



Modular LFP Batteries for Large Format Applications

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K2 Energy Solutions



- Est. 2006
- Headquarters in Henderson, NV
 - Sales & Marketing
 - Research & Development
 - Prototype & pack production
 - 2010: Wound & Prismatic Pilot line & EV production
- Shanghai China (*partnered with DLG Battery Co.*)
 - Cylindrical cell manufacturing (6MWh/month capacity)
 - ISO 9001:2000 certified
- Varkaus, Finland (*partnered with European Battery*)
 - Large-format cell manufacturing (~12MWh/month capacity)
 - Facility on-line, mid-2010

K2 Li-ion Batteries in Large Format Applications

- Focused on LFP chemistry due to safety, cycle life, and cost.
- Large format (>125Wh) cells in development, manufacturing capacity is in 26650EV & 26650P cells.
- K2 batteries are currently in >90 EDV's world-wide
- What is the best strategy for fabricating large batteries from small cylindrical cells?

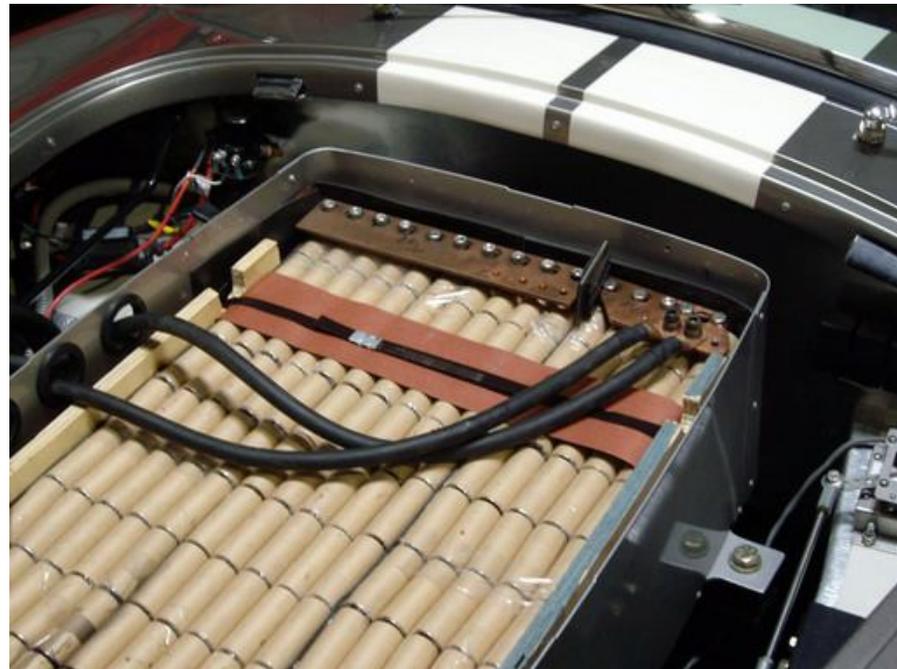


Shelby Cobra EV – a “monolithic” approach

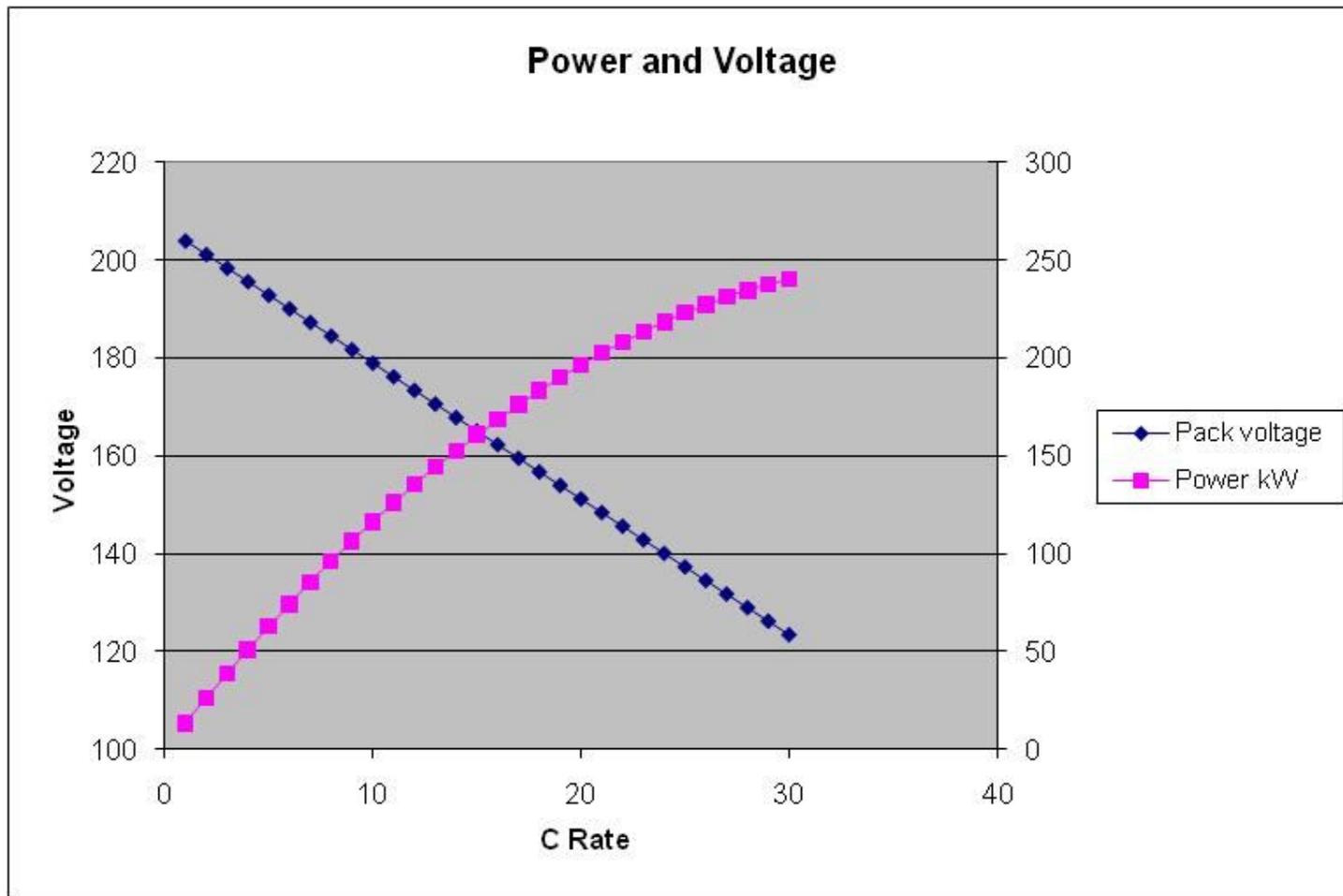


Shelby Cobra EV specifications

- Battery:
 - 1375 LFP26650P cells, configured as 66s25p
 - Split into two packs connected in series
 - 225V, 14kWh battery
- Motor:
 - TransWarP 9
 - 300 HP @ 225V
 - 1000 ft-lbs at 0 rpm
- Car
 - 0-60 mph in 3.2 sec
 - 40 to 60 mile range



Shelby Cobra EV Battery Performance



GM Hummer H2 EV



GM Hummer H2 EV Batteries

Main battery:

- 154 V, 20 kWh
- 86 kW max power
- 1920 LFP26650EV cells, 48s40p

Booster battery:

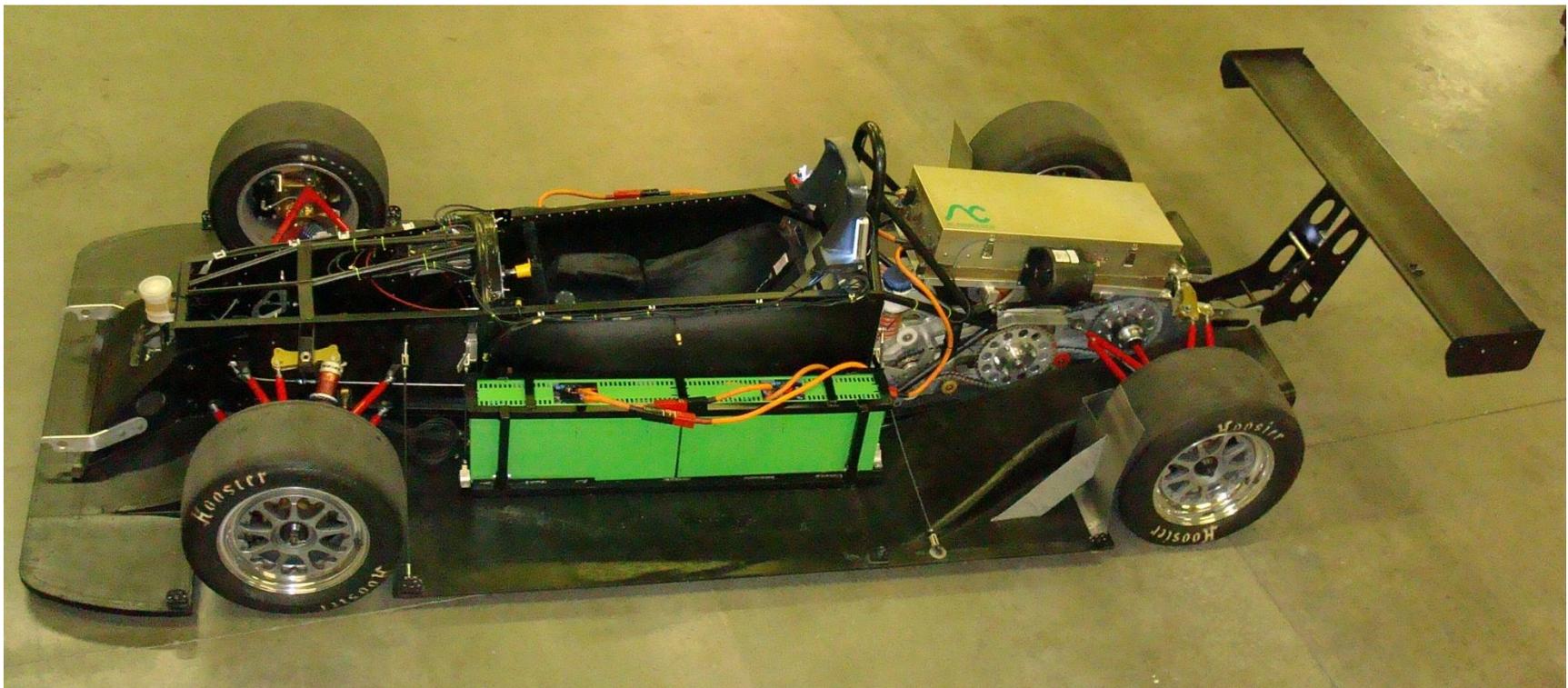
- 154 V, 4.8 kWh
- 72 kW max power
- 576 LFP26650P cells, 48s12p



Issues with “Monolithic” batteries

- Large, monolithic batteries tend to be customer-specific.
 - Each battery requires redesign of cell arrangement, interconnections, and BMS.
 - Welding fixtures typically not economical
 - Large batteries create shipping and other logistical issues
 - Maintenance is difficult
 - Difficult to delineate warranty responsibilities

