Idaho National Laboratory

Electric Drive Vehicles and Infrastructure Overview

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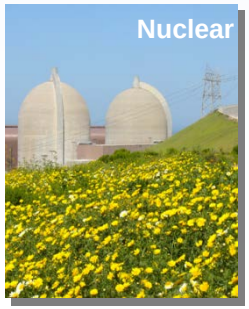
2011 AT&T Global Fleet Operations' annual Alternative Fuel Vehicle planning session
St. Louis, MO
Feb 9, 2011

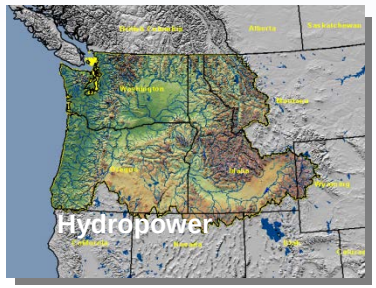
Presentation Outline

- Idaho National Laboratory (INL) / Advanced Vehicle Testing Activity (AVTA) backgrounds
- Comparison of Internal combustion engine (ICE), hybrid electric (HEV), plug-in hybrid electric (PHEV), and battery electric (BEV) vehicle technologies
- Grid connected vehicle charging infrastructure, charging levels, and codes and standards
- INL / AVTA electric drive vehicle testing
- American Recovery and Reinvestment Act (ARRA) – DOE's Transportation Electrification Demonstrations and Educations Programs
- DOE's Vehicle Electrification Project Data Collection
- OEM Electric Drive Vehicle Deployment Announcements
- Acknowledgement and AVTA WWW Address (Test Reports / Fact Sheets)

Idaho National Laboratory

- Eastern Idaho based U.S. Department of Energy (DOE) Federal laboratory
- 890 square mile site with 3,600 staff
- Support DOE's strategic goal:
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Energy Critical Infrastructure Protection





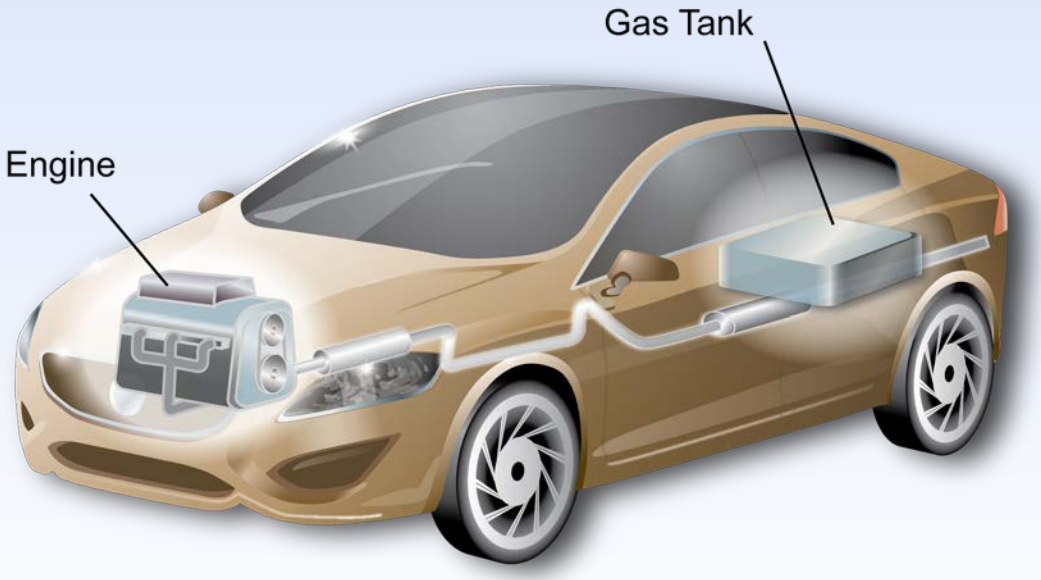
AVTA Description

- Advanced Vehicle Testing Activity (AVTA) is conducted by INL for DOE's Vehicle Technologies Program
- AVTA tests light-duty vehicles, battery subsystems, and fueling infrastructures that employ / support:
  - 100% Electric and dual-fuel electric drive systems
  - Advanced energy storage systems
  - Some ICE 100% Hydrogen and HCNG blended fuels
  - Advanced control systems (i.e., start/stop HEVs)
- Provide benchmarked vehicle and infrastructure testing results to R&D programs, modelers, OEMs, battery manufacturers, and target/goal setters (DOE)
- Assist early adaptor fleet managers and the general public in making informed vehicle purchase, deployment and operating decisions
- Presentations to industry groups, including via Clean Cities' sponsored webinars and symposiums

Review of Vehicle Technologies

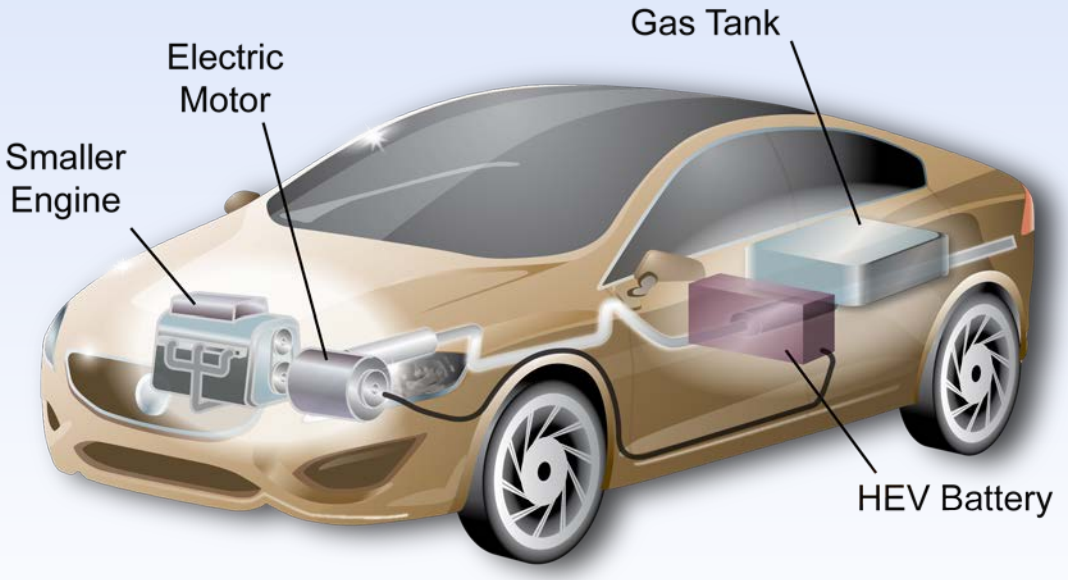
Comparison of Vehicle Technology

- **Conventional vehicle with internal combustion engine (ICE) only**



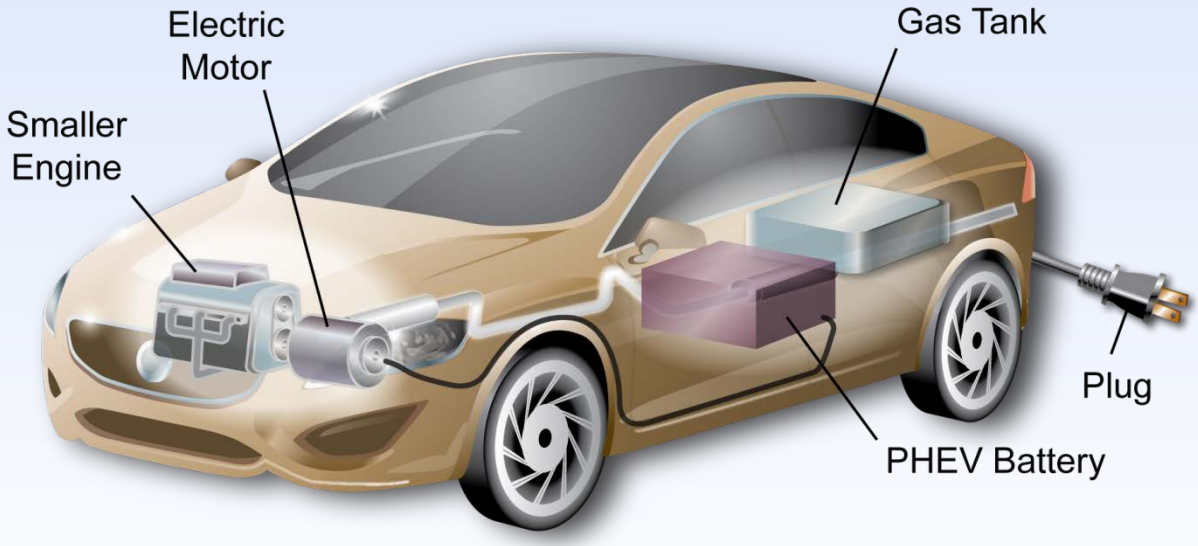
Comparison of Vehicle Technology

- **Hybrid Electric Vehicle (HEV) with ICE and electric drive**
- **Does not plug in to electric grid**



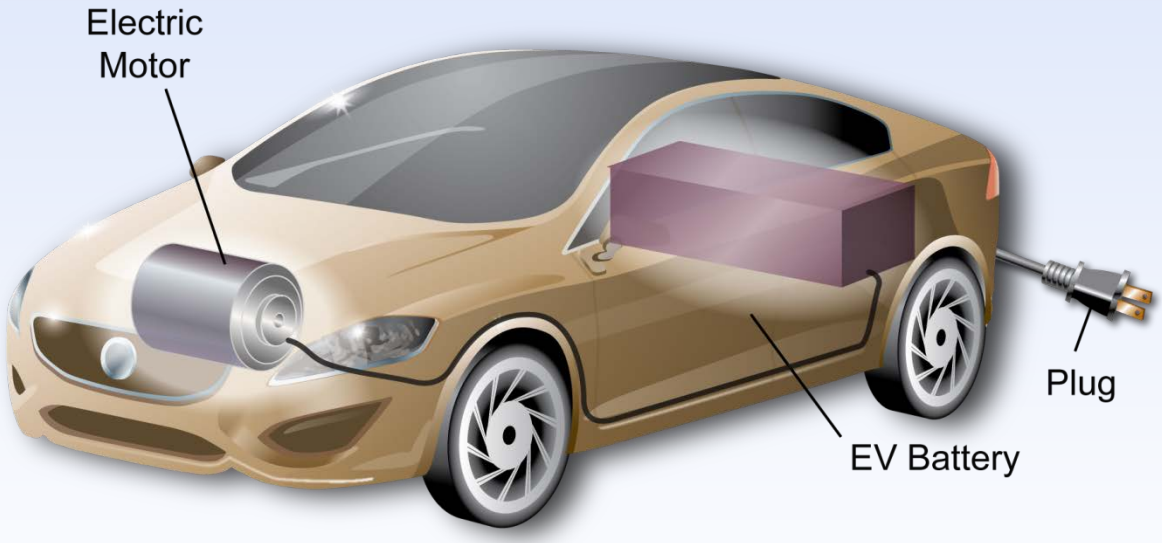
Comparison of Vehicle Technology

- **Plug-in Hybrid Electric Vehicle (PHEV) with ICE and electric drive**
- **Extended range electric vehicle (EREV) with ICE and electric drive**



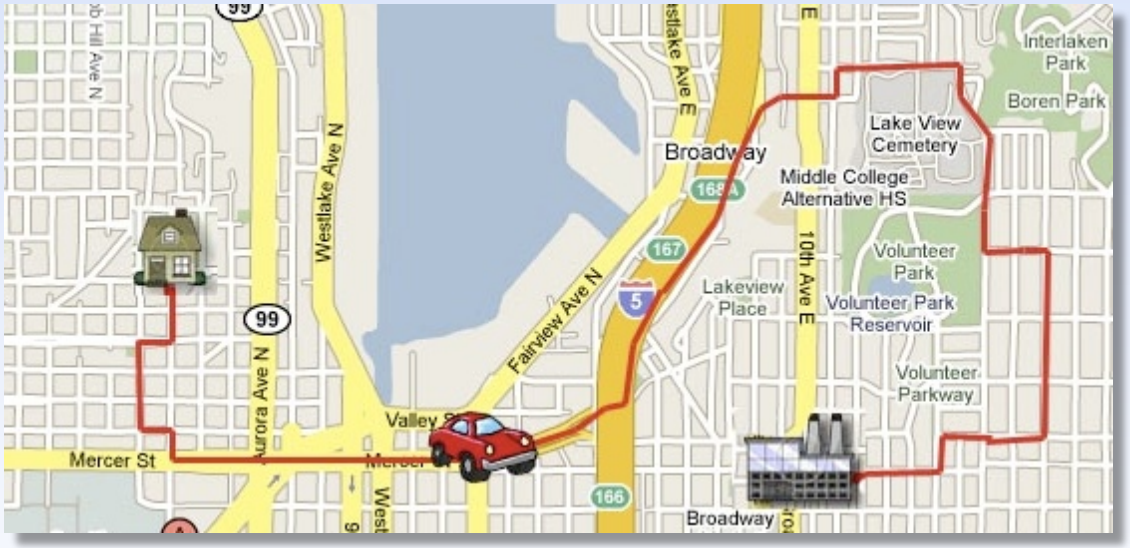
Comparison of Vehicle Technology

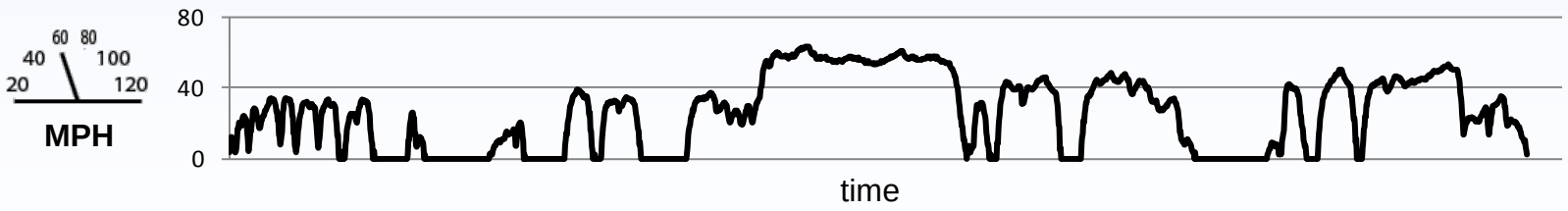
- **Battery Electric Vehicle (BEV) with electric drive only**



