SP ENERGY NETWORKS

NASPI Work Group and first International Synchrophasor Symposium
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Expanding the WAMS Reach – VISOR Project in the UK

Synchrophasor Pilot, Standards and GB Roadmap

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Presentation Agenda

Introduction

SP Energy Networks

The GB Transmission System

Overview of VISOR

- *Problem:*

  The Evolving Network

- *Method:*

  The VISOR WAMS

  Lesson's learnt

Future steps

- *Solution*

  Roadmap

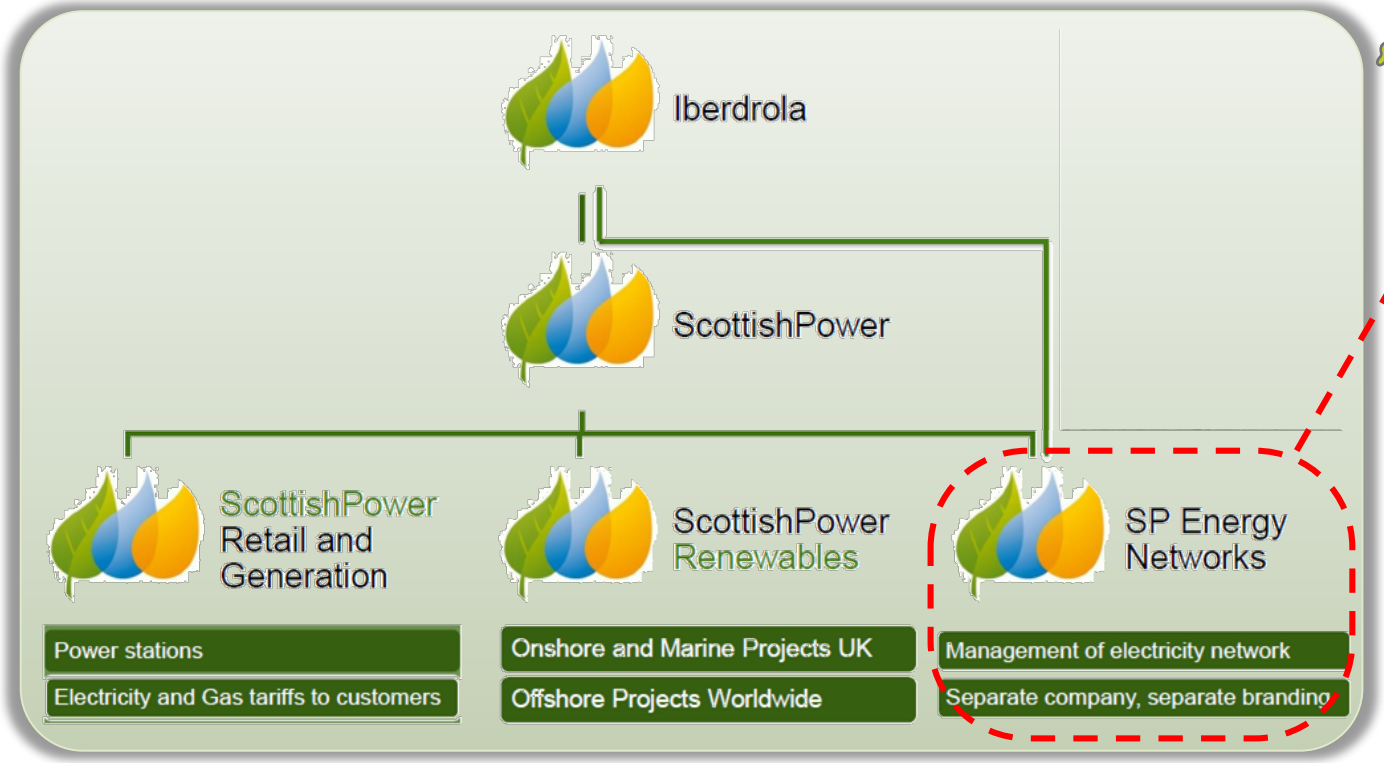
Questions

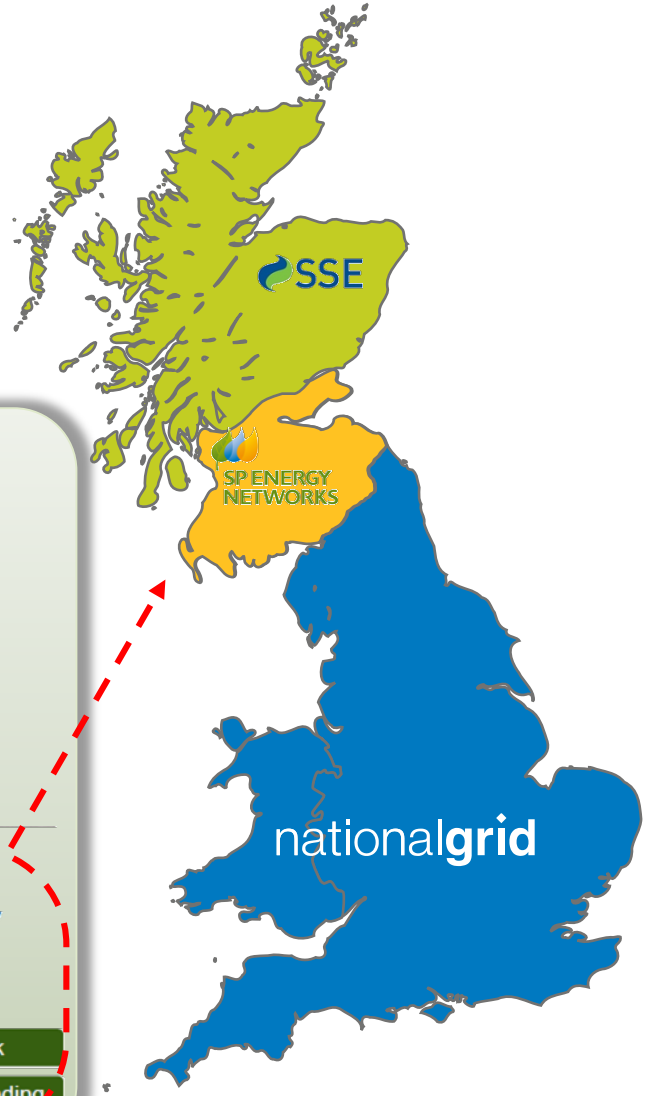
Who are SP Energy Networks?

