Energy Efficiency
Environmentally Friendly Distributed Resources
Energy Storage Battery
Pulse Power Nickel Metal Hydride

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Electro Energy, Inc.

Funded By:
US Department of Energy / Energy Storage Research
Through Sandia National Laboratories

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DOE Program Overview

- Market Study and Assessment
- Ni Metal Hydride Core Cell Development
- Two Formation Studies
- Fabrication of 50v Modules
- Manufacturing Process Development
- Program Management

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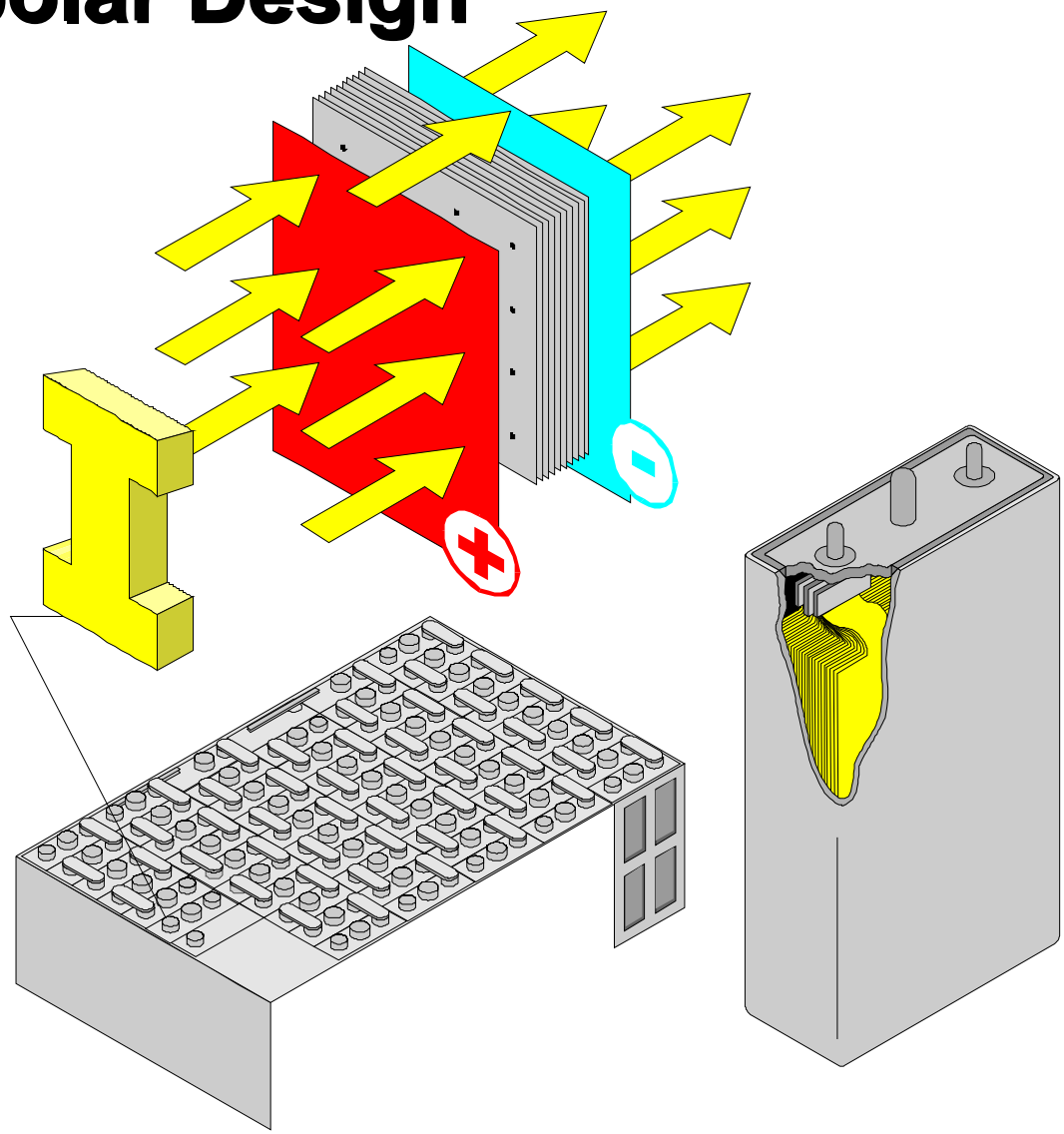
Advantages of EEI Nickel Hydride Wafer Bipolar Design

- Each cell individually sealed
- Scaleable to large area, capacity, high voltage
- Compatible with plastic bonded electrodes
- Automated flexible manufacturing
- Improved energy and power density
- Lower cost



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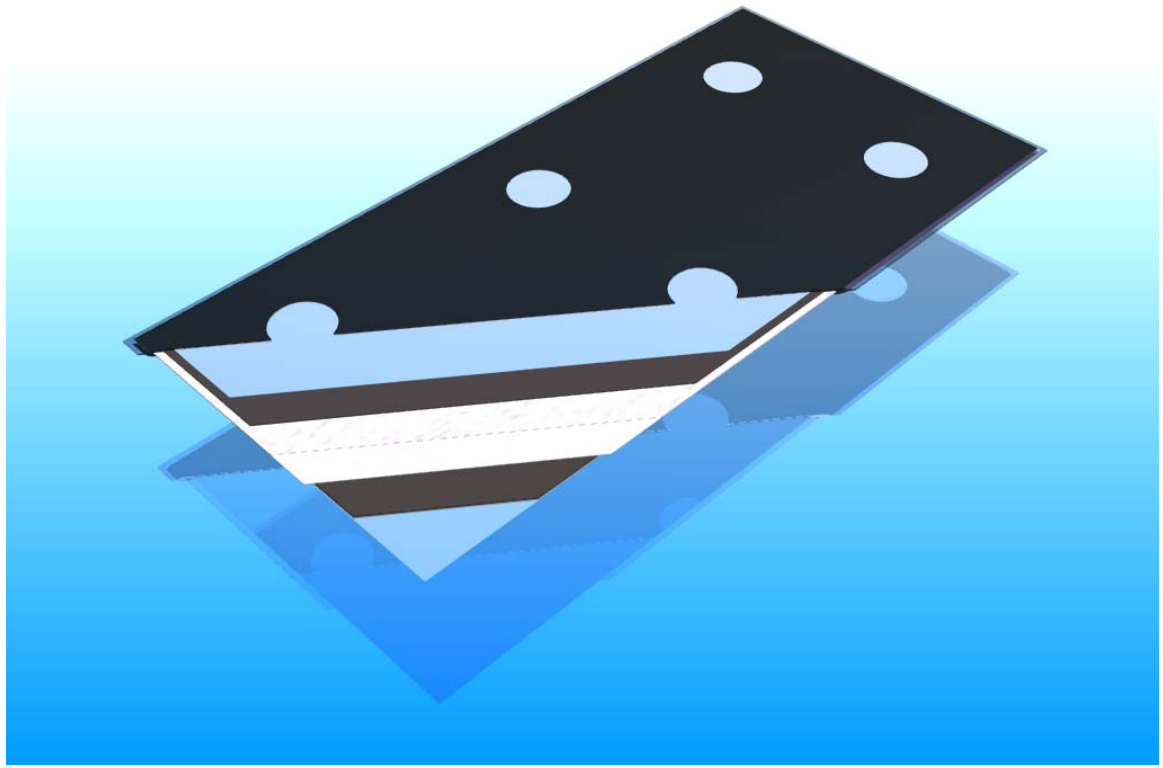
Wafer Cell



