Optimizing Participation of Buildings and Aggregations in Incentive-Based Demand Response Programs

Utkarsha Agwan, Costas J. Spanos, and Kameshwar Poolla

Electrical Engineering and Computer Sciences, UC Berkeley

Smart buildings can bid in their electric load flexibility to provide demand response services on the power grid.

Demand Response Contract Sizes

Sources of load flexibility:
- HVAC
- Lighting
- Plug loads

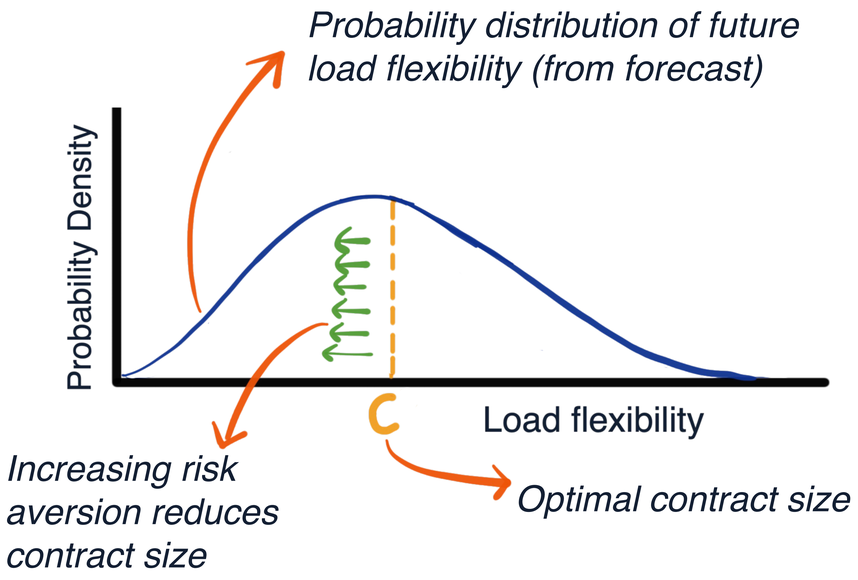
Uncertain!

Depend on
- Outdoor temperature
- Occupancy
- Usage patterns

Use a ***probabilistic forecast*** of future load flexibility. In the demand response program:
- Building promises to *reduce energy consumption* by a contracted value **C**, receives an **incentive** paid ahead of time
- Building must pay a **penalty** if load reduction is less than **C**

Building must balance **expected revenue** from program and **penalty risk**

*The **optimal contract** is a quantile of the probabilistic forecast of load flexibility*



Forming Aggregations

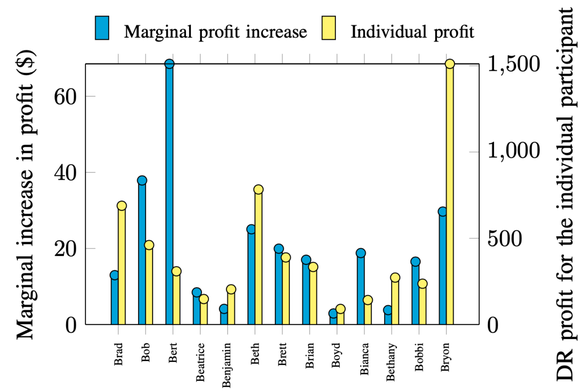
One building is ***too small*** a resource to participate directly in DR markets.

Solution: ***aggregate multiple buildings to submit bids as a single resource***
Aggregate capability is the sum of load flexibilities of all participants

What makes a good aggregation?

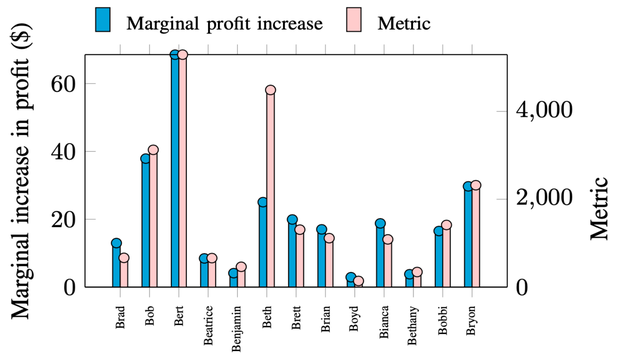
Participants' revenue ↑, penalty risk ↓

Each building's profit is not a good indicator of whether it will increase the aggregation's revenue



Complementarity metric: measures the **lack** of correlation between different buildings' load flexibilities. Uncorrelated buildings help spread the penalty risk!

$$\Delta\sigma = \sum_{k \in \mathcal{N}} \sigma_k - \sigma_{ag}$$



Complementarity metric is a good indicator of marginal profit increase for the aggregation

Forecasting Load Flexibility

Forecasting future load flexibility is tough:
- Infrequent DR events, few data points
- DR events occur during grid peaks when building consumption differs from the usual consumption
- Causal factors (occupancy, usage patterns) may not be measured

Confounding factors:
- Load reduction is measured w.r.t. a *baseline,* which can be a source of error
- Buildings are not properly incentivized to curtail, so many don't reduce their consumption during a DR event, i.e., *fail to perform*

Approach:
- Identify **true performance**, i.e., true load reduction
- Find *similar* times, i.e., times when consumption is similar. Use to extrapolate load flexibility
- Learn performance characteristics for a *cluster of buildings*, rather than individually

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