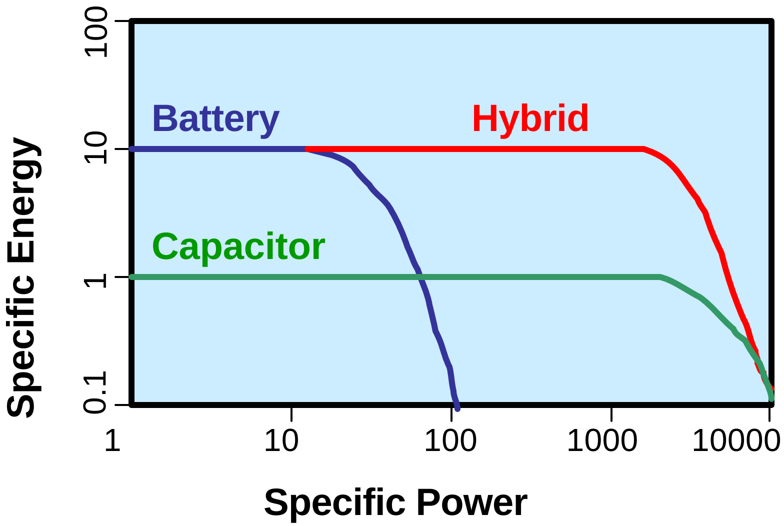
Hybrid Power Sources



OBJECTIVE:

- Develop a safe compact, light and longer lasting power source to meet future Marine Corps Mission requirements.

PAYOFF:

– Demonstrate state of the art man portable alternative power sources systems that can keep pace with growing power requirements caused by emerging C4I systems.

TECHNICAL CHALLENGES:

- Increase energy density of electrochemical double-layer capacitors.

TECHNICAL APPROACH:

- Employ nano- and meso- porous materials that display double layer and pseudo-capacitance (transition metal oxides).
- Develop asymmetric capacitors. Up to 4X capacitance of symmetric.
- Use organic electrolytes for 2X voltage
- Interface with high energy density zinc/air battery.

PERFORMERS: NSWC, Carderock

SCHEDULE:

	FY03	FY04	FY05
Metal Oxide Electrode Characterization			
Asymmetric Capacitor Development			
Zinc/Air Cell Reconfiguration			
Bat/Cap Hybrid Modeling			
Cap/Bat Hybrid Design and Test			

Electrochemical Capacitor

When an electric potential is applied between two identical electrodes immersed in an electrolytic solution, ionic species absorbed on the electrode surface are balanced by electronic charges in the electrode.