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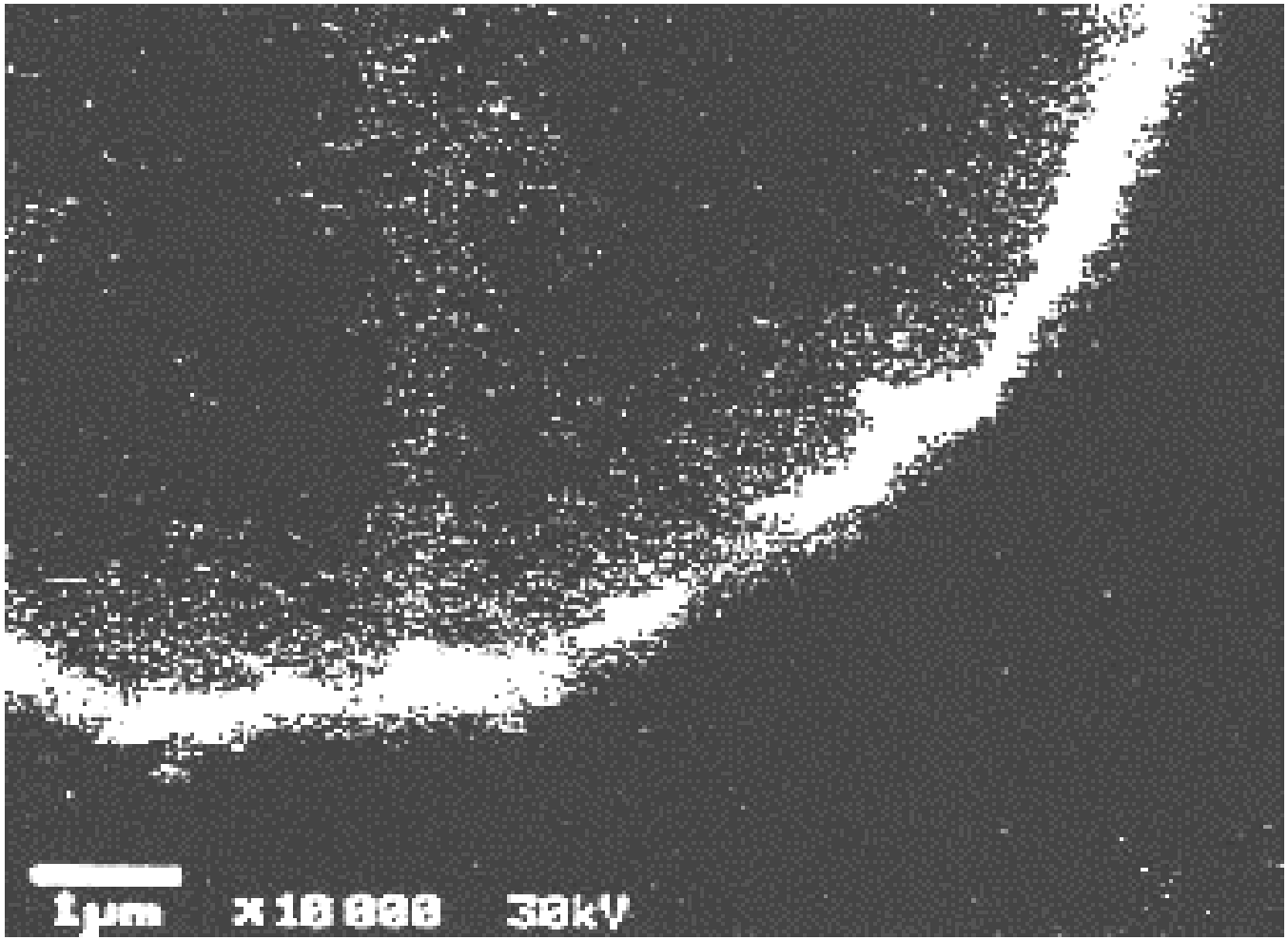
Coated Nickel Hydroxide



