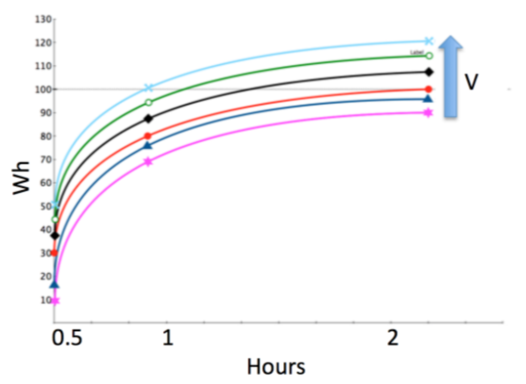
Energy Storage Based Adaptive Demand Response in Smart Commercial Buildings

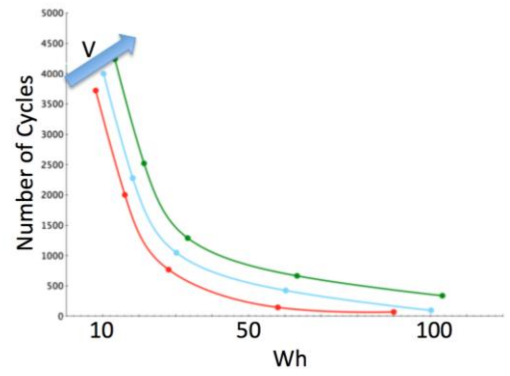
Motivation

- ❑ High peak demand and more **intermittent renewable energy** requires energy storage to ensure reliability, stability and resilience of the power grid.
- ❑ Novel **ultra low-cost, compact, and scalable Zn-MnO2 batteries** as distributed solution in concert with building automation systems.
- ❑ Lower net ownership cost and grid stress via **adaptive demand response** algorithm that supports **different tariff structures**.
- ❑ Battery size and control **optimized for cost and occupant comfort**.

Key Battery Features

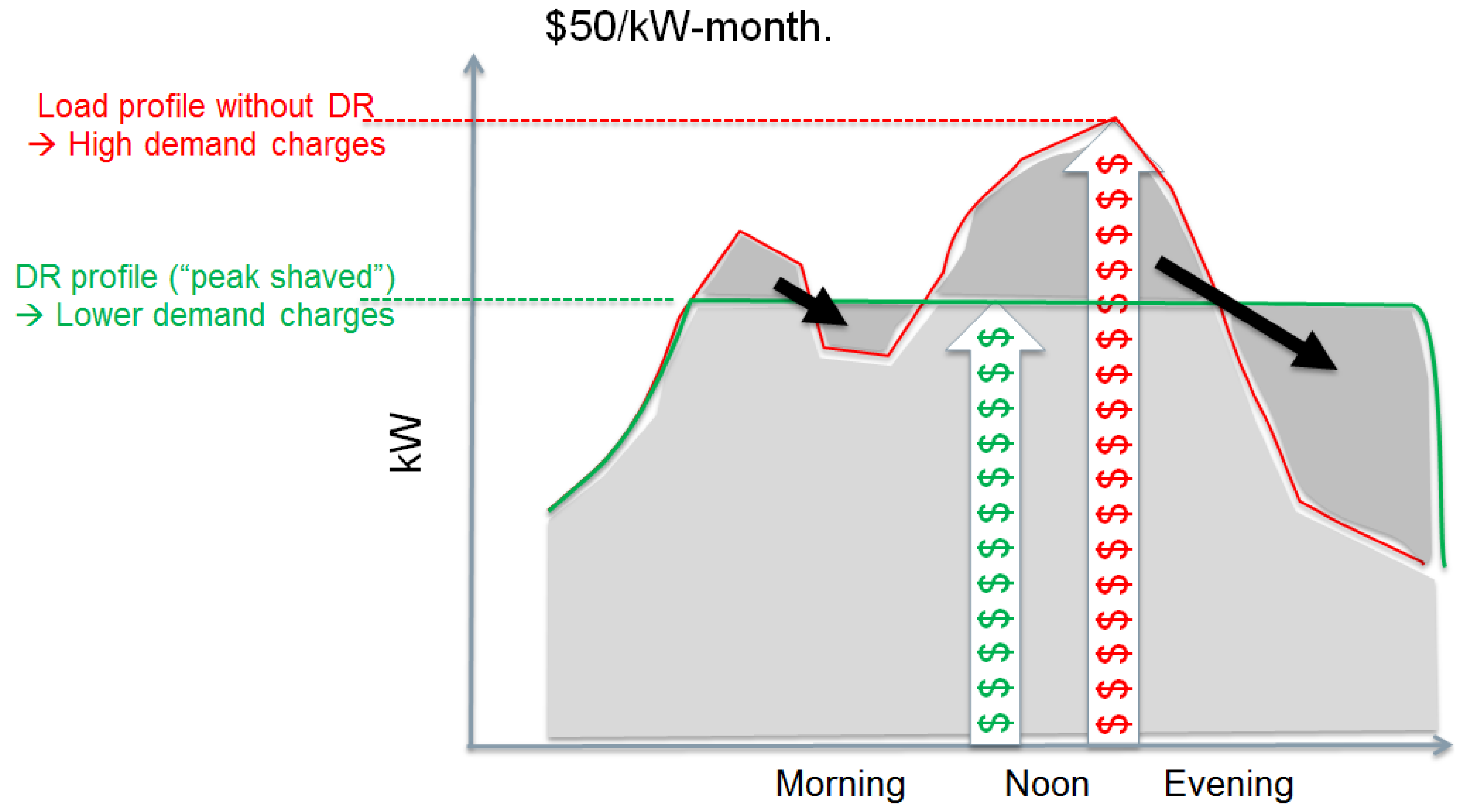
- ❑ **Half** the price of Li-ion ($80/kWh).
- ❑ **Twice** the cycle number (3,000 cycles)
- ❑ Completely safe and stable.
- ❑ Same components as used in Duracell.



