Photovoltaics in Modern Power Systems

Worldwide consumption of electricity is expected to nearly double over the next two-and-a-half decades. International Energy Agency (IEA) predicts that meeting this demand for power will require over 5,000 GW of new electricity generating capacity (including replacement capacity) at a cost of over $5 trillion. The new plants will require an additional $6 trillion worth of additional infrastructure, making electric power an $11 trillion market over the next 25 years. The search for new generation technologies is accelerating.

In 2013, photovoltaic generation accounted for 0.28 percent of the renewable generation mix in USA. It has recently been growing at an annual rate of over 220 percent. The proliferation of PV systems offers opportunities (such as a reduction in peak load and loss) but also potential for use in Volt/Var management and control. It also creates need for additional generation that covers uncertainty involved in PV output. In fact, they may in some cases increase fossil fuel consumption (compared to not using renewables with rapid output changes) because of their intermittency. In addition, viewed in hourly resolution (averaged every hour), the PV system has a stable output. Rapid variations in short-term PV generation, typically in minute-averaging resolution, result from transient weather changes. Therefore, this study models the short-term intermittency and investigates the impact that it may have on operation of thermal resources intended to complement the renewables.

Numerous North American utilities are integrating growing numbers of investor-owned photovoltaic distributed generation (PV-DG) plants into their distribution systems to comply with state-mandated Renewable Portfolio Standards (RPS). Given the fact that distribution systems have been designed to be operated in a radial fashion, interconnection of PV-DG may lead to significant impacts on planning and operations that need to be studied to identify mitigation measures and ensure seamless integration. We look at the impacts of PV-DG on power distribution systems planning and operations, including those of steady state and dynamic nature, with emphasis on utility-scale PV-DG. We also discuss mitigation measures to address these impacts and present a few illustrative results of analyses conducted on real distribution feeders and other ramifications of their increased use in distribution networks, especially urban ones.