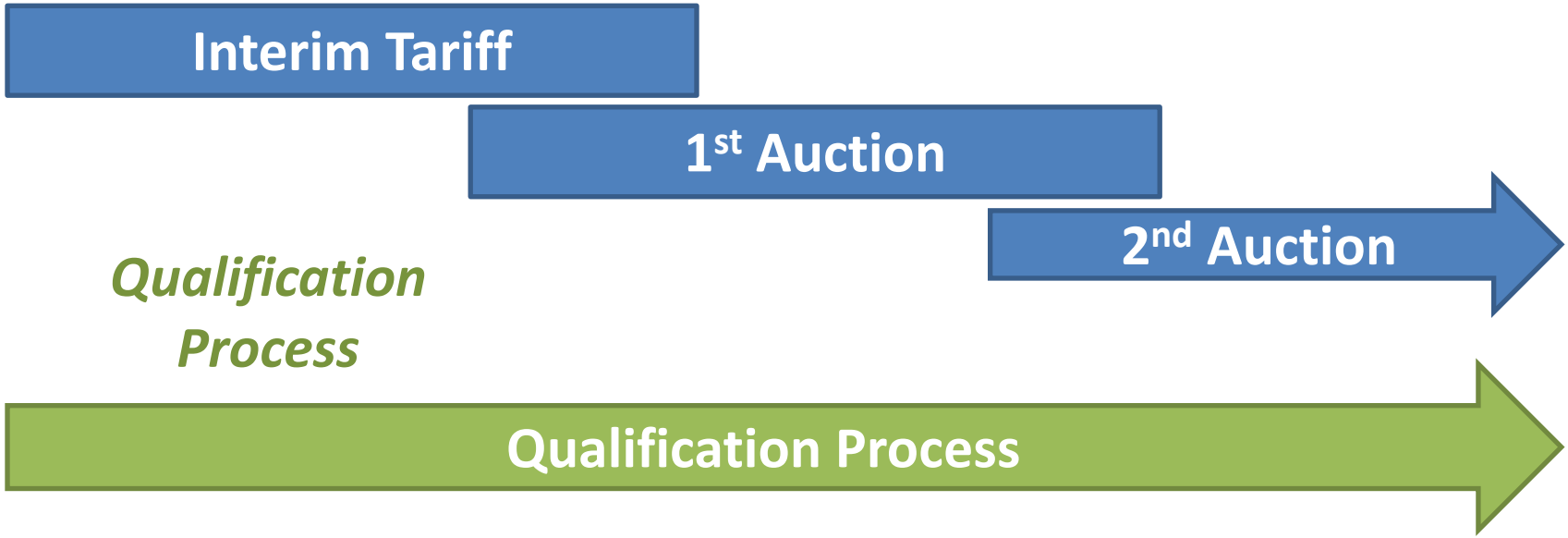
Central and Qualifier processes

DS3 System Services Timeline



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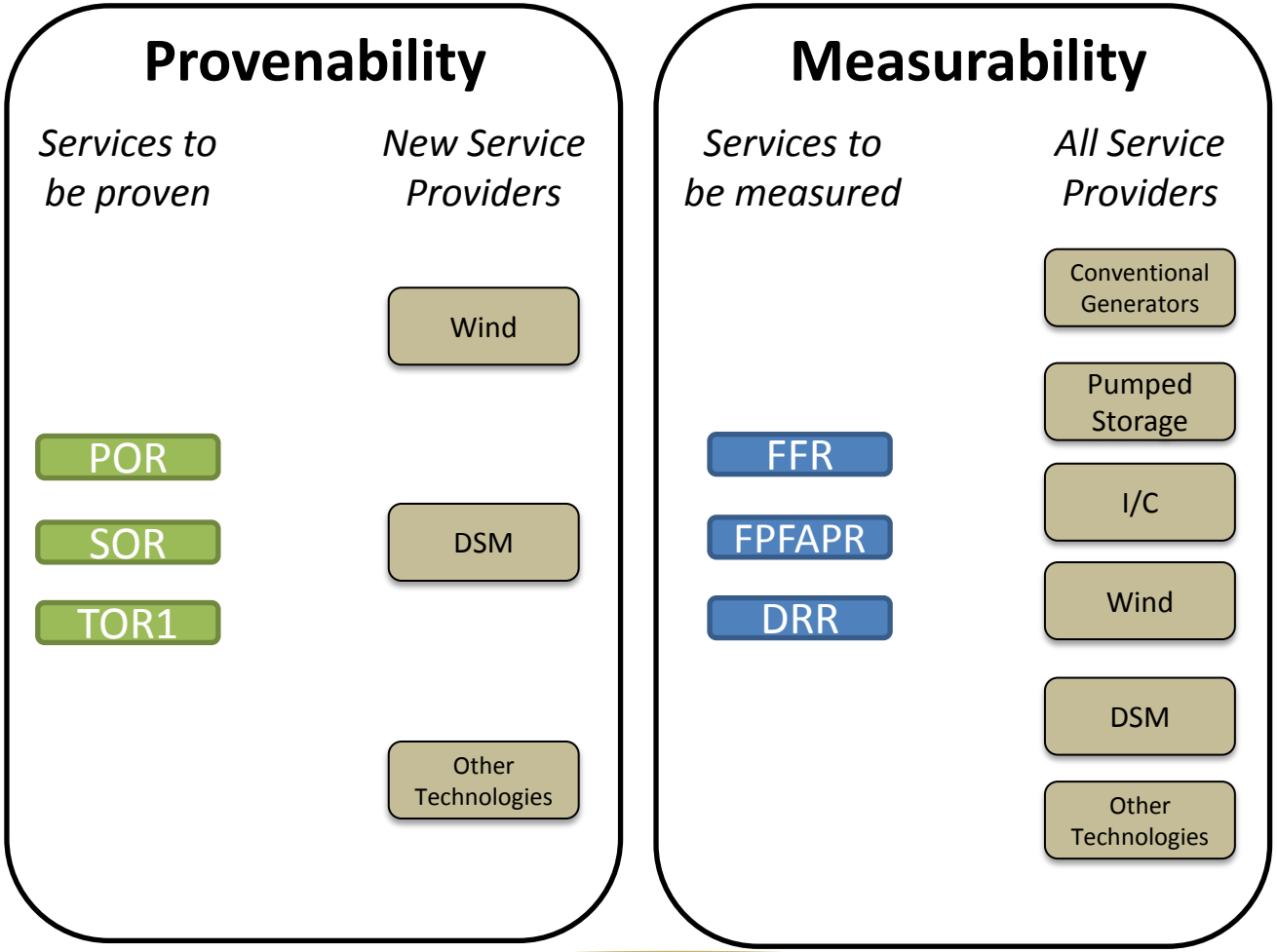
Proposed Trial Format



High-level competition criteria

- Proposal on how System Service(s) will be provided
- Proposal on how to measure the delivery of the System Service(s)
- Potential for scaling to increase capacity in future
- If connected at distribution system level, plan for mitigating impact on distribution system operation, as required.

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Key Points

- Qualification Process will be in parallel to Interim and Enduring Arrangements main procurement process
- Aims to prove capability and measurability of new and existing system services from new & existing service providers
- The process will target new technologies to widen the range of service providers…but in a prudent manner

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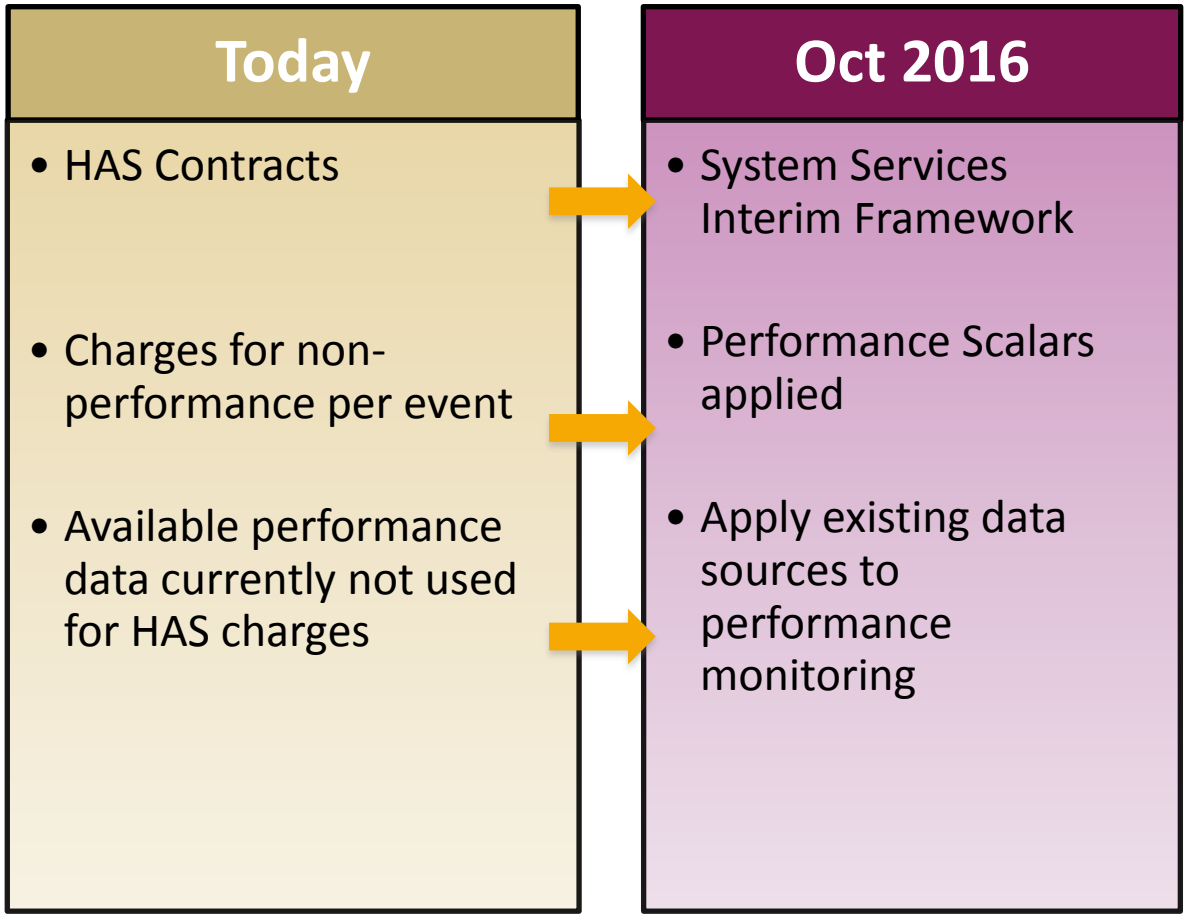
Interim Performance Monitoring



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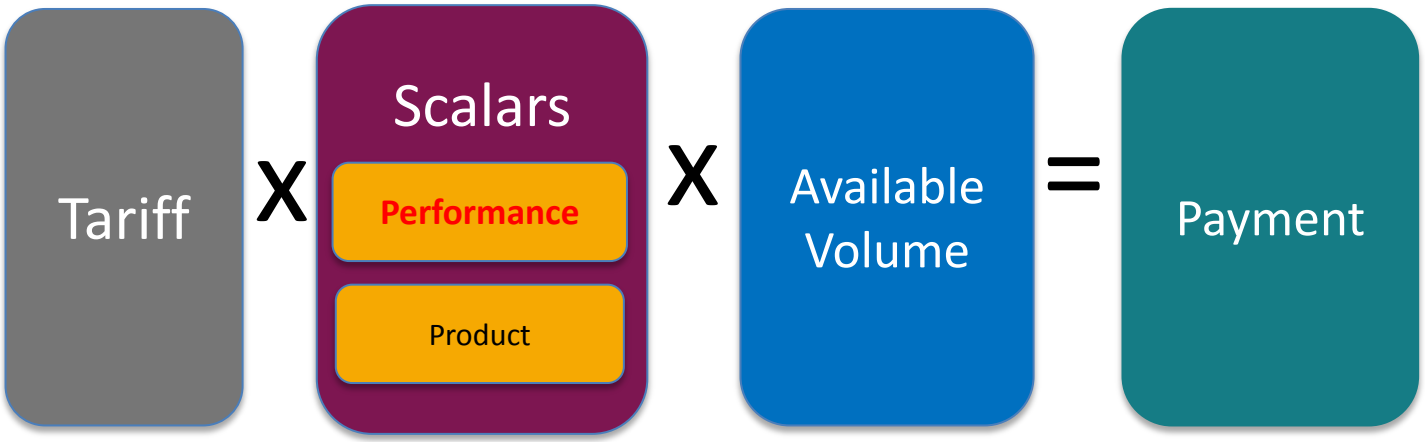
Performance Scalar



