Stand Alone Battery Thermal Management System

2013 DOE Vehicle Technologies Program Review

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May 13, 2013

Project ID: ES135

DENSO

Overview

Timeline

•Start: October 1, 2011

•End: September 30, 2014

•Percent Complete: 48%

Barriers

• Barriers Addressed

- Cost
- Reliability
- Life

Budget

•Total Budget

- Government Share: $2,610,555
- Contractor Share: $693,924

•Government Funding Received:

- FY11: $37,981
- FY12: $478,710

• Government Funding for FY13

- $816,236

Partners

• National Renewable Energy Laboratory

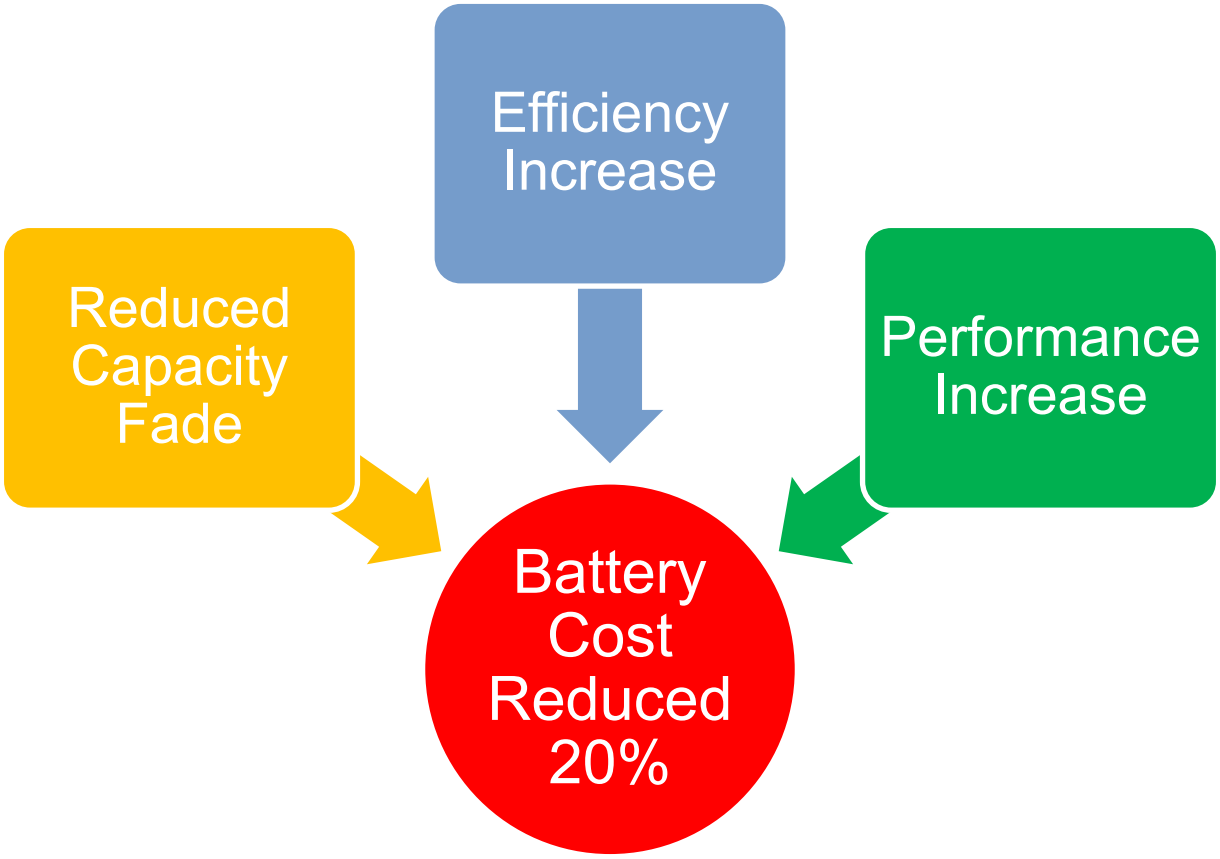
Cell Testing, Simulation Support

• Chrysler Group LLC

System Targets, Concept Approval

