Demand response (DR) refers to the increased flexibility in usage of electricity due to the intentional adjustment of end users’ consumption. It is an inexpensive source of capacity, and has become important in ensuring the grid remains balanced – i.e. that electricity supply matches demand at all times.

This work introduces a number of novel solutions for problems related to DR. Firstly, we consider residential programs, specifically in regards to appropriately scheduling deferrable loads resulting in an aggregate load profile more desirable to the system operator. This in turn could lead to reduced peak consumption of power, less ramping of generators and lower emissions of greenhouse gases. We have developed an algorithm which automatically schedules deferrable loads. The scheduling is carried out by a greedy algorithm which attempts to reduce the error between the scheduled load profile and a predefined ‘target’ load profile. The algorithms rely on appropriate approximation methods and have been evaluated on a dataset collected from a large number of households.

Secondly, we focus on the issue of designing fair compensation mechanisms for DR programs. We model the problem in a game theoretic setting and design a payment distribution mechanism based on the Shapley Value. As exact computation of the Shapley Value is in general intractable, we propose estimating it using a reinforcement learning algorithm that approximates optimal stratified sampling. We have applied this algorithm to a DR program that utilizes the Shapley Value for payments and quantify the accuracy of the resulting estimates.

Finally, as participation in a DR event is often voluntary, we propose a method for modeling user behavior in DR programs. Using a dataset from a number of participants in such a program, we have shown that a small number of features can be used to model whether or not a participant will respond as requested to a DR event.

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