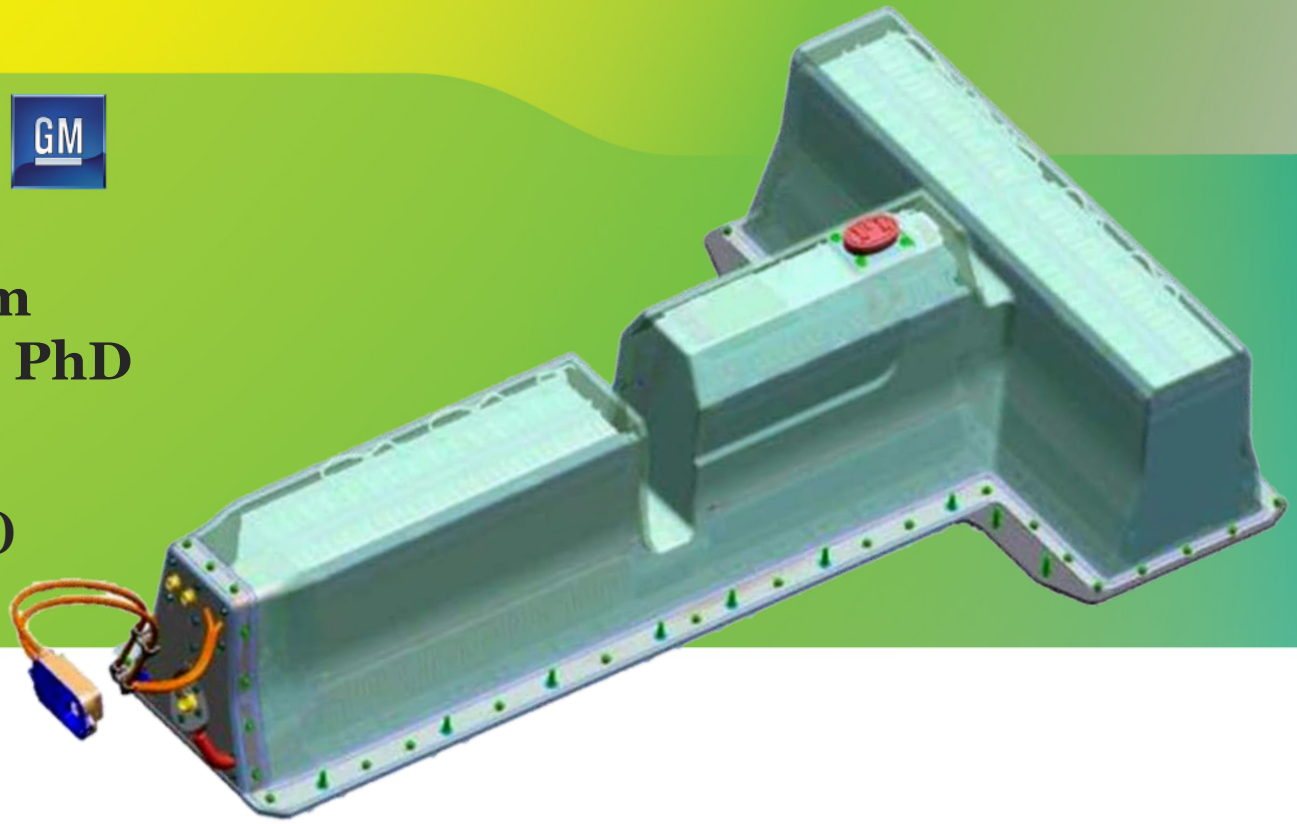
2012 DOE Vehicle Technologies Program Review:

GM Li-Ion Battery Pack Manufacturing



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OVERVIEW
GM Li-Ion Battery Pack Manufacturing

Timeline

- Start: August 2009
- Finish: September 2013
- Percent Complete: 62%

Budget

Total Project Funding: $234.8M

- DOE share: $105.7 M
- GM share: $129.1 M

Funding received: $66.8M

- FY10: $28.7M
- FY11: $24.9M
- FY12: $13.2M

Barriers

- Acceptance of new technology
- Product cost

Partners

- University partnerships in continuous improvement activities

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
  - 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 2011 and early 2012, GM continued production of battery packs for the Chevrolet Volt and launched the Opel Ampera battery pack
  - Additional portfolio entries are underway to respond to market demand
  - 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 Vehicle Electrification
  - The Chevrolet Volt's battery pack is designed for high-volume production
  - To maximize volume and reduce cost, component sharing between hybrid families is optimized
  - Parallel work on next-generation systems will accelerate cost reduction

