Evaluation of Hybrid Energy Storage (HES) Devices

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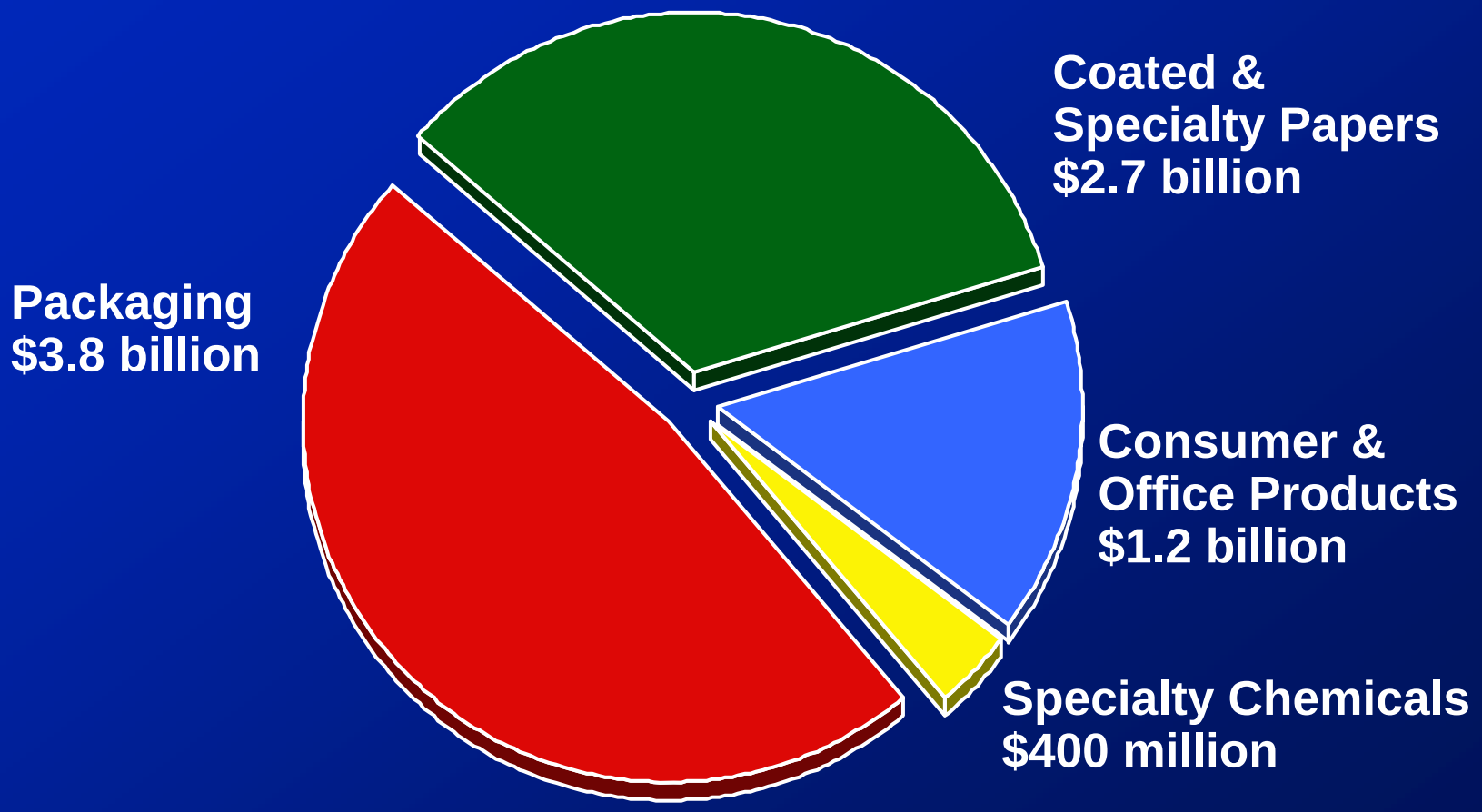
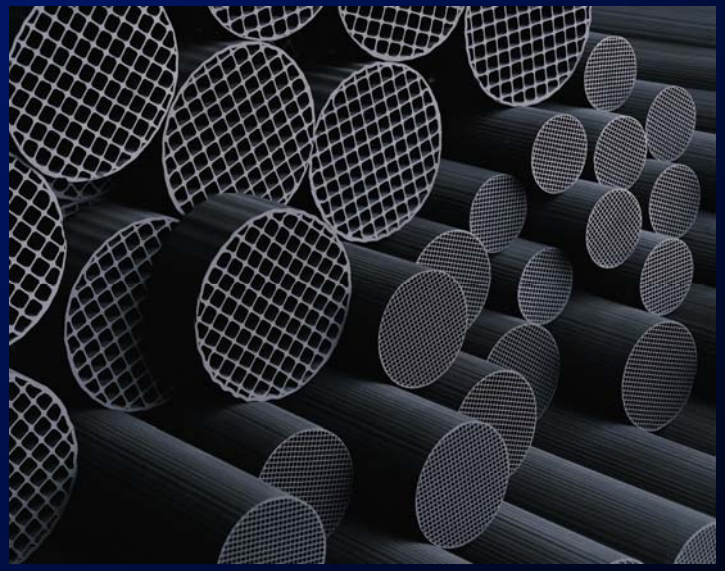


