CIGRE Study Committee B4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG N° B4.101	**Name of Convenor: Changjiang ZHAN** (China) **E-mail address**: zhancj@nrec.com
Strategic Directions #[2]: 1	**Sustainable Development Goal #[3]: 7 & 9**
The WG applies to distribution networks: ☒ Yes / ☐ No	
Potential Benefit of WG work #[4] : 1, 2 , 3, 4	
Title of the Group: Industrial Implementation and Application of Grid Forming Energy Storage Systems (GFM ESS)	

Scope, deliverables and proposed time schedule of the WG:

Background:

The global energy world is now undergoing a dynamic transition towards a secure, cost-effective, low-carbon or even carbon-free and sustainable future with more and more decentralized and decarbonized renewable energy penetrated into the power systems. Almost all Variable Renewable Energy (VRE) such as wind power and Photovoltaics (PVs) connecting to the grid are interfaced through power-electronics in Grid Following (GFL) configurations. These GFL Converter Interfaced Generation (CIG) or GFL Inverter-Based Resources (IBR) possess the new characteristics of dynamics which are significantly different to those of traditional synchronous generator based sources. This ever-growing trend brings various challenges, for instance, power balance & transfer, low inertia, low system strength, et al., to operate a secure and stable power system due to the continuous displacement of synchronous generation sources. For those remote and large-scale VRE such as in offshore or desert, the GFL converters/inverters can be more susceptible to instabilities or oscillations particularly when integrated into a weak AC grid.

Grid Forming (GFM) converters have the potential capability to address some of these operational challenges with respect to system strength, synchronous inertia, voltage and frequency regulation, wide-band frequency oscillations, et al. Moreover, Grid Forming Energy Storage Systems (GFM ESS) including Battery Energy Storage Systems (GFM BESS) and GFM STATCOM of some demonstration projects in the world have proved the core grid-forming capabilities that cannot be provided by GFL converters – such as: synchronous voltage source behavior, inertia response, phase jump response, weak grid operation and system strength support, seamless islanding and black start – along with typical well-validated GFL BESS capabilities, for example: peak shaving, ramping control, fast active power injection or Fast Frequency Response (FFR), voltage regulation, reactive power support and commercial market services. Grid Forming is becoming an emerging technology to enable high penetration ratios of large-scale VRE, or even a preferable and feasible solution for the remote energy hub or island, towards regional 100% power-electronics-dominant power systems in the future. However, some barriers to further promote GFM technology into a bulk power system are still existing.

As a good starting point, CIGRE's now implements certain WG activities to work on introduction of emerging Grid Forming technologies/applications into global power and energy markets:

- Cigre Task Force B4-77 published its findings in the CSE journal, Volume No. 15, October 2019, and addressed some initial discussions on Grid Forming/Virtual Synchronous Machine (VSM) capabilities of VSC HVDC systems.

- WG B4.87 “Voltage Source Converters (VSC) HVDC responses to disturbances and faults in AC systems which have low synchronous generation” further proposes the EMT simulation models for testing purposes, and reviews the potential control impact on the equipment rating and on the interconnected AC system.
- WG B4.84 “Feasibility study and application of electric energy storage systems embedded in HVDC systems” investigates the connection of electric storage to HVDC/MVDC systems and the AC/DC converters with inherent storage capability, and provides the assessment of techno-economic benefits of electric storage in DC systems, including grid forming capability.
- WG B4.94 “Application of VSC-HVDC in a System Black Start Restoration” focuses on a more comprehensive analysis of black start technology and a list of requirements for VSC-HVDC system to operate in black start mode.
- WG B4/C4.93 “Development of Grid Forming Converters for Secure and Reliable Operation of Future Electricity Systems” aims to review both the GFM functions and requirements from the system level and the GFM equipment capability from the converter level, respectively. It also aims to develop models/benchmark simulation & testing systems as well as relevant test specifications for GFM compliance testing purpose. It has a more general system level and structure to address GFM: definitions, functions, requirements, verification & validation.

Since there are other working groups addressing the subject of GFM, the objective of this proposed working group is to provide a more comprehensive investigation on Grid Forming Energy Storage System (GFM ESS) in enhancing integration of remote and large-scale VRE. And it is focused on the GFM ESS implementation & application, to further promote the GFM technology to expand its industrial applications for secure and reliable operation of future power systems.

Scope:

1) To investigate background and specify technical challenges and requirements for the GFM Energy Storage Systems (ESS), with the focus on the lithium Battery Energy Storage System (GFM BESS) and GFM STATCOM with an energy storage like super-capacitor.
2) To analyze different operation and control strategies for the different types of GFM ESS, operated under the network-connected mode, the islanding mode, and/or operation mode transitions
3) To identify the potential black start processes for the restoration of remote VRE sources, and for the restoration of the AC network system, by using GFM ESS.
4) To assess the technical benefits of GFM ESS in weak AC systems, such as: Voltage Stability, Angular Stability & Frequency Stability, Fault Ride Through (FRT) capability, Ancillary services, et al. General technical comparisons of GFM BESS v.s. synchronous generator, and GFM STATCOM v.s. synchronous condenser, will be included.
5) To share industrial good practices of the existing GFM ESS applications around the world.

The WG will invite a corresponding member from SC C4 and C6, as its scope also creeps into the typical activities of those two SCs.

Deliverables:

☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☒ Tutorial
☒ Webinar

Time Schedule: start: December 2023	**Final Report**: November 2026
Approval by Technical Council Chairman: **Date**: October 30th, 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.