DS3 Programme Status Update

25/09/13

Robbie Aherne

DS3 – Shaping the Power System of the Future

System Services
Performance Monitoring
Grid Code
Demand Side Management

Frequency Control
Voltage Control
Renewable Data
RoCoF

Studies & Model Development
Control Centre Tools
Wind Security Assessment Tool

DS3 Programme

1. Re-planning of DS3 work streams underway
   - Regulatory decisions
   - TSO-DSO engagement

2. Timelines for revised publication of DS3 deliverables:
   - Published by end November 2013

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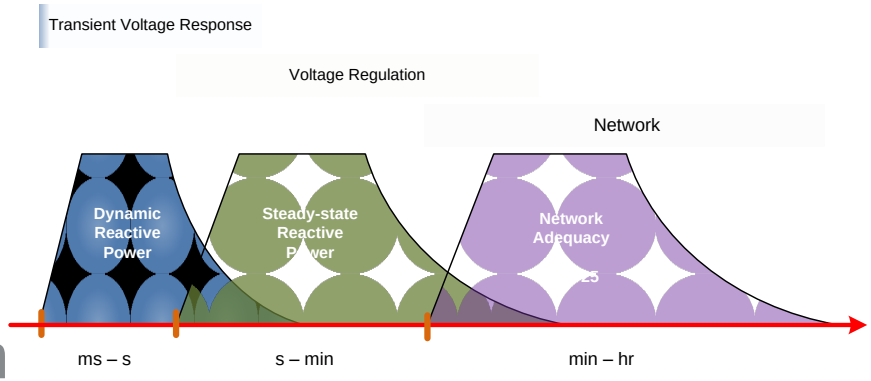
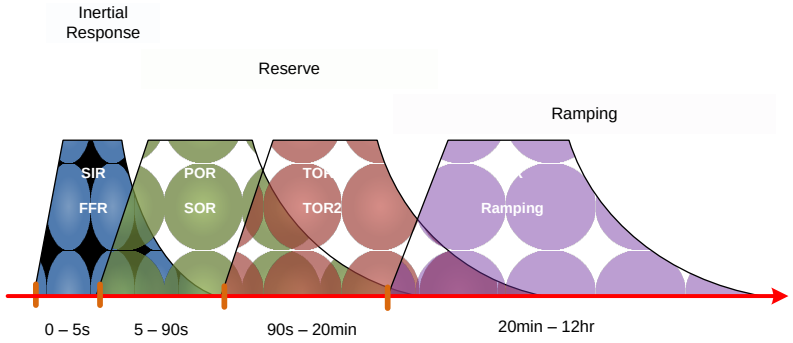
RoCoF

- **CER**: proposed decision published on 28th June
- **NIAUR**: proposed decision published on 27th August
- **EirGrid:** published DS3 Frequency Transient Analysis report on 10th September
- **NGUK**: are currently consulting on proposals to implement an identical change to distribution RoCoF protection standards in GB.

System Services



- System Services Industry Forum
- Substantial interest from different technology providers in SS
- SEM Committee published their proposed decision on 3rd September
- SEM Committee seeking further cost benefit analysis



TSO-DSO Interaction

- TSOs and DSOs working together on a “DS3 TSO-DSO Engagement Plan “

- This Engagement Plan sets out:
  - a high level work plan for all aspects of DS3 engagement
  - a governance structure

Grid Code

- Previously approved WFPS modifications
  - “Windfarm Modification Guideline” issued as per industry request
- Wind Farm Settings Schedule
  - With UREGNI for approval
- Dynamic Model modifications
  - Modification presented at respective GCRP for approval on 11/09/2013
  - Agreement in principal pending further supporting documentation

DSM

- 2 DSU operational (~ 60 MW)
- Grid Code
  - Ireland and Northern Ireland Grid Code DSU modifications awaiting decisions from RAs
  - JGCRP working group being established
- A DSU Operator workshop took place on 23rd July
- New pilot communication protocol between DSU Control Centre and NCC implemented

Renewable Data

- 2012 Curtailment Report approved by Regulators
- All Island Renewable Connection Report- 36 Month Forecast

Total Connected RES (MW) Installed Capacities as of End of Q2, 2013							
Jurisdiction	Wind	Hydro	Bio Energy	RES CHP	Ocean	Solar	Total RES
NI	554.3	2.3	19.6	0.0	1.2	5.5	582.9
IRE	1,833.8	238.1	65.7	5.3	0.0	0.1	2,142.8
All-Island	2,388.1	240.4	85.2	5.3	1.2	5.6	2,725.8

- Wind Constraint & Curtailment Template
  - Q1 reports to be published by end October

Operational Studies

- Pilot PV study of Donegal region complete
- Fast acting frequency response study ongoing
- Testing enhancements to WSAT generic wind farm models
- Voltage dip induced frequency dips ongoing
- Min number of generator studies underway

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Actions from Last Advisory Council Meeting #1

General

- Draft new wind farm modifications for the Distribution Code **[DSOs]**

DS3 Programme Update

- Ensure updated versions of Grid Code are available **[TSOs]**
- Share draft All Island Performance Monitoring & Testing procedure with Advisory Council **[TSOs]**
- Prepare a short paper on Loss of Largest Infeed for the Advisory Council **[TSOs]**
- Clarify if RoCoF reports will be published. Provide information on the steps which must be taken to update the Distribution Code according to the changes which have been made to the Wind Farm Settings Schedule. **[DSOs]**
- Provide a timeline in which this update will be completed. **[DSOs]**
- Follow up meeting between the TSOs and wind industry to be scheduled. **[TSOs]**

Actions from Last Advisory Council Meeting #2

ROCOF:

- Circulate CER paper once published **[TSOs]**

- Revert with new timelines for increasing SNSP and the likely effect this will have on the curtailment levels **[TSOs]**

- Re-programme RoCoF workstream following the receipt of updates from both CER and UREGNI **[TSOs]**

Voltage Control:

- TSOs and DSOs to work together on further consideration of control arrangements and their implementation. **[TSOs and DSOs]**

Wind Constraint and Curtailment Template

- Investigate producing regional specific, half hourly “All Island dispatch down of wind volumes” charts to further help identify times and regions possibly effected by network constraints. **[TSOs]**

- Publish the 2012 curtailment report pending sign off from CER **[TSOs]**

Actions from Last Advisory Council Meeting #3

System Services:

- Confirm venue for System Services workshop on 26th June **[TSOs]**

- Input the feedback received from the Advisory Council into the presentations at the System Services workshop. **[TSOs]**

Minimum Number of Units Study

- Carry out more in-depth Minimum number of sets studies. Ramping requirements are to be included in these studies. **[TSOs]**

DS3 Advisory Council Review

- Circulate an Advisory Council Review questionnaire to the Council members requesting feedback in relation to format, content, timing, and location of the meetings. **[TSOs]**

DS3 Programme Outlook

- Project will evolve over the coming months
  - Key role for the RAs and DSOs
  - Progress is dependent on decisions on System Services, RoCoF
  - Move toward implementation of change in existing operational policies

- What is the best way to progress over the next phase?
  - Role of Advisory Council
  - Interaction between stakeholders


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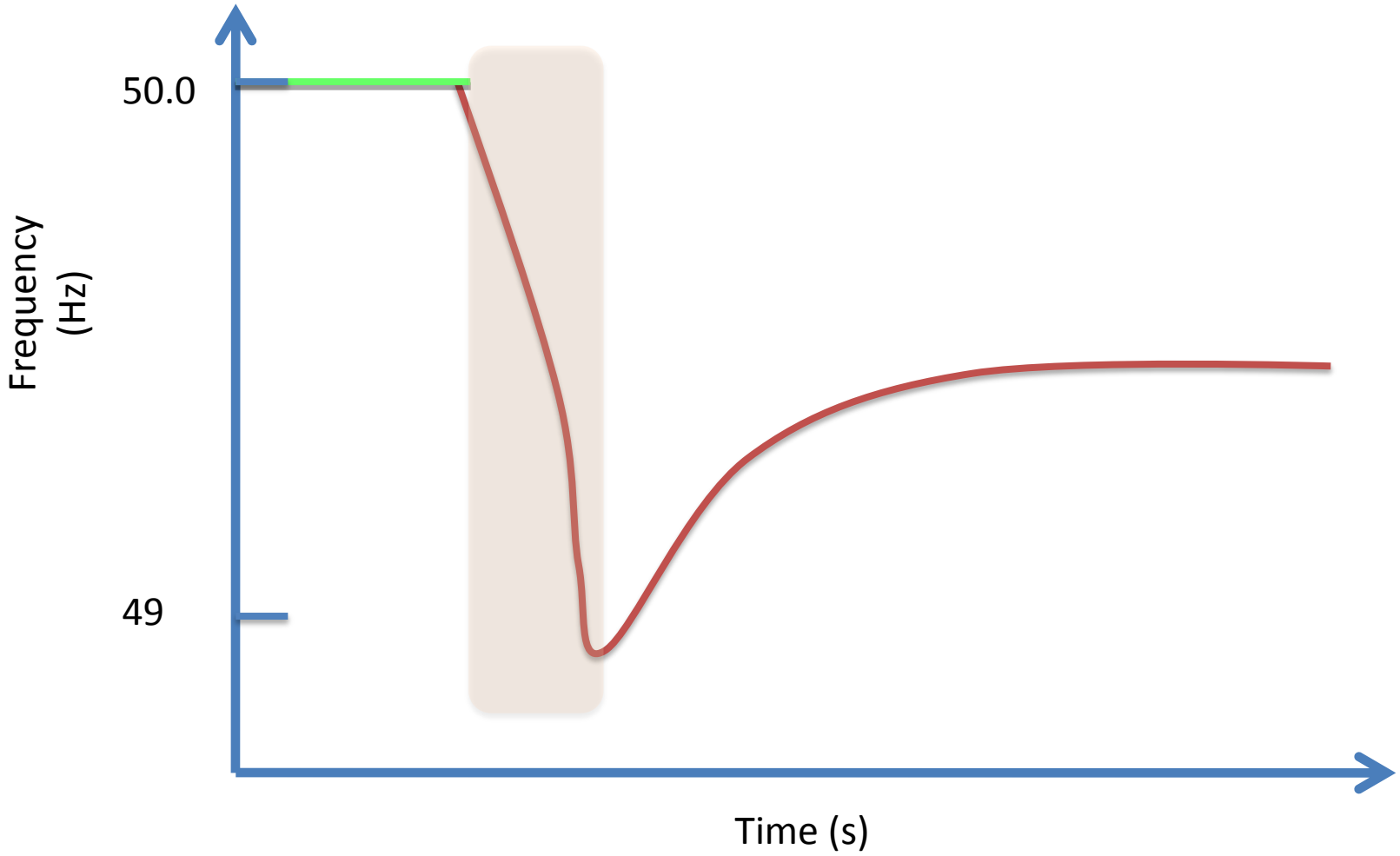
Rationale for ROCOF Workstream

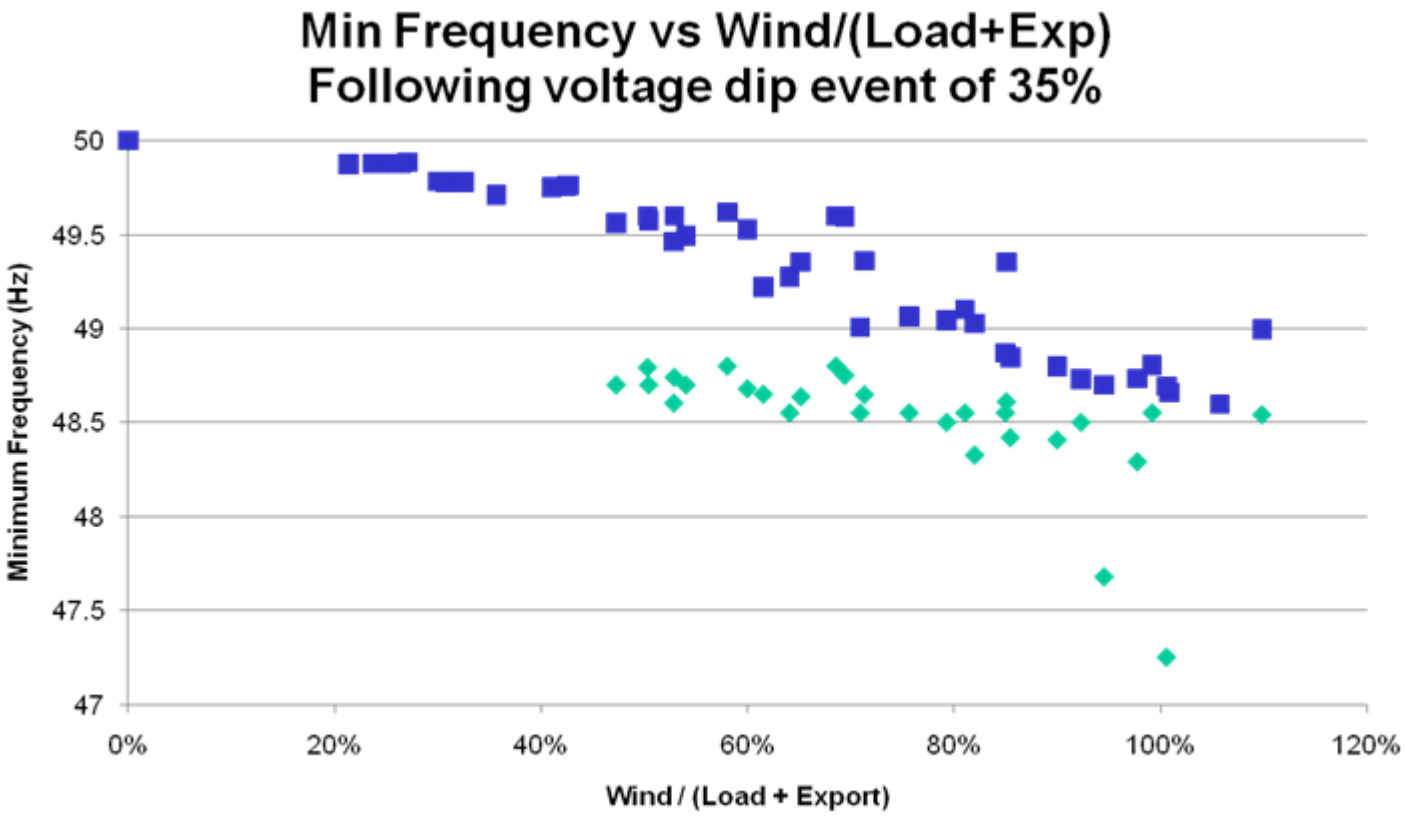
25th September 2013

Robbie Aherne

ROCOF Concept (Measured in Hz/s)



Impact of ROCOF Change

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Update on RoCoF

25th September 2013

Paul Brandon (CER)

Commission for Energy Regulation
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Regulatory Update on DS3

Presentation to DS3 Advisory Council

25th September, 2013

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Overview

- ROCOF
- System Services
- Other issues

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ROCOF: Proposed Framework

Modification

- Approve in principle
- Effective after confirmation from studies
- 18 Month timeline

Implementation

- Generator studies; TSO co-ordination
- TSO-DSO implementation project
- TSO led alternative solutions
- project

Financial Arrangements

- No Cost recovery
- GPI to apply after 18 months

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CER Proposed Decision

- Approve MPID 229 in principle
- Effective in Grid Code after TSO confirmation re system security
- 18 month lead-time assumed (studies etc)
- Co-ordinated project led by TSO with RA oversight
- Public status reporting
- Generators responsible for project management of own studies
- Co-ordination where possible (i.e. similar units)

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Financial Arrangements

- Options for Cost Recovery for studies
  1. Status Quo (i.e. no cost recovery)
  2. Cost recovery through G-TUoS
- **Preferred option**: no cost recovery
- Generator Performance Incentive to apply to prevailing ROCOF standard
  - Effective 18 months from decision
  - Potential for sliding scale relating to size of plant

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Responses (1)

- Consultation closed on 9 August;
  - 12 responses received.
- Wind generators broadly supportive:
  - ROCOF should be implemented as matter of urgency
  - A key part of delivering the 2020 targets and reducing curtailment levels
  - GPI generally supported
  - Project Governance: hard deadlines & public reporting critical

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Responses (2)

- Conventional generators highly critical:
  - Should not approve mod before completion of studies;
  - Alternative solutions project needs to be prioritised;
  - The 18 month period unrealistically short; several years needed;
  - OEMs don't have resource capacity to carry out studies on all plant within 18 months;
  - Certain plant should be exempted e.g. older plant, peaking plant;
  - Generators should be allowed cost recovery as ROCOF capability is a direct cost with no benefit for a conventional plant;
  - The GPI is penal and not an appropriate incentive;
  - Project Governance: Concern re the role of TSO. CER or a CER appointed consultant should be in this role;
  - Strong support for alternative solutions project, but some calls for it to be completed before generator ROCOF studies commence

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Next Steps

- CER to complete review of responses and develop its positions
  - Meetings with various respondents have taken place. CER to also meet with TSOs and technical advisers.
- UR consultation closes 27th September
- Engage with UR to agree an aligned approach to ROCOF
- Final CER decision by end of 2013


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System Services

Shane Rourke

25th September 2013

DS3 System Services – Consultation process

First paper (Dec 2011)

- Scope & Principles
- Bilateral meetings (Feb 2012)
- DNV Kema International SS Review

Second paper (Jun 2012)

- Products & Technical aspects
- Workshop (July 2012)

Multi-stage Consultation

Third paper (Dec 2012)

- Financial aspects
- Bilateral meetings (Jan 2013)
- DNV Kema Capital Cost Paper

Recommendation (April 2013)

- Response to queries
- Price regulation with review
- Products / Rates / Next Steps

TSO Recommendations Paper

- TSO Recommendations Paper published May 2013
  - Papers provided for information purposes only and are not issued for consultation
- System Services workshop held with Industry held on 26th June 2013
- SEM Committee proposed decision published on 3rd September
  - Minded to agree with the technical aspects
  - Reservations on economic rationale and commercial arrangements
- SEM Committee seeking further cost benefit analysis
  - Will have a significant impact on DS3 programme


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Update on System Services

25th September 2013

Paul Brandon (CER)

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System Services

- SEMC Consultation Paper
  - Published 3rd September
  - Closes 11th October
- Proposed to approve technical definition of Services as recommended by TSOs
- SEMC has reservations on the proposed economic rationale and commercial arrangements recommended by TSOs

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System Services

- Significant work at SEM Committee and RA level since TSOs recommendations submitted in May;
  - Detailed review by RA's consultants (Poyry);
  - TSOs and Poyry presented to SEM Committee at end June;
  - Detailed SEM Committee discussions in July and August
- SEM Committee has now decided on a "way-forward":
  - Phased approach to System Services Review;
  - Takes account of the significant work delivered to date by TSOs;
  - Allows for further economic analysis to address the SEMC's concerns.

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System Services: Next Steps

- Decision on technical definitions of services by year end
  - Consultation Paper issued in early Sept;
- Further economic analysis to determine the approach to valuing and remunerating system services
  - Terms of Reference for economic analysis discussed by SEMC at end Aug;
  - Approach involves determining the appropriate "counter-factual" against which system services scenarios will be modelled;
  - Modelling a range of different scenarios
  - Alternative options for valuation and procurement mechanisms to be developed.
- RA – Poyry - TSOs workshop held in CER Offices yesterday
  - Discussed the SEMC terms of reference, various scenarios and options for modelling, approach to be taken, resourcing and timelines
  - Planning to publish more details on economic analysis after October SEM Committee
  - Planning for analysis to be completed and moving towards decision in Q1 2014 (dependent upon final modelling).


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Industry Perspective

25th September 2013

Denis McBride (AES)

DS3 – A Conventional Generator's Perspective

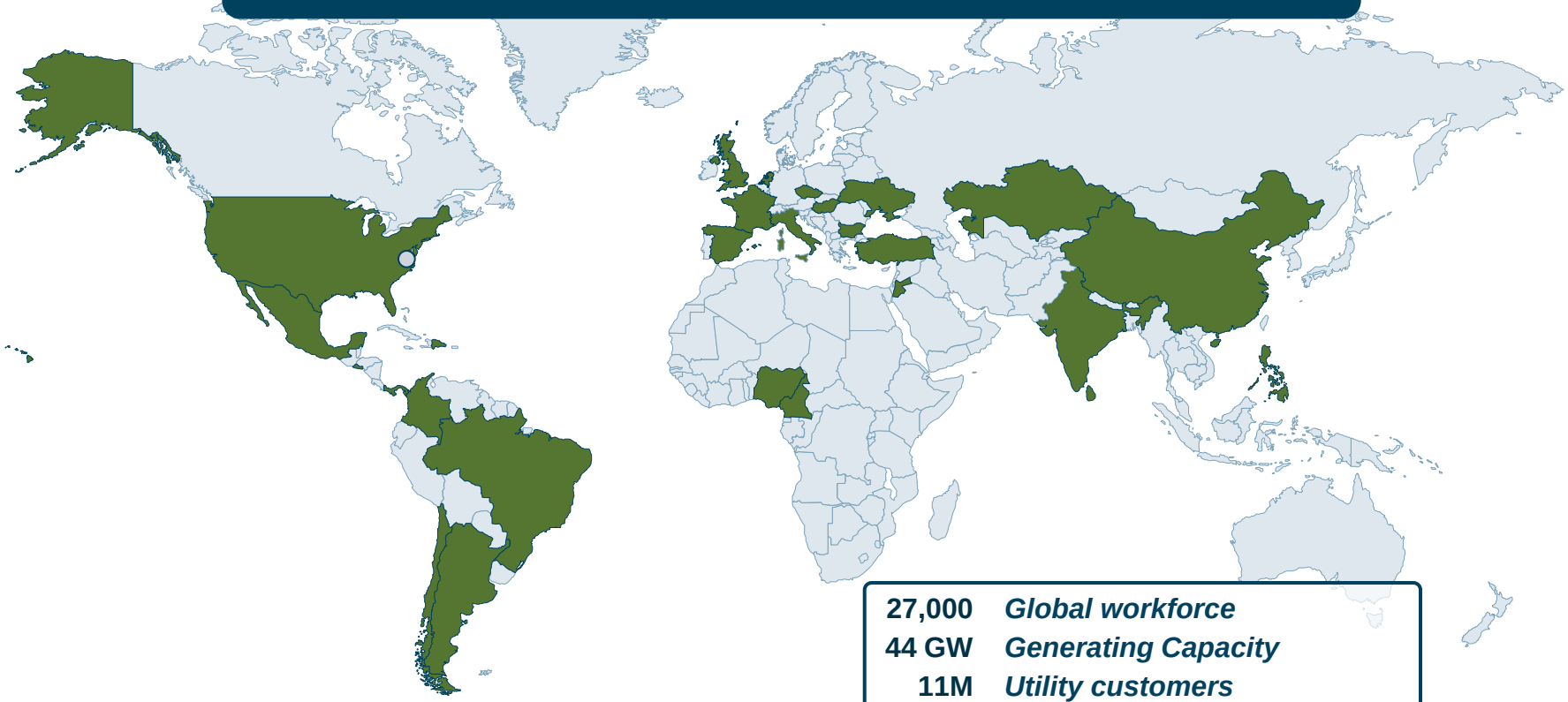
Flexibility has Value

September 2013
Dublin

v2

AES footprint provides a platform for solving power challenges.

Our mission is to improve lives by providing safe, reliable and sustainable energy solutions in every market we serve.



27,000	***Global workforce***
44 GW	***Generating Capacity***
11M	***Utility customers***
$17.2 Billion	***2011 Revenue***

Key ○ AES Headquarters ■ AES Operations

AES UK

- AES involvement in the DS3 process to date
- Specific issues
- Ongoing Concerns

AES Ballylumford

AES Kilroot

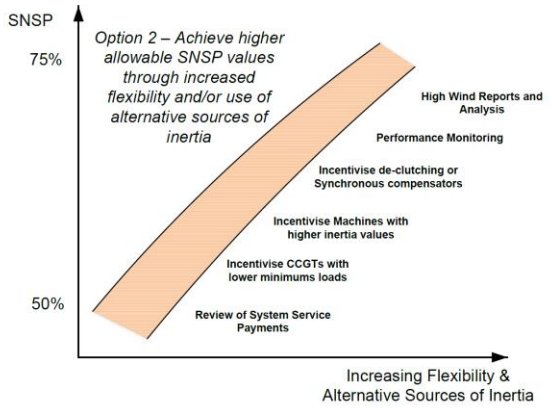
- Specific Issues
  - RoCoF Impact
  - Ancillary Services
  - Performance Monitoring

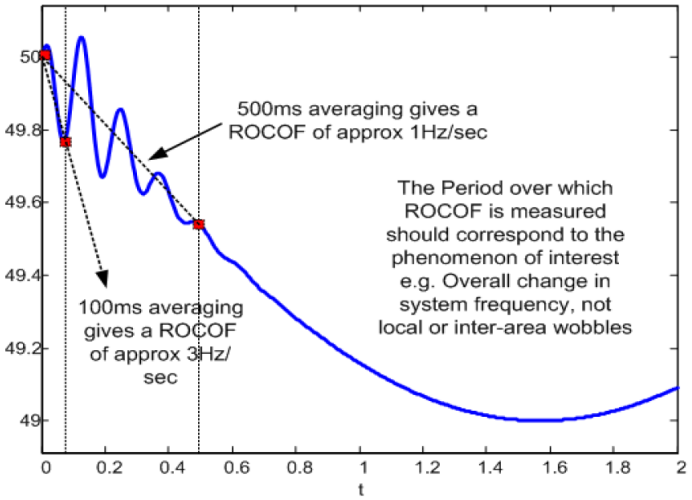
AES Involvement in the DS3 Process – to date

- Owner and Operator of 1918 MWs of Conventional Generation in NI and 87MWs Wind Generation UK (pipeline of >250MWs)
- Members of the Joint Grid Code Review Panel DS3 Advisory Council
- Involvement in the JGCRP DS3 Working Group - RoCoF
- Consultation responses - various issues
  - RoCoF
  - Ancillary Services
  - Performance Monitoring

RoCoF – Rate of Change of Frequency

- Process
  - Cascade Tripping risk - Individual Plant Study for 1Hz/sec and 2Hz/Sec (NI)
  - 2Hz/sec NI – Transmission risk passed to Generators
  - Definition of RoCoF requirement – 1Hz/s measured over 500ms





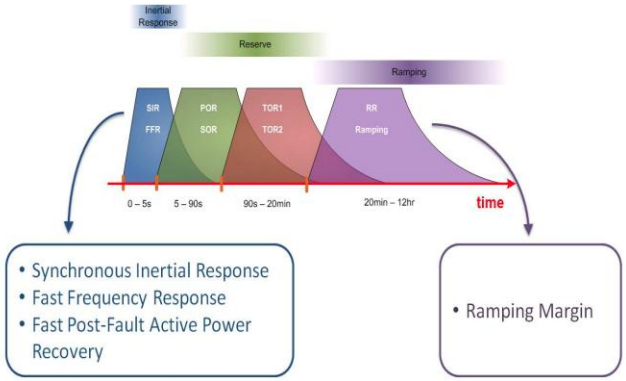
- Grid Code modification - retrospective
- Joint working group view - Generator Studies – OEM Impact Assessment

RoCoF – Rate of Change of Frequency

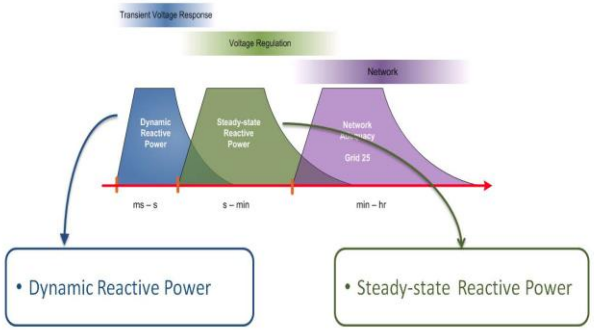
- Engagement with OEM
  - technical study – 1 Year/€1M
  - Increased wear and tear risk
  - TSO Proposed time scales - optimistic
- Cost recovery options
  - System Benefit – SMP reduction
  - Wind Generation benefit
  - Socialised costs
- Compliance/non compliance Testing
  - Method for verifying compliance?
  - GPI – RoCoF
  - Derogation implications?
  - Precedent set re retrospective application

DS3 New Ancillary Services

- **Product Designs -** Targeted
  - Grid Code min Standard compliance
  - TSO obligation/discretion to contract
  - Inertia product threshold too high



- **Remuneration -** Targeted
  - Dispatch vs capability payment
  - Associated reduction in capacity pot
  - Product Scalars
  - Performance Scalars
  - Rate Scalar
  - Investment certainty vs cost to consumer

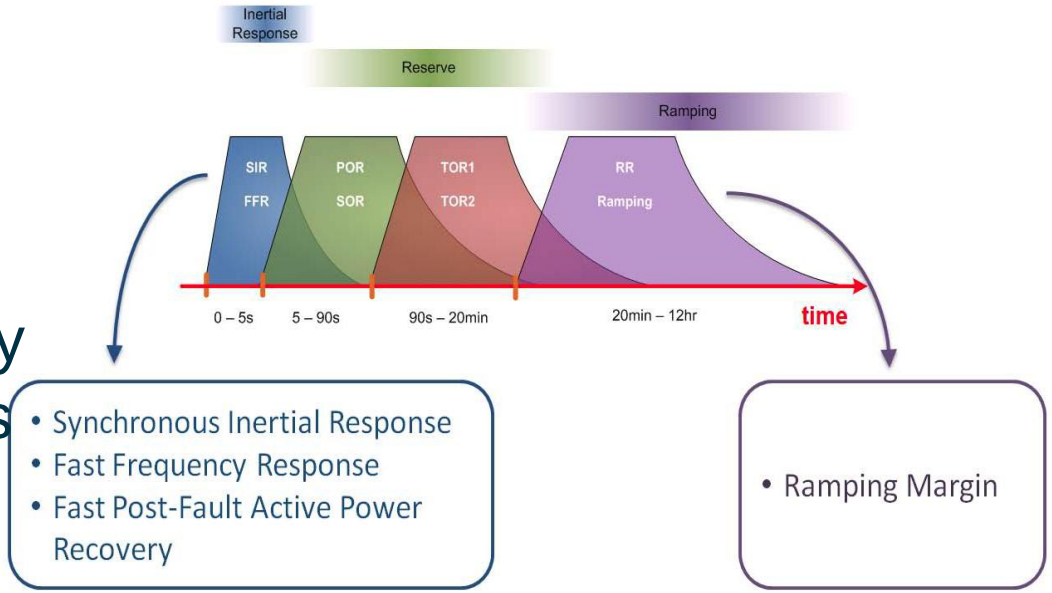


DS3 New Ancillary Services

- Investment risk uncertainty
- Plant modification cost vs Return from AS Products
  - FFR - investment required?
  - SIR - Reducing Min Gen – Capability payment
  - Ramp - Increasing Ramp Rates - Dispatch Payment

