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Evaluation of Lead-Carbon Devices
DOE Energy Storage Program
Contract # 407411

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November 3, 2006
Washington DC

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Participants

- MeadWestvaco
  - Developing carbons for energy storage
  - Lab scale and battery testing
- DOE Energy Storage Program and Sandia National Labs
  - Verification and battery testing
  - Analytic Support
- NorthStar Battery Company
  - Manufacturing and Battery Testing
  - Battery Expertise
- ETA
  - Testing
  - System Estimates
- WPS Energy
  - Valuation

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Program Overview

Phase 1

- Evaluate lead based energy storage technologies
- Develop carbon for lead based technologies
  - Increase cycle life for some applications
  - Improve charging characteristics

Phase II

- Select best technology for 1MW utility demonstration

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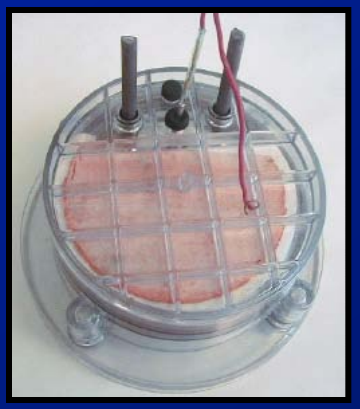
History

1. Lead Carbon Asymmetric
   - Research Cells
2. Evaluation of carbon modified lead acid batteries
   - Research Cells
   - 2 battery trials (250 Batteries)
3. Testing of Batteries and cells under several tests



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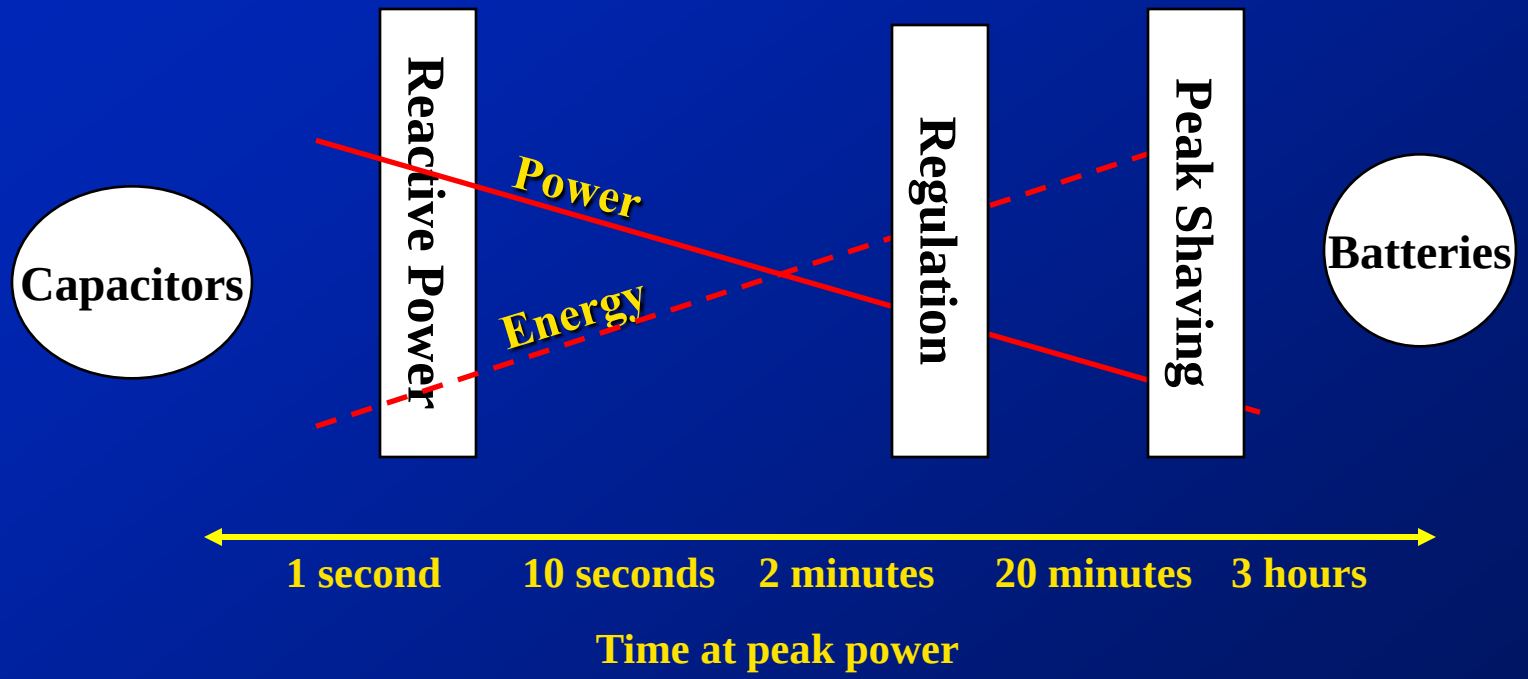
Utility Market Opportunity



