Transportation and Climate Change Resource Center

REAL SOLUTIONS FOR CLIMATE CHANGE

Electric Vehicles - What, When, Why, and How

March 17, 2011

Presented by:

DAHLIA GARAS, Plug-in Hybrid & Electric Vehicle Research Center, UC Davis
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JEFF DOYLE, Washington State Department of Transportation

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Introduction to Plug-in Hybrid and Electric Vehicles:

MARCH 17, 2011

Presented by:

Dahlia Garas
Program Manager

Mike Nicholas
Post-Doctoral Researcher

Plug-in Hybrid & Electric Vehicle Research Center, UC Davis

Moving to Electric Drive

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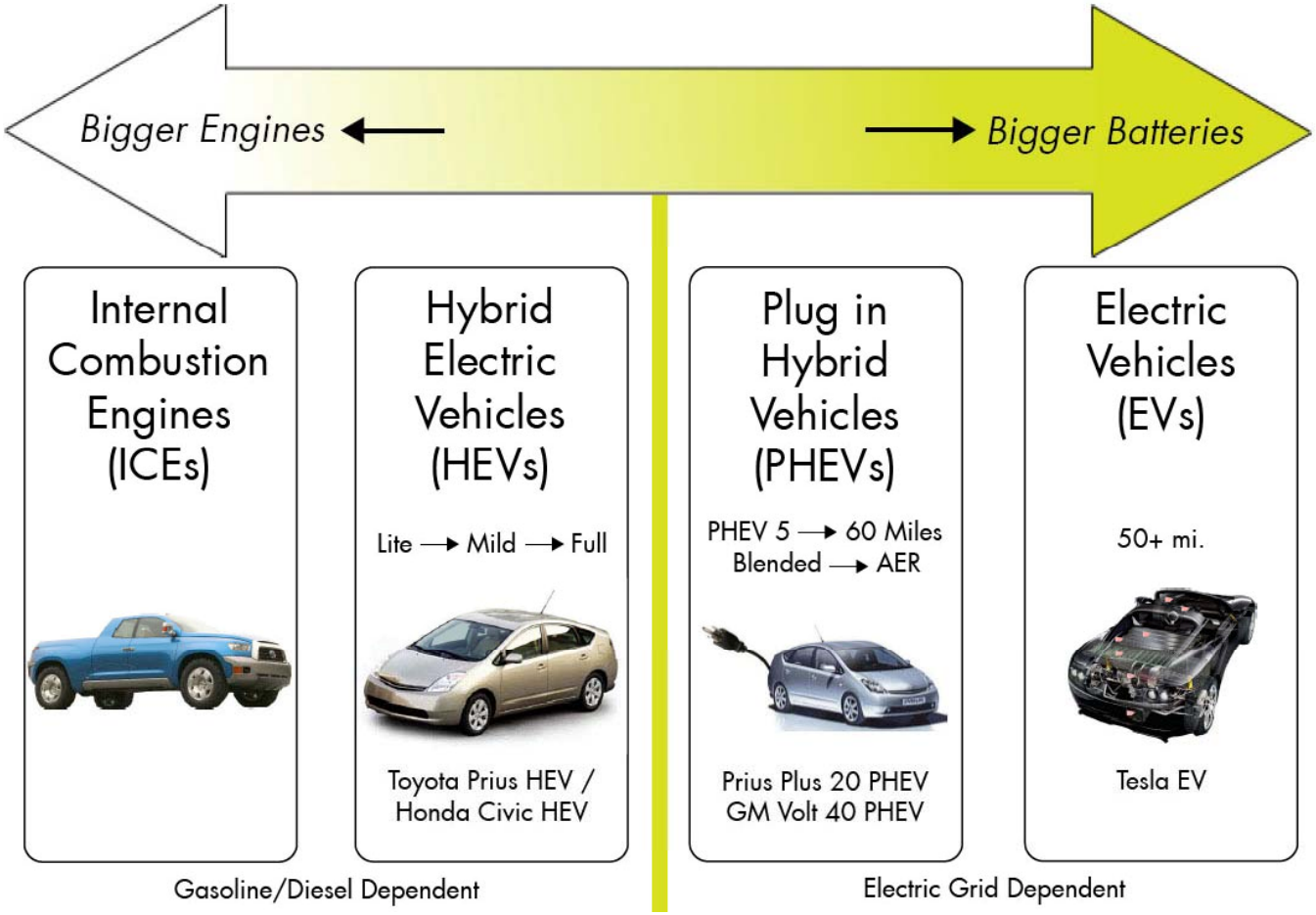

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Comparing Benefits

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UC DAVIS
PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER
of the Institute of Transportation Studies

Reducing Your Transportation Footprint:

Based on the following criteria: miles driven per year: 10,000, 1 gallon of gas = 19.37 lbs. CO_2; standard vehicle 25 mpg and uses 379 gallons of gas/yr.; hybrid vehicle 45 mpg and uses 211 gallons of gas/yr.; plug-in hybrid 70 mpg and uses 135 gallons of gas/yr. Battery Electric Vehicle pack size: 24 kWh, BEV consumption per year=2640 kWh, PG&E electrical grid 0.52 lbs CO_2 per/kWh of electricity

Eliminate 10 Miles of Driving per Week:

403 lbs. of Carbon Dioxide Eliminated

- Ride a bike
- Walk
- Work From Home
- Ride Public Transportation
- Carpool

- 52 weeks per year=520 miles
- 1 gallon of gas= about 20 lbs. of CO_2
- Thats about 21 gallons of gas saved per year!
- 21 gallons of gasoline creates about 403 lbs. of CO_2
- With a little effort and planning, anyone can do this.
- Possible to reduce CO_2 footprint further, by driving less!

Purchase a Hybrid Vehicle:

3265 lbs. of Carbon Dioxide Eliminated

- Toyota Prius: 48 mpg
- Honda Civic: 43 mpg
- 211 Gallons of gas used per year

- About 169 gallons less per year than standard 25 mpg vehicle!
- At about 20 lbs. CO_2 per gallon of gas, thats 3265 lbs. of CO_2 eliminated per year!

Purchase a Plug-in Hybrid Vehicle:

4523 lbs. of Carbon Dioxide Eliminated

- 2011 Chevy Volt
- 2011 Toyota Plug-in Prius
- 2011 Fisker Karma

- About 244 gallons less per year than a standard 25 mpg vehicle!
- At about 20 lbs. CO_2 per gallon of gas, that's 4523 lbs. of CO_2 eliminated per year!

Purchase an All Electric Vehicle:

6035 lbs. of Carbon Dioxide Eliminated

- 2010 Nissan LEAF
- 2011 BMW Active E
- 2011 Ford Focus

- Saves 379 gallons of gas used per year in a standard 25 mpg vehicle as electric vehicles use no gas!
- Only emission are "up steam" and created during electricity generation
- A large portion of PG&E's system generation is hydro, nuclear, wind, and solar
- On the PG&E system, 1 kilowatt hour accounts for 0.524 lbs of CO_2
- BEV with 24 kWh battery pack is estimated to use 2640 kWh/yr.

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Fuel and CO2 Savings

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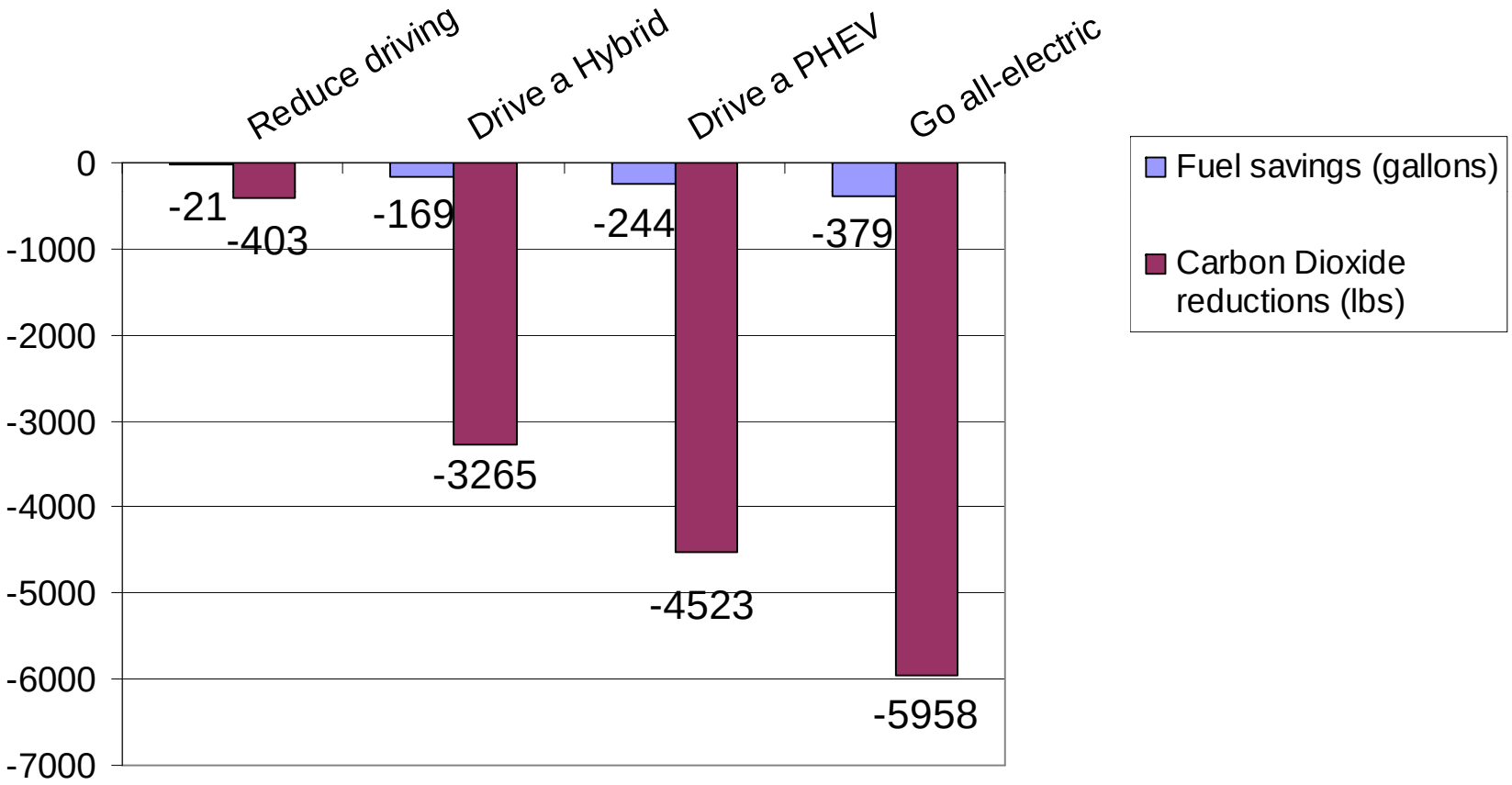

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Highly Operation Dependant

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CO_2 benefits depend on:

- Battery size & range: PHEV 10 to PHEV 40+
- Lifestyle: frequency of travel over “electric range”
- Charging opportunities: Home, Work, Costco, Starbucks
- Price of gasoline & electricity
- Instrumentation of vehicle
- Speed and Terrain

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PHEV Operating Costs

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- Assumptions: mid-size car, baseline PG&E rates, 3$/gal and conventional vehicle fuel economy of 30 mpg
- Electric: 11.09cents/kWh *.25kWh/mi = 2.77 ¢/mile
- Gasoline only: (3.00$/Gal)/(30 mi/gal)= .10$/mi = 10 ¢/mile
- Conventional Hybrid: (3.00$/gal)/(48 mi/gal)= .0625 $/mi= 6.25 ¢/mile
- Plug-in Hybrid: (Not so easy to calculate, depends on how long you drive, if you charge, etc.) = 3-6 ¢/mile

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Median Generation and Demand for the Month of August (CA)

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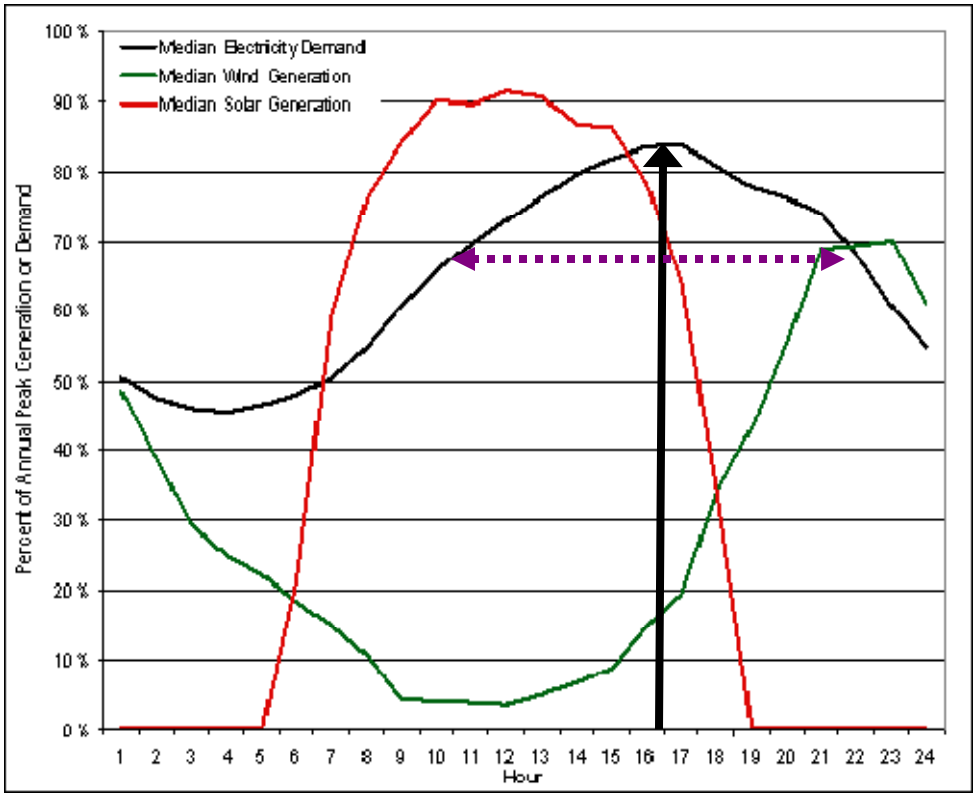

Source: Christopher Yang, UC Davis

- CA can easily demand 85% of maximum generating capacity on-peak
- Below 50% demand off-peak
- Last 25% of generating capacity is used less than 10% of the time; last 5% of generating capacity used less than 50 hrs/year
- Analysis shows the CA grid can charge 1 Million PHEVs off-peak, accounting for less than 1% of total electricity demand.
- Wind and solar are complementary renewable energy sources.