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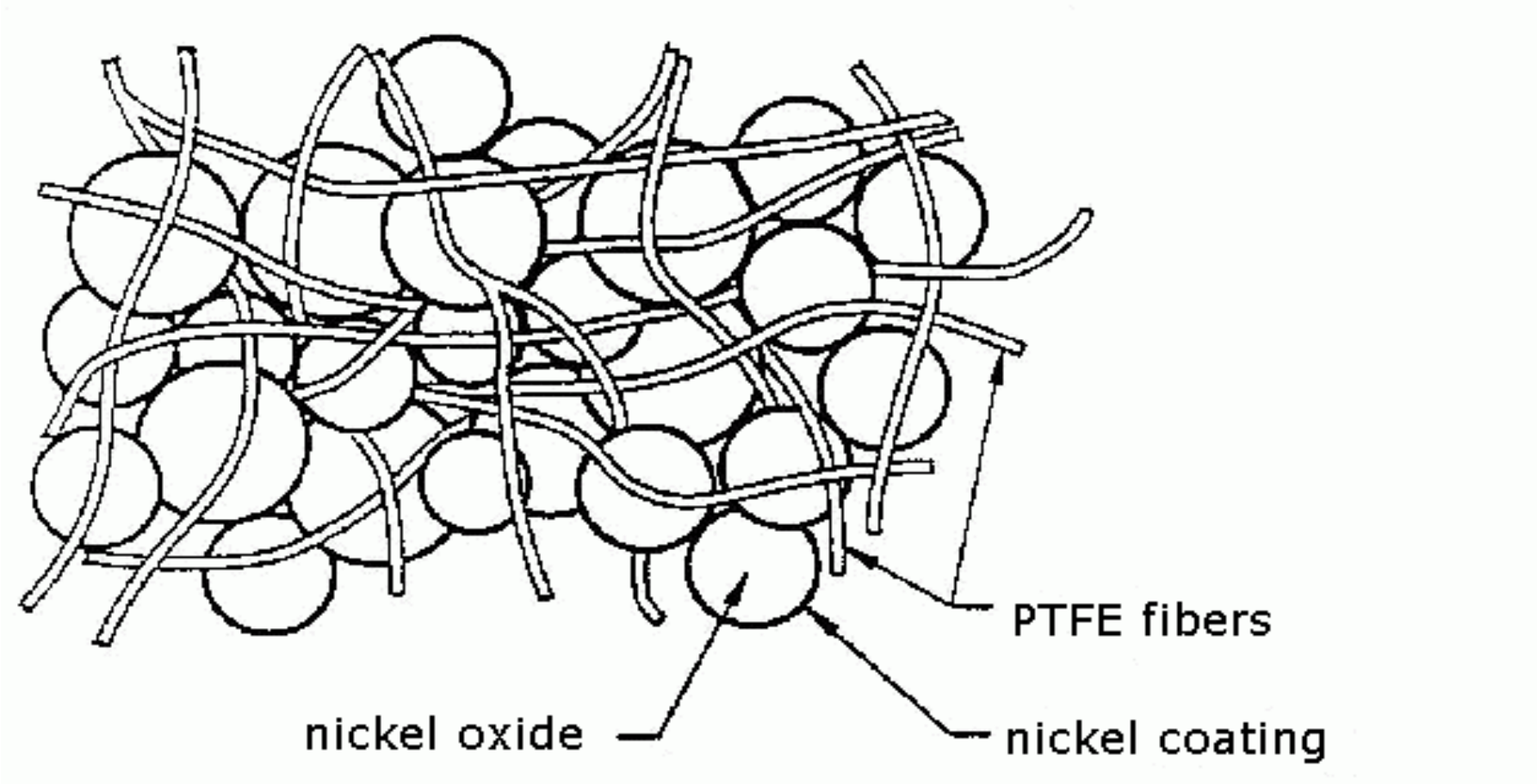
Fibrillated Teflon



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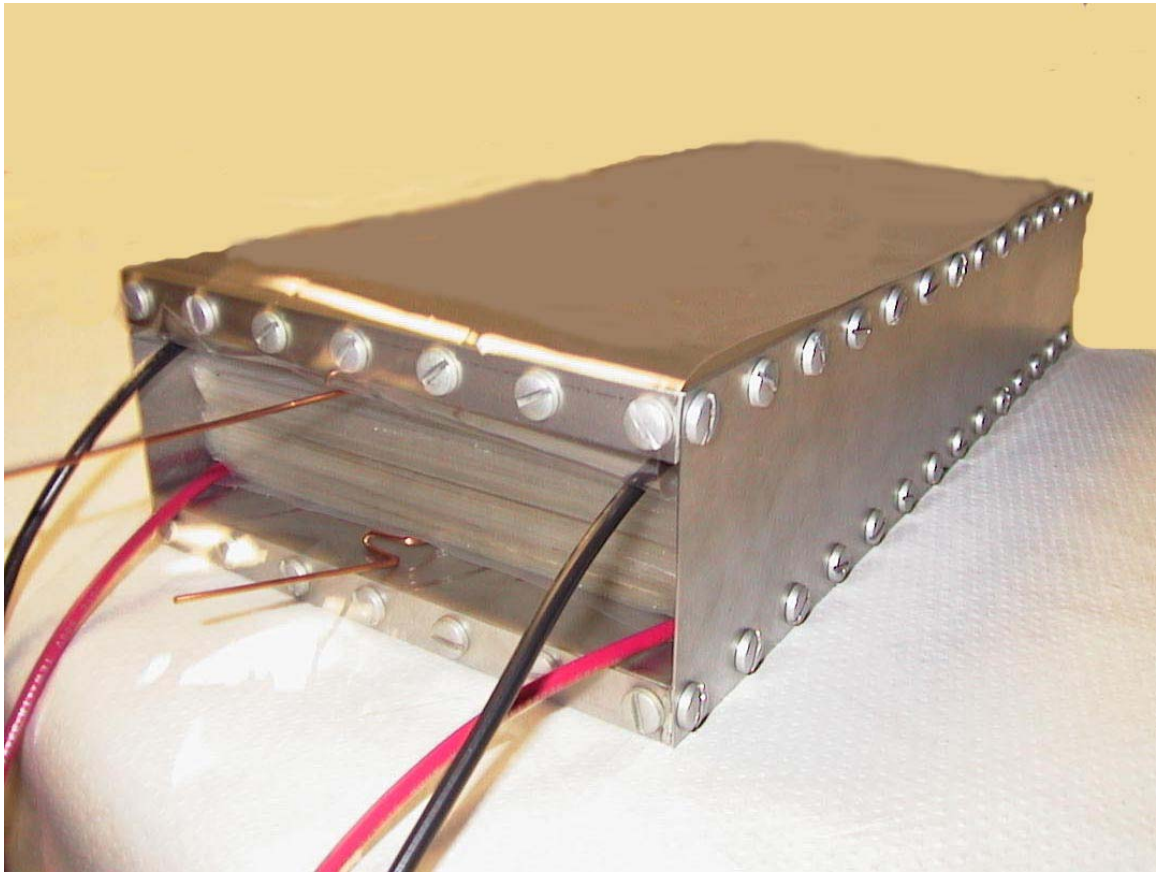
50 Volt Battery



