2013 DOE Vehicle Technologies Annual Merit Review
Advanced Vehicle Electrification & Transportation Sector Electrification

PI: Greg Cesiel

Presenter: Sandra Monterosso

General Motors LLC

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Project ID#ARRAVT071

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OVERVIEW

Timeline

- Start: March 2010
- Finish: March 2014

75% Complete

Barriers

- Cost of the advanced technology for electric vehicles
- Wide availability of charging infrastructure to support electric vehicles

Budget

- $61 M project
  - $30.5 M DOE
  - $30.5 M GM

Partners

- DOE
- EPRI
- Utilities:
  - Austin
  - DTE
  - Dominion
  - Duke
  - PGE
  - PEPCO
  - Progress
  - Southern Cal Edison
  - SMUD

OBJECTIVES

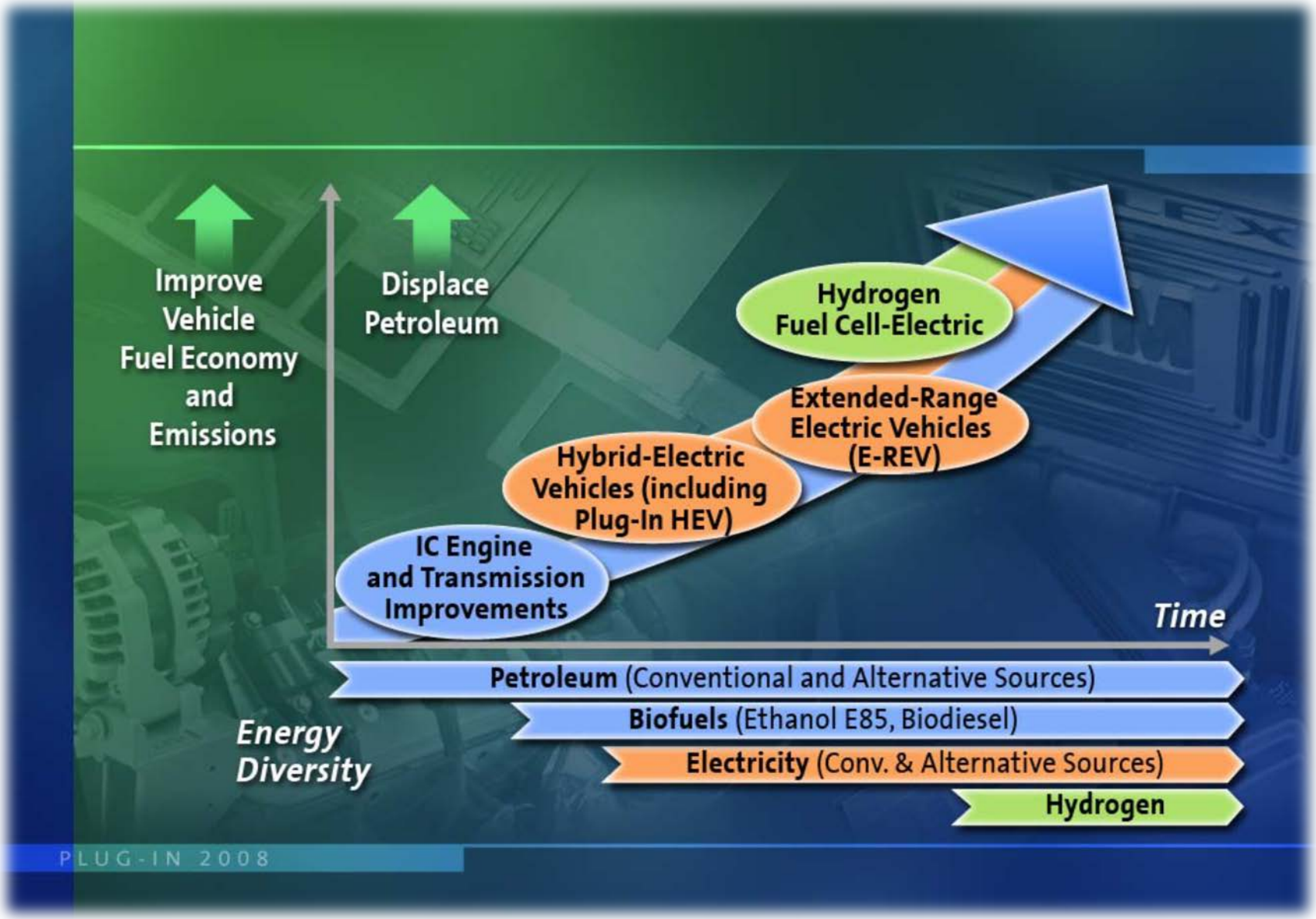
- **Develop electric vehicle with extended range advanced propulsion technology and demonstrate a fleet of vehicles to:**
  - ➢Gather data on vehicle performance and infrastructure
  - ➢Understand impacts on commercialization
- **Accomplished:**
  - ➢By leveraging the unique telematics of OnStar, standard on all Chevrolet Volts, to capture the operating experience that shall lead to a better understanding of customer usage
  - ➢Through customers in several diverse locations across the United States
  - ➢Installation, demonstration and interaction with charging infrastructure

