

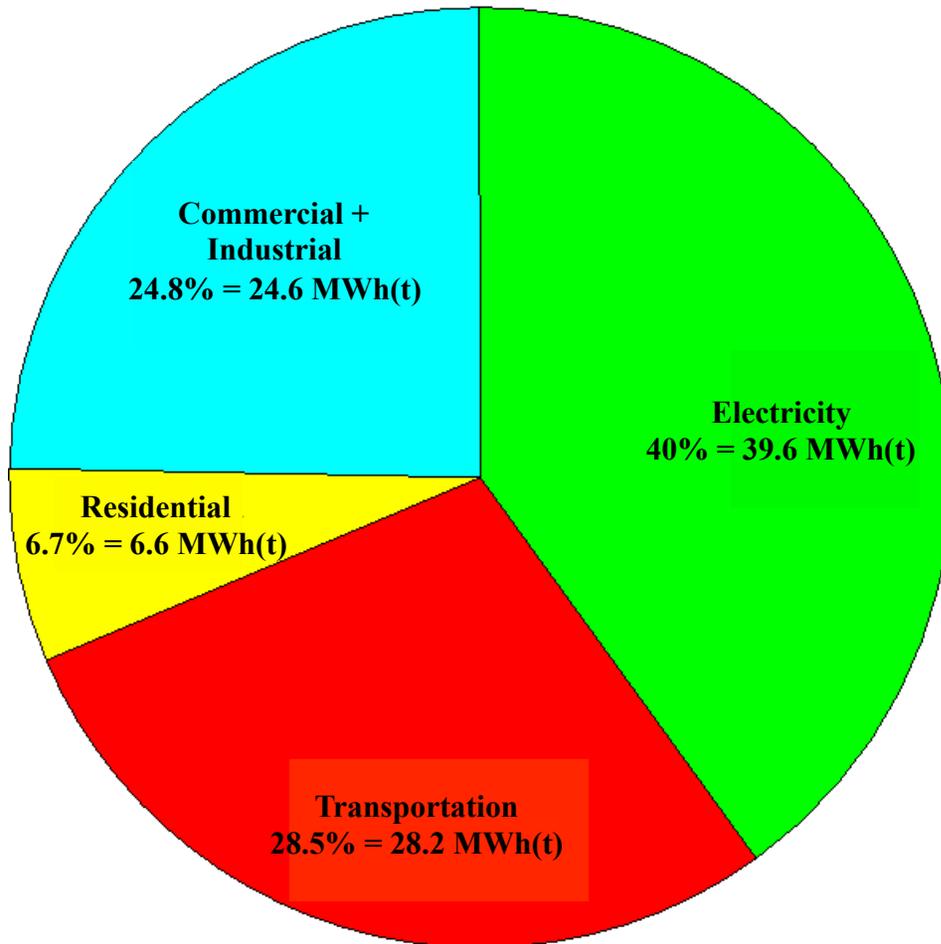
## TOPICS

**Electricity storage** is key to enabling integration of intermittent renewable energy sources into the grid

**Electricity storage** could enable efficient utilization of existing capacity using load leveling and peak shaving

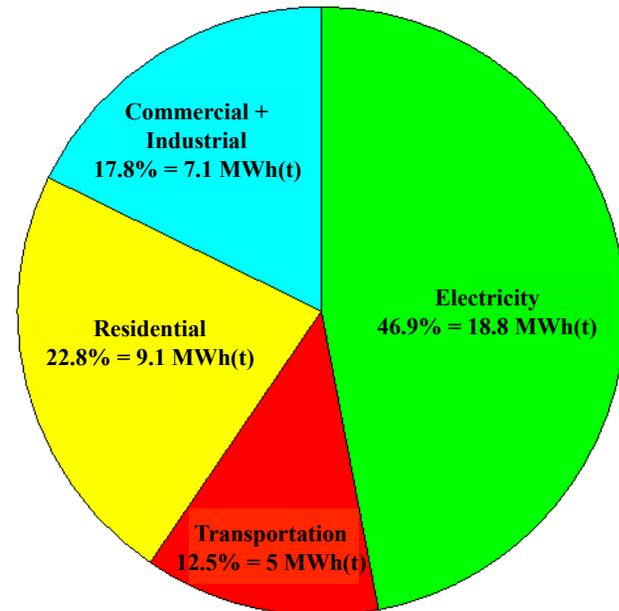
# Annual US & NYC Energy Consumption per Capita by Sector (DOE; NYISO)

