Enabling the Operation of Future Grids Using New Tools in Control Theory and AI

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The shift towards a more sustainable energy future has led to a number of critical challenges in how to reliably and efficiently operate the electric power grid. In power grids, supply and demand must be balanced at all times; however, renewable energy resources such as wind and solar produce power when the wind blows and the sun shines, not necessarily when we need it, and there is very little storage. Further, some have proposed pathways to sustainable energy systems through electrification of resources that directly consume fossil fuels like cars, heating systems, and some industrial processes along with decarbonization of the electricity grid. However, electrification greatly increases the load on the grid, which in many parts of the country and world is already operating at its limit.

New tools in control theory, optimization theory, and artificial intelligence/machine learning are helping us better operate electric power grids undergoing these significant transformations. To accommodate more wind and solar, researchers are developing approaches to exploit the flexibility of distributed energy resources (DERs) including small scale storage (batteries) and electric loads with flexible consumption patterns (electric vehicles, air conditioners, water heaters). Key challenges are to develop algorithms that are scalable enabling coordination of large numbers of DERs, low-cost to implement, low/no impact on electricity consumers, and reliable. Other research is focusing on ways to better utilize existing infrastructure/resources, which would allow the grid to safely operate even closer to its limits. Key challenges include dealing with uncertainty, nonconvexity, and insufficient sensing that limits situational awareness. This talk will describe a number of these challenges and the creative approaches being developed to address these challenges.