2013 DOE Annual Merit Review
Advancing Transportation Through Vehicle Electrification – Ram 1500 PHEV
DOE Funded Project

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Chrysler Group LLC

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Project ID # ARRAVT067

Overview – Ram 1500 Project

Timeline

- Project Start Date: September 2009
- Project End Date: August 2014
- Phase I: 90% Phase II: 30%

Budget

- Total Project Funding
  - DOE: $48,000,000
  - Chrysler/Partner: $49,408,996
- Funding received FY10 : $ 9.79M
- Funding received FY11 : $17.77M
- Funding received FY12 : $ 7.69M
- Funding received FY13 : $ 2.46M
- Chrysler/Partner Share(1): $38.98M

(1) As of January 31, 2013

Barriers

Current:

- Battery performance across extreme ambient conditions

Resolved:

- Charging System Integration
- Understanding customer acceptance and usage patterns for PHEV technology

Development Partners & Key Suppliers

• Behr America • Electrovaya • Hitachi • Delphi • TDI • Continental • CASCO Products • EPRI• Michigan State University • University of Michigan • Sacramento Municipal Utility District (SMUD) • NextEnergy • UC Davis • NAVTEQ

Demonstration Partners

• SMUD, Sacramento, CA • City of Yuma, AZ • DTE, Detroit, MI • Duke Energy, NC • MBTA, MA • National Grid, NY, MA, RI • Tri-State, CO • CenterPoint, Houston, TX • New York Police Department, New York • Nevada Energy, Las Vegas & Reno, NV • City of Auburn Hills, MI • Central Hudson, NY • EPRI (NC, CA) • Argonne National Labs / INL • City and County of San Francisco, CA • DOD (LA Air Force Base and Fort Carson, CO)

Relevance – RAM 1500 PHEV Project Objectives

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Phase I:

- Demonstrate 140 pickup trucks in diverse geographies and climates, spanning across the United States, and a range of drive cycles and consumer usage patterns applicable to the entire NAFTA region
- Verify plug-in charging mode performance based on charger and battery model
- Verify AC power generation mode
- Prove product viability in “real-world” conditions
- Develop bi-directional (communication and power) charger interface
- Support the creation of “Green” Technology jobs and advance the state of PHEV technology for future production integration
- Develop an understanding of Customer Acceptance & Usage patterns for PHEV technology
- Quantify the benefits to customers and to the nation

Phase II:

- Advanced Li-Ion batteries demonstrated an unexpected degradation rate which required a directional change using a new cell design built into new packs.
- Demonstrate the viability of the high voltage energy storage system with a new cell technology for a new production application
- Test advanced Li-Ion Battery technologies, charging systems, Reverse Power Flow, and Electrified Powertrain Control Systems
- Demonstrate 24 pickup trucks in diverse geographies and climates

Relevance – RAM 1500 PHEV Program Results

Federal and Partners Real World Test Data – Phase I

Federal Test Procedures Results

Objective	Target	Status	Procedure	R/G/Y
RANGE	Equivalent All Electric Range (EAER) of 20 miles	20+ miles EAER achieved	California Exhaust Emission Standards And Test Procedures, as amended December 2, 2009	**GREEN**
EMISSIONS	ATPZEV Compliance	<table><tr><th>Test</th><th>Test Mode</th><th>Standard</th><th>Results</th></tr><tr><td>FTP City</td><td>CD & CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>US06</td><td>CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>SC03</td><td>CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>Highway</td><td>CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>50 F City</td><td>CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>20 F Cold</td><td>CS</td><td>SULEV</td><td>Passed ✓</td></tr><tr><td>Evaporative</td><td>CS</td><td>PZEV</td><td>Passed ✓</td></tr><tr><td>Purge Volume</td><td>CS</td><td>PZEV</td><td>Passed ✓</td></tr></table>	California Exhaust Emission Standards And Test Procedures, as amended December 2, 2009	**GREEN**
FUEL ECONOMY	Charge Depleting City 32 MPG	– Charge Depletion: – **City**: 37.4mpg; **Hwy**: 32.5 mpg	SAE J 1711 as published	**GREEN**

Real World Results

	RAM 1500 PHEV Status	Background
Partners FUEL ECONOMY & Mileage Accumulation (Real World)	• Charge Depletion: Accumulated Miles – **230,741** – **City**: **22** mpg; **Hwy**: **26** mpg • Charge Depletion / Charge Sustaining: Accumulated Miles – **88,728 (CD) / 155,504 (CS)** – **City**: **19** mpg; **Hwy**: **21** mpg • Charge Sustaining: Accumulated Miles – **564,843** – **City**: **16** mpg; **Hwy**: **19** mpg	• Data taken from **111** partner vehicles deployed throughout the United States • Partners Total Mileage : **1,039,138** through Sept. 2012 • Vehicle fuel economy is based on customer usage and may not be representative of maximum potential fuel economy