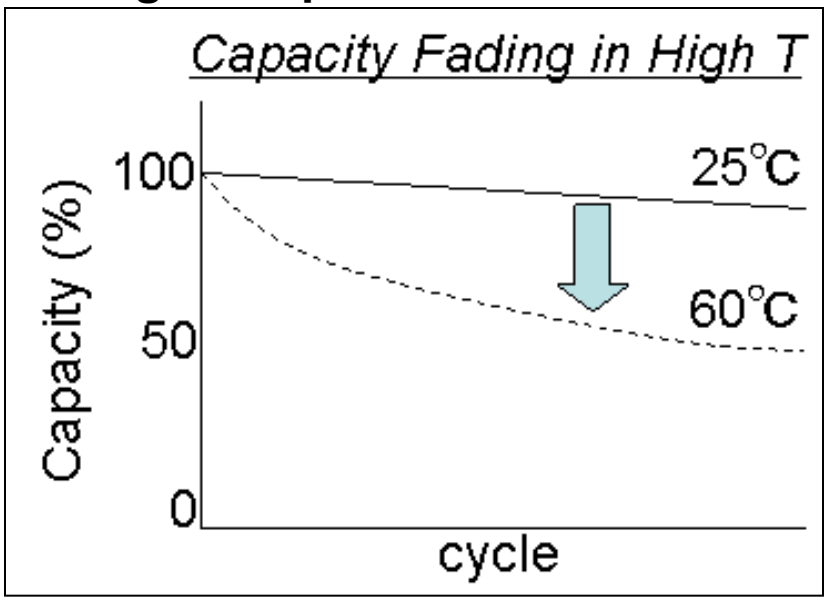
Relevance - Project Objective

Research, development, and demonstration of innovative thermal management concepts that reduce the cell or battery weight, complexity (component count), and/or cost by at least 20%.



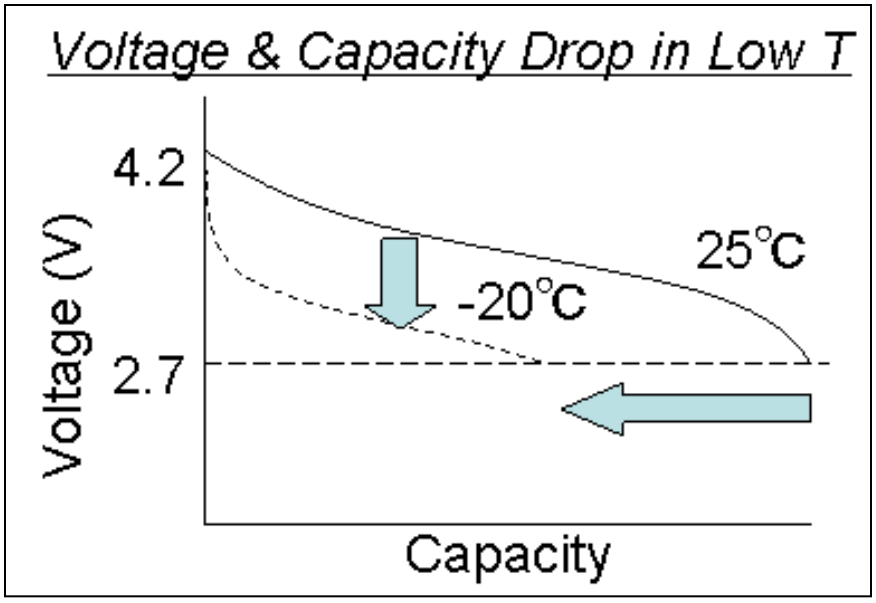
Relevance – Temperature Effect On Batteries

High Temperature Effect



The more time the battery is subjected to high temperatures, greater the capacity is reduced = reduced battery life.

Low Temperature Effect



Battery Voltage and Capacity is reduced at low temperatures = reduced driving range.

Thermal Management is Required to Enable a Reduction in Battery Size
(Prevent over-size of battery pack to overcome temperature effects)

