Virtual Energy Storage Sharing and Capacity Allocation
Dongwei Zhao¹, Hao Wang², Jianwei Huang¹, Xiaojun Lin³
¹IE, CUHK, ²Civil and Environmental Engineering, Stanford University, ³ECE, Purdue University

Energy storage can play an important role in energy management of end users. To promote an efficient utilization of energy storage, we develop a novel business model to enable virtual storage sharing among a group of users. Specifically, a storage aggregator invests and operates the central physical storage unit, by virtualizing it into separable virtual capacities and selling to users. Each user purchases the virtual capacity, and utilize it to reduce the energy cost. We formulate the interaction between the aggregator and users as a two-stage optimization problem. In Stage 1, over the investment horizon, the aggregator determines the investment and pricing decisions. In Stage 2, in each operational horizon, each user decides the virtual capacity to purchase together with the operation of the virtual storage. We characterize a stepwise form of the optimal solution of Stage-2 Problem and a piecewise linear structure of the optimal profit of Stage-1 Problem, both with respect to the virtual capacity price. Based on the solution structure, we design an algorithm to attain the optimal solution of the two-stage problem. In our simulation results, the proposed storage virtualization model can reduce the physical energy storage investment of the aggregator by 54.3% and reduce the users’ total costs by 34.7%, compared to the case where users acquire their own physical storage.