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The Near Future of Electric Transportation

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Global Climate Change Research Seminar

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Mainstream PEV Commercialization Began December 2010

Chevrolet Volt

- Extended Range Electric Vehicle
  - (EREV - A plug-in hybrid with a guaranteed electric range).
- EV Range of 25 – 50 miles
  - 35 mi EPA rating
- Charging: 8-9 hours at 120V, 12A
  3 hours at 240V, 15A

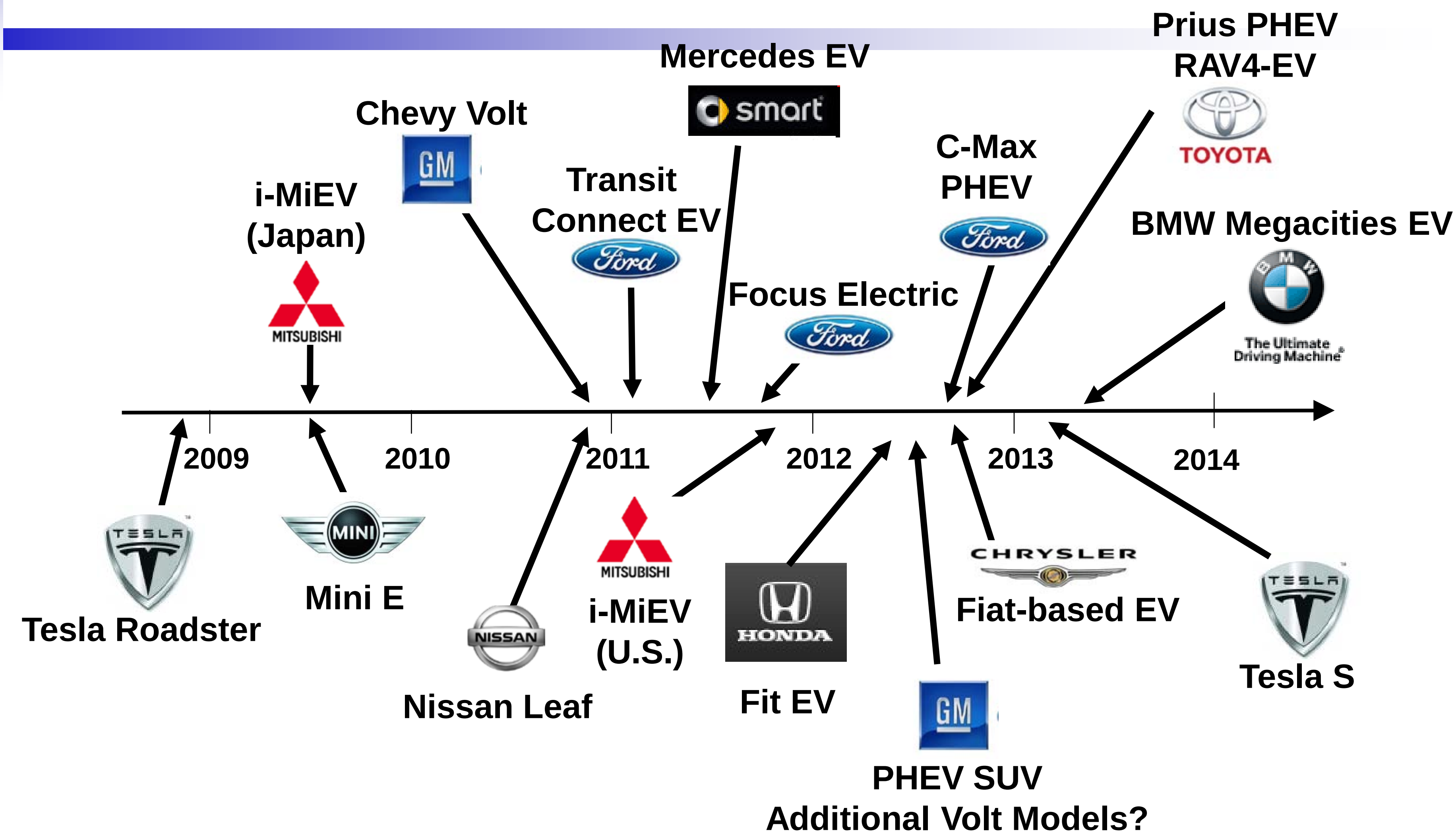
Nissan Leaf

- Battery Electric Vehicle
- EV range of 80 – 100-miles
- Charging: 20 hours at 120V, 12A
  8 hours at 240V, 15A
  30 min at 400V, 150A

Status of PEV Rollout

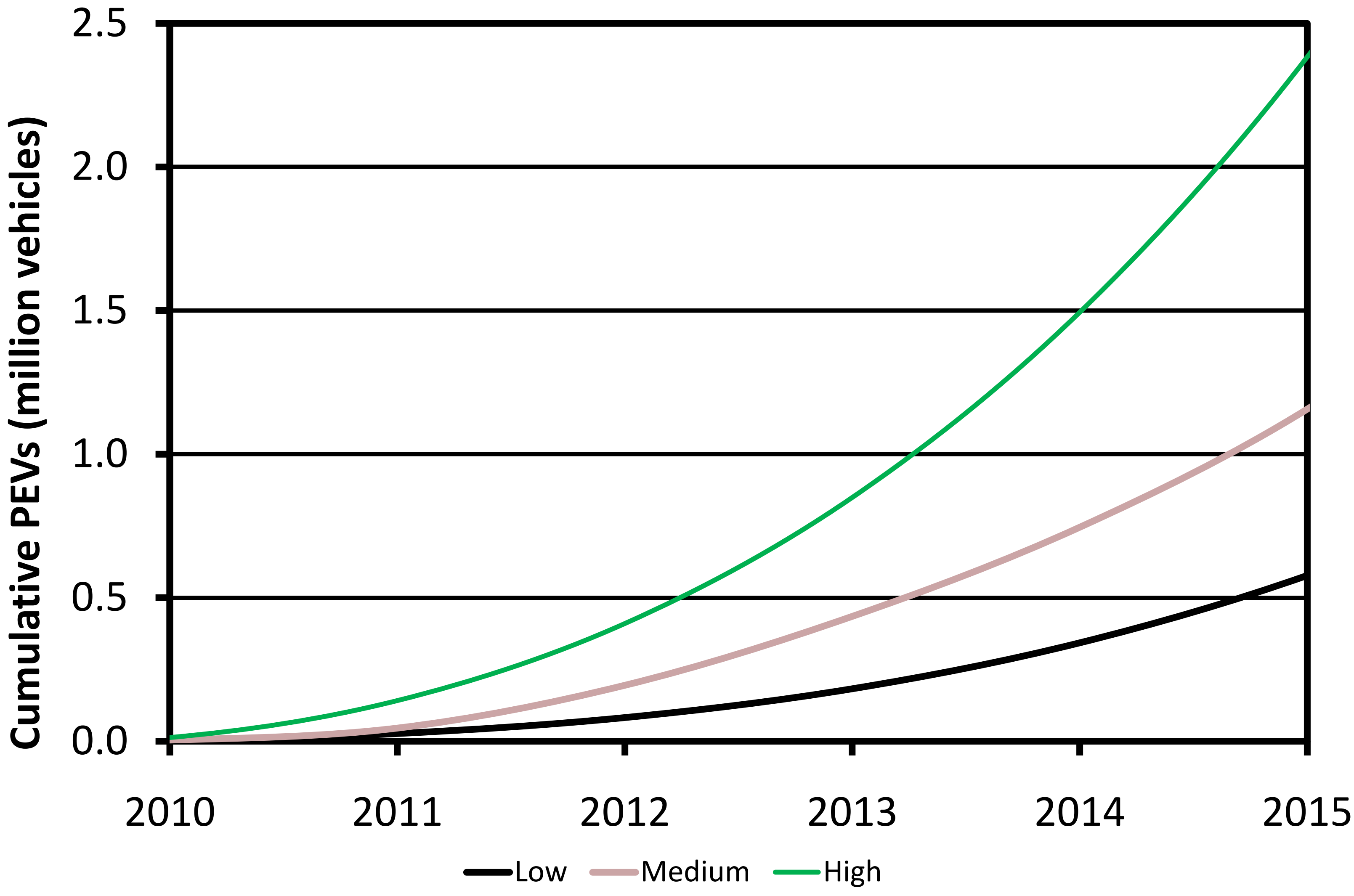
- Nissan successfully launched the Leaf battery electric vehicle in December 2010
  - **Dec: 16 deliveries CYTD: 1,025 deliveries**
  - 2011 production estimated at 30,000
  - Building U.S. EV, battery plant in Smyrna, TN
- General Motors successfully launched the Chevrolet Volt Extended Range Electric Vehicle in December 2010
  - **Dec: 326 deliveries CYTD: 1,703 deliveries**
  - 2011 production estimate ~10,000—2012 production estimates of 60,000 to 120,000
  - 2 new Volt models announced, possibly also an SUV
- Ford announced timing for the Focus Electric and C-Max PHEV, began delivery of Transit Connect Electric
- Toyota announced timing for Prius PHEV, RAV4 EV