## USA



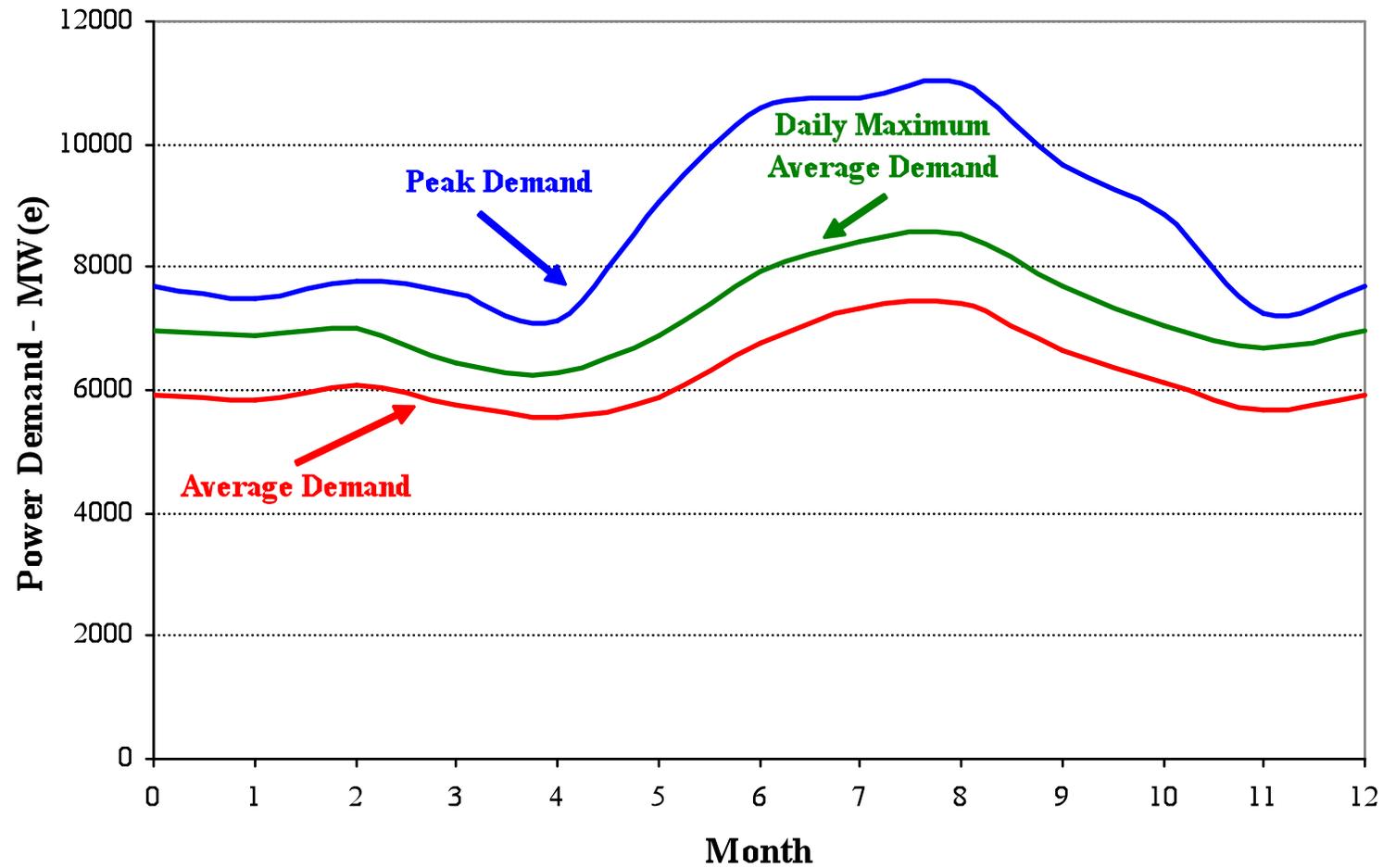
**Energy/capita = 99 MWh(t)/a**

## NYC

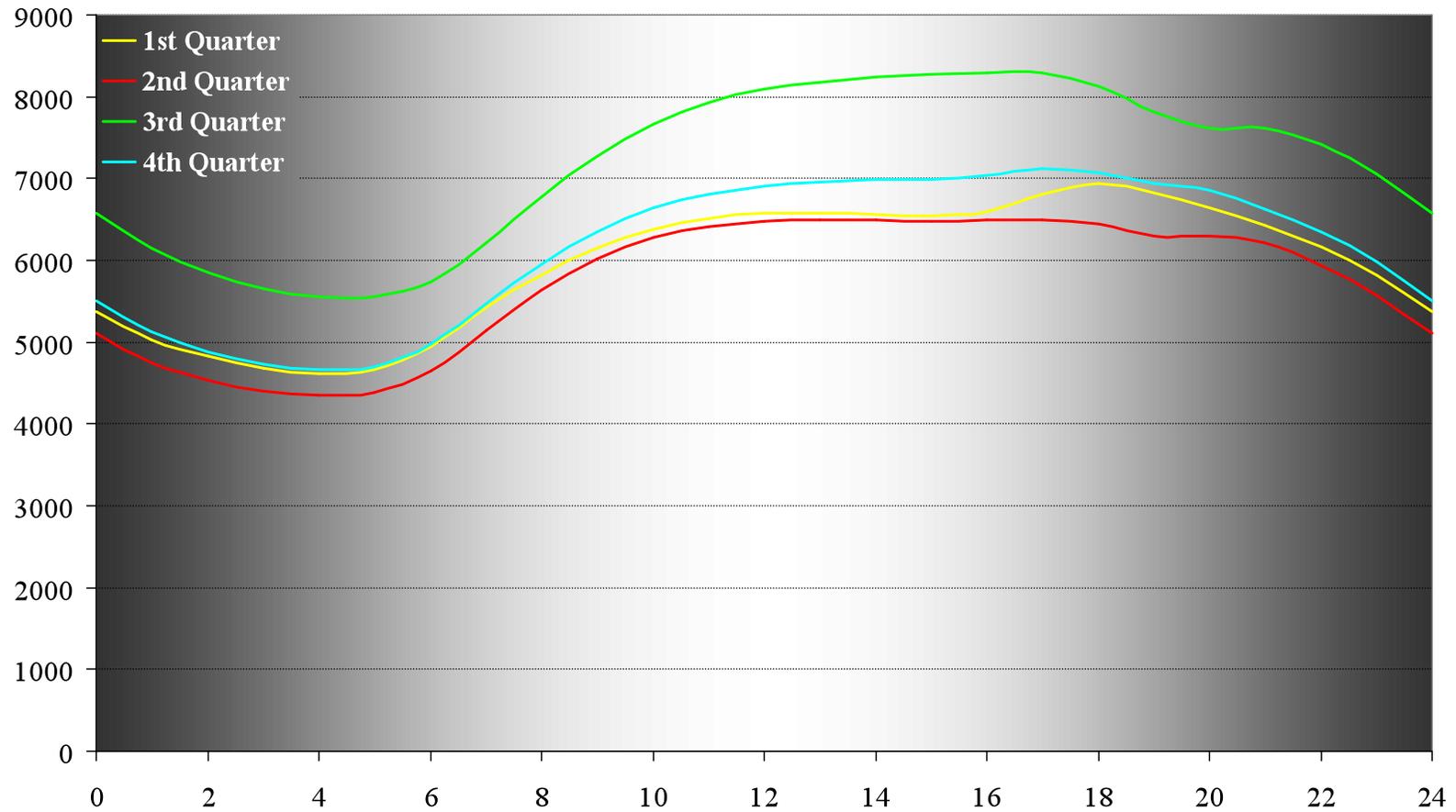