We Are

- Transmission Operator (asset owner) for central belt of the UK
- Jointly owned by Iberdrola and ScottishPower

ScottishPower own separate Retail and Developer businesses





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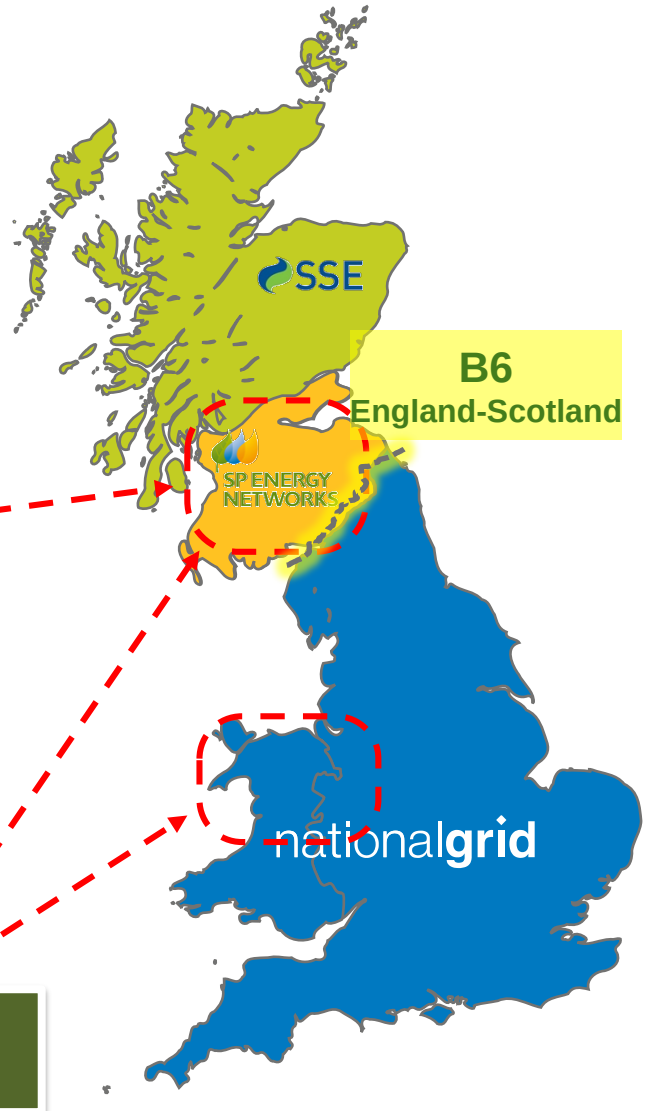
Transmission Network Owner in Southern Scotland

- SP Transmission (SPT) 132kV – 400kV
  - 4% of annual electricity bill
  - 56% of Scotland's transmission connected renewable generation
  - Highly reliable system (0.00002% ENS in 2014/15)
  - Scotland-England "B6" boundary critical asset



Distribution Network Owner in Southern Scotland and North Wales

The GB Transmission System

Transmission Owners (Asset Owners)

	nationalgrid	SP ENERGY NETWORKS	SSE
km of Circuit	14,000 400, 275kV	4,000 400, 275, 132kV	5,000 400, 275, 132kV
# of Substations	340	80	40
Demand GW	54.3	4.39	1.65

UK System Operator

nationalgrid

Operational View		GB Interconnectors	
Winter Peak Demand	~ 60GW	France	2GW
Generation Capacity	~ 80GW	N. Ireland	0.5GW
		Ireland	0.5GW
		Netherlands	1GW

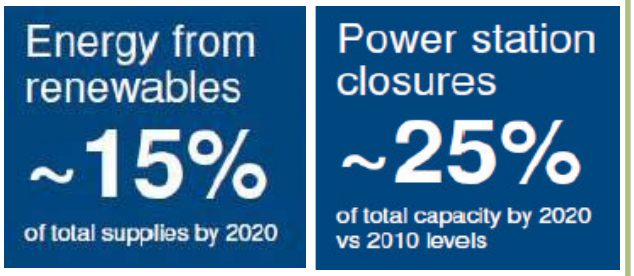
Some background…

UK subject to EU law-binding renewable energy targets

Decarbonisation targets dramatically changing the UK energy landscape

UK targets

- 15% of all Energy from Renewables by 2020
  - 30% of Electricity, 12% Heat, 10% transport
- 25% of power station closure by 2020