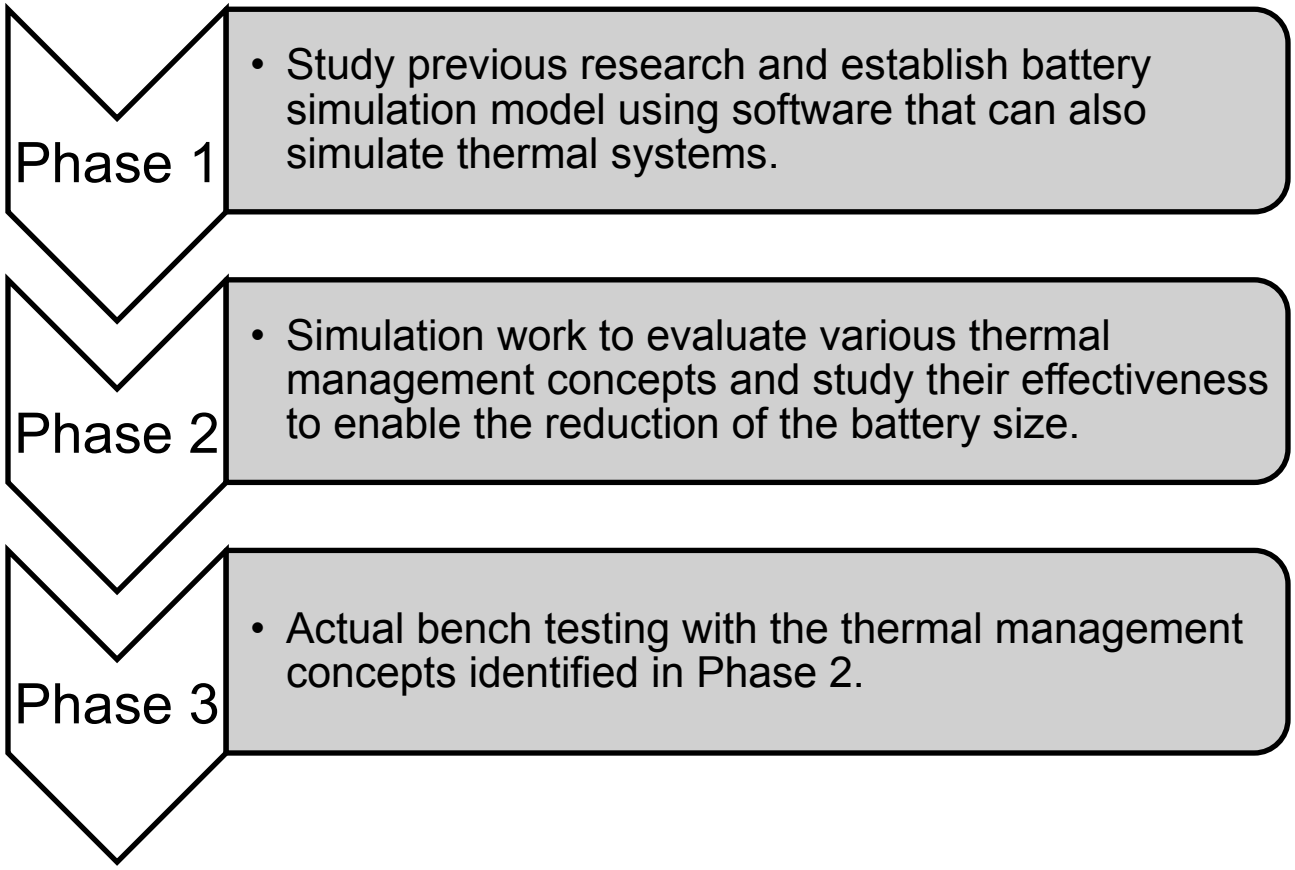
Milestones (FY12 & FY13)

Target Completion Date	Milestone	Status
4/05/2012	Milestone 1: Testing Conditions for Simulation and Bench for Entire Project	Done
5/30/2012	Milestone 2: Thermal Characteristics of Battery Cells / Modules	Done
1/15/2013	Milestone 3, Budget Period 1 Judgment: Simulation Complete: Does it Match Vehicle Test Data? (Yes/No)	Done
04/11/2013	Milestone 4: Vapor Compression Cycle 1	On Target
07/10/2013	Milestone 5: Vapor Compression Cycle 2	On Target
10/04/2013	Milestone 6: Vapor Compression Cycle 3	On Target

FY12 Milestones were successfully completed on time.

FY13 Milestones are planned to be completed on time.

Approach – Project Strategy



As the title of the project shows, the thermal system being developed is one that is dedicated to the battery pack which has high efficiency and high reliability for the thermal needs of the battery pack to enable the size reduction of the pack.

