THE GOAL OF 100% RENEWABLE ENERGY SOURCES TO FIT THE GREEN TRANSITION: CHALLENGES AND SOLUTIONS

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Abstract

It can be stated that the sustainable development of our planet is considerably related to a significant and constant reduction of environmental pollution in the next years. In this perspective, the technological transition of power production from traditional energy sources to 100% renewable energy sources, represents a valuable solution to the global climate change challenge, decreasing Greenhouse Gas (GHG) emissions. Indeed, this is one of the most relevant actual topics of all governments policy and it has considerable attention in the scientific community.

As well known, electrical power systems are changing from centralized generation systems to distributed generation systems due to the increase of renewable energy sources. In the next future, the main grid will be composed by interconnected microgrids that can be managed and controlled independently. In particular, in a power system with conventional power plants, where synchronous machines are adopted, and distributed generation plants, where static conversion systems are used, the system stability is entrusted only on the conventional power generation systems thanks to their rotating inertia and damping. Indeed, static power converters cannot provide inertia and damping to power systems, so they are vulnerable to power dynamics and system faults. Thus, power system stability is degraded as the penetration of renewable energy sources increases and this issue is amplified in a possible future power system with only renewable sources.

The "Smart Inverters" concept represents a promising solution to overcome the operative limits of traditional renewable energy sources. A Smart Inverter is an inverter with the capability to make a proactive and autonomous decision based on local measurements and external data. This new concept allows obtaining an energy source able to perform different functions, in real-time operations, like grid-supporting mode to provide ancillary services or grid-forming mode in the case of islanded microgrid following a fault. Also, innovative energy storage systems and hybrid solutions play an important role in order to ensure a power reserve to increase grid stability.

In this context, the aim of this tutorial is to provide the audience with the actual scenario and the future perspective on the innovative solutions and control strategies in the inverter-based renewable energy sources. Moreover, a detailed overview of the energy storage systems and innovative hybrid solutions will be discussed.

More in detail, the tutorial is structured as follows:

The first part will be focused on the actual technological transition to an electrical system with 100% renewable energy sources in terms of innovations and operative limits of the traditional systems. These innovative paradigms will also address the social impact and government policies.

The second part of the tutorial will examine the new scenarios of the future power system in terms of the interconnected microgrids with particular attention to the stability of the low-inertia systems.

Finally, the tutorial will give particular attention to the Smart Inverters and their features and challenges in terms of functions, performance improvement, and operation mode. An extensive analysis regarding the control strategies based on the Virtual Synchronous Machine concept and multilevel technologies will be provided. Moreover, a part of this tutorial will be focused on storage systems, innovative hybrid solutions, and management strategies.