**Energy/capita = 40 MWh(t)/a**  
**Total NYC = 316,000 GWh(t)/a**

## 2007 Yearly Peak and Average Power Demand in NYC (NYISO)

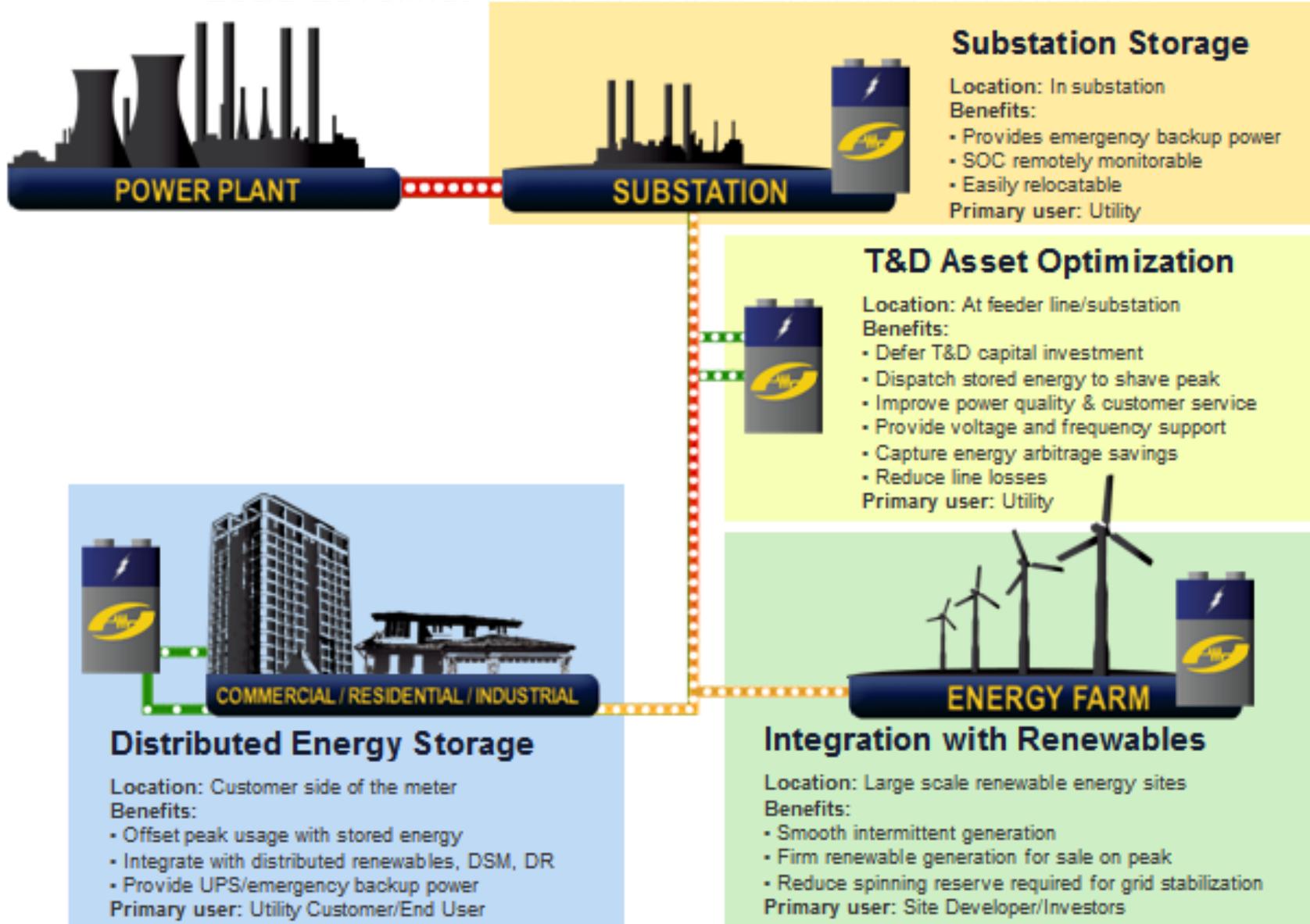


# 2007 NYC Daily Average Power Demand - MW(e) (NYISO)

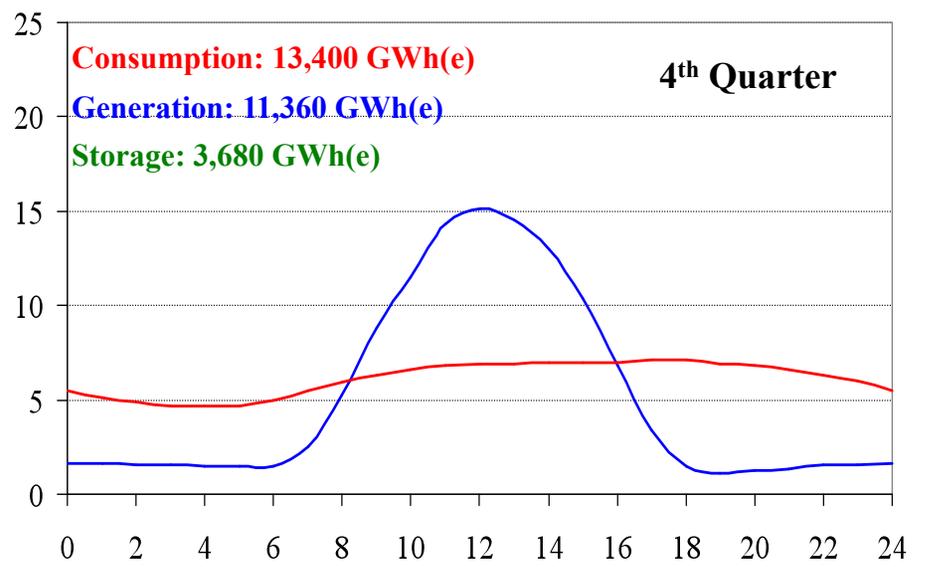
