Rethinking power grid resilience: experiences and lessons from the COVID-19 pandemic

In November 2019, the first cases of a new disease, later named COVID-19 by the World Health Organisation, were reported by health care workers in Wuhan, China. In December 2019, researchers from Wuhan reported a cluster of pneumonia cases caused by a novel coronavirus. The COVID-19 pandemic has resulted since then in severe stresses on essential services and operations of critical infrastructures around the world. The battle against this virus pandemic has placed and is placing tremendous pressure on countries' healthcare system, the economy, activities in general society, and especially on the ability of utilities to perform their operations and duties entrusted to them. Electricity utilities have swiftly mobilised across the world to implement measures to support, protect and empower their employees with reliable and accurate information about COVID-19, while keeping the lights on for critical essential service providers. Various measures have been taken in order to limit exposure or spread of the virus to their employees or public.

Multi-dimensional impacts of COVID-19 on power systems

Utility COVID-19 response and recovery plans aim to secure the health and safety of the employees when they perform their duties:

1. *Safeguard employees in a manner that does not compromise the health and safety of either the public or the employees;*
2. *Provide guidance and support to all employees to ensure that they adhere to preventive practices and lockdown regulations; and*
3. *Ensure that utility is operational, and duties are performed in the most efficient manner during this lockdown period.*

As other critical sectors, electrical power systems have been greatly affected, threatening not only their operation and maintenance activities, but also their longer-term sustainability. Drastic measures to contain the spread of this virus pandemic, such as home-working and partial or total shutdown of commercial and industrial activities, have led to significant reductions in electricity demand, reaching even 20% in the most severely affected countries. Significant reductions are also seen in electricity prices, leading to cascading impacts at the revenue of generation companies. Severely affected customers can be in a very difficult position to pay their bills, further worsening the situation of electricity companies. As this is an unforeseen situation, the uncertainty in demand projections and daily electricity use challenge even the most reliable forecasting tools, creating various issues in both planning and operation strategies. The reduction in load has led to curtailment of renewable generation and several coal units being place in reserves. In certain countries, the reduction in baseload allowed an increase in the maintenance of generators.

Staff shortages and complexities in organizational decision-making and prioritization of tasks during such large-scale crises result in delays to both planned maintenance and emergency repair. Network operators and reliability coordinators are reacting to this by urgently bringing back to service planned outages for maintenance or postponing planned outages to boost the network and generation capacity of the system, while might as well be compromising its reliability and resilience. Furthermore, the disruptions in the supply chains have many interdependent effects, such as refuelling bulk generation plants, performing maintenance or commissioning of plant, which may negatively affect continuity of supply. In addition, the restriction measures imposed by countries due to COVID-19 would make the response to a major disturbance (e.g., driven by an extreme weather event) challenging and may significantly increase the risk exposure leading to a deterioration of the reliability and resilience of electricity supply. This COVID-19 pandemic strains the capability of the emergency response agencies, utilities and operators; resulting in an inability to contain the impact and respond in a co-ordinated manner.

Are infrastructure and operational resilience enough?

The CIGRE Working Group (WG) C4.47 "Power System Resilience" has formulated a definition of resilience that captures and reflects the behaviour and response of a power system exposed to severe stress and extreme events. The CIGRE WG C4.47 defined resilience as "*the ability to limit the extent, severity, and duration of system degradation following an extreme event.*" This definition is achieved through a set of key actionable measures to be taken before (*anticipation and preparation*), during (*absorption)* and after (*sustainment of critical system operations, rapid recovery and adaptation)* the event. These actionable measures could only be achieved by well-planned, executed interventions to preserve and enhance power system resilience at all phases of extreme events, such as the COVID-19 pandemic that is being experienced worldwide.

This definition, as the more generic understanding and interpretation of resilience in the wider power system community (at least in the pre-COVID-19 era), has been mainly related to *infrastructure resilience*, referring to the physical strength and robustness of the system to withstand the impacts of an event, and to *operational resilience*, referring to the operational strength of the system to ensure uninterrupted supply to customers and the rapid and flexible restoration. However, this pandemic has clearly demonstrated that business continuity is as important (many will argue even more important) as infrastructure and operational resilience. Having in place efficient pandemic planning ensures the secure and uninterrupted continuity of the key functionalities, helping the network operator to ride through the crisis and keep the lights on at a 24/7 basis.

This emphasizes the need to consider *organizational resilience* as a key dimension of power system resilience if we were to effectively respond to such large-scale crises as the COVID-19 pandemic outbreak. In terms of COVID-19 response efforts, organizational resilience is essential in having key staff available, and in swiftly mobilising measures to support, protect and empower this staff to sustain rapid response and recovery and limit exposure to the virus. Such provision is imperative to ensure the smooth, safe and secure execution of operations, maintenance and construction activities to ensure electricity provision.

Hence, the CIGRE WG C4.47 is proposing to expand the definition to include these important aspects and provide a more holistic approach of the definition of power system resilience, namely *organizational, infrastructure and operational*.

Expanding the definition and recognizing the importance of organizational resilience as a key element in surviving a crisis that does not directly and physically affect or stress the assets of the infrastructure but the underlying mechanisms and strategies keeping the infrastructure together, is a fundamental step towards achieving the three essential capabilities of a resilient system, namely *absorptive, adaptive and restorative capacities.*

Looking ahead to a more resilient future

It is important to keep in mind that a hazard does not develop to a disaster if the appropriate measures are in place and rapidly activated. However, this is only possible through effective multi-discipline management and strategic planning over the years to predict and effectively manage the impacts of disruptive incidents to the continuity of mission critical operations. This requires risk-averse or risk informed decision-making and proactive rather than reactive thinking to develop holistic resilience enhancement frameworks, which would proactively enhance the infrastructure, operational and organisational resilience to be able to withstand and rapidly recover form large-scale, disruptive incidents.

The coronavirus pandemic is testing the leadership in every sector around the world and its consequences could last for longer and present greater difficulties than anyone anticipates. These challenge calls for a conscious and resilient leadership through COVID-19 lessons learnt. However, the industry is rising to the challenge, co-ordinating effectively with government partners and taking aggressive steps to confront these threats to the reliability and resilience of the power system.

Safety measures have been instituted to safeguard utility employees, contractors, and the public at all times from infections. Electricity utility's contribution to the COVID-19 fight is to sustain electricity provision, especially to critical and essential sites, and to residents under the national lockdown period. When returning back to workplace, utilities must have COVID-19 risk assessments and plans in place and must conduct worker education on COVID-19 protection measures. These safety measures must be monitored to ensure that compliance and effectiveness with the safety protocols and identification of new infections among employees.

Although the wider electricity industry has reacted quickly and efficiently to this threat without any major problems so far, it is becoming increasingly imperative to develop a more in-depth understanding of the impacts of such events on the operation and planning of a power system, market mechanisms and business continuity. Such an understanding would help put in place those measures that would provide the flexibility and absorptive capacity to deal with similar events in the future. As these impacts are multi-dimensional and propagate across different interdependent infrastructures, collective response from organizations and stakeholders across multiple sectors (moving away from in silo planning and operation) is of paramount importance for building resilient and sustainable infrastructures and business continuity mechanisms.