

# California Energy Commission Workshop

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## *Wind and Energy Storage*

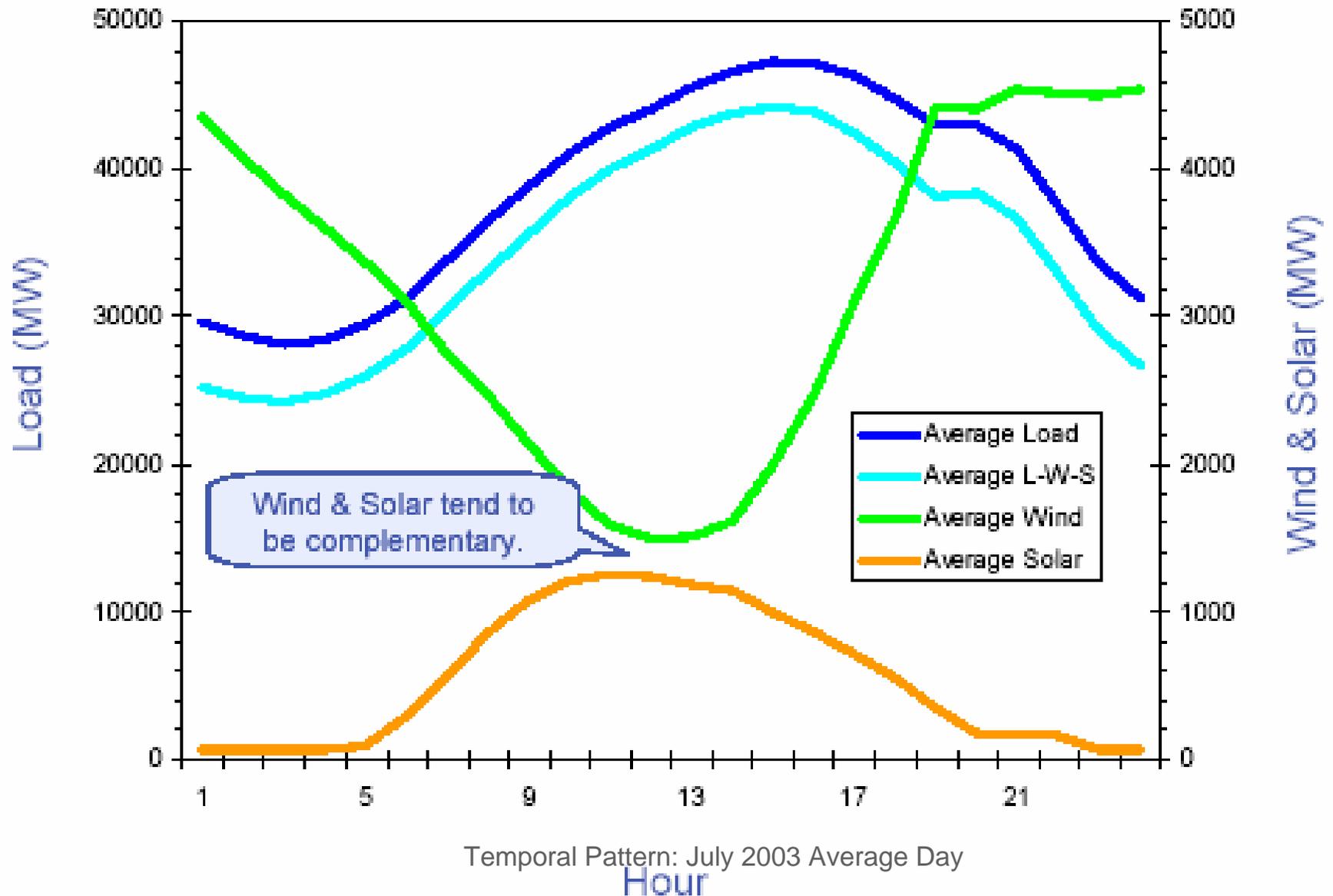


*Pacific Gas and  
Electric Company™*

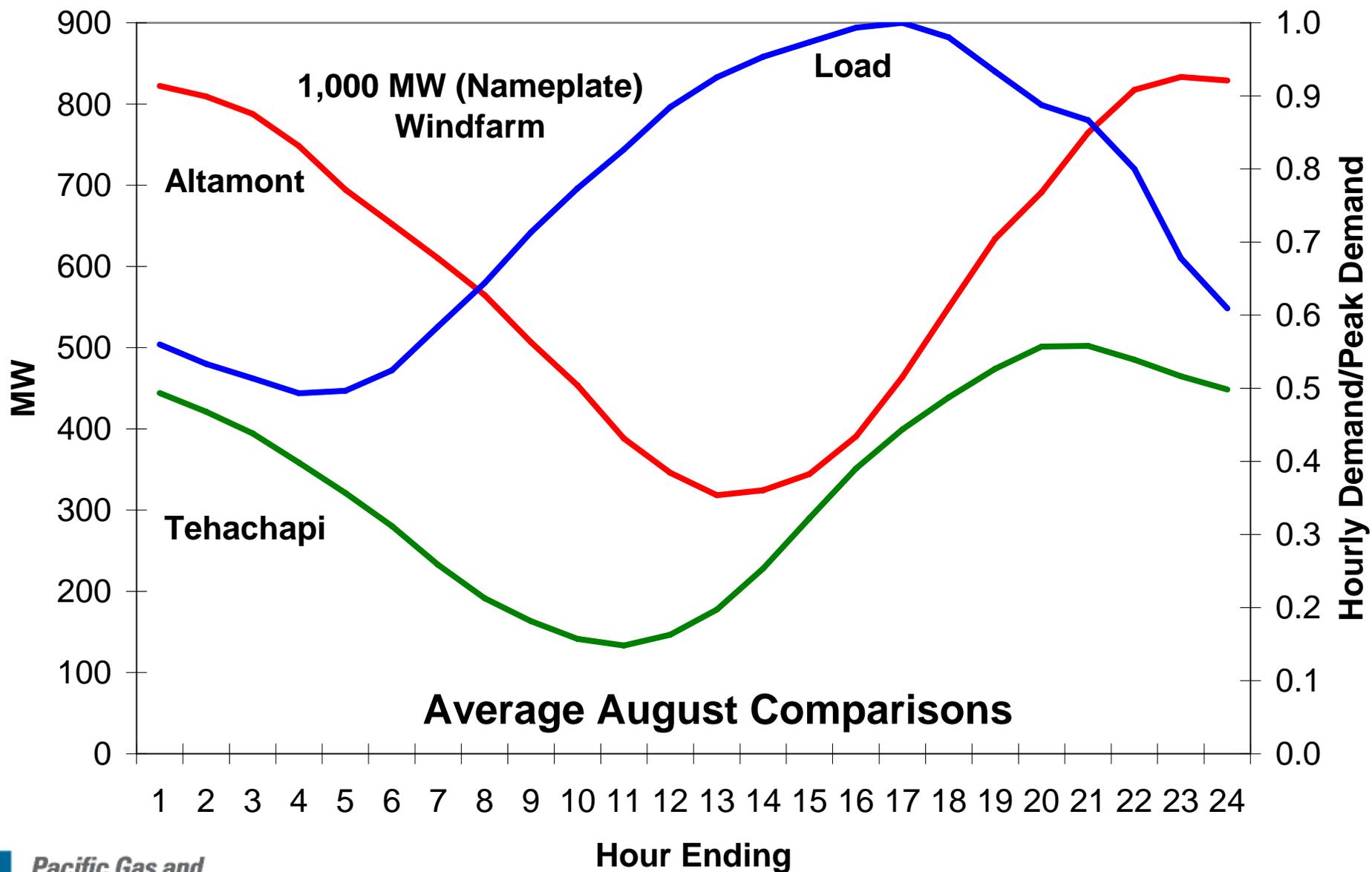
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October 3, 2007

