CIGRE Study Committee C1

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG[1] N° C1.52	**Name of Convenor:** Qixin Chen (China)
Strategic Directions #[2]: 1,2,3	**Sustainable Development Goal #[3]: 7,11,13**

This Working Group addresses these Energy Transition topics:

- [ ] **Storage**
- [ ] **Hydrogen**
- [ ] **Digitalization**
- [ ] **Sustainability and Climate Change**
- [ ] **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

Title of the Group: Virtual Power Plants: Role and deployment in large power systems' operation and planning

Scope, deliverables and proposed time schedule of the WG:

Background:

Current power systems are witnessing great changes and challenges coming from:

(1) Global consensus on carbon neutrality goals has encouraged high penetration of renewables into the power systems.

(2) Electrification of other sectors (such as the transportation, heating and various industrial sectors), which shall increase the electricity loads and change the characteristics in power systems.

(3) Due to the intermittent nature of renewables and difficulties to forecast electricity loads, the need for flexibility resources, such as peak shaving, ramping, and regulation reserves, is on the rise.

(4) Extension of flexible resources. including Virtual Power Plants (VPPs) shall be needed, to alleviate the peak demand loads and reduce inefficient generation, transmission and distribution investments.

(5) Dispatching architecture of bulk power system and wholesale market mechanisms shall have to accommodate the new entities (like VPPs).

The flexibility provided by the existing flexible resources is insufficient to meet the requirements of new power system, especially since traditional thermal power plants are phased out to avoid their CO2 emissions. The growing need of flexible resources in the power system calls for unlocking demand side flexibility and coordinating the interdependent profiles of generation and load.

The technological development of renewables, energy storage, and communication led to the formation of energy communities in collaboration of renewable generation, distribution, and consuming. Meanwhile, the idea of VPP is proposed and comes into pilot practice in recent years, in order to facilitate power system operations and electricity market. A VPP is understood as a party or a system that realizes aggregation, optimization and control of flexible resources which are not necessarily within the same geographical area. Energy communities and also aggregators could be considered as some specific forms of VPPs, while VPP acts as the central control entity aggregating and managing the energy produced and consumed by the community or the aggregated customer loads, allowing for more efficient distribution and usage of energy within the community, and also providing a means for the community or for small individual loads or distributed energy resources to interact with the higher-level power grid and electricity market.

VPPs have important value in mitigating transmission capacity constraints, resource allocation optimization, and bulk power system reliability, by providing quantifiably reliable generation capacity and regulation services. For example, the launch of Shenzhen VPP in South China in 2022 provides dispatchable capacity of 870 MW, which explores to participate into the spot market to reduce the overall cost of operating the bulk power system. The Jibei VPP aggregates flexible resources of 390 MW participating to the cross-regional ramping up and down energy market, which improves renewable energy consumption, reduces wind curtailment rate, and alleviates transmission system congestion. Also in 2022, PJM (US) introduced VPPs into BRA (Base Residual Auction) to pre-sale the 2025/26 generation capacity, so as to realize optimal allocation of bulk power generation resources, and in Europe, energy communities and aggregators are well-defined in Regulations and contribute thousands of MW to various European markets. Generally, VPPs are eligible to compete with other market entities on the same platform in the wholesale market to provide frequency regulation, reserving, and other services.

Purpose/Objective/Benefit of this work:

The introduction of VPPs can help to reinforce the flexibility and resilience of large power systems. Since the inception, VPPs have gained interest worldwide, and different jurisdictions have developed their own practices, mechanisms, organization modes, and policies of VPPs; it is therefore important to learn from and exchange ideas with each other.

The modeling of heterogeneous flexible resources and the interaction between the VPP operators, network operators and other stakeholders/consumers are essential for the efficient and reliable operation of VPPs. Attention needs to be paid to the impacts on and analysis methodologies for operation & planning decisions, especially from the perspectives of the distribution and transmission systems, specifically:

(1) Identifying criteria for feasibility / eligibility of the physical units included in a single VPP, often described in network or grid codes.

(2) Description of approaches for standardized modeling and aggregation of massive heterogeneous flexible resources for system-level dispatch.

(3) Description of optimal dispatch and coordinating schemes of VPPs from the perspectives of distribution and transmission system operators.

(4) Description of impact mechanisms and economic analysis approaches for the impacts of VPPs on bulk power system operation and planning.

System-level integration of VPP is the main issue for this WG, requiring comprehensive understanding of mechanisms, methodologies, experiences as well as the technical details of the corresponding cyber-physical-social system. Gathering the worldwide experiences and insights from experts with academic and industrial background would be beneficial to improve such understanding. Therefore, the proposed working group well matches CIGRE's distinctive character of unbiased vision and worldwide excellence.

Scope:

The brochure should introduce technologies, models and practices of VPPs. In addition, the influencing mechanism, economic efficiency and benefits of VPPs on power system operation and planning will be included. It will also compare the operation of VPPs with traditional aggregators in electricity markets.

The investigated dimensions will include:

1. Collecting the main examples of VPP realizations and their models of flexible resources considered in the aggregation of VPP from countries of all continents at present. Generation and storage resources connected to transmission and distribution networks are to be included.
2. Summarizing lessons learned from current VPP practice. Collecting overview of models and methods for transmission system economic dispatch considering VPPs' coordination from companies or system operators. Searching and reviewing relevant prior work, including CIGRE's previous papers and technical brochures.
3. Discovering the impact and function of VPPs on distribution and transmission system planning and operation. Unlocking the impact of aggregation capacity of VPPs on the decision for flexible resource allocation, renewable energy consumption and distribution and transmission system resilience.
4. Identifying specific requirements for VPP integration into flexibility mechanisms and markets. Summarizing learnings from current VPP practice about requirements for VPP integration into flexibility mechanisms and markets, and comparing with other forms of resource aggregation such as energy communities and load aggregators.

For the above topics, a survey of existing data and cases shall be done, analyzing the drivers, rationale and criteria for selected VPPs, in order to infer some general principles as useful guidelines for the design of future projects. Innovative models, technologies and analysis methods directly relevant to VPPs shall also be summarized, especially if they become clear from the survey and are aimed at achieving the goal of a reliable and resilient power system.

Remarks:

The working group foresees liaisons with the following other working groups that are active at the time:

- JWG C6-C2.34: Flexibility provision from distributed energy resources
- WG C6.43: Aggregation of battery energy storage and distributed energy resources (DER), including solar PV
- WG C6.35: Distributed energy resources aggregation platforms for the provision of flexibility services
- JWG C1-C4.46: Optimising power system resilience in future grid design

Moreover, the interdisciplinary character of the VPP topic calls for collaboration with C2 (System operation and control).

Liaison members from C2, C4 and C6 will be invited and welcomed to provide relevant support.

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, WiE, NGN)	Qtr 1 2024
• Develop final work plan	Qtr 1 2024
• Draft TB for Study Committee Review	Qtr 1 2025
• Final TB	Qtr 2 2025
• Tutorial & webinar	2025-2026

Approval by Technical Council Chair:

Date: February 12th, 2024

Marcio Szechtman

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, WiE and NGN nominees.

b. WG nominees by NCs 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.