Symmetric Capacitor

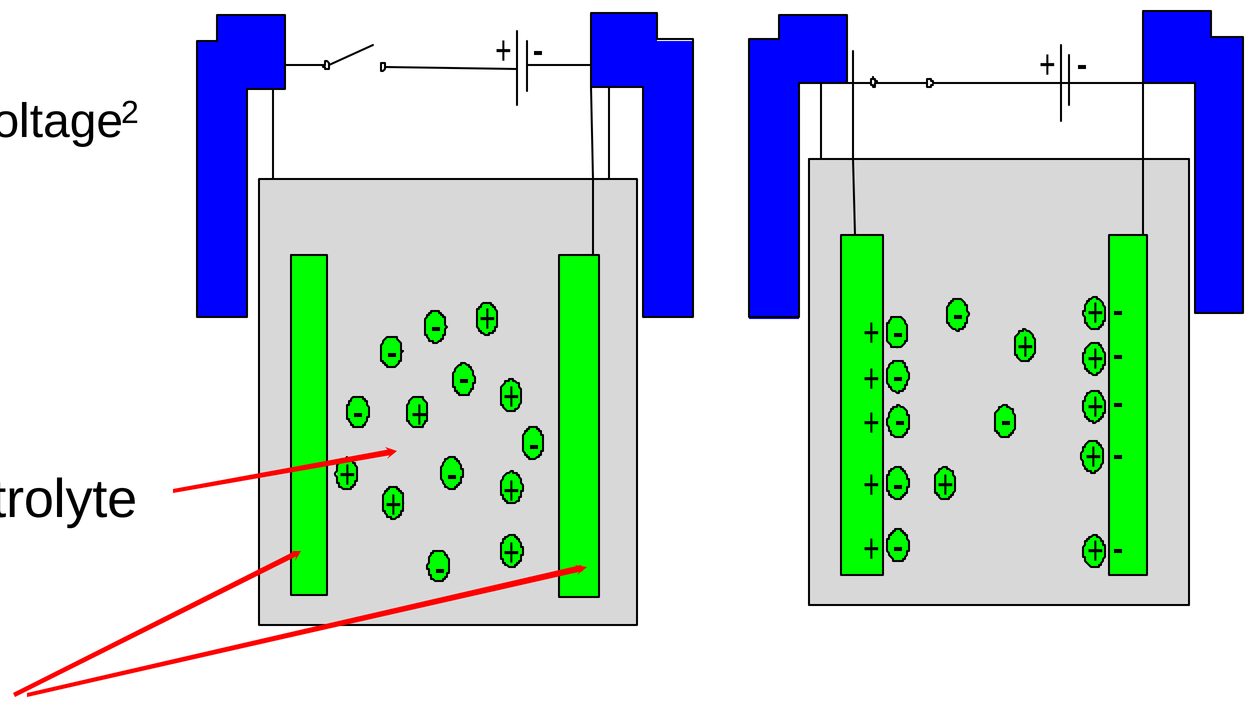
$E = ½ \text{ capacitance x voltage}^2$

$C = 1/C_A + 1/C_C$

Since $C_A = C_C$

$C = C_A/2$

$E_{Symmetric} = 1/4 C_A V^2$



Asymmetric Electrochemical Capacitor

- One electrode fabricated with high surface area carbon
- Other with highly porous, high surface area, metal oxide
  - Capable of faradaic (pseudo-capacitance) as well as non-faradaic behavior. Capacitance much greater.
- Voltage 2X symmetric (organic electrolyte)

Asymmetric Capacitor

E = ½ capacitance x voltage^2

$C = 1/C_a + 1/C_C$

But $C_c >>> C_a$

Therefore, $C = C_A$

$E = ½\, C_A\ [2V]^2$

$E = 2C_AV^2$

8X the Energy!

