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HYPERDRIVE

AVID Innovation Ltd

Transnational E-Mobility NSR Expert Seminar

30th March 2012

Introduction

I started working on Electric Vehicles with an extensive background on vehicle dynamics as a mechanical engineer. I expected that we would purchase parts, put them together and then use my dynamics experience, however, it wasn't quite like that and my paper this morning is mainly about the energy source, the batteries and what followed.

- AVID CUE-V
- 2 Motor E-Differencial
- 24 Cells 100v syst.
- 19.7kW.hrs = 100miles
- 80 mph + max speed
- 0 to 60 = 9seconds

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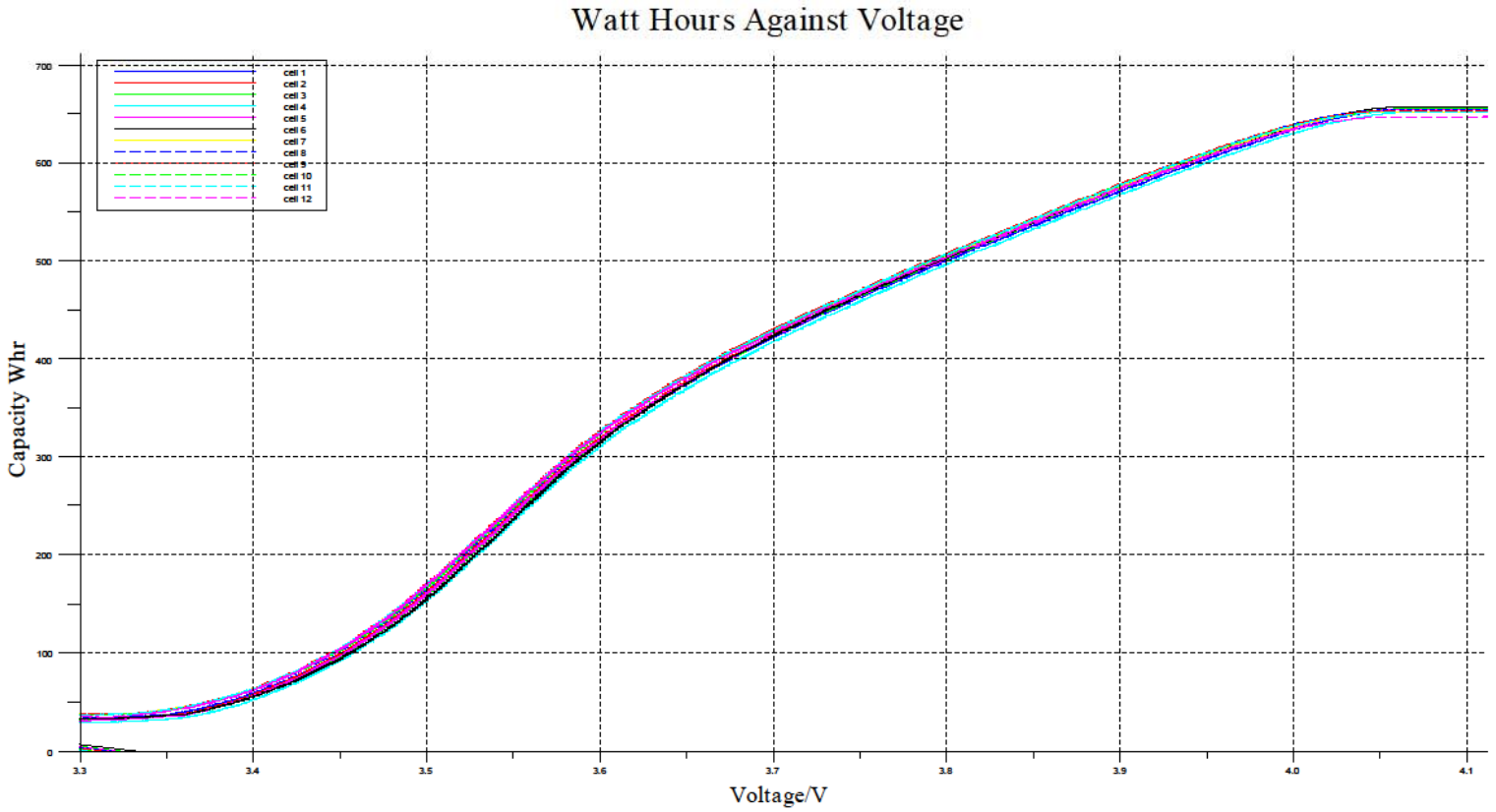
Typical Battery Performances 100v Cars = 24 cells 400v cars = 96 cells