Real world data was acquired using September 2012 INL report data

Relevance – Ram 1500 PHEV Program Results

Federal and Partners Real World Test Data – Phase II

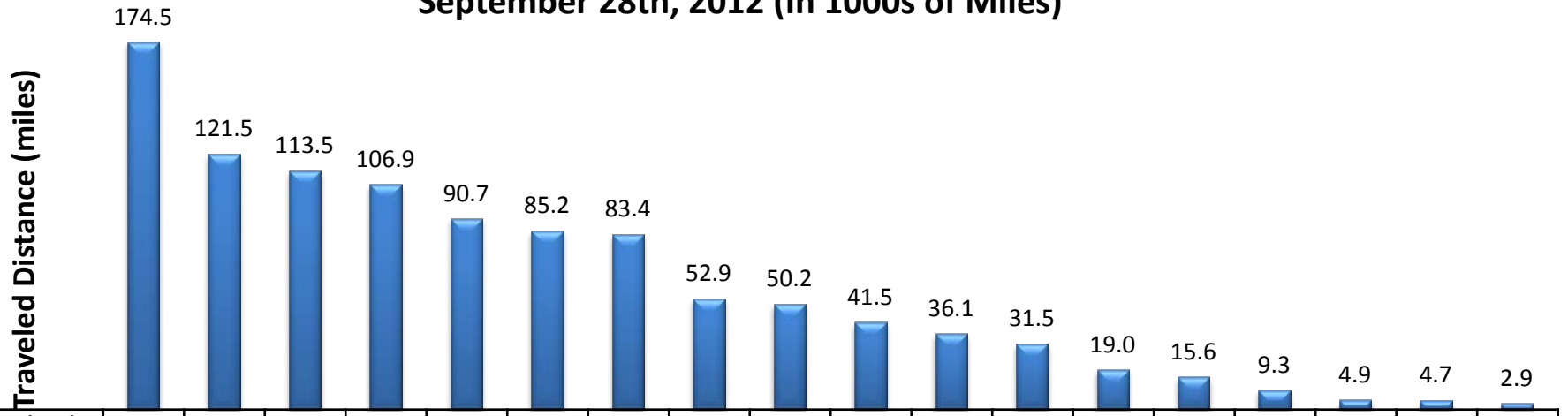
Federal Test Procedures Results

Objective	Target	Status	Procedure	R/G/Y
RANGE	EAER 10	EAER 14 (Based on simulations)	California Exhaust Emission Standards And Test Procedures, as amended December 2, 2009	GREEN

Relevance – Ram 1500 PHEV Program Results

Deployment Partners Total Distance Traveled (miles)

Phase 1 Accumulated Partners Mileage by Deployment Location through September 28th, 2012 (In 1000s of Miles)



	Duke Energy	DTE Energy	Tr-iState	SMUD	MBTA	City of Yuma	City of Auburn Hills	Nevada Energy	Center Point Energy	San Francisco	Central Hudson NY	National Grid - NY	National Grid - MA	NYPD	EPRI - CA	EPRI - NC	Argonne Nat. Lab	Idaho Nat. Labs
Avg. Time (hrs.) Charging/Event	2.7	2.2	2.8	2.3	2.1	1.7	2.0	3.4	3.2	1.7	2.0	2.4	2.3	2.4	3.1	2.3	2.3	2.0
Avg. Number of Charges/Veh./Day	0.5	1.6	1.0	0.9	0.3	1.1	1.3	0.6	1.1	0.6	0.8	0.5	0.5	0.7	0.6	0.7	0.2	1.1
# of Veh.	10	10	7	14	10	10	5	7	5	14	3	2	4	5	1	1	1	1
Service Months	12.1	13.7	9.1	12	11.8	16	11.6	10.5	13.8	10.5	10.5	11.9	11.9	10.5	13.7	13.7	13.7	7.7

Total Deployed Fleet Mileage Accumulated through 9/28/2012	1,039,138 miles
Charge Depletion Accumulated Miles	230,741miles (CD)
Charge Depletion / Charge Sustaining: Accumulated Miles	88,728 miles (CD) 155,504 miles (CS)
Charge Sustaining: Accumulated Miles	564,843 miles (CS)

*INL reported period from fleet deployment date through September 28th, 2012

Relevance – Ram 1500 PHEV Program Results

Analysis & Learning: Capturing Lessons Learned

Data Formatted by:
Fleet, Site, Vehicle & time period

Thermal:
HV Battery Cell Temps Monitoring
Thermal System Operating Modes Monitoring
Thermal Systems Function Monitoring
AC Operation Monitoring

Charger:
Charge Function Monitoring
V2G Monitoring

Battery:
Voltage Monitoring
Current Monitoring
HV Power Monitoring
Energy Usage Monitoring
SOC Monitoring

Drive / FE:
Mode / Gear Monitoring
ICE Operation Monitoring
12 volt Function Monitoring
Regenerative Brake Monitoring
Trip / Usage Monitoring

Develop optimization plan within customer usage profiles. Apply lessons learned to Phase II redeployment and future Electrification applications

Relevance – Technical Approach

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Analysis & Learning: Capturing Lessons Learned