The Pipeline for New Models is Promising



Between 1999 and 2004, there were three hybrids introduced to the U.S. market (Prius, Insight, Civic Hybrid)

Near-Term PEV Projections
Establishing market, sustainable business case



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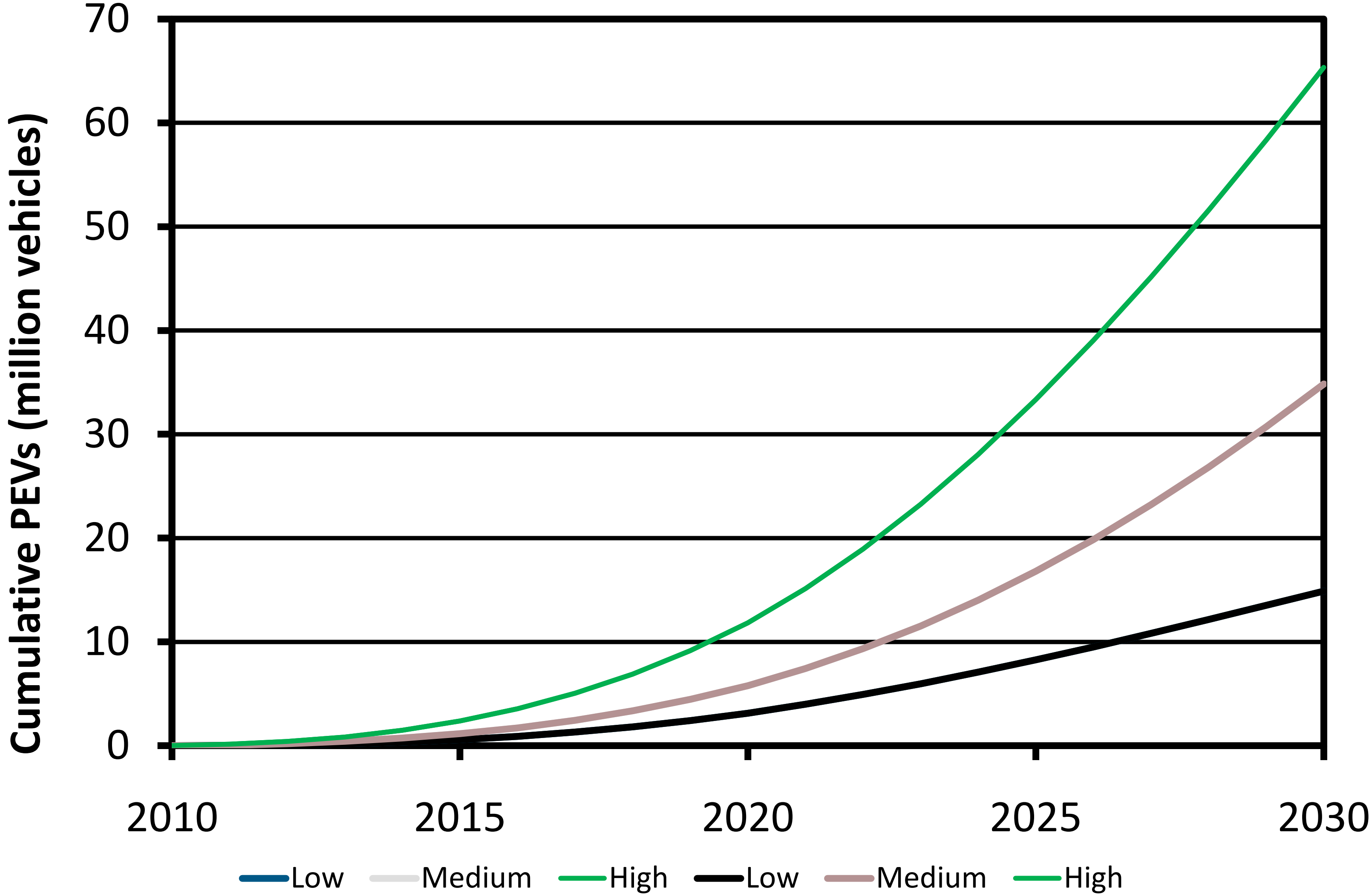
Long-Term PEV Projections

Production volume, cost, awareness for a mainstream product



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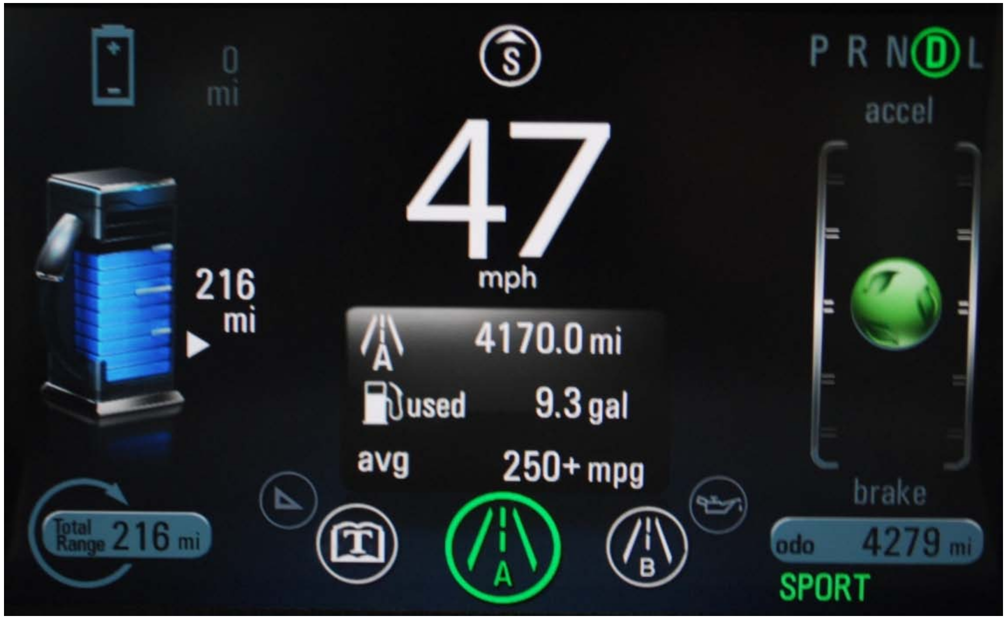
Near-Term Objectives

