DS3 Advisory Council Meeting

22nd September 2015, Belfast

EIRGRID GROUP

Agenda

	Time	Speaker
Introduction	10.30	Louis Fisher (5 mins)
Industry Perspective	10.35	Presentation: Mark McGranaghan - EPRI (10 mins) Presentation: Kevin Chan - Alstom (10 mins) Presentation: Patrick Mohr – NTMA (10 mins Discussion: All (10 mins)
Actions from last meeting **DS3 Programme Status Update**	11:15	Presentation: Robbie Aherne (30 mins) Discussion: All (10 mins)
Rate of Change of Frequency (RoCoF)	11:55	Presentation: David Cashman (10 mins) Presentation: DSOs (10 mins) Presentation: RAs (5 mins) Discussion: All (10 mins)
System Services	12:30	Presentation: Eoin Kennedy (15 mins) Presentation: RAs (15 mins) Discussion: All (15 mins)
Risk Workshop	13:15	Workshop: All (45 mins)
Lunch & Networking (14:00 – 14:40)		
EWIC Export Study	14:40	Presentation: Séamus Power (10 mins) Discussion: All (5 mins)
Over Frequency Scheme Study	14:55	Presentation: Eoin Sweeney (10 mins) Discussion: All (5 mins)
Closing Remarks and Actions	15:10	Louis Fisher (15 mins)
Session Closed / Networking	15:25	

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Industry Perspective

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EPRI Research Focus for Flexibility and Integration of Renewables

Mark McGranaghan
Vice President, Power Delivery and Utilization

DS3 Advisory Committee Meeting, Belfast

22 September, 2016

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EPRI Power Delivery and Utilization Research Sector

Vision/ Issues

Transmission

Distribution

End Use

Information and Communications

R&D Collaboration → **Application of Results** → **Standards, Industry Guides**

Coordinated Research | Tech Transfer | Change the Practice

Global Thought Leadership for R&D in Power Delivery and Utilization

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Global Innovation – Annual International Technology Innovation Summit: 2014 Dublin Ireland

U.S. UTILITIES

Bonneville Power Administration
Southern Company
Duke Energy
Southern California Edison – An Edison International Company
New York Power Authority
AEP American Electric Power
pjm
TVA
SCANA – Power For Living
Ameren

INTERNATIONAL UTILITIES

EDF
RWE – The energy to lead
Iberdrola
ESB
alliander
nationalgrid
KEPCO
Enel
gas natural inc.
amprion
e·on
Northern Ireland Electricity
EirGrid
ISO
Eskom
unesa – Asociación Española de la Industria Eléctrica

TECHNOLOGY PROVIDERS

IBM
AREVA
Bechtel
Glen Dimplex – Professional Appliances
SMA
energy technologies institute
Engineers Ireland
IRDG – Industry Research + Development Group
C3 Energy
Siemens
Alstom
IWEA – Irish Wind Energy Association
passivSYSTEMS
S&C Electric Company – Excellence Through Innovation
Cisco
Schneider Electric
sgi – smartgridireland
Microsoft
intel
Toshiba

OTHERS

UCD Dublin
Danish Energy Association
Technology Strategy Board – Driving Innovation
The University of Nottingham – United Kingdom · China · Malaysia
European Commission
EI Ireland
Morgan Stanley
CER – Commission for Energy Regulation
Fortum
entsoe – Reliable Sustainable Connected
IFA
NRDC
University of Cyprus
seai – Sustainable Energy Authority of Ireland
eurelectric – Electricity for Europe
Gníomhaireacht Bainistíochta an Chisteáin Náisiúnta – National Treasury Management Agency
National Academy of Sciences
ESRI

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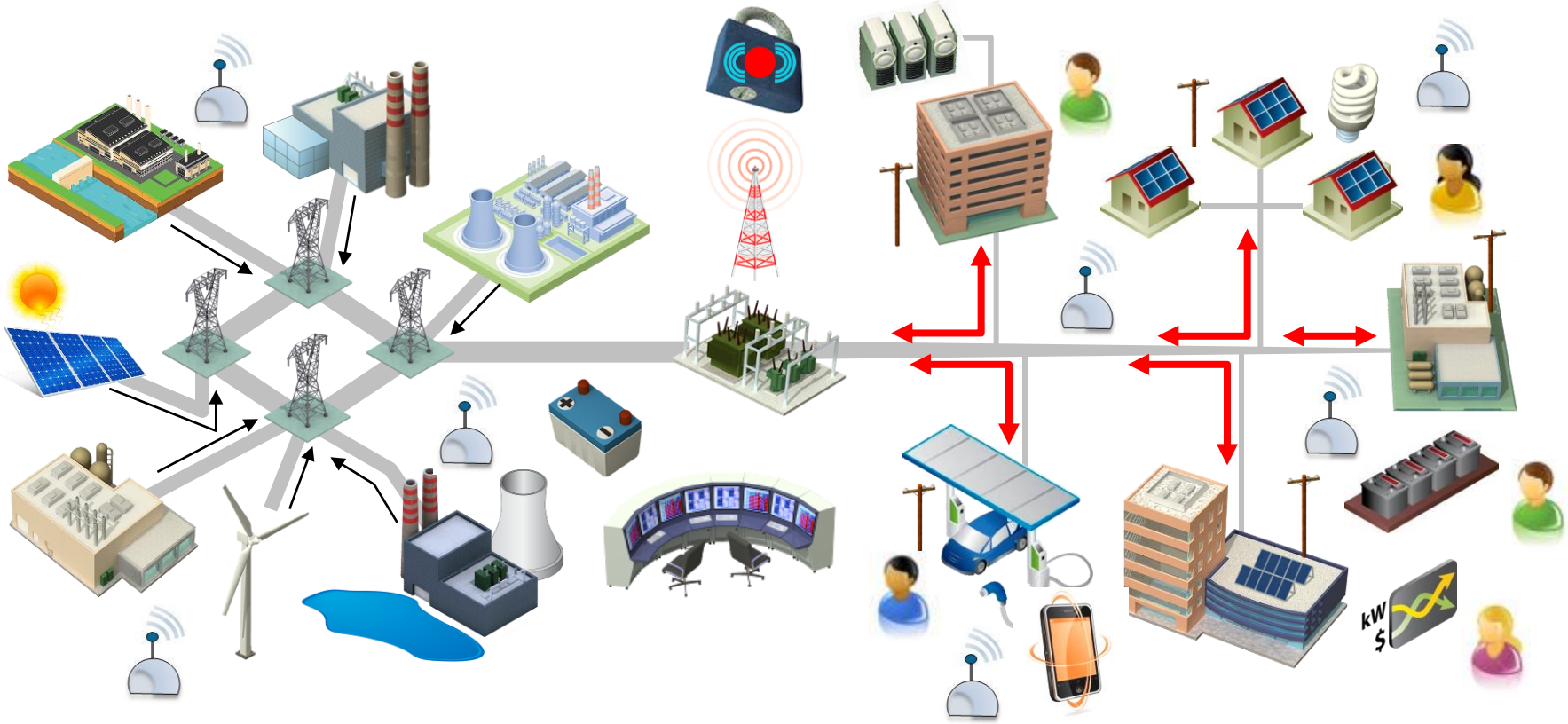
The Vision



Power System that is Highly Flexible, Resilient and Connected and Optimizes Energy Resources

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Bulk Renewable Integration R&D Focus

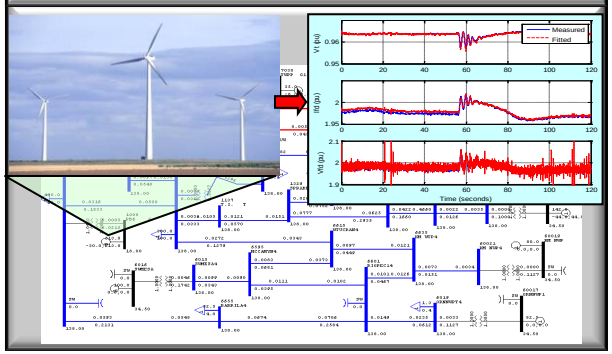
Monitoring

Analysis

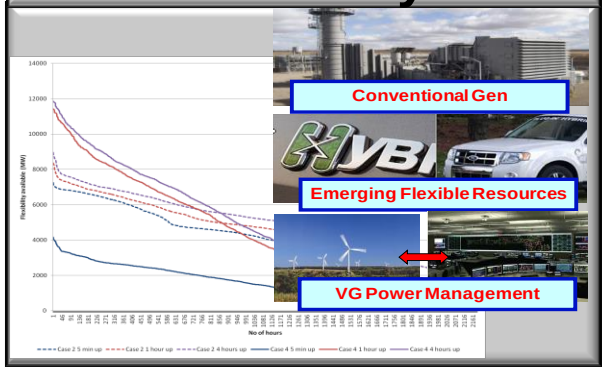
Decision Support

Control

Modeling & Protection

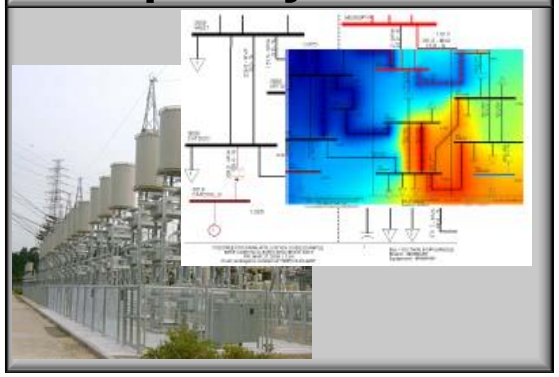


Variability & System Flexibility



Schedule, Dispatch & Reserves

Voltage & Frequency Control



New Methods/Tools

Reliable & Efficient Operation

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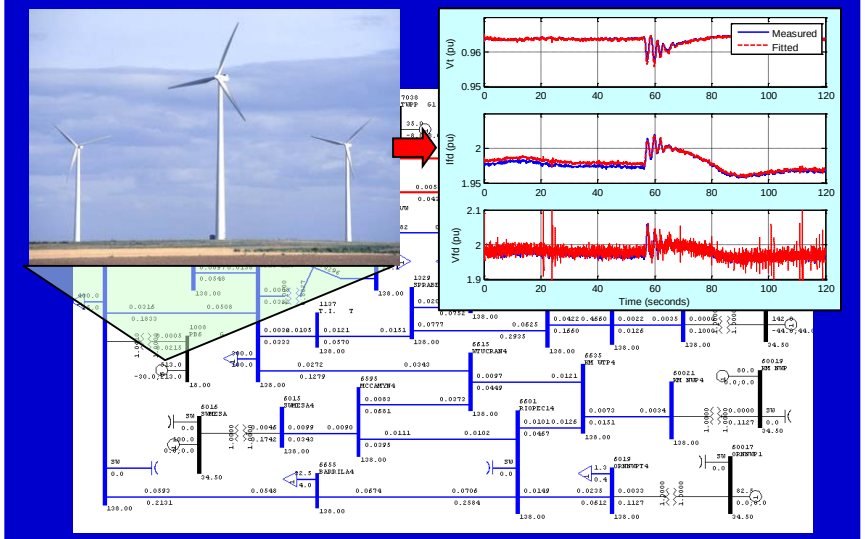
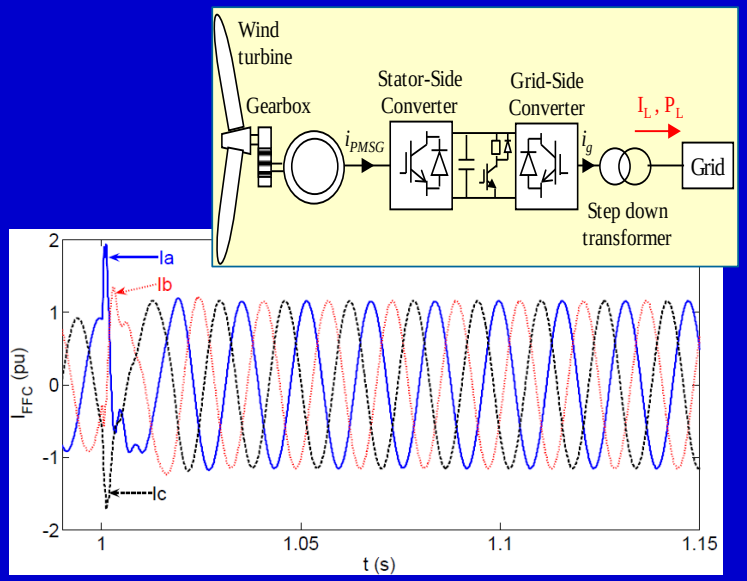
Needs for Planning and Protection – Better Models

Wind/PV Dynamic Model Development and Validation



- Renewable Energy Model Validation (REMV) tool
- Generic dynamic models of wind, PV and energy storage

Protection Impacts of Inverter-Based Wind/PV



- Guidelines for protection schemes & studies on systems with high wind/PV
- Frequency-domain short-circuit models for wind/PV

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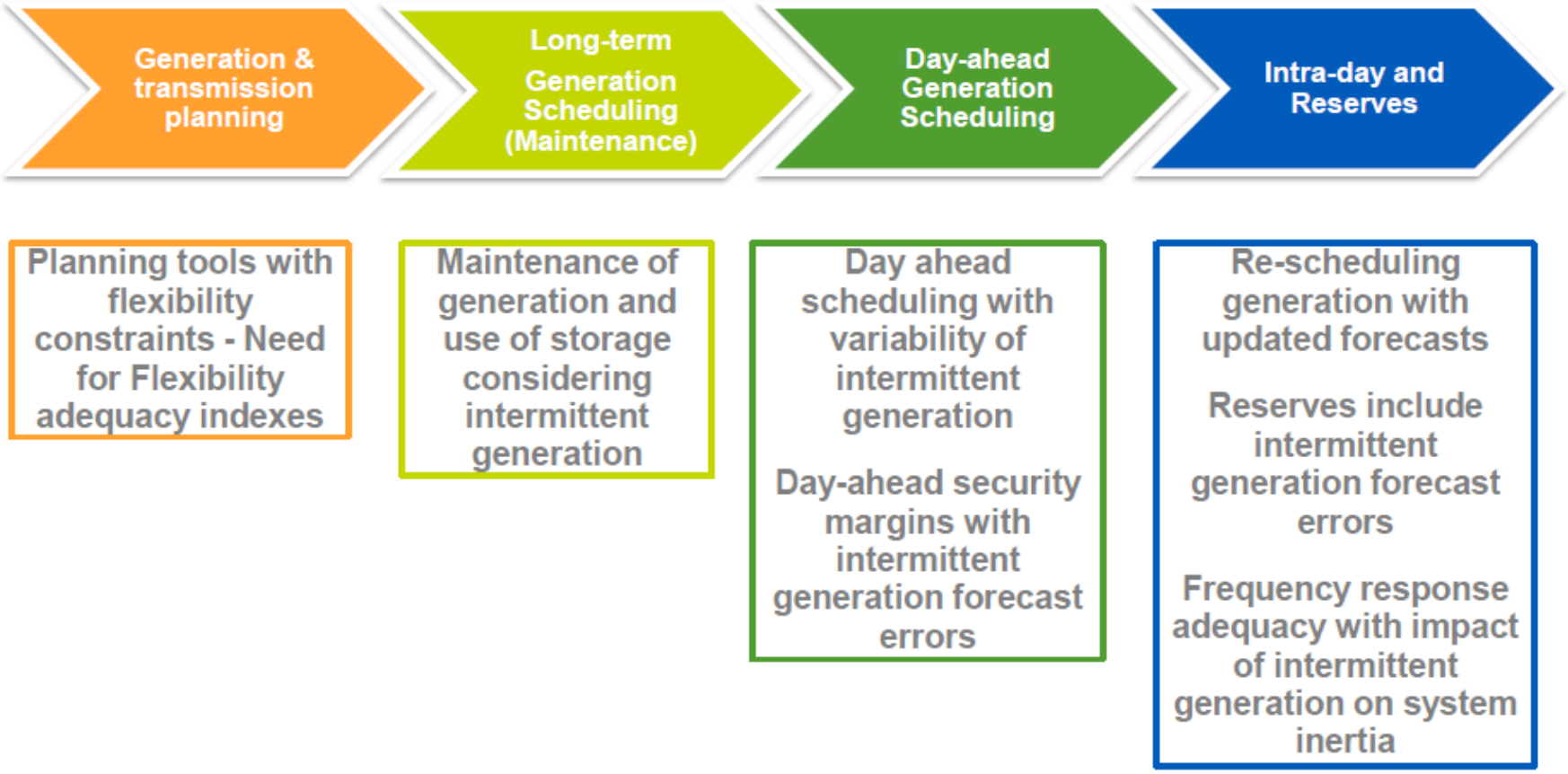
Flexibility Requirements



Source: V. Silva, EdF R&D

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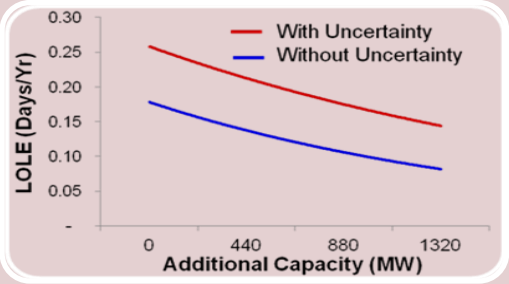
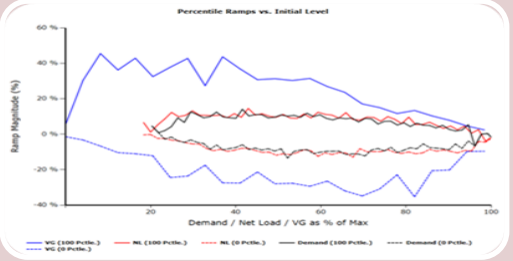
EPRI Flexible System Planning R&D





