

Optimization of Energy Storage System for Hybrid Electric Vehicle

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- Methodology to determine the optimal ESS size to maximize a vehicle utility
- Tool to make realistic comparison of various technologies

Description of ESS

- Battery Cells
- Battery monitoring electronics and management system
- DC/DC Converter
- Thermal management system
- Physical Architecture

- Automotive performance - a specified driving duty cycle.
- Hybrid Electric Vehicle simulation model
 - Series Electric Drive
 - Drivetrain electrical and mechanical dynamics
 - Vehicle mechanical dynamics
- Unique Power/Energy Management Control Scheme was developed
- Logical Decision for Windows (LDW)

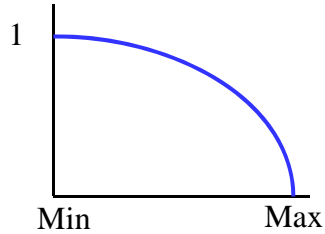
Measures Defining Vehicle Utility **BAE SYSTEMS**

- ESS Mass
- ESS Cost
- Vehicle Performance
 - Elapsed Time
 - Fuel Consumption
 - Dash (Time to move out danger zone - 750m)
 - Peak Power for transient loads
 - Usable Energy for silent operations

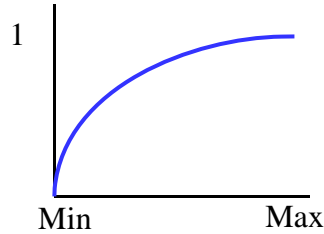
Weights of Measures

- ESS Mass : 25%
- ESS Cost : 25%
- Vehicle Performance :
 - Elapsed Time : 15%
 - Fuel Consumption : 15%
 - Dash : 5%
 - Peak Power : 5%
 - Usable Energy : 10%

