Mladen Kezunovic

energy & distribution

what's next in these management systems

THE GOALS OF THIS ISSUE OF *IEEE Power & Energy Magazine* are to assess state-of-the-art developments in energy management systems (EMSs) and distribution managements system (DMSs) over the last few years, contrast such developments against the original design from approximately 50 years ago for EMSs and 40 years ago for DMSs, and discuss changes needed for the years to come.

The first article, coauthored by researchers from Texas A&M University, raises a question of how EMS and DMS design may evolve to address resiliency issues. Resiliency is a different consideration than the traditional reliability requirement since, the authors say, "While minimizing the likelihood of large-area, long-duration outages is important, a resilient system is one that acknowledges that such outages can occur, prepares to deal with them, minimizes their impact when they occur, is able to restore service quickly, and draws lessons from the experience to improve performance in the future."

The resiliency issue is discussed by M. Panteli and P. Mancarella, in their articles published in *IEEE Systems Journal* (vol. 11, no. 3, pp. 1733–1742, Sept. 2017) and the article by D.N. Trakas and N.D. Hatziargyriou in *Proceedings of the IEEE* (vol. 105, no. 7, pp. 1202–1213, July 2017). This notion is conveyed in Figure 1, which takes a view that resiliency is just a reformulation of the reliability requirements to meet the conditions of rare but extreme events, and in Figure 2, which adds the complexity of resiliency viewed as a set of measures that will assure a quick recovery of the electricity supply.

Typical examples of rare but potentially disastrous events mentioned by the authors are catastrophic weather conditions (hurricanes, tornados, and ice storms), as well as fires, earthquakes, and

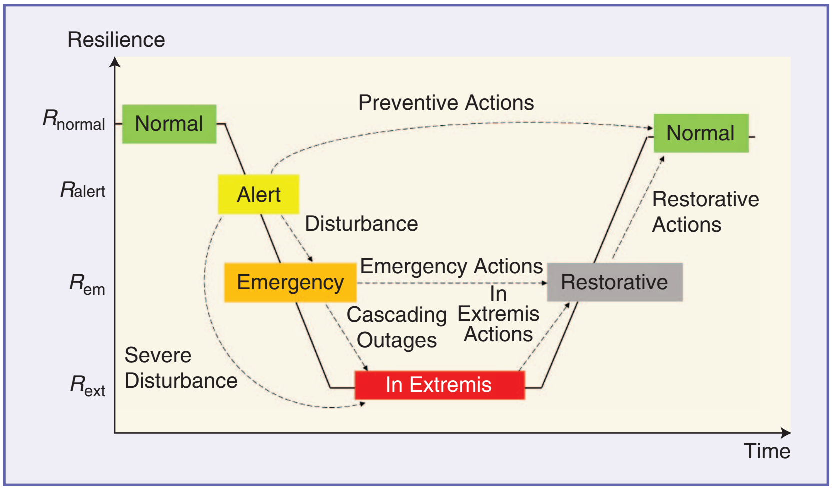

figure 1. Resiliency interpretation as an enhanced reliability for rare, but extreme, events.

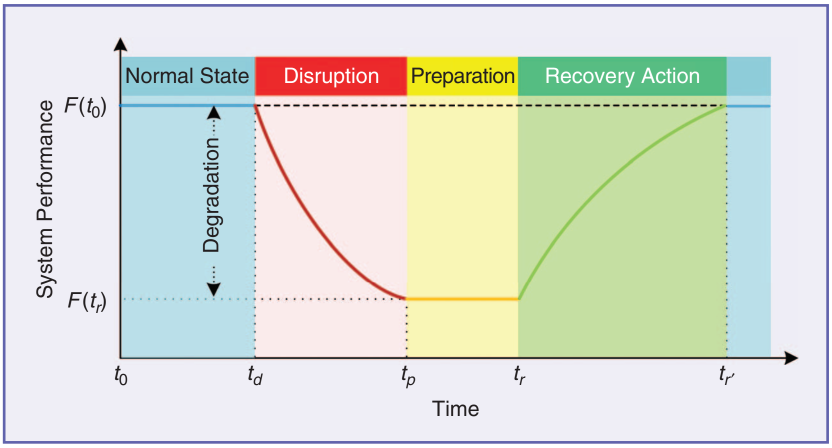

figure 2. Resiliency interpreted as a time line for a quick recovery.

Digital Object Identifier 10.1109/MPE.2017.2779550
Date of publication: 21 February 2018

geomagnetic interferences. The authors point out that resiliency considerations have to be incorporated into EMS design and also reflected in the market management system (MMS), and the two solutions need to be well coordinated to account for the resiliency arrangement between the physical electricity grid and its market conditions. The authors propose that risk-based metrics and predictive features should become part of EMS and DMS design in the future to allow utility staff to make informed decisions under unfolding threats in the planning and operations stages as well as outage and asset management realms. They also suggest that future EMS/DMS designs should allow a systemwide view over the entire interconnection, with closely coordinated actions among operations, protection, and asset management, which is not traditionally done today.

The second article is prepared by a group of authors from Tsinghua University and a former chief engineer at the State Grid in China, who were intimately involved in the development of Chinese EMS systems for over a decade. They point out that the new requirements to serve large-scale centralized systems consisting of many regional grids imposes critical considerations of built-in cybersecurity measures and standardization such as service-oriented architecture and the Common Information Model. They also suggest that modern EMS design should benefit from synchophasor technology for certain applications, and they are exploring how integration among supervisory control and data acquisition remote terminal units and phasor measurement units may complement each other. They have focused on the smart grid operation system recently pursued by both the State Grid and The Southern Grid, the two major state power companies in China.

