The ISO Problem

Research Objective

Research Challenges
1. How to price the power so as to regulate demand as well as allocating the generation from multiple fossil fuel and renewable sources?
2. Generators, storages and loads are all dynamical systems with constraints, e.g. ramping rate constraints for generators, capacity and rate constraints for storages, comfort range constraints for thermal inertial loads like air conditioners.
3. Renewable generation is stochastic. So is the future demand.
4. Generators (for business reasons) and loads (for privacy reasons) do not want to disclose their own utility functions, dynamics, and states.

Key Question: How should the ISO price power, so as to maximize the social welfare of generators, loads, and storages?

Proposed Architecture: Iterative Bidding Scheme

Formulation

\[
\text{minimize } E \left[ \sum_{t=0}^{T} \left( u_i(t), u_l(t) \right) \right] \quad \text{subject to} \quad (1) \sum_{t=0}^{T} u_i(t) = 0, \quad \forall t = 0, 1, 2, \ldots, T \quad (2) \quad x_i(t+1) = f_i(x_i(t), u_i(t)), \quad u_i(t) \quad \text{(Assumption: the cost function is convex in the vector } \{u_i(t)\}_{t=0}^{T} \text{, for each realization of noise sequence.)}
\]

Results: Algorithm for Iterative Bidding Scheme

for bidding times \( s = 0 \) to \( T \), do

\( k = 0 \)
repeat

each agent solves argmin \( E \left[ \sum_{t=0}^{T} \left( x_i(t), u_i(t) \right) + \lambda_k u_i(t) \right] \) subject to (1), (2) \( \lambda_k \) converges as \( k \rightarrow k + 1 \)
end repeat

ISO then declares new price sequence via subgradient iteration

and submits the bidding sequence \( \{u_i(t)\}_{t=0}^{T} \) to the ISO.

The LSE Problem

Research Objective
A theory for operation of the Load Serving Entity (LSE) to enable demand response by controlling the aggregate power consumption for a population of thermostatically controlled loads (TCLs) such as residential air conditioners.

Research Challenges
1. How to design the reference total power trajectory as a function of the forecasted price of energy?
2. The room temperature, setpoint, and ON/OFF binary state of any individual TCL cannot be measured for privacy reasons.
3. The LSE may have different contractual obligations for different TCLs in terms of their comfort ranges.

Key Question: What is the optimal plan for the LSE to schedule the purchase of power? Also, how to control the TCLs in real-time to track the reference total power, while respecting privacy and comfort range constraints?

Idea: Adjust setpoints to meet the optimized target consumption.

Proposed Architecture: A Two Layer Approach

Formulation

First layer: optimal planning of target consumption

\[
\text{minimize } \left\{ \sum_{i=1}^{N} \left( u_i(t) + u_2(t) + \ldots + u_N(t) \right) \right\} \quad \text{subject to} \quad (1) \quad u_i(t) = \theta_i(t) - \hat{b}_i(t) - b P u_i(t) \quad \forall t = 1, \ldots, N, \quad (2) \quad \int_0^T \left( u_1(t) + u_2(t) + \ldots + u_N(t) \right) dt + \tau = E_T \quad (given) \quad \forall t = 1, \ldots, N, \quad (3) \quad L_{\min} \leq \theta_i(t) \leq L_{\max} \quad \forall i = 1, \ldots, N
\]

ISO then declares new price sequence via subgradient iteration

Results

References


References