Materials Scale-Up Facility

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Overview

- Timeline
  - Project start date: 4/1/2010
  - Project end date: 3/31/2012
  - Percent complete:
    - 85% Construction funds committed
    - 9% Construction funds spent
    - 94% Equipment funds committed
    - 70% Equipment funds spent
- Budget
  - Total project funding:
    - $3.3M Construction funds for facility
    - $2.5M Capital equipment funds for process and analytical equipment
- Barriers
  - Lack of adequate facilities to produce sufficient quantities of battery materials to effectively support the transition from concept validation through advanced development in the overall battery R&D process.
- Partners
  - Barton Malow – Design-Build subcontractor
  - United States Army Tank Automotive Research, Development and Engineering Center (TARDEC)

Relevance to the DOE Vehicle Technologies Program

- The objective of this project is to design and build a pilot-scale battery-materials production facility (Materials Engineering Facility) to scale up bench-scale battery chemistries and produce bulk quantities of new materials for evaluation in prototype cells to enable quick turnaround validation of new 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.
- One of the primary contributing factors to the lack of a significant domestic Li-ion battery manufacturing capability is the lack of adequate facilities to enable the research community to produce quantities of materials for prototype cells to enable quick-turnaround validation screening of new materials chemistries throughout the R&D process.

Relevance to the US Battery Manufacturing Industry

- The Materials Engineering Facility will also provide the basis for meeting broader industrial needs to reduce the risk associated with developing and maintaining a domestic commercially viable battery manufacturing capability. These needs include:
  - Development and specification of process conditions (at staged scale-up) for the production of bulk quantities of materials, which will enable process scale-up and confirmation of process costs;
  - Manufacturing process R&D for scalable (high-volume, least-cost, quality-controllable) production of advanced materials;
  - Production of large volume quantities of materials for performance validation and market evaluation of those materials;
  - Validation, qualification, and specification of residual contamination limits for recycled battery materials;
  - An “off-line” pilot-scale facility to evaluate proposed process and product improvements by materials suppliers and manufacturers (as an alternative to trying to schedule R&D improvement studies in a commercial production facility);
  - Materials synthesis and production capability for in-line pilot evaluation of improved downstream automated battery-manufacturing equipment and processes (e.g., high-speed deposition of active materials on electrodes) that are being developed by universities, national labs, and equipment manufacturers; and
  - Workforce training for students, post-docs, scientists, and engineers of industrial and university users of the facility.

Approach

- To enable the process development and scale-up of new battery materials, the facility is planned to have:
  - Suitable space
    - Materials Engineering Facility will contain high hazard Group H-Occupancy labs to accommodate the larger volumes of hazardous materials used as processes are scaled up.
  - Modular process equipment
    - The facility and equipment design will incorporate modular equipment to enable quick change out of unit operations, as required for a range of materials process R&D.
  - Analytical lab for materials analysis
    - A dedicated analytical lab to characterized materials during scale up allows for rapid process optimization and can also provide materials quality assurance analysis.
  - Staff experienced in process scale-up R&D
    - Scientists and engineers trained and experienced in process development and scale up are a critical component to the program.

Approach to Achieve Facility Plan

- Establish conceptual design of facility (CDR)
- Establish Design Build contract for facility
  - Following the principals of the DOE Project Management Process
- Establish interim scale-up labs during the design and construction of the facility
  - To allow for the scale up of battery materials to begin now
- Prepare the environmental and safety plans and NEPA for the facility construction and interim labs
- Begin work in interim labs to demonstrate that scaling is possible

Approach – Milestones and Deliverables

Materials Engineering Facility Construction

Milestone / Deliverable	Description	Date	Status
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 (3 facilities)	9/30/2010	2 COMPLETED 9/17/2010
Deliverable 2	Complete full facility construction	2/1/2012	
Deliverable 3	Open full facility	3/31/2012	