VOLT

RELEVANCE

- **The Chevrolet Volt introduces new vehicle technologies powered by domestically produced alternative fuels that will:**
  - Reduce our dependence on petroleum
    - Increases use of domestic resources
    - 25 to 50 mile electric vehicle range
    - 2011 MY EPA label: MPGe = 93; MPG = 37
  - Decrease greenhouse gas emissions
    - No tailpipe emissions while operating in EV mode
    - Provides additional options, including renewables, for fueling vehicles
  - Maintain skilled jobs required to sustain U.S. technical leadership
    - Vehicle and battery engineering
- **Vehicle usage and typical operation needs to be understood to**
  - Accelerate the vehicle usage learning curve
  - Achieve mass market penetration

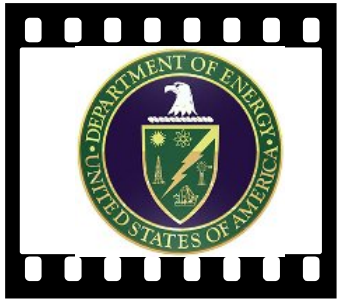
RELEVANCE



MILESTONES - 2012

First aggregate data available on INL Website (Q2, 2011)

146 Vehicles Deployed for Demo (Q4, 2011)



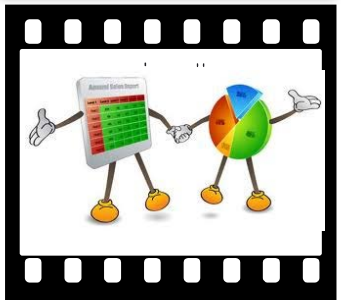
2012 Annual Merit Review (May, 2012)

Project rescoped to include Gen II Volt Development (August, 2012)

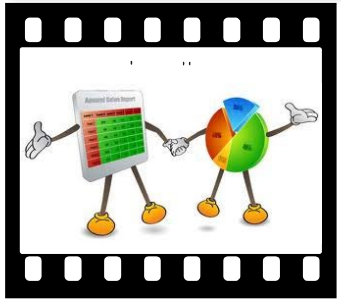
Battery to Grid Demo Complete (December, 2012)

2011 | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | 2013

On-site Technical Review with DOE (April, 2012)