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Charging Options

- 120 V
  - Slow, but works with a standard outlet, may find more charging opportunities, may be up to 24 hrs to fully recharge
- 240V
  - Home recharging, requires a charging unit to be installed, typical 4-6 hour recharging time
  - Works for public charging at places where you WANT to be for a few hours
- Fast-charging
  - 20 minutes for about 80 miles of range, may allow for extended driving distances
  - Requires serious and expensive charging unit and installation

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New ARRA Tax Credit

- Plug-In Electric Drive Vehicle Credit
  - Vehicles with 4 wheels and GVWR<14,000 lbs
  - Purchased after Dec. 31, 2009
  - Battery with at least 4 kWh that can be recharged from an “external source of electricity”
  - Minimum credit of $2,500, up to $7,500 depending on the size of the battery ($417/kWh after 4kWh)
  - Credit phases out after the manufacturer has sold at least 200,000 vehicles

  - FS-2009-10, April 2009, Section 1141

Issues Surrounding Fast Chargers

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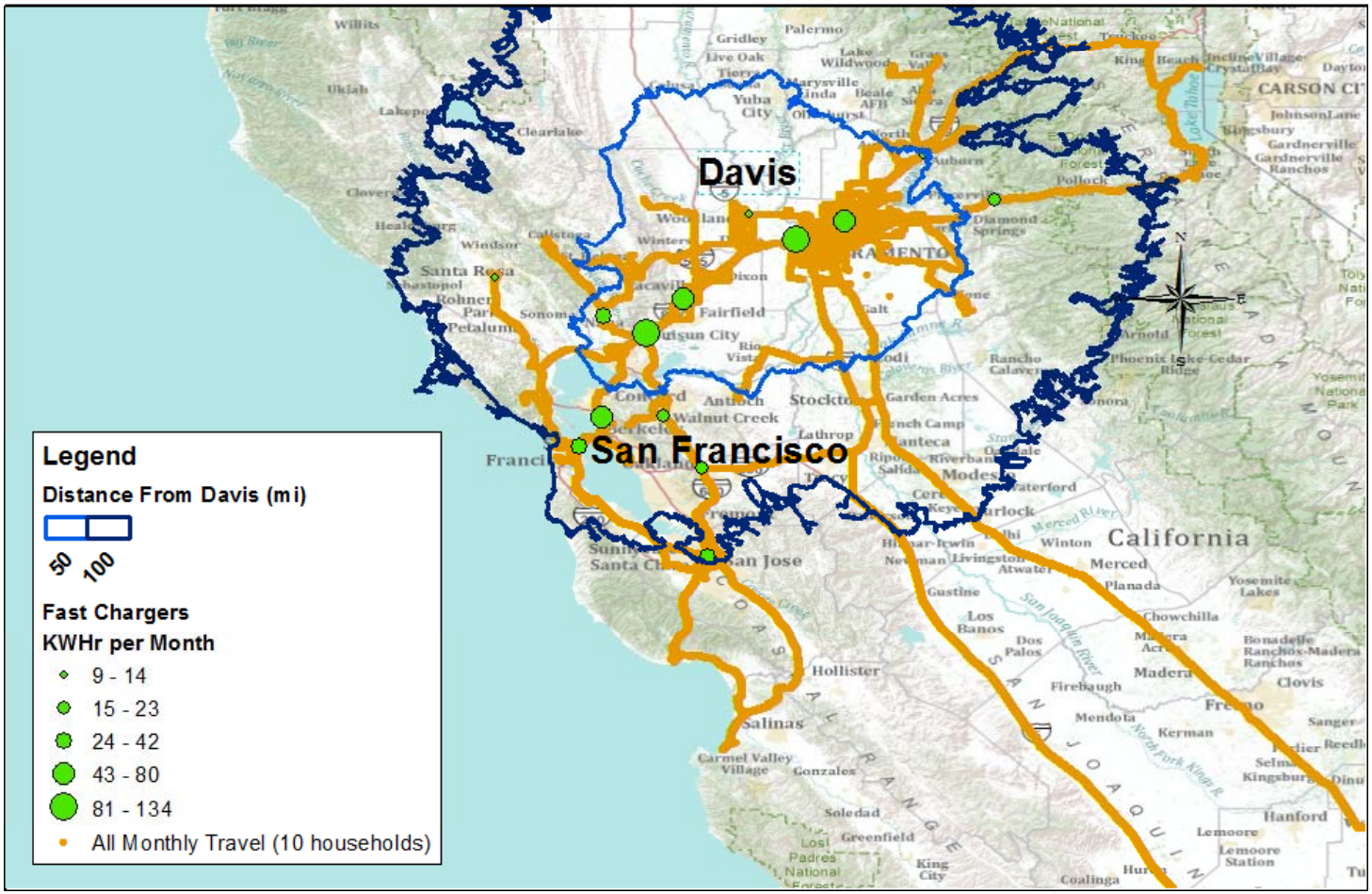

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10 Households, ~1 Month of Data

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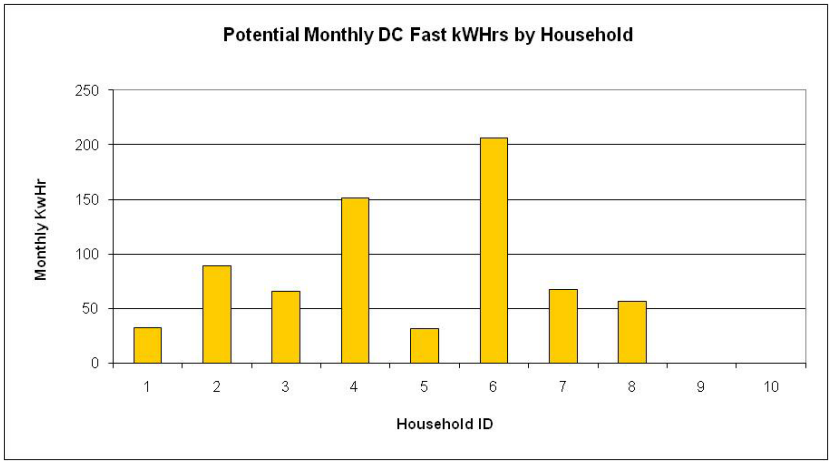

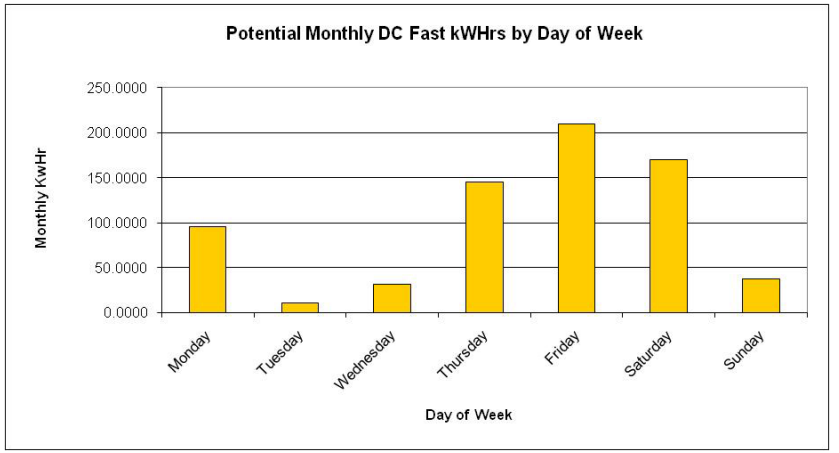

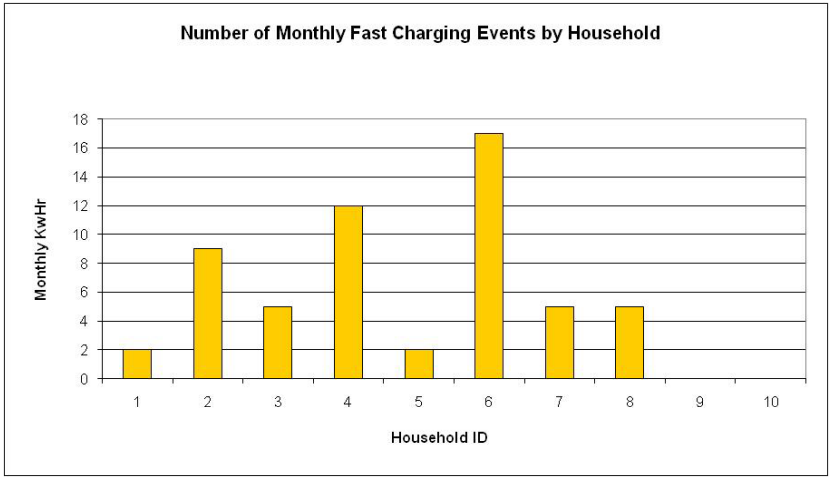

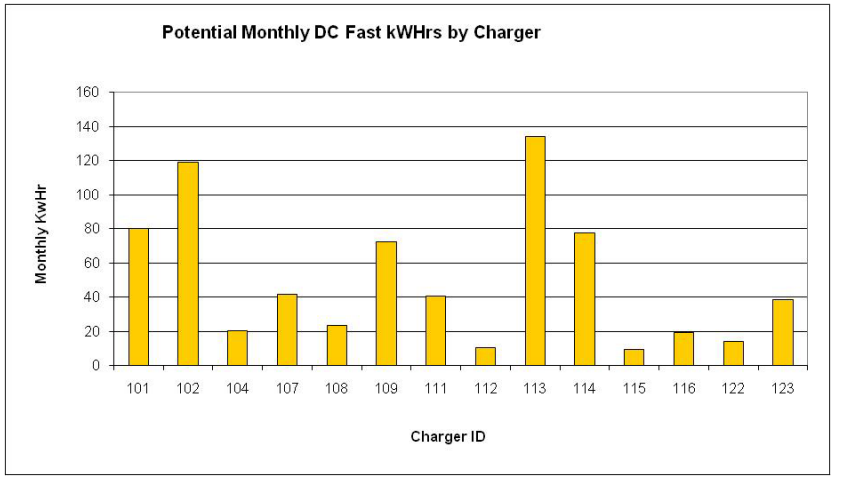

Mini E Study Provides Insight

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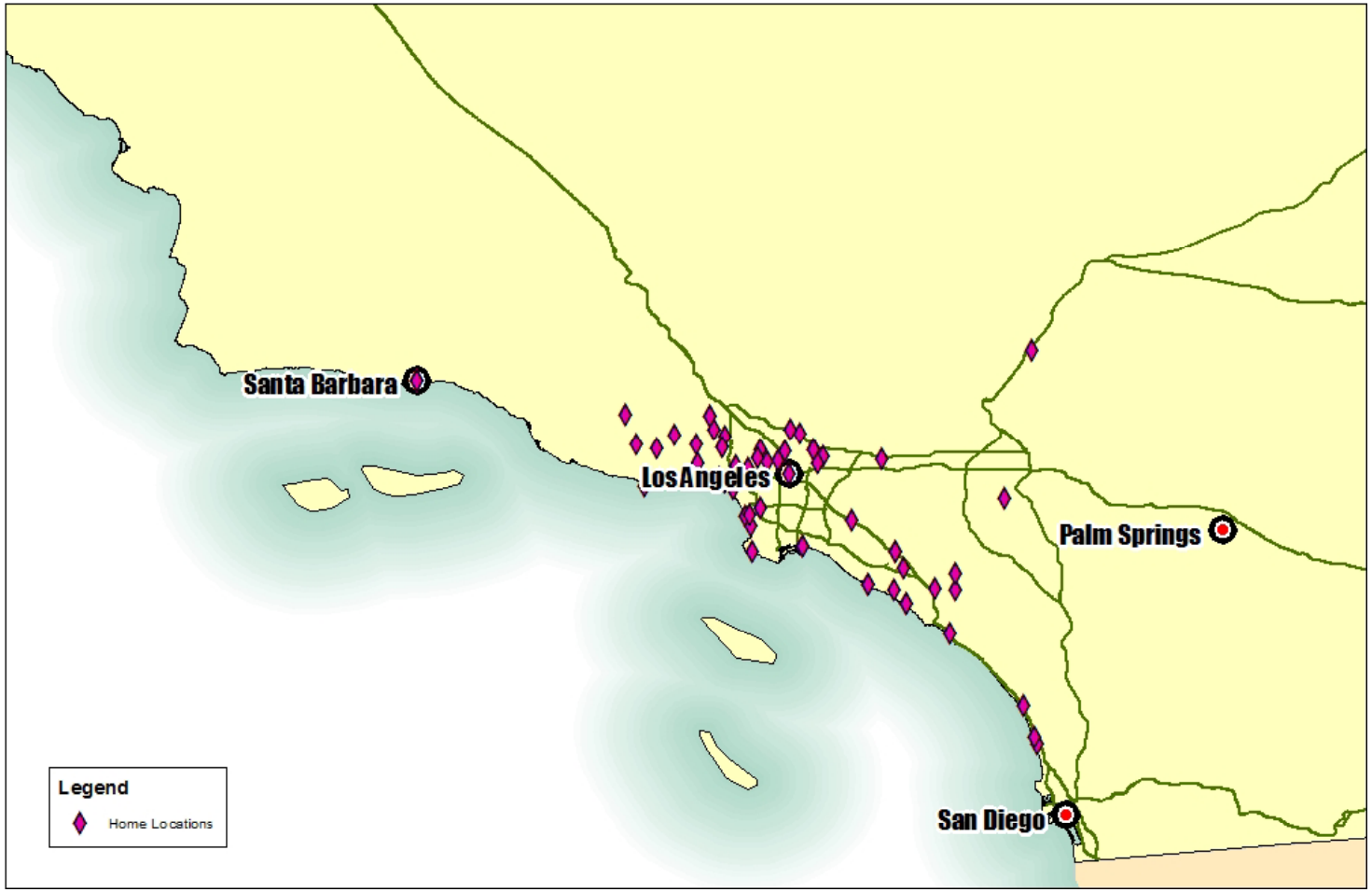