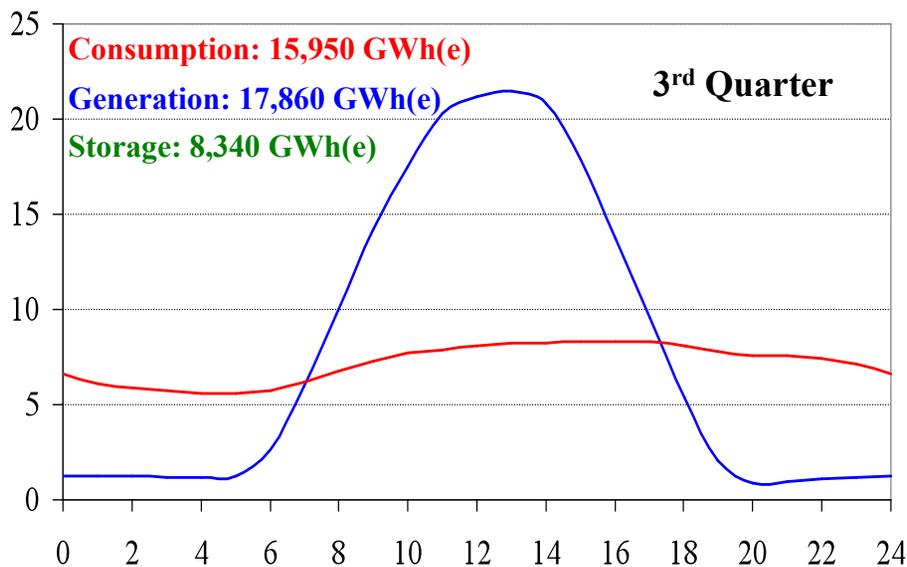
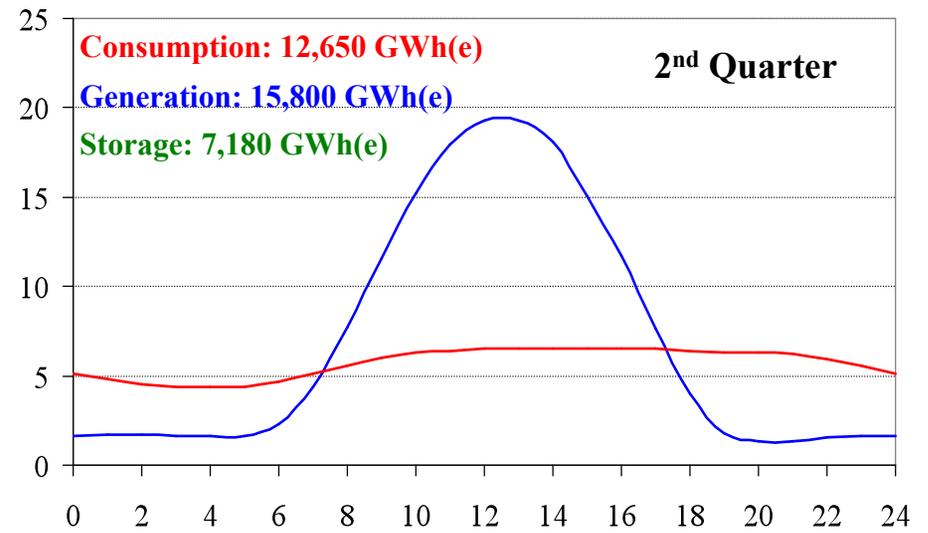
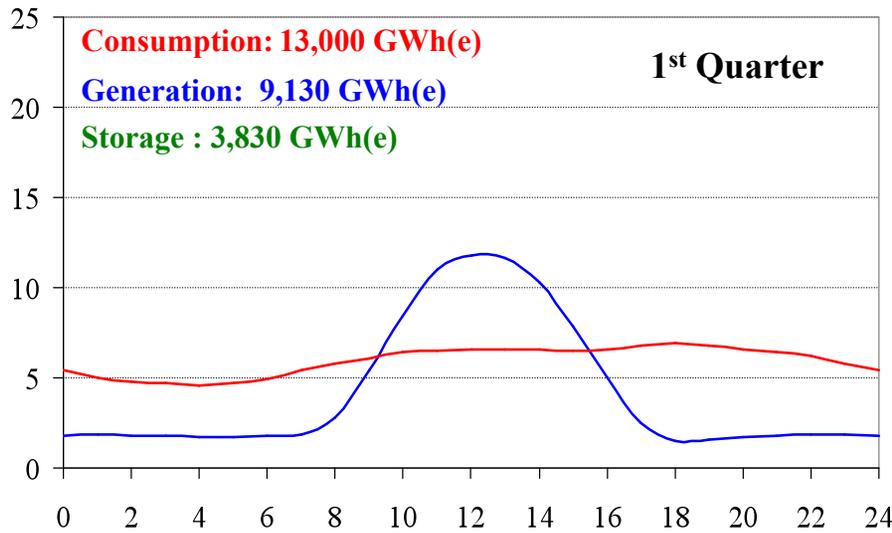