Flexibility Assessment Software Tool

- Flexibility metrics
- Screening analysis
- Detailed flexibility evaluation

Resource and Transmission Flexibility

- Resource adequacy: variability/uncertainty & operation methods
- Transmission impact on flexibility

Utility/ISO Flexibility Case Studies

- Insights as to time horizons concerns
- Order of magnitude of possible risk

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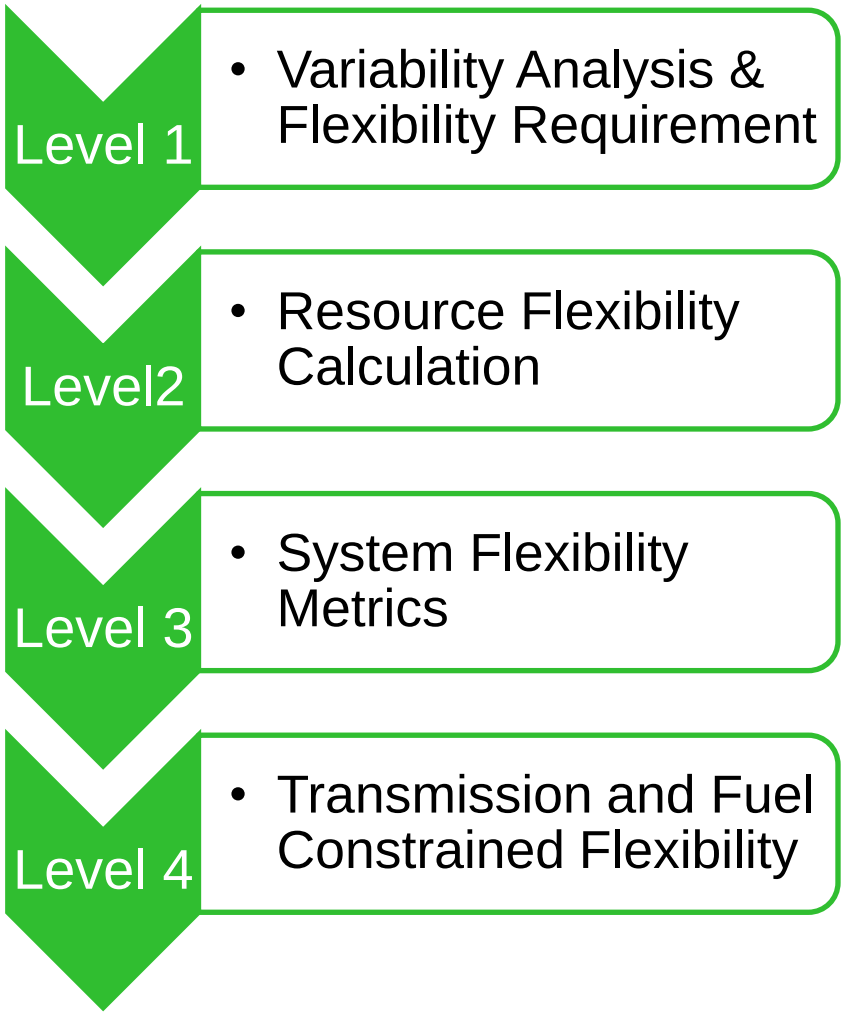
Flexibility Metrics for system planning

- Multi-Level Approach
  - Levels 1 and 2 →screening
  - Levels 3 and 4 →detailed metrics
- Three detailed metrics:
  - Periods of Flexibility Deficit
  - Expected Unserved Ramping
  - Insufficient Ramping Resource Expectation
- Post-processed metrics based on simulation or historical data



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Flexibility screening: Time of day/year

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	-9	491	317	361	218	65	61	487	228	295	244	691
1	145	538	283	469	463	218	158	243	396	315	220	789
2	164	380	400	533	514	385	359	274	747	406	230	603
3	586	829	679	516	534	595	423	502	626	584	826	681
4	943	975	1,002	747	749	829	666	797	836	914	1,217	957
5	1,444	1,180	967	811	949	990	845	878	853	947	1,368	1,258
6	1,039	802	1,194	854	1,073	906	908	815	769	893	907	1,044
7	759	474	1,131	621	862	615	597	620	632	639	806	777
8	517	267	736	268	652	401	369	569	374	359	586	408
9	445	241	192	70	272	228	218	150	217	434	352	195
10	378	313	65	62	127	120	117	205	115	395	498	198
11	389	267	104	29	256	136	103	134	1	633	449	190
12	412	407	210	50	250	61	75	166	33	510	317	440
13	568	575	204	331	126	100	66	199	189	272	389	443
14	602	549	356	483	263	218	153	273	385	506	786	684
15	828	553	633	749	202	346	258	356	681	448	786	762
16	882	534	696	655	273	433	237	480	646	406	388	475
17	613	393	516	613	354	464	304	475	663	337	78	162
18	139	322	223	334	407	454	248	232	531	265	85	36
19	229	8	61	220	317	438	217	60	286	178	-60	97
20	44	-52	325	-54	89	205	-37	2	37	369	-108	-108
21	164	14	6	-54	48	54	-28	-154	-141	130	138	171
22	358	167	120	40	-53	-107	-80	-96	45	63	419	102
23	249	339	189	277	154	-13	55	253	100	72	390	435

Load Ramping versus Net Load Ramping

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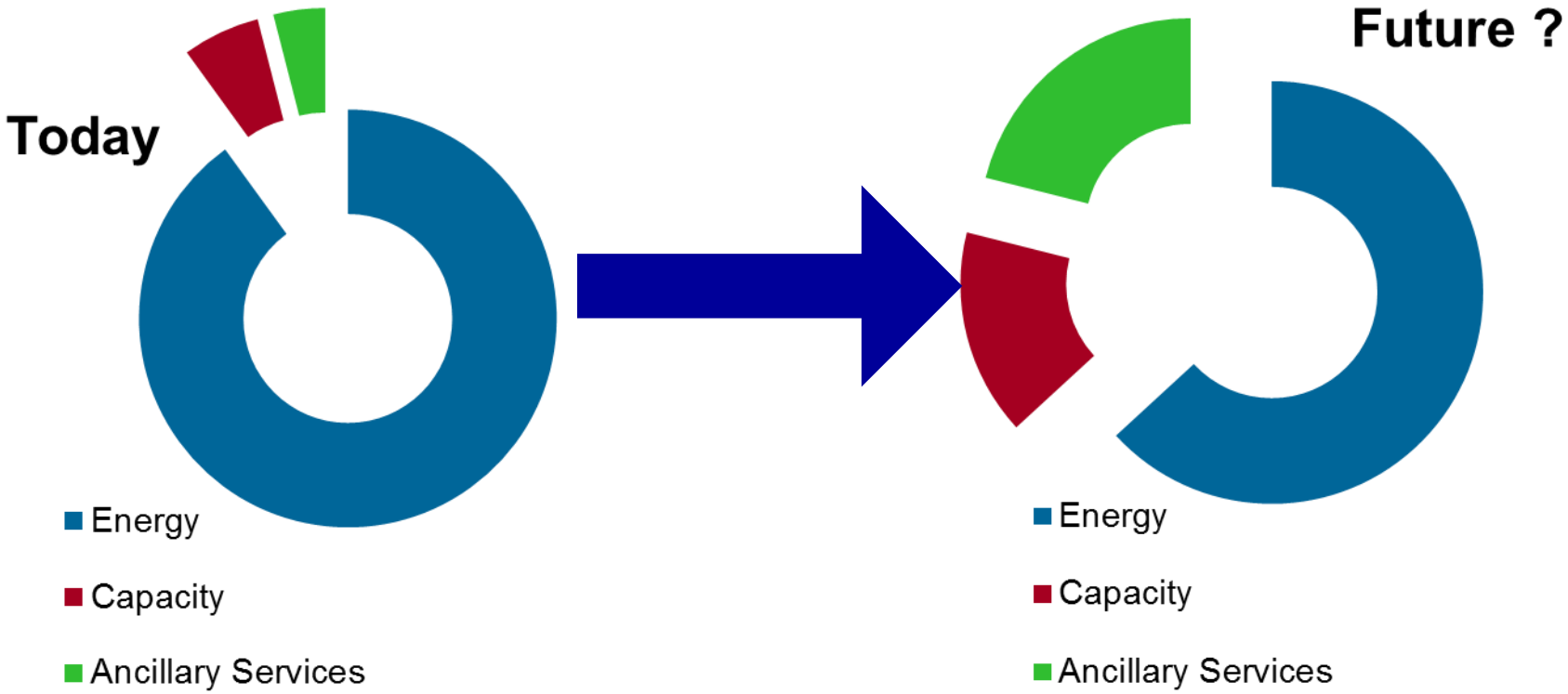
Value of Capacity and Services



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Industry Developments in North America

Integrating the Customer is becoming critical to the entire grid

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- Metrics for Quantifying Flexibility in Power System Planning
  - http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004243
- Reliability Contributions White Paper
  - http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002006400
- Capacity and Energy White Paper
  - http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002006692
- Probabilistic Planning White Paper
  - http://www.naruc.org/grants/Documents/EISPC_RiskBasedPlan_WhitePaper_FINAL_01312015_EPRI%20.pdf
- Integrated Grid Analytical Framework
  - http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004878

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Together…Shaping the Future of Electricity

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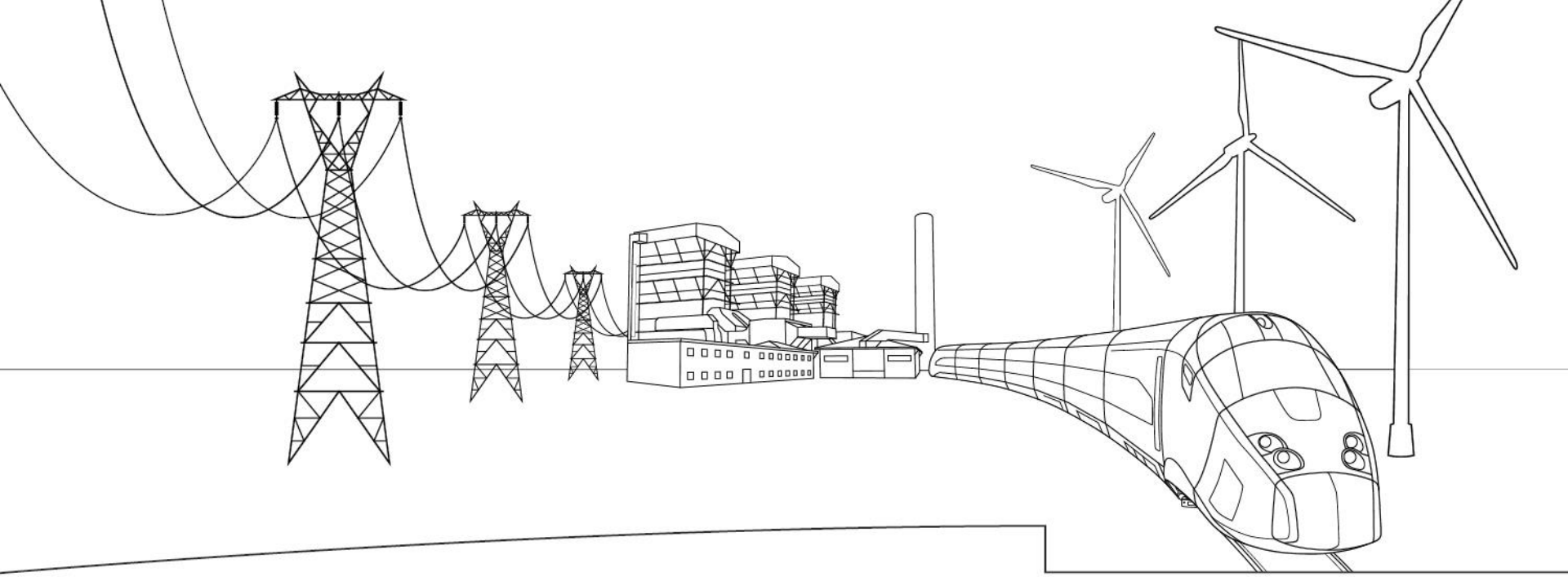

ALSTOM Thermal Power- Introduction

Kevin Chan

Belfast

22/09/2015

ALSTOM

Shaping the future

Three main activities in four sectors

Equipment & services for power generation
Alstom Thermal Power

Equipment & services for power transmission
Alstom Grid

Alstom Renewable Power

Equipment & services for rail transport
Alstom Transport

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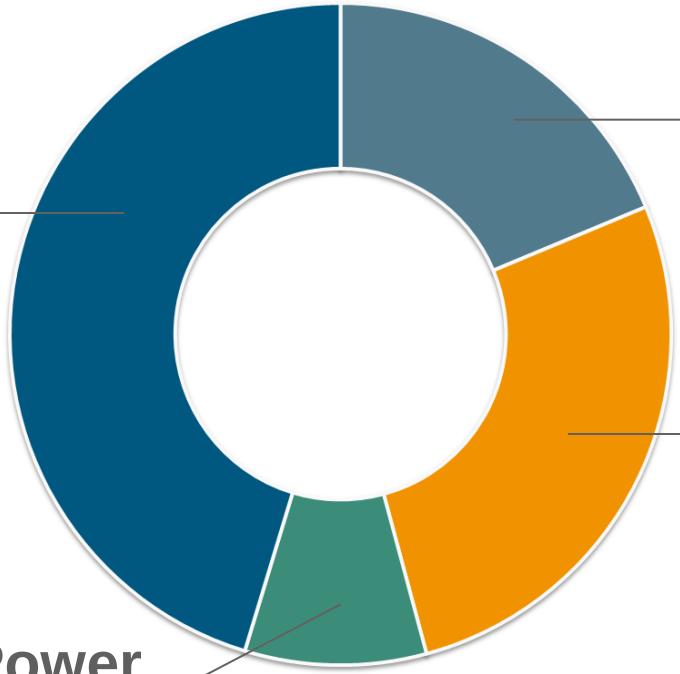
Three main activities in four Sectors

Group sales



- Total sales 2013/14 = 20.3 billion
- Total orders 2013/14 = 21.5 billion

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Alstom Power: present in all markets

GAS

COAL

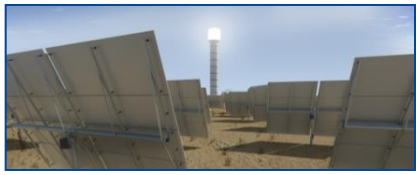
OIL

NUCLEAR (conventional island)

HYDRO

WIND (offshore and onshore)

SOLAR



GEOTHERMAL

BIOMASS

TIDAL

...for new plants or the installed base

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ALSTOM

Working Experience

2015

From 1982 - Present

- ALSTOM Turbogenerators R&D - Expert Generator Grid Interaction.
- ALSTOM Gas Business – Head of Power Systems Studies & Grid Code Compliance.
- ABB High Voltage Technologies – Section Manager Power Systems.
- ABB Network Control - Group Leader Power System Software.
- BBC – R&D power systems engineer.
- Asea – Project engineer.
- PROMET – Plant & Commissioning Engineer

1982

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ALSTOM

Area of Expertise

From 1982 - Present

- Electrical erection & commissioning.
- Power system software development.
- Power systems studies.
- HV substation technologies.
- Development of PQ and FACTS technologies.
- Development of power plant control systems.
- Power plant grid code compliance.
- Development of converter based enhancement for thermal power generation.

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Professional Organisation

From 1987 - Present

- Fellow IET and CEng.
- Senior member IEEE.
- Member CIGRE.
- CIGRE/CIRED C4-C6.35 Joint Working Group “Modelling and Dynamic Performance of Inverter based Generation in Power System Transmission and Distribution Studies”
- CIGRE/CIRED C4.24 Joint Working Group “Power Quality and EMC Issues associated with future electricity networks”
- CIGRE/CIRED C1.29 Joint Working Group “Planning criteria for Future Transmission Networks in the presence of a greater variability of power exchange with distribution systems”
- CENELEC BTWG 143-2 and ENTSO-E Standardisation activities.
- EUTurbines – ENTSO-E Grid Code Task Force.
- IEEE EMC TF on Coordination of Grid Codes and Generator Standards: Consequences of Diverse Grid Code Requirements on Synchronous Machine Design and Standards
- CIGRE Task Force TF38-02-25 Modeling of Gas Turbines and Steam Turbines in Combined-Cycle Power Plants from 2001-2003.
- IEEE Task Force Dynamic Models for Turbine-Governors in Power System Studies from 2008-2013.

