DS3 Grid Code Workstream: Rate of Change of Frequency (RoCoF) & Voltage Control

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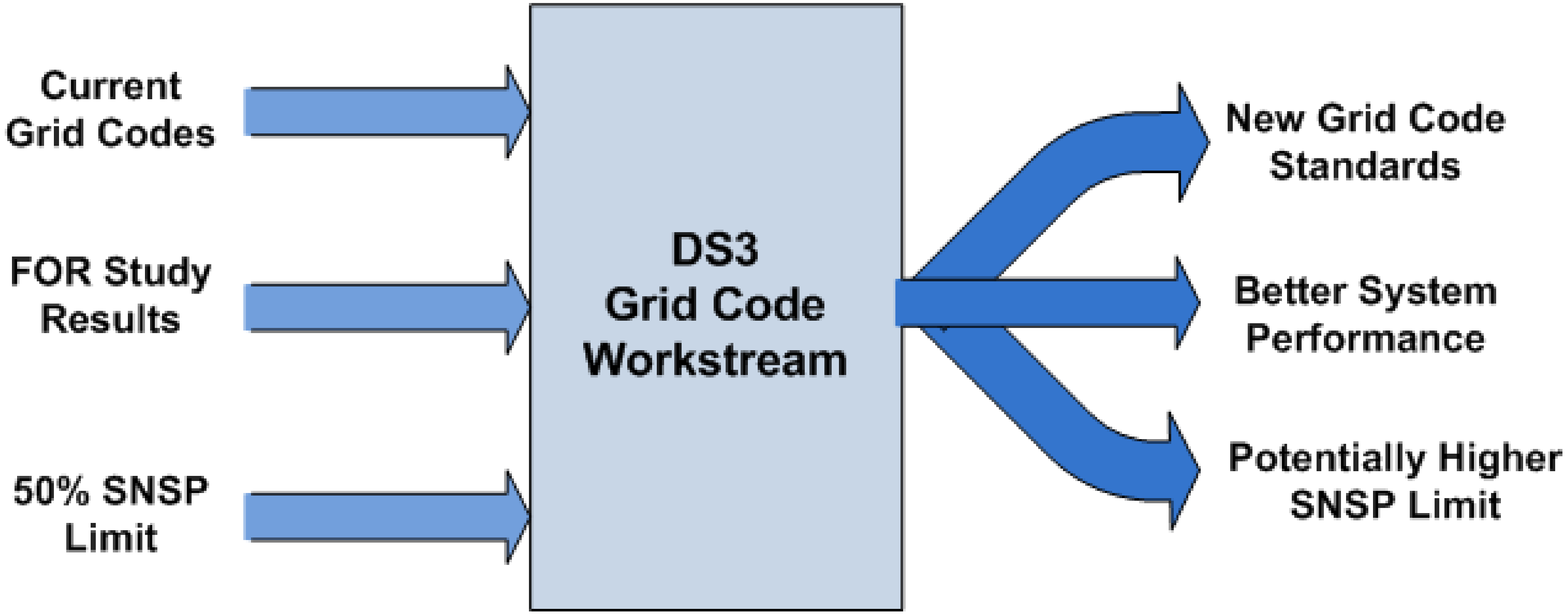
DS3 Industry Forum

14th March, 2012

Engineers Ireland

Motivation for Grid Code Changes



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Grid Code Workstream

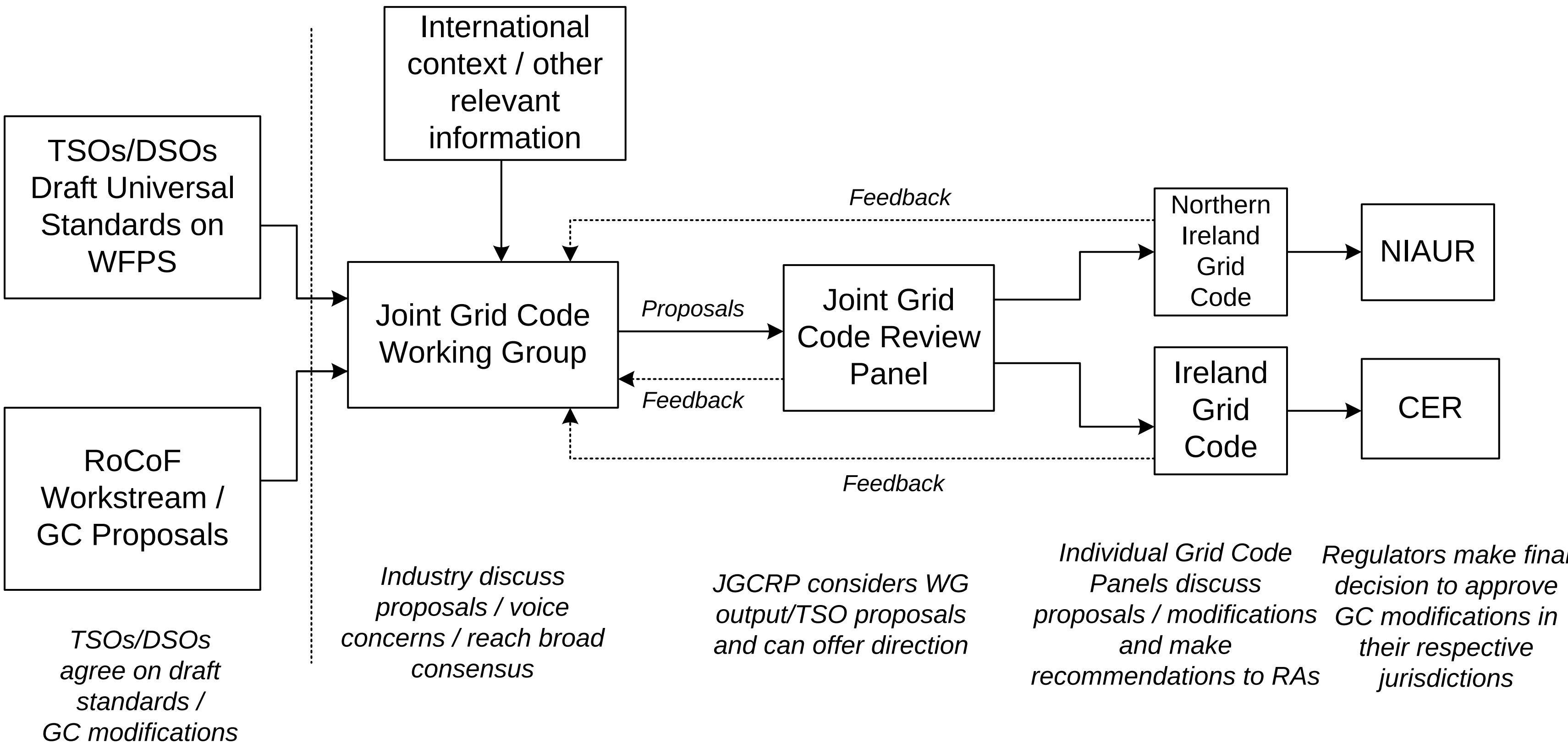
Main areas:

- WFPS steady-state control modes
- WFPS and Conventional Plant: dynamic active and reactive response
- WFPS and Conventional Plant: RoCoF Ride-Through Capability

Other:

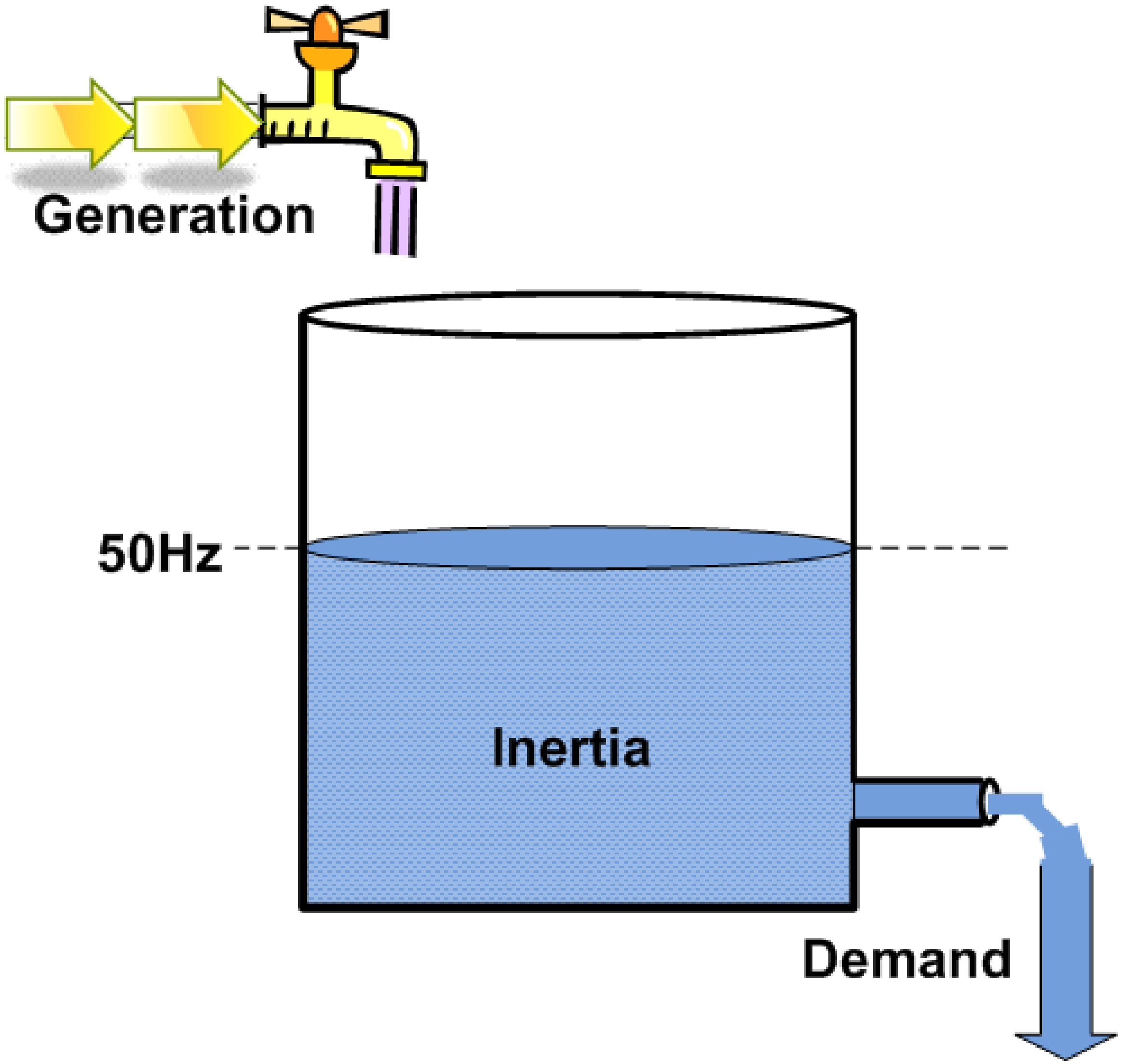
- Demand-side management
- New Technologies, Biomass, Energy Storage Devices
- Negative Reserve
- Dynamic Modelling Requirements

