II. AMERICAN RECOVERY & REINVESTMENT ACT (ARRA) OF 2009

Integrated Battery Materials Production, Cell Manufacturing, and Battery Assembly Facilities

Battery Cell and Pack Assembly Facilities

Battery Materials Production Facilities

Battery Recycling Facilities

Battery Research Facilities

II. American Recovery & Reinvestment Act (ARRA) of 2009

The American Recovery and Reinvestment Act of 2009 (ARRA) (Public Law 111-5) is an economic stimulus package enacted by the 111th United States Congress in February 2009. This Act of Congress is based largely on proposals made by President Obama early during his Administration and is intended to provide a stimulus to the U.S. economy in the wake of an economic downturn. The measures are nominally worth $787 billion and include federal tax cuts, expansion of unemployment benefits and other provisions, including domestic spending in education, health care, and infrastructure, including that in the energy sector.

As part of ARRA implementation, on August 5, 2009 President Obama announced $2.4 Billion in manufacturing grants to accelerate the manufacturing and deployment of the next generation of U.S. made batteries and electric vehicles – by funding 48 new advanced battery and electric drive components manufacturing and electric drive vehicle deployment projects – including PHEV and EV demonstration and education projects – in over 20 states. The grantees were selected through a competitive process conducted by DOE and were intended to accelerate the development of U.S. manufacturing capacity for batteries and electric drive components as well as the deployment of electric drive vehicles to help establish American leadership in developing the next generation of advanced vehicles. The new awards included $1.5 billion in grants to U.S. based manufacturers to produce batteries and their components and to expand battery recycling capacity, distributed over all parts of the country. As shown in Figure II - 1, these grants cover a range of manufacturing areas including those associated with material supply, cell components, cell fabrication, pack assembly, and recycling. The recipients and amounts for the individual grants are listed in Table II - 1.

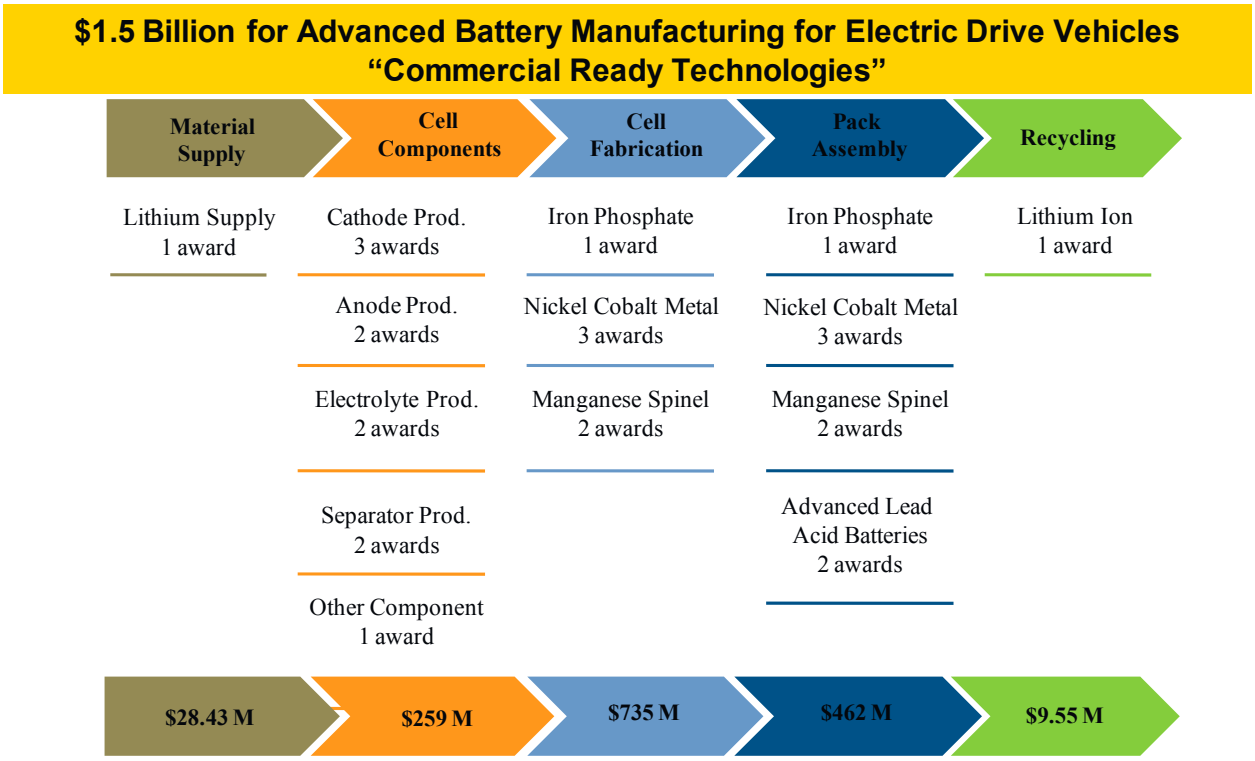

Figure II - 1: American Recovery and Reinvestment Act (ARRA) 2009 grants distribution for battery and electric drive manufacturing.

The rest of this section presents a brief summary of the individual ARRA grants.

Table II - 1: Recovery Act Awards for Electric Drive Vehicle Battery and Component Manufacturing Initiative.

Applicant	DOE Award (Dollars in Millions)	Project Locations	Technology
Cell, Battery, and Materials Manufacturing Facilities			
Johnson Controls, Inc.	$299.2	Holland, MI Lebanon, OR (Entek)	Production of nickel-cobalt-metal battery cells and packs, as well as production of battery separators (by partner Entek) for hybrid and electric vehicles.
A123 Systems, Inc.	$249.1	Romulus, MI Brownstown, MI	Manufacturing of nano-iron phosphate cathode powder and electrode coatings; fabrication of battery cells and modules; and assembly of complete battery pack systems for hybrid and electric vehicles.
KD ABG MI, LLC (Dow Kokam)	$161	Midland, MI	Production of manganese oxide cathode / graphite lithium-ion batteries for hybrid and electric vehicles.
Compact Power, Inc. (on behalf of LG Chem, Ltd.)	$151.4	St. Clair, MI Pontiac, MI Holland, MI	Production of lithium-ion polymer battery cells for the GM Volt using a manganese-based cathode material and a proprietary separator.
EnerDel, Inc.	$118.5	Indianapolis, IN	Production of lithium-ion cells and packs for hybrid and electric vehicles. Primary lithium chemistries include: manganese spinel cathode and lithium titanate anode for high power applications, as well as manganese spinel cathode and amorphous carbon for high energy applications.
General Motors Corporation	$105.9	Brownstown, MI	Production of high-volume battery packs for the GM Volt. Cells will be from LG Chem, Ltd. and other cell providers to be named.
Saft America, Inc.	$95.5	Jacksonville, FL	Production of lithium-ion cells, modules, and battery packs for industrial and agricultural vehicles and defense application markets. Primary lithium chemistries include nickel-cobalt-metal and iron phosphate.
Exide Technologies with Axion Power International	$34.3	Bristol, TN Columbus, GA	Production of advanced lead-acid batteries, using lead-carbon electrodes for micro and mild hybrid applications.
East Penn Manufacturing Co.	$32.5	Lyon Station, PA	Production of the UltraBattery (lead-acid battery with a carbon supercapacitor combination) for micro and mild hybrid applications.
Advanced Battery Supplier Manufacturing Facilities			
Celgard, LLC, a subsidiary of Polypore	$49.2	Charlotte, NC Aiken, SC	Production of polymer separator material for lithium-ion batteries.
Toda America, Inc.	$35	Goose Creek, SC	Production of nickel-cobalt-metal cathode material for lithium-ion batteries.
Chemetall Foote Corp.	$28.4	Silver Peak, NV Kings Mtn., NC	Production of battery-grade lithium carbonate and lithium hydroxide.
Honeywell International Inc.	$27.3	Buffalo, NY Metropolis, IL	Production of electrolyte salt (lithium hexafluorophosphate (LiPF6)) for lithium-ion batteries.
BASF Catalysts, LLC	$24.6	Elyria, OH	Production of nickel-cobalt-metal cathode material for lithium-ion batteries.
EnerG2, Inc.	$21	Albany, OR	Production of high energy density nano-carbon for ultracapacitors.
Novolyte Technologies, Inc.	$20.6	Zachary, LA	Production of electrolytes for lithium-ion batteries.
FutureFuel Chemical Company	$12.6	Batesville, AR	Production of high-temperature graphitized precursor anode material for lithium-ion batteries.
Pyrotek, Inc.	$11.3	Sanborn, NY	Production of carbon powder anode material for lithium-ion batteries.
H&T Waterbury DBA Bouffard Metal Goods	$5	Waterbury, CT	Manufacturing of precision aluminum casings for cylindrical cells.
Advanced Lithium-Ion Battery Recycling Facilities			
TOXCO Incorporated	$9.5	Lancaster, OH	Hydrothermal recycling of lithium-ion batteries.

II.A Integrated Battery Materials Production, Cell Manufacturing, and Battery Assembly Facilities

II.A.1 ARRA-supported Production Facility Project (JCI)

Christopher Johnson (NETL Project Manager)
Grant Recipient: Johnson Controls, Inc.

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Start Date: July 2009
Projected End Date: October 2014

Introduction

Johnson Controls is a leading supplier of hybrid and electric battery systems that make vehicles more energy efficient. In 2009, Johnson Controls received a $299.2 million matching grant – the largest grant awarded – from the United States Department of Energy under the American Recovery and Reinvestment Act (ARRA) to build domestic manufacturing capacity for advanced batteries for electric drive vehicles. The grant will help to build a U.S. advanced battery industry that allows for long-term growth, new jobs, and global leadership in the development and manufacture of today's hybrids and electric vehicles.

- Description of facilities: This project involves the construction or expansion of facilities related to the Li-ion battery industry: Li-ion battery production up to 30M cells, a comprehensive technology center, and the expansion of a Li-ion separator facility
- Total Value of award: $299,177,757
- Percent of funds expended: 42% of the funds have been expended as of Sept. 30, 2012

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Progress and Current Status

Meadowbrook Lithium-Ion Battery Plant

Johnson Controls Power Solutions new Meadowbrook facility in Holland, Michigan is the first facility in the United States to produce complete lithium-ion battery cells and systems for hybrid and electric vehicles.

This project has led to the accomplishments towards the stated goals:

- Investing in America
  - Making an investment in the U.S. to build an advanced energy industry
  - Developing and bringing advanced products to market
  - Sourcing more than 90% of equipment and materials from the U.S. to retain and create jobs in the domestic supply chain
- Investing in people
  - Hiring engineers, technicians, and an experienced manufacturing workforce in the U.S.
- Delivering successes
  - Building a domestic supply base, as well as anchoring foreign suppliers in the U.S.
  - The JCI plant is has begun domestic production of complete advanced battery systems.
  - JCI is also exporting batteries to customers in Europe.

Accomplishing Johnson Controls' goals of manufacturing excellence:

- Installing state-of-the-art equipment to deliver:
  - Automotive quality product
  - High volume capability
  - Significantly reduced cost
  - Minimized environmental impact
  - Processing efficiency
- Reducing costs
  - Domestic sourcing of materials
  - Design optimization
  - Manufacturing process optimization
  - Johnson Controls operational excellence, Best Business Practices, and continuous improvement

Accomplishing goals – sustainability:

- Certified U.S. Green Building Council LEED® gold factory
  - The plant performs more efficiently with less impact on the environment
- Cooling for free
  - The plant's cooling towers relieve significant pressure from our facility's chiller plant
  - As a result, the plant will have more consistent operating costs throughout the year
- Recovering heat
  - Heat from the battery formation process is captured and used in other areas of battery manufacturing
- Reclaiming what would have been wasted
  - Designed processes to reclaim materials used in manufacturing to save time, cost and energy

Facility statistics:

- Construction complete (100%)
- Equipment Installed (76%)
- Production started
- Jobs: There are currently 130 permanent employees, with 320 expected at full capacity
- Jobs: 1,000 temporary/construction workers were employed at this site during the construction phase

Battery Technology Center / Battery Test Facility

Johnson Controls Power Solutions' newly renovated, state-of-the-art Battery Technology Center and Battery Test Facility is located at its Power Solutions headquarters in Glendale, Wisconsin. A specific portion of this facility was matched by the DOE to support the testing capabilities for component qualification, validation and launch battery systems in support of customers' production programs including domestic supplier qualifications, and expanding production capacity to manufacture separators for electric vehicle applications. The facility is the largest energy storage technical center in North America.

More than 46,000 square feet of existing labs and office space was redesigned in the Battery Technology Center (BTC) to enhance labs used to support mass battery production for customers.

The newly renovated facility features the most high-tech equipment available, including a CT Scanner, X-ray Diffractometer and Dry Room. The renovation marks the first time the facility has been overhauled on a major scale since 1983.

The Battery Test Facility, built in 2007, was also re-designed. Its size increased by 50 percent to 9,000 square feet and state-of-the-art equipment was installed for testing of advanced batteries in extreme conditions such as heat, cold and vibrations.

The ARRA grant and Johnson Controls' matching investment have so far created 60 jobs at the company's Power Solutions headquarters in Glendale.

Facility statistics:

- Construction complete (100%)
- Equipment Installed (100%)
- Production has started
- Jobs: 60 permanent fulltime positions have resulted from this project
- Jobs: 500 temporary/construction workers were employed at this site during the construction phase

ENTEK Separator Expansion

Under this project, Entek is expanding their production capabilities of Li-ion separator production.

Engineering scope has been developed and construction is underway on the new production line.

All major equipment has been installed on existing production line.

Long lead time equipment has been ordered for new production line.

Facility statistics:

- Construction complete
- Equipment Installed (100%, 45% on the new line)
- Production has started
- Jobs: One additional employee has been hired, with 26 expected at full capacity

Pictorial Overview

Figure II - 2: Michigan Li-ion battery plant during construction – 1000 construction workers were employed in the construction of our Michigan plant.

Figure II - 3: Construction included the upfit of an existing building for Li-ion battery production, including the construction of new outbuildings to house equipment and materials.

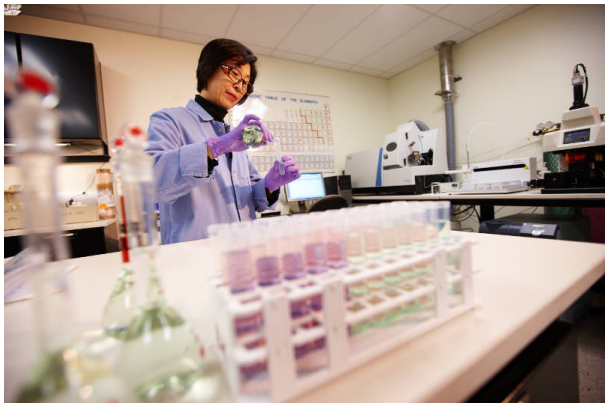

Figure II - 4: This project helped fund the material characterization and test facilities critical to support advanced energy production programs.

Figure II - 5: Johnson Controls' facilities include the equipment necessary to perform all relevant battery and cell tests, including cycle testing in controlled temperature environments.

Figure II - 6: Pilot scale equipment installed in controlled environments support the mass production programs.

Figure II - 7: Equipment – Pack assembly was up and running within 10 months of receiving the award from the Department of Energy.

Figure II - 8: Equipment – Cell assembly equipment is installed and production has begun.

Figure II - 9: Complete battery packs and systems are assembled domestically prior to being sent to the customer.

Planned Work for FY 2013

In the remainder of the project, the JCI Holland, Michigan plant will:

- Assemble complete battery packs with domestically produced cells
- Accelerate market demand to support the full capacity of our plant
- Continue to obtain production contracts to produce xEVs
- Continue to make technology investments to maintain Johnson Controls' leadership position

Customers and Other Information

The following customers, among others, are currently sourced from or are being transitioned to the Holland, MI facility, as well as others which Johnson Controls is not able to discuss per customer confidentiality requirements.

Production for Daimler is transitioning to Michigan from the JCI European plant.

JCI has announced a contract with XL Hybrids to supply Li-Ion batteries for fleet vehicles for Chevy and GMC vans beginning in 2013.

II.A.2 Vertically Integrated Mass Production of Automotive Class Lithium-ion Batteries (A123 Systems)

Ralph Nine (NETL Program Manager)
Grant Recipient: A123 Systems

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Start Date: December 3, 2009
Projected End Date: December 30, 2014

Figure II - 10: Livonia Cell Assembly Line.

Objectives

- Description of facilities: this program will construct three (3) facilities: 1) Livonia- Cell Assembly/Module Pack; 2) Romulus 1- Coating, 3) Romulus 2- Cell Assembly/Module Pack
- Total Value of award: ($249M)
- Percent of funds expended: at the close of FY 2012 the funds provided by the DOE will amount to $133,398,425 which represents approximately 50% of the funds.

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Progress and Current Status

Facility 1 – Livonia (Cell Assembly/Module Pack)

- Construction complete (100%)
- Equipment Installed (100%)
- Production Started (100%)
- Jobs: permanent (524 full time employees)

Facility 2 – Romulus 1 (Coating)

- Construction complete (100%)
- Equipment Installed (100%)
- Production Started (100%)
- Jobs: permanent (114 full time employees)

Facility 3 – Romulus 2 (Cell Assembly/Module Pack)

- Facility construction has not commenced

Planned Work for FY 2013

The general philosophy of manufacturing expansion is to cost-effectively meet the rapidly escalating customer volume needs while managing operational risk. This approach began with transferring our existing low-risk, mature process technologies from Asia, improve the processes and level of automation, and systematically increase throughput and lower costs over time. The first portion of the build-out involves the rapid deployment, using a "Copy Improve" approach wherein the initial Livonia cell and module/pack factory capacity will be installed with the same processes and equipment currently used in A123's Asian factories, while increasing the level of automation for material movement and process control to increase output and boost productivity.