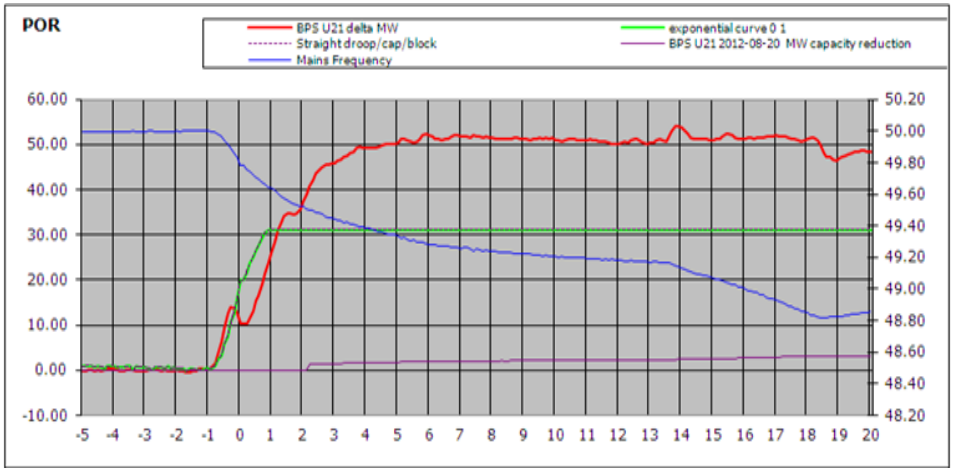
- Uncertainty of plant dispatch profile – commodity exposure

- Targeted approach may not work – efficiency vs flexibility trade off



Performance Monitoring

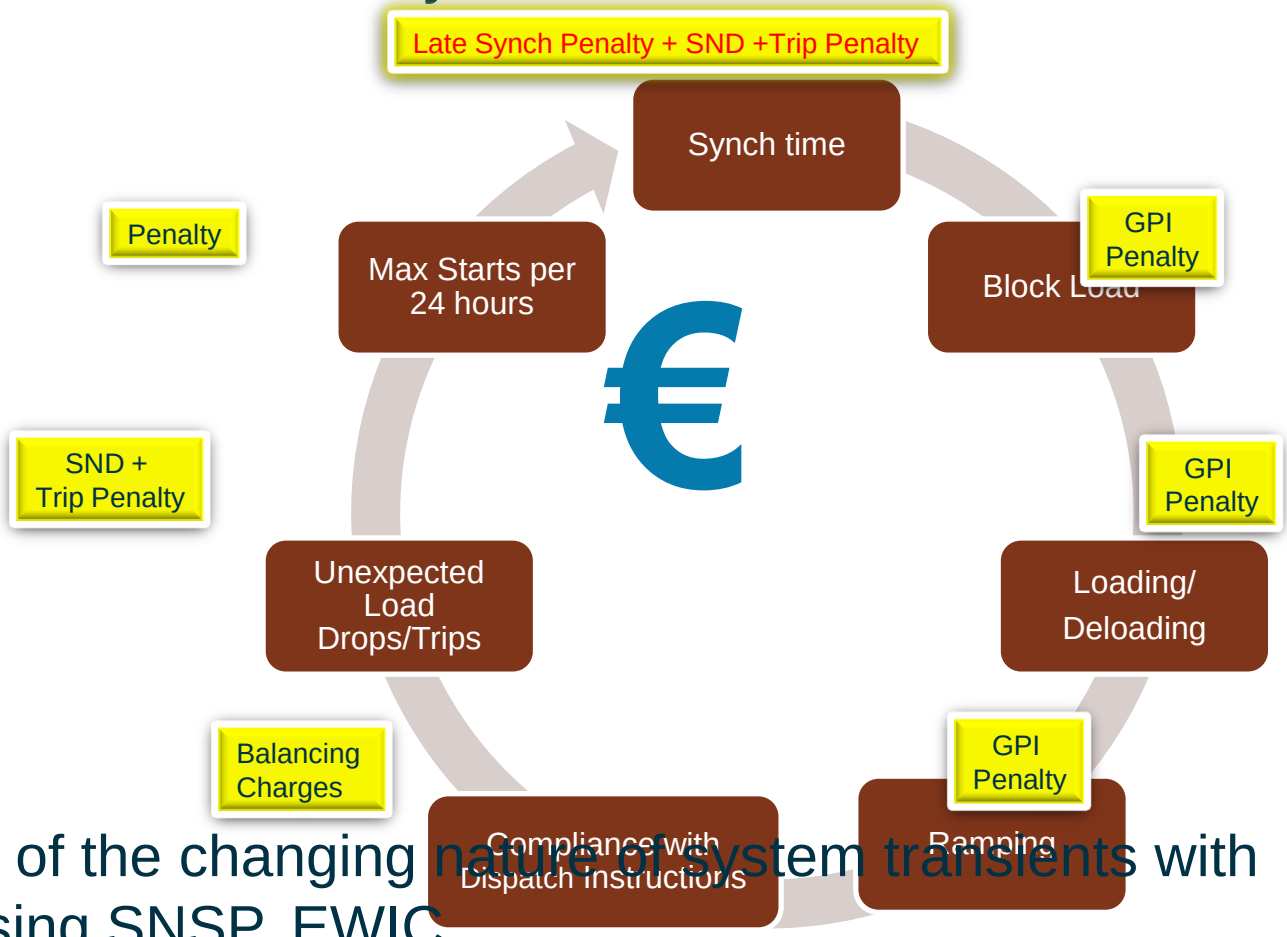
- Performance Monitoring since privatisation - GUAs
  - Penalties for under performance Availability/ Rebates
- Penalties - Trip, SNDs & GPIs
  - GUAs provided effective signals for improved performance



- Good Provision of data for assessment of performance
- Improved by installation of PMUs
- Difference of opinion on Fail Synch
- Visibility of monitoring process - real time

Performance Monitoring

- Active Power/Flexibility

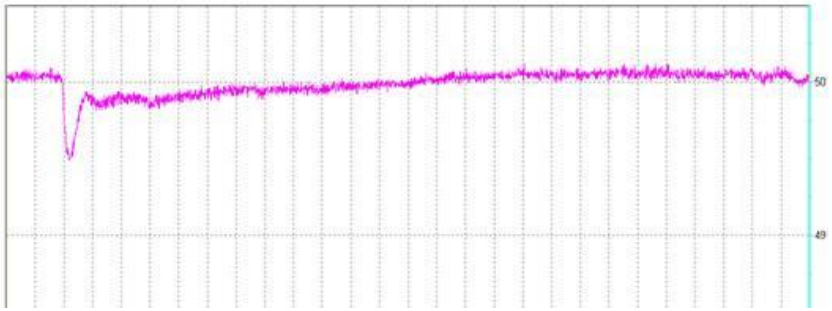


- Impact of the changing nature of system transients with increasing SNSP, EWIC
- Performance monitoring of TSO – framework, transparent

Performance Monitoring

Examples of Variation of System Transients as SNSP increases

1



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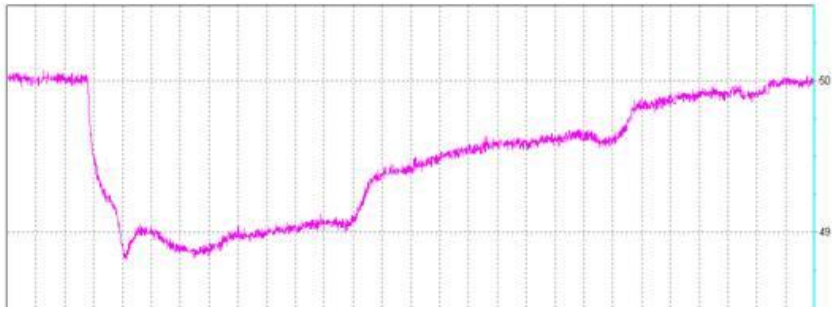
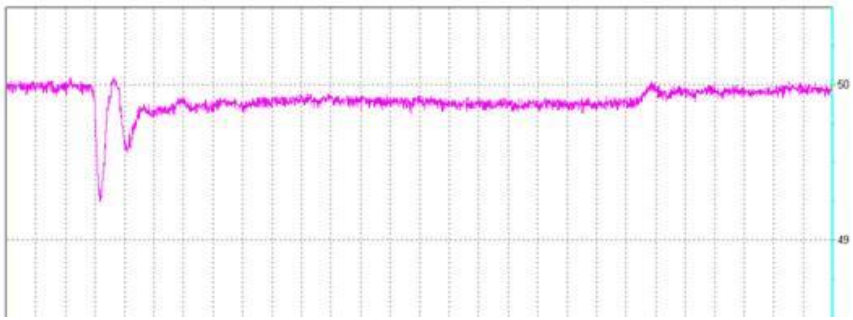


The changing nature of system transients, rapid recovery, double dip and rapid rise, slow rise transients

4



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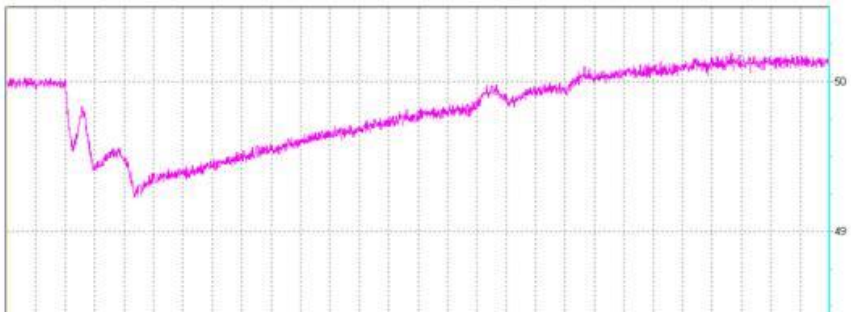
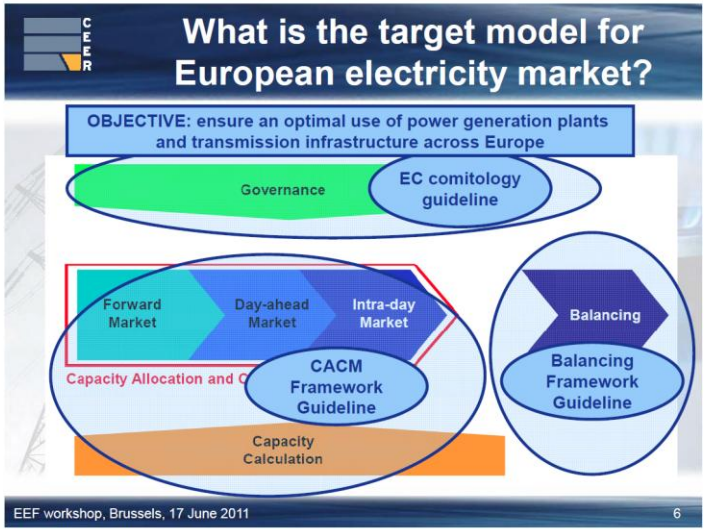


Market Reform and EU Target Model Integration

- Impact of requirement to implement the EU target model
- What is the best way to value and reward plant flexibility
- Potential impact on new and existing products



- Potential opportunities from balancing time frame standard products - to be determined by TSOs
- AES committed to being involved in the integration process

Conclusions/Concerns

- AES is a proactive participant in the journey to DS3
- RoCoF – OEM studies and subsequent potential plant modification, outages etc – cost recovery should be socialised
- Impact of non compliance/derogation on dispatch
- Ancillary Services – investment required vs unpredictable return - TSO discretion, dispatch, product rates
- Performance Monitoring – concern over the changing nature of transients as SNSP increases.
- Transparency of monitoring – TSO's,Warning/monitoring process
- Potential opportunities from Market reform and compliance with EU Target Model
- Flexibility has value but also has cost


We replaced the carrot
& stick motivation model
with a stick & stick approach.
So far we're realizing
substantial savings in carrots!
cubicle20.com

THANK YOU

DS3 New Ancillary Services - Appendix

- The system services remunerated on a Dispatch Dependent basis are:
  - Ramping Margin (1, 3, 8 hour),
  - Primary, Secondary, Tertiary and Replacement Reserves,
  - Fast Frequency Response

- The system services that are remunerated on a Capability basis are:
  - Synchronous Inertial Response,
  - Dynamic Reactive Power,
  - Fast Post Fault Active Power Recovery,
  - Steady State Reactive Power

- Capability based payments should employ an additional rate scalar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TSO/DSO Engagement

25th September 2013

Simon Tweed

TSO/DSO Engagement

25th September 2013

Sam Alexander (NIE)

DSO and TSO DS3 Work Plan and Governance

DS3 Advisory Council Meeting

25TH September 2013

Northern Ireland Electricity

ESB NETWORKS

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DSO and TSO Work Program and Governance

- Governance
- Work Program

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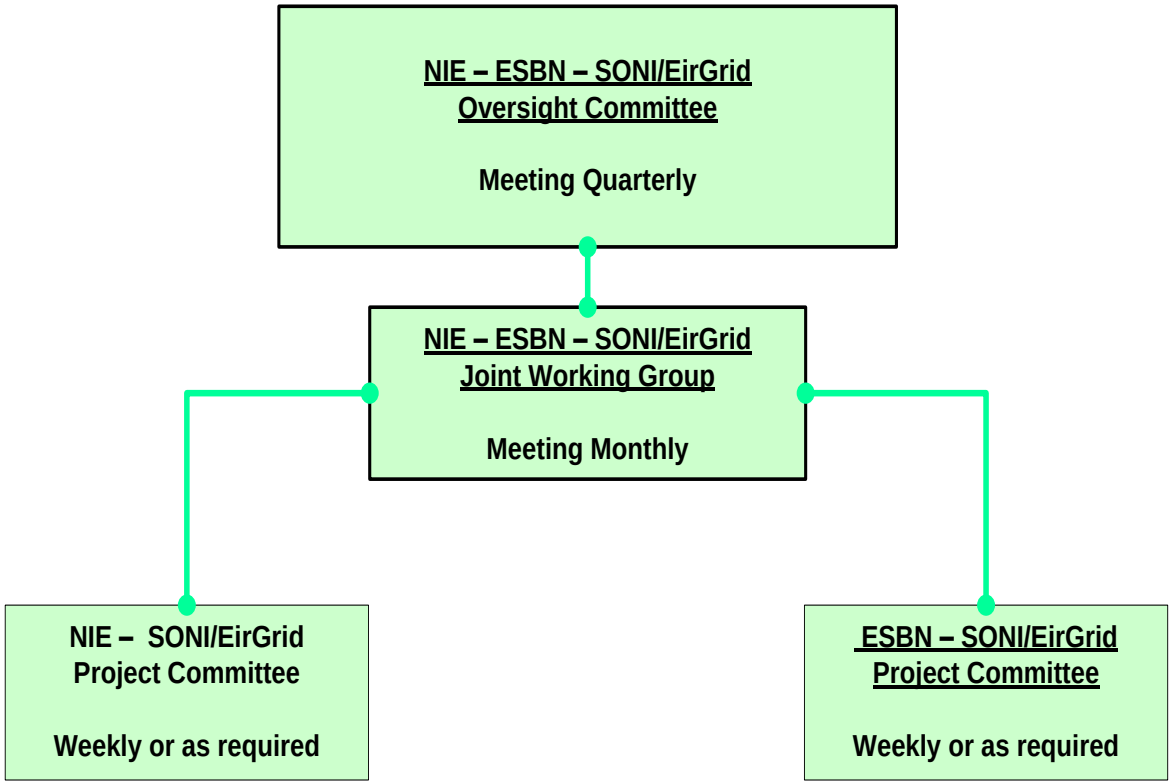
Governance



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Work Program

The work program consists of 6 work streams

1. Loss of Mains
2. Development of a High Frequency Generation shedding schedule
3. Voltage Control
4. Projected System Requirement studies
5. Demand Side Management
6. Compliance and Performance Monitoring

Northern Ireland Electricity ESB NETWORKS EIRGRID SONI System Operator for Northern Ireland

Loss of Mains

- Commencing with required code changes through to an enduring process

- Commences Q4 2013
- Completion Q4 2014

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High Frequency Shedding Schedule

- The work plan ranges from development of policy through to implementation.
- Commencing Q4 2013
- Estimated completion Q4 2014

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Voltage Control

- The program ranges from developing functional requirement through to pilots and finalising on DSO/TSO voltage control protocol
- Commencing Q3 2013
- Estimated completion Q2 2015

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Projected System Requirement Studies

- Requirement for internal steady state and dynamic studies through to planting of FACTs devices
- Commencing Q3 2013
- Estimated Completion Q1 2017

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Demand Side Management & Performance Monitoring

- Work plans to be developed commencing Q4 2013

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Thank you


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DS3 Grid Code Update

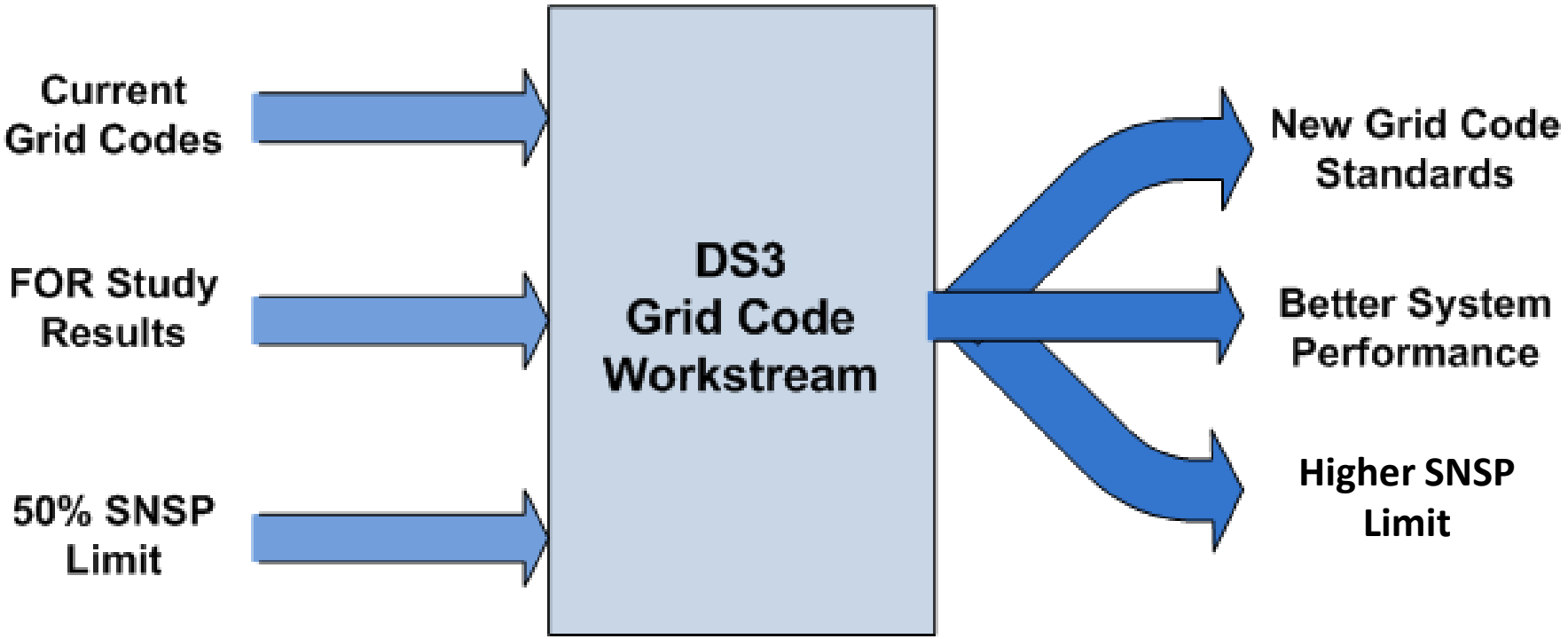
25 September 2013

Alan Kennedy

Presentation Outline

- Reminder of the drivers and issues
- Progress since last Grid Code Update
- Summary of Next steps

Motivation for Grid Code Changes



Progress since last meeting

- Significant progress has been made in the following work areas
  1. Wind Farm generator requirements
  2. Requirements for Demand Side Units
  3. Dynamic Modelling requirements

Requirements for Wind Farm Power Stations

Update – Grid Code Mods for Wind Farm Generators

- EirGrid DS3 Mods for Wind Farms
  - Working Group met 6 times between Feb 2012 and Aug 2012
  - Grid Code mods presented at GCRP on 4 Dec 2012
  - Approved by CER on 26 Feb 2013

- SONI Grid Code mods and WFPS Settings Schedule
  - Consultation 16 July 2013 to 28 August 2012
  - Submitted to RA 7 March 2013
  - Currently awaiting RA approval

Dynamic Modelling

Motivation for accurate Models

- Accurate models of the power system are fundamental to efficient planning and operation of the power system
- Several DS3 Workstreams dependant on accurate modelling :
  - Model Validation and Studies
  - WSAT
  - Frequency control and Voltage control
- Use of online simulation tools to make real time Operational decisions
- Future technical studies

Motivation for accurate Models

- Increasing SNSP:
  - Increased complexity of system performance
  - Increased requirement for accurate models
- Mods will also be incorporated into D-Codes

Current Modelling Deficiencies

- Current Grid Code requirements are outdated and inconsistent
- Models may not have been fully validated
- TSOs only have “black box” models for many generators
- WFPS models only reflect turbine level behaviour, not the entire wind farm
- WFPS models do not adequately represent frequency performance

Progress – Dynamic Modelling

- Bi-lateral discussions have been held with several OEMs
- Presentation was made to the JGCRP on 1 May 2013 outlining TSO requirements
- Joint workshop held on 30 July 2013 in Dundalk
- Further presentation made at 11 Sept 2013 JGCRP
- EirGrid presented draft Grid Code modification at GCRP meeting on 11 Sept 2013
- SONI confirmed at their GCRP meeting on 11 Sept 2013 that they will issue a consultation paper for a similar Grid Code mod before the next GCRP meeting in Dec 2013

Demand Side Units

DSU Update – EirGrid Grid Code

- Two DSUs have been operating in Ireland during the past year
- Based on this operational experience, a Grid Code modification was tabled at the EirGrid GCRP on Feb 13 and approved at the May 13 meeting
- The mod has been sent to CER for approval
- A workshop was held at the Oval on 23 July 2013 to facilitate dialogue
- TOR for a Joint Working Group have been circulated to enable further discussion and possibly develop additional Grid Code mods

DSU Update – SONI Grid Code

- Licencing issues have precluded the registration of DSUs in NI
- In order to ensure that the Grid Code requirements for DSUs remain consistent across the island, SONI has developed similar modification proposals
- SONI consulted on its proposed mod 10 May 2013 to 07 June 2013
- Following consultation, no substantive changes made to the original drafting
- Submitted to UREGNI for approval 22 July 2013

Summary of Planned Further Work

- Demand Side Units
  - TOR for a Joint Working Group have been circulated to interested parties
  - WG will facilitate further discussions and propose further Grid Code mods, if required
- Dynamic Modelling
  - Eirgrid to seek RA approval for modification tabled at Sept 2013 GCRP subject to the provision of further supplementary documentation
  - SONI will issue a consultation for a similar mod before the December 2013 GCRP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Constraint & Curtailment Template Report

25 September 2013

Jon O'Sullivan


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Advisory Council Review

25 September 2013


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Afternoon Technical Session

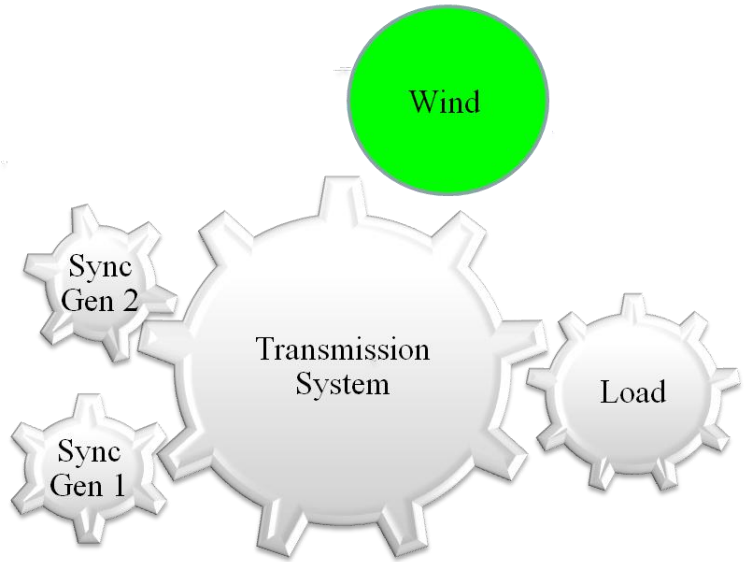
25 September 2013

Short-term System Frequency Response

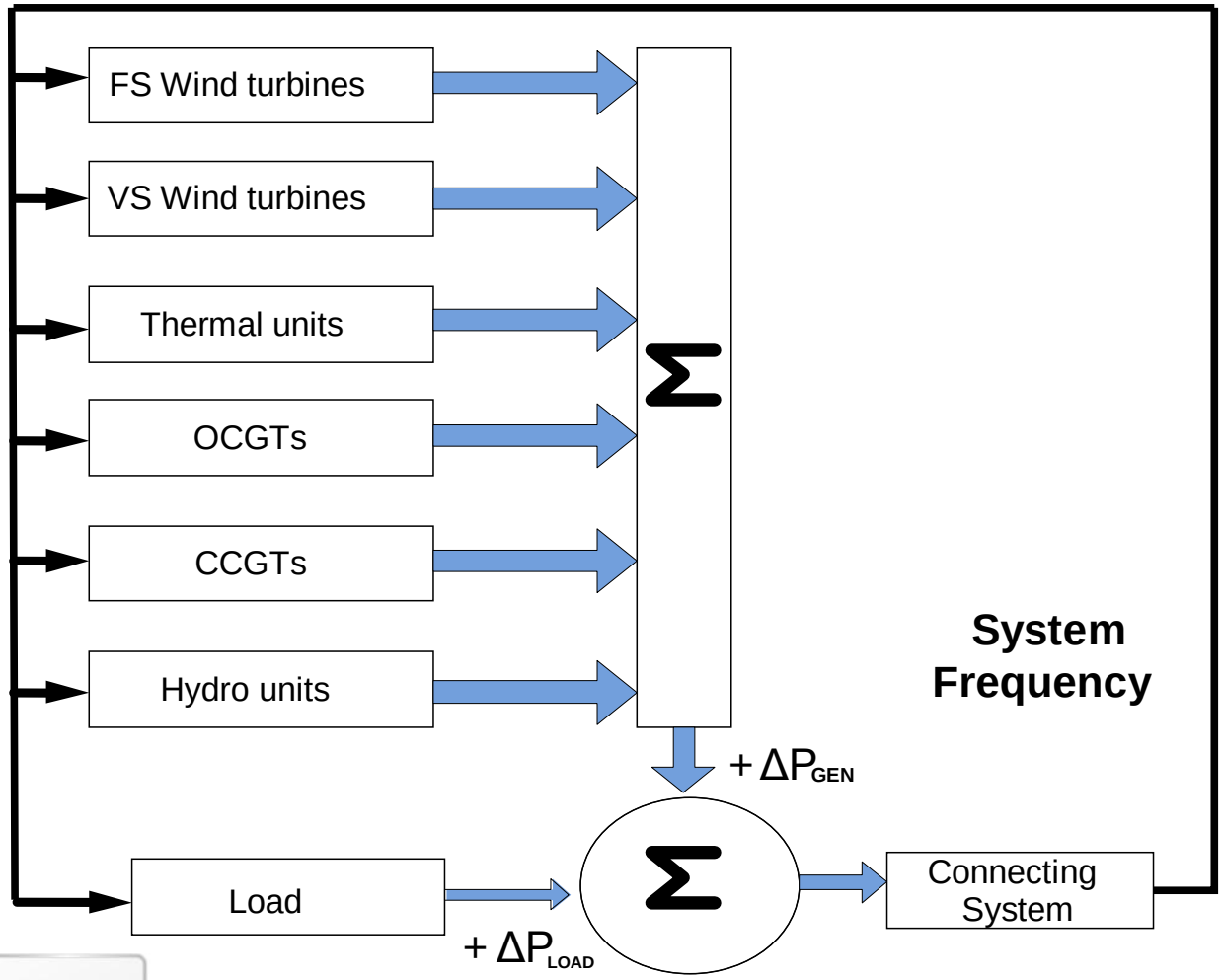
Lisa Ruttledge

Background

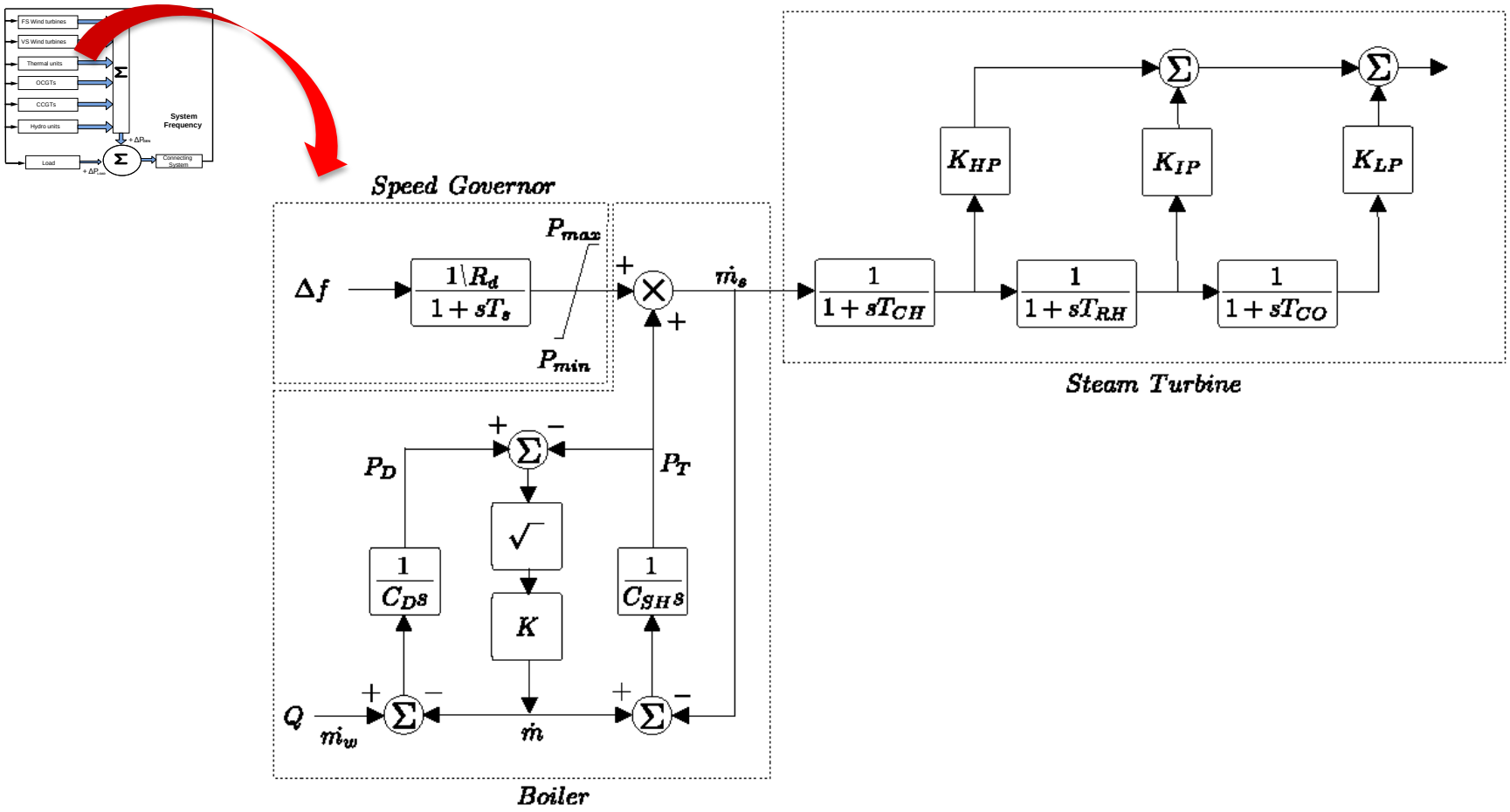
- Power balance on conventional systems well understood
- Higher wind penetration levels
- Fewer conventional generators ***plus*** associated ancillary services
- Investigate short-term frequency response capability