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Data Rich vs. Data Poor

Data Poor $\leqslant$ **4** $<$ **Data Rich**

Events / Instructions

Industry Average

Performance average

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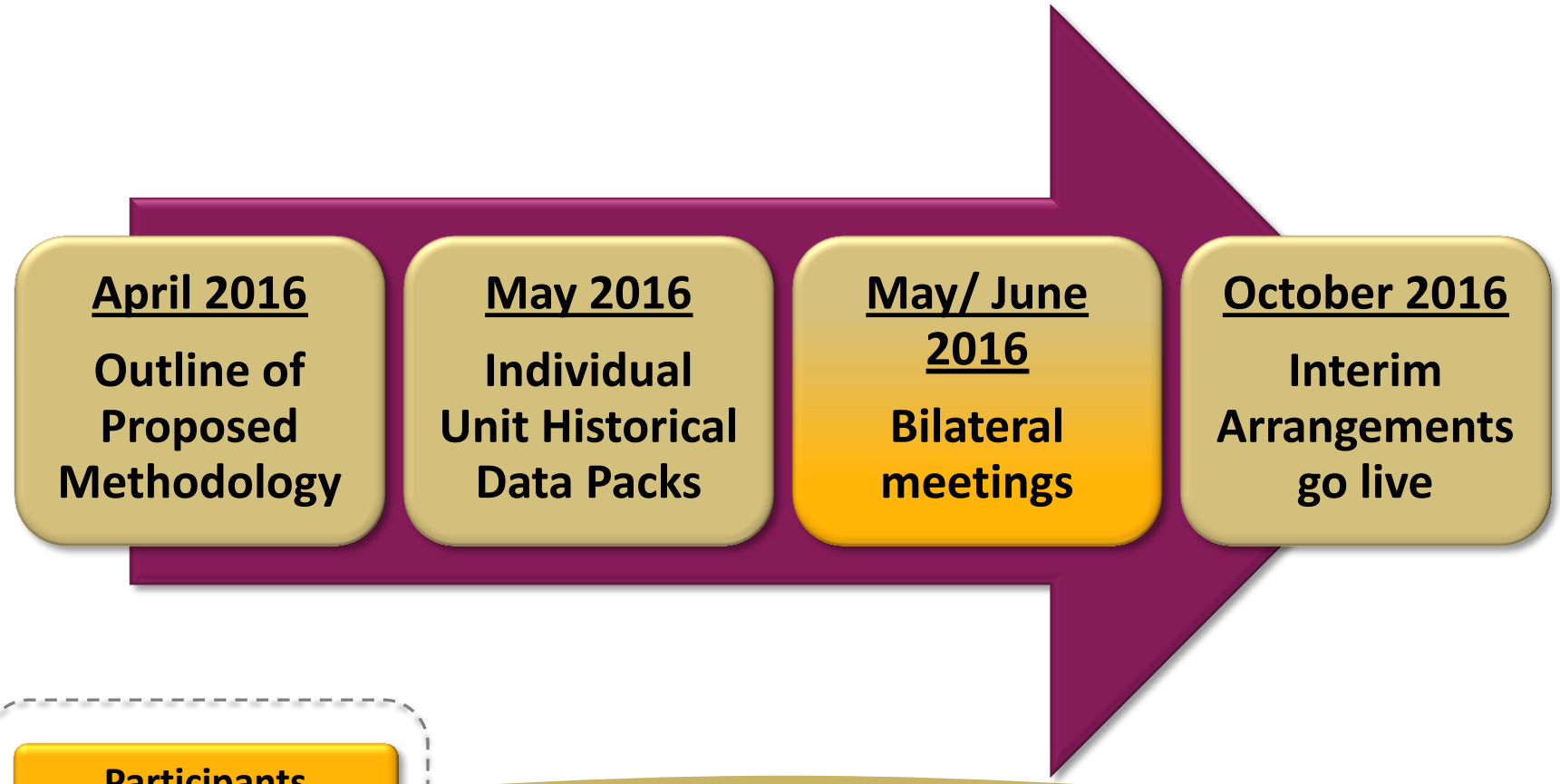
Going forward



Participants

TSOs

EIRGRID GROUP

SMART Power Factor Study

DS3 Advisory Council Meeting 24/05/2016

14.05-14.25 pm

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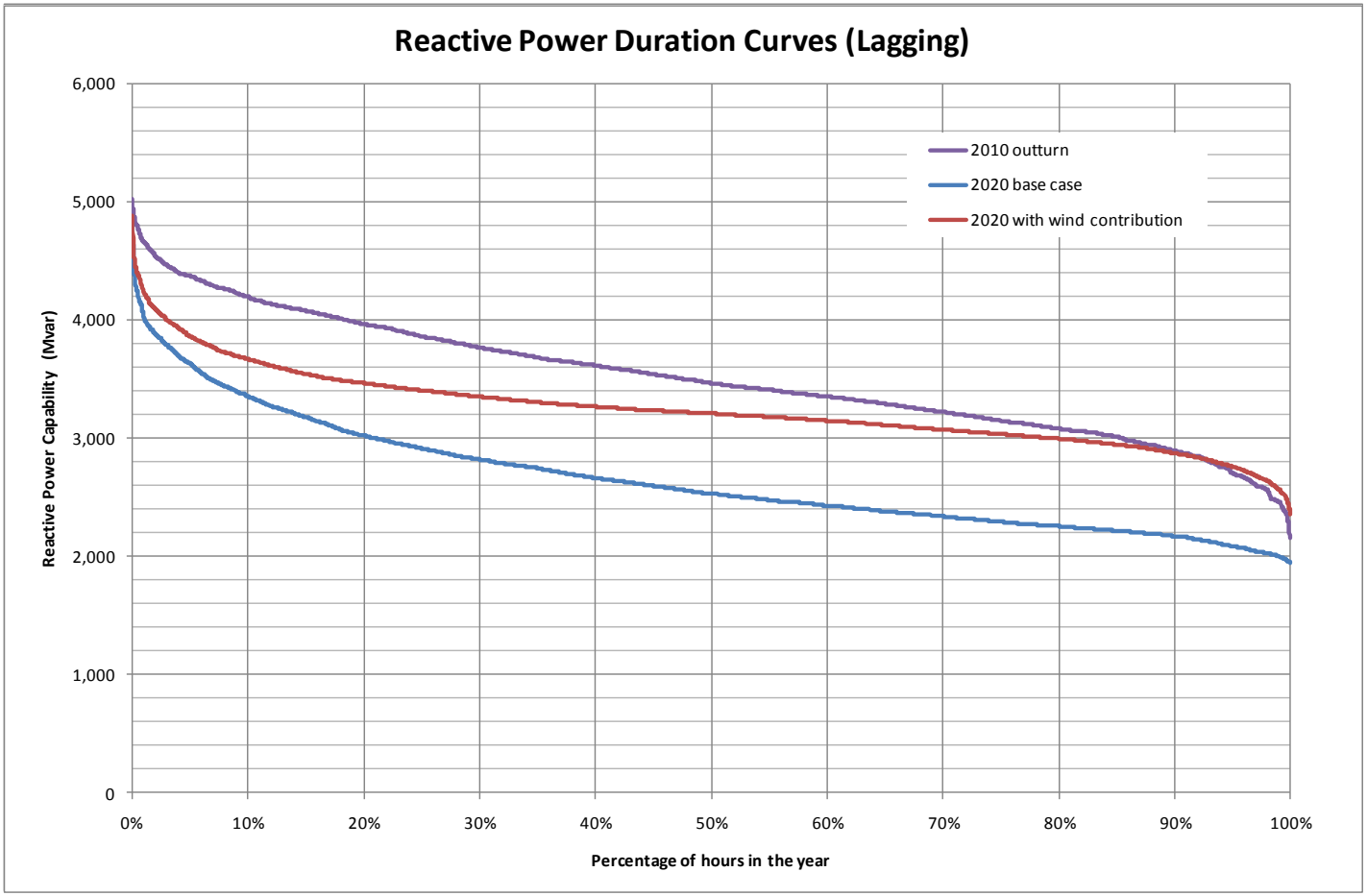
Context


Reactive Power Duration Curves (Lagging)
6,000
5,000
4,000
3,000
2,000
1,000
0
Reactive Power Capability (Mvar)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of hours in the year
2010 outturn
2020 base case
2020 with wind contribution

Previous Study

Control Scheme	Tapping Activity	Active Losses	Q/V Response	Q/P Response	Ease of Roll-out
Voltage Control					
Unity Power Factor					
Smart Power Factor					
Nodal Voltage Controller					

'*Reactive Power From Wind Farm Clusters*', Paul Cuffe, 2013.

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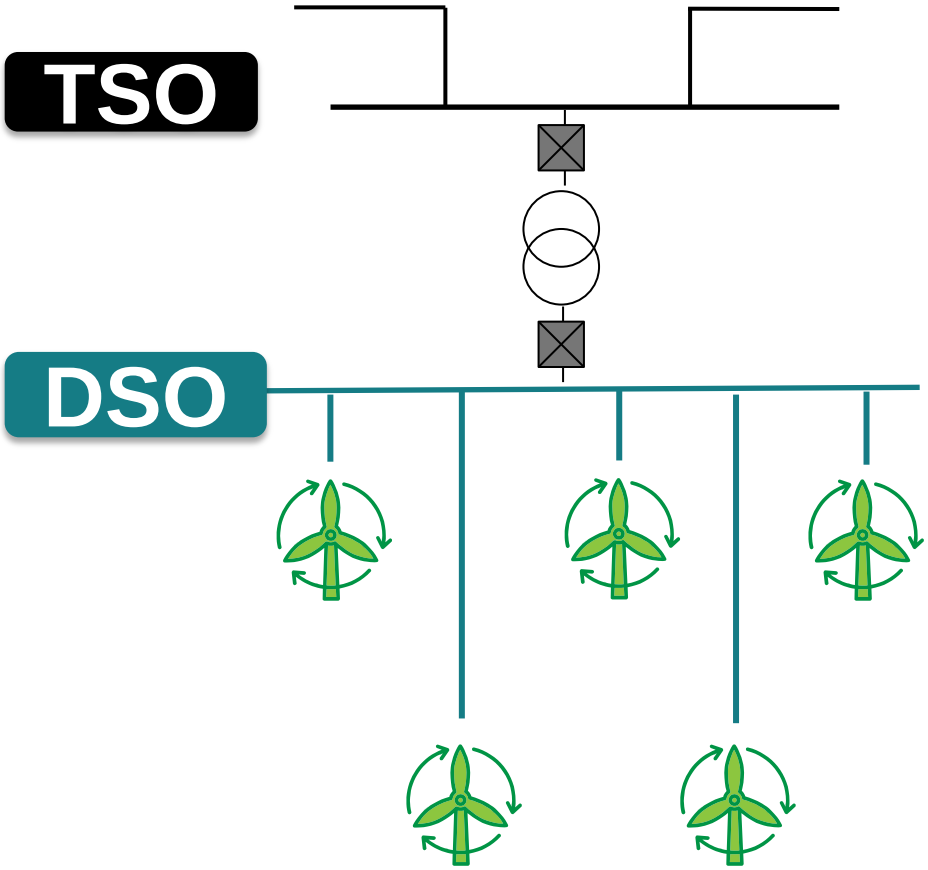
Smart Voltage Control



- Realise potential of DSO generation
- IE: Nodal Voltage Controller
- NI: Smart Power Factor

