Expanding U.S.-based Lithium-ion Battery Manufacturing

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EnerDel, Inc.
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Overview

Timeline
- Start January 2010
- End April 2013
- > 50% Complete

Barriers
- Lagging Customer Demand
- Financing
- Long Development Cycle(s)

Budget
- Total Project Funding $236 M
  - DOE - $118 M
  - EnerDel - $118 M
- Funding Received FY 2011: $54 M

Partners
- Equipment Suppliers
- EV Partners (Volvo, HHI, ATC)
- Purdue University
- USABC
Objectives - Relevance

- Develop competitive mass production capability for Lithium-ion battery cells & battery pack systems
  - Vertically integrated cell fabrication through pack assembly
  - Create domestic manufacturing capacity & skilled workforce
- Enhance supply chain & competitiveness of base materials
  - Develop and qualify domestic & international material suppliers
  - Improve performance, cost, & availability
Objectives - Relevance

• Position EnerDel as a tier-one transportation supplier of advanced Lithium-ion battery pack systems
  – Implement APQP product development framework
  – Meet standards and acquire industry certification
Approach

• Scalable facility footprint
  – Adapt & upgrade existing cell fabrication site
  – Acquire a new mixed-use manufacturing facility

• Achieve maximum leverage of process infrastructure
  – Achieve breakthrough process cycle times to minimize equipment & people footprint
Approach

- System/equipment optimization approach
Approach

• “Seed” initial capacity installation; scale upon customer acquisition
  – Design-in batch & serial production build capability
  – Flex capacity with manpower/line-shifts
  – Address system bottlenecks as needed
  – Develop capability to process alternative source rolled or cut electrode materials
    • Develop material packaging & storage methods
Approach

• Layout and automation guidelines
  – Follow lean manufacturing principles
  – Focus automation on Special Process Characteristics (SPC)
  – Flex through-put with manpower +/-
Approach

• Tool to one standard form factor for cell
  – Adjust chemistry or electrode content to specialize cell characteristics

• Tool to one standard form factor for battery module
  – Standardized piece stack-up

• Customize for applications at pack level
## Technical Accomplishments/Progress

### Manufacturing Start-up

<table>
<thead>
<tr>
<th>Component</th>
<th>Acquire</th>
<th>Install</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility II</td>
<td>3 mos.</td>
<td>1 mos.</td>
<td>2 mos.</td>
</tr>
<tr>
<td>Electrode</td>
<td>14 mos.</td>
<td>2 mos.</td>
<td>2 mos.</td>
</tr>
<tr>
<td>Cell Assy</td>
<td>7 mos.</td>
<td>2 mos.</td>
<td>7 mos.</td>
</tr>
<tr>
<td>Formation</td>
<td>9 mos.</td>
<td>3 mos.</td>
<td>3 mos.</td>
</tr>
<tr>
<td>Module/Pack</td>
<td>9 mos.</td>
<td>1 mos.</td>
<td>1 mos.</td>
</tr>
</tbody>
</table>
Technical Accomplishments/Progress

• Cell manufacturing
  – Production approval for EnerDel’s first Lithium-ion cell mass production system
  – Validation phase productivity improvement
Technical Accomplishments/Progress

• Production validation cell test results

10A Cycle @ 30C
Production Validation cell: Line 2 / Reference Cell: Line 1 PVP&R
Technical Accomplishments/Progress

- Module & pack manufacturing
  - Capacity ramped in 6 months to 17k equivalent EV Packs
  - Packs in customer use
**Technical Accomplishments/Progress**

- Alternative material supplier evaluations completed
  - Cathode active material
  - Anode active material
  - Foils
  - Electrolytes
  - Packaging laminates
  - Separators
Collaborations/Partnerships

• Strategic alliances result in the most advanced solutions as technology and infrastructure evolve