Formula I EV



Formula I EV



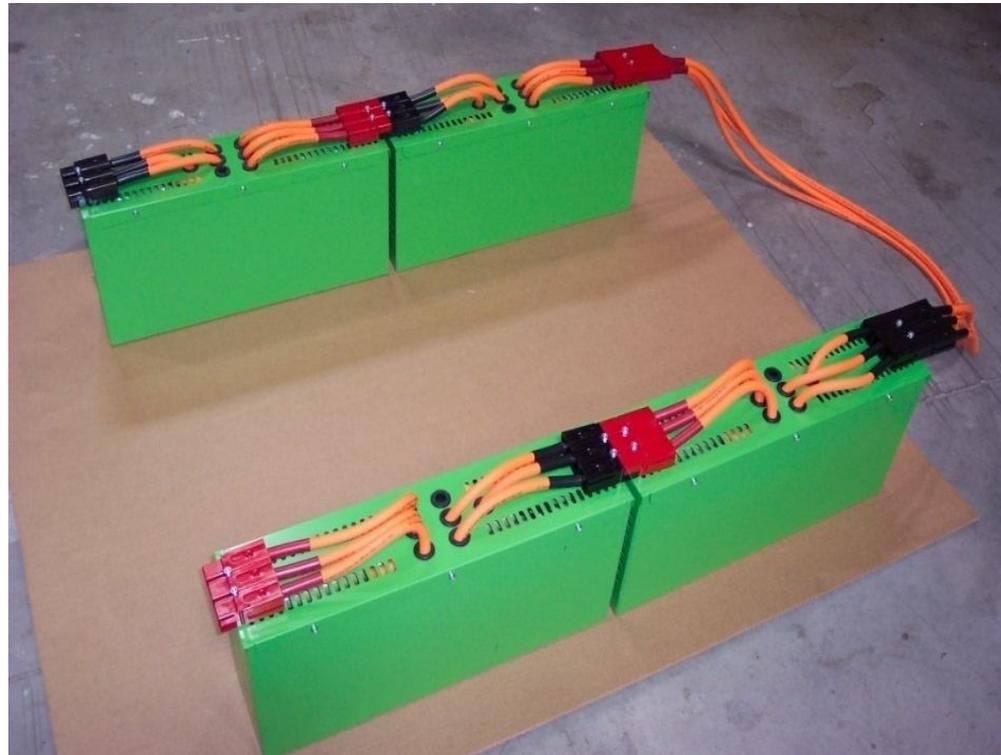
Battery:

Four modules

384 V

8 kWh

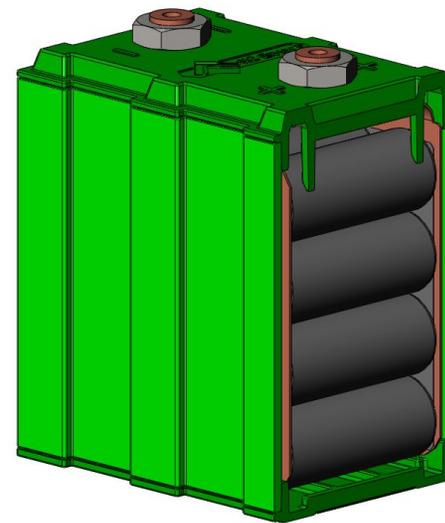
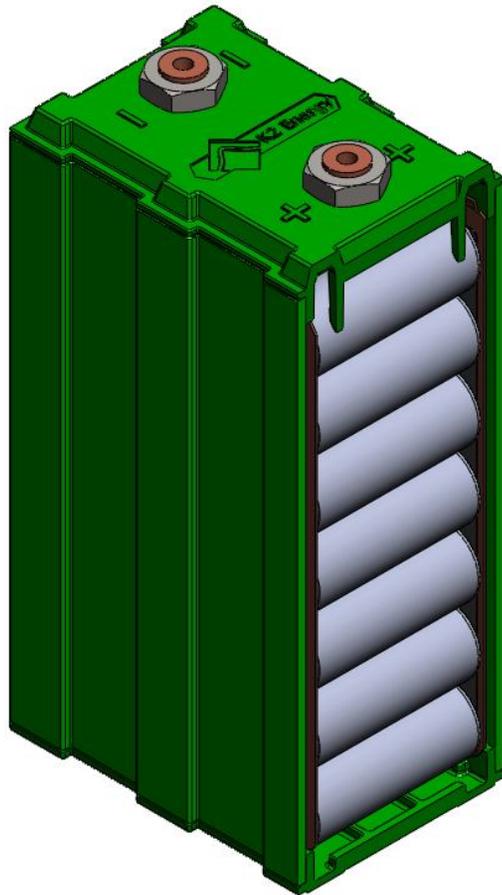
192 kW



