Wind farm collector systems and grid integration

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TNEI

- Energy Management and Renewables
- Planning and Environment
- Power Systems and Technology
  - Energy / Power Economics
  - Power Systems Analysis
  - Model Development
- IPSA Software - Easy to use GUI, graphics based interface

Background

- Future renewable energy electricity generation scenarios
- Wind versus conventional generation
- Network issues
- Network solutions and technologies

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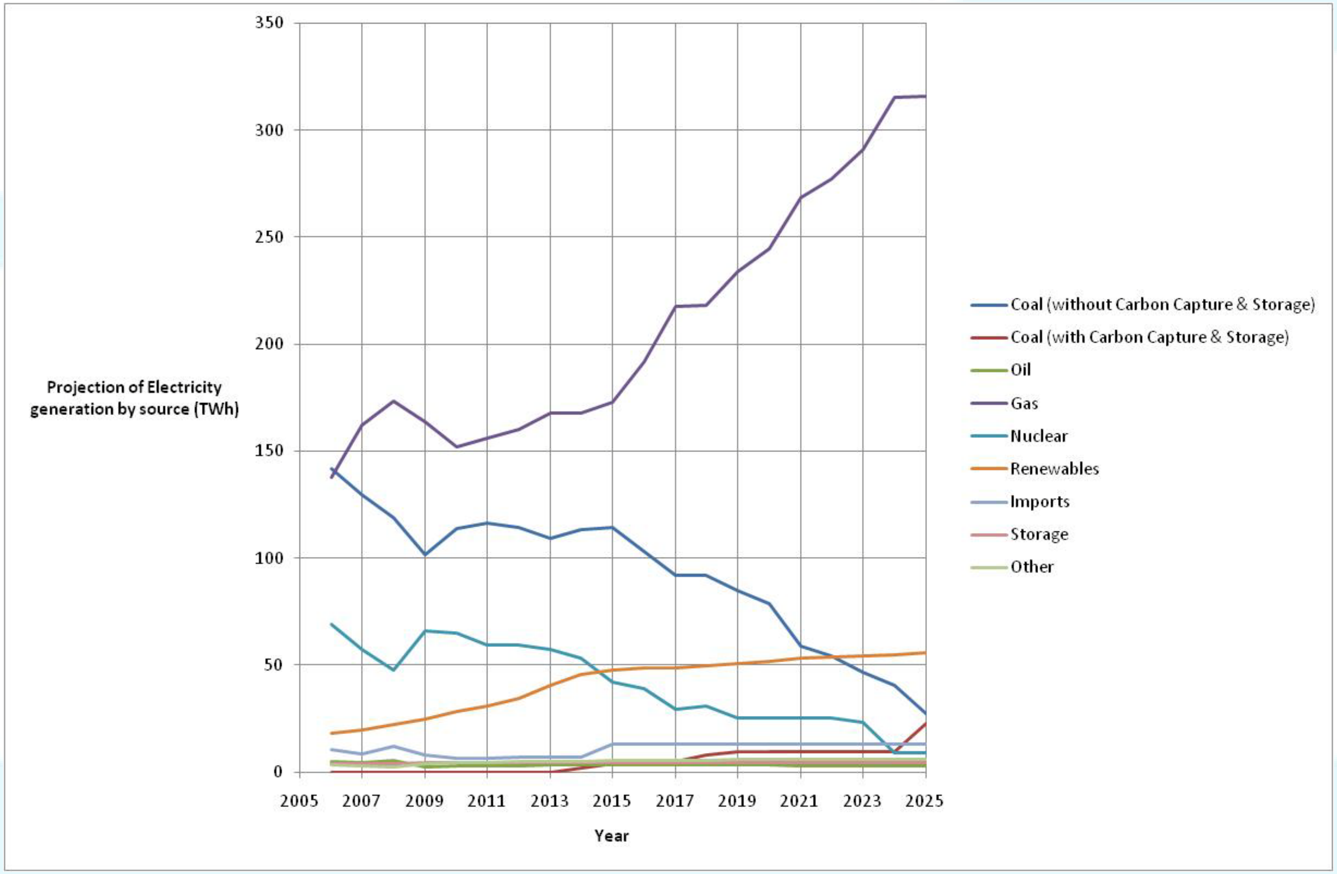
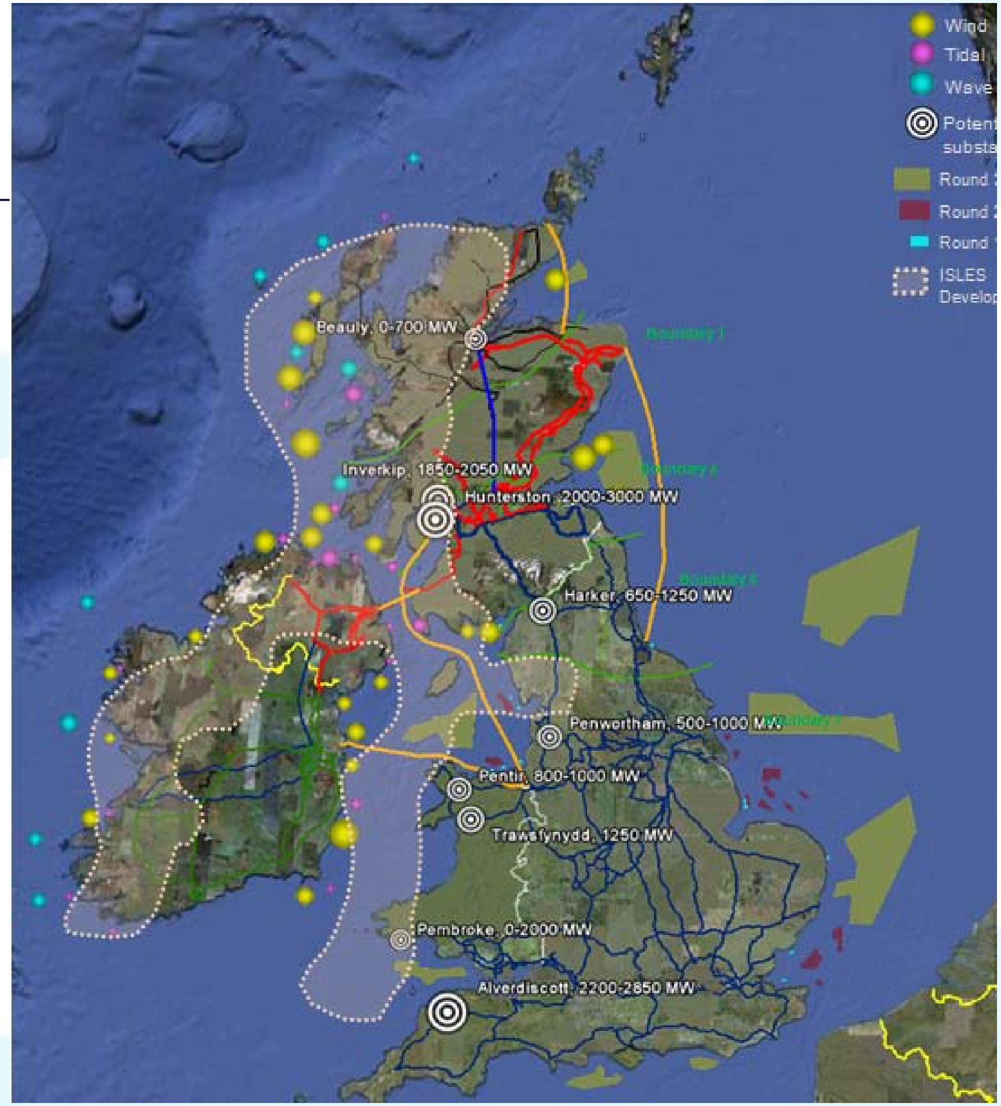
Projected of electricity generation by source