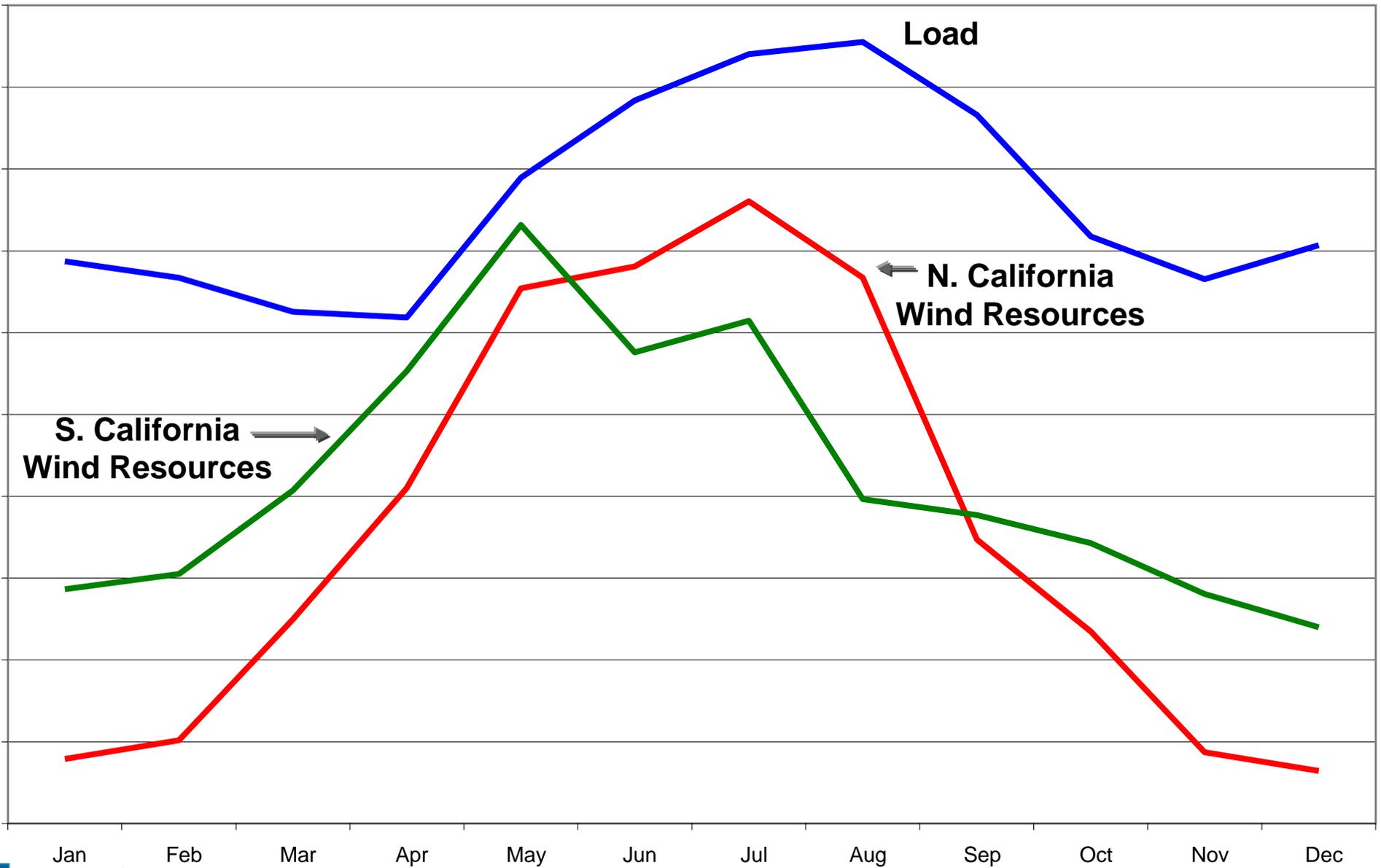
# Loads & Resources



# Best Fit Comparison for Peak Demand Month



# Monthly Profile Comparisons



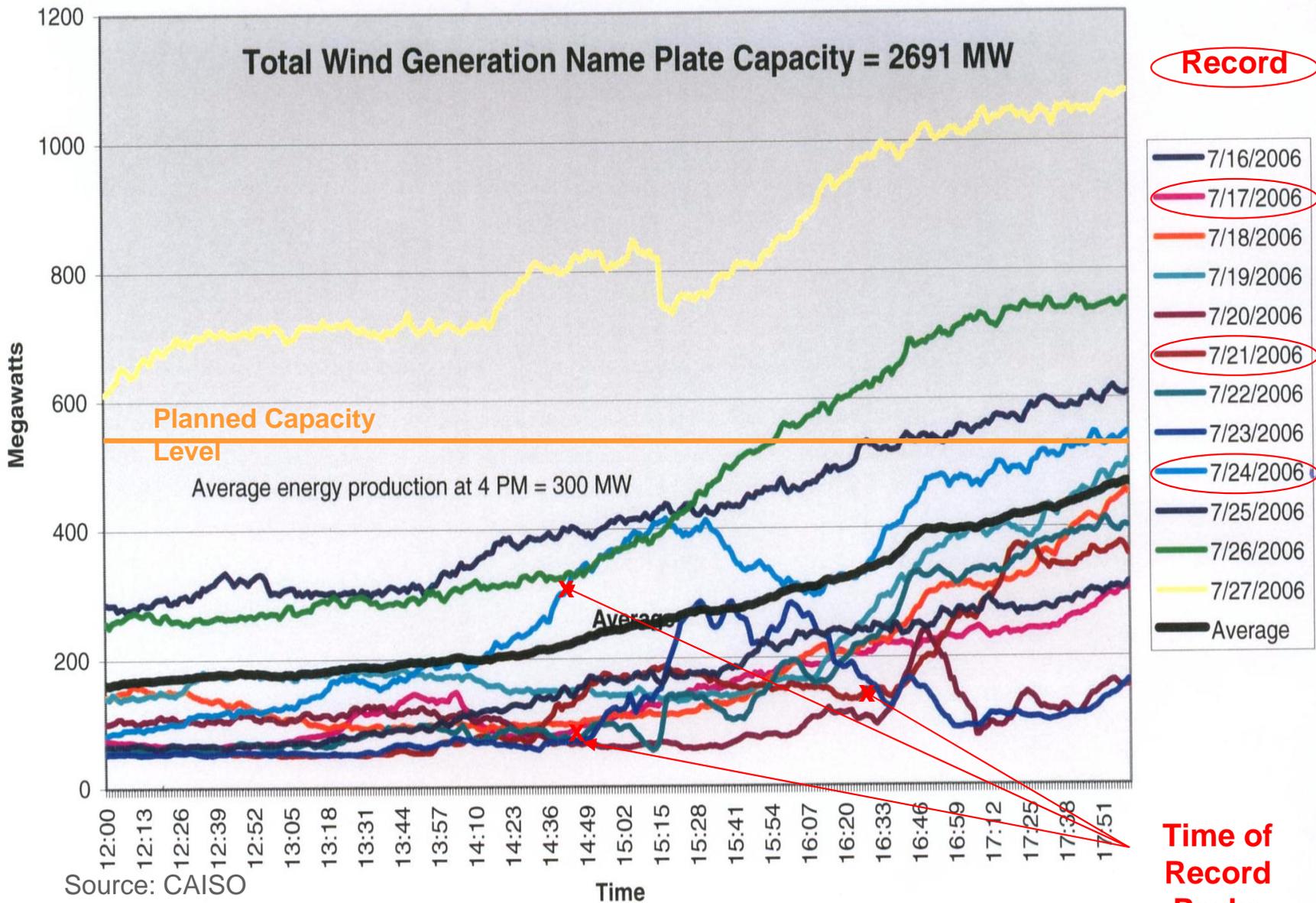
# July 2006 Heat Wave – Peak Hours Wind Generation Energy Production