Approach – Phase 1 Review

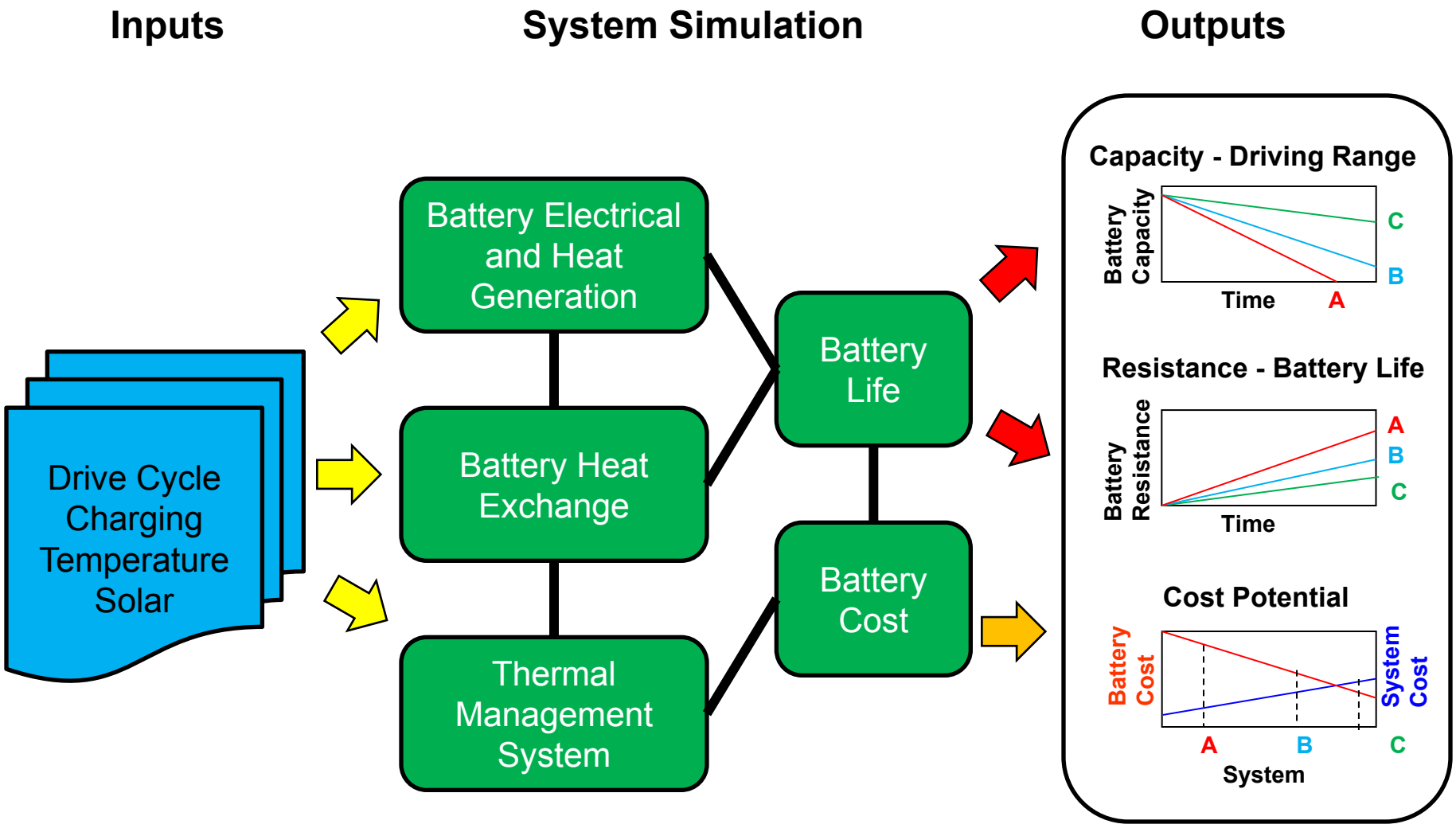
Phase 1: October 2011 → January 2013

For Phase 1, the project created a battery simulation model in LMS AMEsim software package.

- Simulate battery cells
- NREL helped characterize battery cell thermal characteristics
- NREL also helped in creation of the battery model
- Simulation model correlated to actual vehicle test data from Chrysler

Battery Simulation Model Was Successfully Created In Phase 1

Approach - Battery Simulation Model



Input electric & thermal load to the model, then calculate battery life, mileage, etc…

Approach – Phase 2 Overview

Phase 2: January 2013 → January 2014

For Phase 2, the project will analyze various thermal management concepts using LMS AMEsim software. (Using the battery model created in Phase 1)

- This will use DENSO previous and on-going research into high efficiency vapor-compression cycles to be used for active battery thermal management.
- Other technologies will be studied which will provide passive thermal management.