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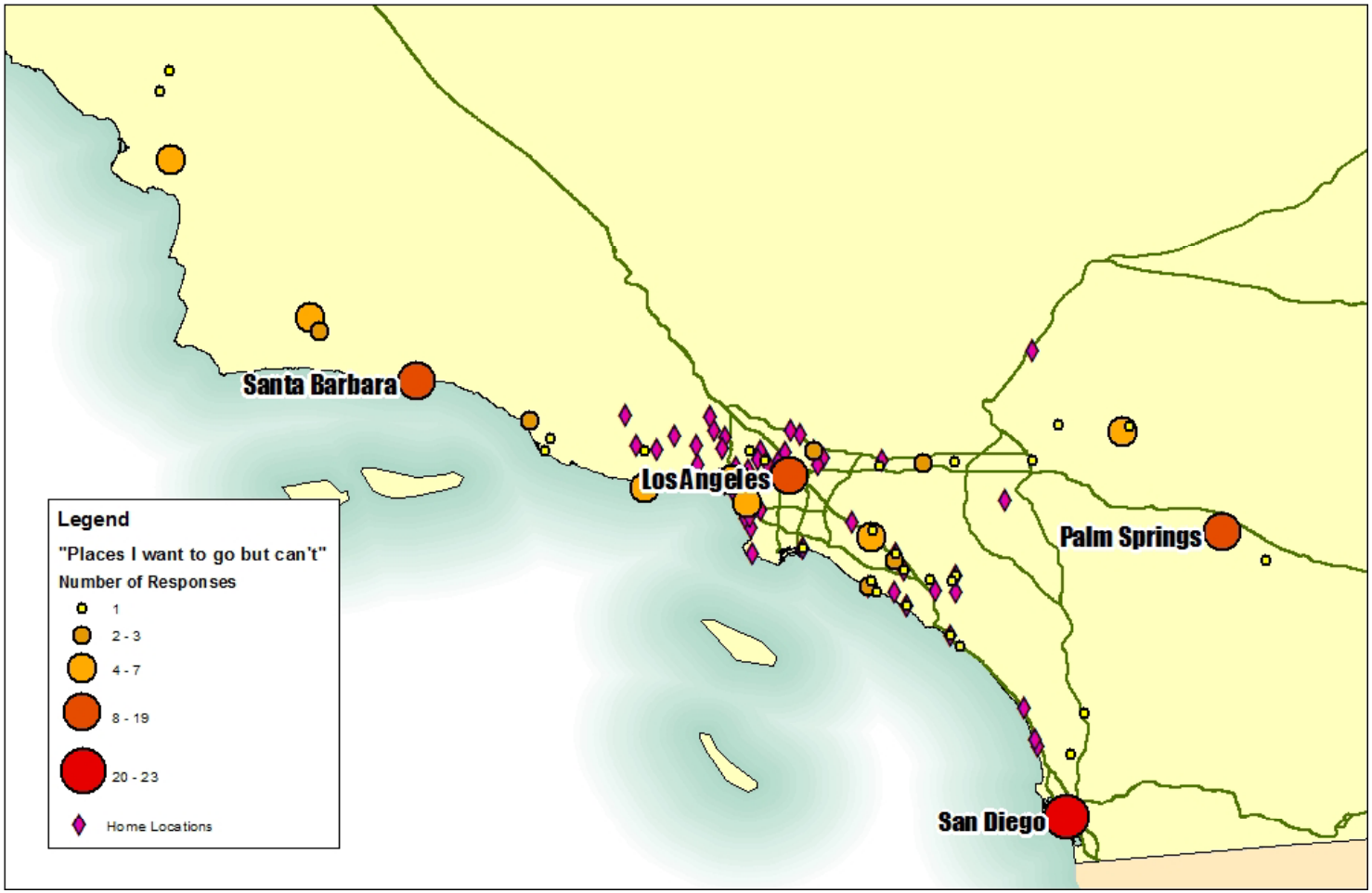
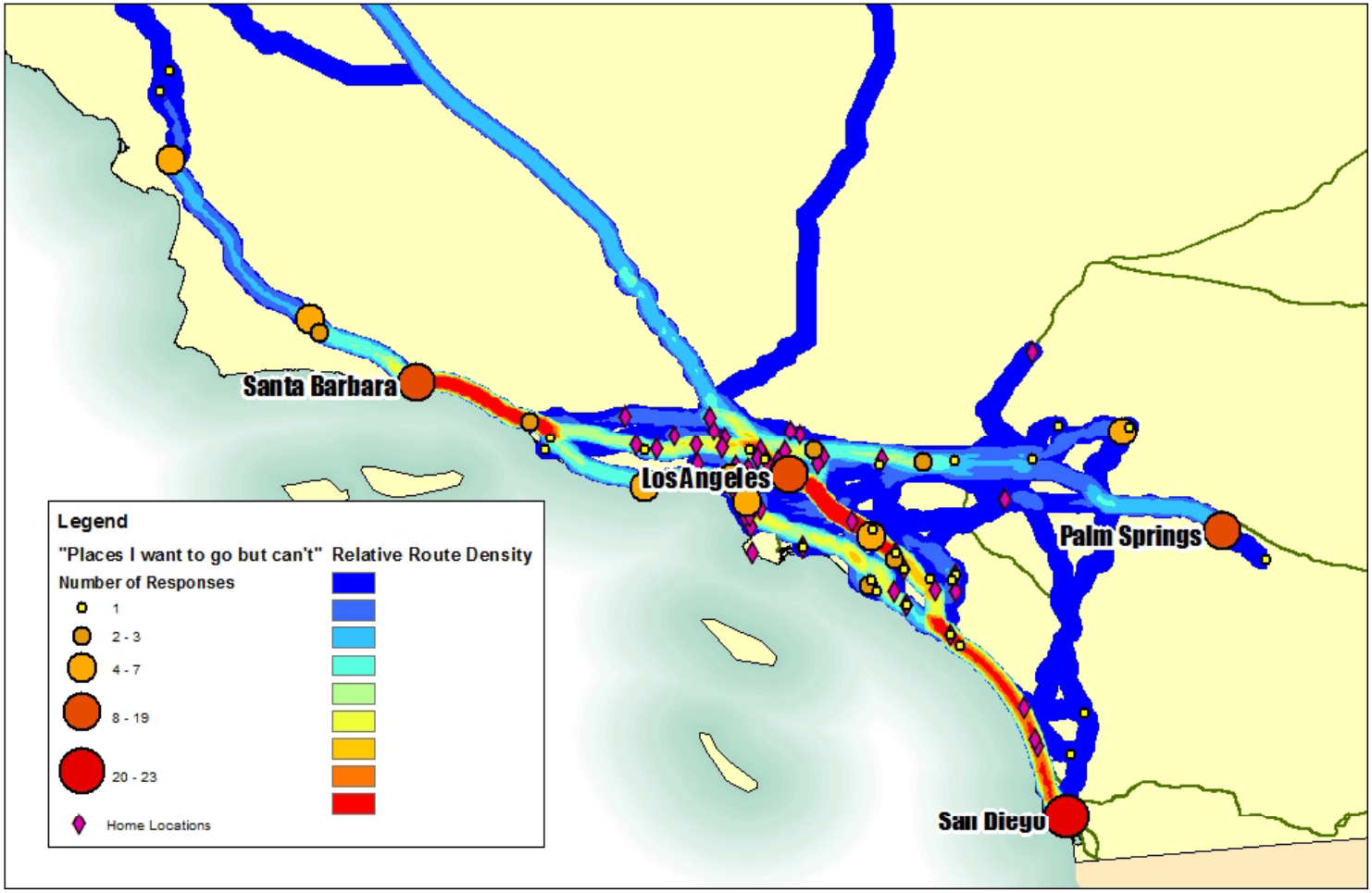
Where did they “want to go but couldn’t due to range issues?”



Route Density



Destination Breakdown

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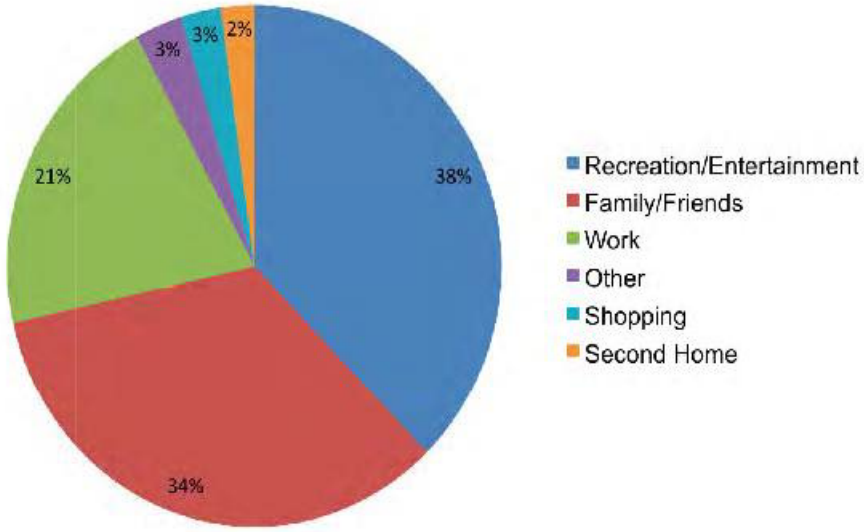
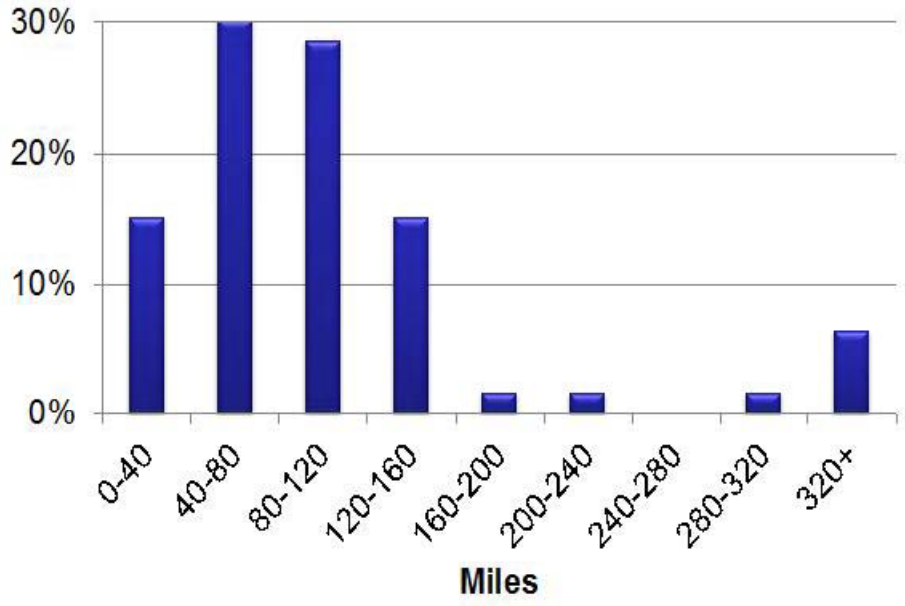
Desired Destination Categories and Range Distribution From Maps 2 & 3 (n=126)





Charging Areas

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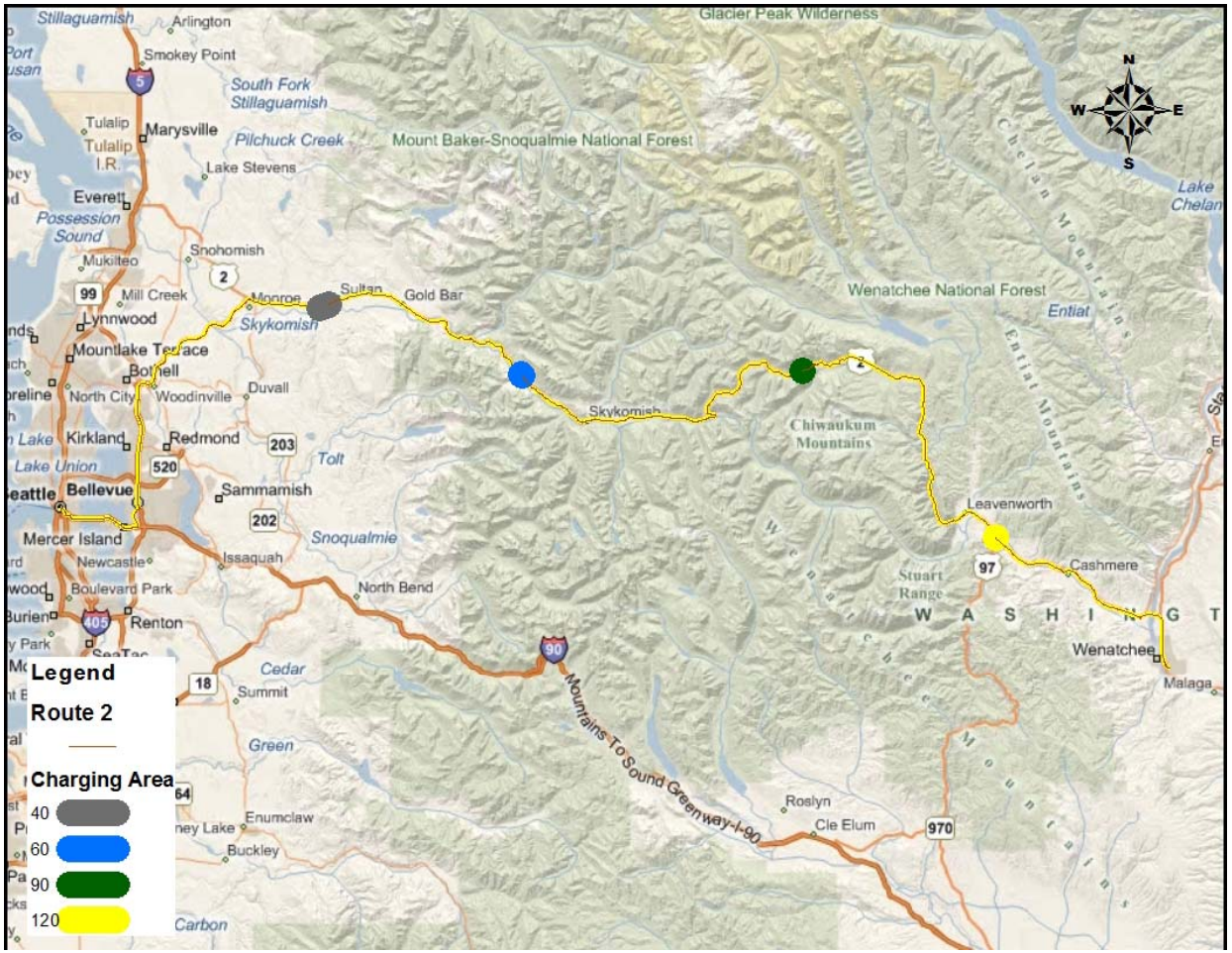