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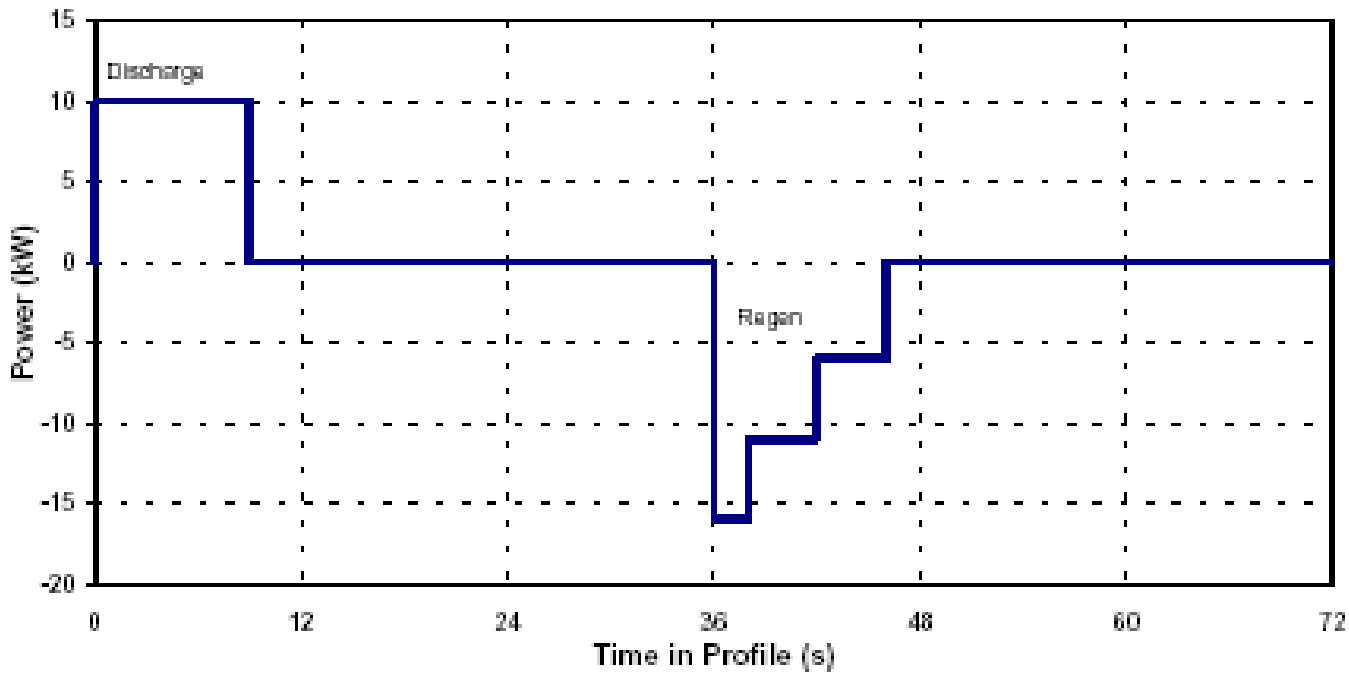
Power Assist Hybrid Vehicle Life Cycle



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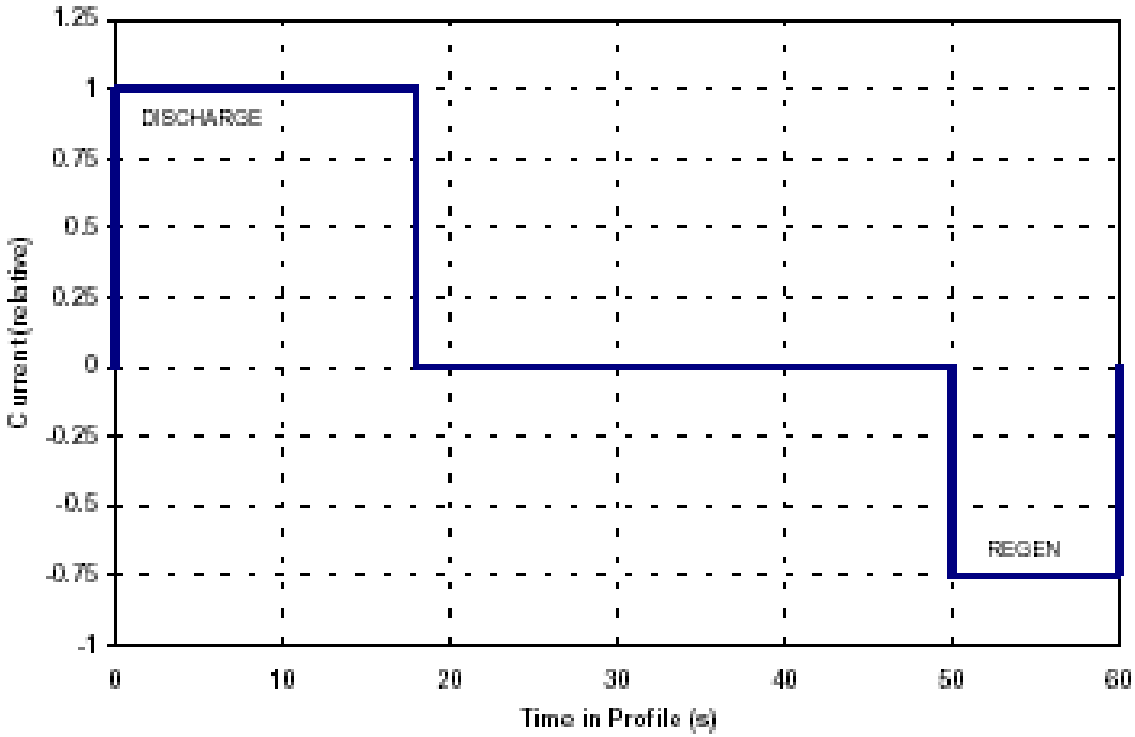
High Pulse Power Characterization Profile



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Power Performance of HV223 Cell Series

Cell ID	# cycles	BSF	Ea (kWh)	P-dis (kW)
HV223-01	300341	328.5	0.300	25.00
HV223-02	300217	347.0	0.300	25.00
HV223-03	300791	313.5	0.300	25.00
HV223-04	300791	362.3	0.301	25.00
HV223-05	300844	313.8	0.300	25.00
HV223-06	300748	284.5	0.300	25.00
Targets	300000	-	0.300	25.00

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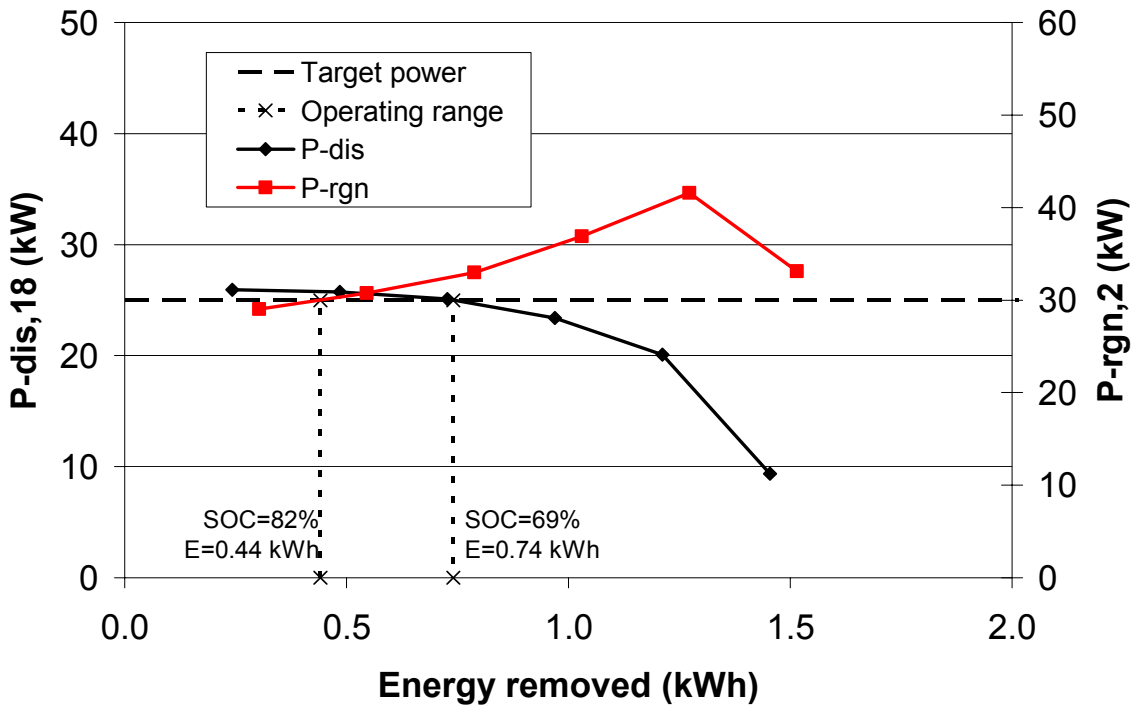
Hybrid Vehicle Analysis