# Demand Side Energy Storage & Management

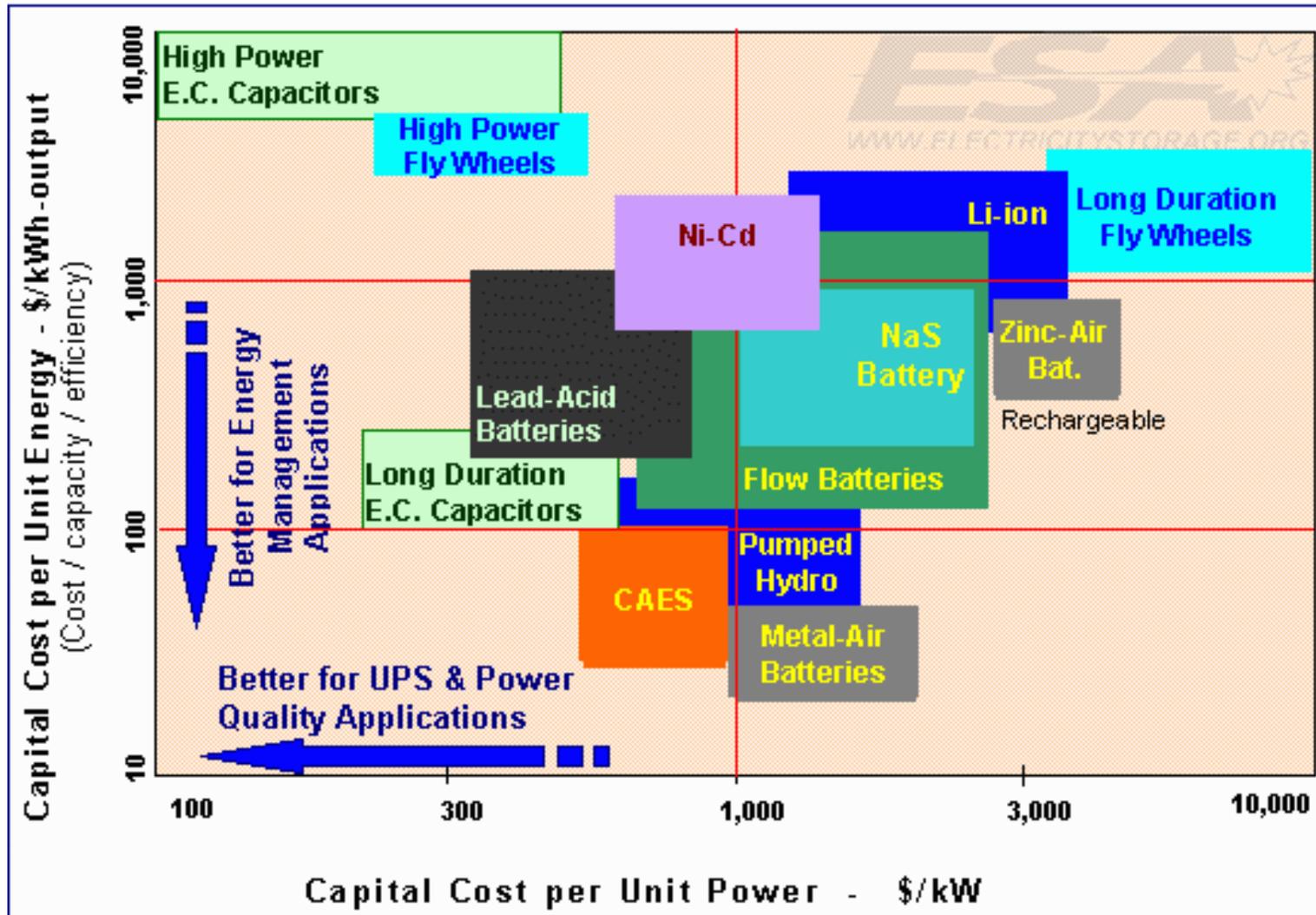
Load Leveling. Peak Shaving. Enabling Renewables



