Issues Affecting Anti-Islanding Detection in Power Systems with High Wind Penetrations and Low Inertia

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Introduction

• Irish Experience
• Loss-of-Mains Detection and Power System Inertia
• Phasor Measurement Units for Loss-of-Mains
Ireland

- Synchronously isolated, 6.5 GW peak
- 2.5 GW installed wind (June 2014)
- 40% renewable target (2020)
- 2 HVDC links to Great Britain
- 16.5% of energy from wind in 2013
<table>
<thead>
<tr>
<th>Region</th>
<th>Electricity Usage 2011 (TWh)</th>
<th>Installed Wind Capacity 2011 (GW)</th>
<th>% Electrical Energy from Wind 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCTE</td>
<td>2700</td>
<td>81.5</td>
<td>6%</td>
</tr>
<tr>
<td>Nordic</td>
<td>400</td>
<td>4.6</td>
<td>2.5%</td>
</tr>
<tr>
<td>GB</td>
<td>350</td>
<td>6.1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Ireland</td>
<td>37</td>
<td>2.0</td>
<td>12%</td>
</tr>
</tbody>
</table>
25-27 January 2014

Wind Penetration %

Wind Gen MW
System Demand MW
Wind Penetration %

Power, MW

00:00 12:00 00:00 12:00 00:00 12:00 00:00
Major Operational Issues

- **Less Power System Inertia**
  - 50% non-synchronous limit (Wind + HVDC)
  - A future 70%-80% non-synchronous limit

- **Loss-of-Mains Detection**
  - Current rate-of-change-of-frequency (ROCOF) setting: 0.5 to 0.6 Hz/s
  - Future ROCOF 1.0 to 2.0 Hz/s

- **Small-signal stability**

- **Reactive power provision**

- **Ramp rates**
Power Systems with Different Inertia

DC Interconnector between Ireland and Great Britain trips resulting in 500 MW imbalance.
Inertial response of 26 MW wind farm
Inertia constant = 4.4 s
DFIG Wind Farm - No Inertial Response

28.5 MW DFIG wind farm
Inertial constant ≈ 0 s
Power System Inertia

Solutions:

Curtail wind and keep the synchronous machines on.
Curtailment

Wind Production (MW)

Date

24/12 25/12 26/12 27/12 28/12 29/12 30/12

Actual Wind Output
Forecast Output
Power System Inertia

Solutions:

- Curtail wind and keep the synchronous machines on.
- Emulated inertia from wind turbines, battery storage, etc.
- Load response techniques.

Even so, there will still be an increase in maximum ROCOF:

- Can plant cope with these dynamics?
- Islanding detection will be desensitised – will it work?
Loss-of-Mains Detection (ROCOF and Vector Shift)

G59/3 – distributed generation connection in UK

“ROCOF, knock-off” (Nuisance tripping)
Islanding Caused by ROCOF

Major disturbance observed in GB on September 30th 2012

Flotta (Red) has islanded from the main system (Blue) for approximately 10 minutes.
Loss-of-Mains Detection (ROCOF and Vector Shift)

G59/3 – distributed generation connection in UK

“ROCOF, knock-off” (Nuisance tripping)

– With high system ROCOF no acceptable balance between nuisance tripping and non-detection can be achieved.

Vector Shift

– Debatable as a suitable islanding detection method.

– Given the choice DG owners tend to choose vector shift in high ROCOF systems.

Communications based solutions using PMU are a possible solution.
Phasor Measurement Units

OpenPMU and Commercial units installed.
Islanding Detection using PMU
Methods

Differential ROCOF

Phase Difference
Islanding Detection using PMU

The phase difference based method:

- Eliminates nuisance tripping.
- Effectively has a non-detection zone of zero, at least in terms of avoiding out-of-phase reclose.

Latency of internet communications within suitable range (<100 ms).

Communications based loss-of-mains requires contingency.

Phase variation is site specific.
Summary

High wind penetrations tend to reduce power system inertia.

This is already a concern in Ireland, and many other power systems will follow suit.

Island detection may no longer be viable by conventional methods.

Synchrophasors offer a solution to loss-of-mains detection.
Questions?

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