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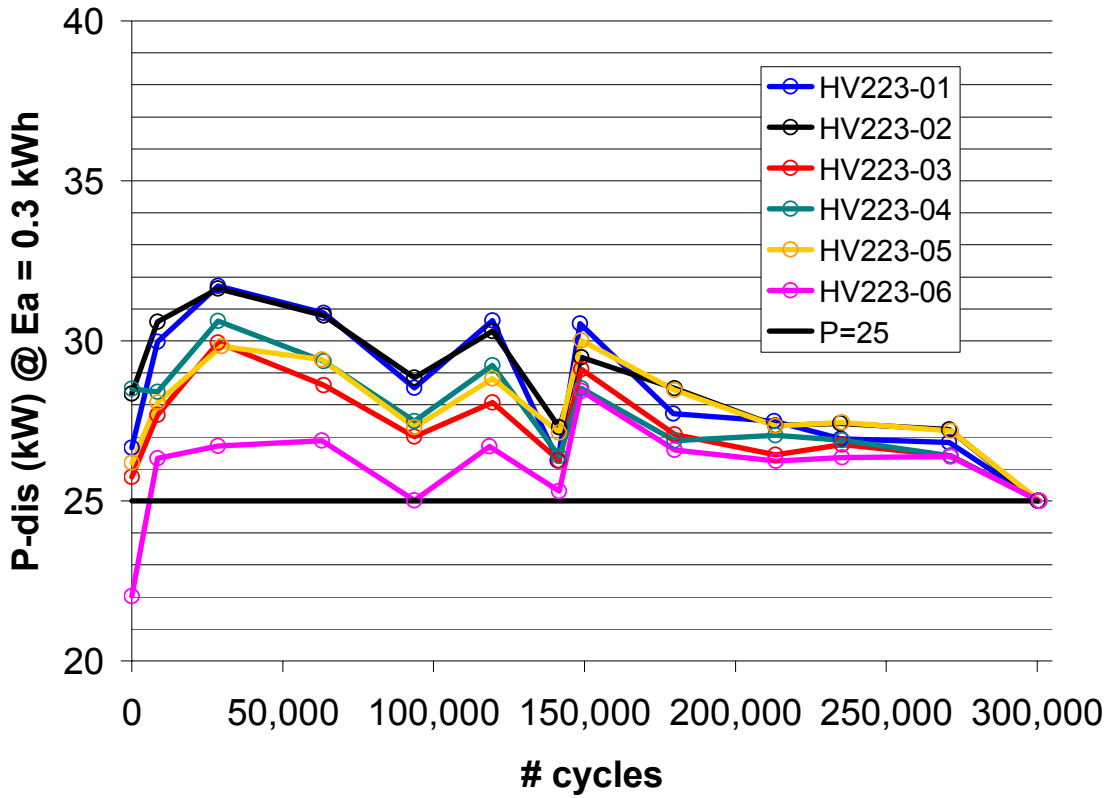
Hybrid Vehicle
Energy/Power Crossover vs. Life



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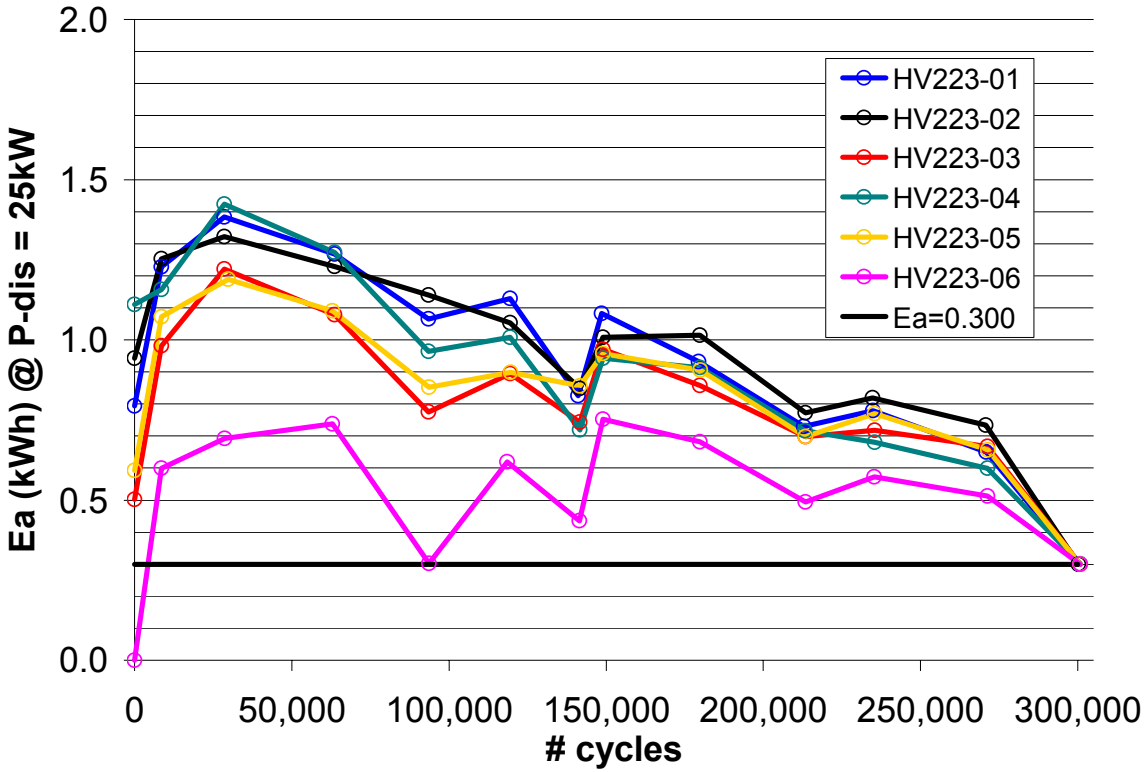
Energy Fade vs. Life