10 seconds to 20 minutes charge/discharge requires device that has capacitor and battery properties.

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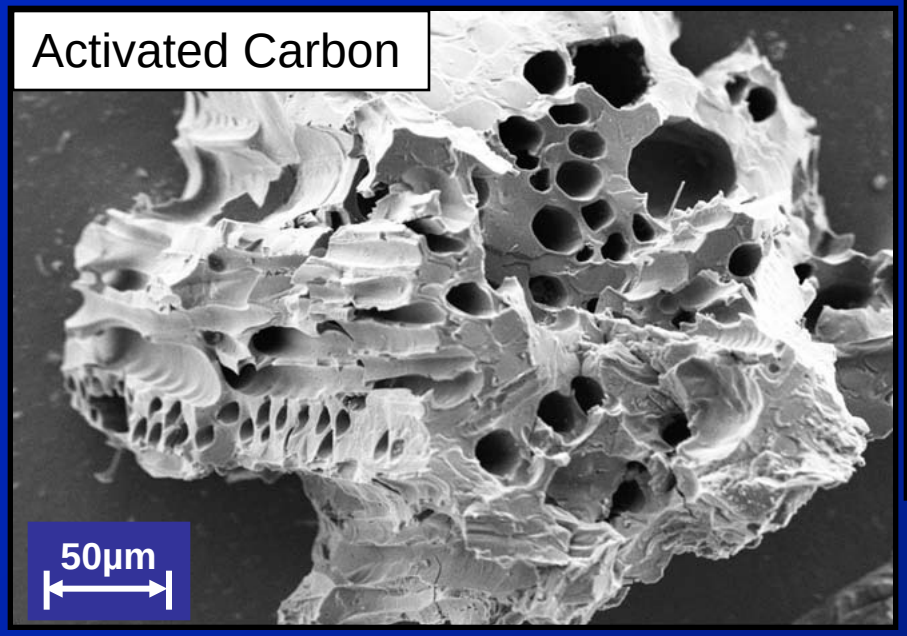
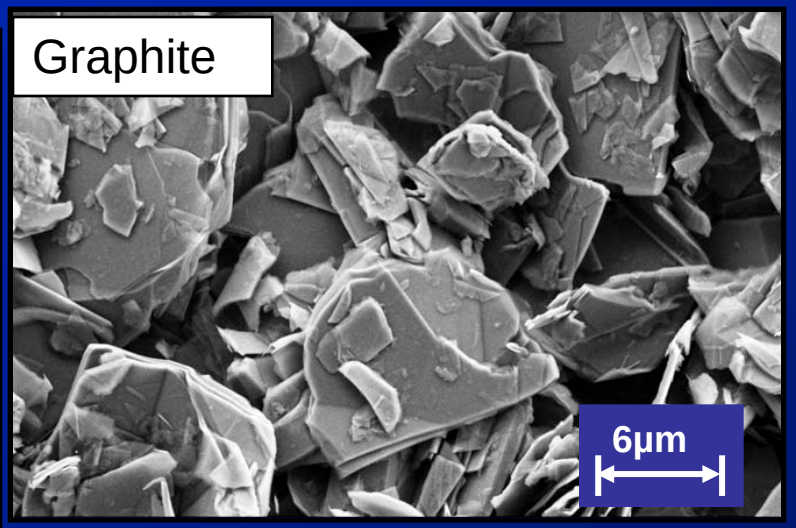
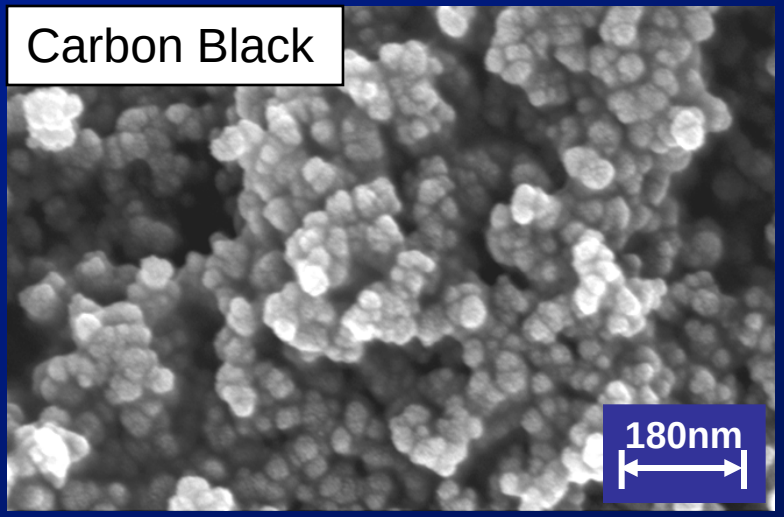
Carbons Under Review