Joint Grid Code Working Group

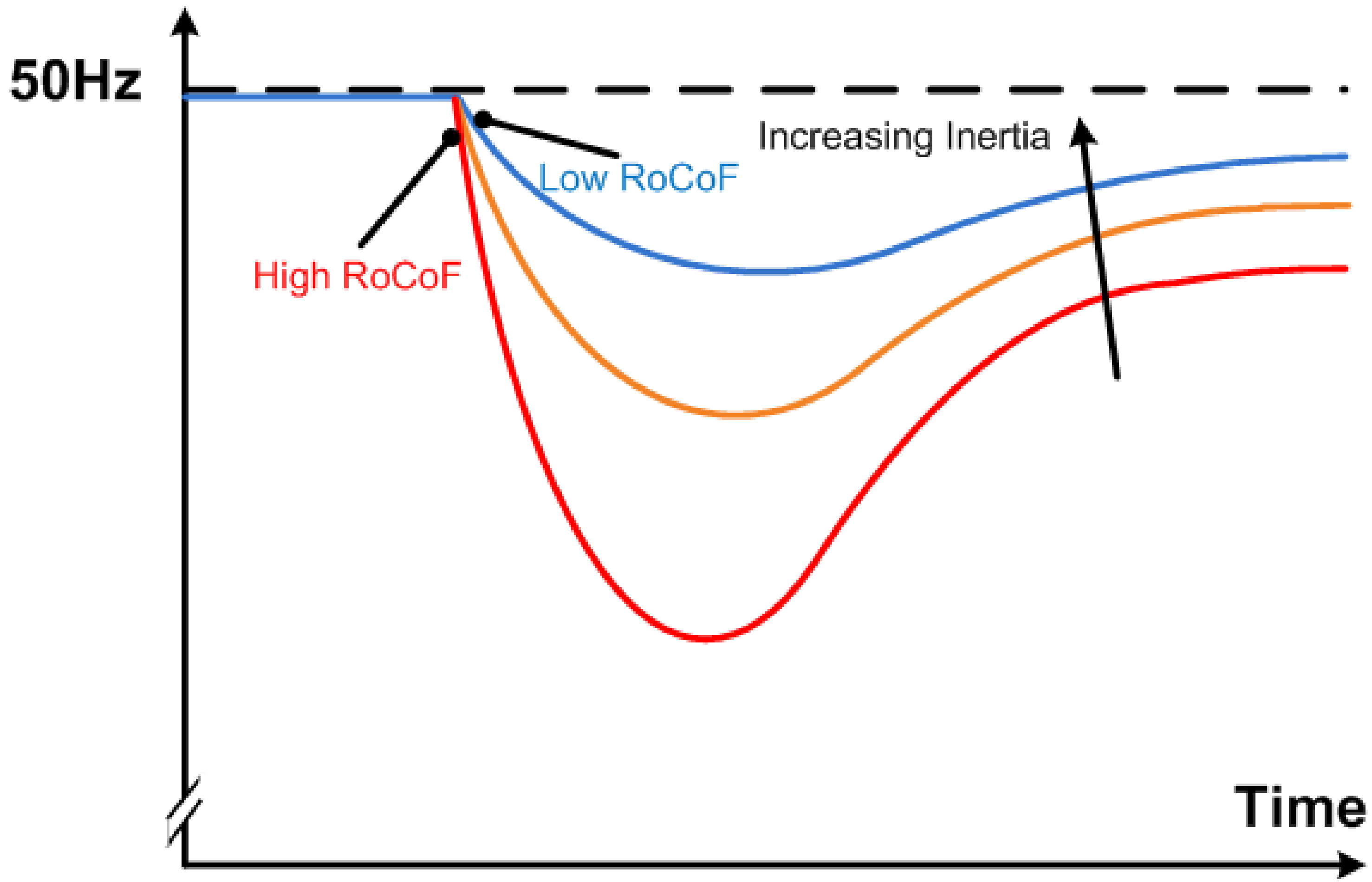


RATE OF CHANGE OF FREQUENCY

Supply/Demand Analogy



RoCoF and Inertia



RoCoF Issue 1: Loss of Largest Infeed/Outfeed

Loss of a large infeed (or outfeed, e.g. EWIC) in a low inertia scenario could cause RoCoF > 0.5Hz/s

Options:

- Move to a system with lower inertia
  - Need to ensure all conventional / WFPS can cope with higher RoCoF values

- Maintain enough system inertia so RoCoF < 0.5 or X Hz/s