- Cost reductions—both vehicle and infrastructure—are critical
- Build public awareness
- Develop realistic and efficient public infrastructures
- Simplify infrastructure installation and offerings
- Migrate PEV technology to new platforms

At this point in time, nothing is more important that getting the as many great PEVs in the hands of drivers as possible

Initial Impressions of Vehicles & Infrastructure

- Impressions, not data at this point
- High proportion of Level 2 requests
- Significant issues with multi-unit dwellings (condos, etc)
- Public infrastructure just getting started
- Probably will see increased emphasis on workplace charging



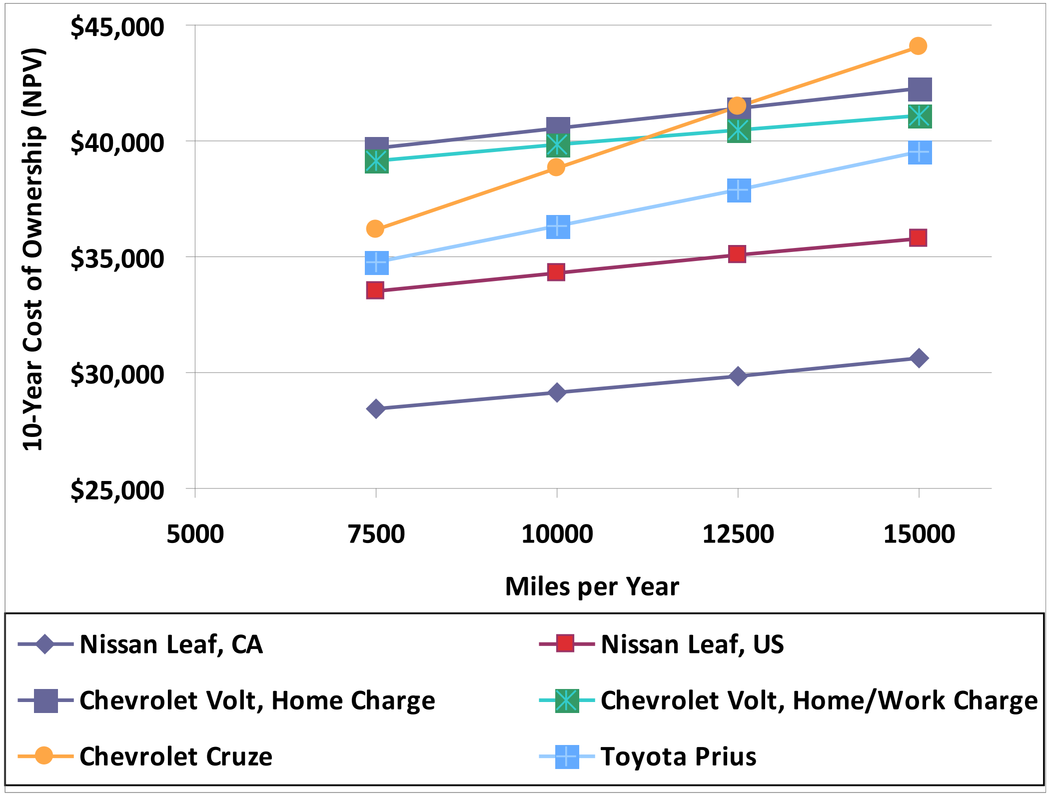
Chevrolet Volt
50-mile roundtrip commute

Level 1 – Home Charging
Level 2 – Workplace Charging

~92% Electricity Utilization

Plug-In EV Owner Economics

- **Cost ≠ Price**
  - Difficult to compare early market PEVs with gasoline vehicles – PEV pricing is not yet stable
- First generation PEVs are surprisingly competitive economically
  - Cost reduction must equal, then exceed tax credits
- Comparable gasoline car fuel economy ~ 30 mpg
  - 100k mile fuel costs ~ $13,500
  - 150k mile fuel costs ~ $20,000



Simple 10-Year Ownership Assumption

Electricity: $0.11/kW Gasoline: $4.04/gal

Incentives: $7500 federal, $5000 state (Leaf only)

Level 2 Home Infrastructure = $2000 (Leaf only)

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Three Ways to Charge a PEV

120V – Level 1

Portable cordset
Use any 120V outlet

Up to 1.44 kW

DC Fast Charging

Up to ~ 50 – 60 kW

Fast, expensive

240V – Level 2

Permanent charge station (EVSE)

Typ. 3.3 – 6.6 kW, but up to 19.2 kW

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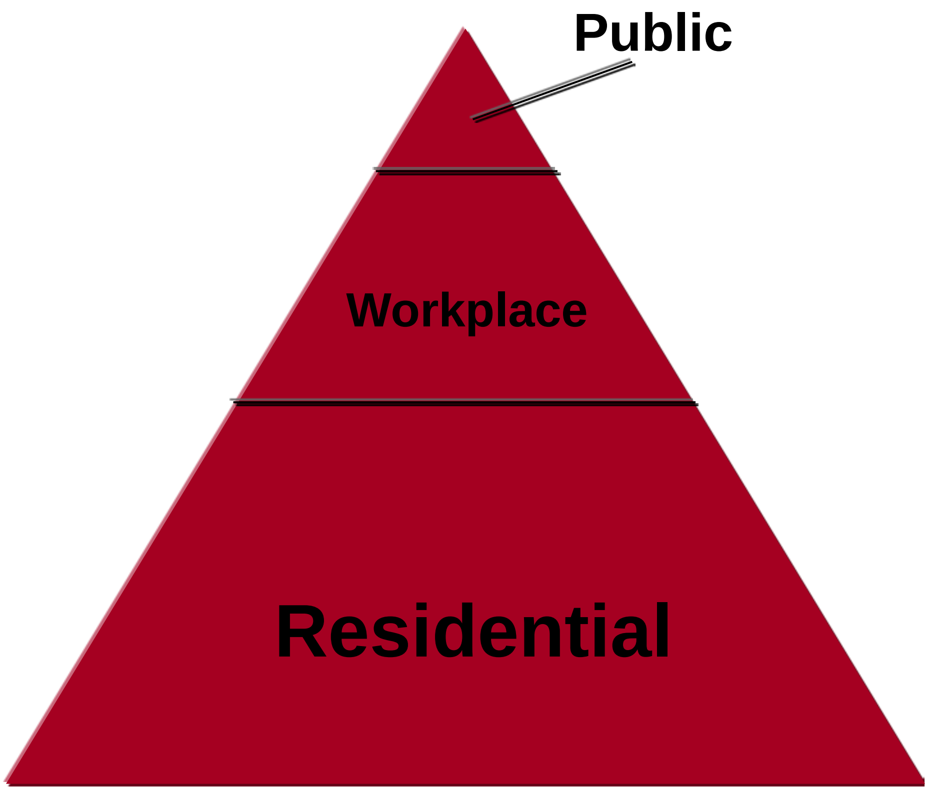
Three 'Places' to Charge

