CIGRE Study Committee C2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° C2.26	**Name of Convenor:** Babak Badrzadeh (AUSTRALIA) **E-mail address**: babak.badrzadeh@aemo.com.au	
Technical Issues #[2]: 1,3,5,6,8		**Strategic Directions #[3]: 1,2**
The WG applies to distribution networks[4]: Yes		
Potential Benefit of WG work #[5]: 2,4,5		
Title of the Group: Power system restoration accounting for a rapidly changing power system and generation mix		

Scope, deliverables and proposed time schedule of the WG:

Background:

System restart capability has been traditionally provided by synchronous generators. Given rapid changes in power systems worldwide, including increased installation of inverter connected generation and retirement of conventional synchronous generation, numerous challenges have emerged for system restoration. These include the availability of sufficient black start capable synchronous generators, utilisation of HVDC for restoration support, and the need for increased utilisation of inverter connected generation either as a black starter with the use of grid forming technology or to provide support as early as possible during system restoration. Changes are also impacting the network to which system restoration relies. It is therefore prudent to consider whether changes are required to network support devices, e.g. reactive power support plant, and to assess the veracity of network control and protection schemes during extreme operating conditions requiring a system restoration.

Increased uptake of inverter connected distributed energy resources such as rooftop photovoltaic (PV) is also impacting system restoration. This is because the distributed energy resources (DER) is progressively reducing the amount of stable load available for pick-up. It occurs that in several cases both loads and rooftop PV are co-located in the same distribution sub-stations. With significant penetration of rooftop PV, certain restoration pathways may not be possible anymore, and restart may eventually become impossible during daylight hours unless mitigation measures are implemented.

In addition to physical changes to the power system and generation mix, cyber security aspects are becoming increasingly important. It is therefore critical to understand and minimise the impact of cyberattacks on power system restoration, and to ensure that system restoration can succeed if the cause of a system black event is a cyberattack rather than a natural disaster.

This proposed working group aims to identify and manage emerging risks on system restoration, investigate opportunities for increased utilisation of new and emerging technologies during system restoration, and enable system operators and network owners to continue to execute a successful system restart when required despite rapidly changing generation mix.

The proposed scope of the working group is as follows:

1. **State of the art**
    - Restoration Strategies (top-down, bottom-up, hybrid)
    - Overview of worldwide restoration practices
    - Revision of previous CIGRE work (e.g. WG C2.23)
2. **Generation**:
    - Opportunities and limitations associated with different power system and generation mix, and impact on system restoration
        - 100% synchronous generators; do not use inverter connected generation at all
        - 100% synchronous generators, use inverter connected generation at later stages of restoration to provide reactive power and voltage support at no or low loads
        - Synchronous condensers + all grid following inverters
        - Synchronous condensers + some grid forming inverters + some grid following inverters
        - Some grid forming inverters + some grid following inverters
        - 100% grid forming inverters with no synchronous device

      These scenarios would be studied with HVDC as well (both the grid forming and grid following types).
    - International requirements to facilitate the use of new generation technologies during system restoration
2. **DER and loads**: Impact of distributed energy resources on system restoration
    - Best practices to segregate between clean loads required during restoration, and loads attached with DER.
    - Consider new types of controllable loads including various forms of energy storage systems such as batteries and pumped hydro storage to alleviate the above problem.
    - Requirements for disconnection and reconnection of DER during restoration to avoid adverse impacts on system restart.
    - System restoration via distribution (as well as the transmission) network, e.g. formation of microgrids.
    - Include DER impact assessment in the operators' training sessions
3. **Network**
    - Overview of possibilities to create situational awareness after a blackout and during the restoration process, accounting for possible new methods due to the changes in the power system and generation mix
    - Assess the impact of changing power system and generation mix on the need to change network support devices, e.g. for voltage control, or change to settings/types of protection systems.
    - Physical testing of system restoration involving non-black start generators, and transmission and distribution networks
    - Assess the impact of diminishing network minimum loads on the ability to restart the power system
    - Utilisation of HVDC links for restoration support (both VSC-HVDC and LCC-HVDC)
4. **Cyber-security**
    - System restoration during cyber attacks
    - Determining critical infrastructures in the network that could be subject to cyberattack and assessing the impact on system restoration
5. **Models and data**
    - Data required to determine the overall reliability of a restoration path
    - Tools and data required to derive a system restart standard, e.g. cost-benefit, probabilistic, and other types of analysis.
    - Model and data for procuring system restart services and developing restoration path

- Appropriate modelling and simulation tools for determining the capability of various black start sources, and developing system restart plans
- Model and data used in control rooms for decision making during system restoration
- Strategies for validating simulation models under extreme operating conditions

Time Schedule (physical meetings) :

- Proposed start coinciding with Aalborg Symposium, June 2019
- Second meeting, Canada, October 2019
- Third meeting, Between February and April 2020, Australia
- Fourth meeting, August 2020 coinciding with Paris General Session
- Final meeting, during first half of 2021 to review final draft of TB, China.

Final reporting : By December 2021 (2.5 years)

Deliverables:

☒ Technical Brochure and Executive Summary in Electra

☒ Electra Report

☒ Tutorial[6]

☒ Webinar[6]

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

Approval by Technical Council Chairman:

Date: March 18th, 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.