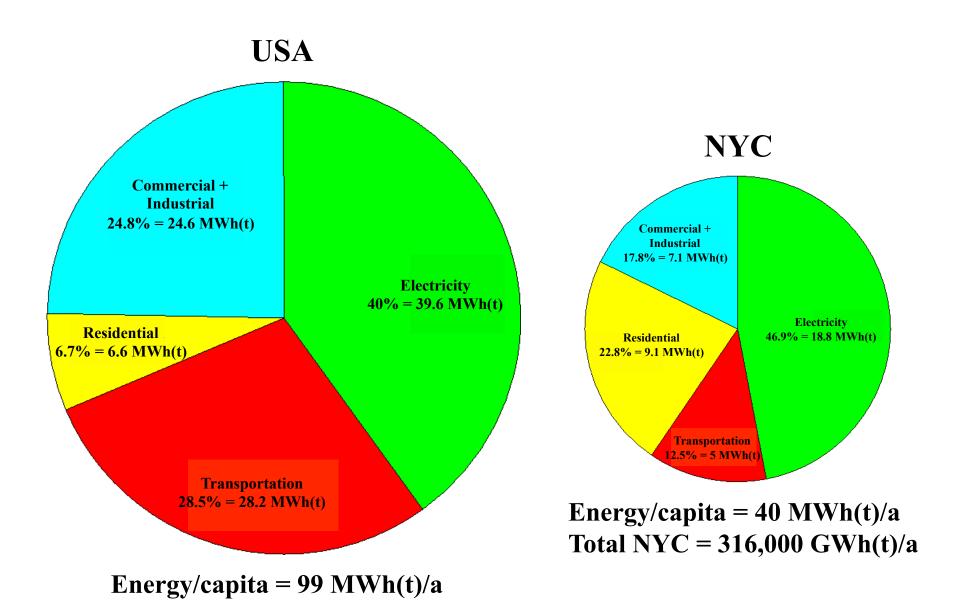
### **TOPICS**

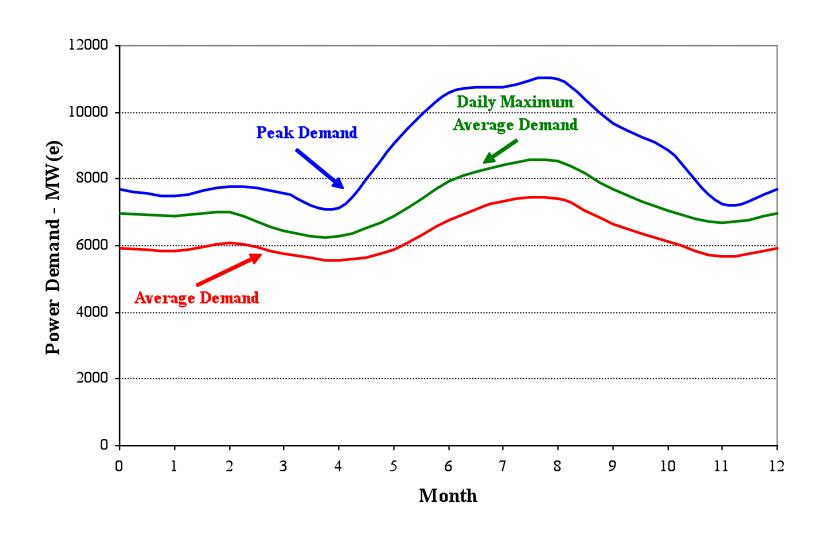
**Electricity storage** is key to enabling integration of intermittent renewable energy sources into the grid