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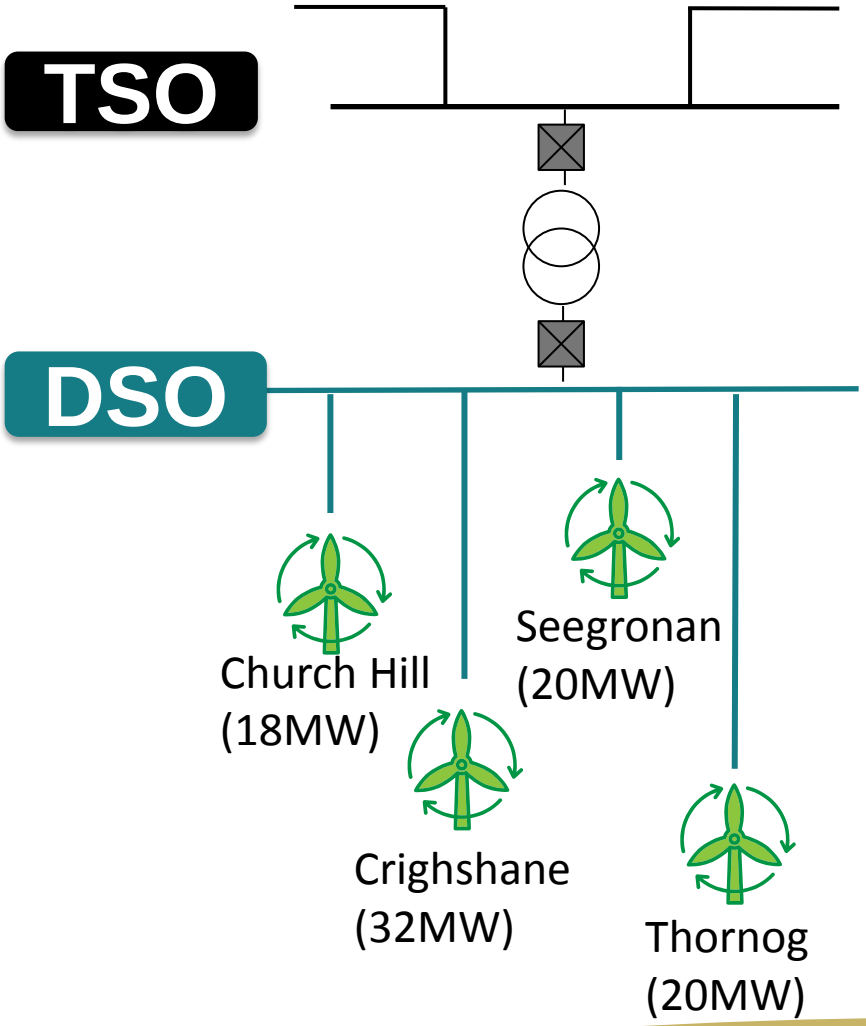
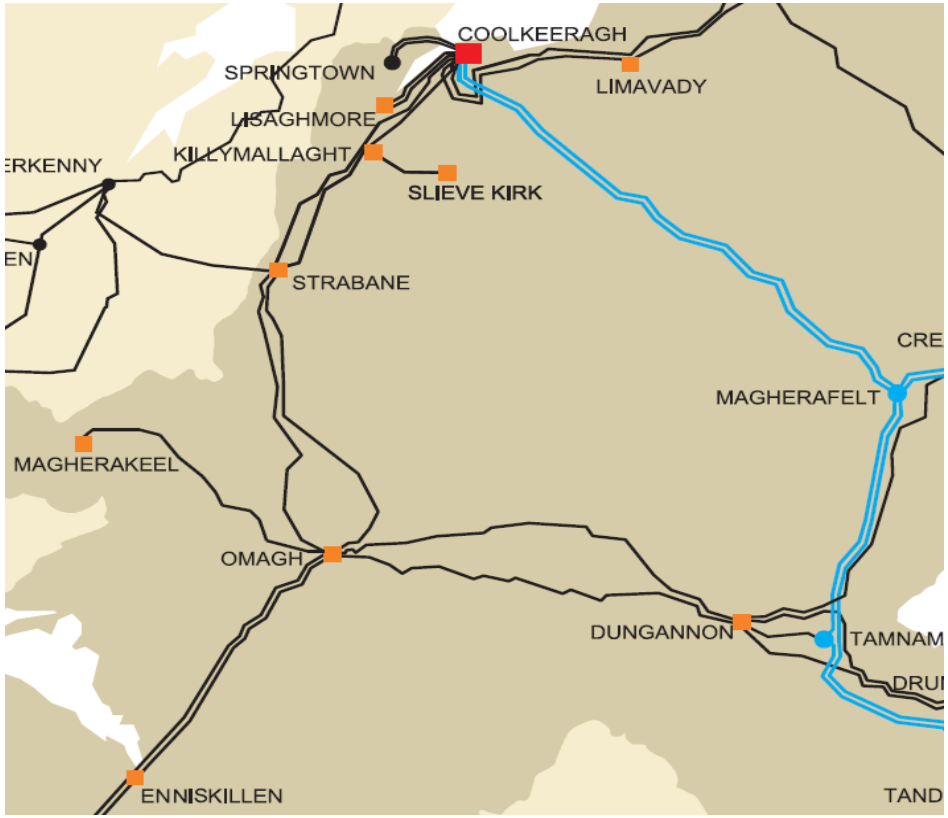
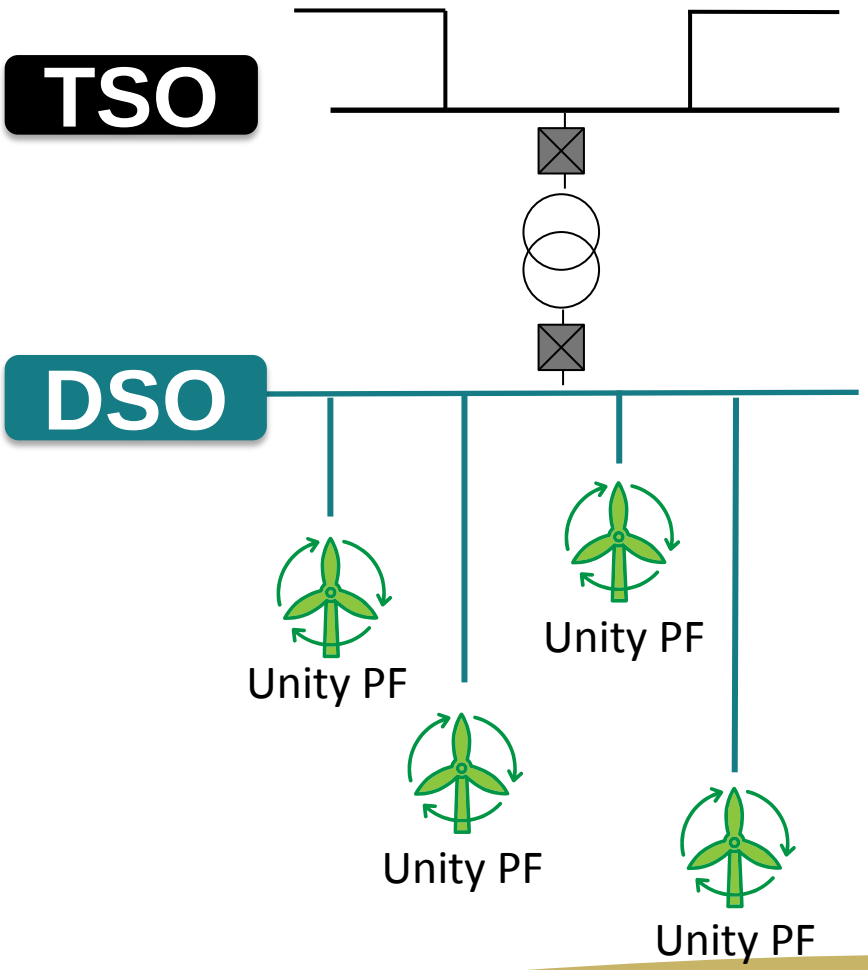
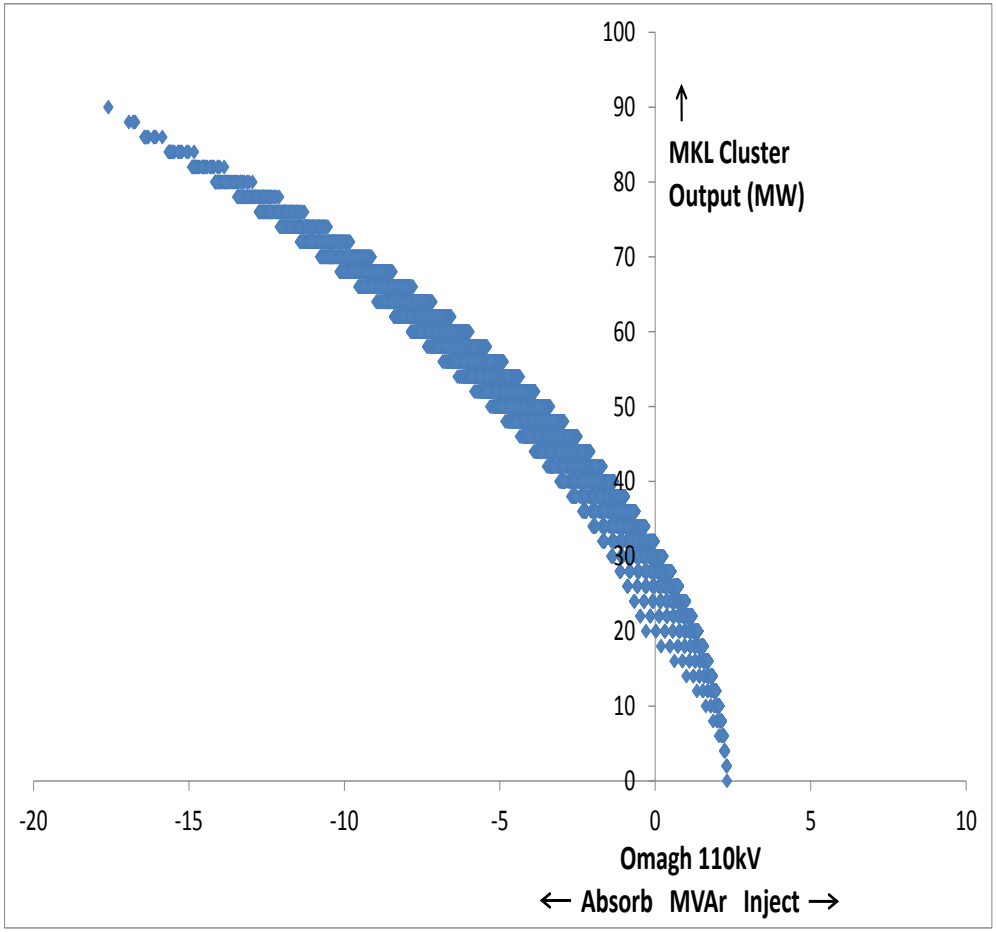
Magherakeel