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Current Theories

- Activated Carbon
  - Pore Former (Acid Reservoir)
  - Increase Capacitance
- Graphite
  - Conductivity
- Carbon Black
  - Conductivity

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Properties

Carbon	Surface Area (m2/g)	Capacitance (F/g)	Conductivity (ohm-cm)	Pore Volume (cc/g)
Graphite	1-20	1-5	0.001-0.1	0-0.1
Activate Carbon	500-2000	50-200	0.5-2.0	0.5-1.3
Carbon Black	50-1700	5-100	0.1	0.1-0.3

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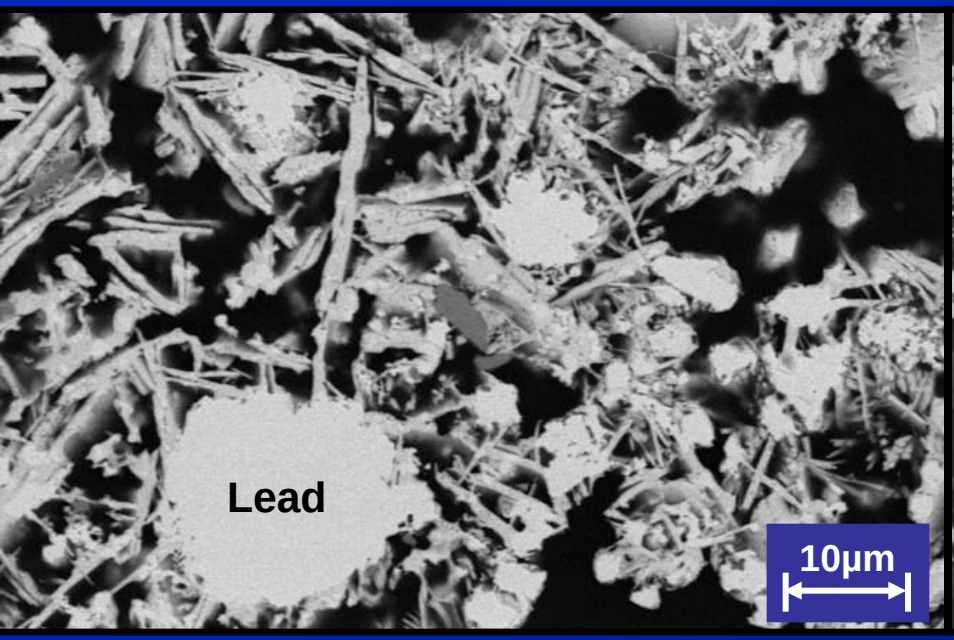
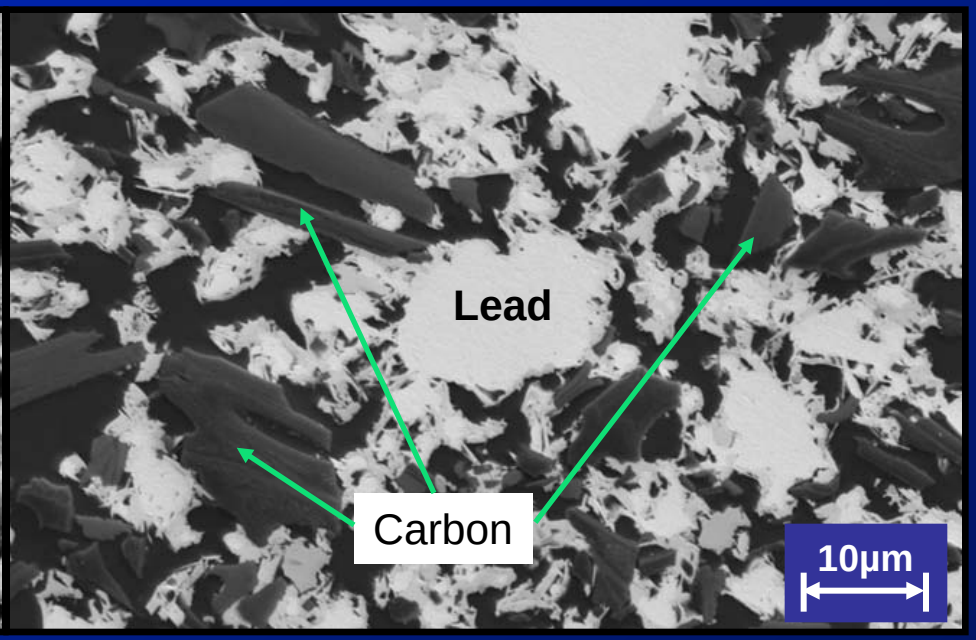
Standard Negative Electrode