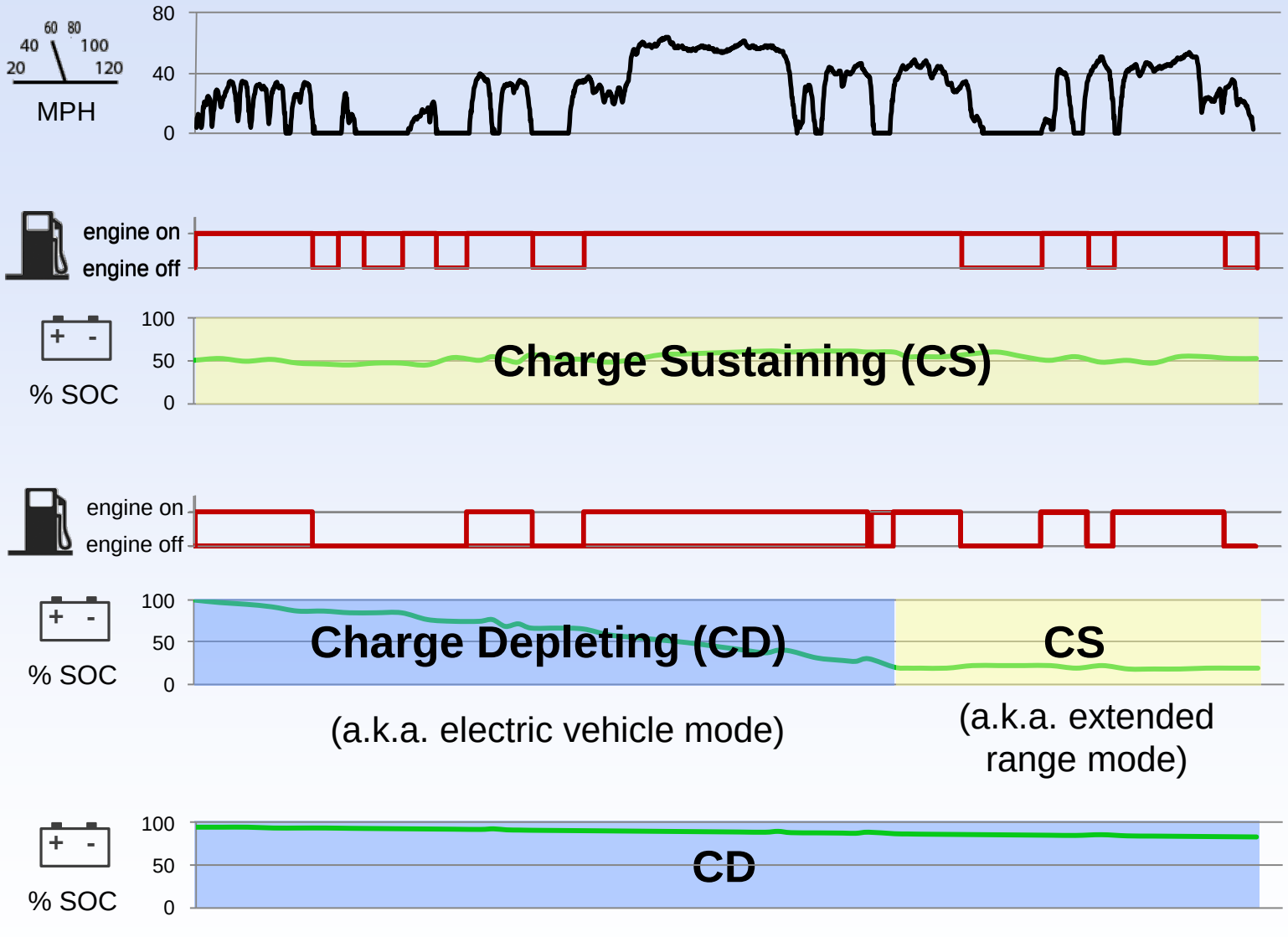
Conceptual Comparison of Vehicle Operation

- **Hypothetical 15 mile drive cycle**





Conceptual Comparison of Vehicle Operation

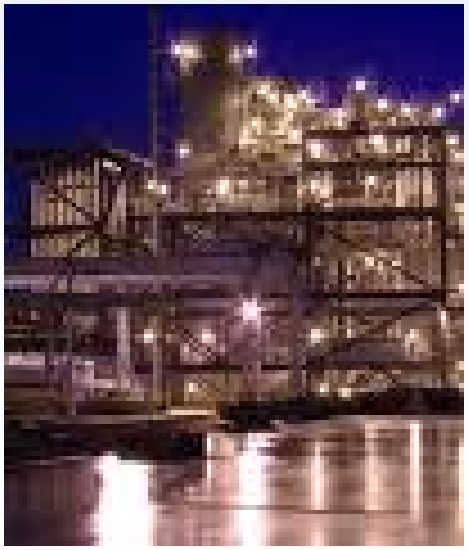


PHEVs, EREVs, and BEVs can be generally called Plug-in Electric Vehicles (PEV) or Grid-Connected Vehicles (GCV)

Grid Connected Vehicle Charging Infrastructure Overview

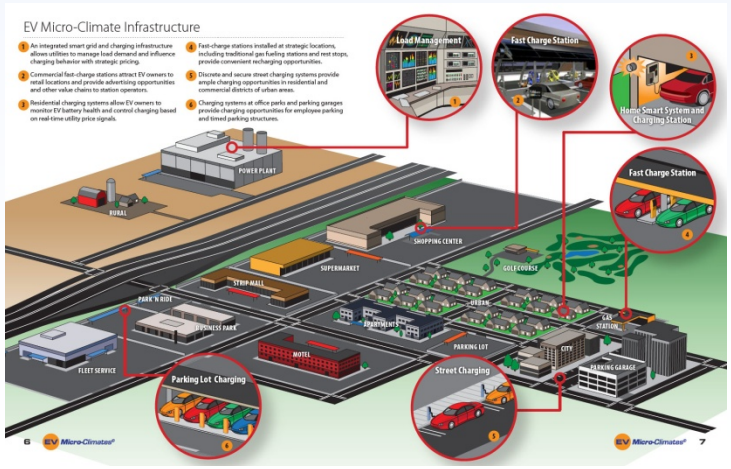
Vehicle Electrification: Grid Impacts

- In the U.S., current grid capacity could supply electricity for 70% of our vehicles without adding capacity, but assumes:
  - Vehicles would only charge off-peak
  - "Perfect" distribution of electricity
  - No local impacts such as overburdening neighborhood transformers
- EVs and PHEVs will not cause a grid "meltdown" but we clearly need to work fast to reduce vehicle rollout impacts
- Smart charging will be key to lowering costs and minimizing impacts
- Time of day pricing also important
- Administration Goal: 1 Million Plug-in Vehicles by 2015



Build-out of Charging Infrastructure

- Key today: Home Charging
  - Need to get the cost and installation process right. Currently a significant barrier
- Public Charging
  - Expensive if not well utilized
  - Expensive to fully cover full driving patterns
- Ideally need market pull to determine public infrastructure build-out
  - PHEVs may be key to help initiate market pull for public infrastructure



Innovative Approaches

- Battery swapping
  - Requires OEM buy-in
- Fast Charging (becoming less innovative)
- Innovative Financing
- Secondary use of batteries
  - Utility ancillary services
  - Bulk energy storage
  - Present value
- Vehicle to Grid (V2G)

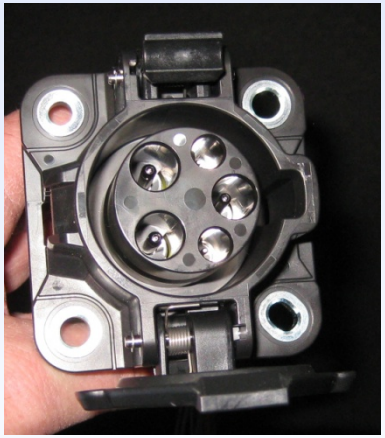
AC Level 1 Charging Level

- This method allows broad access to charge an EV or PHEV by plugging into the most common grounded electrical outlet in the U.S.
- AC energy transfer to onboard charger
- Typical hardware includes portable cordset that must utilize a vehicle connector UL approved for the purpose, a GFCI, and otherwise meet NEC 625 requirements and SAE standards, including the J1772 connector:
  - Separate circuit
  - Standard 120V/15A or 20A
  - Current 12 amps or 16 amps (80% of amp breaker)
  - Power 1.44 kW
- Charge Times (general approximation)
  - BEV 14 hours (20 kWh battery) to 39 hours (56 kWh battery)
  - PHEV 3 to 8 hours

Examples of Level 1 Electric Vehicle Supply Equipment (EVSE)

AC Level 2 Charging Level

- Expected to be most common method for residential and commercial charging
- EVSE for AC energy transfer to onboard charger
- Permanently attached wall box, GFCI, some vehicle communication, UL approved, NEC 625 requirements and SAE standards, including J1772 connector:
  - 240V single phase up to 100A
  - Current up to 80A (80% of amp breaker)
  - Power up to 19.2 kW
  - 3.3 kW or 6.6 kW more typical initially
- Charge Times (general approximation)
  - BEV 20 kWh battery 3 hours (at 6.6 kW) to 56 kWh battery in 8.5 hours (at 6.6k kW)
  - PHEV 3 to 8 hours



Examples of Level 2 EVSE Hardware

AC Level 3 Charging Level

- **This charge level is NOT “FAST Charge” as currently used**
- **Typically would be 480VAC energy transfer to an onboard charger**
- **Current up to 400 amps**
- **Typically 60 kW to 120 kW, but can be up to 200 kW**
- **HOWEVER, no light-duty original equipment vehicle manufacturer plans to use onboard chargers at these energy levels**

DC Fast Charging

- Expected to be used in an intercity grid pattern or along travel routes between cities in commercial settings
- Off-board charger (high cost, large volume and weight)
- Used for DC energy transfer to vehicle
- Requires most charger-to-vehicle communication and control
- No current U.S. SAE standard connector, however, U.S. fast chargers are using Japanese TEPCO (Tokyo Electric Power Company) connector per CHAdeMO protocol
- Up to 500VDC and 125A. 60 kW likely
- Charge Times are dependent on battery size
  - BEV intent is 50% recharge in 15 minutes and 80% recharge in 30 minutes
  - Charge times dependant on charger / battery relative sizing
  - Generally not used for PHEVs due to small relative battery sizes

Examples of DC Fast Charging

Selecting the Charger Type & Rate

- AC (On-board DC Charger)
  - Level 1
    - Convenience charge cord typically provided with PEV used for emergency purposes.
    - Charge times range from 6+ hours (PHEV) to 24+ hours (BEV)
    - Could be used to charge PHEV on a daily basis but dissatisfaction can occur if PHEV does not fully charge
  - Level 2
    - 240VAC EVSE connected to dedicated branch circuit
    - Charge times range from 2 hours (PHEV) to 8 hours (BEV)
    - Good for Malls, Movie theatres, Work Place

Selecting the Charger Type & Rate (cont'd)

- DC (Off-board Charger)
  - Level 2 (>20kW and up to 80kW)
    - 50kW is currently the most common power output today
    - Provides 3-5 miles / minute of charge
    - Good for City corridors, convenience stores and fast food restaurants

Overview of Authorities, Codes, Standards

- **Automotive**
  - **SAE (Society of Automotive Engineers)**
  - **JARI (Japan Automotive Research Institute)**
    - **CHAdeMO DC Fast Charge Standard (Japan)**
  - **ISO (International Organization for Standardization)**
- **PEV Connector and Equipment Safety**
  - **SAE J1772 PEV Conductive Charge Connector**
  - **IEC 61851 PEV Conductive Charging System (International Electrotechnical Commission)**
  - **IEC 62196 Industrial plugs and sockets-outlets**
  - **OSHA (Occupational Safety and Health Administration) Nationally Recognized Testing Laboratory (NRTL)**
    - **UL 2594 Electric Vehicle Supply Equipment**
  - **NEC 625 (National Electrical Code) Electric Vehicle Charging System**
  - **Permitting and inspection authority having jurisdiction (AHJ)**

Installation Requirements

- Local Authority Having Jurisdiction (AHJ) Permitting and Inspection Requirements
- Licensed/Bonded/Insured Electrician
- Circuit Requirements
  - Level 1
    - Dedicated 125VAC / 15A or 20A branch circuit
  - Level 2
    - Dedicated 240VAC / 40A (typical) branch circuit
    - Up to 80A (100A branch circuit) allowed by SAE
  - DC Fast Charger
    - 208VAC/3 Phase or 480VAC/3 Phase
    - Breaker sized appropriately to power level

Commercial Site Considerations

- Geographic Coverage / Planning
- Local attraction(s)
- Proper charger level for location
- ADA Requirements
- Lighting / Security
- Signage
- Access
- Local Permitting Authority

- EVSE deployment guidelines by ECOtality North Amercia can be found at:

  www.theevproject.com/documents

Signage Example

Ignoring The Signage Example

INL / AVTA Electric Drive Vehicle Testing

AVTA Vehicle Testing Approach

- Depending on vehicle technology and capabilities, vehicles are tested via:
  - Closed test tracks
  - Dynamometer testing
  - Laboratory testing (batteries)
  - Accelerated testing, using dedicated drivers and other methods to accumulate miles and cycles
  - Fleet testing, uses unstructured vehicle utilization
  - Different testing methods are used to balance testing control/repeatability, sample size, and costs
- Current INL staff has used onboard data loggers to document vehicle and charging operations since 1993
- Publish testing results in relevant ways to accurately
  - Document real-world petroleum reduction potentials
  - Document fuel and infrastructure use
  - Document life-cycle risks and costs

Testing by Vehicle Technology

- Plug-in hybrid electric vehicles (PHEVs)
  - 12 models, 259 vehicles, 3 million test miles
- Hybrid electric vehicles (HEVs)
  - 22 models, 56 vehicles, 5+ million test miles
- Neighborhood electric vehicles (NEVs)
  - 23 models, 200,000 test miles
- Hydrogen internal combustion engine (HICE) vehicles
  - 7 models, 500,000 test miles
- Full-size battery electric vehicles (BEVs)
  - 41 EV models, 5+ million test miles
- Urban electric vehicles (UEVs)
  - 3 models, 1 million test miles

- 15 million test miles have been accumulated on 1,600 electric drive vehicles representing 107 different electric drive models