Unity Power Factor





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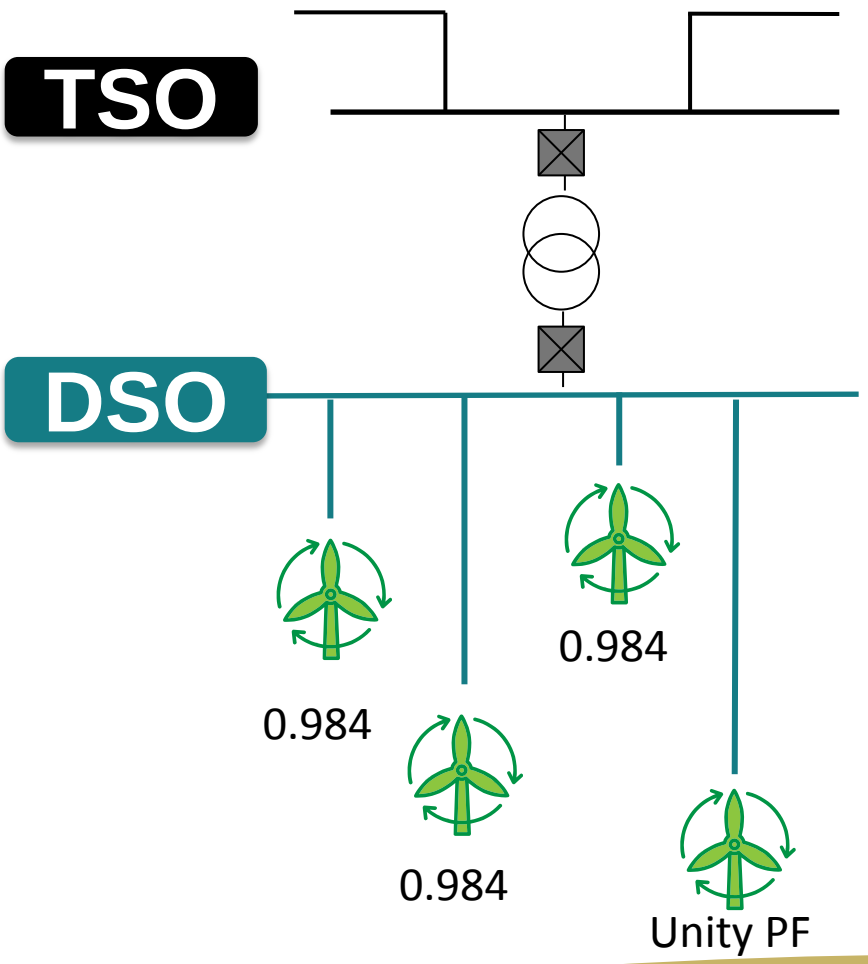
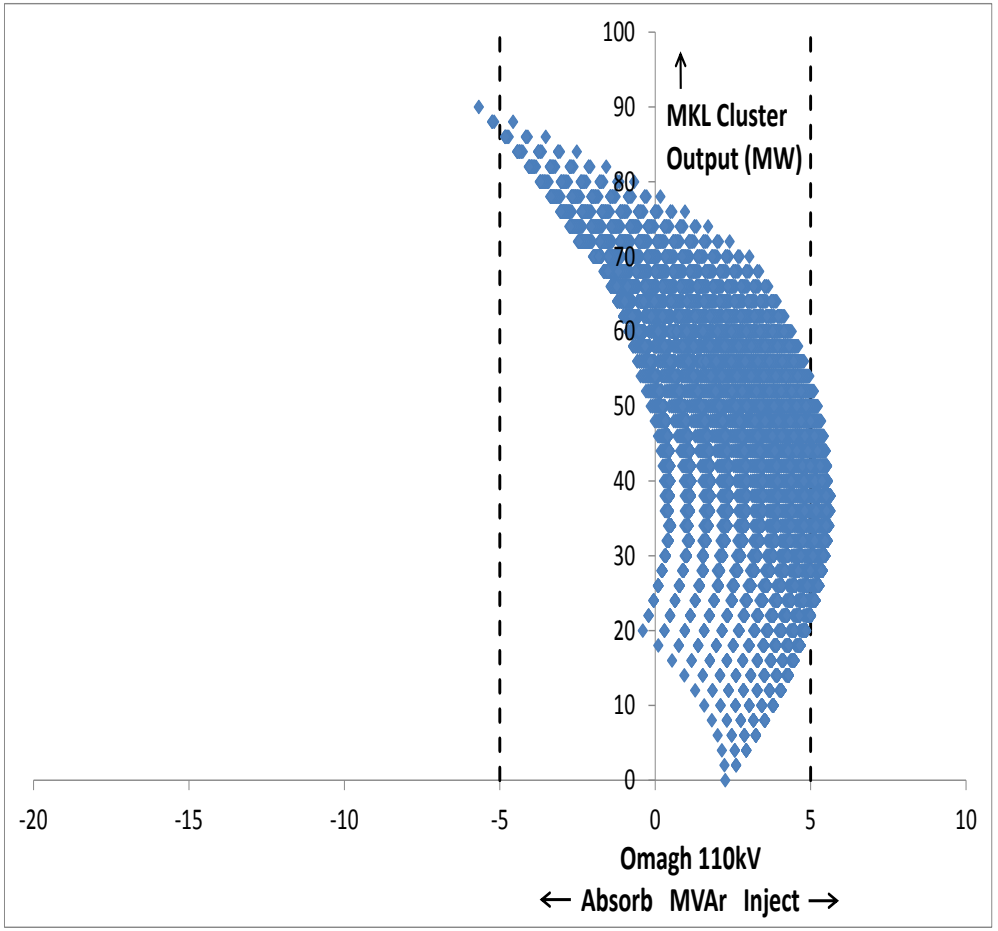
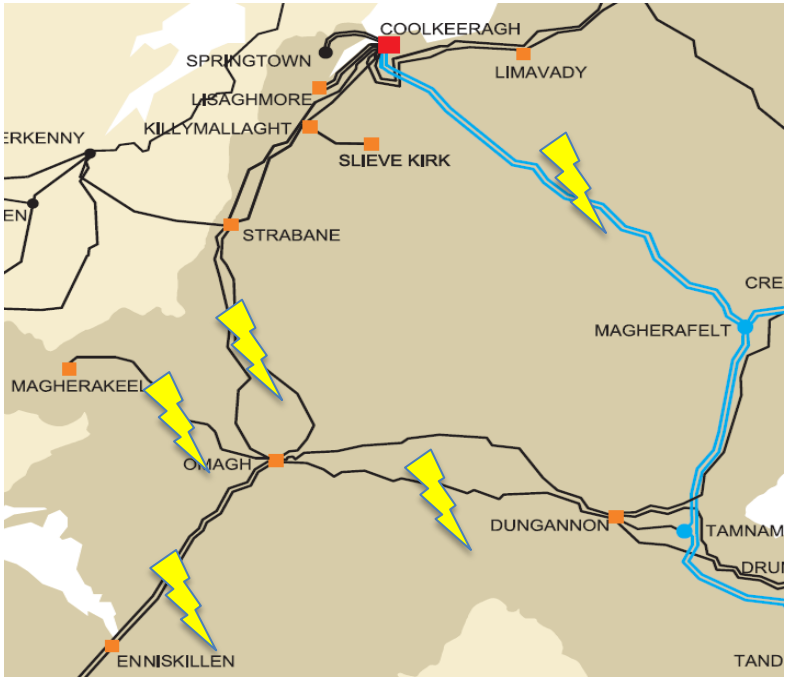
Smart Power Factor





