CIGRE Study Committee C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° C4.60	**Name of Convenor:** Aboutaleb Haddadi (United States) **E-mail address**: ahaddadi@epri.com	
Strategic Directions #[2]: 1,2,3		**Sustainable Development Goal #[3]: 7,9,13**
The WG applies to distribution networks: ☒ Yes / ☐ No		
Potential Benefit of WG work #[4] : 3,4,5		
Title of the Group: Generic EMT-Type Modelling of Inverter-Based Resources for Long Term Planning Studies		

Scope, deliverables and proposed time schedule of the WG:

Background:

With the increasing share of renewable energy resources in power systems, there is an increasing need for accurate models of these resources to enable various renewables-related power system studies at planning stage. Most commonly, these resources are interfaced to the power system through a power electronic interface and hence are referred to as inverter-based resources (IBRs). IBR models can be broadly categorized into vendor specific and generic models. Vendor specific models, which are the focus of WGs C4.56 and JWG B4.82/IEEE, are based on proprietary manufacturer’s data and are used for site specific studies. While these models are critical and have their place, they cannot be used for long term planning studies wherein an actual IBR installation does not exist. Such studies require generic IBR models which provide a reasonable representation of the trend of IBR behaviour but may not accurately represent the minute details. This Working Group addresses the need for generic IBR models and does not consider vendor specific models.

Development of generic IBR models is challenging due to the complexity of IBR controls and sophisticated requirements in data. Due to the high level of modelling details, it is neither simple nor practical to develop and maintain a unique generic IBR model for various studies. This leads to use of different types of generic IBR models, including RMS-type and electromagnetic transient-type (EMT) models, depending on the type of study and the frequency content of the studied phenomenon during system expansion or planning studies. Compared to RMS models, EMT IBR models represent IBR dynamics in a wider range of frequencies, thus enabling the study of a wider range of power system phenomena. The challenge is the required amount of data.

While generic positive-sequence models of bulk-connected IBRs have been around and are standardized and used in planning stage studies, generic EMT IBR models are rare. Existing public EMT IBR models developed by different EMT software vendors as library models are not standardized and may lead to inconsistent results. Existing vendor specific EMT IBR models are not publicly available. These challenges highlight the need for publicly available generic and accurate EMT IBR models.

To address this gap, this Working Group will deliver a set of publicly available generic EMT IBR models which could be used to compare various results, solutions, and new methods on the same basis while performing planning stage studies. The developed models will be validated and benchmarked across various EMT software platforms to ensure model consistency.

Potential values of the developed EMT IBR models include:

- They enable exploratory and futuristic IBR-related EMT studies;
- They provide a tool for researchers and engineers to compare simulation results, methods, and solutions on the same basis and thus have more confidence in results and conclusions; and
- They can be further utilized towards developing forward looking IBR interconnection standards and technical interconnection requirements development.

Scope:

The emphasis of this Working Group is on generic EMT models, modelling methods, grid code requirements and various aspects being considered in IBRs for EMT simulations. The scope is as follows:

1. Give an overview of the capabilities and applications of IBR EMT models
    a. Include converter modelling techniques at different accuracy levels.
    b. Include various control and protection systems.
    c. Aggregated and detailed modelling.
2. Deliver new generic EMT models of the following types of IBRs:
    a. Type-IV wind turbine generator and parks.
    b. Type-III wind turbine generator and parks.
    c. Photovoltaic (PV) resources and parks.
    d. Grid-forming inverters.
    e. Voltage source converter (VSC) connected wind farms.
    f. Battery energy storage system (BESS).
    g. Electric vehicle (EV) charging station.
    h. Inverter based demand (such as data centres, electrolyser connections)
    i. Off-line and real-time models will be considered.
    j. Numerical aspects will be considered.
3. Performance analysis and details
    a. Test benchmarks will be delivered that emphasizes generic EMT models, modelling methods, grid code requirements and various aspects being considered in IBRs for EMT simulations. These models will differ from those of WG C4.56 in terms of system size and simulation objective.
    b. Performance under short-circuit conditions.
    c. Performance under grid transient conditions.
    d. Performance under input variation conditions.
    e. Harmonic analysis models to estimate harmonic emission from individual devices (or equivalent harmonic model with emission and impedance).
    f. Performance test against IBR interconnection standards including IEEE P2800, IEEE 1547, UL 1741, and grid codes such as VDE-AR-N 4120.
4. Validate the developed IBR models through
    a. Cross-examination against laboratory test data (small-scale and large-scale inverters).
    b. Field test data.
    c. Manufacturer tests.
5. Demonstrate and compare generic EMT models developed to existing generic RMS-type models.
6. Benchmark the developed models across various EMT simulation platforms and share with software vendors.

Deliverables:

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

Time Schedule: start: December 2020 **Final Report**: December 2023

Approval by Technical Council Chairman:

Date: December 29th, 2020

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.