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ALSTOM Activities Related to DS3 Programme

Current Activities

- Low turn-down capability – Low & Zero Load Capabilities.
- 2s Frequency Response delay – Steam turbine participation.
- Fast Frequency Response – Conventional (steam-cycle, batteries) and converter-based (SynchroGrid©) solutions.
- Inertial Response - Conventional and Converter-based (SynchroGrid©) solution.
- Reactive Power – Synchronous condensers.
- RoCoF Investigations for CCGT and Steam Plants in Ireland.
- R&D Program on Operational Flexibility of CCPP

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ALSTOM Activities Related to DS3 Programme

SynchroGrid©

Turbogenerator Converter System With Enhanced Grid Support Features - Design and Applications -

ALSTOM imagination at work

SCA1 Cigre Madrid 2015

300MW Class System

- **Type Test:**
  - Full-scale test at GT base-load and up to 350MW, connected to the 50Hz Swiss Grid.
  - Functionality of all components proven
  - >250h test operation
  - >70 starts of the plant
  - System performance validated, e.g.:
    - Power capability
    - Speed variation capability
    - Efficiency:
      - Generator: 98.6 %
      - Converter: 99.4 %
      - → System: 98,0%

World premiere in the 300 MW class:
Turbogenerator connected to the grid via a direct converter

www.cigre-sca1-Madrid2015.org

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ALSTOM Activities Related to DS3 Programme

SynchroGrid©

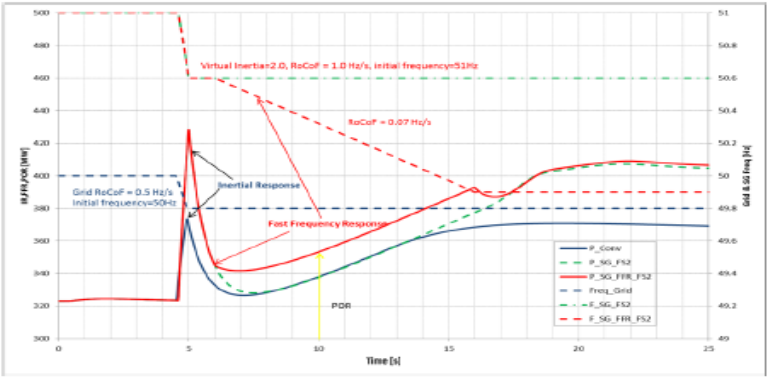
Turbogenerator Converter System With Enhanced Grid Support Features - Design and Applications -

ALSTOM imagination at work

SCA1 Cigre Madrid 2015

Enhanced Grid Support Applications

- **Frequency Support**
  - Converter with new operating concepts enables:
    - Flexible Inertial Response (IR)
    - Fast Frequency Response (FFR) not available from conventional unit
    - Improved Primary and Secondary Operating Reserves (POR & SOR)



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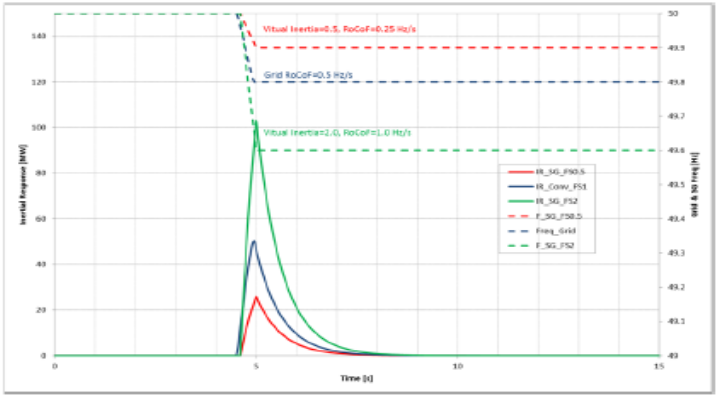
Inertia Response



Inertial Response
Fast Frequency Response
Primary Operating Reserves

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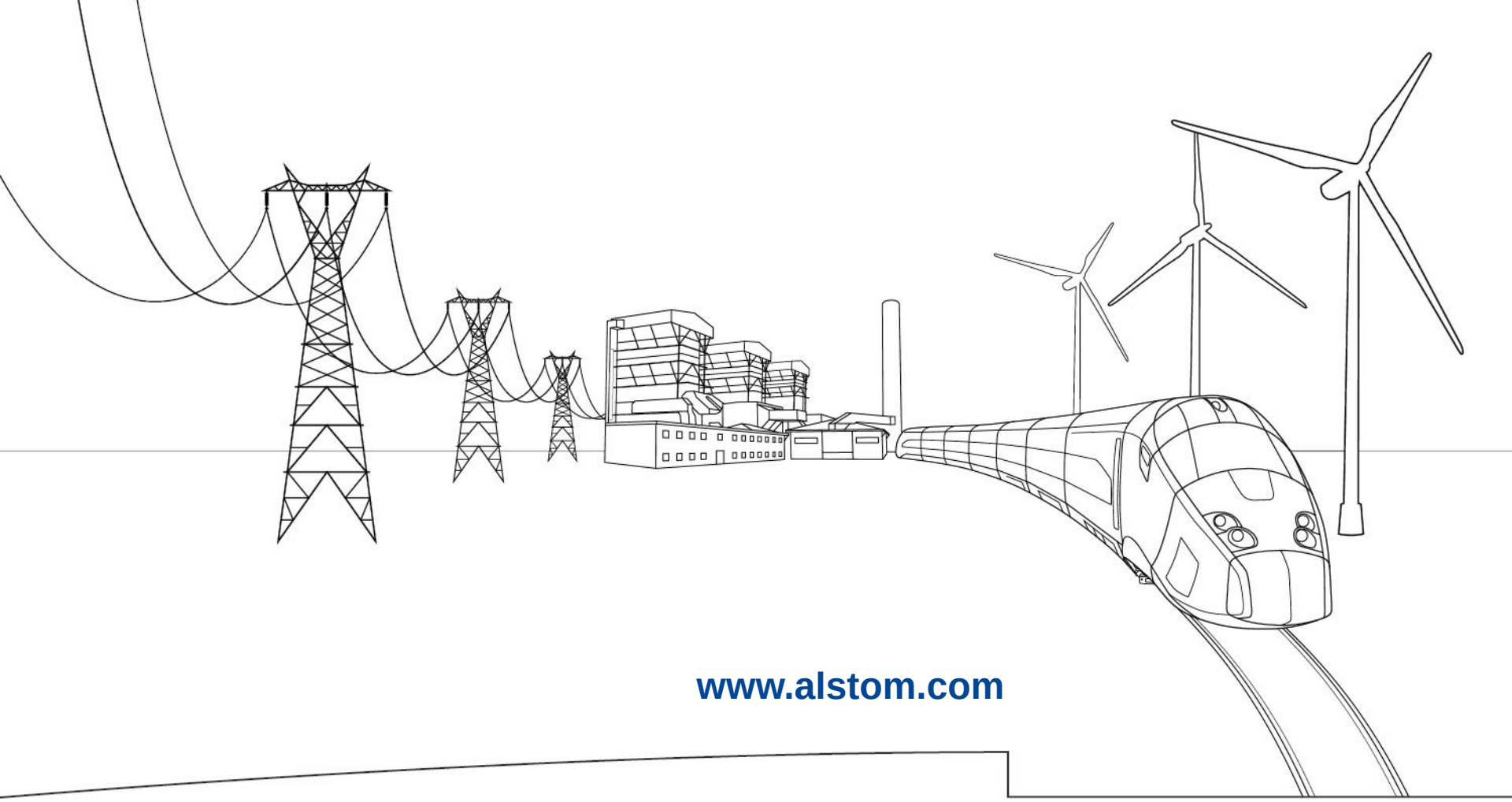

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Shaping the future

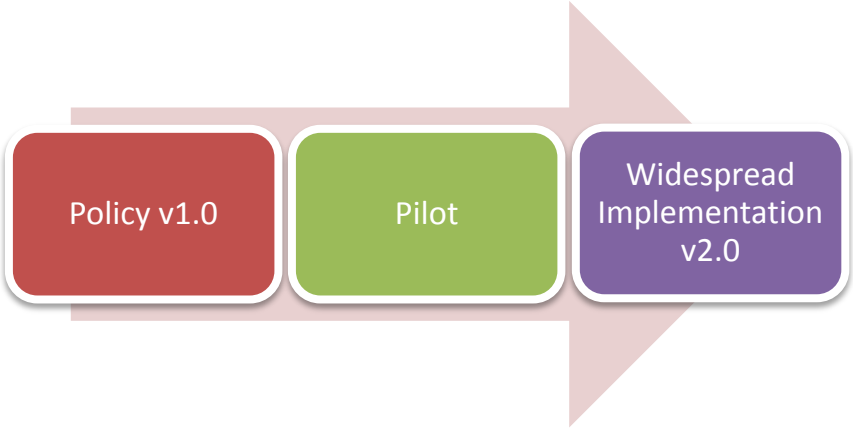
DS3 Programme Status Update

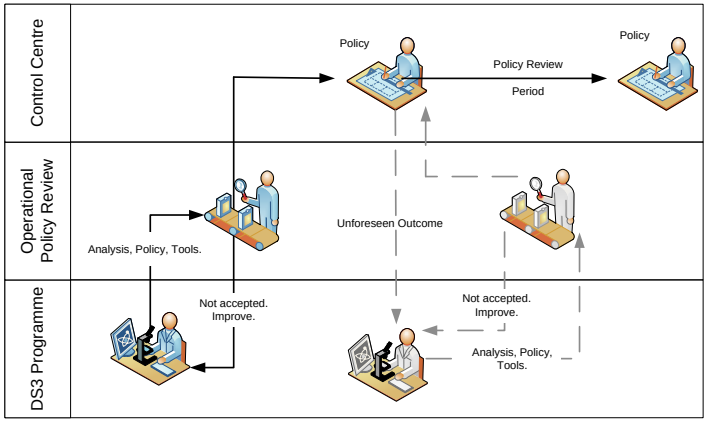
Robbie Aherne

EIRGRID GROUP

Control Centre Trial – SNSP < 55%

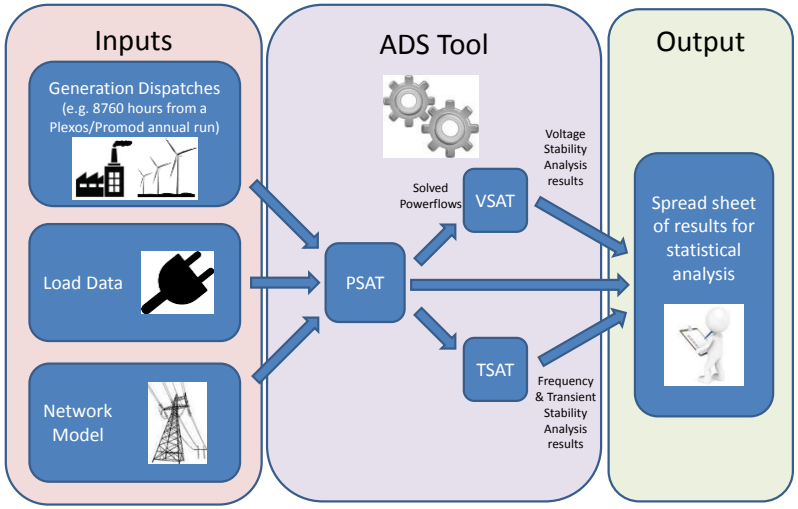
- System trial where maximum SNSP level is increased to 55% SNSP
- Builds on the policies and tools brought through the OPR Committee
- Will inform future operational policy
- Day time periods, beginning October 2015 subject to conditions



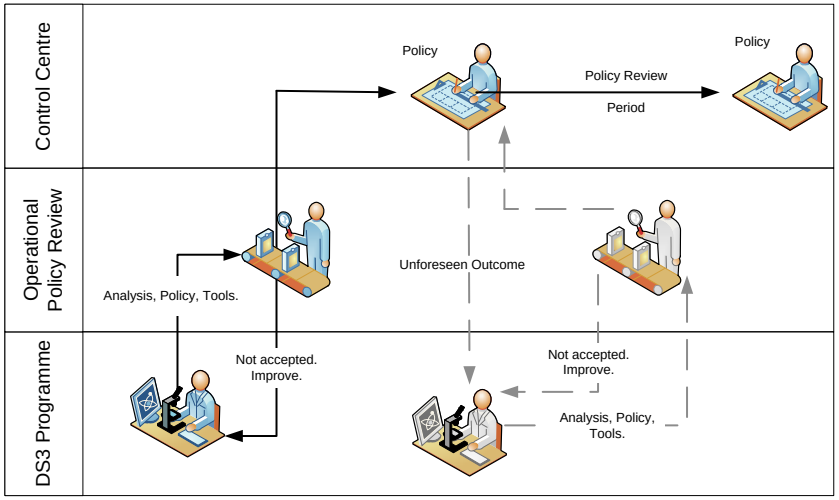


Operational Policies & Related Studies

- EWIC export study (complete)
- Over Frequency Scheme (complete)
- Busbar rating monitor (complete)
- Voltage dip induced frequency dip (on-going)
- Quantitative frequency oscillation analysis (on-going)
- Cauteen Nodal Voltage Control Pilot Project (on-going)
- Northern Ireland Nodal Voltage Control Pilot Project (on hold)



Operational Policy Review Committee



DS3 System Services

Interim Regulated Tariff

1st Oct 2016 – 30th Sept 2017

Regulated Tariff & Annual Auction

1st Oct 17 onwards

235 €M Cap in 2020/21

- Complexity of design and interdependencies between workstreams apparent
- Timelines for consultations, procurement of the system services, and delivery of IT systems means that the scope of the Interim Tariff arrangements will likely need to be refined
- Continued focus on timely delivery of the enduring arrangements

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RoCoF Implementation Project

Plan A: Move to 1 Hz/s over 500ms

Plan B: Stay at 0.5 Hz/s

Generator Studies Project

TSO-DSO Implementation Project

Alternative / Complementary Solutions Project

Can synchronous generators ride through a high RoCoF event?

Great Island GI4 ✓

Can DSOs protect against islanding using different settings or measures to RoCoF?

Can embedded synchronous generators ride through a high RoCoF event?

Investigate and, if appropriate, propose alternatives

Complements requirements for System Services

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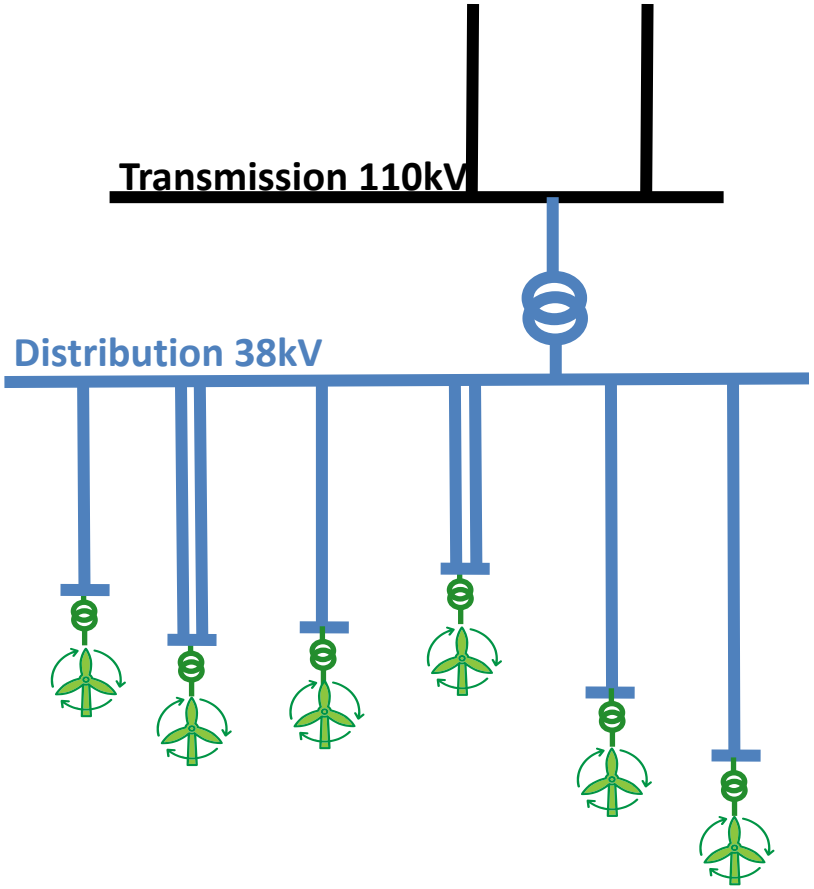
Smart Voltage Control



- Avoid transmission network reinforcement by realising potential of DSO generation
- Progress continues to be made on the Cauteen Nodal Voltage Control Pilot Project
- Final control modes are agreed in principle with ESB Networks

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DSM Growth….A Balancing Challenge

Consumer & DSM

Trust, data privacy, cyber security, solid commercial foundation

Power System

Flexibility requirements, TSO and DSO secure operation, performance monitoring

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EWIC Export Limit

EWIC Interconnector	MW	B	-526 <MW< 504 Current restriction is -300<MW <504	EWIC Interconnector	This applies to all units registered as EWIC Interconnector units. It ensures that all flows do not exceed an import of 504MW to Ireland and an export of 526MW to UK (values taken from Portan). This is required to ensure that the limits are respected. Current restriction is due to a high frequency limit on the island.

