Maxwell™ TECHNOLOGIES

The Ultracapacitor Company

How To Use an Ultracapacitor?

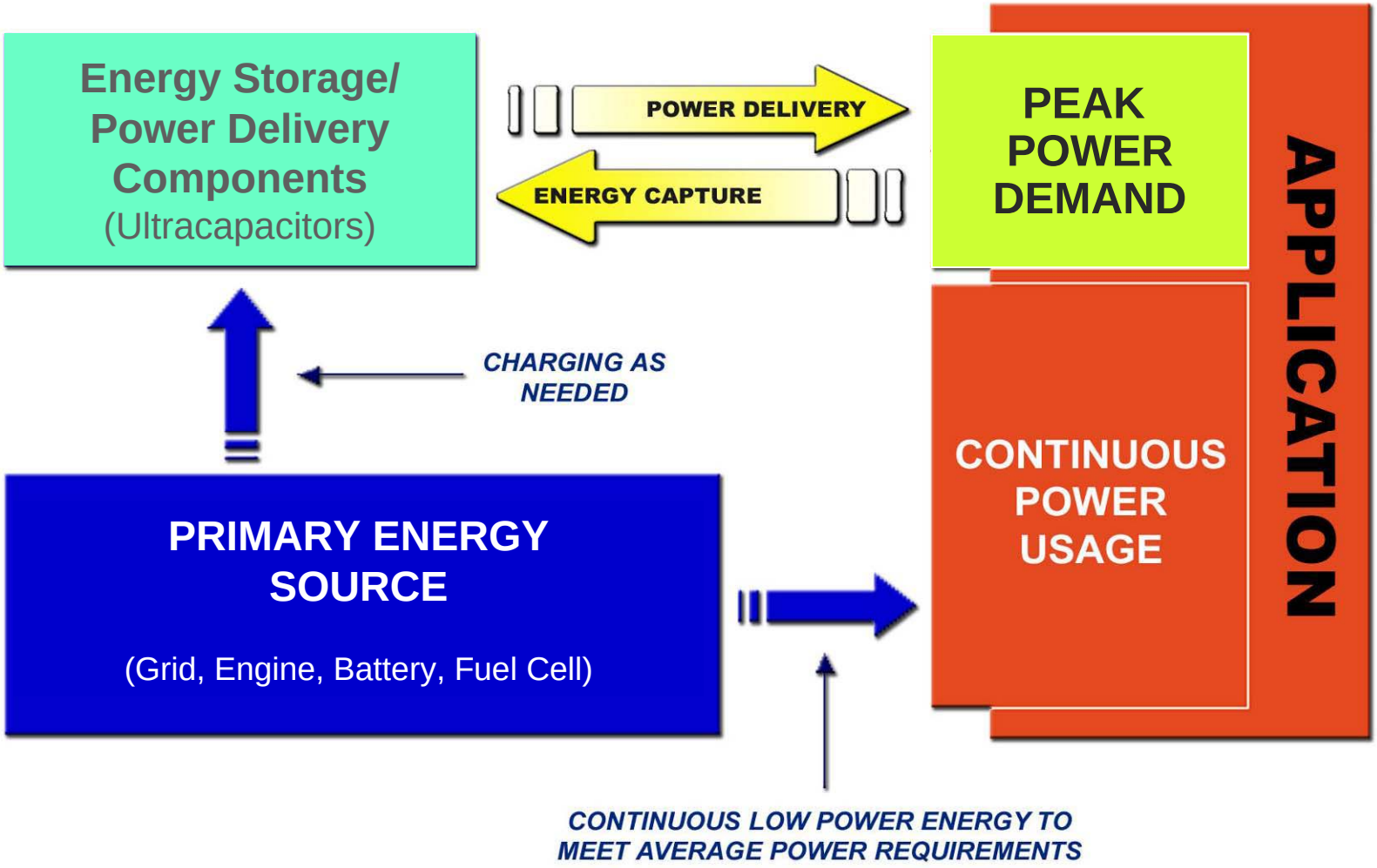
Peak power needs

- Ultracapacitors are used in tandem with batteries for systems that require both a constant low power discharge for continual function and a pulse of power for peak loads
- Ultracapacitors relieve batteries of peak power functions, resulting in an extension of battery life and/or a reduction of overall battery size
- Ultracapacitors provide high-power pulses in power-intensive systems

Temporary backup power

- Until recently, batteries were the only source of backup power
- Ultracapacitors are alternatives to batteries in applications where the ultracapacitor is charged from the primary power supply, but functions as a backup power source when the primary source fails.
- Short duration high power, or long duration low power bridging applications are served by ultracapacitors

Ultracapacitor Application Model



Technology Position

Available Performance	Lead Acid Battery	Ultracapacitor	Conventional Capacitor
Charge Time	**1 to 5 hrs**	**0.3 to 30 s**	**10^{-3} to 10^{-6} s**
Discharge Time	**0.3 to 3 hrs**	**0.3 to 30 s**	**10^{-3} to 10^{-6} s**
Energy (Wh/kg)	**10 to 100**	**1 to 10**	**< 0.1**
Cycle Life	**1,000**	**>500,000**	**>500,000**
Specific Power (W/kg)	**<1000**	**<10,000**	**<100,000**
Charge/discharge efficiency	**0.7 to 0.85**	**0.85 to 0.98**	**>0.95**

Performance - Comparison

Type of cell	Energy density [Wh/kg]	Power density [W/kg] (matched)	Time constant [s]	Weight [kg]	ESR [mOhm]	Loss @ 100A [W]
Li Ion Power	67	**1'811**	67	0.37	**6**	**60**
Li Ion Energy	150	664	407	1.07	5.6	56
BCAP0650	6	**25'700**	0.4	0.18	**0.6**	**6**

Li Ion reference: SAFT

Voltage & Current vs. Time

C = 15 farad; R_{esr} = 100 milliohm
V_o = 48V; I = 30A