  - Keep conventional plant online
  - Lower minimum generation levels
  - Incentivise new machines with more inertia
  - Network solutions: Synchronous Condensers etc

RoCoF Issue 2: Voltage Dip-Induced Frequency Dips

In future high wind scenarios, (2020) severe faults near a large cluster of windfarms will cause them to see a large voltage dip

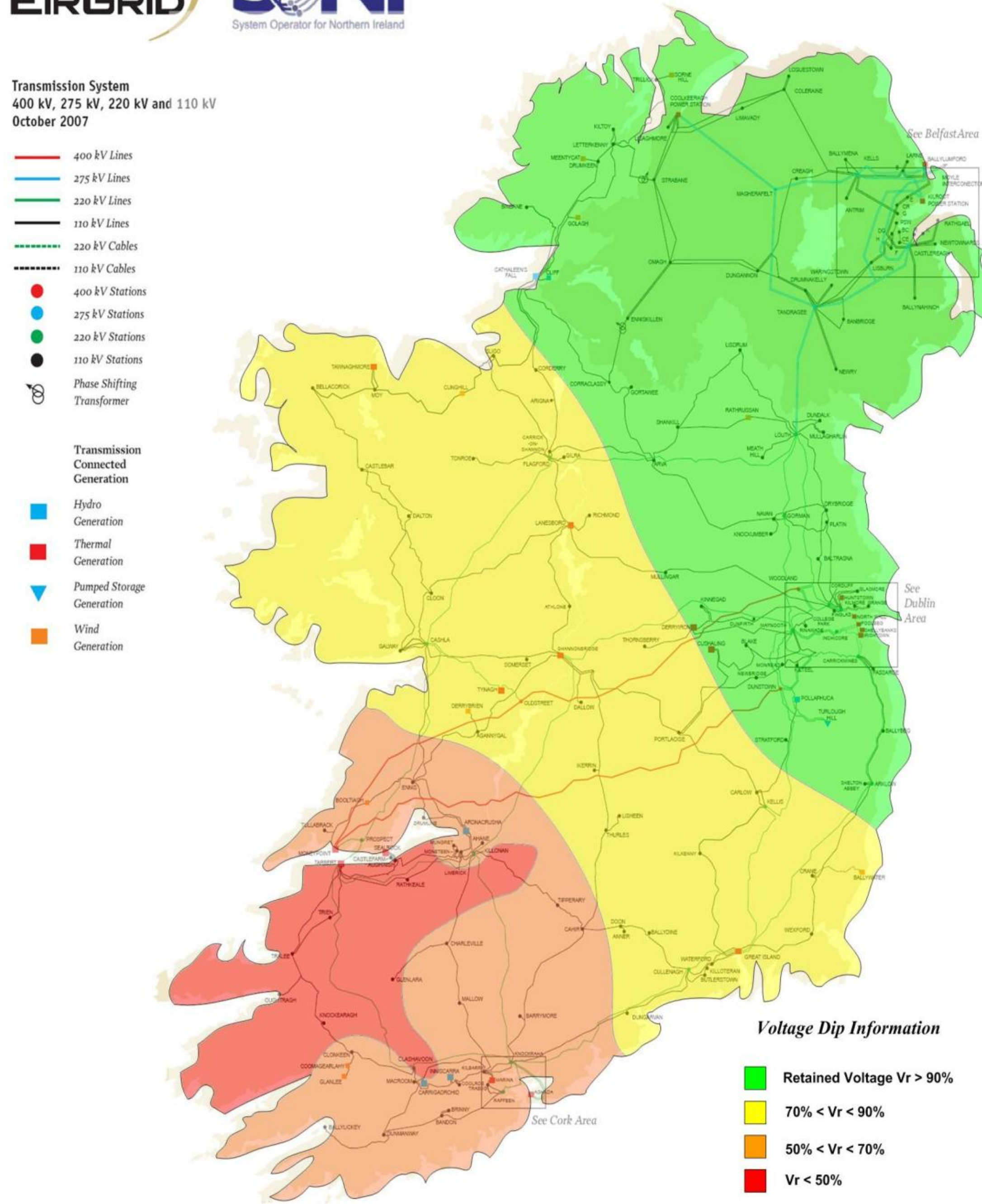
→ a significant temporary energy imbalance