Geographical Distribution of UK Wind Resource



Existing and future UK electrical demand

- Largest demand in the south of the UK
- Requirement to move renewable energy and traditional generation from the north to load centres in the south
- Seasonal and diurnal load profile may become flatter due to
  - Increase in air-conditioning
  - Demand side management
  - Electrical vehicles

Wind versus Conventional Generation – Power System Point of View

Wind

- Intermittent generation – semi-dispatchable
- Location dependent (remote areas/offshore) not near load centres
- Relatively large area required for windfarms
- High MWh/£

Conventional

- Dispatchable
- Can be located anywhere generation available
- Relatively easy to site
- Low MWh/£

Fundamental Power System Requirements and Aims

- Reliability and security of supply
- Generation matches demand
- Thermal limits of system equipment
- Voltage limits of system and equipment
- Faults levels, safety and protection
- 50Hz, sinusoidal supply
- Grid code/distribution code compatibility

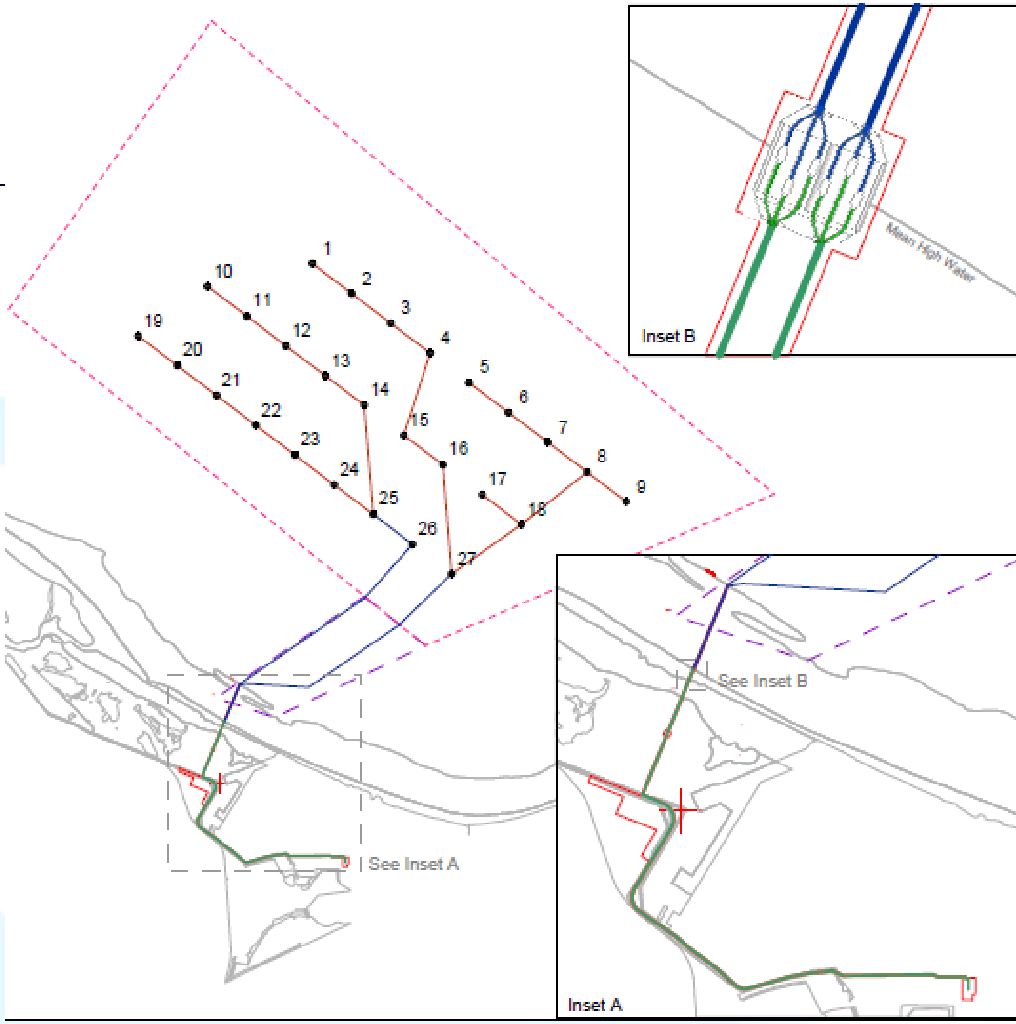
Issues associated with wind generation

- Intermittent generation (too little or too much!!)
- Thermal capacity
- Reactive power capability
- Voltage rise
- Change in fault levels
- Harmonic injection and electrical flicker
- Fault ride through
- Large losses associated with windfarms in remote locations e.g. off-shore

