Expanding the WAMS Reach – VISOR Project in the UK

Synchrophasor Pilot, Standards and GB Roadmap

Priyanka Mohapatra, VISOR Project Lead
pmohapatra@spenergynetworks.co.uk
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
Introduction

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

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

Expanding the WAMS Reach – VISOR Project in the UK Synchrophasor Pilot, Standards and UK Roadmap
Introduction

The GB Transmission System

Transmission Owners (Asset Owners)

<table>
<thead>
<tr>
<th></th>
<th>km of Circuit</th>
<th># of Substations</th>
<th>Demand GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>nationalgrid</td>
<td>14,000</td>
<td>340</td>
<td>54.3</td>
</tr>
<tr>
<td>SP Energy Networks</td>
<td>4,000</td>
<td>80</td>
<td>4.39</td>
</tr>
<tr>
<td>SSE</td>
<td>5,000</td>
<td>40</td>
<td>1.65</td>
</tr>
</tbody>
</table>

The GB Transmission System

- **Operational View GB Interconnectors**
  - GB Interconnectors
    - France: 2GW
    - N. Ireland: 0.5GW
    - Ireland: 0.5GW
    - Netherlands: 1GW

- **Winter Peak Demand**: ~ 60GW
- **Generation Capacity**: ~ 80GW
Overview – Changing Energy Landscape

Some background...
Overview – Changing Energy Landscape

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
- 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

Onshore Incremental (Joint SPT & NGET)
- B6 to ~4.4GW
- Series Comp
- East-West 400kV Upgrade
- Shunt comp

Moffat 400kV Series Compensation Equipment
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
- Bidirectional
- 2250MW
- Subsea

Hunterston Projects – Hunterston Converter (Western HVDC)
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

- 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
**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
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

**Comms infrastructure**

**Logical view**

- Scottish Hydro Electric Transmission
- Scottish Power Transmission
- IPSec & MLPS
  - National Grid
- Existing WAMS server
- VISOR WDC
- VISOR WDH
- IPSec
- PMUs
- WMs
- 50Hz, 200Hz
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
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

Applications

Tools deployed focus on three main areas

Managing Risk & Events

Oscillation Monitoring & Source Location
0.002 – 0.1 Hz Governor & Common
0.1 – 4 Hz Electromechanical & Voltage Control
4 – 46 Hz Torsional, Resonance & Control interaction

Maximising Assets

Demonstration & Evaluation of Angle-Based Security Limits
WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations

Reducing Uncertainty

Demonstration & Evaluation of Hybrid State Estimation
Impact of Uncertainty on Security Margins
Dynamic Model Validation

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Managing Risk & Events

Disturbance Detection, Location & Characterisation

Maximising Assets

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Reducing Uncertainty

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Managing Risk & Events

Disturbance Detection, Location & Characterisation

Maximising Assets

WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations

Reducing Uncertainty

Demonstration & Evaluation of Hybrid State Estimation
Impact of Uncertainty on Security Margins
Dynamic Model Validation

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Managing Risk & Events

Disturbance Detection, Location & Characterisation

Maximising Assets

WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations

Reducing Uncertainty

Demonstration & Evaluation of Hybrid State Estimation
Impact of Uncertainty on Security Margins
Dynamic Model Validation

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Managing Risk & Events

Disturbance Detection, Location & Characterisation

Maximising Assets

WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations

Reducing Uncertainty

Demonstration & Evaluation of Hybrid State Estimation
Impact of Uncertainty on Security Margins
Dynamic Model Validation

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS

Managing Risk & Events

Disturbance Detection, Location & Characterisation

Maximising Assets

WAMS Infrastructure Requirements, Evaluation & Rollout Recommendations

Reducing Uncertainty

Demonstration & Evaluation of Hybrid State Estimation
Impact of Uncertainty on Security Margins
Dynamic Model Validation

WAMS Software Applications

Demonstrated in Alstom Grid’s PhasorPoint WAMS
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

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