Interim Facilities and Equipment

Milestone / Deliverable	Description	Date	Status
Milestone 1	Interim facility equipment purchased & installed (3 facilities)	12/31/2010	2 COMPLETED 9/17/2010
Milestone 2	Production scale-up facility equipment purchased & accepted	12/31/2011	FUNDING INADEQUATE
Deliverable 1	Interim facility open (3 facilities)	9/30/2010	2 COMPLETED 9/17/2010
Deliverable 2	Full facility open	3/31/2012	

1-10kg batches

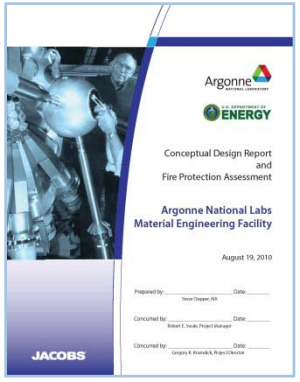
10-100kg batches

Technical Accomplishments and Progress

- The environmental and safety plans and NEPA for the facility construction and interim labs have been approved.

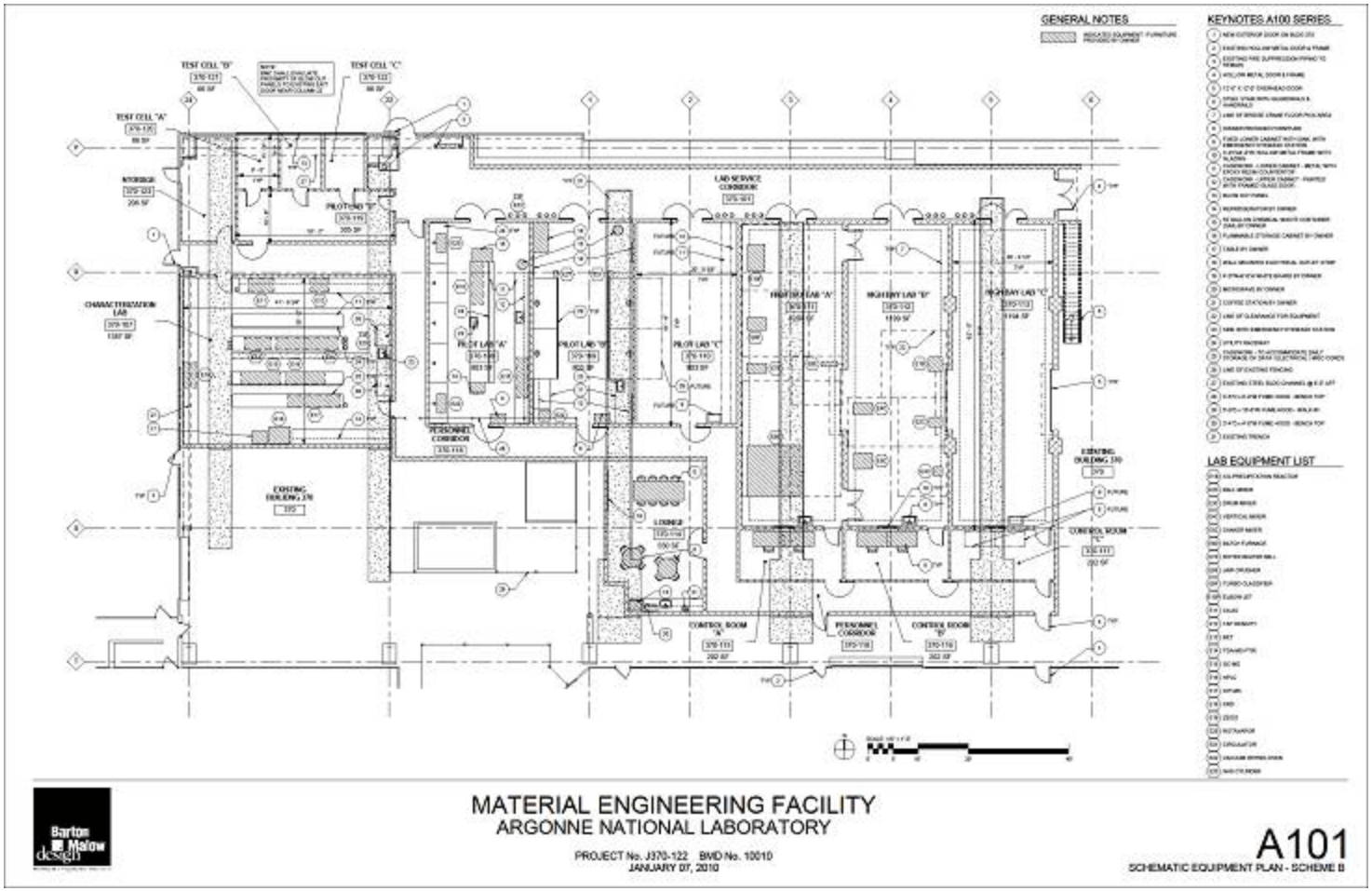
- First Construction milestone completed – 8/19/2010
  - Jacobs Engineering drafted the Conceptual Design Report and Fire Protection Assessment

