PLUG-IN ELECTRIC VEHICLES IN CALIFORNIA


Maggie Witt, MS
Matthew Bomberg, MS
Presentation Outline

• California’s PEV policy landscape
  — Existing and forthcoming policies

• Emissions reductions for 2020 air quality modeling
  — Motivations and objectives
  — Methodology and assumptions
  — Grid dispatch and impact assessment results
CALIFORNIA’S PEV POLICY LANDSCAPE
Existing Policies

• Global Warming Solutions Act of 2007 (Assembly Bill 32)

• Zero Emissions Vehicle (ZEV) Program

• Low Carbon Fuel Standard (LCFS)
ZEV Regulation & GHG Goals

Likely ZEV Regulation compliance scenarios for 2015-2025 necessary to reduce GHG emissions to 80% below 1990 Levels by 2050.

Source: CARB (2010).
ZEV Regulation

• 2009 ZEV Review
  – Incorporate GHG emissions reductions goals.
  – Phase out credits for partial ZEVs, etc. in order to encourage the rollout of PEVs and facilitate the development of new ZEV technology.
Low Carbon Fuel Standard

- Issues related to electric fuel and the LCFS
  - Role of electric-fuel (e-fuel) in meeting state goals
  - Tracking and reporting e-fuel

http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf
Recent and Forthcoming Policies

• CPUC's Alternative-Fueled Vehicle Rulemaking
  – Phase 1 (May 2011): Charging facility operators are not utilities and thus should be treated like retail customers.
  – Phase 2 (July 2012): Rates designs, utility costs/revenues, metering, data and information collection, and public education/outreach.
Phase 2 AFV Rulemaking: Key Aspects

- Rate designs
  - TOU or electricity for PEV-specific rates discussed
  - Current PEV rates sufficient for early market
- Electricity Metering
  - i.e. separate metering or submetering (figure below).

Source: CPUC (2010).
AIR QUALITY MODELING: MOTIVATIONS & OBJECTIVES
Research Objectives

• Assess air quality **costs and benefits** of shifting emissions from tailpipes to smokestacks
• Account for **spatial variation** in impacts
• Consider **uncertainty** in PEV adoption and charging behavior
• Bay Area case study
The tail of natural gas plant damages distribution is long: how bad is the marginal plant?

Source: NAS (2010)
AIR QUALITY MODELING: METHODOLOGY & ASSUMPTIONS
Vehicle Adoption Scenarios

• Expected Scenario:
  – Based on TIAAX “Expected Population” (TIAAX LLC 2009)
• Aggressive Scenario
  – Ramped up BEV consumption
  – Achieve 1 million PEVs in California
  – “Beyond Oil”
Charging Profiles

- **Controlled Charging**
  - “Valley filling”
  - Marginal cost minimizing demand allocation
- **Uncontrolled Charging**
  - “Plug and Play”
  - Based on travel diaries (Axsen et al. 2011)
# Data sources and caveats

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<td>• 2010 grid mix</td>
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<td>Tailpipe EFs</td>
<td>EMFAC 2020 model</td>
<td>• Baseline fleet turnover assumptions</td>
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<td>Grid dispatch</td>
<td>E3’s PLEXOS Production Simulation Model</td>
<td>• Least cost dispatch</td>
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<td>• Policy compliant (low load) baseline</td>
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<td></td>
<td>• No ozone</td>
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<td></td>
<td></td>
<td>• Only human health</td>
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AIR QUALITY MODELING: GRID DISPATCH RESULTS
All natural gas generation; emissions rates vary little across scenarios
All scenarios within same flat region of heat rate curve

- **Similar plants** coming online in all scenarios
- Load **increment too small** to push into new regime of plants
- Emissions will **scale linearly** with e-fuel demand
  - BUT Impacts may NOT – differences in exposure

Figure from E3
AIR QUALITY MODELING: IMPACT ASSESSMENT RESULTS
Air quality benefits are within an order of magnitude of available EV subsidies

Net Present Value of Lifetime Environmental Benefits

Notes: annual benefit discounted at 4% assuming 15 year vehicle lifetime
Air quality benefit covers substantial part of private cost gap

Assumes:
- Vehicles amortized at 4% for 15 yrs
- $3.50/gal, 12¢/kWh
- 30 mpg, $18,000 CV
- Low: $20/ton GHGs
- High: $50/ton GHGs
All Bay Area counties are net air quality beneficiaries, though size of benefit differs.
Location of air quality benefits independent of PEV penetration

Maps show per capita benefits from reduced emissions of criteria air pollutants (GHGs excluded)
Takeaways and policy implications

• AQ benefits
  – Cover up to 50% of private cost gap
  – Within order of magnitude of EV subsidies

• Emissions and AQ impacts insensitive to level of PEV penetration
Closing thoughts on EV subsidies

• Why subsidize EVs?
  – Economist: internalize a positive externality

• Blunt instrument

• Advantages
  – Dispersed costs
  – Prime demand to move to lower cost part of supply curve
Thank you! Questions of comments?