Enabling technologies for grid integration of wind generation

- Demand side management
- Larger windfarms offshore
- Larger interconnected on-shore and off-shore electricity grids
- Dynamic line ratings
- Energy storage
- FACTS and distribution level power electronics devices
  - HVDC (CSC) and HVDC Light (VSC)
  - STATCOMS
- Harmonic filters

Case study – 62MW onshore windfarm



33kV Subsea 240 mm sq

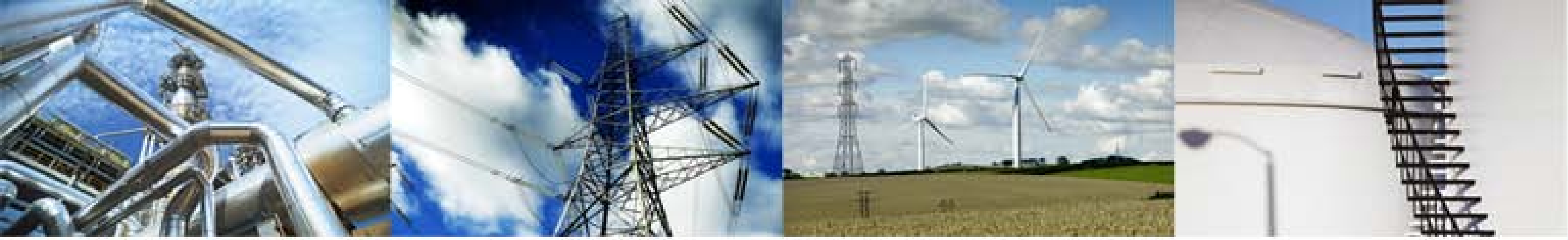
33kV Subsea 630 mm sq

33kV Land 800 mm sq

Onshore Consent Corridor

Offshore Consent Corridor

Awarded Site Area



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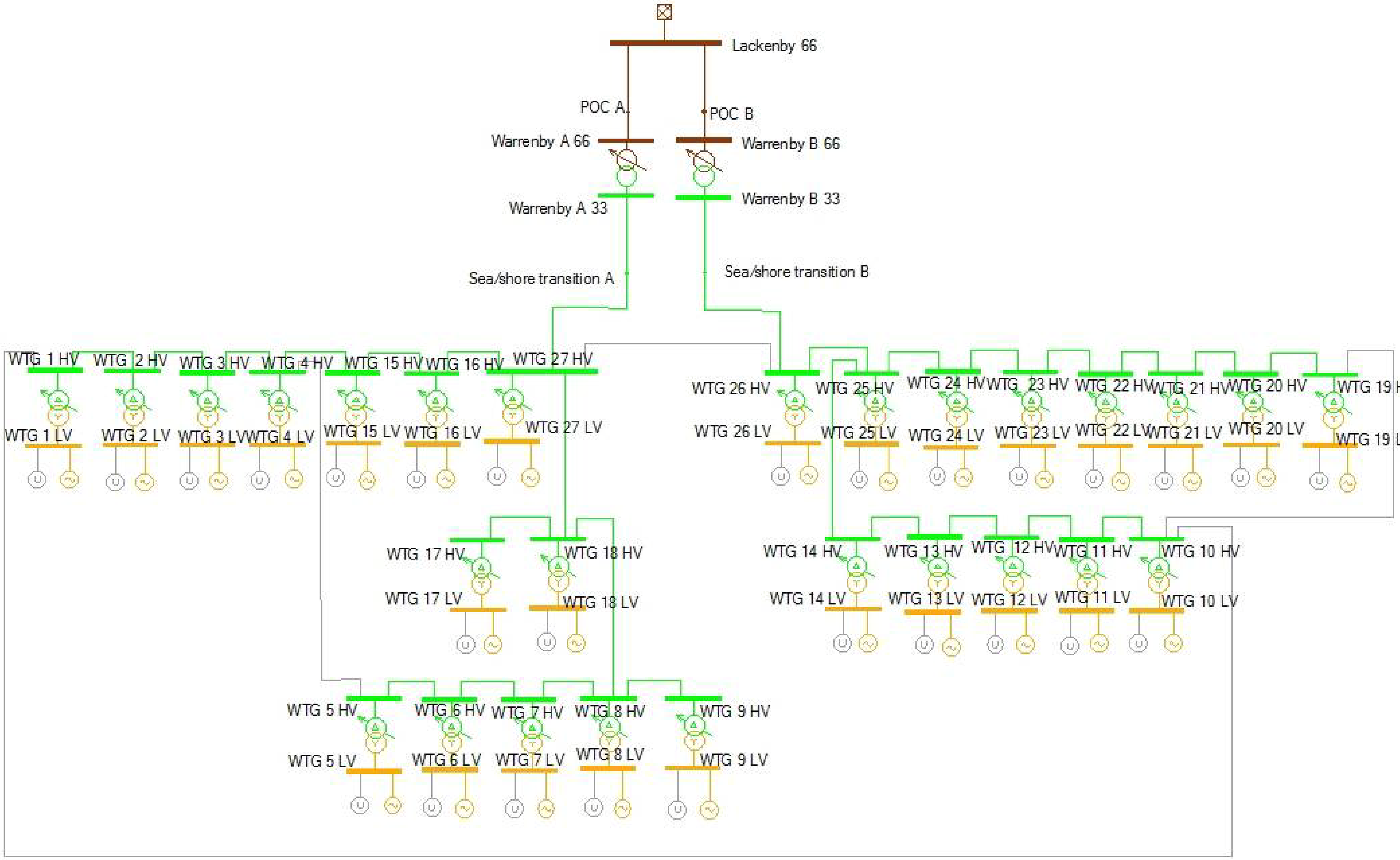
Network Model

