Informational Update On
Zero Emission Vehicle
Regulation Revisions
Overview

History
Path to 2050: GHG Reductions
Current Technology Status
Policy Alternatives
Complementary Policies
Summary and Next Steps
Presentation Overview

- All ZEV technologies are required to achieve 2050 GHG goal
- ZEV markets launched by 2020
- Regulatory mandate necessary
- Comprehensive policy approach needed to overcome market barriers unique to ZEVs
Successful ZEV Commercialization

Number of ZEVs (Regulation)

Available Clean Fuels

Consumer Acceptance
ZEV Regulation History

- In 1990, requirement in LEV I to achieve ultimate criteria pollutant reductions
  Improvements in conventional vehicle technology not sufficient to meet air quality standards, ZEVs were needed
- Modified to better align requirements with state of technology
ZEV Program Accomplishments

- Demonstrated ZEVs technically viable
  - Several thousand vehicle demonstration
  - Accelerated battery and fuel cell development
  - Initial public charging infrastructure
  - ZEVs on threshold of early commercialization

- Hybrids commercialized
- PZEVs widely available

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Numbers</th>
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<tbody>
<tr>
<td>ZEV</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>250</td>
</tr>
<tr>
<td>Battery Electric</td>
<td>4,800</td>
</tr>
<tr>
<td>Neighborhood Electric</td>
<td>28,000</td>
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<tr>
<td>AT PZEV</td>
<td></td>
</tr>
<tr>
<td>Hybrid or CNG</td>
<td>258,000</td>
</tr>
<tr>
<td>PZEV</td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>1,158,000</td>
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</table>
## Current ZEV Requirements

<table>
<thead>
<tr>
<th></th>
<th>2012-2014</th>
<th>2015-2017</th>
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<tbody>
<tr>
<td>ZEVs – Type IV Fuel Cells</td>
<td>7,500</td>
<td>25,000</td>
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<tr>
<td>Enhanced AT PZEVs – Plug-In Hybrids</td>
<td>~ 60,000</td>
<td>~ 85,000</td>
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Board Direction – 2008

- At the March 2008 Board Hearing, the Board adopted Resolution 08-24 directing staff to:
  - Review the LEV, Pavley (LEV-GHG), and ZEV programs, keeping in mind the need to reduce criteria pollutant emissions, climate change emissions, and dependence on petroleum,
  - Strengthen the ZEV program for model years 2015 and subsequent, focus on ZEVs and Enhanced AT PZEVs,
  - Ensure California is the center of ZEV commercialization development, and
  - Return to the Board by the end of 2009.
Implications: Policy Integration

- Add GHG reduction to ZEV program goals
  - Match vehicle requirements to achieving 80% GHG reduction goal by 2050

- ZEV focus: Moving technology from development to early commercialization
  - PZEV and Hybrids are commercial
    - Remove from ZEV program
    - Consider in setting more stringent LEV and GHG standards
  - Enhanced AT PZEVs (plug HEV) and ZEVs (BEVs, FCVs) not yet commercial
    - Focus of revised ZEV program
    - Sunset program when commercialization successful
ZEV Redesign Process

- **2050 GHG Analysis**
  Policy Question: How many ZEVs are necessary to achieve an 80% GHG reduction by 2050?

- **Technical Review**
  Policy Question: What is the current status of ZEVs and ZEV enabling technologies?

- **Policy Structure**
  Policy Question: What ZEV Regulation structure sets a path to 2050 yet provides appropriate incentive structure for industry success?

- **Review of Complementary Policies**
  Policy Questions: What other policies, besides the ZEV regulation, are needed to prevent or remove market barriers?
Total GHG Emissions and Policy Targets

11 Million Metric Tons (CO2 Equivalent)

<table>
<thead>
<tr>
<th>Year</th>
<th>1990</th>
<th>2000</th>
<th>2004</th>
<th>2020</th>
<th>2050</th>
</tr>
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<tr>
<td>1990 Emission Baseline</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>AB 32 Target</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>EO S-3-05 Target, 80% Reduction</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
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</table>

Trans. sector 38%, LDV Sub-sector, 28% of GHG total

Most relevant for ZEVs, will require dramatic changes in vehicle markets starting in 2020
Passenger Vehicle GHG Scenarios

Year

Carbon Dioxide Emissions (MMT CO2e)

All advanced vehicles necessary, early commercialization by 2020

2050 Goal: 80% below 1990 (22 MMT CO2e)

Scenario 1: 100% ZEV sales by 2050, 1 billion gallons gasoline equiv (BGGE) biofuels

Scenario 2: 100% ZEV sales by 2040, and more biofuels (1.7 BGGE)

* Hypothetical BAU for this analysis only, does not represent ARB projections. Assumes Pavley 1 and LCFS are implemented.
New Vehicle Emissions

Path to 2050

- 100% sales are HEVs (by 2030)
- Need ZEVs to remain on Path to 2050
- 2050 Goal for Passenger Vehicle Subsector