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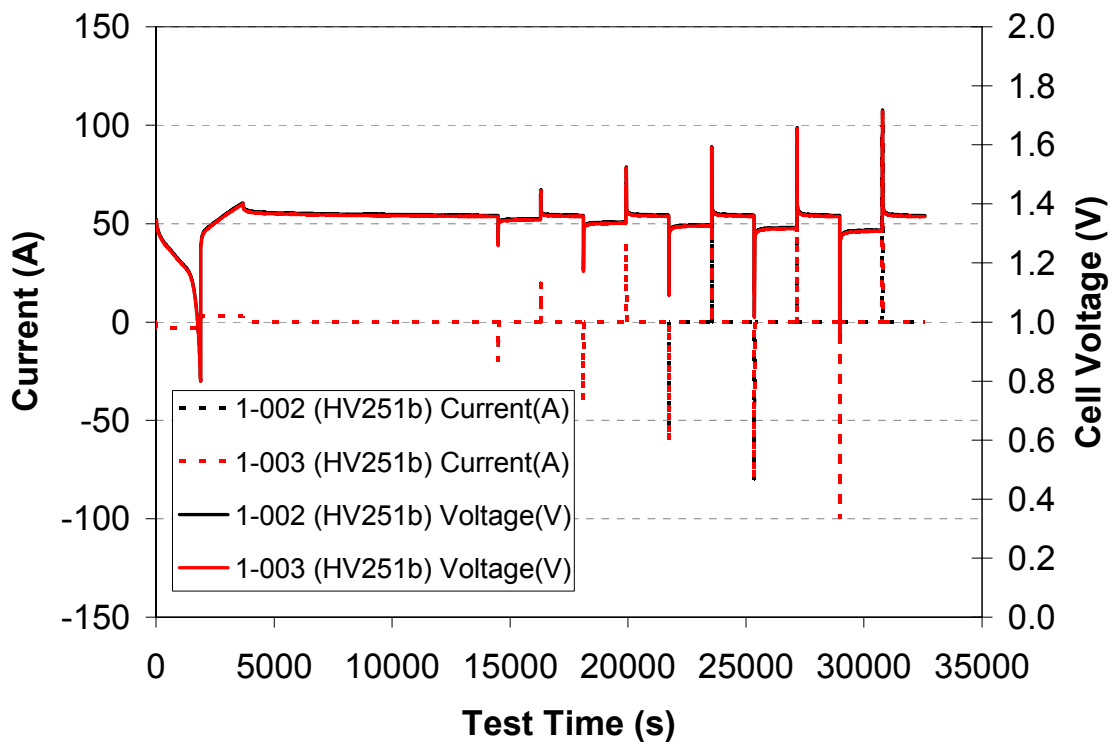
10 Second Power Test



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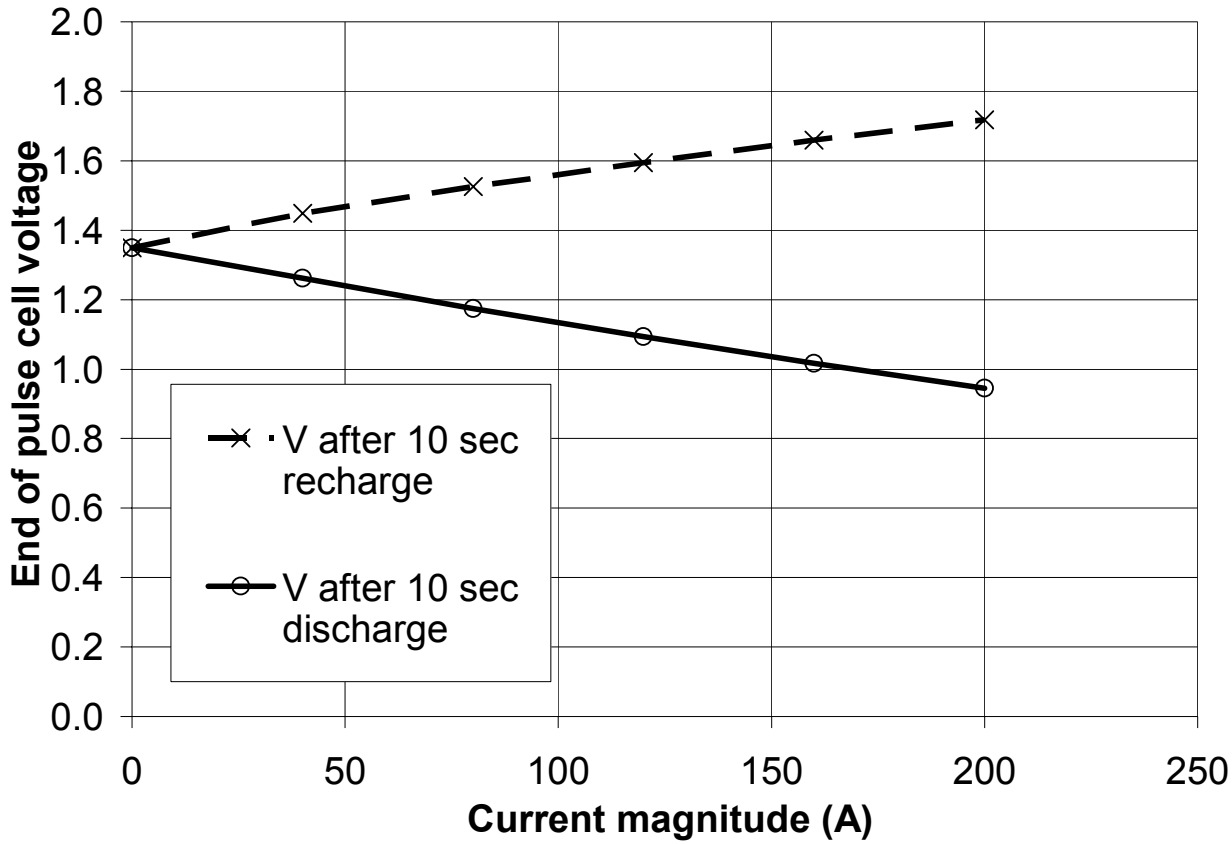
50% SOC 6Ah Cell



