CIGRE Study committe C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG C4.81

NAME OF THE CONVENOR
BADRZADEH Babak (AUSTRALIA)

TITLE
Best practice modelling and study methods for large inverter-based loads for connection, planning and operation

THE WG APPLIES TO DISTRIBUTION NETWORKS: YES

ENERGY TRANSITION
2 / Hydrogen
3 / Digitalization
5 / Grids and Flexibility
7 / Consumers, Prosumers and Electrical Vehicles
8 / Sector Integration

POTENTIAL BENEFIT OF WG WORK
1 / commercial, business, social, economic benefits
2 / potential interest from a wide range of stakeholders
3 / likely to contribute to new or revised industry standards
4 / state-of-the-art or innovative solutions or directions

STRATEGIC DIRECTION
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-ofthe-art technological advances

SUSTAINABLE DEVELOPMENT GOAL
9 / Industry, innovation and infrastructure

BACKGROUND :

Power systems are undergoing rapid electrification of demand, with a growing share of large demand facilities interfaced through power electronics, including data centres, electrolysers, high-power EV charging hubs, industrial variable-speed drives, and other power-electronics interfaced demand equipment. These inverter-based loads (IBLs) can exhibit fast, control-driven behaviour during steady-state and disturbance conditions that differ materially from those of conventional passive loads and inverter-based resources (IBRs).

Internationally, the planning, connection, operational impact, and technical behaviour of large IBLs remain comparatively less scrutinised than generation, and recent experience has highlighted that inadequate characterisation and modelling can result in concerns being discovered in real time rather than picked up during grid connection studies. CIGRE Study Committees C4, C2 and C1 have established the
Task Force on the role and requirements for large inverter-based loads
to identify critical gaps and recommend targeted activities.

In parallel,
CIGRE WG C4.77

is developing best practices for conformity assessment of IBRs and has explicitly flagged the need for a subsequent activity focused on devices operating as loads only, including large IBLs. This proposed Working Group builds on these foundations and provides focused, practical guidance on modelling and study methods for large IBLs across the connection lifecycle, planning studies, and operational assessment, while recognising confidentiality constraints and the diversity of technologies and operating modes.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

This Working Group will develop internationally applicable best-practice guidance for **modelling and technical studies of large IBLs,** to support consistent, efficient, and risk-based connection, planning and operational assessment. The work will:

- improve clarity on **minimum data and model requirements**, and when higher-fidelity modelling, including EMT, is justified;
- promote **repeatable validation and lifecycle revalidation** practices, recognising the impact of control updates, operating mode changes, and facility expansion/application change;
- provide practical approaches to balance **accuracy, time, cost, and confidentiality**, while maintaining power system security and power quality;
- support convergence of practices across jurisdictions and inform future guidance, standards, and grid code development where appropriate.

SCOPE :

The Working Group will investigate and report on the following topics, focusing on **large power-electronics interfaced demand facilities** that are capable, individually or in aggregate, of materially impacting the host grid. The WG will prioritise practical guidance and decision frameworks that are usable within typical planning and connection timeframes, and will provide tiered recommendations (screening, standard, and detailed) where appropriate.

1. **Definitions, taxonomy and boundary conditions** for IBLs, and differentiation from IBRs and conventional loads, including consideration of mixed facilities with on-site UPS, DC distribution, storage, and back-up generation where applicable. This will include a structured classification framework for IBLs and mixed facilities, covering primary function, converter technology and control characteristics, dynamic behaviour class, and impact scale relative to local system strength.
2. **Functional performance expectations** relevant to power system technical performance, including stability, protection, and power quality, and identification of behaviours or failure modes that warrant explicit assessment.
3. **Screening and prioritisation methods** to determine when an IBL should be treated similarly to an IBR, when streamlined analysis is sufficient, and when detailed assessment is required, accounting for device characteristics, aggregation effects, and the electrical strength and criticality of the connection point.
4. **Modelling approaches and levels of detail** for connection, planning, and operational studies, including aggregated versus detailed representations, and selection of phasor-domain (RMS) versus EMT versus hybrid approaches. This will include guidance on when mixed-facility sub-systems may be aggregated versus modelled separately, and how to represent mode-changing elements (for example UPS inverter/bypass).
5. **Model specification, documentation and governance**, including practical guidance on parameterisation, treatment of adaptive controls, and approaches for handling proprietary models and confidential data sharing between stakeholders.
6. **Verification and validation methods**, including guidance on verification and validation approaches, rather than performing validation of specific facilities. Recognising confidentiality and data availability constraints, the guidance will cover evidence sources and practical approaches such as anonymised disturbance records, site test results, benchmark or representative events, and synthetic test cases that still enable defensible model verification and validation.
7. **Connection process and lifecycle framework**, including early data submission expectations, model submission and type selection, performance assessment studies, evaluation of modelled versus expected behaviour, post-connection validation, and triggers for revalidation following upgrades, expansions, purpose or operating mode changes.
8. **Roles and responsibilities** across TSOs, DSOs, demand owners, OEMs, EPCs and consultants, including recommended workflows and interfaces with relevant standards and grid code processes.

Remarks:

This Working Group will align with, and build on, outputs from the CIGRE Task Force on large loads and will use WG C4.77 outputs as background on conformity assessment principles and model governance. The intent is to provide practical, technology-neutral recommended practices for connection, planning and operational studies of large IBLs, including workable approaches to confidentiality and lifecycle revalidation, without prescribing jurisdiction-specific code clauses.

DELIVERABLES AND EVENTS

Deliverables Types
Annual progress and activity report to Study Committee
CSE
Electra report
Future connections
Technical Brochure and Executive Summary in Electra
Tutorial
Webinar

Time schedule

Q2	2026	• Recruit members (National Committees, WiE, NGN)
Q3	2026	• Develop final work plan
Q2	2029	• Draft TB for Study Committee Review
Q4	2029	• Final TB
Q1	2030	• Webinar
Q3	2030	• Tutorial

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:
Rannveig S. J. Loken
March 18th, 2026