New Vehicle CO2 g/mi (Avg.)
ZEV sales reach 100% by 2040, but on-road fleet is still mixed:
ZEVs are 87% of on-road fleet in 2050
## ZEV Sales in 2020 & 2025

<table>
<thead>
<tr>
<th>Scenario</th>
<th>% ↓ GHG In 2050</th>
<th>Sales in 2020</th>
<th>Sales in 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ZEV mandate</td>
<td>25%</td>
<td>25,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>66%</td>
<td>25,000</td>
<td>250,000</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>80%</td>
<td>25,000</td>
<td>425,000</td>
</tr>
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</table>
Implications for Policy Development

- Rapid sales growth of ZEVs needed, with high volume production beginning by 2020
  - 10,000s by 2020 (pre-commercialization)
  - 100,000s by 2025 (commercialization)

- Expansion of low-carbon fuel & electricity supply is essential
  - Policies that can influence this include RES, LCFS, SB 1505, AB 118

- VMT per capita reductions are important and have large implications on the other two (vehicles, fuels)
Zero Emission Vehicle Roll Out
And Fleet Stratification

- Overall Trends
  - Fuel economy and GHG emission focus

- 2010 to 2015
  - Increased market share of advanced technologies
  - Electrification of light duty vehicle fleet
  - Many companies exploring PHEVs and short-range BEVs

- 2015 and beyond
  - Short to mid-range BEVs, PHEVs with greater all electric range
  - Fuel cell vehicles
# Incremental Retail Price of Future Propulsion Technologies

[Using MIT Assumptions]

<table>
<thead>
<tr>
<th>VEHICLE TYPE</th>
<th>RETAIL PRICE INCREASE [$2007]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td></td>
</tr>
<tr>
<td>2035 Hybrid retail price</td>
<td>$24,100</td>
</tr>
</tbody>
</table>

Incremental relative to 2035 hybrid:

| 2035 Plug-in Hybrid (30 mile AER)                      | $3,400                        |
| 2035 Battery Electric (100 mile range)                 | $5,500                        |
| 2035 Fuel Cell                                         | $2,800                        |
Status of Technology: Fuel Cell Vehicles

- Many technological barriers have been overcome
- Two largest remaining challenges: **cost** and **durability**
- Fuel cell system approximately 2x conventional engine cost (according to U.S. DOE current estimates)
- Cost: $61/kW at high volume (2009 DOE projection)
- Daimler, Ford, GM, Honda, Hyundai/Kia, Toyota and alliance Renault SA and Nissan issue a joint LUA
  
  “…automakers strongly anticipate that from 2015 onwards a significant number of FCV could be commercialized”

- Pre-commercialization possible with 2015 technology and costs, though continued R&D needed on durability
Status of Technology: Batteries

- Li-ion **durability** and **cost** challenges remain, but have the potential to become commercially viable and profitable within next 10 years
- **Cost**: $1000/kWh (today), potential for $300/kWh at high volume
- **Durability**: Challenges remain for hot climates
- **Production capacity** is “on track” to support the required 2012-2014 pre-commercial BEVs and PHEVs
Market Projections: BEVs, FCVs and PHEVs

- All major OEMs believe technology portfolio approach necessary.

- Most OEMs committed to BEV and PHEVs pre-commercialization meeting regulatory requirements.

- Several OEMs are prepared to commit to FCVs provided fueling infrastructure is available.

- Several manufacturers plan over compliance
  Two manufacturers plan to significantly exceed the ZEV production requirements of the regulation
Zero Emission Vehicle
Demo/Production Start Years

Chrysler
Ford
GM
Honda
Nissan
Toyota

BEVs
PHEVs (commercialization)
FCVs (Commercialization)
PHEVs (demo)
FCVs (demo)
ZEV Mandate is Needed

- Guarantees CA remains on path to 2050
- Market forces along will not sufficiently bring ZEVs to commercialization
- Specific regulatory mechanisms needed for ZEVs
  - ZEVs require slower transition
- Mandate appropriate for 2015-25 to ensure ZEV vol, reduces risk of early market failure
  - Emission benefits not substantial enough at low volumes to guarantee ZEV development
- Once model and technology variety established, performance std. will take fleet to 2050
ZEV Policy Future

Mandate (ZEVs per yr)

Performance Std. (CO₂ Fleet Avg.)

- Pavley 1
- LEV III GHG
- LEV IV GHG
- ZEV 2.0: Effort and Flexibility
- ZEV Demos
- ZEV Early Com.
Policy Alternative 1

LEV III GHG takes over in 2017, Regulation pushes volumes to commercialization, LEV IV takes over in 2025 to get deep reductions needed for 2050.

ZEV Vol. Req.:
- 2% in 2010
- 10% in 2020
- 20% in 2030
- 10% in 2040
- 20% in 2050

Policy Alternatives
Policy Alternative 2

Red: Steeper LEV III GHG curve, with lower ZEV req.

Blue: LEV III GHG curve, with higher ZEV Req.

New Vehicle CO₂ g/mi Avg.

