CIGRE Study Committees A1 & C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG [1]N° A1/C4.66	**Name of Convenor:** Dhananjay.K. Chaturvedi (INDIA) **E-mail address**: dkc01851@yahoo.com
Strategic Directions #[2]: 1, 2	**Technical Issues #[3]: 3, 5, 7**
The WG applies to distribution networks[4]: Yes	
Potential Benefit of WG work #[5]: 1, 2, 3, 7	
Title of the Group: Guide on the Assessment, Specification and Design of Synchronous Condensers for Power Systems with Predominance of Low or Zero Inertia Generators	

Scope, deliverables and proposed time schedule of the WG:

Background:

As part of carbon emission reduction mechanisms, many countries have adopted policies to increase the installed capacity of renewable generation, based on Solar and Wind technologies, to either supplement or replace existing thermal generation. Wind and Solar have proven to be the most economical choices up to this point in time and have been deployed en-masse at both transmission and distribution voltage levels.

System owners/operators, market regulators and wider stakeholders now increasingly appreciate the impacts that the 'generation transition' is having on the power system. The displacement of traditional synchronous machines with various forms of power electronic (PE) interfaced energy sources is contributing to fundamental changes in power system steady-state and dynamic behaviour, including:

- Reducing levels of system inertia
- Reducing levels of 'system strength' (with fault level / short circuit power typically used as a general proxy)
- Reducing levels of synchronising and damping torque components which impact on the interaction of remaining synchronous machines.

Significant reductions in system inertia will impact network frequency control capability including observable rates of change of frequency (ROCOF) following credible and non-credible contingency events. At low inertia levels, there is likely to be a need to increase and possibly improve primary frequency control capabilities. The ability of under frequency load shedding and/or over frequency generation shedding schemes to operate correctly following non-credible events is also likely to be impeded if 'minimum' levels of inertia are not maintained.

An inability to maintain adequate 'system strength' will have multiple negative impacts on the power system including:

- Reduced voltage regulation capability (higher sensitivity to changes in P and Q flows throughout the network).
- Operation of power electronic (PE) based equipment closer to minimum acceptable short circuit ratios (SCR) potentially impacting on fault ride through performance and other system critical dynamic behaviours.
- Significant alterations to the harmonic impedance profile of the network which may result in undesirable power quality outcomes.
- Insufficient fault current to reliably operate impedance and over-current based protection schemes.

One mitigation strategy seeing resurgence in popularity is the deployment of synchronous condensers. This mitigation can counteract many of the issues outlined above as well as provide (potentially) significant reactive power contributions. The design of modern synchronous condensers can be optimised to address select or a broad range of network needs depending on the situation at hand. Increasingly, ‘off the shelf designs’ will not be sufficient to address specific networks issues. This will require anyone looking to purchase a synchronous condenser solution to understand not only what is technically possible, but also what trade-offs may exist in the design and construction of plant including corresponding cost impacts.

The main objective of this WG will be to produce an application guide which power network owners/operators and other parties can use to help determine network needs and thereby specify synchronous condenser design requirements.

Scope:

The application guide will cover the following topics:

- Overview of large scale renewable generation including existing installed capacities and future penetration levels.
- Technical capabilities of conventional turbo/hydro generators versus PE interfaced renewable generation.
- Challenges faced by the power system due to reduced synchronous machine commitment.
- Effectiveness of synchronous condenser solutions to deliver:
    - Inertia
    - System strength including transient capability to supply short circuit current
    - Other dynamic stability contributions.
- Case Studies on the use of synchronous condensers to improve system operation.
- Comparison of synchronous condenser solutions with alternate technologies.
- Physical design of new purpose built synchronous condensers and options available depending on power system requirements, e.g. added flywheel to increase inertia, optimised stator/excitation system design where limited steady state reactive power capability is required etc.
- Retrofit schemes whereby decommissioned/redundant thermal generators can be repurposed as synchronous condenser units.
- Modification of existing gas turbine generators to operate in both generator and synchronous condenser mode of operation.
- Benefits of synchronous condensers compared to other solutions.
- Impact of renewable energy on the electrical design of machines, such as sub-transient reactance.

Collaborative work with IEEE Electrical Machines Committee is also planned.

Deliverables:

☒ Technical Brochure and Executive Summary in Electra

☐ Electra Report

☒ Tutorial[6]

☐ Webinar[6]

Time Schedule: start: February 2019 **Final Report**: December 2021

- TOR approval – January 2019
- Form WG – April 2019
- Questionnaire Circulation – July 2019
- Discussion during SC Meeting - September 2019
- Draft outline (possible table of contents) of Guide – October 2019
- Preliminary sections distributed to SC-A1 members – November 2019
- Draft of guide – July 2020
- Comments by members and experts – August 2020
- Final version of document – April 2021
- Document publication (TB and summary for Electra) – December 2021

Approval by Technical Council Chairman:

Date: January 31st, 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.