Three charger scenario

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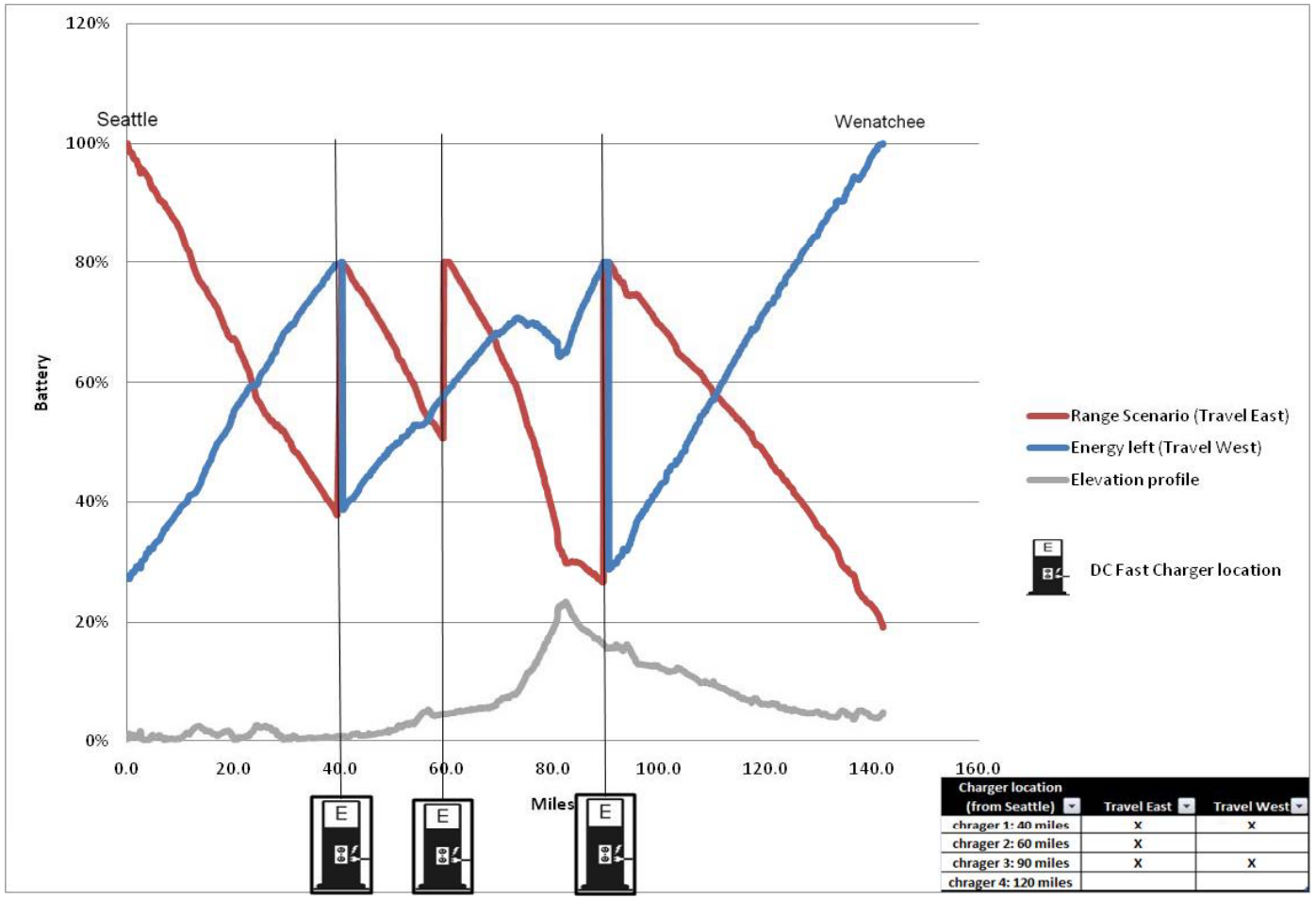

Charger location (from Seattle)	Travel East	Travel West
chrager 1: 40 miles	x	x
chrager 2: 60 miles	x	
chrager 3: 90 miles	x	x
chrager 4: 120 miles		

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Survey Tools

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UCDAVIS UNIVERSITY OF CALIFORNIA

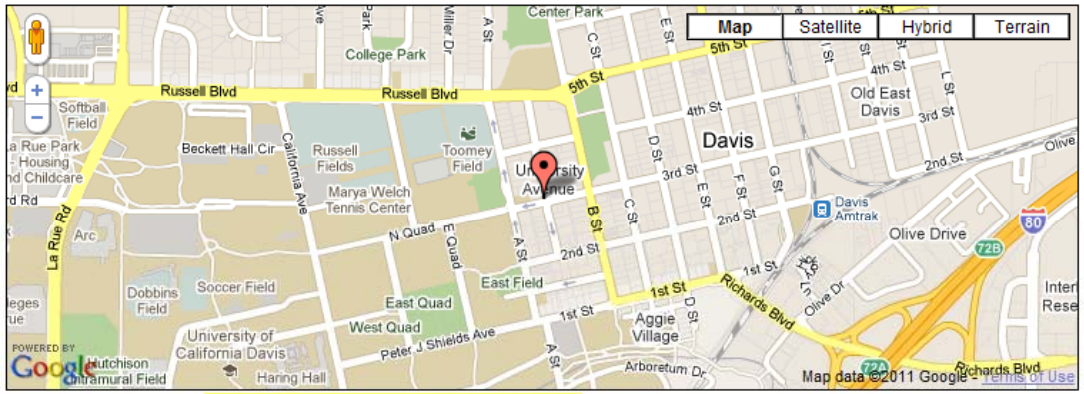
Section 5: Your Household

The information in this section will be used only for descriptive purposes. We need to know how well our respondents match the descriptions of households who buy new cars in the United States

5) Where do you live?
This information is used only for the survey purposes.
Note: You can move the location marker.

Address or intersection: 3rd and u

City: davis State: CA Zip Code:



Formatted Address: 3rd St & University Ave, Davis, CA 95616

If the point on the map is not the correct location please move the red marker or Retry with a new address

If the marker is the right loction, click Next

http://gis.its.ucdavis.edu

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Electric Vehicles and the Power Grid

March 17, 2011

Presented by:

Esrick O. McCartha
Client Manager
PJM Interconnection, LLC

PJM's Responsibilities

- Ensures the reliability of the high-voltage electric power system
- Coordinates and directs the operation of the region's transmission grid;
- Administers a competitive wholesale electricity market;
- Plans regional transmission expansion improvements to maintain grid reliability and relieve congestion.

PJM's Responsibilities

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Operators of for Energy Markets…

Air Traffic Controllers for the Transmission Grid….

SIMULTANEOUSLY!

RELIABLY!

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PJM as Part of the Eastern Interconnection

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6,038 substations

KEY STATISTICS

PJM member companies	650+
millions of people served	51
peak load in megawatts	144,644
MWs of generating capacity	164,905
miles of transmission lines	56,250
GWh of annual energy	729,000
generation sources	1,310
square miles of territory	164,260
area served	13 states + DC
Internal/external tie lines	250

26% of generation in Eastern Interconnection

23% of load in Eastern Interconnection

19% of transmission assets in Eastern Interconnection

19% of U.S. GDP produced in PJM

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PJM's Role in the Smarter (Robust) Grid

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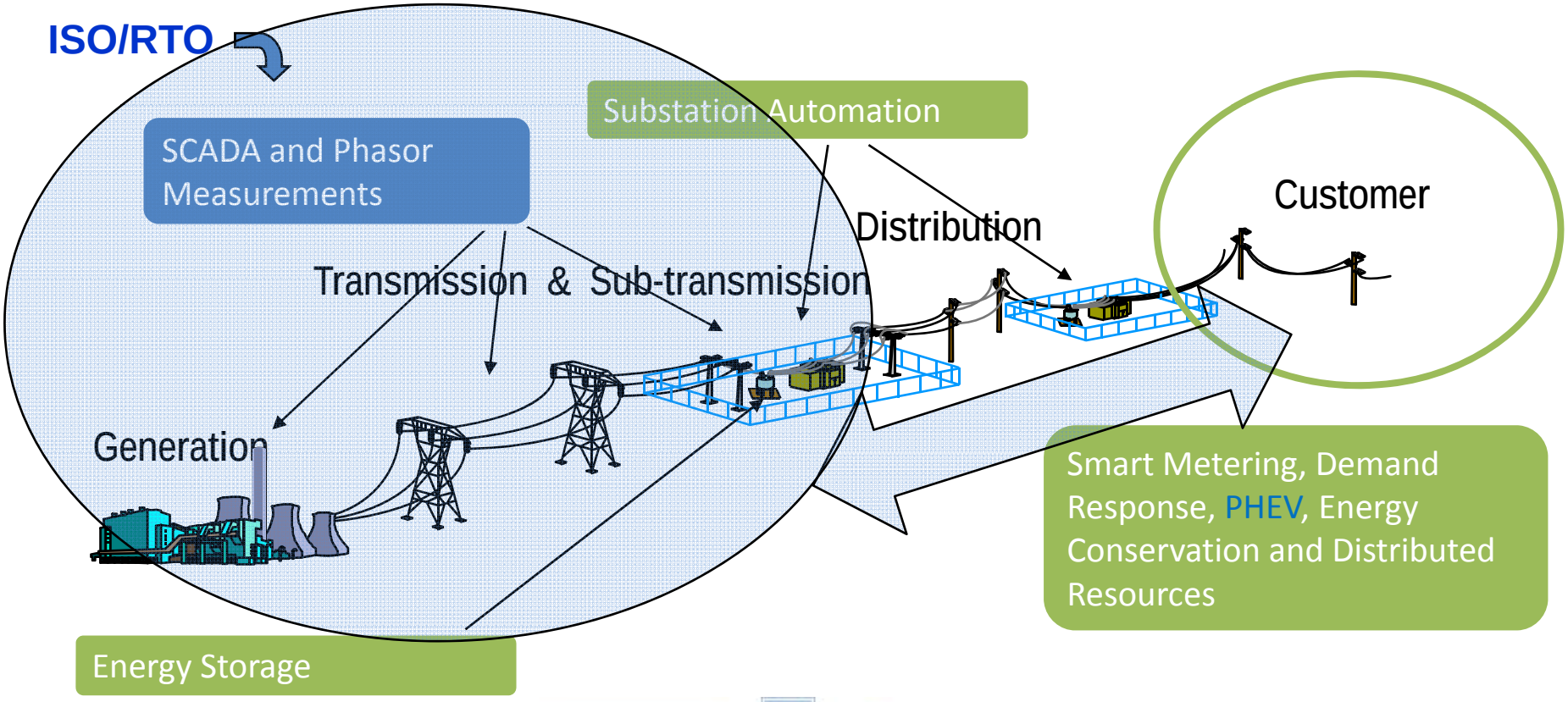
The Smart Grid is realized by merging data from these areas of automation to achieve a total end-to-end system view by integrating information technology and operational technology.