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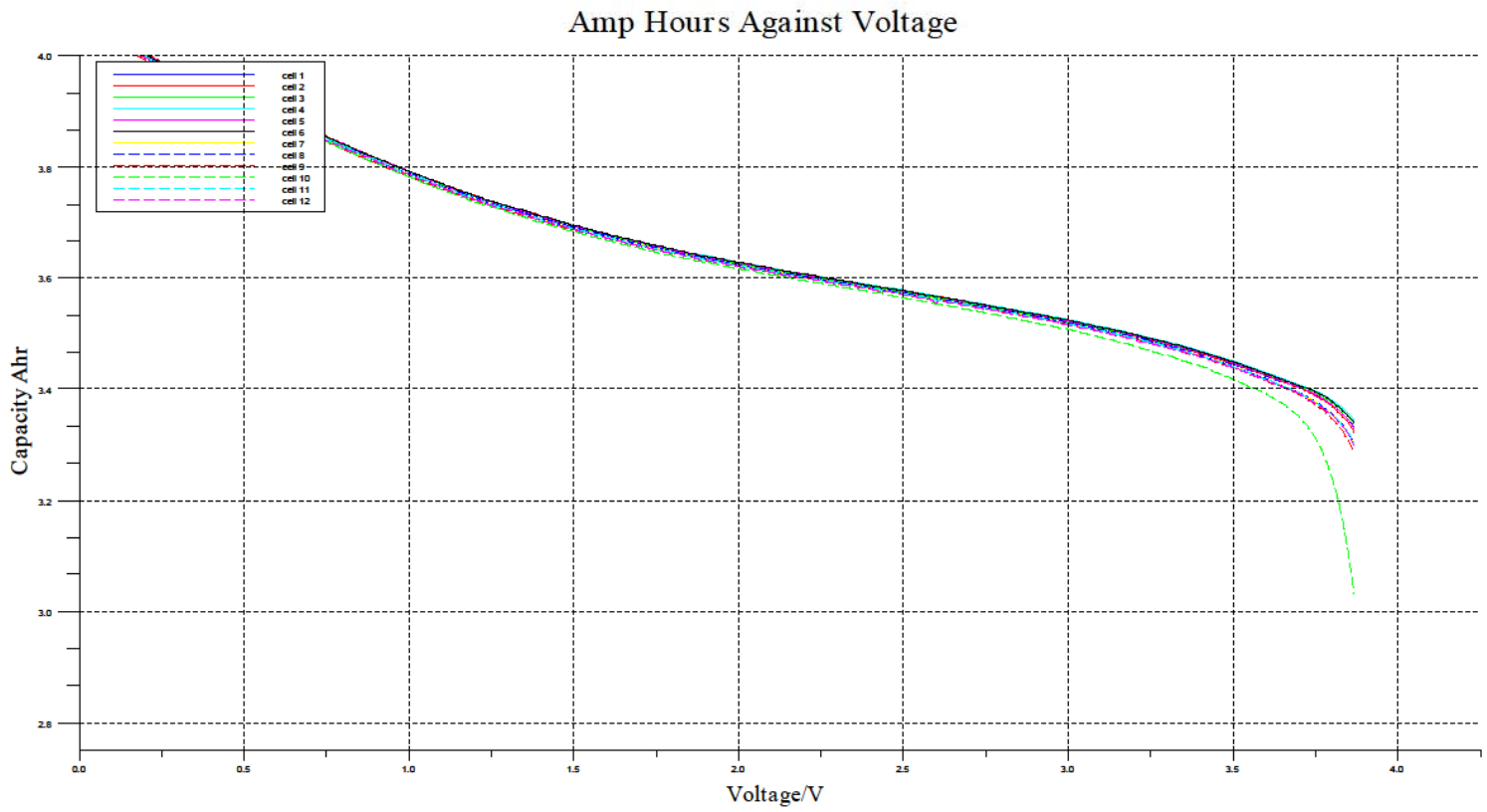

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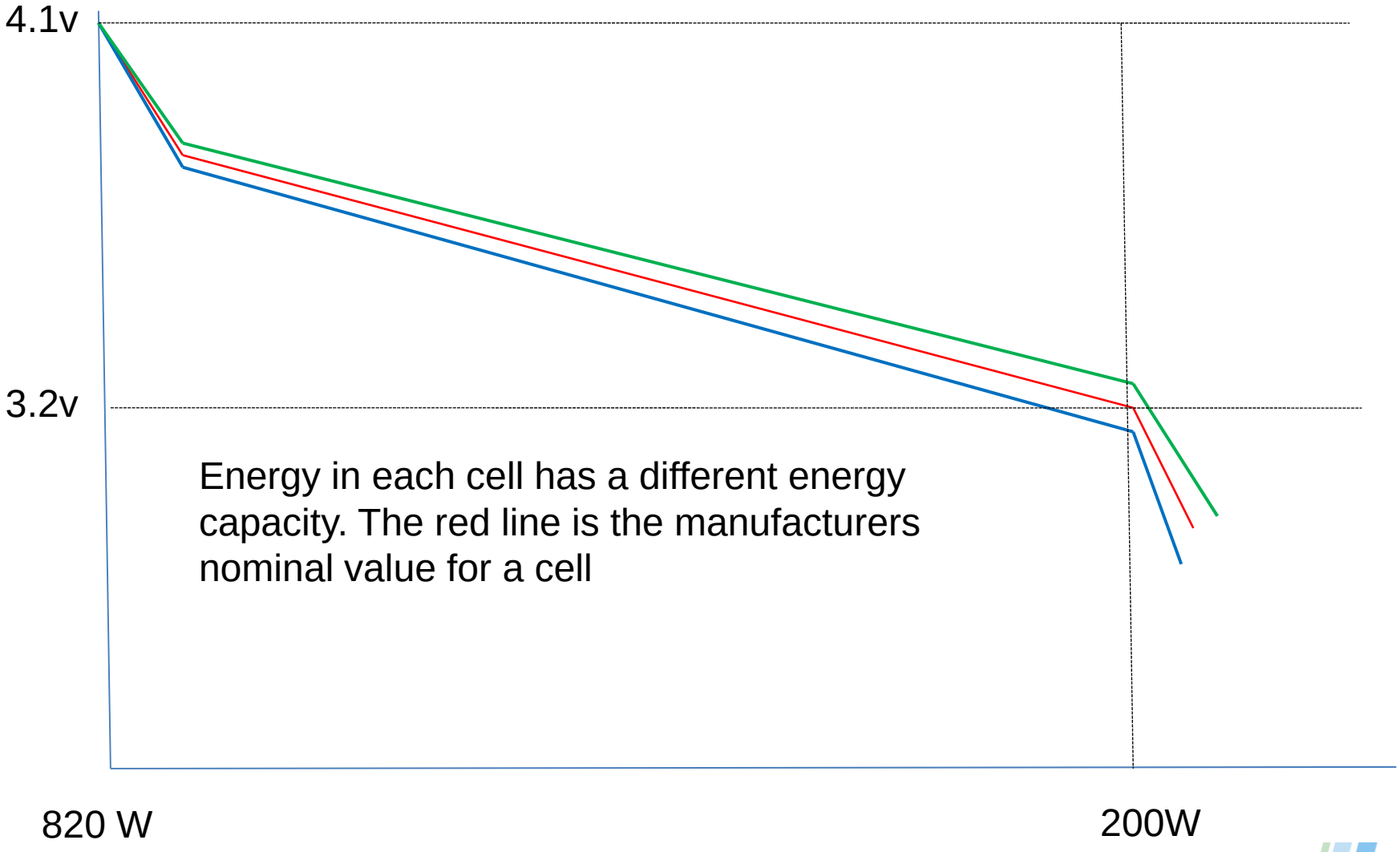