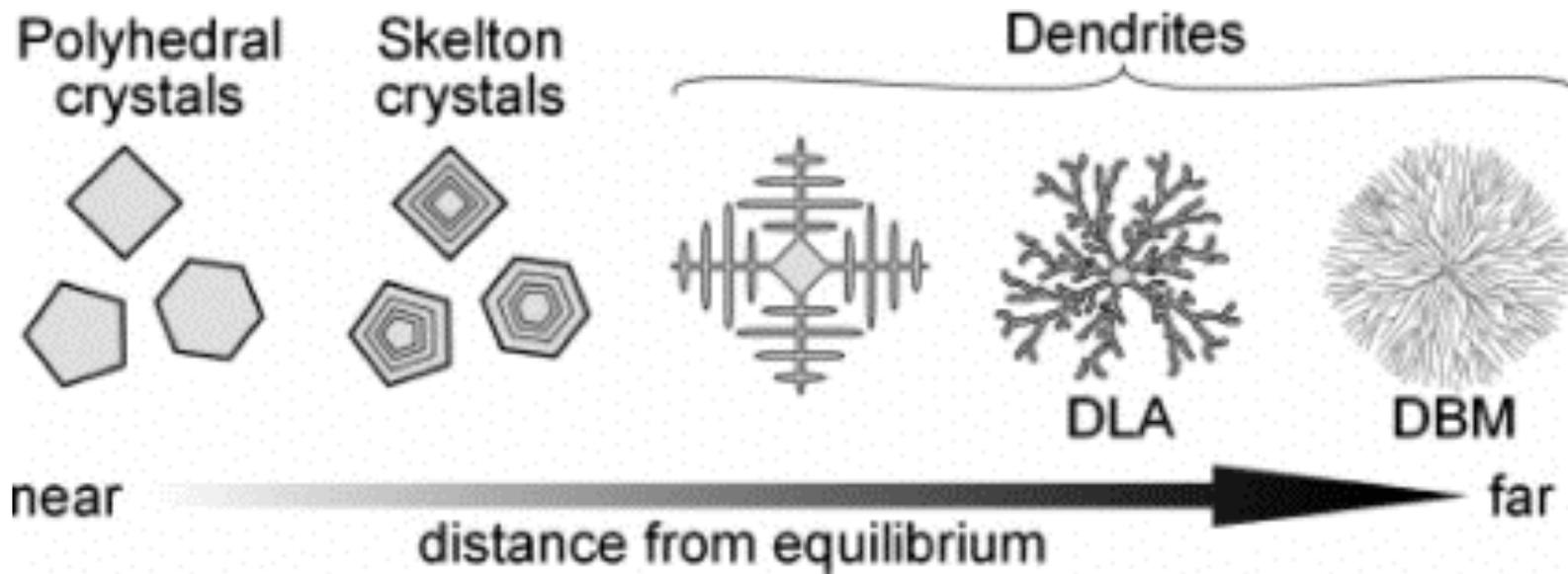
# NYC Daily Average PV + Wind Generation & Electricity Consumption GWh(e)/hr (NREL; NYISO)