% of Yearly Sales

2010 2020 2030 2040 2050

2% 10% 20%
To ensure ZEV markets emerge, additional “complementary” policies needed in next 10 years.
Electric Charging Infrastructure

- Current infrastructure minimal with limited compatibility among different vehicles and chargers
- Near-term: home charging is key
- CPUC Rulemaking 09-08-009
- ARB review of electric infrastructure policies and submit plan to board in 2010
Hydrogen Infrastructure

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012-14</th>
<th>2015-17</th>
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<tbody>
<tr>
<td>Total FCVs¹</td>
<td>193</td>
<td>370</td>
<td>712</td>
<td>4,307</td>
<td>49,600</td>
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<tr>
<td>H2 Stations²</td>
<td>6</td>
<td>10</td>
<td>13</td>
<td>19-31</td>
<td>tbd</td>
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1. Source: Aggregated OEM projections from CaFCP 2008 action plan
2. Does not include bus infrastructure

Options to infrastructure: Three Prong Approach

1. Financial incentives
2. Fuel performance regulations
3. Alternative fuel infrastructure regulation
1. Infrastructure Incentives

Financial incentives

- **Hydrogen Highway funding - ARB**
  - $14.9M to date - Seven stations funded
  - SB 1505 requirements met for emissions and renewables
  - Funding from this source discontinued

- **AB 118 funding - administered through CEC**
2. Fuel Performance Regulation

LCFS credit incentives

- Focused on fuels with long-term potential and larger market barriers
- Internal evaluation of the benefits and challenges
- Workshops with stakeholders
- Maintain LCFS primary goals
3. Revised Clean Fuels Mandate

13CCR Section 2300 et seq.

- Focus on vehicle/fuel technologies that align near term infrastructure growth with 2050 low carbon fuel needs
- Energy providers match fuels and outlets to OEM deployments
- Align stations placements with vehicle placements
- Shift compliance burden to suppliers
Conclusions

- ZEV regulation has helped introduce vehicle technologies with very low smog-forming emissions

- Regulation can be modified to also be an effective tool to address GHG emissions:
  - a large increase in the number of ZEVs on the roads
  - All ZEV technologies are encouraged for the future

- Complementary policies needed to encourage the purchase and use of ZEVs during near term commercialization
Timeline

- **Q1 2010:** LEV and ZEV public workshops
- **Q2 2010:** Update to the Board on electric infrastructure
- **Q2 or 3 2010:** LEV III ISOR and Hearing
- **Q4 2010:** ZEV ISOR and Hearing
BACKGROUND SLIDES
Sensitivity Study – Key Factors that Change ZEV Sales

Scenario 1 (reference)

(a) Start ZEV sales curve 5 yrs earlier

(b) Steeper ZEV sales curve

(c) Scenario 2 *

(d) Less VMT reductions

% Below 1990 GHG

ZEV sales per year in CA (thousands)

* Includes ZEV sales from (b) and an increase in biofuel usage (1.7 BGGE instead of 1 BGGE in Scenario 1)
3 ZEV Sales Scenarios

- **66% GHG, Scenario 1**
- **73% GHG, Same slope, start “Earlier”**
- **75% GHG, “Steeper” slope * (80% GHG if more biofuels)**

* Scenario 2 includes this “steeper” ZEV sales trajectory and an increase in biofuel usage (1.7 BGGE instead of 1 BGGE in Scenario 1).

Similar GHG gains with “earlier” vs. “steeper”. Different market challenges – early technology readiness vs. unknown long-term sales rates.
Passenger Vehicle On-Road Fleet – Scenario 2

- Fleet turn-over takes time, 100% sales in 2040 → 87% Fleet (2050)
- ZEV fleet in this scenario: 120,000 (2020), 1.4 million (2025) *

* Combined cars and trucks (Passenger Vehicle Sector)
LDV New Vehicle Sales (Auto only) – Scenario 1

- All advanced vehicle technologies necessary
- ZEV sales in this scenario: 25,000 (2020), 230,000 (2025) *

* Combined cars and trucks (full LDV)
Comprehensive, multi-policy approach for trans GHG, ZEV Regulation ultimately phase out, merges with Pavley

Limited Timeframe: Addressing market barriers

“3 Legged Stool” Vehicles, Fuels, VMT

Permanent: Market and performance based standards

Merge

2010 2020 2030 2040 2050

RPS Standard

LCFS Regulation

ZEV Regulation

Vehicle GHG Standards (Pavley and Fed programs)

Cap and Trade Program (AB 32 and future CA/Fed program)

Land-use GHG Standards (SB 375 and Fed programs)
ZEV 2.0 Simplifications

Harmonizing Vehicle Regulations

Pavley

Pavey 2

Pavey 3

LEV

LEV 3

ZEV

PZEVs

AT-PZEVs

ZEVs

2010  2015  2020  2025  2030

END
U.S. DOE Fuel Cell System Cost

2009 fuel cell system cost: $61/kW
Successful ZEV Commercialization

- Numbers of ZEVs (Regulation)
- Fuel
- Consumers
- VMT