In Scotland

- Unprecedented increase in renewable generation and loss of inertia in SPT

2010/11 forecast	Contracted
2.5GW by 2021	**~5GW** by 2021

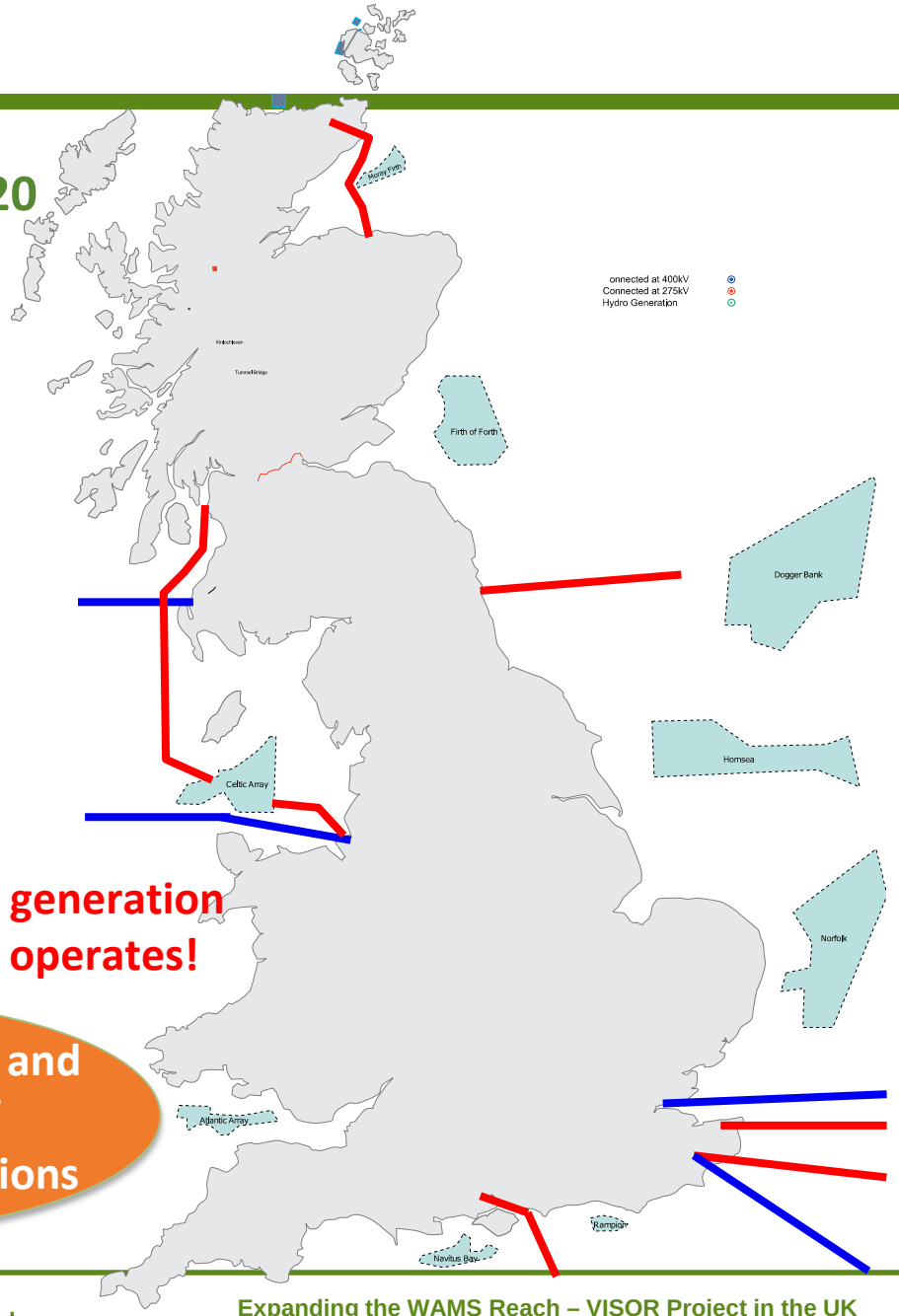
- 100% of Scotland's gross electricity from renewables by 2021 (50% in 2015)
- Closure of last coal station at Longannet by 2016
- Closure of last nuclear power stations at Hunterston and Torness by 2030
- **SNP policy for no new nuclear plants in Scotland**

Both Transmission and Distribution Networks are evolving to facilitate this…

Overview – The Evolving Network

Transmission Network Reinforcement to 2020

- **– Increased Interconnection to Europe**
  - *ELEC Link 1000MW*
  - *NEMO 1000MW*
  - *IFA2 1000MW*
  - *NSN 1400MW*
- **– Increased Intra-Network HVDC**
  - *Western Link (2200MW across B6)*
  - *Caithness-Moray (1200MW)*
- **– Increased Series Compensation**
  - *Thyristor-Controlled and Fixed*
  - *Increase B6 stability to 4.4GW*



But increased power electronics and intermittent generation on both T&D networks changes how the network operates!