The optimal thermal management system will be chosen based on many simulation iterations with various technologies.
This simulation model should be able to prove that the battery temperatures can be controlled to a point which would reduce the cell or battery weight, complexity (component count), and/or cost by at least 20%.

Approach – Phase 3 Overview

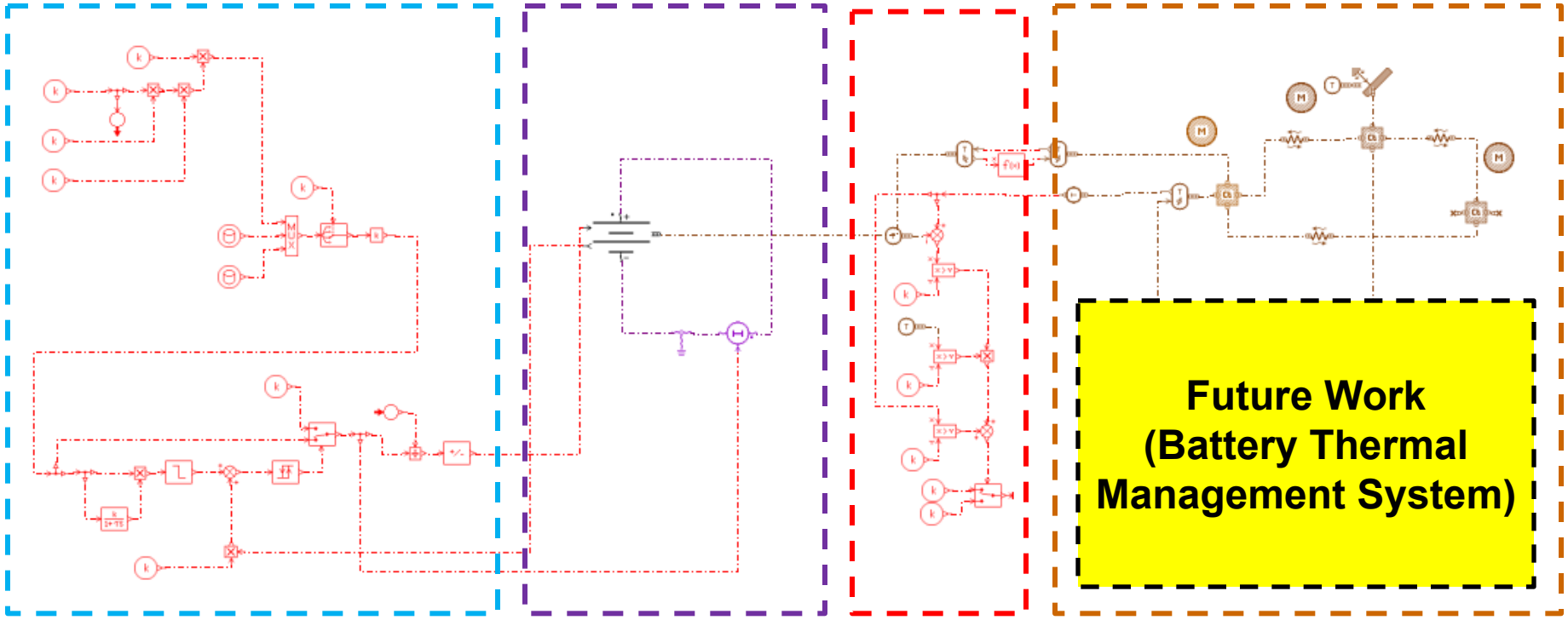
Phase 3: January 2014 → September 2014

For Phase 3, the project will create prototype samples of the technologies identified in Phase 2, and do actual bench testing.

Bench testing will be done at DENSO in Southfield, MI in a new EV thermal system test bench.

This testing will show with actual samples that the battery temperatures are able to be controlled in such a way to achieve the project goal of reducing the cell or battery weight, complexity (component count), and/or cost by at least 20%.