The second portion of the build-out uses near identical equipment to that used in the Livonia production factory, but with increased throughput at specific operations that are at low risk. This will be the "Factory of the Future" approach for high volume manufacturing (HVM) will further reduce cost and headcount through additional automation, data collection and improved manufacturing execution platforms. This approach will be used as A123 brings up the coating operations at the Romulus campus.

II.A.3 ARRA-supported Production Facility Project (Exide)

Bruce W. Mixer, P.E. (NETL Project Manager)
Grant Recipient: Exide Technologies

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Start Date: December 22, 2009
Projected End Date: December 21, 2012

Introduction

- This project covers the expansion of Exide Technologies' manufacturing capacity for producing advanced AGM batteries in existing U.S.-based battery plants. The project plan is to implement a combined increase in yearly production capacity of 1.5 million additional units at two of Exide's current manufacturing locations – Columbus, Georgia and Bristol, Tennessee.
- These advanced battery technologies are targeted to have an accelerated near-term impact for micro-hybrid vehicles, idle reduction commercial vehicles, and other strategic market segments.
- Total Value of award: $34,294,772
- Percent of funds expended: 97.28% as of 09/30/2012

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Progress and Current Status

This manufacturing expansion project involves two of Exide's global technologies: a Flat Plate Absorbed Glass Mat (AGM) design and a Spiral Wound AGM design, both of which to be manufactured with or without advanced carbon technology as required by customer specific applications.

During the FY12 period of performance, both of the project sites progressed successfully toward the project plan's final stages. There has been no slippage in projected timing from the start of the project, no changes that would impact either the scope or cost of the project, and no unforeseen problems that would prevent a successful completion according to plan.

Facility 1 – AGM Flat Plate, Columbus, Georgia

- Construction complete (%) N/A - No facility construction funded by ARRA grant project.
- Equipment Installed (100%)
- Production: Capability (100%); Started (15%)
- Jobs: permanent (current = 67; at project completion, assuming full production = 200)

The Columbus project made significant progress over this reporting period – both in implementing the production operation systems, as well as in attracting interest from major OEM customers for the new advanced technology product introductions. This reporting period began early in the Product Validation phase of the project and extended through actual production start-up and market introduction by the middle of the period. The late portion of the period included activities to validate an increasing number of product models and ramping up of production to satisfy the growing market demand for the new advanced battery designs.

The Columbus Expansion Team continued to meet weekly on site and via conference calls. Additional meetings were also implemented as necessary over the period to discuss the operational effectiveness of key equipment and major operations. A summary of the FY12 activities and accomplishments follows in the paragraphs below. Figure II - 11 shows the Exide Technologies Battery Manufacturing Site Located in Columbus, Georgia

Figure II - 11: Photograph showing the Entrance to the Exide Technologies Battery Manufacturing Site that is Located in Columbus, Georgia.

- Battery Manufacturing Expansion: During FY12 the new expanded production capacity for advanced AGM battery production at the Exide Columbus, Georgia battery plant moved through all stages of the product validation phase of the Project Management Plan. A concentrated effort extended throughout FY12 to seek to satisfy the growing (confidential) list of existing and prospective OEM customers for the upcoming new advanced AGM battery products. The focus served the new and developing US market demand for more robust batteries that will enable the introduction of competitively priced advanced fuel-saving vehicles. The start of actual production from

the new expanded capacity operations began as the new technology was introduced to the market in March 2012. One example of the new products being produced on the new expanded production lines is shown below in Figure II - 12.

Figure II - 12: Exide's new advanced AGM battery, the Exide EdgeTM with SureLifeTM Graphite Technology.

- Battery Market Introduction: Exide's new advanced AGM battery, the Exide Edge™ with SureLife™ Graphite Technology was introduced to the automotive marketplace in a nationally published media event and grand opening of the new advanced battery production operation in Columbus, Georgia on March 13, 2012. In an associated press release (approved by DOE) the President and Chief Executive Officer of Exide Technologies, Jim Bolch, commented with regard to the new product offering from the new operation: "This is an exciting announcement for our company, because it signals a great new product for our customers in the Americas and is the result of understanding our customers' needs and designing a solution…."
- Deliverable Batteries Shipped to DOE: On March 27, 2012 the Columbus, Georgia project site shipped their required 18 deliverable batteries to the DOE designated battery test site – the Idaho National Laboratory in Idaho Falls, Idaho. The testing proceeded according to the DOE pre-approved testing protocol and in accordance with the legally established NDA with that testing facility. The deliverable batteries were from early production on the newly completed production lines as required by the DOE/ARRA grant project agreement.
- Battery Production Status: As of the end of FY12, the Columbus, Georgia project site has completed all of the manufacturing expansion activities according to the project plan, and has verified through associated validation procedures the capability to produce the new advanced batteries at the targeted production rates. The actual production rate for this operation is progressing according to market demand and, as of the end of FY12, is operating at approximately 15% of the target capacity.

Facility 2 – AGM Spiral Wound, Bristol, Tennessee

- Construction complete (%) N/A - No facility construction funded by ARRA grant project.
- Equipment Installed (100%)
- Production Started (0%)
- Jobs: permanent (current = 24; at project completion, assuming full production = 120)

The Bristol project began FY12 with most of the major production equipment installed and proceeding into debug and commissioning. Then, after a slow down period during the second quarter (as described below), the Bristol site (Figure II - 13) proceeded aggressively by mid-year into the critical stages of equipment commissioning, and process validation. Near the end of FY12, all the major production operations were fully implemented and ready for production trials. During September 2012, the project shifted to production trials and product validation which will lead to production start-up activities in early FY13, thereby allowing the successful and timely completion of the project.

Coordination of the Bristol project continued throughout the period via weekly Implementation Team conference calls. In addition, the pace of personnel traveling to Bristol to assist in project implementation and equipment start-up and validation increased substantially during the second half of the fiscal year. A summary of some of the FY12 activities and accomplishments follows below.

Figure II - 13: Exide Technologies' New Expanded Facility for Production of Advanced Spiral Wound AGM Batteries Located in Bristol, Tennessee.

- Strategic Shift of Resources: By the end of the first quarter of FY12, the Bristol site's project milestones were updated to reflect a strategic realignment of project timing requirements for the overall project. At that point there continued to be an emphasis of Original Equipment Manufacturer (OEM) customer interest in Flat Plate lead acid AGM batteries for their upcoming advanced vehicle platforms, as well as, for associated aftermarket demand. Accordingly, Exide intensified efforts to accelerate the supply of Flat Plate lead acid AGM, and therefore, shifted certain key technical resources to intensify the project implementation focus toward the Columbus, Georgia plant. Due to the overall technical resources required, there were necessary modifications to the planned

implementation schedules for the overall project. The result was that the Columbus milestones remained close to the original plan, while Bristol's plan was delayed by several months. These modifications to the implementation schedules did not alter the overall project timeline, thereby allowing the final project completion date to be maintained.

- Battery Manufacturing Expansion: During FY12, the newly installed production capacity for advanced spiral wound AGM battery production at the Exide Bristol, Tennessee battery manufacturing operation moved through all stages of Process and Product validation phases of the Project Management Plan. The marketing plan is moving forward with a focus on existing and developing US customer demand for more robust batteries to service special markets such as marine and heavy duty trucks; as well as, extending to upcoming new markets for the expected new advanced fuel-saving vehicles such as micro-hybrid and start-stop. An example of the new batteries to be produced on the new spiral wound AGM production line is shown below in Figure II - 14 and an overall view is shown in Figure II - 15.

Figure II - 14: Exide's new advanced Spiral Wound AGM battery, the VortexTM with SureLifeTM Graphite Technology.

- Deliverable Batteries to be Shipped to DOE: The Bristol, Tennessee project site is scheduled to ship their required 18 deliverable batteries in early October 2012 to the DOE designated battery test site – the Idaho National Laboratory in Idaho Falls, Idaho. The testing will proceed according to the DOE pre-approved testing protocol and in accordance with the previously mentioned NDA with that testing facility. The deliverable batteries will be from early production validation units from the newly completed production lines as required by the DOE/ARRA grant project agreement.
- Battery Production Status: As of the end of FY12 the Bristol, Tennessee project site has completed all of the manufacturing expansion activities according to the project plan, and was beginning verification through associated validation procedures for the capability to produce advanced spiral-wound AGM batteries at the targeted production rates. This verification is expected to be completed by the targeted project end point – December 21, 2012. The start of actual production for customer orders from the newly implemented production operation is planned for formal market introduction during the spring of 2013.

Figure II - 15: Overall View of new State of the Art Spiral Wound AGM Battery Production area in Bristol, Tennessee Exide Battery Plant.

Planned Work for FY 2013

The focus of work for FY13 will involve continuing ramp up of production in the Columbus, Georgia project site, proceeding as the market allows and as additional customer requirements build. The project is expected to end during the first quarter of FY13 as originally planned.

The Bristol, Tennessee project site will follow a similar pattern, and has been several months later in the scheduled implementation plan due to slower customer response for the new spiral wound format. The current plan calls for the shipment of DOE deliverables from early production validation runs to the designated test site during October 2012, thereby allowing rapid progression toward the final project requirements being met during the first quarter of FY13, also as originally planned.

Customers and Other Information

Exide Technologies does not publicly discuss specific customers or other business sensitive information. As mentioned earlier, we have been working with a number of OEM vehicle manufacturers to be ready to satisfy their advanced battery requirements for the upcoming new generation of fuel saving vehicles.

For the FY12 reporting period, a public announcement was made for the Columbus, Georgia site as detailed above. The nationally publicized media event and grand opening of the new advanced battery production operation was introduced by a press release by the Company on March 13, 2012.

II.A.4 ARRA-supported Production Facility Project (East Penn)

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Grant Recipient: East Penn Manufacturing Co., Inc.

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Start Date: December 2009
Projected End Date: November 2012

Introduction

Description of facilities: The objective of this project is the expansion of production capacities to manufacture high volumes of Advanced Valve Regulated Lead-Acid (VRLA) batteries and the UltraBattery, both proven commercially viable technologies. East Penn will use a recently constructed manufacturing plant that will be populated and fully developed with specialized battery manufacturing equipment.

- Total Value of award: $32,500,007
- Percent of funds expended: 93% of funds have been expended as of September 30, 2012, the end of fiscal year 2012.

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Progress and Current Status

The non-ARRA funded recently constructed 739,000 square foot manufacturing plant will be equipped with electrode formation, current collector and cell assembly equipment (suitable for both Advanced VRLA batteries and the UltraBattery), battery assembly equipment, and equipment for electrolyte filling, finishing, conditioning, and testing. Also, component production (containers and covers) and distribution facilities will be expanded to support the additional production capacities. This funding is not utilized for any building construction.

Facility 1 – Automotive Battery Plant A4 Equipment

At the present time 73% of the battery manufacturing equipment is installed. Production is currently at 45% of planned capacity.

Currently, 170 direct permanent job positions have been created at this location with a total of 190 direct permanent job positions anticipated at project completion. At the present time 36 construction/contractor job positions have been retained. (Reference Figure II - 16, Figure II - 17, Figure II - 18, and Figure II - 19)

Facility 2 (if applicable) – Injection Molding Plants IM1/IM2 Equipment

At the present time, 65% of the Injection Molding equipment is installed. Production is currently at 99% of planned capacity. Currently, 59 direct permanent job positions have been created at this location with a total of 65 direct permanent job positions anticipated at project completion. At the present time, 0 construction/contractor job positions have been retained. (Reference Figure II - 20, Figure II - 21, and Figure II - 22)

Facility 3 (if applicable) – Distribution Center Equipment

At the present time, 0% of the equipment is installed. Production is currently at 0% of planned capacity. Currently, no direct permanent job positions have been created at this location with a total of 5 direct permanent job positions anticipated at project completion. At the present time, 0 construction/contractor job positions have been retained.

Pictorial Overview

Figure II - 16: Facility 1 – Automotive Battery Plant A4 Equipment (View 1).

Figure II - 17: Facility 1 – Automotive Battery Plant A4 Equipment (View 2).

Figure II - 18: Facility 1 – Automotive Battery Plant A4 Equipment (View 3).

Figure II - 19: Facility 1 – Automotive Battery Plant A4 Equipment (View 4).

Figure II - 20: Facility 2 – Injection Molding Plants IM1/IM2 Equipment (View 1).

Figure II - 21: Facility 2 – Injection Molding Plants IM1/IM2 Equipment (View 2).

Figure II - 22: Facility 2 – Injection Molding Plants IM1/IM2 Equipment (View 3).

Planned Work for FY 2013

Anticipated work for this time period will include the installation, start-up and validation of:

- Electrolyte Fill Chiller System – Final Phase
- Vertical Reciprocating Conveyor #3 – Final Phase
- ITS Curing Ovens (12) – Final Phase
- COS10 Cast on Strap #3 - Final Phase
- COS10 Cast on Strap Tooling – Final Phase
- Lab Equipment – Final Phase
- IM1 Cooling System – Final Phase
- IM1/IM2 Injection Molding Machines – Final Phase
- Topton AS/RS System – Final Phase

These equipment functions are key components of this project that need to be completed to achieve project objectives. Our final planned annual production rate is 2,800,000 batteries. These batteries will be VRLA (Valve Regulated Lead-Acid) and the Ultra Battery, both proven commercially viable technologies. Our current annual production rate capacity is 1,250,000 batteries. By the end of FY 2013 and the end of the program (November 2012) the last key equipment element will be made functional and validated which will allow East Penn to meet final planned production and project objectives. Based on current projections at the end of FY 2013 and project completion direct job creation total should be at 260 which exceeds our initial direct job creation totals for the entire project.

Customers and Other Information

Public Relations and Media

- **Reading Eagle Newspaper** – Release from last 3 years such as:
  - "Battery plant in Berks gets $32 million in stimulus" Thursday, August 6, 2009
  - "East Penn wins Energy Dept. funding" Wednesday, November 25, 2009
  - "East Penn wins funds for Advanced BatteryResearch" Wednesday, December 23, 2009
  - "East Penn powering battery industry growth [Transportation officials says investment and recovery money will create up to 200 jobs]" Saturday, July 17, 2010
- Channel 69 Television News – Grant project coverage
- **WEEU AM Radio** – Grant project coverage
- **Batteries International magazine** – Grant project and Advanced Battery Technological coverage
- **BEST magazine** – Advanced Battery Technological coverage
- **ALABC Newsletter article** – Involvement with organizations like the ALABC (Advanced Lead Acid Battery Consortium) and CSIRO (Commonwealth Scientific and Industrial Research Organization) and their venues for promotion add a higher level of project exposure among the scientific community.

Trade Shows: Multiple venues featuring signs and supporting content that highlights advanced battery projects supported by government funding

- Industry shows
- Customer events

Internal

- Repeated features in **company internal newsletter** distributed to over 6,000 employees
- **Open house displays** such as "UltraBattery Car" that features an implementation of advanced battery technology, supported by the DOE, for HEV use

Other

- **UltraBattery and Advanced VRLA battery brochures** educating and promoting technology and its benefits in applications that conserve fuel, reduce carbon emission, and create clean, renewable energy.
- **UltraBattery Car flyer** promoting UltraBattery use in HEV to reduce carbon emissions and conserve fuel
- **UltraBattery Test Vehicle** (on site at East Penn Mfg.) (See Figure II - 23)

Figure II - 23: UltraBattery Test Vehicle on site at East Penn Mfg.

II.B Battery Cell and Pack Assembly Facilities

II.B.1 ARRA-supported Production Facility Project (Dow Kokam, MI)

Ralph Nine (NETL Project Manager)
Grant Recipient: Dow Kokam MI, LLC

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Start Date: May 30, 2010
Projected End Date: January 31, 2013

Introduction

- Dow Kokam, MI, will construct a 400,000 Square Foot (SF) highly automated large-format battery manufacturing facility in Midland, Michigan.
- This facility, Midland Battery Park, will use a proprietary and patented technology that will produce affordable advanced Lithium-ion batteries Superior Lithium Polymer Batteries (SLPB) for the electric vehicle (EV) and hybrid electric vehicle (HEV) markets.

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Progress and Current Status

This annual period began with the completion of the building and the infrastructure (see Figure II - 24), and ended with the production of commercial grade cells in a pre-buy-off run, with final validation pending, of process equipment.

The Kokam battery line equipment was delivered, installed, with performance testing completed and pre-buy-off battery cells produced. The buy-off runs are scheduled for Q1 2013.

97% of the Project budget has been expended or $313.7 million, primarily for process equipment engineering, technology licensing, progress payments on manufacturing equipment, and completed construction of the building and infrastructure.

Facility 1 – Midland Battery Park

- Construction complete (100%)
- Equipment Installed (100%)
- Production Started (%)

Planned Work for FY 2013

- The buy-off runs are scheduled for Q1 2013, with commercial production starting thereafter. Total project completion is expected by or before 1/31/2013.
- Pre-buy off run produced-commercial sales have begun in October 2012.
- Planned invoice costs to the Department of Energy in FY 2013:
  - 1st quarter of FY 2013 $4,131,623
  - 2nd quarter of FY 2013 $0 – (project is financially completed)

Pictorial Overview

Figure II - 24: Photograph(s) of the Dow Kokam, Midland Battery Park Facility.