Solution: Modular batteries



K2 Modular 3.2V Batteries



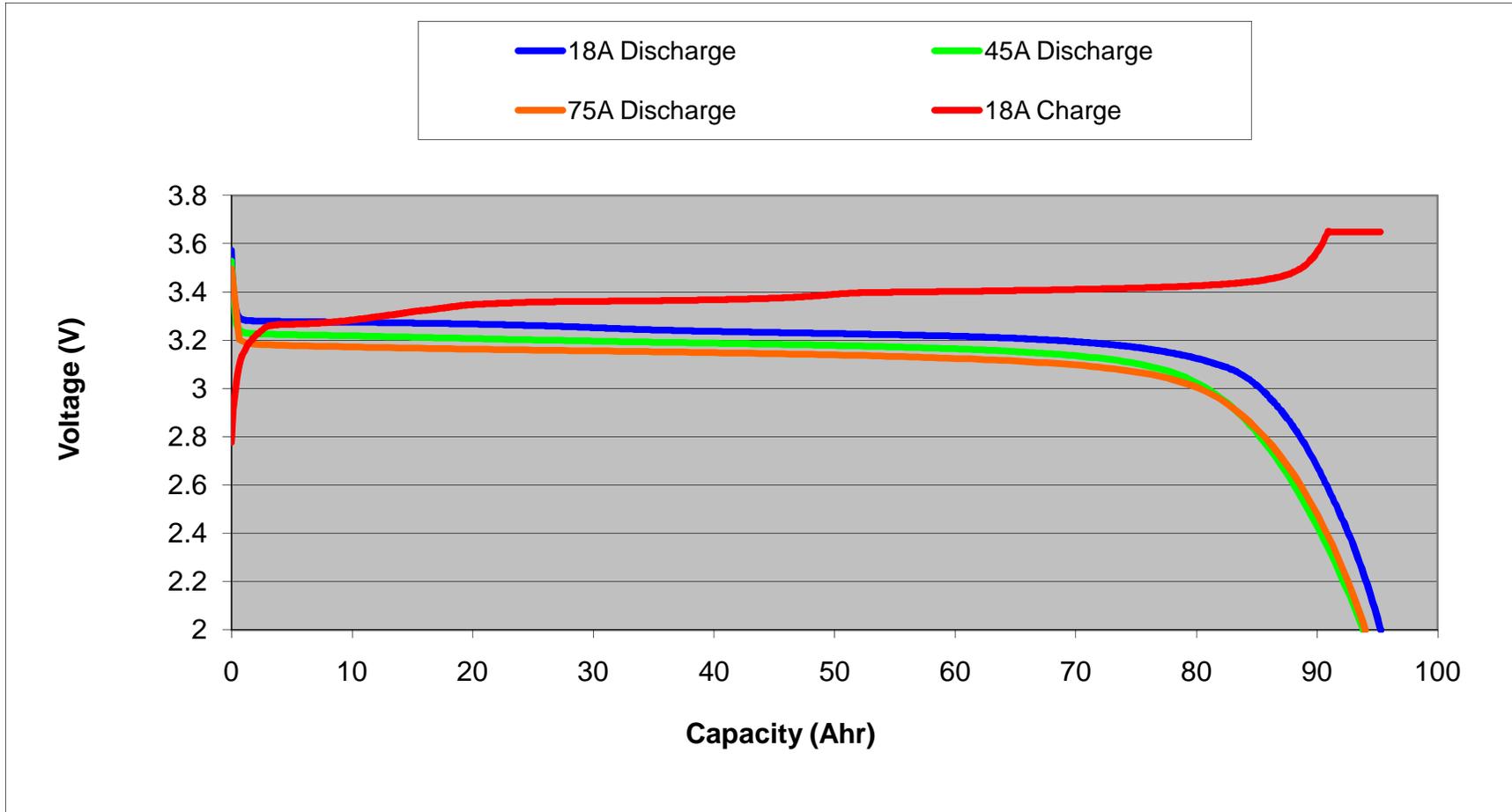
Module specifications



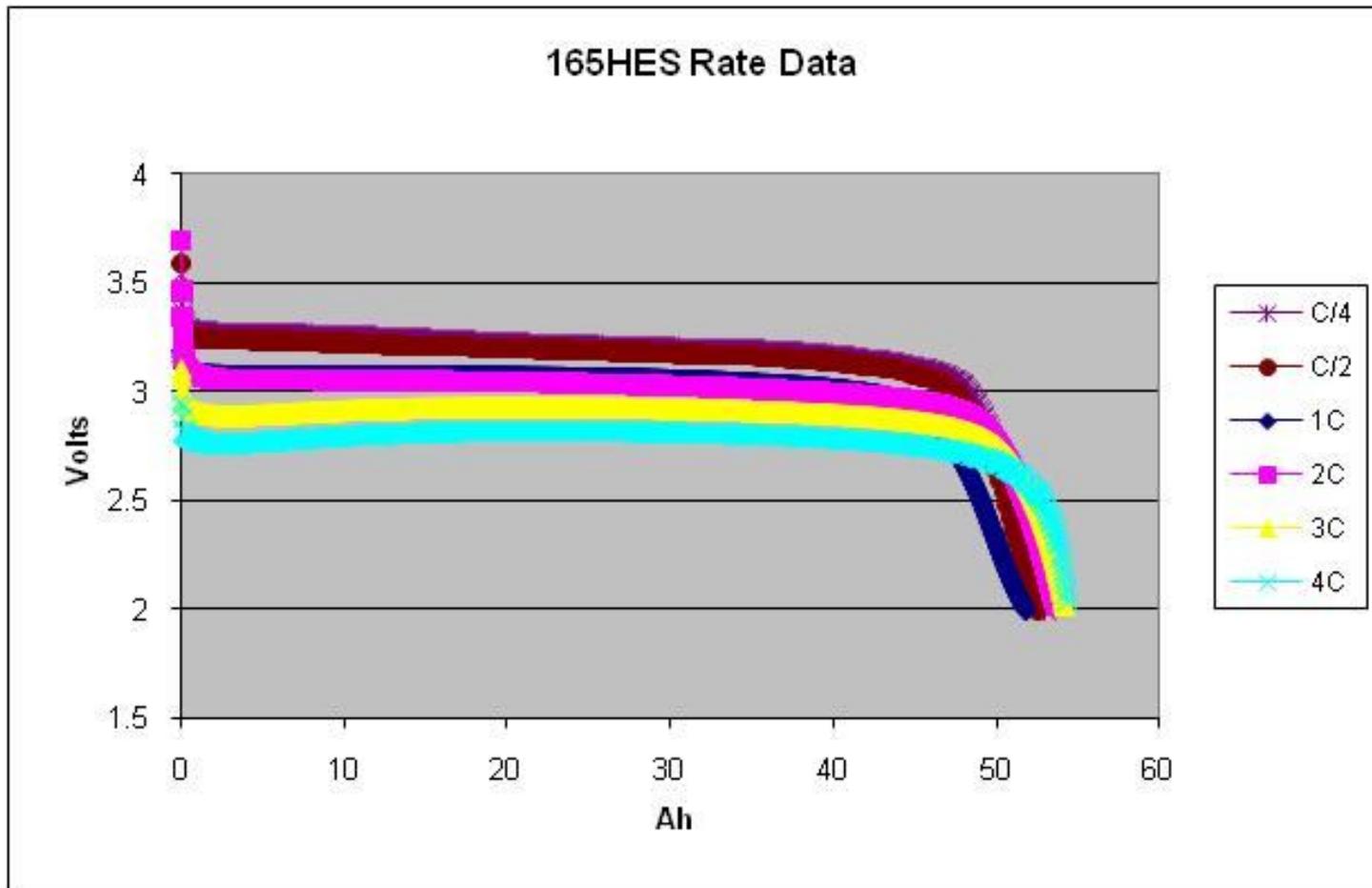
Module	Capacity (Ah)	Weight (kg)	Size (mm)	Continuous Discharge (A)	Pulse Discharge (A - 30 sec)
LFP300HES	90	3.0	208 x 81 x 123	90	300
LFP300HPS	72.8	3.0	208 x 81 x 123	280	725
LFP165HES	51.2	1.8	133 x 81 x 123	51.2	170
LFP165HPS	41.6	1.8	133 x 81 x 123	160	400

All modules UN/DOT certified w/o circuit board.

LFP300HES Rate Graph



LFP165PES Rate Graph



LFP165HPS Pulse Testing



LFP165 HPS Current vs Temperature Testing. (8 Modules in Series)					
Reading #	Current (A)	Voltage (v)	Temperature (C)	Time (sec)	Comments
1	0	27.8	30.5	initial	Initial Voltage at Ambient Temperature w/ No load
2	768	18.3	32.2	2	2 sec pulse/ 2 min rest
3	466	21.3	34.4	20	20 sec pulse/ 2 min rest
4	460	21.6	36.6	10	10 sec pulse/ 2 min rest
5	452	22.3	38.3	10	10 sec pulse/ 2 min rest
6	460	21.7	40	10	10 sec pulse/ 2 min rest
7	464	21.8	43	0	Performed a 1 min duration pulse.
8	444	21.4	43	15	
9	434	21.5	45	30	
10	427	21.6	47.8	60	