## New Records

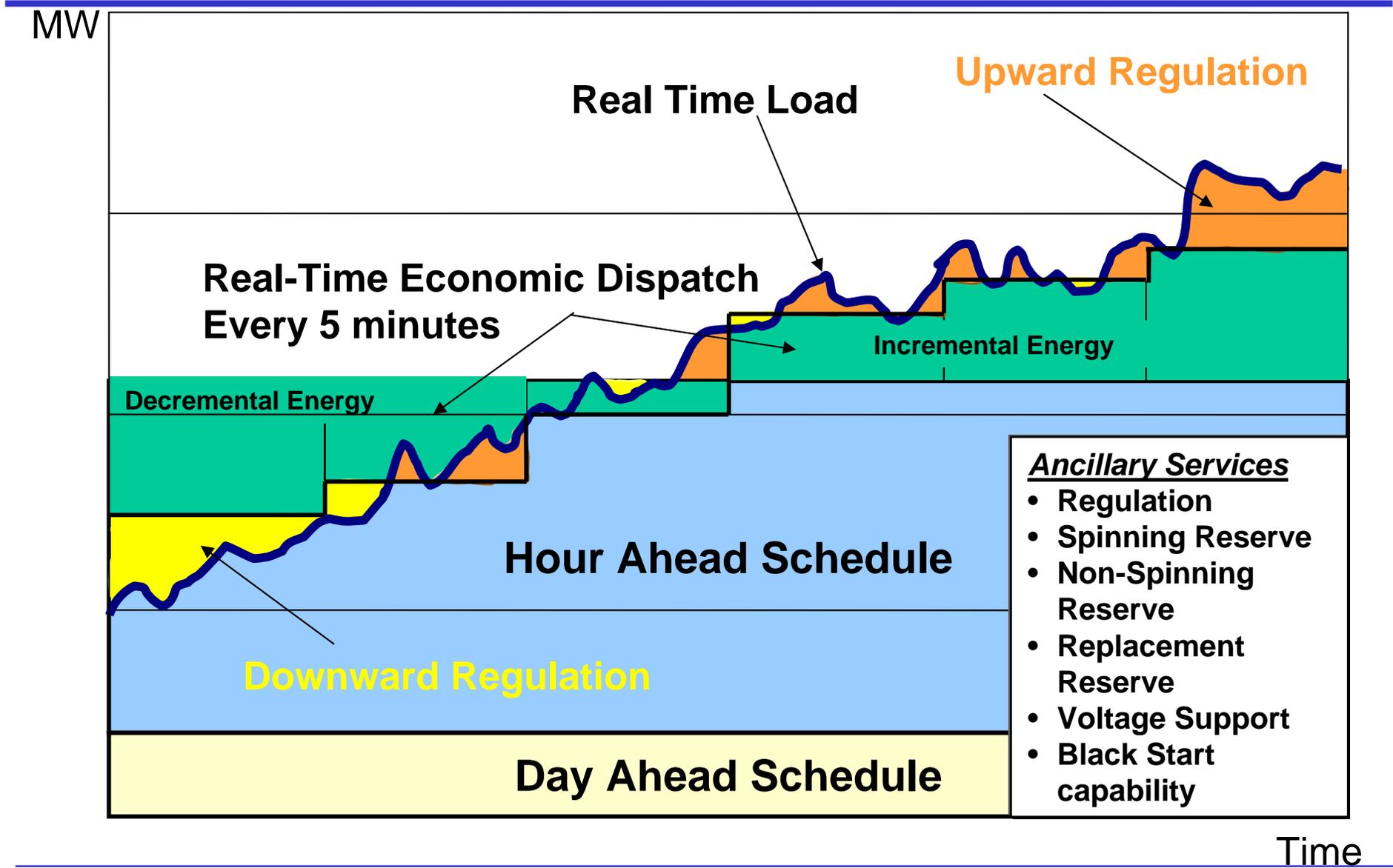
**July 17:**  
**(2:41 pm)**  
**46,561 MW**