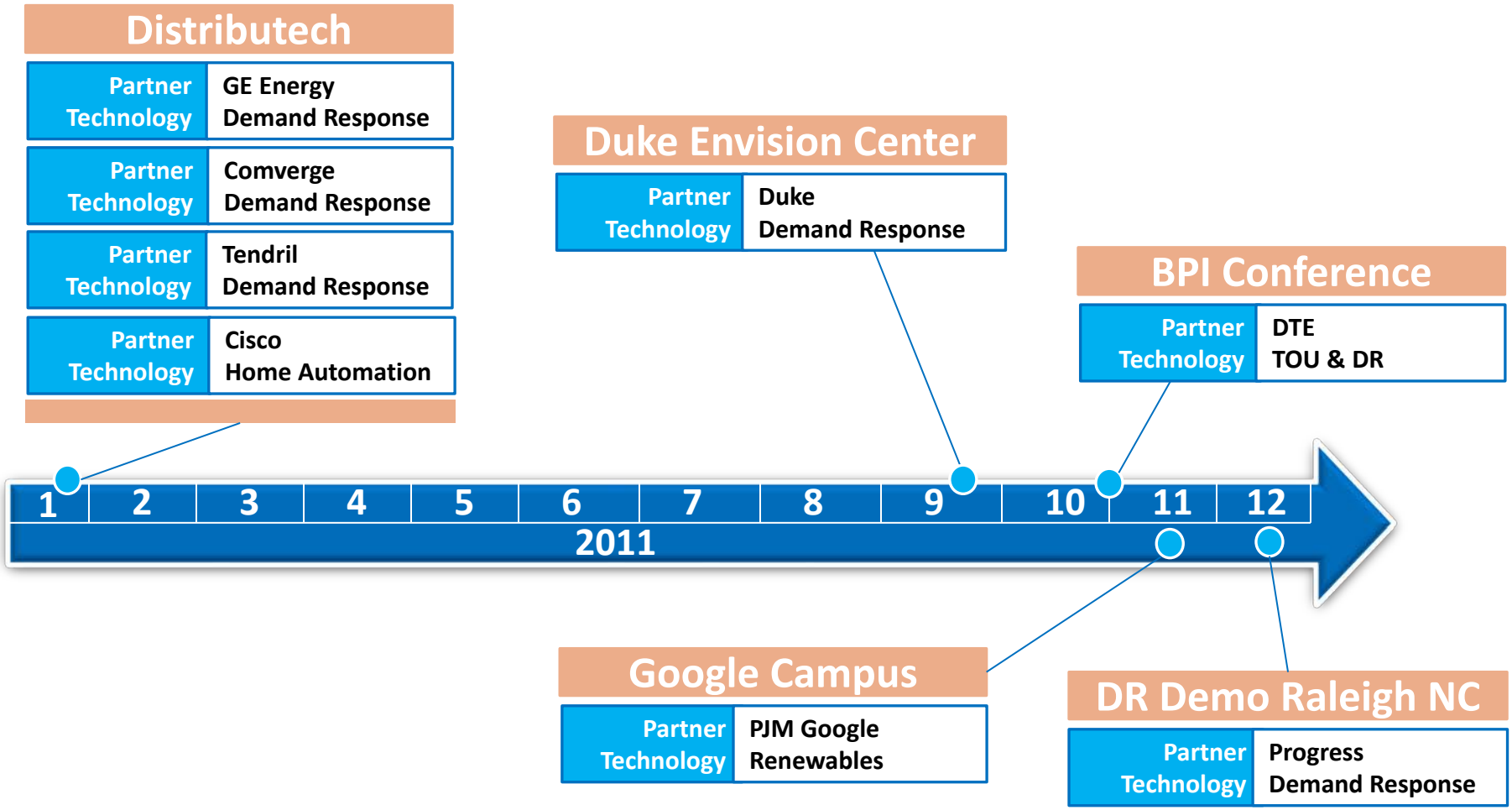
On-site Technical Review with DOE (September, 2012)