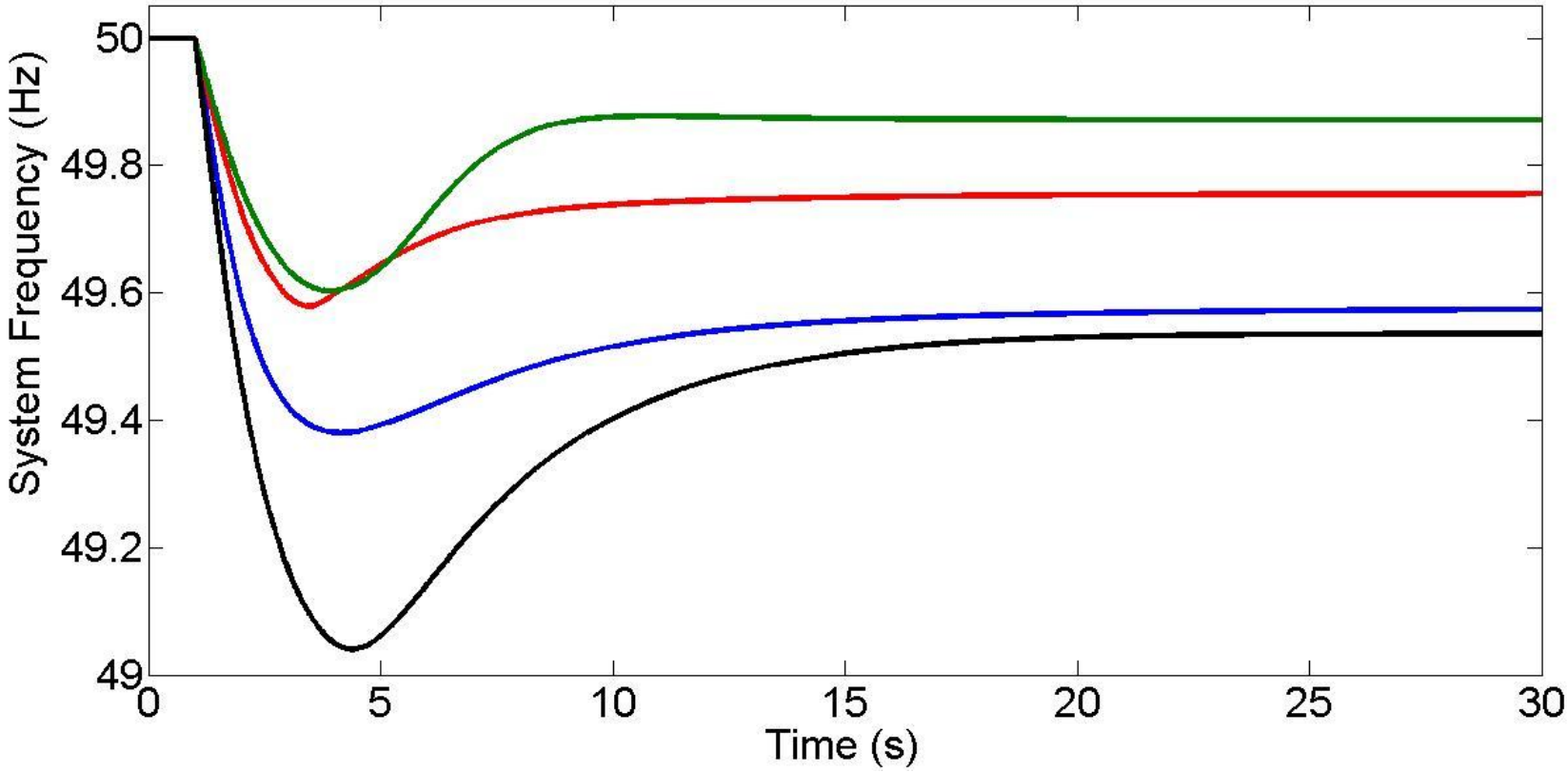
Frequency Model



Frequency Model



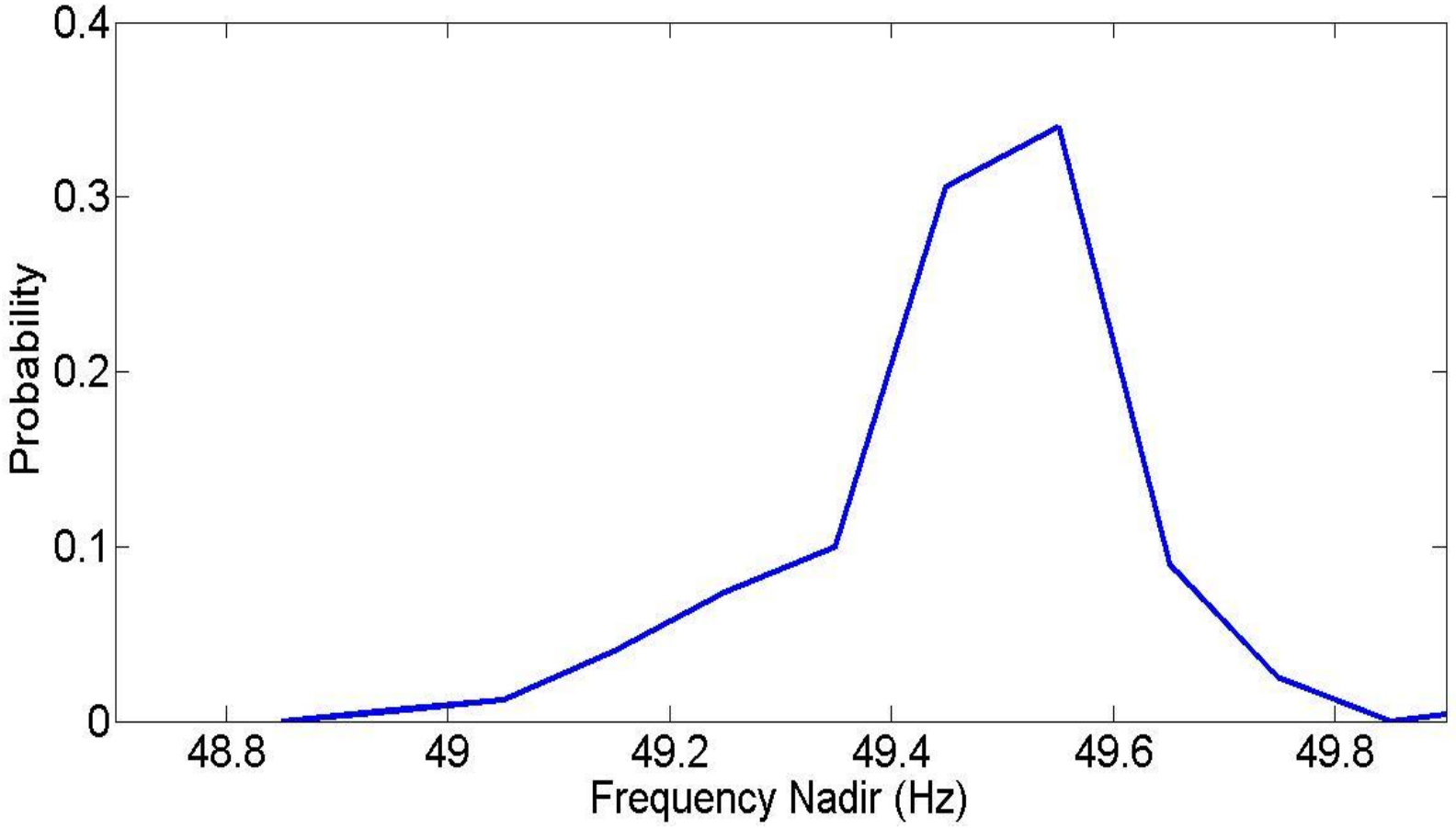
System Frequency Response



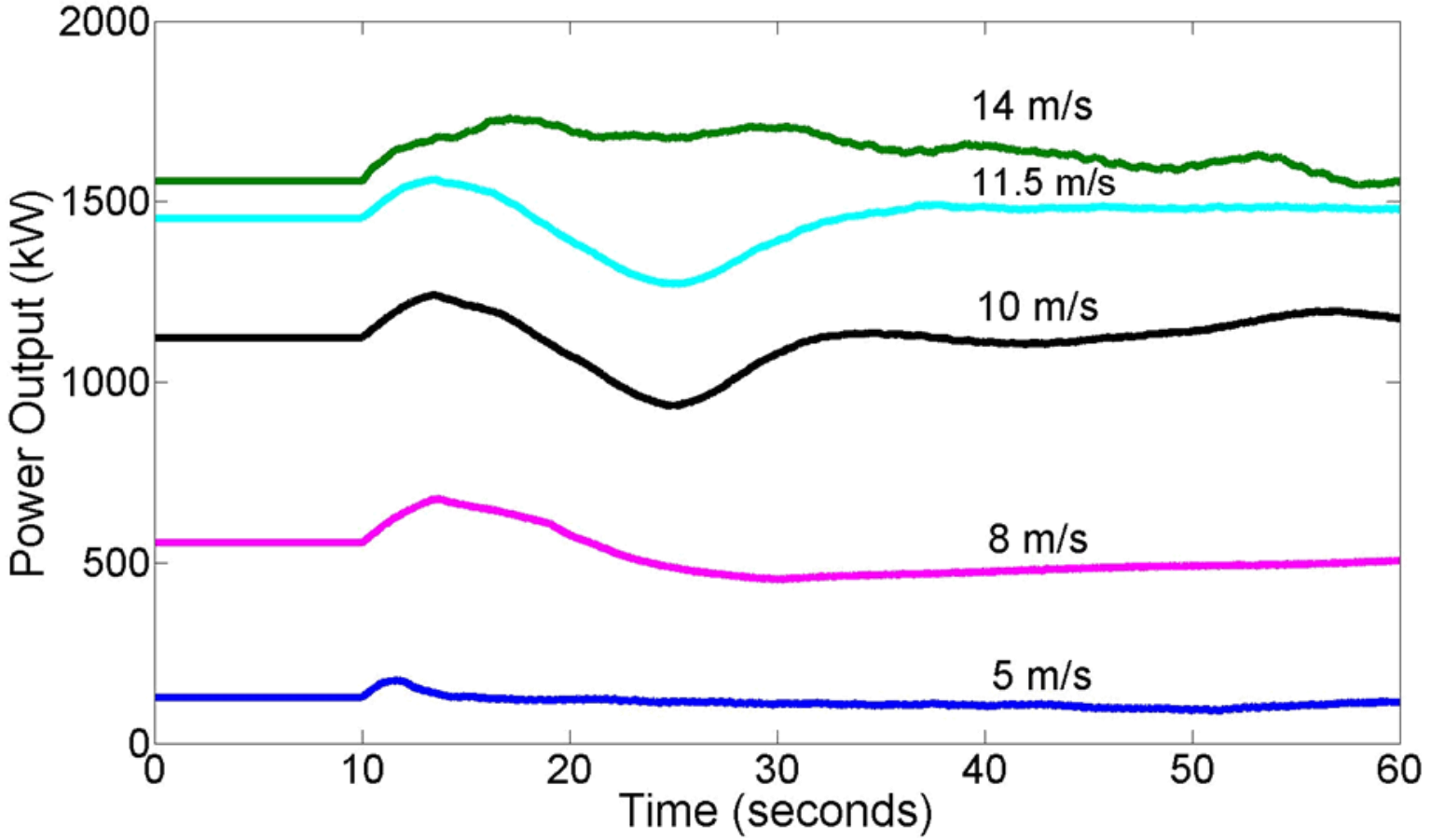
Operating Security Standards

Description	Range
Nominal Frequency	50 Hz
Normal operation	49.8 to 50.2 Hz
During transmission system disturbances	48.2 to 52.0 Hz
During exceptional Transmission System disturbances, not exceeding 60 mins duration for frequency in the range 47.5 to 49.8 Hz and 50.2 to 52 Hz and not the exceeding 20 s for frequency in the range 47 to 47.5 Hz.	47.0 to 52.0 Hz
Maximum rate of change of frequency	0.5 Hz/s