Changes dynamic behavior and increases complexity

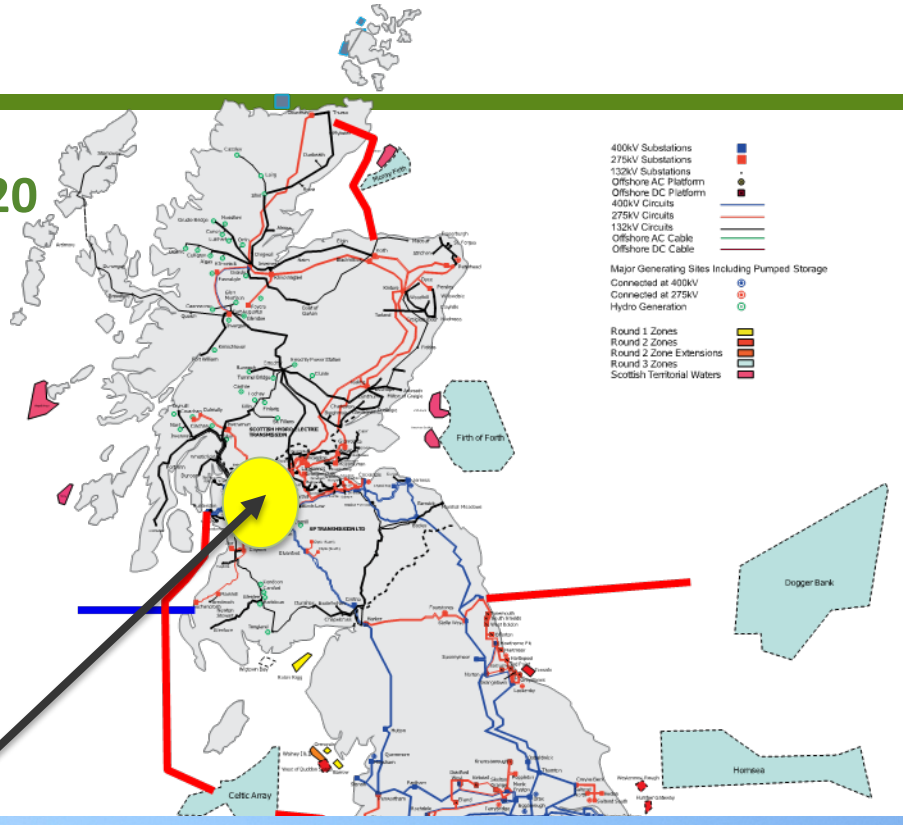
Increased uncertainty and Increased potential of interactions & oscillations