• Build Today's Infrastructure Today

- Infrastructure is expensive
  - ~ $1500 home, $2500+ public
- Focus on Residential
  - – 95% of vehicles end day at home
  - – Costs can exceed $2200 - $2500
  - – Cost and lead time minimization
- Workplace
  - – 2nd priority in terms of use
- Public Charging
  - – Critical vs. convenience
  - – **Understand DC Fast Charging**
  - – Long-term sustaining of infrastructure



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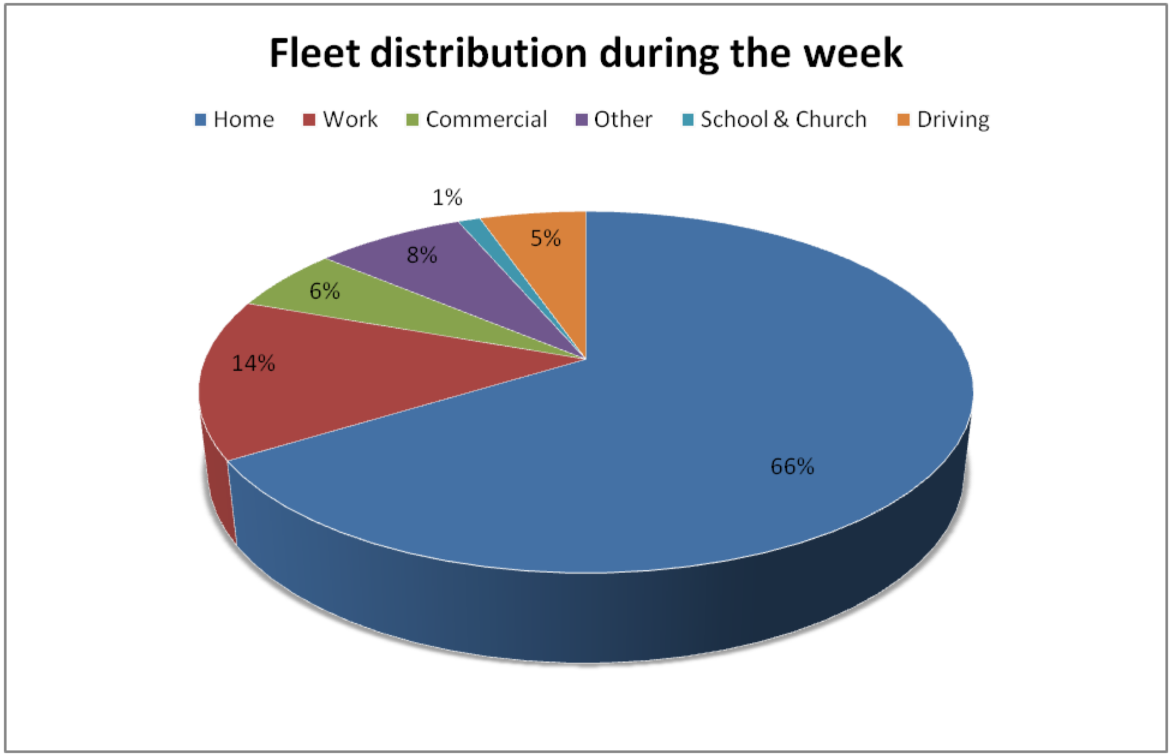
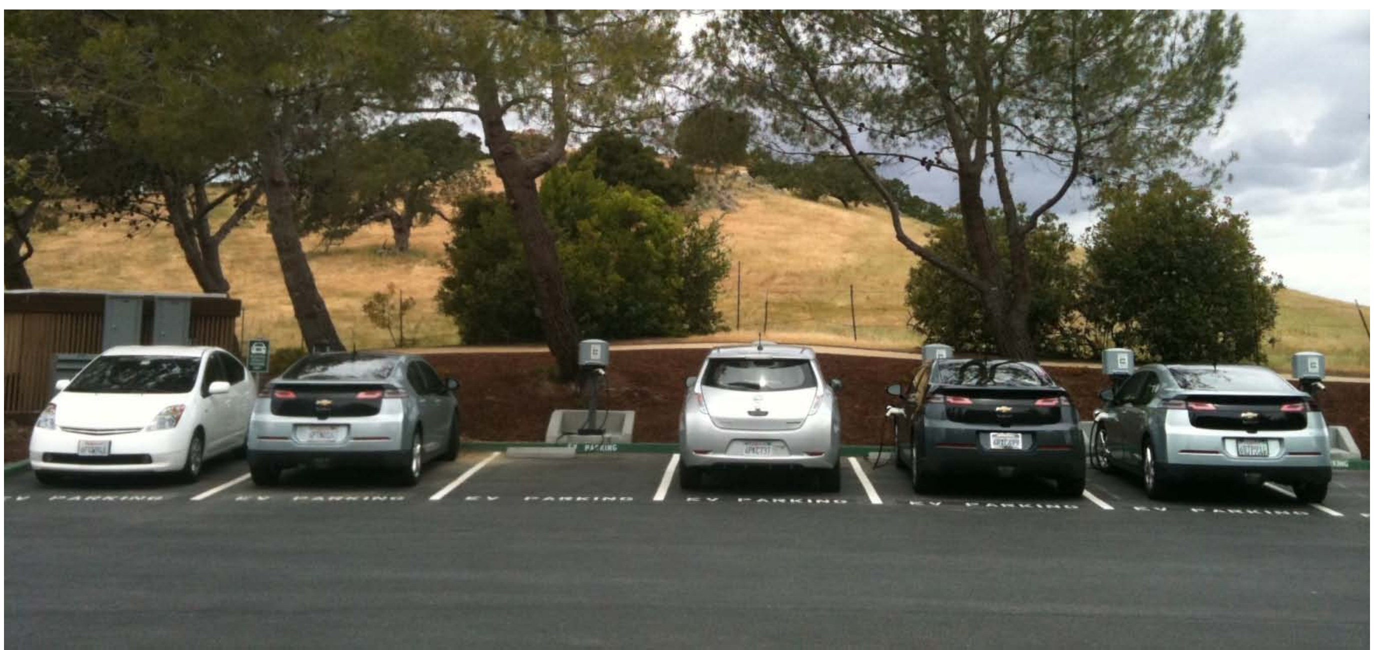
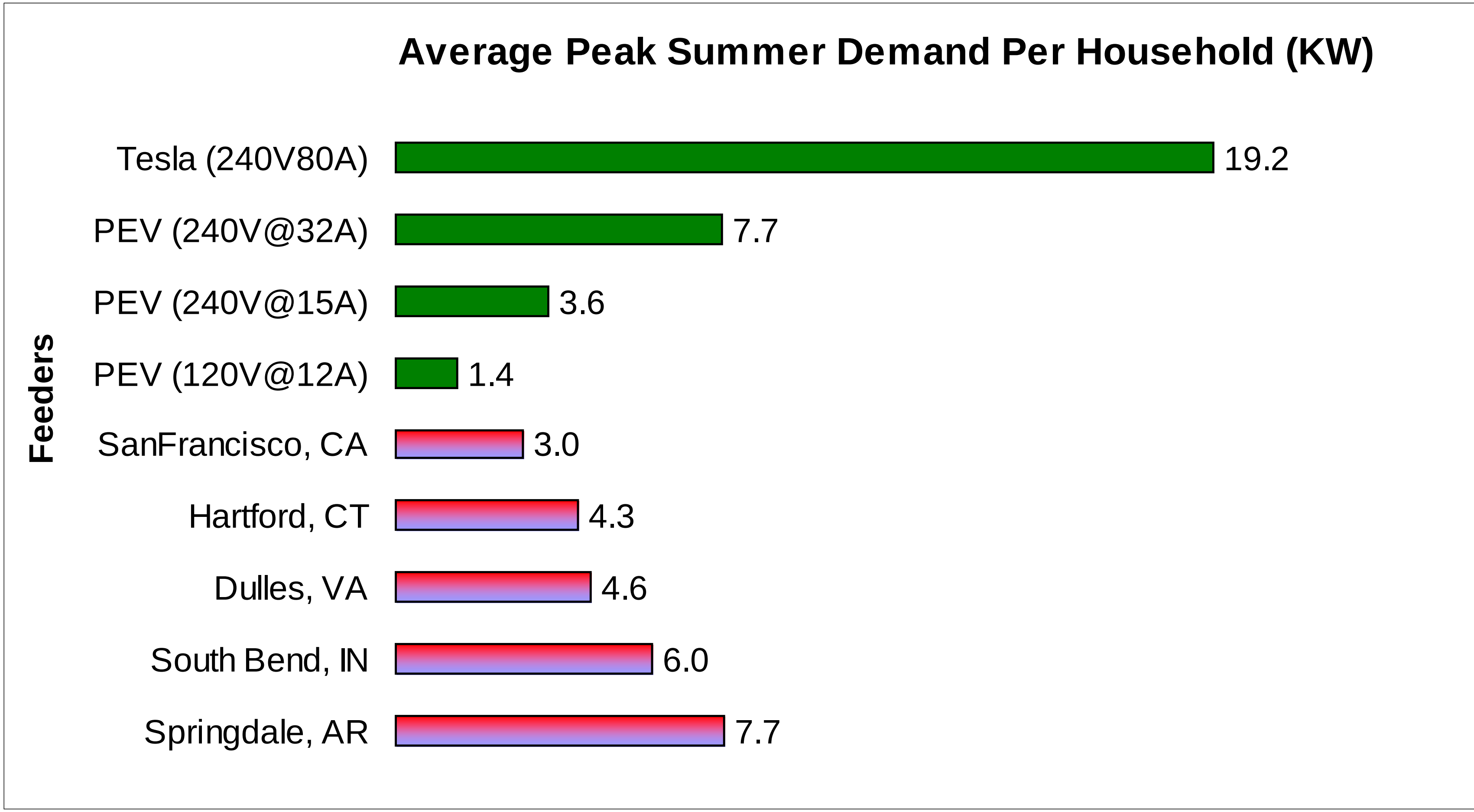