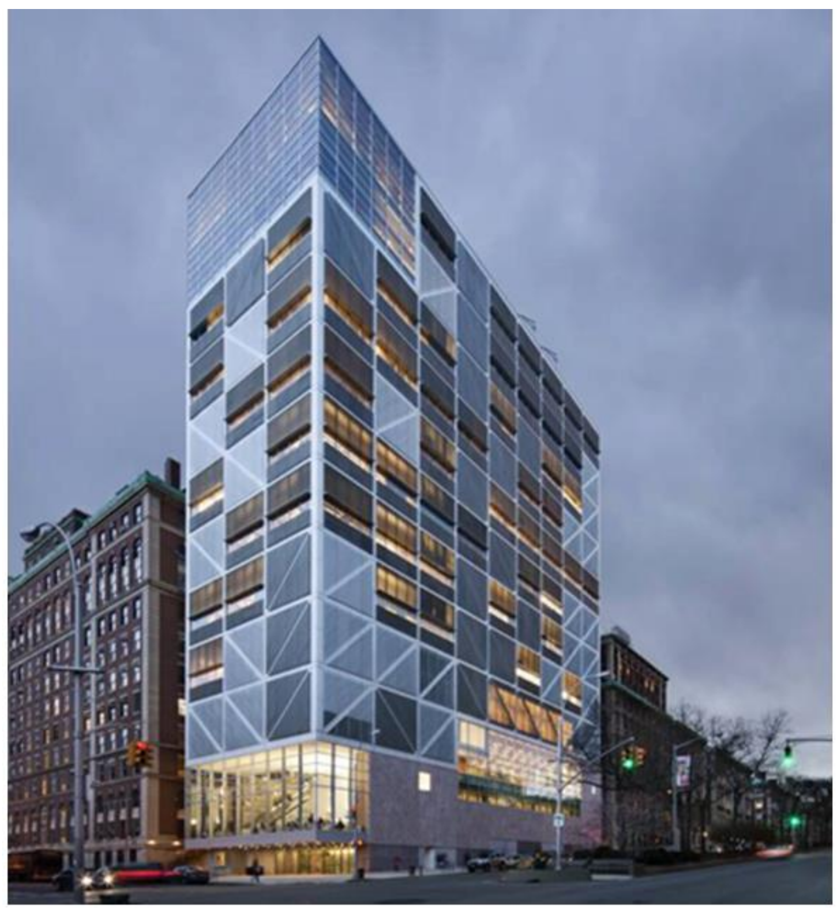


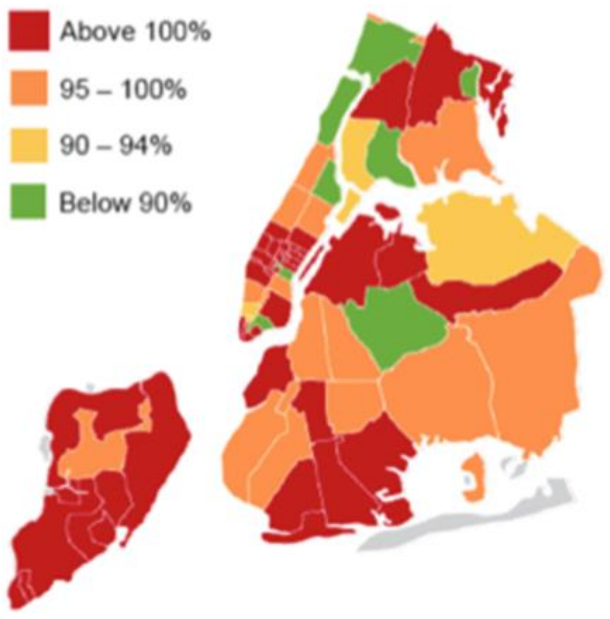
Building Owners Face High Demand Charges

Electricity tariff for peak demand is as high as $50/kW-month.



Testing Site





Optimal Control and Design Optimization

Innerloop Optimal Controller: when and how to charge and discharge the batteries.

Objective Function

$$J_1[n] = \min f_1(X[n];\ \theta)$$

Subject to

$$g_1(X[n];\ \theta) = 0$$
$$g_2(X[n];\ \theta) \le 0$$

$f1$ is aggregated objective function based on performance and energy costs.
g_1 is for schedule, set points and air quality requirements.
g_2 is for comfort, tariff.