**July 21:**  
**(4:28 pm)**  
**49,036 MW**

**July 24:**  
**(2:44 pm)**  
**50,270 MW**



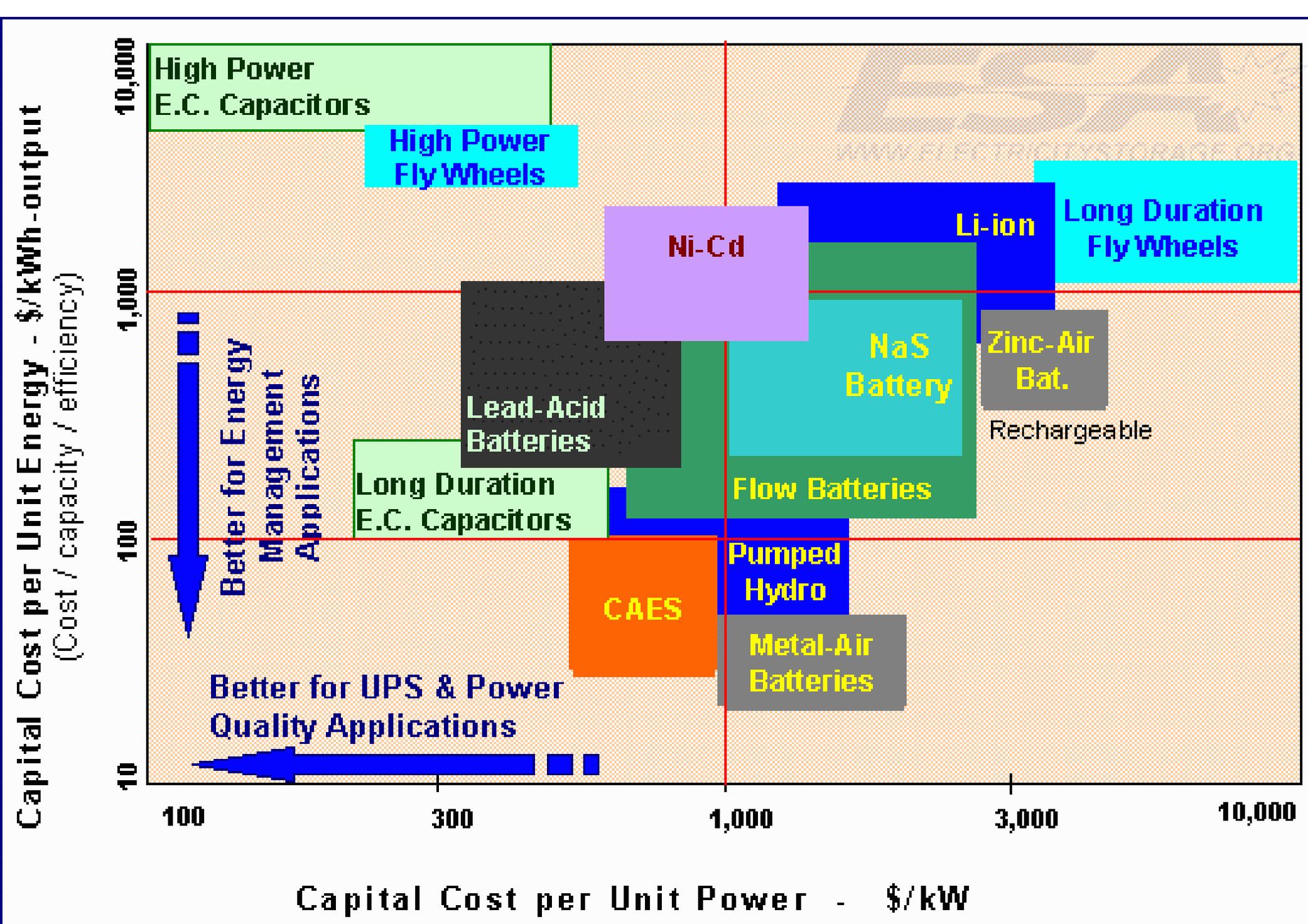
# Balancing Function - Area Control



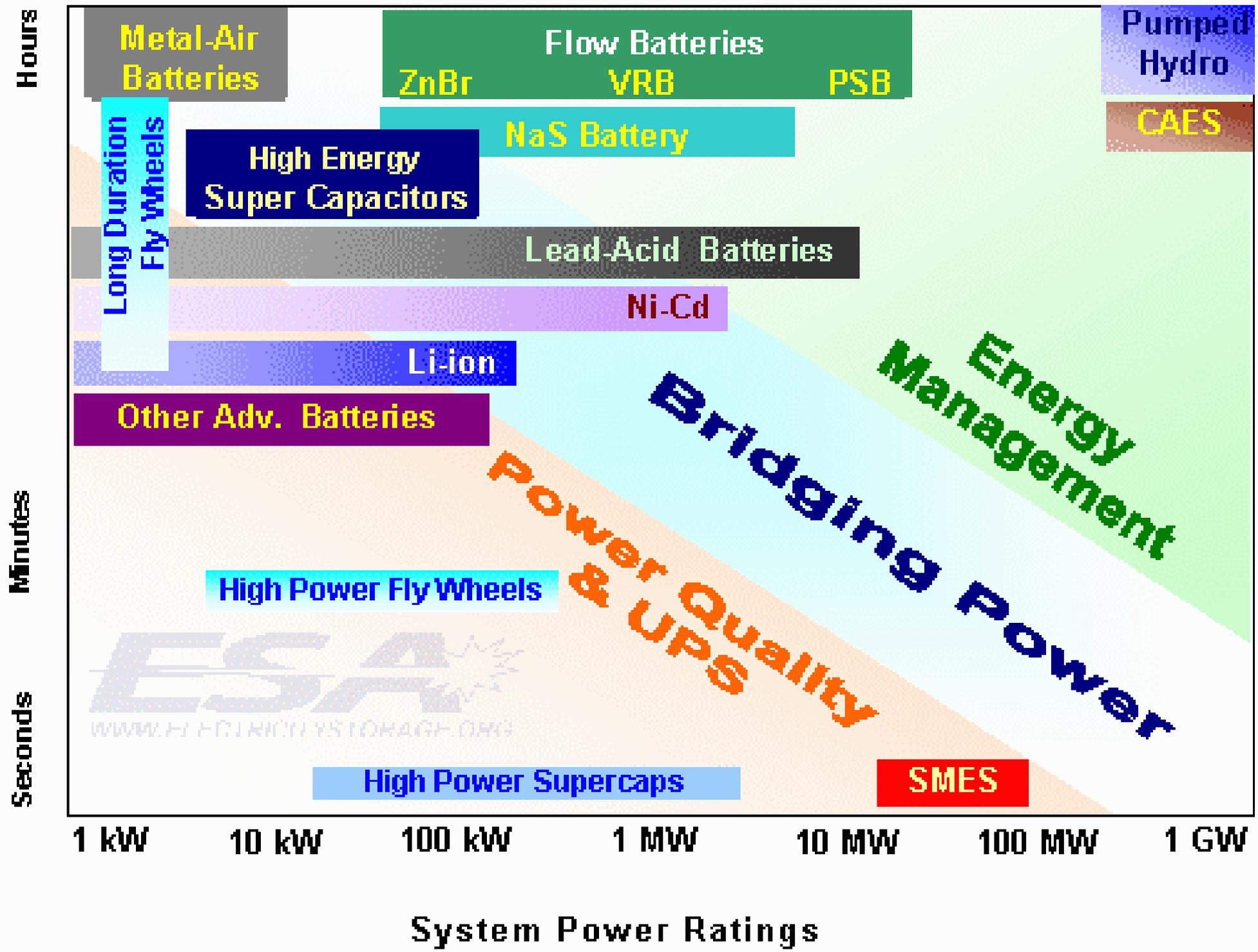
# Energy Storage Technologies

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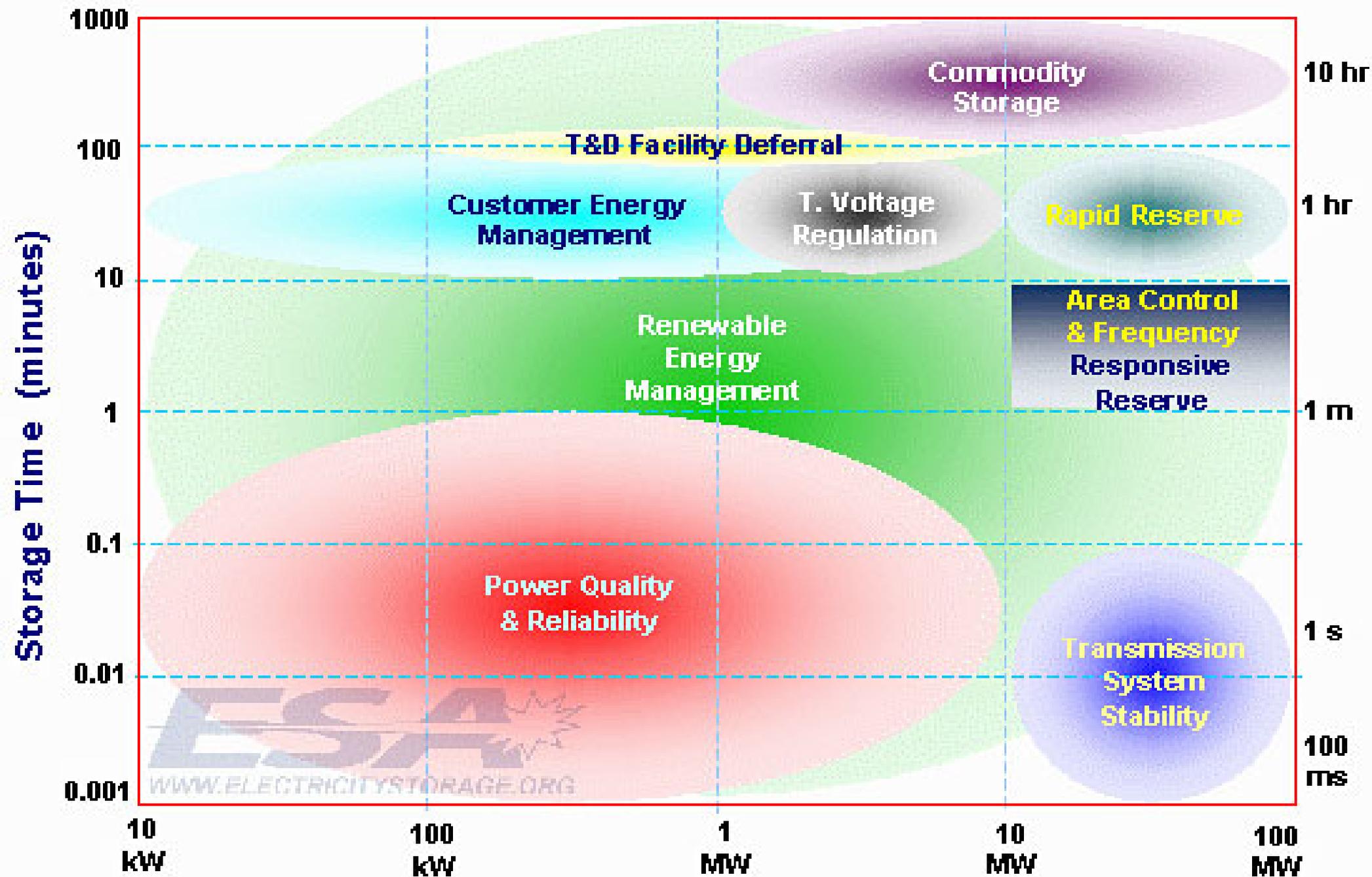
- Many different energy storage technologies are available for use in storage for renewable integration applications
  - *Pumped Hydro*
  - *Compressed Air Energy Storage*
  - *Lead-acid batteries*
  - *Nickel-cadmium batteries*
  - *Lithium ion batteries*
  - *Sodium-Sulfur Batteries*
  - *Flow Batteries*
  - *Flywheels*
  - *Ultracapacitors*
- Each technology has advantages and disadvantages
- Not all of these technologies are appropriate for all applications