Activated Carbon for a Variety of Markets

Pelletized Activated Carbon

Granular Activated Carbon

Powdered Activated Carbon



Activated Carbon Honeycomb

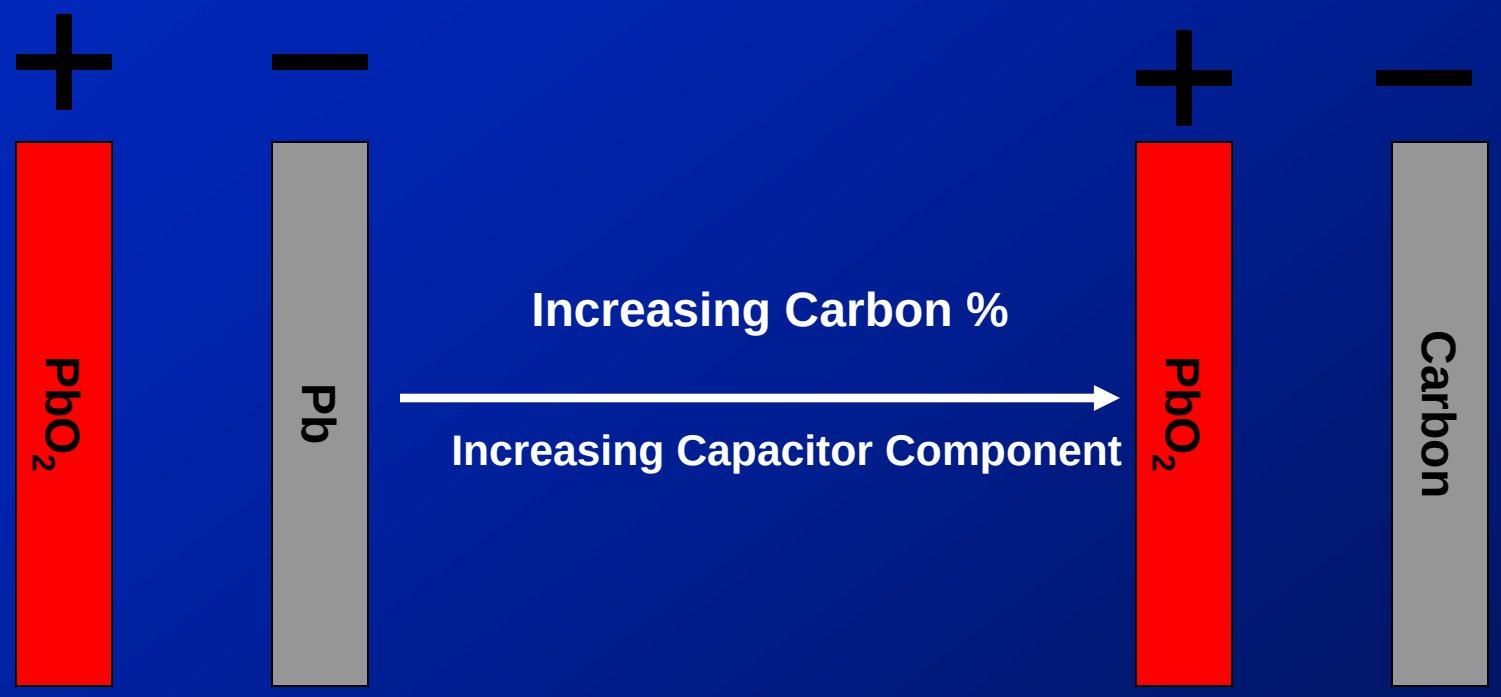
Phase I Overview

- Develop lead-carbon based technologies
  - Increase cycle life
  - Improve charging efficiency
  - Identify areas of opportunity
  - Develop charging protocols
  - Cost within 1-1.5 times lead acid battery
- Review of carbon based technologies

Participants

- MeadWestvaco
  - Developing carbons and lignins for energy storage
  - Lab scale testing
  - Negative Electrode Development and formulation
- Sandia National Labs and DOE
  - Battery Testing
  - Verification
  - Technical Collaboration
- Northstar Batteries
  - Manufacturing
  - Battery Expertise
  - Algorithm Development
- Various Industry Collaborations
  - Asymmetrics that are not compatible with traditional manufacturing
  - Other carbon based technologies