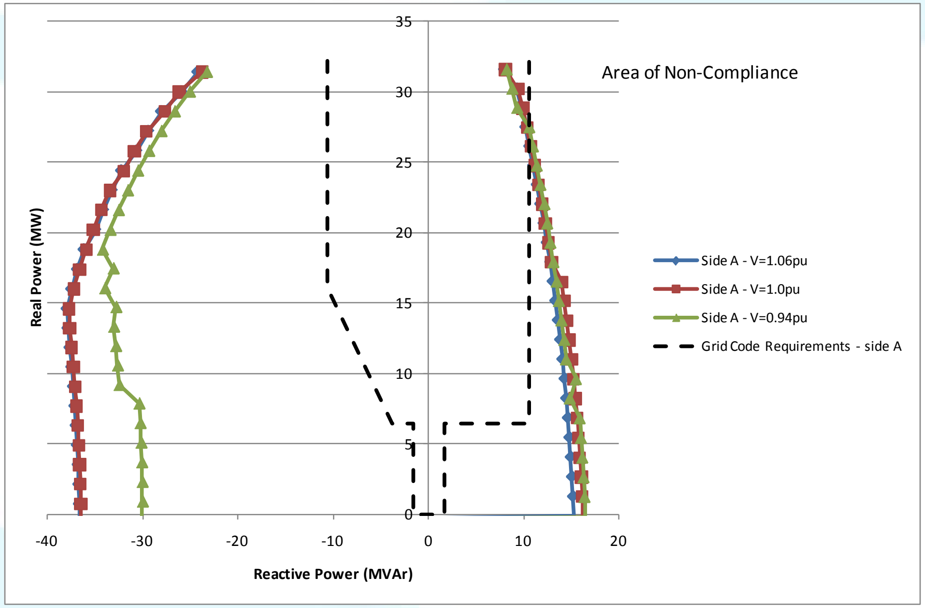


Design Studies

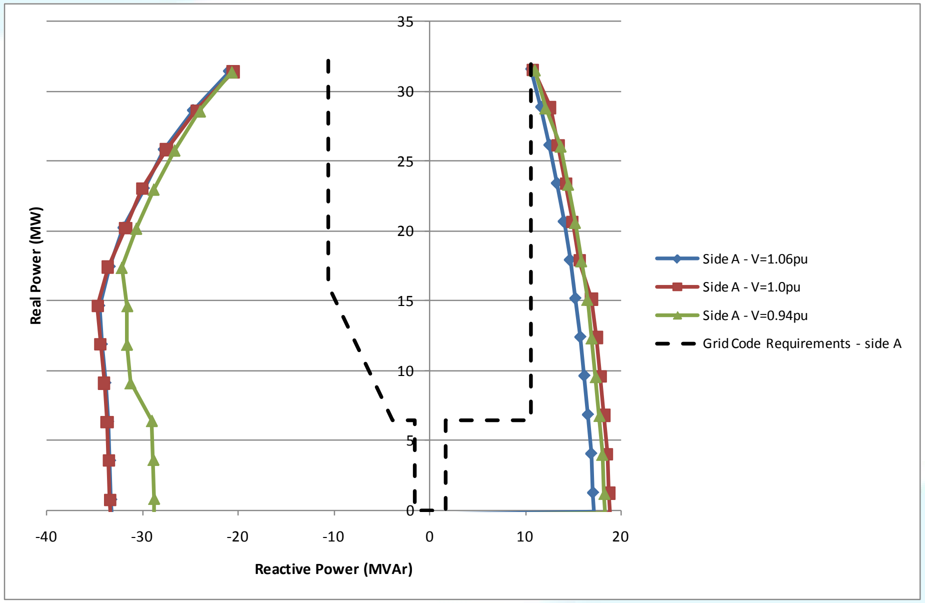
- Conductor ratings
- Electrical losses and energy yield
- Reactive power capability
- Fault level analysis
- P28 Compliance – Power Quality
  - Turbine transformer energisation
  - Loss of power output
  - Flicker studies
- Harmonic Analysis

Reactive Capability

Without capacitive compensation



With capacitive compensation

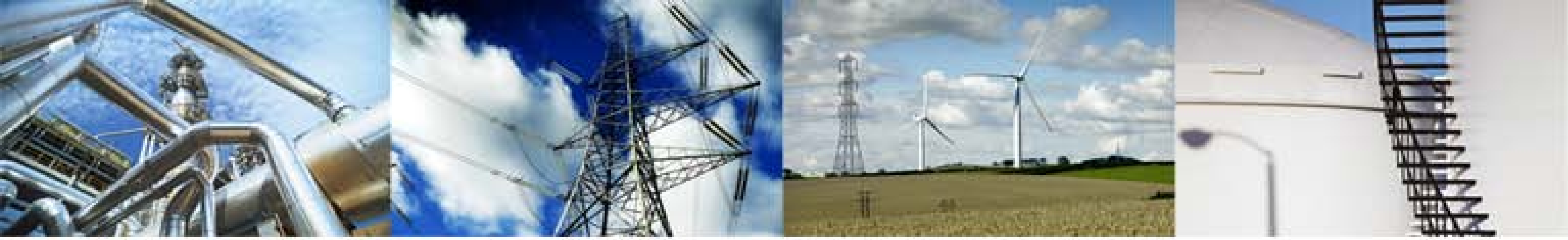


Fault level analysis

	Fault Level (MVA)				Rating	
	Without WF		With WF			
	Peak Make (@ 10ms)	RMS Break (@ 100ms)	Peak Make (@ 10ms)	RMS Break (@ 100ms)	Peak Make (@ 10ms)	RMS Break (@ 100ms)
66kV Existing GSP Substation	6078 MVA (53.2 kA)	1953 MVA (17.1 kA)	6191MVA (54.15 kA)	2020 MVA (17.67 kA)	6378 MVA (55.8 kA)	2505 MVA (21.9 kA)
Substation 1 - 66kV A	N/A	N/A	2630 MVA (23.01 kA)	1182MVA (10.34 kA)	N/A	N/A
Substation 1 - 66kV B	N/A	N/A	2630 MVA (23.01 kA)	1182 MVA (10.34 kA)	N/A	N/A
Substation 2 - 33kV A	N/A	N/A	798 MVA (13.96 kA)	330 MVA (5.78 kA)	N/A	N/A
Substation 2 - 33kV B	N/A	N/A	798 MVA (13.96 kA)	330 MVA (5.78 kA)	N/A	N/A