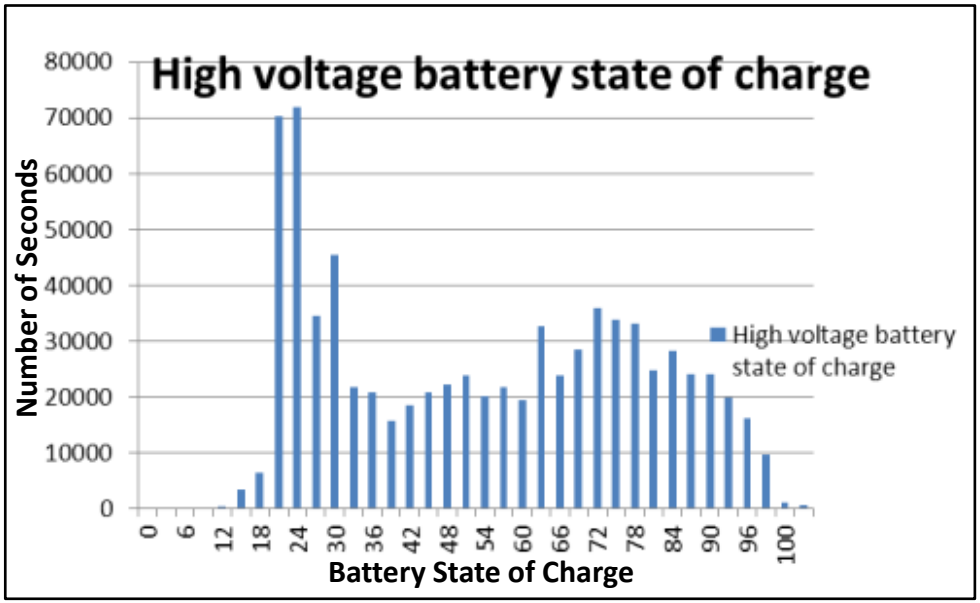
Areas Being Considered

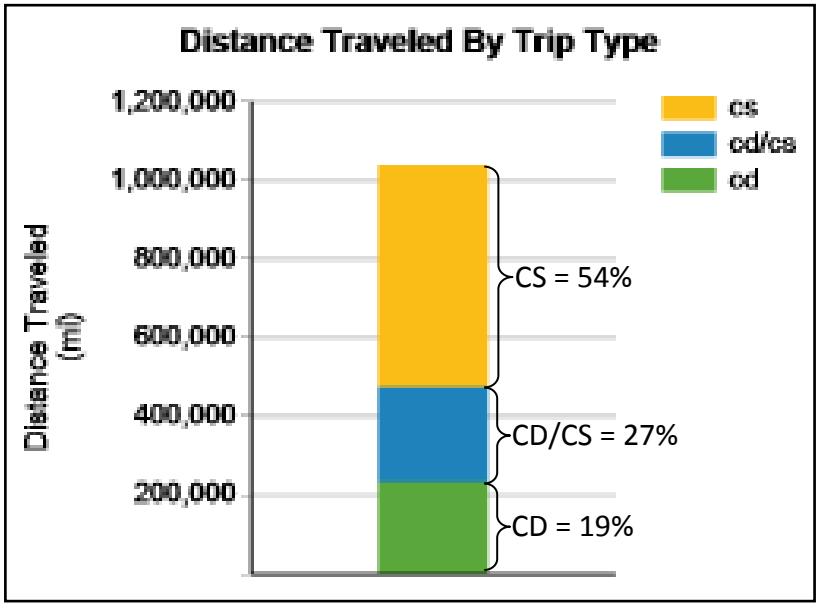
a. Driver Behavior: Are there any driver duty-cycles that influence design direction?
b. Consumer Acceptance: Are the customers using the technology as intended?
c. DVP: Is it adequate, over or under contented?
d. FMEA: Is it adequate, over or under contented?
e. Functionality: Does the system meet the field requirements?
f. Fuel Economy: Can we use field data to improve fuel economy?
g. Content: Can we use field data to reduce design content?
h. Mass: Can we use field data to reduce mass?
i. Benchmark Vehicle: What is the best vehicle that has this system?
j. Current Reports: Are they adequate or did you create new ones?
k. Gas, Diesel, Alternative Fuel Applicable: Can this lesson be used on future fueled vehicles?
l. HEV, PHEV, BEV Applicable: Can this lesson be used on future hybrid electric vehicles?

Next Steps: Develop optimization plan within customer usage profiles. Apply lessons learned to future Electrification applications and system/vehicle level testing parameters

Relevance – Results

Analysis & Learning: Lessons Learned



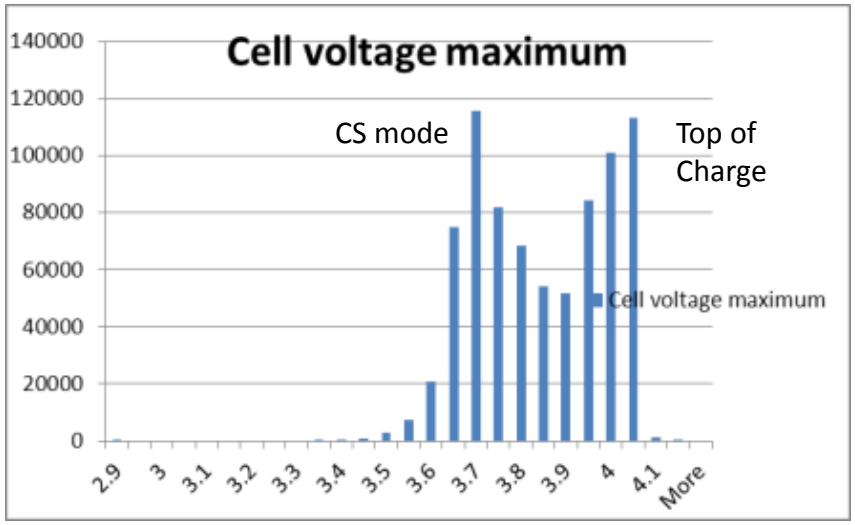


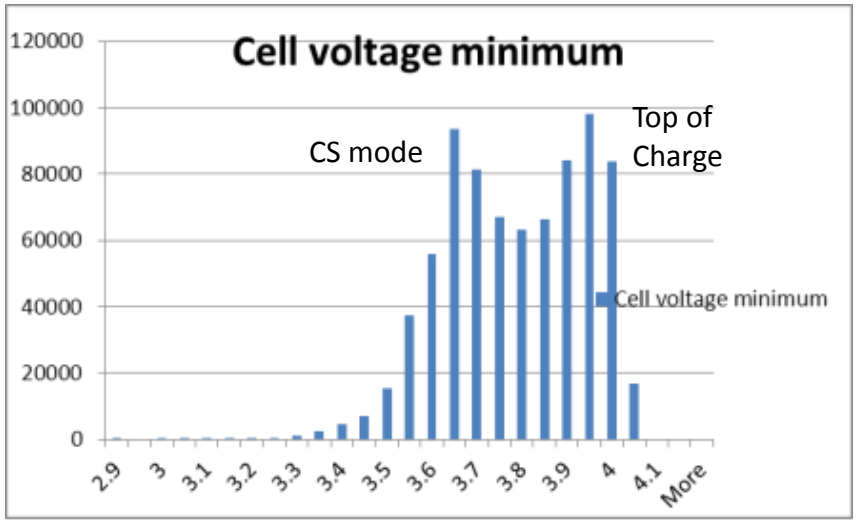
- High voltage battery SOC profile indicates states of less than 35%
- The majority of the distance traveled during Phase I of the demonstration period was spent in Charge Sustaining Mode, 54%
- Drivers / customers need to be adequately trained to achieve optimal fuel economy