Secondary Electron Image (SEI) in SEM

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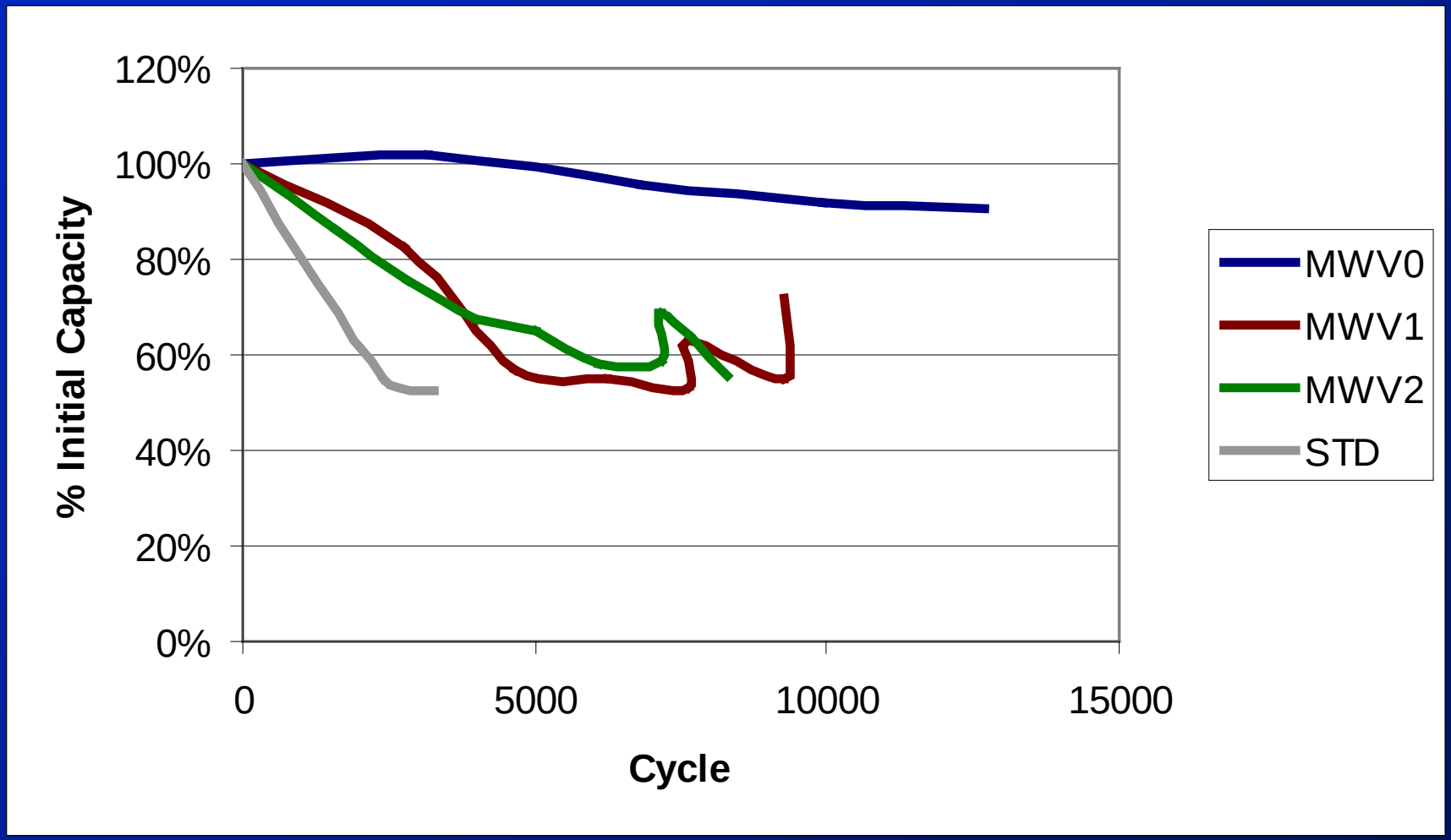
Battery Build

