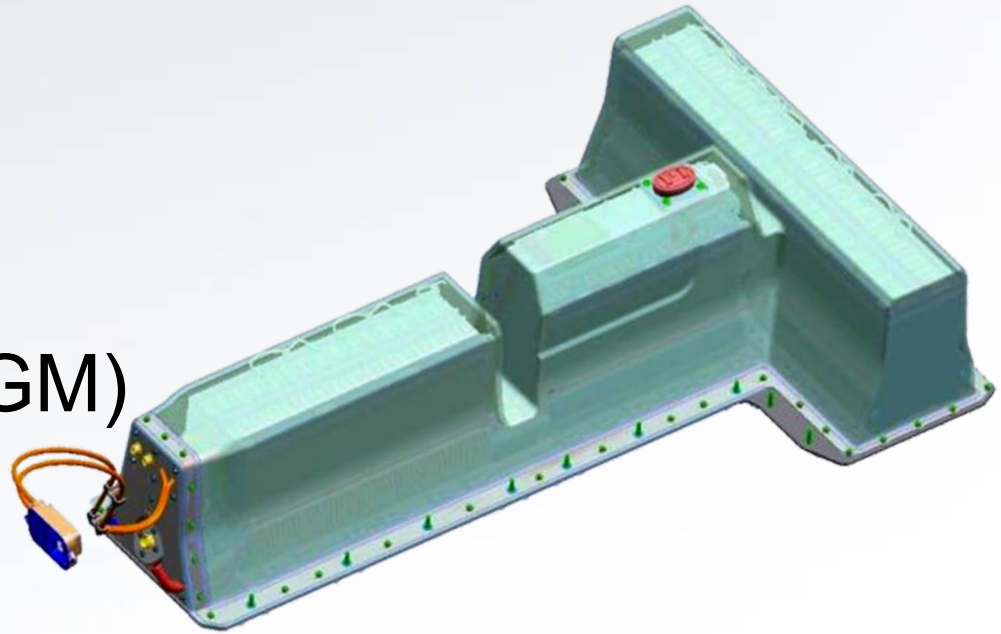
2010 DOE Vehicle Technologies Program Review Presentation:

GM Li-Ion Battery Pack Manufacturing

Linda M. Trumm
Joy L. Manthey
General Motors, LLC (GM)
June 7, 2010

Project ID #: ARRAVT005



Overview: GM Li-Ion Battery Pack Manufacturing

Timeline

- Start: August 2009
- Finish: September 2013
- % Complete: 10%

Barriers

- Consumer acceptance and new technology implementation
- Product cost

Budget

Total Project Funding

- DOE share: $105.6 M
- GM share: $129.1 M

Funding received in FY09: $0

Funding received to date in FY10: $11.3M

Partners

- Future university partnerships in continuous improvement activities
- Partnerships not yet finalized

Relevance: Project Impact on ARRA goals

- Aid in the nation's economic recovery by creating U.S. based manufacturing jobs
  - GM will create and retain jobs in manufacturing and engineering
  - GM estimates as many as 100 advanced technology jobs in the Brownstown Battery Assembly plant when ramped to full capacity
  - Jobs will be created and retained at machinery and equipment suppliers and battery component suppliers

Relevance: Project Impact on ARRA goals

- Accelerate production of Electric Vehicle (EV) drive systems
  - In 2010, GM will start production of battery packs for the Chevrolet Volt
  - Additional portfolio entries are planned to respond to market demand and to increase overall volume
  - GM's EV production will substantially reduce petroleum consumption and contribute to our nation's energy independence
- Establish manufacturing capacity for cost-effective, high-volume battery pack production to support the introduction of EVs
  - The Chevrolet Volt's battery pack is designed for high-volume production starting in late 2010
  - To maximize volume and reduce cost, component sharing with hybrid vehicles is maximized
  - Parallel work on next-generation systems will accelerate cost reduction and increase volume capability

Relevance: Specific Project Goals and Objectives

Overall project goal is to establish and validate production capability for GM Li-Ion Battery Pack Manufacturing with the following specific objectives

- Establish and execute plans to ensure performance to requirements and proper reporting and accountability
- Establish and validate production capability for multiple battery pack manufacturing programs in GM's portfolio plan
- Provide specialized workforce training in new battery pack manufacturing technology
- Provide continuous improvement and innovation cycles to move battery pack technology down the cost curve

FY10 efforts will focus on production launch of Chevrolet Volt battery pack manufacturing, continuous improvement and initial planning for subsequent battery pack programs

Approach: A Proven Method for Successful Transition to High Volume

- Utilize proven, industry-standard and GM internal processes for product launch and manufacturing validation
  - Production Part Approval Process (PPAP)
  - GM's Global Vehicle Development Process
  - GM's Global Launch Process
- Provide specialized training via classroom, web-based and on-the-job activities
  - Integrated training plan to identify and track training progress
  - Focus on Health and Safety, Global Manufacturing Systems, Technical Maintenance, and Production Operations
- Provide continuous improvement and innovation cycles
  - Focused projects using engineering analysis and process testing on critical areas to improve quality, manufacturing flexibility, and cost

Note: Battery pack manufacturing operations are installed in an existing facility, NEPA was submitted with grant application.