- Second Construction milestone completed – 11/22/2010
  - Design Build contract was awarded to Barton Malow
  - Preliminary design has been submitted
  - Contractor is on schedule for final design



Barton Malow
Design/Construction Services

Technical Accomplishments and Progress – Facility Final Design is Underway



Technical Accomplishments and Progress - Interim Battery Materials Facilities Have Been Established

- Electrolyte materials scale up lab – fully operational
  - 2 full time staff have been hired – currently under temporary contract pending funding
  - Equipment has been delivered and installed
  - Lab safety plan has been written and approved
  - Materials have been ranked for scale up R&D
  - First material has been successfully scaled up to the kilogram batch size
- Battery materials analytical lab – fully operational
  - 1 full time staff has been hired – currently under temporary contract pending funding
  - Equipment has been delivered and installed
  - Lab safety plan has been written and approved
- Cathode materials scale up – under construction
  - 1 full time staff and 1 part time staff have been identified – currently under temporary contract pending funding
  - Equipment has been delivered and is in the process of being installed
  - Lab safety plan is being written
  - Materials will be ranked for scale up R&D

Technical Accomplishments and Progress – First Process Scale-Up Success

- The redox shuttle ANL-RS2 was made on the bench scale using a complex process
  - Reaction time was 17h
  - Product yield was 60% (unknown purity)
  - Hazardous feed materials were used
  - Large volumes of waste generated
  - Largest batch size was less than 1g
- A modified, scalable process was developed
  - Reaction time was 5h
  - Product yield was 79% at 99.94% purity
  - Far less hazardous feed materials were used
  - Waste generated was approximately 40 times less than the bench scale process
  - Material was produced in 158g and 1,562g batches
  - The yield and purity of material are highly reproducible from batch to batch
  - ANL-RS2 synthesized by the new process was chemically analyzed and its electrochemical performance characterized and was found to be consistent to the bench scale material synthesized

Collaborations

- Barton Malow
  - Selected as the design build contractor for the Materials Engineering Facility
- United States Army Tank Automotive Research, Development and Engineering Center (TARDEC)
  - Provided approximately 45% of the funding for the construction of the facility
  - TARDEC is interested in lithium-ion battery systems that exhibit improved safety, energy density and power density for military and commercial applications.
- Steering committee
  - An advisory board of stakeholders and potential facility users is being established to ensure that the facility will meet the needs of the users and will provide beneficial use to industry.

Future Work

- MEF design will be finalized and construction will begin on the facility
  - Facility construction to be completed by 2/1/2012
- Additional electrolyte materials will be scaled up in the interim lab
  - Targeting electrolytes 1NM3, 2SM3 and additive ANL-RS6
- The cathode materials interim scale up lab is under construction
  - Materials will be ranked and scale up R&D will begin
  - Initial focus will be on Argonne's next generation high energy cathode materials

Summary Slide

- The Materials Engineering Facility was established to bridge the gap between bench-scale development and commercial manufacturing of advanced battery materials.
- The Materials Engineering Facility will enable the development of manufacturing processes that will provide industry with tested “production-ready” processes, and bulk materials with full quality assurance analysis.
- Facility is on schedule.
- Interim scale-up R&D labs have been established.
- Successfully scaled and produced advanced battery materials.