II.B.2 ARRA-supported Production Facility Project - Li-Ion Battery Manufacturing (LG Chem, MI)

Beomgi Lee (NETL Project Manager)
Grant Recipient: LG Chem Michigan Inc. (LGCMI)

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Start Date: September 1, 2009
Projected End Date: May 31, 2013

Introduction

- Description of facilities: The objective of this project is to produce Lithium-ion polymer battery cells and batteries for automotive applications including, but not limited to, hybrid electric, plug-in hybrid electric, pure electric vehicles for commercial purposes, and military hybrid vehicles, as well as for aviation, smart grid support, broadband backup power, and energy storage for renewable energy. The project includes construction of a 600,000 square foot, $303 million manufacturing facility located in the City of Holland, Michigan, with a small portion of the proposed project site located in the adjacent Fillmore Township as well as procurement, installation, and validation of manufacturing equipment. LGCMI is a key supplier of battery cells to General Motors for the Chevy Volt Program.
- Total Value of award: $151,387,000
- Percent of funds expended: 93% as of 9/30/2012

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Progress and Current Status

With the cooperation of various USA partners, the building and its utilities and equipment were efficiently constructed and installed to support cell manufacturing technologies (see Figure II - 25 to Figure II - 34). The overall dimensions of the building for this project are 1,137 ft (L) x 523 ft (W) x 85 ft (H). LGCMI has hired and trained full time employees with differentiated and systematic training programs. Additionally, intensive process and product verification tests (process capability, dimensions, performance, reliability, safety, and etc.) have been performed in preparation for the start of production (SOP).

Phase 1 Facility. It includes the buildings for cell manufacturing lines #1, #2, and #3. The cell manufacturing lines for the Phase 1 facility consist of the separator, assembly, and formation processes. The separator lines consist of mixing, coating, and slitting equipment. The assembly lines consist of notching, lamination, folding, and packaging equipment. The formation lines consist of charging/discharging, aging, and end of line inspection equipment. (*Note: While the assembly and formation processes have three manufacturing lines, the separator process has four manufacturing lines.)

- Construction complete (100%)
  - The Phase 1 facility consists of general production floors, a dry room, clean rooms, utilities, quality control rooms, and shipping and receiving areas. It also includes three separate buildings: a safety building, a general storage building, and a hazardous storage building.
  - All construction work was completed by the end of August, 2011.
  - Certificate of Occupancy (CO) from the City of Holland was issued on September 9, 2011.
  - The recreational areas for the employees include 1 cafeteria, 1 fitness center, and 4 break rooms.
  - The main lobby includes a promotional show room to present general information about LG Chem and the background on its advanced battery business.
- Equipment Installed (100%)
  - All the equipment installation for the Phase 1 facility was completed by the end of October, 2011.
  - The final inspection of the separator equipment for lines #1, #2, and #3 was completed by the end of January, 2012.
  - The first cells were produced for validation of the separator lines #1, #2, and #3 by the end of January, 2012.
  - The final inspection of the separator equipment for lines #4 was completed by the end of March, 2012.
  - The first cells were produced for validation of the separator lines #4 by the end of March, 2012.
  - The final inspection of the assembly and formation equipment for lines #1, #2, and #3 was completed by the end of February, 2012.

  - The first cells were produced for validation of the assembly and formation lines #1, #2, and #3 by the end of February, 2012.
- Production Started (80%)
  - LGCMI has received Technical approval, a letter of conformance, on January 31, 2012, and has satisfactorily addressed the management system requirements identified in ISO/TS 16949:2009 with the exception of having the required 12 months performance data.
  - Supplier sourcing and assessment have been completed by the end of February, 2012, and a continuous monitoring of suppliers' quality is in place.
  - Advanced Product Quality Planning (APQP) is a structured method to define and establish the necessary steps to ensure that product meets all customer requirements, and it was completed by the end of July, 2011.
  - 4M (Man, Machine, Material, and Method) validation is a process to verify four aspects that are key to product quality. Man is defined as workforce and its skills. Machine is defined as equipment and its reliability. Material is defined as raw material and its quality. Method is defined as production process and its capability.
- Internal 4M validation was completed by the end of December, 2011.
- Customer approval for the 4M validation was signed off on June 6, 2012.
  - Production Part Approval Process (PPAP) is to verify all engineering design record and specification requirements and to ensure that the manufacturing process is capable of producing product consistently meeting these requirements during an actual production run at the quoted production rate (Run at Rate).
- Part Submission Warrant was issued for saleable product on June 27, 2012. This document confers customer approval for the production process, verifying the results for dimensional measurements, material and functional tests, and statistical process package of the product. These results meet all design record requirements.
- PPAP will be completed approximately one month prior to the Start of Production.
- Permanent Jobs: 151 direct employees as of September 30, 2012; 200 at project completion on May 31, 2013.
- Temporary/Construction Jobs: 0 employee as of September 30, 2012; maximum of 226 employees as of June 30, 2011.

Phase 2 Facility. Includes the building for electrode process line #1. The electrode process is divided into anode and cathode manufacturing lines. Each of the electrode manufacturing lines for Phase 2 consists of mixing, coating, roll press, and slitting equipment.

- Construction complete (100%)
  - The Phase 2 facility consists of clean rooms, utilities, quality control rooms, and shipping and receiving areas.
  - All construction work was completed by the end of July, 2012.
  - Certificate of Occupancy (CO) from the City of Holland was issued on August 1, 2012.
  - There are 4 levels for the mixing tower of the electrode process.
  - The Solvent Recovery Process (SRP) is an outdoor facility used in the NMP recycling system consisting of holding tanks and two separation towers.
- Equipment Installed (100%)
  - All the equipment installation for the Phase 2 facility was completed by the end of July, 2011.
  - The final inspection of the electrode equipment for line #1 was completed by the end of August, 2012.
- Production Started (0%)
  - LGCMI will be prepared to receive the letter of conformance for ISO/TS 16949:2009 in 2013.
  - Supplier sourcing and assessment will be completed in 2013.
  - Advanced Product Quality Planning (APQP) is scheduled to be completed in 2013.
  - 4M validation is scheduled to be completed in 2013.
  - Production Part Approval Process (PPAP) will be completed approximately one month prior to the Start of Production (SOP).
- Permanent Jobs: 30 direct employees as of September 30, 2012; 50 at project completion on May 31, 2013.
- Temporary/Construction Jobs: 0 employee as of September 30, 2012; maximum of 100 employees as of June 30, 2011.

Pictorial Overview

Figure II - 25: An overhead view of the LG Chem Michigan Inc. facilities.

Figure II - 26: A street view of LG Chem Michigan Inc. facilities.

Figure II - 27: The Regenerative Thermal Oxidizer (RTO) by the separator facility.

Figure II - 28: The SRP outdoor facility in front of the separator facility.

Figure II - 29: The bag filters on the 4th floor of the mixing tower of the electrode process.

Figure II - 30: The roll press equipment for the electrode process.

Figure II - 31: The folding equipment for the assembly process.

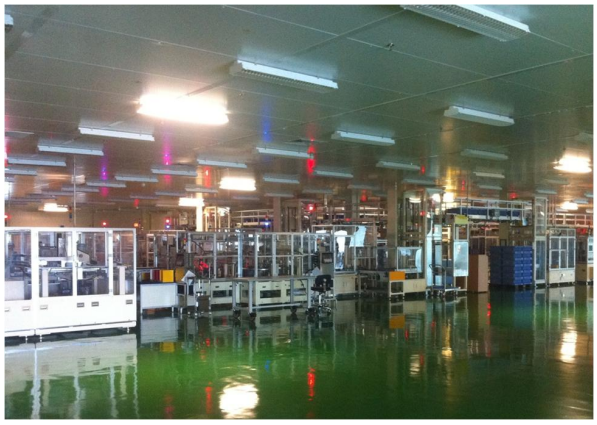

Figure II - 32: The end of line inspection equipment for the formation process.

Figure II - 33: LGCMI employees at the main lobby in February, 2012.

Figure II - 34: The Li-ion battery cell produced during the equipment validation process.

Planned Work for FY 2013

After the start of production, various efforts will be continued through 2013 to stabilize production and to provide quality products to the customers. LGCMI will continue to hire and train new employees for this project. At the end of FY 2013, LGCMI expects to reach its full-scale operation, and more than 250 direct employees (Operators, Engineers, Management & Administration staff) will be working at the facility. The following plans are expected to be implemented in 2013 in order to successfully complete the project:

- Plans for the Phase 1 facility
  - LGCMI plans to receive an ISO/TS 16949:2009 certification.
  - PPAP will be completed approximately one month prior to the SOP.
  - It is estimated to have 200 permanent employees at the project completion.
- Plans for the Phase 2 facility
  - LGCMI will be prepared to receive a letter of conformance for ISO/TS 16949:2009.
  - In preparation for the SOP, it is estimated to complete supplier sourcing and assessment, APQP, 4M validation, and PPAP.
  - It is estimated to have 50 permanent employees at the project completion.

FY 2012 Announcements/Publications

1. News item: “Study shows Holland is the 'battery capital of North America,' says economic development official” on March 26, 2012, published by MLive.
2. News Item: “Expert to talk market for local batteries” on September 22, 2012, published by Holland Sentinel.

II.B.3 ARRA-supported Lithium-ion Cell Production and Battery Pack Assembly (EnerDel)

Christopher D. Johnson (NETL Project Manager)
Grant Recipient: EnerDel, Inc.

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Start Date: January 9, 2010
Projected End Date: April 30, 2013

Introduction

The project includes the expansion and upgrade of EnerDel facilities in the greater Indianapolis, Indiana area. Included is a new 211,000 Sq. Ft. facility located in Mt. Comfort fitted for production of battery modules and battery packs systems as well as final Li Ion cell Formation processes. Also included is the upgrade of an existing Li Ion battery manufacturing facility (Hague Rd.) located in Indianapolis that houses battery cell electrode fabrication and assembly activities.

The total value of the award is $236,936,232 under a 50/50 cost share. At the end of FY 2012, 52% of the project funds have been expended.

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Progress and Current Status

All Phase I facility fit-out and upgrades were completed by September 2012. Phase I Battery Module and Battery Pack Assembly lines have been full qualified and PPAP certified since August of 2010 and commercial production is ongoing (cells sourced from our Korean affiliate). Battery assembly operations team members have been trained and qualified to operate the equipment and achieve required quality standards.

As of June 2011, EnerDel has fully installed all Phase I equipment necessary to coat, cut, assemble, and form Li Ion Battery Cells. Validation and ramp-up of cell electrode fabrication and cell assembly lines have been the primary engineering activities since April 2011. These activities include on-going product validation runs to ensure all equipment/processes are fully capable of meeting product requirements at high volume and benchmark efficiency rates. During this period, Cell Operations team members have been trained and qualified to operate the equipment and achieve required quality standards.

EnerDel employed 195 people at the end of the 2012 FY. Temporary construction jobs have been negligible during the 2012 FY. Final employment numbers will be dependent on commercial customer demand for our products. At the end of the 2012 FY EnerDel was operating at a fraction of its Phase I installed capacity base.

Pictorial Overview

Figure II - 35: EnerDel Hague Rd. Facility.

Figure II - 36: EnerDel Mt. Comfort Facility.

Figure II - 37: Dry-room Construction – Hague Rd.

Figure II - 38: Cell Formation Equipment – Mt. Comfort.

Figure II - 39: Facility Preparation – Mt. Comfort.

Figure II - 40: Completed Dry-room – Hague Rd.

Figure II - 41: Cell Assembly Equipment – Hague Rd.

Figure II - 42: Unwinder Anode Coater – Hague Rd.

Figure II - 43: Battery Module Assembly Line – Mt. Comfort.

Figure II - 44: EnerDel Li-Ion Cell.

Figure II - 45: EnerDel Battery Modules.

Planned Work for FY 2013

EnerDel will continue to respond to key customer request for Battery Pack and Battery Energy Storage systems applications heading into 2013. Many of these applications are currently under development with the expectation that production contracts will be awarded in 2013.

The final activities to fully validate the US cell production system will be completed in early 2013 (EV, PHEV, Cells). Other battery cell related validation activities will be initiated in 2013 including production validation of a Power Cell and additional 2nd source raw material suppliers.

The calendar year 2013 is expected to be a transitional period where performance measurement will be mostly milestone based (i.e., contract awards, capability). This is reflective of the long lead times associated with Li-ion application development and industry demand recovery in a market that is still in its developmental stages.

Customers and Other Information

Recent News Releases:

EnerDel Appoints New CEO David Roberts and Bolsters Management Team
(June 4, 2012)

EnerDel Secures Second Order to Supply Lithium-ion Battery Pack for Volvo's C30 Electric Car
(Aug. 27, 2012)

EnerDel Launches Services and Aftermarket Group
(Aug. 29, 2012)

EnerDel Announces Guaranteed Residual Value for its Products
(Oct. 10, 2012)

Recent Articles:

Lithium-ion energy storage takes the HyRoad
(Sept. 1, 2012)

II.B.4 Li-Ion Battery Pack Manufacturing (GM)

Rondle Harp (NETL Project Manager)
Grant Recipient: General Motors LLC

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Start Date: August 2009
Projected End Date: September 2013

Introduction

- Description of facilities: Brownstown Battery Assembly Plant, Brownstown Township, MI
- Total Value of award: $234.8M
- Percent of funds expended: 74% as of September 30, 2012

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Progress and Current Status

Activities for FY2012 reflect a continuation toward the overall project objectives:

- Establish and validate production capability for GM Li-Ion Battery Pack Manufacturing operations
- Provide specialized workforce training in advanced battery pack manufacturing technology
- Provide continuous improvement and innovation cycles to move battery pack technology down the cost curve

Significant progress was made toward completion of project goals during FY2012. A highlight of this progress was the successful Start of Regular Production (SORP) for the 2012i and 2013 Model Years Chevrolet Volt Extended Range Electric Vehicle (EREV) battery pack at the Brownstown Battery Assembly Plant (Figure II - 46 and Figure II - 47). 100% of the manufacturing equipment and processes for the 2012i and 2013 model year battery pack design and 2012 calendar year volume is installed and validated (Figure II - 48 and Figure II - 49). Cumulative jobs created or retained for the project activities based on ARRA guidelines was 67.7 Full Time Equivalents. Hourly and salary employment at Brownstown is 100 people, as of September 30, 2012.

Many things must come together to achieve a successful SORP. The product, process and people systems must be established and validated. Production systems were installed for additional model years and capacity. Product builds, both preproduction and manufacturing validation, were completed to confirm the product and process designs, along with associated quality systems. Equipment and tooling designs were also validated during these builds. All components and the complete battery pack achieved full Production Part Approval Process (PPAP) status. Production acceleration has been matched to the vehicle assembly plant to meet market demands.

One of the key deliverables required by the DOE for ARRA funded projects is product testing. Witness testing of the 2012i EREV production battery pack was successfully completed at the GM Battery Systems Lab (Figure II - 50). Test data was reviewed and analyzed by an independent third party and passing results were received.

Establishing a capable workforce is fundamental to achieving success. Additional staffing and training of the engineering and plant teams were completed. Training focused on health and safety, Global Manufacturing System, technical maintenance, equipment and production operations.

In addition to the SORP for 2012i and 2013 EREV model years and the increased production capabilities, efforts continued on subsequent model years for the EREV packs and future battery pack programs. Manufacturing Engineers continued work on process planning, and equipment and tooling procurement. Preproduction builds in support of these programs continued during FY2012. Design for Manufacturability concepts have been incorporated into product designs.

The third overall project objective of continuous improvement (CI) further enhances the capabilities of the production system, improving quality, cost and manufacturing flexibility. Deliverables from CI activities have been implemented in the production system upon plant review and acceptance. Key areas being worked for CI include:

- Joining Manufacturing and Quality Processes
- Battery Design For Assembly
- Battery Assembly Process Variation Reduction
- Assembly Tooling Durability
- Battery Charging & Diagnostic Testing
- Assembly Process Improvement

Project status at the end of FY2012 reflects two key takeaways: 1) SORP for new model years and additional capacity of the Chevrolet Volt EREV battery packs was successful and the system is poised to ramp volumes to

meet market demand, 2) Implementation of continuous improvement projects are solving complex challenges in real time.

The bottom line for the project is that GM's Li-ion Battery Pack Manufacturing project creates and retains jobs, establishes US-based battery pack manufacturing capability, improves our nation's energy independence and drives significant advancement of electric vehicle battery pack manufacturing technologies.

Pictorial Overview

Figure II - 46: Facility location in Brownstown Township, MI.

Figure II - 47: GM Brownstown Battery Assembly Plant, Brownstown Township, MI.

Figure II - 48: Battery Pack Lift Assist.

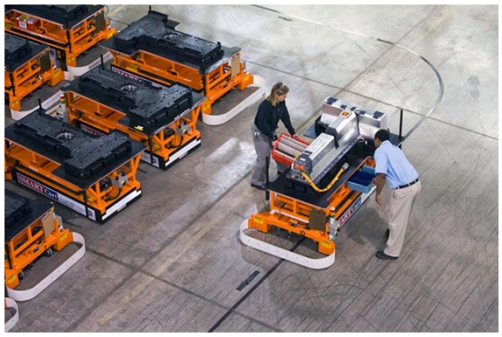

Figure II - 49: Battery Pack Assembly on Automated Guided Carts.

Figure II - 50: Chevrolet Volt Battery in the GM Battery Systems Lab in Warren, MI.

Figure II - 51: 2013 Chevrolet Volt Battery & Specifications.

Planned Work for FY 2013

A grant modification request has been submitted and is under review. Planned activities and expected status for FY 2013 are pending resolution of that request.

Customers and Other Information

Li-Ion battery packs produced by the GM Brownstown Battery Assembly Plant will be utilized in multiple General Motors products.