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

FY12 efforts focus on expansion of Extended Range Electric Vehicle (EREV) battery pack manufacturing capability, continuous improvement and continued Manufacturing Engineering planning activities

APPROACH
Proven Methods for Successful Launch

- 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
  - Focus on Health and Safety, Global Manufacturing Systems, Technical Operation and 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
DOE Project Milestones

Milestone criteria is per DOE definition and instruction.
2010/2011 Milestones have been successfully completed per established timeline.

	Q2 FY2012 (Jan-Mar 2012)	Q3 FY2012 (Apr-Jun 2012)	Q4 FY2012 (Jul –Sep 2012)	Q1 FY2013 (Oct-Dec 2012)
Line 1, Phase 2	1st Production Unit Complete Product Delivery for Testing			
Line 1, Phase 4	100% Line Installed	100% Line Validated 1st Production Unit Complete		
Line 1, Phase 5				100% Equip Installed

Milestones associated with additional planning efforts are confidential and not for public disclosure

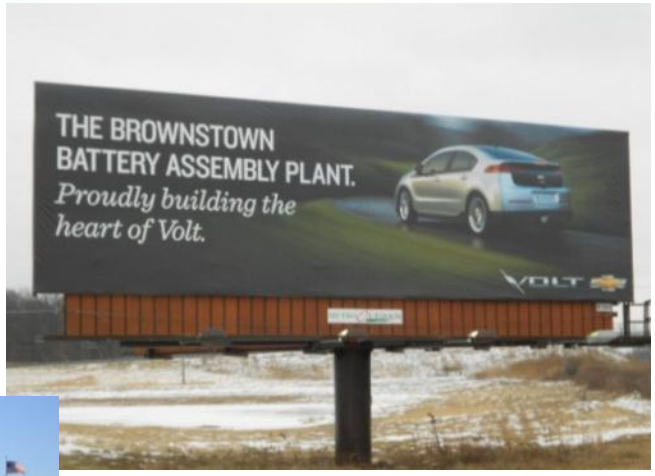
TECHNICAL ACCOMPLISHMENTS
Volt Battery Pack Program In The Lead

- ☑ Additional staffing and workforce training complete to plan
  - *Cumulative GM jobs retained or created based on ARRA guidelines: 74.4 FTE as of Q1 FY2012*
- ☑ Production systems installed and validated for Calendar Year (CY) 2011 additional capacity
- ☑ Ramp up for equipment, processes and people to CY 2011 volume complete
- ☑ Continued work with component suppliers for robust volume production.
- ☑ Achieved Start of Regular Production for Model Year (MY) 2012 Volt battery pack
- ☑ Built 2 battery packs for testing, completed witness testing on MY 2012i Volt battery pack.
- ☑ Transition from refurbishment processes to root cause and dealer service underway.
- ☑ Preproduction builds and production process planning underway for model year enhancements.
- ☑ Additional accomplishments are confidential and not for public disclosure

TAKE HOME: Chevrolet Volt Battery Pack Program continues successful launch and model year enhancements, positioned to meet market demand. Implementation directly supports ARRA goals and objectives.