Lead Acid Technology



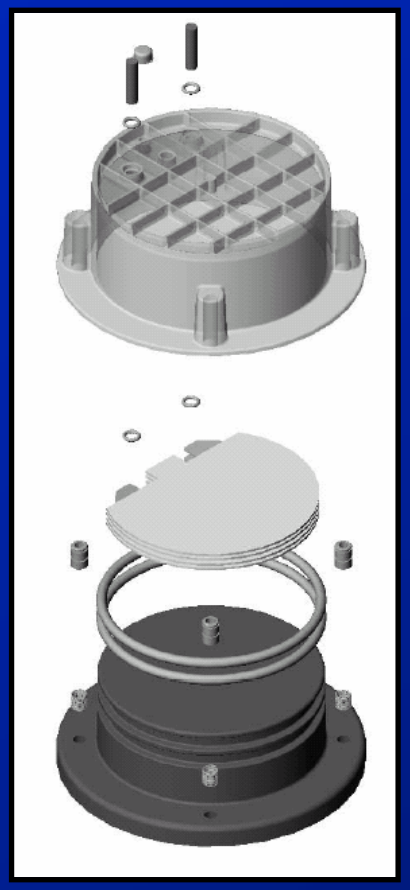
Lead Acid Battery

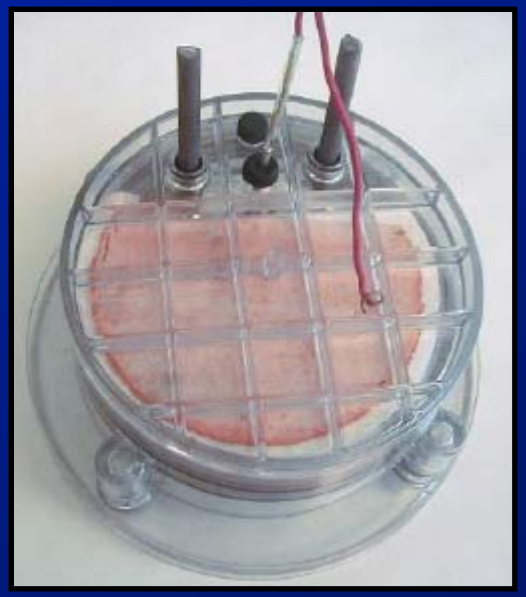
2.45Volts -> 1.7Volts

Hybrid Energy Storage (HES)