VW Passat EV (FEVT)

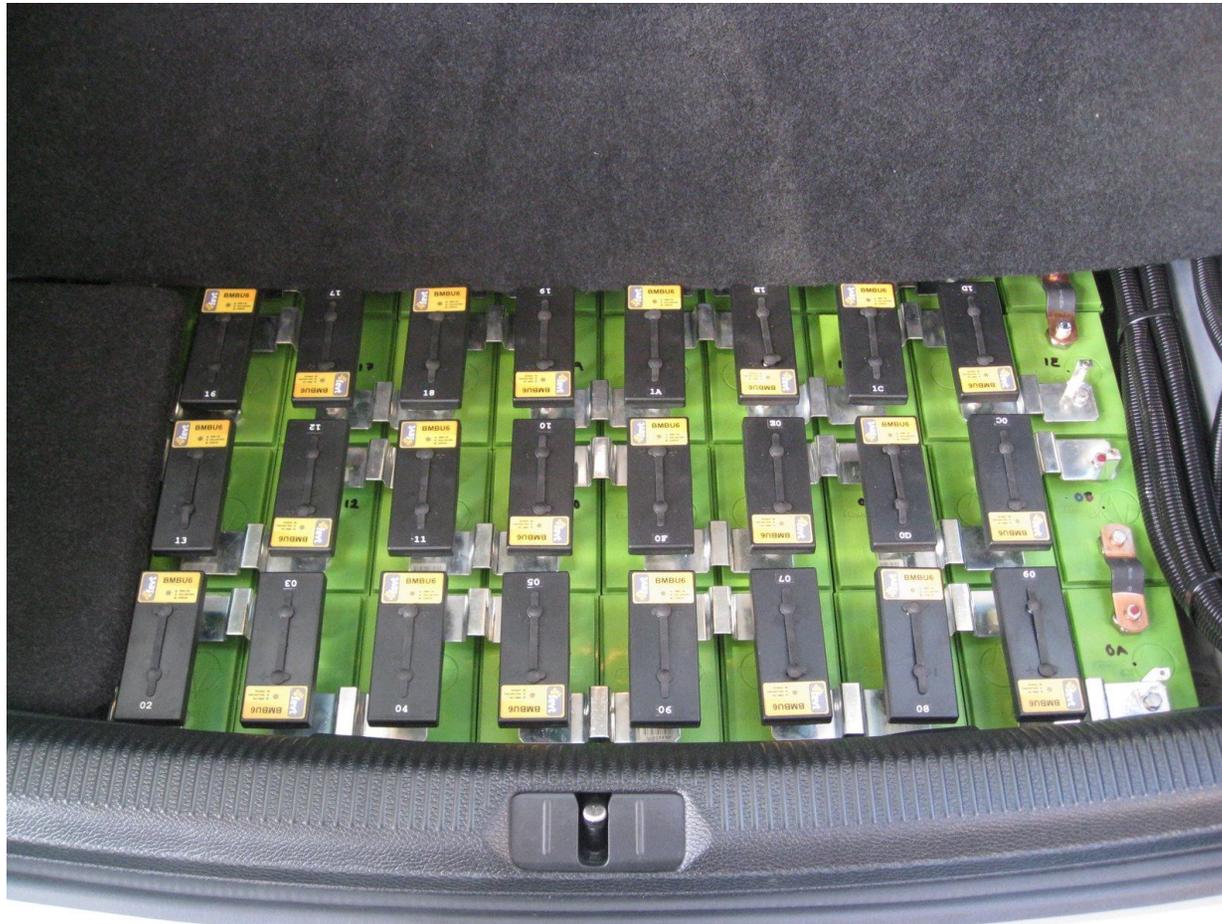


VW Passat EV (FEVT)

- Motor/Torque rating: 70kW @2200rpm / 300Nm
- Battery capacity: 24kWh (84 LFP300HES in series)
- Driving distance: 120km Urban, 100km highway (calculated 80% nominal capacity) Top speed: 150km/h
- Acceleration: 5s 0-50km/h; 15,5s 0-100km/h