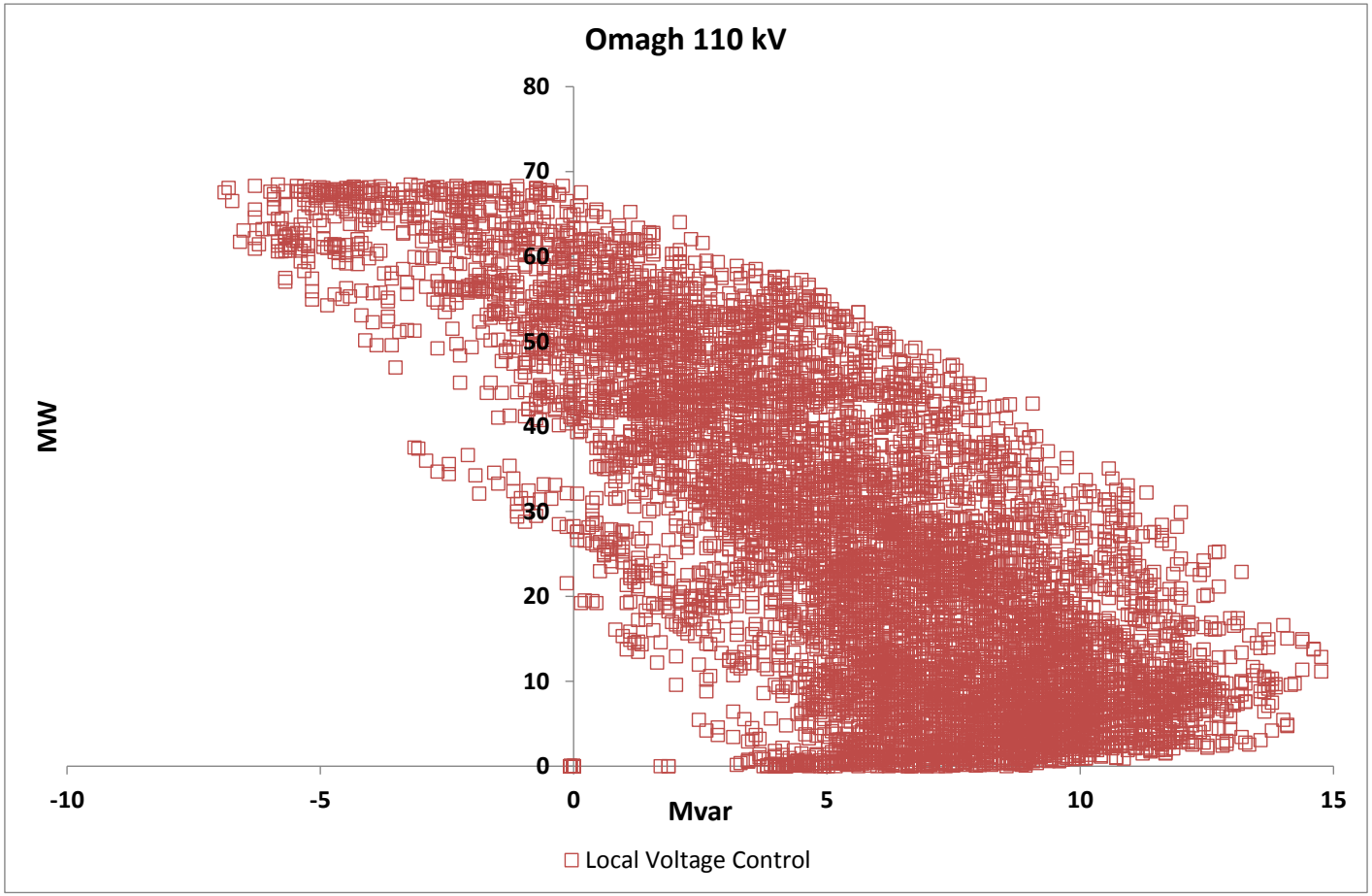
Analysis

- PV Analysis

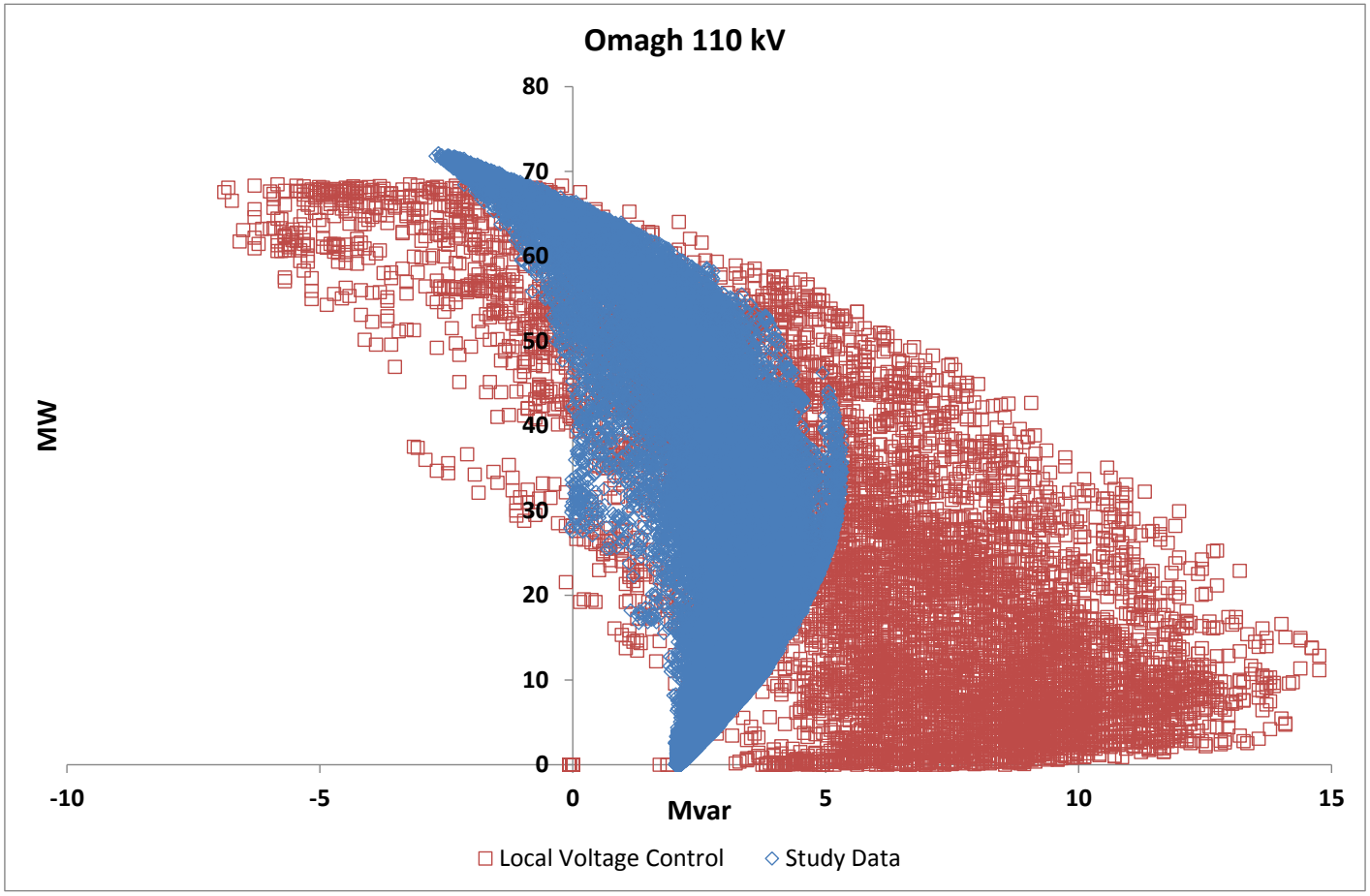


- Number of Tap Changes
  - 1 Month (~45,000 simulations)
  - 86 tap changes

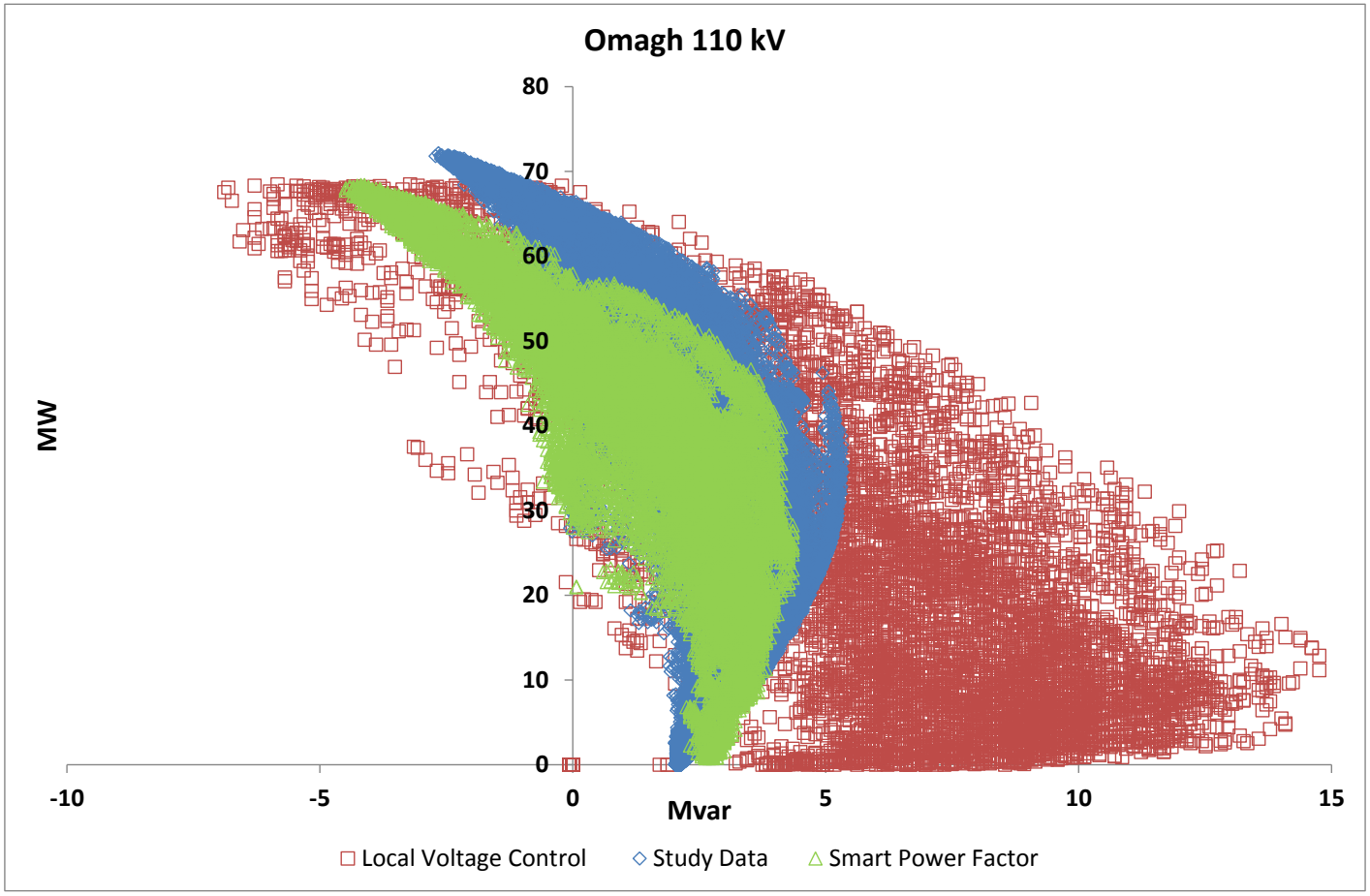
PQ Plot – Pre Smart PF



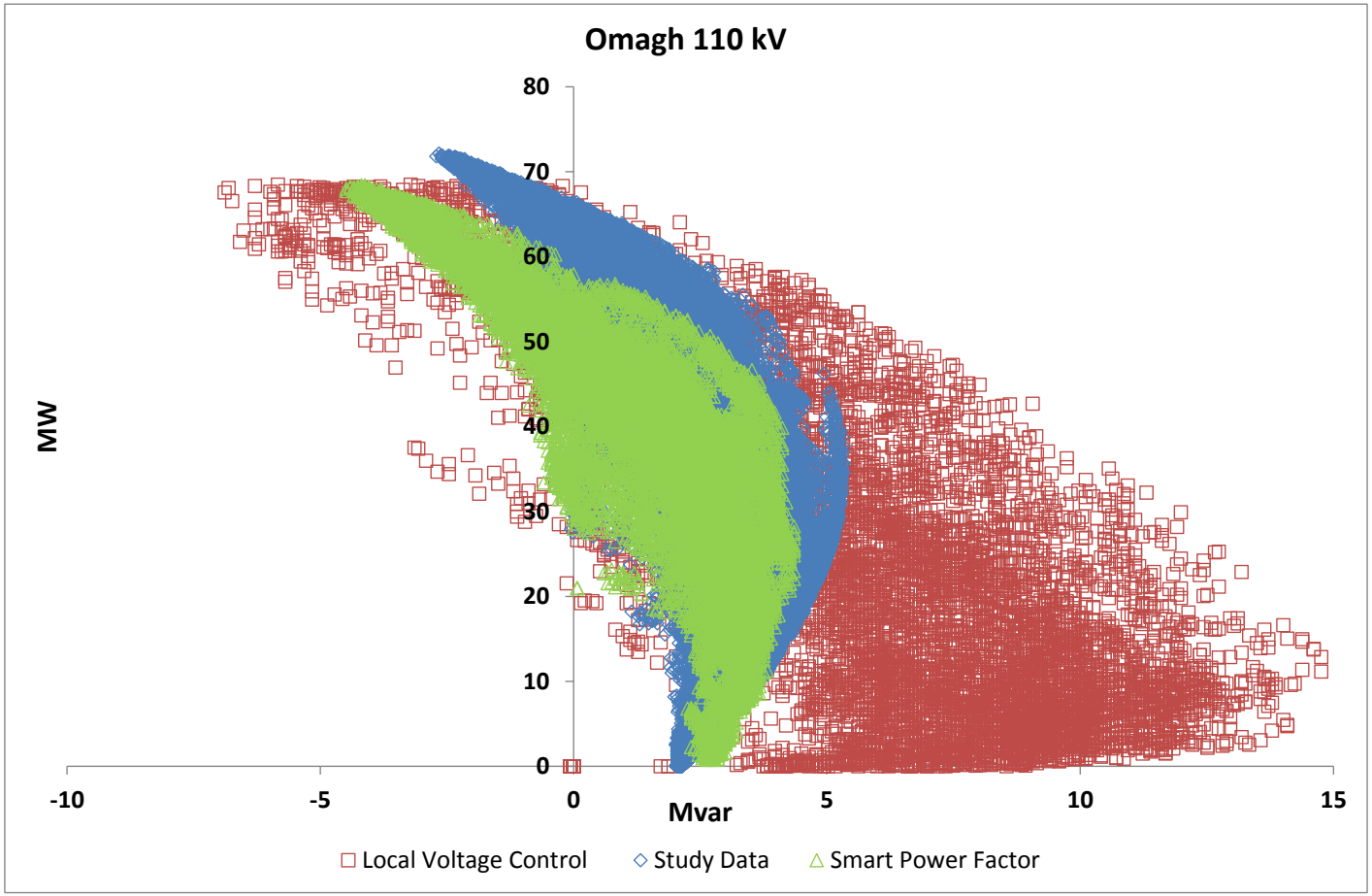
PQ Plot – Study Data



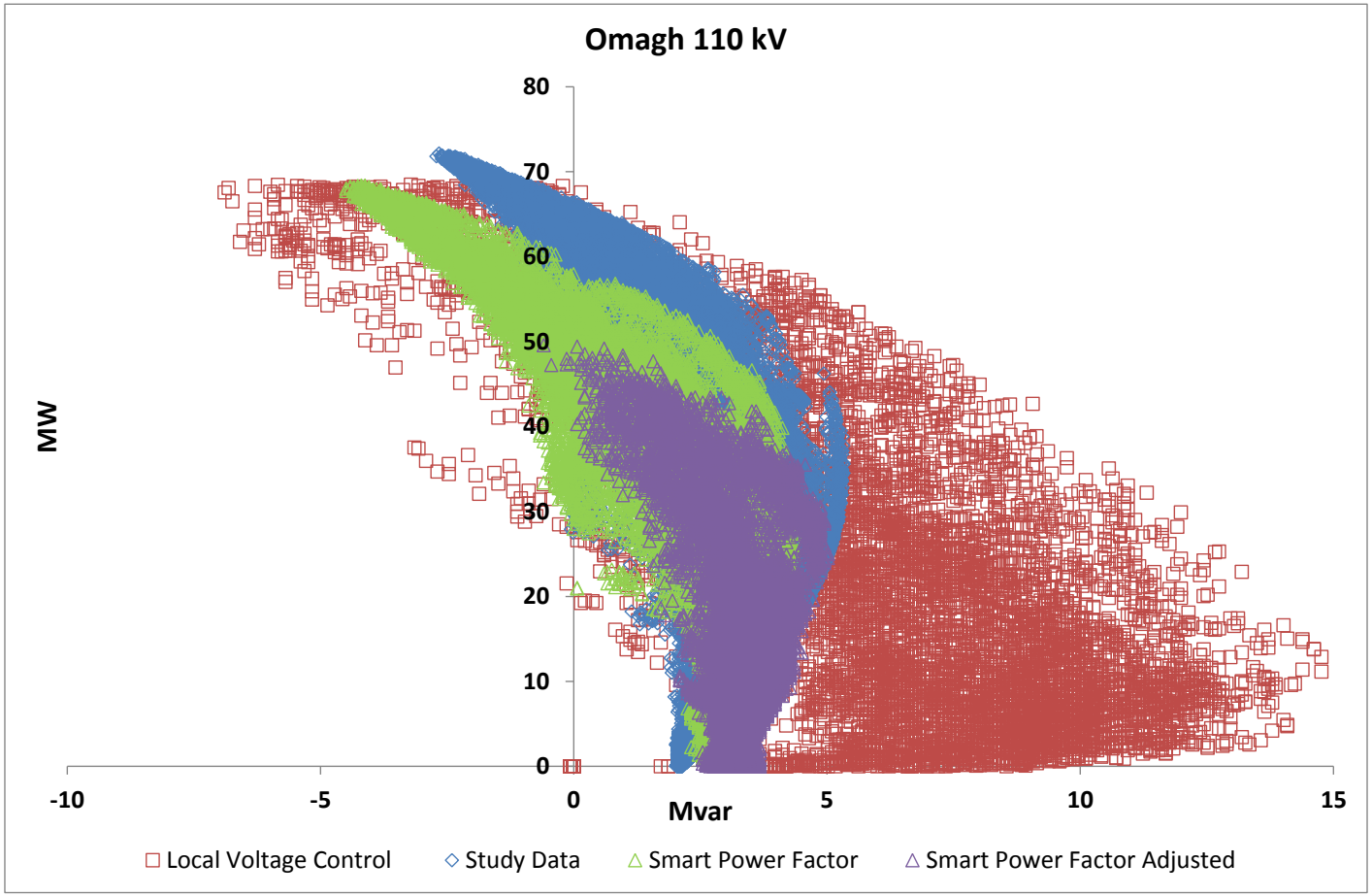
PQ Plot – Smart PF Trial



PQ Plot – Smart PF Trial



PQ Plot – Smart PF Trial



Conclusions & Next Steps

- Smart Power Factor
  - Reactive Power within +/- 5 Mvar at the MKL feeder at OMA 110 kV station
  - More predictable Mvar profile as seen by Tx
  - No voltage stability issues observed
  - Scalable
- Smart Power Factor Trial
  - Commenced 27/04/2016

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Northern Ireland Electricity Networks

NIE NETWORKS' ROCOF IMPLEMENTATION PROJECT

Overview

Two main work streams from a Distribution Network perspective:

1. Generator Rate of Change of Frequency (RoCoF) withstand capability
   - Necessary to ensure that all generating plant connected to the system has the capability to withstand large RoCoFs.
   - Proposed Grid Code modification did not cover Independent Generating Plant which is defined as "A **Power Station** which is not subject to **Central Dispatch** and is not a **Controllable WFPS**".
   - NIE Networks was requested to propose a Distribution Code modification to ensure that all Independent Generating Plant can remain connected and operate up to and including 2Hz/s measured over 500ms.

2. Loss of mains amendment process
   - Necessary to amend generator Loss of Mains (LoM) settings to ensure that generation remains connected to the system during large events.
   - Amending LoM settings will result in an increased risk of islanding
   - Strathclyde University were engaged to quantify the risks of amending generator settings

Generator RoCoF Withstand

- It was agreed by the D-Code Review Panel to consult on proposed D-Code RoCoF changes, from 1Hz/s to 2Hz/s, to:
  - Give the TSO an understanding of the capability of independent generating plant to remain connected to the distribution system and operate for RoCoFs up to 2Hz/s measured over 500ms.
  - Ensure harmonisation of the D-Code with the Grid Code.
- Direct contact made with 386 individual stakeholders and the consultation ran for 3 months.