PHEV Testing To Date

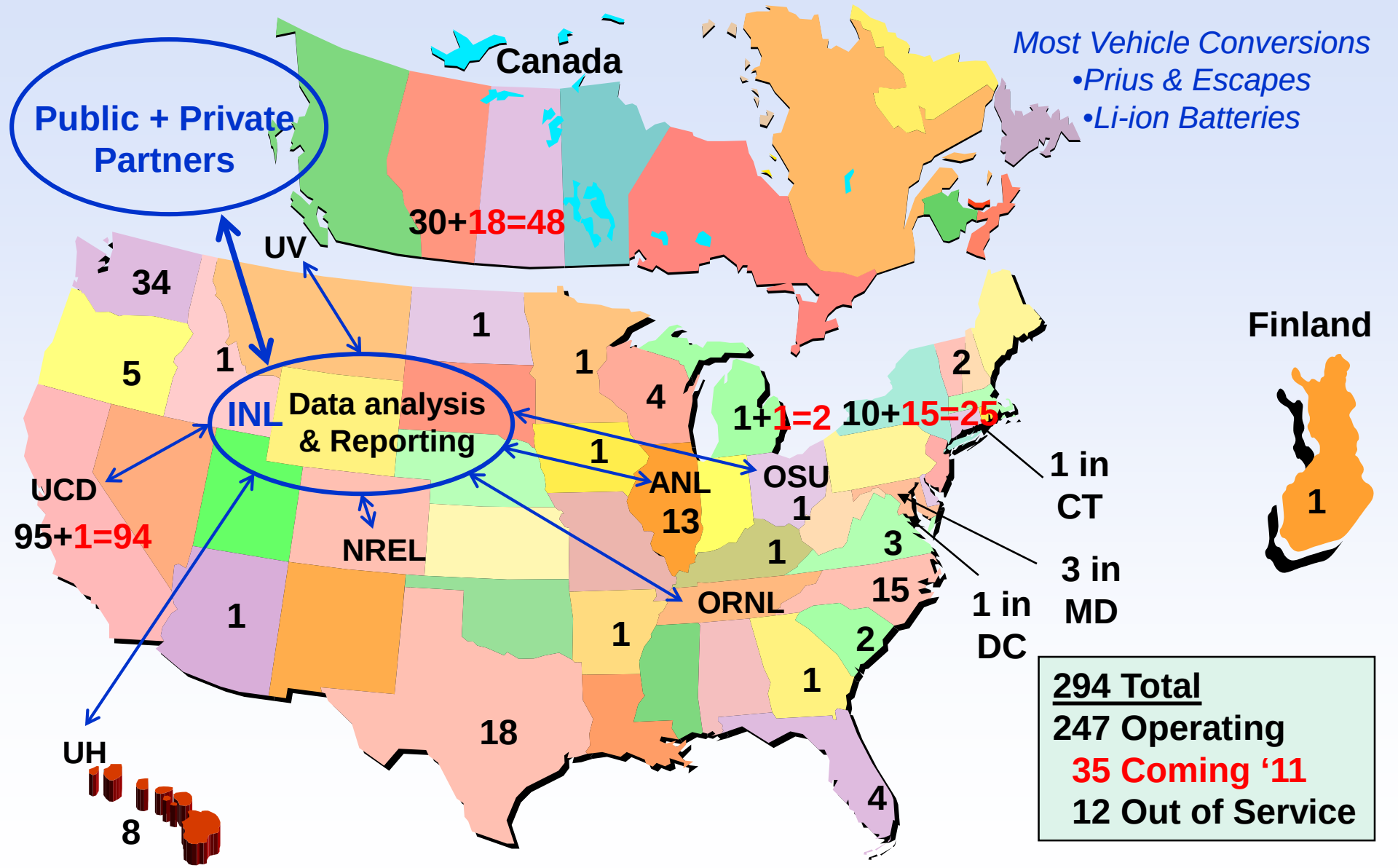
- 12 PHEV models tested to date
  - Hymotion Prius (A123 Systems)
  - Hymotion Escape (A123 Systems)
  - Ford E85 Escape (Johnson Controls/Saft)
  - EnergyCS Prius, 2 models (Valance and Altair Nano)
  - Electrovaya Escape (Electrovaya) - done
  - Hybrids Plus Escape, 2 models (Hybrids Plus and K2 Energy Solutions)
  - Hybrids Plus Prius (Hybrids Plus)
  - Manzanita Prius (lead acid and Thunder Sky)
  - Renault Kangoo (Saft NiCad) - done

  (Lithium unless noted)
- Testing focus is on the PHEV technology concept and batteries, and driver and environmental impacts on fuel efficiencies and charging rates, not on individual PHEV conversions

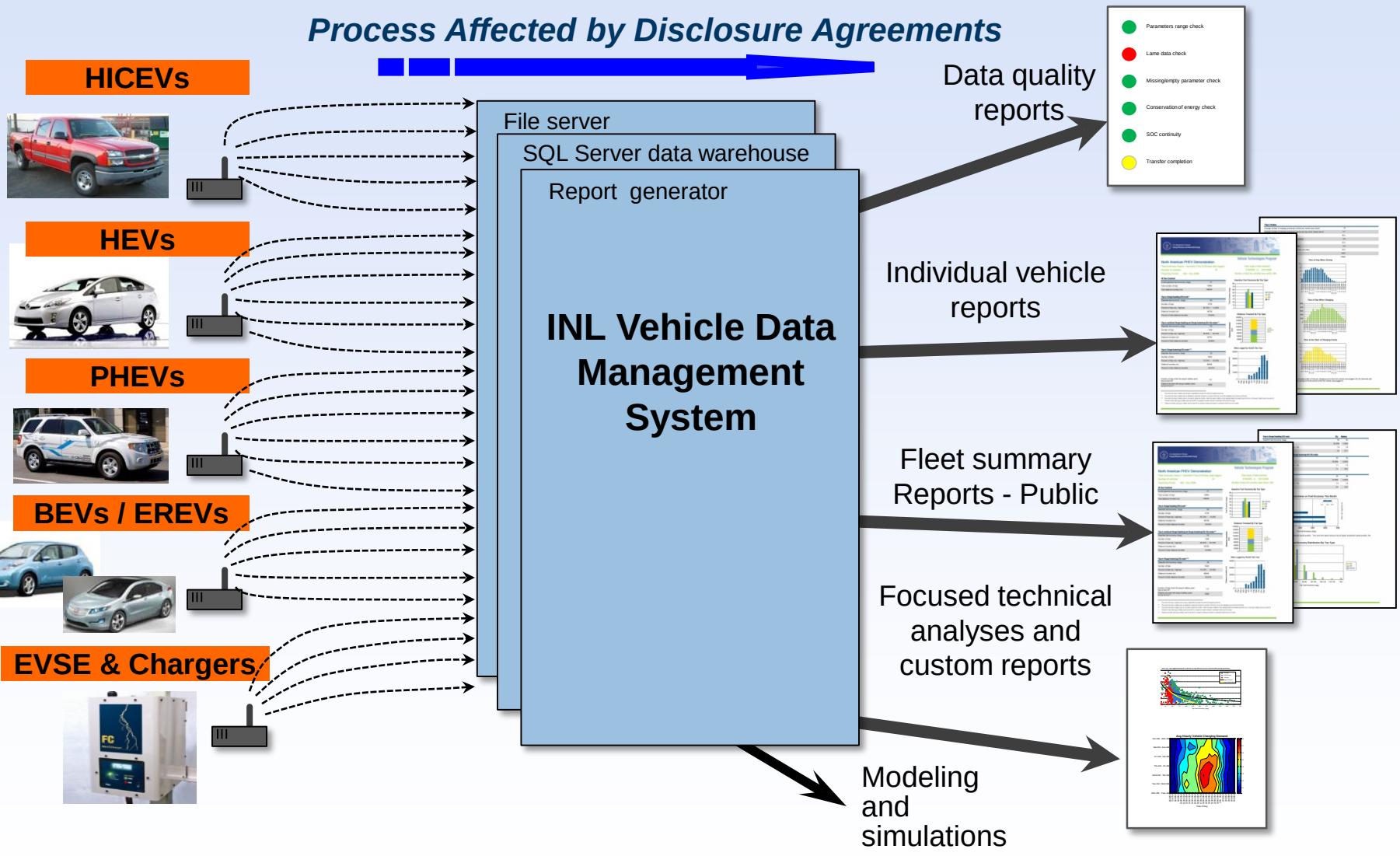
PHEV Testing Partners

- 259 PHEVs in 26 states, Canada and Finland, 3 million miles - AVTA only purchased 2 PHEVs and conducted 12 conversions. Highly leveraged testing activity
- 93 PHEV testing partners include:
  - 38 Electric utilities
  - 10 County governments
  - 4 State governments
  - 10 Canadian government groups
  - 3 Sea ports and military bases
  - 2 PHEV conversion companies
  - 5 Private companies and advocacy organizations
  - 9 City governments
  - 10 Universities
  - 2 Clean Air Agencies
- 3,000+ automated monthly 3-page summary reports have been generated and disseminated to testing partners

Current PHEV Conversion Demonstrations



Vehicle Data Management Process



Vehicle and Infrastructure Data Sources

Vehicle time-history data (1 second interval)	HEV and Start/Stop: 15 vehicle models, 1 data logger
	HICE: 1 vehicle model, 1 data logger
	Conversion PHEVs: 9 vehicle models, 3 data loggers
	USPS eLLV conversions: 5 models, Gridpoint wireless logger
	Ford Escape PHEV, Ford wireless logger
	Chrysler Ram PHEV, Chrysler wireless logger
Vehicle event data (key-on, key-off)	**Nissan** Leaf, Nissan/ATX telematics
	Chevrolet Volt, OnStar telematics
Charger event and time-history data (15 min interval)	**ECOtality** Blink networked level 2 EVSE and DC fast chargers
	Coulomb ChargePoint networked level 2 EVSE

Managing 29 different data models

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

North American PHEV Demonstration

Vehicle Technologies Program

Fleet Summary Report: Hymotion Prius (V2Green data logger)

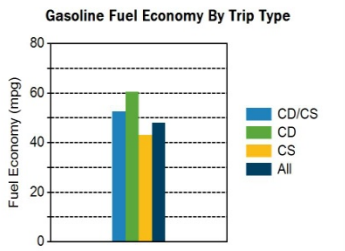
Number of vehicles: 197

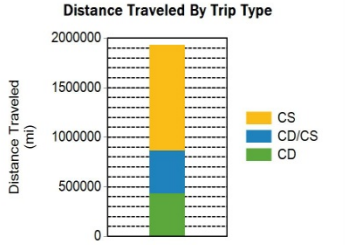
Reporting Period: Apr 08 - Aug 10

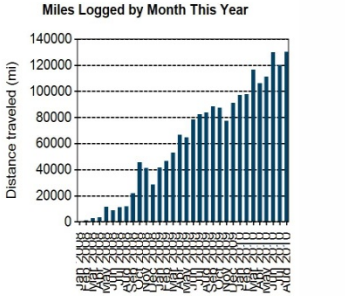
Date range of data received: 4/1/2008 to 8/31/2010

Number of days the vehicles were driven: 881

All Trips Combined	
Overall gasoline fuel economy (mpg)	48
Overall AC electrical energy consumption (AC Wh/mi) [1]	58
Overall DC electrical energy consumption (DC Wh/mi) [2]	37
Total number of trips	210,900
Total distance traveled (mi)	1,950,859
Trips in Charge Depleting (CD) mode [3]	
Gasoline fuel economy (mpg)	60
DC electrical energy consumption (DC Wh/mi) [4]	121
Number of trips	91,431
Percent of trips city / highway	86% / 14%
Distance traveled (mi)	431,953
Percent of total distance traveled	22%
Trips in both Charge Depleting and Charge Sustaining (CD/CS) modes [5]	
Gasoline fuel economy (mpg)	53
DC electrical energy consumption (DC Wh/mi) [6]	46
Number of trips	17,399
Percent of trips city / highway	50% / 50%
Distance traveled (mi)	430,460
Percent of total distance traveled	22%
Trips in Charge Sustaining (CS) mode [7]	
Gasoline fuel economy (mpg)	43
Number of trips	98,129
Percent of trips city / highway	76% / 24%
Distance traveled (mi)	1,067,850
Percent of total distance traveled	55%
Number of trips when the plug-in battery pack was turned off by the vehicle operator [8]	6448
Distance traveled with plug-in battery pack turned off by the vehicle operator (mi) [9]	174,634





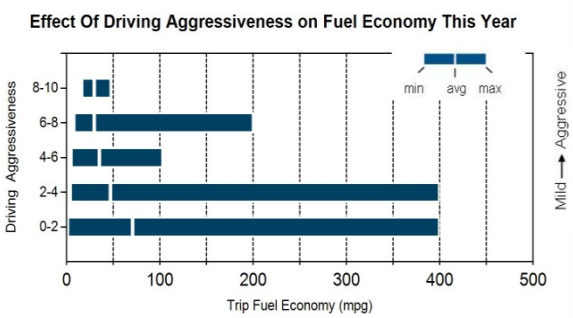


Notes: 1 - 9. Please see http://avt.inel.gov/phev/reportnotes for an explanation of all PHEV Fleet Testing Report notes.

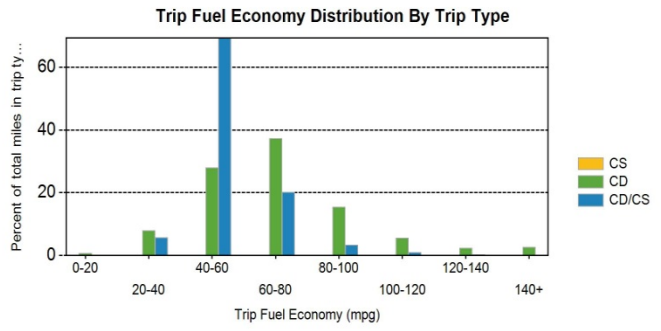
PHEV 3-Page Report

- Reports 2 million Hymotion Prius test miles and 211,000 trips
- Report by charge mode:
  - Charge depleting (CD)
  - Charge sustaining (CS)
  - Mixed (CD/CS)
- All trips, 48 mpg, 58 AC Wh/mi & 37 DC Wh/mi
- CD, 60 mpg & 121 DC Wh/mi
- CD/CS, 53 mpg & 46 DC Wh/mi
- CS, 43 mpg

Trips in Charge Depleting (CD) mode	City	Highway
Gasoline fuel economy (mpg)	58	64
DC electrical energy consumption (DC Wh/mi)	146	90
Percent of miles with internal combustion engine off	31%	13%
Average trip aggressiveness (on scale 0 - 10)	1.7	1.7
Average trip distance (mi)	3.1	15.2
Trips in both Charge Depleting and Charge Sustaining (CD/CS) modes		
Gasoline fuel economy (mpg)	53	52
DC electrical energy consumption (DC Wh/mi)	75	41
Percent of miles with internal combustion engine off	26%	8%
Average trip aggressiveness (on scale 0 - 10)	1.7	1.6
Average trip distance (mi)	7.8	41.6
Trips in Charge Sustaining (CS) mode		
Gasoline fuel economy (mpg)	37	45
Percent of miles with internal combustion engine off	23%	7%
Average trip aggressiveness (on scale 0 - 10)	1.9	1.7
Average trip distance (mi)	3.4	34.6



Aggressiveness factor is based on accelerator pedal position. The more time spent during a trip at higher accelerator pedal position, the higher the trip aggressiveness.