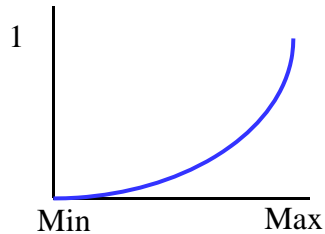
Utility Functions



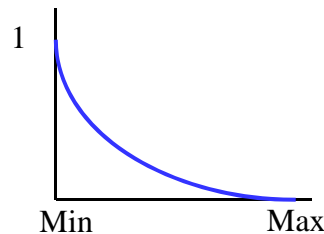
ESS Mass
ESS Cost
Dash Time



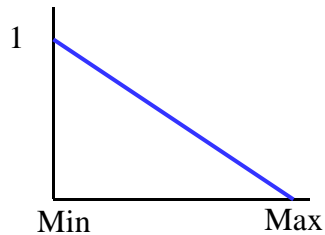
Usable Energy



Peak Power



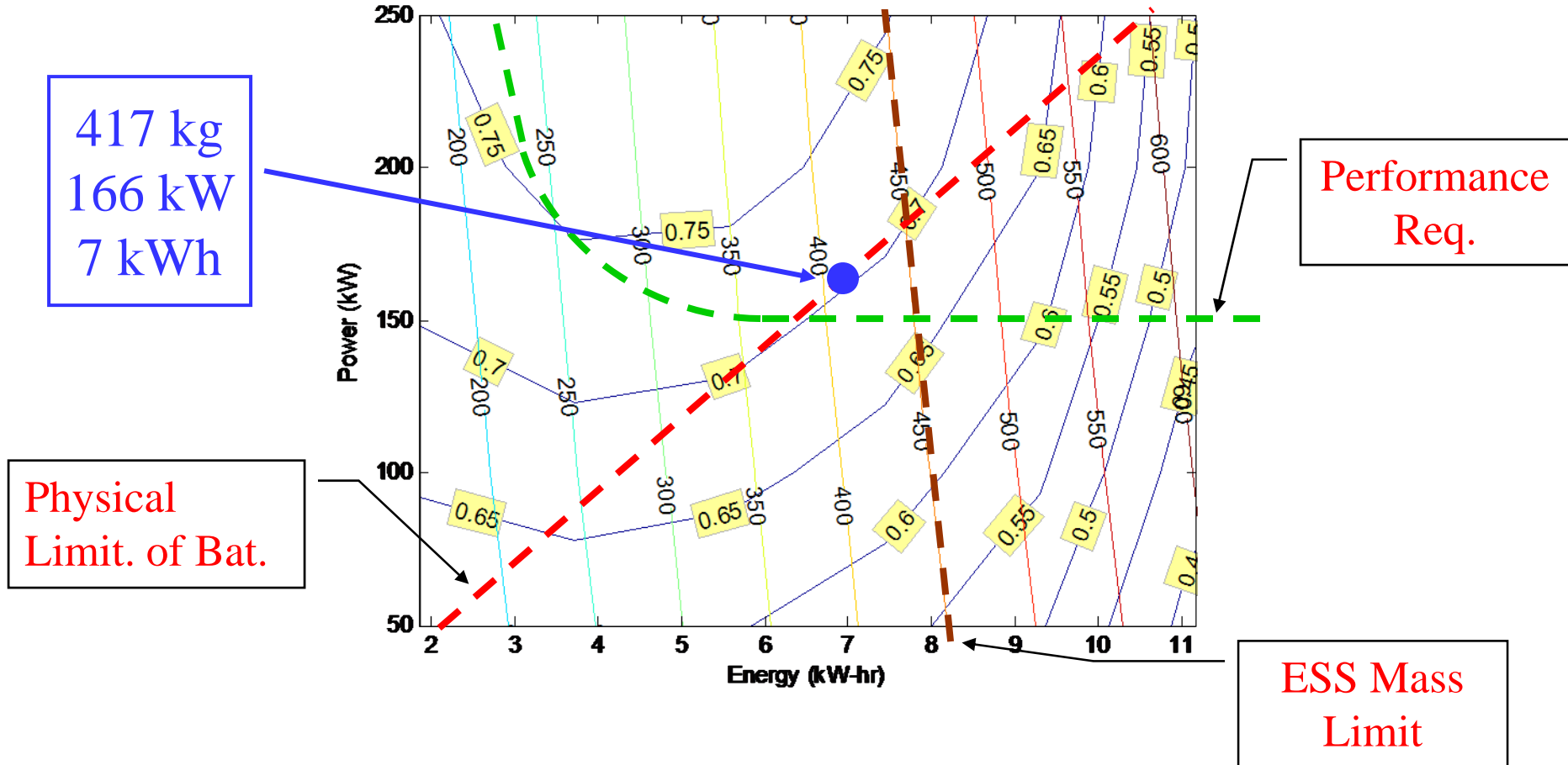
Fuel Consumption



Elapsed Time

- 3 samples of our test cases for evaluation of the Optimization Tool
 - 3 different cell types

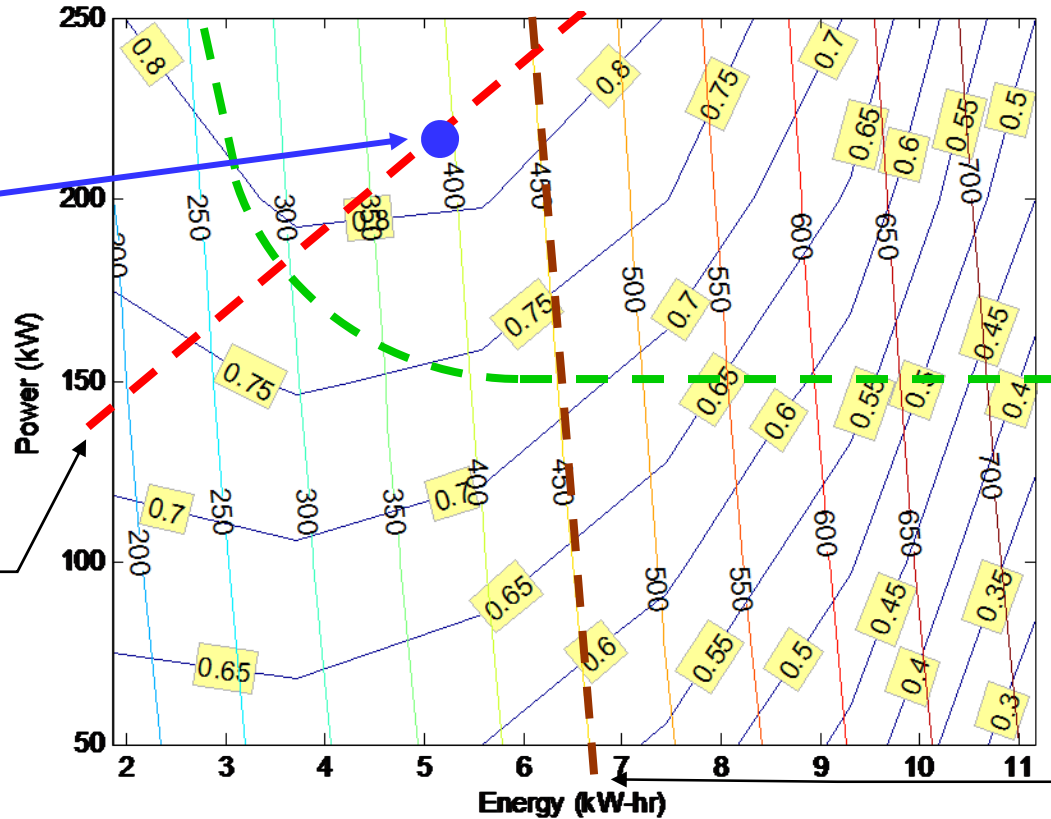
Cell Type A



Cell Type B

390 kg
215 kW
5.1 kWh

Physical
Limit. of Bat.



Performance
Req.

ESS Mass
Limit

■ ESS Optimal Size

Optimal ESS Size	Cell Type A	Cell Type B	Cell Type C
Vehicle Utility	0.71	0.82	0.43
ESS Power	166 kW	215 kW	155 kW
ESS Energy	7 kWh	5.1 kWh	12 kWh
ESS Mass	417 kg	390 kg	490 kg

- Cell Type B has Highest Vehicle Utility
 - High Power Density
- Power is more important than Energy among the sample cases

- The design tool to optimize ESS
- Realistic comparison of different energy storage technology
- Flexibility - different types of hybrid vehicle