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

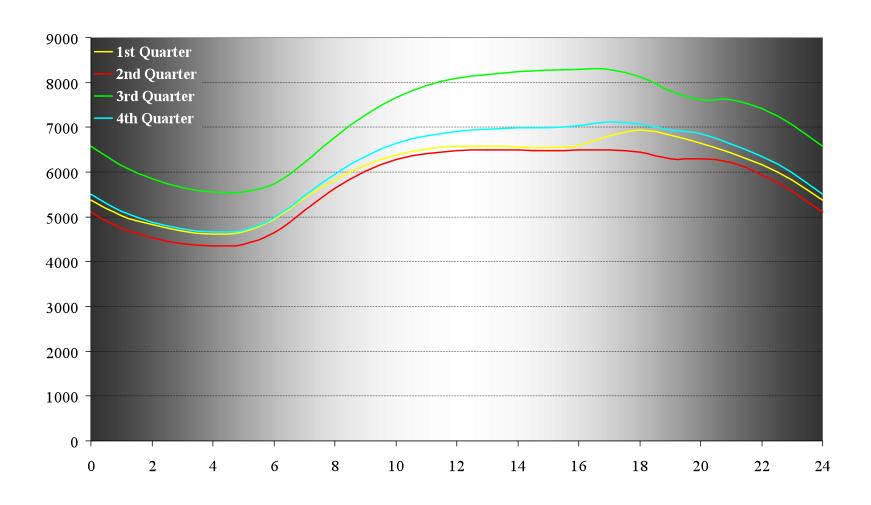
### Annual US & NYC Energy Consumption per Capita by Sector (DOE; NYISO)



# 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



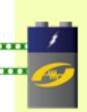


#### Substation Storage

Location: In substation

- Benefits:
- · Provides emergency backup power
- SOC remotely monitorable
- Easily relocatable

Primary user: Utility



#### T&D Asset Optimization

Location: At feeder line/substation Benefits:

- · Defer T&D capital investment
- · Dispatch stored energy to shave peak
- Improve power quality & customer service
- Provide voltage and frequency support
- · Capture energy arbitrage savings
- Reduce line losses

Primary user: Utility



### Distributed Energy Storage

IMERCIAL / RESIDENTIAL / INDUSTRIAL

Location: Customer side of the meter Benefits:

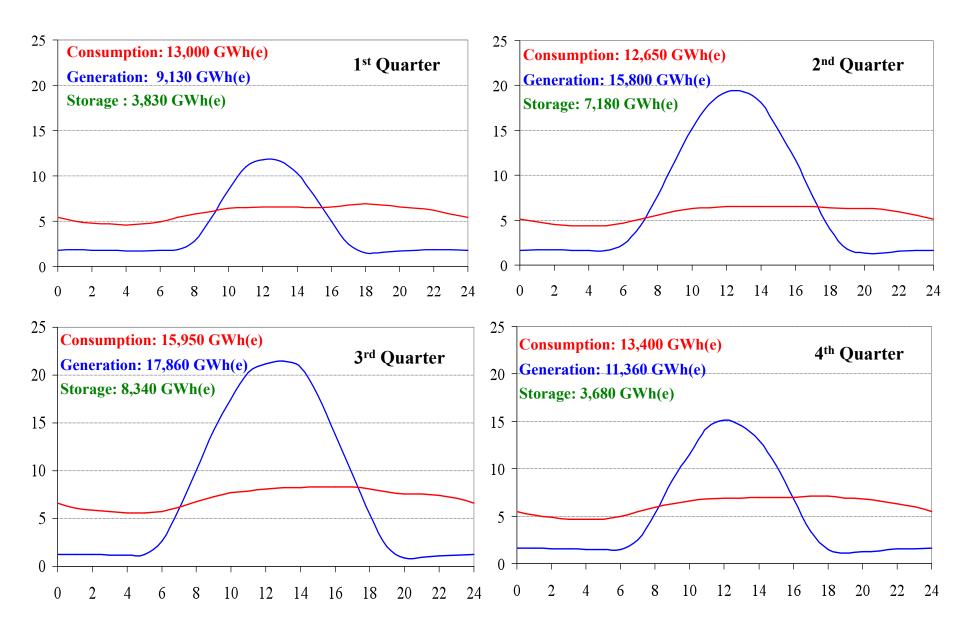
- · Offset peak usage with stored energy
- · Integrate with distributed renewables, DSM, DR
- Provide UPS/emergency backup power
  Primary user: Utility Customer/End User