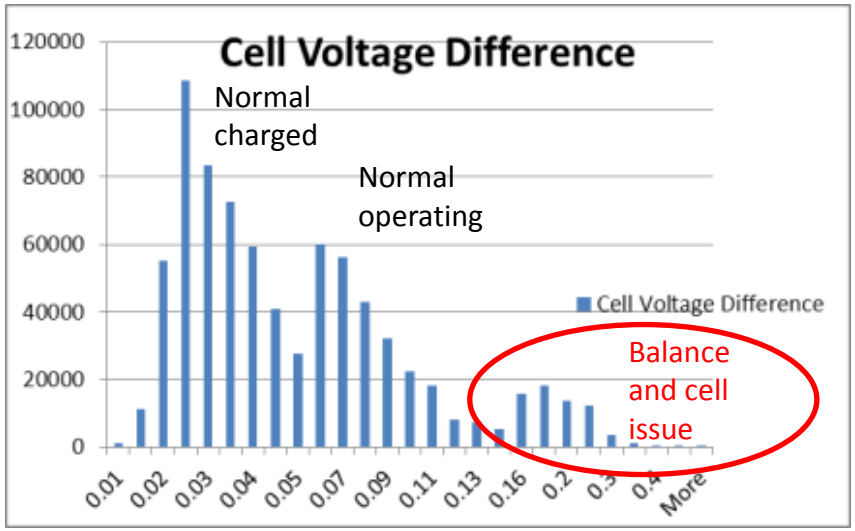
Note: Above data are taken from the combined Chrysler Minivan and Ram 1500 PHEV fleets

Relevance – Results: Lessons Learned

Battery Observations: Cell Balancing and Self-Discharge





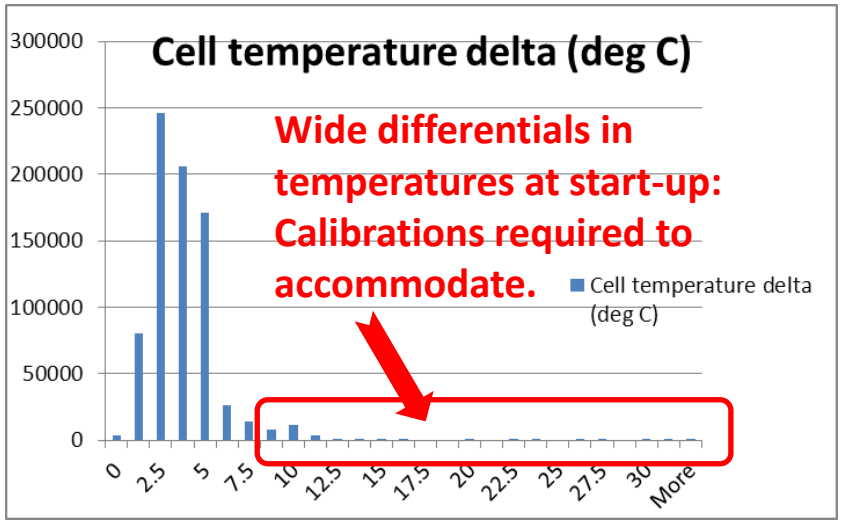


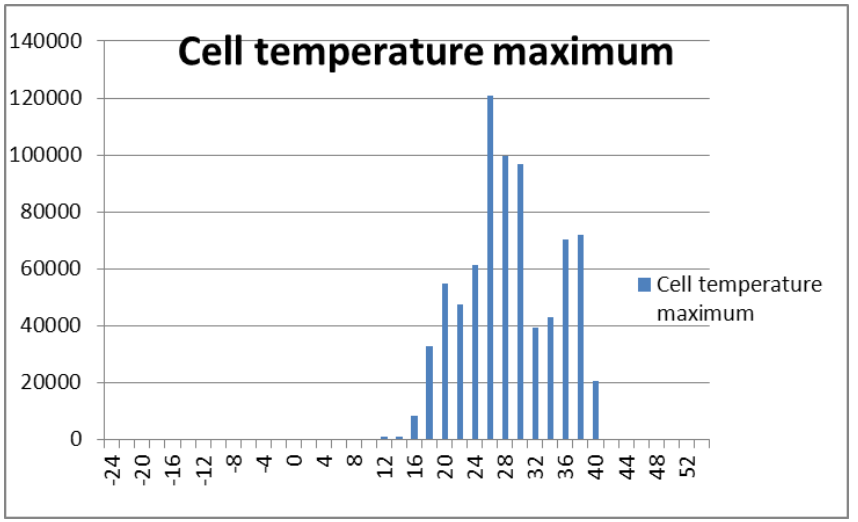
Target ≤40mV (0.04V) cell-to-cell variation or less
Cell Voltage Maximum = Highest Voltage in 96 Cell Pack
Cell Voltage Minimum = Lowest Voltage in 96 Cell Pack
Cell Voltage Difference = Cell Voltage (Maximum - Minimum)

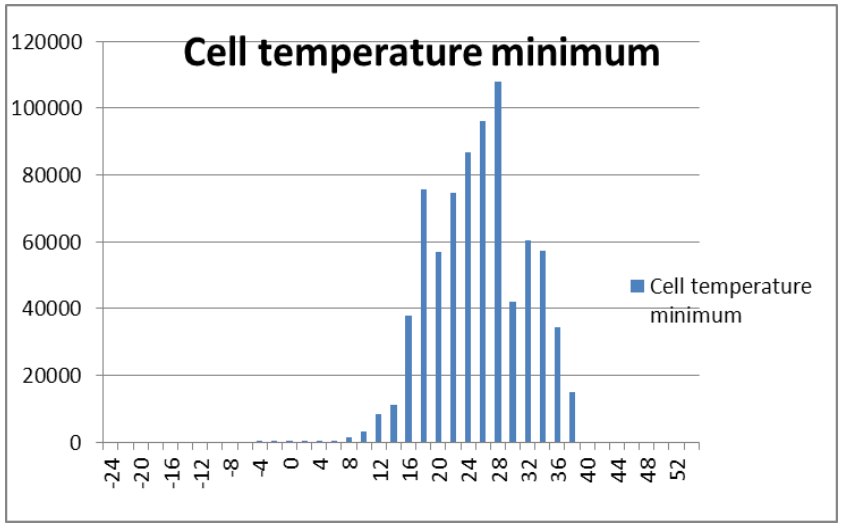
It was possible to track cell imbalance issues in the field, and root cause the issues remotely. This identified the need to improve battery cell technology and controls for Phase II