GM Brownstown Battery Assembly Plant

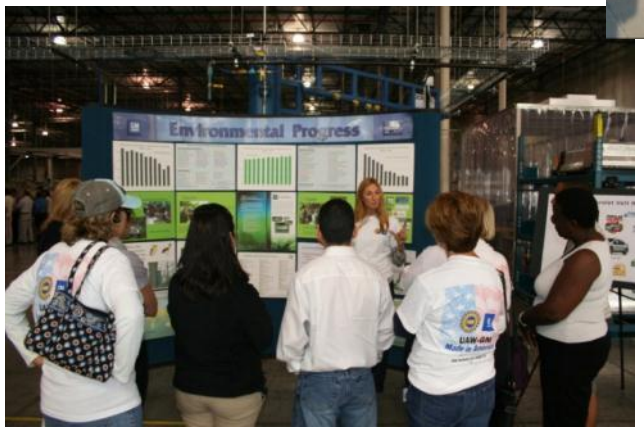
2011 -2012 Highlights

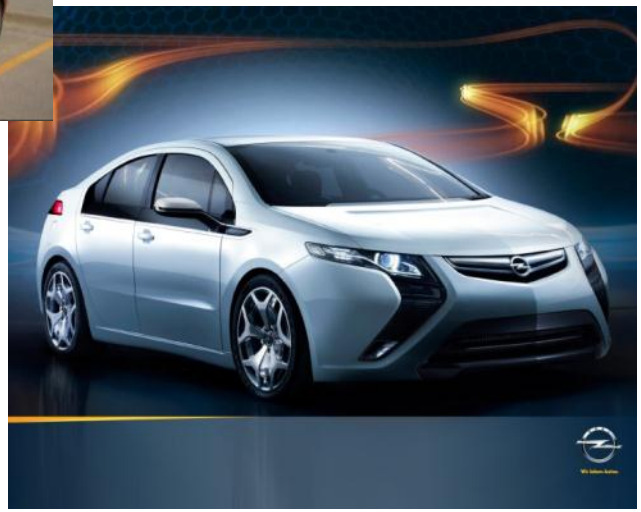


Open House: September 13 and 14, 2011

- Public tours of facility with informational displays and acknowledgement of DOE support
- Ride and Drive Event featuring Chevrolet Volts and other GM products

2012 Launch of the Opel Ampera Battery Pack





Chevrolet Volt Battery Pack Recognition

- 2011 Chevrolet Volt battery pack and General Motors, BASF Corp, Mann & Hummel GmbH, and Omega Corp were recognized at the 41st Annual Automotive Society of Plastics Engineers (SPE) Innovation Awards.
- Award recognizes the innovative use of plastic materials, and manufacturing technology in the Volt battery repeating frame application.

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TECHNICAL ACCOMPLISHMENTS

Future Battery Pack Programs Expand Lineup

- ☑ Process planning for future battery pack programs continue
- ☑ Preproduction builds continue, manufacturing learnings in-process
- ☑ Design for Manufacturability concepts incorporated into product design
- ☑ Preproduction build equipment and processes are installed and operational at Brownstown site

TAKE HOME: Future planning is on track to GM plans. Co-location of preproduction builds at Brownstown heightens engagement and provides a solid foundation for ongoing manufacturing validation.

TECHNICAL ACCOMPLISHMENTS

Continuous Improvement Enhances Launch

- ☑ Supporting equipment and facilities are operational.
- ☑ Ongoing 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
  - Assembly Process Improvement
- ☑ Continuous improvement deliverables are being implemented in production process upon plant review and acceptance.

TAKE HOME: Implementation of Continuous Improvement projects are solving real challenges in real time.

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COLLABORATIONS/PARTNERSHIPS

Leverage key resources outside 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 continues. Project focus areas are in Joining Manufacturing and Quality Processes. Collaborations include:
  - New York Institute of Technology
  - Purdue University
  - University of Michigan
  - University of Texas
  - University of Wisconsin
  - Wayne State University

FUTURE WORK

Increase capacity and prepare for the future

- 2012
  - Continue preproduction builds for EREV model year enhancements
  - Validate and achieve SORP for EREV model year enhancements
  - Meet market demand for EREV battery packs
    - Continue plant staffing and workforce training as needed
    - Continue equipment installation and manufacturing validation for the EREV battery pack future phases.
  - Implement continuous improvement results into production process
- 2013
  - Complete EREV MY enhancements
  - Implement continuous improvement results into production process
  - Product “delivery” for witness testing
  - End of ARRA project period, project close-out

Additional future work is confidential and not for public disclosure

SUMMARY
GM Li-Ion Battery Pack Manufacturing

- **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 is demonstrated by the ongoing production of Chevrolet Volt battery pack. Future planning efforts are on track. Continuous Improvement activities directly impact quality, cost and throughput performance.
- **Collaborations:** University-based knowledge is strategically targeted to near-term production challenges.

General Motors is committed to the success of Electric Vehicles and Advanced Propulsion Technologies