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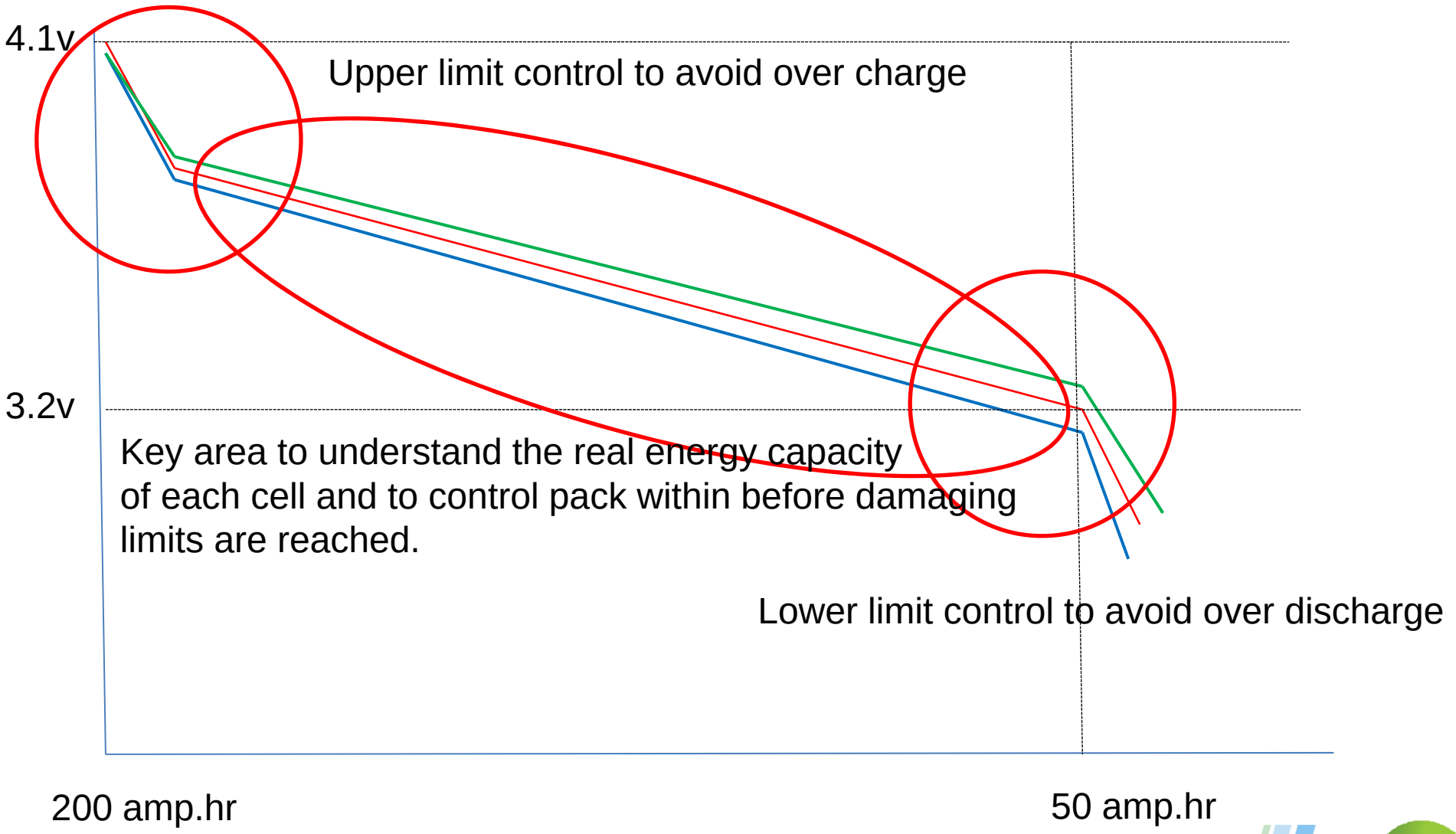