- Largest single out-feed – mitigate potential for high frequency event
- Market flows are unaffected
- High frequency mitigation studies complete – 300 MW limit prudent
- Solution: Over Frequency Scheme

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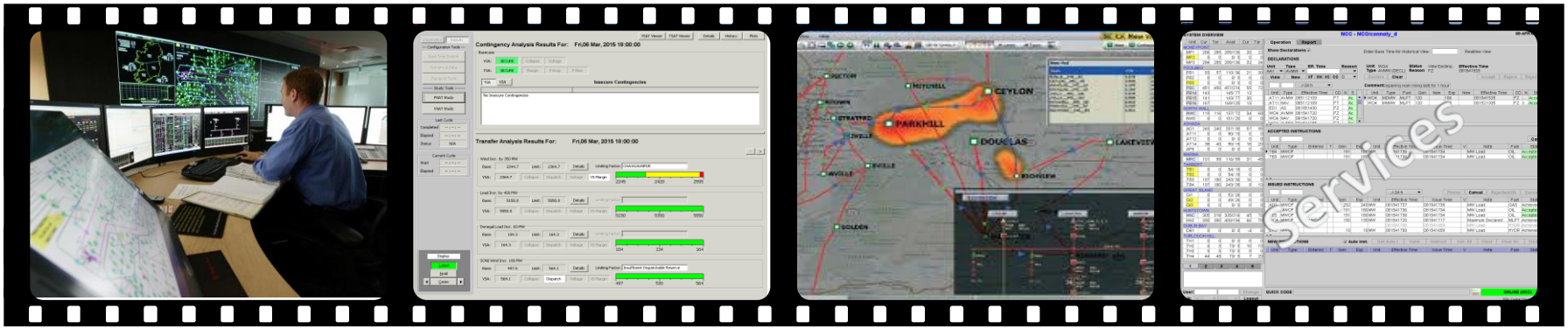
Control Centre Tools

- Ramping tool and policy (implementation)
- Short circuit tool (complete)
- EMS integration project (on-going)



Existing Control Centre Tools

2011

Tools Delivered

WSAT, Short Circuit, Wind Dispatch, Synchrophasor….

2012 - 2015

New Tools

Regulation, Ramping, Voltage Trajectory, WSAT Look ahead, System Services….

2015 - 2017

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DS3 Programme Summary

- RoCoF workstreams progressing
- System Services underway but significant design and implementation issues need to be worked through
- Need to maximise contribution from embedded generation and demand side response – DSO/DNO collaboration key
- Operational policy and tools need to develop in parallel in a considered manner

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Actions

RoCoF Project Overview

David Cashman

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RoCoF Project Overview

Generator Studies Project

- Can synchronous generators ride through a high RoCoF event?
- Great Island GI4 ✓

TSO-DSO Implementation Project

- Can DSOs protect against islanding using different settings or measures to RoCoF?
- Can embedded synchronous generators ride through a high RoCoF event?

Alternative / Complementary Solutions Project

- Investigate and, if appropriate, propose alternatives
- Complements requirements for System Services

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Generator Studies Project

- Generators progressing on RoCoF studies
  - Currently the majority of units are Green status
- EirGrid and SONI currently investigating implementation RoCoF remuneration mechanism
  - A 6 week industry consultation will be issued on the proposals
- RoCoF GPI mechanism also to be implemented in coming months
- Interim tri-lateral meetings with category 1 generators to be scheduled

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TSO-DSO Project: Ireland

- Frequency injection bench testing of RoCoF relays complete ✓
- Settings change requests issued to generators
- Distribution Code Modification for RoCoF on embedded generators to be presented to DCRP in September
- Initial database of distribution connected settings submitted ✓
- ESBN update included in slide pack

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NETWORKS

ESBN DS3 Advisory Council Meeting September 2015

ESBN Reactive Power Update

Presentation Structure

Distribution Code DS3 (Reactive Power) Modification

Reactive Power / Voltage Control Nodal Controller Pilot – Cauteen Cluster

Distribution Code DS3 (Reactive Power) Modification

Distribution Code DS3 Modification

- **The following DS3 modification was discussed at the last DCRP meeting (9th June 2015) but not formally proposed:**
- **Distribution Code and WPF Bumpless Transfer**

- **It is expected to be formally proposed at the next DCRP meeting (18th September 2015).**

Background:

It is vital that this proposed modification is passed because the current Nodal Controller algorithm and proposed Reactive Power test procedures rely on its presence.

Reactive Power / Voltage Control Nodal Controller Pilot – Cauteen Cluster

Nodal Controller Pilot – Cauteen Cluster

- **The high-level functionality has been agreed between ESBN and EirGrid and we are currently working through the lower-level implementation details.**
- **ESBN is currently engaging with a supplier to work through the detailed design of controller.**
- **ESBN is currently working with ESBI station designers to work through the detailed station design element including, but not limited to, the integration of the OLTC.**
- **ESBN is currently working with ESB Telecom Services to bench-test the hardware and associated communications systems.**
- **ESBN and EirGrid are jointly assessing the DS3 derogation requests and specifically those pertaining to WFPSs connected to Cauteen.**

Overview

- Questionnaire and Settings Change
- Relay Injection Tests
- Conclusion

Questionnaire and Settings Change

ESB NETWORKS

Wind Generators

- **Instruction to change settings resent to all Wind Farm contacts**
- **More engagement with industry required**
- **Waiting on number of returns**

Non-Wind Generators

- **Significant engagement with non-wind generator representative**
- **Slow response from non-wind generators on request to change interface settings**
- **D-Code mod before DCRP with respect to voltage and frequency capabilities of all distribution connected generators**

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

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 Settings 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 a copy of the relay settings file, with any changes reflected and confirm that the settings 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 _____

Phase 1 of Relay Tests Complete

ESB NETWORKS

Legacy Settings

	Legacy Voltage & Frequency Settings							
	A	B	C	D	E	F	G	H*
RoCoF 0.4 Hz/s	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by df/dt	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	Trip	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt
RoCoF 0.6 Hz/s	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by df/dt	Trip by OF	Trip by OF	Trip by OF	NO TRIP
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
RoCoF 1.0 Hz/s	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	NO TRIP
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	NO TRIP
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	Trip	Trip by OF	Trip	Trip by OF	Trip by OF	Trip by OF	Trip by OF	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP

New Settings

	New Voltage & Frequency Settings							
	A	B	C	D	E	F	G	H*
RoCoF 0.4 Hz/s	Trip	Trip by df/dt	1.746	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by df/dt	1.825	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	NO TRIP	by df/dt / Vector S	1.586	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by df/dt	1.825	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	1.745	Trip by df/dt	Trip by df/dt	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	1.824	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by Vector Shif	1.585	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	2.062	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt
	NO TRIP	Trip by df/dt	2.334	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt
RoCoF 0.6 Hz/s	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	NO TRIP	by df/dt / Vector S	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	Trip	Trip by df/dt	Trip	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	1.745	Trip by df/dt	NO TRIP	Trip by df/dt	Trip by df/dt	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	Trip by Vector Shif	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP
	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt	NO TRIP	Trip by df/dt
RoCoF 1.0 Hz/s	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	Trip	Trip by VS	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	Trip by Vector Shif	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	Trip by VS	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	Trip by Vector Shif	Trip	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	Trip by df/dt
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP
	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP	NO TRIP

- **Some relays issue trip signal for traces provided with new settings applied**
- **Most stable at 1Hz/s**

Conclusion

- **More Engagement from Industry required**

- **D-Code Mod. on FRT requirements for all Distribution Connected Generators before DCRP**

- **Relay Injection Test performed indicate potential issues with some relay types**

Thank You – Questions?

TSO-DSO Project: Northern Ireland

- RoCoF project timelines revised based on NIE projections
- Current plan is to assess the impact of G59 rev 3 setting changes in advance of implementing 1 Hz/s settings
- Database of settings for wind generation has been compiled ✓
- Currently obtaining embedded generation settings and volumes
- Modification of Distribution Code for RoCoF requirements: ✓
  - embedded generators > 100 kW approved
  - Consultation commenced for generators < 100 kW

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DS3 Advisory Council – NIE RoCoF Update

22nd September 2015

Rodney Ballentine

Network Operations Manager

Generator Withstand Capability

- Necessary to determine the RoCoF withstand capability of all generation connected to the Northern Ireland electricity system.

- It was decided that the consultation process associated with a D-Code RoCoF modification would be the most prudent method of determining generator withstand capability.

- After discussions held at the DCRP meeting on 5th August 2015 a consultation commenced on 11th September 2015 for a D-Code RoCoF modification from 1Hz/s to 2Hz/s and will run for 3 months.

- Direct contact made with 386 individual stakeholders.

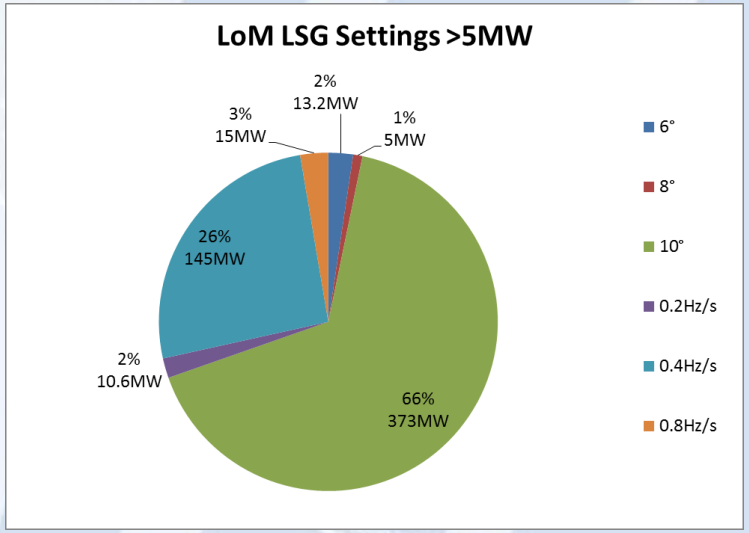
- To avoid confusion this proposed D-Code modification does not require any amendments to generator protection settings, but necessitates that all generation has the capability to withstand 2Hz/s.

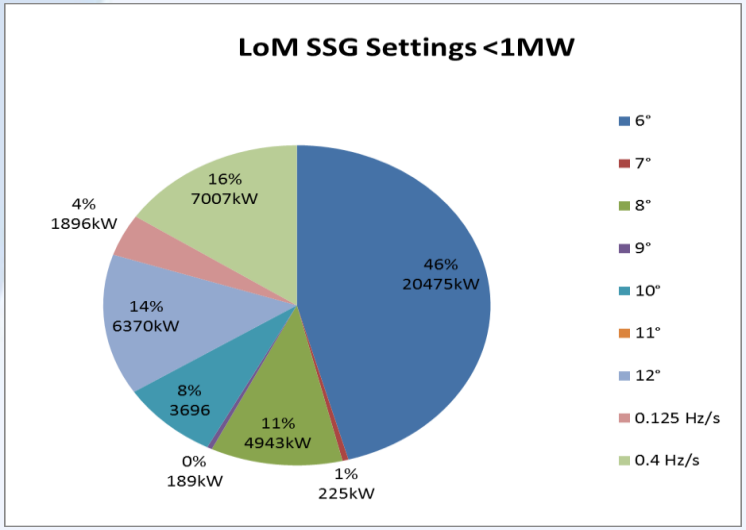
- Comments from all relevant stakeholders are welcomed. The consultation papers can be found at the following URLs:

  http://www.nie.co.uk/documents/P-150911-D-Code-Modifications-Consultation-RoCoF
  http://www.nie.co.uk/documents/Attachment-proposed-D-Code-mods-(RoCoF)

Generator LoM Settings

- LoM settings collated for LSG
- LoM settings partially collated for SSG





- Academic research to investigate:
  - Relaxing LoM settings
  - Increasing Over-frequency setting
  - Utilising a combination of RoCoF • Vector shift LoM protection to increase stability

RoCoF Alternative/Complementary Solutions Project

Phase 1

- Range of theoretical options assessed at a high level via weighted scoring matrix approach
- Viable options selected for Phase 2 analysis

Phase 2

- More detailed review of the viable options from Phase 1
- Technical and techno-economic studies to be performed

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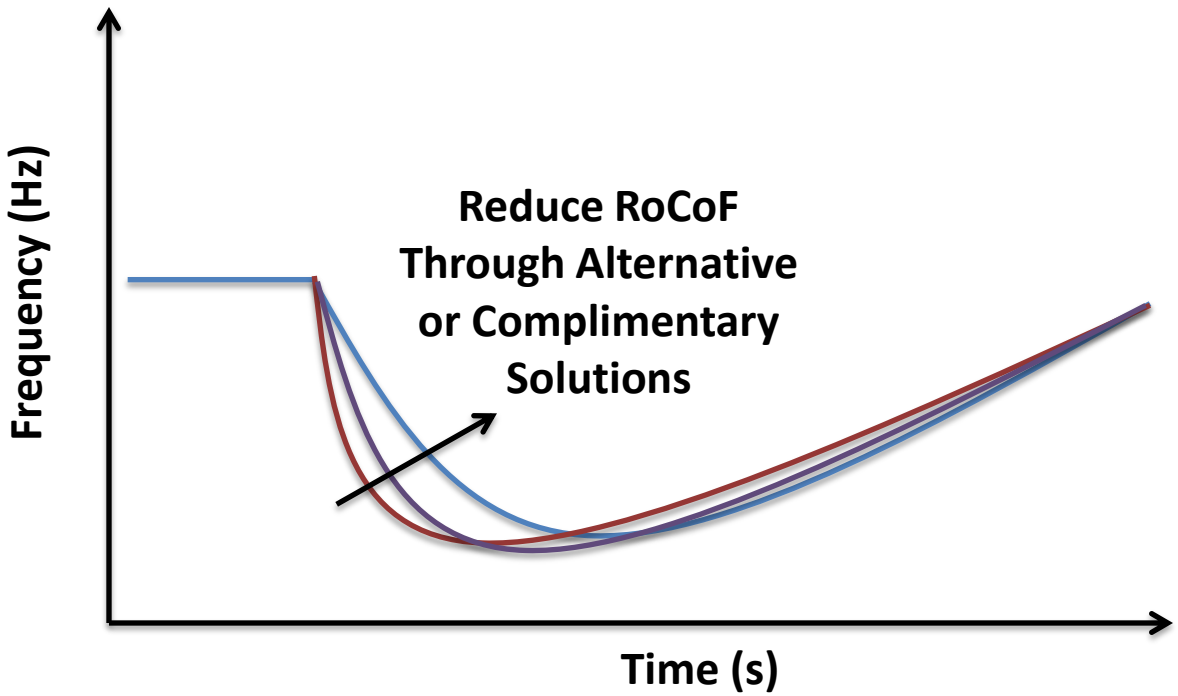
Project Objective



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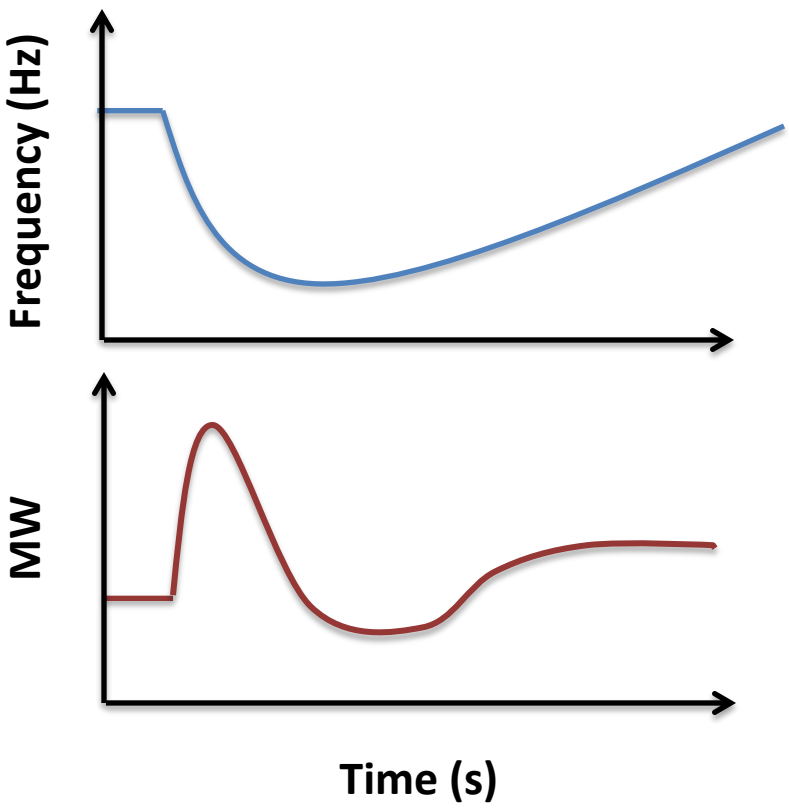
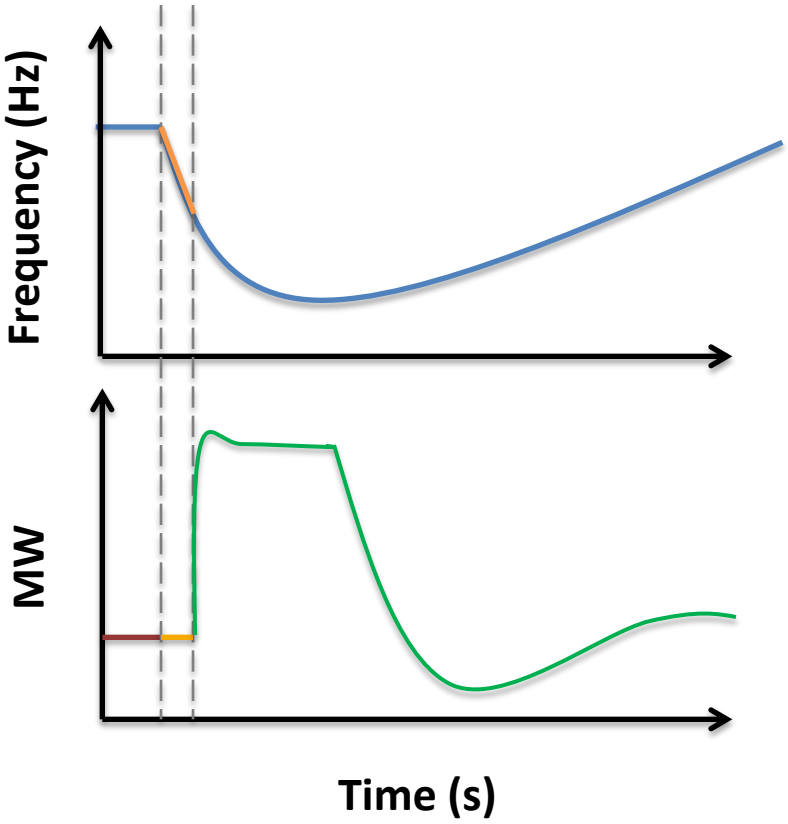
Synchronous and Synthetic Inertia