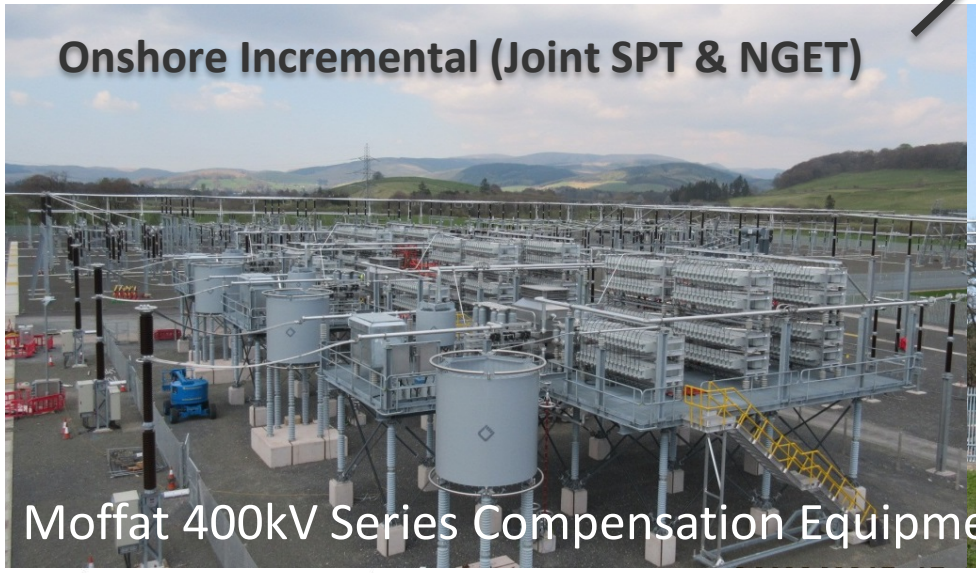
Overview – The Evolving Network

Transmission Network Reinforcement to 2020

Increased power electronics in SPT in conjunction with NG

- Series compensation





Moffat 400kV Series Compensation Equipment

- *B6 to ~4.4GW*
- *Series Comp*
- *Shunt comp*
- *East-West 400kV Upgrade*

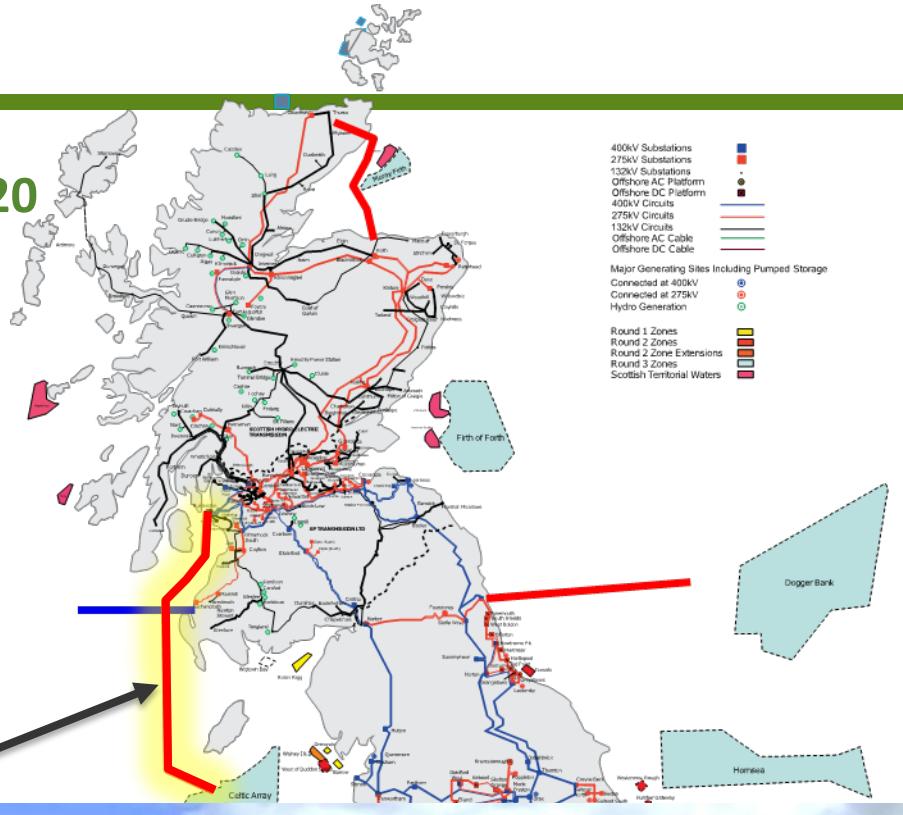
Overview – The Evolving Network

Transmission Network Reinforcement to 2020

Increased power electronics in SPT in conjunction with NG

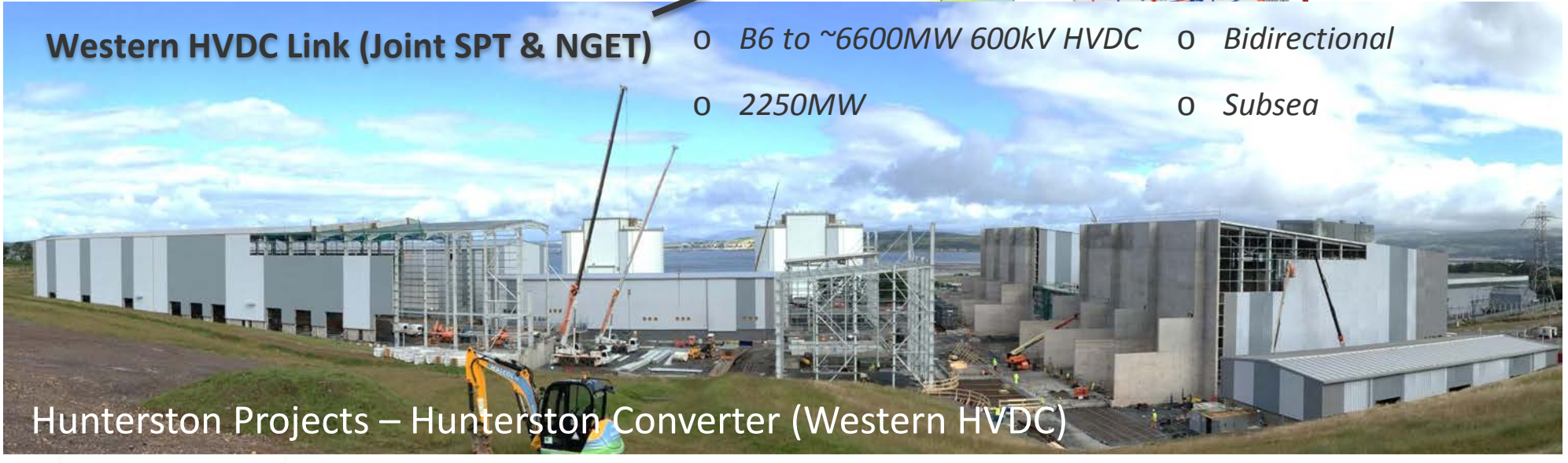
- Series compensation
- HVDC interconnectors

Increase the potential for oscillation



Western HVDC Link (Joint SPT & NGET)

- *B6 to ~6600MW 600kV HVDC*
- *2250MW*
- *Bidirectional*
- *Subsea*



Hunterston Projects – Hunterston Converter (Western HVDC)

