CIGRE Study Committee C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

<table>
<tr><td rowspan="2">**WG [1]N° C4.56**</td><td colspan="2">**Name of Convenor:** Babak Badrzadeh (AUSTRALIA)
E-mail address: babak.badrzadeh@aemo.com.au</td></tr>
<tr><td>**Technical Issues #[2]: 3,5,6,8**</td><td>**Strategic Directions #[3]: 1,2**</td></tr>
<tr><td colspan="3">**The WG applies to distribution networks[4]: Yes**</td></tr>
<tr><td colspan="3">**Potential Benefit of WG work #[5]: 2,3,4,5**</td></tr>
<tr><td colspan="3">**Title of the Group: Electromagnetic transient simulation models for large-scale system impact studies in power systems having a high penetration of inverter connected generation**</td></tr>
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Scope, deliverables and proposed time schedule of the WG:

Background:

Power system operators and network owners rely on power system modelling and simulation to maintain secure operation of power systems in real time. Conventional power system simulation models, typically referred to as root-mean square (RMS) models, have been used worldwide by all major network owners and system operators for predicting the response of power systems subjected to credible and non-credible contingency events. These types of models represent a trade-off between acceptable accuracy and simulation speed and have proven to be acceptable for power systems having a large amount of conventional synchronous generation and a limited penetration of non-synchronous energy sources.

However, such system models lose accuracy as the ratio of synchronous to non-synchronous generation (including wind turbines, solar inverters, battery energy storage systems, and variable speed pumped storage units) declines. This primarily stems from the fast control systems used in non-synchronous generation, the dynamics of which cannot be adequately represented in RMS simulation tools. It follows that such models are not suitable for predicting the response of power systems to major disturbances, e.g. causation chain that may result in a major supply disruption, or during extreme operating conditions which may include islanding events that follow loss of major transmission in-feeds.

Electromagnetic transient (EMT) simulation tools address the deficiencies of RMS models however often impose a significant computational burden due to the level of detail that is included (given that they are usually a one-to-one representation of the actual physical plant). Such modelling tools are in use by all major power system plant manufacturers for designing equipment however they have (to date) found limited application as part of large-scale power system studies. This is due to the computational burden associated with running large numbers of EMT models in parallel as well as the difficulties in many jurisdictions of sourcing such models from the original equipment manufacturers (OEMs).

To address the speed of simulation issues associated with EMT models, state-of-the-art solution techniques are being progressively developed by software developers in collaboration with system operators and network owners. Concurrently, improvements are being applied to the speed and robustness of the simulation models developed by OEMs.

System operators in regions having a very high penetration of inverter connected generation are already observing limitations in the use of RMS-type models and have developed large-scale EMT-type models of their systems. This includes Australia and Texas where EMT-type models are used extensively for making operational decisions.

The proposed working group is intended to serve as a platform for the dissemination of knowledge, lessons learned, recommended practices, intended applications, and underlying reasons for the use of EMT-type models for large-scale stability studies in power systems having a high penetration of inverter connected generation.

The proposed scope of the working group is as follows:

1. Review and coordinate work and information with:
   - JWG C4/C6.35/CIRED
   - CIGRE JWG B4.82/IEEE
2. Comparison of the applicability of RMS- and EMT-type models for power systems having a high penetration of inverter connected generation.
3. Time-domain vs frequency-domain analysis methods with EMT-type models.
4. Approaches for large-scale network modelling in EMT-type tools including how to develop appropriate ‘equivalent networks’.
5. Techniques for simulation speed improvement.
6. Correct modelling of system frequency during abnormal operating conditions.
7. The level of detail required to model different generator technologies and network components as a function of the phenomena of interest.
   - This includes modelling inverter connected distributed energy resources, e.g. rooftop PV, and loads, e.g. variable speed motor drives and data centres.
8. Generic vs site-specific vendor-specific EMT models.
9. Protection system modelling for network and generation equipment, including wide-area control and protection schemes.
10. Acceptance testing and validation of EMT-type models.
11. The use of EMT-type models for determining system strength requirements:
    - Determining whether or not an inverter connected generation source adversely impacts system strength.
    - Determining system-wide system strength requirements.
    - The use of EMT-type models for developing operational constraints.
12. The use of EMT-type models for assessing adverse control and harmonic interactions due to connection and parallel operation of multiple inverter connected plant.

Time Schedule (physical meetings) :

- Proposed start coinciding with Aalborg Symposium, June 2019
- Second meeting, Canada, October 2019
- Third meeting, Between February and April 2020, Australia
- Fourth meeting, August 2020 coinciding with Paris General Session
- Fifth meeting, coinciding with International Colloquium on “Lightning and Power Systems”, 2021, Suzhou, China.

Final reporting : By June 2022 (3.0 years)

Deliverables:

☒ Technical Brochure and Executive Summary in Electra

☒ Electra Report

☒ Tutorial[6]

☒ Webinar[6]

Time Schedule: Start: June 2019 **Final Report**: June 2022

Approval by Technical Council Chairman:

Date: April 16th, 2019

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3] See attached Table 2, [4] Delete as appropriate, [5] See attached Table 3,
[6] Presentation of the work done by the WG

Table 1: Technical Issues for creation of a new WG

1	Active Distribution Networks resulting in bidirectional power and data flows within distribution levels up to higher voltage networks
2	Digitalization of the Electric Power Units (EPU): Real-time data acquisition includes advanced metering, processing large data sets (Big Data), emerging technologies such as Internet of Things (IoT), 3D, virtual and augmented reality, secure and efficient telecommunication network
3	The growth of direct current (DC) and power electronics (PE) at all voltage levels and its impact on power quality, system control, system operation, system security, and standardisation
4	The need for the development and significant installation of energy storage systems, and electric transportation, considering the impact they can have on the power system development, operation and performance
5	New concepts for system operation, control and planning to take account of active customer interactions, and different generation types, and new technology solutions for active and reactive power flow control
6	New concepts for protection to respond to the developing grid and different generation characteristics
7	New concepts in all aspects of power systems to take into account increasing environmental constraints and to address relevant sustainable development goals.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics
9	Increase of right of way capacity through the use of overhead, underground and submarine infrastructure, and its consequence on the technical performance and reliability of the network
10	An increasing need for keeping Stakeholders and Regulators aware of the technical and commercial consequences and keeping them engaged during the development of their future network

Table 2: Strategic directions of the Technical Council

1	The electrical power system of the future: respond to speed of changes in the industry
2	Making the best use of the existing systems
3	Focus on the environment and sustainability
4	Preparation of material readable for non-technical audience

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.
7	Work addressing environmental requirements and sustainable development goals.