Fleet distribution during the week
Home
Work
Commercial
Other
School & Church
Driving
1%
5%
8%
6%
14%
66%

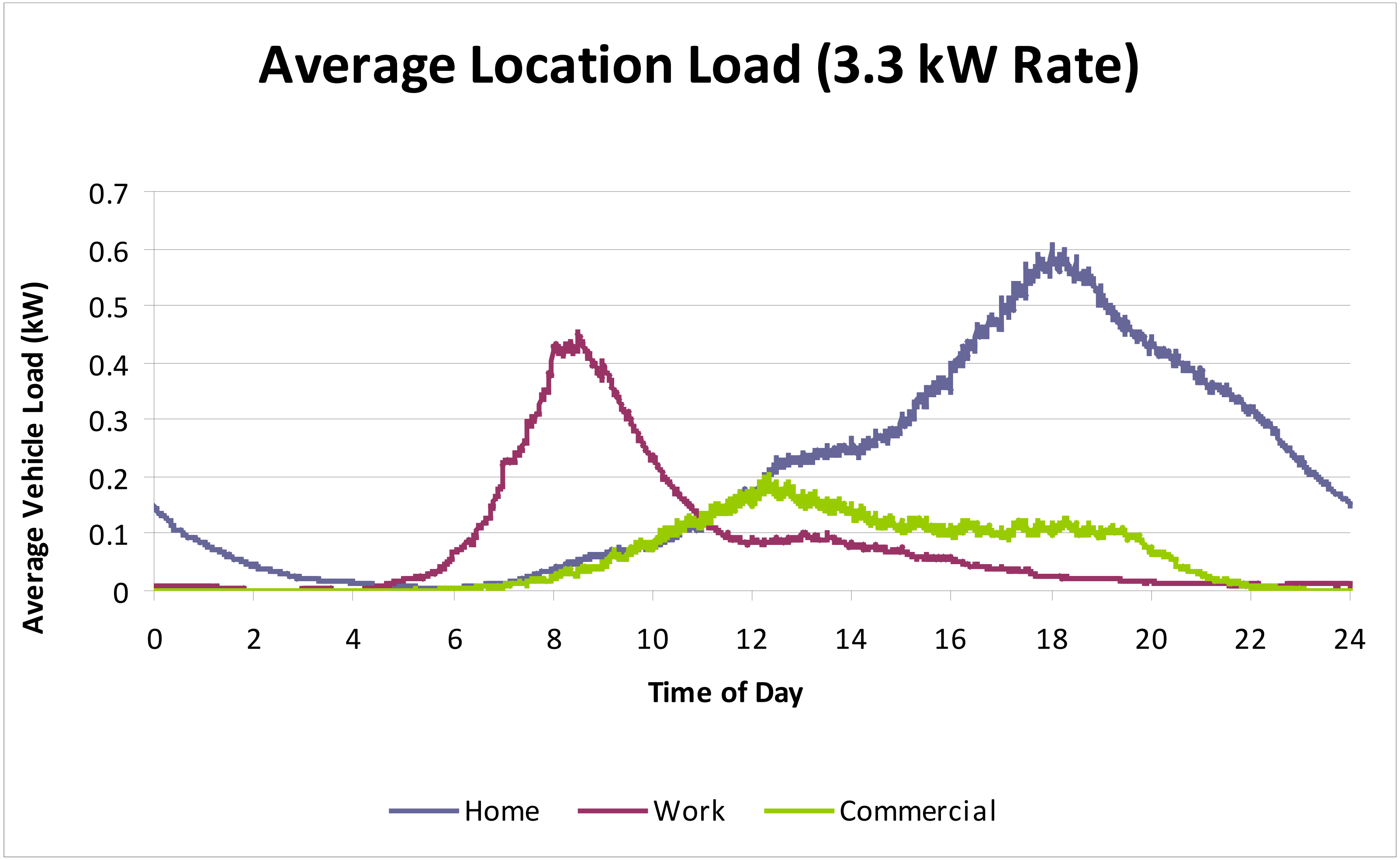


Peak Demand



PEV Peak Demand Depends on Charging Capacity (Voltage/Amperage)