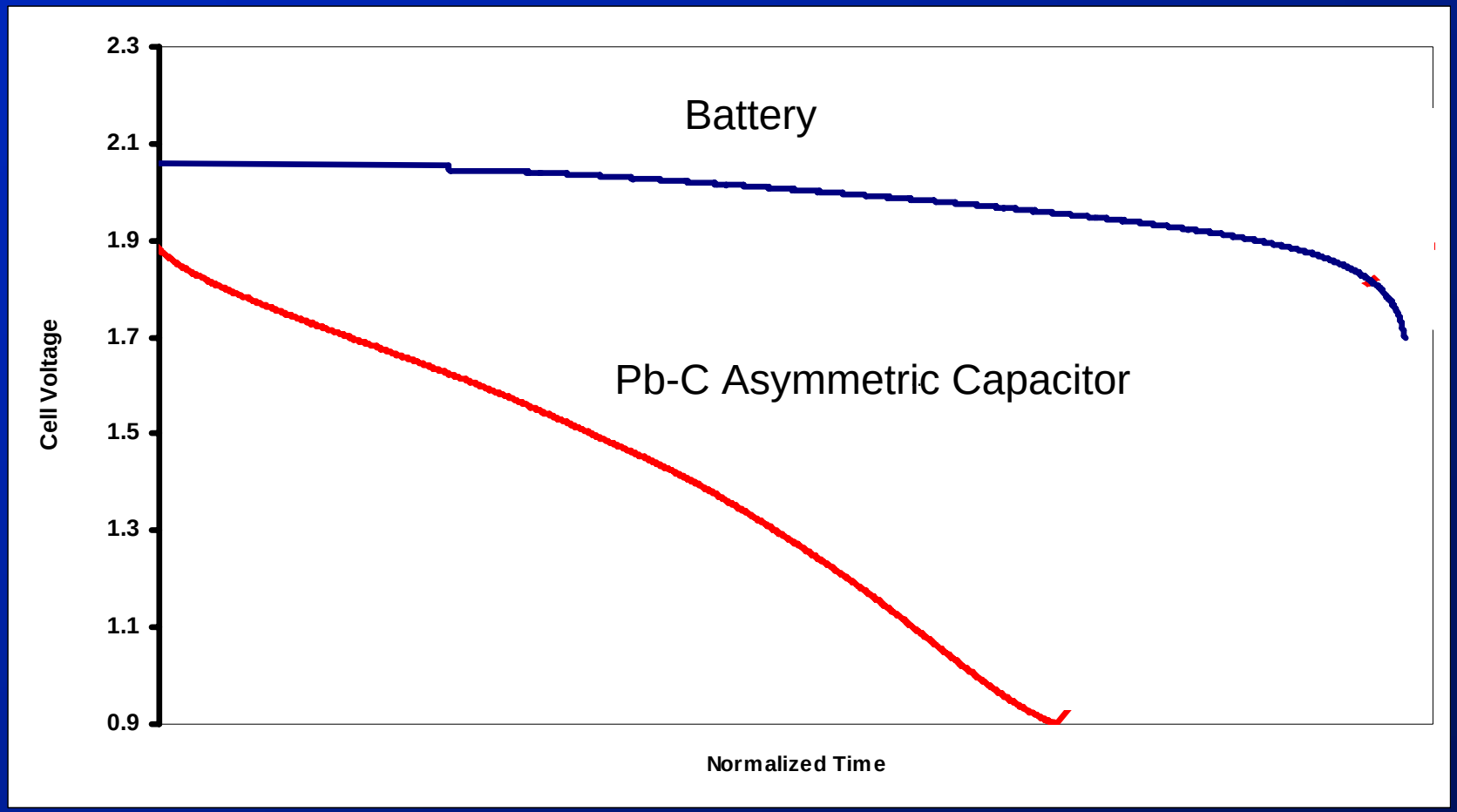
2.3Volts -> 0.9Volts

Test Cell

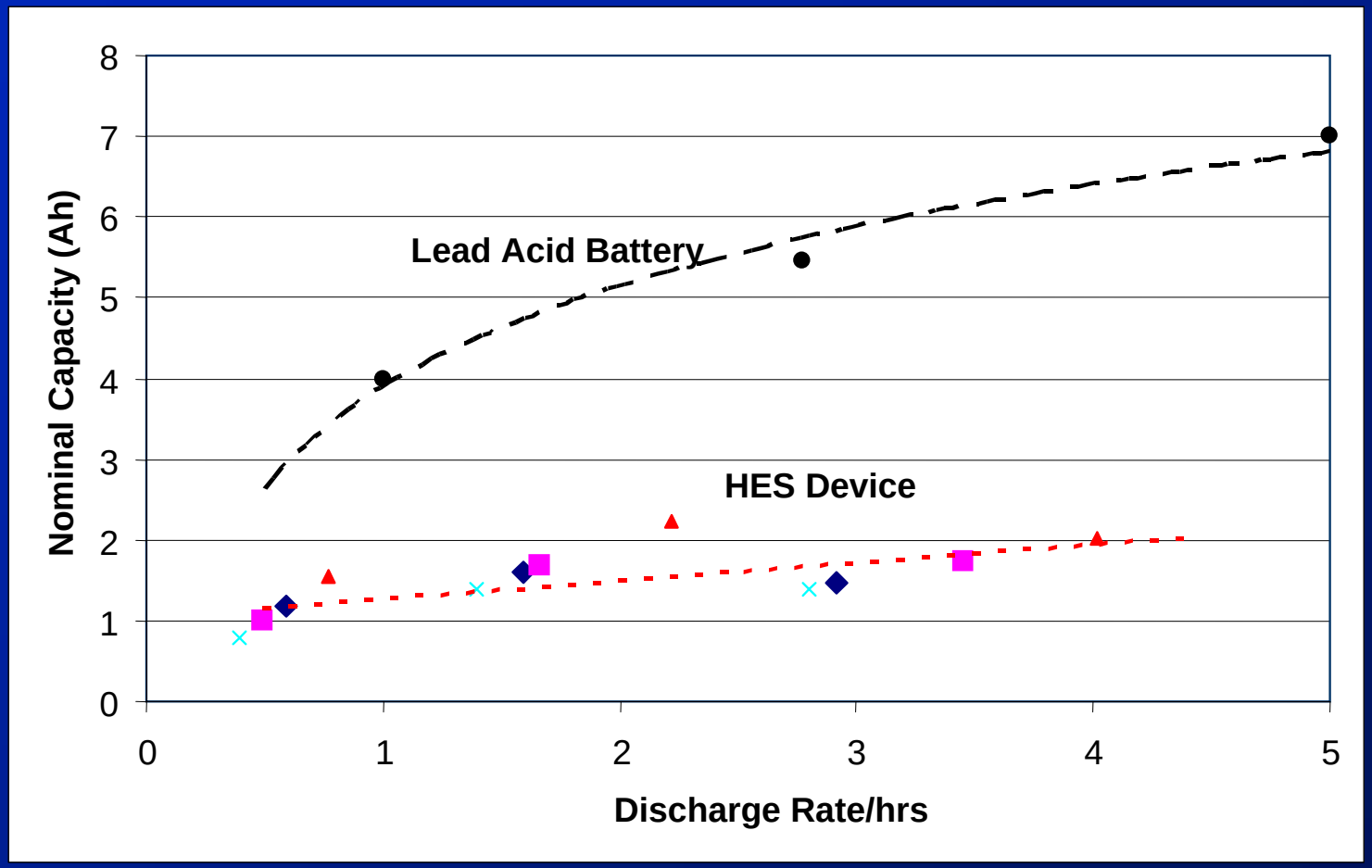




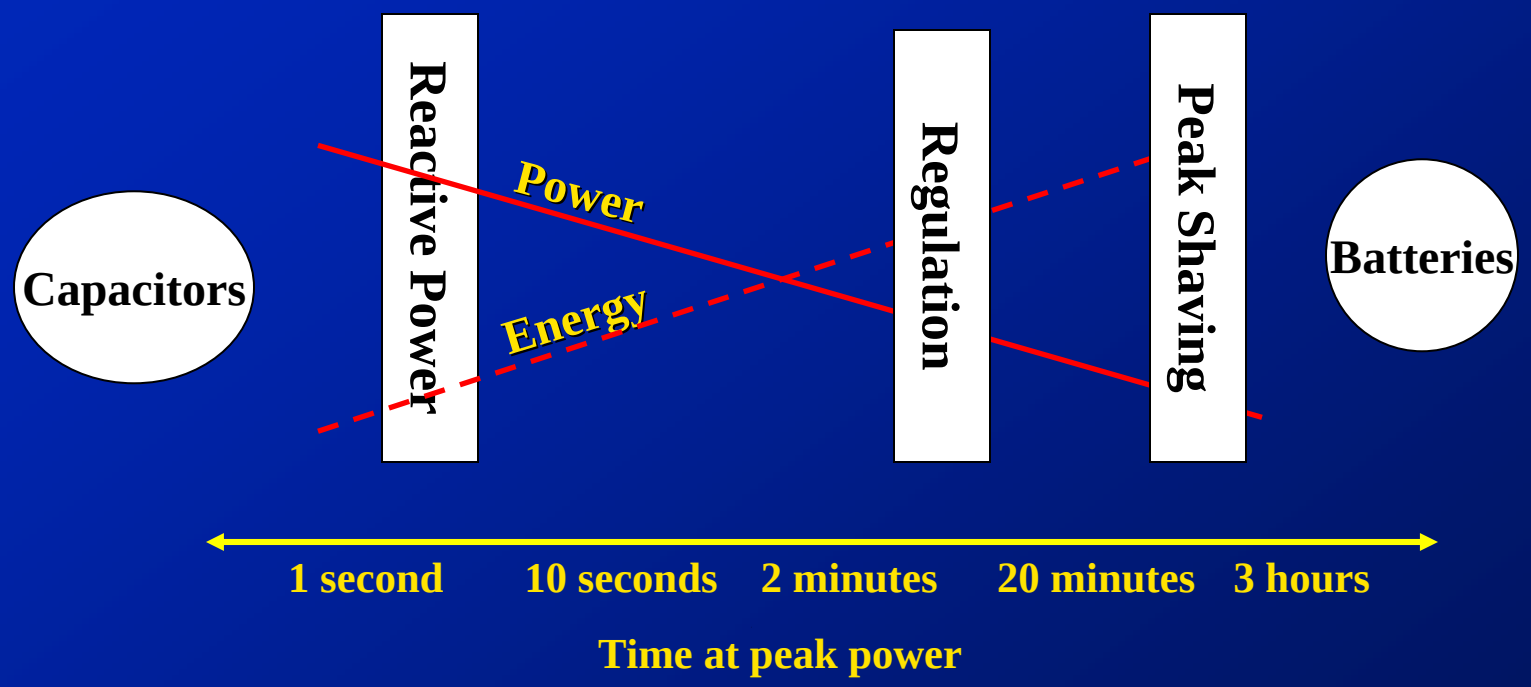