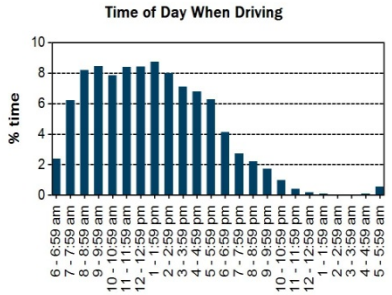


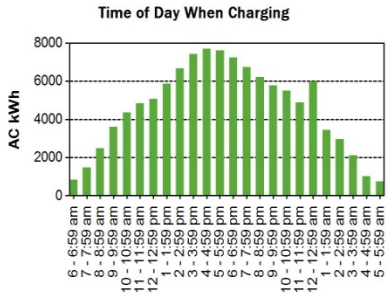
PHEV 3-Page Report

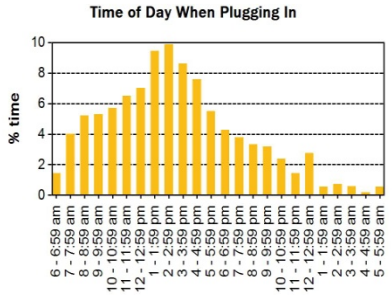
- Report fuel use by highway/city cycles and driver style
- CD city, 58 mpg, 146 DC Wh/mi
- CD highway, 64 mpg, 90 DC Wh/mi
- CS city, 37 mpg
- CS highway, 45 mpg
- Less aggressive driving (0 to 20%) averages ~70 mpg
  - (Aggressiveness = accelerator pedal position)

Plug-in charging

Average number of charging events per vehicle per month when driven	14
Average number of charging events per vehicle per day when vehicle driven	1.0
Average distance driven between charging events (mi)	47.0
Average number of trips between charging events	5.1
Average time plugged in per charging event (hr)	22.3
Average time charging per charging event (hr)	2.8
Average energy per charging event (AC kWh)	2.7
Average charging energy per vehicle per month (AC kWh)	37.8
Total number of charging events	41,515
Total charging energy (AC kWh)	112,465



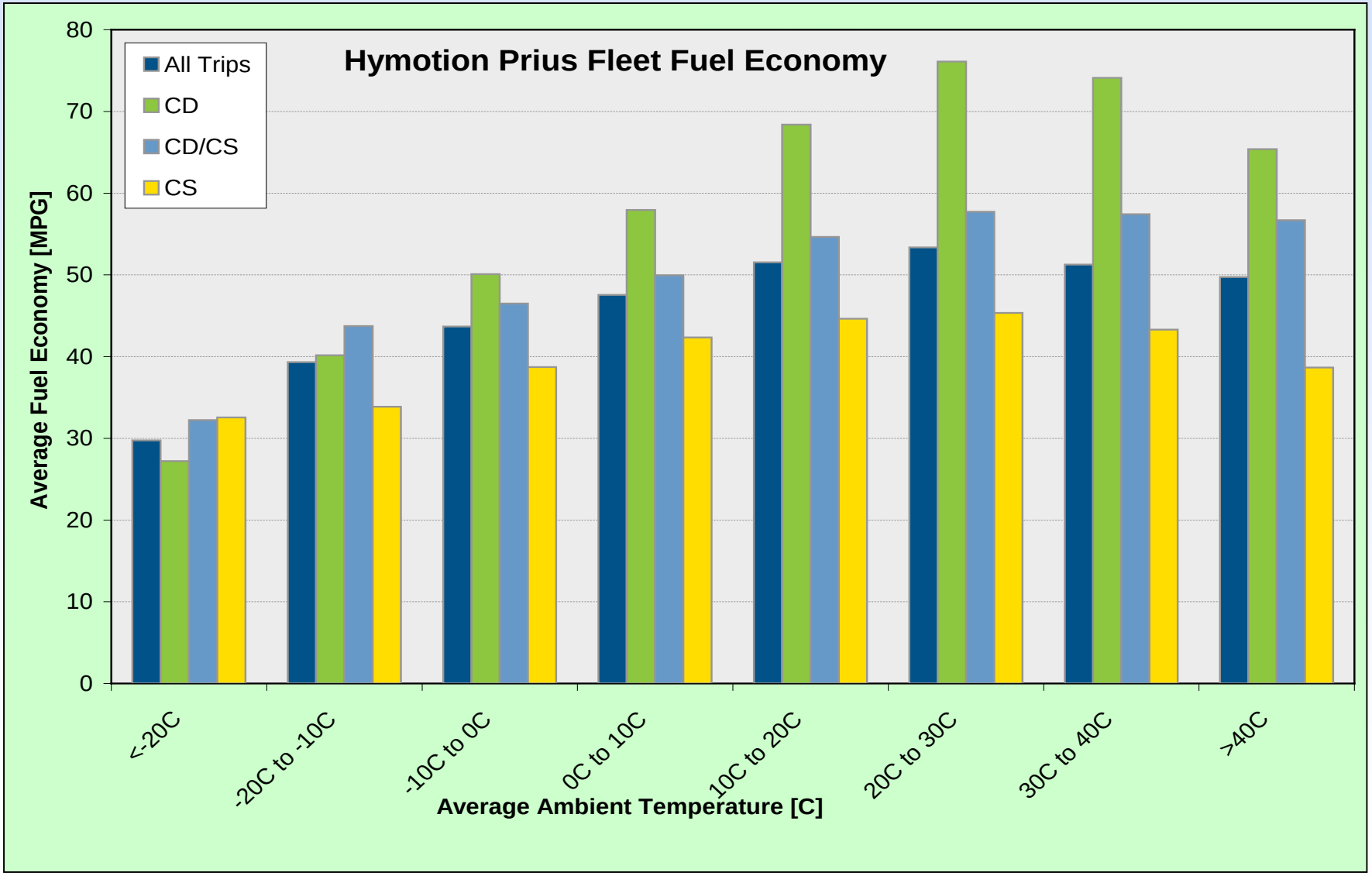




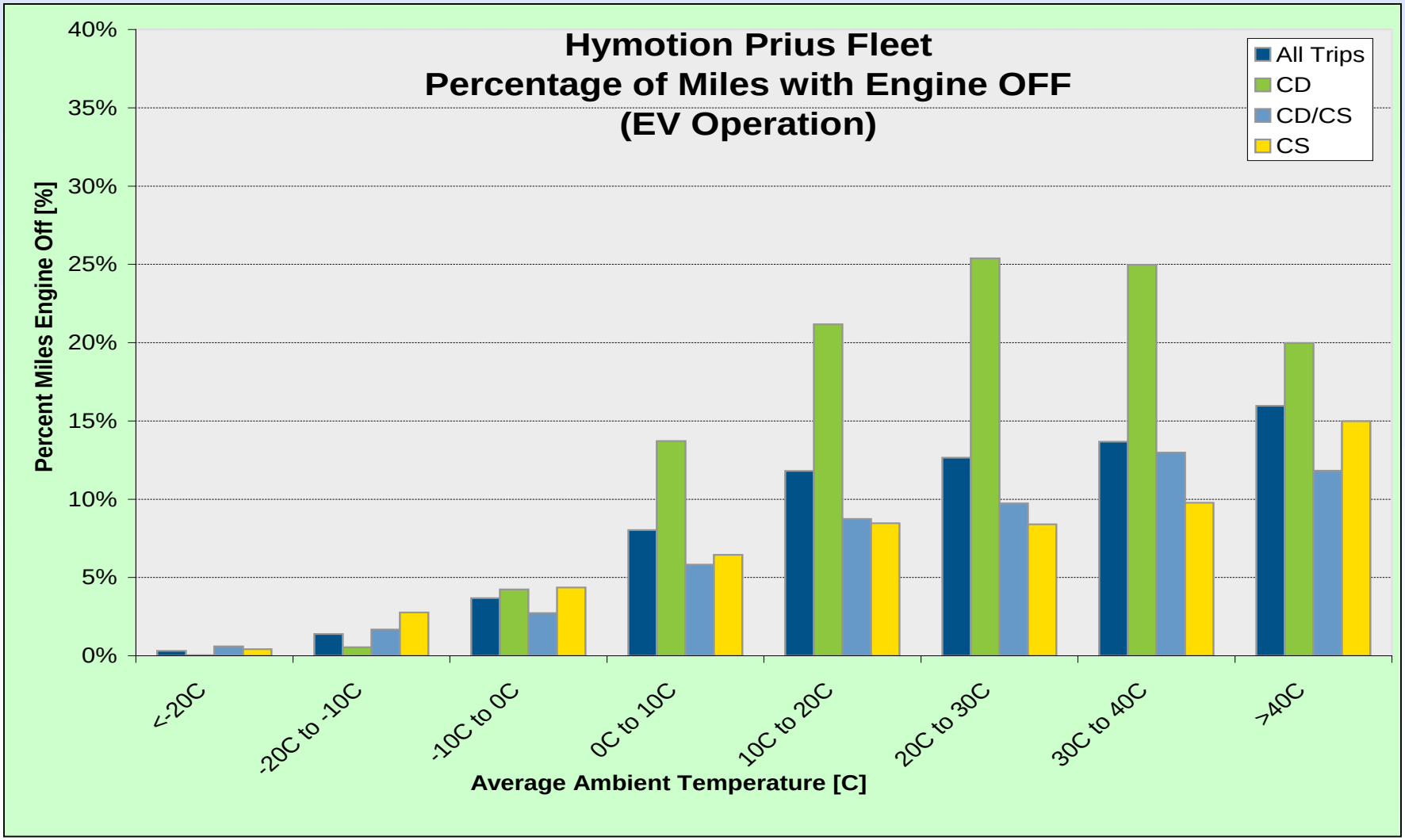
PHEV 3-Page Report

- Report charging stats, time of day driving, and charging profiles
- Average 1 charging event per day when PHEV driven
- 47 miles between charge events
- 5.1 trips between charge events
- 2.8 hours per charge
- 22.3 hours time plugged in per charge
- 2.7 AC kWh per charge event

