High-Volume Manufacturing of LiPF$_6$, A Critical Lithium-ion Battery Material

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May 16, 2012
Overview

Timeline
- Contract Start: April 16, 2010
- Contract End: April 15, 2013
- 23% Complete

Barriers
- Historically tight supply, global shortage of LiPF$_6$ in 2008
- Very difficult to produce at required quality, only 3 Asian producers
- Existing suppliers dependent on Chinese raw materials

Budget
- Total Project: $54.9M
  - DOE share: $27.3M
  - Honeywell Share: $27.5M

Partners
- Letters of intent from customers representing >50% of global demand
- Fully integrated on key raws
Relevance: All Lithium-Ion Batteries Require LiPF$_6$

- Build the first world-scale US manufacturing facility for LiPF$_6$
- Establish cost-effective domestic supply for critical material in the EDV supply chain
- Ensure the US-based lithium-ion battery industry has secure access to the highest quality LiPF$_6$ to avoid disruptions in supply and/or quality from foreign sources
ARRA

- Creates 151 direct engineering and construction jobs as well as additional jobs at U.S.-based suppliers
- Creates 34 long-term professional and manufacturing jobs
  - Highest quality, lowest cost position ensures long-term viability
- All lithium-ion battery manufacturers and their EDV customers benefit from secure and cost-effective supply of LiPF$_6$

Vehicles Technology Program

- Reduce petroleum consumption
- Promote energy security
  - Avoid replacing imported oil with imported batteries/battery materials
  - Current Asian LiPF$_6$ producers dependent on Chinese raw materials

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Battery Size (kWh)</th>
<th>Annual Production</th>
<th>LiPF$_6$ (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEV</td>
<td>2</td>
<td>100,000</td>
<td>30</td>
</tr>
<tr>
<td>PHEV</td>
<td>15</td>
<td>100,000</td>
<td>200</td>
</tr>
<tr>
<td>EV</td>
<td>23</td>
<td>100,000</td>
<td>310</td>
</tr>
</tbody>
</table>
Critical Li-ion Battery Component – LiPF$_6$

Why Honeywell?

- Developed novel process to deliver highest purity LiPF$_6$ at the lowest cost
- Multiple letters of support confirming Honeywell’s quality
- Fluorine (HF) is ~50% of the raw material cost in LiPF$_6$
  - Honeywell is the world’s largest producer of HF
  - 50+ years experience in developing and scaling up new F-based molecules
  - Existing LiF supplier to Li-ion battery industry

Honeywell Existing Products

<table>
<thead>
<tr>
<th>Li:</th>
<th>LiF</th>
</tr>
</thead>
<tbody>
<tr>
<td>F$_6$:</td>
<td>HF</td>
</tr>
<tr>
<td>P:</td>
<td>P-source</td>
</tr>
</tbody>
</table>

LiPF$_6$
Approach

- Honeywell has developed novel process to deliver highest purity with the lowest cost

- Leverage synergies unique to Honeywell
  - Existing know-how and assets to bring LiPF$_6$ to market quickly
  - Key raw materials on site
  - Qualified operations and management teams in place
  - Existing permits

- Phase 1 – Build LiPF$_6$ plant at Buffalo, NY facility
  - Fastest path to provide material for customer qualification
  - Team that invented process located on-site

- Phase 2 – Planned construction of world-scale LiPF$_6$ plant
Buffalo Plant

LiPF₆ Plant

- Developed and scaled up all new fluorine-based products since 1980s
- Existing production, safety and utility infrastructure
- Key personnel on-site
Technical Accomplishments and Progress

- Environmental reviews complete
  - Buffalo site received Categorical Exclusion CX designation
  - Illinois site Finding of No Significant Impact issued Sept 2010

- Job Creation
  - 23.4 jobs created in 2nd half of 2010
  - 22.8 jobs created in 2011

- Reporting
  - In compliance with all DOE and ARRA reporting requirements

- Completed Milestones
  - Basic engineering
  - Detailed design and procurement
  - Mechanical completion of Buffalo plant

- Future Work
  - Complete customer sampling and qualification
  - Complete detailed design of world-scale plant
  - Complete construction of world-scale plant
Summary

- All lithium-ion batteries need LiPF$_6$
- Secure supply of highest quality LiPF$_6$ is critical to success of DOE’s Battery Manufacturing Initiative
- Honeywell is uniquely positioned to deliver US production of LiPF$_6$
- Honeywell is meeting the goals of the ARRA and the DOE Vehicle Technologies Program
  - 22.8 jobs created in 2011
  - $14.2M spent to date