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High-Volume Manufacturing of $LiPF_6$, A Critical Lithium-ion Battery Material

Project ID: ARRAVT014

Overview

Timeline

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

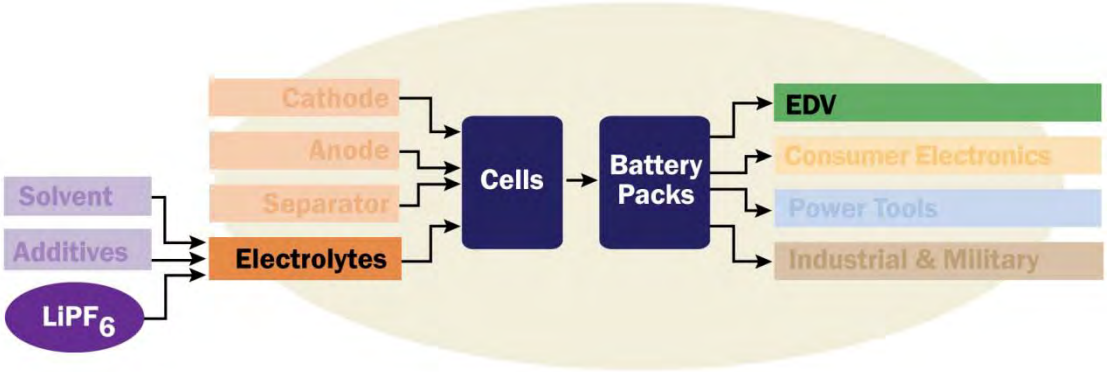
Budget

- 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

Relevance

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

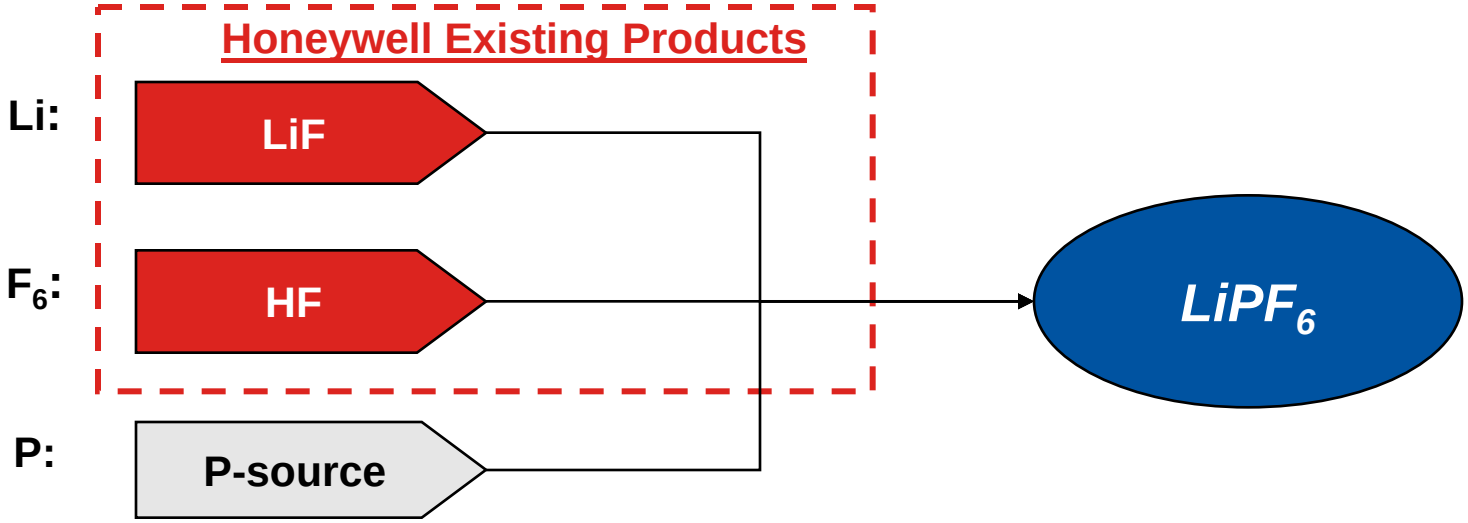
- Reduce petroleum consumption
- Promote energy security
  - Avoid replacing imported oil with imported batteries/battery materials
  - Current Asian $LiPF_6$ producers dependent on Chinese raw materials

Vehicle Type	Battery Size (kWh)	Annual Production	$LiPF_6$ (MT)
HEV	2	100,000	**30**
PHEV	15	100,000	**200**
EV	23	100,000	**310**

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



World Capacity for HF Production

World HF Capacity*	
Location	**HF capacity (K MT)**
North America	**413**
Japan	157
China	700
Western Europe	266
ROW	154
Total	**1,690**

Major North America HF Capacity*		
Company	**HF capacity (K MT)**	**% NA share**
Honeywell	**183**	**44%**
Mexichem	100	24%
DuPont	82	20%
Solvay	35	8%
Others	13	4%

