

## 2013 DOE Vehicle Technologies Program Review:

# GM Li-Ion Battery Pack Manufacturing



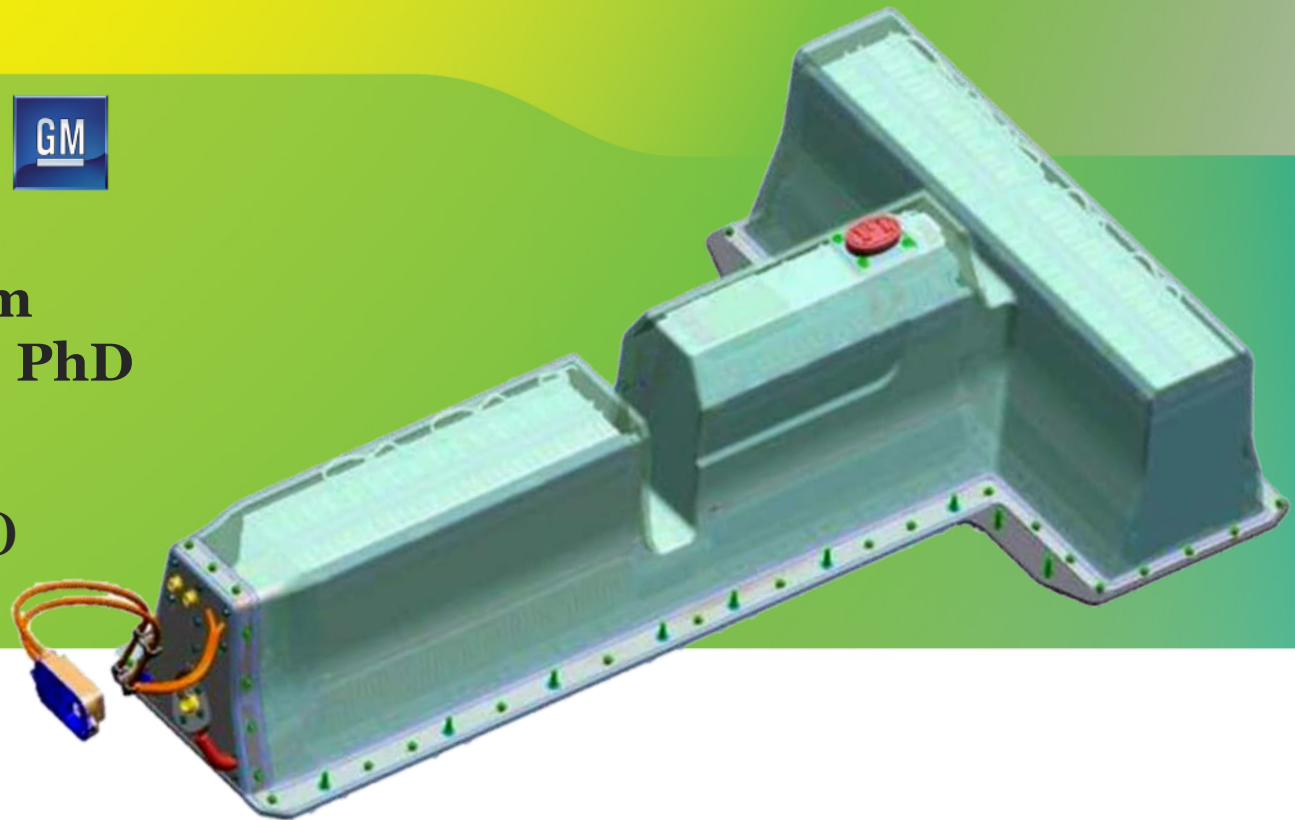
U.S. DEPARTMENT OF  
**ENERGY**



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# OVERVIEW

## GM Li-Ion Battery Pack Manufacturing

### Timeline

- Start: August 2009
- Finish: June 2015
- Percent Complete: 77%

### Budget

Total Project Funding: \$234.8M

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

Funding received: \$81.5M

- FY10: \$28.7M
- FY11: \$24.9M
- FY12: \$23.3M
- FY13: \$4.6M

### 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, MI 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 2012 and early 2013, GM continued production of battery packs for the Chevrolet Volt and Opel Ampera battery packs, and began the Cadillac ELR battery pack launch.
  - Additional portfolio entries are underway to respond to market demand
  - GM's EV production will help to 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

FY13 efforts focus on continuation 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.

2011/2012 Milestones have been completed and/or modified per proprietary plans.

	Q2 FY2013 (Jan-Mar 2013)	Q3 FY2013 (Apr-Jun 2013)	Q4 FY2013 (Jul –Sep 2013)	Q1 FY2014 (Oct-Dec 2013)
Line 1, Phase 5	100% Line Validated	1 <sup>st</sup> Production Unit Complete		

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

# TECHNICAL ACCOMPLISHMENTS

## Volt Battery Pack Program In The Lead

- ✓ Staffing and workforce training complete to plan
  - *Cumulative GM jobs retained or created based on ARRA guidelines: 63.6 FTE as of Q1 FY2013*
- ✓ Production systems installed and validated for Calendar Year (CY) 2012 additional capacity
- ✓ Ramp up for equipment, processes and people to CY 2012 volume complete
- ✓ Continued work with component suppliers for robust volume production.
- ✓ Achieved Start of Regular Production for Model Year (MY) 2013 Volt battery pack
- ✓ Transition from refurbishment processes to root cause and dealer service nearly complete.
- ✓ Preproduction builds and production process planning underway for future programs.
- ✓ Additional accomplishments are confidential and not for public disclosure