PHEV Ambient Temperature MPG Impacts

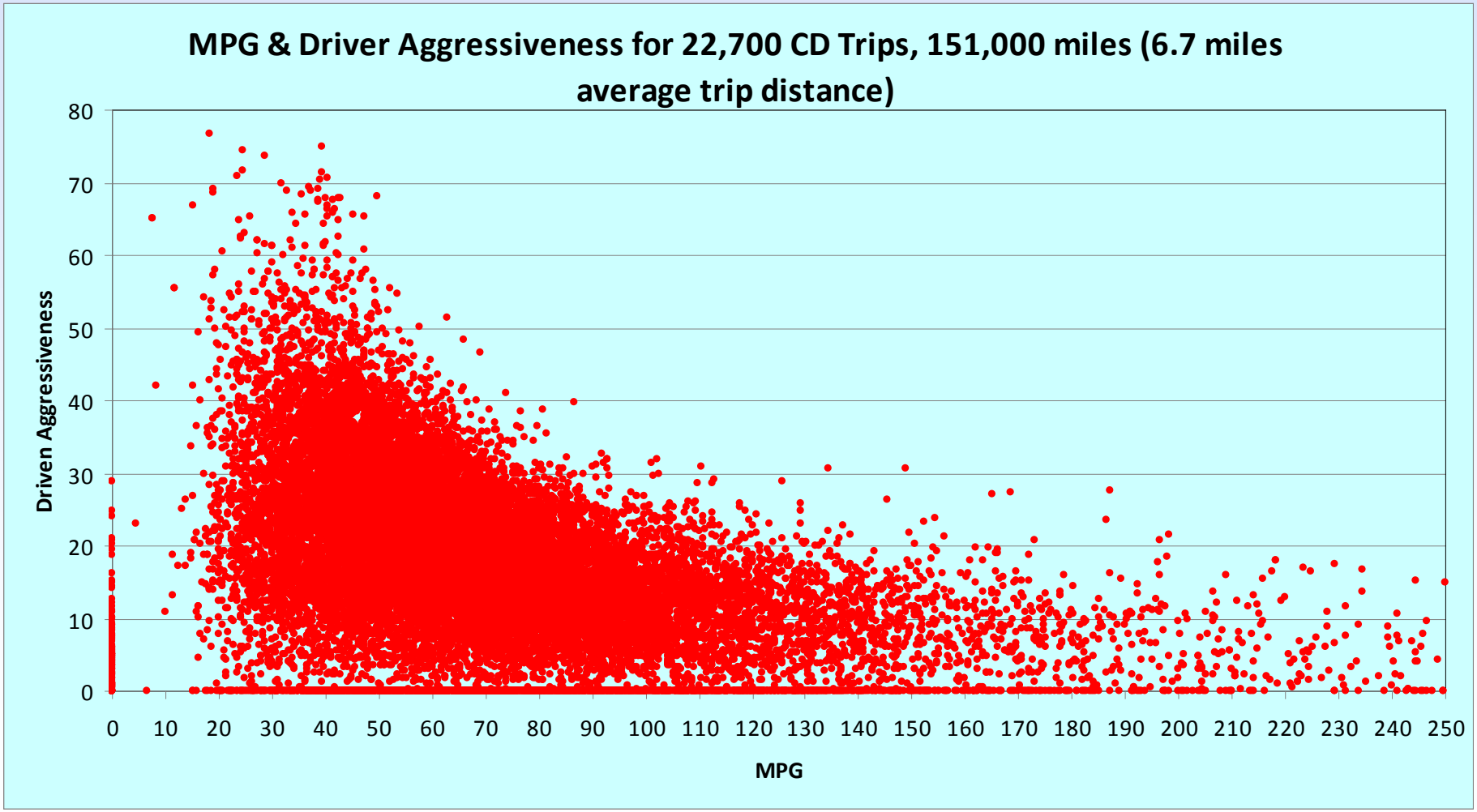


Engine Operation is a Main Factor for PHEV Fuel Economy Changes



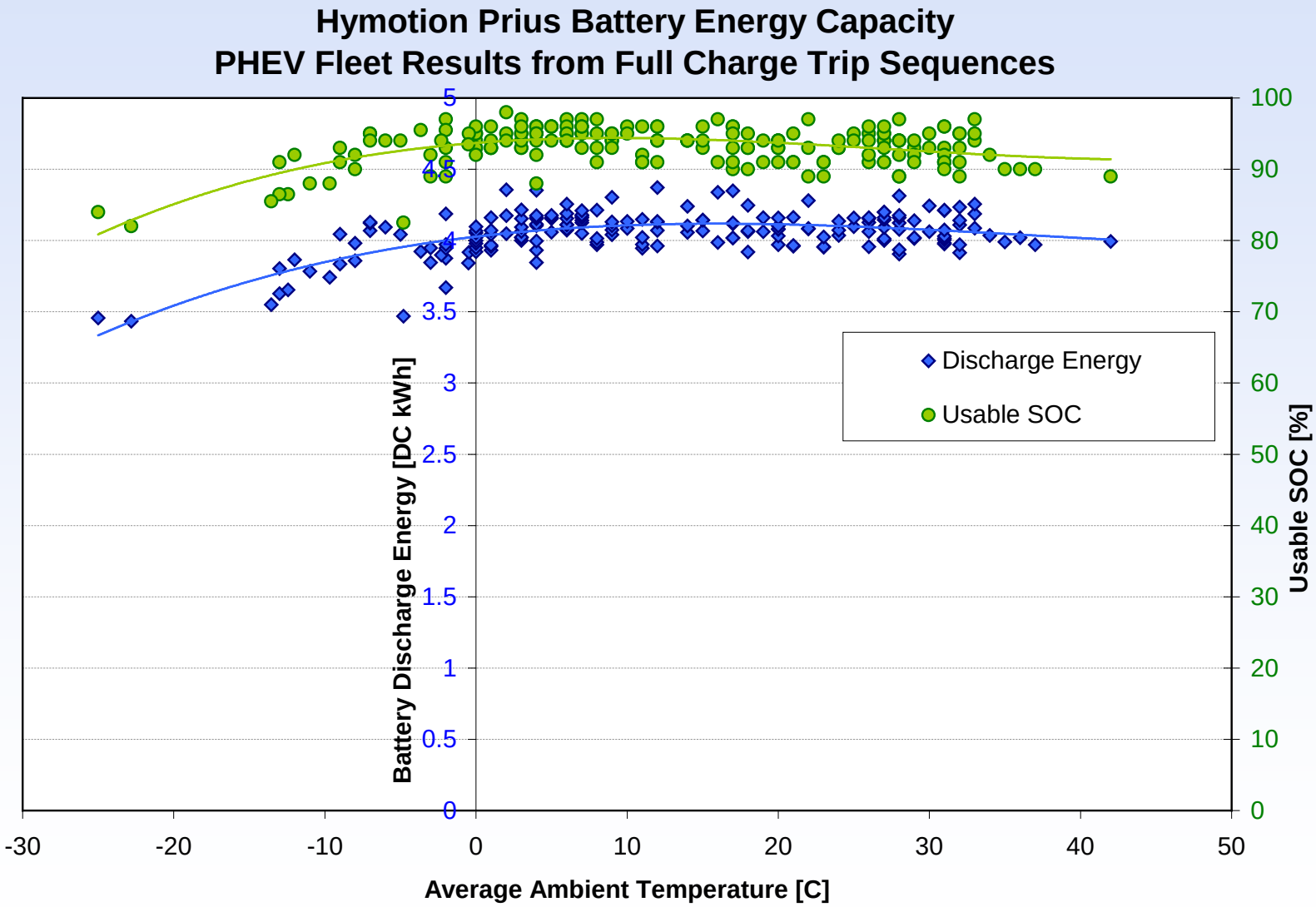
Hymotion Prius PHEVs – CD Trips

- **MPG and aggressive driving impacts March '08 – May '09**

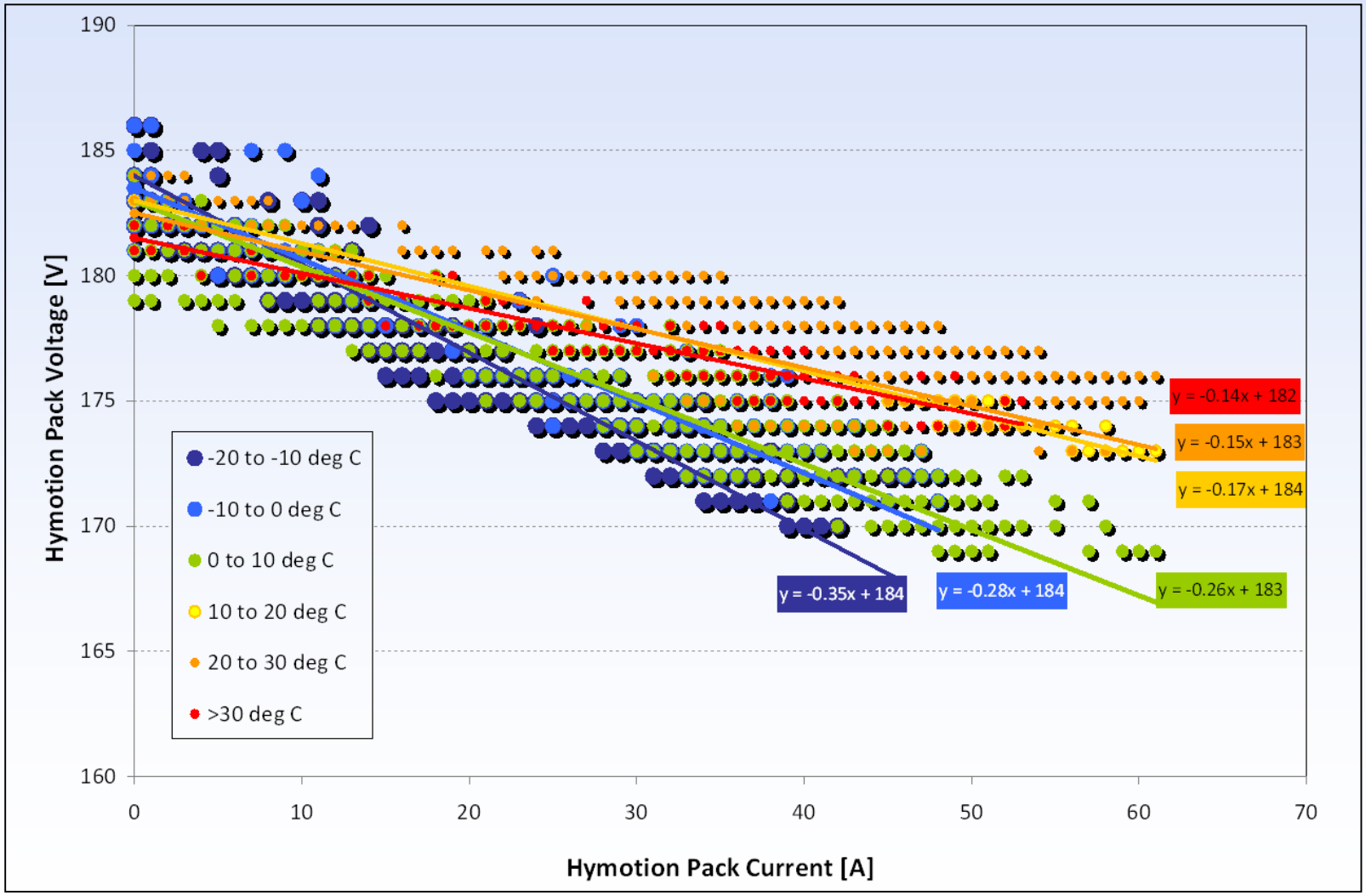


Data from 150 Hymotion Prius with V2Green and Kvaser loggers

Usable Battery Capacity is Slightly Effected by Temperature

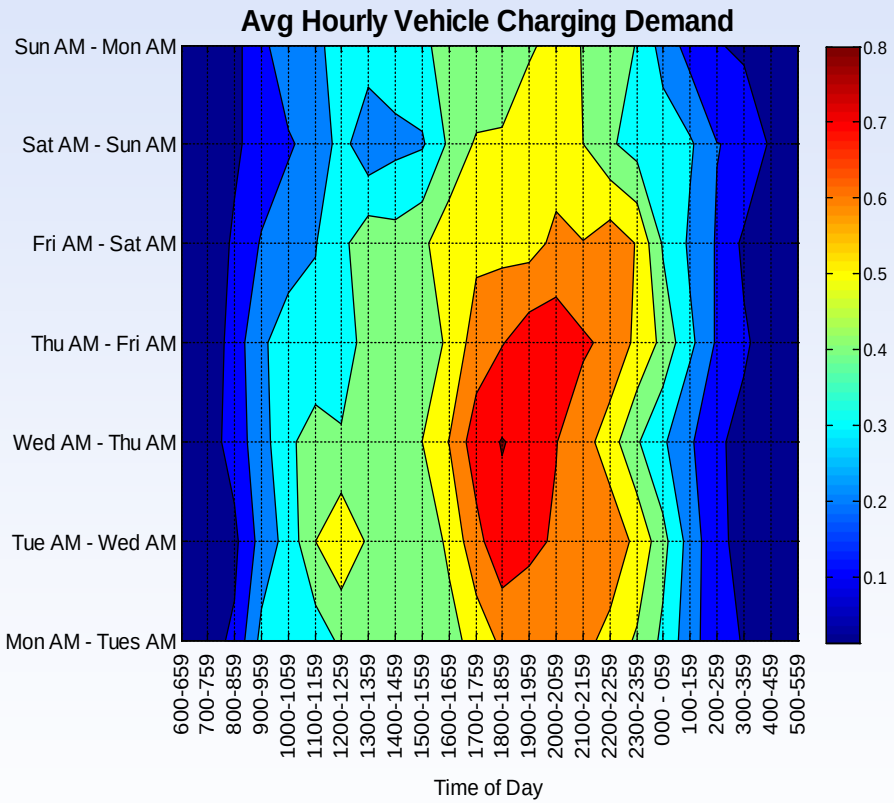


Hymotion Li-Ion Battery Internal Resistance Change with Temperature

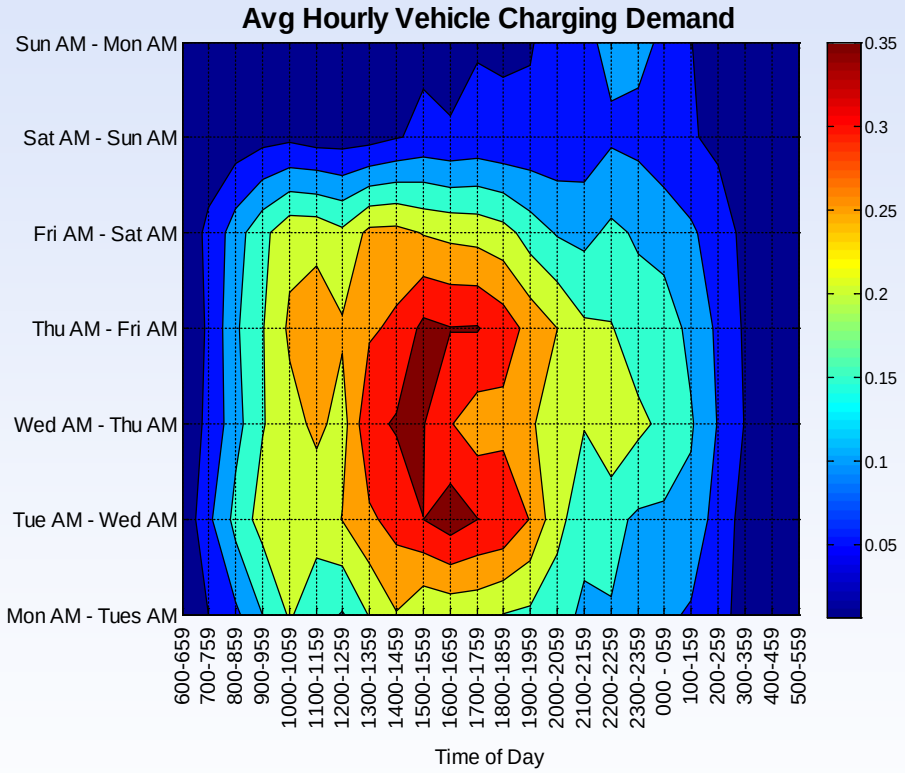


Commercial / Private Fleet Charge Demand

Private Fleet



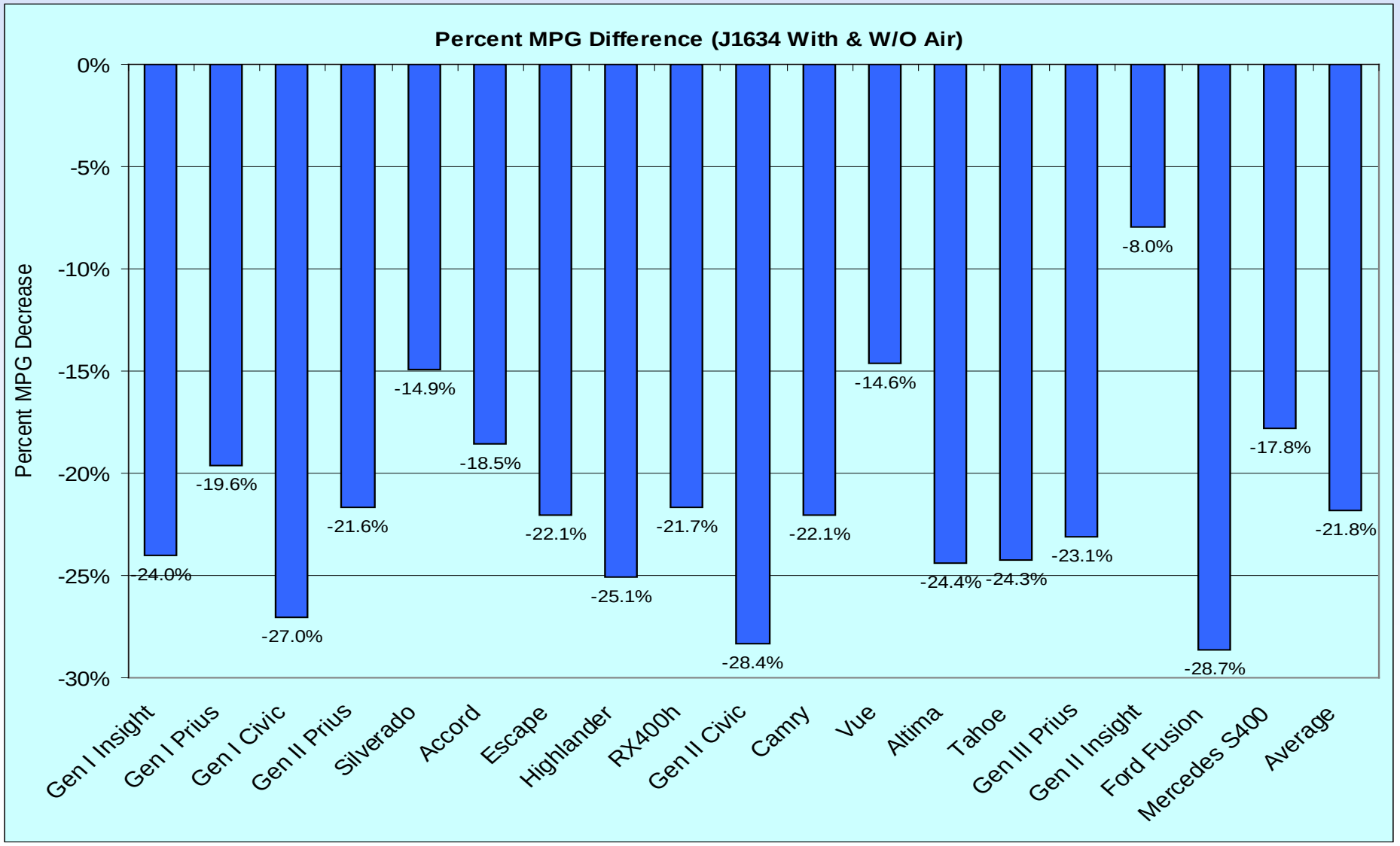
Commercial Fleet



HEV Testing

- 5 million total HEV testing miles
- 22 HEV models and 56 HEVs tested to date:
  - 6, 2001 Honda Insight
  - 6, 2002 Gen I Toyota Prius
  - 4, 2003 Gen I Honda Civic
  - 2, 2004 Chevrolet Silverado
  - 2, 2004 Gen II Toyota Prius
  - 2, 2005 Ford Escape
  - 2, 2005 Honda Accord
  - 3, 2006 Lexus RX 400h
  - 2, 2006 Toyota Highlander
  - 2, 2006 Gen II Honda Civic
  - 2, 2007 Saturn Vue
  - 2, 2007 Toyota Camry
  - 2, 2008 Nissan Altima
  - 2, 2008 GM 2-mode Tahoe
  - 2, 2010 Ford Fusion
  - 2, 2010 Toyota Prius
  - 2, 2010 Honda Insight
  - 2, 2010 Mercedes Benz S400
  - 2, Honda CRZ
  - 3, 2010 Smart Fortwo Pure Coupe
  - 2, 2010 Mazda 3 Hatchback
  - 2, 2010 Volkswagen Golf TDI.
- HEV testing includes beginning and high mileage HEV traction battery testing – HPPC, Static Capacity tests, as well as acceleration and fuel economy tests

HEV Air Conditioning use MPG Impacts



HEV Maintenance Sheets

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

HEV Fleet Testing

Advanced Vehicle Testing Activity

Maintenance Sheet for 2007 Nissan Altima

VIN # 1N4CL21E27C177982

Date	Mileage	Description	Cost
1/31/2008	4,856	Changed oil	$25.45
2/18/2008	9,817	Changed oil	$35.84
4/8/2008	18,289	Changed oil and filter	$27.85
5/27/2008	30,947	Changed oil and filter	$30.24
7/7/2008	39,387	Changed oil and filter	$32.58
8/5/2008	48,243	Changed oil and filter, replaced air filter and cabin air filter, exchanged coolant, filled air conditioning coolant, and rotated tires	$259.08
8/22/2008	52,506	Changed oil and filter	$28.08
9/9/2008	58,349	Changed oil and filter	$28.31
9/25/2008	63,648	Changed oil and filter, exchanged coolant, replaced cabin air filter, and purchased tire life preventative maintenance package	$444.64
10/13/2008	66,826	Changed oil and filter	$28.08
11/3/2008	72,156	Changed oil and replaced, balanced, and aligned two front tires	$207.32
11/7/2008	73,172	Changed oil and filter	$28.08
12/4/2008	79,464	Changed oil and filter and rotated tires	$35.10
1/14/2009	91,050	Changed oil and filter	$28.08
2/11/2009	99,340	Changed oil and air filters and balanced two tires	$268.34
3/25/2009	111,501	Changed oil and filter, replaced alternator belt and replaced wiper blades	$125.56
4/17/2009	117,676	Changed oil and filter, replaced front and back brake pads and shoes, and turned rear rotors	$414.26
5/1/2009	122,141	Changed oil and filter and replaced air filter	$48.56
6/1/2009	133,892	Changed oil and filter and installed and balanced two tires	$321.34
6/19/2009	142,317	Changed oil and filter	$28.21
7/20/2009	154,225	Changed oil and filter	$28.21
7/24/2009	154,986	Installed and balanced two tires	$229.10

eere.energy.gov

2-Page HEV Fleet Testing Fact Sheets

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy | VEHICLE TECHNOLOGIES PROGRAM