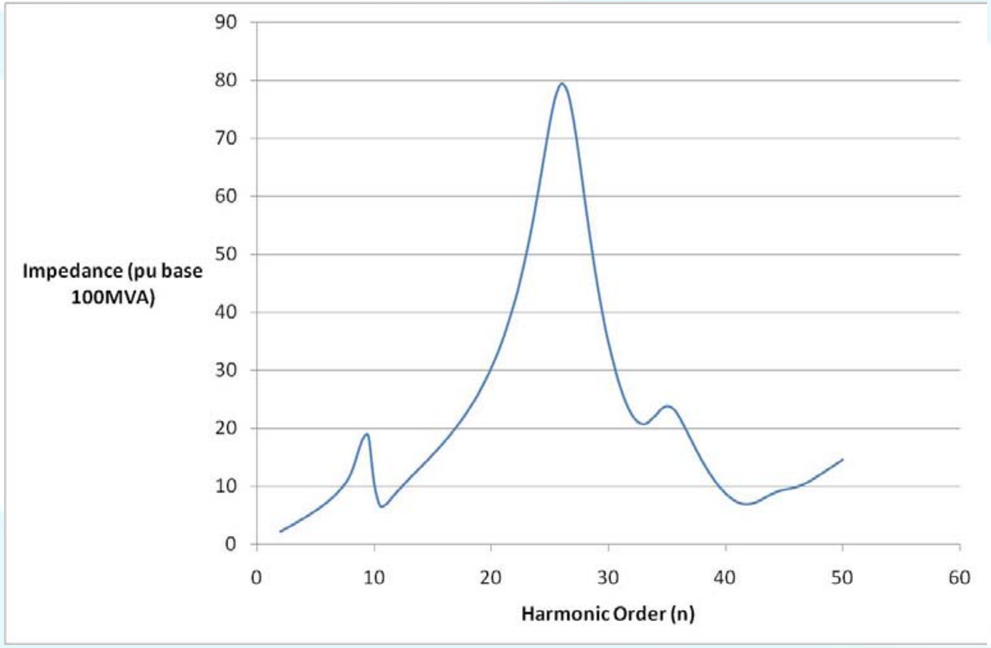
P28 Compliance Studies and Harmonic Analysis

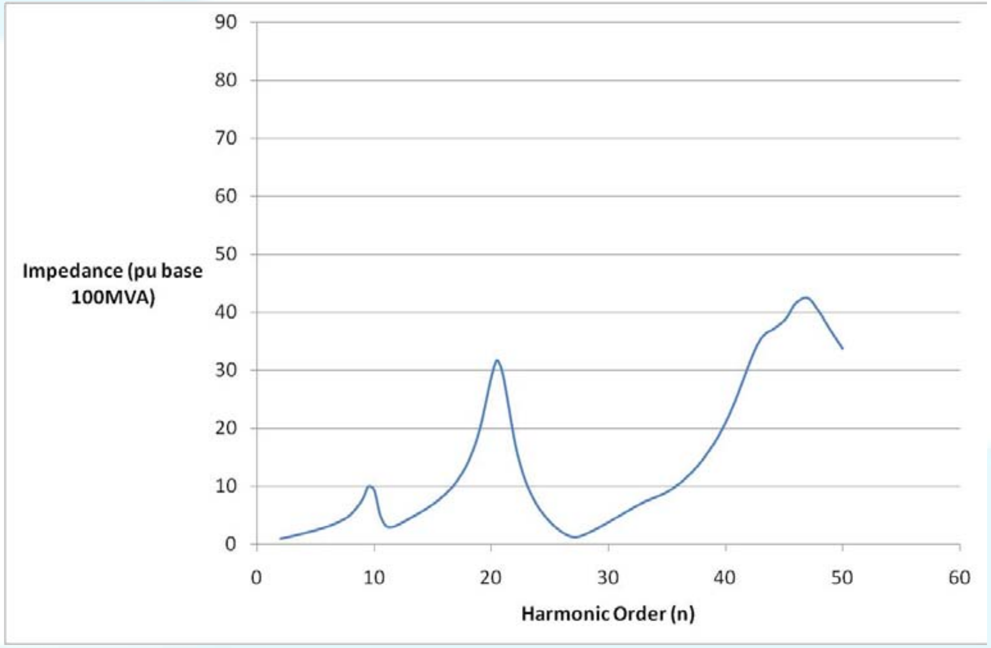
- Wind turbine transformer energisation
- Loss of power output
- Flicker studies
- Harmonics analysis
  - Initial stage 2 study spreadsheet based
  - Stage 3 study requires model



