CIGRE Study Committee B4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG[1] B4.104	**Name of Convenor: Dr eng. Arkadiusz BUREK** (Sweden)
Strategic Directions #[2]: 1, 2	**Sustainable Development Goal #[3]:7, 9**

This Working Group addresses these Energy Transition topics:

	Storage
	Hydrogen
*	**Digitalization**
	Sustainability and Climate Change
*	**Grids and Flexibility**
	Solar PV and Wind
	Consumers, Prosumers and Electrical Vehicles
	Sector Integration
	None of them

Potential Benefit of WG work #[4] : 4

Title of the Group: HVDC Digital Twin – concepts and roadmap

Scope, deliverables and proposed time schedule of the WG:

Background:

The application of HVDC technology has expanded in the past decade. Digitalization and the transformation of the Energy Sector, including HVDC Systems, is speeding up. Synergies between asset suppliers can be more beneficial at the distinct stages of the product lifecycle and enhance monitoring, maintenance and performance optimization. The application of digitalization and digital twin (DT), holds immense potential in effectively managing risks associated with HVDC assets. In the face of life–cycle management, these technologies offer asset management alternatives by enabling life extension strategies, optimizing maintenance practices, and enhancing overall operational efficiency.

Digitalization allows for real-time monitoring of the HVDC System assets by integrating sensors that collect data or parameters such as power, voltage, current, temperature, converter or transformer load level, dissolved gas analysis (DGA) of transformer oil, bushing tap current, vibrations, and many other timeseries. By continuously monitoring the HVDC Systems condition, potential issues or abnormalities can be detected early on, allowing for timely maintenance and preventing costly outages.

Digital twins can be created for the HVDC system, representing their physical counterparts in a virtual environment. The digital twin can simulate different operating scenarios, monitor performance, and predict future performances. Data analytics such as physics-based models, machine learning (ML) models, artificial intelligence (AI) algorithms, hybrid models, and statistical tools help identify optimization opportunities, evaluate the impact of operational changes such as dynamic overloading, and test maintenance strategies without affecting the physical HVDC System. Prognostics involve forecasting the future performance and health

of the whole HVDC System and/or key assets, estimating the remaining useful life, and assessing the probability of failure.

Purpose/Objective/Benefit of this work:

The objective of the group is to study and discuss the digital twin concept when applied to the HVDC System and identify the existing processes in the HVDC Systems lifecycle that could benefit the most from the digital twin concept (design, manufacturing, operation, maintenance, life management, real-time data monitoring, etc.), how models could be shared and enhanced throughout the HVDC Systems lifecycle, and then define the priorities for future developments.

Scope:

The WG will study the digital twin concept for the HVDC Systems main assets: converter station equipment such as the converter, the control and protection system, the DC cable terminations and accessories, DC gas insulated switchgear (GIS), high voltage (HV) switchgear, DC bushings and instrument transformers for the HVDC systems as well as future design considerations such as the potential impact of multi-terminal HVDC solutions. The focus will be on the review and proposal of **harmonization of digital twin models for HVDC System** performance aspects and HVDC lifetime.

The WG will undertake the following steps to determine the harmonized digital twin models of HVDC Systems:

- Review the literature on DTs and supporting solutions applied to HVDC.
- Propose a CIGRE definition for HVDC digital twin - Identify the common features in the digital twin model of a HVDC system.
- Identify the processes in the HVDC lifecycle that could benefit most from the concept of digital twin (design, manufacturing, operation, maintenance, life management, etc.) and identify means for that benefit to be achieved.
- Develop a roadmap for future developments and recommend means to allow practitioners to upgrade present early twin modules to complete HVDC digital twins, and to apply the methodology for other assets.
- Make recommendations for standardization (data, models, etc.) which can be applied across a range of HVDC stations, applications and with varying availability of data.

These concepts enable advancements in thermal modelling, provide insights into HVDC system health through condition assessment and diagnostics, guide maintenance practices, explore the potential of digital twin technology, and facilitate the interpretation of critical monitoring data.

Remarks:

This new WG will cooperate and coordinate with other WGs that are working on digital twin components such as JWG A2/D2.65 “Transformer Digital Twin – concept and future perspectives” and make ensure that the work is not duplicated.

It will also be in close co-operation with other groups such as CIM (Common Information Model) or IEC 61850 wherever is applicable.
If HVDC Digital Twin model is recommended to be included in HVDC performance data, then cooperation with WG AG B4.04 and JWG B4.89 - Condition Health Monitoring and predictive maintenance of HVDC Converter Stations will be required.

Deliverables:

☒ 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, WiE, NGN) Qtr 2 2024
- Develop final work plan Qtr 3 2024
- Draft TB for Study Committee Review Qtr 4 2025
- Final TB Qtr 2 2026
- Tutorial Qtr 3 2026
- Webinar Qtr 4 2026

Approval by Technical Council Chair:

Date: May 17th, 2024

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 works refer to other SDGs or does 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, WiE and NGN nominees.

b. WG nominees by NCs 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.