Grid Impacts



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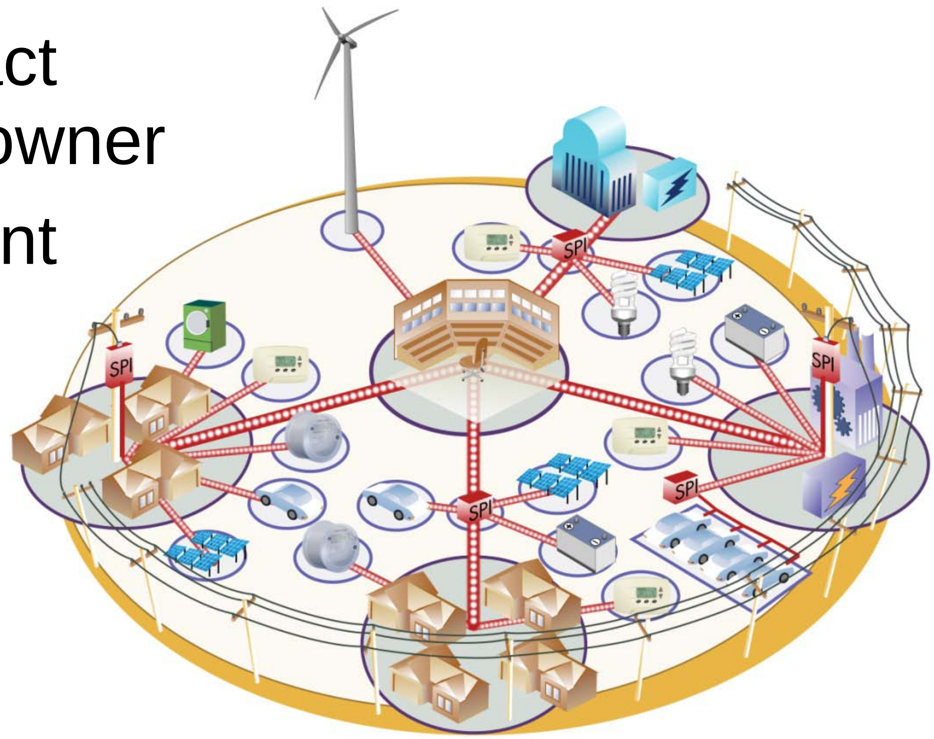
Smart Charging is the Key to Reducing Grid Impacts

Vision – By 2015, all new plug-in vehicles can communicate to the smart grid and charging is intelligently controlled

- 'Smart charging' is a compact between utility and vehicle owner
  - Low in cost and convenient for vehicle operator
  - Minimize system impacts
- Implement with AMI, HAN, internet, telematics, etc.
- Vary time-of-day and charge power



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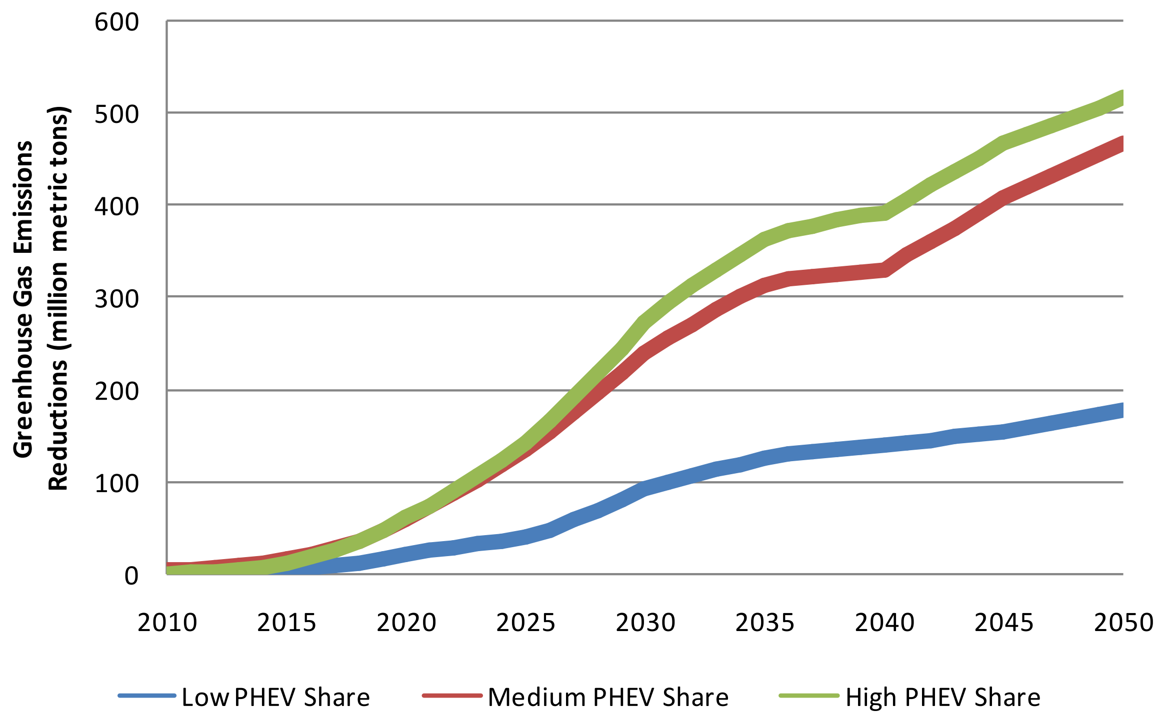
Greenhouse Gas Emissions

- Electricity grid evolves over time
- Nationwide fleet takes time to renew itself or “turn over”
- Impact would be low in early years, but could be very high in future
- A potential 400-500 million metric ton annual reduction in GHG emissions