Voltage Profile During Discharge



Capacity Comparison



Market Opportunity



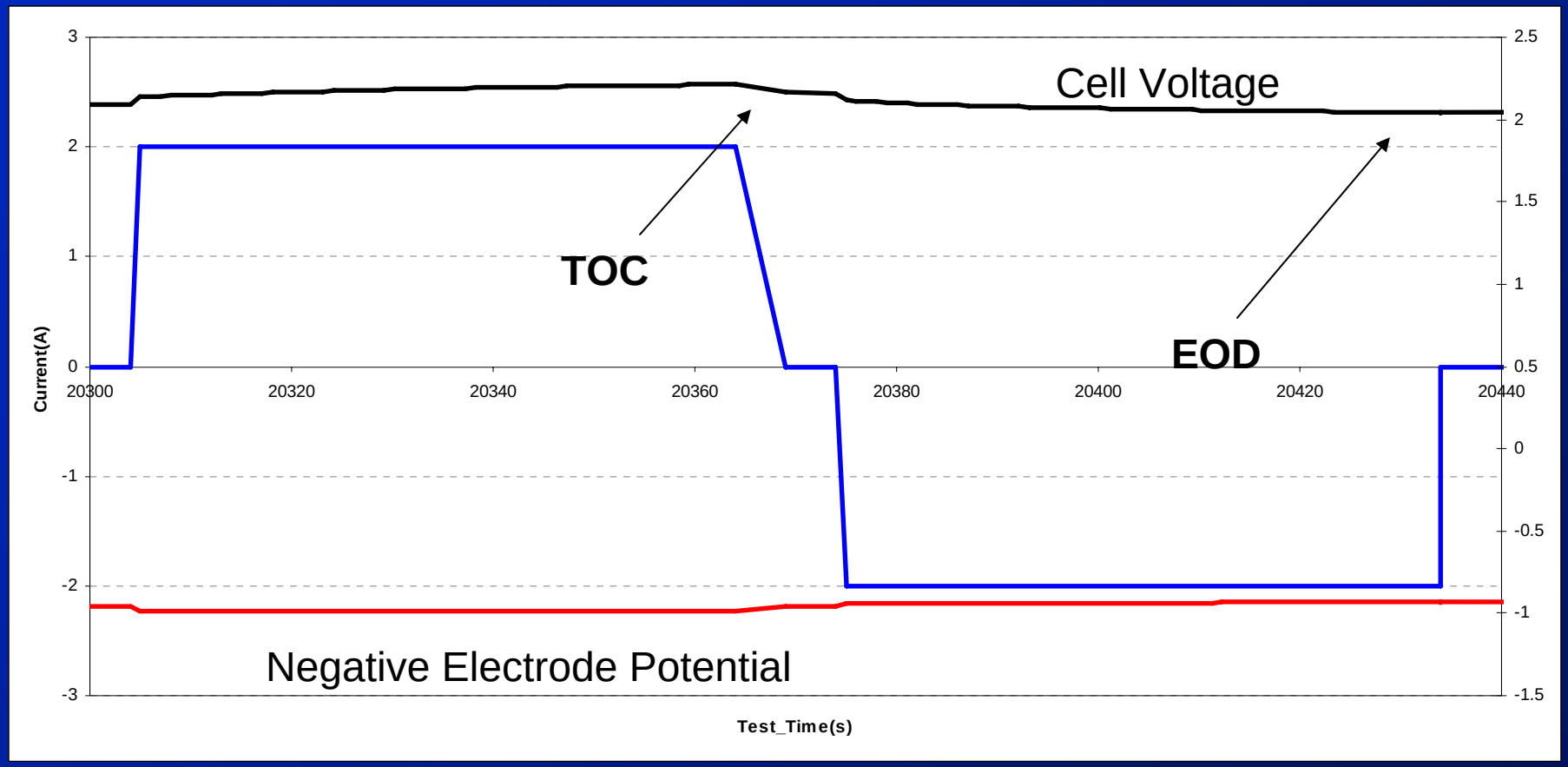
Program Direction

- Device Design