The new architecture focuses on horizontal integration and vertical penetration meeting the need to integrate relevant functionalities across multiple departments (horizontal integration) and coordinate operation among hierarchically positioned control centers in the various provinces (vertical penetration). Their use of the virtual private network assures the required separation between various security zones and yet allows for fast communication across different control system layers. The goal is to use an open platform for future developments and expansion of the system design and allow for the integration of products from different vendors. The final message the authors convey is that further developments are needed: "Much more R&D work has to be done in the future, especially in dedicated control cloud, dedicated real-time Internet of Things, distributed real-time big data, global grid operation, etc."

The next article is from Japan, authored by staff members from Chubu Electric and a professor from Toyo University with extensive experience in the vendor environment. It addresses the important issues that came out of recent electricity sector reform in Japan: establishing the cross-regional coordination of transmission operators to enhance nationwide system operations in 2015, a full retail choice and full liberalization of wholesale power generation in 2016, and further securing the neutrality of the transmission and distribution sector through legal unbundling in 2020. Such reforms were also driven by the Fukushima Daiichi Nuclear Power Station disaster as well as the rapid deployment of photovoltaic (PV) distributed generation. In meeting such requirements, EMS and DMS designs were integrated, and further assimilation with a future independent market operator is envisioned.

It is well known that the Japanese industry is always looking at new technologies to solve complex problems, so IT solutions are the main focus of the article. The Chubu Electric special design in the planning area interfaces transmission system operators, Organization of Cross-Regional Coordination of Transmission Operators, and Japan Electric Power Exchange to optimize the nationwide network operation. Chubu Electric EMS and DMS designs are merged since the utilities still own both transmission and distribution segments of the grid.

Due to the penetration of renewables, particularly solar PV generation, their central dispatch center has an extensive PV output forecast system connected to the Japan Meteorological Agency for continuous monitoring of solar radiation and other weather conditions. A new control and protection system prevents cascading events as a part of the EMS/DMS design. They are also using Internet Protocol networks and anticipate integrating data across substations and feeders, including smart meters and specialized sensors. The authors discuss the importance of integrating dispersed databases for asset management, diverse IT systems, and geographic information systems, resulting in an IT system for transmission planning, operation and maintenance. The final goal is the integration of EMSs and DMSs with enterprise resource planning and enterprise asset management systems.

In the following article, a group of authors from RTE France presents a number of crucial developments in the EMS area: 1) the use of the large-scale grid as a smoothing mechanism (expansion in large systems), 2) dynamic load management, 3) the optimal use of the system by operating the grid closer to its limits and taking minimal preventive margins through the full use of all grid control variables (topology and management of transmission flows and voltage), 4) the implementation of power storage strategies, and 5) pooling different energy systems into one delivery ecosystem. In response to such challenges, the authors describe EMS functionalities that will be implemented in the RTE control center in 2018 as well as the smart substation design, which is already operational in one substation and will be rolled out in subsequent years to others.

In the EMS realm, emphasis is on the proactive and action-oriented tools to improve short-term planning (Day + 2) ahead. They are also focused on tools to address uncertainties. The smart substation design has some unique fast communication features with redundant communication protocols and low-power instrument transformers that facilitate digitalization in the substation switchyard for more reliable measurements during dynamic transient conditions. The authors' goal is to achieve a self-healing design that will also offer much higher sampling rates and entail an open platform design. Their focus is on improved monitoring techniques for asset assessment. They also consider acquiring more weather-related data from specialized sources. Consequently, they see computational resources as necessary enhancements to deploy new data analytics intensive functionalities.

The final article is from an advanced DMS (ADMS) vendor and coauthored by one of its customers, Duke Power Company. This article articulates some of the leading features used in DMSs today: monitoring and control, loss optimization, distribution system demand response, emergency control, and storm tracking. The authors focus on an elaborate solution for volt/var optimization integrated with the near-term load forecasting, load flow, and state estimation. They propose a very rich design of ADMS functionalities to meet custom demands in different DMS environments. The design framework integrates traditional grid monitoring, analysis, operation, and management with fault location, isolation and supply restoration, as well as the outage management systems. Their interest is also in meeting the mobility needs for web-based operation and incorporating measurements from thousands of specialized voltage sensors distributed along the feeders. The authors' emphasis on load peak reduction and associated advanced emergency control tools reflects their desire to provide more resilient service even under rather difficult environmental and operational conditions, such as the polar vortex experienced in Duke's service territory in 2014. The additional challenge is to manage over 1,000 MW of solar and other distributed energy resources and coordinate them to support grid operation during extreme peak load demands.

In summary, this issue of *IEEE Power & Energy Magazine* has achieved the goal of pointing to the future requirements and design options for the EMS and DMS solutions, with a clear message that more integration across EMS, DMS, and MMS designs is needed. Almost all the contributions introduce some advanced technologies and information and communications technology solutions that are heavily utilized to achieve the goal of resilient operation. While the authors have indicated that further studies are needed to accommodate fast-evolving changes in the grid, they have not speculated what these future systems should look like except for the examples provided and future directions recognized as "work to be done."

Based on the lessons learned from a few examples of the most advanced solutions, it becomes clear that there is a need to more precisely define how the resiliency requirement should be fulfilled in the future, along with all the other operational objectives that companies may pursue based on their internal service area needs and requirements. We hope this issue will stimulate further discussions in the IEEE and broaden the design paradigm and objectives for the next 50 years while keeping in mind that the electricity grid is undergoing perhaps its most dramatic and wide-scale change since it was invented over 130 years ago.

p&e