Two-Way Communication and Control



Smarter Grid Network – Smart Home

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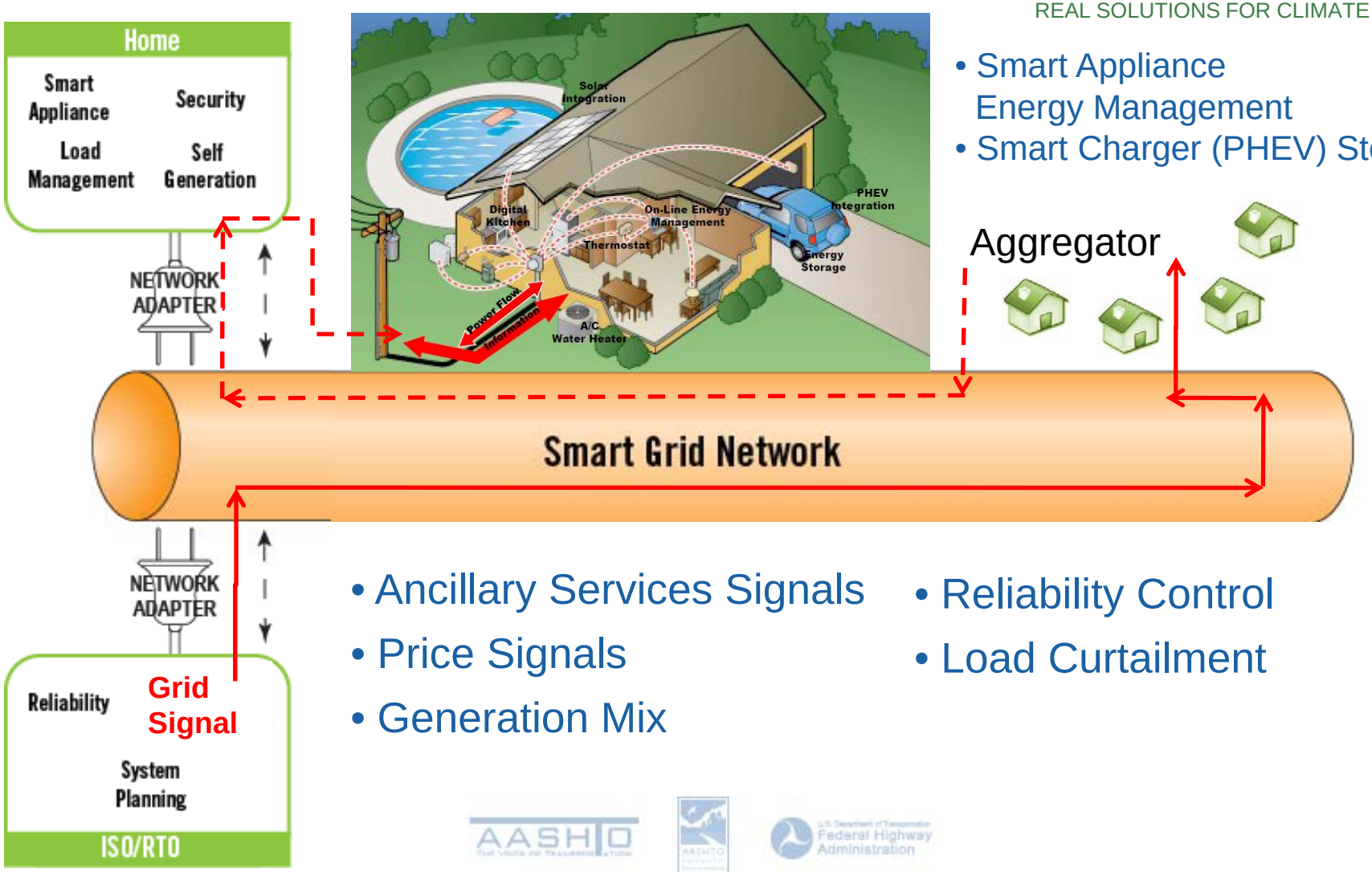
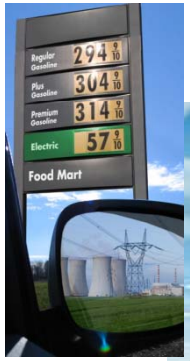


- Smart Appliance Energy Management
- Smart Charger (PHEV) Storage

- Ancillary Services Signals
- Price Signals
- Generation Mix

- Reliability Control
- Load Curtailment

Integrate SMART Grid with PHEVs



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- Enable greater penetration of PHEVs through coordination with state SMART Grid and retail tariff innovation initiatives
- Develop infrastructure to support non-traditional demand based regulation resources
- Develop operational tools and forecasting techniques to enable PHEV deployment

- Develop Vehicle to grid / Plug-in hybrid electric vehicles (PHEVs) protocol
- Participate in Mid-Atlantic Grid Interactive Cars Consortium (MAGICC) – electric companies, research institutes, and vehicle manufacturers
- Test storage batteries in regulation markets

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Vehicle Economic Charging

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Assumptions

- 1,000,000 PEV Vehicles by 2015
- ~18% of U. S. Population is within the PJM territory
- ~ 180,000 PEV Vehicles in the PJM Territory
- ~ 33** Miles traveled per vehicle per day
- ~ Average vehicle fuel usage: 22** mpg
- ~ No tax compensation

Daily cost per PEV Vehicle

- Gasoline: 33 miles/day * $3.00 /gal // 22 miles/gal = $4.50
- Electric: 33 miles/day * $.07 / kWh // 4 miles/kWh = $0.60

Annual cost/savings

Cost:

- Gasoline: 365 days * $4.50 /day = $1650
- Electric: 365 days * $0.60 /day = $220

Savings:

- **~ $1400 annually per vehicle**
- **180,000 vehicles (within PJM) = ~ $250,000,000 annual**

** U.S. Bureau of Transportation Statistics

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Wind Generation in PJM - Operational and Proposed

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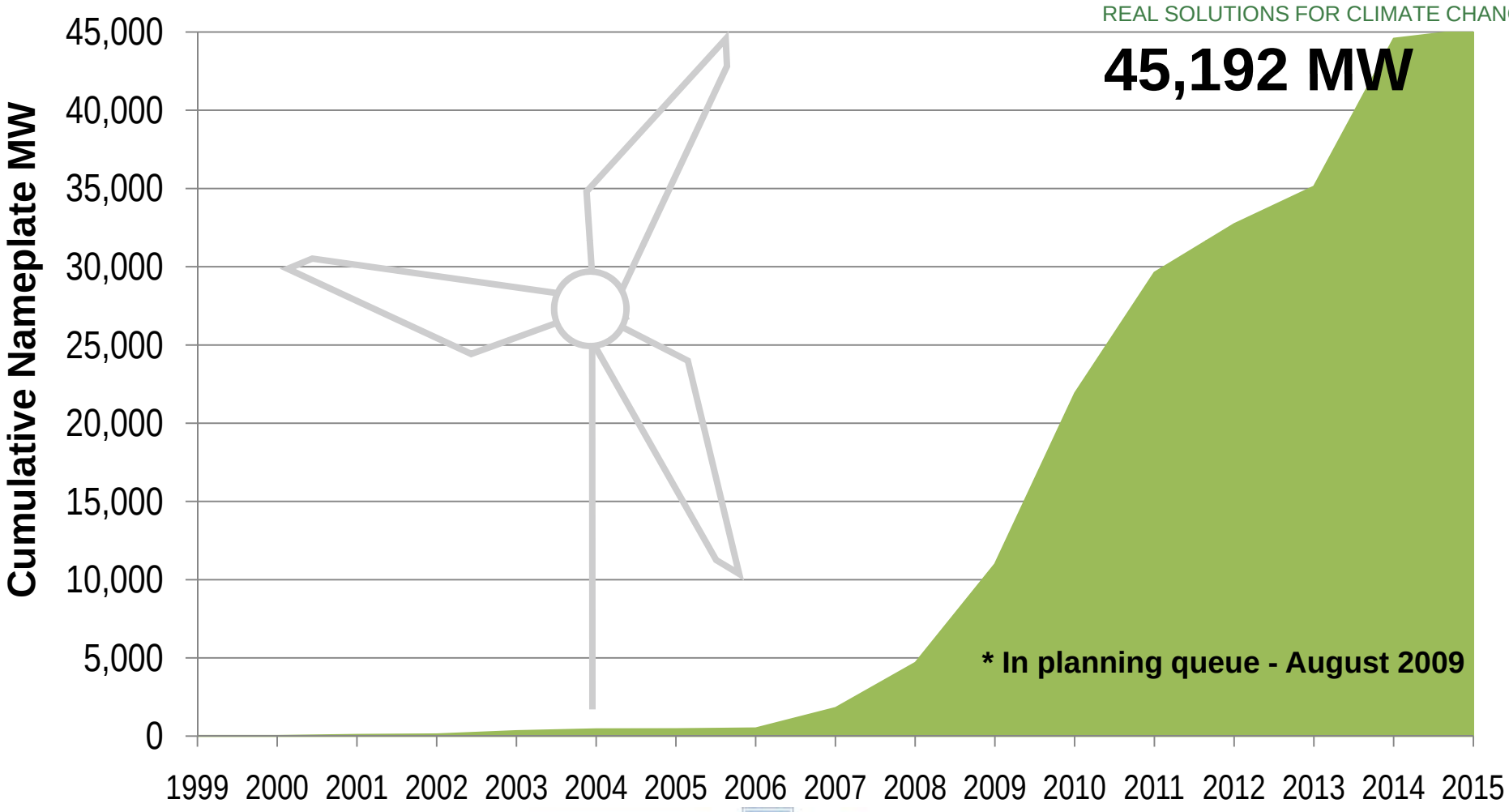

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PJM Load and Wind Resources – August 26, 2009

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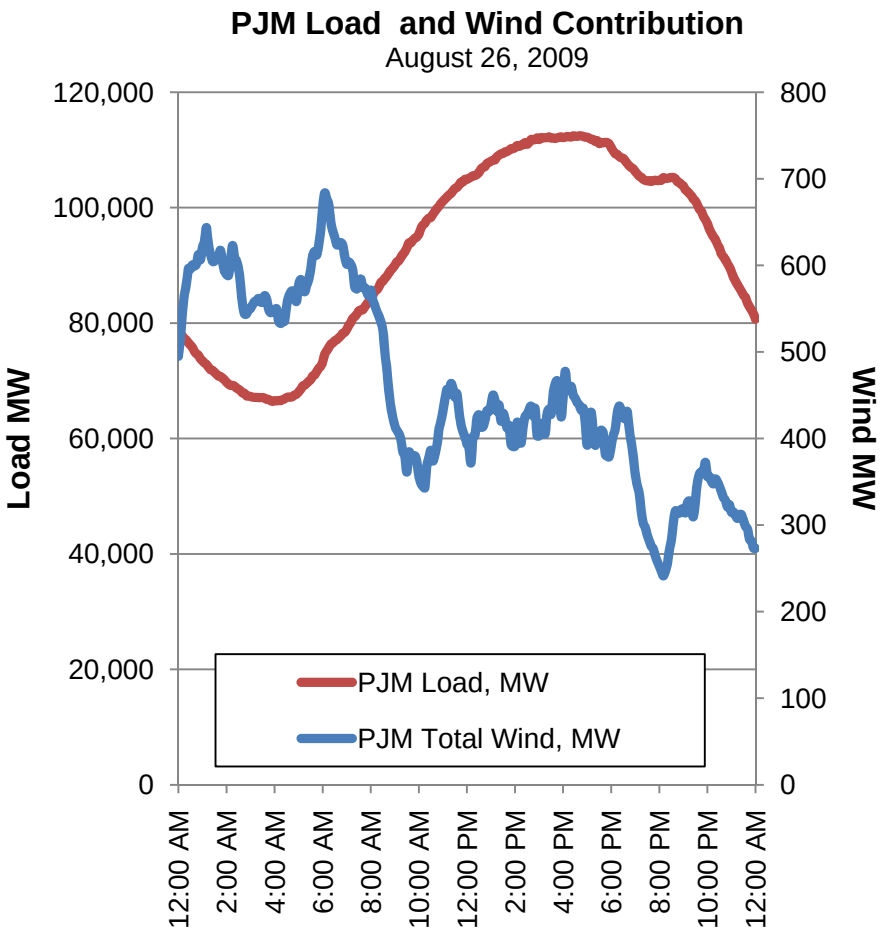