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Report Highlights

- Both Synchronous and Non-synchronous devices have capability to prevent high RoCoF events
- Timely event detection is key for Non-synchronous devices
- Scoring Matrix results do not favour any specific solution
- A combination of devices is likely to be required to resolve the RoCoF issue

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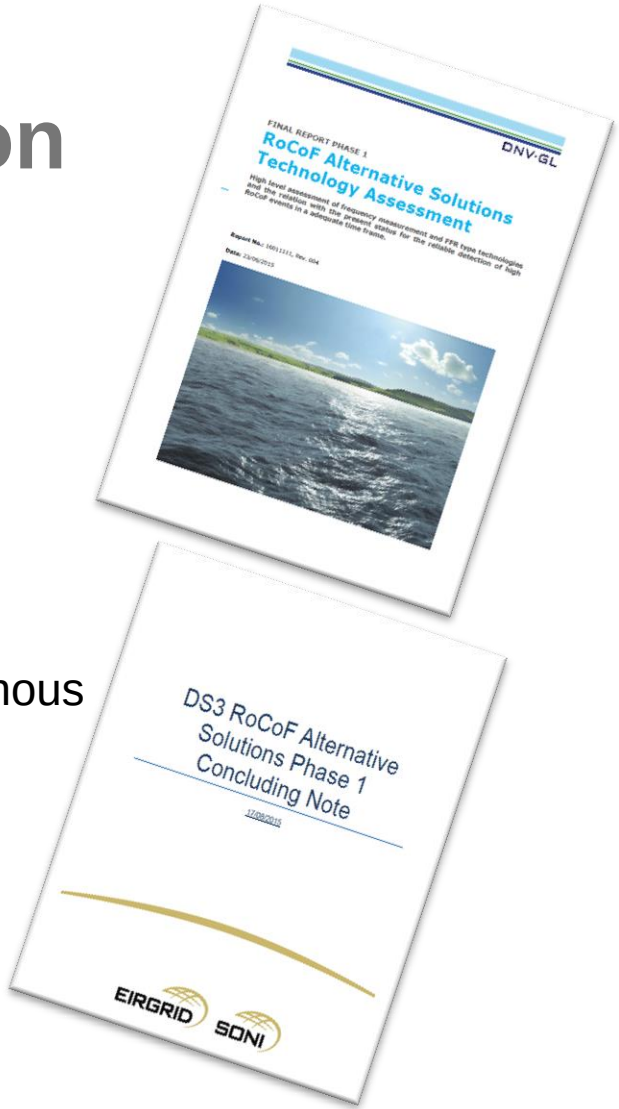
Phase 1 Conclusion

- 15th September 2015 TSOs publish
  - Final DNV GL report
  - TSOs Concluding Note on Phase 1
- 14 Industry Comments received
- TSOs seeking further views from industry
  - RoCoF detection and response times of Non-Synchronous Devices
- All technologies to be considered in Phase 2
  - AC Interconnection not considered



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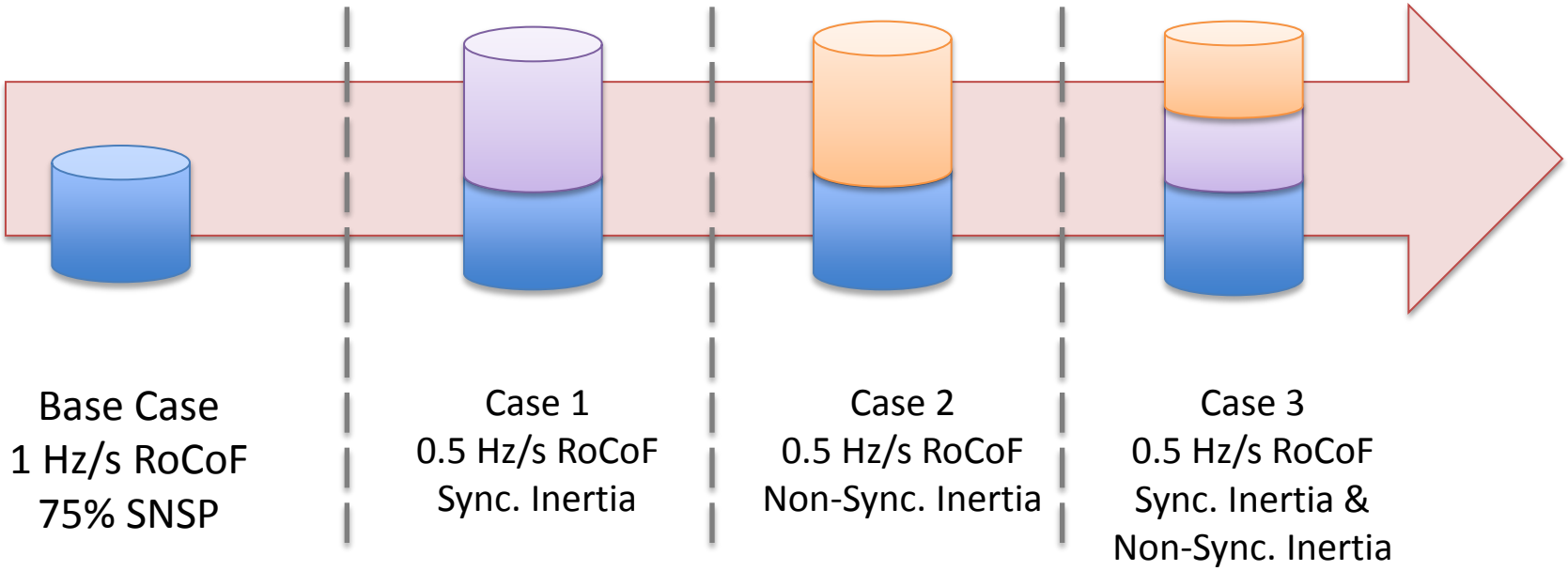
Phase 2 Objectives

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



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Summary

- Phase 2 to consider more detailed studies of possible synchronous and non-synchronous solutions
- Technical and Techno-economic studies will be performed to determine the inertia volumes
- Sensitivity analysis of non-synchronous device responses
- Studies are **NOT** aimed at determining System Services volumes or act as beginning of procurement process

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System Services

Eoin Kennedy

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Agenda

- Background
- Progress since publication of Project Plan
  - Volumes
  - Enduring Regulated Tariff and Scalars
  - Auction Design
- Project Plan
  - Timelines to March 2016
  - Project Scope and Timelines
- Interaction with Stakeholders
- Next Steps

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DS3 System Services Decision

235 €M Cap in 2020/21

- Prepared for all 14 services and in place by Oct 2016
- Allows for early implementation of System Services and potentially brings forward investment

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Project Plan (May 2015)

Approach

- Scheduled the various tasks to facilitate meeting the deadlines
- Significantly compressed the time durations allocated for some tasks and, in so far as possible, scheduled tasks to be completed in parallel

Highlighted areas requiring further assessment

- Procurement (Qualification Process, Other procurement exercises)
- IT systems (Auction platform, Settlement system, Operational tools)
- Complexity of aspects of the design
- Performance monitoring infrastructure
- Other TSO readiness activities
- I-SEM interactions and alignment of incentives

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Next Steps (May 2015)

Methodology Development

- Develop the principles and methodologies for how various aspects of the technical design would work

Further Assessment

- Explore the areas highlighted as requiring further assessment

Update Project Plan

- Update the plan in September

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Progress since Publication of Plan

Techno-Economic Design

- EirGrid has engaged external professional assistance to assist with development of the principles and methodologies for how various technical aspects of the market arrangements will work. This work is expected to be completed by October.
  - Regulated tariff model
  - Detailed auction design
  - Payment scalars

Procurement Process

- External legal experts are providing EirGrid with a legal opinion as to the most appropriate procurement strategy to lawfully and successfully deliver the required DS3 Systems Services contracts

Other

- Development of the volume calculation methodology
- Focus on TSO readiness activities including IT systems

What do we mean by Volumes?

1. Real-time requirement

- Real-time volume requirement set using metrics / constraints
  - e.g. Current POR requirement is 75% of the Largest Single Infeed (LSI)

2. Portfolio capability

- For each service, sum of the capability of all service providers needed to ensure that the power system can be operated securely for all credible scenarios
- Sets the service volumes procured in an auction

3. Remuneration volumes

- This is the half-hourly volume remunerated and is dependent on the payment basis
- In a half hour period, this may be greater than the real-time requirement

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Objectives of Volumes Workstream

- Determine real-time metrics for each service as non-synchronous generation levels increase
  - E.g. Primary Operating Reserve must be at least x% of LSI
- Determine the portfolio capability required to operate the system securely for all credible scenarios for input into the auction
- Provide input to the TSO Procurement Strategy e.g. scarcity and number of long term contracts
- Forecast likely annual expenditure on DS3 System Services using payment rates

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Approach to Volumes Workstream

- Consultation paper covering (i) portfolios and (ii) the calculation methodology
- Studies to determine volumes will be conducted post-consultation
- Consultation on results of studies in Q2 2016
- Possible re-evaluation of volumes to be used in the auction following the Qualification Process

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Enduring Regulated Tariffs & Scalars

- Holistic approach to design of Regulated Tariff and Scalars needed
- Close to settling on a possible preferred methodology
- Approach based on following objectives:
  - Incentivise performance from existing assets in services that are needed by the TSOs;
  - Reflect the value of each service, and in particular place greater value where there is scarcity;
  - Promote investment in both enhancement of existing assets and new entry when needed; and
  - Be underpinned by a simple and transparent methodology.

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Auction Design

- Payment basis and number / nature of services makes auction design challenging
- Honing in on an auction design option that we believe is consistent with the framework set out by the SEM Committee
- Expect to provide the final auction design report to the RAs in October

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Timelines to March 2016

Consultation		Responsible Party	Issue Date
Competition Metrics	Consultation Paper	SEMC	22nd Sept 2015
	Decision Paper	SEMC	24th Dec 2015
Volume Calculation Methodology	Consultation Paper	TSOs	14th Oct 2015
	Decision Paper	TSOs	11th Feb 2016
Qualification Process	Consultation Paper	SEMC	29th Oct 2015
	Decision Paper	SEMC	2nd Feb 2016
Regulated Tariffs	Consultation Paper	TSOs	28th Oct 2015
	Decision Paper	TSOs	3rd March 2016
Contract Principles	Consultation Paper	SEMC	29th Oct 2015
	Decision Paper	SEMC	2nd Feb 2016
Auction Design	Consultation Paper	SEMC	11th Nov 2015
	Decision Paper	SEMC	3rd March 2016
Scalar Design	Consultation Paper	TSOs	23rd Nov 2015
	Decision Paper	TSOs	3rd March 2016

Project Scope & Timelines

- Complexity of design and interdependencies between workstreams has led to greater development times
- Timelines for consultations, procurement of the system services, and delivery of IT systems means that the scope of the Interim Tariff arrangements will likely need to be refined
- Continued focus on timely delivery of the enduring arrangements
- Detailed timelines for post-March 2016 deliverables are being developed and will be published in December 2015

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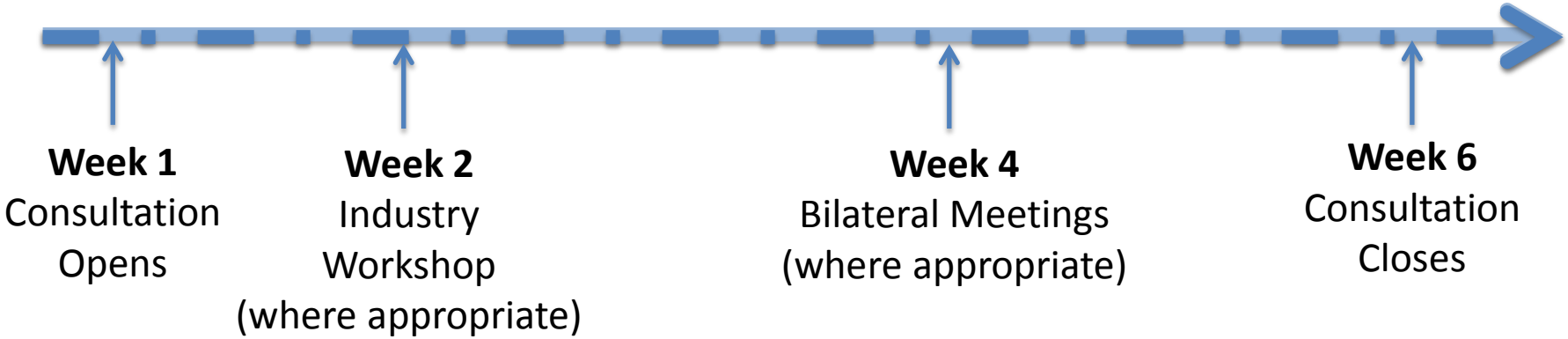
Interaction with Stakeholders

- Communication with stakeholders via consultations and industry forums/workshops (e.g. workshop shortly after opening a consultation)
- Consultations will need to be overlapped
- May provide opportunity for bilateral meetings during consultation (or batch of consultations) e.g. time set aside for meetings with slots allocated on a first come basis



Example timeline assuming 6 week consultation period

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I-SEM Interaction

Design

- Examples:
  - Balancing arrangements
  - Contractual arrangements
  - Payment basis
  - Auction design
  - Control Centre Tools

Delivery

- Examples:
  - Timing of DS3 and CRM auctions
  - IT Systems / Control Centre tools

- Aim is to ensure design and implementation is achieved in the most cost-effective manner with the overarching objective of delivering maximum value to consumers

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Next Steps

- Finalise and publish consultation papers
- Continued focus on timely delivery of the enduring arrangements
- Refine scope of the Interim Tariff arrangements and publish project plan for delivery of these arrangements
- Develop and publish timelines for all post-March 2016 deliverables in December 2015

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Questions

Risk Workshop

Robbie Aherne

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Purpose

1. To capture those risks which may **impact on the ability of the DS3 Programme to deliver its objectives**, namely developing solutions to the challenges of operating the electricity system in a secure manner while facilitating 2020 renewable electricity targets;

2. To assess the impact of the identified risks should they occur; and

3. To assess the likelihood of the identified risks occurring taking into account how well they are currently being managed.