Overview – The Evolving Network

Transmission Network Reinforcement to 2020

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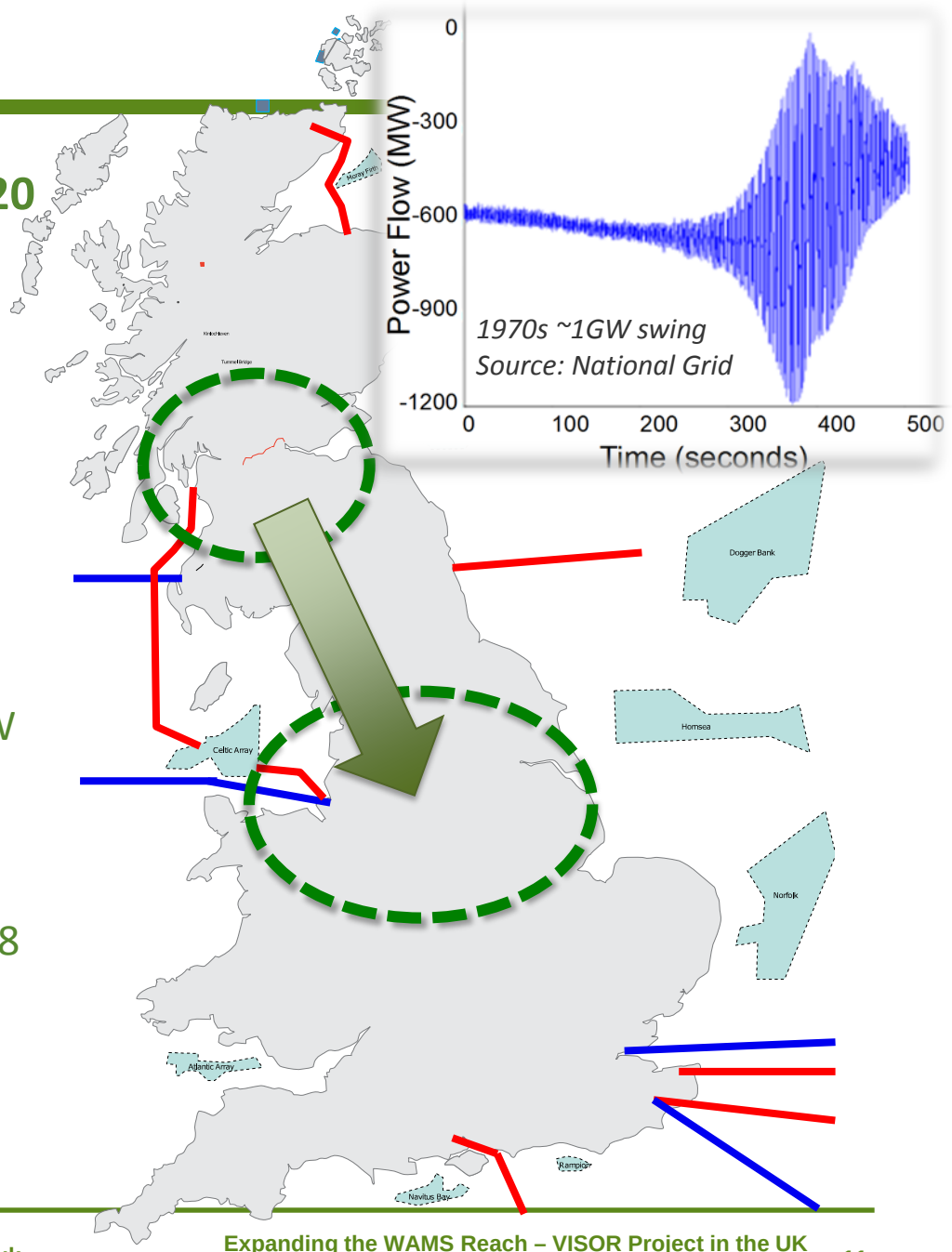
Increase the potential for oscillation



- 0.5Hz Oscillations between Scotland and E&W since late 1970's, involving the whole GB system
- Real-time Wide Area Oscillation Monitoring (early warning) live in control room since 1998
- Upgraded to PMU-based system in 2011

The evolving network and changing energy landscape present significant challenges for TO and SO

- Maintain system stability and reliability with more renewables and less inertia
- Increased diversity of power electronic equipment
- Increasing need to transfer power from the North to the South
  - Major infrastructure projects to increase transfer capacity across Scotland-England “B6” boundary (WHVDC, series compensation etc)
- Increased need to maximise utilisation of existing assets and wayleaves
- Ability to recover from Black Start
- Potential for new markets – Distribution Network to provide services to System Operator – impact on existing assets etc

Project VISOR is designed to assist tackle these challenges

VISOR - Visualisation of Real Time System Dynamics using Enhanced Monitoring

Project VISOR WAMS Pilot project 2014-2017

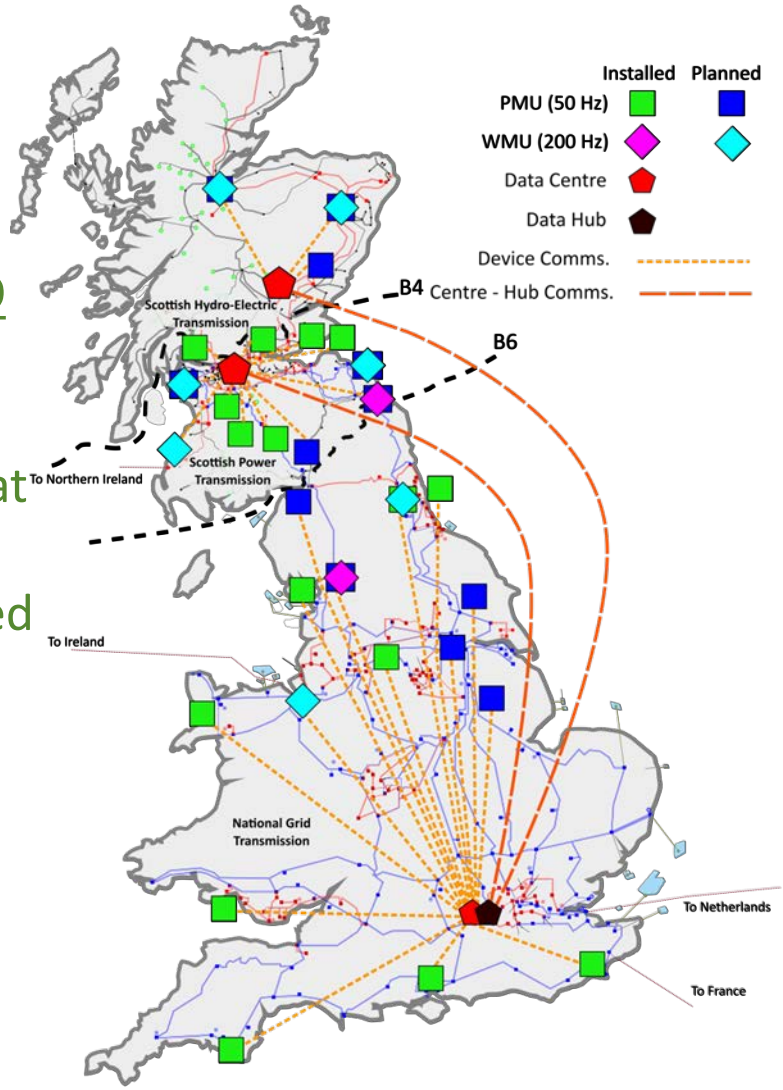
- ❑ Establish first GB WAMS taking measurements from all mainland TOs
- ❑ Install and develop tools to build confidence in use of technology and the benefits
- ❑ Demonstrate phasor-based measurements to improve dynamic understanding of network
- ❑ Evaluate post-project investment options and roll-out strategies