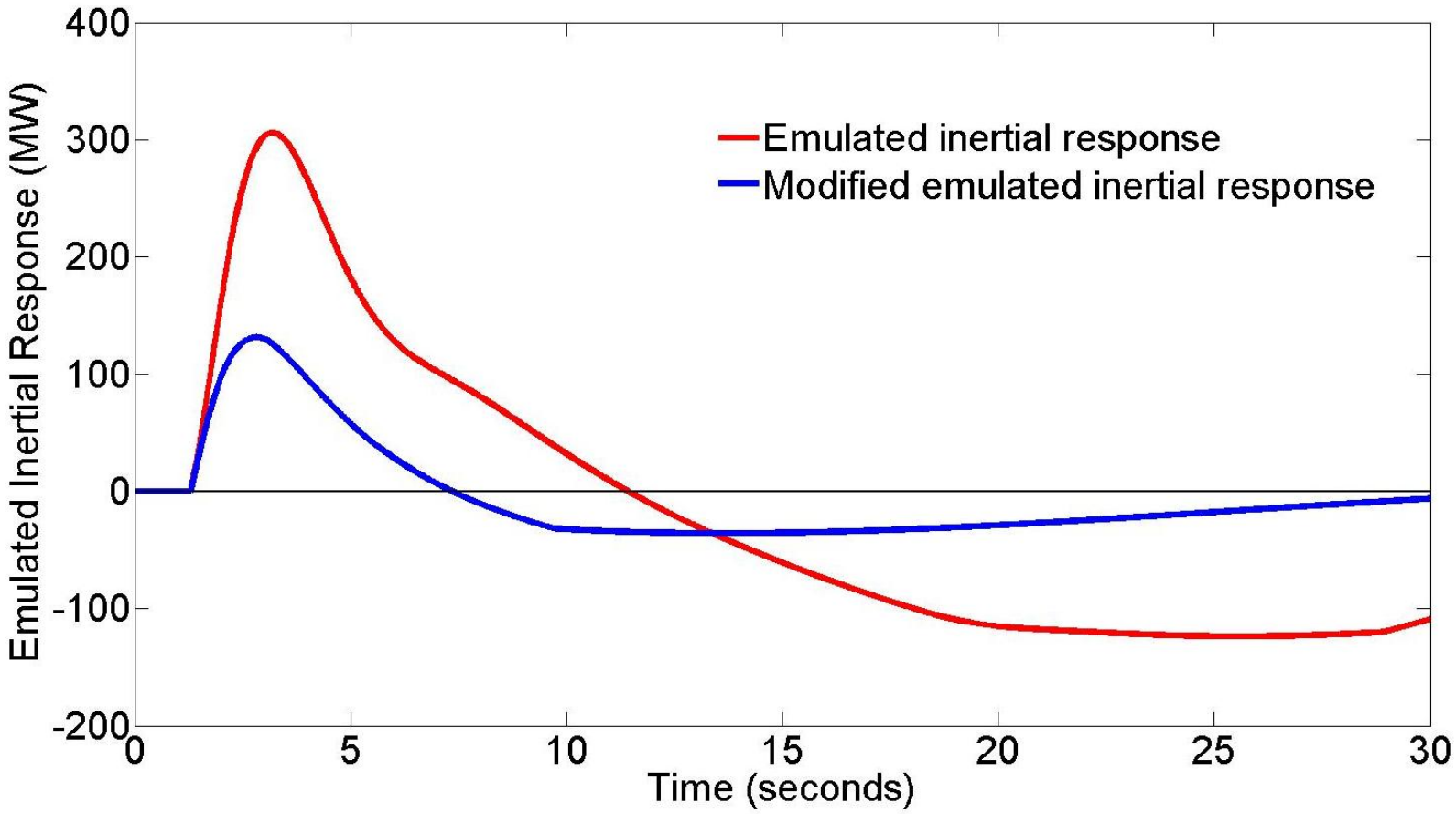
Frequency Nadir Distribution



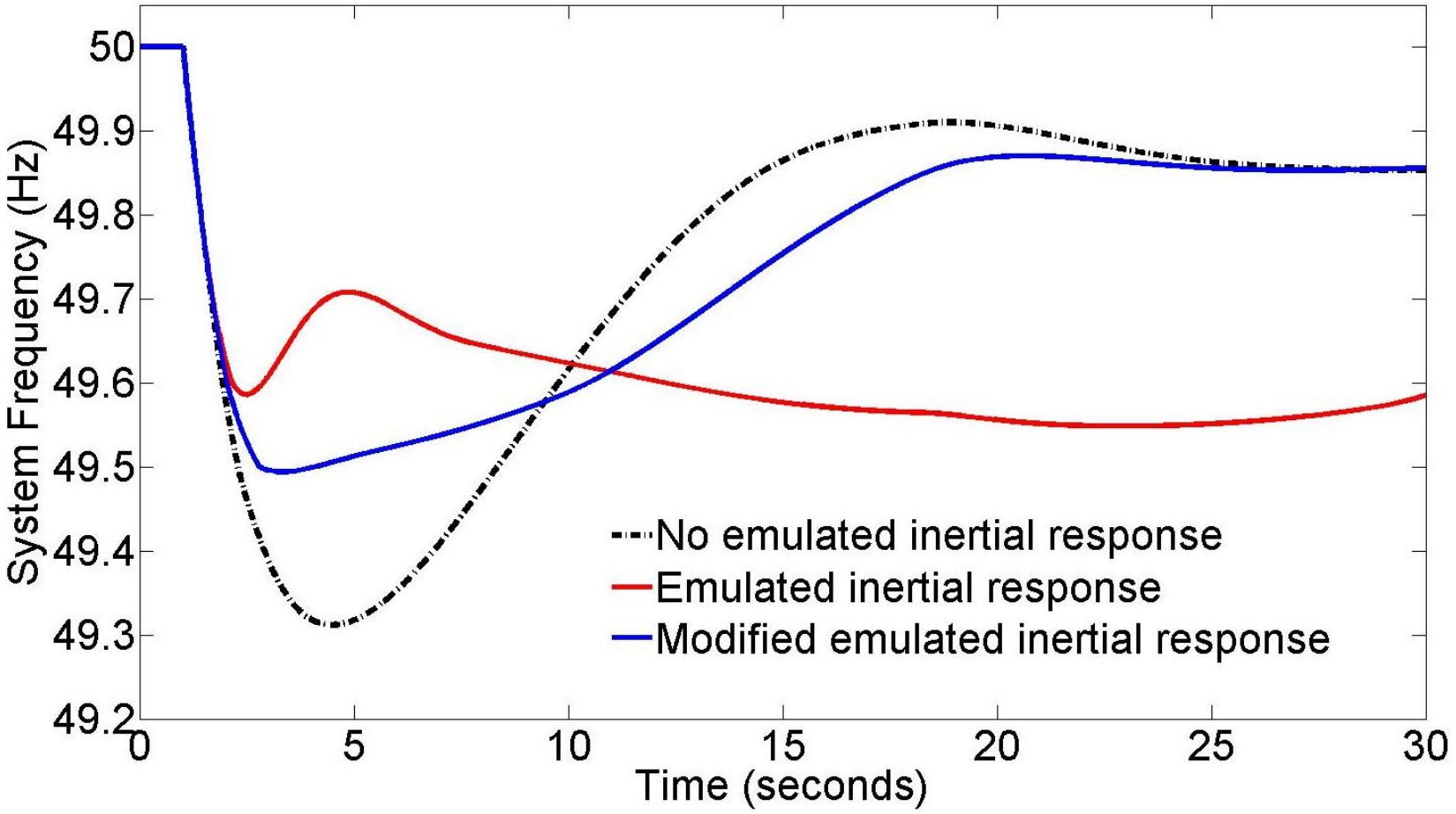
GE WindINERTIA



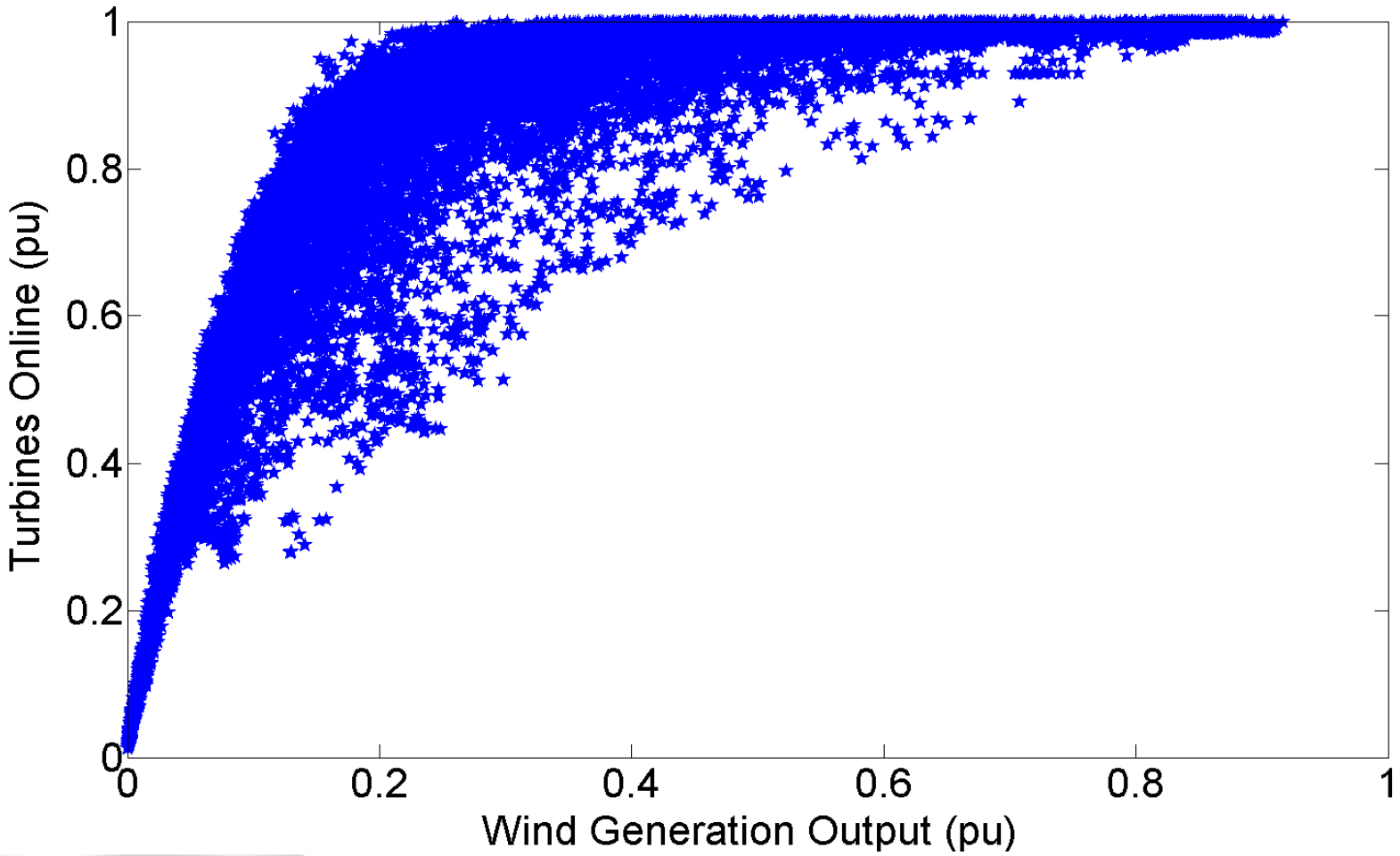
Response Shape



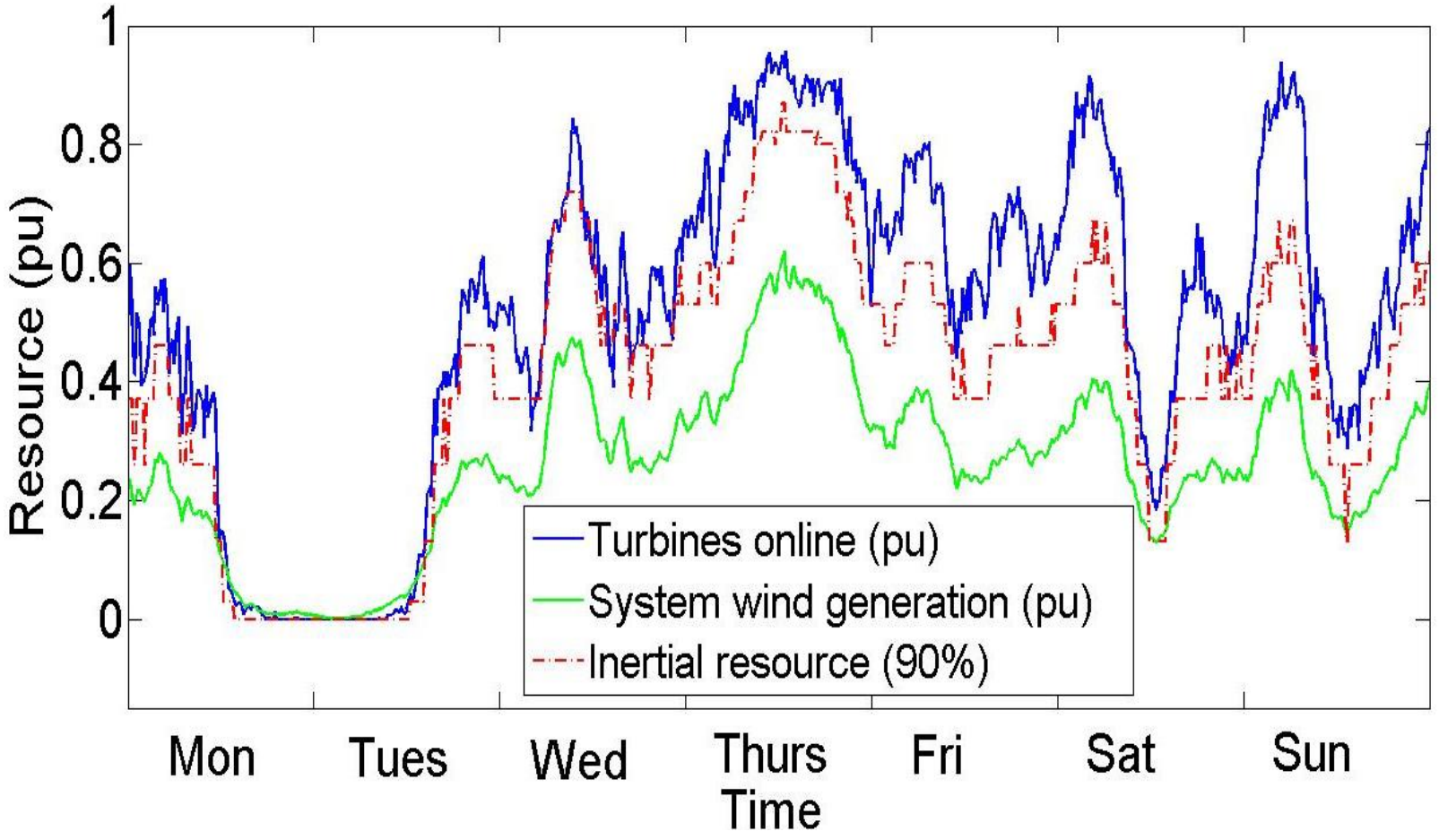
Response Shape



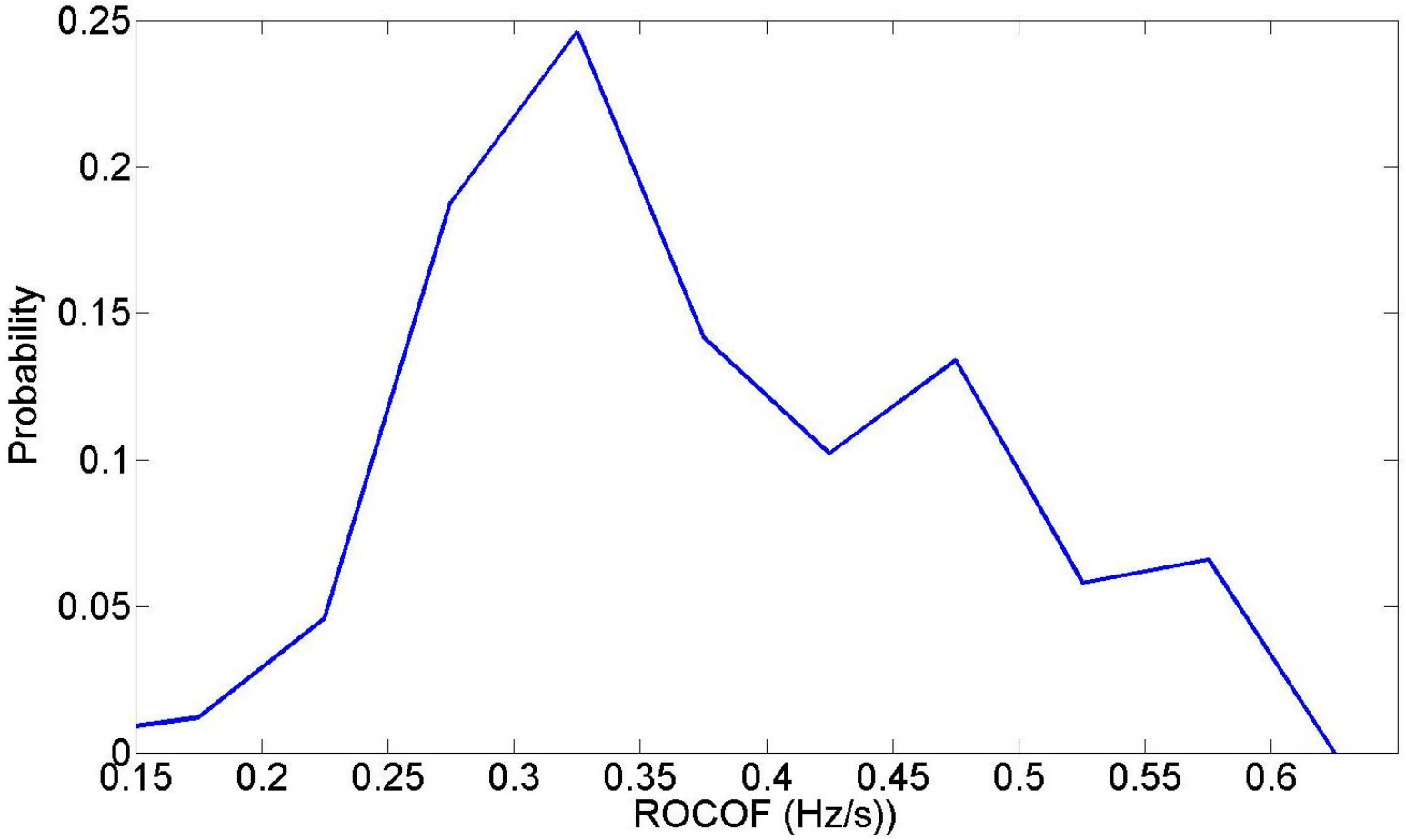
Wind Farm Aggregation



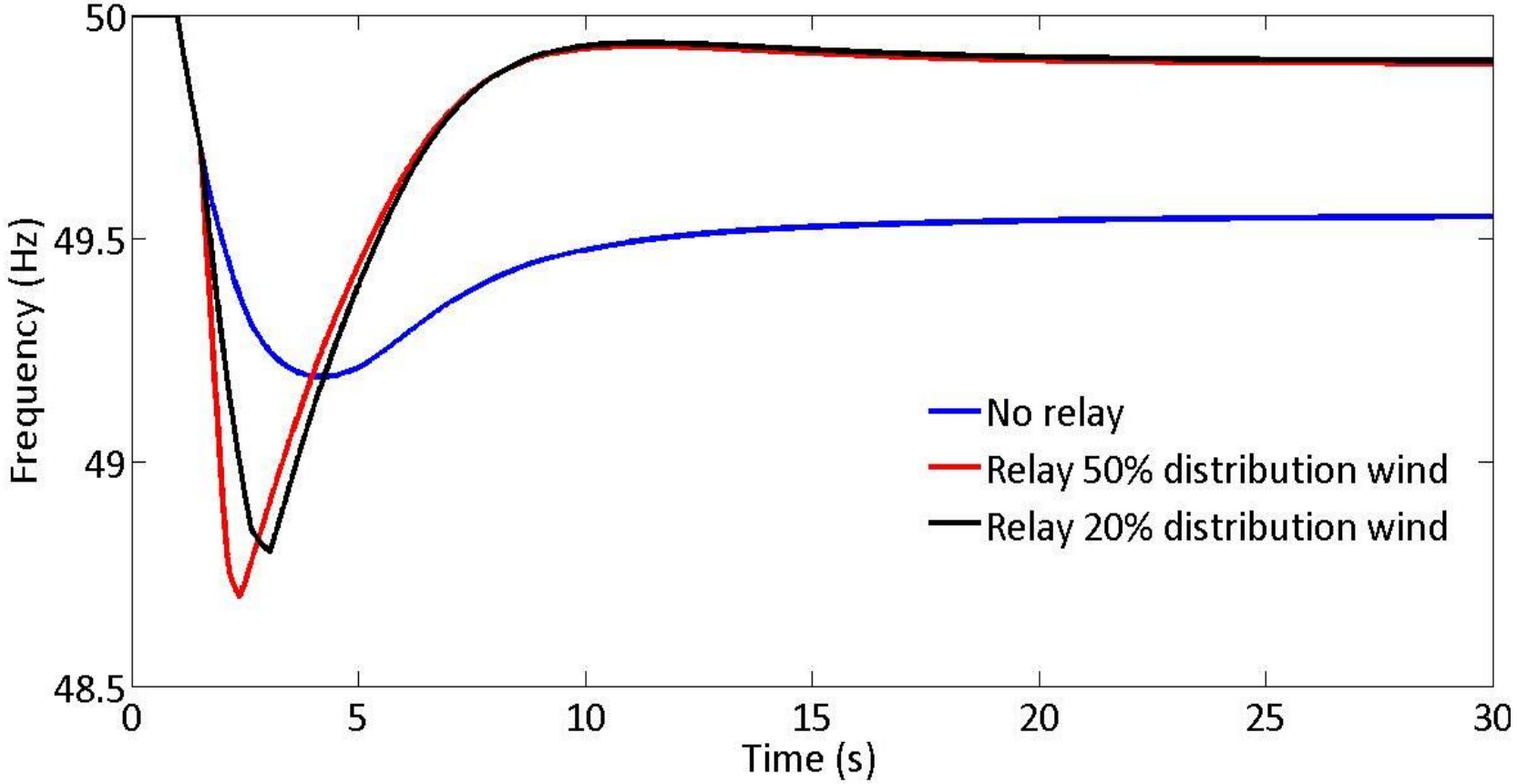
Resource Availability



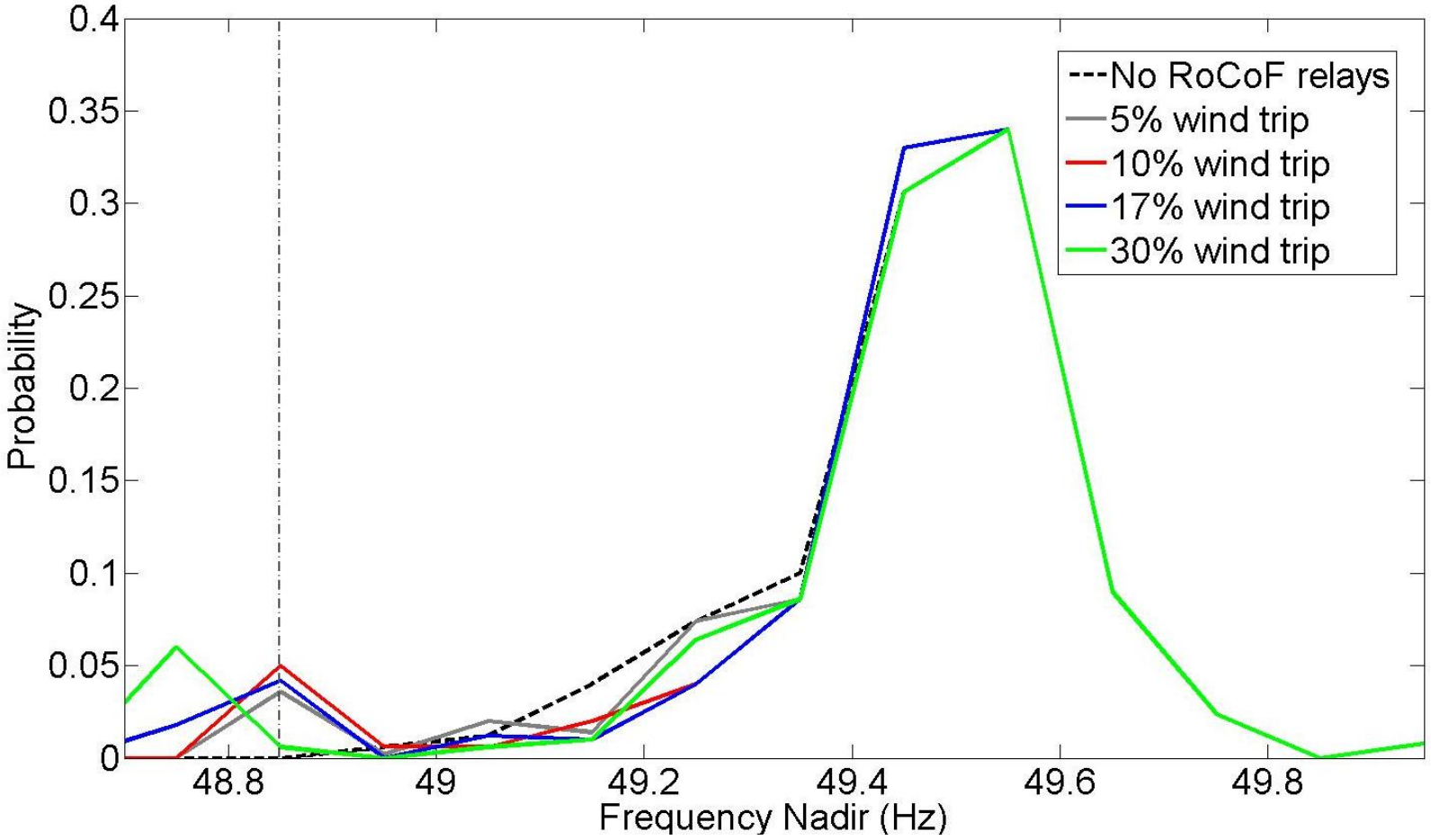
RoCoF Distribution



Impact of RoCoF Relays



Impact of RoCoF Relays



Demonstration project

- Demonstrate GE WindINERTIA product
- Understand response capability
- Tune service to suit the Ireland system
- Assess monitoring method for the basis of potential remuneration

Conclusions

- Decay in frequency response behaviour
  - *Milliseconds* → *seconds*
- RoCoF relays
- Synthetic inertia considerations

Next Steps

- Over-frequency response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PV Analysis Study
A focus on Donegal area

25/09/2013

Mostafa Bakhtvar

Introduction

Wind Farms a rich source of renewable energy

Higher capacities of wind

Displacement of power generated by conventional generators

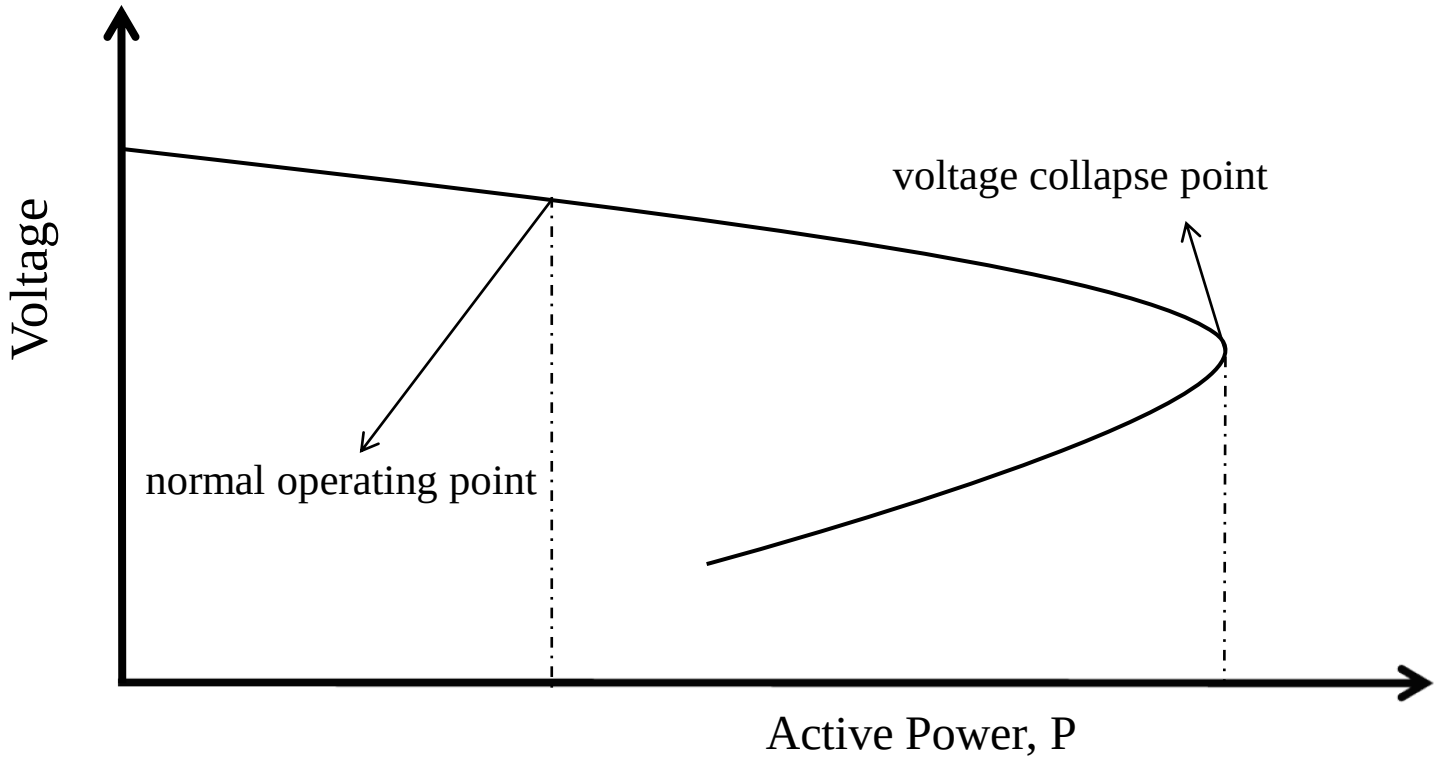
Reduction in reactive power sources in the network

Operation of the electric network close to its limits

Stability:

Voltage

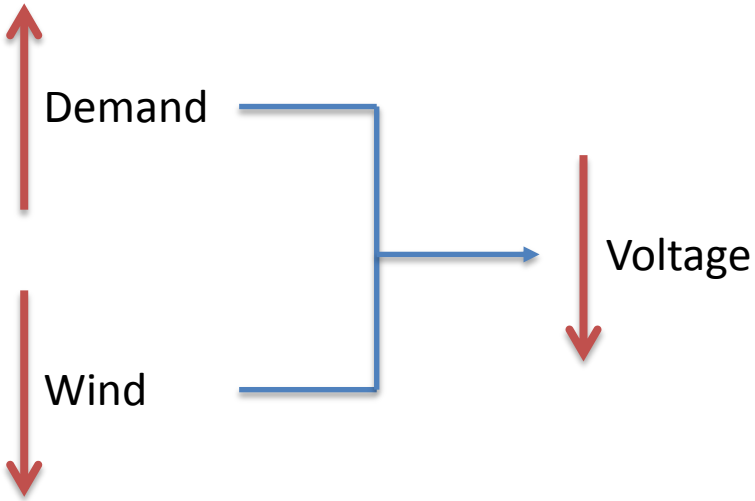
Introduction: PV Curve



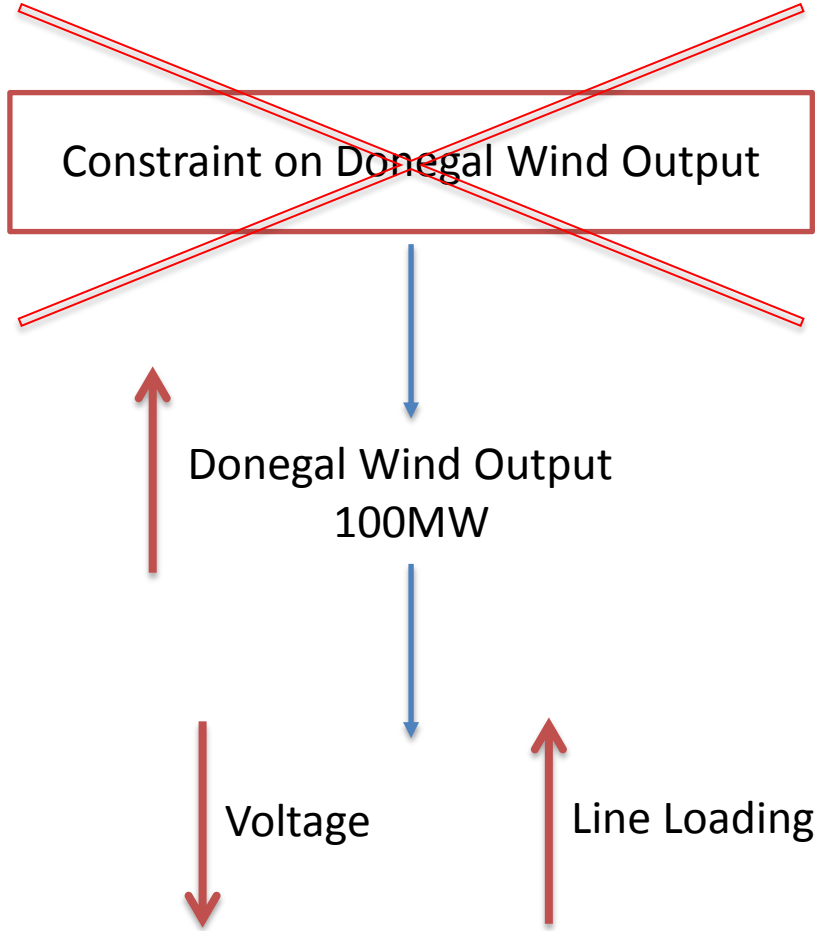
Donegal Area

Donegal events in the recent years

December 2010



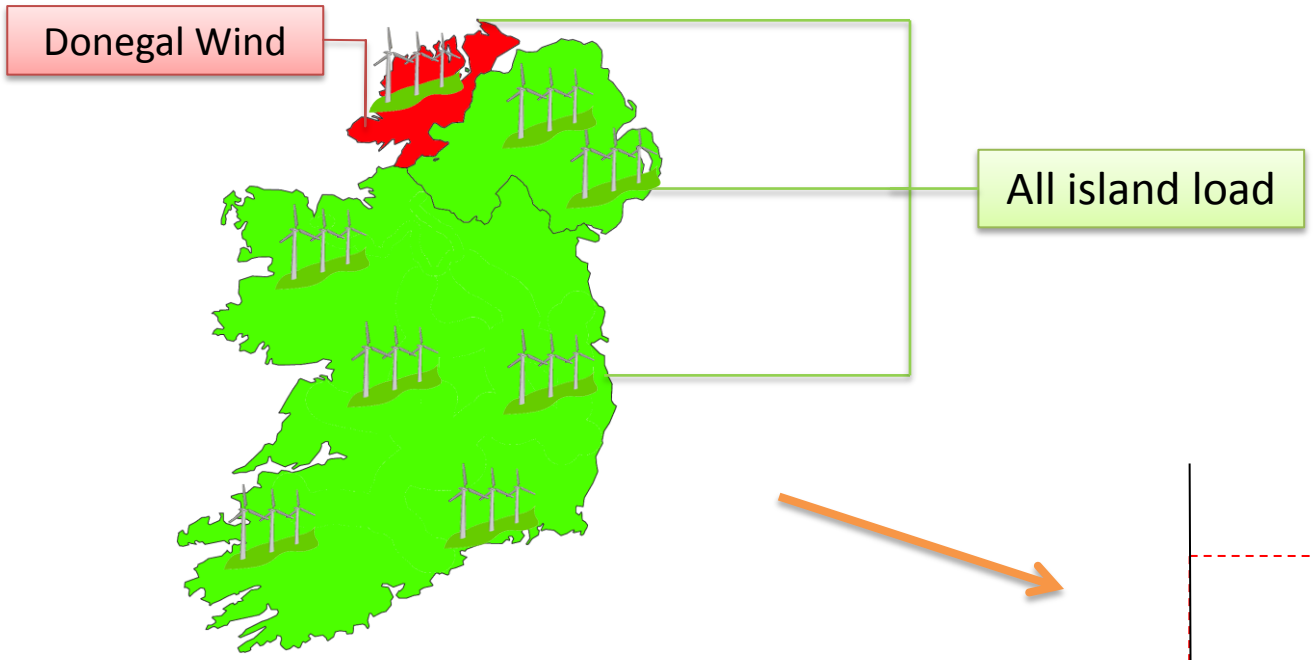
July 2013

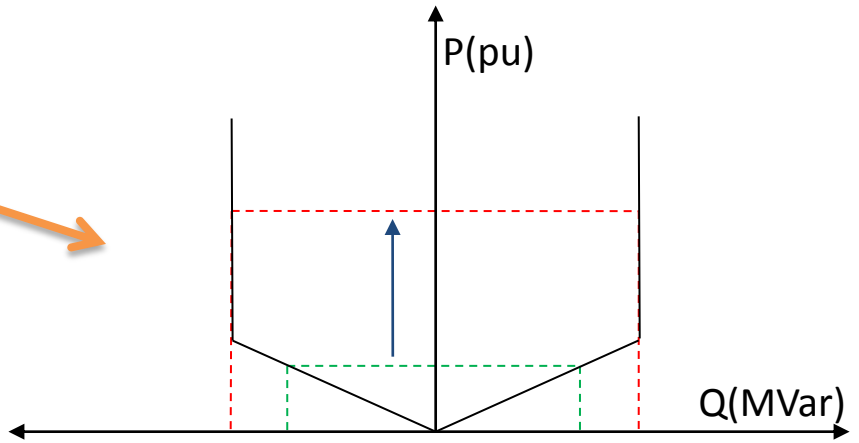


Analysis Type: Wind Rise

Increase in Donegal wind output from base case operating point

Compensated by increase in all island load





Reactive power control schemes

- **0.95 Inductive power factor:** All wind farms in Donegal area generate power with 0.95 inductive power factor
- **Unity power factor:** All wind farms in Donegal area generate power with unity power factor
- **Voltage control:** All wind farms in Donegal area control voltage at

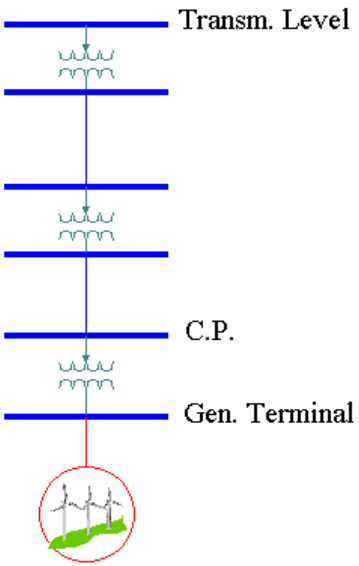
Transmission voltage level

TSO

Aggregated generator terminal

DSO

Voltage set point 1.03 ~ 1.06 p.u.

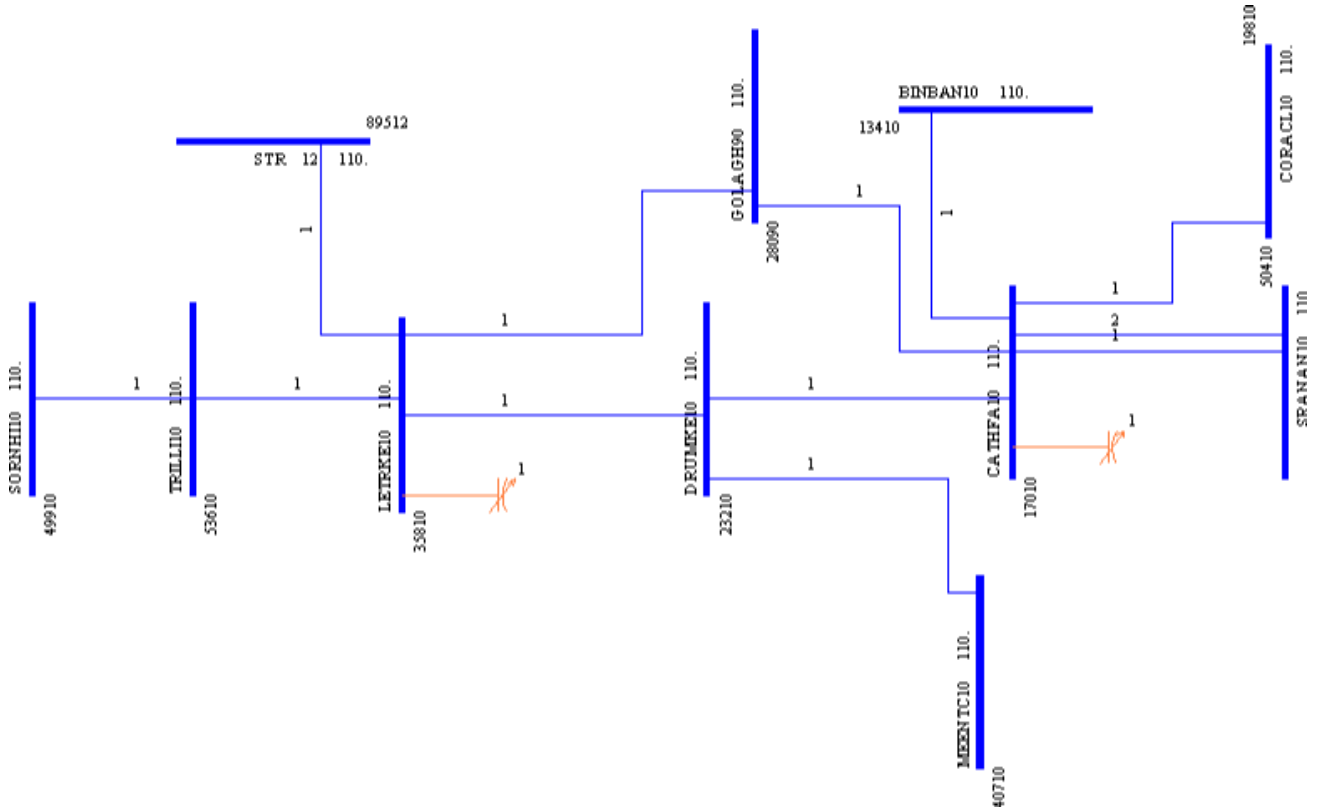


Further Assumptions

- Tapchanging transformers
- Shunt compensators
- Hydro generators
- Network Topology