Symmetric Capacitor

E = ½ capacitance x voltage^2

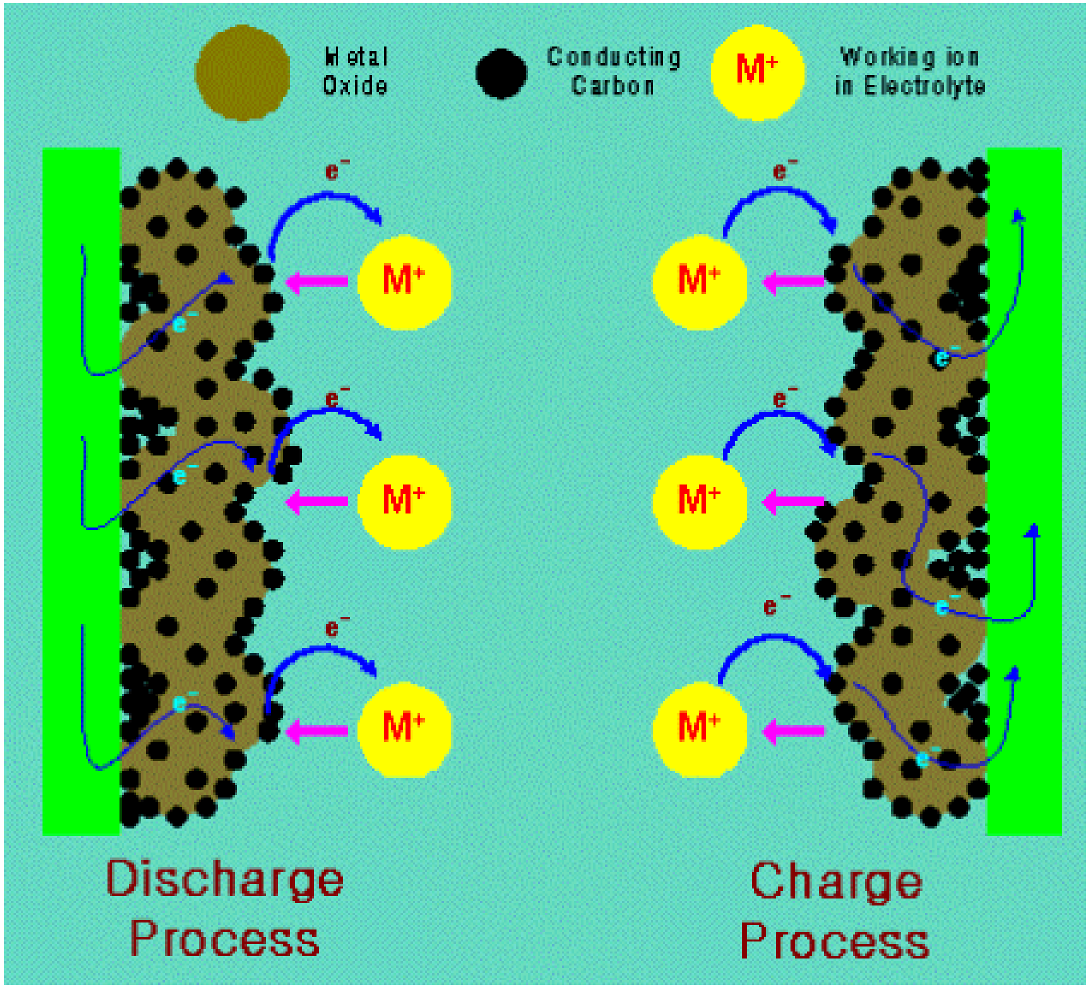
$C = 1/C_A + 1/C_C$

Since $C_A = C_C$

$C = C_A/2$

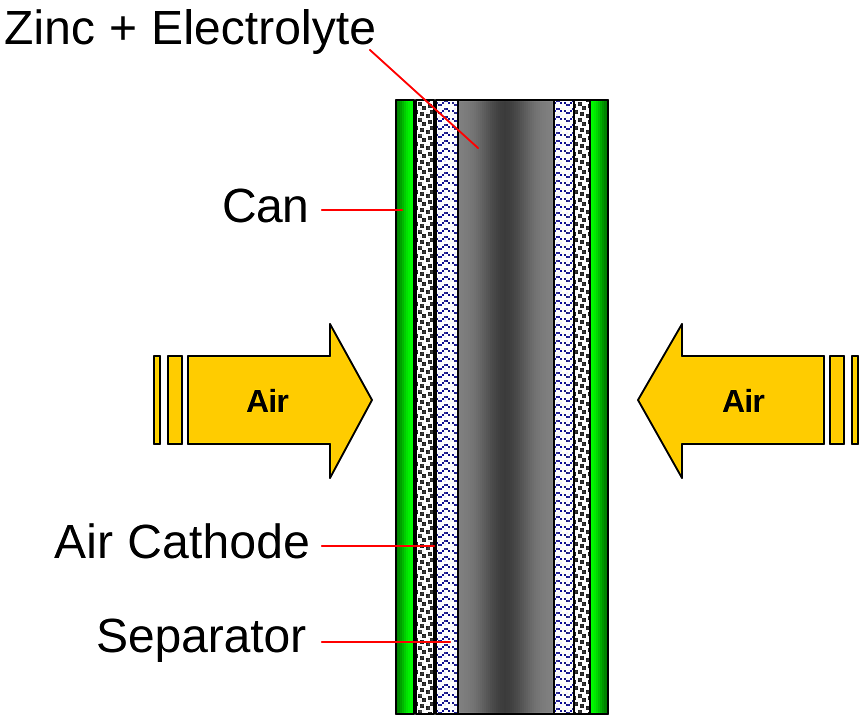
$E = 1/4C_AV^2$

PseudoCapacitance
(Surface-Redox Type Processes)



Zinc/Air

Cylindrical Cell



Electrochemistry

Anode $Zn + 2OH^- \leftrightarrow ZnO + H_2O + 2e^-$

Cathode $1/2O_2 + H_2O + 2e^- \leftrightarrow 2OH^-$

Cell $Zn + 1/2O_2 \leftrightarrow ZnO$

Theoretical Voltage: 1.65 V

Nominal voltage: 1.4 - 1.2 V

Advantages

- High energy density (250 Wh/Kg,) compared to present Li/SO_2 (175 Wh/kg)
- Inexpensive
- Good safety record