Monitoring infrastructure

- Existing DFRs converted to PMUs
- **New 200Hz measurement units trialled to detect SSO from 4 to 46Hz**
- PhasorPoint PDC installed at each TO
- Central 'Super PDC' installed at System Operator

Comms infrastructure

- IPSec and MPLS communications between PDCs and SO PDC



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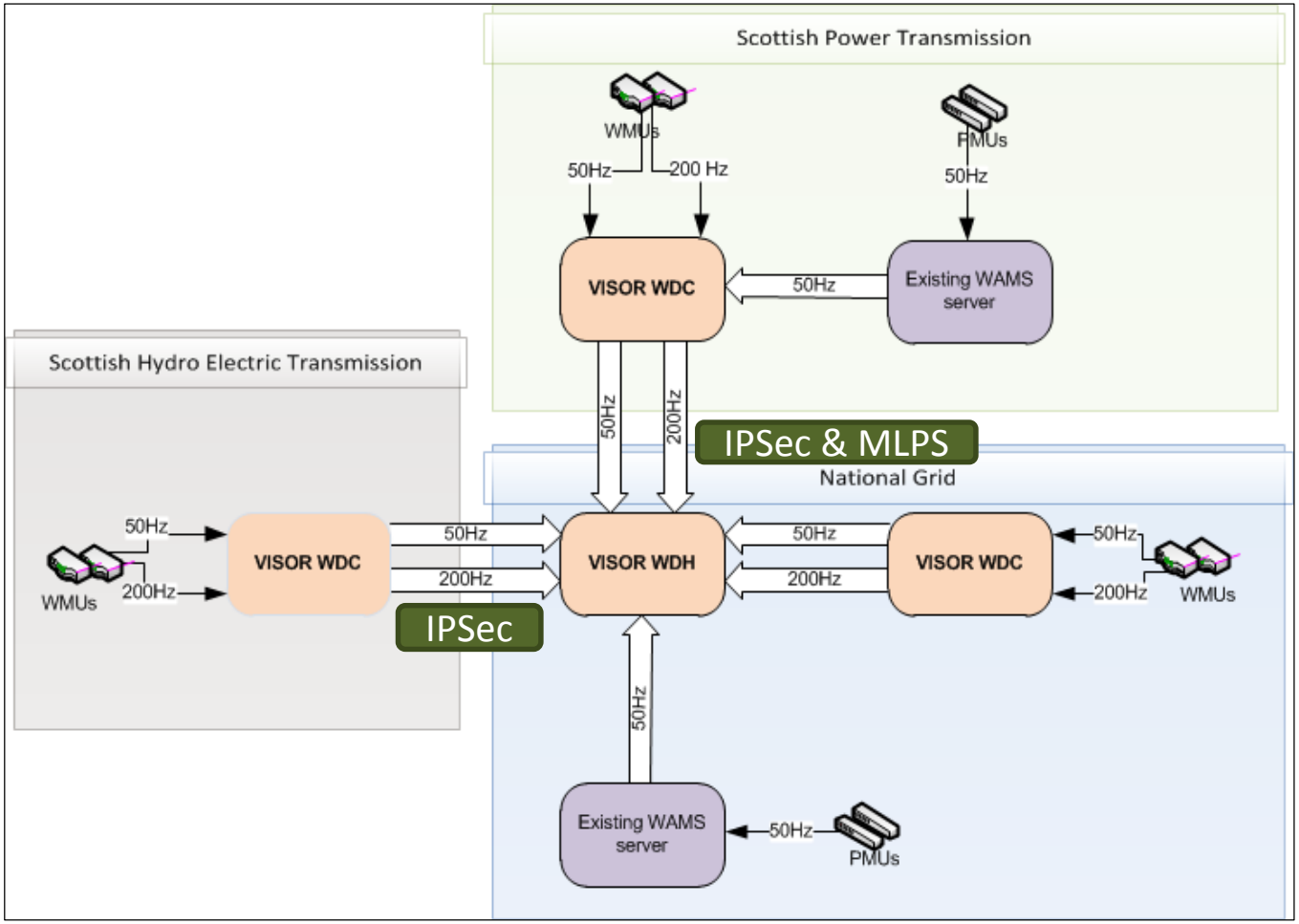
Comms infrastructure *Logical view*