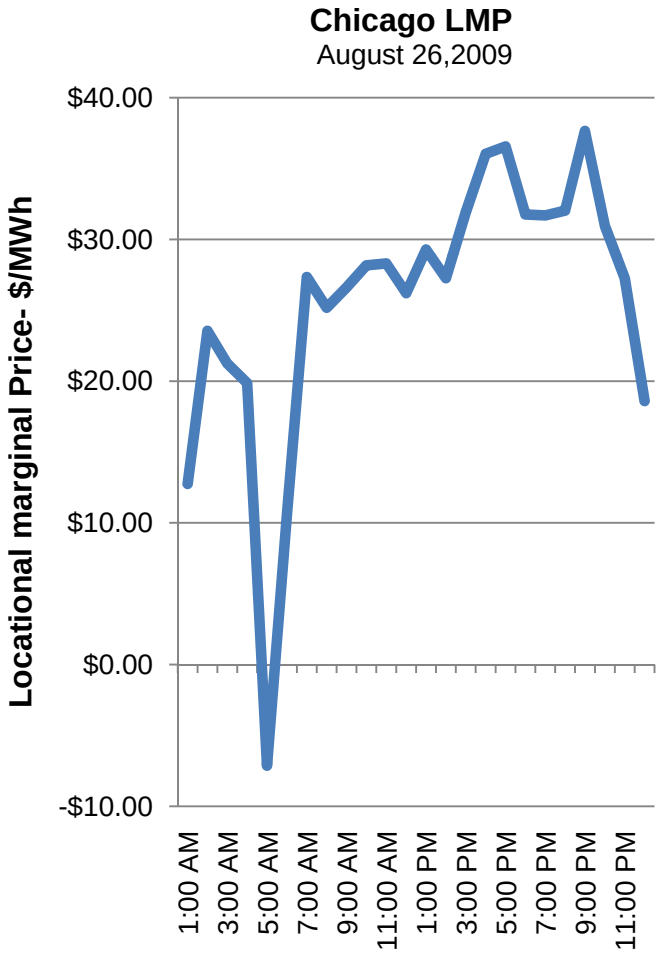

Vehicle Charging Impact on PJM

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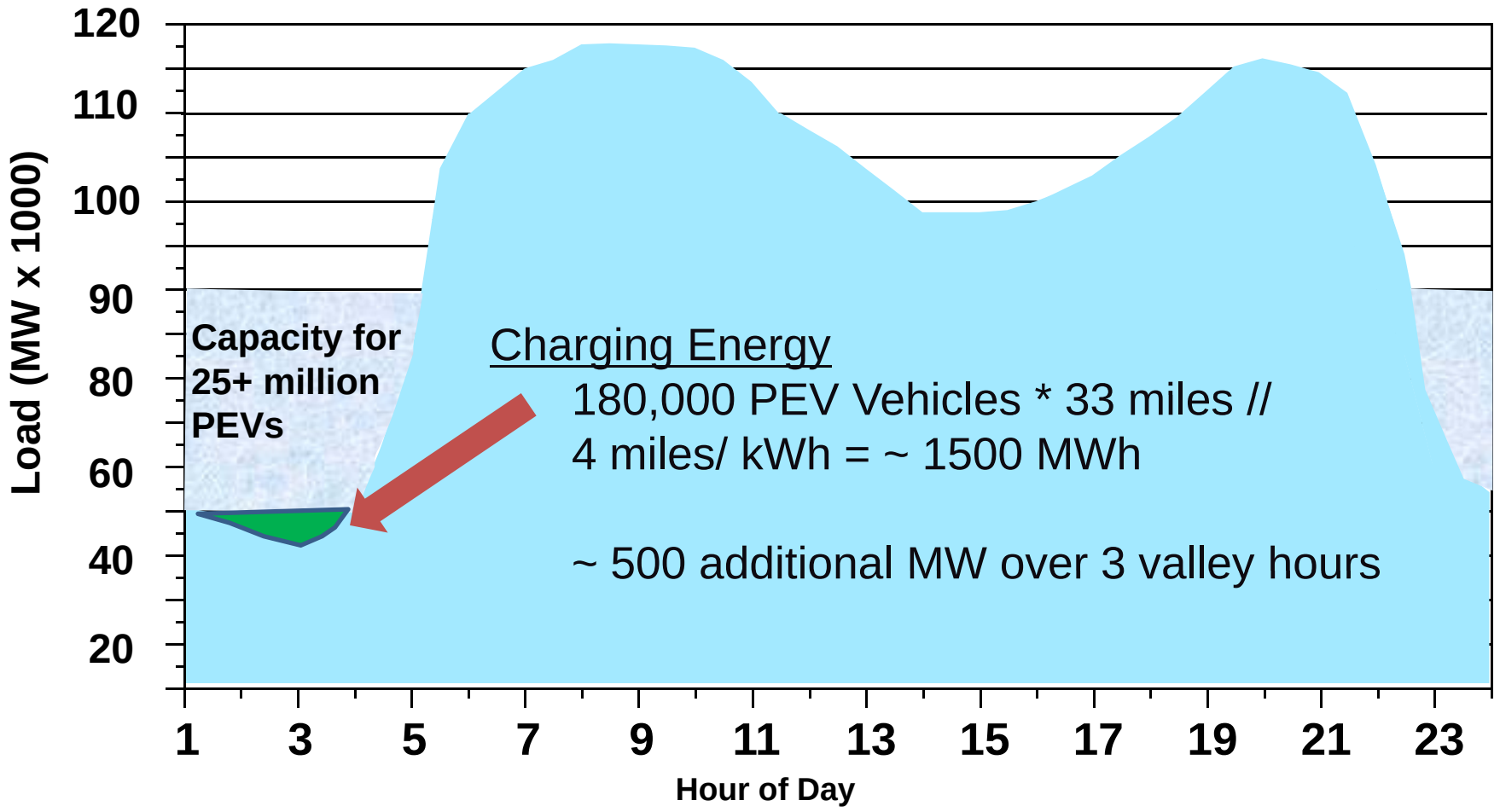
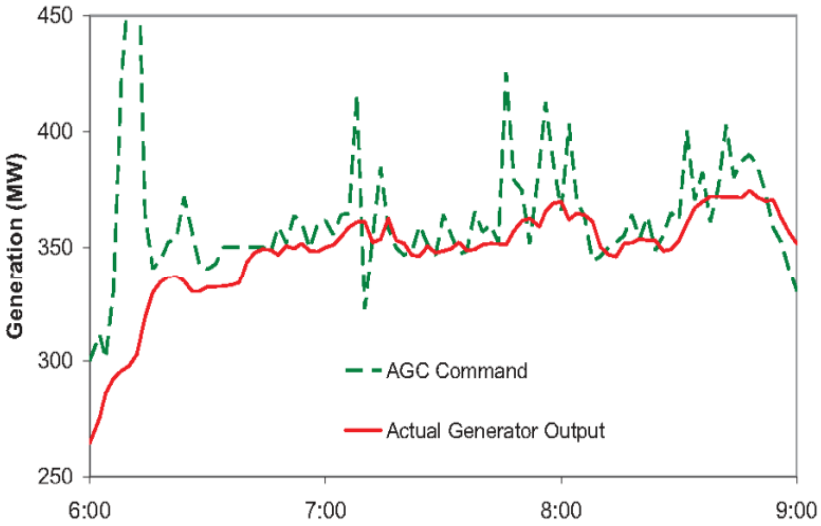
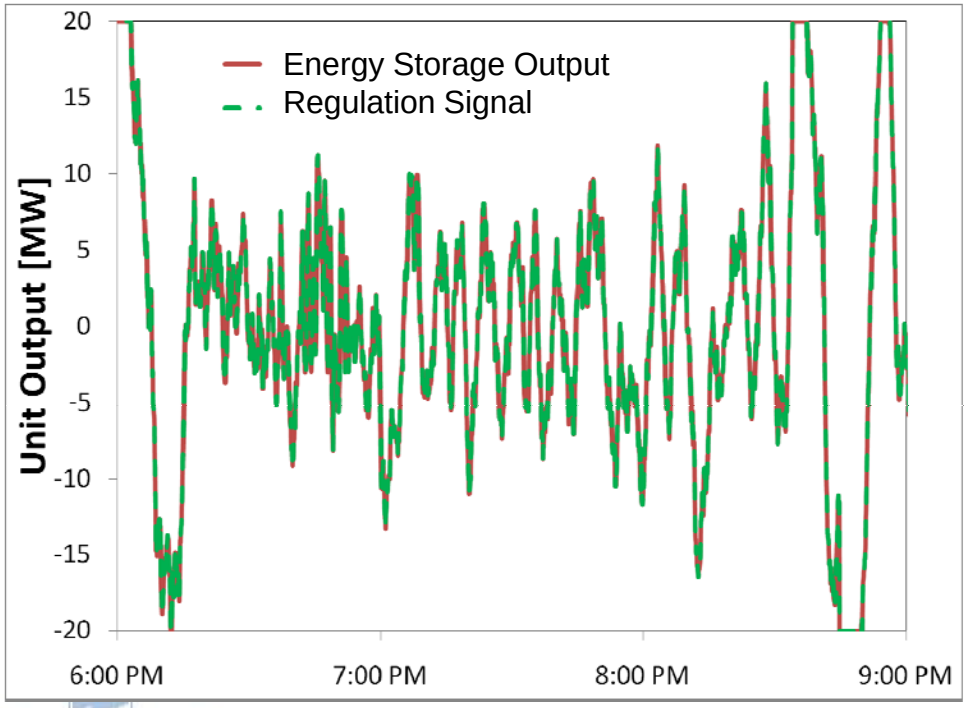


Fast Regulation: Speed Matters…



A fossil power plant following a regulation command signal



Energy Storage (batteries / flywheels) accurately following a regulation command signal

Grid Benefits – Regulation vs. Economic Dispatch

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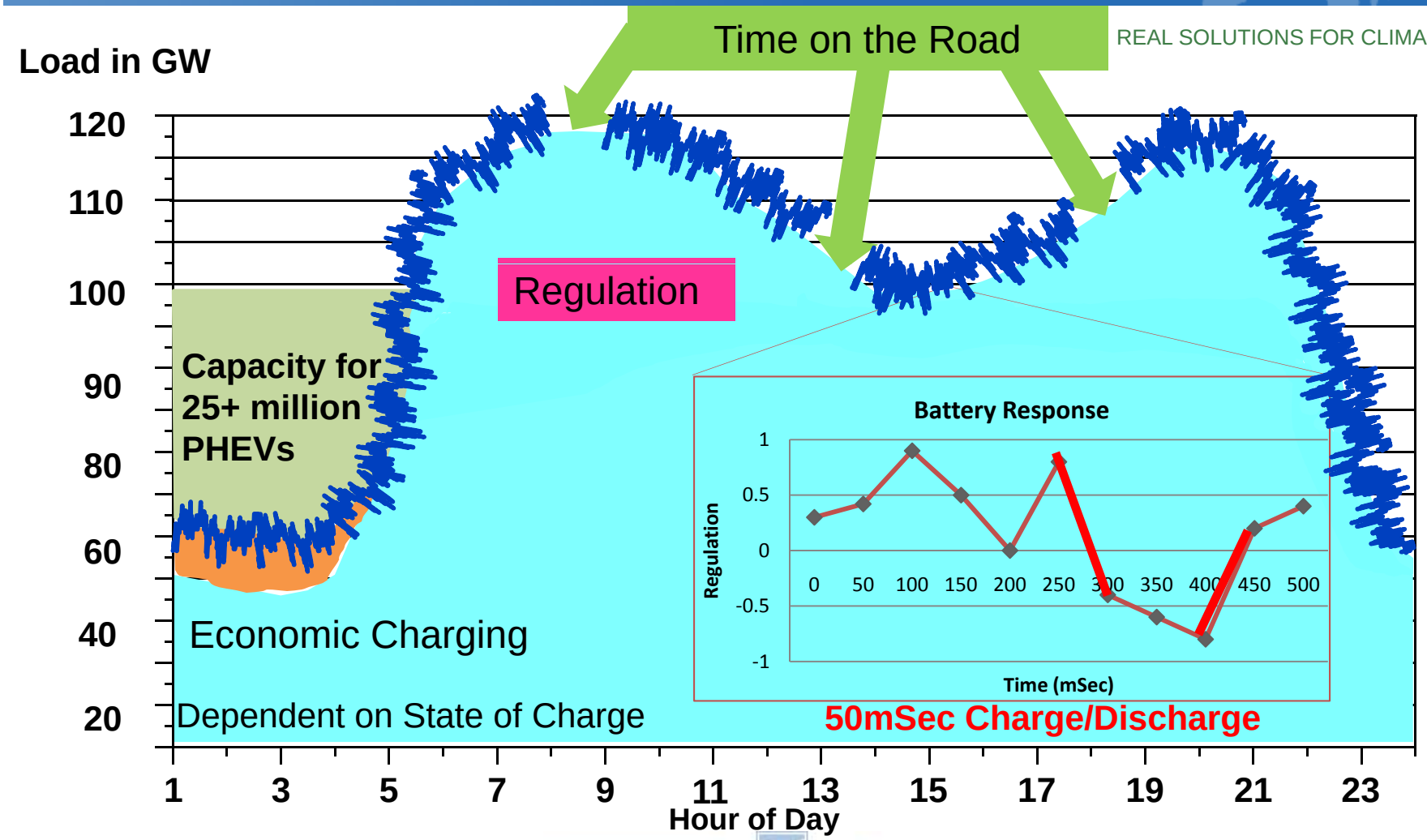

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Vehicles w/ Vehicle-2-Grid Participating in the Regulation Market

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Vehicles

- ~18% of U. S. Population is within the PJM territory
- 180,000 PEV Vehicles in the PJM Territory

V2G Equipped PEVs within PJM

- Assume 10% of Vehicles have V2G capability
- Bi-Directional Power (with inverter) – 15 kW
- 18,000 vehicles * 15 kW = 270 Mw

Availability for Participating in Regulation

- Plugged In 12 hours each day (6PM – 6AM) > 365 days * 12 hours = 4380 hours/year

Payment for participation in the PJM Regulation Market

- PJM average historic price paid for regulation = $35/MWh
- PJM Regulation price during valley load periods = $28/MWh
- Per Vehicle: 4380 hrs * $28 * .015 MW = **$1800 annually**
- PJM Overall: 4380 hrs * 270 MW * $28 = **~$33,000,000 annually**

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Will Work for Fuel

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MAGICC – PJM's PHEV Demonstration Project

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- Smart Meter allows car to roam
- Mid-Atlantic Grid Interactive Car Consortium (MAGICC)
- **Over one year experience**

University of Delaware

Pepco Holdings Inc

AC PROPULSION

comverge

ACUA

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AES Grid-Scale Energy Storage System

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Operational Details

- Altairnano, Inc – Lithium Ion nano titanate battery
- Power: 1 MW for 15 minutes
- Usable Charge Range: 5% - 99%
- Energy: 300 kWh
- Efficiency: 90% round trip