X is the control variables.
Θ is configuration parameter, including battery size and inverter types.

Outerloop Design Optimizer: what is the most economical system setup, including battery size and inverter type, etc.

Objective Function

$$J_2 = \min f_1(\theta)$$

Subject to

$$J_1[n] = \min f_1(X[n];\ \theta)$$
$$g_1(X[n];\ \theta) = 0$$
$$g_2(X[n];\ \theta) \le 0$$

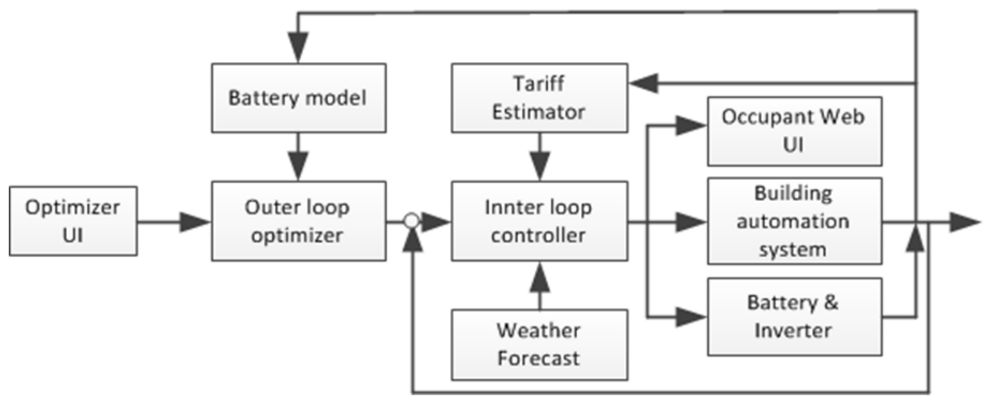
$f2$ is building and battery life cycle costs.

Tariff Model

$$C_1 = W_1 \int_{T1}^{T2} p(t)dt + W_2 \max(p(t))$$

Battery Model

$$SOC = \int_{T1}^{T2} kI(t)dt$$
$$SOH = f_3(I(t), R(t))$$



System Architecture and Simulation Engine