- **Negative activate material (NAM) modifications**
  - **Standard** Standard Battery Formulation
  - **MWV 0** 2% C-black and 2% graphite (Hammond-ALABC)
  - **MWV 1** 4% activated carbon
    - A-type Activated Carbon
  - **MWV 2** 4% activated carbon and 1.5% C-black
    - A-type Activated Carbon
  - **MWV 3** 3% activated carbon
    - B-type Activated Carbon
  - **MWV 4** 3% activated carbon and 1.5% C-black
    - B-Type Activated Carbon

PSoC Screening test on 30Amphr Batteries



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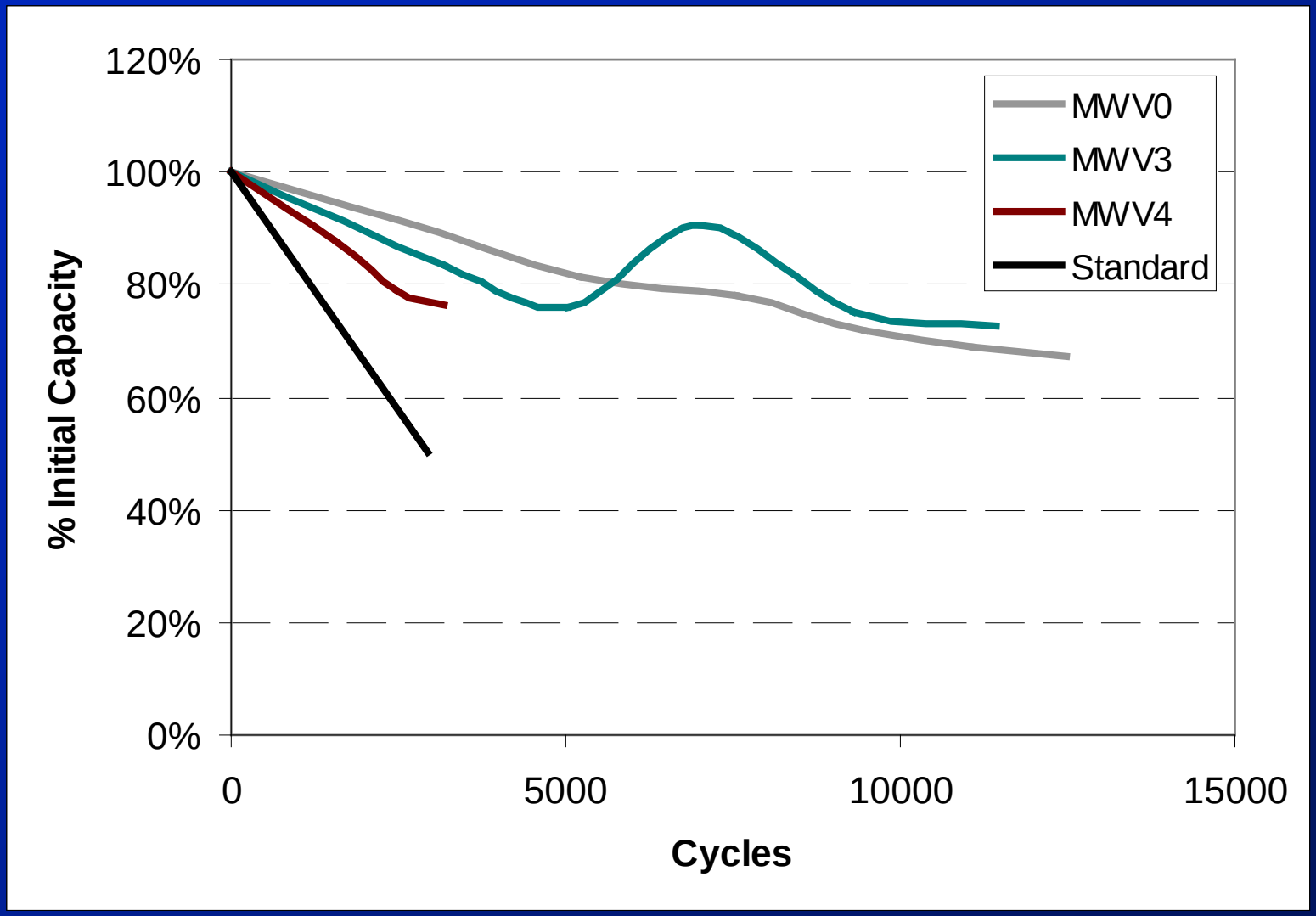
PSoC Screening test on 50AmpHr Batteries



