Synthetic Cloud-Based Regulation Reserve Distribution Management (SECURED)

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The past decade has seen advancements in renewable energy technology, making even smaller solar and wind installations at residential level an economically viable option. Hence, large amounts of distributed energy sources (DERs) with high penetration of renewables will form a key component of an urban energy grid. This not only reduces the inertia of the system but also injects large unpredictable disturbances into the grid. Furthermore, the end user devices are getting smarter, resulting in added uncertainty in demand. The intermittent generation from renewables and changing consumption patterns are required to be compensated through dispatchable conventional generation sources in order to prevent frequency excursions caused due to generation demand mismatch. However, it is envisioned that large amounts of DERs and adjustable loads causing high frequency disturbances can also be used to the advantage at system level. These collectively provide reserves and balancing services to the grid for frequency regulation, specifically in the presence of high renewable energy integration. Today's demand response programs fail owing to complexity involved in large scale coordinated control of a vast number of DERs at finer time resolution. Proper market strategies enabling participation of end-users in decision making is what is needed to make provision of robust synthetic reserves a commercially feasible option.

This poster addresses these issues by proposing a scalable cloud based synthetic regulation reserve management systems. The core control strategies are based on the extension of Dynamic Monitoring and Decision systems (DyMONDS) framework. This framework lets the end-user devices do most of distributed decision making locally, eliminating the need for centralized coordination. Cloud-based platform is used to collect all the bids of individual entities belonging to a geographical area, aggregate them and send to the system operator for consideration of interests of small end-user devices. This tremendously reduces the computational burden and communication complexity. The proof-of concept simulations are conducted on a distributed agent-based simulation platform called Smart Grid in a Room Simulator (SGRS), developed by our research group. A representative microgrid test system with real data is used for the analysis, where existing flexible loads are replaced by a fleet of electric vehicles to show proof of concept simulations of bids produced by end-users. It should be noted that these end-user modules can be generalized to other loads such as water heaters, batteries and HVAC systems as well. The problem is set up in more realistic scenario by modeling uncertainty in energy forecast, load profile and renewable energy generation. Hence, each entity is formulated as a Markov Decision Program (MDP) to account for the uncertainty. The problem formulation in system operator module is such that both energy and reserve markets are cleared simultaneously through co-optimization. The poster shows the detailed models of each module participating in the simulation. Finally, simulation results are shown for the test system under consideration.