  - 10 second to 30 minutes
- Operate Battery or HES device in partial-state-of-charge (PSoC)
- New modes of operation
  - Will require proper charge and discharge protocols
- Verify lab data with prototype batteries

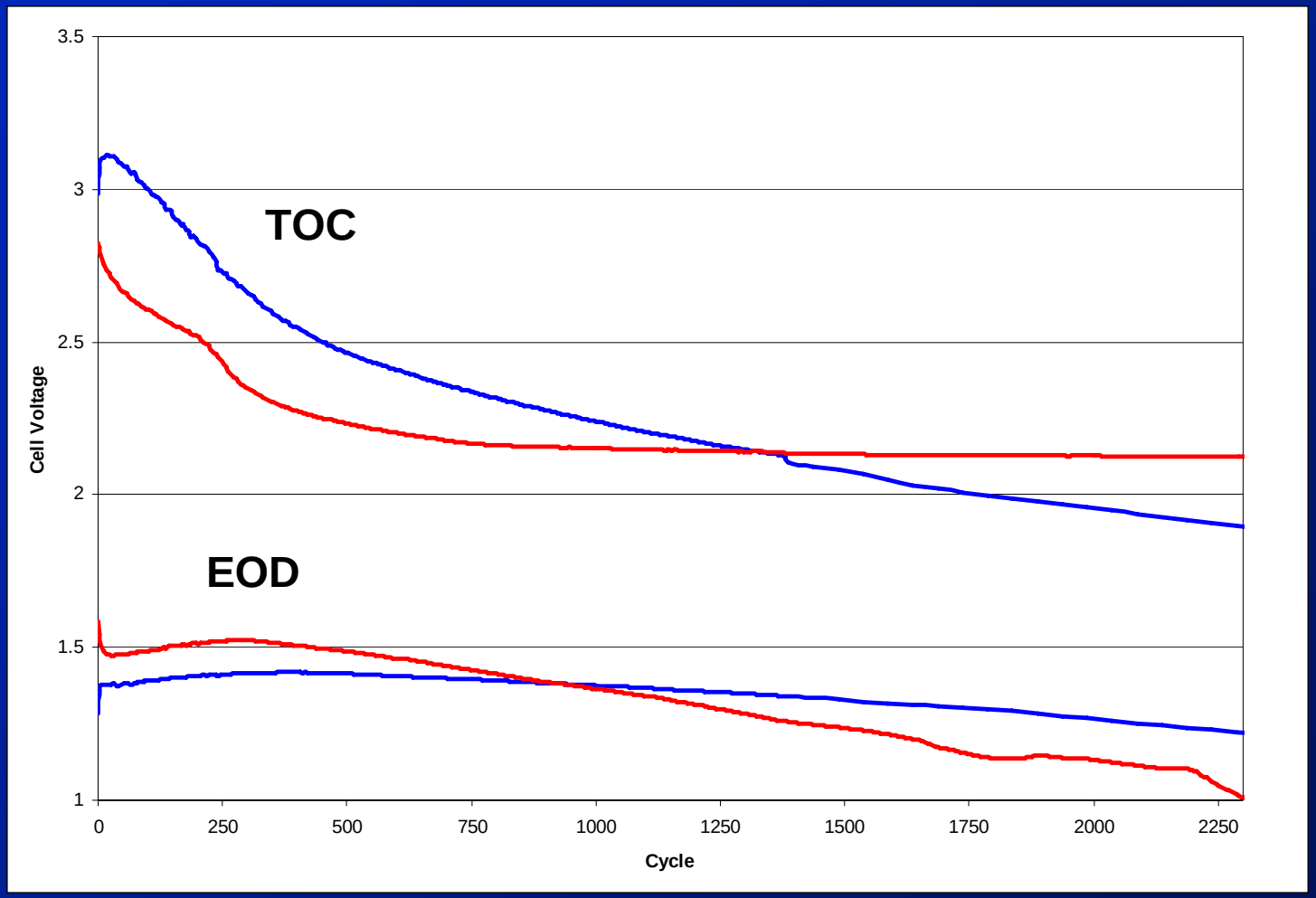
Test Protocol for HES and lead acid Devices