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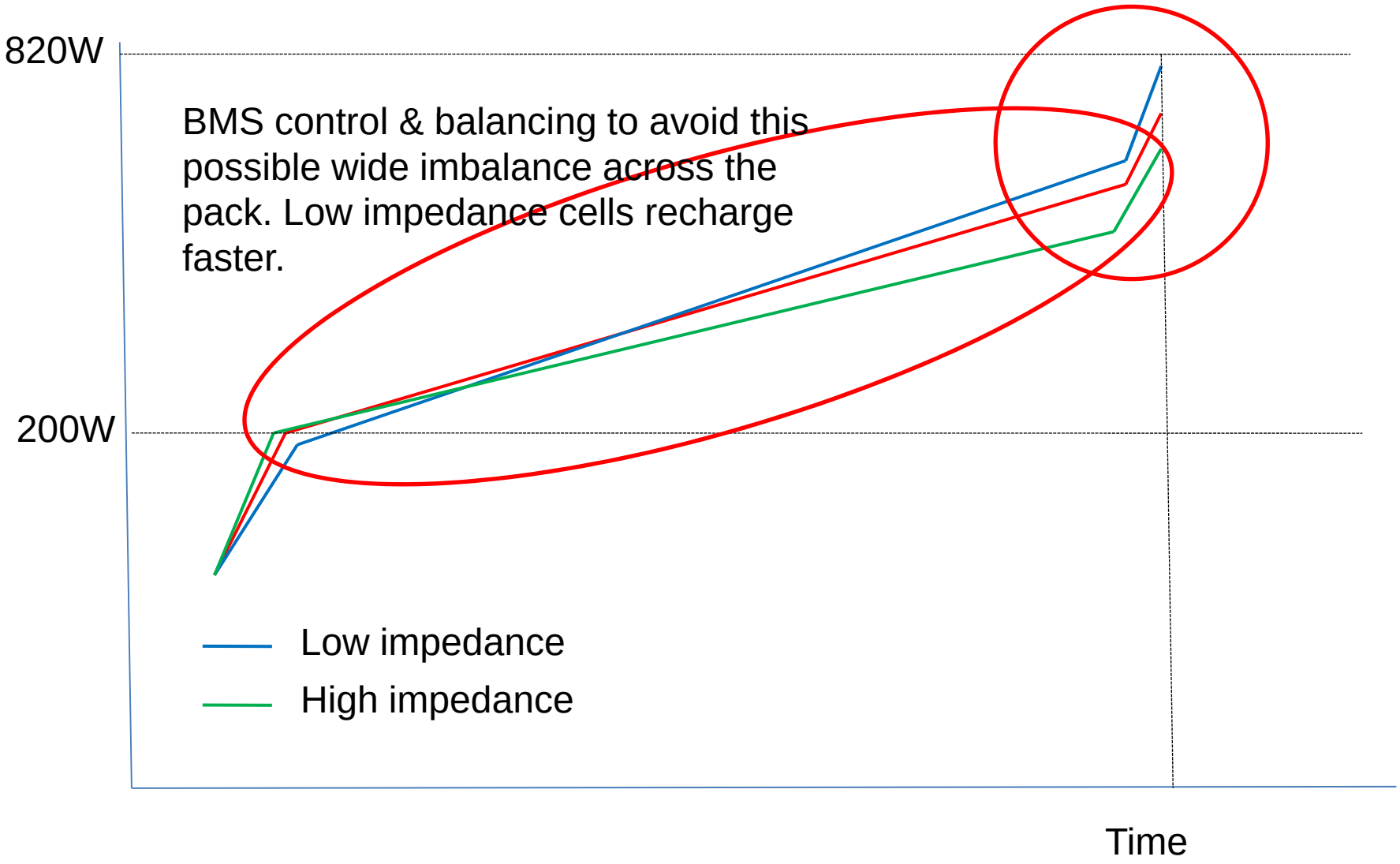
Battery Impedance effect on Recharging



Energy to Power an Electric Vehicle

- Energy to Power an Electric Vehicle comes from an external power source, national grid, wind turbine, solar, biomass, etc. and is stored in the battery.
- Larger batteries or larger battery packs take more power from the infrastructure source so the recharge time depends on the power supply 3kW, 7kW & 50kW.
- Charge time is then a simple calculation with a reduction in charge rate at start and finish of charge process.
- Batteries are just the store for the energy to power an electric vehicle and without very careful management and control their usable capacity is much less than their headline figures, The capacity is actually set by the strongest and weakest cells in the pack.