The Chevrolet Volt continued to receive awards during 2012 FY. Driving range of the 2013 Chevrolet Volt was increased by 3 miles, approximately 8.6%. 2013 battery pack specifications were revised to reflect improved performance (Figure II - 51).

US sales of the Chevrolet Volt have been steadily increasing over the last several months of FY12. Sales to

date for the 2011, 2012 and 2013 model years have exceeded 25,000 units as of October 2012.

In December 2011, General Motors and Mann & Hummel received recognition from the Society of Plastic Engineers for innovative design and manufacturing of the thermoplastic battery frame components in the battery pack.

There were no specific employment related news items for battery pack manufacturing during the timeframe. However, the demographics of the Brownstown workforce represent some interesting qualities. The facility is attracting a younger workforce. Forty-five percent of the hourly workers are between 24 and 31 years of age, which makes them part of the generation known as the Millennials. This generation has its' own unique characteristics, and is helping to successfully build GM's line of EREV battery packs.

II.B.5 Lithium-ion Cell Production and Battery Pack Assembly (Saft America)

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Start Date: December 2009
Projected End Date: December 2013

Objectives

- Construct a 235,000 square foot Li-ion Factory of the Future in Jacksonville, FL for high volume production of batteries for military hybrid vehicles, smart grids, renewable energy storage, broadband and aerospace application.
- Provide a showcase of environmentally friendly and energy efficient design concepts.
- Employ hundreds of U.S. workers in well-paid jobs.
- Produce lithium-ion cells, modules, and battery packs at a competitive cost to enable renewable energy storage systems, Smart Grid, broadband systems, military hybrid vehicles and aviation, thereby achieving significantly reduced carbon emissions and fuel savings.

Introduction

Saft is using its considerable experience in building factories for lithium-ion cell and battery manufacturing and expertise in lithium-ion technology to build a Factory of the Future capable of manufacturing and delivery of high quantities of lithium-ion cells, modules and batteries to the military hybrid vehicle, industrial energy, eledtric drive and aerospace markets.

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Approach

Saft is investing immediately, along with DOE, in establishing the factory and manpower to support manufacturing which will be used in delivery of lithium-ion cells and batteries in high volumes. Saft is creating at least 280 jobs within 5 years of beginning the project, with the job creation of 154 new jobs at the end of the second year. Saft is using lean manufacturing techniques to ensure that the factory is established with consideration for cost savings. Also, Saft is employing risk mitigation and risk management practices which will assure being able to provide on-time schedule and technical performance.

Saft is using the Earned Value Management System of assigning and managing project costs in respect to the financial objectives of the program. It is using LEED® green factory initiatives in the buildings, power usage and waste management; all of which are complemented by its recycling plan for batteries once used. The decision to use LEED® techniques in designing the Factory of the Future is consistent with the markets intended to be addressed, which are renewable energy related.

Accomplishments

Factory Design and Equipment Specification. The factory design was contracted to The Haskell Company and was completed in April 2010. The design is consistent with LEED® Silver requirements.

Equipment specifications for all equipment were completed by October 2010.

Factory Construction and Equipment Procurement. Construction of the factory began with site preparation starting in February 2010. The building was completed and Certificate of Occupancy issued by the City of Jacksonville in June 2011 (Figure II - 52).

Figure II - 52: Saft Factory of the Future – completed.

Procurement of all equipment for the first and second of three cell production lines is complete, and all items of equipment have been received. Procurement of all equipment for the third production line has begun.

Equipment Installation. The equipment received for the first and second production lines have been installed. Procurement for the equipment for the third production line has begun.

Process and Product Qualification. This task has been completed for first line and is well underway for the second production line.

Program Management. The Program Management Plan and Statement of Program Objectives have been

submitted to DOE and updated quarterly as required. A Risk Assessment was conducted as part of the Risk Management Plan. Quarterly progress reports, Earned Value Management reports and ARRA progress reports have been submitted on time and are current.

EVMS indicators: SPI=1.00 indicating the program is on time (Note: schedule has been re-baselined after receipt of approved contract extension). Projected completion date for the project is 31 December 2013. CPI=0.93 indicating that spending is higher than initially planned. This is due primarily to an overrun of the cost of the building. Saft is projecting completion of the program on budget. The program is approximately 75% complete at end-September 2012.

Conclusions and Future Work

The Saft Factory of the Future program is proceeding and meeting its goals. There were over 200 construction workers employed on the factory site during 2010-2011, and there are now 154 Saft employees in Jacksonville. Saft has received LEED Silver certification. First production line has been installed, qualified and product is being produced and sold from this line. The second line has been installed and is well into the qualification process.

In 2013, Saft anticipates installation and qualification of the third production line

FY 2012 Publications/Presentations

1. 2012 DOE Annual Peer Review Meeting Presentation.

II.C Battery Materials Production Facilities

II.C.1 ARRA-supported Production Facilities (Celgard)

Bruce Mixer (NETL Project Manager)
Grant Recipient: Celgard, LLC

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Start Date: February 1, 2010
Projected End Date: January 31, 2013

Introduction

The overall project objective was to develop new jobs and manufacturing capacity of Celgard® separator for the Electric Drive Vehicle (EDV) lithium-ion battery market. The project was executed in a two-phase approach. **Phase 1** expanded an existing manufacturing facility at the current Charlotte, N.C. site. **Phase 2** developed a new manufacturing facility at a site in Concord, N.C. The proven Celgard manufacturing process was duplicated to minimize risk and allow rapid implementation of the new capacity in order to meet the developing EDV market needs.

Celgard received notification of being selected for an award on July 31st, 2009. The project activity was started immediately but at a pre-award activity level. On December 22nd, 2009, DOE approved a pre-award spend period that covered work from July 31st, 2009 to the award signing date. Subsequent meetings and discussions concerning the project detail and the final Terms and Conditions resulted in the award being signed February 1st, 2010.

The total value of the award was $48,750,325. As of September 30th, 2012 all 100% of the award funds have been disbursed to Celgard.

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Progress and Current Status

Phase 1 Facility – Charlotte, N.C. This Phase 1 project provided an up-fit of the existing Charlotte, N.C. manufacturing facility, which consisted of moving the existing warehouse and installing the necessary manufacturing infrastructure. The general contractor on this project was Charlotte-based Myers & Chapman, Inc. The moving of the existing warehouse was successfully completed. All infrastructure elements and multiple new and complete manufacturing units have been installed. The new manufacturing equipment is fully operational and commercial sales were achieved for all target products in 2011. The manufacturing capacity remains fully commercial in 2012.

Job creation in the Phase 1 project resulted in 105 permanent, full-time Celgard employees. Additional temporary jobs are estimated at an aggregate total of 93 directly on the project. The temporary jobs were due to construction on the existing facility, services and installation of the equipment. This Phase 1 project is complete and no further project work is planned at this time.

Phase 2 Facility – Concord, N.C. A new manufacturing facility was planned and constructed in Concord, N.C. The new building included in this award is approximately 150,000 square-feet and sits on approximately 20 acres in the International Business Park in Concord, N.C. This is the second phase in Celgard's strategy to expand separator production capacity for lithium-ion batteries used in EDVs. Merriman Schmitt Architects, Inc. designed the Concord plant and Myers & Chapman, Inc. served as the general contractor. Both companies are based in Charlotte.

Celgard celebrated the completion and grand opening of the new building in Concord on July 25th, 2011. Management and professional staff were hired early in 2011, trained on Celgard® Separator technology, manufacturing systems and immediately following the building opening. 100% of the hourly operations staff required to support the Concord Phase 2 project have also been hired, fully-trained and are operational at this time.

All manufacturing equipment has been installed. Multiple complete manufacturing units have been installed and are operational, and commercial sales exist for all target products.

The total number of permanent jobs created at the Concord facility as a result of this Phase 2 project is 146. Additional temporary jobs resulting from construction, services and equipment installation are estimated at an aggregate total of 140.

Pictorial Overview

Phase 1 Project in Charlotte, N.C.

Figure II - 53: Celgard completed warehouse in Charlotte, NC.

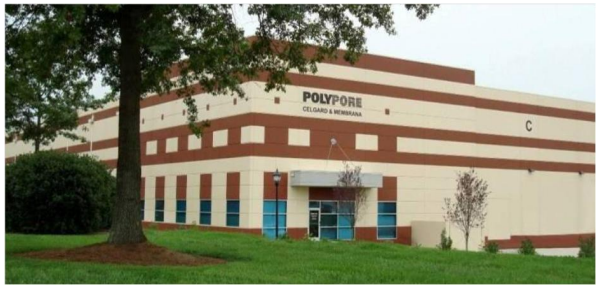

Figure II - 54: Celgard facility in Charlotte, NC.

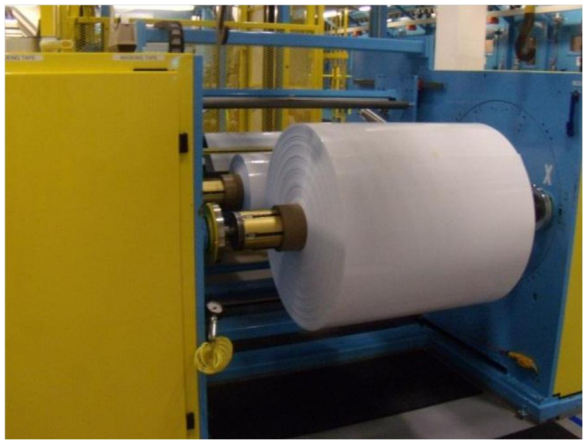

Figure II - 55: Celgard Fully-formed flat sheet membrane from new equipment.

Figure II - 56: Celgard Quality testing on the manufacturing floor.

Phase 2 Project in Concord, N.C.

Figure II - 57: Celgard Concord building.

Figure II - 58: Celgard Concord Grand Opening event.

Figure II - 59: Celgard Concord Equipment installation activity.

Figure II - 60: Celgard Concord Operations' install and startup team.

Figure II - 61: Celgard Concord Completed internal qualification of Slitters.

Figure II - 62: Celgard Concord Oven line startup.

Planned Work for FY 2013

Phase 1 & 2 complete and no additional work planned.

Other Information

The Celgard project EE0002611 met all award performance metrics defined in the award statement of project objectives:

- Demonstrated the award level of annual capacity of Celgard® separator for use in the EDV markets.
- Created approximately 250 permanent new jobs.
- Final project expenditure was within accepted estimating error.
- Completed on or before February 1st, 2013.

Celgard press releases can be found at: http://www.celgard.com/press-releases.aspx

II.C.2 Advanced Cathode Materials Production Facility (Toda America)

John Tabacchi (NETL Project Manager)
Grant Recipient: Toda America Inc.

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Start Date: February 2010
Projected End Date: February 2015

Introduction

- **Company:** Toda America Inc. is a jointly owned company by Toda Kogyo(Toda) and ITOCHU Corporation. Toda is a leading cathode materials supplier to Li-ion battery manufacturers worldwide. The principal objective of this project is to establish Toda America Inc. as a high-volume cathode materials manufacturing facility and a strategic supplier partner to the U.S. advanced battery industry. ITOCHU Corporation, a diversified global trading company, has partnered with Toda in this venture.
- **Description of facilities:** Toda America Inc. Advanced Cathode Materials Production Facility produces oxide materials for Lithium-ion Battery Cathodes (including LNCA and LNCM) as a battery materials source for electric drive vehicles. The project includes construction of an 80,000 square foot manufacturing facility located within the Fort Custer Industrial Park in Battle Creek, Michigan, as well as procurement, installation, and validation of manufacturing equipment and processes. The project is executed in two phases with Phase 1 comprising two production lines and Phase 2 comprising two more lines, totaling four lines when completed.
- Total Value of award: $35 million
- **Percent of funds expended:** 46% of funds expended by September, 2012.

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Progress and Current Status

As of September, 2011, end of Federal FY 2011, Phase 1/Step 1 construction was 100% completed, all equipment installed and commissioned and operational.

Managerial and technical staffing for Phase 1/Step 1 was completed, adding 29 full time jobs at the facility. Production validation was achieved, and cathode materials were successfully produced for customer delivery.

As of September, 2012, end of Federal FY 2012, the construction schedule for subsequent lines were adjusted based on current market conditions. A revised Project Management Plan was filed with the DOE, with approval for revised project end date of February, 2015. During FY 2012 normal business operations continued with 29 full time permanent jobs at the Battle Creek, Michigan facility.

Pictorial Overview

Figure II - 63: Toda America Inc. Battle Creek Facility, Phase 1.

Planned Work for FY 2013

During FY 2013, we expect that the second production line of Phase 1 will be substantially completed, with planned construction to start in December, 2012. Once the two production lines of Phase 1 are completed, Toda will have capacity to produce nearly 2,000 tons of cathode materials annually. By end of FY 2013, the Toda Battle Creek Production Facility project will be approximately 67% complete.

Customers and Other Information

Toda America Inc. has successfully shipped advanced cathode materials produced at the Battle Creek facility for customer testing and use beginning 1Q2011 and during FY 2012. Cathode materials for various customers are being shipped for current and future application programs, and operations and sales activity are progressing normally. Toda's Battle Creek facility earned ISO9001 Quality Certification in February 2012.

II.C.3 ARRA-supported Production Facility Project (Chemetall Foote Corp)

Christopher Johnson (NETL Project Manager)
Grant Recipient: Chemetall Foote Corp.

John Grooves
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Start Date: April 2010
Projected End Date: April 2014

Introduction

- We are expanding Lithium Carbonate production in Silver Peak, Nevada by 100%, converting the main electrical source at that location to Geothermal energy which will reduce operating costs of the plant, and in Kings Mountain, NC expanding the company's capability to produce Lithium Hydroxide by more than 100%. Total award is $28,425,258. Amounts invoiced thus far thru September 30, 2012 is $21,267,001 which is 75%.

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Progress and Current Status

Lithium Carbonate

- Completed Construction+/- 93% cost estimate
- Equipment Installed+/-67% Equipment Installed
- Production Started+/-71% Production Started
- Wells 120A, 99 C and 387 on-line and pumping. Well 395 expected to be on-line in the next few weeks. Current production rate is 10 MM gallons per day. Well 395 will raise total to approximately 11.5 MM gallons per day. Additional wells will be drilled after maintenance is completed on drill rig.

Geothermal Power Plant

- Completed +/- 5% cost estimate
- Equipment Installed +/- 0% Equipment Installed
- Production Started +/- 0% Production Started
- The Exploration EA, which comprises Rockwood's drilling observation and production wells, is in the final review cycle with public comment set to begin in late October to early November 2012. Working with BLM (Bureau of Land Management) to construct the GDP's (Geothermal Drilling Permits) for the upcoming exploration drilling.
- Rockwood is preparing to kick-off the second Environmental Assessment necessary for construction of the power plant. This is the Development EA and is referred to as the Utilization plan. Rockwood has made specific schedule requests to both BLM and DOE in order to complete within a time frame so as to permit construction completion of the plant by end of year 2013.
- FEL engineering is approaching project conclusion. Final design review should take place in November 2012 and HAZOP should occur in December 2012.
- Rockwood has concluded the power plant will be best designed and operated with air cooling using finfans.
- Rockwood is performing process study analysis on the turbine generator set acquired in order to determine optimized design format with regards to the impeller operating pressures. The turbine has two chambers and was originally designed to operate at different pressures on each side. Depending on the geothermal resource, it could be optimum to have each chamber operate on the same pressure. This is critical work and will be completed this year and will directly impact the refurbishment pathway. The turbine generator equipment is expected to begin refurbishment in later Q1 of 2013. This design pathway also greatly affects the process layout and the quantity of equipment necessary.
- The bedplate for the turbine generator set has been designed and is out for estimation. This design represents a single one piece skid and will permit the turbine generator set to be mounted and aligned in the shop prior to field installation.
- At this juncture, Rockwood is performing an analysis to determine what long lead equipment must be ordered to fulfill the 2013 year end construction/start-up target. This equipment must be on order before the end of year 2012. Rockwood must evaluate the risk level to determine whether to proceed with this activity.
- Geotechnical soils work has been completed for the power plant location and the possible pipeline locations. Engineering design is underway for pipeline supports and structurally supporting of the power plant facilities.
- Rockwood is preparing to begin site preparation activities by mid Q1 of 2013 at the Silver Peak location. Construction start is targeted for late Q1 of 2013.

Lithium Hydroxide

- Completed 100% cost estimate.
- Equipment Installed 100% Equipment Installed.
- Production Started +/-100% Production Started.
- Installed all major equipment plus equipment insulation, instrumentation, relief valves, rupture disks, structural steel, process piping, pressure and temp transmitters, safety showers and eye wash stations.
- Completed installing new structural steel. Completed erection on of new pre-engineered building.
- Completed installation of block walls for Firewater pump house and for new control room and I/O room, break room and rest rooms.
- Air Permit Exemptions have been received. Received construction permits for the erection of the structural steel, control room, fire water pump house and packaging building.
- Completed installation of the new 10" steam header and began installation of new 4"condensate header.
- City of Kings Mountain installed 12" water line into the plant.
- Making on-spec product mid-September 2012.
- Project to be closed out financially late October 2012.
- Samples for battery testing to be sent to DOE.

Planned Work for FY 2013

Lithium Carbonate – 2013 Plans are to complete all except the Brine Solar Evaporation Period which will run into 3rd Q 2013.

Geothermal Power Plan is currently waiting on the Environmental Assessment (EA) from BLM. Upon timely approval, the expected Production Wells should continue thru 2013 and the power plant systems should purchase thereafter. Major decision points in 2013 will determine work planned for coming months after EA

Lithium Hydroxide samples will be sent to DOE for testing.