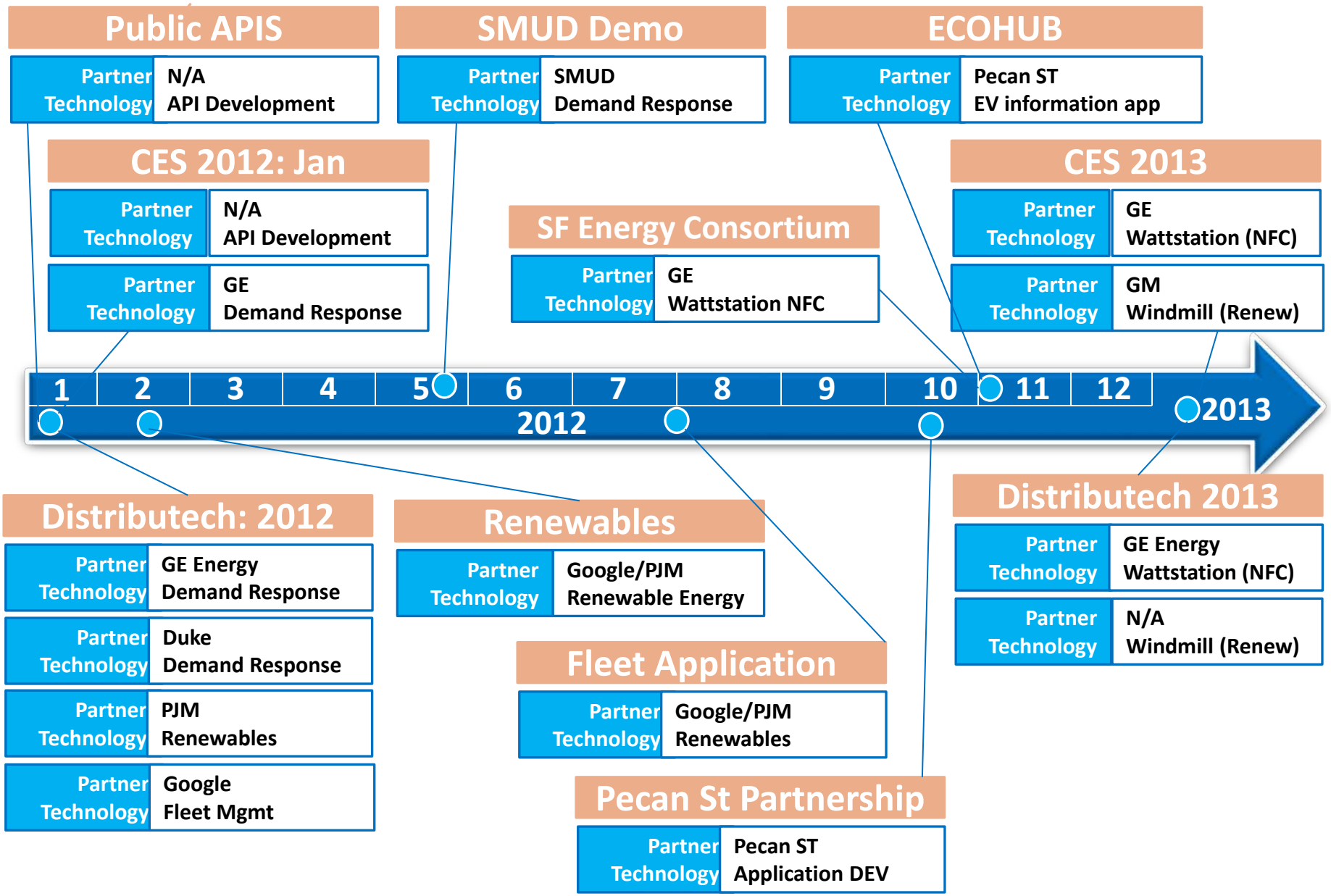
FY 2012 Annual Report Submitted (October 15, 2012)

Charge station installations complete (February, 2013)
(Total = 278)
Home = 30
Business = 203
Public = 45

Milestones : OnStar Smart Grid Activities



Milestones : OnStar Smart Grid Activities



APPROACH/STRATEGY – Development & Deployment

- **Chevrolet Volt is an electric vehicle with extended range capability**
  - Powered by electricity all the time
  - Battery provides 25 to 50 miles of driving, using no gasoline = no tail pipe emissions
  - Battery can be charged with grid energy
  - Unlike purely electric vehicles, drivers can take long trips as total vehicle range is up to 380 miles when the onboard generator engine is utilized

- **Volt Gen II development by General Motors working towards the reduction of cost, increase of volumetric density and increase of gravimetric energy density**

