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Is Pumped-Hydroelectric Storage (PHS) the solution for growing renewable generation in New England?

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New England (United States) exhibits an increasing rate of both roof-top and major solar photovoltaic systems. More recently, projects for new solar and wind farms, including offshore, are also surging given the ambitious renewable energy goals established by the New England States (e.g. 50%/40% renewable penetration by 2030 in MA/CT). These renewable energy penetration plans will increase the dependence of electricity supply and demand on weather. This is critical because electricity grid operators usually do not know the exact location and installed capacity of privately owned renewable systems. For instance, the New England ISO only 'sees' less than 5% of the currently installed photovoltaic capacity. Given the existing electricity grid, such an increase in behind-the-meter (BTM) production can lead to unanticipated and undesirable outcomes such as the increase in the residual load variability and power ramps, which complicate significantly planning and operation of the electricity grid and associated backup systems. Mitigation of such challenges calls for an increase in flexible electricity storage. Today, Pumped Hydroelectric energy Storage (PHS) is by far the most established technology for electricity storage at a large-scale. PHS power plants are currently mainly used for price arbitrage (e.g., store potential energy during low prices at night and generate power during high price periods during the day).

In this work we explore the potential of combined wind and solar energy sources across New England, with particular focus on their variability at temporal and spatial scales that are relevant for planning and operation of pumped-hydropower storage units. Specifically, we investigate the effect of growing BTM solar photovoltaic systems on the load. For doing so, we input high-resolution remotely-sensed and atmospheric and hydrologic reanalysis data to state-of-the-art models for simulate BTM solar photovoltaic at ungauged locations, streamflow and the load. Through this modeling framework we investigate the modification of the PHS plant operation when used for mitigating the impact of BTM generation on the load relative to the standard use for price arbitrage. The analysis reveals the potential for PHS to increase the penetration of renewables to reach the ambitious regional goals.