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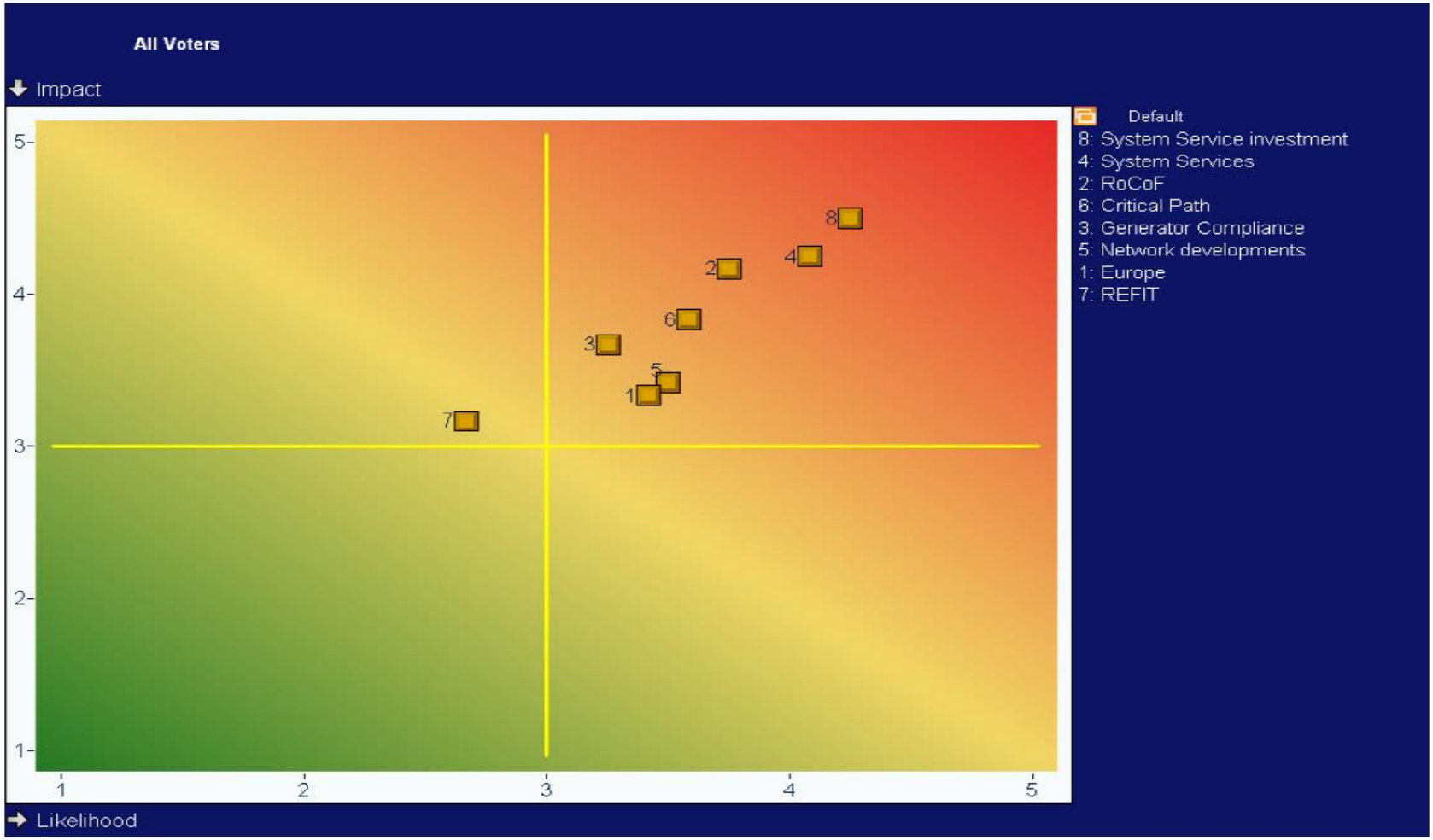
2014 Risk Workshop



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EWIC Export Study

Séamus Power

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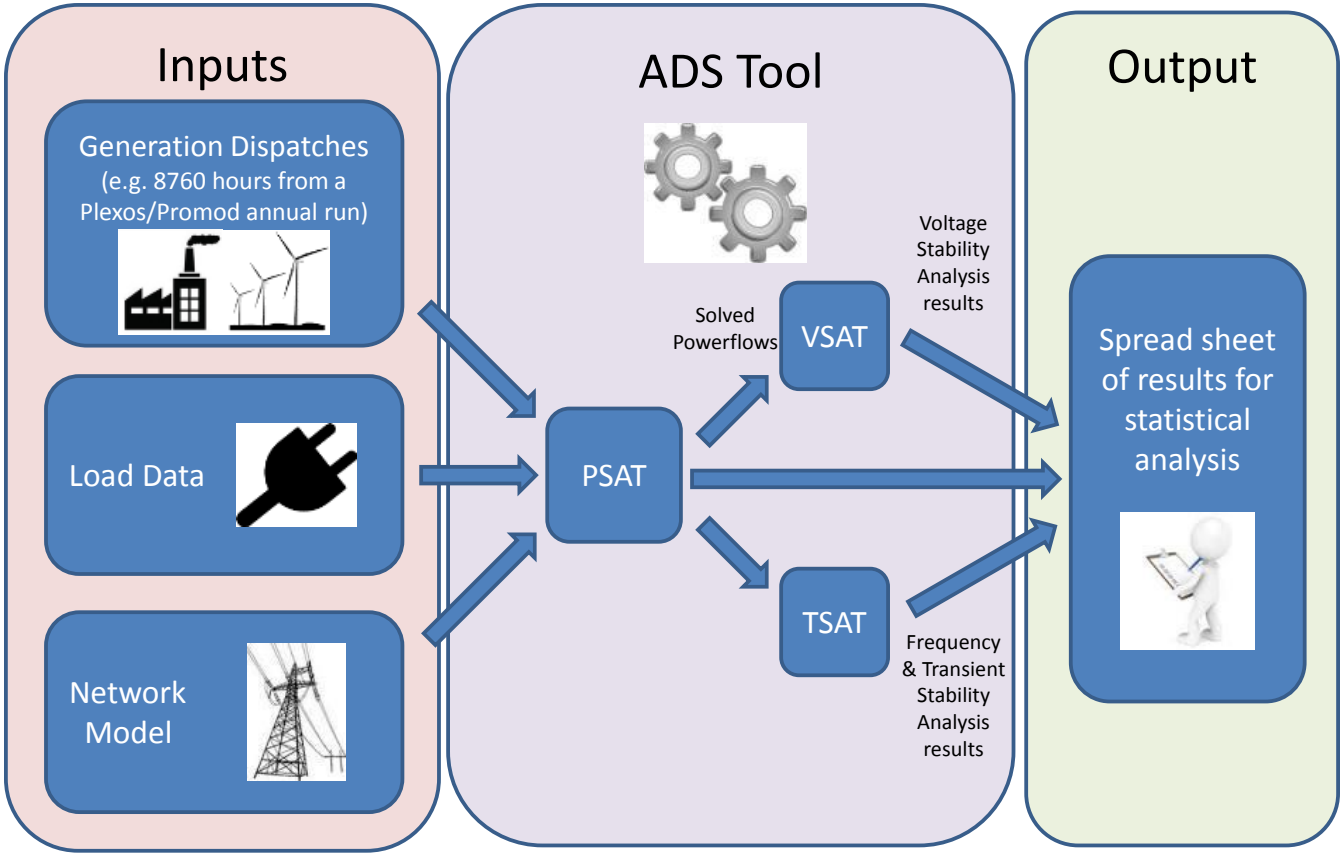
Automated Dynamic Studies Tool



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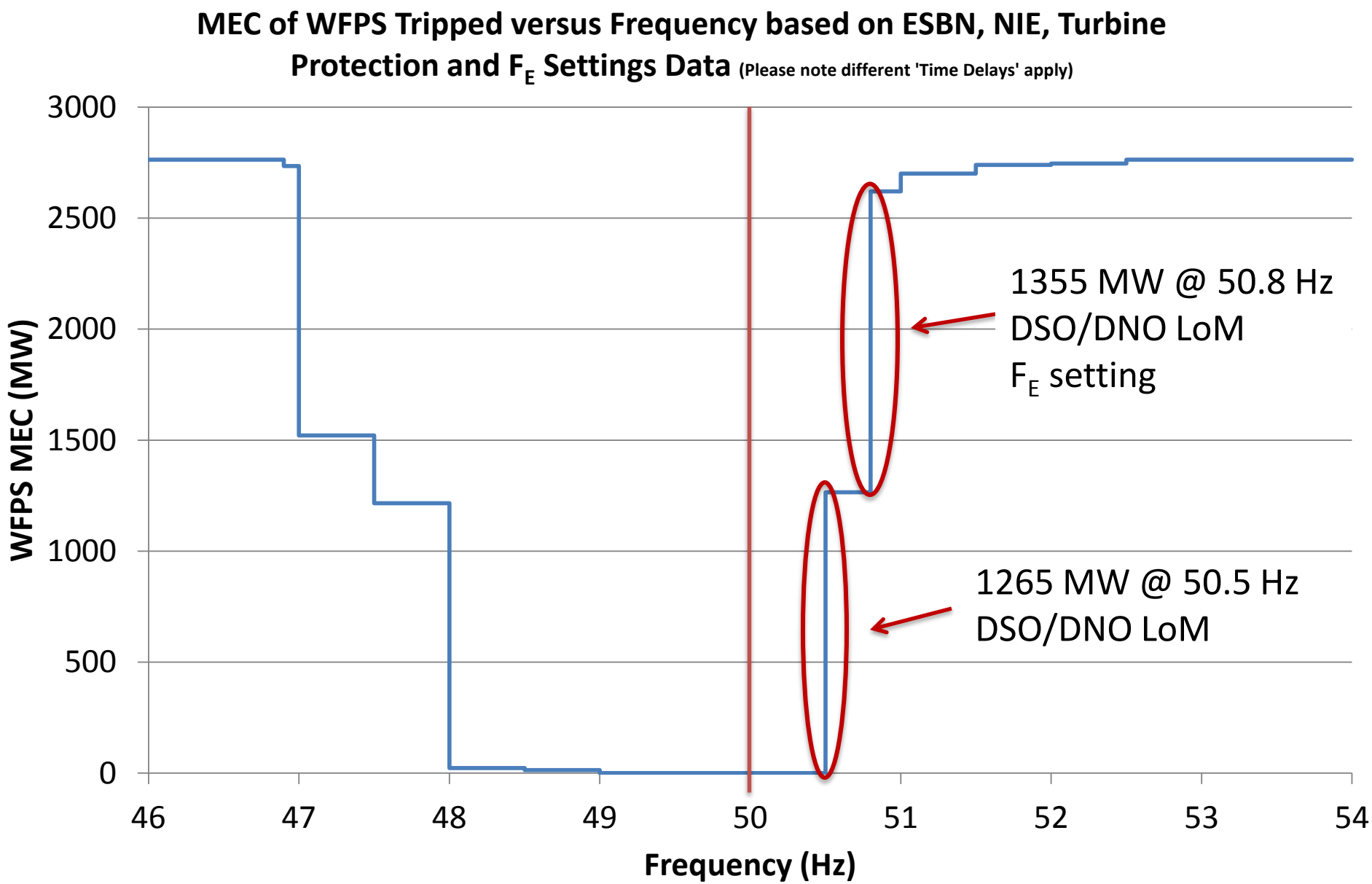
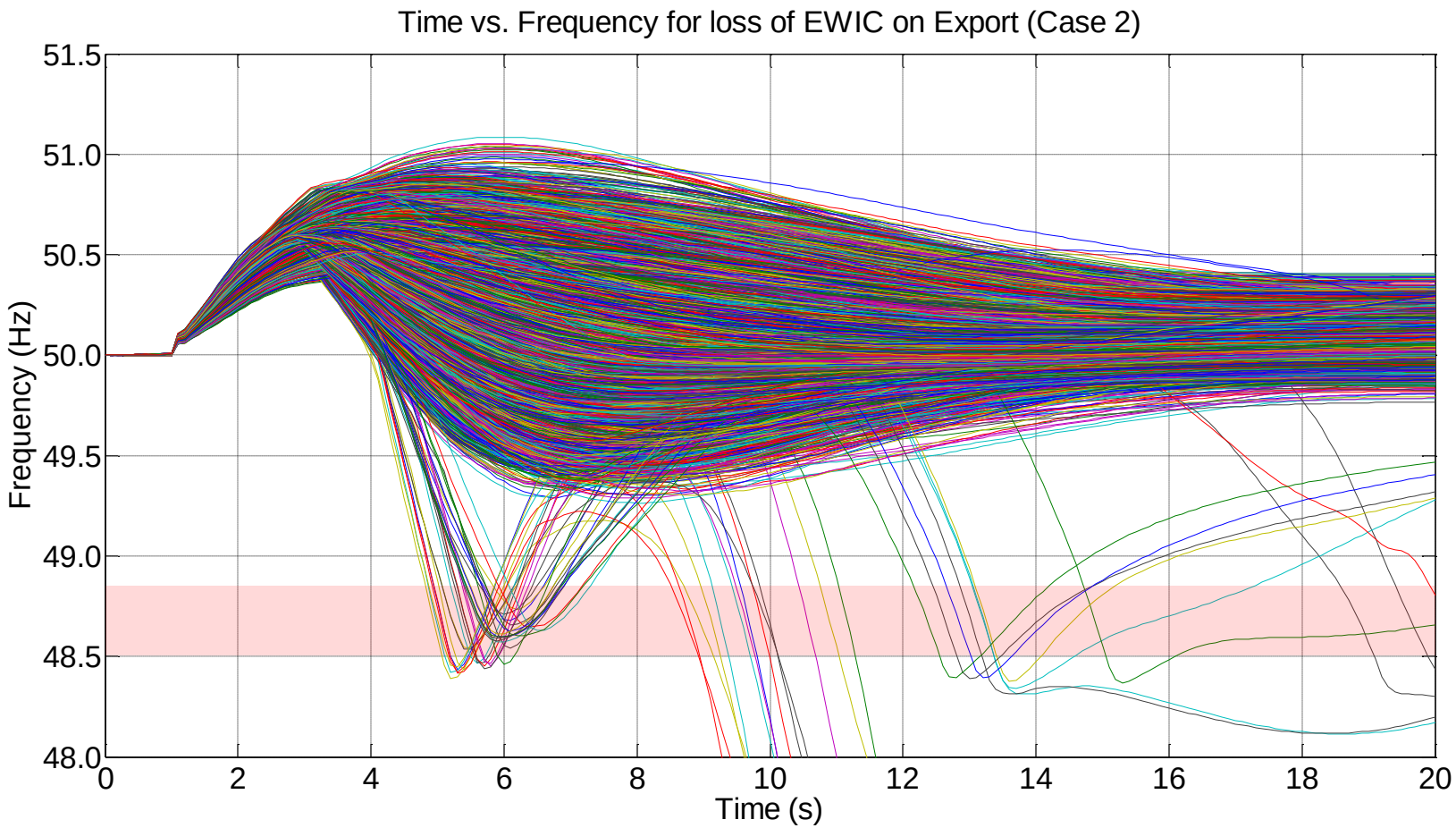
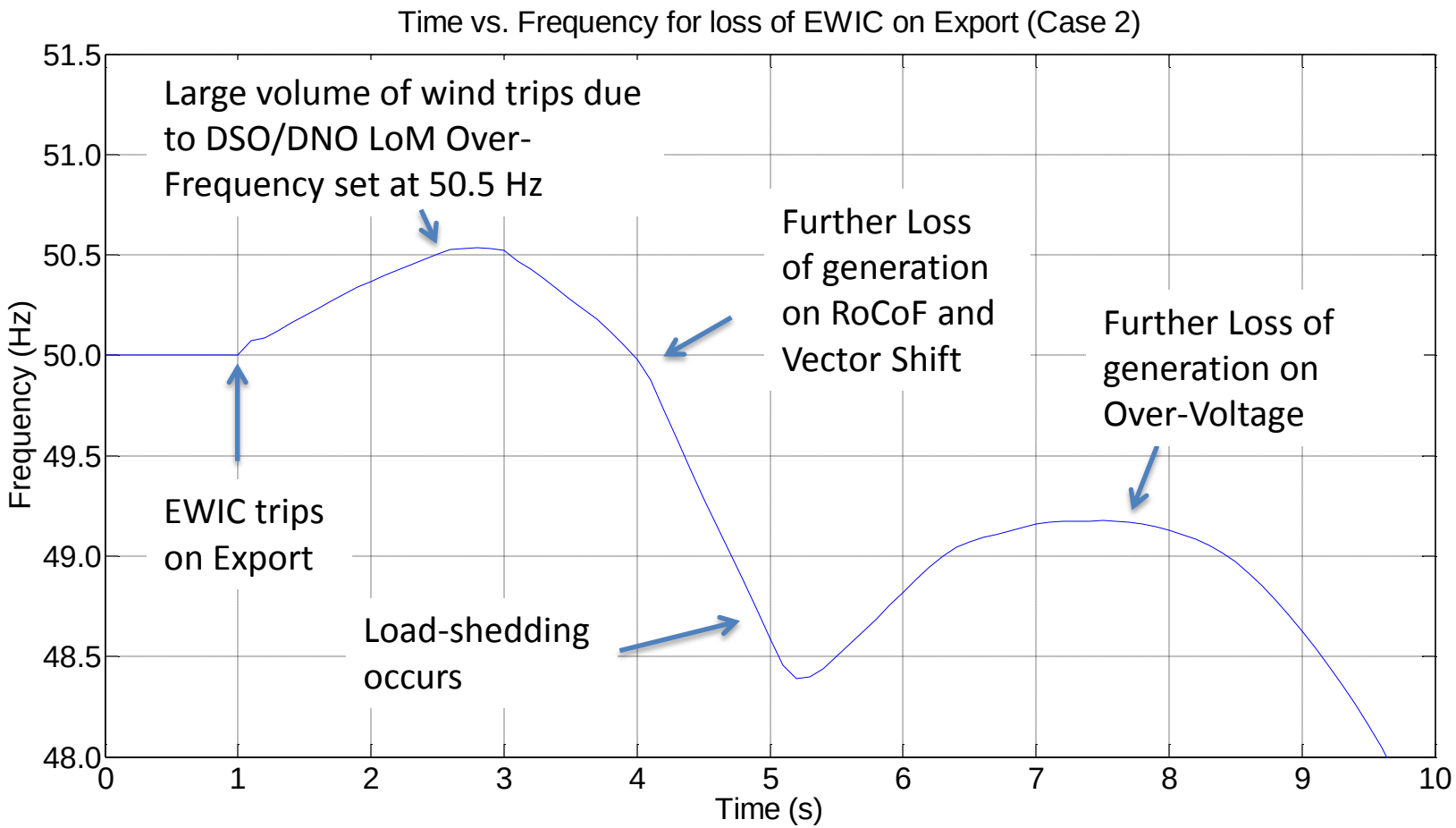
Over-/Under-Frequency Shedding