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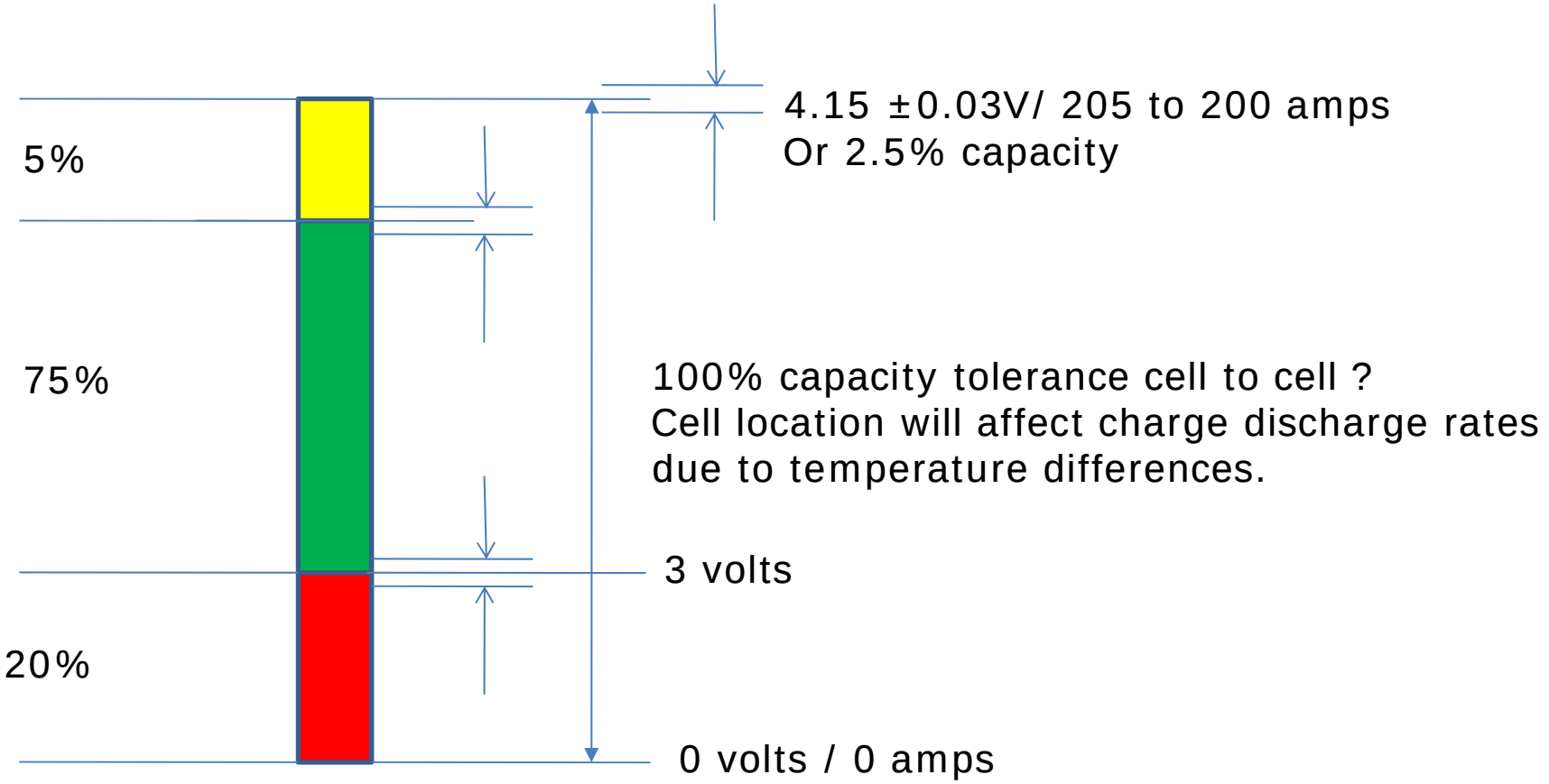
BMS Design Criteria & Pack Sizing



- A simple BMS iterates to ??mvolts between cells pulling pack down to lowest common denominator. If this process can't match battery tolerances or the rapid charge discharge cycles of regular usage, control and balance of the pack will be lost.
- Based on our experiences the actual usable pack capacity will be based on highest and lowest cells energy giving less than 75% usable capacity.

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BMS Design Criteria & Pack Sizing

- Packs charge status must be controlled within the % the BMS can correct for within the available time. To do this it's essential to understand real user cycles and time available to balance. The rate at which the BMS can adjust the pack balance needs to match the real pack usage.
- The BMS correction rate for vehicles in continual operation needs to be much more aggressive as over repeated cycles of continuous usage the BMS must be capable of balancing the pack after higher C rates. Vehicles working a 24 hour cycle with high performance requirements and powerful chargers exaggerate the tolerance / variations between cells so they diverge rather than converge and without adequate cycle time a balance will not be achieved.
- Pack charge discharge rate will also vary with temperature and location in the vehicle. i.e. engine bay vs. under body.
- Building up database of real usage patterns that can then be used as a design tool is essential.