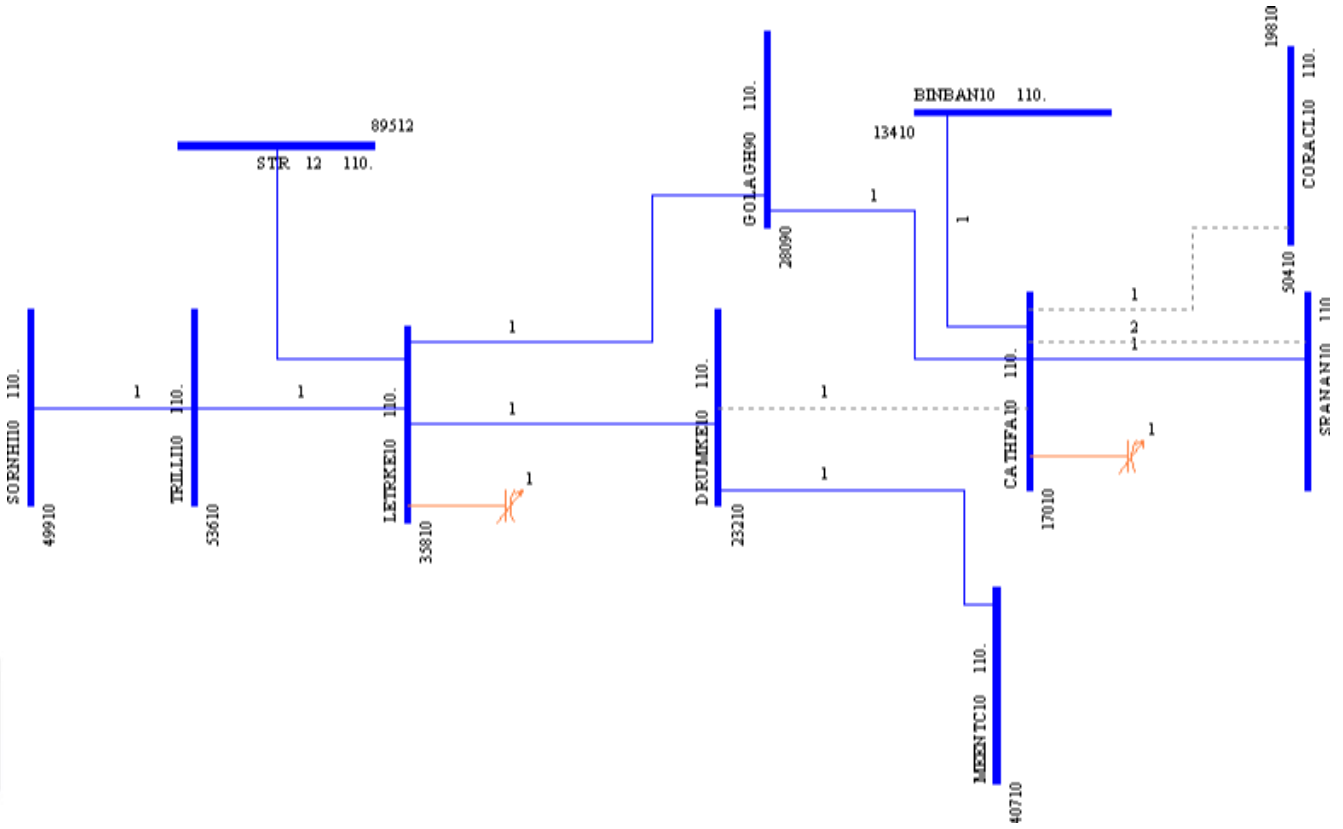
Study Scenarios

Scenario	All Island Wind Output (MW)	Donegal Wind Output (MW)	All Island Demand (MW)	Donegal Demand (MW)
High Wind – High Demand	1461	231	4667	129

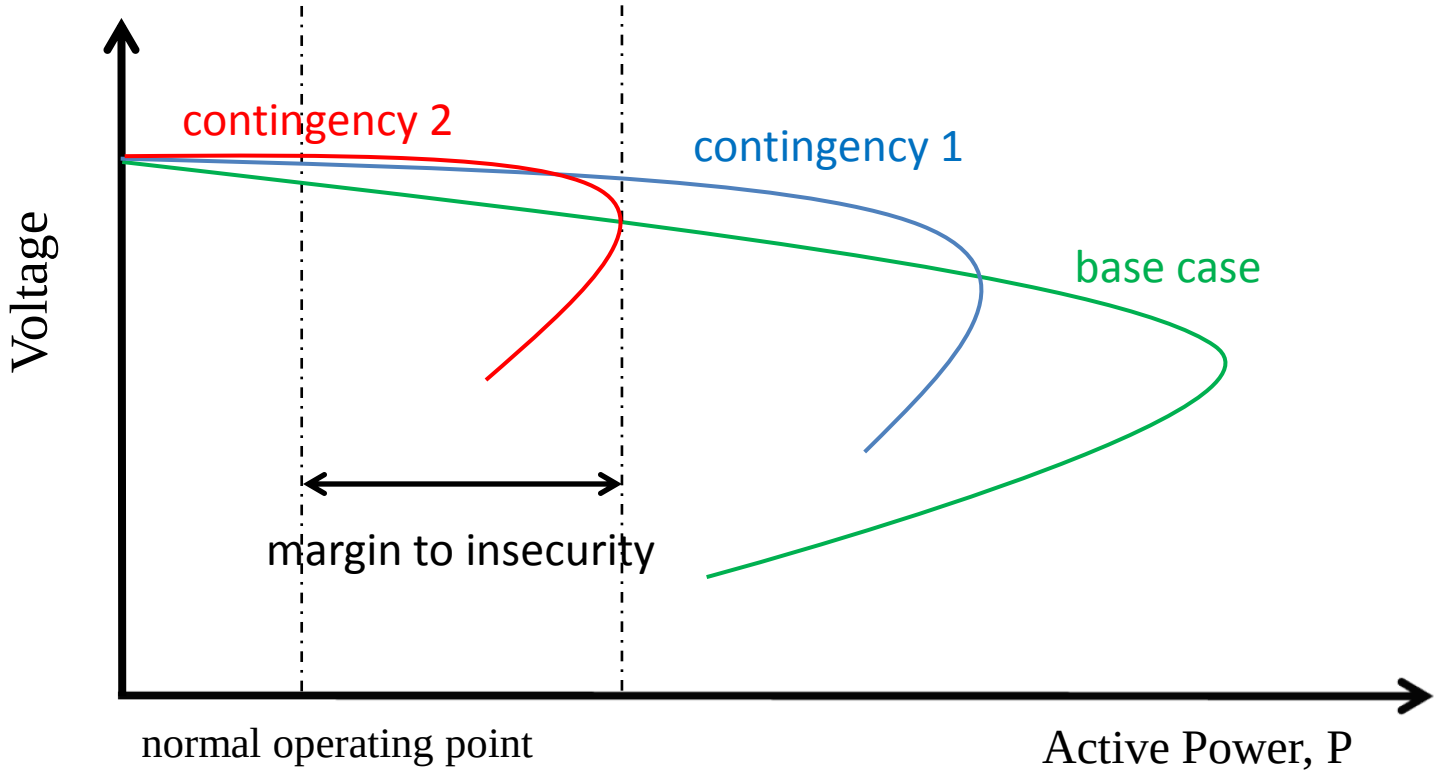


Study Scenarios

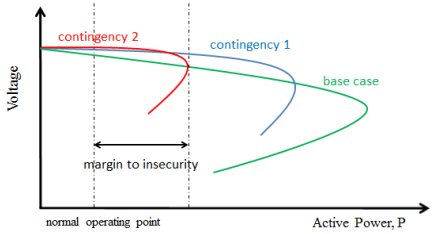
Scenario	All Island Wind Output (MW)	Donegal Wind Output (MW)	All Island Demand (MW)	Donegal Demand (MW)
High Wind – Low Demand	1114	111	2176	28

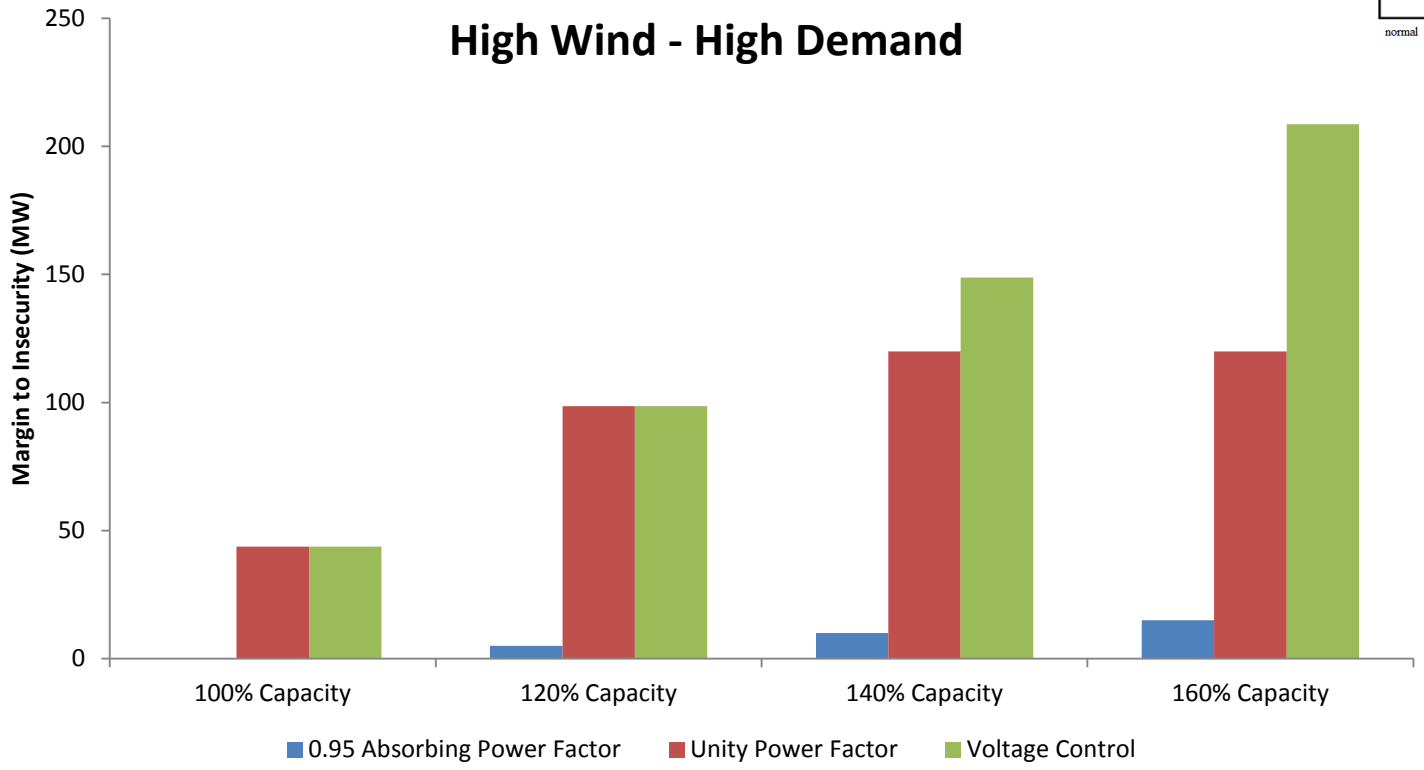


Results: Margin to Insecurity

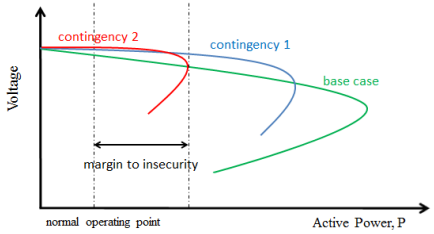


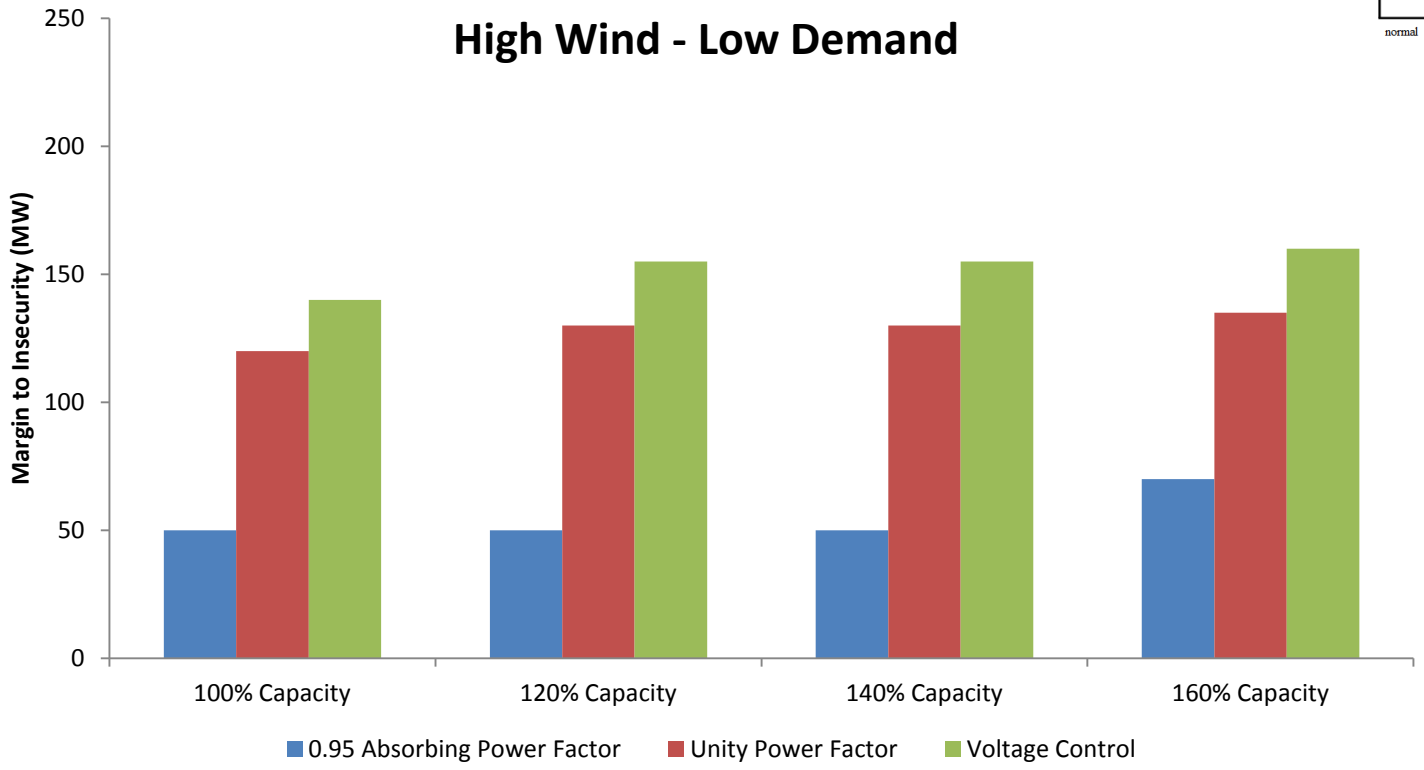
Results: Margin to Insecurity



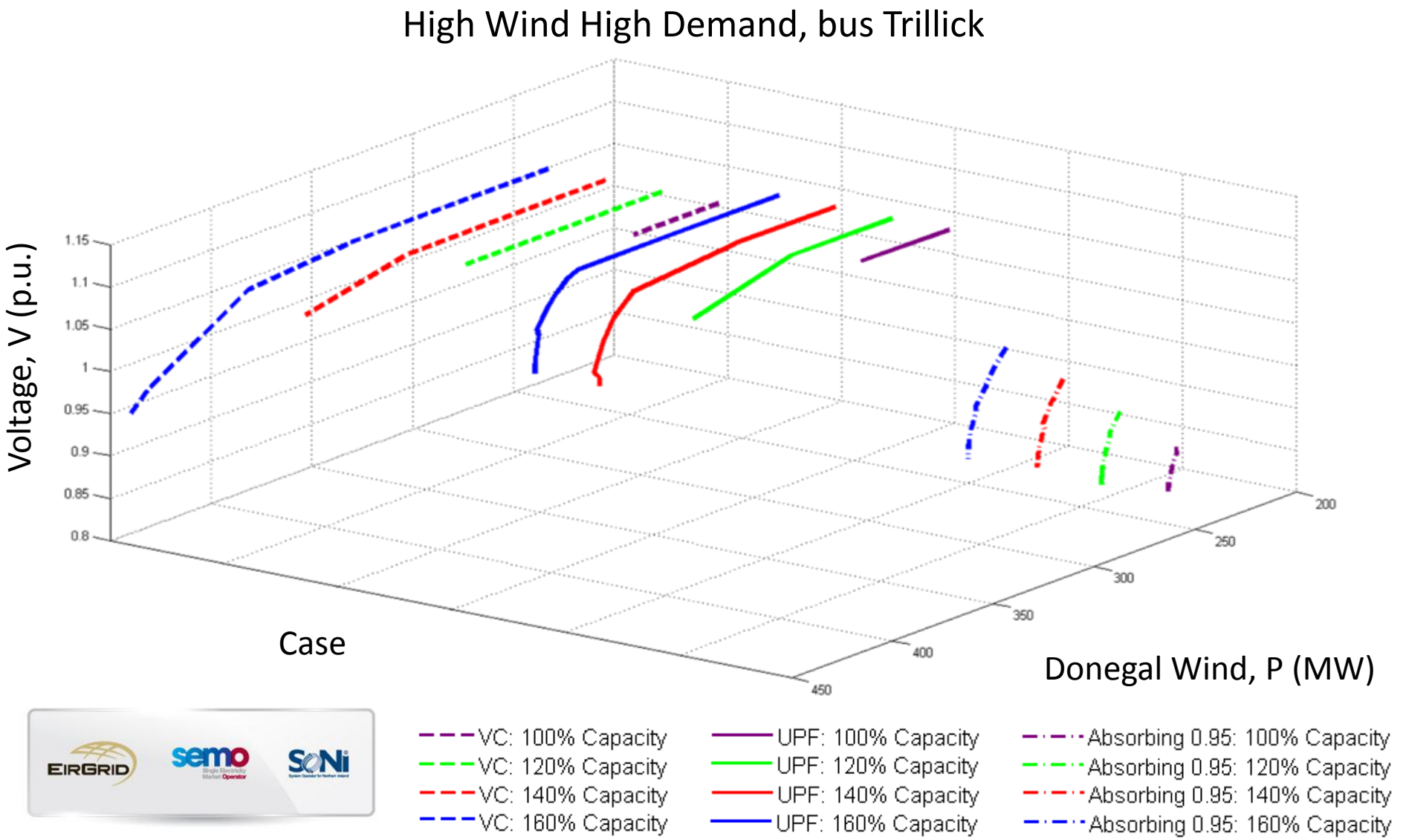


Results: Margin to Insecurity

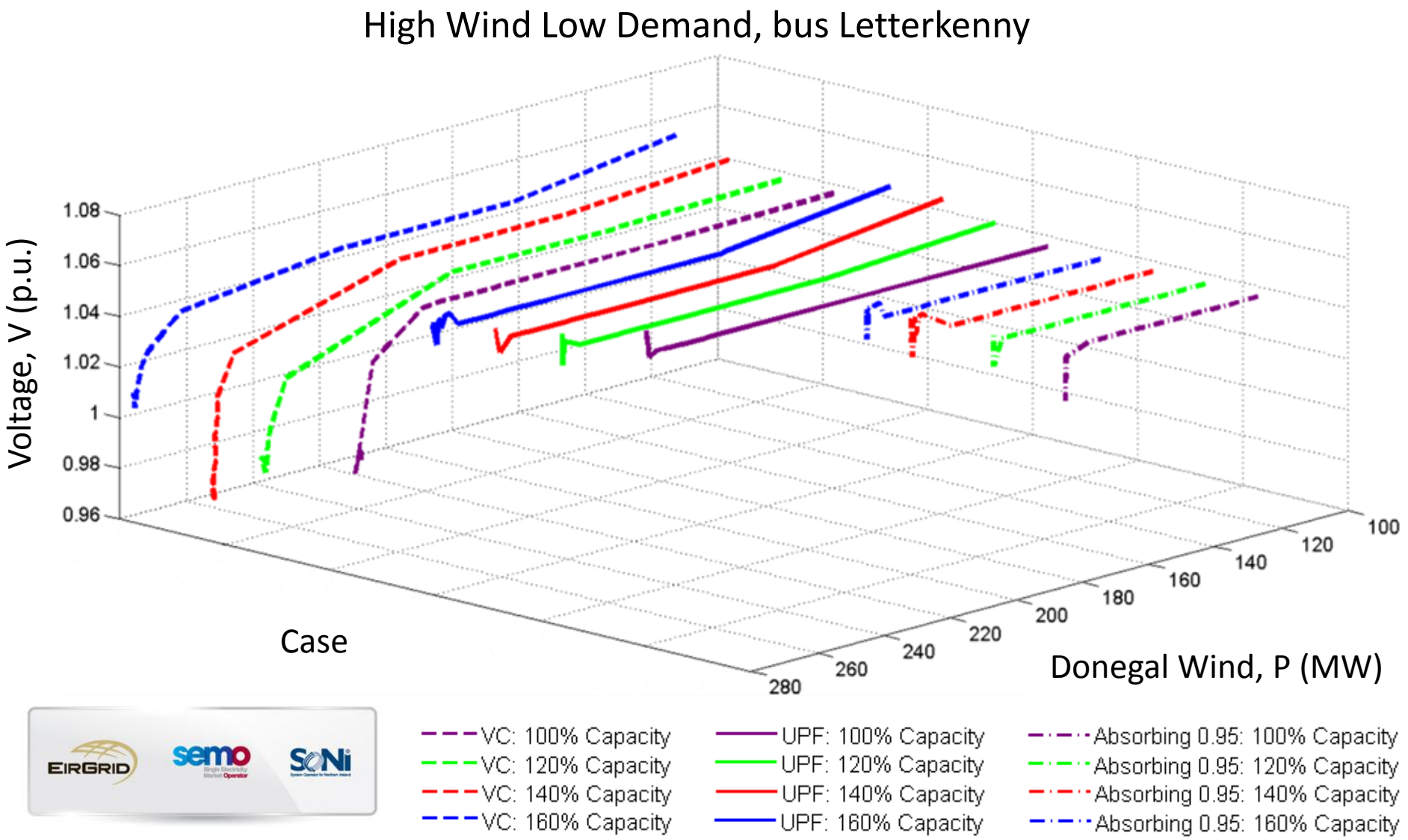




Results: Loss of NI Connection



Results: Loss of NI Connection



Summary

- **An analysis of the voltage stability in Donegal area**
  - ❖ Strong network: High Wind – High Demand
  - ❖ Weak network: High Wind – Low Demand

- **Margin to voltage collapse:**
  - ❖ Constant power factor schemes (0.95 inductive power factor & unity power factor)
  - ❖ Voltage control scheme

- **Indication of voltage collapse:**
  - Constant power factor schemes (0.95 inductive power factor & unity power factor)
  - Voltage control

Next Steps

- **WSAT Model:**
  - ❖ Consider adding a more representative model for distribution level
  - ❖ Consider wind transfer increase for Donegal area (4th July 2013)

- **Further Studies**
  - ❖ Weak and intact network cases
  - ❖ Wind transfer increase and decrease for Donegal area

- **Future study to consider**
  - ❖ Voltage control scheme vs. additional transmission equipment

- **Consider changing policy on 0.95 absorbing power factor to unity power factor or voltage control**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Voltage Dip-Induced Frequency Dips Study

Séamus Power

25th September 2013

Voltage Dip-Induced Frequency Dip

Severe System Fault

Voltage Dip

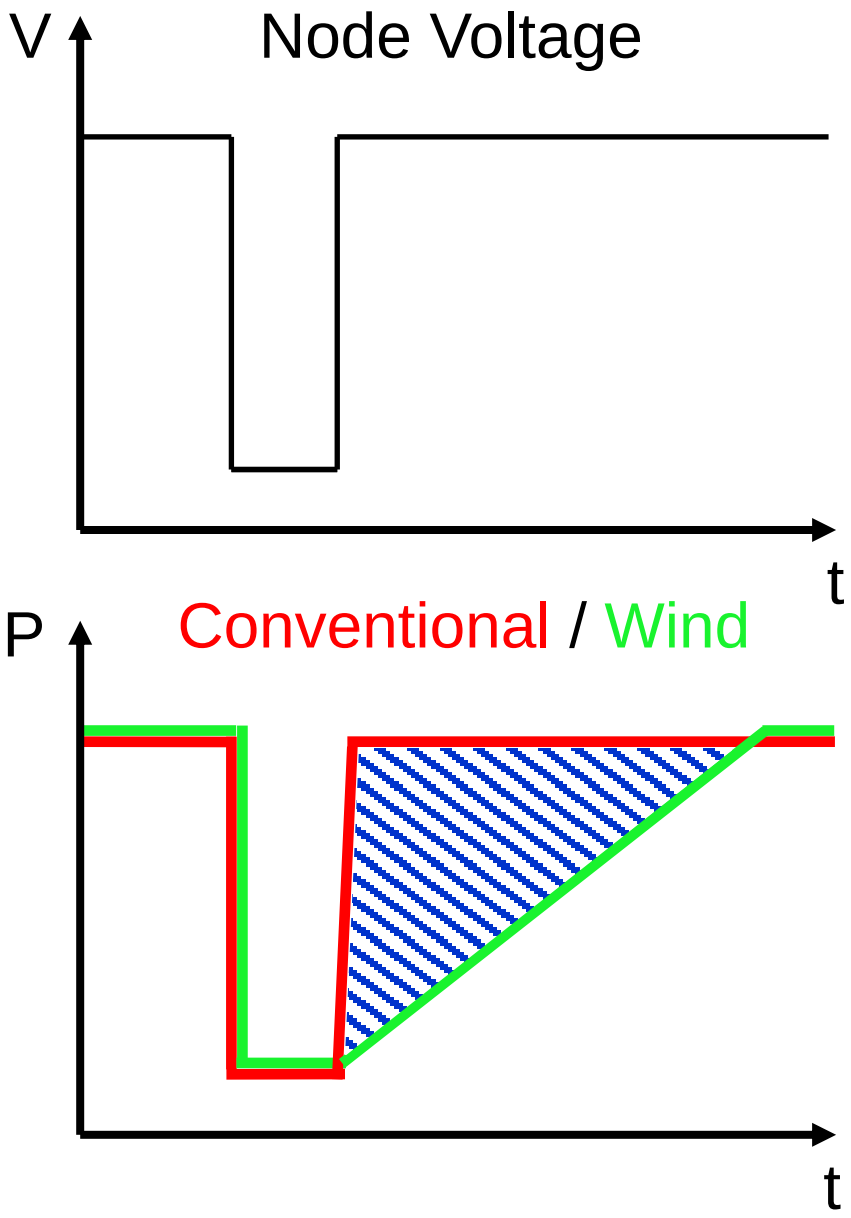
Reduction in Active Power

Fault is Cleared

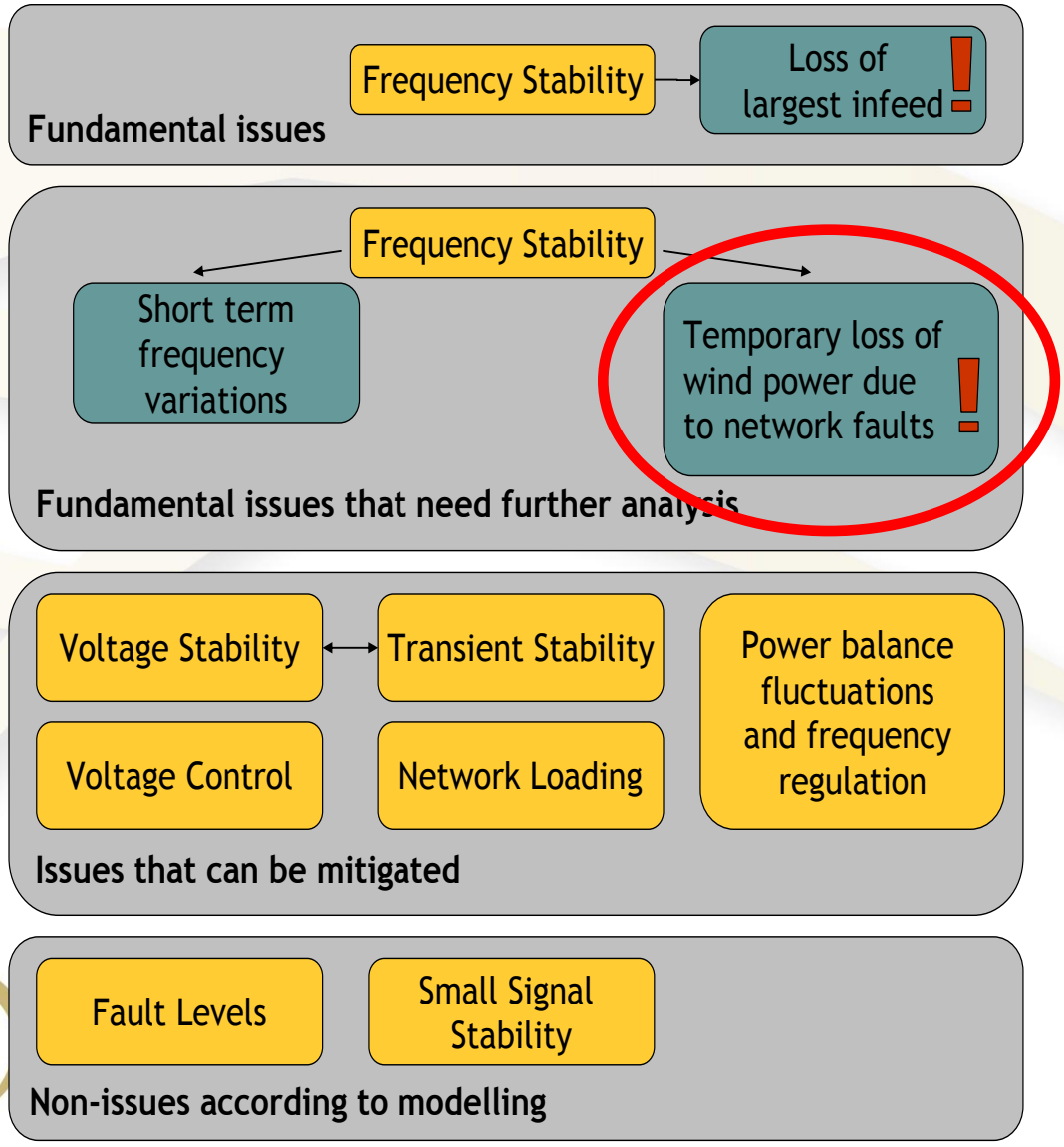
Slow Active Power Recovery

Temporary Energy Imbalance

Frequency Dip



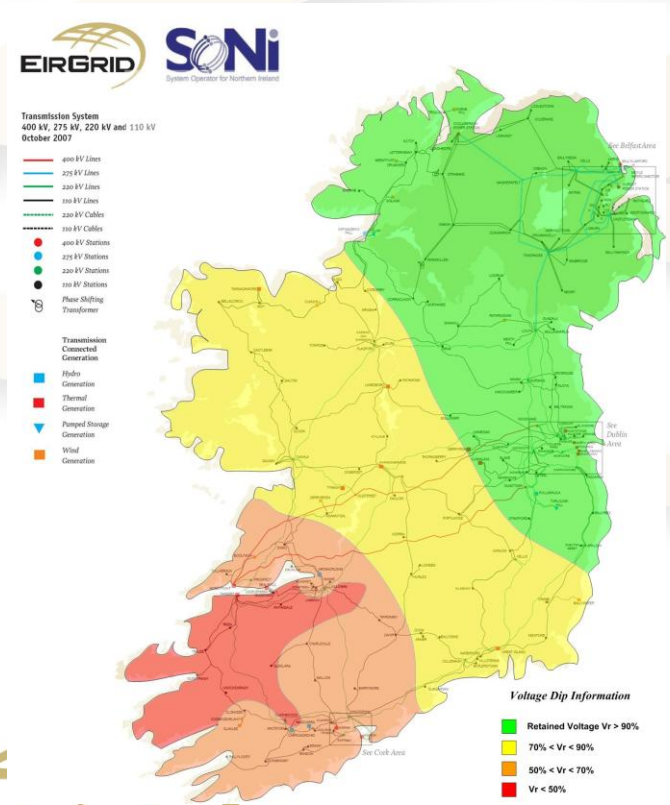
Key Findings

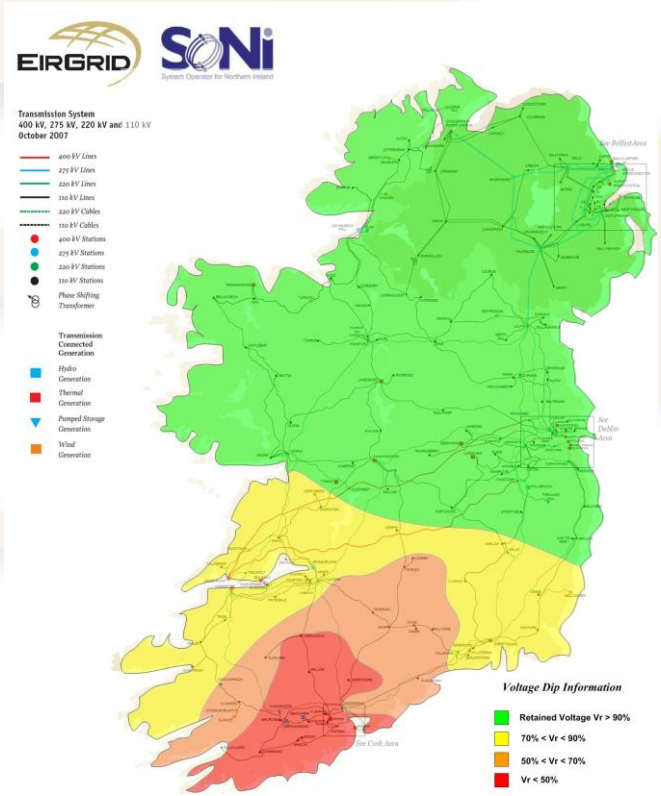


EIRGRID

Key Finding 4: Single Largest Contingency may change

With large amounts of wind power, a transmission fault of 100ms has the potential to result in a MW reduction greater than that of the largest single in-feed, potentially resulting in serious frequency events.