→ Potentially very high RoCoF value

Not currently an operational issue.

Needs further study

Grid Code Standards: Faster active power recovery of windfarms



Issue 3: Anti-Islanding Loss of Mains Relays

Loss of Mains protection (G10/EGIP/G59) is used to detect electrical islands in the distribution system

High RoCoF → tripping of distribution-connected windfarms and generation due to operation of anti-islanding loss of mains relays (RoCoF and Vector Shift)

The DSOs (NIE / ESB Networks) are currently investigating if Loss of Mains protection settings can be changed, while maintaining the necessary security, stability, and safety of the distribution system

International Context

- Hawaii
  - RoCoF of 0.37Hz/s;
- New Zealand
  - RoCoF event of 0.75Hz/s with no cascade trips
  - Studies by TransGrid showed RoCoF up to 1.5Hz/s for some credible contingencies
- Cyprus
  - RoCoF event of 1.3Hz/s, resulting in the loss of a significant amount of wind generation

- ENTSO-E are proposing 2Hz/s as their RoCoF standard

Addressing RoCoF Issues

- Joint Grid Code Working Group considering RoCoF and other DS3 issues
- Generator Testing
- Loss of Mains Protection Changes
- New Windfarm Standards
- Studies / Operational Policy Reviews

VOLTAGE CONTROL

Voltage Control

- Voltage and Frequency Control are two main planks of power system control
  - Frequency is a system variable and an indicator of energy balance
  - Voltage is a local variable and is an indicator of reactive power balance:
  - Traditionally, voltage support is supplied by conventional generation
- Conventional plant offer solid voltage support over a wide operating range
  - Also provide excellent dynamic voltage support during faults
  - Significant provision of fault current
  - Traditionally located near load centres
  - Transmission-connected

Voltage Control Challenges

- In high wind scenarios, conventional plant is displaced
  - Less reactive support at load centres in steady-state
  - Dispersed reactive sources / distribution-connected
  - Less dynamic voltage support during faults, with implications for system transient stability
- Changed relationship between Transmission and Distribution : Bulk supply points cannot be considered as an infinite bus
- Distribution system is active not passive
- Reactive power in WFPS proportional to output – can lead to problems in falling wind/increasing load scenarios

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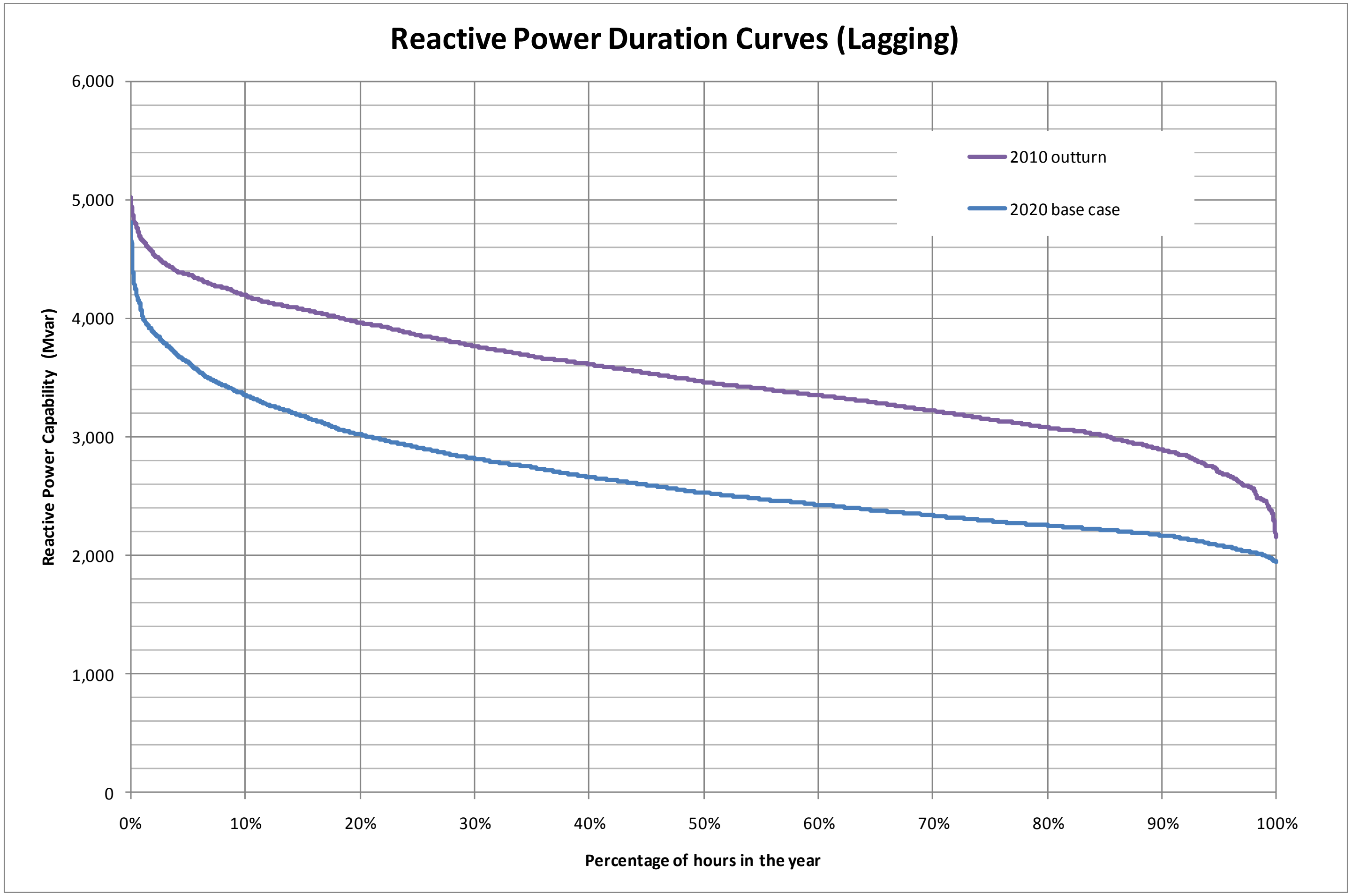
Potential Change in Reactive Power Capability