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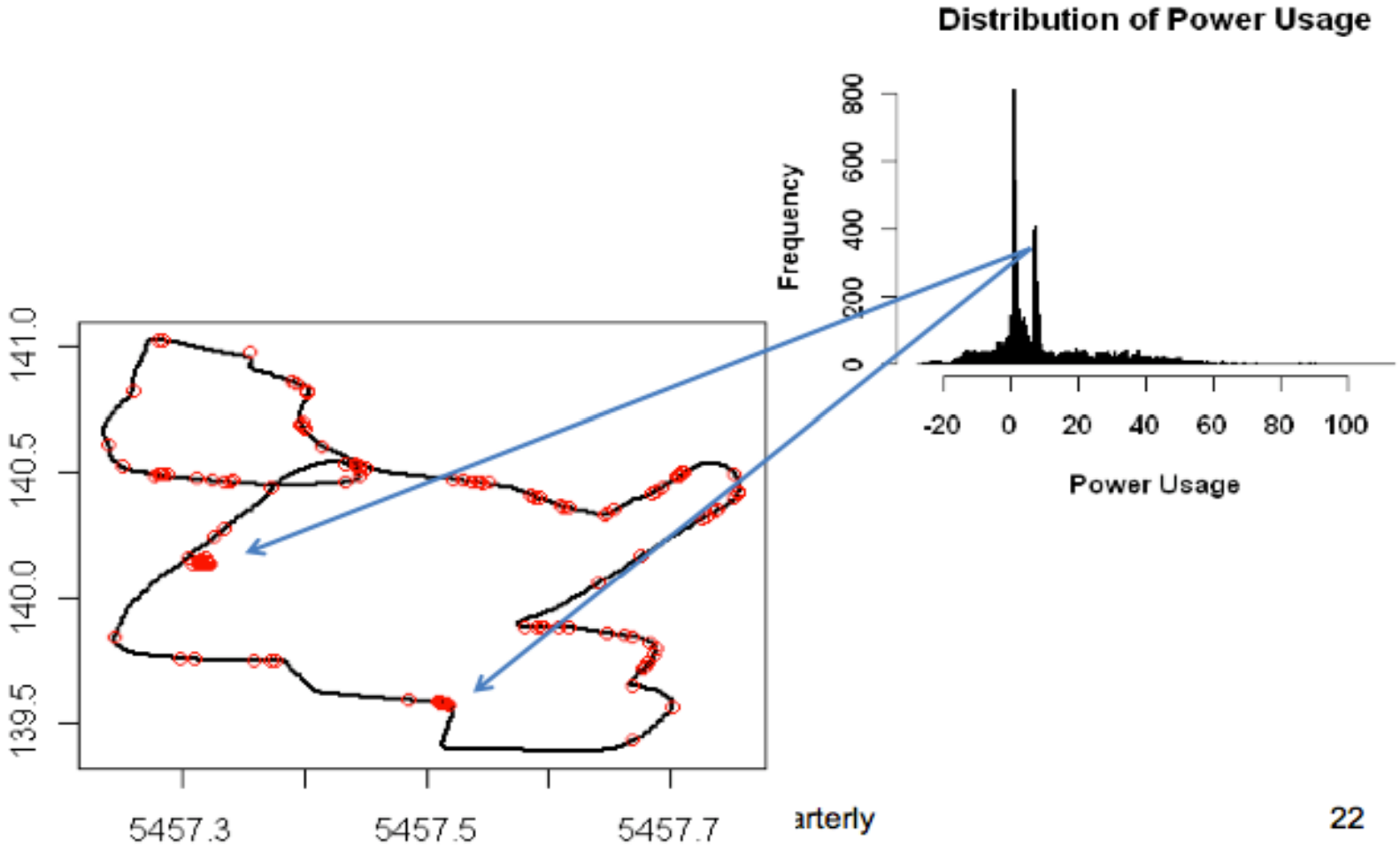
Real Energy Usage Data



