

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.



part of  **Scottish & Southern**
Electricity Networks

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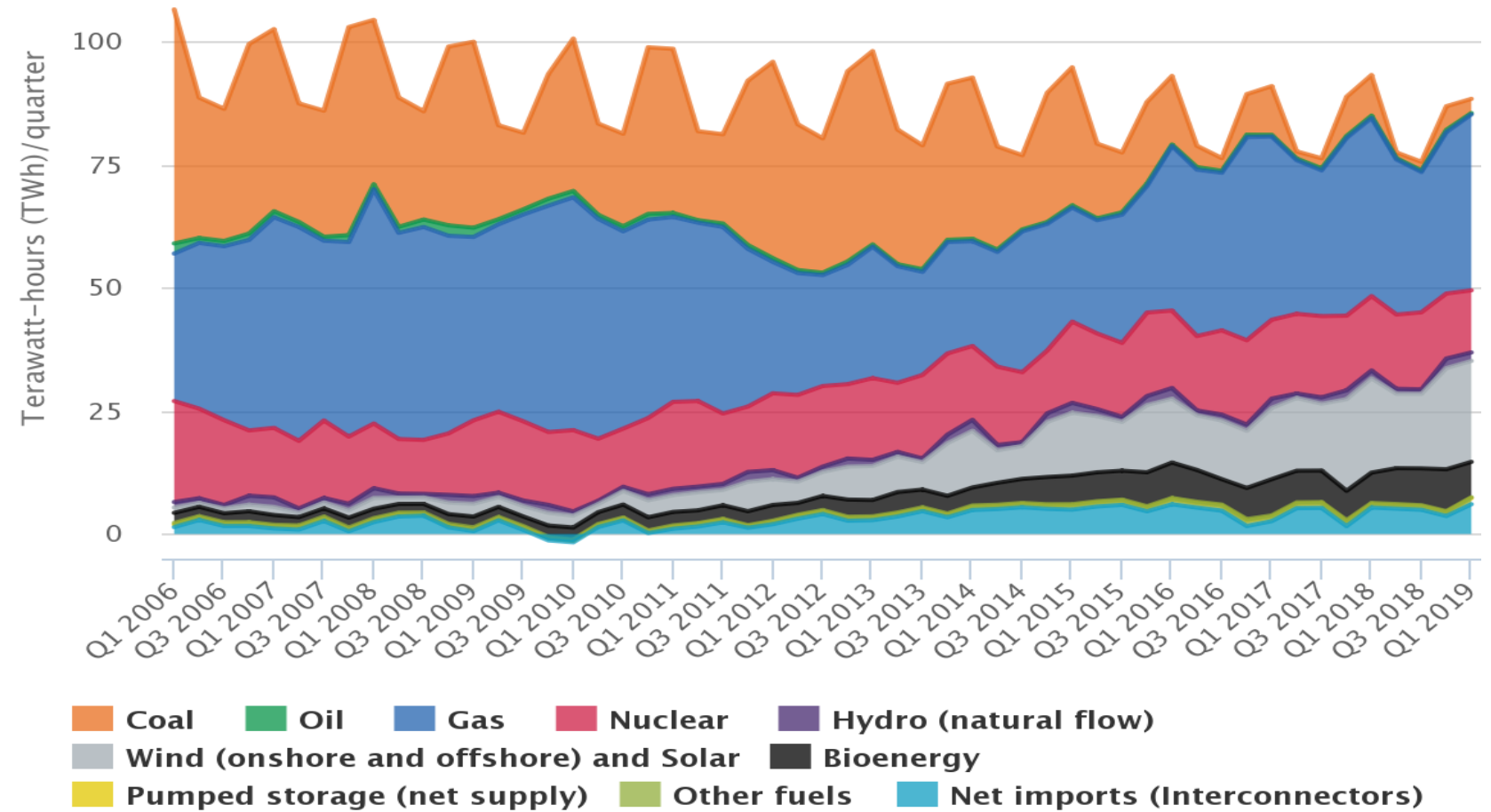


- ❑ Change in GB electricity generation mix and HVDC developments;
- ❑ Analysis of HVDC performance across GB Black Start and restoration requirements;
- ❑ Case study of Scotland and North-East England HVDC connections; and
- ❑ Specific recommendations for maximising HVDC support for GB Black Start.

