CIGRE Study Committee C2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP[1]

JWG N° C2/C4.41	**Name of Convenor:** Mpeli Rampokanyo (South Africa) **E-mail address**: mrampokanyo@csir.co.za
Strategic Directions #[2]: 1, 2	**Technical Issues #[3]: 5, 10**
The WG applies to distribution networks[4]: Yes	
Potential Benefit of WG work #[6]: 2, 3, 4	
Title of the Group: Impact of high penetration of inverter-based generation on system inertia of networks	

Scope, deliverables and proposed time schedule of the Group:

Background:

The worldwide drive to reduce carbon emissions in the environment has led to the global community looking for alternative sources of energy that are less polluting and cheaper to harness than traditional primary energy sources that are currently widely used such as fossil fuel sources. This has led to the widespread introduction of renewable energy sources (RES) as alternative energy sources for the future. While the introduction of RES generation onto the electrical grid brings with it some major benefits, it is certainly not without challenges.

Not all RES are non-synchronous but a majority of them are and this is expected to have a significant impact on the way the power system is operated. One major challenge with the introduction of non-synchronous generation on the grid is the reduction of natural inertia that is provided by conventional synchronous machines on the grid. This natural inertial response from synchronous generating sources helps in damping frequency excursions during system disturbances such as generator trips or sudden loss of a large load. With depleting inertial energy, the rate of change of frequency (RoCoF) increases substantially, leading to a lower nadir, such that Primary Frequency Response (PFR) systems and even defence schemes such as Under Frequency Load Shedding Schemes (UFLS) may fail to protect the system during major frequency excursions. This has become a big challenge for system operators across the globe as penetration of inverter-based renewable sources is increasing tremendously and RES are seen as an imminent replacement of conventional generating sources. System operators have to be prepared for a more dynamic system, not only operating the system within tight security constraints, but also performing congestion management and facilitating a competitive electricity market.

Scope:

The objective of this WG is to advise and formulate philosophies for system operations in order to prepare the on-going energy transition. Primary Frequency Response studies will be carried out (or existing studies will be reviewed) in order to analyse and mitigate against the impact of the reduction of synchronous inertial energy on the power system as a result of integration of non-synchronous renewable generation using various networks around the globe as case studies. The integration of the existing knowledge between system operation and system performance, as well as the interaction with system planning, is crucial to achieve the proposed goals.

The JWG will address amongst others the following issues:

a) Review of previous (CIGRE) work relating to the current topic (e.g. TB 527 and TB 666) and the connection with on-going work (e.g. JWG C2/B4.38 and JWG C4/C6.35).

b) Survey existing practises used to determine primary frequency response requirements.

c) Define operational measures to manage the dispatch of inertia and reduce the risk when operating with low inertia on the system.

d) Quantify Primary Frequency Requirements (PFR) with increasing RES penetration
   1. Demand Response (DR) requirements
   2. Primary Reserves requirements
   3. Fast Frequency Response (FFR) techniques and requirements
   4. Trade-offs between inertia and FFR /DR techniques (checking if FFR can be a substitute for inertial response)

e) Methodology to establish rate of change of frequency (RoCoF) limits with increasing non-synchronous RES penetration levels, and the integration of the methodology into the operational environment.

f) Review existing Grid Code policy around PFR requirements in light of higher penetration levels of RES.

g) Investigate possible control strategies for inverter-based generation in order to provide wider future designs possibilities of inverters/converters and to achieve the most efficient way to use the technology. Also to work in connection with JWG C2/B4.38.

h) Survey possible/ existing mitigation techniques and increased system controllability
   1. Synthetic inertia (including technologies based on voltage source converters)
   2. Flywheels etc.
   3. FFR
   4. DR etc.

Deliverables:

☒ Technical Brochure and Executive summary in Electra

☒ Electra report

☒ Tutorial[5]

Time Schedule: start: July 2018 **Final Report**: Dec 2020

Approval by Technical Council Chairman:

Date: 06/07/2018

Notes: [1] or Joint Working Group (JWG), [2] See attached Table 2, [3]See attached Table 1, [4] Delete as appropriate, [5] Presentation of the work done by the WG, [6] See attached table 3

Table 1: Technical Issues of the TC project "Network of the Future" (cf. Electra 256 June 2011)

1	Active Distribution Networks resulting in bidirectional flows
2	The application of advanced metering and resulting massive need for exchange of information.
3	The growth in the application of HVDC and power electronics at all voltage levels and its impact on power quality, system control, and system security, and standardisation.
4	The need for the development and massive installation of energy storage systems, and the impact this can have on the power system development and operation.
5	New concepts for system operation and control to take account of active customer interactions and different generation types.
6	New concepts for protection to respond to the developing grid and different characteristics of generation.
7	New concepts in planning to take into account increasing environmental constraints, and new technology solutions for active and reactive power flow control.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics.
9	Increase of right of way capacity and use of overhead, underground and subsea infrastructure, and its consequence on the technical performance and reliability of the network.
10	An increasing need for keeping Stakeholders aware of the technical and commercial consequences and keeping them engaged during the development of the network of the future.

Table 2: Strategic directions of the TC (ref. Electra 249 April 2010)

1	The electrical power system of the future
2	Making the best use of the existing system
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 or economic benefit 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 direction
5	Guide or survey related to existing techniques. Or an update on past work or previous Technical Brochures
6	Work likely to have a safety or environmental benefit