HEV Fleet Testing

2006 Toyota Highlander Hybrid

Final Fleet Testing Results

Operating Statistics

Number of Vehicles Tested: 2

Distance Driven[1]: 297,852 mi

Average Trip Distance[2]: 13.8 mi

Stop Time with Engine Idling[2]: 23%

Trip Type City/Highway[2]: 74%/26%

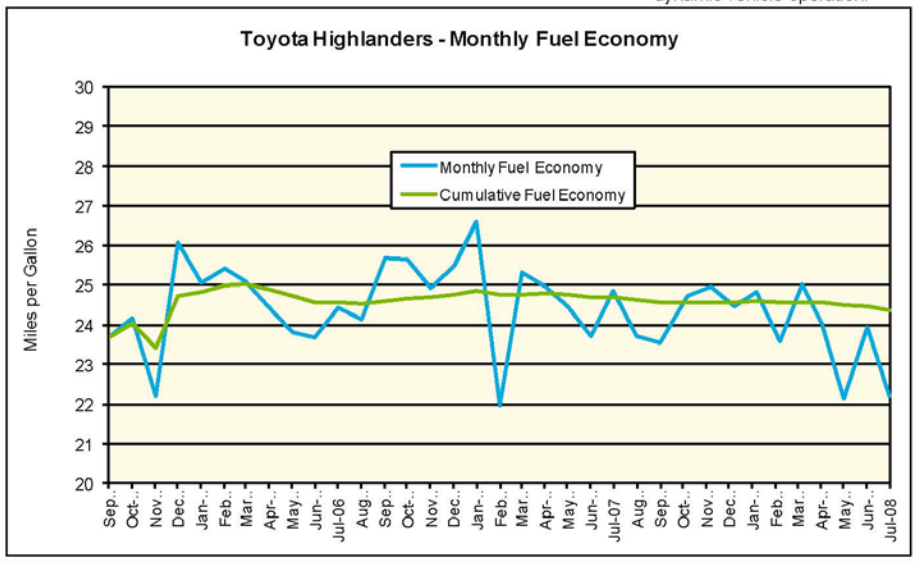
Operating Performance

Cumulative MPG[1]: 24.4

See HEV America Baseline Performance and Fleet Testing Fuel Economy fact sheets for more information on vehicle specifications and fuel usage reporting, available at http://avt.inl.gov/

Test Notes

1. Calculated over the life of the vehicle based on odometer reading and fuel logs. More information available in Fleet Testing Fuel Economy sheet.
2. Calculated from electronic data logged over a subset of total miles traveled equal to 118,838 miles.
3. Fuel economy calculated for this figure using mass air flow over dynamic vehicle operation.



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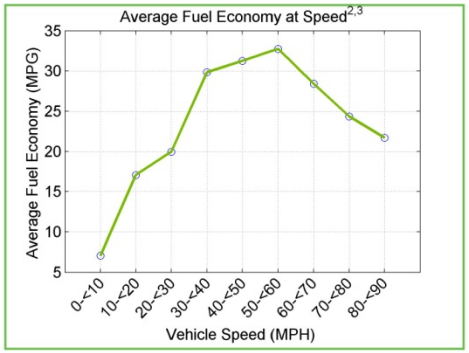
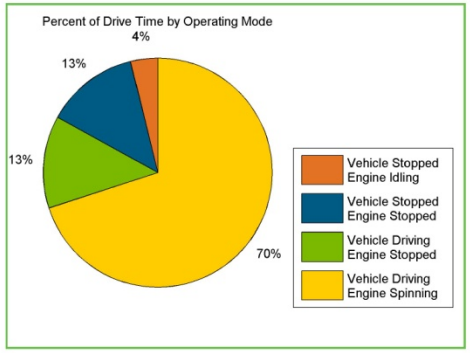
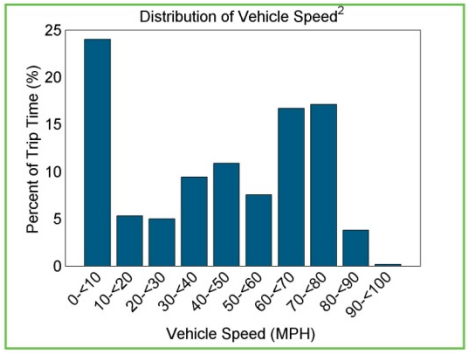
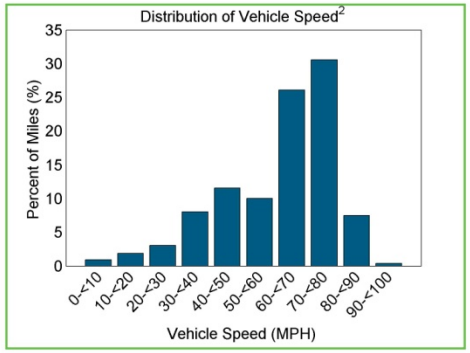
INL Idaho National Laboratory | U.S. DEPARTMENT OF ENERGY

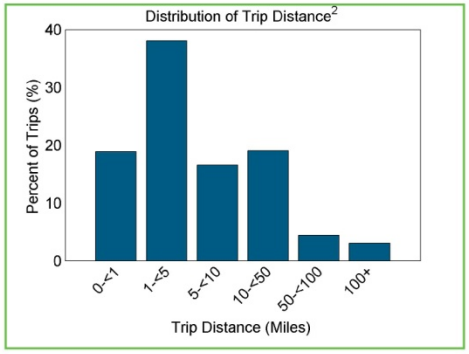
2-Page HEV Fleet Testing Fact Sheets – cont'd

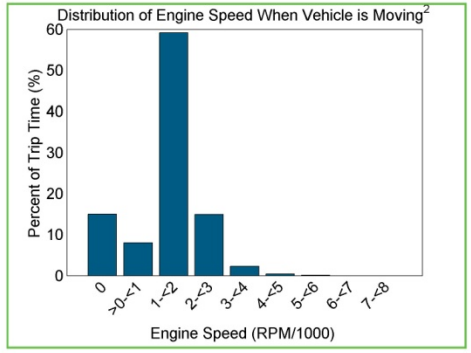






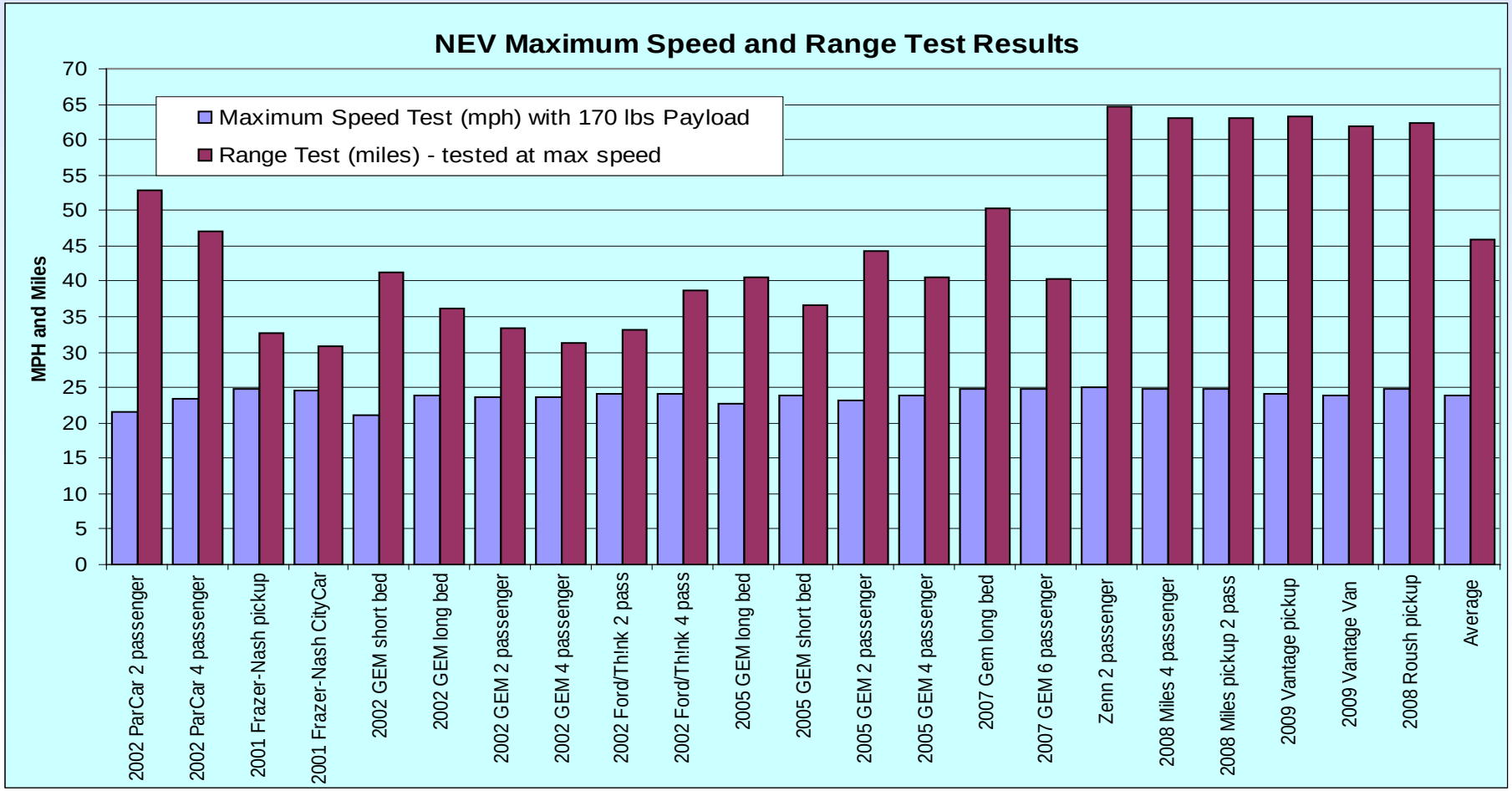




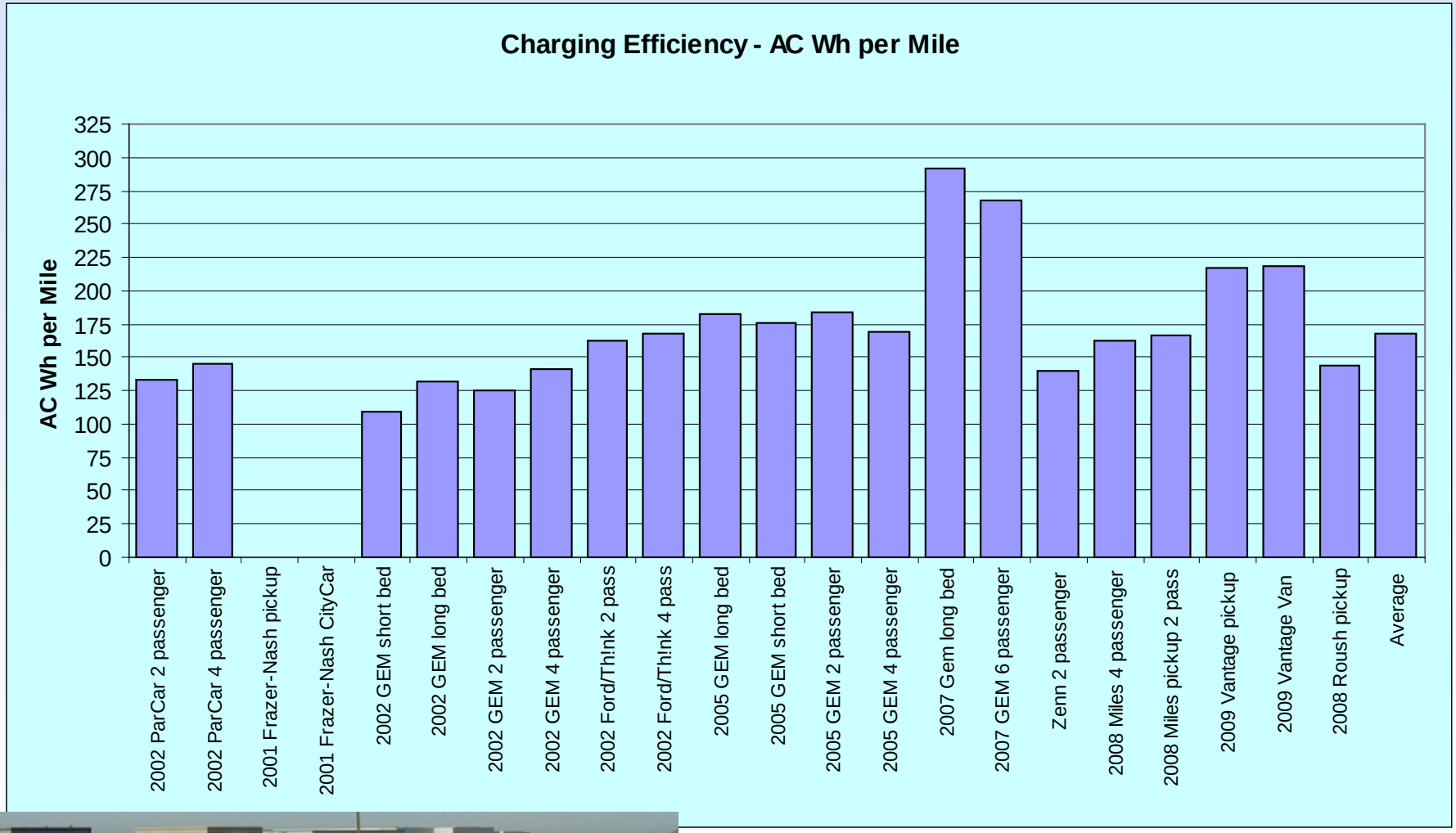


NEV Testing

- **CARB requires all NEVs be tested by AVTA to be eligible for incremental funding – 25 models tested to date**



AVTA NEV Testing – cont'd



American Recovery and Reinvestment Act (ARRA) – DOE's Transportation Electrification Demonstrations and Educations Programs

American Recovery and Reinvestment Act (ARRA)