Customers and Other Information

N/A

Pictorial Overview

Figure II - 64: Photographs of the Chemetall Foote Corp. Facilities.

II.C.4 High-Volume Manufacturing of $LiPF_6$ - A Critical Lithium-ion Battery Material (Honeywell)

Bruce Mixer (NETL Project Manager)
Grant Recipient: Honeywell International, Inc.

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Start Date: April 16, 2010
Projected End Date: April 15, 2015

Introduction

Honeywell is building a U.S. manufacturing facility to produce a critical Li-ion battery material – lithium hexafluorophosphate, $LiPF_6$. Honeywell's $LiPF_6$ project directly supports the DOE's objective to build and validate production capability of battery materials in the U.S. This project will result in the first U.S. manufacturing facility for $LiPF_6$, establish a secure domestic supply for this critical material in the Electric Drive Vehicle (EDV) supply chain, and help form the foundation of a sustainable domestic Li-ion battery industry.

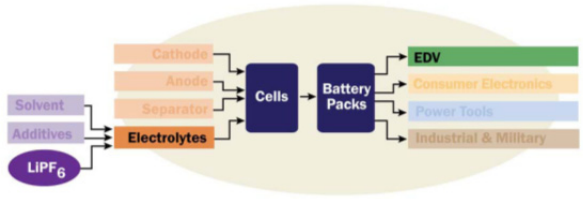

Figure II - 65: $LiPF_6$ is Required in all Li-ion Batteries.

All Li-ion batteries require $LiPF_6$ (Figure II - 65), a material that is not currently manufactured in the U.S. It is imperative that the U.S.-based Li-ion battery industry have secure access to the highest quality $LiPF_6$ to avoid disruptions in supply and/or quality from foreign sources. All domestic Li-ion battery manufacturers, and their EDV customers, will benefit from this secure and cost-effective supply of $LiPF_6$.

Leveraging our capabilities as the world's largest producer of hydrofluoric acid (HF), the Honeywell team developed a novel process to prepare high-purity $LiPF_6$ as demanded for high-quality lithium-ion batteries. HF is the key raw material required for $LiPF_6$ production (Figure II - 66) and Honeywell has over 50 years of experience in developing and scaling up new F-based molecules. Our project will leverage significant existing assets and knowhow, which enables us to bring $LiPF_6$ to market quickly.

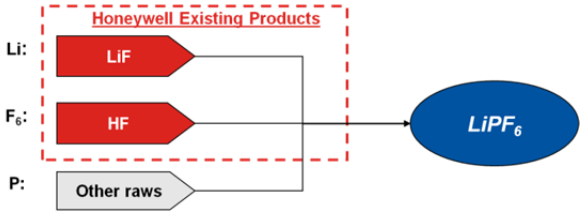

Figure II - 66: Honeywell Produces Key Raw Materials.

The objective of this project is to support the EDV Battery Manufacturing Initiative by commercializing Honeywell's novel $LiPF_6$ process into an operating Commercial Plant. The program has been divided into two phases. The first phase is the construction and operation of a smaller $LiPF_6$ Plant at an existing Honeywell site in Buffalo, NY. This plant will leverage existing infrastructure, including an existing building, to accelerate construction. This will allow customers to qualify product in their process quickly while the world-scale Commercial Plant is under construction. These customer samples will be integrated into batteries, tested and qualified for full-scale battery production. In the second phase of the project, a world-scale Commercial Plant will be built, which will be the first U.S. $LiPF_6$ production plant.

Honeywell began construction of the Buffalo, New York plant in 2010 and completed construction in the first half of 2011. This plant will produce sufficient quantities of $LiPF_6$ to enable our customers to begin the material qualification process. Engineering of the Phase 2 Commercial Plant began in 2011.

Our project will create 151 direct engineering and construction jobs to build the facility, as well as additional jobs with American equipment suppliers. Honeywell will also add 34 long-term professional and manufacturing jobs to manufacture this strategic Li-ion battery material.

The project is supported by a $27.3M grant from the U.S. Department of Energy under the American Recovery and Reinvestment Act (ARRA). As of the fiscal year end (Sept 30, 2012), $8.2M or 30% of the grant has been expended.

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Progress and Current Status

Facility 1 – Buffalo, NY Plant. The Buffalo NY facility is Honeywell's Center of Excellence for Fluorine

products and was chosen as the location of the initial LiPF6 plant because it was the fastest path to provide material for customer qualification. The $LiPF_6$ plant is able to leverage significant existing assets as well as a skilled workforce. Additionally, the technology team that invented the novel manufacturing process is based here.

Detailed engineering and construction began in 2010. 100% of the equipment is installed and construction was completed in the first half of 2011. The plant has begun producing product and will produce sufficient quantities of $LiPF_6$ to enable our customers to qualify the material.

Currently, there are 11 permanent employees. During construction, the project reached a maximum of 33.5 temporary employees in addition to the 11 permanent positions. Once the Phase II facility is operational and the project is complete, there will be a total of 34 permanent employees across Honeywell sites.

Facility 2 – World-Scale Commercial Plant. In Phase II, Honeywell will construct a world-scale manufacturing facility in Illinois. Engineering for this facility began in 2011. Construction has not begun and no equipment has been installed at this location.

This phase of the project will create a maximum of 151 engineering and construction jobs. Once the Phase II facility is operational and the project is complete, there will be a total of 34 permanent employees across Honeywell sites.

EVMS Metrics. Honeywell uses EVMS metrics track adherence to schedule and cost. A cumulative CPI of 0.90 indicates that the project is slightly over budget and a cumulative SPI of 0.99 indicates that it is on schedule.

Pictorial Overview

Figure II - 67: Aerial view of Honeywell's Buffalo, NY facility.

Figure II - 68: Buffalo NY $LiPF_6$ plant.

Figure II - 69: Special container for shipping finished product.

Planned Work for FY 2013

In FY 2013, Honeywell will safely operate the Buffalo facility to provide $LiPF_6$ samples for our customers to qualify. Once the material is qualified, we will also negotiate and execute supply agreements. Work on the Phase II facility will also continue.

Customers and Other Information

1. 2012 DOE Annual Merit Review poster session
2. Customer details are covered by non-disclosure agreements and cannot be shared in this report

II.C.5 Construction of a Li-ion Battery Cathode Production Plant (BASF)

John G. Tabacchi (NETL Project manager)
Grant Recipient: BASF Corporation

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Start Date: February 2010
Projected End Date: December 31, 2012

Introduction

- BASF has made a commitment to become a major lithium-ion cathode producer in the United States as well as on a global scale. Prior to making this commitment, BASF secured a license from Argonne National Lab for the portfolio of cathode in the lithium nickel, cobalt, manganese phase space. These materials are currently the materials of choice by many cell manufactures for the automotive market due to their superior performance, cost and safety properties. Another factor that led to BASF's commitment was a feedback from some of our customers on the performance of our cathode materials supplied by our US based pilot facility. These factors, along with BASF's technical competence in scale up of inorganic e materials, formed the base of our commitment for our investment in a US cathode production facility.
- The total value of the award for this program is $24,604,762 and at the end of FY-2012, BASF has spent 100% of the award.

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Progress and Current Status

BASF is currently ahead of schedule for this project. The original contract was to end in June 2014 but BASF now anticipated to complete the project by the end of calendar year 2012. At the end of FY-2012 (September 30, 2012), BASF had essentially completed all of the construction and installation of all equipment. For the next quarter, BASF will continue the commissioning process and have our ribbon cutting ceremony on November 13, 2012 at which time the facility will be fully operational. BASF will continue to build statistical information on our cathode production processes for the balance of 2012.

BASF has about 20-30 full time employees that are currently participating on the commissioning of the facility.

Pictorial Overview

Figure II - 70: Current Picture of BASF Cathode Facility.

Planned Work for FY 2013

After the commissioning of the facility on November 13, 2012, BASF will run the facility to provide materials to our global customers. BASF intends to have cells made by one of our US customers with our material from Elyria to deliver to DOE.

Customers and Other Information

BASF is in qualification with a number of cell manufactures for NCM cathode materials. Qualifications cannot be fully completed until lots are received from its production facility slated to be on line in the fourth quarter of 2012

II.C.6 ARRA-supported Nanoengineered Ultracapacitor Material Production Facility Project (EnerG2)

John G. Tabacchi (NETL Project Manager)
Grant Recipient: EnerG2, Inc.

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Start Date: April 20, 2010
End Date: May 31, 2012

Introduction

- EnerG2, Inc. concluded construction of the first facility in the world dedicated to the commercial scale production of synthetic, high-performance carbon materials for energy storage, and the only U.S. facility to manufacture electrode materials for ultracapacitors (a market currently dominated by Japanese suppliers). Our products deliver a next generation ultracapacitor with significantly higher power density and much lower cost per kW. This achievement will enable the combination of ultracapacitors and batteries in electric drive vehicles to reduce battery replacement costs, improve mileage efficiency, and increase vehicle road performance.
- The new plant will eventually produce enough electrode carbon materials to supply production of 60,000 EDVs annually. The total value of the project was $29,300,000, with $21,300,000 provided by the DOE, and was completed on May 31, 2012.

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Progress and Current Status

- During this past year, we completed Phase IV of the project, successfully commissioning all equipment and control systems. Process optimization to meet our first product specifications was completed and the first batches of finished product were produced. Operating personnel are continuing to be hired as the plant moves towards producing at full capacity. EnerG2 created more than 200 temporary construction jobs during the course of the project, and expects to fill more than 35 permanent position jobs when running at full capacity.

Planned Work for FY 2013

The Project is complete. Throughout the rest of 2012 and most of 2013, EnerG2 will work to refine its integrated manufacturing line, based on EnerG2's proprietary manufacturing processes, to meet the carbon electrode demands of 60,000 EDVs per year.

Albany Plant Overview Pictorials

Figure II - 71: EnerG2 Ribbon Cutting Ceremony in Albany, Oregon (February 2012).

Figure II - 72: EnerG2 Freeze Drying in Process.

Figure II - 73: EnerG2 Pyrolysis Kilns.

Other Information

(News article) EnerG2 launches Albany plant By Steve Lathrop / Albany Democrat-herald / Posted on February 14, 2012 at 7:00 AM

After nearly two years of waiting, EnerG2 opened for business in Albany Monday.

Company CEO Rick Luebbe said that this week the company, built in part with federal stimulus money, will begin to produce carbon material used in energy storage.

"What is fun about this plant is that what we are doing has so many applications for the technology," Luebbe said Monday before a ribbon-cutting ceremony officially launched the opening of the plant.

Luebbe said that EnerG2 will be in the forefront of an energy storage revolution featuring technology that is the first of its kind in the world. To start, EnerG2 will produce 20 metric tons per month of the pure carbon material that can increase storage capacity for electric car batteries and other devices.

According to Luebbe the electric vehicles were the driving force behind the plant.

"That's what has been moving this forward," he said. "But the possibilities for the product extend far beyond that."

Eventually Luebbe said the carbon material could be used in all kinds of batteries.

EnerG2 got $21 million from the stimulus program to launch the company that uses Oregon Freeze Dry technology for part of the production. OFD remains a partner in the process and the Albany plant is housed in its former 74,000-square-foot warehouse.

The plant was under construction for eight months and all of the processes have been tested to make sure they are operational.

"A lot of space is unused but that sets us up well for expansion which we project could increase production four times," Luebbe said.

Over 30 people will be employed in Albany. Additional engineering and research will be conducted in Seattle, EnerG2's home base.

Manufacturing turns resin into pure carbon through a closed loop process which pipes material from system to system. The final product will be a very fine black powder distributed to customers shipped worldwide.

One of the specific aspects of the material is its purity which Luebbe says is 20 times better than any similar material.

"The product is designed to influence high performance in the ultra capacitor and lead acid batter industries," Luebbe said.

Eventually EnerG2 plans to increase production to run two work shifts under plant manager Sean Mortensen of Albany.

"This plant is unique in the world," Luebbe said. "It's the first to produce nano-engineered carbons for energy storage. It's something Albany can be proud of."

Several dignitaries including Congressman Peter DeFazio, OFD President Jim Merryman and Albany Mayor Sharon Konopa were guest speakers at the private ceremony to open the plant Monday afternoon.

"It's a great way to announce that we are ready to roll and to celebrate internally what we have done," Luebbe said.

II.C.7 ARRA-supported Production Facility Project (Novolyte)

Dr. Christopher Johnson (NETL Project Manager)
Grant Recipient: Novolyte Technologies, Inc.

Ralph Wise
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Start Date: April 30, 2010
Projected End Date: April 29, 2015

Introduction

- The project is a two phase $40 M plant expansion effort. The first phase of the project increases Novolyte's electrolyte manufacturing capacity at its Zachary, LA facility from 1500 metric tons (MT) to 4,500 MT. The goal of the second phase of the project is to increase plant capacity from 4,500 MT to 10,000 MT.
- Total Value of Award: $20,618,047
- Percent of funds expended: 2.5%

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Progress and Current Status

Novolyte's electrolyte plant capacity expansion is a two phase project, timed to intersect with future market demand. Project risk is carefully managed by working closely with domestic customers to forecast and foresee project delays or to accelerate the completion of key tasks, if necessary.

Phase I tasks of the expansion project, started in 2010 and extending through 2013, include the installation of new large scale raw material storage tank and associated equipment, building a new motor control center (MCC) upgrading the solvent distillation system, building a new control room center, upgrading the high voltage transformer, installing a new steam boiler and new vessel cleaning station and upgrading the lab and flammable storage building.

During the 4th calendar quarter of 2011, eighty of the 400 215 L vessels that were ordered were received as well as fittings for half of the entire fleet. Transfer line upgrade in the electrolytes unit to stainless steel was completed. A project to install a hot box for melting of raw materials was approved and installed with progress made to further install the piping and instrumentation. Laboratory equipment upgrades were completed and the vacuum heat sealer for small packaging was received. Engineering identified key critical debottlenecking and general upgrading projects.

During the 1st calendar quarter of 2012, the project to install a hot box for melting of raw materials was completed and the vacuum heat sealer for small packaging was received, installed, and placed in service. A new weighing scale for electrolytes additives was purchased, qualified and installed. Further, a project was approved to install a solvent blend tank in the electrolytes unit to improve electrolyte production efficiency.

During the 2nd and 3rd calendar quarters, the procurement project for the 400 new 215-L electrolytes shipping vessels was completed and procurement of 250 new 215-L electrolyte shipping vessels was initiated. The vessels had been received, yet at the time, only a partial delivery of the fittings was confirmed. We upgraded the water analyzer in our laboratory and approved an upgrade project to the distributed control system in the electrolytes control room. The project to convert a storage tank into a solvent blend tank in the electrolytes unit was under completion and we purchased a new Mettler balance for the electrolytes dry box in the laboratory.

In April, Novolyte Technologies was acquired by BASF. Project management remained with legacy Novolyte personnel for the second and third calendar quarters with BASF assuming control of project management and reporting by the end of the fourth quarter. As of this report writing, the award was under novation from Novolyte to BASF.

Activities for the planned expansion of electrolyte capacity are being reviewed for the 2012 and 2013 Phase II project milestones in order to assess the pace of the xEV market, closely match supply and demand, review competitor capacity plans for North America, and to match supply with forecast changes from customers.

Facility 1 – description

Construction complete (1%)

- Construction and fittings for 700 215L shipping vessels, re-piping of the sample reactor and warehouse upgrades for the storage of raw materials were completed. Sample and 150-gal. reactor piping upgrade, Automation Engineering, upgrade transfer lines to stainless steel.
- Equipment Installed (7.5%)
- An ion chromatograph was received and installed, a production portable scale was purchased and placed into service, an electrolytes sump pump was installed a vacuum sealer for small sample packaging for x EV

customers is to be received in the fourth calendar quarter of 2011.

- Production Started (0%)
- Phase 1 production upgrades: No new production capacity has been implemented to date. Plans are being made for implementation of capacity expansion through debottlenecking of existing reactors as well as through installation of additional reactor capacity.
- Jobs: permanent (9 current, 18 at project completion)
- Jobs: temporary/construction (0 current, 65 maximum)

Pictorial Overview

Figure II - 74: Several examples of the 400 215-L Electrolytes shipping vessels purchased in 2010 (Novolyte).

Figure II - 75: Ion Chromatograph (Novolyte).

Figure II - 76: Two examples of the small Electrolytes shipping vessels purchased in 2011 (Novolyte).

Planned Work for FY 2013

Go no/go decision on reactor expansion, completion of EA for new site, if required, go no/go decision point on Phase 2 completion of reactor expansion, kick off Phase 2 and the completion of Phase 1.

II.C.8 ARRA-supported Production Facility Project (FutureFuel Chemical Co.)

John Tabbachi (NETL Project Manager)
Grant Recipient: FutureFuel Chemical Company

Gary McChesney – Principal Investigator/Project Director
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Introduction

- **Objective:** Establish and Expand Commercial Production of Graphite Anode Materials for High Performance Lithium-ion Batteries
- **Description of Facilities:** FutureFuel Chemical Company (FFCC) designed and constructed, commissioned and qualified a commercial-scale plant to produce Intermediate Anode Powder – the key component in ConocoPhillips' (COP) line of CPreme® Anode Materials. FFCC retrofitted an existing manufacturing plant located in Batesville, Arkansas, to produce the Intermediate Anode Material. The Intermediate Anode Material plant has the capacity to produce 8,000,000 pounds per year of material.
- Total Value of Award: $12,595,762
- Percent of Funds Expended as of 11/30/2011: 97.8%

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Progress and Current Status

Qualification of the Intermediate Anode Material plant was completed in October 2011. Construction of the associated nitrogen plant was completed in November 2011. The project was completed and closed on November 30, 2011. The nitrogen plant began supplying nitrogen to the anode plant in January 2012. The first commercial production campaign of anode material was completed in December 2011 and January 2012. A short-term production rate test was conducted in January 2012. During the test a rate equivalent to 10.3 million pounds per year was achieved.