Change in GB Electricity Generation Mix

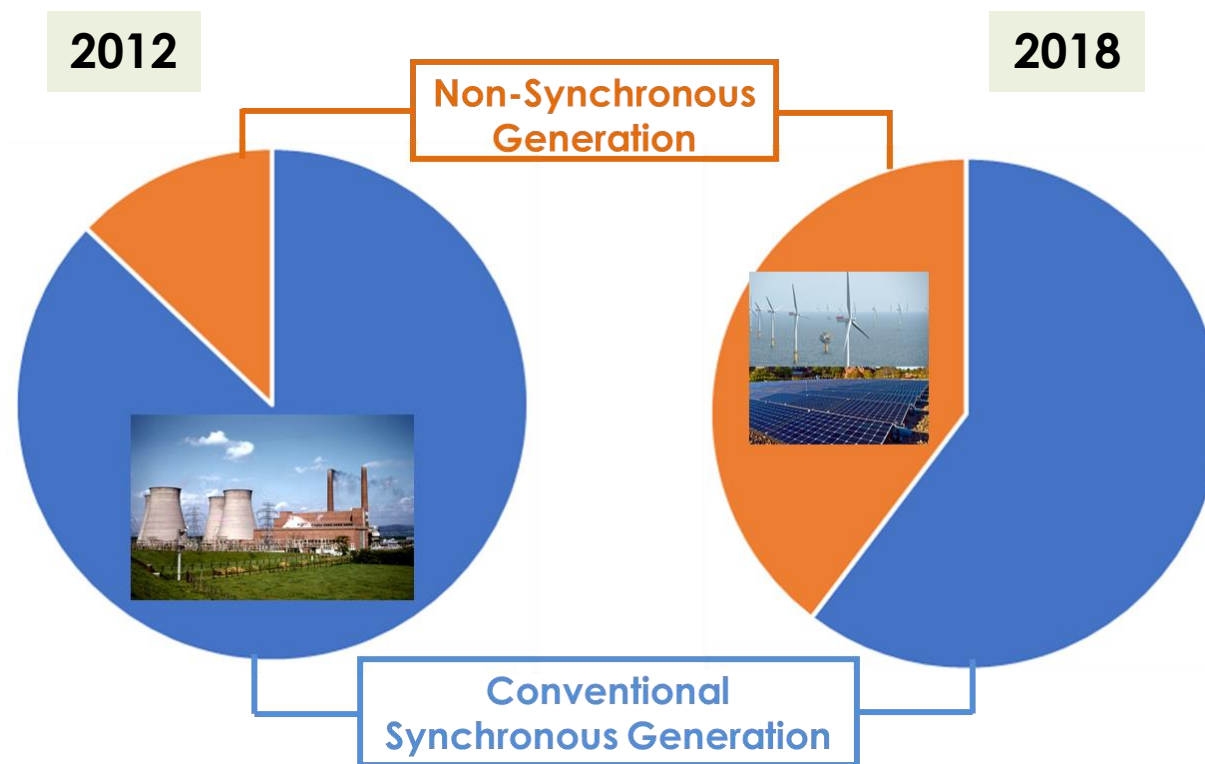
The transition to a low carbon economy is driving changes in the GB electricity system.

□ GB Electricity Generation Mix by quarter & fuel source [2006 – 2019]



Source: Ofgem Data Portal – [Wholesale Energy Market Indicator](#)

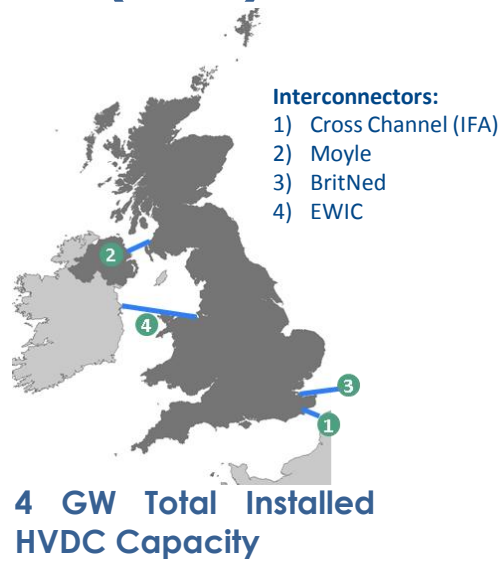
- ❑ **17GW** conventional synchronous generation replaced by **31GW** low-carbon non-synchronous technologies from 2012 to 2018.
- ❑ Conventional coal & gas power stations typically can Black Start (re-start) the grid in the unlikely event of shutdown.
- ❑ However, declining levels of conventional generation could increase risk of system operation, and Black Start restoration.