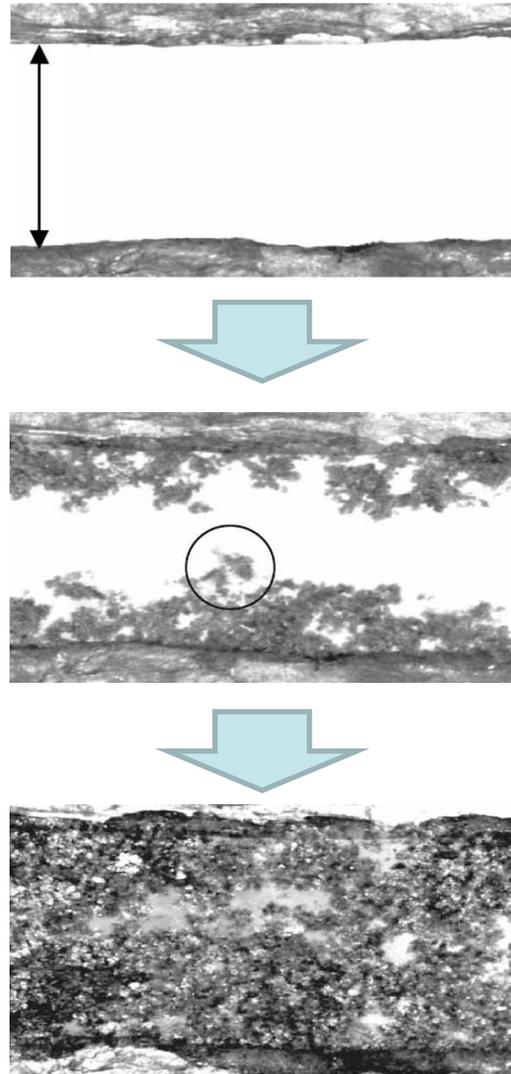
# Cost comparison per unit energy



## The Key Challenge: Structure vs. Distance from Equilibrium



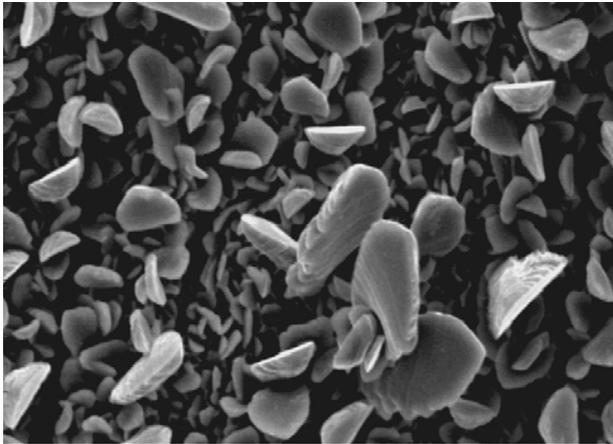
## Dendrite growth in battery



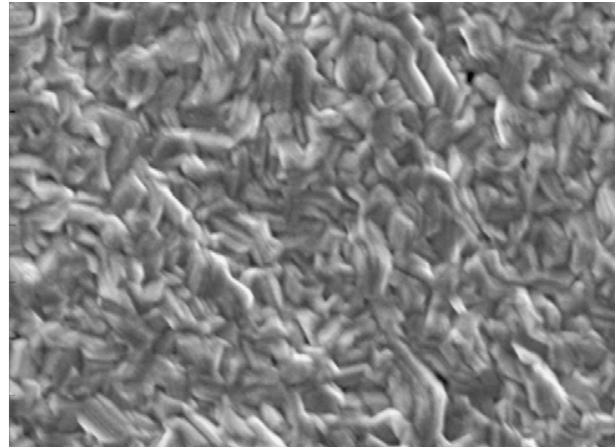
## Battery short circuit: dendrite formation



## Deposited zinc dendrites

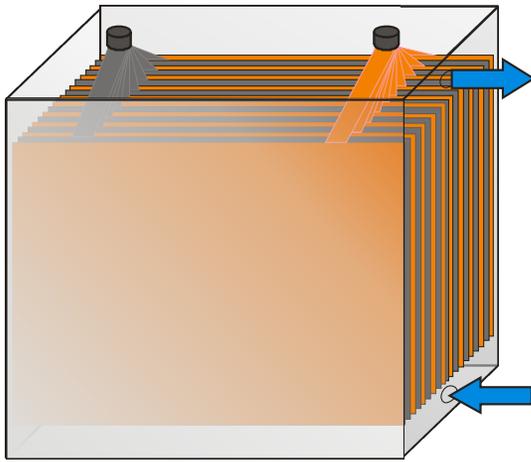


Without flowing electrolyte

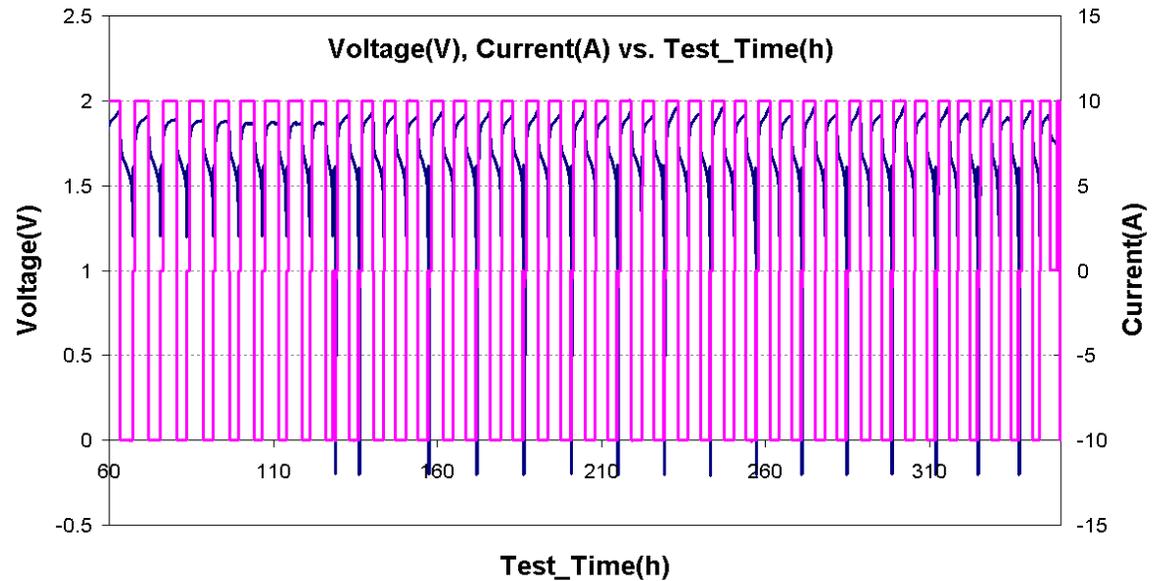


With flowing electrolyte

# Scale up to kWh size

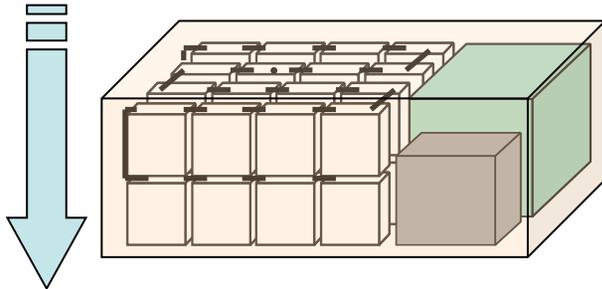


56Wh (1.6V-35Ah) battery cell  
\*10 anodes and cathodes in a cell



*for scale up*

- \*More electrodes in a cell for larger capacity
- \*Cell stacking for higher voltage



**5kWh (48V-100Ah) battery**

