CIGRE Study committe C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG C4/A3.79

NAME OF THE CONVENOR
Jinliang He (CHINA)

TITLE
Temporary overvoltage protection technologies for high-voltage transmission systems with large-scale renewable energy bases

THE WG APPLIES TO DISTRIBUTION NETWORKS: **NO**

ENERGY TRANSITION
5 / Grids and Flexibility
6 / Solar PV and Wind

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
6 / work likely to contribute to improve safety

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
2 / Making the best use of the existing systems

SUSTAINABLE DEVELOPMENT GOAL
7 / Affordable and clean energy
9 / Industry, innovation and infrastructure

BACKGROUND :

To promote high-quality and rapid deployment of renewable energy resources, including wind and photovoltaic power, the development and integration of large-scale renewable energy (LRE) bases via long distance transmission circuits has become one of the most important activities worldwide. However, it is well known that phasing out conventional AC synchronous generator sets and replacement with LRE introduces significant challenges. As LRE bases are increasingly integrated into the power grid, issues related to system stability, safe operation, and transmission capacity are becoming more prominent. This ToR focuses on the topic of fault-induced Temporary Overvoltages (ToVs) in transmission corridors serving LRE bases and their impact on associated export capacity.

LRE bases are connected to the power systems using high voltage transmission circuits. In these high-voltage corridors, fault-induced TOVs can become a key factor for power export capacity, safe operation and overall system stability. In effectively grounded systems, TOVs can typically reach 1.3 pu, and their duration, including fault clearing, is generally less than 1 second. However, new TOV characteristics are observed in LRE systems. In particular, Electromagnetic transient (EMT) simulation and artificial grounding short-circuit tests conducted in a 500 kV transmission system serving a LRE base have shown that asymmetric short circuits can lead to TOVs exhibiting new characteristics after the fault is cleared. During single-phase auto-reclosing (SPAR), TOVs in the open phase can exhibit high amplitudes reaching a peak of 1.74 pu within the first 100 milliseconds after fault clearance. The voltage remains above 1.3 pu from approximately 100 milliseconds until SPAR closes the faulted phase. This level of TOV exceeds the current standards – e.g. according to IEEE 1862-2014 and China's national standard GB/T 50064-2014 TOVs caused by faults in high-voltage transmission systems are generally required to remain below 1.3 pu. In order to meet the TOV standard requirement, the power export capacity of renewable energy bases may need to be reduced. Furthermore, current standards do not clearly define the tolerance limits or specific evaluation criteria to assess the new characteristics of TOV observed in LREs.

Recently, CIGRE WG C4.46 covered TOV assessment methods with main focus on low order harmonic content in the voltage waveform. The key outcomes of this WG were: (i) a comprehensive set of guidelines on how to perform TOV simulations and assess associated stress on equipment, and (ii) recommendations for practical mitigation measures.

A knowledge gap has been identified where prospective fault-induced TOVs in high-voltage transmission systems serving LREs has not been thoroughly addressed in previous work. Therefore, it is necessary to study and establish clear evaluation criteria and protection technologies for this new type of phenomena and network topology.

In addition, the TOV withstand capability of surge arresters installed in high-voltage transmission systems serving LRE bases can become a contributing factor limiting the available export capacity of these circuits. Provided that system overvoltage protection requirements are met, enhancing the TOV withstand performance of surge arresters can raise the allowable TOV operating limits of power systems, thereby reducing constraints on export capacity from LRE bases.

Note: The term large-scale renewable energy (LRE) base generally refers to connection clusters with installed capacity of 1 GW and above in large power systems (e.g. China). However, the phenomena and analysis methods covered by this ToR are equally and widely applicable to smaller renewable cluster connections in other power systems.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

Objective:

The objective of this Joint Working Group (JWG) is to summarize the characteristics of fault-induced TOVs and related suppression technologies in high-voltage transmission systems for LRE bases, particularly focusing on TOV protection technology aimed at increasing the power export capacity. This work will build on knowledge from the outcomes and recommendations from previous CIGRE WGs (e.g. [1], [2]). The outcomes of this JWG will provide strong support for the efficient integration of renewable energy and contribute to reducing carbon emissions relevant to power systems.

References:

[1] Technical Brochure 913 “Evaluation of Temporary Overvoltages in Power Systems due to Low Order Harmonic Resonances”, August 2023. CIGRE WG C4.46.

[2] Technical Brochure from JWG B4.C4.B1.73 "Surge and extended Temporary Overvoltages in HVDC circuits". Soon to be published.

SCOPE :

1. Summarize the characteristics of TOVs in high-voltage transmission systems associated with LRE systems, with focus on fault-induced TOVs.
2. Propose TOV evaluation criteria for safety and stability analysis in LRE systems. In particular, assess the effectiveness of various measures – such as (i) advanced control strategies in inverter-based resources (IBRs) and (ii) surge arresters with high TOV withstand capability – in enhancing the power export capacity of a renewable energy base.
3. Review methods for improving TOV withstand capability in high-voltage transmission systems serving LRE bases. Assess the potential to enhance the TOV withstand capability of surge arresters, review the current state of development of the new surge arresters technologies with high TOV withstand capability for LRE high-voltage transmission systems, and analyse the possible impact on other power apparatuses in high-voltage power transmission systems. Those factors, such as power quality, which influence the TOV withstand capability of surge arresters, will also be discussed.
4. Summarize strategies for TOV suppression in high-voltage transmission systems serving LRE bases, including non-full-phase control of new energy units, controlled switching of the single phase cycle, and dynamic reactive power compensation devices in the non-full-phase steady-state stage of the renewable energy transmission systems. Discuss the roles of IBR control strategies in mitigating TOVs, and the technical requirements for IBRs to suppress temporary

DELIVERABLES AND EVENTS

Deliverables Types

Annual progress and activity report to Study Committee
Technical Brochure and Executive Summary in Electra
Tutorial
Webinar
Work Schedule

Time schedule

Q4	2025	Kick-off meeting
Q4	2028	Delivery draft TB for SC review
Q1	2029	TB publication

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:

Rannveig S. J. Løken
August 31st, 2025