- $2 Billion in DOE grants to establish advanced battery, power electronics and motors manufacturing
- $400 Million for Transportation Electrification Demonstration, Infrastructure, and Education
  - 8 Awards totaling over $360M for grid-connected vehicle and infrastructure demonstrations
    - 13,000 vehicles from 9 OEMs and over 22,000 charging stations will be deployed across America
    - Vehicle performance and grid impact data will be gathered and analyzed to support the development of vehicle technologies and grid infrastructure
  - 10 Grants totaling $39M - establish comprehensive educational and outreach programs to educate first responders and emergency personnel for dealing with EV and PHEV accidents
    - Also, public outreach

Transportation Electrification Demonstration Activities

Electric Transportation Engineering Corporation - AWARD: $114.8M

- Demonstration of 5,700 Nissan Leaf EVs and 2,600 Chevy Volt EREVs
- Deployment of 15,000 Level 2 electric vehicle supply equipment (EVSE) charging Stations (EVSE) and 300 fast chargers, in 16 metropolitan areas
- Full instrumentation of vehicles and infrastructure for comprehensive data-collection and analysis effort

Chrysler, LLC - AWARD: $48M

- Development, validation, and deployment of 140 PHEV Dodge Ram pickups
- Deployment of vehicles through 11 partner fleets across a wide range of geographic, climatic, and operating environments

Transportation Electrification Demonstration Activities (cont'd)

South Coast Air Quality Management District - AWARD: $45.4

- Development of a fully integrated production PHEV system for Class 2-5 vehicles (8,501-19,500 lbs GVWR).
- Demonstration of 378 trucks and shuttle buses through network of partner fleets
- SCAQMD based in Diamond Bar, CA; Manufactured in Galesburg, MI, and Elizabethtown, KY

Coulomb Technologies - AWARD: $15M

- Deployment of approximately 4,000 public and private charging stations in up to 9 U.S. Cities
- Locations will be coordinated with OEM deployment of 400 grid connected vehicles

Transportation Electrification Demonstration Activities (cont'd)

Navistar, Inc. - AWARD: $39.2M

- Develop, validate, deploy 950 advanced Battery Electric delivery trucks (12,100 lbs GVWR) with a 100-mile range
- Manufacturing in Elkhard Co., IN; Deployment in Portland, Chicago, and Sacramento

Cascade Sierra Solutions - AWARD: $22.2M

- Deployment of truck stop electrification infrastructure at 50 sites along major US interstate corridors
- Provide 5,450 rebates of 25% of the cost for truck modification to incorporate idle reduction technologies

Transportation Electrification Demonstration Activities (cont'd)

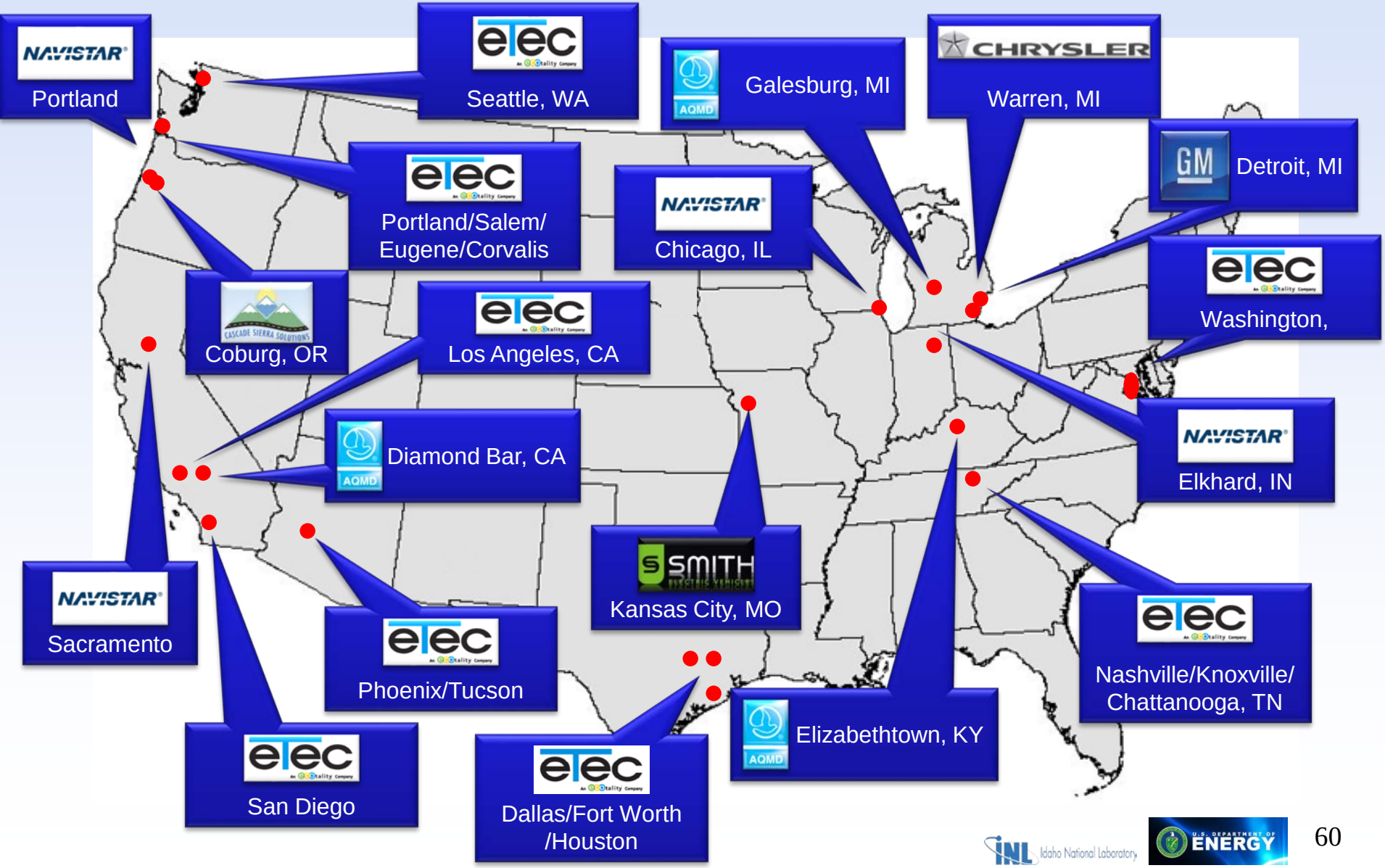
General Motors - AWARD: $30.5M

- Develop, analyze, and demonstrate 125 Chevy Volt EREVs for electric utilities and 500 Volt EREVs to consumers
- Manufacturing in Detroit, MI; Deployment in conjunction with several utility partners

Smith Electric Vehicle - AWARD: $32M

- Develop and deploy up to 500 medium-duty electric trucks.
- Manufacturing in Kansas City, MO; Deployment in conjunction with 20 launch partners representing a range of commercial and public sector markets, geographies, and climates

Transportation Electrification Distribution



Transportation Electrification Education Program

Award Recipient	DOE Award	Project Locations	Project Focus
West Virginia University (National Alternative Fuels Training Consortium)	$6.9M	Morgantown, WV State of South Carolina	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public •Partnering with: NAFTC Headquarters and members; West Virginia Department of Education; South Carolina Department of Education; Greater New Haven Clean Cities Coalition; Innovation Drive, Inc.; Advanced Vehicle Research Center; Auto Exposure LLC; Big Fish Advertising and Public Relations; MotorWeek; Sabre Engineering; Northeast Utilities
Purdue University	$6.1M	State of Indiana West Lafayette, IN	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; General Public •Partnering with: University of Notre Dame; Indiana University Purdue University at Indianapolis (IUPUI); Purdue University – Calumet; Indiana University – Northwest; Ivy Tech Community College
Colorado State University	$5M	State of Colorado State of Georgia Fort Collins, CO Boulder, CO Atlanta, GA	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public •Partnering with: CSU; Georgia Institute of Technology; Arapahoe Community College; Douglas County School System; Nissan NA; KShare; Ricardo; AM General; Motion Reality, Inc.
Missouri University of Science & Technology	$5M	Rolla, MO Warrensburg, MO Linn, MO St. Louis, MO Kansas City, MO Lee's Summit, MO	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Mechanics; Emergency Responders; General Public •Partnering with: University of Central Missouri; Linn State Technical College; St. Louis Science Center; Smith Electric Vehicles U.S. Corporation (SEV-US); Kokam America Inc.

Transportation Electrification Education Program (cont'd)

Award Recipient	DOE Award	Project Locations	Project Focus
Wayne State University	$5M	Detroit, MI Warren, MI	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public •Partnering with: NextEnergy; Macomb Community College
National Fire Protection Association	$4.4M	Quincy, MA	•Educational programs for: Emergency Responders •Partnering with: Fire Protection Research Foundation; Automotive Alliance; NREL
Michigan Technological University	$2.98M	Houghton, MI (Western Upper Peninsula of MI)	•Educational programs for: Graduate, Undergraduate and Secondary Students; General Public •Partnering with: Argonne National Laboratory; AVL; GM; Eaton; Horiba; MathWorks; Schweitzer Engineering Laboratories; Woodward
University of Michigan	$2.5M	Detroit, MI Ann Arbor, MI Dearborn, MI Flint, MI	•Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; General Public •Partnering with: University of Michigan – Dearborn; Kettering University; Ford; GM; Chrysler; Eaton Corp; DTE Energy; Mentor Graphics; Ballard; Quantum Technologies; A123 Systems
J. Sargeant Reynolds Community College	$0.72M	Commonwealth of Virginia and Neighboring Mid-Atlantic States	•Educational programs for: Secondary Students; Technicians •Partnering with: James Madison University; Virginia Department of Education; Ford; GM; Toyota; Firestone/Bridgestone
City College of San Francisco	$0.5M	San Francisco, CA	•Educational programs for: Secondary Students; Service Personnel, Technicians •Partnering with: Chabot College; Central Shops; Pat's Garage; Perfect Sky Inc.

INL Data Collection Activities in Support of DOE's Vehicle Electrification Project

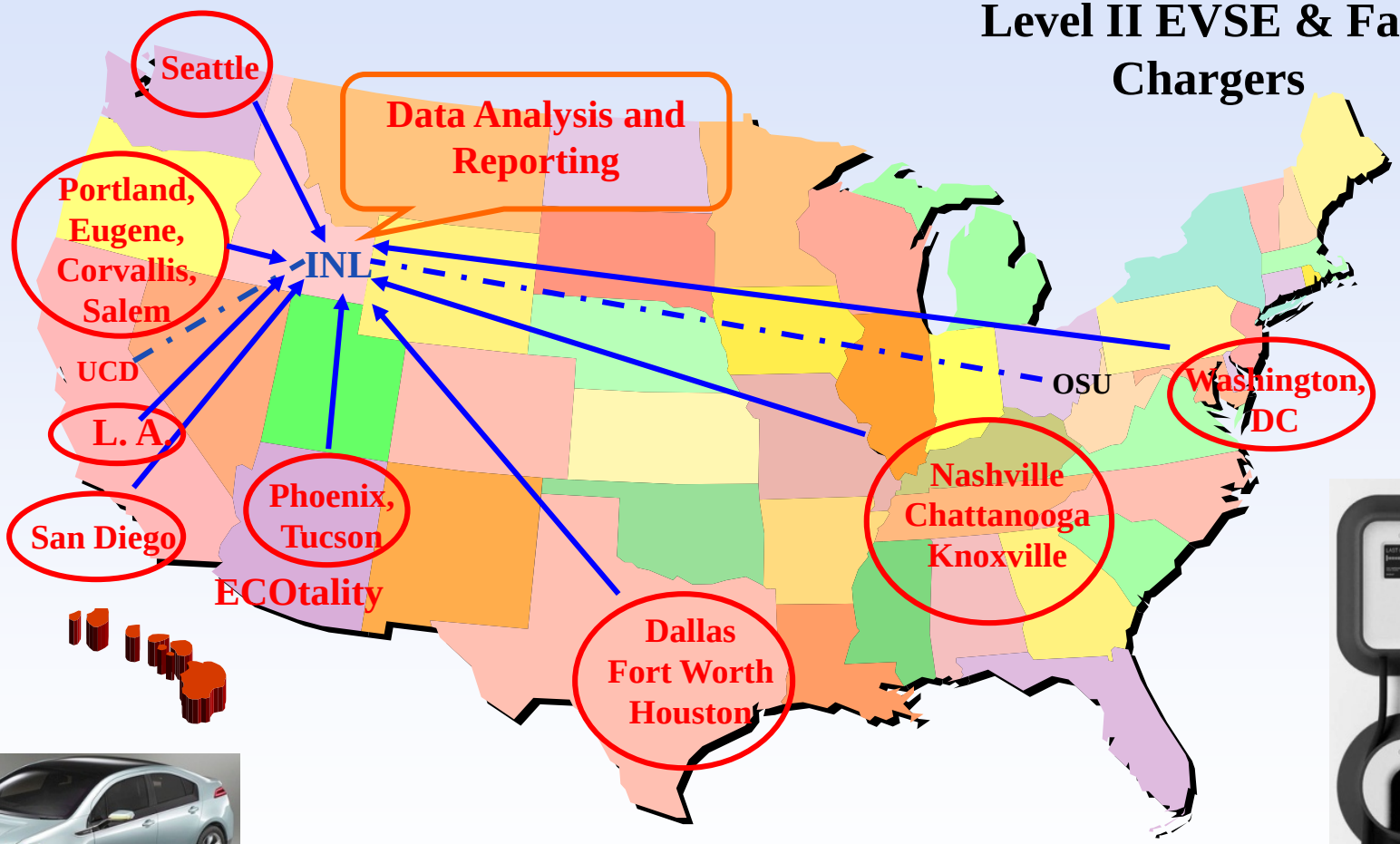
INL ARRA / TADA Data Collection Support

- **INL tasked with data collection, analysis and reporting for five light-duty vehicle and infrastructure deployment projects funded by DOE via ARRA and Technology Acceleration and Demonstration Activity (TADA):**
  - **EV Project: 8,300 Leaf EVs and Volt EREVs, and 15,300 eTec Level 2 EVSE and fast chargers. All 23,600 pieces of equipment are equipped with data loggers (DLs)**
  - **140 Chrysler Ram PHEV Pickups with DLs**
  - **125 General Motors EREV Volts with DLs**
  - **21 Ford Escape PHEV SUVs with DLs**
  - **4,000 Level 2 EVSE deployed by Coulomb with DLs**
- **Raw data and personal information protected by numerous NDAs (Non Disclosure Agreements) with participant partners**

EV Project - Overview

- **$230 million total project funded by a US Department of Energy grant ($115 million) via the American Recovery and Reinvestment Act (ARRA)**
- **Partners cost share match greater than $115 million**
- **Lead by Electric Transportation Engineering Corporation (eTec) (renamed Ecotality NA)**
- **Data will be collected by INL via data streams from eTec (charging infrastructure), and Nissan and General Motors/OnStar (vehicles)**
- **EV Project purpose is to build and study mature electric vehicle charging infrastructure in eight regions – 16 cities**
- **Product: Take the lessons learned from the deployment of these first 8,300 EVs and the 15,300 charging infrastructure units supporting them, to enable the streamlined deployment of the next 5,000,000 EVs**