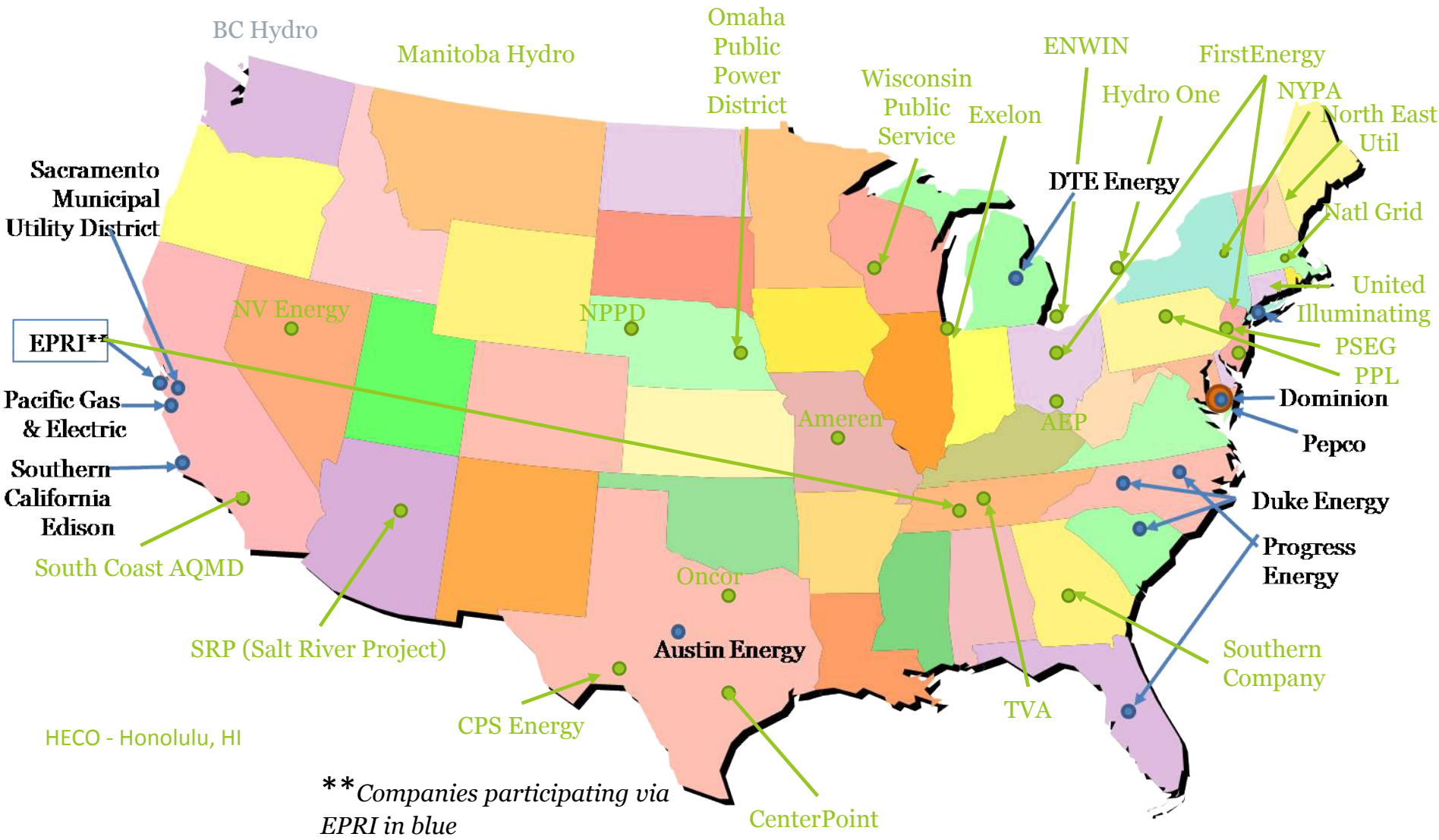
- **Utility installation of charging stations in residential houses, workplaces and public areas**

APPROACH/STRATEGY - Data

Data has been collected on vehicles since Fall 2010

- **Demonstration data will be used to:**
  - Better understand customer expectations
  - Evaluate how well the system addresses customer needs
  - Focus upon understanding operating costs and the customer value equation
  - Understand driver behavior effects on fuel economy
- **Charging and vehicle usage data will be critical for making informed decisions about infrastructure development and integration into smart grid networks**
  - Charging behavior (home verses public)
  - Level 1 (120 volt) vs Level 2 (240 volt) experience
  - Installation of charging infrastructure
- **Information gathered during this period will support the next generation battery designs and infrastructure while expediting learning cycle progression**

UTILITY DEMONSTRATION LOCATIONS



***Companies participating via EPRI in blue*

APPROACH/STRATEGY - Data

Chevrolet Volt Vehicle Demonstration

http://avt.inel.gov/evproject.shtml

Fleet Summary Report

Number of vehicles: 150

All operation

Overall gasoline fuel economy (mpg)	70.5
Overall AC electrical energy consumption (AC Wh/mi)	170
Average Trip Distance	12.4
Total distance traveled (mi)	2,041,556
Average Ambient Temperature (deg F)	64.4

Electric Vehicle mode operation (EV)

