Solar Energy and a Zero-Carbon Future for the US Southwest and Beyond

Stephen M. Goodnick
Deputy Director, QESST Engineering Research Center
School of Electrical Computer and Energy Engineering

Renewable energy from wind and solar energy provides a low-cost, environmentally benign source of energy powering the energy grid. A major driving factor for renewables is decarbonizing the energy system in the face of anthropogenic climate change. The fastest growing form of renewable energy is photovoltaic (PV) solar energy conversion, in which sunlight is converted directly into electricity. The enormous growth of installed PV worldwide has now exceeded 600 GW due to rapid decrease in the price of PV modules (well below $0.5/ watt), resulting in the lowest levelized cost of electricity (LCOE) of any energy technology including natural gas, which detractors a decade ago claimed was impossible. Criticism has shifted in the face of the remarkable cost reductions in PV to the difficulties in grid integration associated with the instability of renewables due to random intermittencies and diurnal (night/ day) cycles of energy production. Predictions again were made that renewables could not contribute more than 15% of the total generation without causing a collapse of the grid. Grid penetration has now exceeded 50% in many places such as the US Southwest during particular times of the year, without disrupting the grid, due to the rapid advances in smart grid and semiconductor-based power electronics technology in managing electrical transmission and distribution on short time scales. However, the mismatch in the southwest of the peak demand in early evening and peak power from solar at mid-day remains problematic in terms of high ramp rates and energy markets, especially in summer, leading to increased focus on storage, either shorter term in terms of batteries or longer term with solar generated fuels. In Arizona, recent utility bids for dispatchable electricity generation have been met by solar plus short-term battery storage, at lower cost than natural gas for the first time. The three largest utilities in Arizona have all provided plans demonstrating the ability to reach 50% reduction in carbon emissions by 2030 based on existing hydroelectric, nuclear and solar/wind power, the closing of coal-based plants, and replacing capacity with the addition of solar and wind generation. Increasing electrification of the transportation system (e.g. EVs) can also be met with increased renewables with storage. The same utilities have committed to the goal of zero net carbon by 2050, although the technological solutions for reaching this goal are as yet undetermined. The present talk with overview the on-going energy transition in Arizona and the Southwest, discussing advances in renewable generation and storage and scenarios for realizing a zero-carbon future.