CIGRE Study Committee A2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG[1] A2/D1.74	**Name of Convenor:** Senja LEIVO (Finland)

Strategic Directions #[2]: 2	**Sustainable Development Goal #[3]: 9**

This Working Group addresses these Energy Transition topics:

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

Potential Benefit of WG work #[4] : 1, 4, 5

Title of the Group: Online moisture monitoring of transformers for ageing assessment

Scope, deliverables and proposed time schedule of the WG:

Background:

Water significantly influences the ageing of cellulose insulation in transformer windings. Current practice involves periodically measuring water content in the liquid insulant and then using equilibrium charts to estimate water content in the cellulose. However, interpreting these measurements is challenging due to load and temperature fluctuations that affect the liquid's water content.

To address this, capacitive film sensors combined with temperature sensors provide continuous monitoring of relative water saturation (RS%) in the liquid. This approach, now described in IEC 60422, allows for calculating the water content. By referring to the RS% and relevant charts (solubility, equilibrium), the absolute water content in both liquid and solid insulation can be estimated. This estimation can be performed at locations such as the hot-spot or the bottom insulation barriers. In the thin hot insulation at the hot-spot location, the water diffusion coefficient is relatively high, and the insulation is approximately in equilibrium with the liquid. However, this is usually not the case for insulation barriers.

Understanding the water content and temperature distribution within a transformer's insulation system allows users to estimate the ageing of insulation paper, assess the risk of bubbling, and evaluate the dielectric performance of the entire insulation system. This technique is applicable to any liquid with documented water solubility.

Purpose/Objective/Benefit of this work:

The purpose of this JWG is to collect and analyse data from moisture sensors installed in the field, along with other relevant parameters such as ambient temperature, oil temperature, hot-spot temperature, loading condition, cooling mode (Oil Normal or Oil Forced) and its operational status, and the type of oil breathing system. Specifically, the JWG aims to understand how moisture content in oil varies with these parameters.

The key objectives are as follows:

- Investigate the feasibility of calculating moisture migration within transformers based on the collected data. This involves understanding how moisture migrates within the insulation system.
- Explore the effect of moisture on the dielectric strength of insulation.
- Study how moisture affects the bubbling temperature during overload condition.
- Investigate the influence of moisture on insulation ageing. Continuous monitoring with capacitive moisture sensors enables users to track the ageing process in real time.

Additionally, the JWG will develop guidelines for real-time moisture monitoring in transformers. These guidelines will cover data collection, interpretation, and recommended actions in case excessive moisture levels are detected.

Scope:

The proposed scope of work is divided as follows:

1. Collect datasets from transformers for initial analysis by the JWG.
2. Explore various use cases for real-time moisture monitoring and data interpretation. If feasible, correlate transformer moisture data with failure cases.
3. Create a succinct information package covering moisture formation, ingress, and migration within transformers. Discuss the effects of moisture on insulation ageing and dielectric strength. Describe the potential impact of elevated moisture levels on transformer loading guidance and load after a service break. Develop a list of recommended actions to address excessive moisture.
4. Develop guidelines for sensor installation, emphasising optimal sensor placement. Provide advice on critical factors to consider when selecting moisture sensors for real-time monitoring. Consider the impact of fluid type and condition on moisture sensor performance and provide advice on moisture sensor maintenance.
5. Develop an algorithm to predict water content in paper insulation, assess the risk of bubbling, and estimate the ageing rate. The algorithm should leverage data such as temperature, load, and moisture measurements, while considering the material type and aging processes.
6. Present strategies for integrating moisture measurement and modelling into digital twin systems. Explore how this integration can enhance operation and asset management.

Remarks:

Consider previous or related activity (IEC 60422, TB 349, TB 741, TB 738, A2 Greenbook).

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 4 2024
- Develop final work plan Qtr 1 2025
- Draft TB for Study Committee Review Qtr 3 2028

• Final TB	Qtr 4 2028
• Tutorial	Qtr 4 2028
Approval by Technical Council Chair: **Date**: August 13th, 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 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, 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.