- Electricity consumption:
 - Urban: 22 kWh
 - Highway: 27kWh
 - Charger: 3.2kW (230V 16A)

VW Passat EV (FEVT)



Chevy Aveo EV (HST)



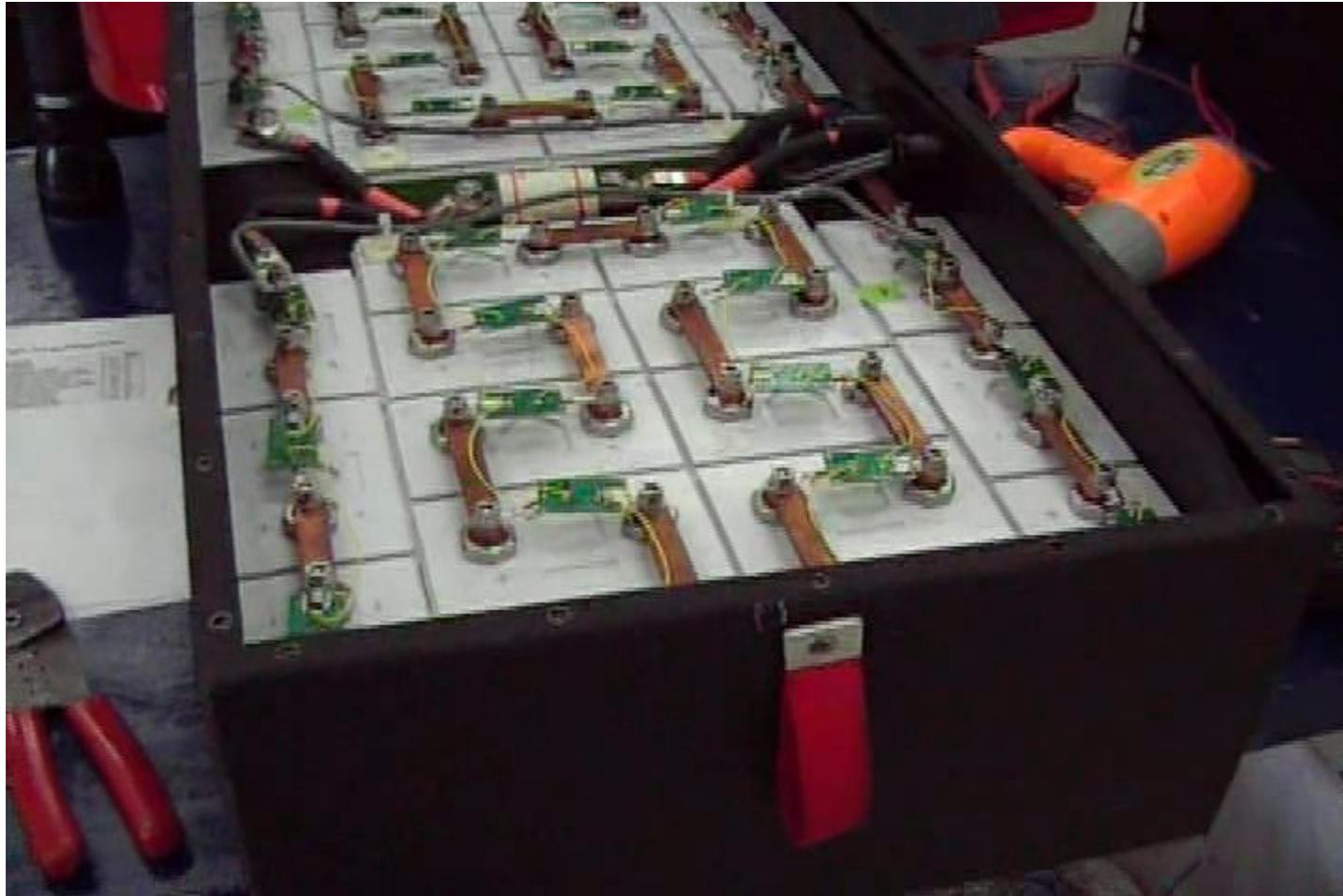
Chevy Aveo EV (HST)



Battery:

- 100 LFP165HES packs
- 320 V, 16.4 kWh system

Chevy Aveo EV (HST)



Questions?