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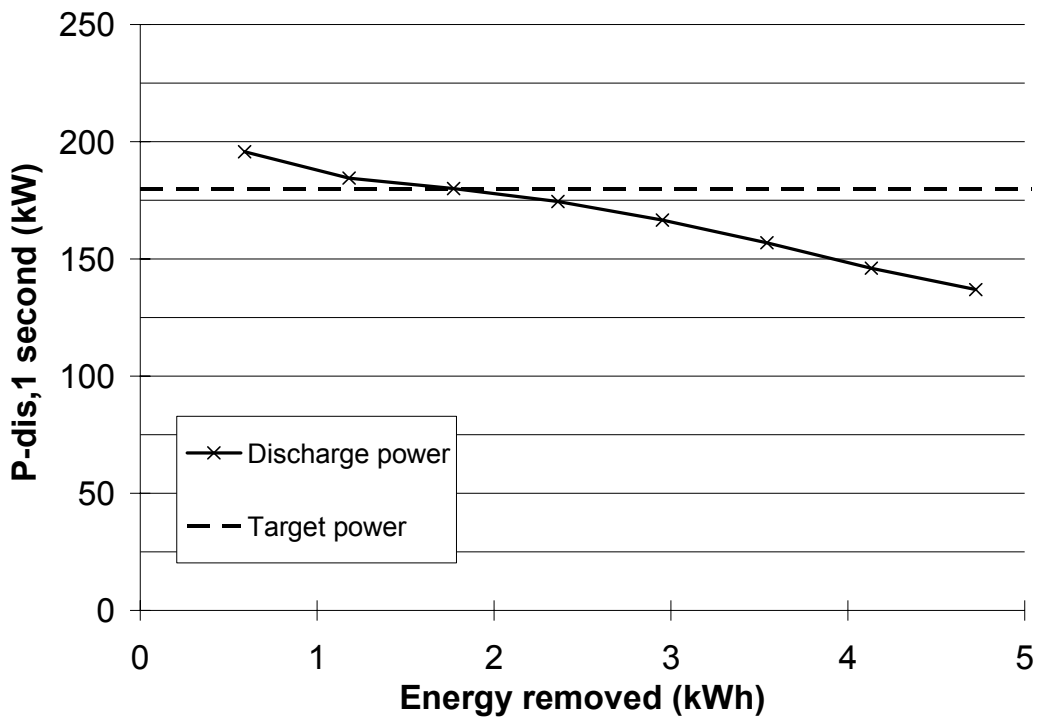
Power vs. SOC relationship. Scale factor used is 800.



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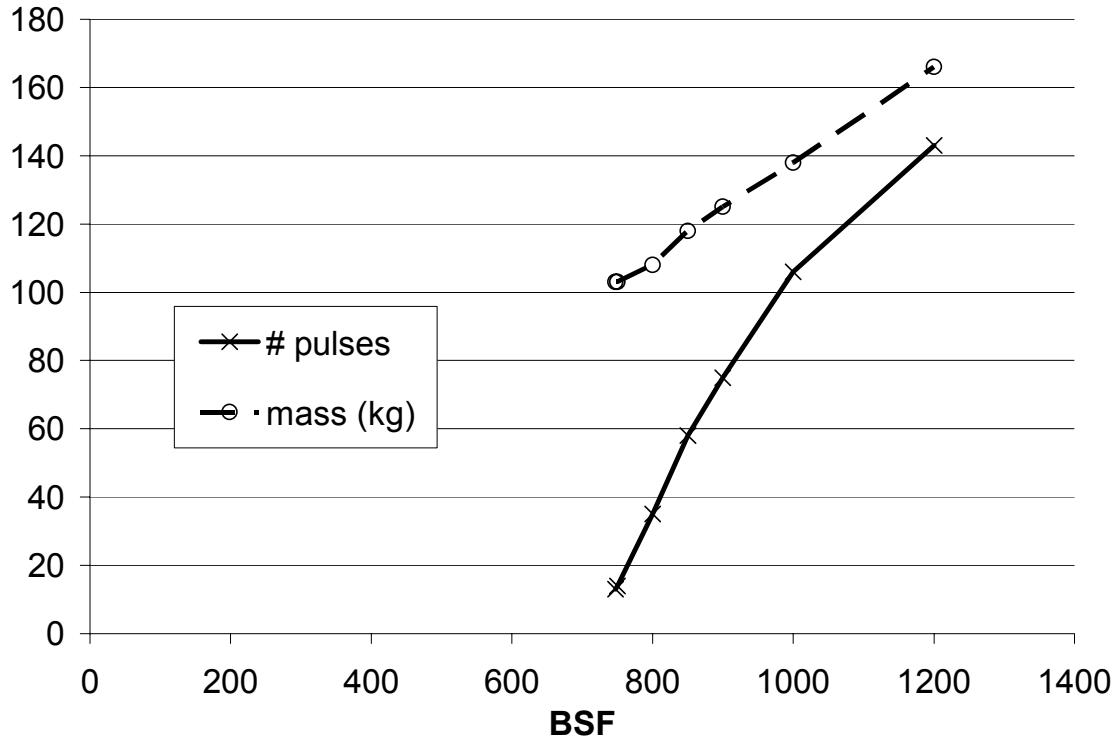
Battery Size vs. Number of Available Pulses