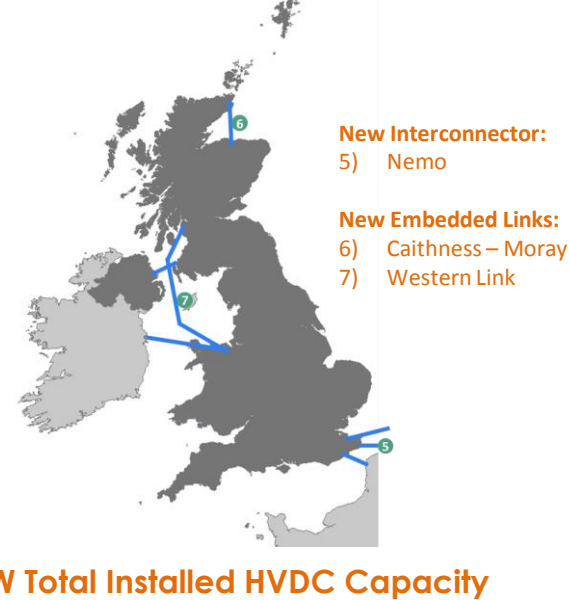
Source: Image. Unknown Author is licensed under [CC BY-SA](#) ;
Chart: based on National Grid ESO Future Energy Scenarios

□ HVDC installed capacity is to increase from 8GW in 2019 to over 16GW by 2027 in GB.

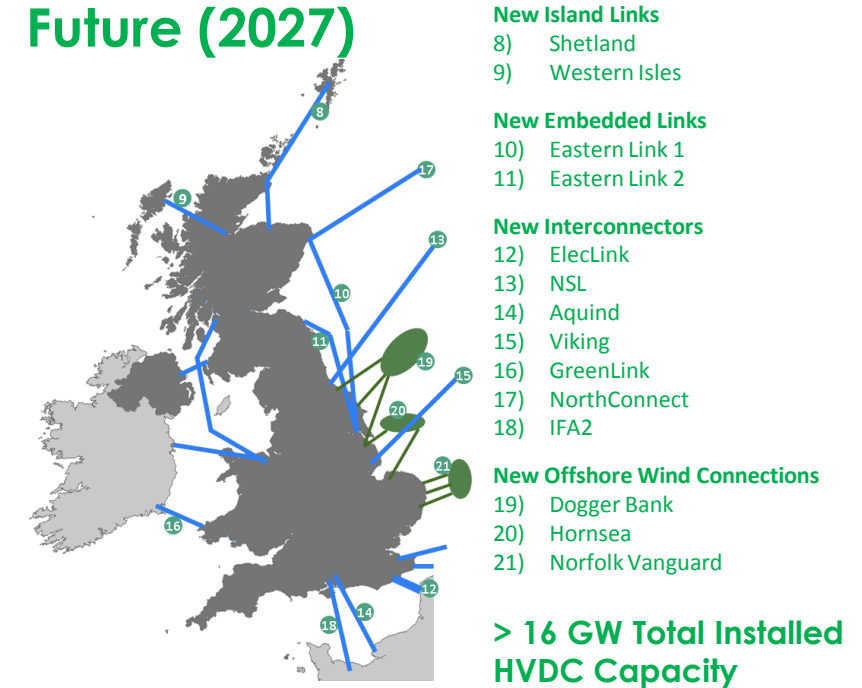
Past (2017)



Present (2019)



Future (2027)



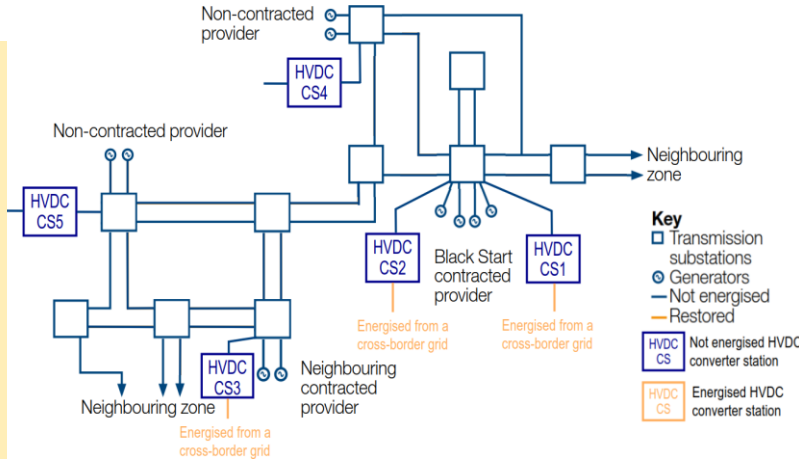
□ The Scottish Government commissioned The National HVDC Centre to investigate how HVDC can contribute to GB Black Start and restoration.