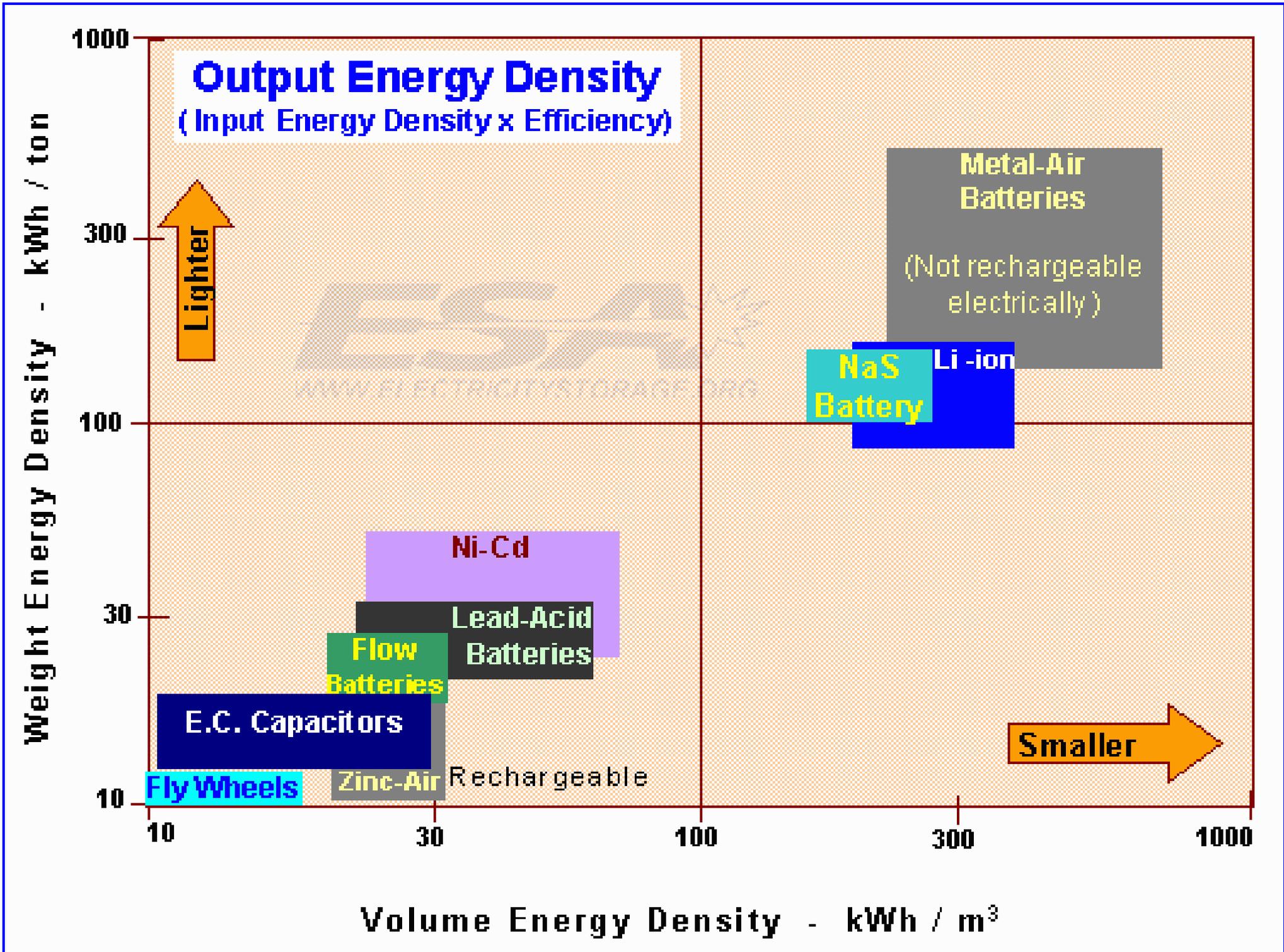
Discharge Time at Rated Power



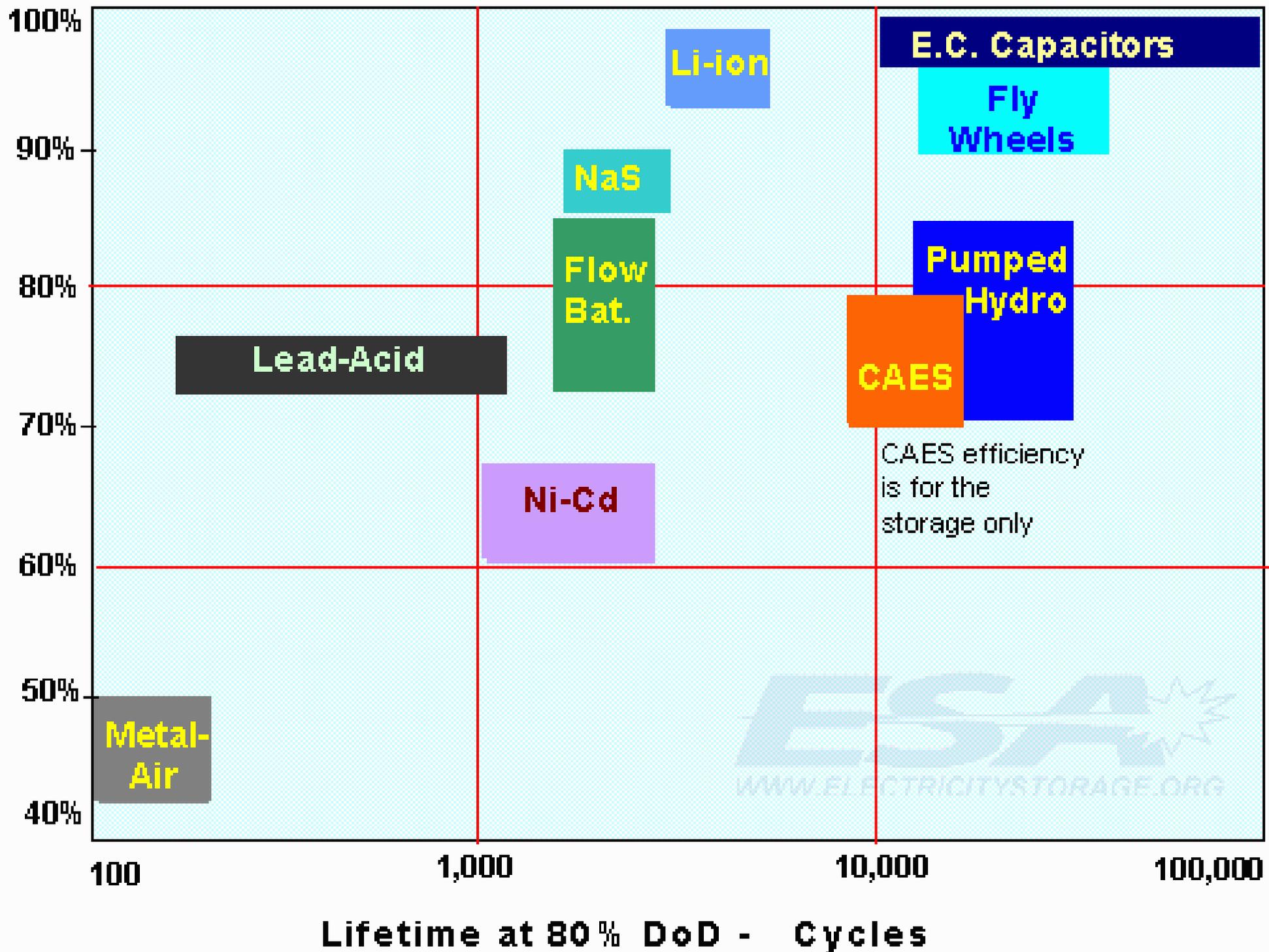
Source: [www.electricitystorage.org](http://www.electricitystorage.org)

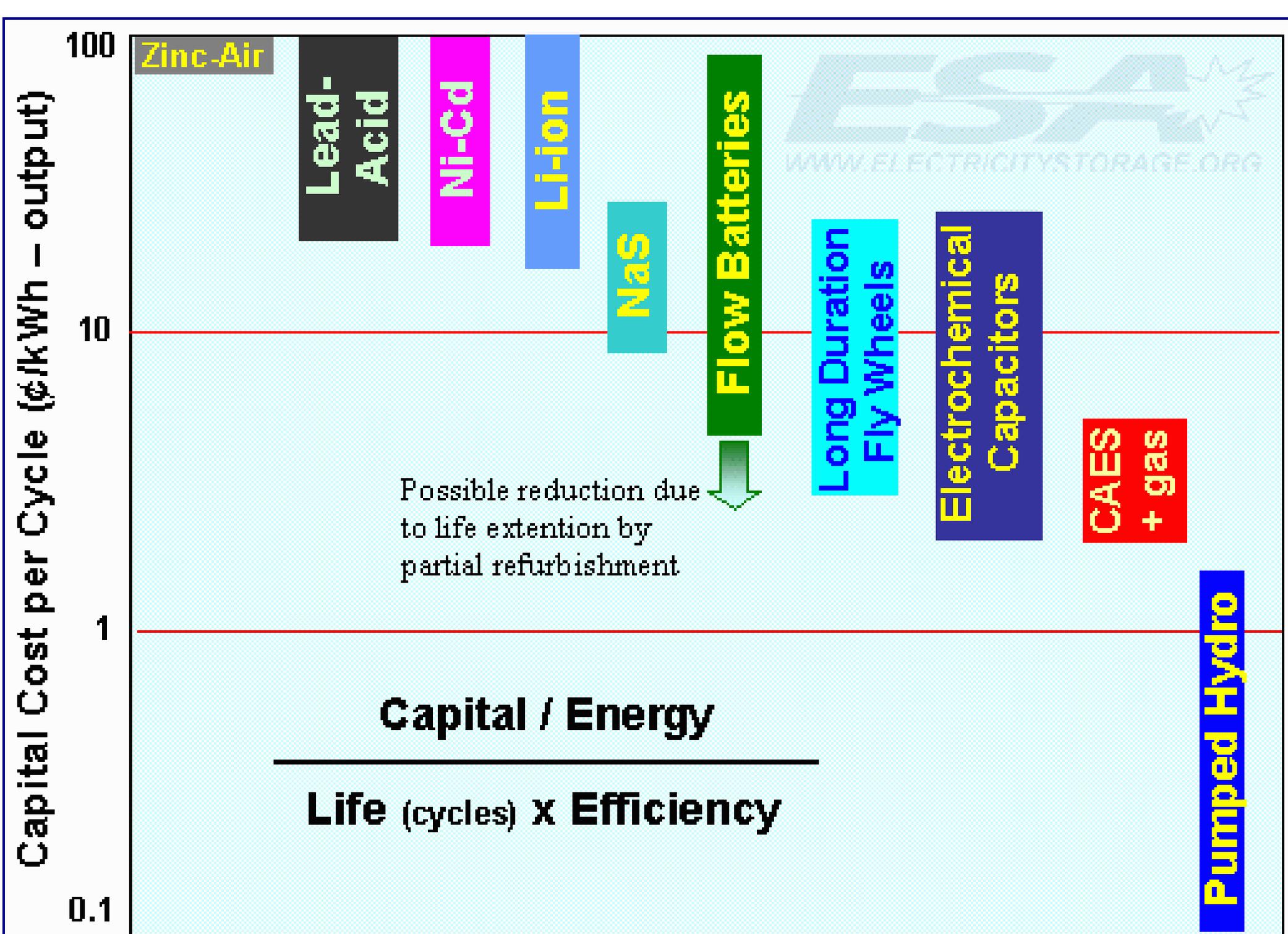


## Storage Power Requirements for Electric Power Utility Applications



Efficiency (w/o power electronics)





