2012 DOE Program Review: **Significant Cost Improvement of Li-Ion Cells Through Non-NMP Electrode Coating, Direct Separator Coating, and Fast Formation Technologies**

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Project Overview

Timeline

- Start: October 2011
- Finish: December 2014
- Final report to DOE: January 2015
- On schedule, 10% completed(1)

Budget

- Total project funding
  - DOE: $3.67M
  - Johnson Controls and sub-recipient: $3.67M
- Funding received in 2011: NA

Barriers

- Barriers for electrification of passenger vehicles(2)
  - Public acceptance of electrified vehicles
  - Vehicle and battery costs
  - Current manufacturing process is electrical energy intensive
- Target: reducing Li-Ion manufacturing cost by > 50%

Partners

- Entek Membranes
- Maxwell Technologies
- University of Wisconsin – Milwaukee

(1) as of Feb 2012; (2) According DOE Vehicle Technologies Program, Table 1

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Project Objective

Project scope

Significant cost improvement of Li-Ion manufacturing process:

- Non-NMP electrode coating process
- Direct coated separator
- Fast formation process
- Optimized cell design

Performance target

>50% cost reduction

(Li-Ion pouch cells)

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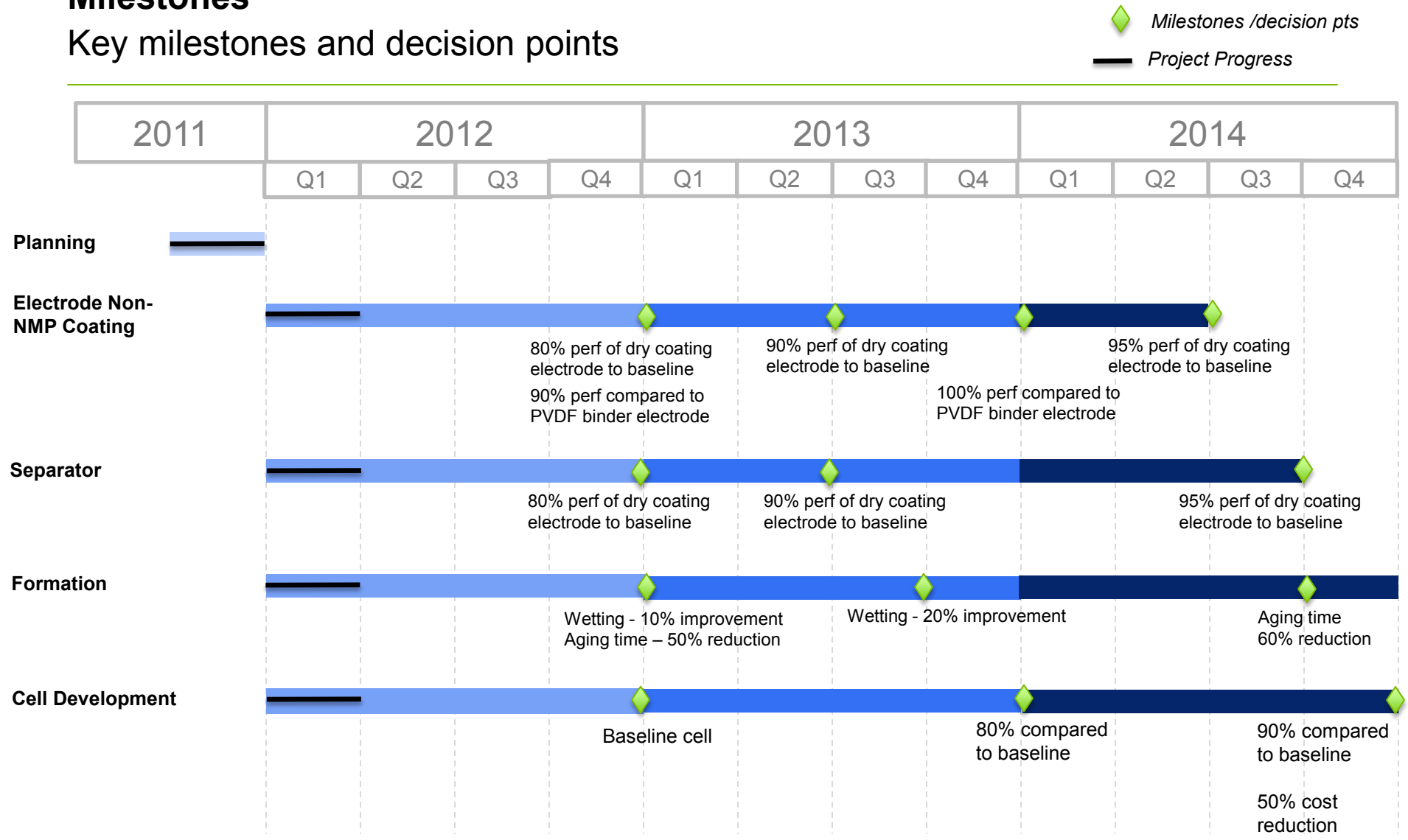
Milestones