Relevance – Results: Lessons Learned

Battery Observations – Temperature Distribution







Battery Pack installed during this test
Cell Temperature Maximum = Highest Temperature in 96 Cell Pack
Cell Temperature Minimum = Lowest Temperature in 96 Cell Pack
Cell Temperature Delta = Max - Min

Deg C	Deg F
0	32
10	50
20	68
30	86
40	104
50	122

It was possible to identify the effects of different operating modes and climates with these data

Approach – Ram 1500 PHEV Project Plan

Project Management, Build and Development Plan – Phase II

	2012					2013											2014						
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July
Milestones – Battery/Vehicle Development – Battery/Vehicle Build – Battery Develop Milestones – Internal Chrysler Testing		Vehicles Returned Supplier Selection			12/5/2012 Preliminary Design Review		Battery Development 3/4/2013 Critical Design Review (CDR) - Build Volumes Frozen		4/12/2013 Lab Packs Available	Battery Upgrade 5/24/2013 DV Test Packs/Hot Trip Packs Available		Vehicle Rework 7/12/2013 Development Vehicle Packs Available			Vehicle Demo Redeploy 8/13/2013 Fleet Retrofit 1st Pack Available								Program Complete
Task 1: Project Management																								
Task 2: Project Preparation & Planning																								
Task 3: Initial Development Builds																								
Task 4: Supplier Readiness Review																								
Task 5: Pre-Demonstration Build																								
Task 6: Fleet Build																								
Task 7: On-Going Vehicle Operation & Testing																								
Task 8: Data Collection & Analysis																								
Task 9: Advanced Energy Storage System Development																								

Approach – RAM 1500 Project Milestones

Month / Year	Milestone or Go/No-Go Decision	Description	Status
Sept 2012	Go/No-Go Decision	Temporarily withdraw Ram 1500 PHEVs from fleet to upgrade high voltage battery	Complete
July 2013	Milestone	Upgrade High Voltage battery packs are available for vehicle testing	On Schedule
September 2013	Milestone	Ram 1500 PHEV deployment vehicle battery retrofit begins	On Schedule
October 2013	Milestone	Begin redeployment of retrofitted Ram 1500 PHEVs to partners	On Schedule
Ongoing	Milestone	Customer field evaluations and data review	On Schedule
July 2014	Milestone	Project Completion	On Schedule

Approach – Uniqueness

Uniqueness of the approach for the RAM 1500 PHEV

Phase I

- Designed, developed and deployed a Plug-In hybrid Pickup Truck, the RAM 1500 PHEV
- Designed vehicle not only to accept power from the grid; but, under controlled circumstances, provide power to the grid
- Implemented Unique Features on the RAM 1500 PHEV:
  - ✓ Reverse Power Flow – Provides external power (120v and 240v)
  - ✓ Scheduled Charging – Web site charging control to allow user to schedule charge events
  - ✓ Map-Based Fuel Economy – Optimized charge depletion: based on learned trip drive and charge cycles
  - ✓ Power Panel – 120 & 240 volt AC generation provides up to 6.6 kW of power through the panel
  - ✓ Smart Charging – Vehicle to grid interface through ERPI's multipurpose router

Phase II

- Using relevant timing and milestones from the Chrysler Product Creation Process, CPCP, to complete the project
- Upgrading Ram 1500 PHEV high voltage batteries with new battery cell technology in order retrofit Chrysler test vehicles
- Testing new battery cells to overcome barriers associated with performance across extreme ambient conditions
- Continuing to develop Reverse Power Flow, Smart Charging and Map-Based Fuel Economy Optimization

Technical Accomplishments – Development

PHEV Development – Completed Prior to May 2012

- Utilized the standard Chrysler Group LLC Vehicle Development Process for a production intent program for development and validation
  - ✓ Augmented development process with modified testing procedures to address specific plug in Hybrid Technologies; ie – Reverse Power Flow, Smart Grid and Map-Based Fuel Economy
- Continued Facility Based Testing: hot static cell, hot drive cell, cold static cell, cold drive cell, altitude chamber, engine dynamometer, transmission dynamometer, NHV cell, EMC cell, emissions test facility; bench Testing: vibration, SOC, thermal, charge / discharge cycling
- Verification Road trips: Hot trip – Mid July 2011 to Mid August 2011; Cold Trip Dec 2011
- Completed PHEV system controls and calibrations; monitored the fleet field data and performance to verify the robustness of the control systems.
- Completed Durability testing: powertrain, high mileage, two charge cycles per day
- Completed build of 140 Demonstration Ram 1500 PHEVs; successfully deployed 111 vehicles to fleet partners
- Monitored the fleet vehicles for a variety of performance metrics:
  - Addressed field service issues
  - Identified Lessons learned
  - Customer usage

Technical Accomplishments – Project

Phase I Accomplishments this Period

- Completed the deployment of 111 out-of 140 vehicles to the fleet partners for real-world testing
- Developed Scheduled Charging: feature to help manage charge power consumption and concerns with large fleets.
- Developed Map-Based Fuel Economy system: optimizes charge depletion of HV battery to fit customer use profile for repetitive drives
- Developed Reverse Power Flow: feature to allow up to 6.6kW support of power grid
- Accumulated over 1 million driven miles of demonstration fleet data
- Obtained an overall fuel economy of 19 mpg across the fleet, on average.
- Retrieved fleet from deployment partners for Phase II vehicle upgrade
- Completed evaluation of new cell technology to be used in Phase II of the project

Phase II Accomplishments this Period

- Finalized the steps and tasks for Phase II of the RAM 1500 PHEV DOE project
- Identified the key high voltage battery integration and battery cell suppliers for the upgraded high voltage battery
- Completed the battery and vehicle validation testing planning requirements
- Identified demonstration partners to participate in Phase II of the project
- Initiated the vehicle retrofit and battery upgrade process for vehicles to be used for Chrysler Group LLC internal testing
- Completed battery design integration with the new cell
    - Pack-to-vehicle interfaces will remain the same with the upgraded battery pack. Upgrades will be contained within the battery pack
- Started cell and battery pack bench testing

