SAND2015-2355R

LDRD Highlight: Enabling Secure, Scalable Microgrids with High Penetration Renewables– LDRD-originating technologies are being developed to address challenges inherent to highly stochastic energy sources and loads, to conceivably satisfy the electrical energy needs of national/international power systems. ***Background:*** The Enabling Secure, Scalable Microgrids with High Penetration Renewables Grand Challenge LDRD (FY11-FY13) aimed to develop a novel intelligent grid architecture, Secure Scalable Microgrid (SSM), based on closed loop controls and an agent-based architecture supporting intelligent power flow control. The approach was to enable self-healing, self-adapting, self-organizing architectures and allow a trade-off between storage in the grid versus information flow to control generation sources, power distribution, and where necessary, loads. ***LDRD Impact:*** The SSM GC LDRD resulted in a SSM research capability engaged in developing technologies to solve many complex challenges in satisfying electrical energy needs. Initial focus has been on enabling resilient and reliable performance when incorporating high penetration levels of stochastic renewable energy sources in power systems. Theories and concepts from multiple fields were integrated to advance solutions, including Hamiltonian Surface Shaping and Power Flow Control (HSSPFC)™ based nonlinear distributed control theory, informatics/agent based algorithms, communication theory, and power electronic system theory. With the advancement of Microgrid power systems that include high levels of renewable energy penetration comes the need to determine energy storage requirements. Because of the stochastic nature of the sources, energy storage is an important design component in Microgrids with high penetration renewables to maintain the system stability. Storage devices can be distributed close to the source and/or at the Microgrid bus (centralized). Selected solutions to these challenges have recently been published in the online journal Electrical Power and Energy Systems, "*Energy storage requirements of dc microgrids with high penetration renewables under droop control*", W. Weaver, et.al. This paper highlights a novel design and analysis approach of energy storage devices in a DC Microgrid system with high penetration renewable energy sources that have high variability. The focus of the study is the effects and trade-offs in placing energy storage close to the sources, or at a centralized bus storage device. In addition, due to the novel nature of the energy storage Unified Power Flow Control (UPFC) architectures, a patent was recently awarded. A simple wind integration with the electric power grid demonstrates this capability and performance (Wilson and Robinett, IEEE MSC 2011). Figure (a) shows a One Machine Infinite Bus (OMIB) model with a UPFC and wind turbine generator. The power and energy storage requirements are given in Figures (b) and (c), where the wind variability is compensated with the UPFC device to provide a constant power output.