Carrying charges, O&M and replacement costs are not included

# Compressed Air Energy Storage (CAES)

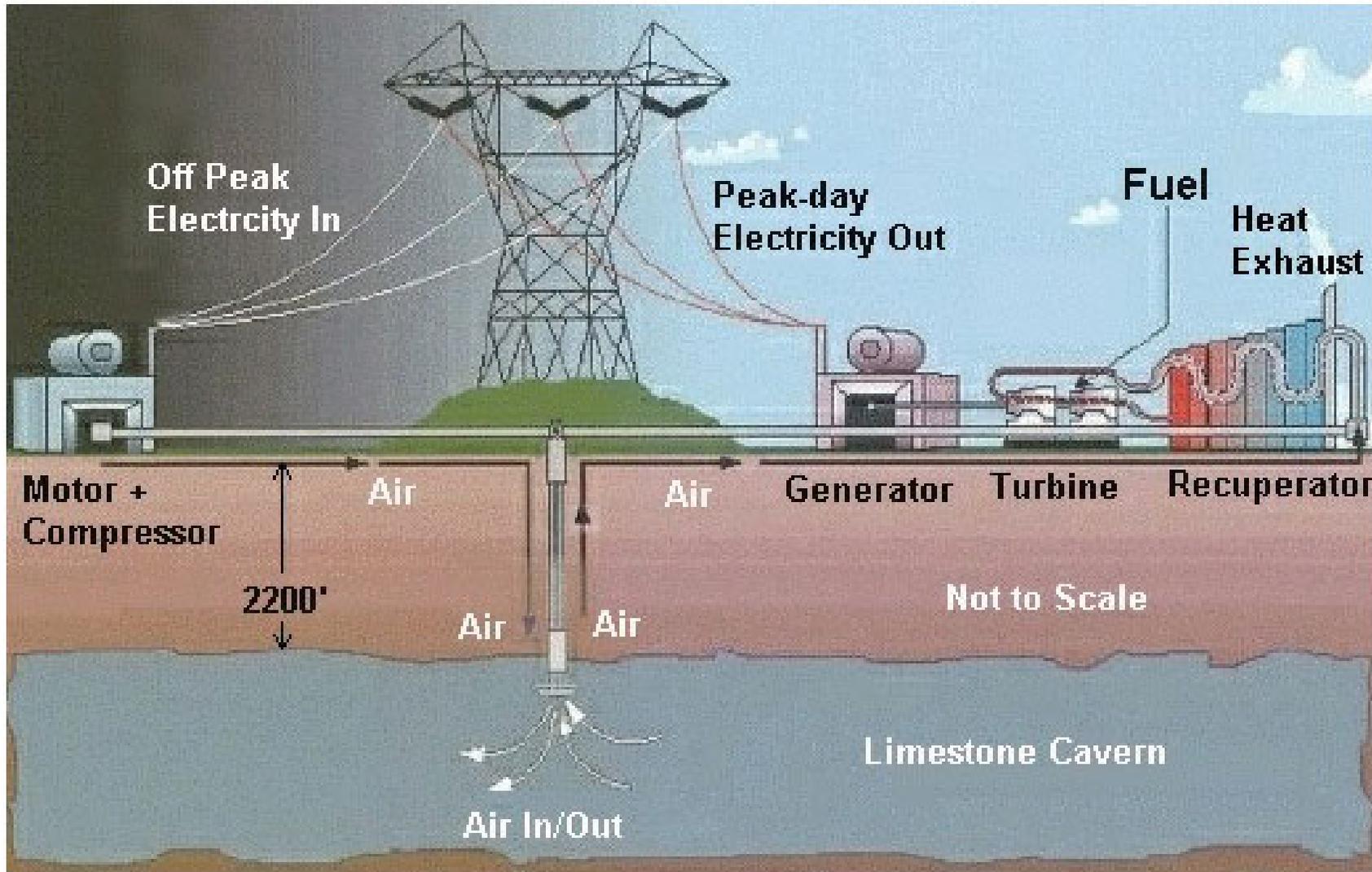


Photo Courtesy of CAES Development Company



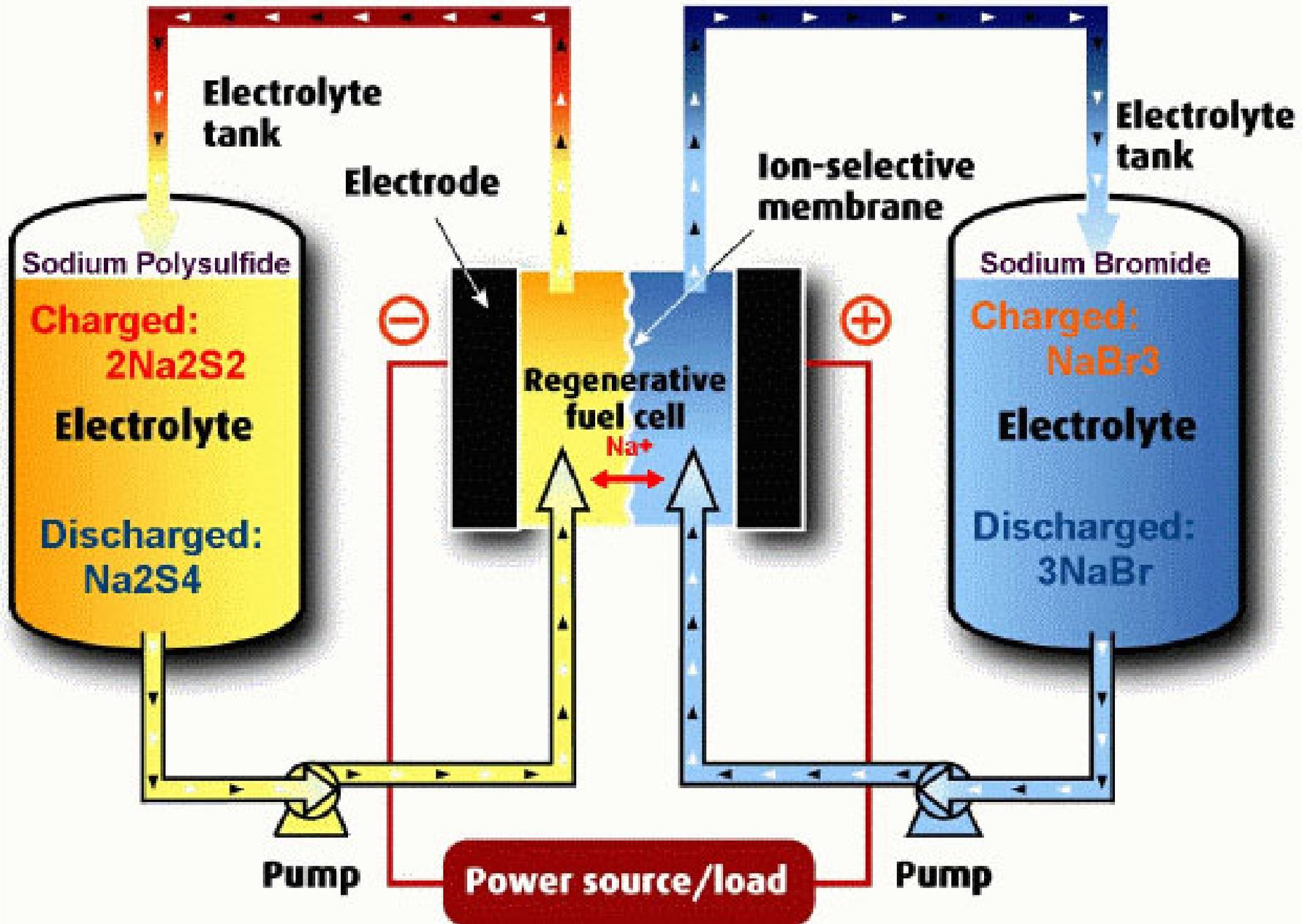
# Lithium Ion at Industrial Scale

100 kW, 15 kWh li-ion battery for UPS applications

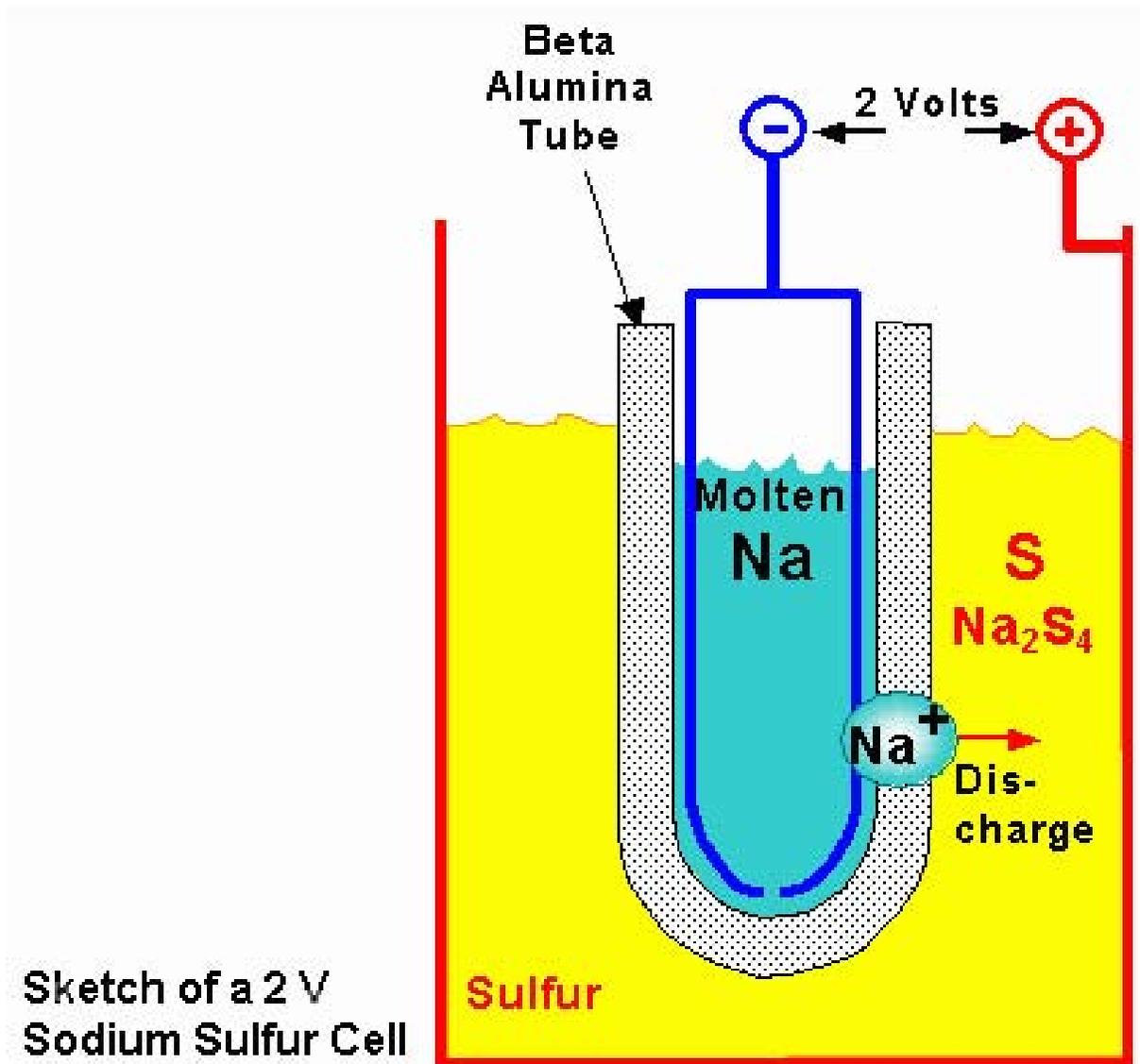