EWIC Export Studies



EWIC Export Studies



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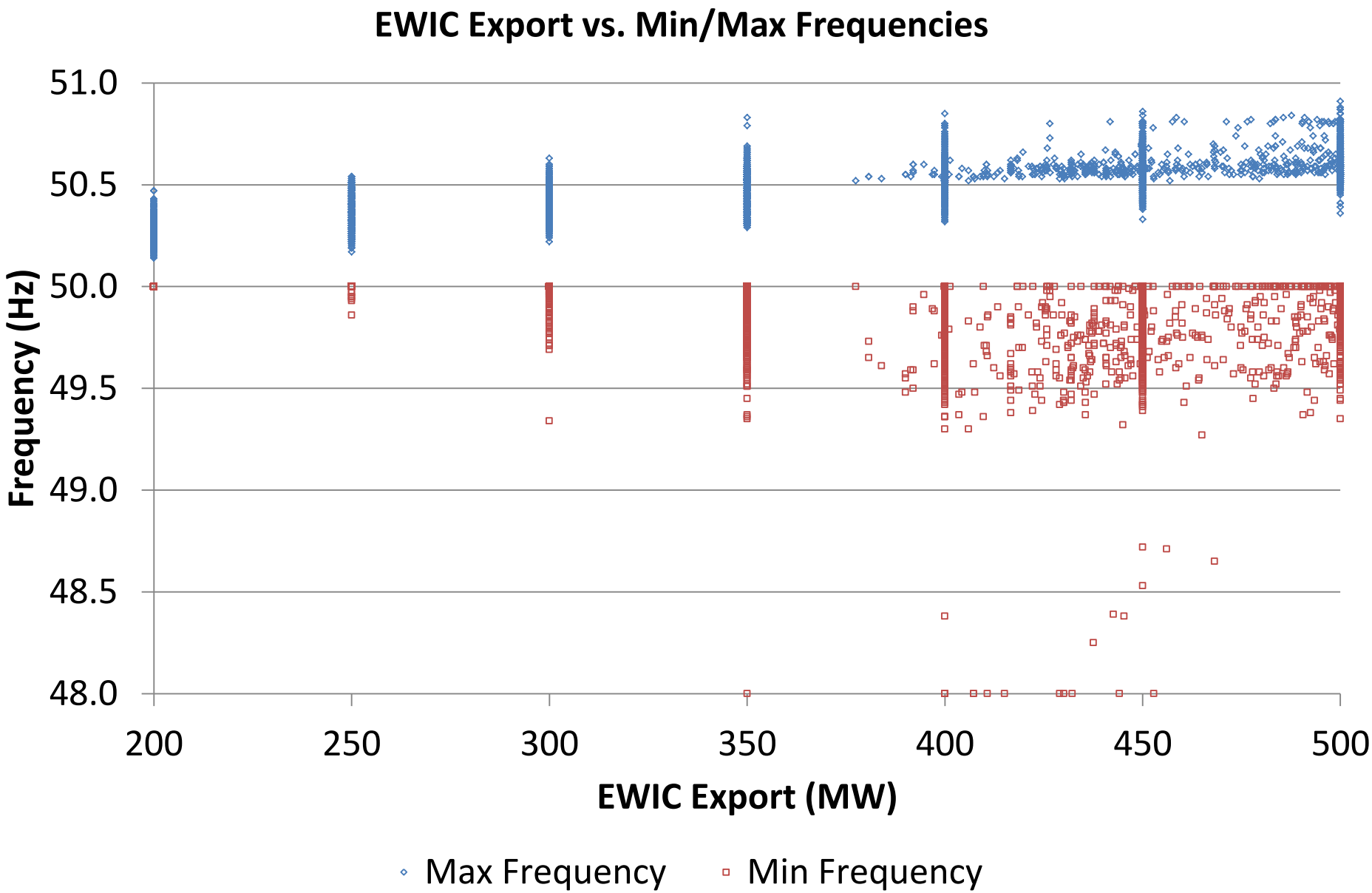
EWIC Export Studies



Conclusions

- Current maximum export of 300 MW is appropriate
- No clear correlation between stability issues and any one metric or number of metrics
- DSO/DNO Loss of Mains:
  - Over-Frequency
  - Vector Shift
- Power-Frequency Response Curves F_E setting require change

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Over-Frequency Scheme

Eoin Sweeney

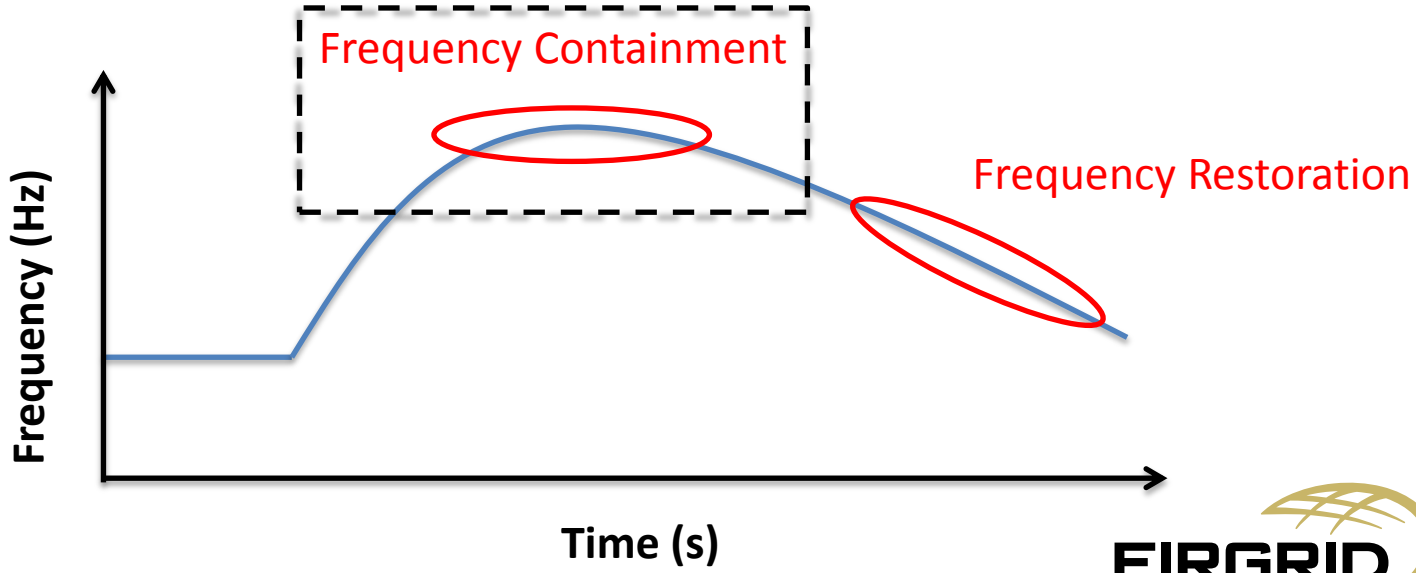
EIRGRID GROUP

Over-Frequency Scheme Objective

Interconnector Exporting

System Separation

Over Frequency Scheme



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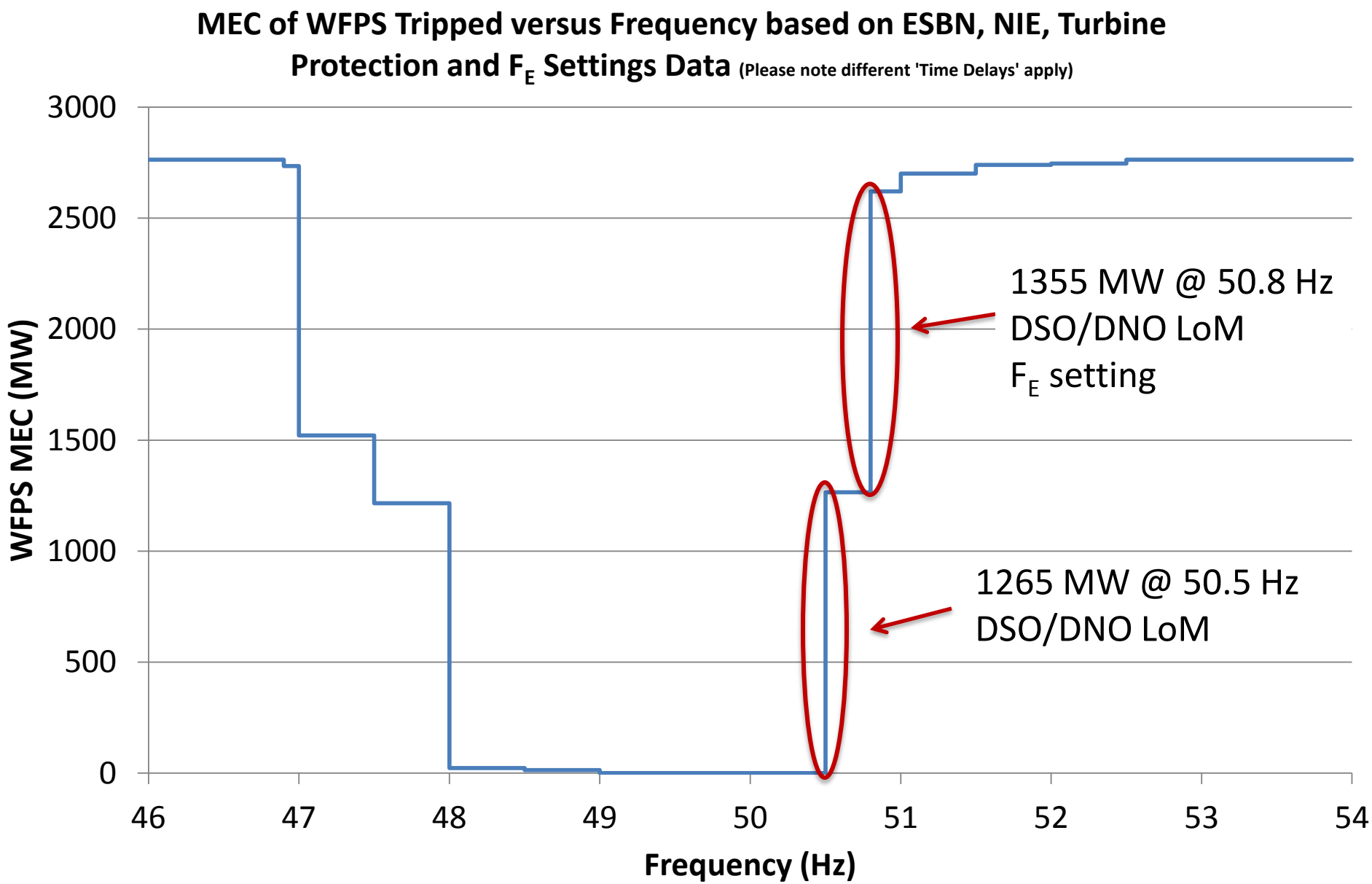
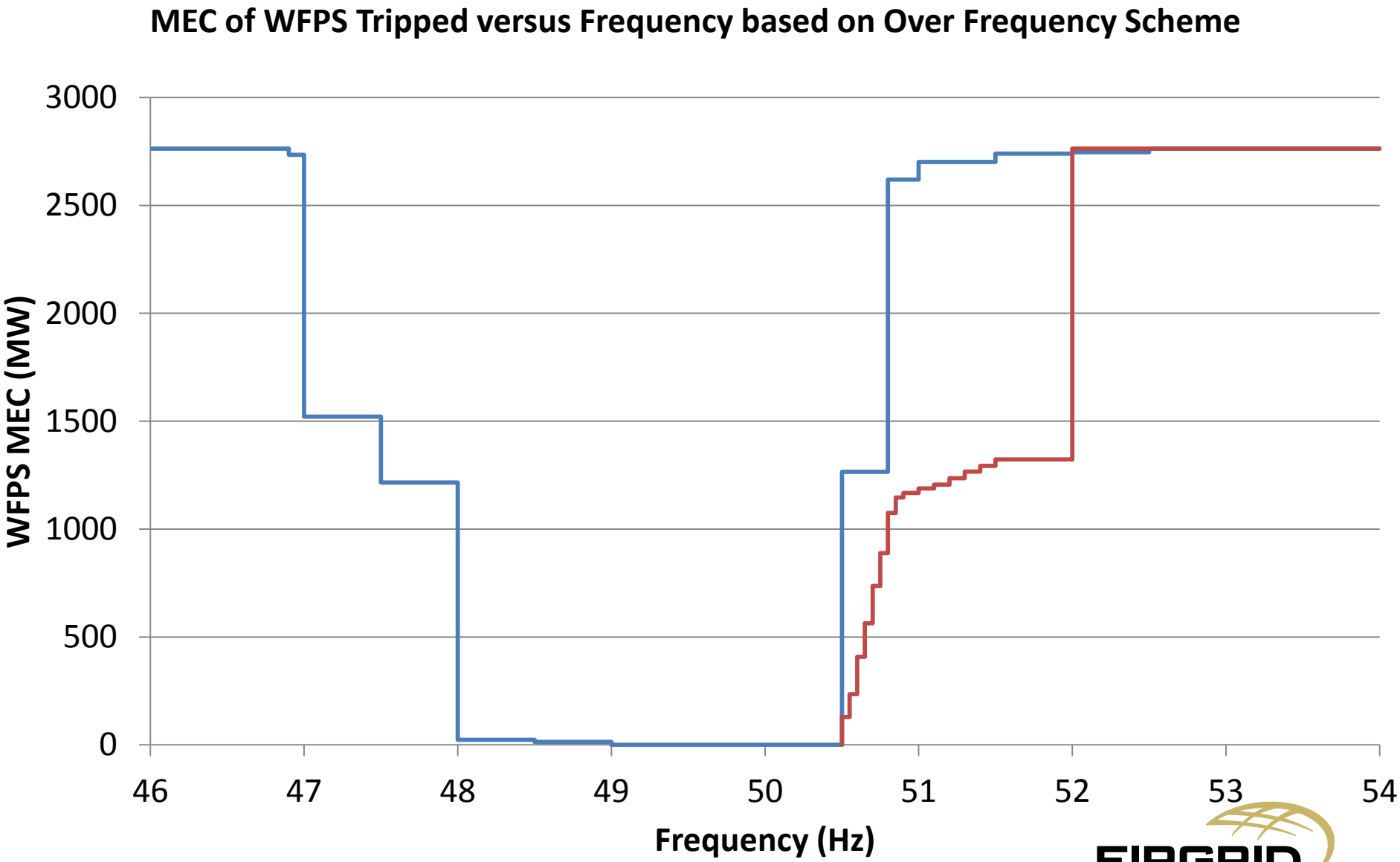
Over-/Under-Frequency Shedding