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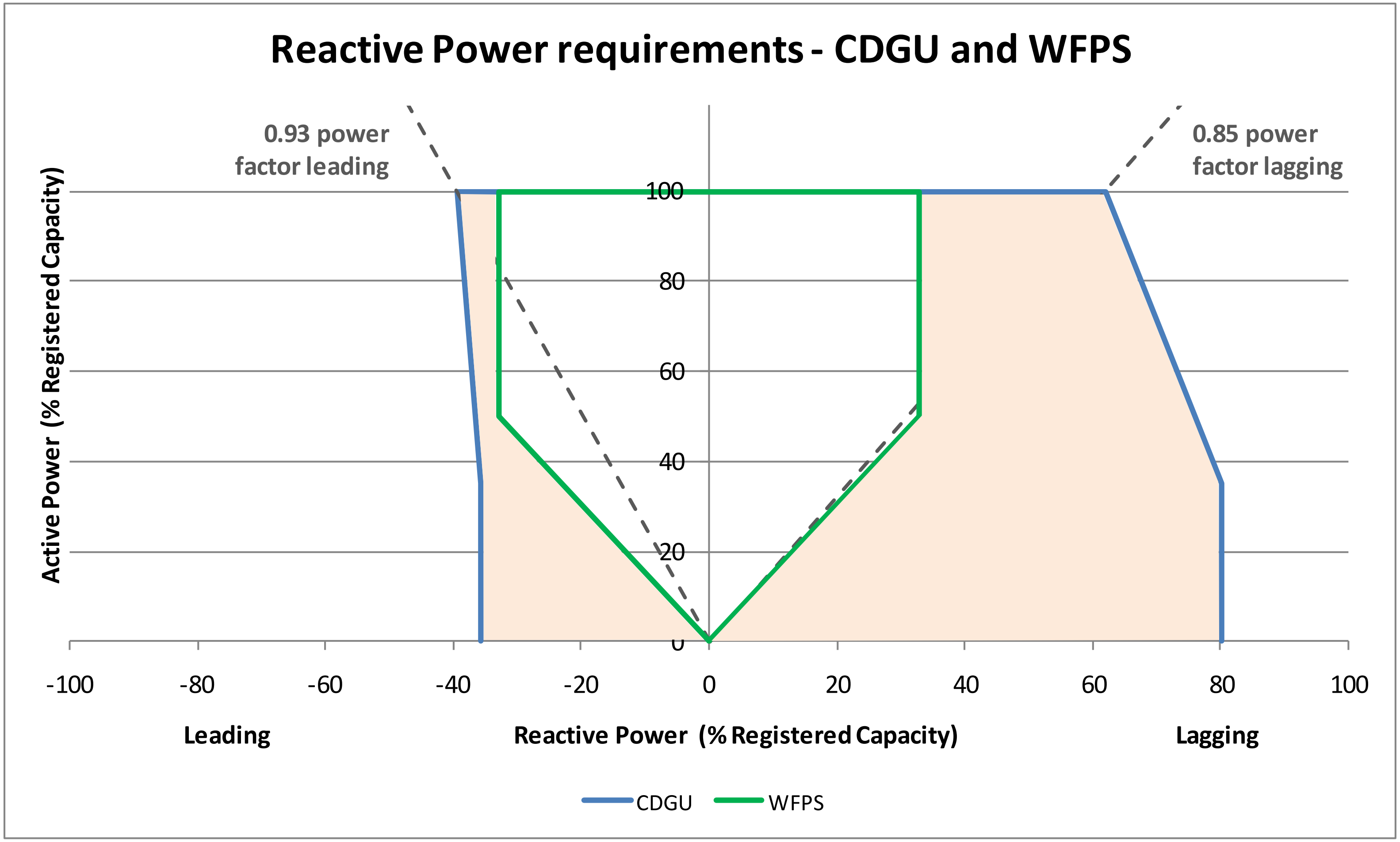
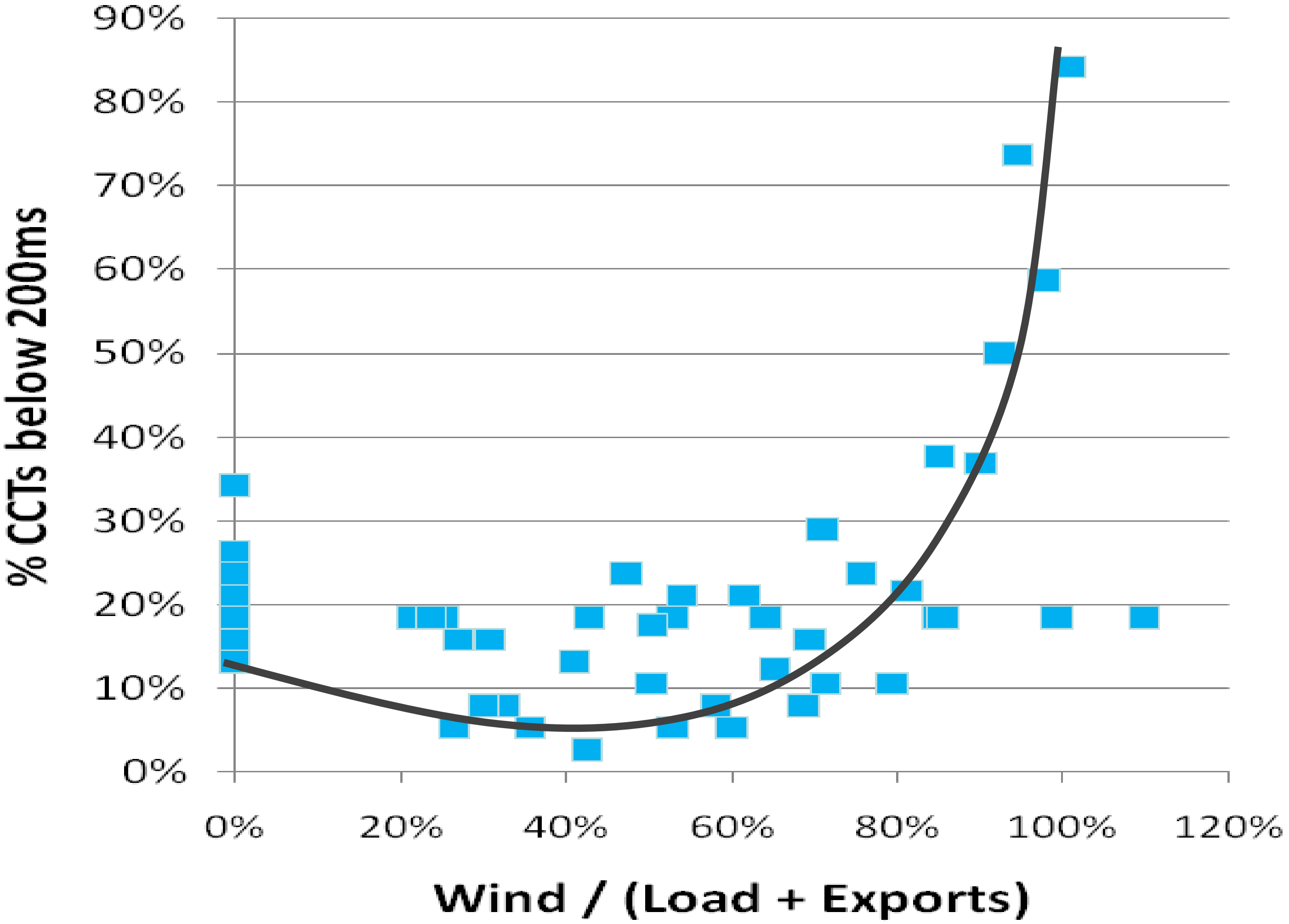
Reactive Power – Grid Code (Ireland)