Photo Courtesy of Saft America

# Flow Battery

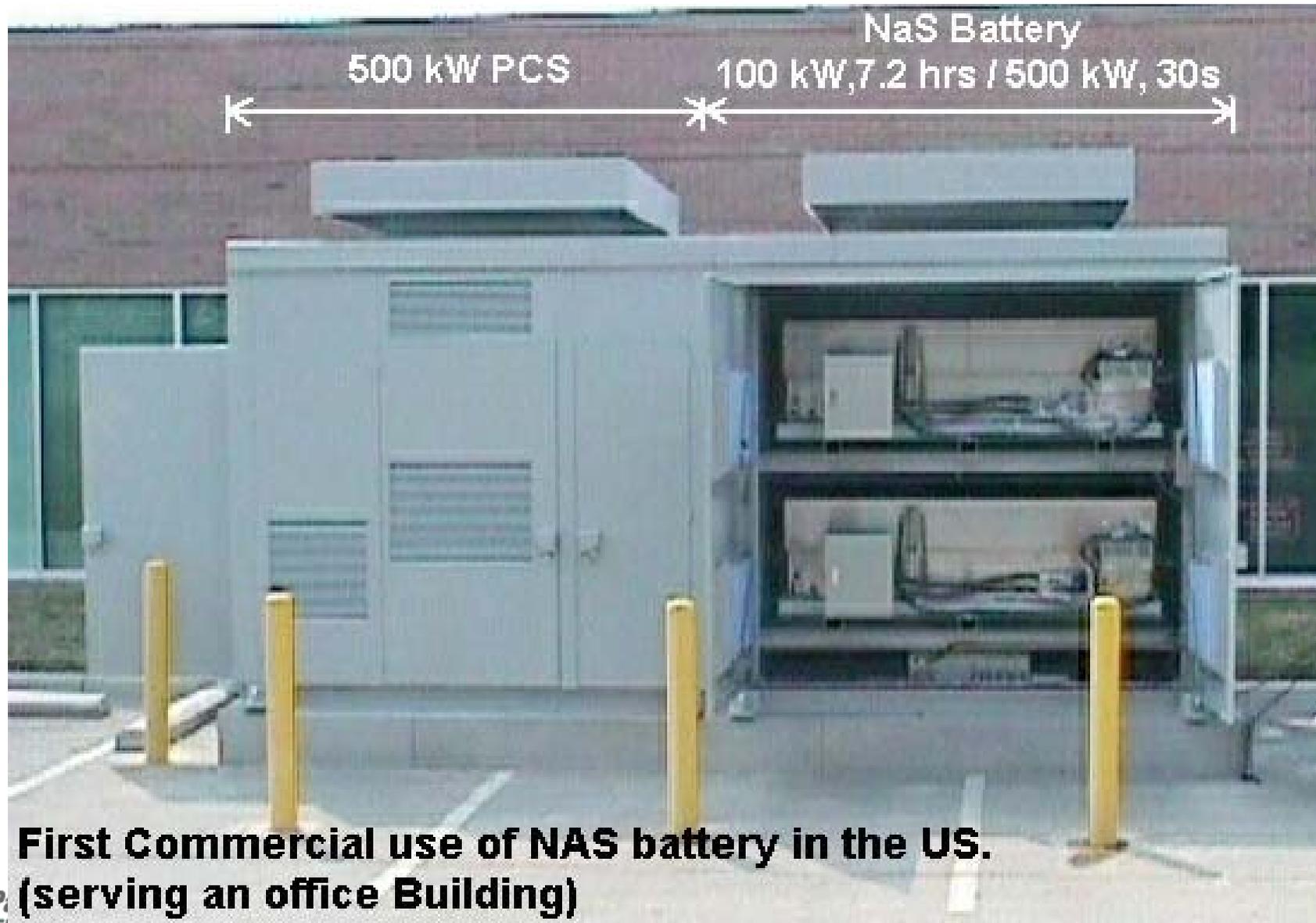


# Sodium Sulfur (NaS) Battery



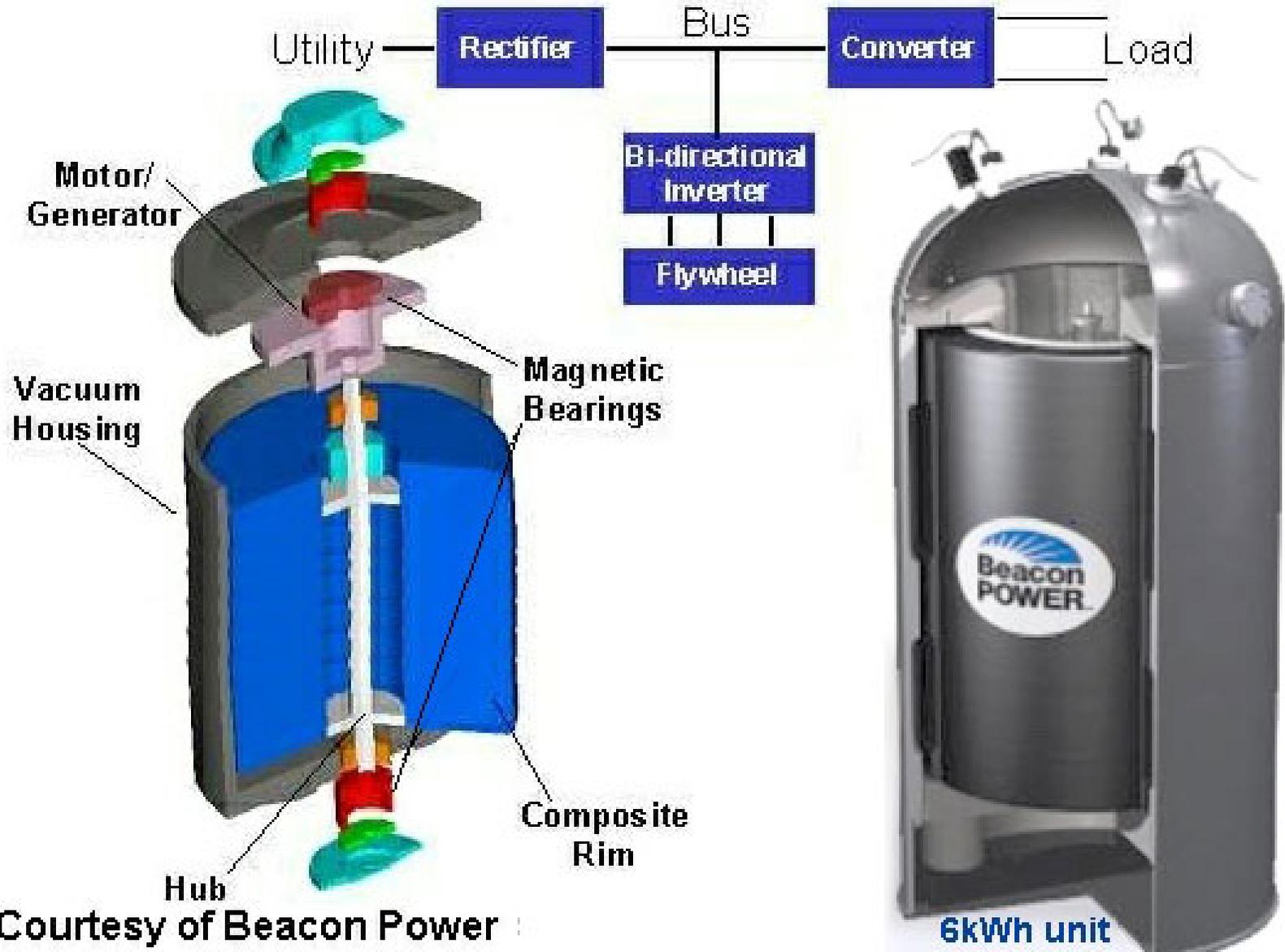
Sketch of a 2 V Sodium Sulfur Cell

# First Utility NaS Application

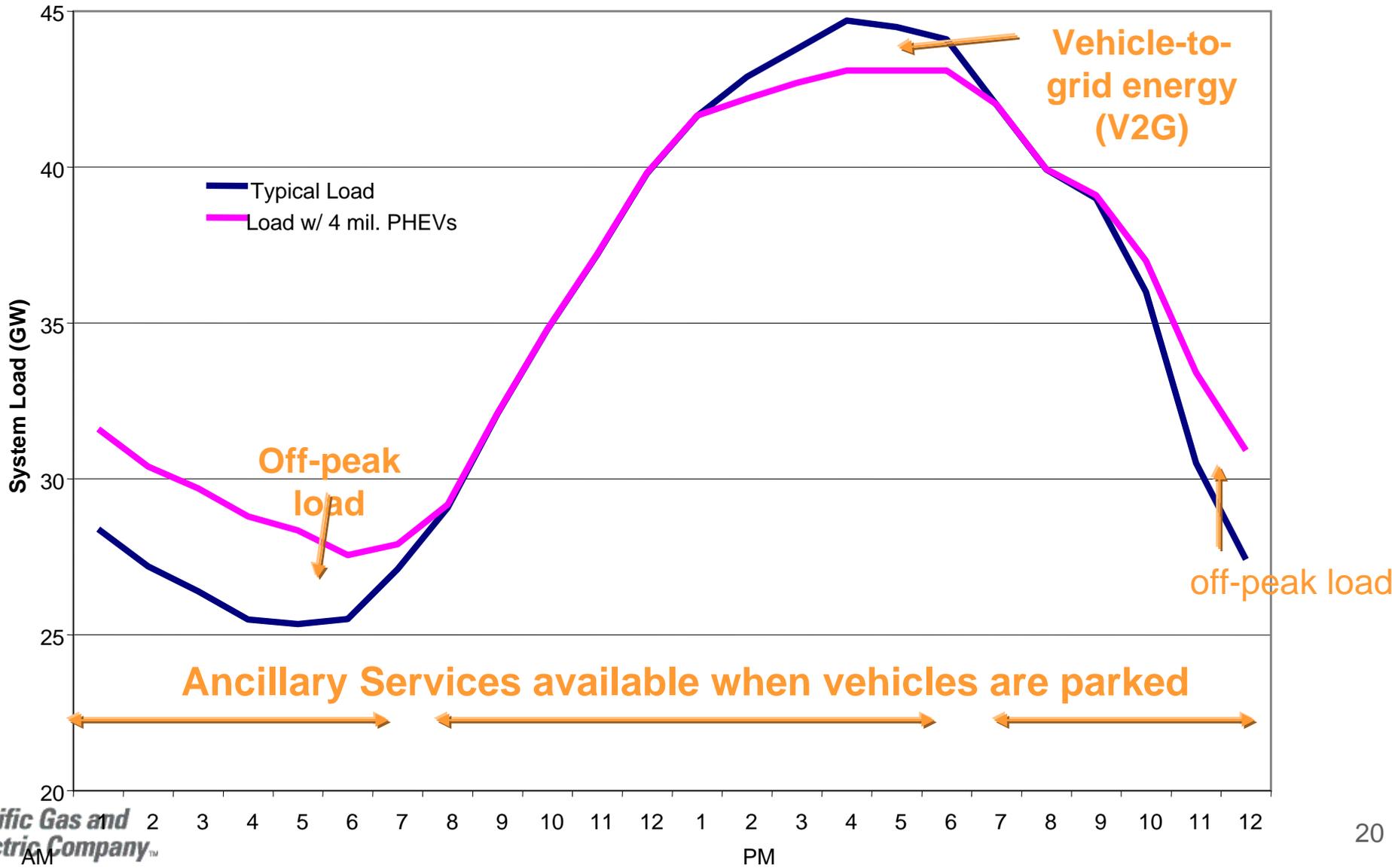


**First Commercial use of NAS battery in the US.  
(serving an office Building)**