The plant has been idle since February 2012. A second commercial production campaign is planned for 2013.

Facility 1 – Intermediate Anode Material Plant

- Construction Complete (100%)
- Equipment Installed (100%)
- Production Started (100%)
- Permanent Jobs (17)
- Temporary Jobs (21)

Pictorial Overview

- Construction (1-2 pictures)
- Facilities (1-2 pictures)
- Equipment (2-4 pictures)
- Product (1-2 pictures)

Figure II - 77: Xylene Tanks (FutureFuel Chemical Company).

Figure II - 78: Pitch Loading Hopper (FutureFuel Chemical Company).

Figure II - 79: Coke Loading Hopper (FutureFuel Chemical Company).

Figure II - 80: Anode Material Bag Out (FutureFuel Chemical Company).

Figure II - 81: Anode Material (FutureFuel Chemical Company).

Planned Work for FY 2013

The project was completed and closed in FY 2012. The project closing report was submitted in February 2012. In 2013 the plant will be operated on an as needed basis to meet customer demand.

Customers and Other Information

FFCC produces Intermediate Anode Material under contract exclusively for COP. FFCC's only customer for Intermediate Anode Material is COP.

II.C.9 ARRA-supported Production Facility Project (Pyrotek)

John Tabacchi (NETL Project Manager)
Grant Recipient: Pyrotek Incorporated

Michael J Sekedat
Finance Manager – Energy Group
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Start Date: October 2009
Projected End Date: December 2011

Introduction

- **Description of facilities:** This project added ninety-three thousand, six hundred (93,600) square feet of manufacturing and storage space within three joined buildings at our Sanborn, New York manufacturing center. In this center, Pyrotek provides high temperature heat treating services with our proprietary graphitization furnaces. In addition to adding facility space, we have also added additional furnace capacity and specialty equipment needed to handle the material before and after the heat treatment process. This project was selected under the DOE Recovery Act – Electric Drive Vehicle Battery and Component Manufacturing Initiative (FOA: DE-FOA-0000026), because our graphitization process is the final step in manufacturing a high performance anode material for Lithium-Ion Batteries used for electric and hybrid automobiles.
- As of the end of December 2011, we had successfully completed the facility construction and the equipment procurement, fabrication and installation defined within the project scope. Our Total Award Value was $11,334,652. As of the end of December 2011, this Award was fully utilized, along with additional funding by Pyrotek to complete the project, which had an ending value of $26,010,254. While this project started as a 50/50 cost share with the DOE, enhancements to the project, along with material cost increases, resulted in a project total that exceeded the original budget. Accordingly, the DOE Award total represents 43.6% of the final project total.

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Progress and Current Status

As of the end of December 2011, 100% of the construction and equipment acquisition was completed. The construction included a thirty thousand (30,000) square foot Material Handling Building, a forty-five thousand, six hundred (45,600) square foot Graphitization Building, and an eighteen thousand (18,000) square foot Warehouse (which has also been configured for future graphitization production).

The Material Handling Building is a steel shell building on a concrete floor, with clear span space, meaning there are zero support posts within the manufacturing space. It is the only building where the material is exposed to the open air. It contains four (4) material handling systems, as well as a material testing lab and storage racking needed to house the material as it is prepared for graphitization, and for when the material returns after graphitization is completed.

The Graphitization Building is also a steel shell building over a steel skeleton, on a concrete floor. This building has space for twelve (12) of our proprietary graphitization furnaces, as well as for the water cooling equipment. The project scope reflects the installation of ten (10) new furnaces, which have all been completed as of the end of December, 2011. The final two (2) furnaces will be acquired and installed as future volumes dictate.

The Warehouse Building is also a steel shell building over a steel skeleton, on a concrete floor. The space within this building is being used to store processing supplies, furnace repair parts, and other processing support materials. The space was constructed with the necessary in floor infrastructure layout to house an additional six (6) graphitization furnaces. These will also be acquired and installed as future volumes dictate. At that time, it is anticipated that additional warehouse space will need to be built on the site.

Planned Work for FY 2013

Our expansion project was completed as of the end of December, 2011. As such, there are no plans for ongoing project work.

Customers and Other Information

As explained in our Award application, our graphitization service is provided to our single customer, whereby we heat treat their raw material to produce a high performance anode material. Pyrotek does not own the material, nor do we sell it to the end users – battery manufacturers. The science behind the material is owned by our customer, as their proprietary information, while Pyrotek owns the proprietary heat treatment process. While the present volumes have not risen to the level of capacity that our new facility can provide, these lower production levels have afforded us the opportunity to evaluate all of our processing efficiencies and cost exposures. The two areas of focus continue to be reducing

production costs while also increasing furnace throughput, both of which will reduce our overall per pound anode material processing cost.

Pictorial Overview

Figure II - 82: Construction at Pyrotech Incorporated.

Figure II - 83: Facilities at Pyrotech Incorporated.

Figure II - 84: Equipment at Pyrotech Incorporated.

II.C.10 Manufacture of Advanced Battery Components (HTTM LLC, H&T, Trans-Matic)

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Jeff Lauinger (HTTM General Manager)
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Start Date: September 2009
Projected End Date: April 2015

Objectives

- Design and engineer unique U.S.-based product development and manufacturing processes which will produce cylindrical and prismatic metal outer shell (can) containers, covers, cover assemblies, and other components and assemblies for sustainable lithium-ion battery products for automotive and other applications;
- Develop and expand a highly skilled technical workforce through hiring & training several new professional, semi-skilled and skilled technicians; and,
- Install the designed processes at the Holland, Michigan facility and begin production.

Technical Barriers

Given the nature and ultimate operating use of the battery container components and other associated parts, the choice of base materials is critical, along with the manufacturing conversion process. Typical commercial grade materials do not normally have the consistency of gage and physical properties required for this application, especially when considering the lot-to-lot variation. This is especially important in the areas of cleanliness and safety vent design. Safety vent consistency and predictability is directly proportional to the base material consistency, tooling precision and process capability.

In addition to the tight control of base material properties, the level of residual particulate matter present on the components after fabrication is critical. The low particle count and surface finish requirements as specified by battery OEMs are well beyond normal manufacturing protocol. In each case, plans are developed to address all of these issues including tool materials and finishes, primary lubricants and coolants, verification and handling of raw materials and components during fabrication and assembly, and immediate in-line final cleaning equipment, followed by immediate inspection and packaging/sealing using specialized containers and dunnage.

Technical Targets

- Develop a metal cell container (can) and cover assembly system to meet OEM technical, quality, durability, safety, and cost objectives.
- Develop the manufacturing technology to produce drawn, stamped, impact extruded, and fold & welded containers, depending upon OEM customer requirements.
- Develop the capability to produce components in low carbon steel, stainless steel, and various grades of aluminum.
- Design and install a manufacturing process to produce consistent hermetically sealable container components for automated assembly at the customer's location.
- Design and produce safety vent features that can be incorporated into the can or cover, whether integral or separate component, that produce a specified range of burst pressures, from 2 bar to 25+ bar, as specified by OEM customers.
- Create and implement an in-tool automated vent feature measurement system that provides accurate and dynamic feedback on 100% of the parts produced.
- Develop an in-line cleaning system that meets Dyne and particulate matter cleaning requirements as specified by OEM customers.

Accomplishments

- Design simulation, development, prototyping, and production capabilities for both cylindrical and prismatic deep drawn, impact extruded, and fold & weld cell cases have been accomplished.
- A variety of steel and aluminum materials have been used for prototyping, preproduction and production components.
- Design and development of vent design features in cell cases and covers that maintain a statistically valid bursting range of < 4 bar. Separate vent disc components have been designed and are being developed and tooled for OEM applications.

- Specialized equipment has been developed and is in use to precisely verify (non-destructively) safety vent physical features during production runs. Statistically capable burst testing equipment is also online and in use for all production runs.
- Currently in development with a new process for attachment of terminals to covers/cans that will result in cost reduction and quality improvements.
- Successful development of an integral termination feature for cell covers as a future value engineering change for additional cost reduction.
- Volume production is underway and products have been delivered to customers on time.

Facility – Introduction

- Description of facilities:
- The facility utilizing the grant funding is located in Holland, MI. The HTTM JV utilizes portions of the existing Trans-Matic Manufacturing CO. INC. floor space for new equipment required for manufacturing and assembly of the advanced battery components, as well as storage of WIP and finished goods.
- Total Value of the Award: $5,040,000
- Percent of Funds Expended: 62%(estimated as of: Sept 30, 2012)

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Progress and Current Status

Facility 1. This project did not involve the construction of new facilities. The project did require some minor building modifications to the Trans-Matic facility and the installation of primary and ancillary production presses, assembly, cleaning, and packaging equipment.

- Construction complete: 100%
- Equipment installed: 100%
- Production Started: 100% (first production orders workload)
- Jobs: (Current – End of Project)
- Jobs-permanent: 7 - 19 (varies per actual workload)
- Jobs-temporary: 4 - 8 (varies per actual workload)

Pictorial Overview

Figure II - 85: Trans-Matic/HTTM Manufacturing Facility.

Figure II - 86: Equipment – Battery Can Stamping Press (HTTM LLC, H&T, Trans-Matic).

Figure II - 87: Equipment – Battery Cover Assembly Equipment (HTTM LLC, H&T, Trans-Matic).

Figure II - 88: Component Pre-Cleaner (HTTM LLC, H&T, Trans-Matic).

Figure II - 89: HTTM Website www.httmllc.com (HTTM LLC, H&T, Trans-Matic).

Results

HTTM (H&T and Trans-Matic) have been successful in working with OEM advanced battery customers to provide the expertise, products and processes needed to be successful in the advanced energy storage market.

HTTM has prototype and production orders with several OEM cell producers to provide cell containers and cover assemblies for various cylindrical and prismatic battery cell systems. HTTM has recently been awarded additional new cell container work.

Tooling and processing equipment design and fabrication have been completed on schedule and on budget for the current projects. Additional customer projects are in play. Facility modifications have been completed to support 2012-2013 volume production requirements.

HTTM has established itself as a subject matter and manufacturing expert for the development and production of advanced battery container components. HTTM utilizes its capabilities on a global basis and has delivered specialized development expertise and flexible manufacturing centers to create high quality and cost effective solutions for its customers.

Conclusions and Future Direction

2010-2011 – 2012-2015

The H&T and Trans-Matic core businesses and technology experience has been successfully transferred to HTTM and effectively applied to the advanced energy storage market.

Building upon its existing relationships with several of the key OEM players, HTTM has won the development and production orders of several OEM battery producers. As the industry, market, and technology evolve, HTTM has the flexibility and capability to deliver optimum metal container systems in a variety of configurations to satisfy any USABC, Verband der Automobilindustrie (VDA), or other OEM requirements.

Several new product developments are underway with additional customers for metal cylindrical and prismatic container systems (cans and cover assemblies). Additional manufacturing press and assembly equipment is being built in anticipation of this new work. Production capacity is available.

Customers and Other Information

Publicly announced current customers include JCS/JCI and Saft. Additional customer work is in process, working within confidentiality agreements.

Jeff Lauinger was made General Manager of the HTTM Joint Venture on May 17, 2011.

Several articles have been published about HTTM and Trans-Matic in MIBIZ, Grand Rapids Press, Grand Rapids Business Journal, Holland Sentinel and other publications.

Publications/Presentations/Exhibitions

1. 2011 USABC Conference – Detroit, MI
2. 2011 Fabtech Exposition – Chicago, IL
3. 2011 Battery Show – Novi, MI
4. 2011 SAE Vehicle Battery Summit – Shanghai, China
5. 2011 Beijing Battery Fair – Beijing, China
6. 2011 AABC Conference – Pasadena, CA
7. 2011 AABC Conference – Mainz, Germany
8. 2011 Advanced Energy Storage Taskforce – Holland, MI
9. 2011 AABC Conference – New York
10. 2011 China Auto Manufacturing Forum – Ann Arbor, MI
11. 2012 Dept of Energy Merit Review
12. 2012 AABC Conference – Orlando
13. 2012 Battery Show – Detroit, MI
14. 2012 Battery+Storage – Stuttgart, Germany

DATE of this report: Oct 9, 2012

II.D Battery Recycling Facilities

II.D.1 ARRA-supported Production Facility Project (Toxco)

Bruce Mixer (NETL Project Manager)
Grant Recipient: Toxco, Inc.

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Start Date: April 14, 2010
Projected End Date: December 31, 2014

Introduction

- Description of facilities: An advanced recycling facility for the recycling and refurbishing of advanced lithium chemistry batteries.
- Total Value of award: $9,517,951.00
- Percent of funds expended: $2,929,900.94 (30.78%) expended through FY2012.

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Progress and Current Status

Facility 1 – LIB Recycling Plant, Lancaster, OH

- Construction complete (75%)
- Equipment Installed (0%)
- Production Started (0%)
- Jobs: 43 permanent at project completion
- Jobs: 40 construction/temporary

Pictorial Overview

Figure II - 90: Toxco Processing Facility completed Exterior.

Figure II - 91: Toxco Building Exterior.

Figure II - 92: Toxco Interior Offices.

Figure II - 93: Process Area.

Planned Work for FY 2013

Work planned for FY 2013

1. Complete Facility Construction and begin operations.
2. Conduct pilot operation of the Lithium Cobalt and NiMH line
3. Install the Lithium Mixed Metal Oxide processing line
4. Install battery refurbishing process line
5. Conduct pilot operation of the battery refurbishing process line

Customers and Other Information

1. **American Metal Market**
   a. Artilce: "Toxco received $9.5M from DOE to expand Ohio Plant"
   b. Author: Lisa Gordon
   c. Published: February 4, 2010
   d. http://re-batteries.wikispaces.com/file/view/Toxco+Receives+$9.5M+from+DOE+to+expand+Ohio+plant.pdf/334909242/Toxco%20Receives%20$9.5M%20from%20DOE%20to%20expand%20Ohio%20plant.pdf
2. **U.S. General Services Administration – Electric Vehicle Program Launch**
   a. Speech: "Johnson Says New Electric Fleet Program Lays Foundation for Electric Vehicle Infrastructure"
   b. Speaker: Martha Johnson
   c. Published: May 24, 2011
   d. http://www.gsa.gov/portal/content/281825
3. **The Columbus Dispatch**
   a. Article: "Lancaster's Toxco Inc. has big plans for recycling "green" car batteries"
   b. Author: Dan Gearino
   c. Published: March 4, 2011
   d. http://www.dispatch.com/content/stories/business/2011/03/04/lancasters-toxco-inc--has-big-plans-for-recycling-green-car-batteries.html
4. **Energy Efficiency & Technology**
   a. Article: "An uncertain future for recycling electric vehicle batteries"
   b. Author: Frances Richards
   c. Published: February 1, 2012
   d. http://eetweb.com/applications/uncertain-future-recycling-batteries-0212/

II.E Battery Research Facilities

II.E.1 ARRA-supported Prototype Cell Fabrication Facility (ANL)

Brian Cunningham (DOE Contact Person)
Grant Recipient: Argonne National Laboratory

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Start Date: April 2010
Projected End Date: December 2012

Introduction

Equipment was purchased in this project to support the establishment of a prototype cell fabrication facility at Argonne to fabricate advanced lithium-ion cells for use in its applied R&D program. A new state-of-the-art dry room and equipment for fabricating prototype cells is now operational. The equipment purchased in this project includes electrochemical cycle testers (for forming and evaluating newly fabricated cells), environmental chambers (for use in extreme temperature testing of these cells), a multi-channel impedance analyzer (for conducting in-depth electrochemical studies on selected cells), an accelerating rate calorimeter (for quantifying thermal abuse characteristics of selected cells), a new controlled-atmosphere glove box (for use in filling the cells with electrolyte), and a new X-ray diffraction unit (for use in quality control of cathode powders that will be used in these cells).

The total funding for this project was one million dollars. Effectively, the project was completed in 2011 with essentially all the funds being spent. The projected end date is when all of the Argonne ARRA projects will be closed out.

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Progress and Current Status

Facility 1 – description

- All equipment have been identified and the orders placed
- All equipment have been received and installed
- List of equipment purchased and installed
  - Prototype cell testing and formation equipment (see Figure II - 94)
  - Environmental chambers and ovens (see Figure II - 94)
  - X-ray powder diffractometer (see Figure II - 95)
  - Accelerating rate calorimeter (ARC) system (see Figure II - 96)
  - Inert atmosphere glove box
  - Multi-channel electrochemical test station and impedance analyzer (see Figure II - 97)
  - Instron Materials Testing Instrument

Pictorial Overview

Figure II - 94: Maccor Series 4000 Automated Test System for testing and formation of prototype cells with environmental chambers and ovens.

Figure II - 95: Bruker D8 advanced powder diffraction system.

Figure II - 96: ARC-254 from NETZSCH.

Figure II - 97: Solartron (Ametek) eight channel electrochemical test station and impedance analyzer.

Planned Work for FY 2013

As this project was completed in 2012, no further work is planned, except to close out the account.