HVDC as part of Black Start and System Restoration

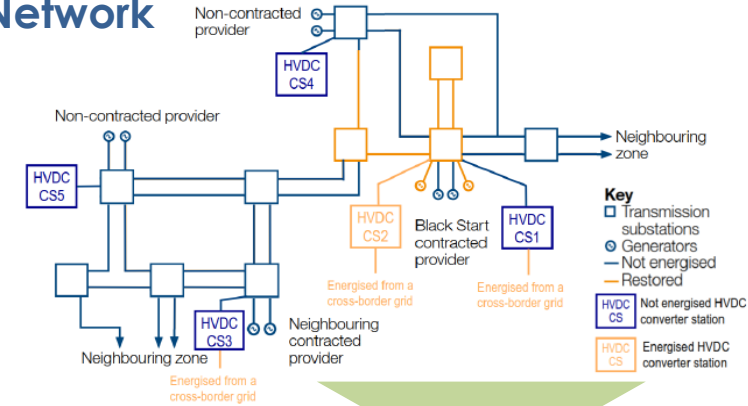
The **Main** Black Start Stages are:

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

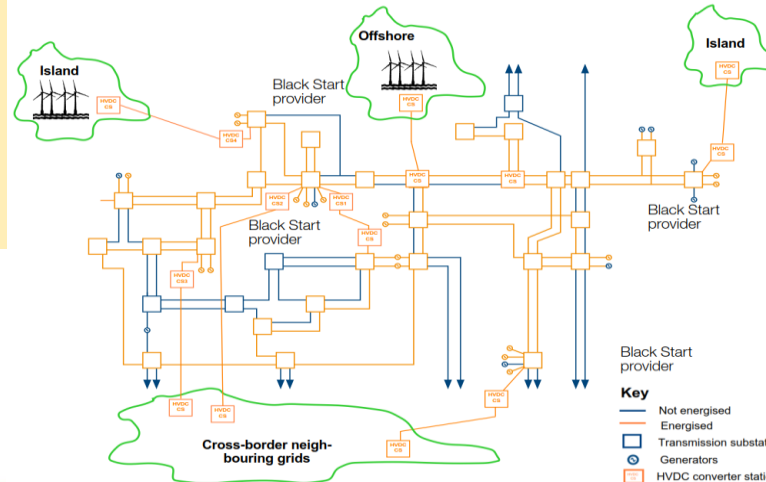
Stage 1. Review and Instruct



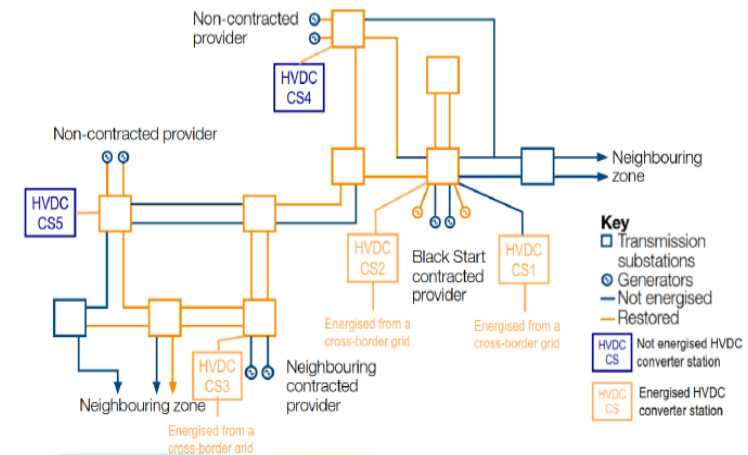
Stage 2. Start-up & Re-energize Network



Stage 4. Create Skeletal Network



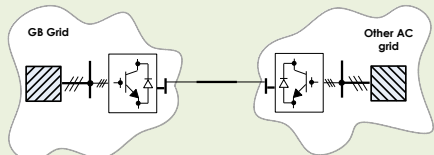
Stage 3. Establish Power Islands



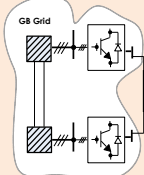
Source: Illustration adapted from 2018 National Grid Product Roadmap - Restoration