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“Cash Back” for Storage

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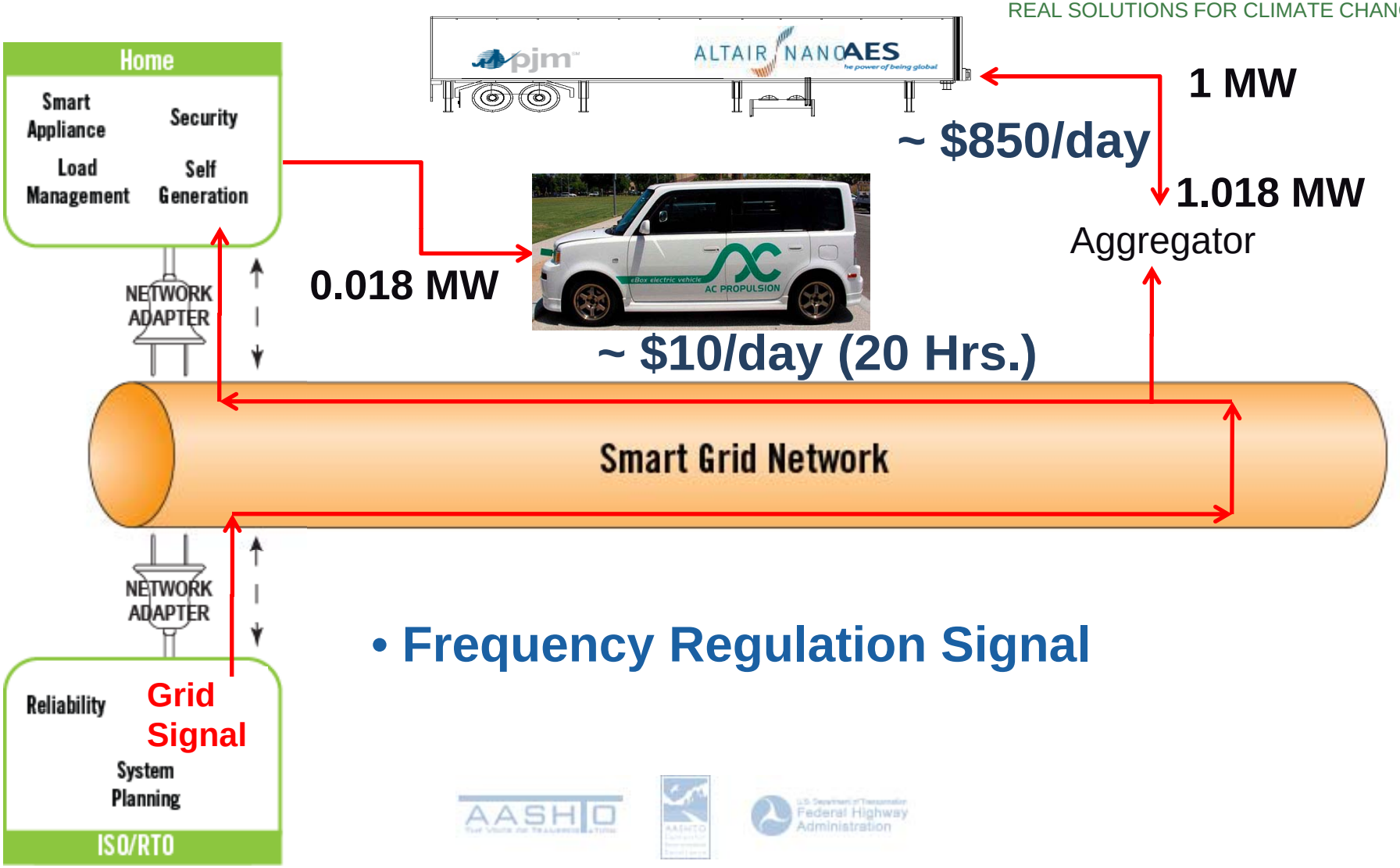

- **Frequency Regulation Signal**

PHEVs: The Momentum Builds

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Battery Electric Vehicles
2010 Coda Automotive Sedan
2010 Mitsubishi iMiEV BEV
2010 Nissan LEAF
2010 Ford Battery Electric Van
2010 Tesla Roadster Sport EV
2011 Peugeot Urban EV*
2011 Renault Kangoo Z.E.
2011 Renault Fluence Z.E.
2011 Tesla Model S
2011 BYD e6 Electric Vehicle
2011 Ford Battery Electric Small Car
2011 Opel Ampera Extended Range BEV*
2012 Fiat 500 minicar

1902 Lohner-Porsche PHEV

2009 BWM MINI E

Battery Electric Vehicles
2012 Renault City Car*
2012 Renault Urban EV*
2012 Audi e-tron
2013 Volkswagen E-Up*
2016 Tesla EV

Extended Range Electric Vehicles
2010 Chevy Volt Extended Range

Plug-in Hybrid Vehicles
Fisker Karma S Plug-in Hybrid
2010 Toyota Plug-in Hybrid
2011 BYD F3DM Plug-in Hybrid
2012 Bright Automotive IDEA Plug-in Hybrid
2012 Ford Plug-in Hybrid
2012 Volvo Plug-in Hybrid

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West Philly: EVX GT
Plug-In Parallel Hybrid Electric Vehicle

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Smart@Car Current Research Activities

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- Modeling of PHEVs and interactions with the grid
- PHEV Energy Management
- PHEV-Grid Connectivity Issues
- PHEV Fleet Studies

Smart@Car-a connection to the grid

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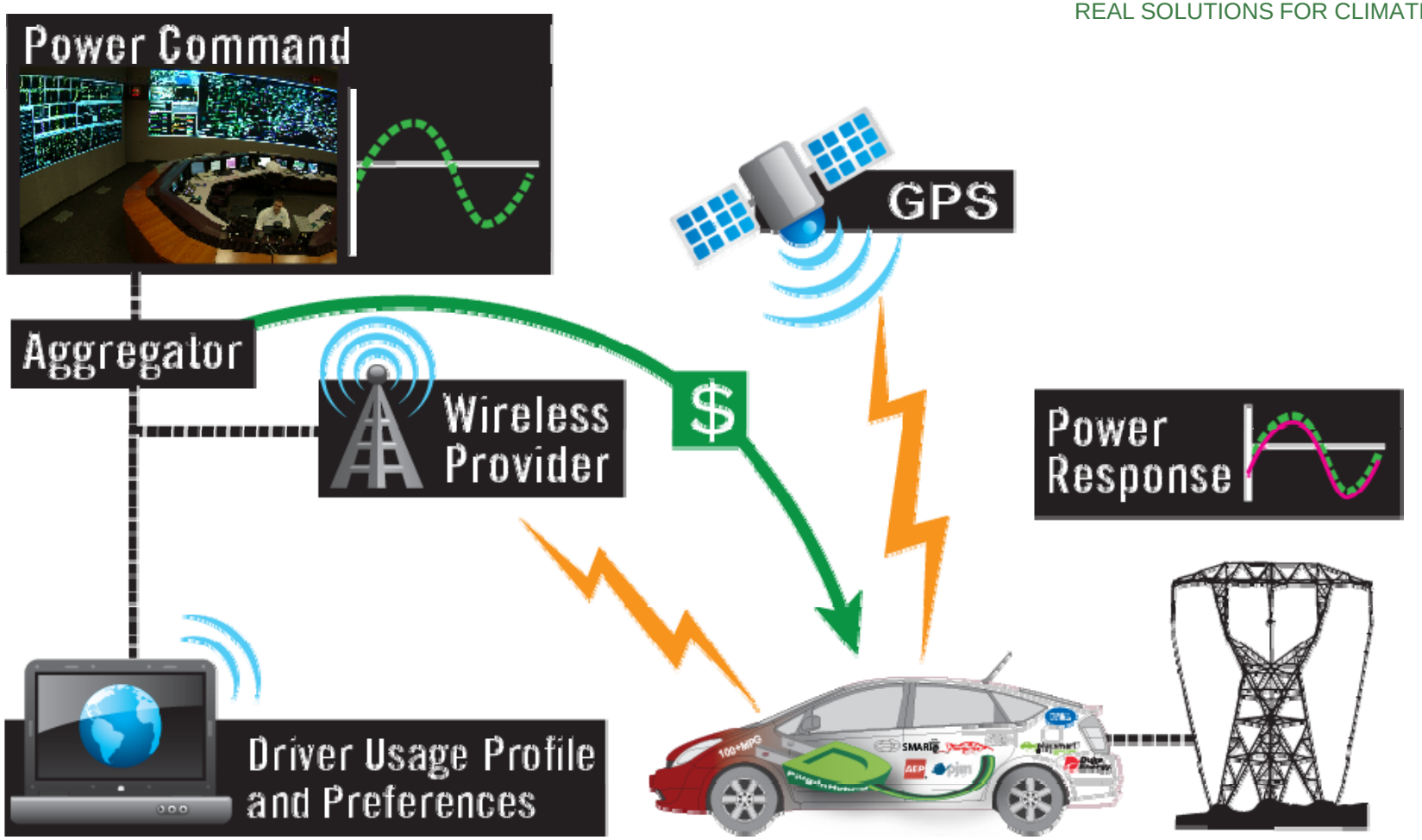

PHEV- Win, Win, Win, Win

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1. Reduce Oil Imports/Energy Independence
2. Reduced Cost of Fuel and Cash Back

3. Reinvent Auto Industry
4. Recharge Off Peak/ Higher Use of Power Industry Assets

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AASHTO Standing Committee on Environment

U.S. Department of Transportation
Federal Highway Administration

Transportation and Climate Change Resource Center

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The West Coast Green Highway:
I-5 Electric Highway Public/Private Partnership Project

March 17, 2011

Presented by:

Jeff Doyle
Director of Public/Private Partnerships
Washington State Department of Transportation

The Transportation-Energy Imperative

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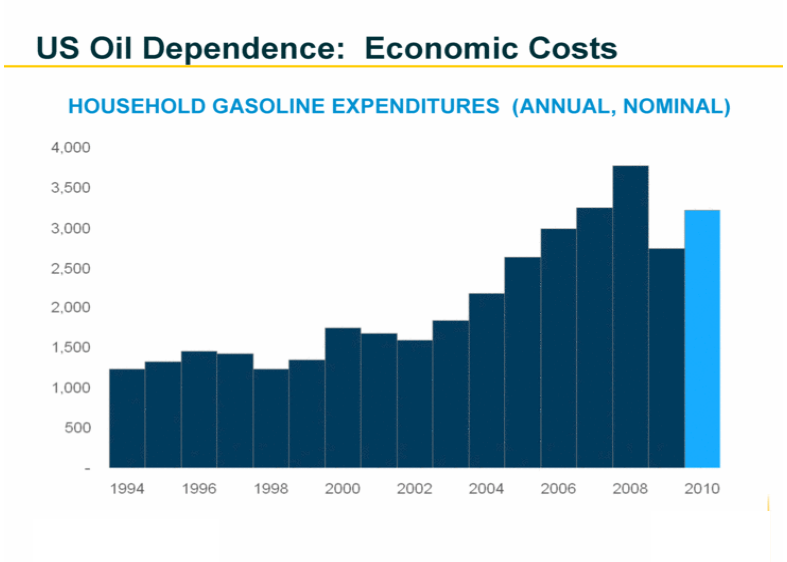
U.S. oil dependence weakens our national security, threatens our economy, and degrades the environment.

National Security Costs of Oil Dependence:

- Securing global supply lines:
  $67.5 - $83 billion per year

Economic Costs of Oil Dependence:

- Every recession over past 35 years preceded by – or concurrent with – an oil price spike



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The Transportation-Energy Imperative

REAL SOLUTIONS FOR CLIMATE CHANGE

Environmental Costs of U.S. Oil Dependence:

- The transportation sector is the single largest *end-use emitter* of carbon dioxide in the U.S (34 percent of total CO2 emissions).
- To reach a 450 ppm Co2 stabilization target, by 2030 more than 60 percent of new vehicle sales must be electric drive.

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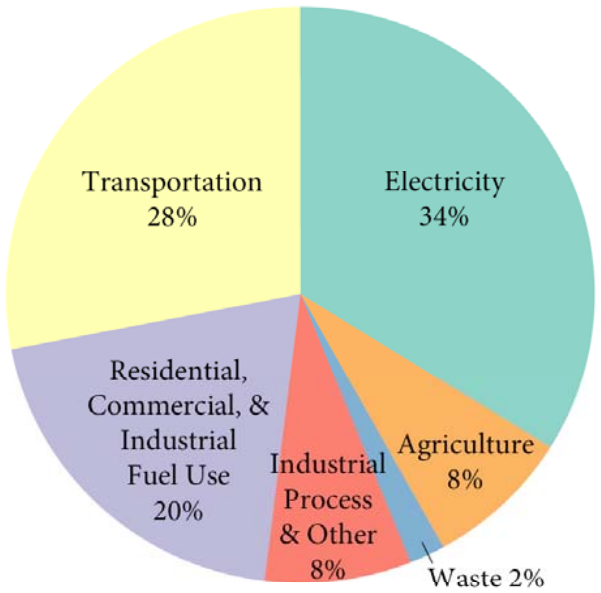
Importance to State DOTs

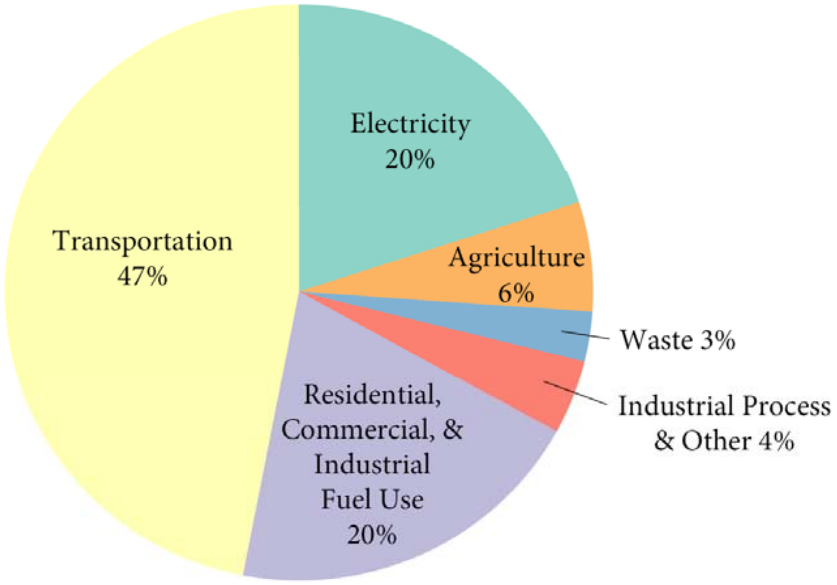
GHG emissions from Washington State's transportation sector (47%) are nearly double the national figures

U.S. Greenhouse Gas Emissions



Source: Washington State Department of Ecology, 2005

Washington Greenhouse Gas Emissions



Source: Washington State Department of Ecology, 2005

Importance to State DOTs

2008 WSDOT Alternative Fuels Corridor Economic Feasibility Study:

"The primary challenge to Alternative Fuels commercialization is how to build a market – simultaneously – for *new vehicle technologies*, *new fuels*, and *new infrastructure* to support them."

http://www.wsdot.wa.gov/Funding/Partners/AltFuelsCorridor.htm

Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

Comparative Factors for Alternative Fueling Stations

	Land & Building	Fueling Equipment	Supply Chain
Gasoline	$ 1,348,500	$ 571,000	Established
Biodiesel	(Co-located?)	$ 127,000*	Limitations
Hydrogen	(Co-located?)	$ 318,000	Not Established
Electricity	Kiosk	$ 50,000 - $90,000**	Grid