Customers and Other Information

1. Argonne Press Release (January 19, 2010): Funding will push Battery Technology from Argonne to the Marketplace
2. BatteryPower (March 11, 2010) publishes article on Argonne's ARRA funded battery facilities

II.E.2 ARRA-supported Material Scale-Up Facility (ANL)

Grant Recipient: Argonne National Laboratory

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Start Date: April 1, 2010
Projected End Date: September 30, 2013

Introduction

- **Description of facilities:** The objective of this project is to design and set up a laboratory-scale battery-materials production facility (Materials Engineering Research Facility or MERF) to rapidly scale up battery chemistries developed on the bench scale and produce bulk quantities of the materials for evaluation in prototype cells to enable quick turnaround validation of the materials chemistries.
- The Materials Engineering Research Facility (MERF) will provide a new capability to Argonne's existing battery facilities, capabilities, and expertise. While the MERF will support Argonne's R&D program in batteries and ultra-capacitors, it will be an open facility and access will be available to other organizations, including other national laboratories, universities, and industry, for the validation of new materials and materials processing schemes. The new facility will also support strategic Argonne partnerships to enable a domestic battery manufacturing industry, such as the Kentucky-Argonne Battery Manufacturing R&D Center. As such, the MERF will enable substantial progress to be made in the development, validation, and ultimate commercial implementation of advanced battery-materials chemistries. Such a facility is a key missing link between the bench-scale development of battery technology and high-volume manufacturing of large-format advanced batteries for transportation applications.
- This project consists of two tasks,
  - Construction of the MERF and
  - Specifying and ordering equipment for the facility.
- Total Value of award:
  - Facility construction award = $3.3M
  - Equipment award = $2.5M
- Percent of funds expended:
  - Facility construction funds expended = $3,269,000 99.1% by end of FY 12
  - Equipment funds expended = $2.5M
- 100% by end of FY 12

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Progress and Current Status

All milestones and deliverables have been completed.

Construction

- Milestone 1 Complete full facility design (CDR) (10/1/2010). – **COMPLETED 8/19/2010**
- Milestone 2 Award full facility construction contract (2/1/2011). – **COMPLETED 11/22/2010**
- Deliverable 1 Open interim facility (9/30/2010). – **COMPLETED 9/17/2010**
- Deliverable 2 Complete full facility construction (2/1/2012). – **COMPLETED 1/31/2012**
- Deliverable 3 Open full facility (3/31/2012). – **COMPLETED 3/30/2012**

Equipment

- Milestone 1 Interim facility equipment purchased & installed (12/31/2010). – **COMPLETED 9/17/2010**
- Milestone 2 Production scale-up facility (MEF) equipment purchased & accepted (12/31/2011). – **No Funding Allocated**
- Deliverable 1 Interim facility open (9/30/2010). – **COMPLETED 9/17/2010**
- Deliverable 2 Full facility open (3/31/2012). – **COMPLETED 3/30/2012**

Facility 1 – Materials Engineering Research Facility

- See construction site pictures below.
- Construction complete (100%)
- Equipment Installed (75%)
- Production Started (50%)
- Jobs: permanent (8)
- Jobs: temporary/construction (30 during construction, 0 as of the end of FY12)

Pictorial Overview

Figure II - 98: MERF Construction Completed (ANL).

Figure II - 99: Electrolyte Materials Process R&D Lab (ANL).

Figure II - 100: Electrolyte Materials Scale-up Lab (ANL).

Figure II - 101: Cathode Analytical Lab (ANL).

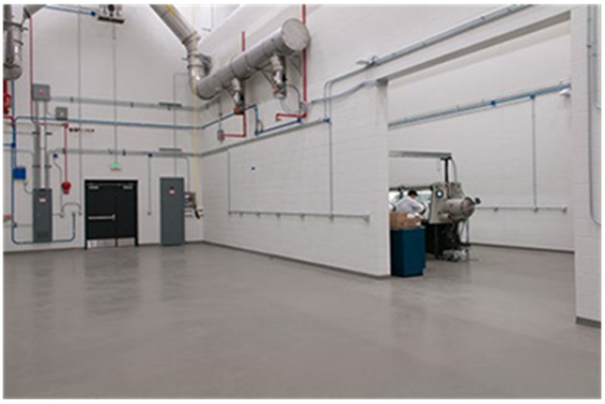

Figure II - 102: Highbay for Cathode Scale-up Lab (ANL).

Figure II - 103: 20L Reactor and Rotavap (ANL).

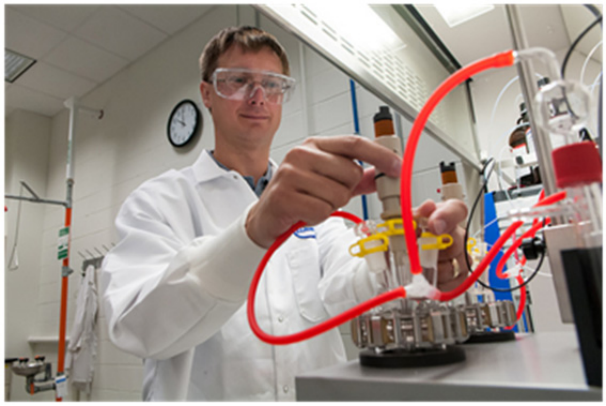

Figure II - 104: Reaction Calorimeter (ANL).

Figure II - 105: Filter-Washer-Dryer Unit (ANL).

Figure II - 106: Glovebox for Coin Cell Fabrication (ANL).

Planned Work for FY 2013

The remainder of the cathode scale-up interium lab will be relocated to the Materials Engineering Research Facility after installation of a powders handling hood. We expect to continue our scale-up work in both electrolyte and cathode materials. We expect to scale-up 4-6 electrolyte materials and 2 cathode materials in FY 2013, pending available operating funds.

Customers and Other Information

1. News Item 1 - The Research Bench Meets Industry: New Facility Scales up Production of Battery Materials – Phys Org http://phys.org/news/2012-08-bench-industry-facility-scales-production.html
2. News Item 2 – How to Build a Better Lithium Ion Battery – Scientific American http://www.scientificamerican.com/article.cfm?id=how-to-build-a-better-lithium-ion-battery
3. News Item 3 – The Future of Rechargeable Batteries – CNN Money http://www.youtube.com/watch?v=zsWhaxeZDu8

II.E.3 Post-test Laboratory Facility (ANL)

Christopher Johnson (NETL Project Manager)
Grant Recipient: Argonne National Laboratory

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Start Date: April 1, 2010
Projected End Date: December 31, 2011

Introduction

- **Objectives:** Establish a dedicated facility for the post-test examination of new and aged cells and batteries. In a controlled environment, components will be harvested from new and aged cells and thoroughly characterized to establish the chemical and physical changes that occur during aging. Post-test characterization of these materials can provide critical information about the degradation mechanisms, which, previously, could be only hypothesized. Physical, spectroscopic, metallographic, and electrochemical tests will be used to aid the further improvement of a given technology by elucidating failure modes.
- **Approach:** Renovate an existing laboratory space to accommodate the needs of the new facility. Purchase a glove box, spectroscopy, microscopy, electrochemical, and metallographic equipment to conduct post-test characterization. Use the experience and techniques developed in DOE's applied battery program in a standardized fashion, similar to the performance test protocols.

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Progress and Current Status

The overall design of the laboratory is shown in Figure II - 107. The design shows the approximate placement of the major pieces of equipment.

An existing laboratory was modified to accommodate the new facility. The existing laboratory was completely demolished and was brought up to current building codes. Establishing the post-test facility requires procuring many pieces of equipment. The milestones are shown in Table II - 2. The progress made in procuring equipment is shown in Table II - 3. Thus, the construction and procurement of equipment are complete.

The facility is now 100% operational and all the funds have been spent. A photograph, showing activity in the facility, is shown in Figure II - 108. The facility has examined batteries from the Argonne's Cell Fabrication Facility (CFF), the Advanced Battery Research (ABR) Program and from commercial sources. Results from the CFF study are described in detail separately (see section IV.E.2.1 Post-Test Diagnostic Activities). The Post-Test Facility is actively collaborating with other research groups, both domestically and internationally. Our domestic collaborations also include the BATT and USABC programs.

Table II - 2: Table of Post-test Lab Facility Milestones.

Item	Due Date	Status
Complete design for post-test laboratory construction	7/30/2010	Complete
Start construction of post-test laboratory	9/30/2010	Late start date: 12/2/2010
Post-test laboratory construction complete	3/31/2011	Complete
Post-test equipment identified	7/30/2010	Complete
Issue solicitation for glove box and equipment	9/30/2010	Complete
Complete construction of post-test facility	12/31/2011	Complete

Financial data:

Total project duration: 21 mo.
Laboratory modifications $300K/6 mo.
Equipment: $2000K/17 mo.

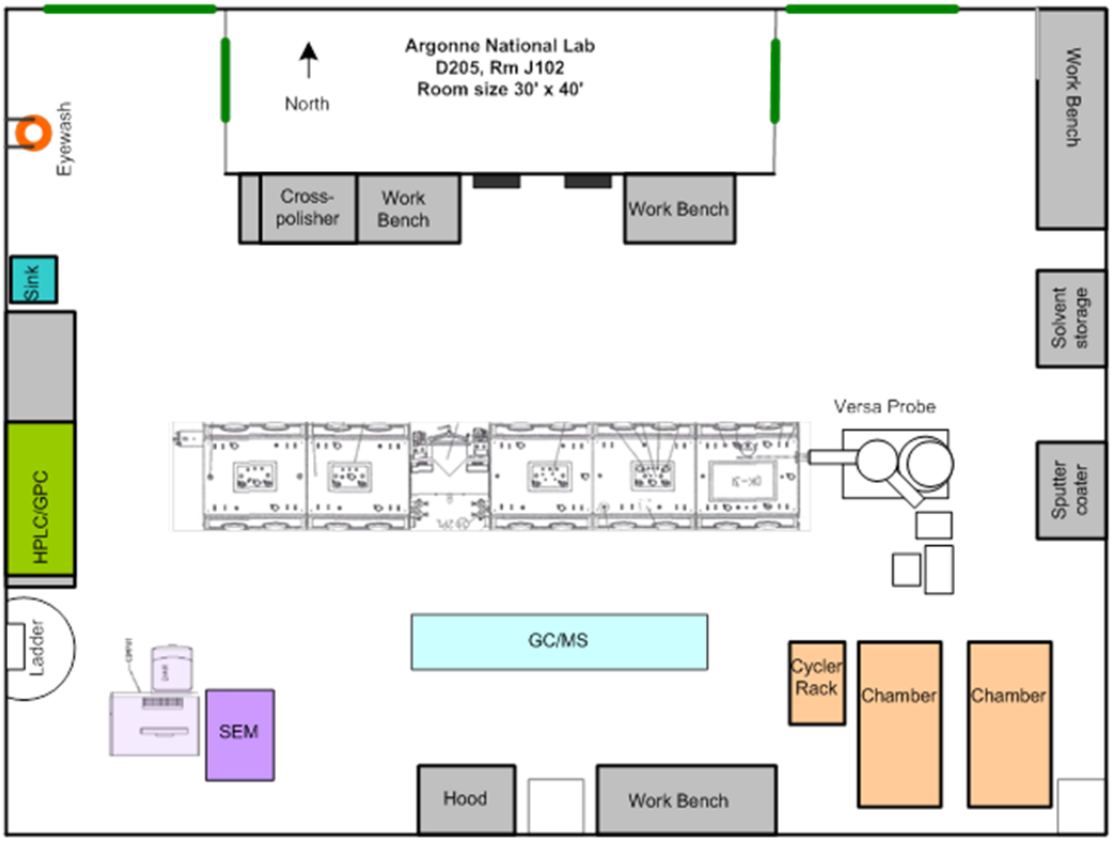

Figure II - 107: Overall design of the post-test facility. The large, open area at the top of the figure is not part of the post-test facility. The VersaProbe X-ray photoelectron spectrometer (XPS) was purchased with funds from the US Department of Defense.

Table II - 3: Status of equipment purchases.

Equipment	Purchased?	Delivered?
Custom glovebox	Y	Y
FT-IR	Y	Y
Raman	Y	Y
Metallography equipment (saws, polishers, grinders, etc.)	Y	Y
Optical microscope	Y	Y
Electrochemical Impedance Spectroscopy	Y	Y
(8-ch frequency analyzer and potentiostat)	Y	Y
Environmental SEM	Y	Y
XPS	Y	Y
HPLC/GPC	Y	Y
Coin cell cyclers	Y	Y

Figure II - 108: Argonne scientist Nancy Dietz Rago analyzes results in the Post-Test Facility. After a battery sample is characterized in the large glove box, it is transferred without exposure to air to the scanning-electron microscope for detailed, microstructural characterization.

II.E.4 High-Energy Battery Testing Facility (INL)

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Start Date: March 1, 2010
Projected End Date: April 30, 2013

Introduction

This project is focused at equipment and facility upgrades needed to fully build and operate the new Idaho National Laboratory (INL) High Energy Battery Test Facility that has been constructed at the INL site in Idaho Falls, Idaho.

- Project Time Line: 03/01/10 – 04/30/13.
- Funding: $5.0M received from DOE.
- Funds Expended through 9/30/13 $4.7M

This project would support the nation's economic recovery by creating U.S. based national laboratory jobs; the INL is building a new 10,000 sq. ft. high energy battery test facility.

The INL project is in response to an identified capability shortfall within the DOE-EERE battery test facility complex. The DOE lead test facilities at the national laboratories current capability to test full size high voltage battery systems and high energy battery cells would not be able to meet the testing demand in support of DOE EERE battery development and manufacturing projects over the next five to ten years. Several DOE/USABC development contracts are scheduled to deliver full-size vehicle battery systems and large numbers of high energy battery cells in the next several years.

The awarded equipment funding will enable electrical performance testing of 5 full-size battery systems and large numbers of high energy battery cells. This expanded capability will also create expanded exposure by DOE battery developers to the testing operations, increasing overall deliverable quality and reducing costly procedural errors. In addition, the creation of a new test facility focused on high energy systems and high energy cells will allow existing facilities to further increase capability for testing DOE-EERE battery deliverables. Lastly, this capability expansion will greatly enhance the INL mission focus on diagnostic testing, providing cradle-to-grave analysis of new battery materials, cells, modules, and full systems, targeting mechanistic-level knowledge that will enable determination of failure mechanisms and subsequent technology improvement and optimization for the intended DOE applications.

Progress and Current Status

Equipment received to date: 09/30/12

- 1 - Vibration test station installed, operational.
- 4 – 5 Volt / 60 Amp 24 channel cell testers
- 1 – 7 Volt / 250 Amp 8 channel cell tester
- 3 – 5 Volt / 250 Amp 8 channel cell testers
- 1 – 7 Volt / 90 Amp 24 channel cell tester
- 1 – 7 Volt / 300 Amp 8 channel cell tester
- 1 - 500 Volt / 350 Amp battery pack tester
- 16 - 1.5 ft^3 cell level temperature chambers
- 2 – Battery pack sized temperature chambers
- 2 – Battery pack level calibrations systems
- 2 – Large walk-in temperature chambers
- 3 – 110 UPS power backup systems
- 5 – 208 UPS power backup systems
- Miscellaneous calibration instruments
- Miscellaneous laboratory support tools
- Control room system completed
- Completed electrical and HVAC upgrades

Equipment to be received in FY 2013:

- 2 – 500 Volt / 350 Amp battery pack testers
- 2 – 1000 Volt / 500 Amp battery pack testers
- 10 – 1.5 ft^3 cell level temperature chambers
- 10 – 3.9 ft^3 cell level temperature chambers

The high current calendar and cycle life test channels will increase the number of cells that can be tested by 160, 120 channels to be used for calendar life testing and 40 channels to be used for cycle life testing. The current battery test lab has 31 high current cell level cycle life channels, 80 high current cell level calendar life channels, 20 module level channels, and 3 pack level channels. The result is a significant expansion in DOE EERE battery and ultracapacitor testing capability.

Lithium ion cell performance is sensitive to temperature. All cell, module, and pack level testing is performed within high precision temperature chambers to add a level of accuracy and safety to the testing.

Figure II - 109 is the street view of the High Energy Battery Test Facility Figure II - 110 is the completed control room, Figure II - 111 shows the south side of the 10,000 sq. ft. testing facility, Figure II - 112 is a view of

the testing stations, and Figure II - 113 is a view of the mid-sized thermal temperature chambers.

Facility Description

- Building construction is 100% complete.
- Equipment Installed 50%
- Battery Testing Started 0 %
- Jobs: 5 permanent (at project completion)
- Jobs: 30+ temporary construction

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Pictorial Overview

Figure II - 109: Street view of completed 10,000 sq. ft. High Energy Battery Test laboratory building. Part of New INL Energy Systems Laboratory complex.

Figure II - 110: View of completed battery test bay laboratory control room.

Figure II - 111: View of the 10,000 sq. ft high bay testing facility, initial test station installations.

Figure II - 112: Additional view of initial test station installations with temperature chambers.

Figure II - 113: View of mid-size thermal temperature chambers delivered in FY12.

Planned Work for FY 2013

Construction on the New INL High Energy Battery Test Laboratory building was completed on September 30, 2012. Staff occupancy is to begin in November 2012. However, battery testing laboratory equipment installation is well underway with approximately 50% of new equipment installed as of this report date (09/30/2012). Equipment moves, staging, and installation is expected to continue into January of 2013. For example, a considerable amount of effort is required to assemble and operate the larger battery pack and walk-in environmental chambers. The equipment vendors are required for assembly and significant plumbing and electrical connections will be done to make those operational. The high power 1,000 Volt test stations require high power electrical connections made by skilled electricians. The remaining funds will be used for a variety of complex installations; support instruments, shop tools, cabling, various electrical parts etc., or to further expand the test capability. Some facility electrical modifications will still be required due to unexpected tester requirements.