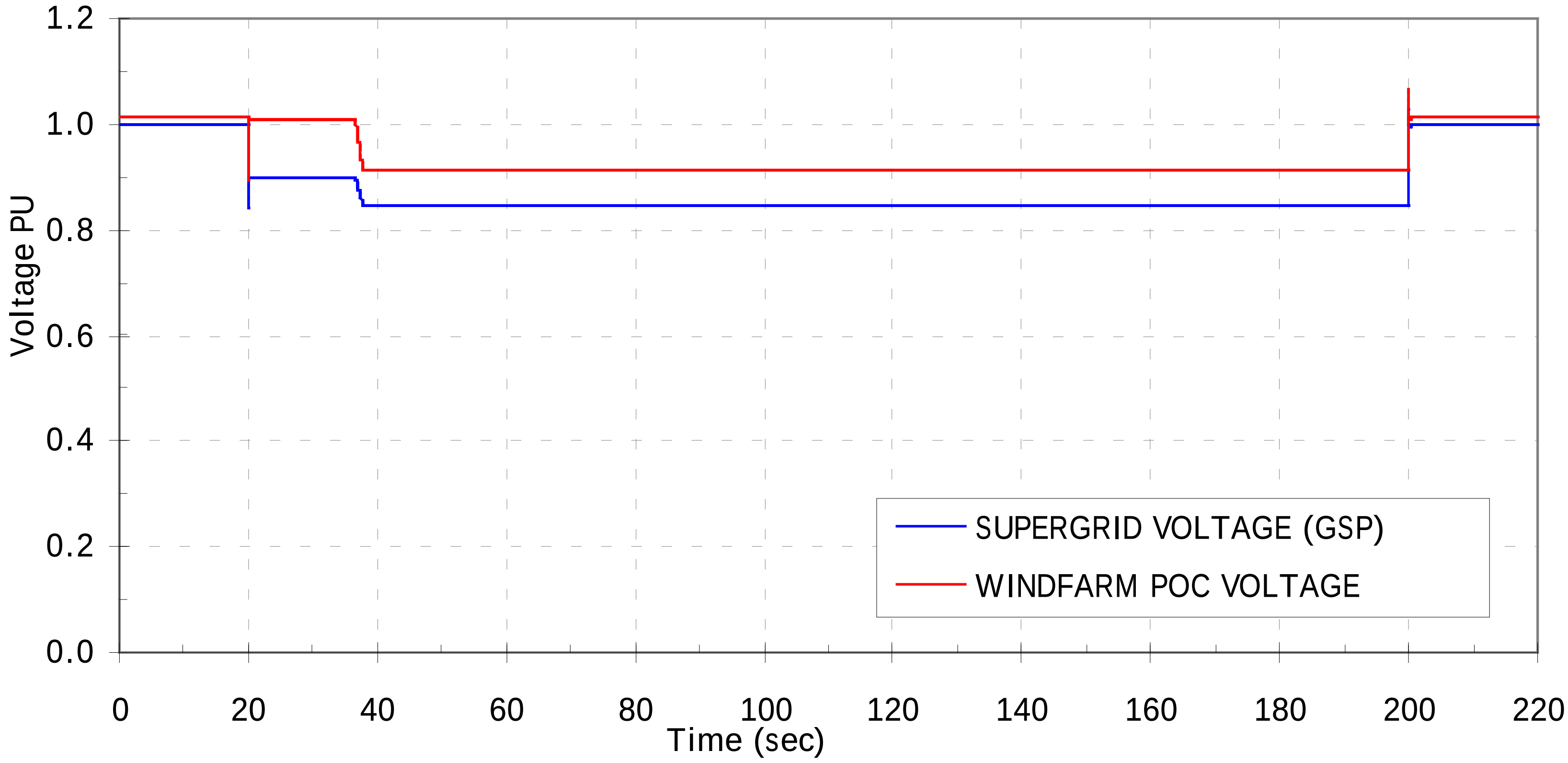
Harmonic Analysis – Impedance

- Without windfarm
- With windfarm





Fault ride through



Summary

- Generation will be located at remote locations rather than large power stations
- Larger, more flexible smarter electricity grid
- Generation will be connected at distribution level voltages as well as at transmission level voltages
- Design studies required to investigate each proposed windfarm
- Newer technologies enable windfarm development in remote regions