- A total of 11 responses were received. The NIE Networks' response to the consultation can be found at the following URL:

http://www.nienetworks.co.uk/About-us/Distribution-code/DC-review-panel

- Some generators declared compliance with the 2Hz/s RoCoF standard, one anaerobic digester stated that they are not compliant whilst others stated that they are unaware what RoCoF their machines can remain connected and operate at.
- NIE Networks submitted a "response to the consultation" document to the Utility Regulator and after review it was agreed that the D-Code modification should be implemented inline with any Grid Code modification.

LoM Amendment Process

- **Necessary to amend the following G59 settings:**

G59 Function	Current Setting	Change Required
RoCoF	0.125Hz/s – 0.4 Hz/s	Yes
Vector Shift	6deg – 12deg	Yes
Over frequency	50.5Hz	Yes
Under frequency	48Hz	No
Over Voltage	+10%	No
Under Voltage	-10%	Yes

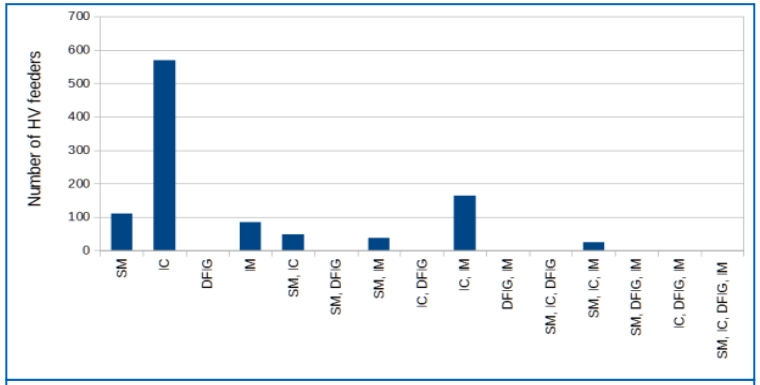
- **Strathclyde University Research is broken into 4 work packages.**
  - WP1 – Analysis of the DG connection registers to establish dominant generating technologies and generation mixes in the identified islanding scenarios.
  - WP2 –Investigation of the LOM protection stability under critical system events.
  - 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.

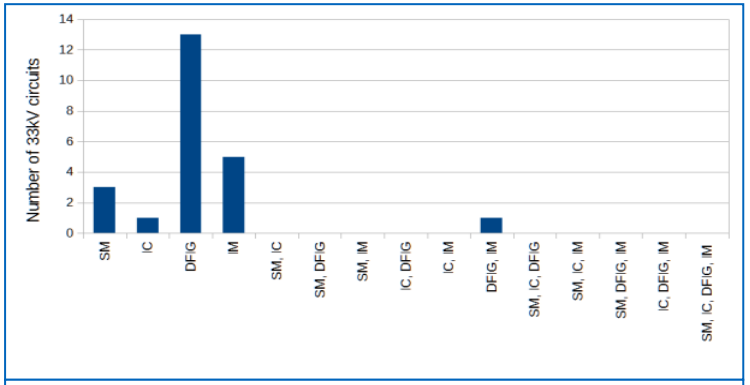
Work Package 1 – DG Registers

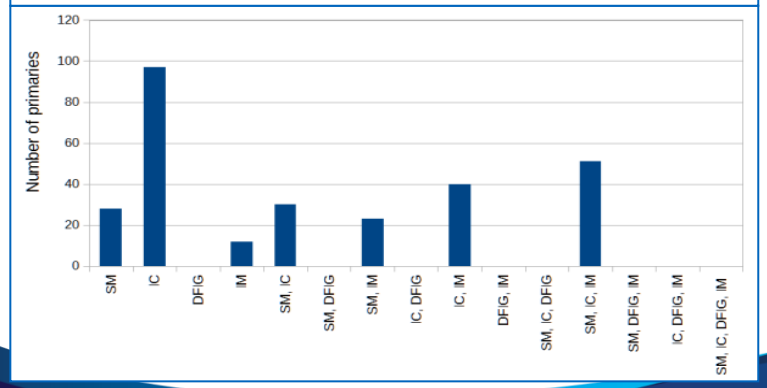
4 islanding groups identified:

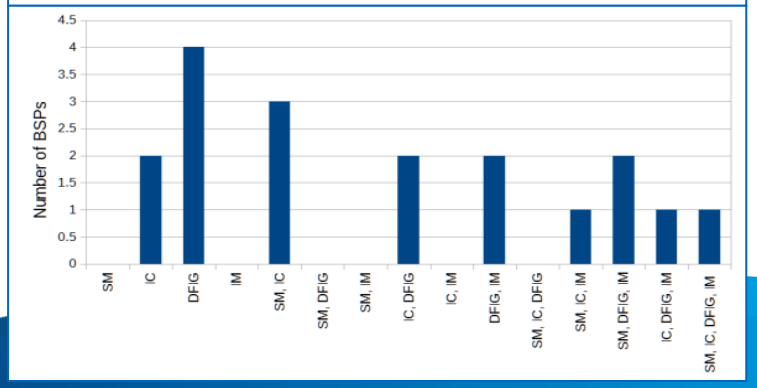
- The loss of a Bulk Supply Point (BSP).
- The opening of a 33kV circuit breaker with generation and/or load connected downstream.
- The loss of a Primary Substation.
- The opening of an 11kV circuit breaker with generation and/or load connected downstream.

The graphs below illustrate the generation mixes for the various islanding groups.



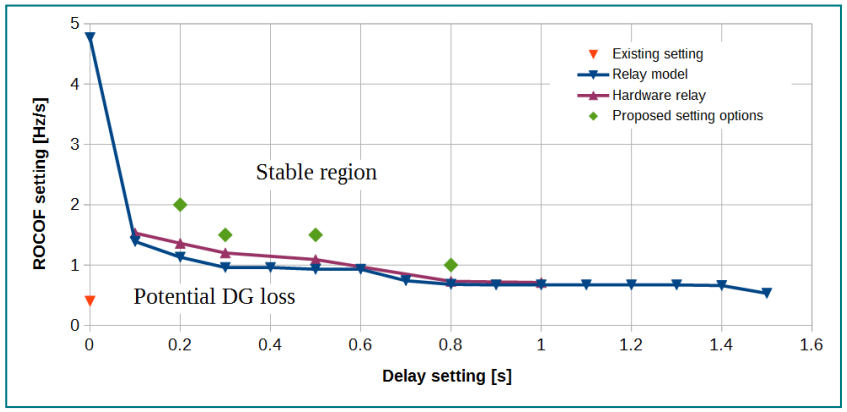


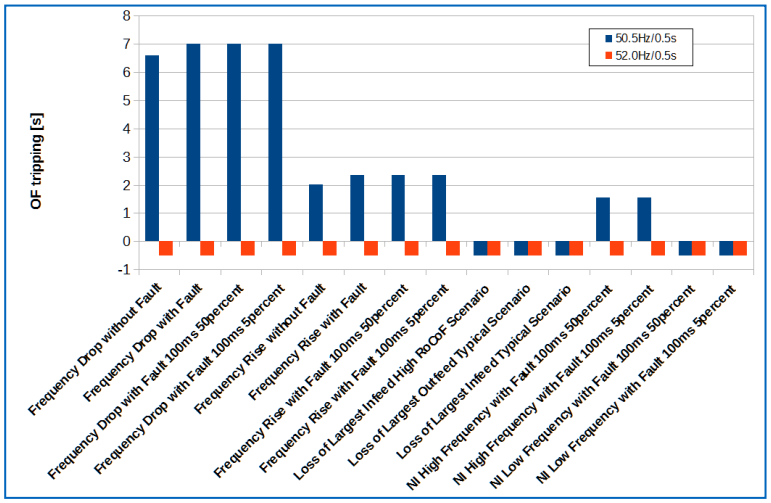




Work Package 2 – Stability Analysis

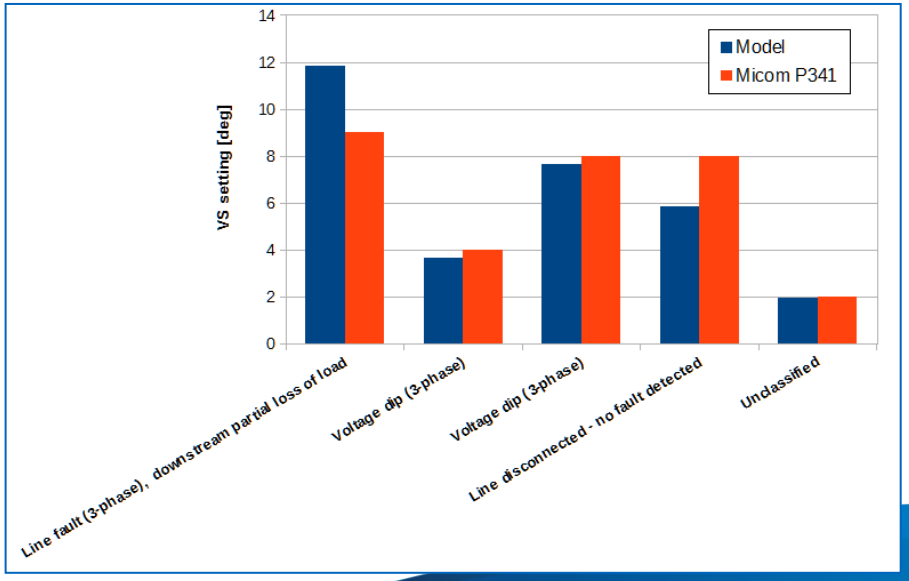
- **Objective: Determine the required G59 settings to ensure stability for all system events**
- **15 modelled events showing RoCoFs up to 2Hz/s measured over 500ms were used in the analysis.**
- **Relay models and actual relays were tested to determine correct settings.**
- **The following results were outputted for RoCoF and Overfrequency settings:**





