CIGRE Study Committee C1

PROPOSAL FOR THE CREATION OF A NEW JOINT WORKING GROUP

JWG [1]N° C1-C5.53	**Name of Convenor:** Jana Breedt (SOUTH AFRICA)
Strategic Directions #[2]: 1, 3, 4	**Sustainable Development Goal #[3]: 7,11,12**

T his Working Group addresses these Energy Transition topics:

	Storage
	Hydrogen
	Digitalization
	Sustainability and Climate Change
X	**Grids and Flexibility**
	Solar PV and Wind
X	**Consumers, Prosumers and Electrical Vehicles**
	Sector Integration
	None of them

Potential Benefit of WG work #[4] : 1,3,5

Title of the Group: Forecasting of demand combined with Distributed Energy Resources penetration driven by consumer behaviour and regulatory schemes influenced by market signals.

Scope, deliverables, and proposed time schedule of the WG:

The objective of this Working Group (WG) is to enhance comprehension regarding the harmonization of market signals, consumer behaviour on these signals, and the integration of Distributed Energy Resources (DER), such as photovoltaic (PV) systems and batteries on the long term demand forecast. Consumer behavior and load necessities are increasingly influenced by economic indicators, originating from market mechanisms or, in some instances, administrative schemes and incentives within certain jurisdictions. This integration significantly impacts demand forecasting, encompassing both peak capacity and energy requirements. The complexity of forecasting future loads necessitates a deeper understanding of available methodologies and emerging practices.

Since there is focus also on markets and regulations, as well as on consumers' behaviour, it will be a joint WG with SC C5, with explicit and direct participation of C6 experts.

The WG will produce a Technical Brochure, an Electra article, provide progress updates during 2024 and 2025 SC meetings, and present a final paper at the 2026 Paris Session Symposium.

Background:

The landscape of the End-to-End electricity forecasting has undergone a significant transformation. Previously characterized by stability and reliance on quantitative time-series-based demand forecasting, it has now evolved to incorporate the interconnection of renewable generation, the timely decommissioning of aging coal-fired power stations, and the widespread adoption of new Distributed Energy Resources (DER) technologies by consumers. These developments have profoundly impacted the management of supply and demand within the electricity system.

Recent shifts have emphasized the importance of new approaches to electricity demand forecasting for several reasons:

- ✓ Demand forecasting serves as a cornerstone for electrical power system planning, informing crucial investment decisions in capital-intensive infrastructure.
- ✓ Forecasts now span a broad time horizon, from operational short-term to strategic long-term planning, driven by factors such as global decarbonization goals, utility market signals reflecting resource scarcity, dynamic pricing, diversified supply portfolios, and the integration of emerging technologies (e.g., residential/small-scale PV, battery systems), as well as the electrification of final uses (Electric Vehicles, Heat Pumps). These disruptive elements and their uncertain evolution render traditional regression or time series-based forecasting methods inadequate.
- ✓ Customer demand, increasingly observed by system operators, reflects a combined net effect of electricity consumption behind the meter and the operation of distributed generation and energy storage units.
- ✓ Investment and operational patterns in consumption, distributed generation, and storage are all influenced by regulatory signals, whether market-driven prices, administrative mechanisms, load curtailment policies, or incentives. Hence, demand forecasting must incorporate the impacts of market-driven DER investment and operation decisions.
- ✓ Depending on the power system planning context, it may be necessary to treat electricity demand not merely as an input but as a variable to be modeled within a market simulation framework. Such modeling should capture the bidirectional interaction between supply and demand, where supply directly depends on demand while demand, in turn, is influenced indirectly by supply dynamics.

Purpose/Objective/Benefit of this work:

There is a need to have a clear view of consumer behaviour and decision-making patterns linked to price/market signals and how this will influence the demand forecast. Clarity on demand profiles per sector or industry is needed to optimise the supply generation mix and to optimise the investment needed from a grid planning perspective to meet the forecasted demand.

Given these factors, balancing supply and demand, especially with Distributed Energy Resources (DER) behind the meter, poses significant challenges. The Working Group (WG) seeks to gather global insights to better understand forecasting methods for long-term strategic studies, enabling a comprehensive interpretation of consumer behavior's impact on demand forecasting. This influence stems from the adoption of DER and Small-Scale Embedded Generation (SSEG), often driven by market signals, utility industry changes, and efforts for net-zero emissions.

As the energy industry undergoes profound transformations toward achieving net-zero emissions, ensuring the security of energy supply aligned with forecasted demand is crucial for both the system and consumers. Establishing synergies between utilities and consumer behavior is essential to minimize the need for generation and grid expansion while maintaining a secure supply-demand balance. Enhancing forecast modeling accuracy and flexibility, either independently or as part of broader market models, is crucial for understanding load behavior within efficient and resilient power system investment planning frameworks.