- Charge to 100%
- Discharge
  - 50-90% SOC
- 60 second charge and discharge
  - 10 second rest in-between
- Recharge
  - 0% SOC (1.7V battery or 1V HES)

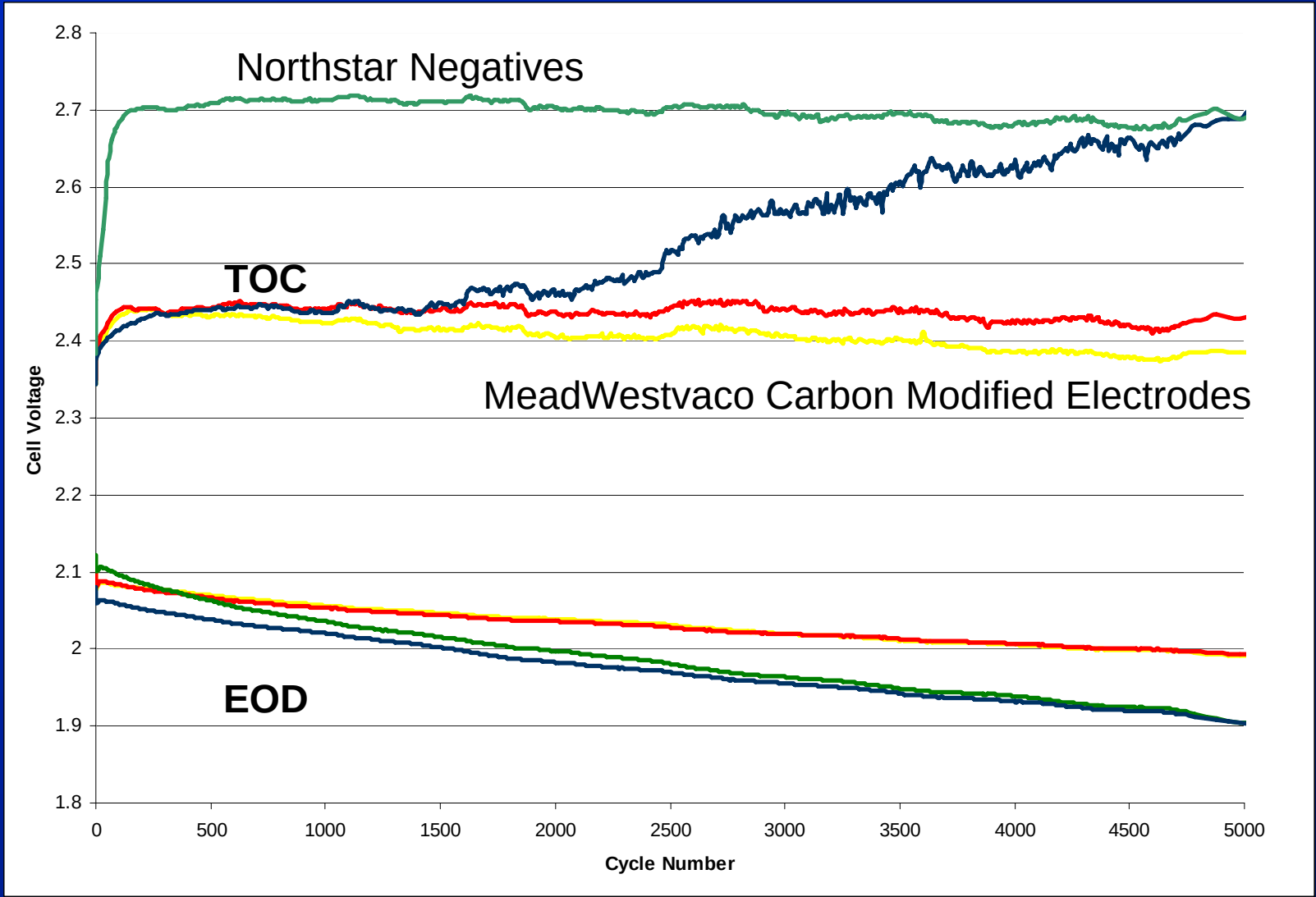
Cycle


Cell Voltage
TOC
EOD
Negative Electrode Potential
Current(A)
Test_Time(s)
3
2
1
0
-1
-2
-3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
20300
20320
20340
20360
20380
20400
20420
20440

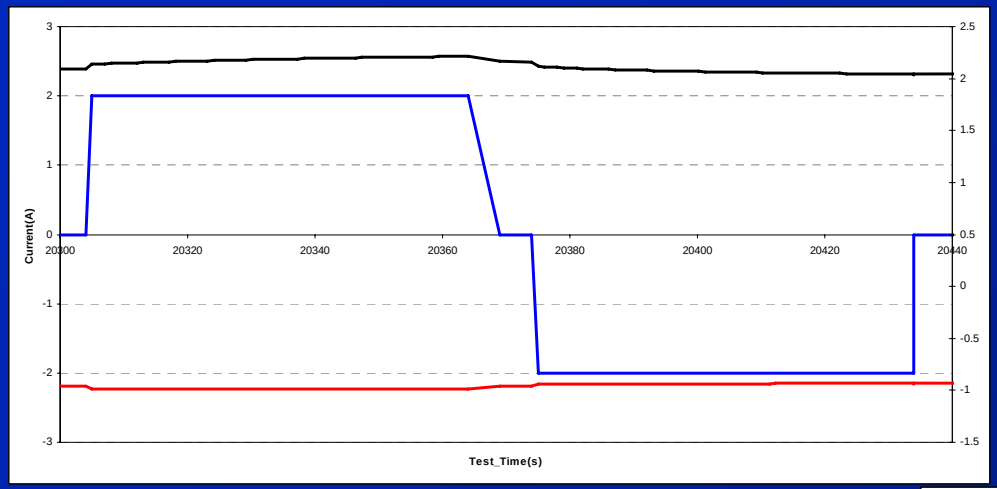
HES (Pb-C) Cycle Data



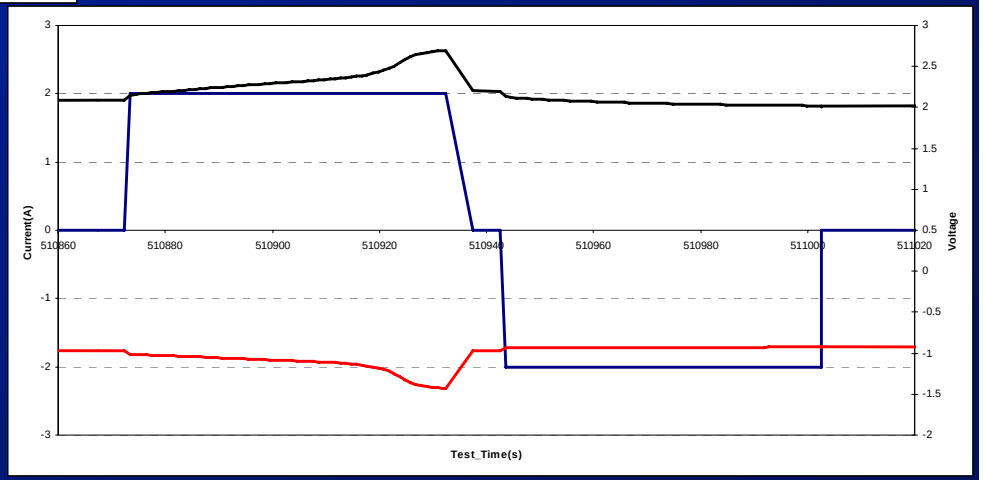
Carbon Modified Lead Acid



Poor Charge Acceptance



Increasing Cycle Number



Summary

- Initial Testing
  - HES and modified Lead Acid Batteries are cycling
  - Positive results with maintaining charge acceptance
- Program Direction
  - Seconds to 30 minute charge and discharge
  - Operate more like “Capacitor”
  - Possible advantages in float applications
  - Determine optimum carbon loadings and types