CIGRE Study Committee B4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° B4.94	**Name of Convenor:** Arash FazelDarbandi (CANADA)	
Strategic Directions #[2]: 1,2		**Sustainable Development Goal #[3]: 7,9**
The WG applies to distribution networks: ☒ Yes / ☐ No		
Potential Benefit of WG work #[4]: 1,2,3,4		
Title of the Group: Application of VSC-HVDC in a System Black Start Restoration		

Scope, deliverables and proposed time schedule of the WG:

Background:

System-wide power outages are fortunately very rare, but when they do occur, a region can be effected from minimal to disastrous degrees. To mitigate this impact, a “black start” power restoration must be achieved as quickly as possible. In a traditional AC system, at least one generator is designated as the black start unit, and is started first, and then connections are sequentially made to restore the full network configuration. The AC system has to be configured to a state of readiness before the restoration begins. For instance, the breakers must be in the correct position so that all extraneous circuits are off. Similarly, the protection must be adjusted to avoid any undesired operation during the restoration process, and so on. During restoration, an overvoltage or overcurrent in equipment can sometimes occur, and the system frequency may also transition beyond an acceptable range. Though AC transmission is presently the method of choice for black start restoration, HVDC transmission, where available, is proving to be an attractive alternative. HVDC transmission is being encouraged to reinforce the existing AC interconnected grid, as well as create new long distance interconnection such as offshore windfarms. As the number offshore windfarm through HVDC connection gains more popularity and grow, it becomes an attractive alternative for black start restoration.

Unlike LCC-HVDC system, the VSC-HVDC does not require any AC voltage source to start, as it synthesizes a three-phase AC voltage waveform from the DC voltage by appropriate switching IGBT valves. One challenge in using HVDC transmission for black start is the difficulty faced by HVDC converters when operating into very weak AC networks. Although VSC-HVDC converters are better at this than LCC, even VSC is challenged when the short-circuit ratio is very low. Additionally, while general information about black start restoration have been published in a number of papers, there is no sufficient information related to VSC to verify and specify black start restoration, design verification, testing in the factory and onsite, etc.

The objective of this working group is to provide a more comprehensive analysis of black start technology and a list of requirements for VSC-HVDC system to operate in black start mode (i.e. rating, control and protection mode, energizing sequence, station auxiliaries/infrastructure requirements, capability and limitation, etc.). An Electro-Magnetic Transient (EMT) test system will be developed to demonstrate the concepts discuss in this technical brochure.

Scope:

1. Identify the capability of VSC converters in the black start restoration.
2. Identify the limitation of VSC converters in the black start restoration.

3. Define the black start restoration procedure including specification, verification, performance definitions and network representation; design verification, testing in the factory and onsite, etc.
4. The VSC-HVDC converter requirements (i.e. converter rating, control and protection, etc.). The importance of converter rating, control & protection methodology during black start restoration will be discussed. In particular,
   - Converter start up requirement(s) when connected to a dead AC system
   - AC system restoration sequence and the impact of load sudden changes on the converter rating
   - Special control/protection features that are necessary
   - Synchronization to other source of generation or re-synchronization to the grid
   - Impact of other synchronous and non-synchronous generation working in parallel during the black start sequence
5. Identify the potential interaction between VSC-HVDC and the AC network during a black start restoration, and between VSC-HVDC and the source of energy driving the black start restoration.
6. An EMT based test system will be developed to demonstrate the black start restoration using a generic VSC-HVDC system. The EMT models developed in previous WGs will be used as a start and will be expanded to demonstrate the restoration process.
   - Example, how an offshore windfarm black starts and provides a source of energy to restore a system

Deliverables:

☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☒ Tutorial
☒ Webinar

Time Schedule: start: Dec 2022 **Final Report**: Dec 2024

Approval by Technical Council Chairman:

Date: September 12th, 2022

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3] See attached Table 2 and CIGRE reference Paper: Sustainability – at the heart of CIGRE's work. [4] See attached Table 3

Table 1: Strategic directions of the Technical Council

1	The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances
2	Making the best use of the existing systems
3	Focus on the environment and sustainability (in case the WG shows a direct contribution to at least one SDG)
4	Preparation of material readable for non-technical audience

Table 2: Environmental requirements and sustainable development goals

	CIGRE selected the 7 SDGs that are the most relevant to CIGRE. In case the WG work refers to other SDGs or do not address any specific SDG, it will be quoted 0.
0	Other SDGs or not applied
7	**SDG 7: Affordable and clean energy** Increase share of renewable energy; e.g. expand infrastructure for supplying sustainable energy services; ensure universal access to affordable, reliable, and modern energy services; energy efficiency; facilitate access to clean energy research and technology
9	**SDG 9: Industry, innovation and infrastructure** Facilitate sustainable infrastructure development; facilitate technological and technical support
11	**SDG 11: Sustainable cities and communities** Increase attention on sustainable and resilient buildings utilizing local (raw) materials, power for electric vehicles, strengthening long-line transmission and distribution systems to import necessary power to cities, developing micro-grids to reinforce the sustainable nature of cities; protect and safeguard the world's cultural and natural heritage; reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and waste management
12	**SDG 12: Responsible consumption and production** E.g. Promote public procurement practices that are sustainable; address reducing use of SF6 and promote alternatives, encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle, address inefficient fossil-fuel subsidies that encourage wasteful consumption
13	**SDG 13: Climate action** E.g. Increase share of renewable or other CO_2-free energy; energy efficiency; expand infrastructure for supplying sustainable energy; strengthen resilience and adaptive capacity to climate-related hazards and natural disasters; integrate climate change measures into national policies, strategies and planning; improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
14	**SDG 14: Life below water** E.g. Effects of offshore windfarms; effects of submarine cables on sea-life
15	**SDG 15: Life on land** E.g. Attention for vegetation management; bird collisions; integration of substations and lines into the landscape

Table 3: Potential benefit of work

1	Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical directions
5	Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures
6	Work likely to contribute to improved safety.

Comments:

1) CIGRE Official Study Committee Rules: WG Membership

https://www.cigre.org/GB/about/official-documents

a. Only one member per country (by exception of SC Chair)
b. WG nominees must first be supported by their National Committee (or local SC Member) as an appropriate representative of their country.
c. Acceptance of the nomination is granted by the SC Chair and advised to the WG Convener

2) Collaboration Space

https://www.cigre.org/article/GB/collaborative-tools-2

CIGRE will provision the WG with a dedicated Knowledge Management System Space.

The WG will use the KMS for drafting collaboration, capture and retention of discussion and meeting records.

Official country WG Members will be sent registration instructions by the Convener.

Official country WG Members may request the WG Convener to allow additional access for an extra national subject matter specialist to aid in the work at the national level, including NGN members.