* Number of pumps scaled for smaller initial demand
** Upper range includes utility connections and necessary upgrades

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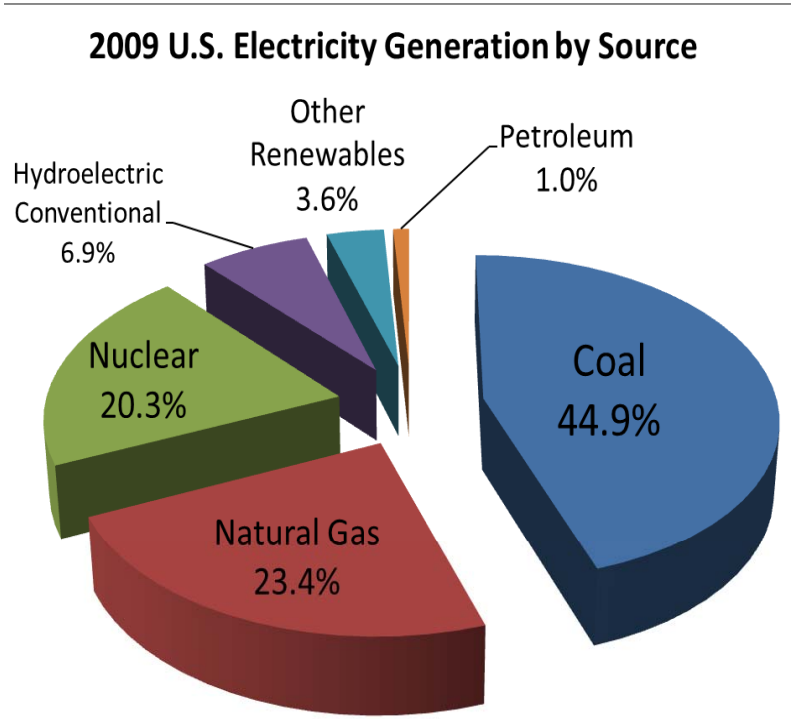
Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

Fuel Source: Electric Power Grid



Advantages:

- Diverse and domestic
- Prices are stable
- Substantial spare capacity
- Network infrastructure already in place
- Electric miles cheaper than gas
- Electric miles are cleaner than gas
- 65 percent of present U.S. light-duty vehicles could be powered by existing off-peak generating capacity

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Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

Electric Vehicles: Battery Electric (BEV) vs. Plug-in Hybrid (PHEV)

Example: Nissan LEAF

- All Electric Range: 60 - 200 Miles, depending on battery size
- Level 1 (120 v), Level 2 (240 v) and optional Quick-Charging (480v)
- Target markets:
  - Urban Commuters
  - Second Car in Every Home
  - Eventually: all-purpose

Example: Chevy Volt

- Battery Electric plus ICE range extender
- 10-40 mi all-electric, 200-300 mi gas
- Level 1 (120v) and Level 2 (240v) Charging
- Target Market: all automotive applications

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Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

Nissan LEAF Range and Vehicle Efficiency

Speed and Driving Conditions	Outside Temp (F)	Accessories	Estimated Range (mi)	Vehicle Efficiency (mi/kWh)*
Cruising 38 mph	68°	None	138	5.75
Fairly steady 24 mph City traffic	77°	None	105	4.38
Steady 55 mph Highway	95°	A/C on	70	2.91
Crawling 15 mph Stop-and-go	14°	Heater on	62	2.60
Average 6 mph Heavy stop-and-go	86°	A/C on	47	1.96

Nissan LEAF has a 24 kWh battery Source: "Nissan Agrees - EV Mileage Will Vary; Leaf Tests Show 91-Mile Variation." Green Car Advisor – edmunds.com. June 15, 2010.

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Why Electric?

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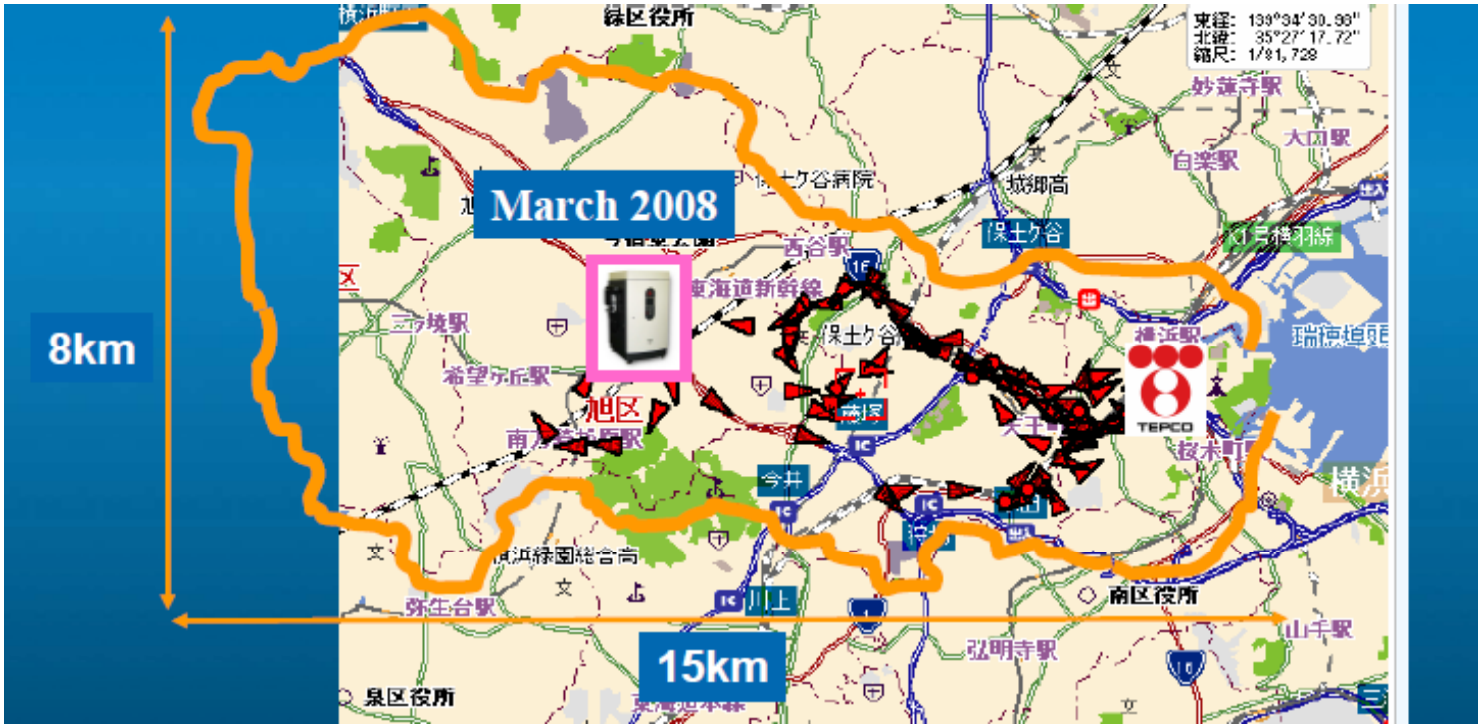
EV's are not fully utilized when "range anxiety" exists



Source: Tokyo Electric Power Company (TEPCO)

Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

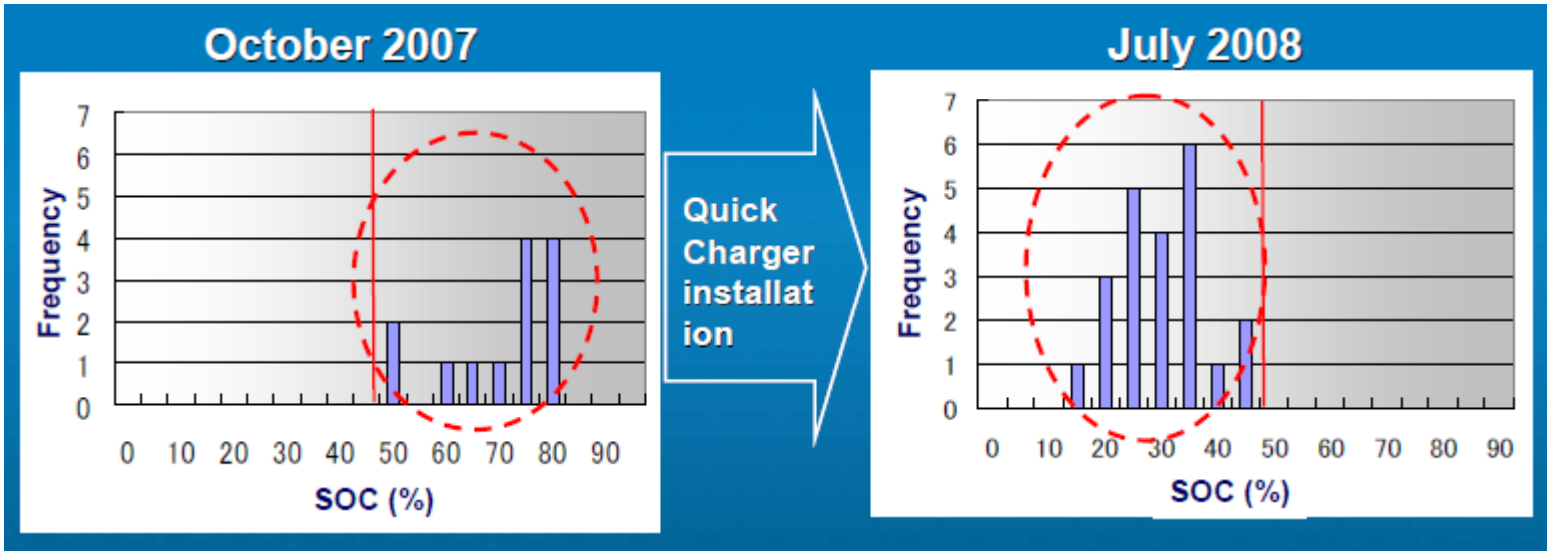
Strategically-located Quick Charge stations alleviate range anxiety

Source: Tokyo Electric Power Company (TEPCO)

Why Electric?

REAL SOLUTIONS FOR CLIMATE CHANGE

Strategically-located Fast Charge stations alleviate range anxiety



Drivers returned EV's with > 50% SOC

Drivers returned EV's with < 50% SOC

Source: Tokyo Electric Power Company (TEPCO)

WSDOT's West Coast Green Highway

REAL SOLUTIONS FOR CLIMATE CHANGE

Project Purpose: Commercialization of Electric Vehicles

- Develop safety net of EV Quick-Charging stations throughout Interstate 5 Corridor – WSDOT's niche is outside Seattle-metro area
- Form public/private partnerships: with retailers to serve as station hosts, and with DBFOM consortium to develop, install and operate chargers
- Coordinate EV infrastructure development with other EV infrastructure planned for Seattle, Vancouver, BC, State of Oregon (ODOT), and eventually, California (missing link)
- WSDOT seed funding: $1.32m US Department of Energy grant for petroleum reduction projects (through Washington State Commerce Dept.)

Public/Private Partnerships for EV Infrastructure

REAL SOLUTIONS FOR CLIMATE CHANGE

Two-Stage Deployment: Essential Charging and Corridor Completion

- **Funding:** $1m federal grant for capital seed funding. Seeking DBFOM partner for maximum leverage (fixed price, variable scope).
- **Target completion date:** October 31, 2011.
- **Focus:** Ease of use for consumers. Turn-key for government sponsors.
- **Minimum Number of DC Quick Charge Stations:** 9 stations (7 on I-5, 2 along SR-2)

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Supportive State Actions

REAL SOLUTIONS FOR CLIMATE CHANGE

Issues to Consider (from WSDOT's perspective):

- Capital efficiency of PPP (leverage) vs. strong government ownership role
- What happens after Year 3 (turn-back)?
- Long-term sustainable business model?

Opportunities and Resources for State DOTs and Municipalities

- **Transportation Pooled Fund Study Opportunity**: *"Strategies and Best Practices for State Departments of Transportation to Support Commercialization of Electric Vehicles (EV) and Infrastructure"* Solicitation #128http://www.pooledfund.org/projectdetails.asp?id=1289&status=1

- West Coast Green Highway (www.westcoastgreenhighway.com)

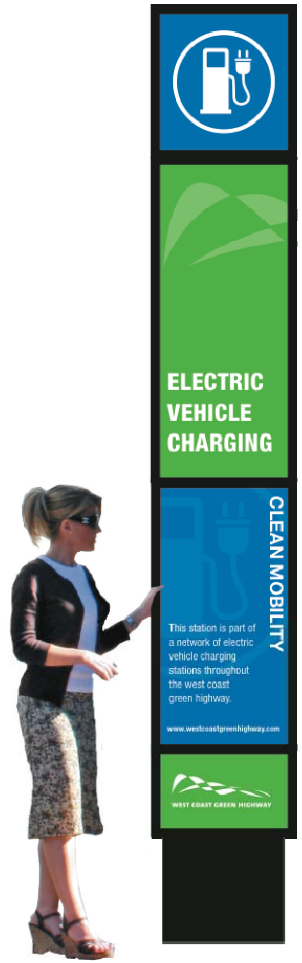
- The EVProject (www.TheEVProject.com)

West Coast Green Highway

REAL SOLUTIONS FOR CLIMATE CHANGE

I-5 Electric Highway Public/Private Partnership Project

For more information, contact:
Jeff Doyle
Director of Public/Private Partnerships
WSDOT (360) 705-7023
DoyleJ@wsdot.wa.gov
www.westcoastgreenhighway.com



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For copies of these slides and webinar recording, go to AASHTO's website:
http://environment.transportation.org/center/products_programs/climate_change_webinars.aspx

These materials will also be available on AASHTO's climate change website, where you can also find more information on climate change:
http://climatechange.transportation.org/webinars/

Thank you!

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