A limited amount of battery and cell testing is expected to begin as early as December of 2012 in the new facility. The current on-going battery and capacitor testing at the INL has not been interrupted or delayed during the construction or the initial equipment installation to date. However, it is expected that as installation proceeds, there will be brief periods where on-going testing must be shut down and moved into the new facility. A detailed move plan developed for this reason will minimize any disruptions to the on-going work.

It is expected that the new facility will be approximately 50% operational by the end of December 2012, and become fully operational by the project end date of April 30, 2013. This new expanded test capability will create an EERE battery testing center with a total of 640 test channels and support systems capable of cradle to grave testing of small experimental coin or pouch cells up to and including full sized vehicle battery systems.

This project is currently on schedule and within the approved budget with a completion date of 04/30/2013. A final status report will be delivered on or before that date.

II.E.5 Battery Thermal Test Laboratory (NREL)

Brian Cunningham (DOE Contact)
Grant Recipient: National Renewable Energy Laboratory

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Start Date: March 2010
End Date: June 2013

Introduction

To facilitate and accelerate the commercialization of advanced energy storage technologies by the U.S. industry, the Department of Energy awarded the National Renewable Energy Laboratory (NREL) $2M to expand and upgrade its battery thermal facility under the 2009 American Recovery and Reinvestment Act (ARRA). Proper thermal design and performance are critical to achieving desired battery life, performance and cost targets. The objective of this project was to expand and upgrade the NREL Battery Thermal Test Facility. In this facility, NREL will perform thermal evaluation and characterization for batteries developed by U.S battery developers to aid them in understanding the thermal characteristics of batteries to improve thermal design.

NREL performs thermal testing, analysis, and modeling for two purposes: (1) assisting DOE and United States Advanced Battery Consortium (USABC) battery developers in designing cells/modules/packs for improved thermal performance, and (2) benchmarking and validating the thermal performance of cell/module/pack deliverables from DOE/USABC battery developers and suppliers.

Benchmarking cells, modules, and packs being developed has been critical for integration of battery systems in advanced vehicles. NREL's current thermal test facilities identify areas of thermal concern as well as characterizing the efficiency and heat generation of cells (with different chemistries) and sub-modules under various drive profiles and at various temperatures. NREL's equipment can also benchmark how changing the design of the cell using a different cathode, anode, current collector, electrolyte, or separator affects the overall performance of the cell.

The information garnered from these tests helps battery and car manufacturers design thermal management systems that reduce the life-cycle cost of battery systems in advanced vehicles. Because DOE's energy storage program has expanded over the past few years, we have a backlog in thermal characterization and testing of prototypes, particularly in heat generation measurement. With the anticipated growth in the DOE program and an increase in the number of batteries coming from domestic battery manufacturing facilities under the ARRA funding, we are adding capacity and enhanced capability by adding new equipment and additional space in our existing facilities. We have added calorimeters, thermal conductivity measuring instruments, pack thermal evaluation equipment, environmental chambers, and high-power cell and module battery cyclers.

- Total Value of award: $2 million
- Percent of funds expended: 99.8% - End of FY12

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Progress and Current Status

Thermal Test Facility Laboratory. We completed the expansion of the Energy Storage Thermal Test Facility. NREL expanded its laboratory space by 1000 ft^2 in the Thermal Test Facility (TTF) to accommodate most of the new equipment purchased under the ARRA funds. The expansion included upgrades to the electricity infrastructure and added chilled water capabilities.

Figure II - 114: Energy Storage Thermal Test Facility occupying 2000 ft^2 in NREL's Thermal Test Facility.

Safety and Characterization Laboratory. We also completed the development of the battery lab in building 16 of the Denver West Building Complex by installing several thermal characterization pieces of equipment.

Equipment was purchased for two specific purposes: 1) Battery cycling channels and environmental controls, and 2) energy storage material characterization equipment such as a bulk and thin film thermal conductivity meter.

Equipment. Under the ARRA program, NREL expanded the number of low, medium, and high power channels available for battery and other energy storage

testing. Table II - 4 outlines the number of testing channels and their respective current and voltage capabilities.

Table II - 4: Low, Medium, and High Power Battery Channels Purchased with the ARRA Funds.

# Channels	Voltage (Volts)	Current (Amps)
2	8-440	± 265
4	0-100	± 300
12	0-36	± 300
16	0-5	± 100
16	0-5	± 50
64	-10 to 10	± 0.5
104	-5 to 10	± 2.0

NREL also purchased a number of environmental chambers and isothermal baths in order to perform thermal and cycle life testing of batteries. Table II - 5 outlines the size and temperature range of the various chambers purchased under this task.

Table II - 5: Environmental Chambers and Isothermal Baths Acquired with ARRA Funds.

Number of Chambers/Baths	Temperature Range (^{o}C)	Internal Volume (ft^3)
4 – Chambers	-45 to 190	32.5
1 – Chamber	-45 to 190	64
2 – Chambers	-20 to 85	4.1
1 – Chamber	-40 to 150	12.4
2 - Baths	-35 to 80	1.6
3 - Baths	-30 to 200	0.46

Finally, the following special-purpose equipment was purchased or designed/fabricated at NREL in order to expand our thermal testing capabilities.

- One coin cell calorimeter
- Two (2) cell calorimeters
- One (1) pouch cell calorimeter
- Glove Box for Destructive Physical Analysis
- Thin Film Thermal Conductivity Meter
- Bulk Material Thermal Conductivity Meter
- Electrochemical Impedance Spectroscopy Unit
- Data Acquisition Systems
- Thermal Management Test Loop
  - Liquid
  - Air

Cost savings realized after the original statement of work was written allowed NREL to purchase several additional pieces of equipment not originally identified in the SOW. The additional equipment not identified in the original SOW included: the EIS unit, the three small environmental chambers (< 15 ft^3), the two large isothermal baths, a pouch cell calorimeter, a cell calorimeter, and the 16 channel ± 50 amp battery cycler.

Since the completion of the new laboratory, the installed battery cyclers and environmental chambers are being used for USABC activities. In particular, we have been using the equipment to test energy storage systems from A123, ActaCell, Cobasys, JCI, JSR Micro, K2, Quallion, and SK Innovation. We have begun using the ARRA purchased thin film and bulk thermal conductivity meters as well as the coin cell calorimeter.

During FY12, we concentrated on the design and fabrication of our cell and pouch calorimeters. We filed a U.S. non-provisional Patent Application 61/532,869 entitled “Calorimeters for Testing Energy Storage Systems and Power Electronics” (NREL ref. 11-102) that outlines the innovative features of the cell calorimeter developed with ARRA funds. Finally, NREL finished the design and construction of the air/liquid battery thermal management test loop.

- Construction complete: 100%
- Equipment Installed: 100%
- Jobs: permanent: 1
- Jobs: temporary/construction: 10

Pictorial Overview

Figure II - 115 to Figure II - 123 contain photographs of new NREL laboratory space and equipment purchased under the ARRA program.

Figure II - 115: New Battery Space at TTF Laboratory before Construction.

Figure II - 116: TTF Laboratory after Construction and Equipment Installation.

Figure II - 117: High and Medium Power Battery Cyclers.

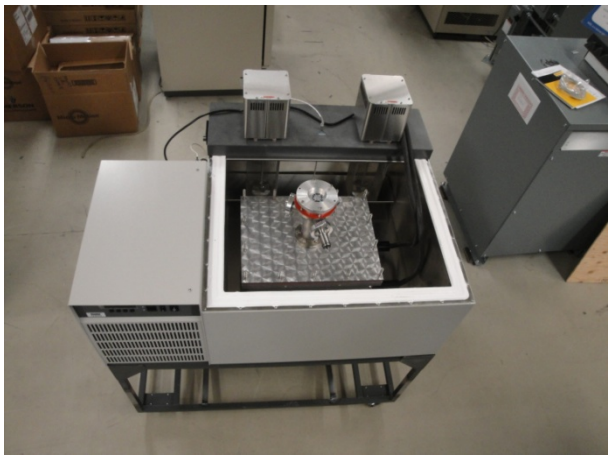

Figure II - 118: NREL Designed and Fabricated Cell Calorimeter in Fluke Isothermal Bath.

Figure II - 119: Liquid Handling Thermal Management In-the-Loop.

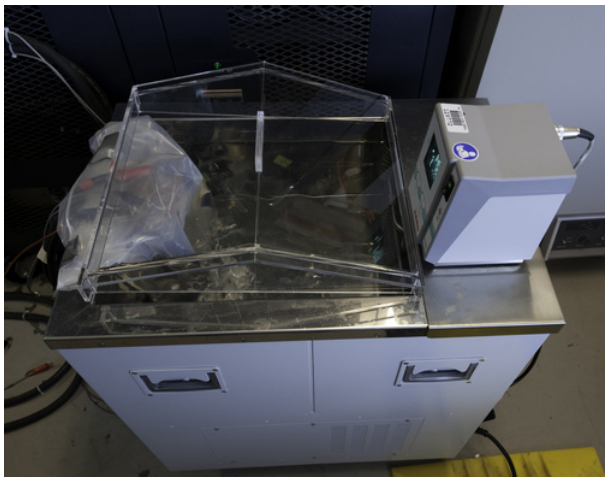

Figure II - 120: Isothermal Bath with battery under test.

Figure II - 123: Life cycle testing of batteries for secondary use applications.

Planned Work for FY 2013

The NREL Battery Thermal Test Facility is complete and no additional purchases are planned for FY 2013. We are utilizing the newly acquired equipment for the thermal characterization of energy storage systems developed by the US battery and automotive industry.

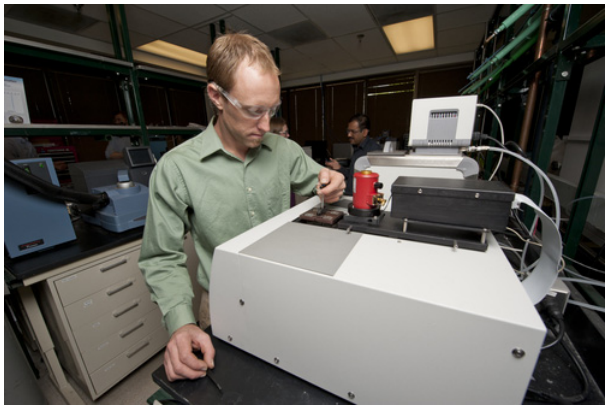

Figure II - 121: Laser Flash Thermal Conductivity Meter for thin battery electrodes.

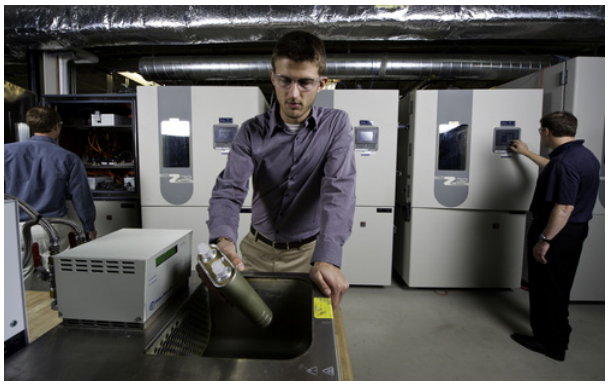

Figure II - 122: Environmental chambers and isothermal bath for battery cell and pack testing.

II.E.6 Battery Abuse Test Facility (SNL)

Brian Cunningham (DOE Contact)
Grant Recipient: Sandia National Laboratory

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Start Date: April 2010
Projected End Date: September 2012

Objectives

- Complete the ARRA project to recapitalize and upgrade the Sandia Battery Abuse Test Facility.
- Update our testing equipment, add testing/characterization capabilities, increase our testing throughput, and upgrade the safety features of the facility to accommodate testing larger PHEV and EV battery packs.

Accomplishments

- Recapitalization effort complete.
- Testing throughput increased with the capability of performing parallel tests.
- Upgrades to the safety envelop of the system (fire suppression, relocation of electrical, upgraded fan and exhaust system).
- Increased calorimetry capabilities and throughput.
- Post- and pre-test forensic capability increased immeasurably with the acquisition of Computed Tomography X-Ray instrumentation.

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Introduction

In 2010, Sandia National Laboratories was awarded funding through the American Reinvestment and Recovery Act (ARRA) for facility upgrades to the Battery Abuse Testing Laboratory. Upgrades to the facility were focused on improving the safety engineering controls and systems required to accommodate abuse testing PHEV and EV sized battery packs, improving our testing efficiency and throughput, updating laboratory equipment and systems to facilitate the growing demand for safety testing and increasing overall documentary efficiency.

With the widespread commercialization of PHEVs and EVs using lithium-ion batteries, the demand for testing the safety and reliability of these systems by the battery developers and auto manufacturers has increased. Sandia has developed a unique testing and characterization facility for these systems over the past decade and the upgrades to the facility outlined in this project have already advanced our capabilities and as more equipment is installed, our capability will continue to grow to meet the needs of our customers now and well into the future. Safety system improvements and facilities upgrades include, upgraded laboratory power and relocated power out of the hardened test bays for safer operation, fire/explosion proofed test bays (lighting, equipment panels, etc.), and added fire suppression capabilities for large test articles. We have upgraded the exhaust/scrubber systems to the facility to ensure safe testing of large scale systems. (See Figure II - 124.)

Figure II - 124: (right) before and (left) after photographs of a typical test cell in the Battery Abuse Laboratory.

Our equipment recapitalization reflects the growing demand for larger scale batteries (> 5 kWh) as well as our vision for adding capabilities to support our testing and R&D programs. Equipment upgrades included high voltage/high current power supplies and battery cyclers, analytical characterization equipment, updated battery calorimetry instrumentation, mechanical test equipment large enough for full PHEV and EV pack testing, large thermal test chambers, and an x-ray computed tomography system for failure analysis. In addition, we have completely renovated our data acquisition systems to allow for fully integrated (data, video, and audio) parallel testing which has significantly improved our efficiency and throughput and will continue to improve as more of the new capability is brought on line.

Results

Facility Renovation. Facility design was completed in December 2010 and construction work on the facility was completed in December 2011.

Upgrades to the facility include:

- Mechanical: removal of unused utilities, relocation of process gases and building exhaust to accommodate new calorimetry/glove box equipment, upgrading the scrubber system, increasing and rebalancing test bay exhaust, redesign common space floor plan to maximize efficiency and usable area.
- Electrical: Complete laboratory redesign and upgrade in power with three new electrical service panels (480 A total capacity) to accommodate large testers (>500V), relocation of power for safer operations.
- Fire protection: explosion proof lighting, explosion proof equipment panels, relocation of power outside test bays, CO_2 fire suppression systems for module and pack tests.
- Analytical: Gas product composition analysis; increased data acquisition rates, channels & quality; durable parallel test hardware support; increased real-time a/v capability.

Equipment Upgrades. > 80% of the instrumentation (by dollar amount) was received and costed in FY11, the balance of the equipment was procured in FY12. Equipment was chosen to support our core testing programs as well as to expand our testing/characterization capabilities. The key equipment included are listed in Table II - 6

The cyclers and testers will facilitate C/D cycling, overcharge abuse, and overdischarge abuse testing of vehicle scale, high energy batteries (>15 kWh). In total, 32 test channels were added and are dedicated for electrical abuse testing (up to 20 kWh). The upgrades to the spectroscopy tools (mass spectrometer and IR spectrometer with heated transfer lines) will facilitate real-time quantitative gas analysis for degradation products from the abuse of these batteries. Additional accelerating rate calorimeters (ARCs, one large and one small volume) will improve our testing throughput of materials, 18650 cells, and will also allow us to perform additional ARC experiments on large format PHEV and EV cells for our DOE programs. The X-ray CT system gives full CT images with resolution on the order of tens of microns (Figure II - 125). This will expand our capabilities to performing failure analysis/forensics on cells and even modules post-test. This will give us some insight *in situ* into failure mechanisms for these systems (e.g., internal short circuit, mechanical abuse failure points, etc.)

Table II - 6: Equipment for Battery Abuse Test Facility Upgrade.

Electrical Test Equipment
Battery Cycler
Cell Level Tester
Pack Level Tester
Analytical Equipment
IR spectrometer
Mass spectrometer
Thermal Test Equipment
Thermal Chambers
Pack Thermal Chamber
Mechanical Abuse Equipment
Hydraulic Press and Controller
Calorimetry and Characterization Tools
IR laser diagnostic platform
X-Ray CT
ARCs (4)
Cell Reaction Calorimeter
Microcalorimeter
Glove Box

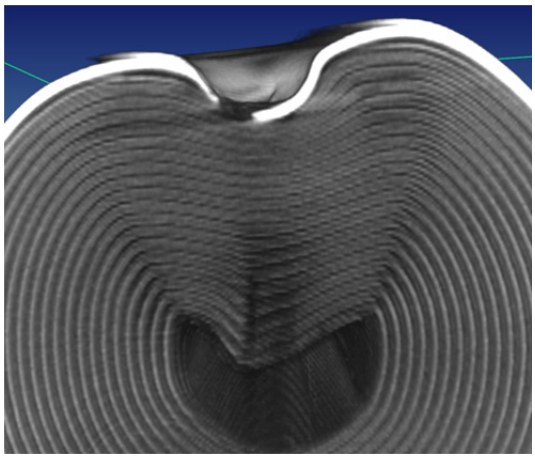

Figure II - 125: CT image of an 18650 lithium-ion showing the mechanical abuse failure point in the electrode roll.

Benefit and Impact

Benefits from the ARRA project have been realized directly after the completion of the project. At the end of FY12, all testing for USABC program deliverables are complete. Turn-around time for testing has been dramatically reduced. Added analytical/diagnostic capabilities have allowed us to determine the root cause of some unanticipated battery failure modes for the DOE programs. The added capabilities and throughput has attracted new work to the Laboratory and has allowed us to add testing staff to support our operations.