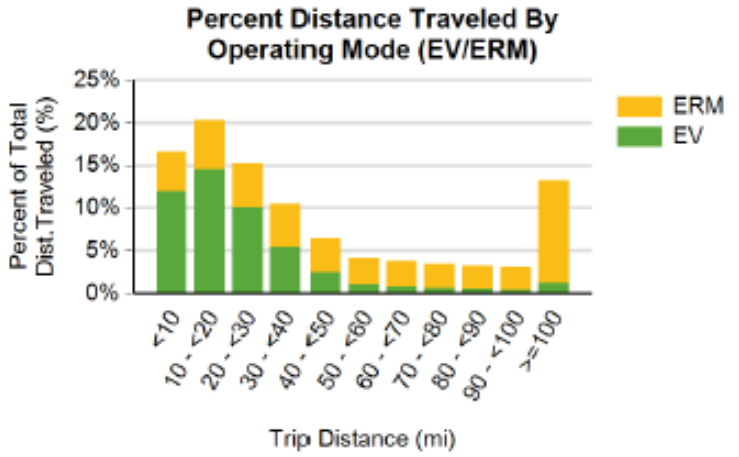
Gasoline fuel economy (mpg)	No Fuel Used
AC electrical energy consumption (AC Wh/mi)	345
Distance traveled (mi)	1,002,495
Percent of total distance traveled	49.1%
Average driving style efficiency (distance weighted)[1]	80%

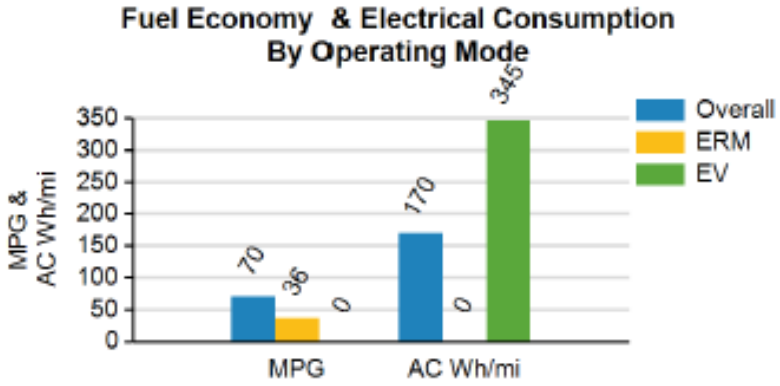
Extended Range mode operation (ERM)

Gasoline fuel economy (mpg)	35.9
AC electrical energy consumption (AC Wh/mi)	No Elec. Used
Distance traveled (mi)	1,039,061
Percent of total distance traveled	50.9%
Average driving style efficiency (distance weighted)[1]	78%

Reporting period: May 2011 through December 2012

Number of vehicle days driven: 35,098





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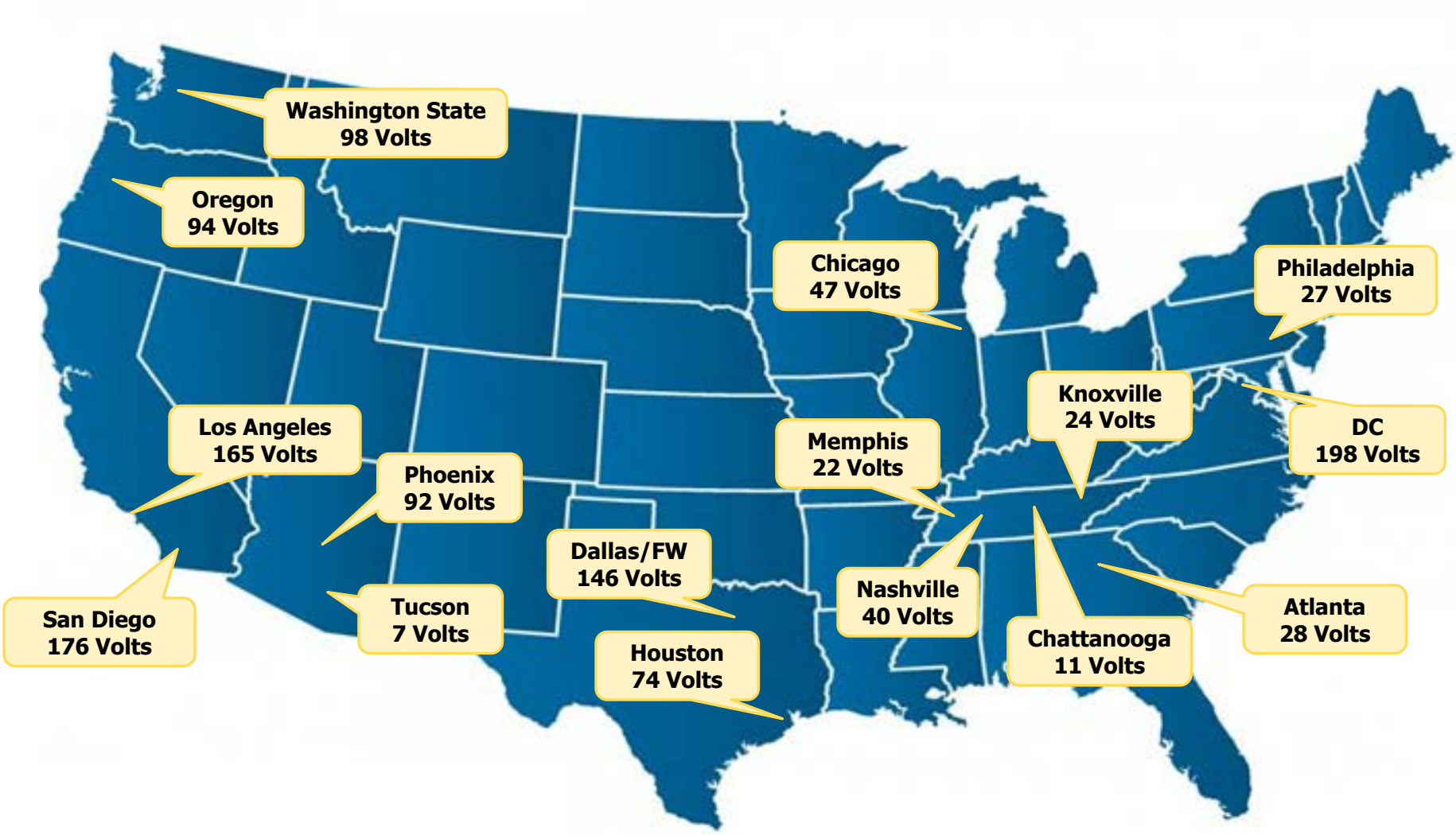
RESIDENTIAL SAMPLING -

