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Approaches to assess and ensure resilience of future net-zero power systems

Due to the evident climate change and environmental pressures the future power/energy systems will have to operate, sooner rather than later, in a net-zero environment, i.e., any carbon emissions created will have to be balanced (cancelled out) by taking the same amount of carbon out of the atmosphere, so that the amount of carbon emissions added to the atmosphere should not be more than the amount taken away. This will manifest in: by mix, at least during the transition period, of wide range of electricity generating technologies including conventional hydro, reducing but still present thermal, possibly increasing nuclear and even higher and accelerated connection of power electronic interfaced stochastic and intermittent renewable generation; blurred boundaries between transmission and distribution system; responsive and highly flexible, typically power electronics interfaced, demand and storage technologies with significant temporal and spatial uncertainty; proliferation of power electronics (HVDC, FACTS devices and new types of load devices); significantly higher reliance on the use of legacy and measurement data including global (Wide Area Monitoring) signals for system identification, characterization and control and Information and Communication Technology embedded within the power system network and its components; and ever increasing emphasis on considering the "whole system", not only comprising different energy vectors, but also ICT, traffic, water and social systems, to ensure energy supply security and efficiency. The key characteristics of such a complex system, if only a few are to be picked, would certainly be proliferation of power electronic devices in different shapes and forms and for different purposes, increased uncertainties in system operation and parameters and much larger reliance on the use of measurement and other data collected. This will increase controllability and observability of the system but may as a tradeoff result in different/unexpected dynamic behaviour of the system and possibly, under some circumstances, deterioration of some aspects of its performance. This presentation first briefly introduces some of the key characteristics of future net-zero power systems, then identifies the key challenges associated with ensuring resilience (the ability to withstand low-frequency high-impact incidents efficiently while ensuring the least possible interruption in the supply of electricity) of such systems and finally discusses examples of the latest research results in the areas of probabilistic stability studies of uncertain systems, data analytics, risk assessment and complex system analysis, which all are essential constituent parts of comprehensive assessment of power system resilience.

Jovica V. Milanović (Fellow, IEEE) received the Dipl.Ing. and M.Sc. degrees in electrical engineering from the University of Belgrade, Belgrade, Yugoslavia, the Ph.D. degree in electrical engineering from the University of Newcastle, Australia, and the Higher Doctorate (D.Sc.) degree in electrical engineering from The University of Manchester, U.K., where he is currently a Professor of Electrical Power Engineering and the Deputy Head of the Department of Electrical and Electronic Engineering.