Annual Reduction in Greenhouse Gas Emissions From PHEV Adoption

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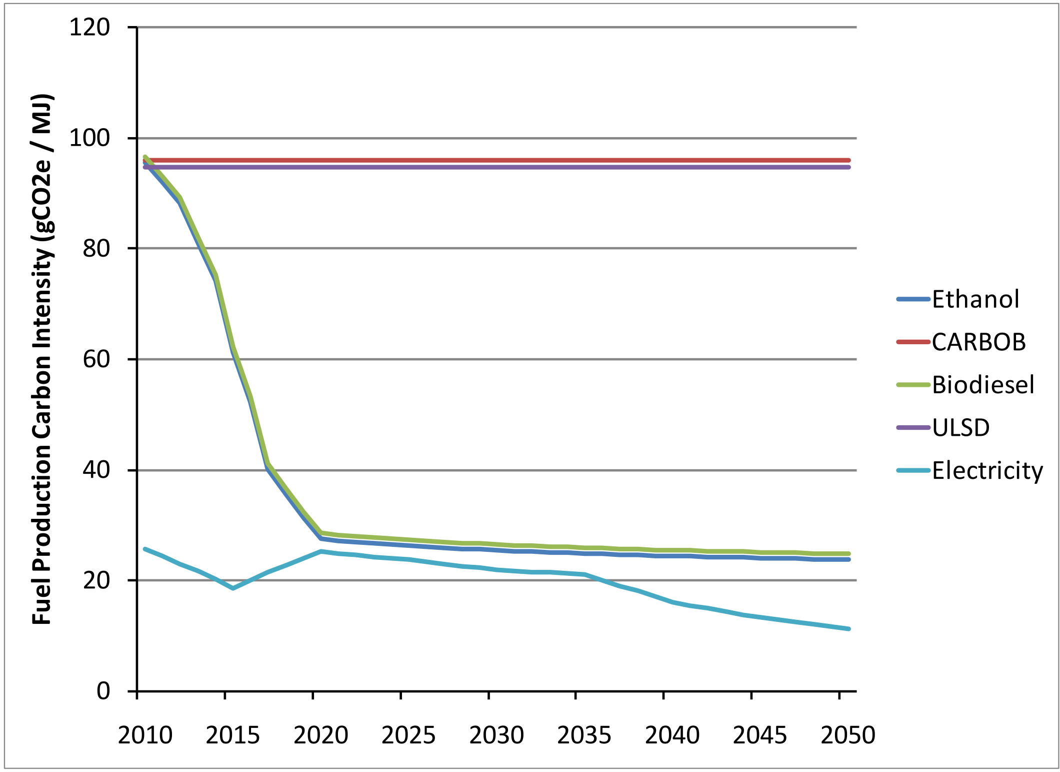
Electricity as a Low Carbon Fuel in CA

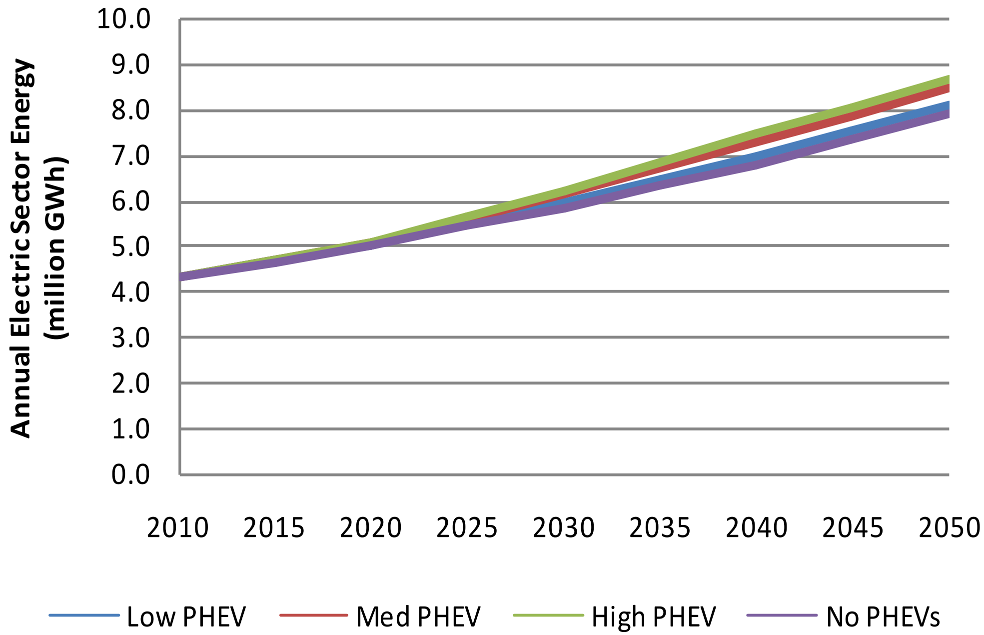
- Marginal electricity supply is low GHG for ET
- Vehicle penetration is dominant factor
- EV range, electricity source not as significant



Fuel Production Carbon Intensity

Impacts to Energy
Electricity and Petroleum

- Moderate electricity demand growth
- Capacity expansion 19 to 72 GW by 2050 nationwide (1.2 – 4.6%)
- 3-4 million barrels per day in
oil savings
(Medium PHEV Case, 2050)



Electricity Demand: Medium CO_2 Case

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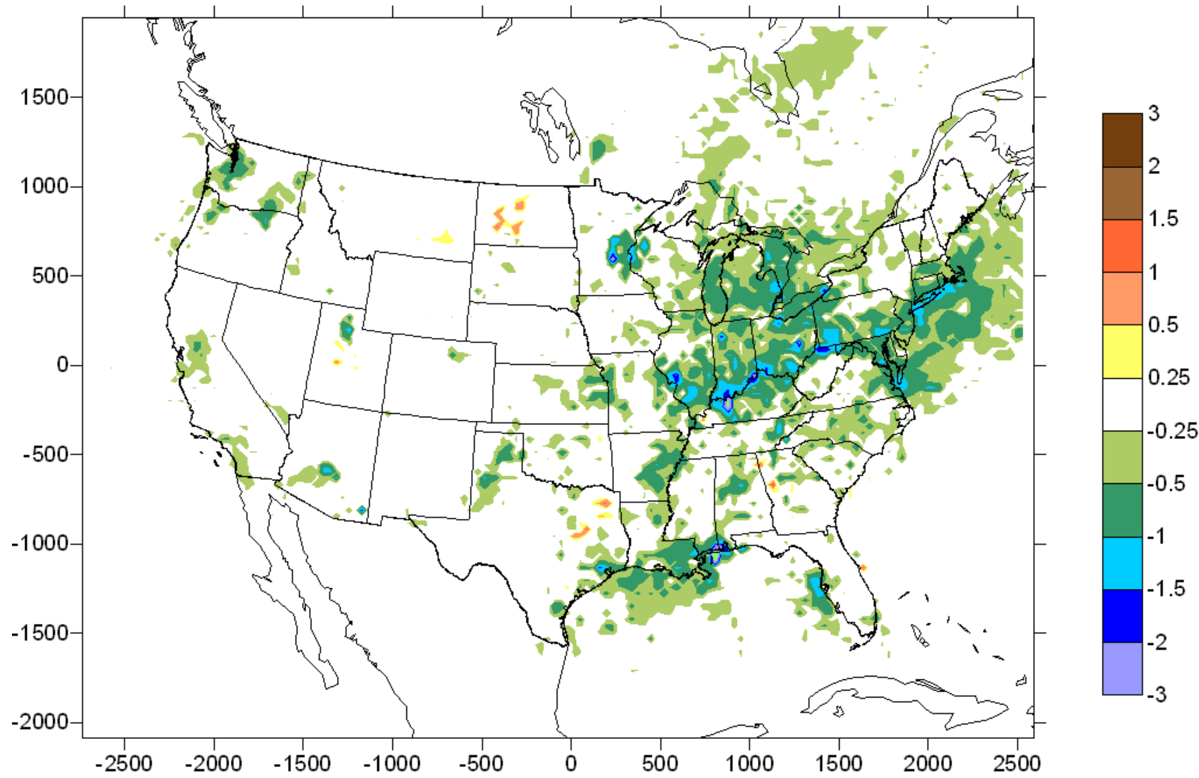
PHEVs Improve Overall Air Quality

Reduced Formation of Ozone

- Air quality model simulates atmospheric chemistry and transport
- Lower NOx and VOC emissions results in less ozone formation particularly in urban areas