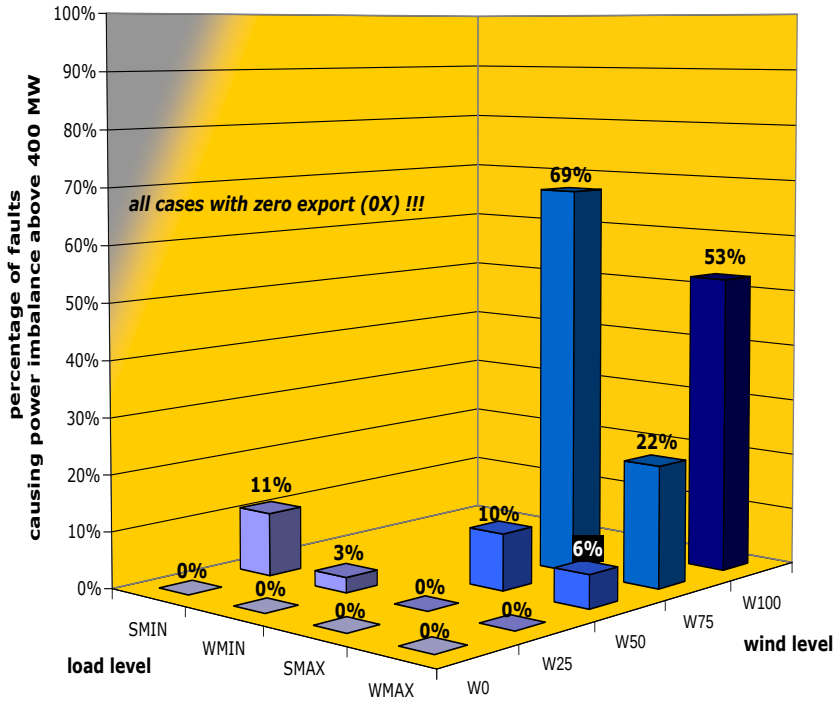




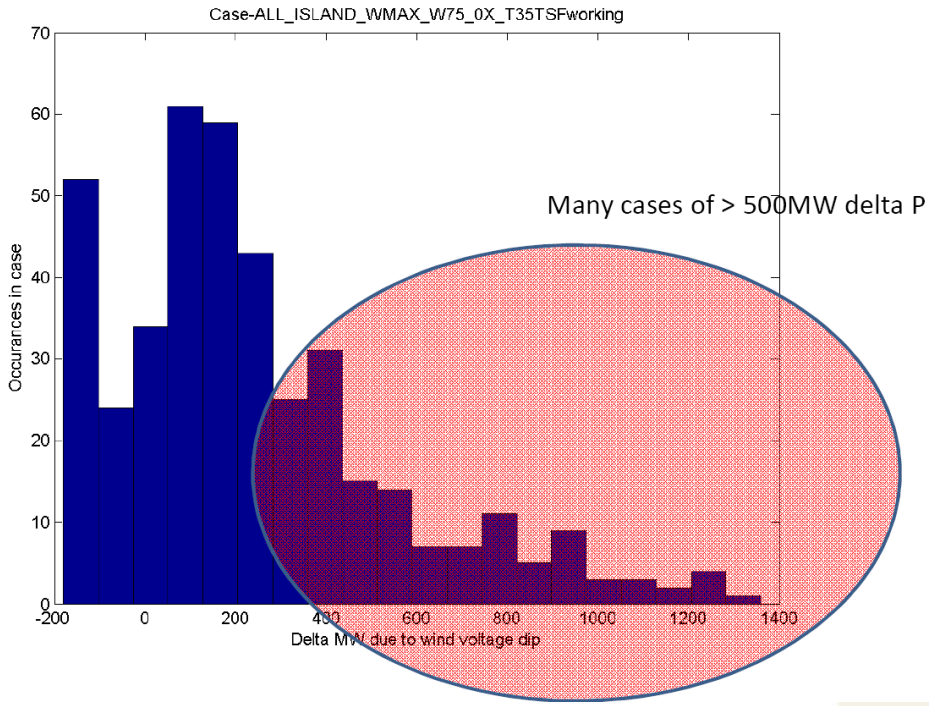
EIRGRID

Key Finding 4: Single Largest Contingency may change

Faults with wind reductions > 400MW



Winter Maximum, 75% Wind - Post fault wind MW reductions



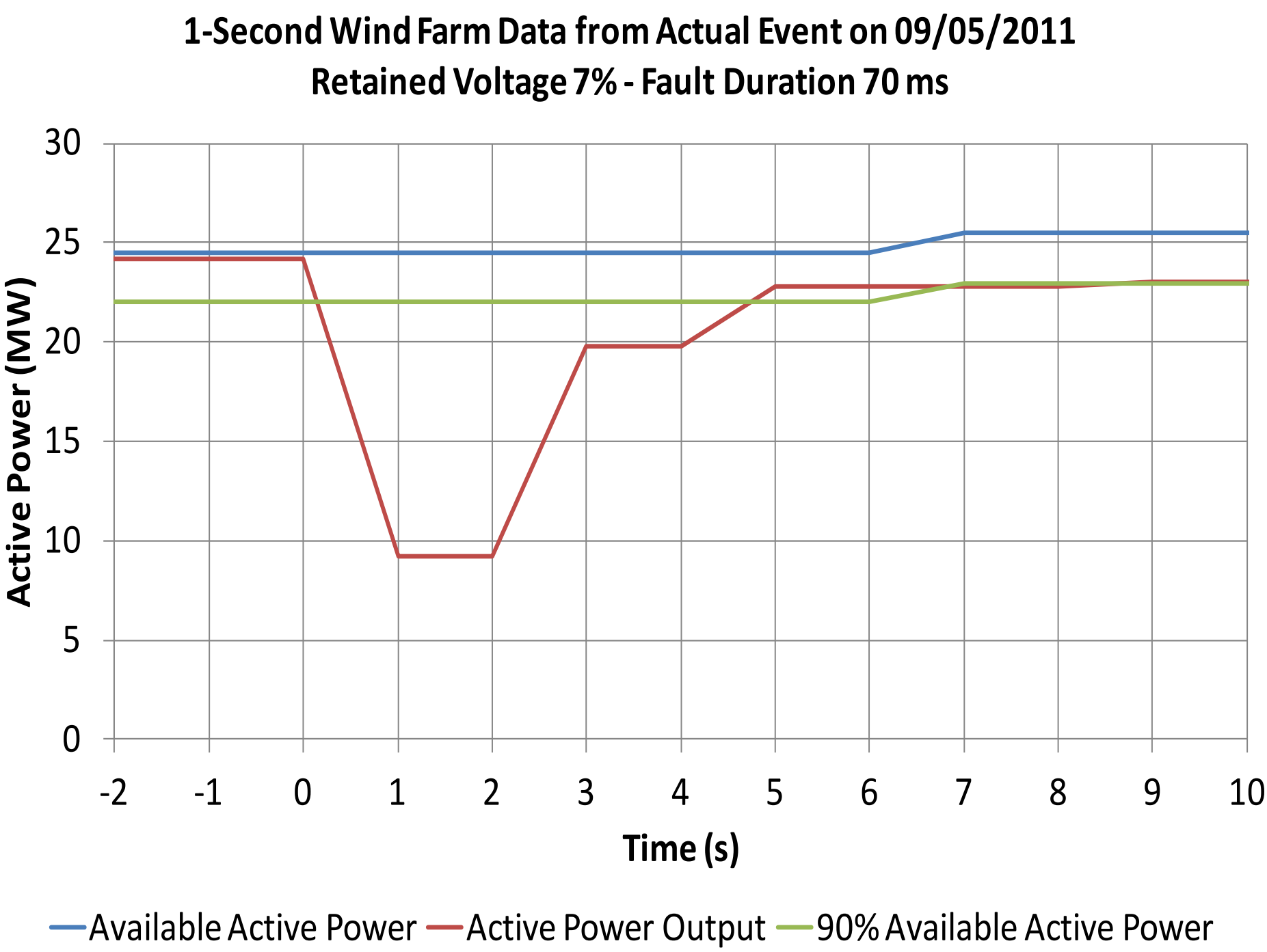
Cause

Wind turbines limiting active power following faults

- Mechanical stresses due to oscillations in the turbine tower

Severity of frequency dip depends on:

- Wind penetration
- System Inertia
- Severity of fault
- Location of fault
- Connection method of wind farms
- Distribution System Anti-Islanding Protection
- Type, make and model of wind turbines

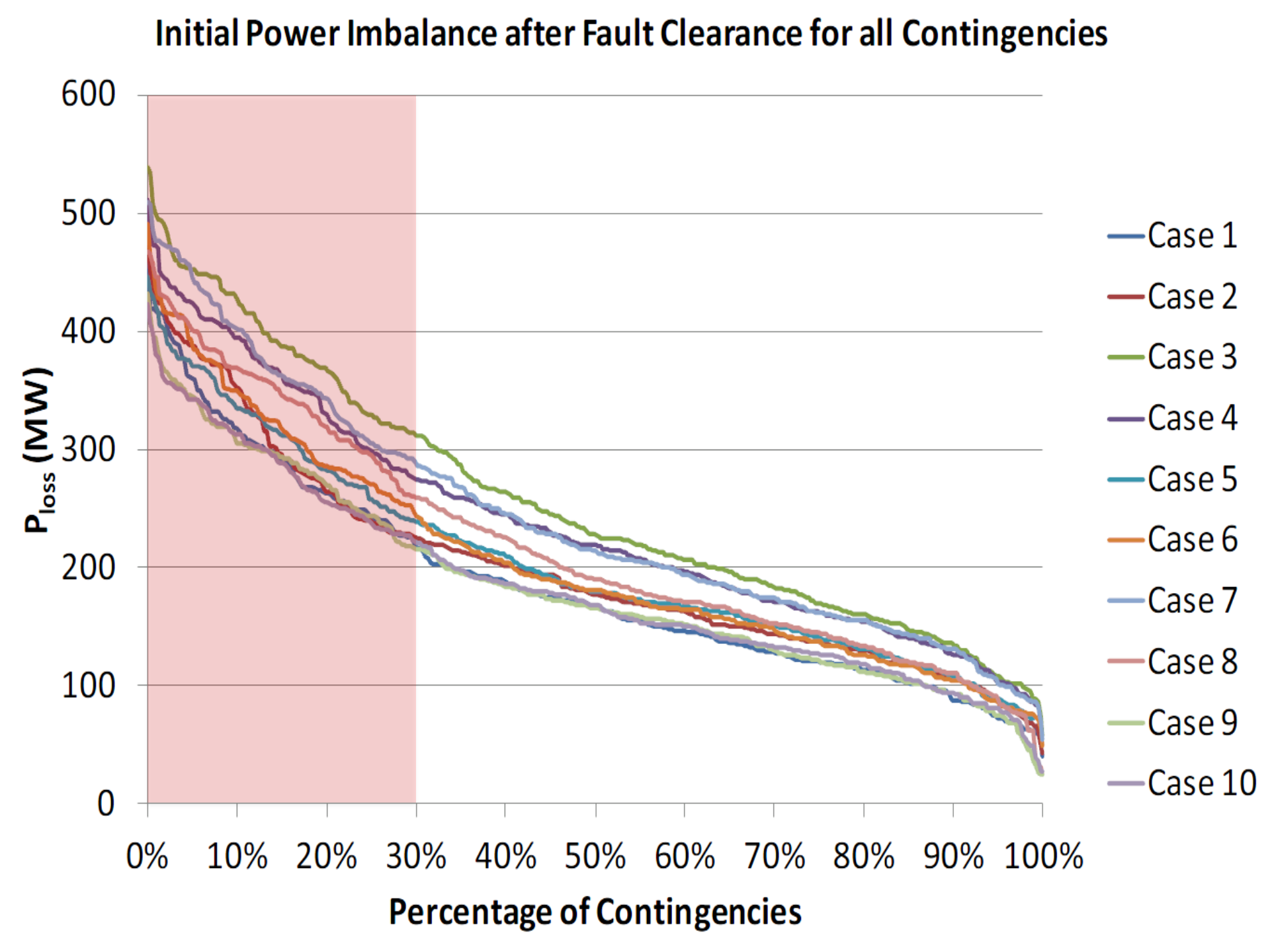

1-Second Wind Farm Data from Actual Event on 09/05/2011
Retained Voltage 7% - Fault Duration 70 ms
Active Power (MW)
30
25
20
15
10
5
0
-2
-1
0
1
2
3
4
5
6
7
8
9
10
Time (s)
Available Active Power
Active Power Output
90% Available Active Power

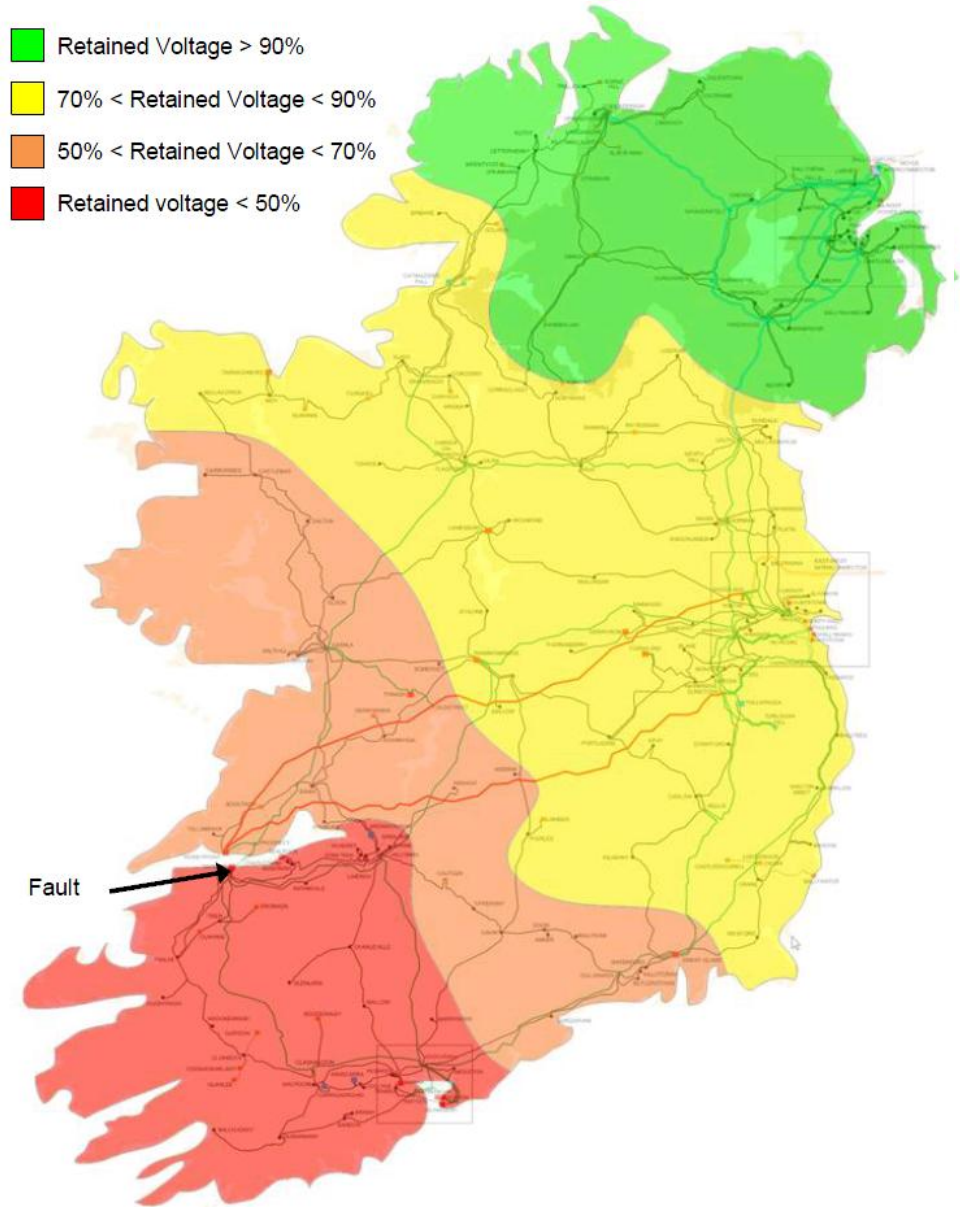
Screening Study

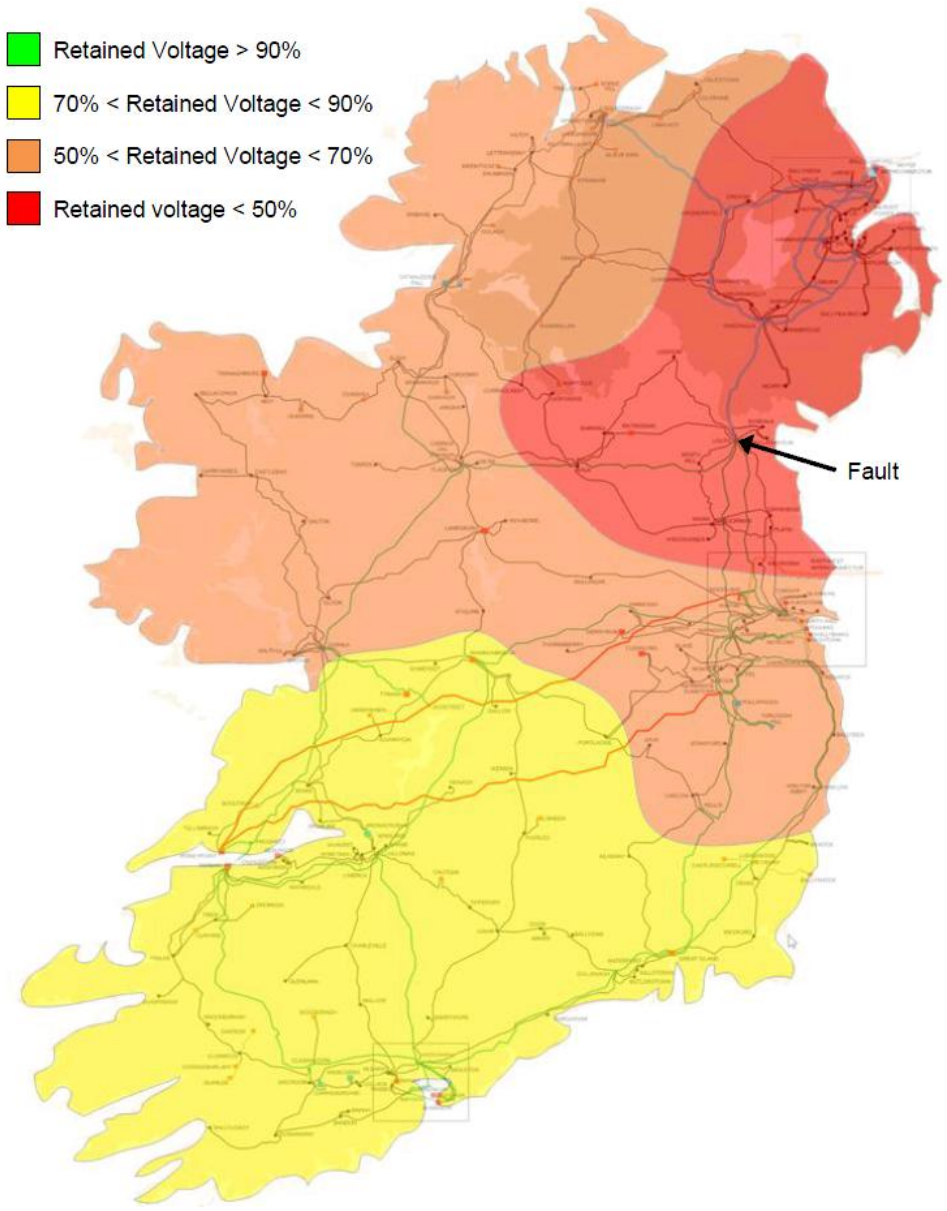
- 10 snapshots of 2012/3 system
  - high wind & variety of demand levels, dispatches, network configurations

- Three-phase faults applied to all busbars in system

$$P_{imb} = \sum_{w=1}^{total\ no.\ of\ wind\ farms} \frac{V_{pre,w} - V_{inc,w}}{V_{pre,w}} \times P_{pre,w}$$

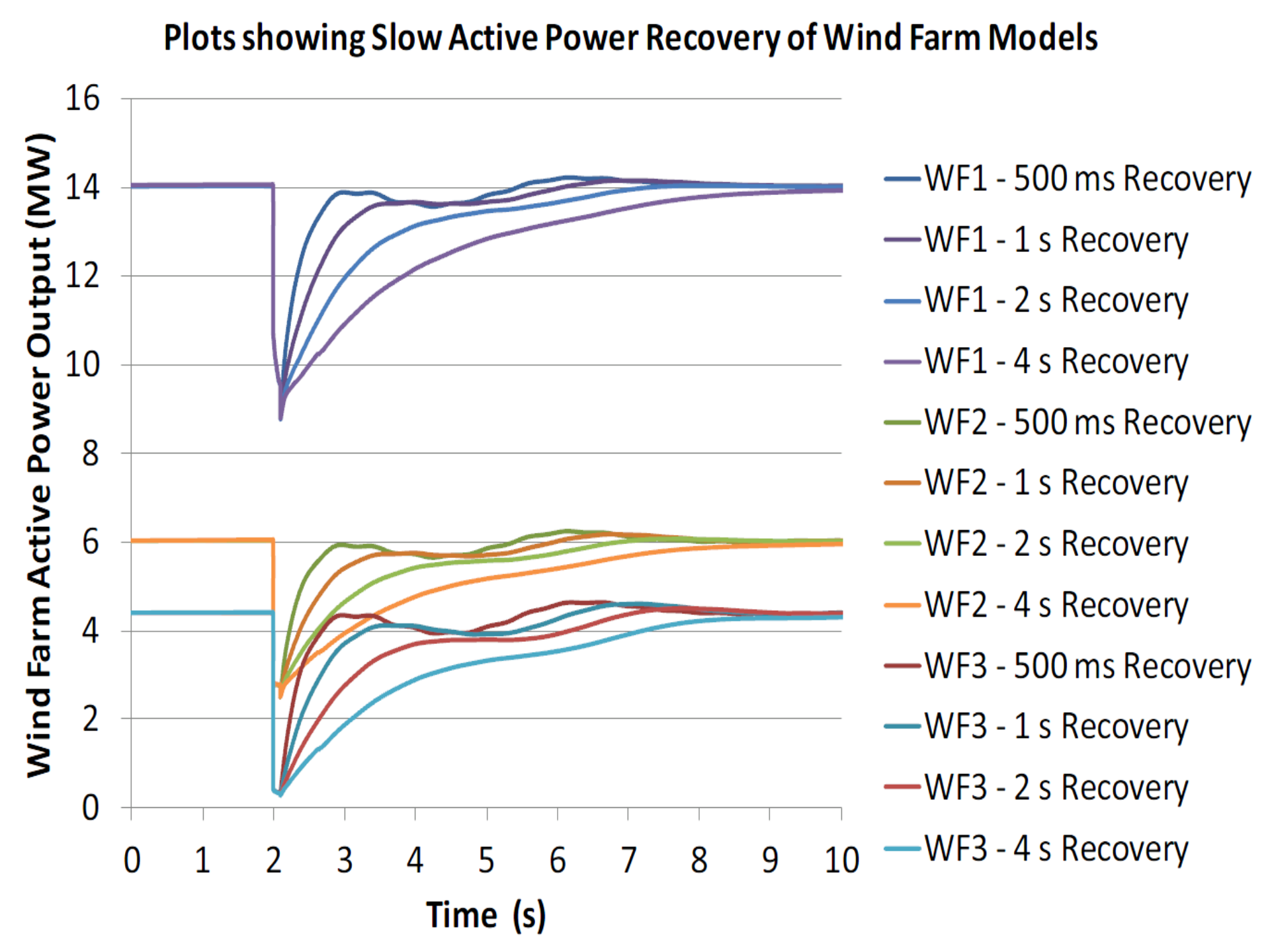

Initial Power Imbalance after Fault Clearance for all Contingencies
600
500
400
300
200
100
0
P_{loss} (MW)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Contingencies
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10

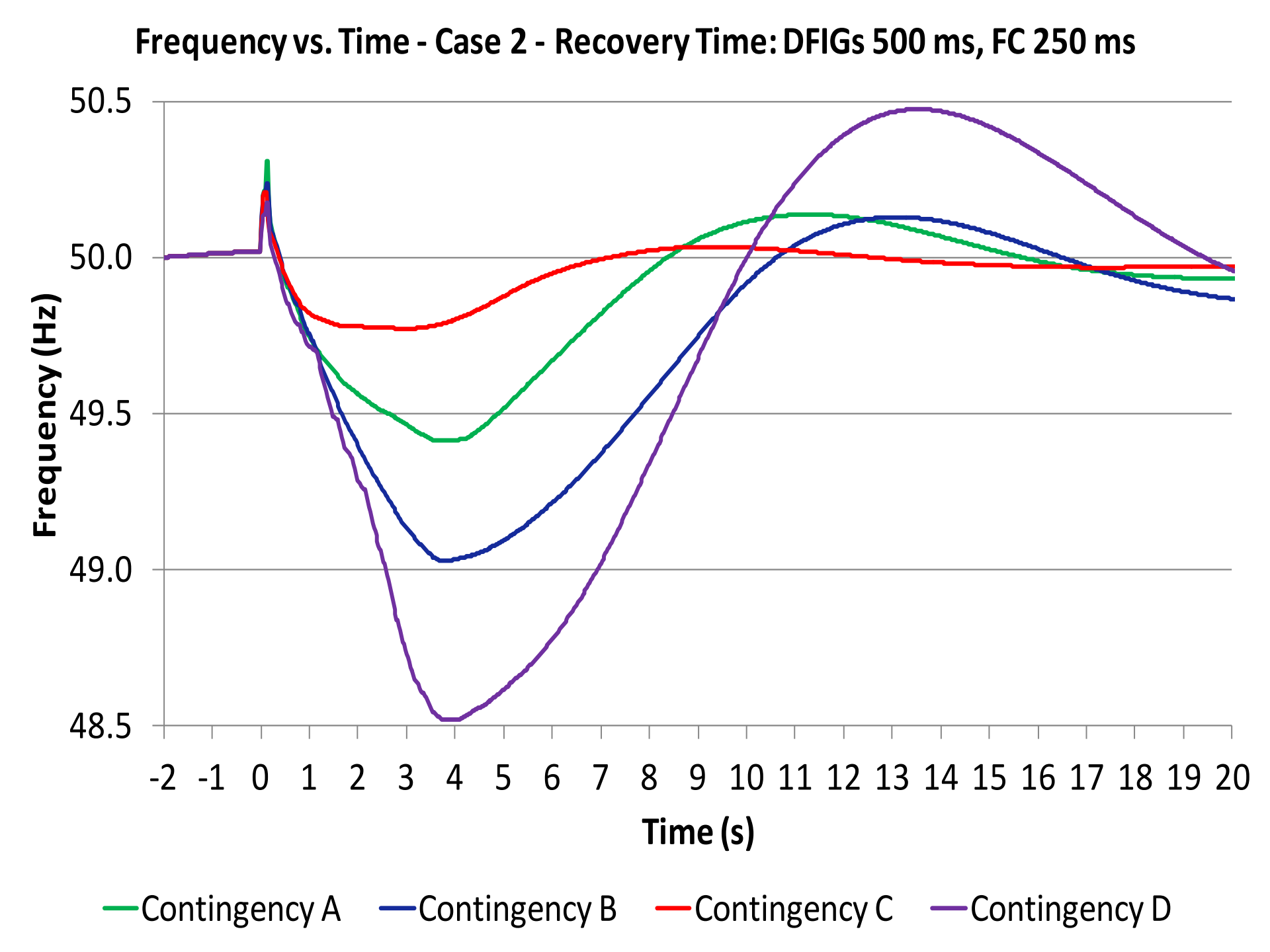

Retained Voltage > 90%
70% < Retained Voltage < 90%
50% < Retained Voltage < 70%
Retained voltage < 50%
Fault

