CIGRE Study Committee B4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG B4.98	**Name of Convenor: Afshin Pashaei (UK)** **E-mail address**: **afshin.pashaei@nationalgrid.com**
Strategic Directions #[2]: 1,2	**Sustainable Development Goal #[3]: 7, 13**
The WG applies to distribution networks: ☐ Yes / ☒ No	
Potential Benefit of WG work #[4] : 1, 2 , 3, 4	
Title of the Group: Design considerations in integration of DC systems to meshed DC/AC Transmission networks	

Scope, deliverables and proposed time schedule of the Group:

Background:

Meshed DC/AC transmission networks represent a groundbreaking advancement in power system infrastructure, combining the benefits of both DC and AC transmission networks. Integration of DC systems in meshed DC/AC network design has become important in the current energy landscape due to its ability to address challenges related to renewable energy integration, grid resilience, energy efficiency, decentralization, and emerging technologies. As the energy sector continues to evolve, deployment of DC systems in meshed DC/AC networks play a crucial role in enabling a more sustainable, flexible, and reliable power system.

Up to date, the design considerations of the DC transmission systems have been more focused on the DC system itself and impact of adjacent AC system. With the increasing utilization of DC transmission in power systems, the network is becoming more and more AC and DC integrated which introduces new issues on the planning and operation of the complicated grid. Integration of DC systems in meshed DC/AC network requires careful consideration of various technical requirements to ensure reliable and efficient operation which has not been addressed specifically or adequately in existing literatures. Some of the key technical requirements that have been identified and to be addressed in the design include:

- **Network Topology:** The DC system should be designed with an appropriate configuration that enables multiple interconnections between different nodes. The networks should provide redundant paths for power flow, ensuring reliability and fault tolerance.
- **Grid Synchronization and Stability**: Synchronization of the DC systems with other AC or DC grids is important for continuous power transfer and grid stability. Synchronization techniques should be employed to achieve accurate frequency and phase alignment. Control measures should be in place to maintain grid stability during load variations, power fluctuations, or network disturbances.
- **Power Flow Control and Stability:** Adaptive (or integrated) power flow control mechanisms need to be implemented in a DC system. This involves designing control strategies to regulate power flow, manage voltage levels, and ensure proper coordination between multiple nodes. Control algorithms can be employed to maintain stable and balanced power transfer within the network. Developing robust control algorithms that ensure stability, reliable power flow, and response to varying load conditions is a challenge.
- **Grid Integration and Operability:** Integrating DC systems with existing AC grids

poses challenges in terms of grid synchronization, stability, and operability. Coordinating control strategies, protection schemes, and communication protocols between DC systems and AC network is essential for seamless integration. Integrating DC systems in the AC grid infrastructure require coordination and interoperability between the two systems.

- **Grid Code Compliance:** Compliance with relevant grid codes and standards is essential in integration of DC systems in meshed DC/AC networks. Grid codes define the technical requirements and regulations for connecting and operating power systems within an electrical grid. Ensuring that the meshed DC/AC network design aligns with grid code requirements is necessary for seamless integration with the existing power infrastructure.
- **DC protection:** DC protection and grounding strategies play crucial roles in ensuring the safe and reliable operation of DC systems. DC protection systems are designed to detect and mitigate faults and abnormal operating conditions within a DC network.

Overcoming these challenges requires close collaboration and coordination among system operators, policymakers, equipment manufacturers, and researchers. It involves a thorough understanding of DC system dynamics, advanced control strategies, and careful system planning and design to ensure efficient and reliable integration of DC networks with existing AC grids.

Scope:

The main objective of the Working Group (WG) is to provide technical recommendations and to propose solutions to address the challenges associated with integration of DC systems in meshed DC/AC networks.

- The WG will focus on developing guidelines, and best practices that can be implemented to overcome the specific hurdles and complexities encountered in deployment of DC systems in meshed DC/AC network.
- The WG will identify the key challenges, such as operability of DC networks and interoperability with existing AC grids, DC protection, power flow management, voltage control and grid synchronization. It will examine these challenges from various perspectives, including technical and operational aspects, to provide holistic recommendations.
- Ultimately, the objective of the WG is to serve as a valuable resource for industry stakeholders, policymakers, researchers, and engineers involved in the design, implementation, and operation of meshed DC/AC networks with embedded DC systems. By offering technical guidance and solutions, the WG aims to promote the successful deployment of operable and reliable integration of DC systems in meshed DC/AC networks, thereby contributing to the advancement of a more efficient, sustainable, and resilient power system.

In summary TB will include followings:

- Fundamentals of integration of DC systems in meshed DC/AC network design
- Identify and analyse key factors and challenges in integration of DC systems in meshed DC/AC network design.
- Integration of DC systems and operability.

- Holistic dynamic design of meshed DC/AC networks with embedded DC systems.
- Design consideration of DC protection for integrated DC systems in meshed DC/AC networks

Remark:

The working group foresees liaisons with SC C1 and C2, and working groups

- JWG C2 B4.43 - The impact of offshore wind power hybrid ACDC connections on system operations and system design.
- JWG C1 B4.49 - Offshore transmission planning

The WG will invite a liaison member from SC B5 and corresponding member from SC C1.

☒ Annual Progress and Activity Report to Study Committee
☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☒ Future Connections
☐ CIGRE Science & Engineering (CSE) Journal
☒ Tutorial
☒ Webinar

Time Schedule:

• Recruit members (National Committees)	Q4 2023
• Develop final work plan	Q1 2024
• Draft TB for Study Committee Review	Q3 2025
• Final TB	Q4 2025
• Webinar	Q1 2026

Time Schedule: Start : November 2023 **Final report** : October 2025

Approval by Technical Committee Chairman:

Date : September 22nd, 2023

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

WG Membership: refer Comments at end of document.

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

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.