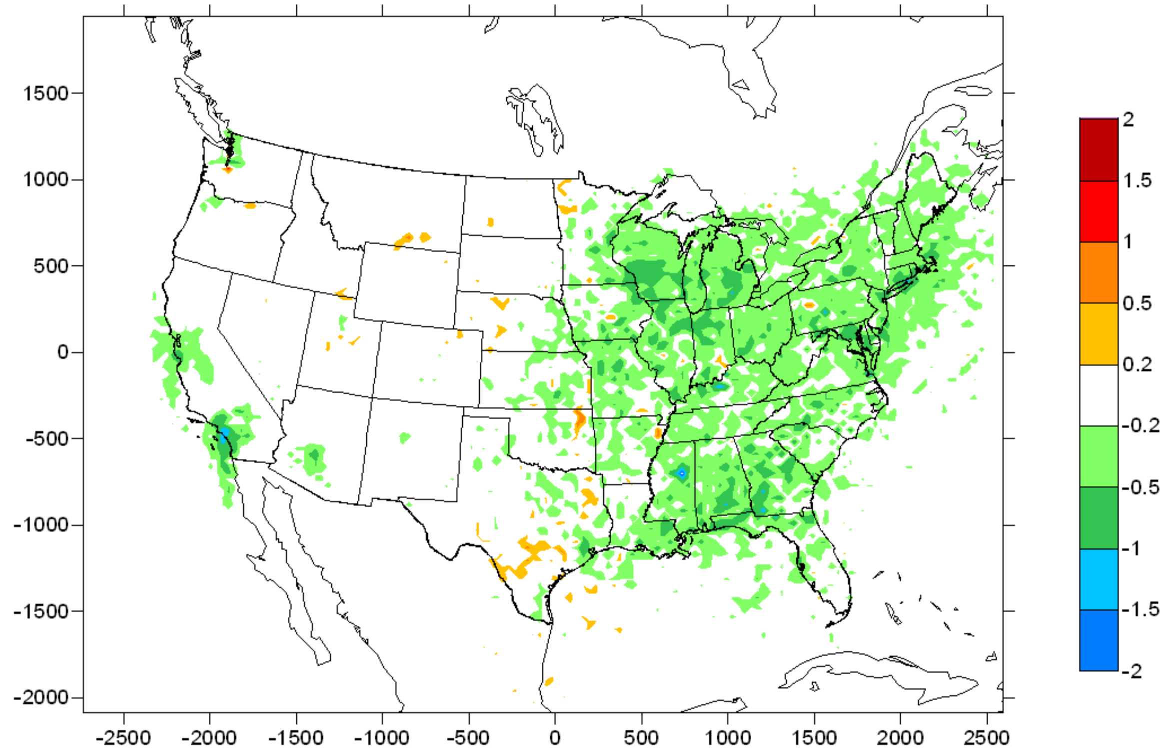


Change in 8-Hour Ozone Design Value (ppb)
PHEV Case – Base Case

PHEVs Improve Overall Air Quality

Reduced Formation of Secondary $PM_{2.5}$

- $PM_{2.5}$ includes both direct emissions and secondary PM formed in the atmosphere
- PHEVs reduce motor vehicle emissions of VOC and NOx.
- VOCs emissions from power plants are not significant
- Total annual SO_2 and NOx from power plants capped by federal law
- The net result of PHEVs is a notable decrease in the formation of secondary $PM_{2.5}$



Change in Daily $PM_{2.5}$ Design Value ($\mu g\ m^{-3}$)
PHEV Case – Base Case

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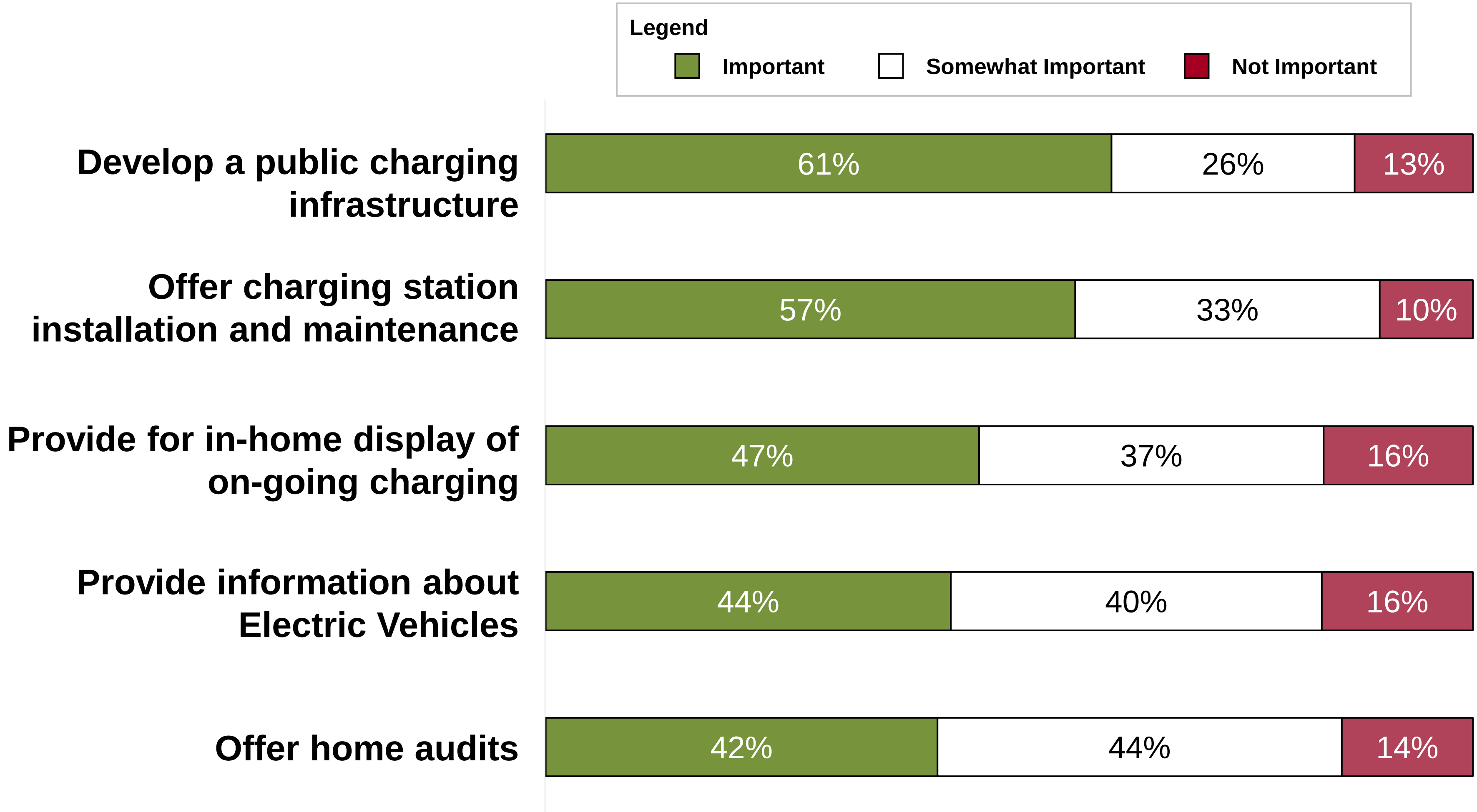
Consumer Expectations of their Utility



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Plug-In 2011 Conference and Exposition July 18-20, Raleigh, North Carolina