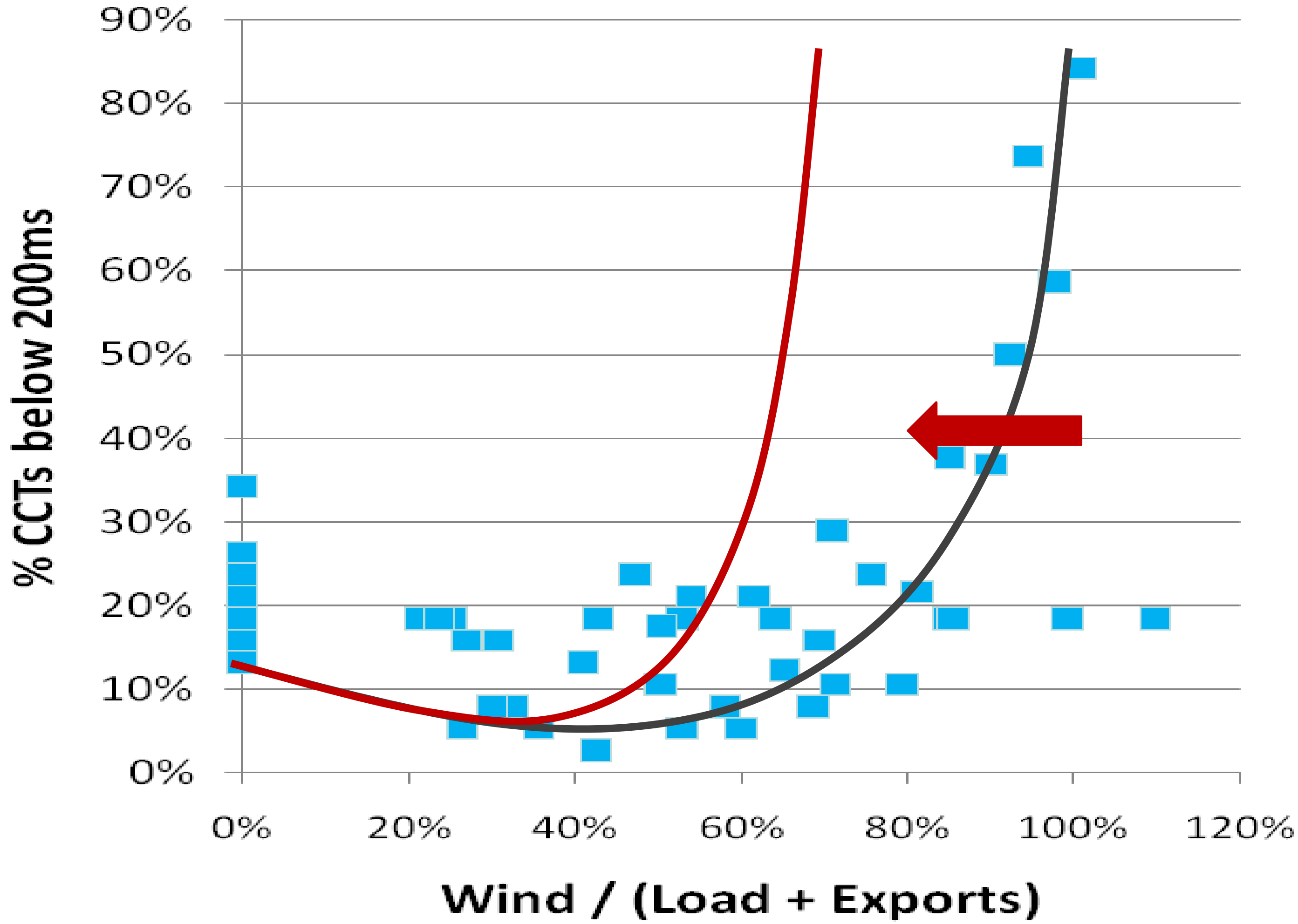


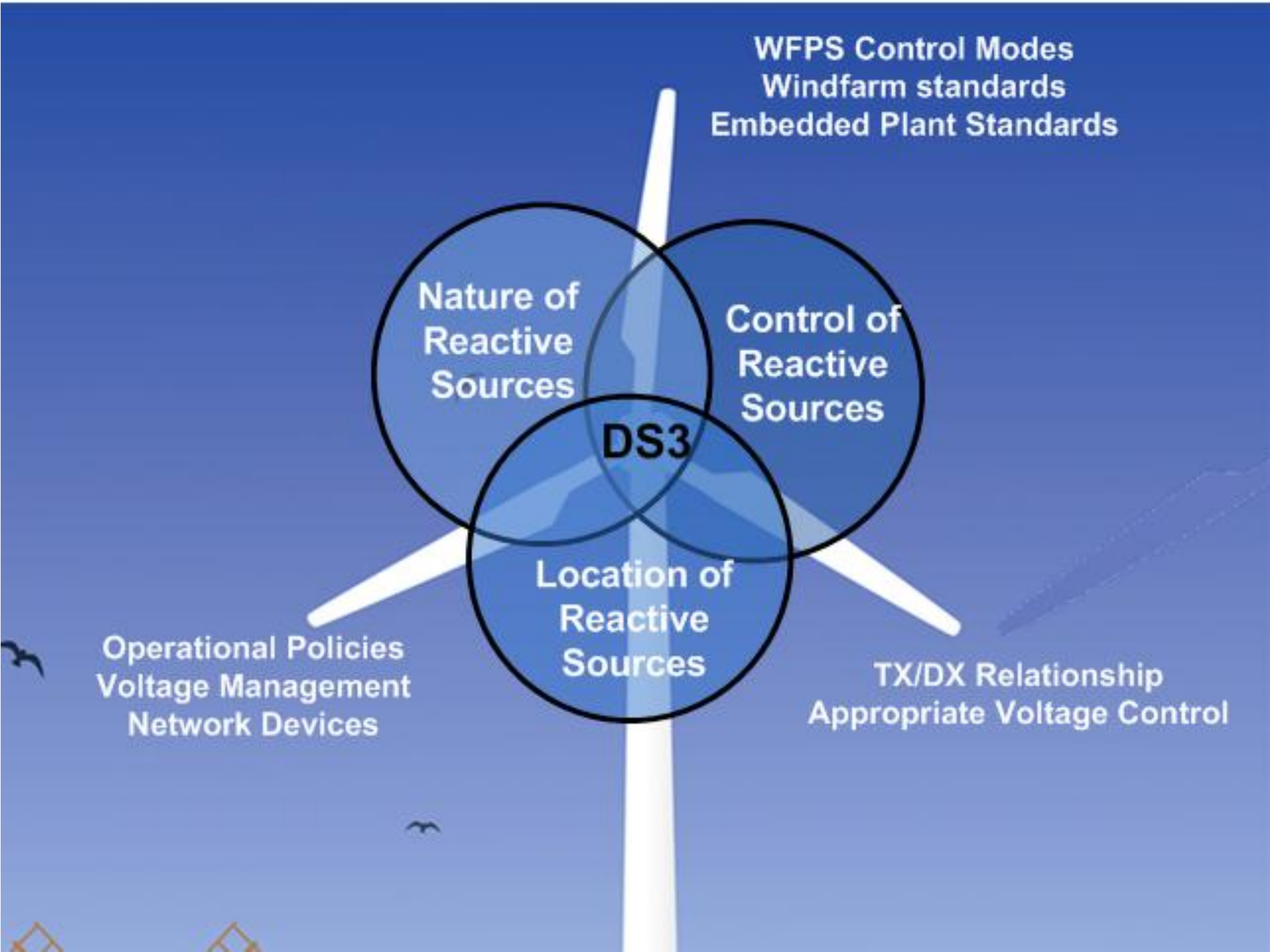
Degradation of Transient Stability in High Wind Scenarios



Moderate amounts of wind power increase dynamic stability, but at high levels of wind power penetration, dynamic stability deteriorates significantly

Degradation of Transient Stability in High Wind Scenarios




WFPS Control Modes
Windfarm standards
Embedded Plant Standards
Nature of Reactive Sources
Control of Reactive Sources
DS3
Location of Reactive Sources
Operational Policies
Voltage Management
Network Devices
TX/DX Relationship
Appropriate Voltage Control

DS3 Strategy: Addressing the Challenges in Voltage Control

Setting Appropriate Standards

- Joint Grid Code Working Group
- Steady-state Reactive Capability and Controllability: WFPS / Embedded Conventional Plant
- Dynamic Performance of WFPS