EV Project Partner Locations



EV Project - Infrastructure Data Collected per Charge Event

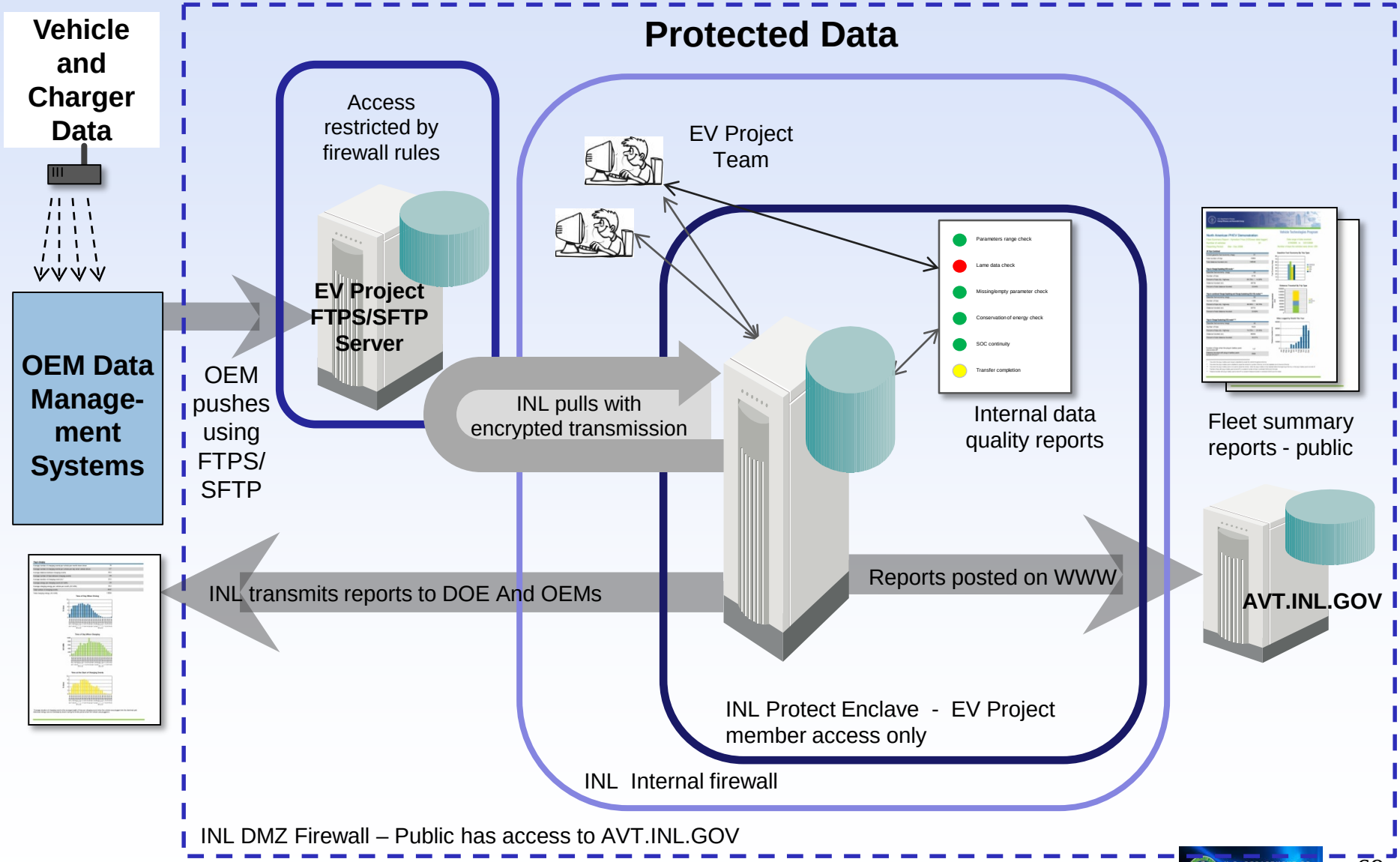
- Date/Time Stamp
- Unique ID for Charging Event
- Unique ID Identifying the EVSE – may not change
- Connect and Disconnect Times (plugged in and out)
- Start and End Charge Times
- Max Instantaneous Peak Power
- Average Power
- Total energy (kWh) per charging event
- Rolling 15 Minute Average Peak Power
- And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)

EV Project - Vehicle Data Collected per each Start / Stop Event

- Vehicle ID
- Date/Time Stamp
- Event type (key on / key off)
- Odometer
- Battery state of charge
- GPS (longitude and latitude)
- Liquid fuel consumption (some vehicles)
- Recorded for each key-on and key-off event

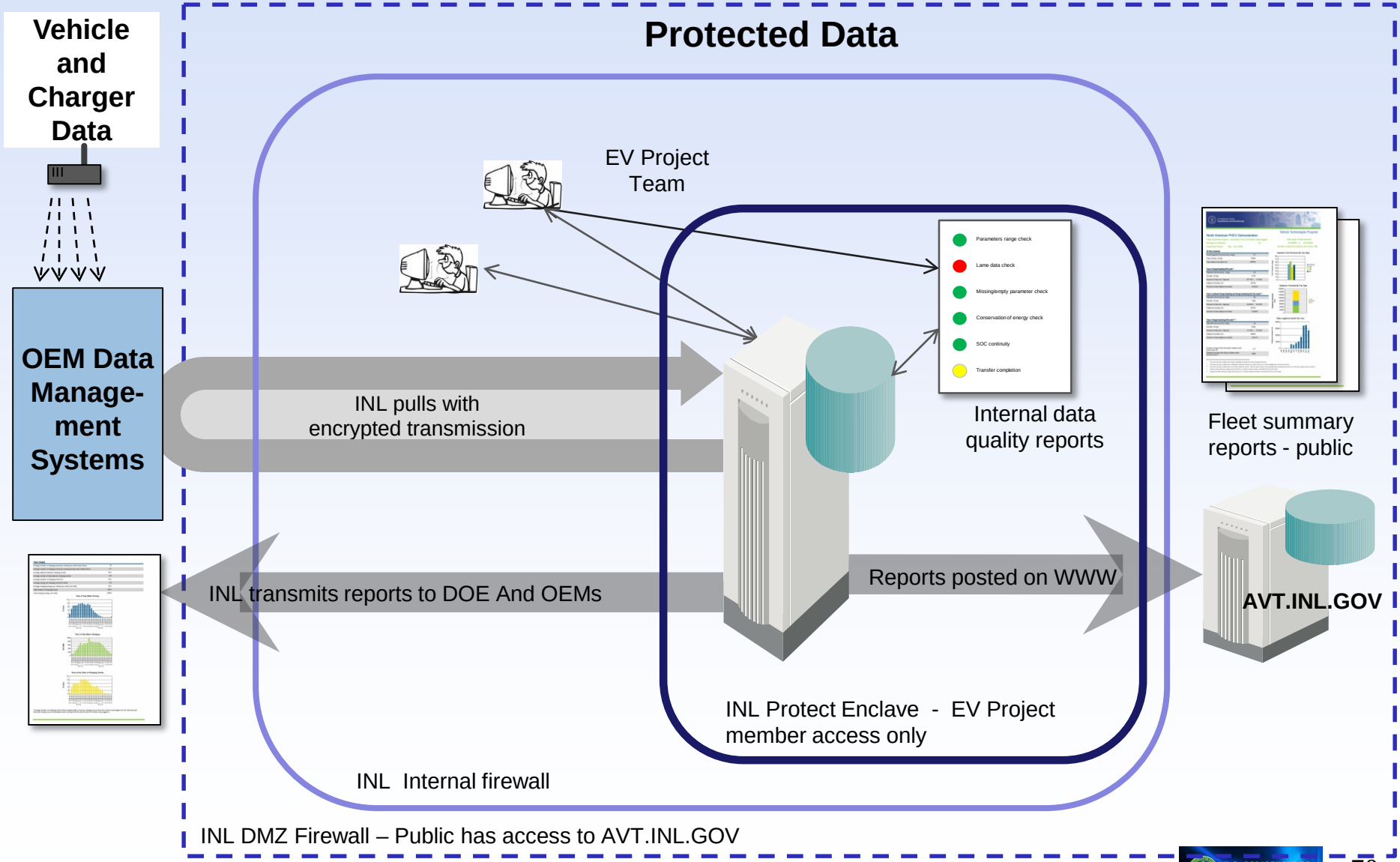
INL Data Management System - Push

(Nissan, GM, Chrysler, Coulomb)



INL Data Management System - Pull

(ECOtality, Ford, conversion PHEVs, HEVs, HICEs)



EV Project - Reporting

- **INL will analyze and report on the charging infrastructure utilization (Level II EVSE units and fast chargers) by the 8,300 Leaf and Volt drivers**
- **INL will report on driver/vehicle charging patterns, and charging infrastructure utilization patterns**
- **Many of the 42+ EV Project partners are electric utilities with high interest in demand / smart charging controls, including multitier time-of-day pricing and micro grid analysis**
- **Reporting targets include: DOE/governments, OEMs, electric utilities, public, etc.**
- **Specialty analyses will include micro grid and other variable influences**

EV Project - Fact Sheet Reporting

- Driving (by reporting period)
  - Number of trips
  - Distance driven (miles)
  - Average number of trips between charging events
  - Average distance between charging events
- Charging Infrastructure
  - EV Project vehicle charging
    - Number of charging events
    - Percent of all charging events
    - Total time plugged in (hours)
    - Percent of all time plugged in
  - Non-EV Project vehicle charging events
    - Number of charging events
    - Percent of all charging events

EV Project Summary

- **Provide feedback on infrastructure deployment decisions**
- **Reporting can not begin until after November/December 2010 start to vehicle and infrastructure roll-outs, and data analyzed**
- **Successful grid-connected electric drive vehicle deployment is dependent on successful infrastructure deployment**
- **Future charging infrastructure deployments must be based on real-world travel and charging patters**
- **Goal is to replace internal combustion engine vehicles with grid connected, and infrastructure dependant, electric drive vehicles**

Original Equipment Manufacturer (OEM) Electric Drive Vehicle Deployment Announcements

Some OEM EDV Announcements

- **The below announcements and dates come from several sources and may change**

Introduction Year	Manufacturer / Model	Battery Technology
2010	Nissan / Leaf	BEV
2010	GM / Volt	EREV
2011	Coda / Coda	BEV
2011	Ford / Focus	BEV
2011	Ford / Transit Connect	BEV
2011	BYD / e6	BEV
2011	Fisker / Karma	BEV
2011	Mitsubishi / i-MiEV	BEV

BEV – Battery Electric Vehicle
EREV – Extended Range Electric Vehicle
PHEV – Plug-in Hybrid Electric Vehicle
EDV – Electric Drive Vehicle

Some OEM EDV Announcements – con’td

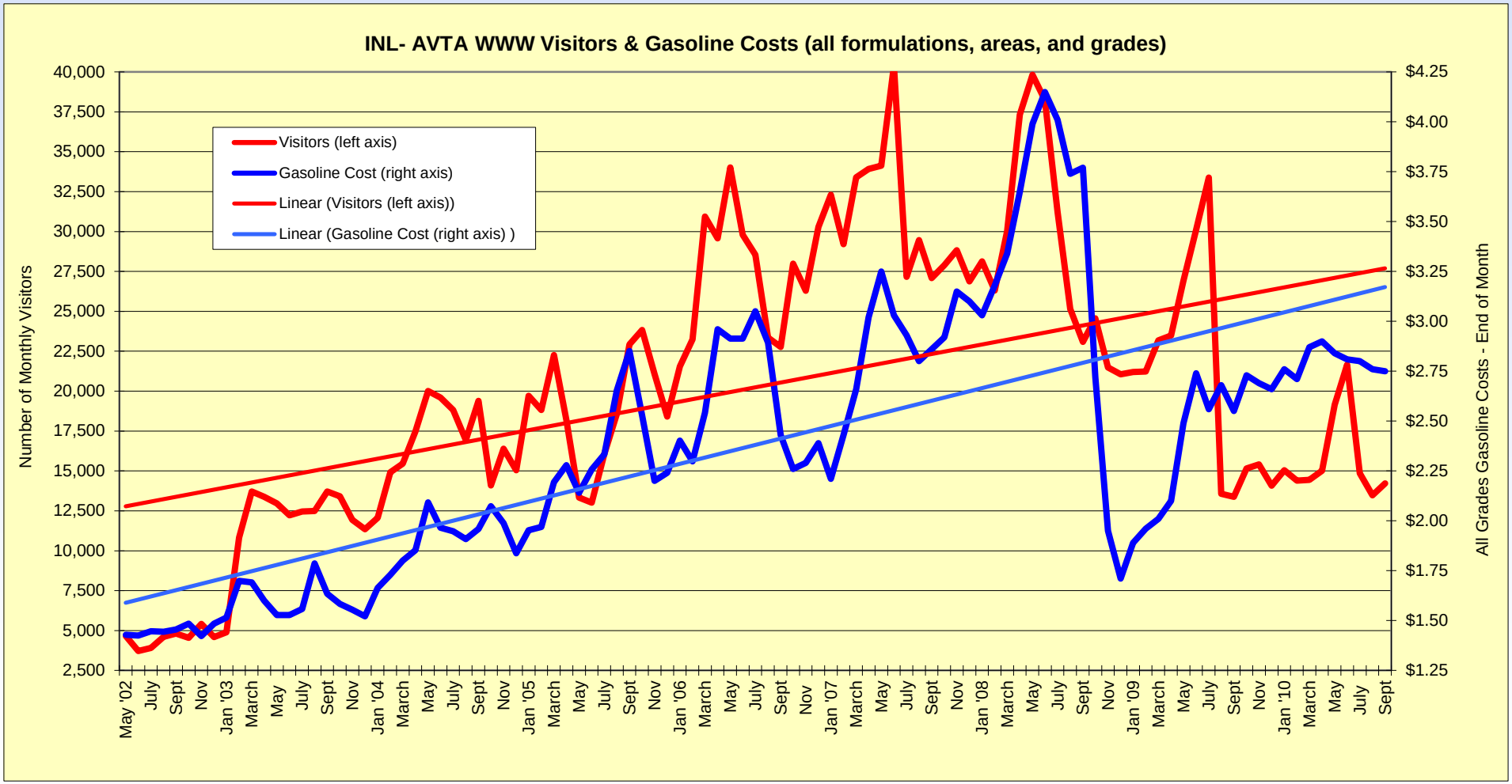
- **The below announcements and dates come from several sources and may change**

Introduction Year	Manufacturer / Model	Battery Technology
2012	Smart / fortwo	BEV
2012	Toyota / IQ-Based	BEV
2012	Tesla / S	BEV
2012	Toyota / Prius	PHEV
2012	Toyota-Tesla / RAV4	BEV
2012	Chrysler-Fiat / 500	BEV
2013	BMW / MegaCity	BEV
2013	Volkswagen / Eup	BEV
There have been another 50+ electric drive vehicle announcements beyond 2010 from Audi to Volvo		

Other INL Data Collection Projects

- Data collection for Ford's PHEV SUVs and Chrysler Ram Pickups include 25+ onboard parameters, such as charging and driving profiles, and vehicle performance; collected via the CAN and data loggers
- Other OEM vehicles may be added to EV Project
- Five USPS electric long life vehicle (ELLV) conversions
  - ELLVs required five customized onboard data loggers
  - Testing to USPS and AVTA test procedures and cycles
- Development of vehicle-based battery test-bed mule

AVTA Summary – WWW Visitors



Acknowledgement and AVTA WWW Address

This work is supported by the U.S. Department of Energy's Vehicle Technologies Program

Additional AVTA Information, Reports, and Fact Sheets @

http://avt.inl.gov

INL/MIS-10-20382, 20653