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A Lyapunov-based real time energy management system for smart IoT homes

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Abstract

Smart homes are an integral component in developing smart cities. This paper studies the problem of real-time energy management of controllable loads for Internet of Things (IoT) connected homes with renewable energy generators and energy storage devices. By exploiting the delay tolerance of elastic loads, we develop a joint real-time energy storage control and load management system, aiming to minimize the long term time-averaged energy consumption cost without reducing energy consumption. This residential energy management problem is formulated as a constrained stochastic programming problem. A Lyapunov-based control algorithm is designed to decompose the long-term optimization problem into per-slot sub-problems and provide an asymptotically online optimal solution that is able to quickly adapt to the system dynamics without requiring any statistics of time-varying load demand and stochastic renewable generation. The proposed online control algorithm jointly optimizes energy consumption, load scheduling, and energy charging/discharging actions while satisfying the time-varying energy consumption preference of the user in each time slot. It is demonstrated through numerical simulations that the low-complexity online control algorithm ensures the load demand of the user served with a lower delay at a relatively low cost.