Chevrolet Volts reporting data through ECOtality The EV Project (Total Vehicles =1,249)



UTILITY FLEET vs. RESIDENTIAL 2012 Data

	Utility (Fleet)	ECOtality (Retail)
Overall fuel economy (mpg)	67.8	139
Overall electrical energy consumption (AC Wh/mi)	180	293
Total distance traveled (mi)	1,473,561	7,188,487
Average trip distance (mi)	12.35	8.1
Average number of trips between charging events	3.6	3.3

TECHNICAL ACCOMPLISHMENTS & PROGRESS

- **Validation of key vehicle components and subcomponents**
- **Completion of all FMVSS and compliance testing**
- **Volt's smartphone application by OnStar developed to help drivers stay connected to their Volt 24/7 with features including:**
  - Scheduling or initiating charging, displaying charge status and level
  - Getting status reports such as how much electric driving range is available
  - Warming or cooling the vehicle before getting in
  - Sending text messages to remind drivers to plug in
  - Showing MPG, EV miles and miles driven for last trip and lifetime

- **Efficiency gauge and green leaf screens developed to guide the operator to drive more efficiently**

COLLABORATIONS & COORDINATION WITH OTHER INSTITUTIONS

- **Idaho National Labs (INL)**
  - Has received data on multiple DOE hybrid and electric vehicle projects
  - Is receiving Volt raw data (fuel used, miles driven, etc.) and amalgamating
  - Facilitation of a common format presentation of data for DOE via INL Website (http://avt.inel.gov/evproject.shtml)
- **Electric Power Research Institute (EPRI)**
  - Facilitating involvement of additional utilities in data demonstration
  - Providing information and facilitating smart charging demonstrations
- **9 Utility Partners**
  - Austin, DTE, Dominion, Duke, PGE, PEPCO, Progress, Southern Cal Edison, SMUD
    - Charging station installations and participating in vehicle demonstrations
- **North Carolina State University**
  - Charging infrastructure analysis in a parking structure

FUTURE WORK

- **Vehicle data collection and the infrastructure demonstration will continue through the first quarter of 2014**

- **Data will continue to be gathered to document driving/charging events**

- **Data will continue to be aggregated and sent to Idaho National Lab for review**

- **Special projects will continue to support fast charging and smart charging; battery secondary use task complete for this project**

- **Volt Gen II development work will continue in an effort to reduce cost, increase volumetric density and increase gravimetric energy density**

PROJECT SUMMARY

- **Relevance:** Consistent with DOE goals to reduce petroleum consumption, reduce greenhouse gases and maintain skilled jobs
- **Approach:** Demonstrate electric vehicle with extended range
- **Technical Accomplishments and Progress:** Extensive validation work and new technologies
- **Collaborations:** Idaho National Labs, EPRI, nine utilities and North Carolina State University
- **Proposed Future Work:** Data will be collected on driving and charging events until the first quarter of 2014. Information will be used to support next generation vehicle and infrastructure.