Collaborations & Partnerships – Development

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Development and content partners

Phase I Completed Tasks

- Electrovaya completed its high voltage battery supply work for the project
- Behr completed its design, development and part supply deliverables for the thermal management system

Phase I – Continuation into Phase II

- UC Davis
  - Collecting and analyzing information from driver and fleet manager interviews and from data recording instrumentation onboard the PHEVs in order to recommend improvements to the vehicle design
- SMUD
  - Performing data collection, analysis and reporting for vehicle to grid
- EPRI
  - Providing Multi-Protocol Router and development of Smart Grid
- University of Michigan – Dearborn
  - Working on hybrid energy storage involving lithium ion batteries
  - Studying soft switching that can help improve efficiency in onboard chargers
- Michigan State University
  - Improving detailed powertrain and vehicle system model
  - Identifying and validating system parameters used in HIL models

Phase II

- Battery integrator and new cell supplier selected to provide battery pack and cell technology to be integrated into the upgraded battery pack

Collaborations & Partnerships – Deployment

The following partners are slated for Phase II of Ram 1500 PHEV project

Partner	Redeployed Number of Vehicles	Goals & Reason
Sacramento	5	Reverse Power Flow(1), Smart Charging(5), Map-Based Fuel Economy(2) and Customer Field Evaluations(Conducted by UC-Davis)
Detroit Edison	5	Reverse Power Flow(4), Smart Charging(5) and Map-Based Fuel Economy(2)
Duke Energy	5	Reverse Power Flow(3), Smart Charging(5) and Map-Based Fuel Economy(4)
Colorado	3	Smart Charging(3) and Map-Based Fuel Economy(1)
National Grid	3	Smart Charging(3) and Map-Based Fuel Economy(1)
CenterPoint Energy	2	Reverse Power Flow(1), Smart Charging(2) and Map-Based Fuel Economy(1)
EPRI	1	Reverse Power Flow(1), Smart Charging(1) and Map-Based Fuel Economy(1)
Totals	**24**	

24 PHEVs with Smart Charging feature
12 PHEVs with Map-Based Fuel Economy feature
10 PHEVs with Reverse Power Flow feature

Future Work – Phase II

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PHEV Development

- Finalize the development and verification of the upgraded high voltage battery
- Continue calibration/controls development and optimize fully integrated systems
- Complete extended vehicle durability and validation with the upgraded high voltage battery
- Continue hot & cold weather validation of vehicle software
- Optimize the following functionality:
  - Reverse Power Flow
  - Smart Charging
  - Map Based Fuel Economy Optimization
- Continue work with selected development partners

Build and Launch Prep

- Retrofit 24 Ram 1500 PHEVs with the upgraded high voltage battery packs

Deployment Fleet & Real-World Testing

- Continue capturing fleet data to support calibration and controls development
- Monitor the performance of Scheduled Charging, Reverse Power Flow, Smart Charging, Map-Based Fuel Economy and upgraded battery cell technology

Summary – Key Objectives

Continuation of the project will enable Chrysler Group LLC to achieve the remaining project goals during Phase II

	Original Project Goals	Phase I (Completed)	Phase II (Planned)	Comments
System Design Objectives	Producing controllable traction forces under different battery conditions	✓	Complete	Continue to monitor performance during Phase II
	Displacing fuel efficiently in all driving scenarios	✓	Complete	Continue to monitor performance during Phase II
	Achieving efficient charge-sustaining operations	✓	Complete	Continue to monitor performance during Phase II
	Verify plug-in charging mode performance	✓	Complete	Continue to monitor performance during Phase II
	Verify AC power generation mode	✓	Complete	Continue to monitor performance during Phase II
	Prove that the system solution represents optimal cost-benefit trade-offs	✓	Complete	Continue to monitor performance during Phase II
Vehicle Verification	Continue to monitor vehicle functional objectives	✓	Complete	Continue to monitor performance during Phase II
	Demonstrate drivability and safety	✓	Complete	Continue to monitor performance during Phase II
Fleet Demonstration Objectives	Profile vehicle usage and customer profiles	✓	Complete	Continue to monitor performance during Phase II
	Prove product viability in "real-world" conditions	✓	Complete	Continue to monitor performance during Phase II
	Rate based charge control interface	Technology Developed	✓	Completed during Phase I. Project goal will continue to be evaluated during Phase II
	Bi-directional (communication and power) charger interface	Technology Demonstrated	✓	Reverse Power Flow (RPF) – Extensive development and testing to be conducted during Phase II of the project
	Confirm that PHEV technology is viable for mass production	Majority of Tech. Confirmed	✓	Battery Cell Performance – A new battery cell will be introduced during Phase II of the project
	Optimize fuel economy	✓	Complete	Continue to monitor performance during Phase II
	Continued Data Analysis and Lessons Learned	✓	Complete	Continue to monitor performance during Phase II

Summary – Project

Phase I

- Created Core Competency “Green” Technology jobs and have a plan in place to sustain them toward future development of electrification programs
- Successful completion of the demonstration fleet vehicles. Deployed 111 of 140 RAM 1500 PHEVs; collected real world data with real world results
- Successfully demonstrated and achieved the following:
  - PHEV 20-miles All Electric Equivalent drive cycle
  - Fuel economy target of 32 mpg in charge depleting cycle
  - Verification of plug-in charging mode performance
  - Verification of AC power generation mode
  - Product viability in “real-world” conditions
  - Development of bi-directional (communication and power) charger interface
  - Capability to meet ATPZEV emission requirements in a pick-up truck application
  - Collection and analysis of customer usage data taken from a range of operational, geographic and climatic environments
- Finalized the steps and tasks for Phase II of the RAM 1500 PHEV DOE project

Phase II

- Identified the key high voltage battery integration and battery cell suppliers for the upgraded high voltage battery
- Completed the upgraded battery and retrofitted vehicle validation testing requirements
- Identified development and demonstration partners who will participate in Phase II of the project
- Initiated the vehicle retrofit and battery upgrade process for the vehicle fleet