Work Package 2 – Stability Analysis

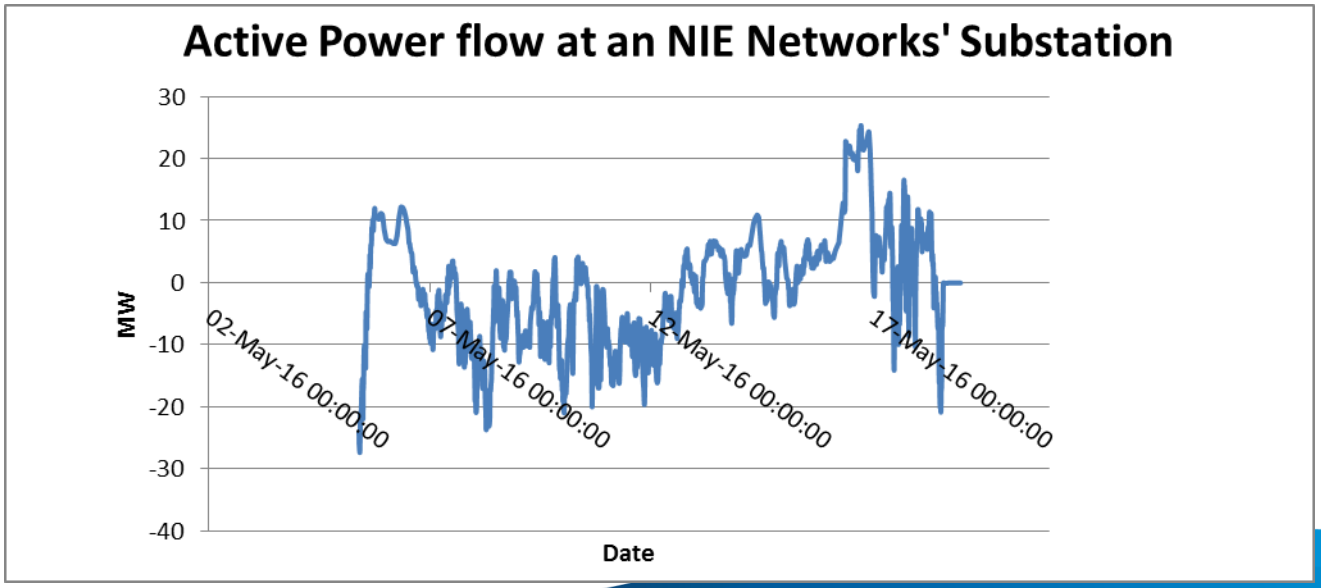
- **Traditionally Vector Shift was considered to be more stable than RoCoF; however, during the 2013 snow storm it was identified that only those generators employing VS protection tripped off.**
- **It was identified that the modelled events may not be suitable for modelling VS stability. VS is more prone to trip under transient phenomenon. Such phenomenon was not captured in the modelled events.**
- **To model VS stability, disturbance recorder data was extracted for 5 actual system events.**



Work Package 3 – Sensitivity Analysis

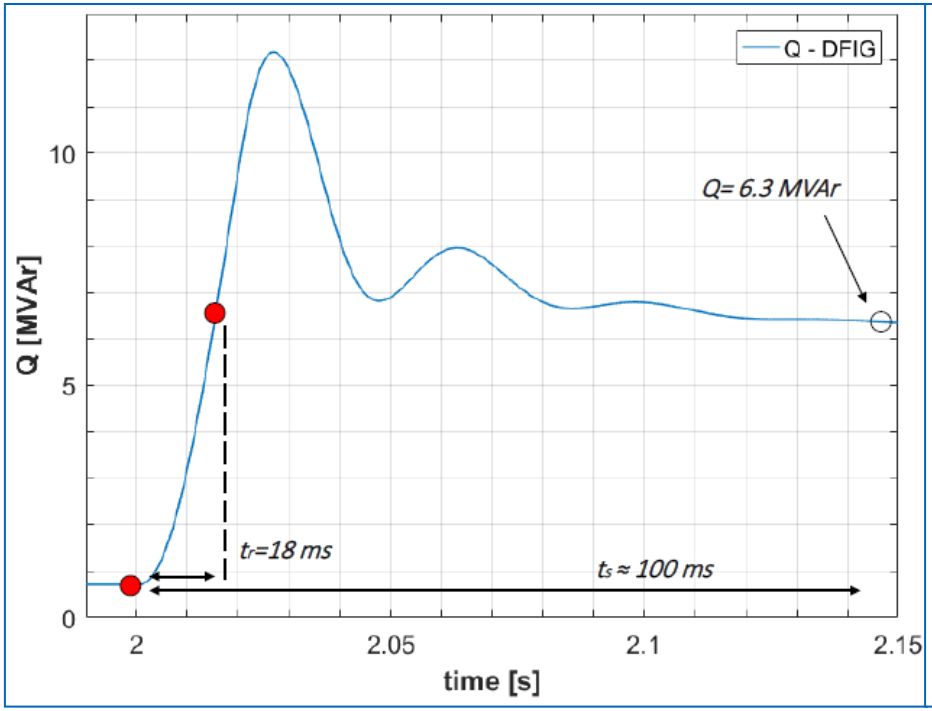
- **Amending G59 settings will result in an increased risk of generator islanding, thus increased risk of:**
  - Operating an unearthed distribution system (increased risk of electrocution)
  - Out of sync reclosure of generation with main system (machine damage)
- **In order to fully quantify the risks it is necessary to determine the following factors:**

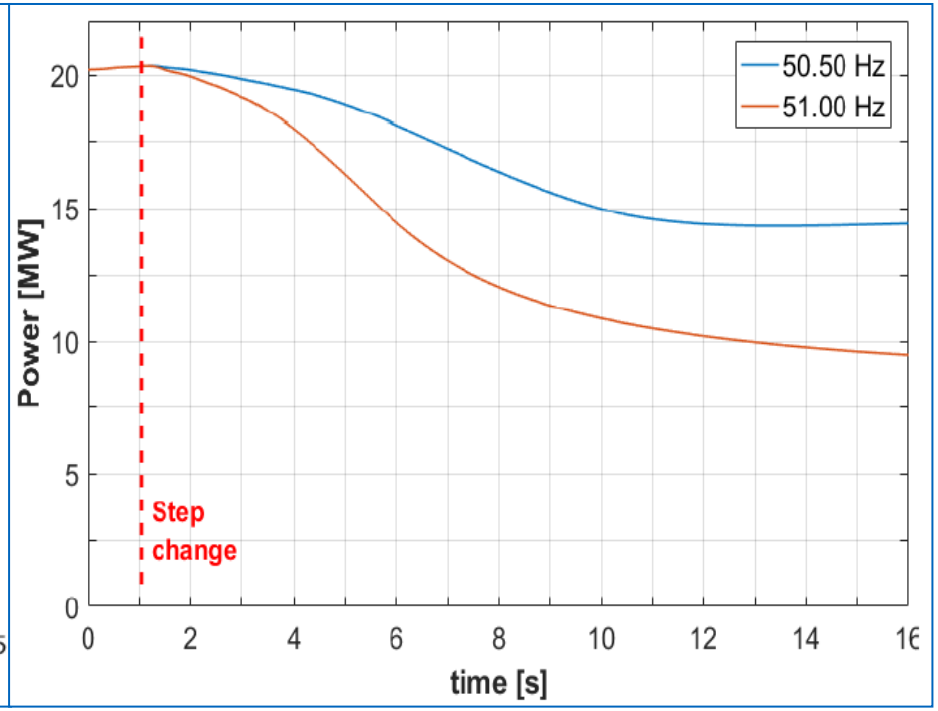
1. The power flows of islanding groups – to determine load/generation balance



Work Package 3 – Sensitivity Analysis

2. Accurate generator models:





3. Generator islanding groups – Work Package 1
4. Required G59 settings – Work package 2
5. Circuit Breaker reclosure dead times – 30s

Future Proofing

- **NIE Networks' believe that any associated G59 amendments should be adequate for future system and generator conditions.**
- **To realise this, the effect that predicted future generation levels and groupings will have on G59 protection have been modelled.**
- **Generator models have been used with response times inline with those required by the RfG and Ancillary Services.**

Timelines

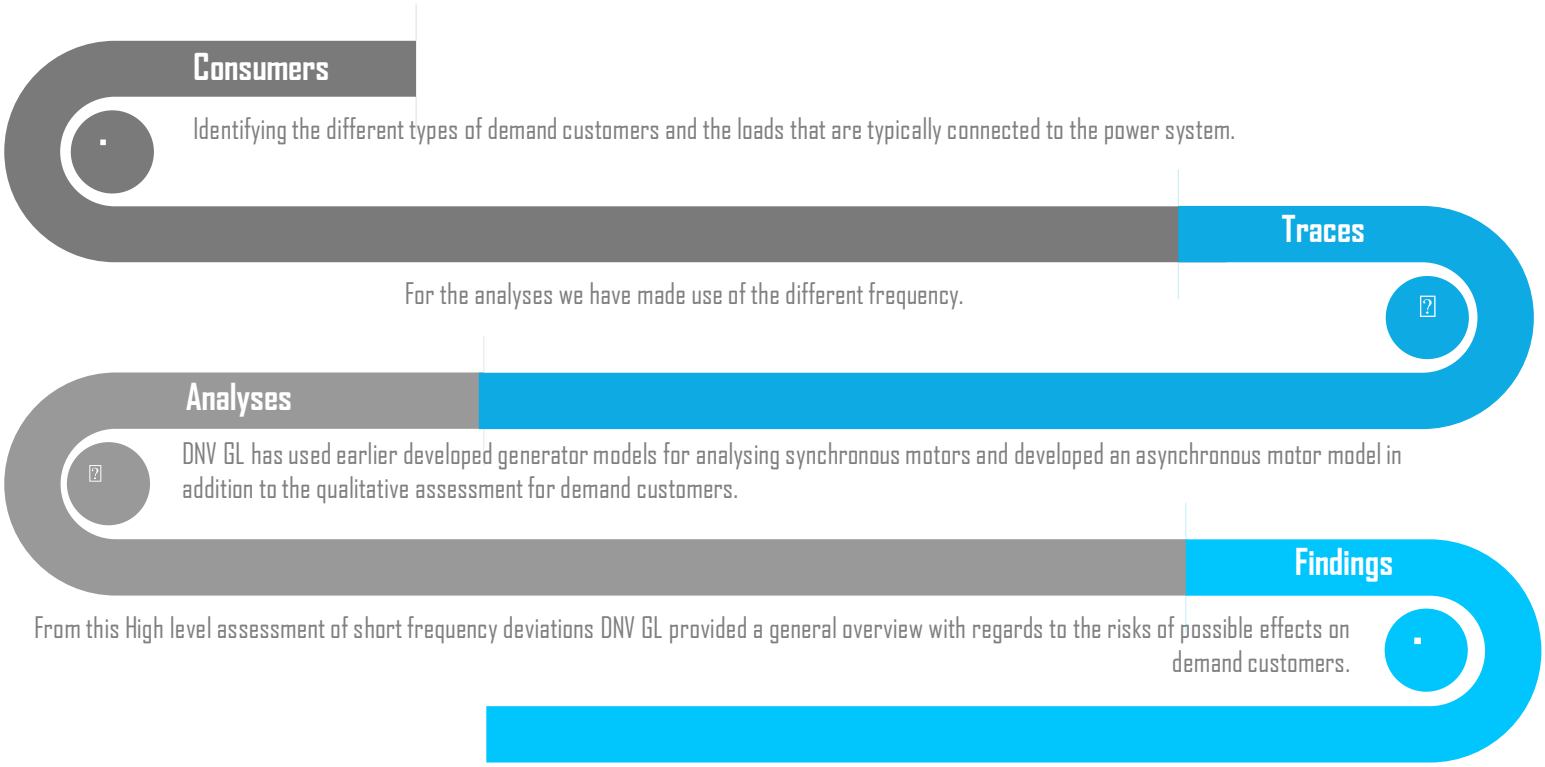
Activity	Due Date	Status
Work Package 1	Q4 2015	Complete
Work Package 2	Q1 2016	Complete
Work Package 3	mid 2016	On Schedule
LSG G59 amendments complete	Q3 2017	On Schedule
Work Package 4	Q4 2016	On Schedule
SSG G59 amendments complete	Q3 2017	On Schedule

QUESTIONS?