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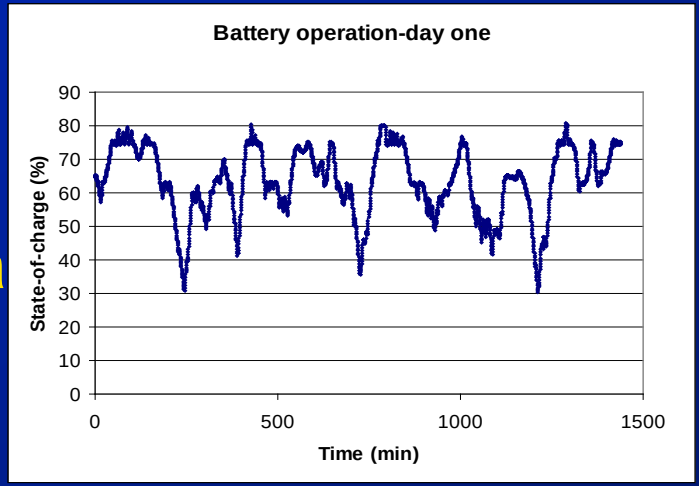
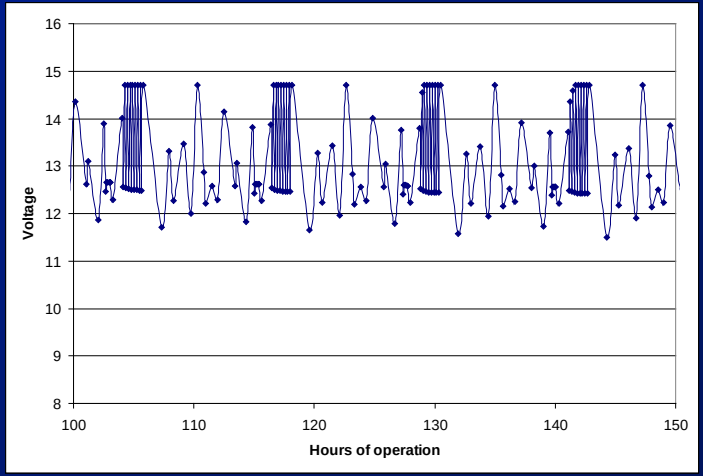
Simulated Utility algorithm

- Develop algorithm based on real data supplied by WPS Energy
- Profile developed
  - 30-80% SOC operation
  - same Ah balance as actual duty
  - SOC adjustment every 24 h
  - recharge 1-2 times per week
- Laboratory cycling of MWV0 and Standard