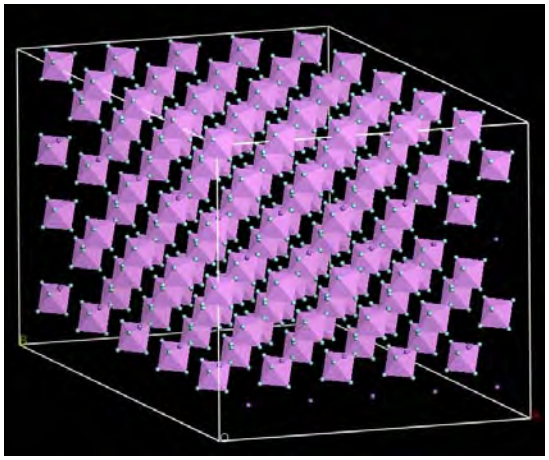
- HF is produced from fluorspar
- Today Japanese HF producers import fluorspar from China
- "In the future it is expected that China will increasingly add further value to acid-spar through the production of downstream products … rather than export the mineral."*

Honeywell Has 44% of North America HF Capacity

* *"Economics of Fluorspar" Tenth Edition, 2009 by Roskill Information Services Ltd.*

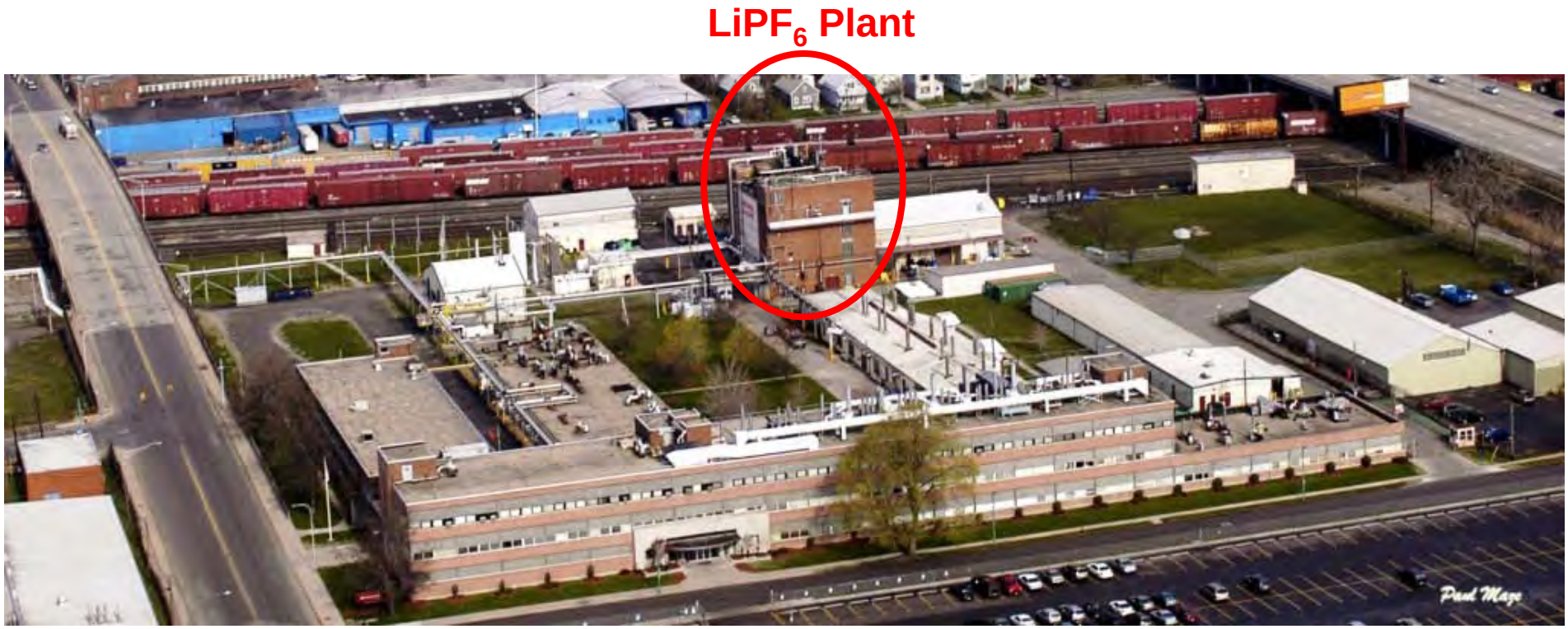
Approach

- 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 – Build world-scale $LiPF_6$ plant in Illinois



$LiPF_6$ Molecule

Buffalo 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
  - 36.7 jobs created in the last quarter
  - 5 new direct hires in 2010
- Reporting
  - In compliance with all DOE and ARRA reporting requirements
- Completed all scheduled 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

In May of 2010, the DOE, Honeywell leaders and Buffalo officials commemorated Honeywell's acceptance of the $27.3 million ARRA grant to produce $LiPF_6$ for vehicle batteries.

Pictured: Tien Duong, Department of Energy; David Franczyk, Buffalo City Council President; Andreas Kramvis, President and CEO of Honeywell Specialty Materials; Byron Brown, Mayor of Buffalo; U.S. Rep. Brian Higgins; and Jay Kelly, Honeywell Site Leader.

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
  - 36.7 jobs created in last quarter
  - $8.7M spent to date
  - All scheduled Milestones achieved