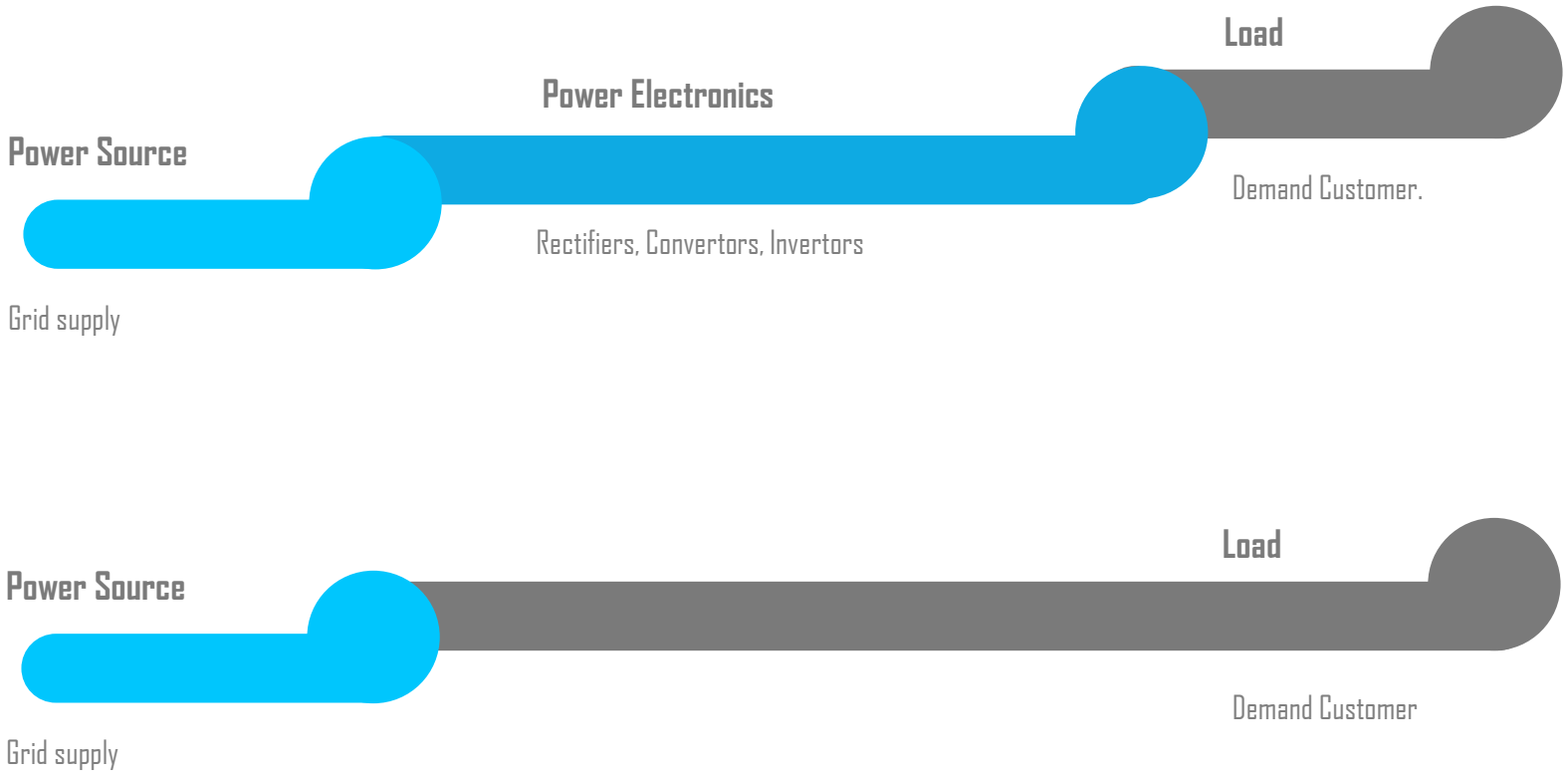
Assessment of higher RoCoF events on demand Customers

Willem Uijlings DNV GL

A general project overview



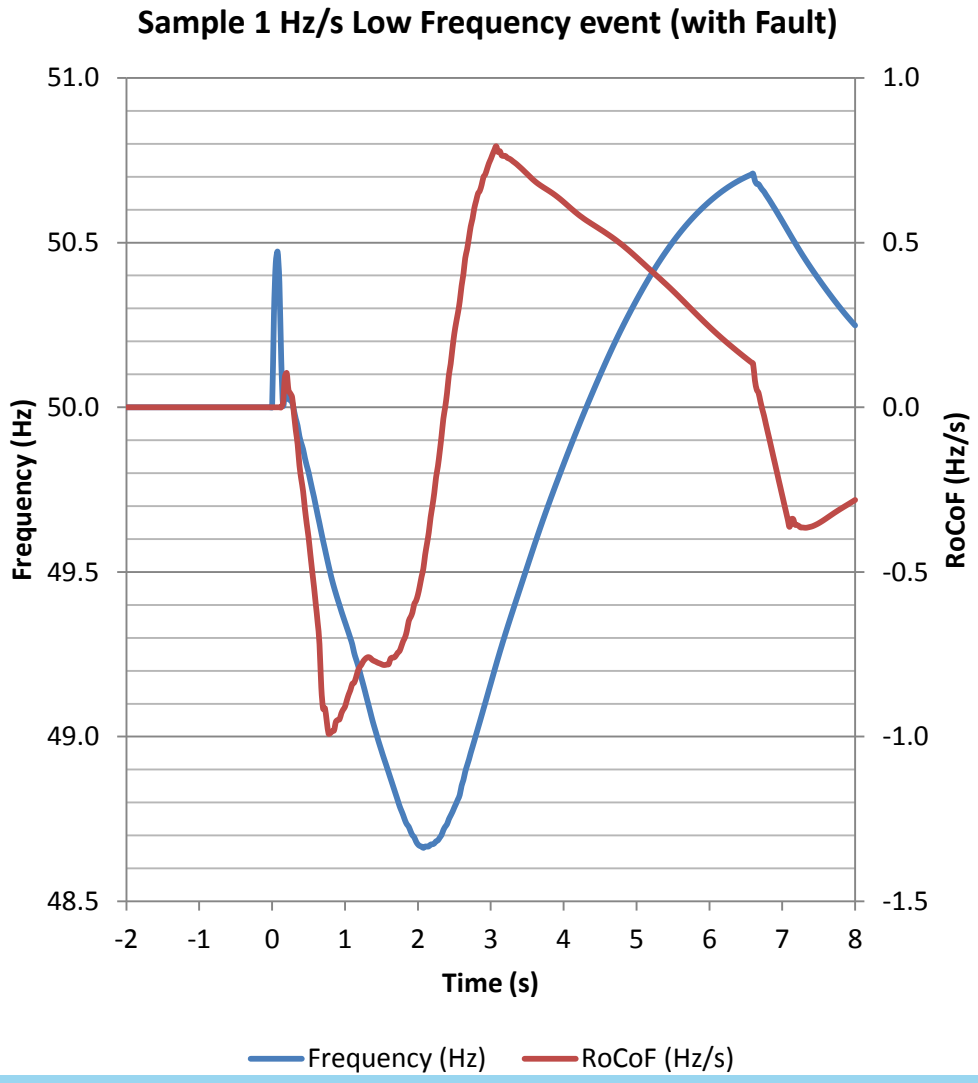
Indirect and Direct AC connected load types



Characterisation load types in the industry

Industrial categories	**Indirect AC connected**		**Direct AC connected**		
	Power Electronics Uncontrolled	Power Electronics Controlled	Synchronous motors	Asynchronous	Resistive load
Pharmaceutical processes		✓			
Semiconductor fabrication		✓			
Alumina refinery	✓	✓	✓	✓	
Cement industry				✓	
Chemical industry		✓		✓	
Data centres		✓	✓		
Critical load including hospitals	✓				
Food & Drink industry	✓	✓	✓	✓	✓

Frequency traces



RoCoF traces

EirGird and SONI have provided different frequency traces, of 0.5, 1, 1.5 and 2 Hz/s low and high frequency events, which DNV GL used for this short study.

0.5 Hz/s

Current RoCoF standard

The current Grid Code in Ireland and Northern Ireland states a RoCoF level of 1 Hz/s.

1.0 Hz/s

In principle agreed RoCoF standard

The Commission for Energy Regulation (CER) agreed RoCoF level in principle.

1.5 Hz/s

Hypothetical RoCoF level A

Rate of Frequency change used for additional reference.

2.0 Hz/s

Hypothetical RoCoF level B

Rate of Frequency change used for additional reference.

High-level findings

This high-level assessment shows that in the majority of the cases the found risks with regards to a 1 Hz/s RoCoF is low.

DNV GL concludes in its report that, although most load types could be influenced by RoCoF, the associated risks for demand customers with regards to the proposed higher rate of change of frequency (1 Hz/s) will be low.

Load type	RoCoF [Hz/s]	No. of RoCoF events annually	Impact
Power electronics uncontrolled	0.5	10	No impact reported
Power electronics uncontrolled	1.0	10	No impact expected
Power electronics controlled	0.5	10	No impact reported
Power electronics controlled	1.0	10	Infrequent and inadvertent tripping could be experienced
Synchronous motor	0.5	10	No impact reported
Synchronous motor	1.0	10	No impact expected
Asynchronous motor	0.5	10	No impact reported
Asynchronous motor	1.0	10	No impact expected
Resistive load	0.5	10	No impact reported
Resistive load	1.0	10	No impact expected

Further Study areas

High-level assessment

DNV GL preformed a high-level assessment with regards to the effects of the in principle agreed Grid Code change to allow for a 1 Hz/s RoCoF value. The high-level results show that the risks for demand customers are expected to be low. A generic statement at this point in time concerning the overall effects of all demand customer loads cannot be made. DNV GL suggests to allow for further analysis in some specific areas.

Embedded generation

The protection settings of embedded generation might not ride-through RoCoF levels of 1 Hz/s, especially where anti-islanding is installed.

Power electronic SP

For controlled power electronics in some cases the set-point (SP) settings might need changing to allow for the anticipated RoCoF levels.

Special motors

Very large (20MW and over) high speed synchronous motors and large Asynchronous motors driving heavy mechanical loads need specific analysis

Thank you

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SAFER, SMARTER, GREENER

Closing Remarks

DS3 Advisory Council 24/05/2016

15.00-15.10pm

EIRGRID GROUP