Technical Back-Up Slides

Relevance Back-up – Program Results

Vehicle Performance: Fuel Economy by Demonstration Partner during Phase I

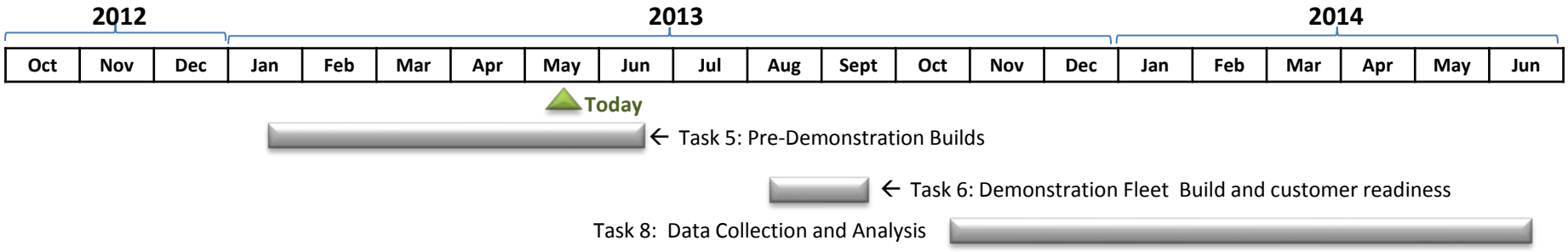
Location	FE CD City	FE CD Highway	FE CD/CS City	FE CD/CS Highway	FE CS City	FE CS Highway	FE Avg. (For Period)
SMUD	23	27	20	22	16	20	19
Tri-State	24	27	21	22	19	21	22
Central Hudson NY	23	25	21	21	17	19	20
EPRI – NC	25	32	21	22	17	21	21
Idaho National Labs	30	31	27	23	18	23	24
DTE	23	26	20	21	17	18	20
EPRI – CA	23	26	23	23	18	20	20
NV Energy	23	23	20	20	17	19	19
Duke Energy	24	27	20	22	17	20	20
National Grid – Mass	23	27	22	21	17	19	19
Centerpoint Energy	24	28	21	23	15	20	20
City of Auburn Hills	24	25	21	20	17	18	21
National Grid – NY	18	25	18	20	15	20	18
NYPD	21	22	19	21	15	18	17
MBTA	22	28	19	21	16	20	18
San Francisco	20	24	20	21	14	19	18
Yuma	20	18	16	17	12	15	15
Argonne National Labs	19	8	25	11	12	8	9

Sources: Idaho National Lab Report – Data from September 2012

CD = Charge Depleting
CS = Charger Sustaining

Technical Back-Up Slides – Functionality

Rate Based Charge Control Interface – Smart Charging



Phase I: Accomplishments

Initial Delivery & Testing

- Initial units completed EMC baseline testing.
- CAN emulator is being used to develop on-board modules while waiting for production units

Deployment

- Met with Duke and CenterPoint Energy to coordinate usage with EPRI to develop and validate Smart Energy Profile 2.0 (SEP2) signals between the Utility Companies and vehicle per SAE standards
- Start with Pricing and DRLC signals, then add advanced functions

Phase II: Objectives

Initial Delivery & Testing

- Target is to complete the development with a validated system of MPRs & cloud control by June 2013.
- Workstream is being finalized to complete CAN to PLC conversion and interface with both SEP1.x & SEP2 utility sites.

Deployment

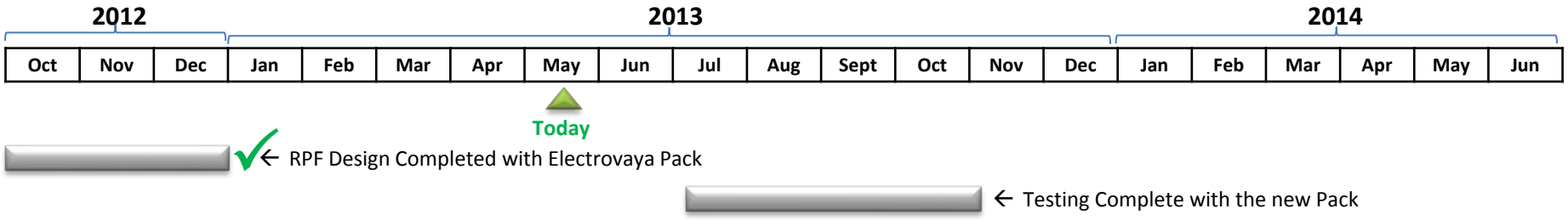
- Add SEP2 advanced features that includes Flow Reservation where the PEV asks for energy and receives confirmation on what and when energy is available plus Distributed Energy Resource that includes Reverse Power Flow

Validation

- Analyze data to validate and refine MPR specifications

Technical Back-Up Slides – Functionality

Bi-Directional (communication and power) Charger Interface – Reverse Power Flow



Phase I: Accomplishments

Documentation and analyses

- Completed Boundary Diagram, Interface Diagram, Fault Tree Analysis & DFMEA review with Chrysler management

Validation

- Completed conformance testing on units at supplier.
- Installed 10 units plus the 2 warranty units in DS vehicles and validated at Next Energy (nominal and boundary conditions for grid voltage and frequency).
- Demonstrated to DTE (March, 2012 @ NE) and DoE (April, 2012 @ CTC).

Phase II: Objectives

Documentation and analyses

- Collect data and analyze usage using the existing web interface.
- Include the interface with SEP2 utility servers for the DER function set that provides direct feedback to the utility.

Validation

- Re-validate RPF with the upgraded packs.

Deployment

- Include additional SEP2 Function set to demonstrate advanced features into the MPR's. This includes a portion of the DER Function set for RPF/charge cycles. This demonstrates how the PEV can interface with Solar and other sources in the home to balance loads.