Over-/Under-Frequency Shedding



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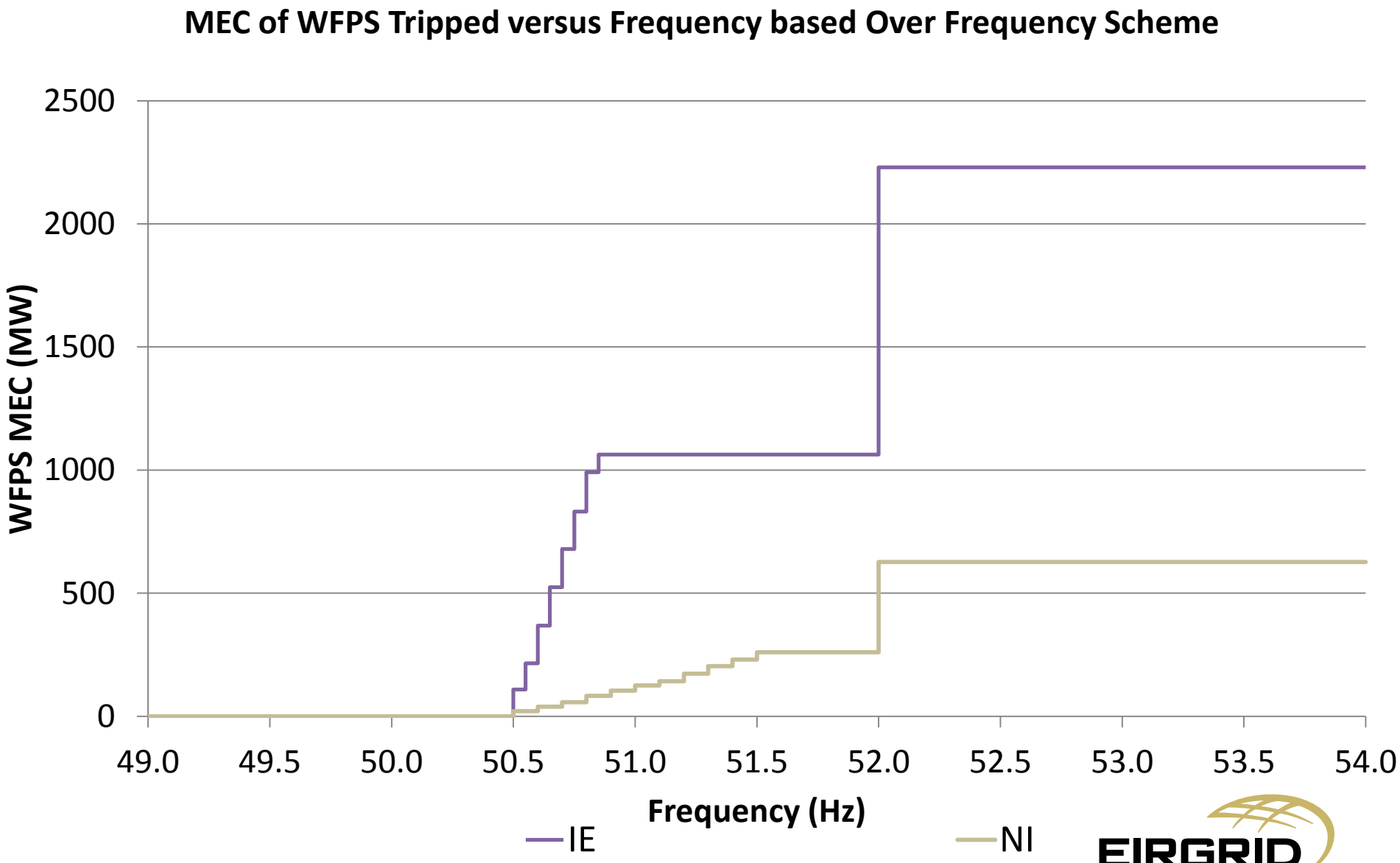
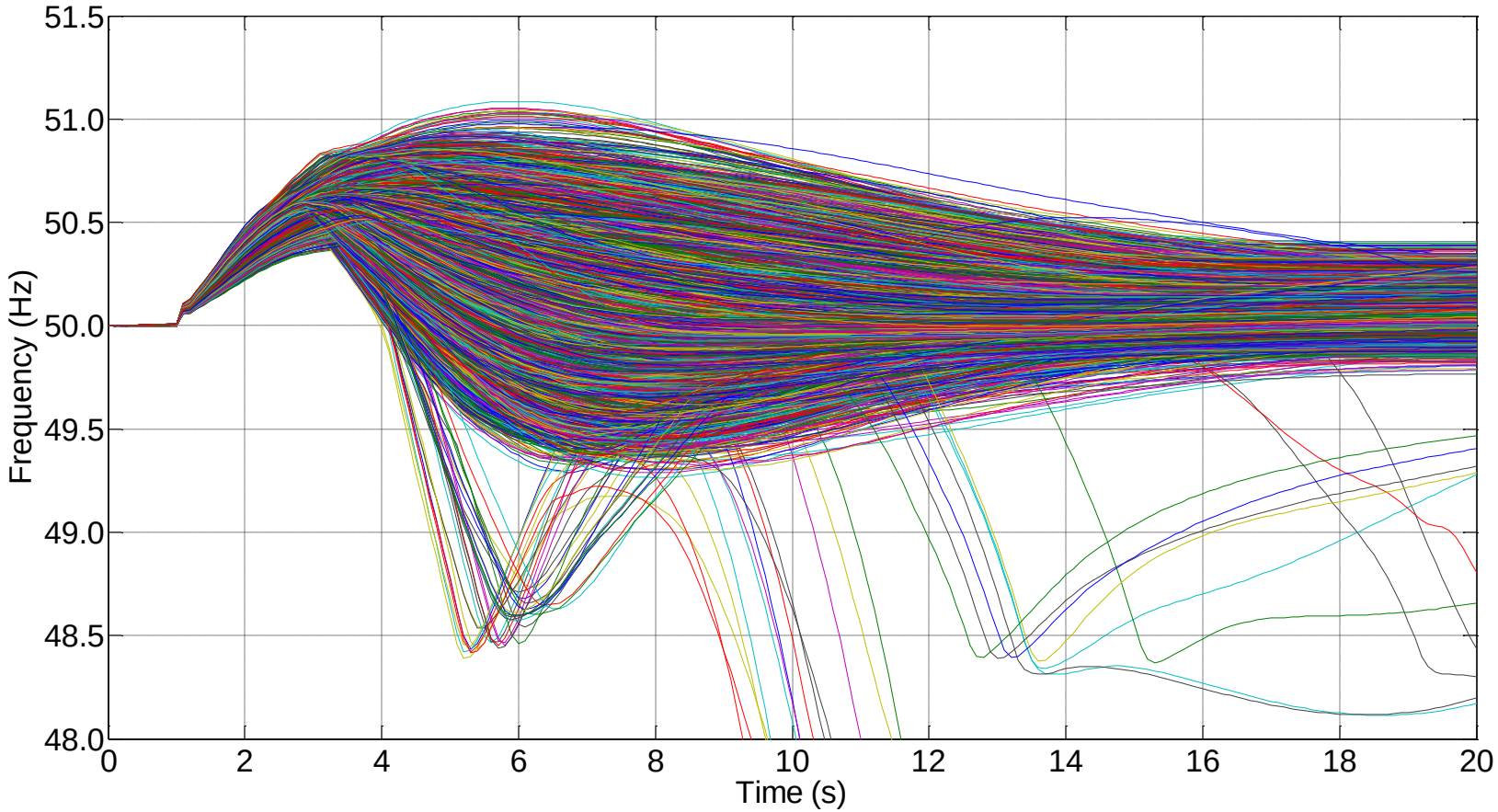
Over-Frequency Shedding



Frequency Traces - EWIC Export



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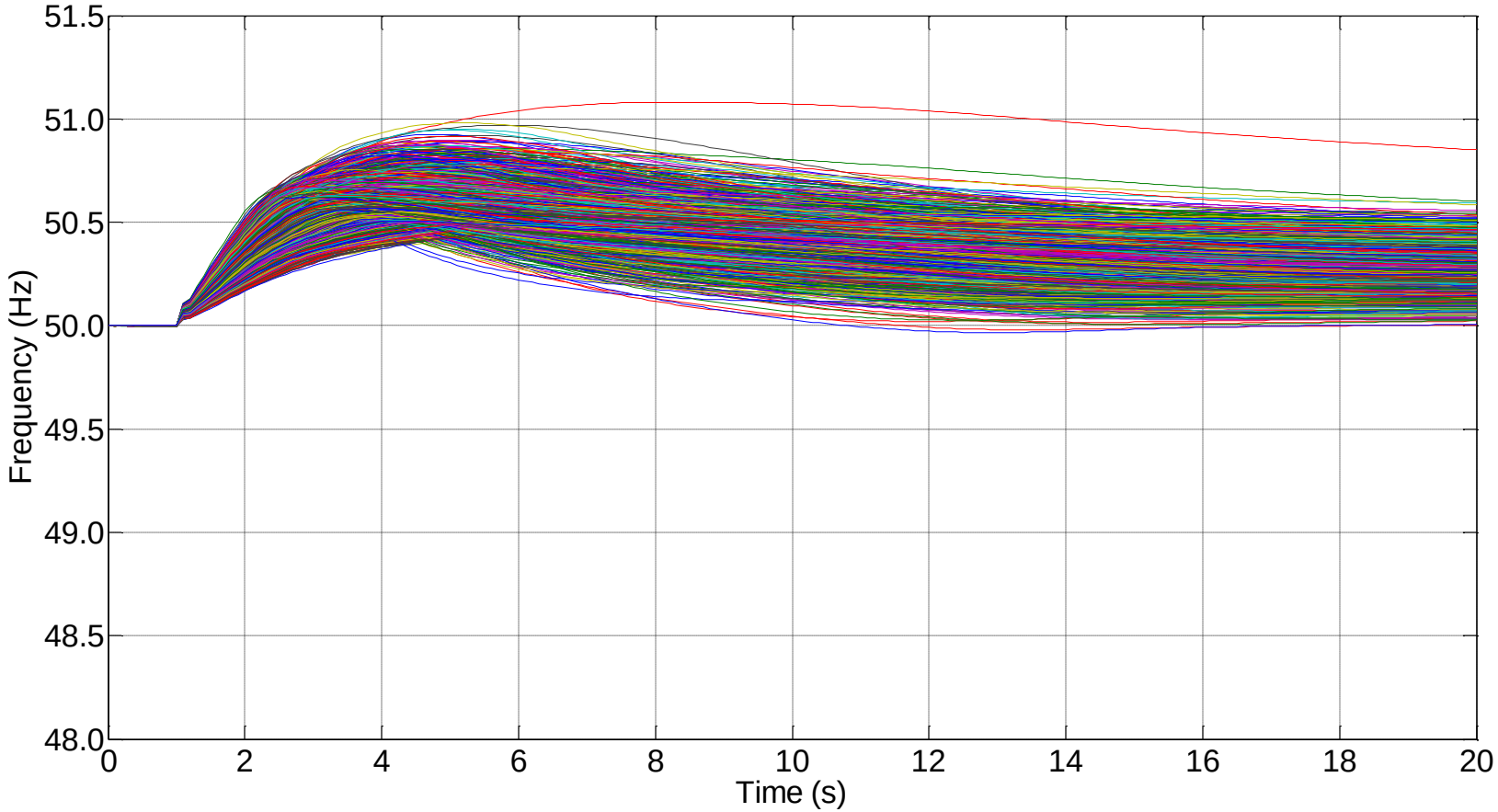

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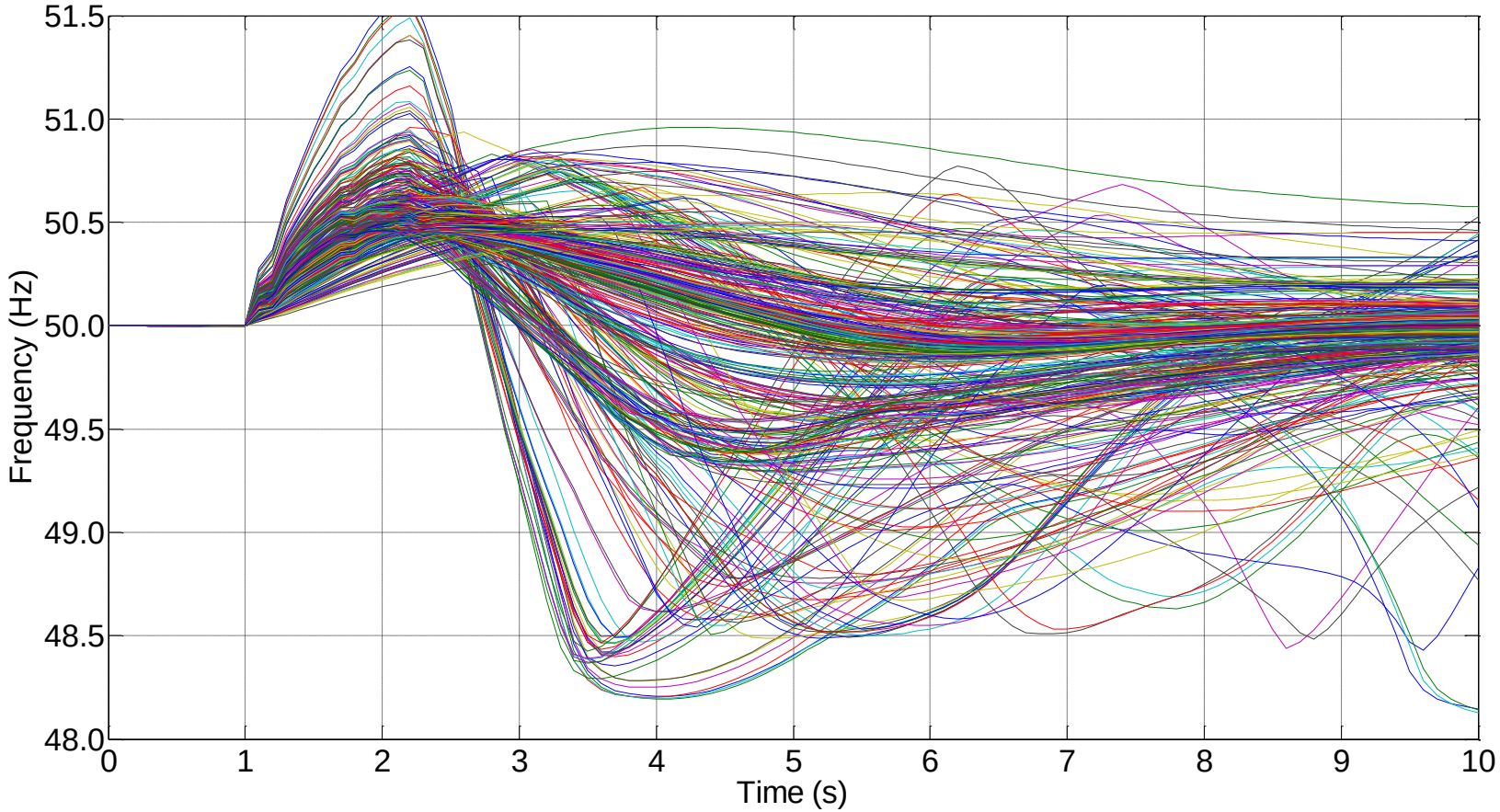
Frequency Traces – Northern Ireland System Separation



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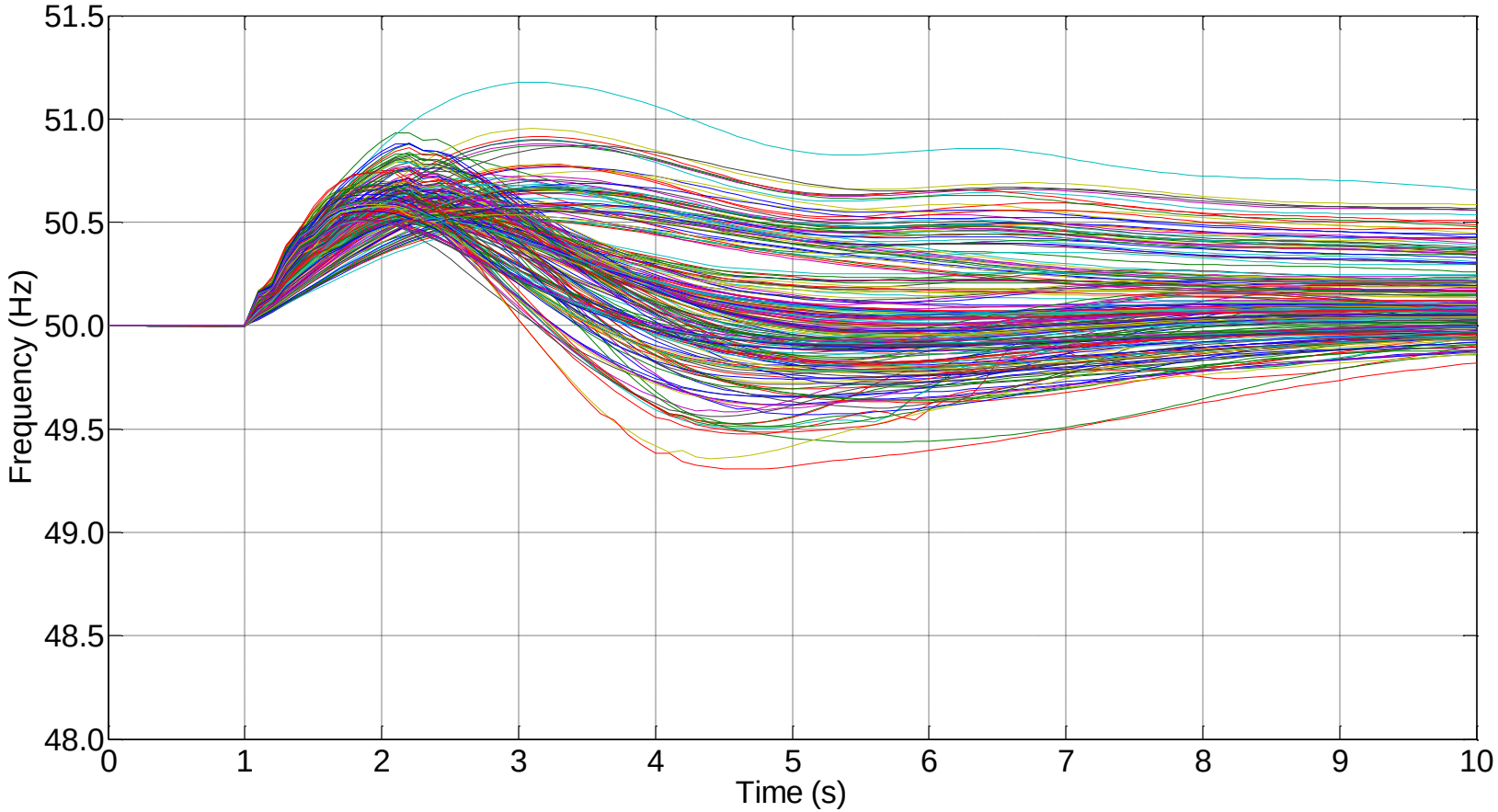
Frequency Traces – Northern Ireland System Separation



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Conclusions

- Over Frequency Scheme effective at containing high frequencies during
  - loss of an interconnector on export
  - system separation

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Next Steps

- Project has been set up in EirGrid/SONI – both ESBN and NIE involved
  - DSO/DNO Loss of Mains (including small-scale)
  - F_D and F_E settings of Controllable WFPS in Ireland
  - Turbine protections settings and confirmation of ride-through capability
  - Large power-quality-sensitive demand customers

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Closing Remarks and Actions

Louis Fisher

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