CIGRE Study Committee A2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG N° A2/D2.65	**Name of Convenor : Patrick PICHER (CA)**
Strategic Directions #[2]: 1	**Sustainable Development Goal #[3]: 9**
The WG applies to distribution networks: ☒ Yes / ☐ No	
Potential Benefit of WG work #[4] : 4	
Title of the Group: Transformer Digital Twin – concept and future perspectives	

Scope, deliverables and proposed time schedule of the Group

Context

The transformation of the power system via digitalisation brings new opportunities for innovation. For example, the digital twin concept has been studied extensively in the scientific literature of recent years, often for the virtual representation of manufacturing processes, but also for modelling of critical assets such as jet engines. However, few applications exist for the electrical power industry.

Because of their strategic importance in electrical networks, transformers are already the focus of international efforts in power asset digitalisation and, therefore one of the top priorities for asset digital twin developments.

To support this transformation, the transformer community should identify the existing processes in the transformer 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 transformer life cycle, and then define the priorities for future developments.

Ongoing research and development activities regarding advanced analytics (e.g. physical, statistical, machine learning or hybrid modelling) provide new opportunities to extract value from the possibly large amount of available data.

Simulating the multiphysics (thermal, dielectric, and mechanical) functional behaviours of transformers in real-time, understanding the 'reality gap' and integrating digital twins in utilities operation and maintenance systems will require collaboration between manufacturers and users, as well as academic and research institutions, hence this new WG proposal.

Scope and aim

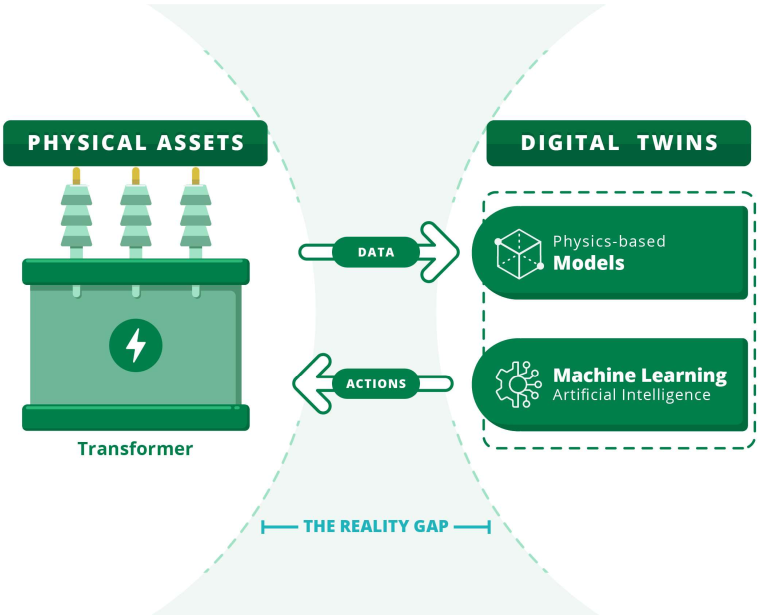
The working group will study the digital twin concept when applied to transformers and discuss the perspectives for future developments. The proposed scope of work will be divided as follow:

- Propose a CIGRE definition for transformer digital twin – the data, models, analytics and other aspects which need to be encompassed in a complete digital twin.
- Review the literature on digital twins and supporting digitalisation technologies applied to transformers (transformer functions and their failure modes, control, monitoring, data management and processing, condition assessment indices, physical models,

machine learning and hybrid approaches, cybersecurity, etc.). Consider the following CIGRE contributions:

- TBs 227 (Life management), 298 (Guide on transformer lifetime data management), 761 (Condition assessment of power transformers) and 630 (Guide on transformer intelligent condition monitoring systems)
- WGs D2.52 (Artificial intelligence application and technology in power industry), D2.53 (Technology and applications of internet of things in power systems), B5.75 (Documentation and version handling related to protection, automation and control functions), C4.64 (Application of real-time digital simulation in power systems), C1.43 (Requirements for asset analytics data platforms and tools in electric power systems).
- Session 2022 papers: A3-PS3 (Digitalisation of T&D equipment), D1-PS3 (Simulation tools partnered with measurement techniques), B3-PS3 (Integration of intelligence on substations).

- Identify the processes in the transformer lifecycle that could benefit the most from the concept of digital twin (design, manufacturing, operation, maintenance, life management, etc.) and identify means for that benefit to be achieved.
- Survey and illustrate the possible use cases, priorities and benefits (e.g. using real transformer data, simulation, modelling), discuss how they can be implemented for new and existing transformers.
- Develop/propose methodologies to assess digital twin reliability (reality gap, confidence interval, etc.).
- Discuss the effect of overhauls/maintenance, as well as part replacements, on digital twins.
- Make recommendations for possible standardisation (data, models, etc.) which can be applied across a range of transformers, applications and with varying availability of data.
- Develop a road map for future developments and recommend means to allow practitioners to upgrade present early twin modules to complete transformer digital twins, and to apply the methodology for other assets.



Deliverables:

☒Technical Brochure and Executive Summary in Electra
☒ Electra Report
☐ Future Connections
☐ CSE
☒ Tutorial
☐ Webinar

Time Schedule: start: Mars 2022 **Final Report:** December 2025

Approval by Technical Committee Chairman :

Date : February 16, 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.