The primary focus of the Working Group's contribution will center on delineating methodological approaches to integrate Distributed Energy Resources (DER) and Small-Scale Embedded Generation (SSEG) investment pathways with demand forecasting, market modeling, and investment planning methodologies. This will encompass recommendations

tailored for utilities, system operators, or regulators, outlining key developments and data points to monitor progress. By providing guidance on necessary adjustments to data collection, forecasting and planning methods, or potential changes to market rules and incentives, the aim is to mitigate risks to security of supply, reliability, and network investment.

Scope:

The working group will investigate and report on:

1. General overview of current and expected uptake of behind-the-meter DER and SSEG from consumer installations from different countries, as background info for this work and to help choose most relevant jurisdictions to learn from.Differentiation between grid-tied and off-grid installations, and how it will impact future demand serviced by a centralised utility infrastructure.
2. Selection of jurisdictions to describe in more detail; the selection shall consider paradigmatic cases, applicable also to other countries.
3. General description of the various different kinds of market levers driving consumers (household, commercial and industrial) towards the installation of DER and SSEG, and how behind-the-meter DER and SSEG are regulated.
4. A description of the evolution of electricity technology development with the increased availability of these sources to the average consumer. This can include but is not limited to installation of EV's , Heat pumps, Rooftop solar, ext.)
5. Overview of regulation in different jurisdictions of DER and SSEG installations at disaggregated locations in the networks, with a special focus on aspects relevant for forecasting purposes and with regards to regulatory or system operator record keeping about installed DER and SSEG equipment and its operation.
6. Review of different forecasting techniques used to include large-scale and distributed renewable sources connected at different locations of the network, focusing on installed capacity forecasts as well as usage or operation forecasts, usually at hourly detail, which depends e.g. on energy and system services the customers provide, on which combination of generation and storage systems are installed, and on the choice of self-consumption vs. supply to the system vs. peer-to-peer or other innovative market settings.
7. Due to diverse regulatory approaches globally and the wide array of forecast applications, this review of forecasting techniques will prioritize structured descriptions of how various aspects and features interact, focusing less on algorithmic intricacies. For instance, the outcomes of demand forecasting hinge on factors such as whether behind-the-meter DER investments are undertaken or well-documented by the utility, system operator, or regulator. Additionally, they are influenced by specifics of retail market liberalization, including the adoption of dynamic electricity pricing and network pricing, as well as system planning methodologies, which may or may not incorporate hourly market simulations universally.
8. The structured description how regulatory and market rules interact with various effects of DER and SSEG investment and usage, and what forecasting techniques and outputs as well as combinations of tools are needed in the different settings, will be used as the basis for conclusions or recommendations in the following areas:
    a. What data does the utility, system operator (both transmission and distribution) and regulator need about household, commercial and industrial DER and SSEG, especially behind-the-meter, and how can this data be collected and communicated or estimated for improved data analytics, modelling and forecasting?

b. Study which DER and SSEG resulting net demand profiles of different sectors and customer classes can be expected to evolve in different settings, what challenges can arise, and how can these challenges be addressed to better meet demand and supply requirements?

c. Market signalling structures / incentivised programs currently in place, and what can be proposed in the different DER and SSEG market signalling structures and incentives settings to optimise improve energy availability, security of supply, system reliability and the overall balance between evolving net demand profiles and the system?

d. Recommendations on how synergies can be established between the utility and system operator business strategies and my/ Market design and signals on one hand, and the consumer DER and SSEG investment and usage behaviour that will influence the long-term demand forecast balance of demand and supply in all time frames and the demand forecasts?

The primary focus of the Working Group's contribution will center on delineating methodological approaches to integrate Distributed Energy Resources (DER) and Small-Scale Embedded Generation (SSEG) investment pathways with demand forecasting, market modeling, and investment planning methodologies. This will encompass recommendations tailored for utilities, system operators, or regulators, outlining key developments and data points to monitor progress. By providing guidance on necessary adjustments to data collection, forecasting and planning methods, or potential changes to market rules and incentives, the aim is to mitigate risks to security of supply, reliability, and network investment.

Remarks:

Previous CIGRE working group results will be taken into account, incl. C1.27 The future of reliability, C1.32 Best practice approaches for credible electricity demand and energy forecasts for network planning, and C1.23 Communication by system planners with stakeholders for new investments and deployment of future networks.

Topics and aspects expressly not addressed in this first-of-a-kind work shall be addressed in subsequent complementary WGs.

A series of new work within CIRED regarding the inclusion of customer behaviour and distributed energy resources can also be investigated.

Deliverables:

☒ Annual Progress and Activity Report to Study Committee
☒ Technical Brochure and Executive Summary in Electra
☐ Electra Report
☐ Future Connections
☐ CIGRE Science & Engineering (CSE) Journal
☒ Tutorial
☐ Webinar

Time Schedule:

- Recruit members (National Committees) Q3 2024
- Develop final work plan Q4 2024
- Draft TB for Study Committee Review Q4 2025
- Final TB Q1 2026

• Tutorial	Q2 2026
Approval by Technical Council Chairman: **Date**: August 13th, 2024	

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.