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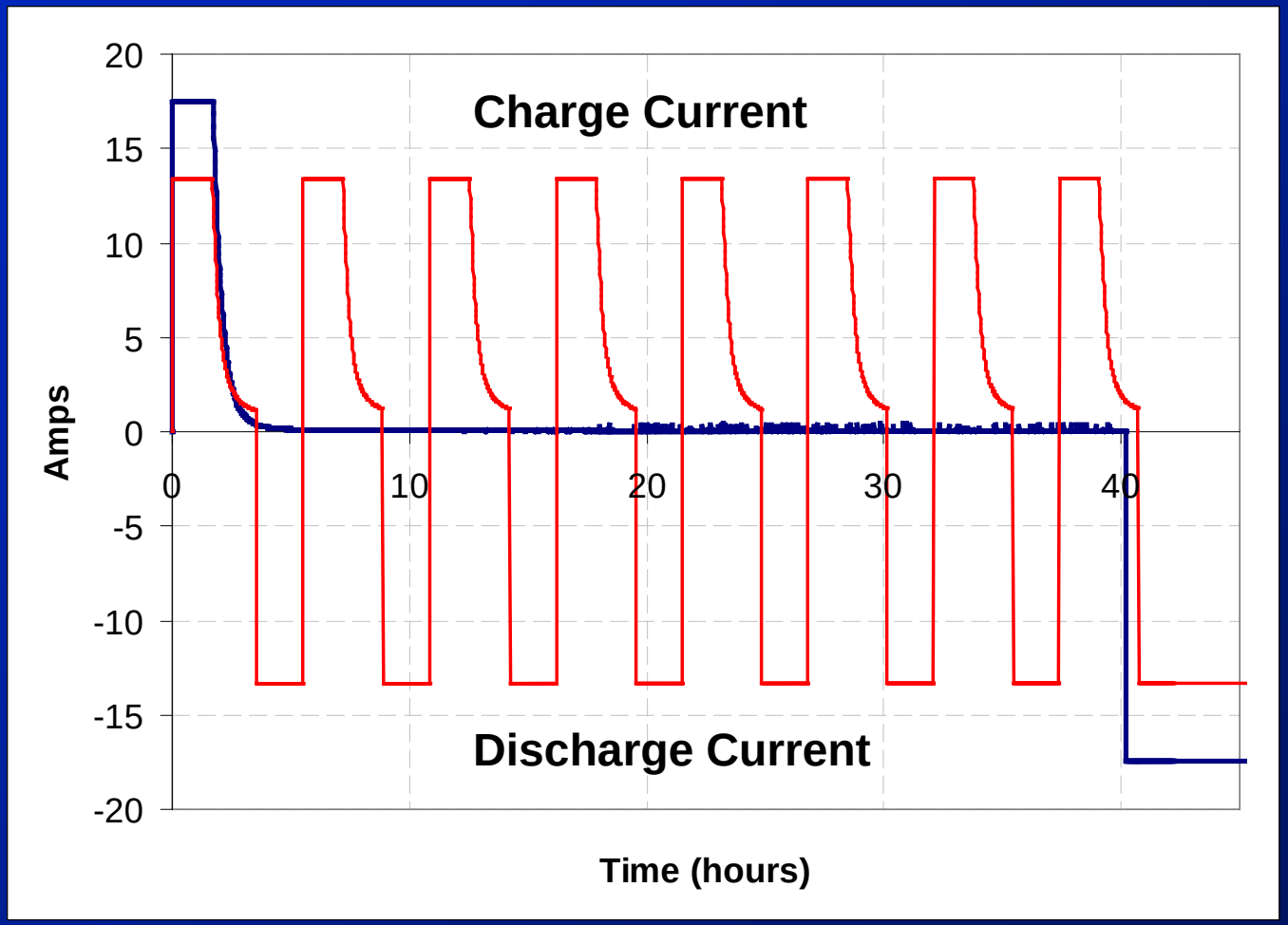
Fast Charge Cycle 108% Cycling