Knowledge driven by data

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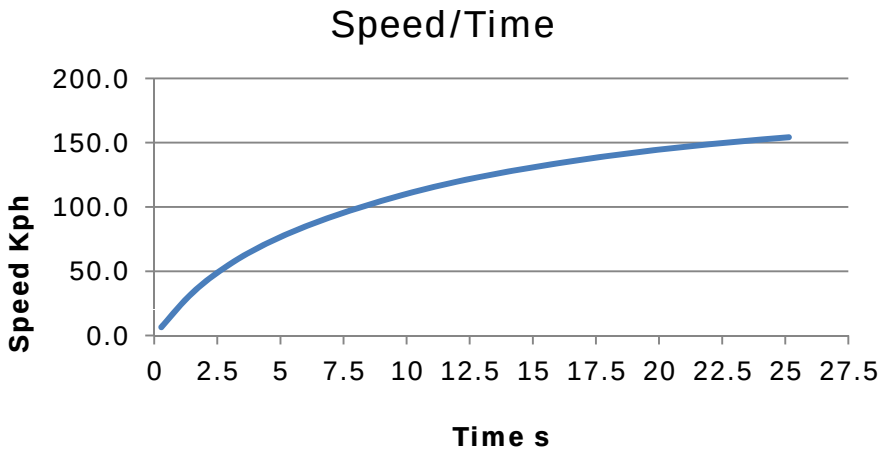
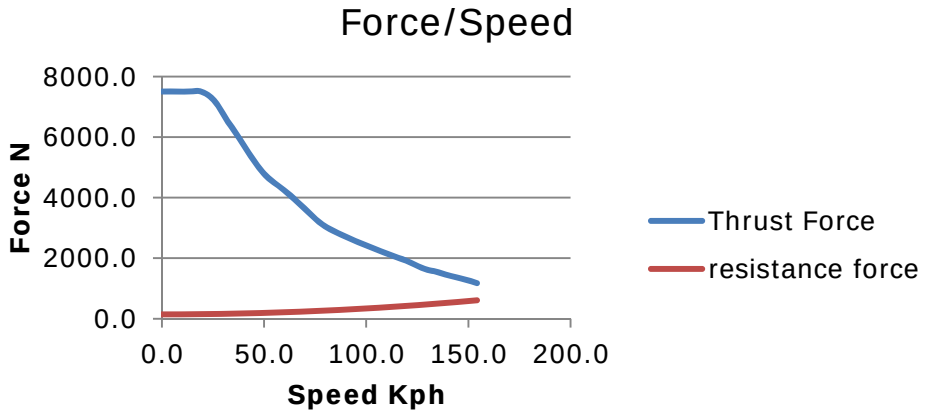
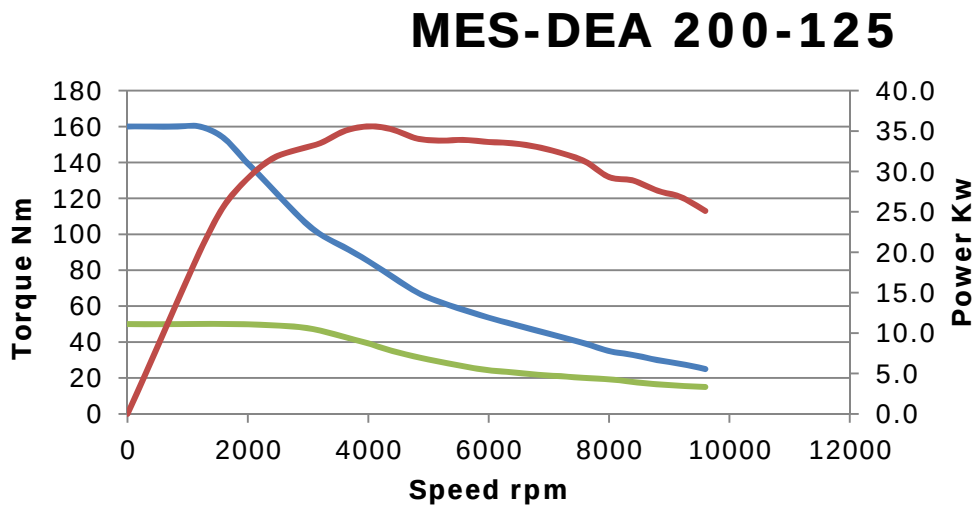
CUE-V
AVID
vehicles
COMPACT URBAN ELECTRIC VEHICLE


Speed/Time
Speed Kph
200.0
150.0
100.0
50.0
0.0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5
Time s


Force/Speed
Force N
8000.0
6000.0
4000.0
2000.0
0.0
0.0 50.0 100.0 150.0 200.0
Speed Kph
Thrust Force
resistance force


MES-DEA 200-125
Torque Nm
180
160
140
120
100
80
60
40
20
0
Power Kw
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0 2000 4000 6000 8000 10000 12000
Speed rpm
Max Torque
Nominal Torque
Max Power

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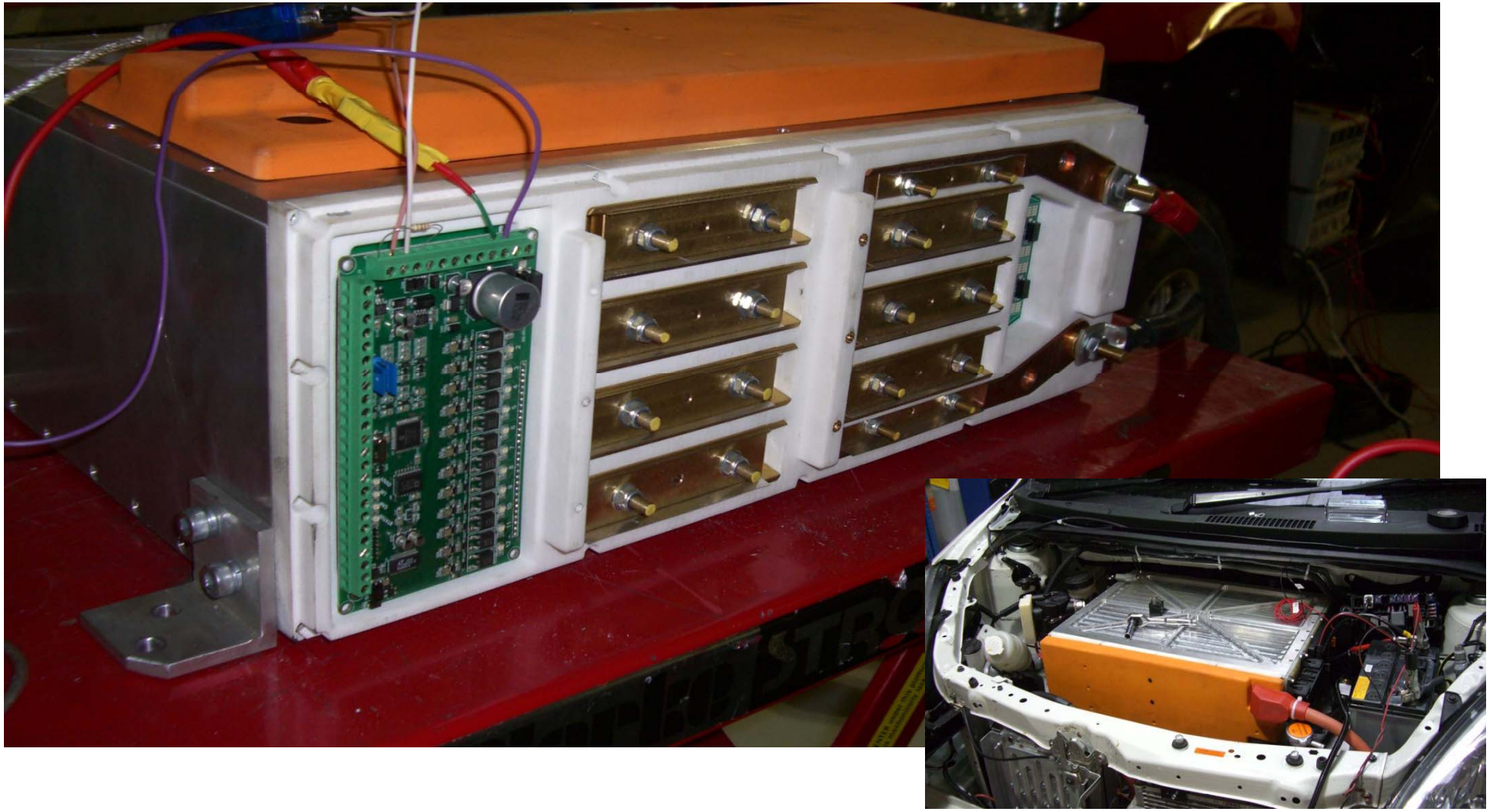
CUE-V Front Battery Pack, sits on drive unit in engine bay



