CIGRE Study Committee B2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG B2.84	**Name of Convenor:** Giorgio Diana (IT)	
Strategic Directions #[2]: 1, 2		**Sustainable Development Goal #[3]:** 9
The WG applies to distribution networks: ☒ **Yes /** ☐		
Potential Benefit of WG work #[4] : 4, 5, 6		
Title of the Group: Assessment of the methodologies to analyze wind induced overhead line conductors motion: applications and limitations.		

Scope, deliverables and proposed time schedule of the WG:

Background:

Overhead transmission line design with respect to wind induced vibrations has been performed for a long time based on previous experience and simplified approaches. Then mathematical models to simulate the single and bundle conductors behavior when subjected to the different types of wind excitation (aeolian vibrations, subspan oscillations, ice galloping) have been elaborated and – at least for some type of excitation (mainly aeolian vibrations) – software that can be used at industry (and not only research) level have been developed on the base of acquired knowledge. These software provide useful information and directions regarding the evaluation of damping devices required on a transmission line. They are used to produce the so called 'damping study' which is more and more often required by utilities all over the world together with tests and certifications when a new transmission line has to be built.

The work of the researchers in this field is continuously progressing, better knowledge of the phenomena is obtained and new models – also taking advantage of sophisticated computation technologies (finite element models, machine learning techniques …) are developed and tested against experimental results in wind tunnels, on laboratory spans and in the field.

It is clear that increasing the model complexity, the phenomenon should be reproduced in greater detail and the quality of its results should improve. However, increasing complexity generally implies that more inputs are required and highly specialized personnel are needed to run the software and produce reliable results.

Industry-specific software and research software are currently available and it is of the utmost importance to know their respective limitations.

Scope:

The general scope of this working group includes:

a) Analysis of the available methods to simulate aeolian vibrations, subspan oscillations and ice galloping:

- Aeolian vibrations for single conductors and bundles.
  - Simulations based on the Energy Balance Principle are widely used to

produce damping studies. They are relatively easy to use and give generally conservative results. More sophisticated approaches are available but less practical and less used. These last methods can be used to better reproduce the turbulence effect on the aeolian vibration level. This will be one of the WG tasks in the analysis of available aeolian vibration methods.

- Many experimental results (more or less detailed) are available for models testing: comparison between analytical and experimental results will allow for assessing the methods capabilities.

- Subspan oscillations and ice galloping: the phenomena are not clearly defined in all their aspects.
  - For instance, it has often been observed that one or two subspans in one phase have large subspan oscillations while the same subspans on another phase do not oscillate. It is clear that it is difficult – if not impossible – to predict such behavior through a mathematical model.
  - In case of ice galloping, the ice shape is clearly of paramount importance and is highly random: What kind of ice accretion shape should be used for simulation?

  For the simulation of subspan oscillations, finite element models (FEM) and energy balance models are available. Again, one of the WG tasks will be the comparison between the results of the available methods and the field tests to assess the capabilities of the method.

  For ice galloping there are FEM models, Energy models, models based on analysis of observed data and machine learning techniques.

  The quality of available experimental results is completely different from those of aeolian vibrations. In many cases only videos showing the phenomenon are available, but, recently, monitoring systems are being used also to monitor and measure the galloping level Also in this case, one of the WG tasks will be the assessment of the methods performances, through comparison among the methods and against experimental data.

b) Evaluate limits / reliability / uncertainties of the different models available

c) Identify a kind of safety margin related to the methods/models used by the line operators to model conductors wind induced vibrations.

References

A lot of work has already been done on the subject within CIGRE and can be found in the following references:

- Regarding aeolian vibrations and subspan oscillations modelling: "Modelling of Vibrations of Overhead Line Conductors - Assessment of the Technology" – Springer International Publishing AG 2018 - Springer - CIGRE Green Books Series - Editor: Giorgio Diana
- Regarding ice galloping: CIGRE B2 TB 322 "State of the art of conductor galloping"

Another important reference is the EPRI Orange Book.

Recent and less recent papers in the IEEE Transactions and other International Journals, mainly referring to ice galloping modelling will be also considered, among others:

- R. Keutgen J., Lilien, "Benchmark cases for galloping with results obtained from wind tunnel facilities and validation of a finite element model," in IEEE Transactions on Power Delivery, vol. 15, no. 1, pp. 367-374, Jan. 2000, doi: 10.1109/61.847275
- B. Yan, X. Liu, X. Lv, L. Zhou, Investigation into galloping characteristics of iced quad bundle conductors, Journal of Vibration and Control, 22 (4), 965–987, https://doi.org/10.1177/1077546314538479, 2016
- L. Zhou, B. Yan, L. Zhang, S. Zhou, Study on galloping behavior of iced eight bundle conductor transmission lines. Journal of Sound Vibration 362, 85–110, 2016
- Z. Mou, B. Yan, X. Lin, G. Huang, X. Lv, Prediction method for galloping features of transmission lines based on FEM and machine learning, Cold Regions Science and Technology, Vol. 173, 2020

Deliverables:

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

Time Schedule: start: June 2021 **Final Report**: August 2023

Approval by Technical Council Chairman:

Date: April 30th, 2021

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.