Technical Accomplishments: Battery Simulation Model

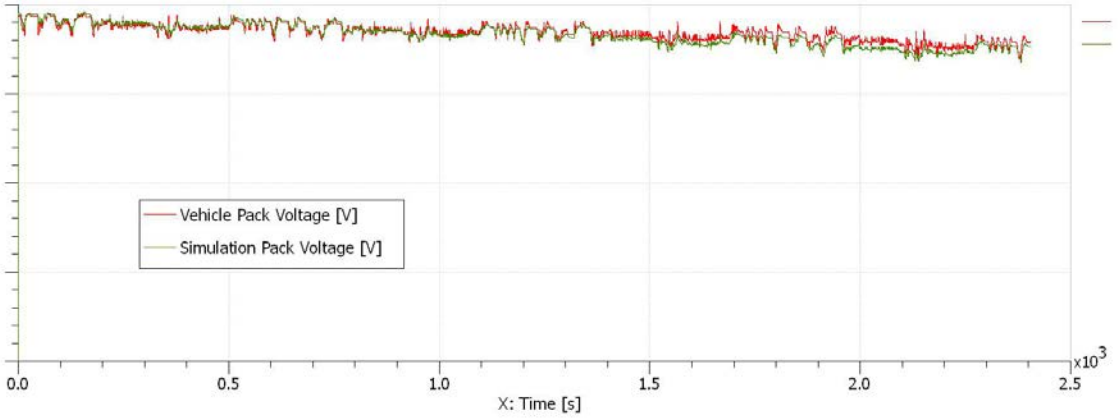


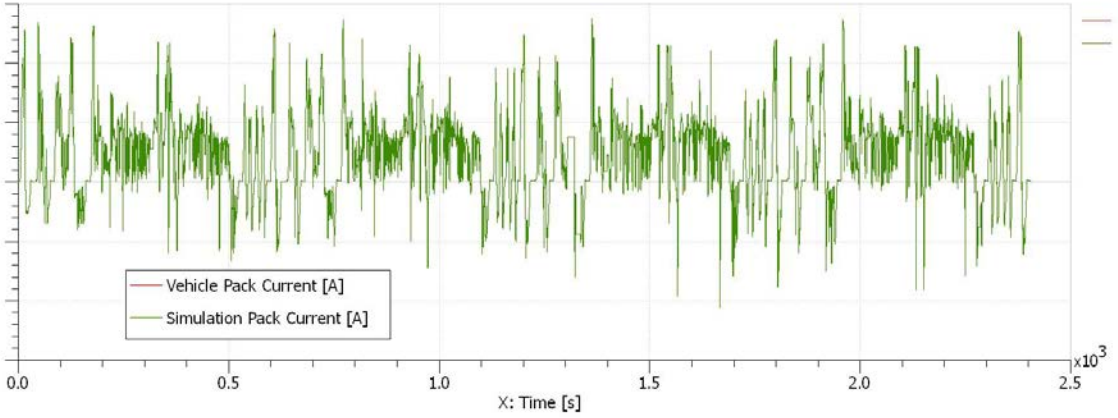
The model is built from several submodels that interact with each other.

Technical Accomplishments: Milestone 3 Results (Go/No Go)

Milestone 3: Budget Period 1 Judgment: Simulation Complete: Does it Match Vehicle Test Data? (Yes/No) Due 01/15/2013

- This milestone is completed successfully.
- The simulation is able to simulate the drive profile current and voltage response.
- Project is a “GO” to move to next phase.





YES: The simulation is able to match the vehicle test data.

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Collaborations

National Renewable Energy Laboratory : During FY12, NREL performed testing and provided data for battery cell characteristics which were used in the battery model. NREL also gave guidance for developing the model.

Chrysler: FY12 they provided target battery temperatures, drive cycle data and testing conditions. Also provided overall guidance for design choices.

Proposed Future Work

FY13

• Create simulation model various vapor compression systems that would be used to thermally manage the battery pack.
• Evaluate other technologies using simulation (not a vapor compression cycle) that can be used to control the battery temperature.
• Compare all results, and find the system that meets the project objective, with a reasonable system cost.

FY14

• Create prototype samples of the thermal system components identified in the simulation work during FY13.
• Perform bench testing in the EV thermal system test bench to demonstrate the effectiveness of the thermal system.

Summary

- The project utilizes the expertise of NREL in battery modeling and thermal evaluation, the real world application experience of Chrysler, and the experience of DENSO, the worlds largest automotive thermal system supplier, to create a vehicle battery thermal system that will enable a 20% cost reduction of the battery pack.
- A battery simulation model was successfully created in AMEsim and correlates with vehicle data.
- The battery simulation model will be used to evaluate various thermal system technologies to achieve the project goal.