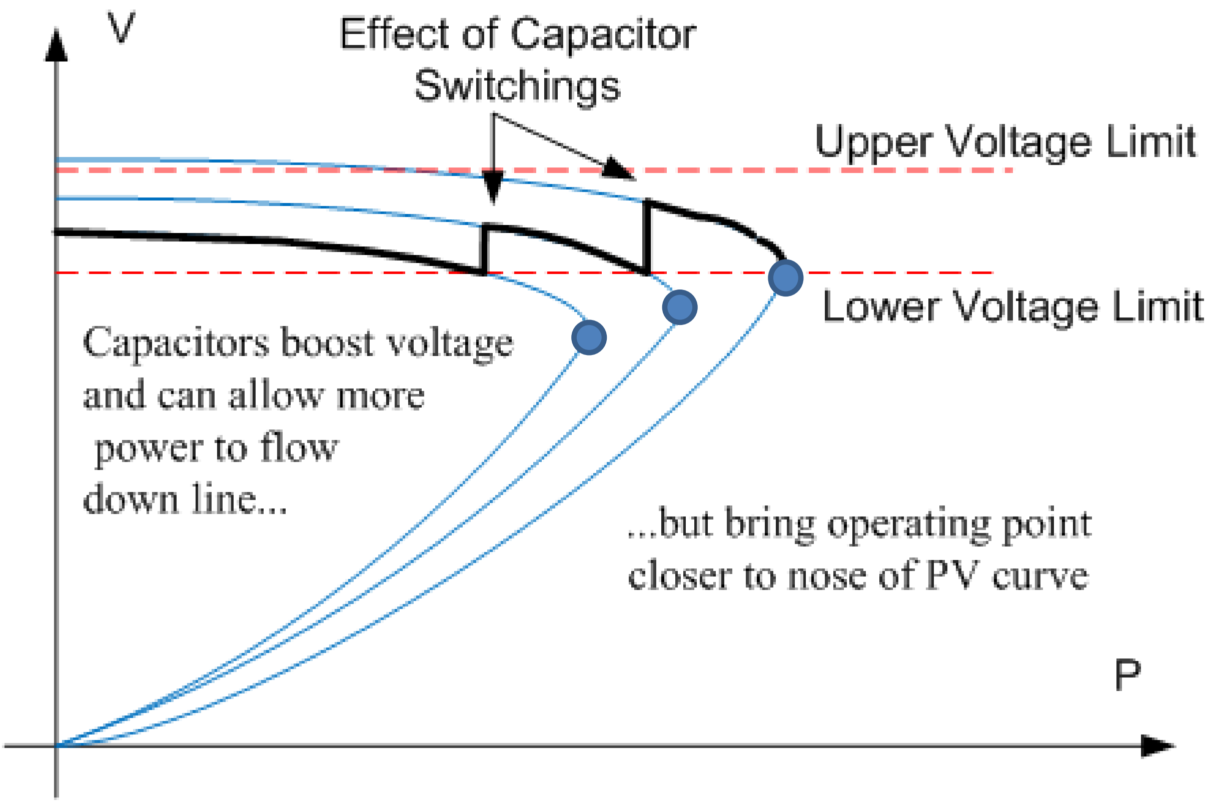
Revising Operational Policies

- TSO Reactive Power Policy
- DSO/TSO Voltage Control Management

Network Solutions and Design

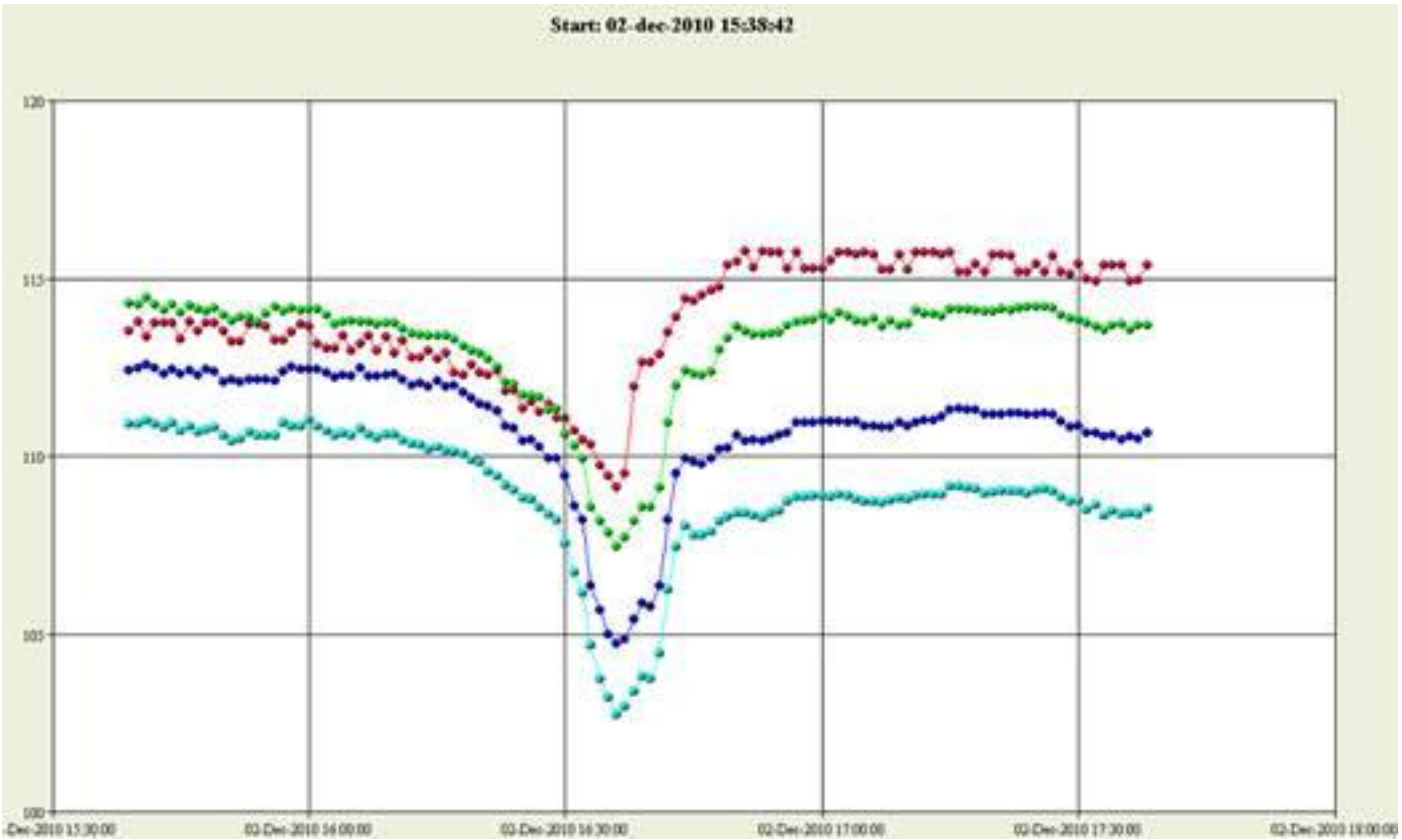
- Pilot /Demo Projects
- Planning Studies
- Network Solutions: Synchronous Condensers, Flywheels etc.

Capacitor Bank Effects



In addition, Reactive Power from Capacitors is proportional to $(\text{Voltage})^2$, exacerbating low voltages

Example: Incipient Voltage Collapse – Donegal 2010



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Next Steps

- Joint Grid Code Working Group on DS3
- Discussions between TSOs and DSOs on best approach to voltage control
- Bring proposed changes to GC review panels North and South
- Performance monitoring to ensure compliance
- Operational Policy Review every 6 months