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

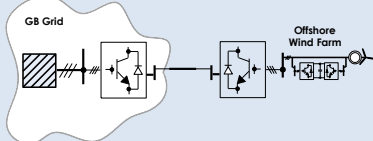
▪ Interconnections



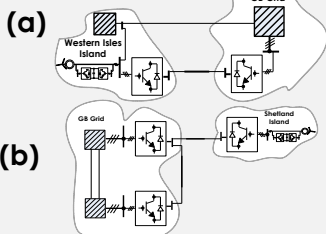
▪ Embedded Links



▪ Offshore Links Wind



▪ Island Links



Technical Requirements	VSC	LCC	VSC	LCC	VSC	(a)	(b)
1. Time for HVDC to Start-up & energize part of the network (≤ 2 hours)	Can create AC voltage	Requires strong AC grid or sync. compensation	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.		
2. Service Availability ($\geq 90\%$) of Each Year	$> 95\%$	$> 95\%$			Offshore $> 90\%$; and onshore $> 95\%$		
3. Voltage Control Capability	Available	Similar to 1			Requires strong AC voltage for energizing offshore converter and HVDC circuit.		
4. Frequency Control Capability	If controller is implemented	Similar to 1			May require de-loaded operation of wind farm or battery energy storage system.		
5. Supply Black Start Service ≥ 10 h	Applicable	Possible if other conditions are met			Requires up to 5% of rated capacity for self-start		
6. Supply Auxiliary Units ≥ 72 h	Battery & diesel generation available				Back-up battery and diesel generation available		
7. Block Loading Size (≥ 20 MW)	Fast active power control capability	Possible if 1 is available			Possible if all above requirements are met		
8. Reactive Power Capability (≥ 100 MVAR Leading)	Available	Requires reactive compensation			Possible if requirements for back-energization of offshore converter and HVDC circuit are met.		
9. Sequential Start-ups (≥ 3 attempts)	Has self-start capability	Possible if other conditions are met			Possible if strong AC voltage is established at terminals		

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.

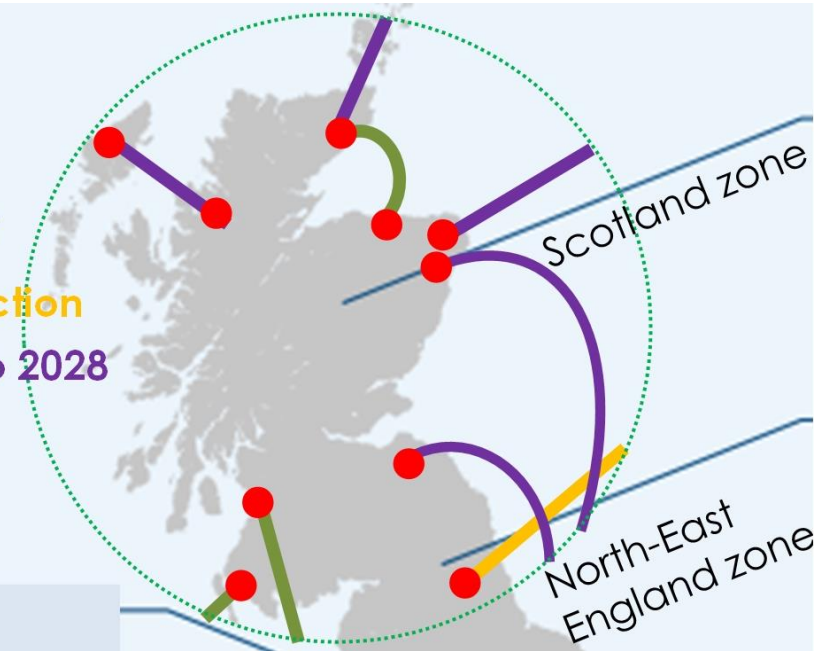
Key:

● Potential HVDC
Black Start Provider

— Existing HVDC in 2019

— HVDC under-construction

— Proposed HVDC up to 2028



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



**The National
HVDC Centre**