Acknowledgments: Jim Williams, Eric Cutter, Snuller Price, Priya Sreedharan, and Ben Haley of E3, Tim Lipman, Brett Williams, and Maggie Witt of TSRC
References


RESERVE SLIDES
PLEXOS Production Simulation Model

- Models **least-cost grid dispatch** subject to transmission constraints
- Dispatch results given at individual plant level, but **higher confidence in zonal results**
- Base load from 2020 IEPR policy compliant scenario

Slide courtesy of E3
EPA’s Cost-Benefit Risk Assessment (COBRA) Tool

- Risk/impact assessment model
- Dispersion based on source type
- Damages based on economics literature
Modeling Caveats

Grid Dispatch Model
- No model will accurately represent individual plants
  - Small heat rate differences
  - Poor representation of transmission constraints
- ARB average emission factors for existing power plants used
- Generation mix will change over time

Risk Assessment Model
- APEEP differentiates source types into low point, tall point, and ground level
- Use of generic ground level damage costs makes results conservative
  - Tailpipe emissions very high exposure
- No accounting for time dependence of exposure
  - People in homes overnight
Absolute GHG Change for Different Scenarios

-800000 -600000 -400000 -200000 0 200000 400000

Change in GHG Emissions (tons CO2eq)

-800000 -600000 -400000 -200000 0 200000 400000

Expected Controlled  Expected Uncontrolled  Aggressive Controlled  Aggressive Uncontrolled

Tailpipe Displaced  Smokestack Added  Net Change
Controlled charge profile offers slight Criteria Air Pollutant reduction
Aggressive penetration more than doubles CAP reductions in Bay Area

- Expected Penetration: 1,200 GWh
- Aggressive Penetration: 3,000 GWh

Change in PM2.5 Tons
-3.29495 - -1.56378
-1.56377 - -0.80692
-0.80691 - -0.18355

Change in PM2.5 Tons
-9.64414 - -4.09445
-4.09444 - -2.12525
-2.12524 - 0.01228
CAP reduction tracks electrified miles closely but NOT completely

Implies CAP reduction not just function of displacing gasoline miles; location of powerplant emissions also important!
Location and size of air quality benefits insensitive to charge profile

Maps show per capita benefits from reduced emissions of criteria air pollutants (GHGs excluded)
Controlled charging shifts emissions to off-peak

Expected Adoption, Uncontrolled Charging

- Summer Peak: 25%
- Summer Off-Peak: 24%
- Winter Peak: 25%
- Winter Off-Peak: 25%

Expected Adoption, Controlled Charging

- Summer Peak: 26%
- Summer Off-Peak: 24%
- Winter Peak: 16%
- Winter Off-Peak: 34%
Benefits from controlling charging less at higher levels of PEV adoption

**Expected Adoption, Uncontrolled Charging**

- Summer Peak: 25%
- Summer Off-Peak: 26%
- Winter Peak: 25%
- Winter Off-Peak: 24%

**Expected Adoption, Controlled Charging**

- Summer Peak: 16%
- Summer Off-Peak: 34%
- Winter Peak: 16%
- Winter Off-Peak: 34%

**Aggressive Adoption, Uncontrolled Charging**

- Summer Peak: 27%
- Summer Off-Peak: 24%
- Winter Peak: 23%
- Winter Off-Peak: 26%

**Aggressive Adoption, Controlled Charging**

- Summer Peak: 33%
- Summer Off-Peak: 17%
- Winter Peak: 33%
- Winter Off-Peak: 17%
Air quality benefit covers up to 33% of first life cost gap

<table>
<thead>
<tr>
<th>Generic Conventional Vehicle</th>
<th>Nissan Leaf</th>
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<tbody>
<tr>
<td>Price</td>
<td>$18,000</td>
</tr>
<tr>
<td>Annualized (15 yrs, 4%)</td>
<td>($1,619)</td>
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<tr>
<td>Engine MPG</td>
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<tr>
<td>Gas Price</td>
<td>$3.50/gal</td>
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<tr>
<td>Annual Gas Cost</td>
<td>($1458)</td>
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<tr>
<td>Total Annual Cost</td>
<td>($3,077)</td>
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<td>First Life Cost Gap</td>
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<td>Per Vehicle AQ Annual Benefit</td>
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Net benefits normalized by e-fuel demand

- Expected Controlled
- Expected Uncontrolled
- Aggressive Controlled
- Aggressive Uncontrolled

Net Benefit per e-fuel Demand ($/MWh)

- No GHGs
- Low GHGs
- High GHGs
Absolute monetized air quality benefits by county

Benefits due to reduced CAPs only (GHGs excluded)
Monetized air quality benefit grows faster than PEV penetration

Per Vehicle Air Quality Net Benefit

Recall: CAP impacts likely undervalued because generic ground level MBA ($/ton) values used – LDVs = very direct exposure
The economics of an externality

Marginal Abatement Cost/Benefit ($/ton)

MBA

MCA

Current Level of Abatement

Quantity Abated (tons)
Caveats with subsidies

• Disadvantage - blunt instrument
  – Trying to influence fuel consumption behavior by pricing the vehicle
  – GHGs – pricing carbon would accomplish same objective and more
  – CAPs – difficult to establish market for individual drivers; problematic to assess upstream since impacts depend on use

• Advantages
  – Politically easy – no organized constituency bears cost
  – Can help prime demand – EV industry growth