### Integration with Renewables

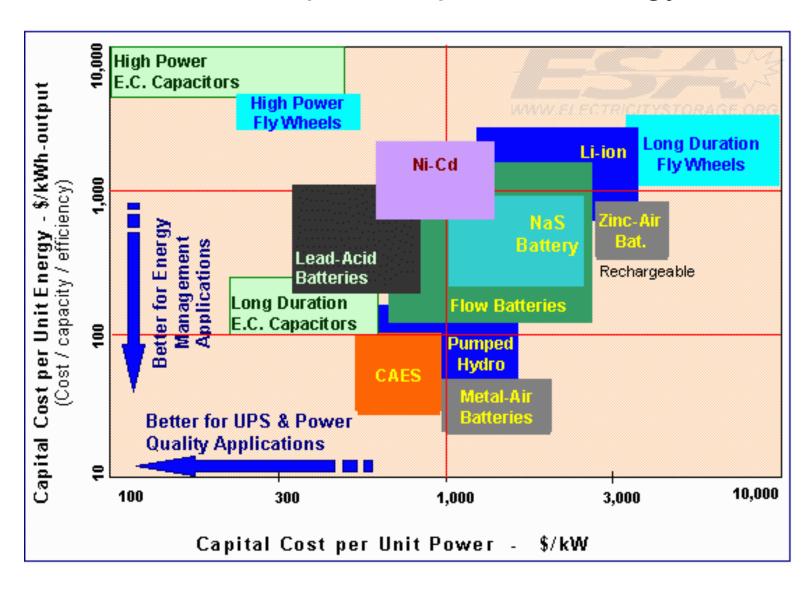
Location: Large scale renewable energy sites Benefits:

- Smooth intermittent generation
- · Firm renewable generation for sale on peak
- Reduce spinning reserve required for grid stabilization
  Primary user: Site Developer/Investors

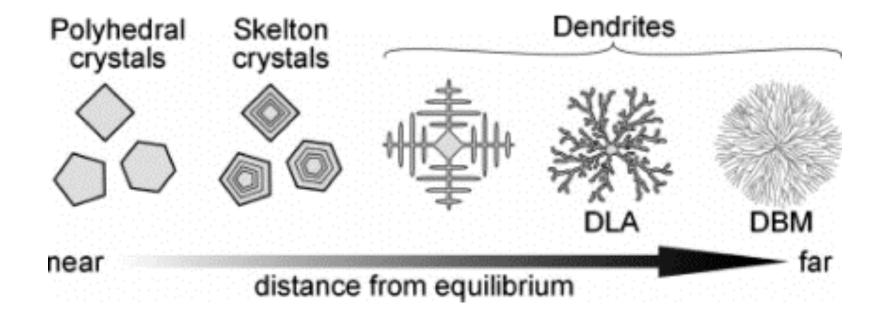
# NYC Daily Average PV + Wind Generation & Electricity Consumption GWh(e)/hr (NREL; NYISO)



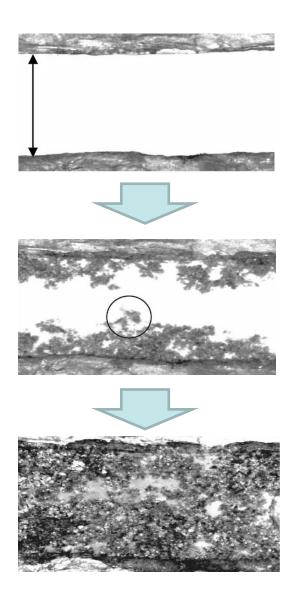
## Cost comparison per unit energy



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



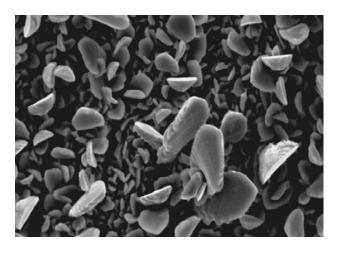
## **Dendrite growth in battery**



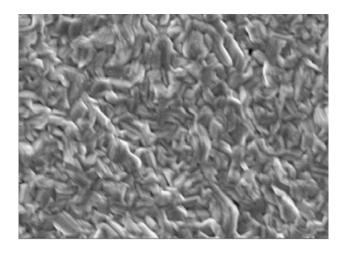
## **Battery short circuit: dendrite formation**



## **Deposited zinc dendrites**

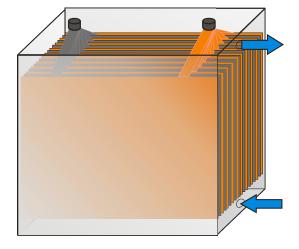


Without flowing electrolyte



With flowing electrolyte

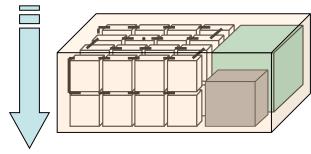
## Scale up to kWhr size



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