**TAKE HOME: Chevrolet Volt & Opel Ampera Battery Pack Programs continue successful launch and model year enhancements, positioned to meet market demand. Implementation directly supports ARRA goals and objectives.**

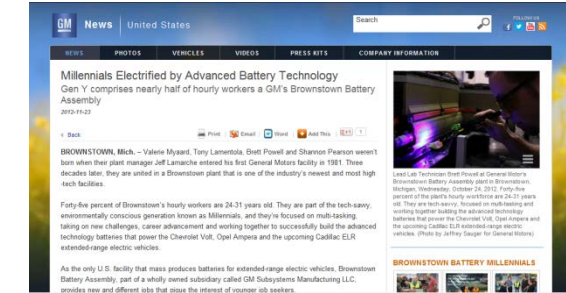
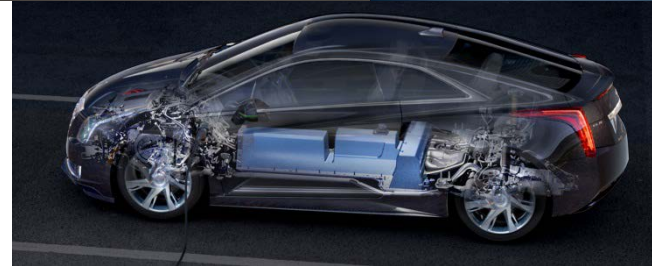




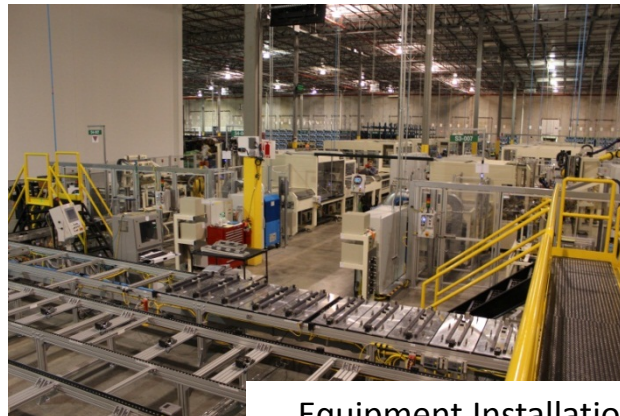
# GM Brownstown, MI Battery Assembly Plant

Production of Chevrolet Volt & Opel Ampera Battery Packs,  
Prepare for Cadillac ELR Battery Pack Launch

## 2012 -2013 Highlights



Millennial Workforce  
Highlighted



Equipment Installation and Validation

# 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, MI site
- ✓ Additional accomplishments are confidential and not for public disclosure

**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.**

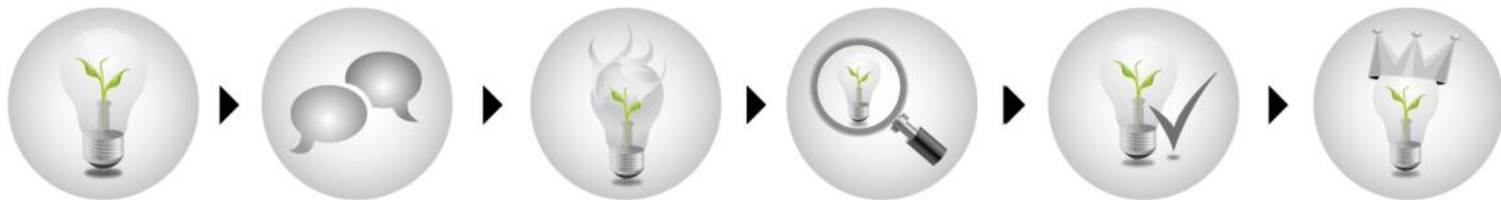


# TECHNICAL ACCOMPLISHMENTS

## Continuous Improvement Enhances Launch

- ✓ Ongoing Continuous Improvement activities include:
  - Joining Manufacturing and Quality Processes
  - Battery Pack Design For Assembly
  - Battery Pack Assembly Process Variation Reduction
  - Assembly Tooling Durability
  - Battery Pack Charging & Diagnostic Testing
  - Assembly Process Improvement
- ✓ Continuous improvement deliverables are being implemented in production process upon plant evaluation 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:
  - Purdue University
  - University of Michigan
  - University of Texas
  - University of Wisconsin
  - Wayne State University





# FUTURE WORK

## Prepare for the future

### ■ 2013

- Validate and achieve SORP for EREV model year enhancements
- Meet market demand for EREV battery packs
  - Continue plant staffing and workforce training as needed
- Implement continuous improvement results into production process
- Continue preproduction builds for future programs
- Continue Manufacturing Engineering activities for future programs

### ■ 2014/2015

- Implement continuous improvement results into production process
- Continue Manufacturing Engineering activities for future programs
- 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. Consumer support of Chevrolet Volt and Opel Ampera is demonstrated by market segment sales leadership in US and Europe.
- **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 & Opel Ampera 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*