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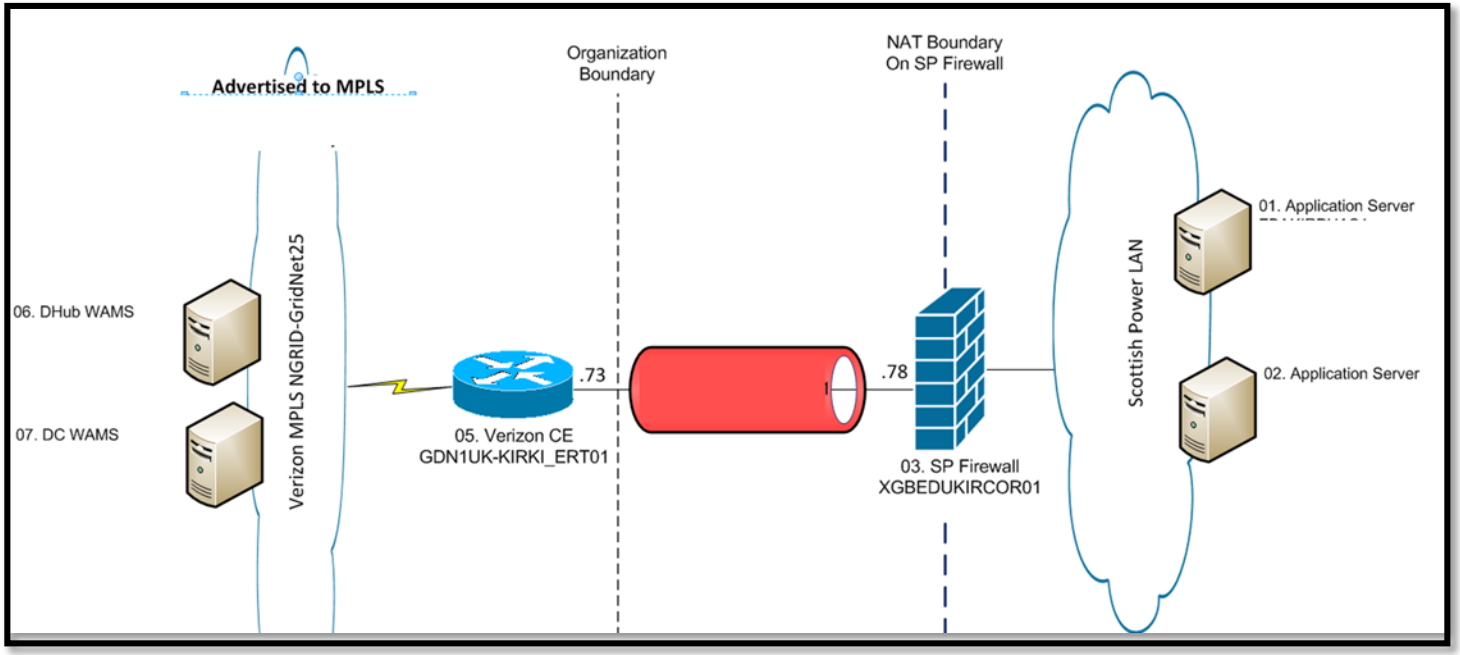
Comms infrastructure

MPLS Link



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Applications

Tools deployed focus on three main areas

Managing Risk & Events	Maximising Assets	Reducing Uncertainty
Oscillation Monitoring & Source Location	Demonstration & Evaluation of Angle-Based Security Limits	Demonstration & Evaluation of Hybrid State Estimation
0.002 – 0.1 Hz Governor & Common	WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations	Impact of Uncertainty on Security Margins
0.1 – 4 Hz Electromechanical & Voltage Control	**WAMS Software Applications** *Demonstrated in Alstom Grid's **PhasorPoint** WAMS*	Dynamic Model Validation
4 – 46 Hz Torsional, Resonance & Control interaction		Robust Line Parameter Estimation
Disturbance Detection, Location & Characterisation		

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- ❑ **Evaluate post-project investment options and roll-out strategies**

Roadmap

Assess outcomes of VISOR; evaluate various business benefits, develop business cases, design infrastructure and propose roll-out strategy

Key areas to address

- Applications and their owners (CR/Planning/Network design)
- Integration with other applications (EMS, Stability Assessment, Model validation)
- Number of devices and specifications (50Hz/200Hz, IEC/IEEE 60255-118-1)
- IEEE 1588, concerns over reliance on GPS
- Comms' requirements
- Big Data Challenges: data & cyber security
- TO & SO visibility – how data shared amongst TOs
- Should SO define the requirements of the TO
- Timescales for deployment, based on similar sized systems

VISOR Experience

Cultural change

End users

- predominantly concerned with doing their duties well
- need confidence/evidence that change will not hinder their defined objectives
- see the merit in new technology which improve elements of their day-to-day objectives
- can be restricted by internal policy, old or out-dated assets or systems, and/or individual's motivation for change

Business change

Decision-makers

- often have wider concerns and varying drivers
- corporate objectives, e.g. expenditure, can dictate uptake
- **will require sufficient evidence of costs and benefits**

Regulatory change

- can enforce change through Licence Code but **will require sufficient evidence of costs and benefits**

Summary

Growing Complexities in the GB System:

- Network changes, shift in generation mix, new & more complex plant
- Increased pressure on system, increased complexity & uncertainty
- Major changes to dynamics: raised potential for interaction or instability

Enhanced monitoring now required

- Existing systems limited in capabilities - Need synchronised visibility, of dynamic behaviour

Motivation for WAMS

- Visibility & monitoring of dynamic behaviour
- Reduced uncertainty in models & operation
- Real-time, post-event, planning and design applications

Challenges

- Communications: reliability, bandwidth
- Big Data: storage, aggregation, effective & useful visualisation
- Analysis: robust, reliable, real-time algorithms

WAMPAC Roadmap

- Control Room integration

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