Maximizing HVDC Support for GB Black Start and System Restoration

30th October 2019

LCNI Conference, Glasgow
The National HVDC Centre at LCNI 2019

The National HVDC Centre is an Ofgem funded simulation and training facility available to support the deployment and de-risking of all GB HVDC schemes.

- **AC Protection Coordination**: 12.00 on Day 1 (30th October)
- **Maximising HVDC for Black Start**: 15.30 on Day 1 (30th October)
- **HVDC Centre Impact**: 12.00 on Day 2 (31st October)
Overview

- Change in GB electricity generation mix and HVDC developments;
- Analysis of HVDC performance across GB Black Start and restoration requirements;
- Case study of Scotland and North-East England HVDC connections; and
- Specific recommendations for maximising HVDC support for GB Black Start.
The transition to a low carbon economy is driving changes in the GB electricity system.

- GB Electricity Generation Mix by quarter & fuel source [2006 – 2019]
Consequence of Change in GB Generation Mix

- **17GW** conventional synchronous generation replaced by **31GW** low-carbon non-synchronous technologies from 2012 to 2018.

- Conventional coal & gas power stations typically can Black Start (re-start) the grid in the unlikely event of shutdown.

- However, declining levels of conventional generation could increase risk of system operation, and Black Start restoration.

Source: Image. Unknown Author is licensed under CC BY-SA; Chart: based on National Grid ESO Future Energy Scenarios
HVDC installed capacity is to increase from 8GW in 2019 to over 16GW by 2027 in GB.

The Scottish Government commissioned The National HVDC Centre to investigate how HVDC can contribute to GB Black Start and restoration.
The **Main** Black Start Stages are:

- Review & Instruct
- Start-up & re-energise
- Establish Power Islands
- Create Skeletal Network

Source: Illustration adapted from 2018 National Grid Product Roadmap - Restoration
## Analysis of HVDC Capability across Black Start Requirements

**VSC Interconnection is suitable for GB Black Start and system restoration**

### Technical Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>VSC</th>
<th>LCC</th>
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<tbody>
<tr>
<td>1. Time for HVDC to Start-up &amp; energize part of the network (≤ 2 hours)</td>
<td>Can create AC voltage</td>
<td>Requires strong AC grid or sync compensation</td>
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<tr>
<td>2. Service Availability (≥90%) of Each Year</td>
<td>&gt; 95%</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>3. Voltage Control Capability</td>
<td>Available</td>
<td>Similar to 1</td>
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<tr>
<td>4. Frequency Control Capability</td>
<td>If controller is implemented</td>
<td>Similar to 1</td>
</tr>
<tr>
<td>5. Supply Black Start Service ≥10h</td>
<td>Applicable</td>
<td>Possible if other conditions are met</td>
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<tr>
<td>6. Supply Auxiliary Units ≥72h</td>
<td>Battery &amp; diesel generation available</td>
<td></td>
</tr>
<tr>
<td>7. Block Loading Size (≥ 20 MW)</td>
<td>Fast active power control capability</td>
<td>Possible if 1 is available</td>
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<tr>
<td>8. Reactive Power Capability (≥ 100 MVAr Leading)</td>
<td>Available</td>
<td>Requires reactive compensation</td>
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<tr>
<td>9. Sequential Start-ups (≥ 3 attempts)</td>
<td>Has self-start capability</td>
<td>Possible if other conditions are met</td>
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**Interconnections**
- Offshore Wind Links
- Island Links
- Embedded Links
- VSC Interconnections

During complete shutdown embedded links cannot participate in early stages of Black Start, but they can contribute to later stages of restoration as part of the transmission system.

- Limited by wind availability or local generation and requires an established AC network for self-start.
- Offshore >90%; and onshore >95%
- Requires strong AC voltage for energizing offshore converter and HVDC circuit.
- May require de-loaded operation of wind farm or battery energy storage system.
- Requires up to 5% of rated capacity for self-start
- Back-up battery and diesel generation available
- Possible if all above requirements are met
- Possible if requirements for back-energization of offshore converter and HVDC circuit are met
- Possible if strong AC voltage is established at terminals
Case Study of Scotland and North-East England

The Centre’s study on use of HVDC to restore Scotland & North-East England identifies that:

- 3 existing HVDC schemes in Scotland and North-East England (Moyle, Western Link & Caithness-Moray);
- 4 future links are planned (NSL, NorthConnect, Eastern Links, Shetland & Western Isles); and
- VSC-HVDC interconnectors & links capacity can meet the required Black Start capability, if appropriate controls are implemented.
Specific Recommendations

In consultation with industry stakeholders, the Centre’s study conclusions are linked to:

- Early specification and design of HVDC Black Start controls;
- Combined factory system testing, field demonstration & operator training on HVDC-led Black Start;
- Use of synchronous compensators to enhance HVDC Black Start capability; and
- Review of definitions for Black Start technical requirements.
Thanks for listening.
Any questions, please?

For further information, please visit www.hvdccentre.com