Special Projects

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CHARGING INFRASTRUCTURE

Current: Hardwired
240 Volt, 3.3 kW
4 hour charge time

Current: Portable
120 Volt, 1.2 kW
10.5 hour charge time

Future: Fast
480 Volt 3 phase DC
30 – 80 kW
<1/2 hour charge time

FAST CHARGING

Goals

- Support development of industry standard electrical and communication interfaces
- Increase understanding of vehicle and grid impacts of fast charging

Tasks

- Support the development of standard connection interface and communication standard
  - DIN 70121, J1772, J2847/2
  - IEC standards
- Design and integrate into the vehicle
- Collect data and analyze:
  - ➢Grid impacts
  - ➢Vehicle impact
  - ➢User ergonomics and efficiency

Progress

- Successfully demonstrated physical, electrical and communication interfaces with ongoing integration and development
- Demonstration of DC fast charging is expected to be complete in 2013

SMART CHARGING DEVELOPMENT

Goals

- Electrical usage varies throughout the day with
  - Peak usage during the day
  - Non-peak usage at night
- Charging during off-peak times can save energy, reduce costs, and increase grid reliability

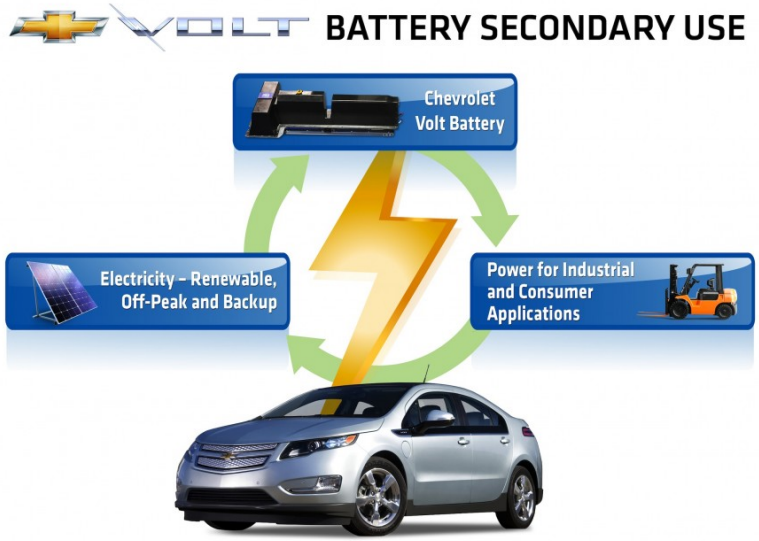
Tasks

- Method 1: Basic: Demonstrate OnStar, a non-AMI (non-automated meter infrastructure) solution, to have customers and utilities control when vehicles are being charged.
- Method 2: Advanced: Develop and demonstrate a home area network solution using AMI (automated meter infrastructure), power line communications and OnStar. Communicate pricing information from the utility to the vehicle to further align charging to off-peak time of use rates.

Progress

- New application for residents of Pecan Street (Austin, TX) that will allow owners of Chevy Volts to match their Volt charging consumption and cost to be tied to their overall whole home energy cost and consumption
- GM/OnStar have worked with other Automakers to create an OEM server concept to allow automakers to agree on the best approach to interface with our respective EVs
- OnStar continues to define new utility demonstrations, providing the ability for utilities to control charging of Volts

SECONDARY USE OF BATTERIES AS GRID STORAGE



Goals

- Create post vehicle residual value by extending the use of automotive batteries to satisfy stationary use requirements
- Enable renewable energy sources
- Reduce infrastructure stress through load management

Tasks

- Ancillary Function Study and System Technical Specification is complete
- Integrate a grid-tied bidirectional power converter with a battery pack to demonstrate battery to grid functionality
- Collect and analyze data to study the grid and battery impacts of bidirectional power flow

Progress

- Bi-directional power flow demonstrated
- Functionality for battery to grid using single battery pack demonstrated
- Conclusion, battery to grid viable, commercialization of technology dependent on market demand for battery based stationary grid storage
- Project task work completed – December 31, 2012