Rear Battery Pack replaces fuel tank – no loss of usable interior space

2 Battery Packs give 100v Cars = 24 cells 19.7 kW.hrs max energy

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The Future – Efficiency & Optimisation

- Gearbox
  - Multi speed hyper efficient gearbox in advanced stages of development.
  - ECU & software to manage gearbox / motor for maximum efficiency.
  - Efficiency increase from 4% to 20% depending on drive cycle & vehicle.
  - Higher operating speeds are also possible with motor optimised.
- Range
  - Active BMS to maximise battery pack capacity & use more of the range.
  - Maximise regenerative energy from coast down and braking (eBrakes).
  - More batteries but this is expensive, longer charging and heavier.
  - Reduce weight, drag, auxiliary drains & on charge thermal balance control.
- Range extenders
  - Optimise battery pack size and back up with an onboard generation system
  - Fuel cells, IC Engine & generator,
- Charging & Rapid chargers
  - Powerful active BMS to balance pack within operating cycle to minimise size and weight penalty.

Hyperdrive Innovation Ltd / AVID Innovation Ltd can support you with any of these opportunities.

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Rotary Club of Hadrian's Wall

www.Greenpower.co.uk – Inspiring Young People

This is a **24/24+ Class Car** which is designed, built and driven by secondary & high school students through to 6th form. It offers mechanical, electronics and software design and development experience. Events are held in the North of England and Nationally.

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Thank You for Listening

Rotary Club of Hadrian's Wall

www.Greenpower.co.uk – Inspiring Young People

The **Greenpower Education Trust's** vision is to inspire young people to become engineers. Our mission is:

- To change current views about engineering, presenting it as a fascinating, relevant and dynamic career choice for any young person.
- To demonstrate the importance of engineering, and associated **STEM** subjects, to solve the problems faced by societies today particularly in the areas of sustainability.
- To link education, industry and community through inspirational engineering projects.

The vision and mission were realized from a study by Sussex Enterprise in 1998 looking at the needs of engineering companies in the region. This uncovered a worrying problem; an industry increasingly reliant on an ageing work force with few young people coming into engineering to learn the skills and replace the workforce.

Further investigation revealed low levels of interest in science, technology, engineering and math **(STEM)** amongst young people, within schools and within communities generally.

After an initial event to promote engineering run by Greeenpower and Sussex Enterprise publicity in the Daily Telegraph brought in requests from around the UK from teachers who wanted a similar project within their region.

Rotary Club of Hadrian's Wall

www.Greenpower.co.uk – Inspiring Young People

Hence the **Greenpower Education Trust** created a number of practical engineering challenges which fulfill our mission and encompass all of our values.

- Inspiration — Learn and invent new solutions
- Motivation — Desire to be best as a team
- Passion — Belief in what you are doing
- Dedication — Team Work to achieve a goal
- Fun — Enjoy the challenge, enjoy life.

Our initial project, an electric car challenge which requires students, guided by their teachers and industry mentors, to design, build and then race an electric car. Holding events at weekends at major motor circuit around the UK ensures excellent attendance from the general public who can witness the amazing vehicles, focus and team work evident at these events.

Greenpower now works with over 500 schools providing events around the UK.
The Greenpower Education Trust is now planning to build on the success of this original project and create a series of additional practical challenges which will introduce young people to the full spectrum of opportunities available from a career in engineering.