Technical Back-Up Slides – Functionality

Map Based Fuel Economy Initiative

Phase I Accomplishments

Currently uses driving history attribute to enable route learning for optimized fuel economy

Results
Overall Fuel Economy (>35% Gain)
Fuel Economy Breakdown • City With Map-Based Fuel Economy: 20.7 mpg • City Without Map-Based Fuel Economy: 11.8 mpg • Hwy With Map-Based Fuel Economy: 27.6 mpg • Hwy Without Map-Based Fuel Economy: 22.7 mpg

Notes: Only Vehicles equipped with Map Based Fuel Economy technology included in the Fuel Economy calculations.

Phase II Next Steps

Potential next step is to incorporate more attributes in addition to driving history such as altitude, speed limits, stop signs, navigation system (route pre-learning), and gradient/path slope

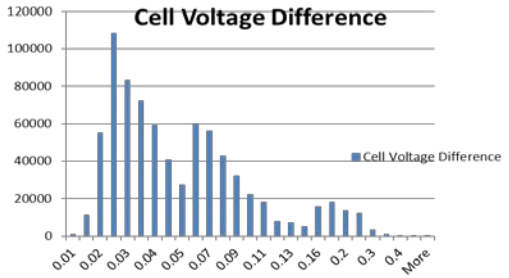
Technical Accomplishments – Lessons Learned

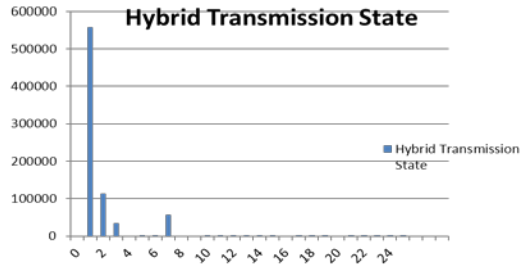
PHEV Project Data Points Lessons Learned:

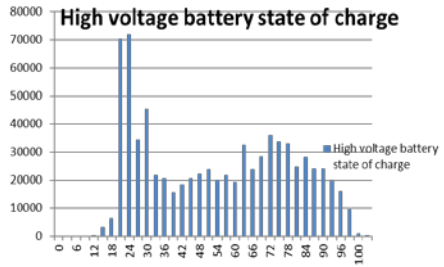
Data Process

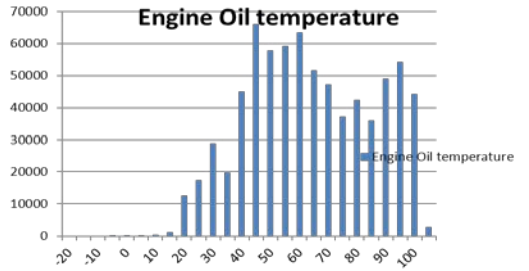
- 66 vehicles were selected across wide range of usages, geographic, climatic and operating environments:
  - City Municipality
  - San Francisco
  - Yuma Police
  - NYPD Police
  - Utility Companies
  - Winter Usages
  - Charging
  - PowerPanel
- Up to 770,000 data points(sec)/ Variable
- Total of 214 hours of 'On Time'
- 93 relevant variables sent to DRM

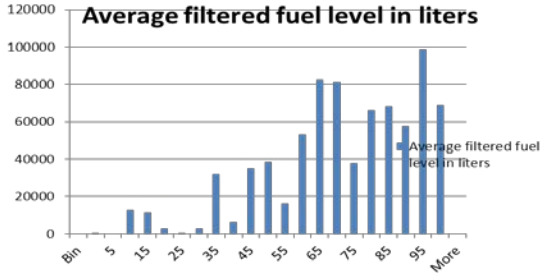
Take Away Lessons: Enhanced Controls, Improved Fuel Economy, Enhanced Drivability, and Increased Understanding Real-World Customer Usage

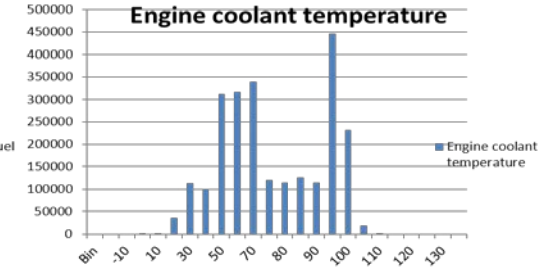


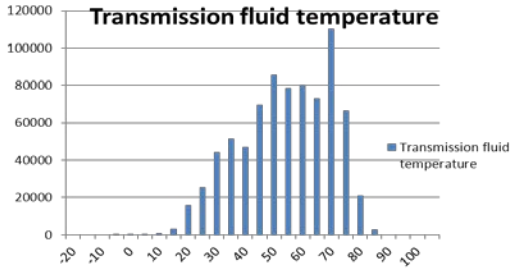






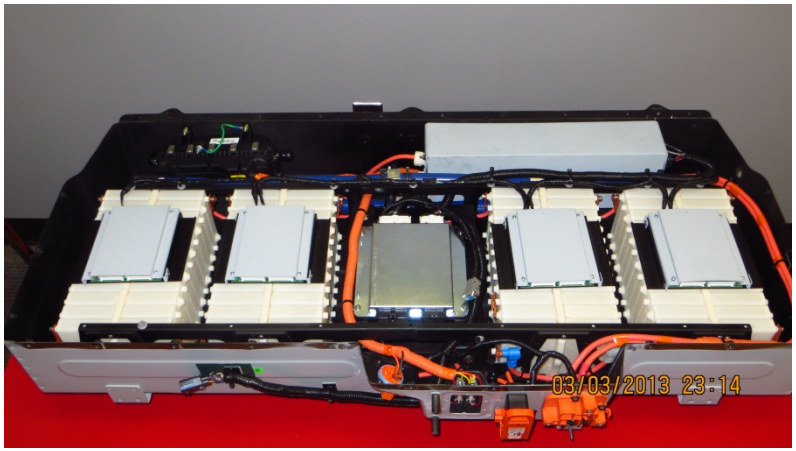






Relevance Back-up – Program Results

High Voltage Battery System – Key Characteristics



Properties	Values
Nominal Voltage	355V nominal
Energy	9.7kWh
Power	>60kW
Mass	140kg
Configuration	96 cells in series
Cell Capacity	27Ah minimum
Thermal Management System	Liquid – 4 zones