Key milestones and decision points



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Approach

Dry coated electrode

- Electrode design optimization
- Binder and electrolyte development
- Process and equipment optimization

Water-based cathode binder

- Eliminate NMP solvent
- Develop material with electrochemical and chemical stability

Direct-coating of separator material on Li-Ion electrodes

- Solvent coating
- Dispersion coating
- Powder coating

Separator lamination on Lithium-Ion electrodes

- Free-standing, high structure stability separator development

Technical Accomplishments
FY 2011

Baseline cell designs

- Design completed for 3Ah and 15Ah pouch cells with 140Wh/kg and 280Wh/l energy density

Dry Coating Electrodes

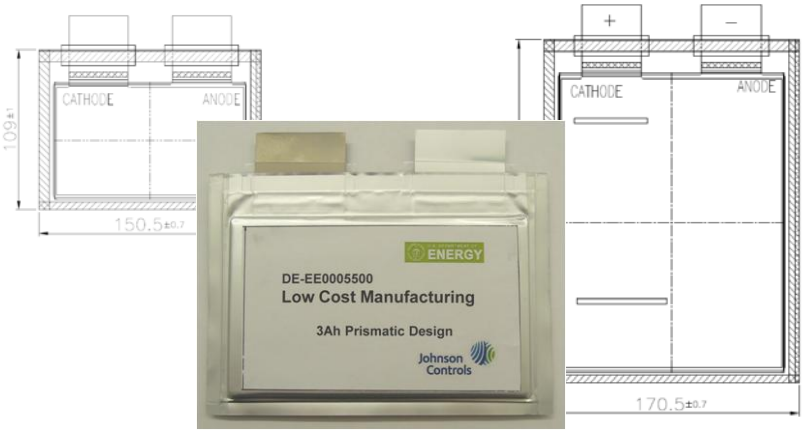
- Initial electrodes are demonstrating positive results in coin cells.

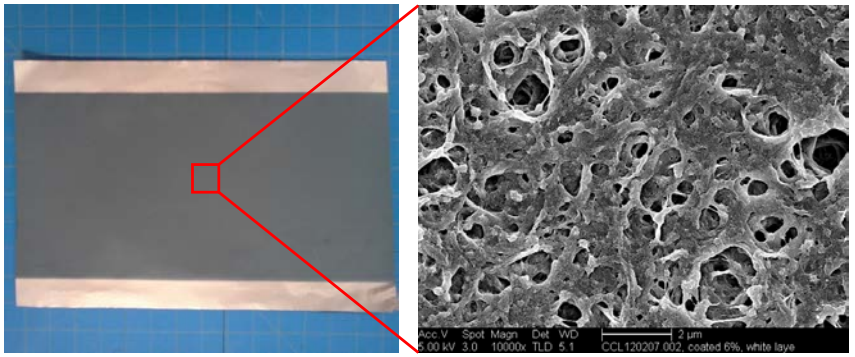
Water based cathode

- Cycling performance meets the reference performance while capacity achieves 90% of target.

Direct coated separator

- Micro porous polymer film applied successfully to electrode surface, half cell performance stable in half cell format.





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Collaborators

Maxwell Technologies

- Award sub-recipient
- Leader in ultracapacitor technology
- Focus on dry coating electrode research

University of Wisconsin – Milwaukee

- Partner in innovation
- Leading institute in material science and energy storage
- Focusing on fast formation modeling and cell characterization

Entek Membranes

- Award sub-recipient
- Leader in microporous membranes
- Focus on direct coated separator

Future Work

Remainder of 2012

- Build and evaluate 3Ah and 15Ah baseline cells
- Build baseline cell cost model
- Build and evaluate coin cells with integrated technologies
- Deliverables to DOE
  - 18 of 15Ah baseline cells
  - Baseline cost model
  - Coin cells results

Remainder of the project

- Build and evaluate new 3Ah and 15Ah incorporating technology advancements
- Optimize dry coating and non-NMP electrode approaches
- Select separator approaches based on cell performance
- Study and evaluate fast formation process
- Deliverables to DOE
  - 2013: 18 of new 3Ah cells
  - 2014: 24 final15Ah cells and cost model

Summary

- Current Li-ion battery cost is a barrier to mass market adoption for xEVs
  - Typical xEVs command ~$10K premium over ICE powertrain counterparts
  - EV battery pack could cost $8K - $18K per vehicle
- Improved process efficiency is a key cost reduction levers for batteries
  - The project aims to reduce manufacturing cost by 50% through
  - Integrated cell design
  - Reducing energy consumption during the manufacturing process
- Our partners are leaders in their respective fields
  - Entek to improve the separator process
  - Maxwell to improve electrode process
  - University of Wisconsin – Milwaukee to assist in modeling and characterization of cell formation
- We are well-positioned to deliver the research goals
  - Initial results have confirmed the validity of the research plan
  - Johnson Controls has long history of commercial innovation and operation excellence

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