# Flywheel Storage



# Plug Hybrid Electric Vehicles Complement Renewables



# Who owns energy storage?

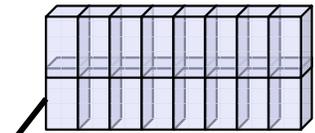
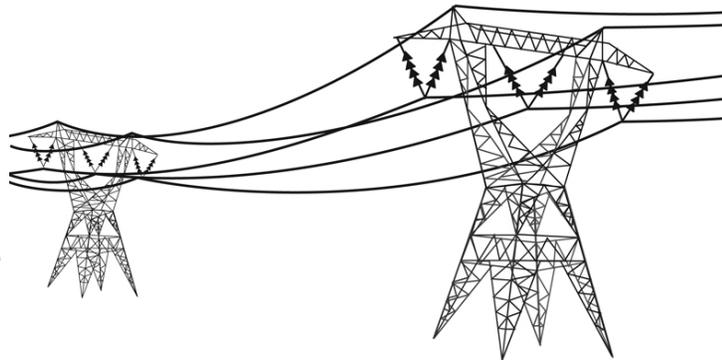
Wind Generation



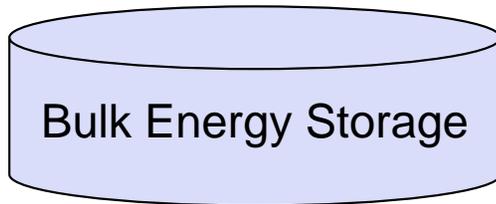
Rooftop PV



T&D Infrastructure



Local Storage



Bulk Energy Storage



End User