Approach: Milestones & Decision Criteria

Milestone	2009/2010 Dates	Criteria
All Equipment on Dock	**Volt**: December 09	Major equipment and tools are received at the plant, ready for installation
System Installation Complete	**Volt**: February 10 **2012 Volt**: November 10	Production equipment installed and operational
Installed System Shakedown Complete	**Volt**: July 10	Production process performs to quality requirements
Start of Regular Production	**Volt**: Q4 2010	Production process performs to quality and throughput requirements

Note: Project is on track to milestones

- Chevrolet Volt Equipment on Dock – December 2009
- Chevrolet Volt Equipment Installation Complete – January 2010

Technical Accomplishments and Progress:
Chevrolet Volt Battery Pack Program Is On Track

- ☑ Engineering team staffed. Plant staffing has been initiated.
  - *Cumulative GM jobs retained or created based on ARRA guidelines: 52.3*
- ☑ Manufacturing processes are defined and standardized work documented.
- ☑ Manufacturing process equipment and tools have been designed, constructed and installed at Brownstown site. Tune-in underway.
- ☑ Preproduction builds completed. Manufacturing validation builds initiated.
- ☑ Recycling operations set-up and validation is underway.
- ☑ Container designs and initial validation are completed.
- ☑ Material scheduling systems and logistics plans have been defined and confirmed for key battery pack components.
- ☑ Refurbishment processes and equipment needs have been identified and procurement initiated.
- ☑ Workforce training is being completed to plan.

TAKE HOME: Chevrolet Volt Battery Pack Program meets required timing to support ARRA goals and program launch

GM Brownstown Battery Assembly Plant

2009 - 2010 Highlights

Technical Accomplishments and Progress:
Future Battery Pack Program Expands Capabilities

- ☑ Initial process planning for future battery pack is underway
- ☑ Proof of Concept builds started, manufacturing learnings in-process
- ☑ Design for Manufacturability concepts incorporated into product design
- ☑ Preproduction build execution plans outlined and approved by leadership (timing, staffing, execution, costs, funding, etc)

TAKE HOME: Future Battery Pack Program is on track. Preproduction build capability improves the transfer of manufacturing learnings.

Technical Accomplishments and Progress:
Continuous Improvement and Innovation Cycles

- ☑ Equipment is in the process of being identified and procured.
- ☑ Continuous Improvement activities include:
  - Joining Manufacturing and Quality Processes
  - Battery Design For Assembly
  - Battery Assembly Process Variation Reduction
  - Assembly Tooling Durability
  - Battery Charging & Diagnostic Testing

TAKE HOME: Innovation cycles are key to quality, cost and throughput performance improvement.

Collaborations/Partnerships:
Leverages key resources outside of GM

- University collaborations are intended to support Continuous Improvement and Innovation Cycle activities.
- Universities bring unique qualities.
  - Fresh technical insight
  - Unconstrained solutions
  - Cross-industry experience
- Work with universities has not begun. Planned collaborations include:
  - University of Michigan
  - University of Illinois
  - University of Texas
  - Wayne State University
  - Additional university collaborations are expected

Future Work:

Taking Battery Packs to the next level

- 2010
  - Continue plant staffing and workforce training
  - Complete the manufacturing validation and production launch for the 2011 Chevrolet Volt battery pack
  - Implement continuous improvement (CI) results into production process
  - Install and validate refurbishment processes and equipment
  - Equip Battery Continuous Improvement lab to support CI activities
  - Conduct preproduction builds for Chevrolet Volt battery pack model year enhancements
  - Continue manufacturing process design and early validation builds for future battery pack program
- 2011
  - Provide increased Chevrolet Volt battery pack capacity as needed for market demand, increase plant staffing as required
  - Establish preproduction build capabilities at Brownstown
  - Implement continuous improvement results into production process
  - Continue manufacturing process design and early validation builds for future battery pack programs

Summary:
GM Li-Ion Battery Pack Manufacturing

- This is the first Annual Merit Review for this project.
- **Relevance:** GM's Li-Ion Battery Pack Manufacturing project creates and retains jobs, establishes a US-based battery pack manufacturing capability, improves our energy independence, and drives significant advancement of electric vehicle battery pack technologies.
- **Approach:** A proven and disciplined approach is being utilized to accomplish the project goals.
- **Technical Accomplishments:** Significant progress has already been demonstrated by the production of Chevrolet Volt battery packs. Continuous Improvement activities are directly impacting quality, cost and throughput performance.
- **Collaborations:** University-based knowledge will be strategically applied to near-term production challenges.
- General Motors is committed to the success of Electric Vehicles.