CIGRE Study Committee C2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° C2.45	**Name of Convenor:** Yaran Li (CN) **E-mail address**: yaran.li@unswalumni.com
Strategic Directions #[2]: 1, 2	**Sustainable Development Goal #[3]:** 7, 9
The WG applies to distribution networks: ☐ Yes / ☒ No	
Potential Benefit of WG work #[4] : 2, 3, 4	
Title of the Group: Estimation, evaluation and provision of power system inertia in networks with a high share of renewable generation	

Scope, deliverables and proposed time schedule of the WG:

Background:

Inertia is the prominent power system capability to immediately resist frequency changes arising from an event that results in active power mismatch, which could be primarily characterized by the rate of change of frequency (RoCoF) and frequency nadir in the event of a contingency. In the conventional power grids, synchronous generators are the promising source to provide inertia. However, for typical renewable generators, the frequency is decoupled from the main grid due to the interface of power electronics devices, thus providing zero or low inertia to the power system. As a result, the increasing decommissioning of synchronous generators and the accelerating penetration of asynchronous generators are potentially creating inertia shortfalls for the power system, which progressively and fundamentally alters power system frequency dynamics. Accordingly, the existing power system frequency regulation framework is required to evolve by considering a deliberate set of choices regarding system inertia that seek to meet the challenges of the rapid uptake of renewables worldwide.

Several incidents have been captured worldwide due to the lack of inertia, such as the South Australia blackout in 2016, the Great Britain power system disruption in 2019, to name just a few. Therefore, power system operators, jurisdictional planning bodies and regulatory commissions in many countries have been actively investigating methodologies to evaluate system inertia and efficient solutions to address the potential inertia shortfalls, which are formulated as national-wise rules to regulate the system inertia above the prescribed level.

There have also been extensive efforts in CIGRE with respect to the management of low inertia systems. CIGRE Technical Brochure 885 gives the guide for placing synchronous condensers in the power system with predominance of low or zero inertia generators, with a specialized focus on the technical requirements that the synchronous condenser shall satisfy to promote power system performances. CIGRE has also published the technical brochure 851 by the joint working group of C2 (power system operation and control) and C4 (power system technical performance) to comprehensively identify and summarize the impact of high penetration of inverter-based generation on system inertia of networks.

Existing work has mainly attempted to develop various strategies for renewable generators with low or zero inertia characteristics to have better compliance with the grid code. Industry has also been collaborating with academia to undertake several trials that will inform inertia capabilities of the key innovative technologies, such as grid-forming battery energy storage systems (BESS). However, there is the conceptual gap in the understanding of inertia response for renewables highly penetrated networks and a lack of research on how to effectively manage the inertia from the perspective of interconnected power systems.

To address the aforementioned gaps, the working group will firstly discuss new definitions for power system inertia in the current context, and then identify the methodologies and requirements to estimate, assess and improve the power system inertia, which ultimately facilitates the maintenance of frequency stability throughout the power system transformation. In addition, the working group will also be served as a platform for the dissemination of innovative technologies, on-site experiences and knowledge sharing.

Scope:

To advise philosophies on inertia management of interconnected power systems with a high share of renewable generation, inclusive of the technical aspects such as estimation, assessment and provision of power system inertia, the content of the work includes but is not limited to the following categories:

1. Review previous CIGRE work relating to the topic (e.g. TB 851 and TB 885) and the connection with other work in this domain.
2. Survey international experiences regarding inertia management of power systems.
3. Revisit definitions and underlying principles
   - Describe new concepts and propose quantification metrics of inertia in renewable highly penetrated power system
   - Reveal mechanisms of inertia affecting frequency dynamics and disambiguation rule for inertia response against fast frequency response
   - Identify inertia classification and contribution from different sources
   - Discuss challenges in the current context
4. Develop methodologies to estimate power system inertia, including
   - Techniques to monitor inertia for single and aggregated components
   - Estimation approaches with merits/demerits identified and compared
   - Technical requirements for measurement devices, data acquisition, etc.
5. Provide insights on effectively evaluating power system inertia, including
   - Determination of critical factors to be considered, such as temporal and geographical distribution of inertia
   - Analysis on the minimum and secure inertia requirements for the network
   - Assessment of power system inertia adequacy for planning and real-time operation horizons
   - Justification of accuracy and feasibility of the assessment methodologies
6. Identify possible inertia remediation schemes to improve power system inertia, including
   - Investigations on strategies by prescribed planning activities, such as network agreements with synchronous inertia providers and grid-forming BESS, inertia commitment and optimized dispatch, etc.
   - Investigations on strategies by market services, such as contracts with power-electronics interfaced devices of virtual inertia capability, flexible demand response, etc.
7. Formulate the framework to guide the management of power system inertia, including
   - Instructions on design specifics
   - Cookbook for the users
8. Study use cases
9. Conclusions and Recommendations

The integration and deliver of the knowledge in the concise and compact Technical Brochure anticipates to assist power system operators on maintaining frequency stability of power systems, original manufacturers on designing the infrastructure with compliant inertial response, and stakeholders on understanding the underlying principles thus determining the investment in the most secure and economic power system services.

Studies published by EPRI, ENTSO-E and NREL with respect to inertia, which provide

deep conceptual understanding of inertia's role in maintaining a reliable power system and practical operational experiences of managing inertia with declining power systems will be included and discussed in the state of art review.

Deliverables:

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

Time Schedule: start: November 2023 **Final Report**: December 2026

Approval by Technical Council Chairman:

Date: October 25th, 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

https://www.cigre.org/GB/about/official-documents

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.