Carbon modified batteries has 8 cycles compared to 1 for standard product

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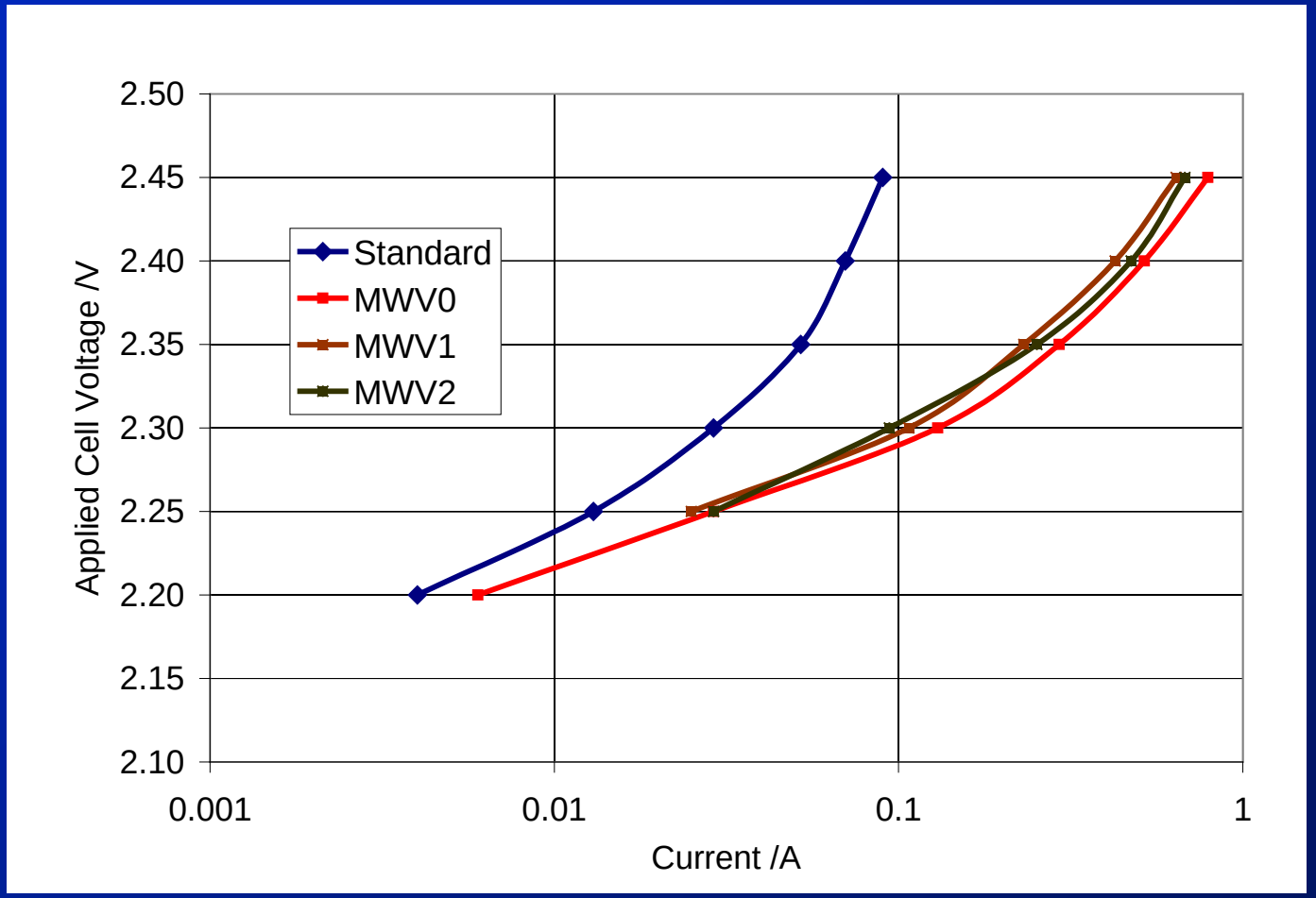
Tafel Data



Carbon modified batteries have an increase in current at all voltages

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Gas lost and float current at 2.45 volts per cell

Battery	Gassing rate to Standard	Float current to Standard	Molar Ratio H2:0
Standard	1	1	21
MWV0	22	20	2
MWV1	20	22	2
MWV3	2	10	3

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Conclusion

- Carbon additives increase cycle life under some conditions.
- Carbon improves charging characteristics
- Carbon increases gas evolution and float currents.

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Future Work

- Build new batteries with improved carbons
- Verify mechanisms for carbon effect
  - Develop new carbons
- Standardizing testing of batteries
- Develop actual system cost for Utility Demonstration

Thanks to Those Involved

NORTHSTAR BATTERY COMPANY

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Leading with Imagination

Sandia National Laboratories

Electric Transportation Applications

WPSenergy.com
A WPS Resources Company