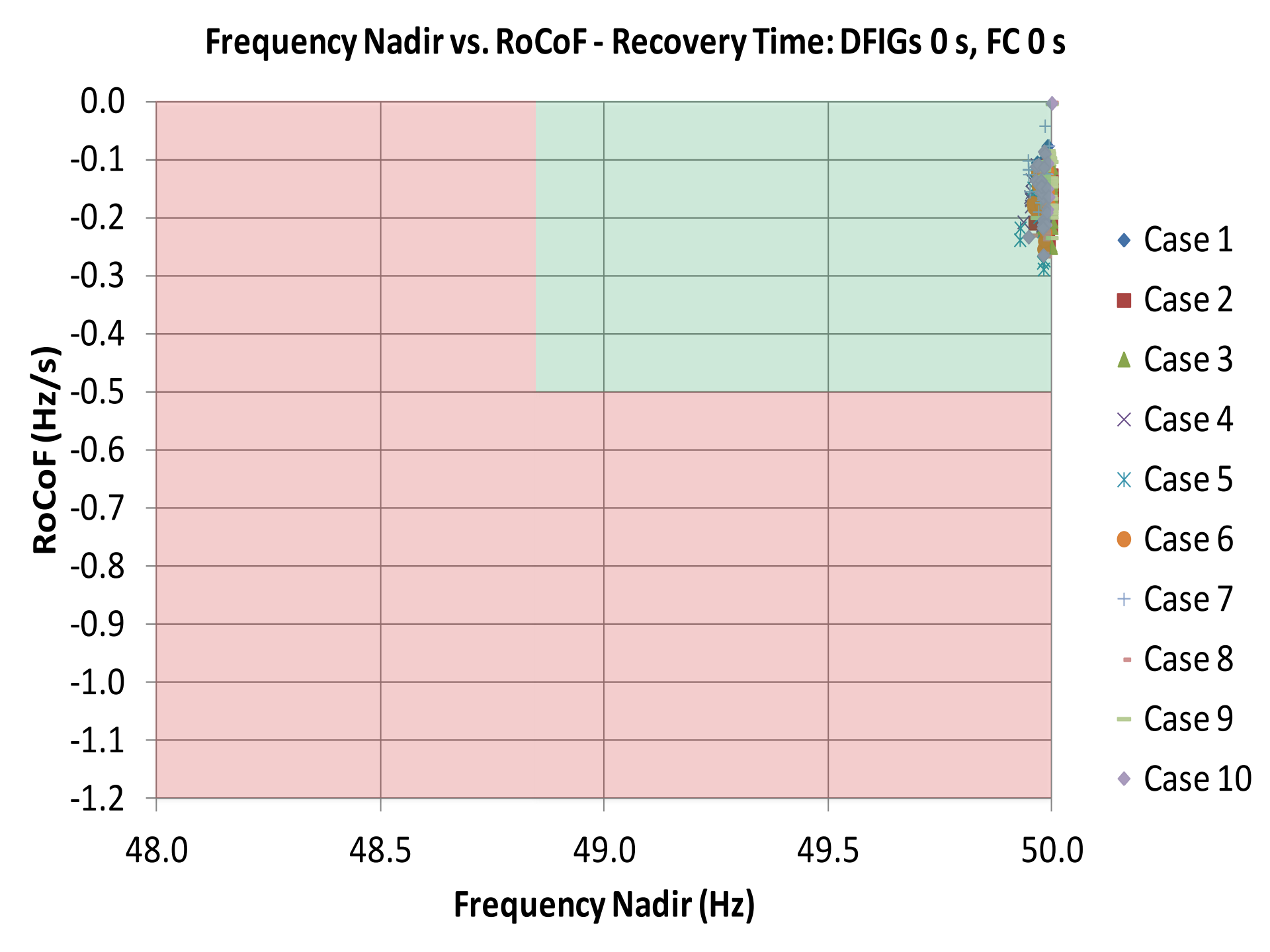

Retained Voltage > 90%
70% < Retained Voltage < 90%
50% < Retained Voltage < 70%
Retained voltage < 50%
Fault

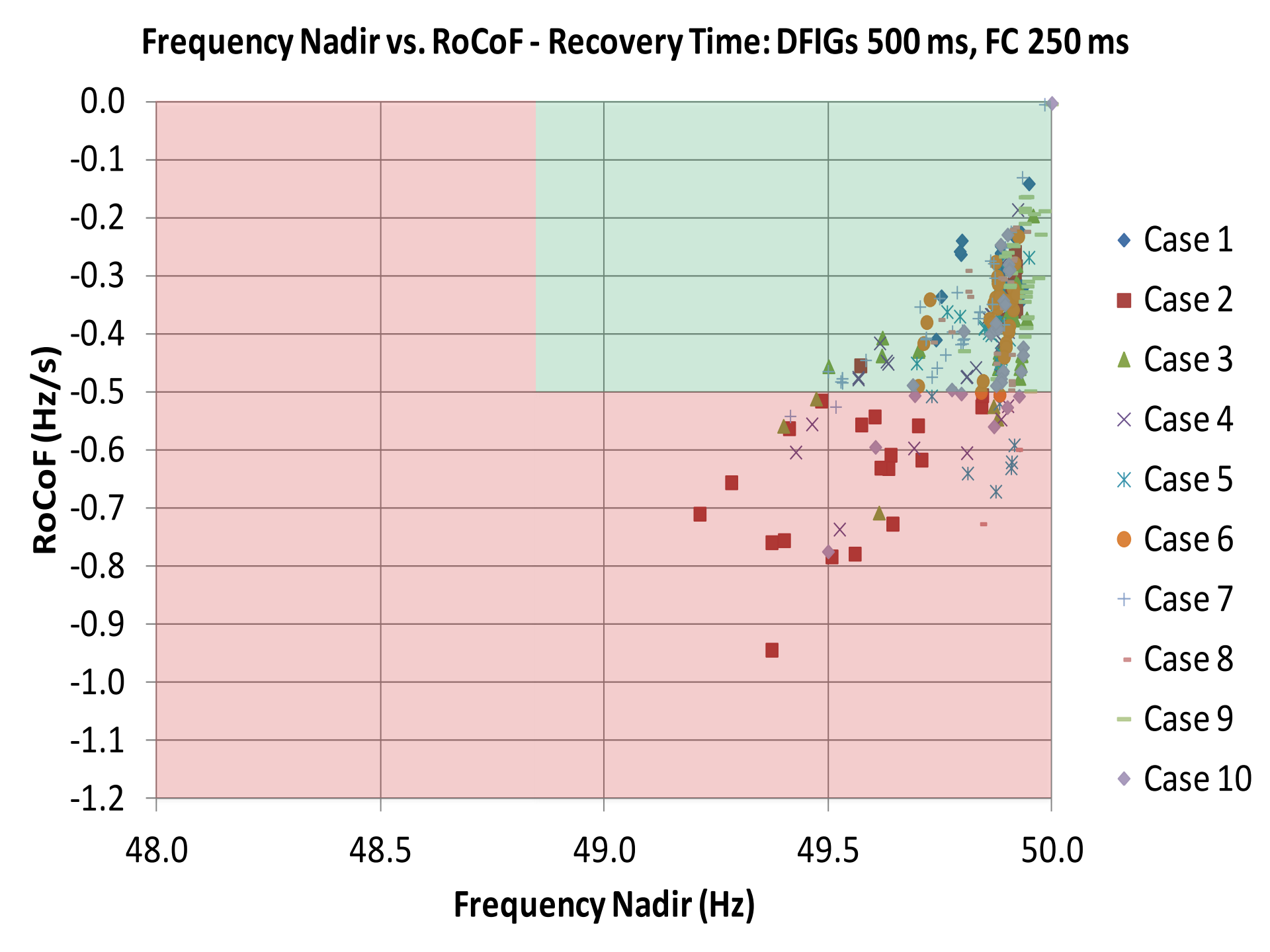
Detailed Dynamic Studies

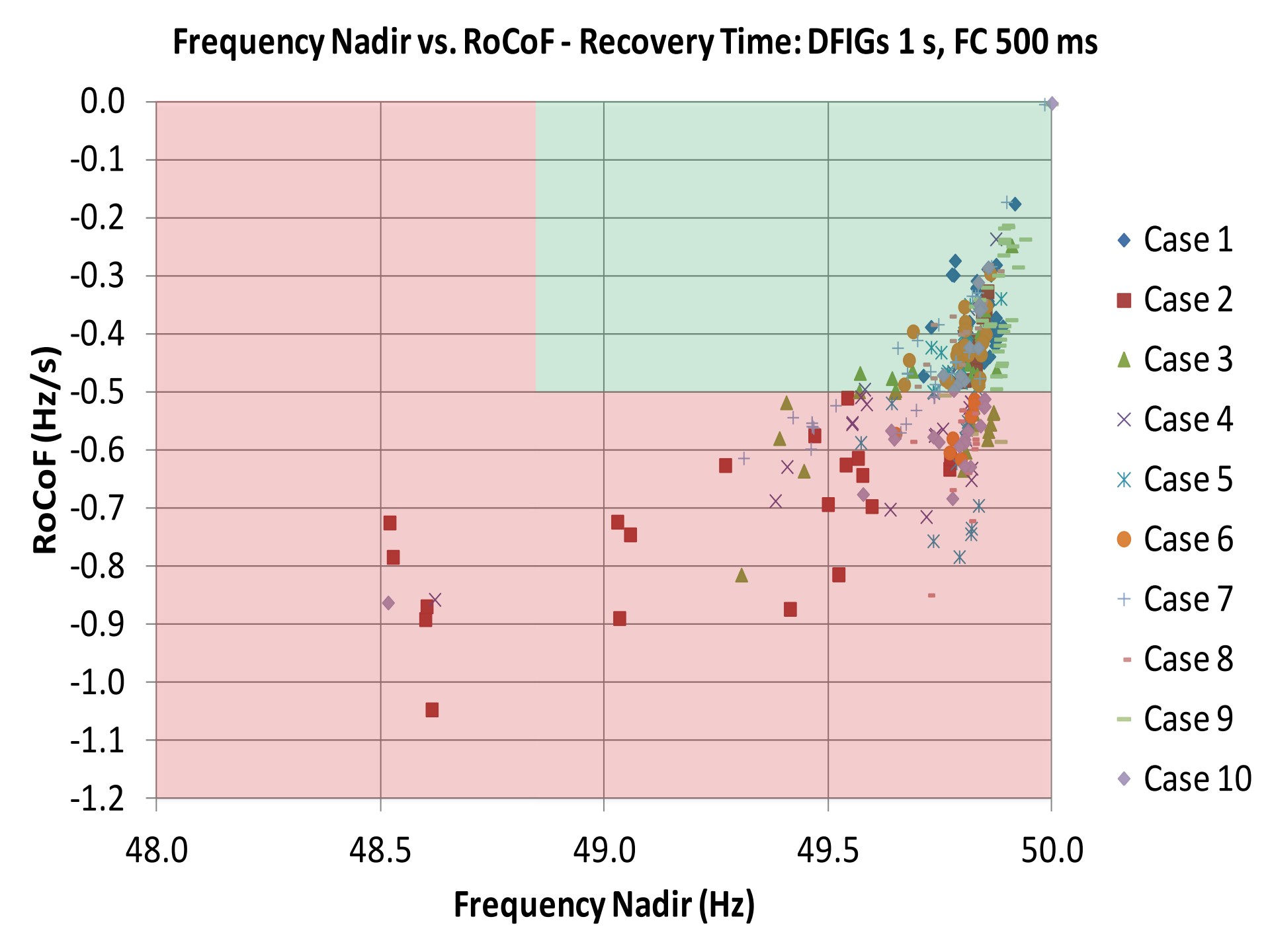
- Worst contingencies from screening study
- Faults at HV terminals of large generators and interconnectors followed by their loss
- Detailed model of transmission system
- Augmented models – slow active power recovery

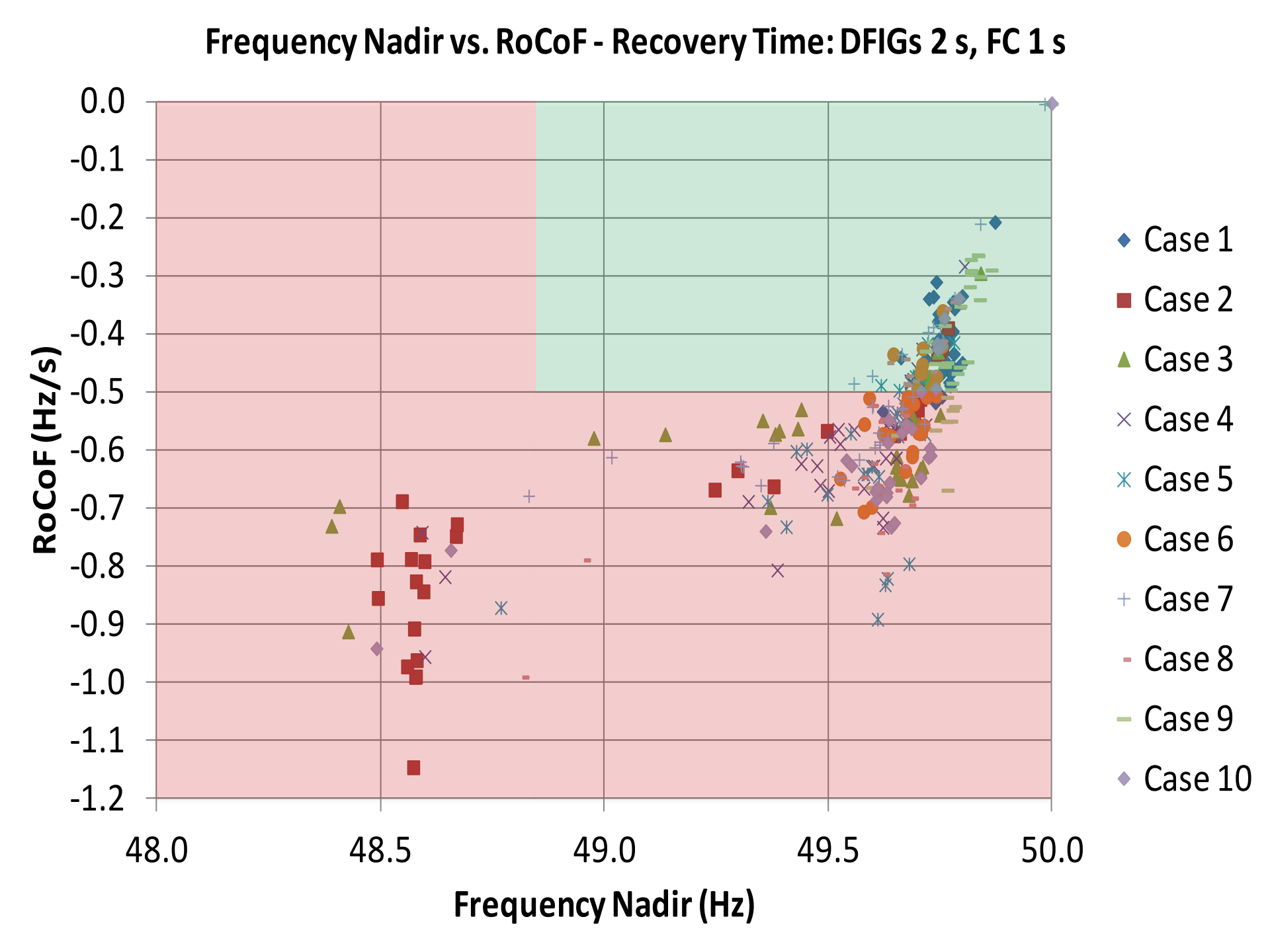

Plots showing Slow Active Power Recovery of Wind Farm Models
Wind Farm Active Power Output (MW)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
Time (s)
WF1 - 500 ms Recovery
WF1 - 1 s Recovery
WF1 - 2 s Recovery
WF1 - 4 s Recovery
WF2 - 500 ms Recovery
WF2 - 1 s Recovery
WF2 - 2 s Recovery
WF2 - 4 s Recovery
WF3 - 500 ms Recovery
WF3 - 1 s Recovery
WF3 - 2 s Recovery
WF3 - 4 s Recovery

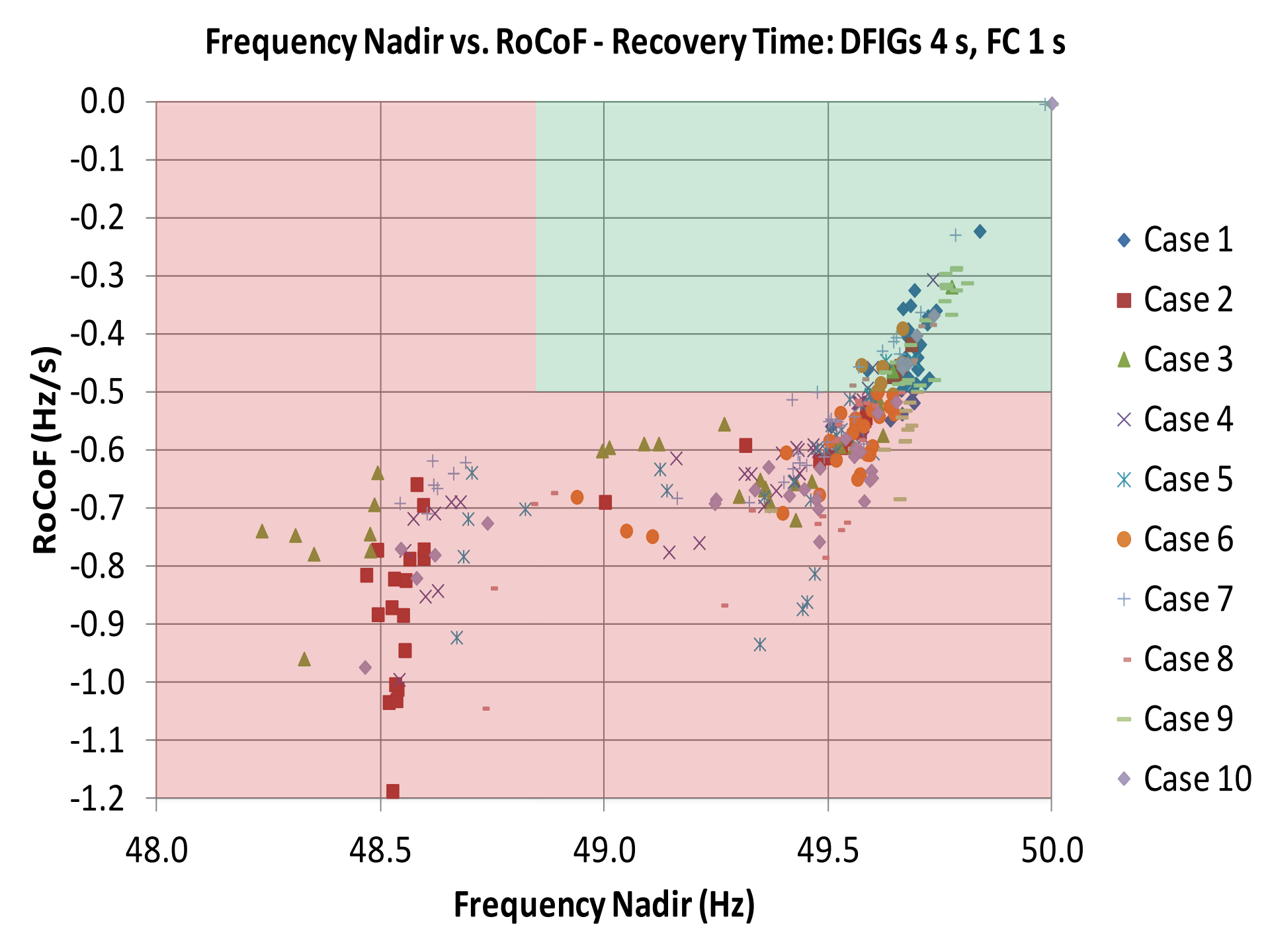

Frequency vs. Time - Case 2 - Recovery Time: DFIGs 500 ms, FC 250 ms
50.5
50.0
49.5
49.0
48.5
Frequency (Hz)
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Time (s)
Contingency A
Contingency B
Contingency C
Contingency D

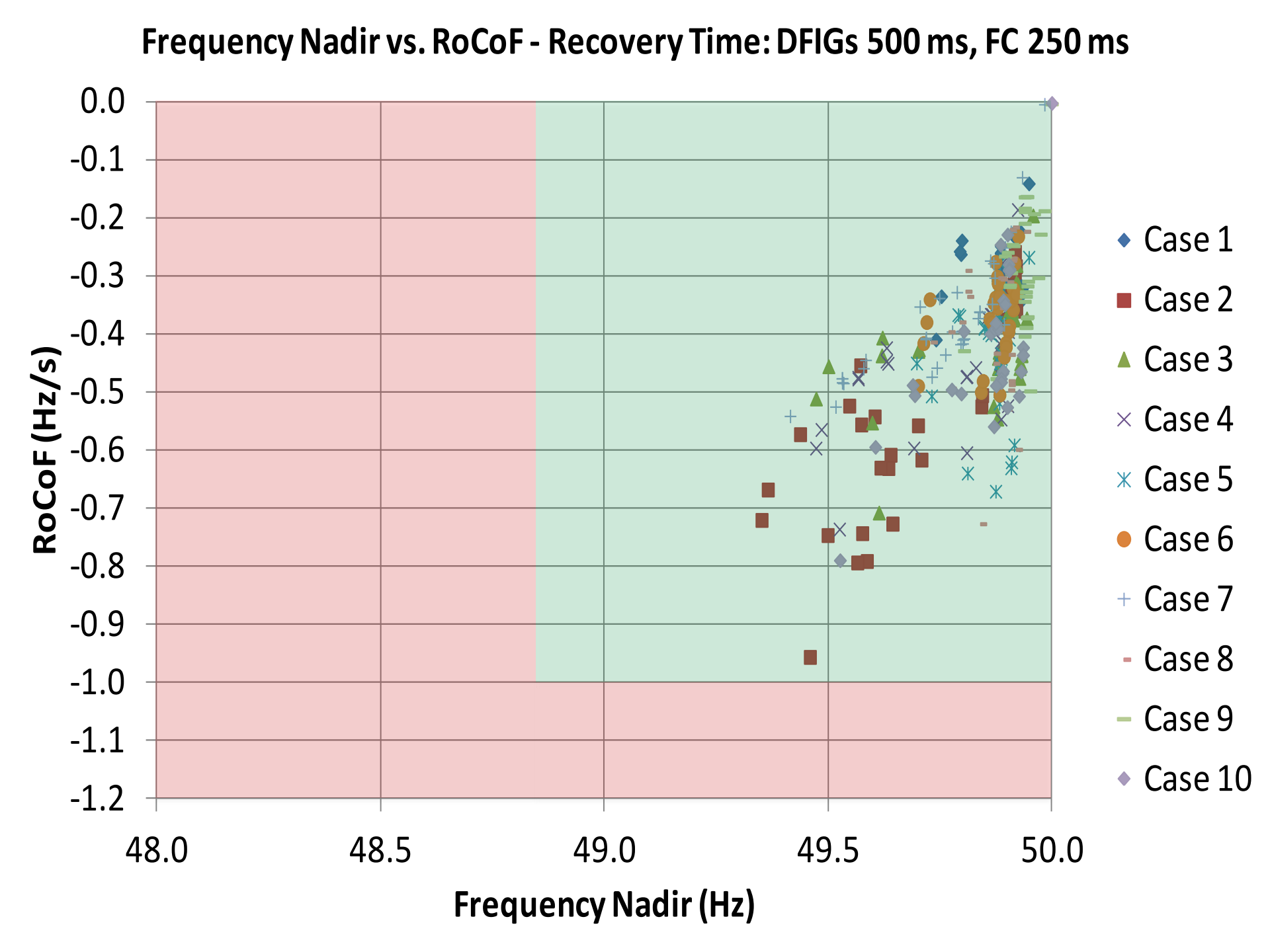

Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 0 s, FC 0 s
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
RoCoF (Hz/s)
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10

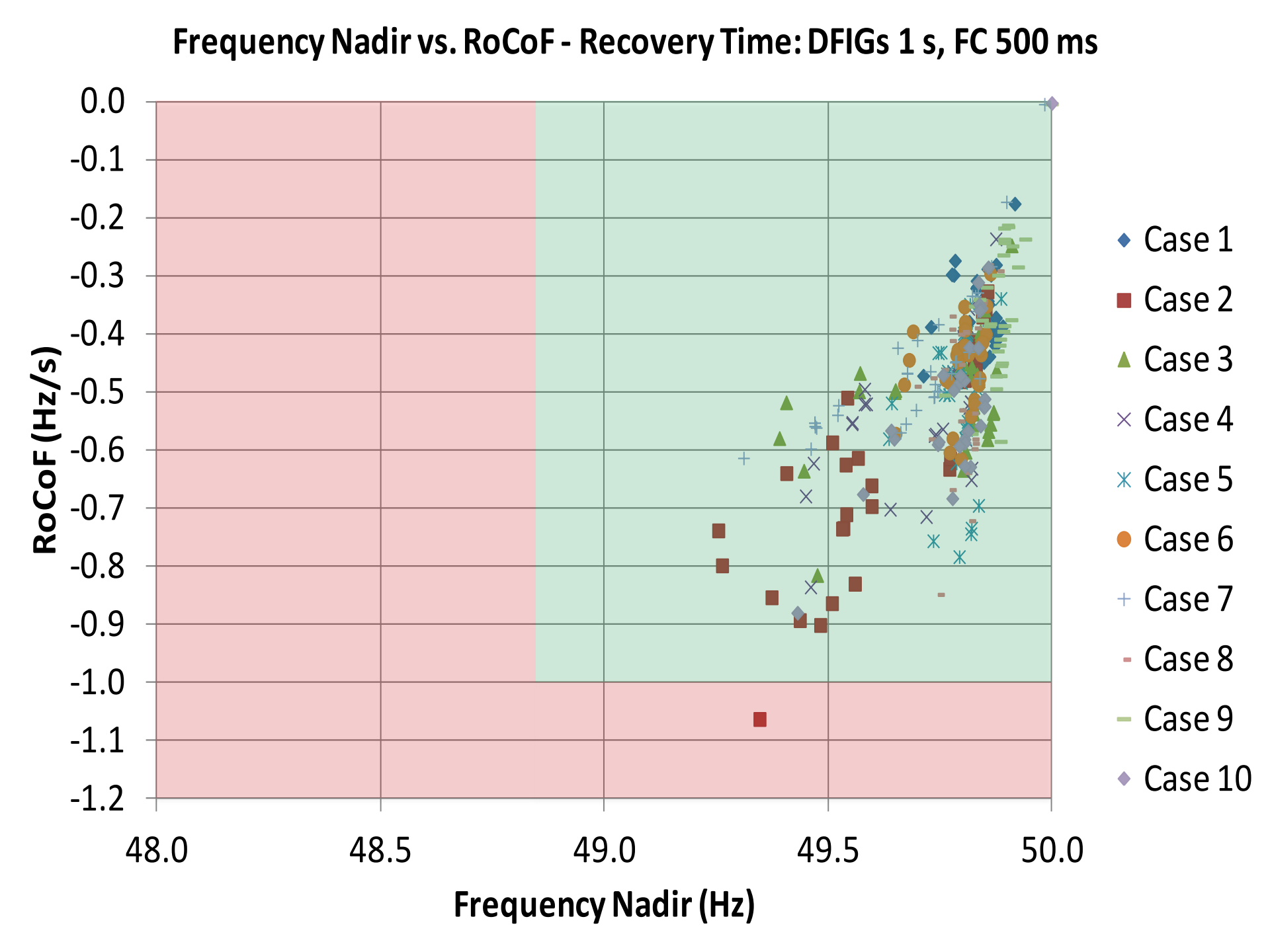

Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 500 ms, FC 250 ms
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
RoCoF (Hz/s)
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10


Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 1 s, FC 500 ms
RoCoF (Hz/s)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10


Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 2 s, FC 1 s
RoCoF (Hz/s)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10


Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 4 s, FC 1 s
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
RoCoF (Hz/s)
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10


Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 500 ms, FC 250 ms
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
RoCoF (Hz/s)
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10


Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 1 s, FC 500 ms
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
RoCoF (Hz/s)
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49.5
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Frequency Nadir (Hz)
Case 1
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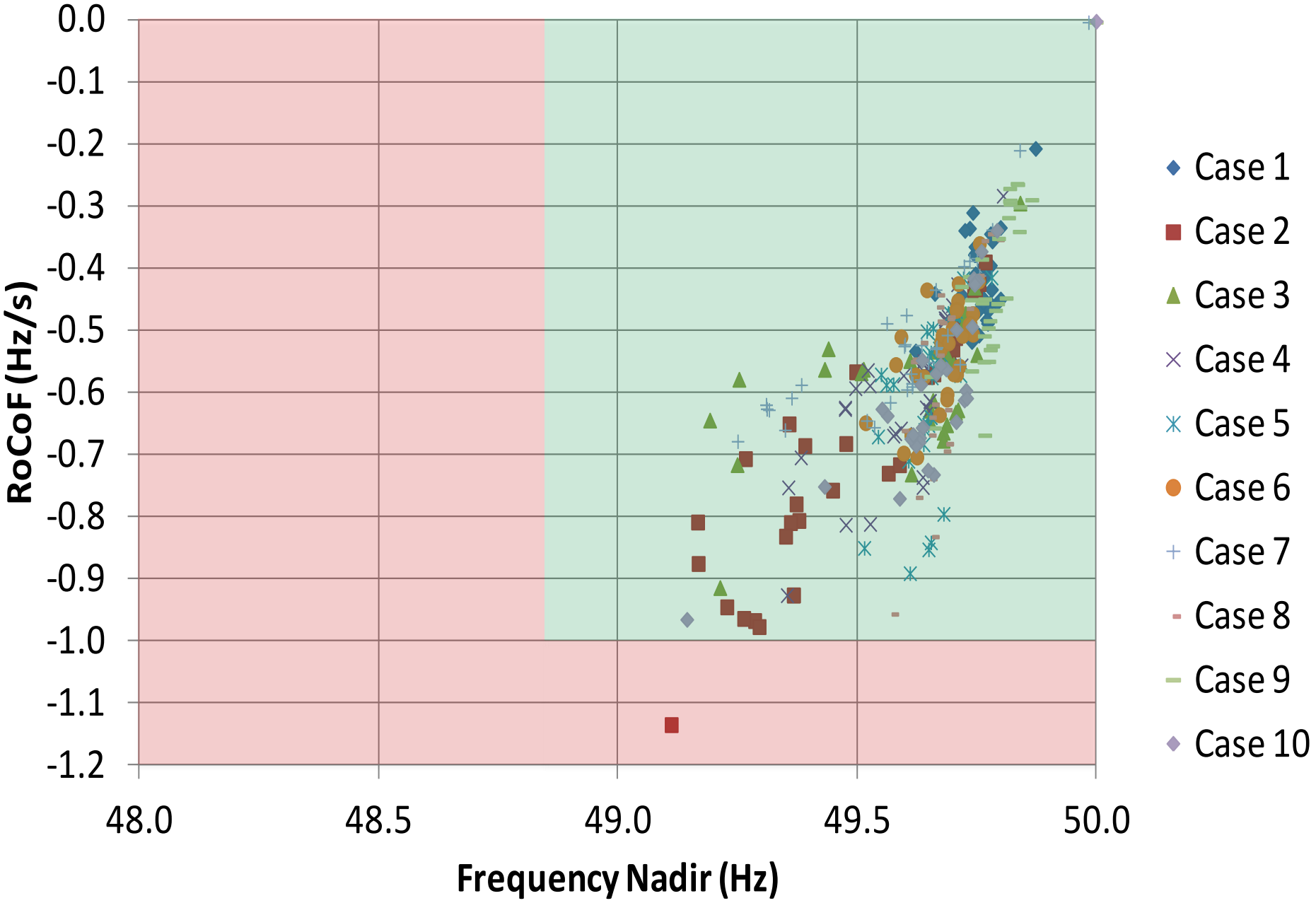
Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 2 s, FC 1 s
RoCoF (Hz/s)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
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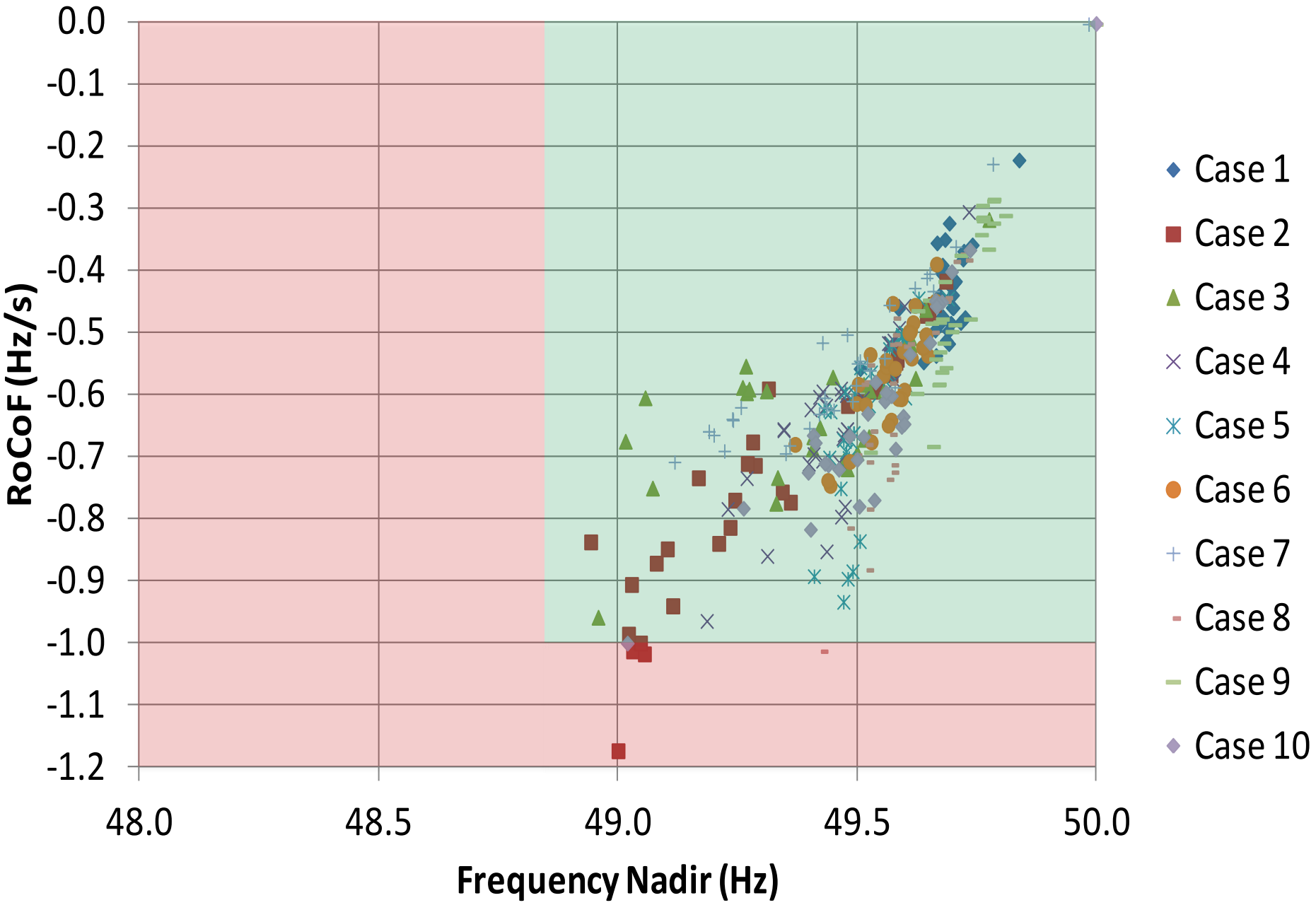

Frequency Nadir vs. RoCoF - Recovery Time: DFIGs 4 s, FC 1 s
RoCoF (Hz/s)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
48.0
48.5
49.0
49.5
50.0
Frequency Nadir (Hz)
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7
Case 8
Case 9
Case 10

Items for Further Consideration

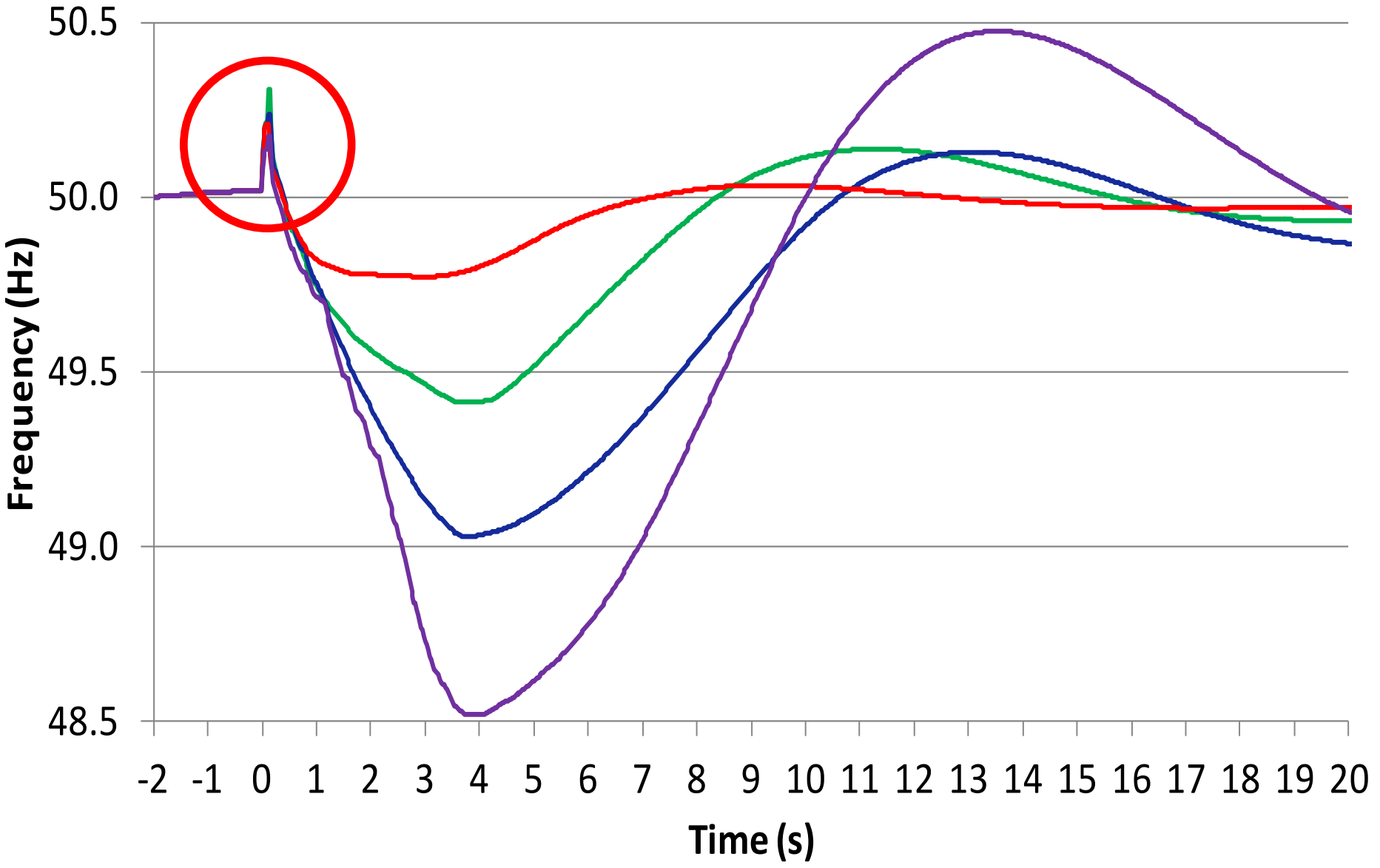
- RoCoF calculation
  - should it include ‘spike’ due to fault?
- Limited Distribution system model
- Wind Farm models

Conclusion

- Capability to study VDIFD

- Further work required
  - Decide on RoCoF calculation methodology
  - How do relays calculate RoCoF
  - Distribution system model
  - Collect data from wind farms during faults

Frequency vs. Time - Case 2 - Recovery Time: DFIGs 500 ms, FC 250 ms



Back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Market Operator
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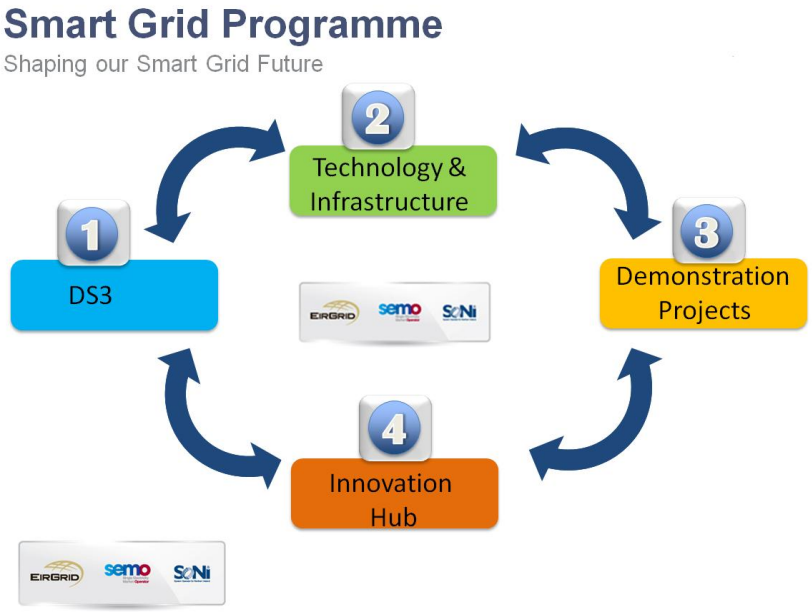
Quantum Demonstration Project (DSM)

25/09/2013

Mark Gormley

Demonstration projects Background

- Trialling new solutions
- Proving new technologies
- Building Shared Learning



- Areas of Interest Include:
  - DSM concepts
  - System Service Provision

- Further Information
- http://www.eirgrid.com/operations/demonstrationprojects/

Quantum Demo Project (Phase1)

- Objective: Demonstrate DSM capabilities of a distributed Electric Thermal Storage
- Partners

- Phase 1 initiated in November 2012
- Two test sites in Dublin area (Cabra, Mulhuddart)
  - Total Apartments: 142
  - Total Heaters: 358
  - Total Hubs: 27

Products – System Services

Product	Time frame	Method of provision
Existing Ancillary Services products		
Primary Operating Reserve (POR)	5 - 15 secs	Automatic
SOR	15 - 90 secs	Automatic
TOR1	90 - 300 secs	Automatic
TOR2	5 - 15 mins	Automatic
Replacement reserve (RR)	15 - 60 mins	Dispatched

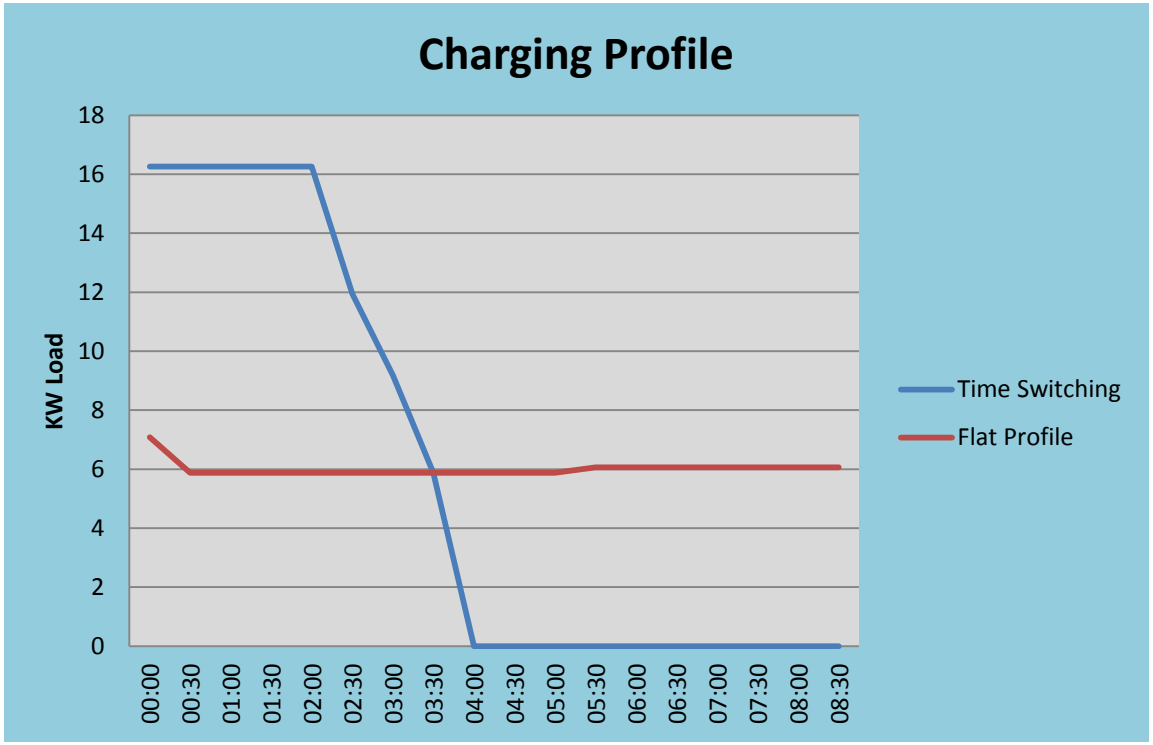
New DS3 System Service Products		
Fast Frequency Response	2 - 10 secs	Automatic
Ramping Margin 1 (RM1)	1 hour	Dispatched
RM3	3 hour	Dispatched
RM8	8 hour	Dispatched

Phase 1 Outline Testing Plan

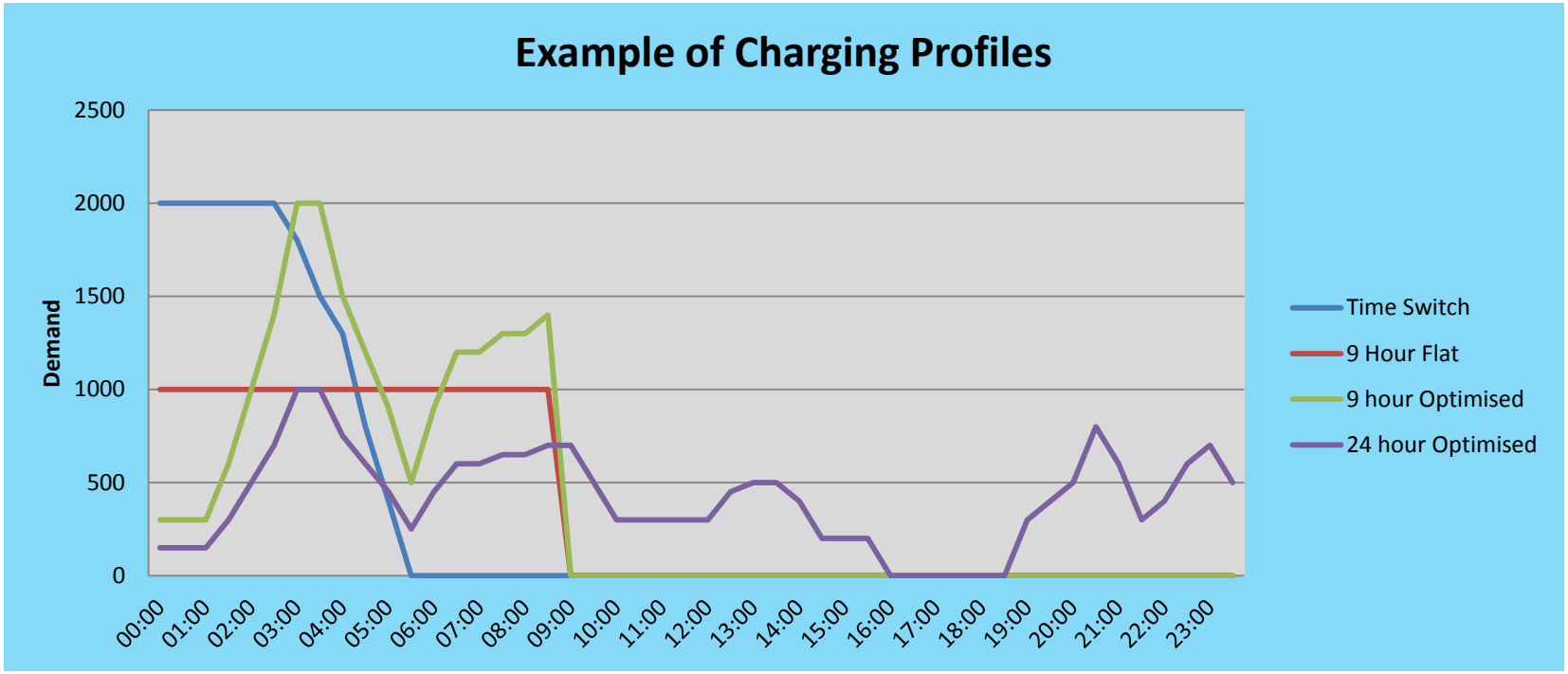
Period	Description	Purpose	Completion Date
Pre testing	Installation and Set Up period	Set Up	Complete
Test period 1	Operation on fixed time switch	Base lining	Complete
Test period 2	Operation on variable switching	Proof of Comms / technology	Complete
Test period 3	Provision of reliable availability profiles	Proof of Concept	Complete
Test period 4	Frequency Response	Proof of Concept	07/10/13
Close out	Close out and final report	Close out	25/10/13

Scheduling

- Undispatched units operate under time switch
- Flat profile used to prove controllability
- Limited to 9 hour optimisation during Phase 1



Charging profiles



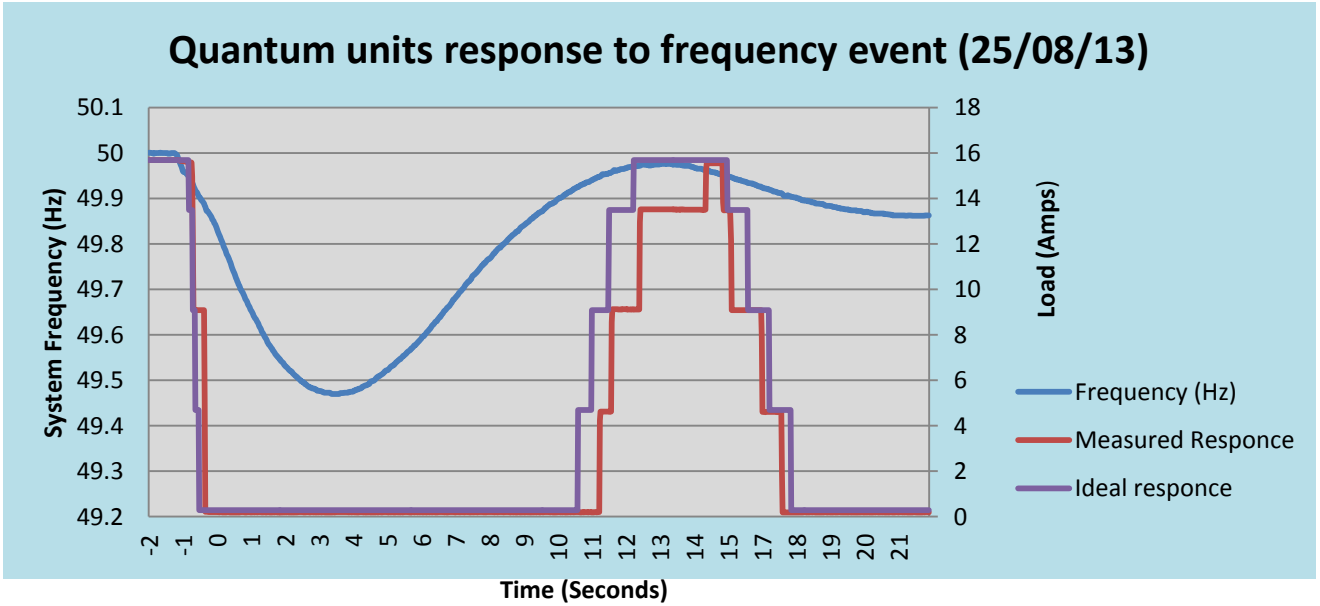
- 24hr optimisation offers greater flexibility and opportunity to dispatch based on:
  - Projected SMP
  - Projected Wind / SNSP levels
  - System service requirements
  - Localised System optimisation

Frequency Response

- 4 subgroups created in lab conditions
- Target to emulate dynamic response
- This response can then be extrapolated over full group set

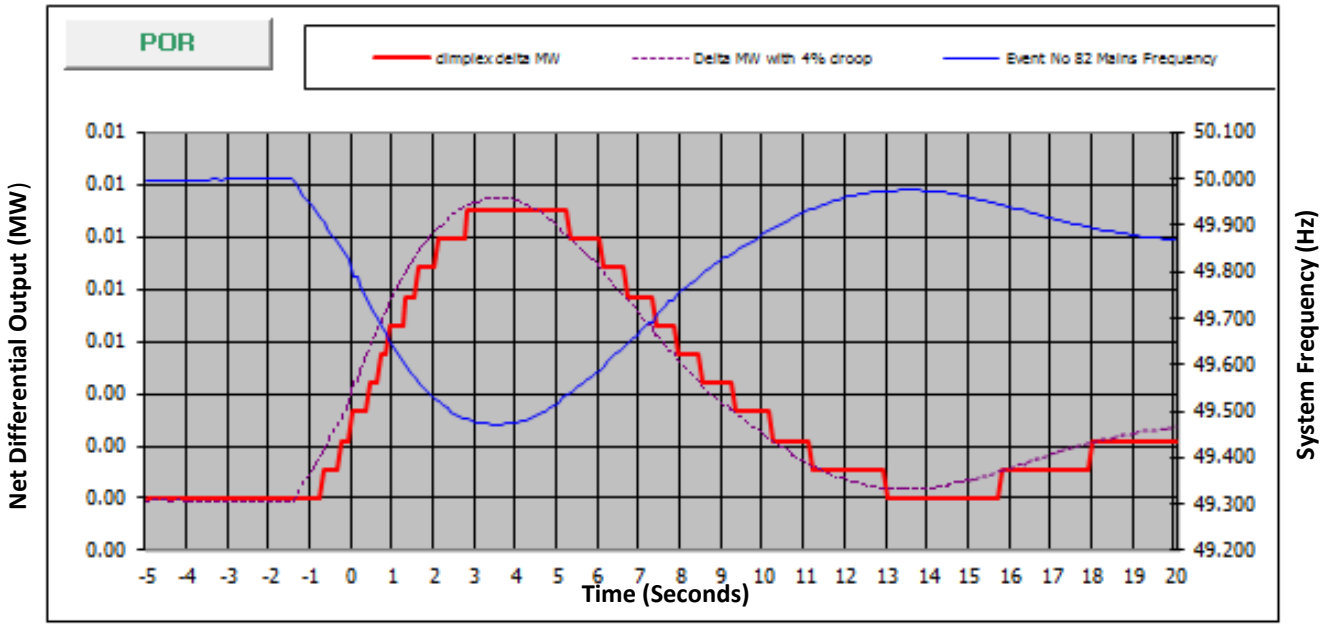
Initial Parameters used

	Response trigger	Reset
Group 1	49.950	49.970
Group 2	49.935	49.955
Group 3	49.920	49.940
Group 4	49.905	49.925



Nature of Response

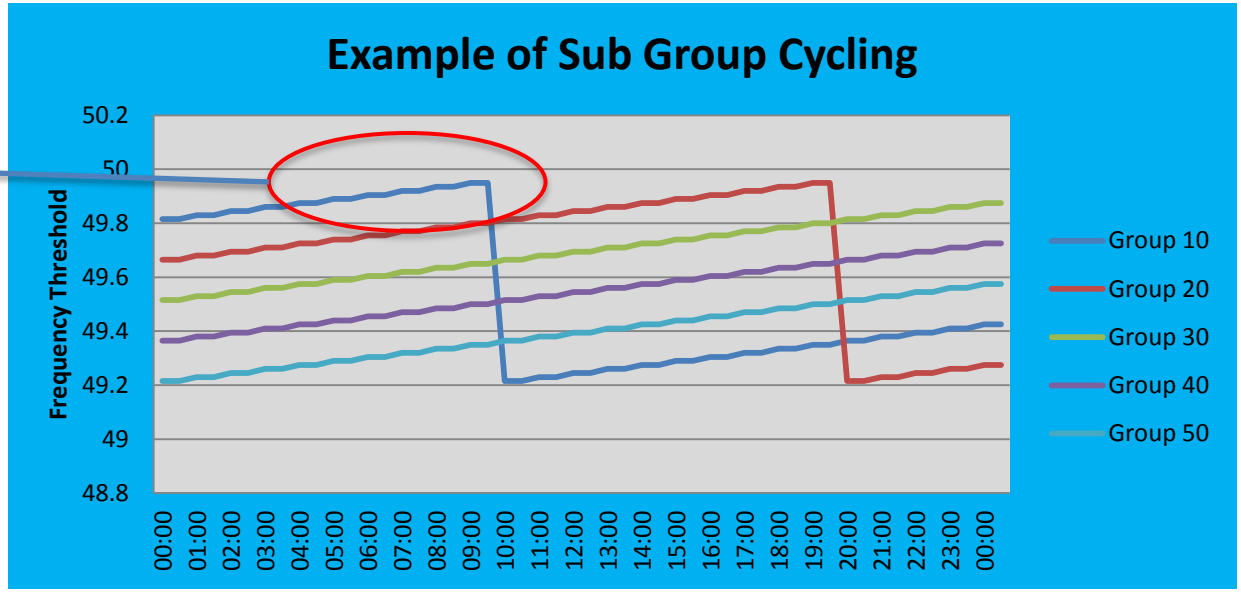
- Response extrapolated over larger group set
- Fast acting (<300 ms)
- Emulation of Dynamic response achievable
- Currently testing to emulate droop characteristics of Synchronous machines



Methodology to be trialled

- Sub Group Cycling
- Each Sub Group will cycle through each frequency threshold
  - Groups cycling will prevent
    - a) Undue stress on units
    - b) Charging optimisation

Groups will cycle through each frequency threshold



Phase 2

Project Partners

EIRGRID

SONI System Operator for Northern Ireland

Glen Dimplex

UCD DUBLIN

intel

Airtricity making energy better

ESB NETWORKS

The Green Way Dublin's Cleantech Cluster

Objectives

- Develop and test communications and technology
- Evaluate business case for large scale deployment
  - System services
  - Demand side units
  - Energy arbitrage
  - CAPEX avoidance through enhanced grid asset utilisation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