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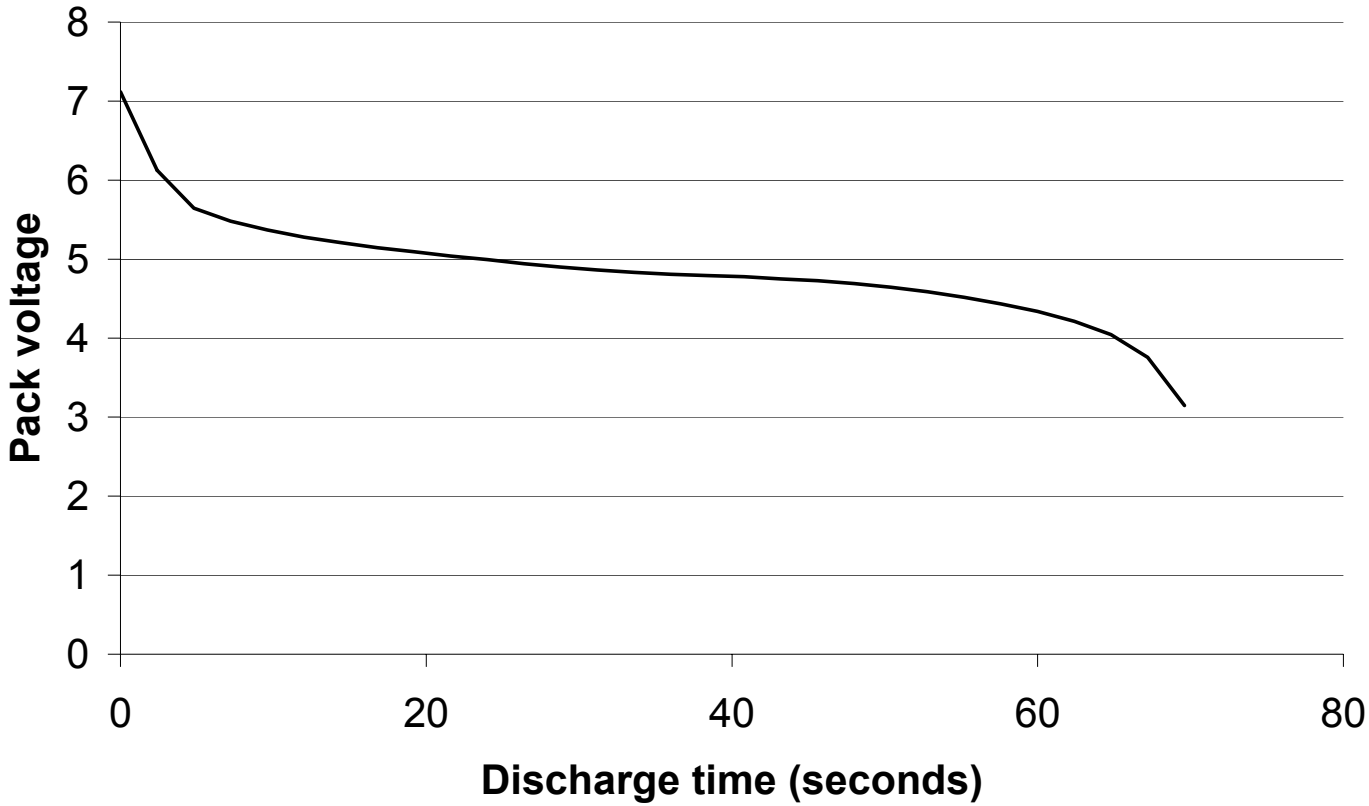
Discharge trace of 5 cell pack PK119 at 35 A (35 C rate).



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Performance characteristics of cell pack PK119

Discharge current (A)	74.4
End-of-discharge voltage	5.6
Discharge power (W)	416.6
Discharge CD (mA / cm^2)	320
Discharge capacity (Ah)	0.02
DOD (%)	2.0
Stack dimensions	7” x 7” x 0.060”
Stack volume (cc)	48
Stack weight (g)	140
Power density (kW / kg)	2.98 2 mil foils
Power density (kW / L)	8.68

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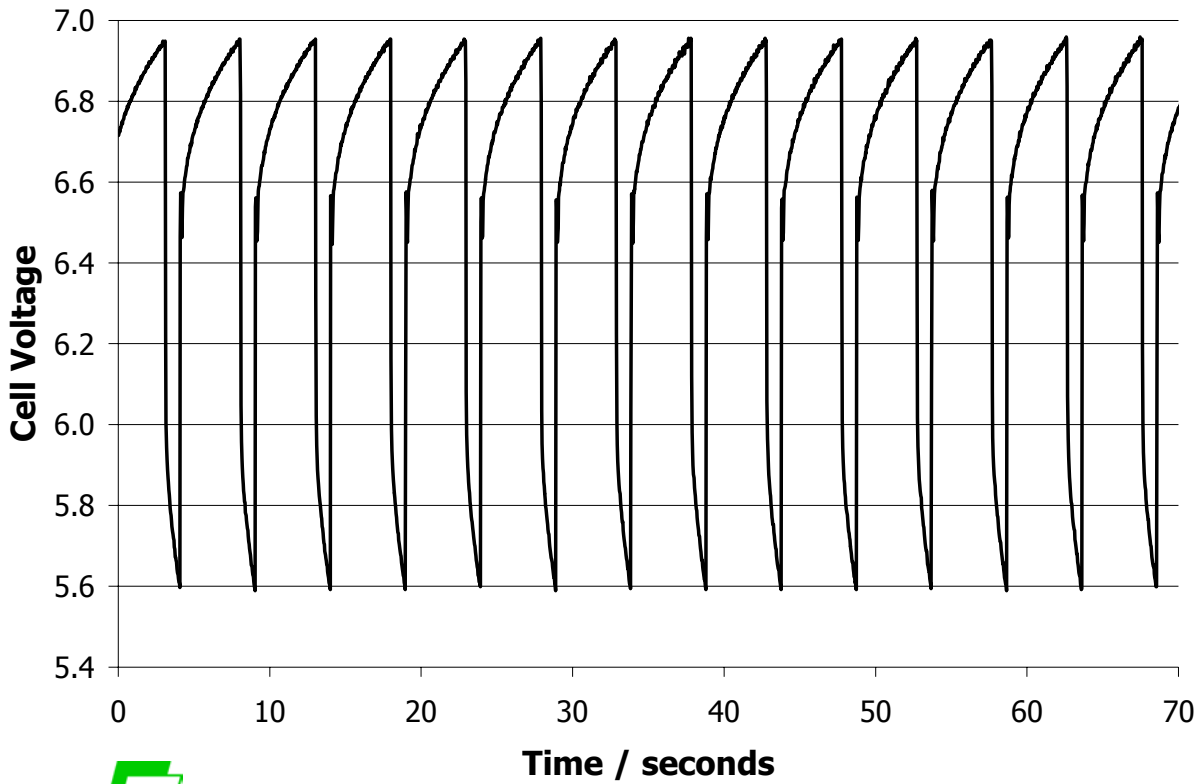
Life cycling performance of cell pack PK119



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Battery Design to Deliver 180 kW One-second pulses

Targets

P discharge (W)	18000
V minimum on discharge	500
1 discharge (A)	360
Measured Values	
OCV (V)	1.357
V-1 sec (V)	1.04
R-dis, 1 sec at 1-dis=200	0.0015
A (ohm)	85
Calculated Values	
Assumed per-cell Vmin	0.95
1-pred, single cell unscaled (A)	256.78
P-pred, single cell unscaled (W)	243.94

Scaled Values

Battery scale factor	737.87
Area scale factor	1.402
Electrode area (in^2)	100.9
# cells	526.3
Battery mass (kg)	102.1
Battery volume (1)	51.06
Power density (kW / kg)	1.76
Power density (kW / L)	3.53
Battery capacity @ C-rate (Ah)	8.40
Battery V @ C-rate, 1.25 V per cell	658
50% E (kWh)	2.77
# pulses to 50@	55

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The authors would like to thank the United States Department of Energy, United States Navy, NAVAIR, United States Air Force, AFRL, Ballistic Missile Defense Organization, Partnership for a New Generation of Vehicles, for their sponsorship, skepticism and criticism