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2017 Transportation Energy Demand Forecast

IEPR Commissioner Workshop on the Revised Transportation Energy Demand Forecast

December 4, 2017
Transportation Energy Forecasting Unit
Demand Analysis Office
Energy Assessments Division
OVERVIEW OF TRANSPORTATION ENERGY DEMAND FORECAST
Key Takeaways

- Electric vehicles continue to gain popularity in California.
- Cost of driving zero-emission vehicles will continue to decline.
- Battery prices will continue to decline; Battery electric vehicle range will continue to increase.
- Hydrogen vehicle and fuel demand are expected to increase.
- Electricity consumption in the transportation sector is projected to increase.
- Overall fuel economy will continue to rise.
- Gasoline demand will decline.
Key Activities Since Preliminary Forecast

- Increased consumer preferences for ZEVs
- DAWG-transportation subgroup
  - Incorporated feedback from stakeholders
- Updated Inputs to the model
  - Economic and demographic forecasts
  - Medium- and heavy-duty vehicle attributes
  - Light-duty vehicle attributes
  - Incorporated new automaker announcements
Electric Vehicle Terminology

- Zero-Emission Vehicle (ZEV)
  - Plug-in Hybrid (PHEV)
  - Battery Electric (BEV)
  - Plug-in Hybrid Fuel Cell (PHFCV)
  - Fuel Cell (FCEV)
- Plug-in Electric Vehicle (PEV)

Degree of Drivetrain Electrification

- Internal Combustion Engine
- Stop/start
- Mild Hybrid
- Full Hybrid
- Plug-in Hybrid
- Fuel Cell
- Battery

Source: IEEE
Transportation Demand Cases

Cases represent different levels of transportation electricity demand

- **Transportation Demand Cases**
  - **High Electricity Demand (High Case)**
    - Inputs selected to represent high level of electricity demand
  - **Mid Electricity Demand (Mid Case)**
  - **Low Electricity Demand (Low Case)**
    - Inputs selected to represent low level of electricity demand

- **Inputs**
  - Income, population, fuel prices, vehicle attributes
## Plug-in Electric Vehicle Scenarios

### Inputs
- **PREFERENCES**
  - **Consumers’ PEV Preference**
    - Low: Constant at 2017 Level
    - Mid: Increase with PEV market growth
    - High: Increase with PEV market growth
    - Aggressive: Increase with PEV market growth
    - Bookend: Increase with PEV market growth

### Incentives
- **Federal Tax Credit**
  - Eliminated after 2019
- **State Rebate**
  - To 2019
  - To 2025
- **HOV Lane Access**
  - To 2021
  - To 2025

### Attributes
- **Availability of PEVs (in 2030)**
  - PEV models available in 11 of 15 CEC LDV classes
- **Vehicle / Battery Price (by 2030)**
  - PEV prices based on battery price declining to ~$120/kWh
  - PEV prices based on battery price declining to ~$100/kWh
  - PEV prices based on battery price declining to ~$89/kWh
  - PEV prices based on battery price declining to ~$73/kWh
  - PEV prices reach parity with gasoline vehicles
- **Avg. Range (2030)**
  - ~230 miles
  - ~230 miles
  - ~270 miles
  - ~270 miles
- **Refuel Time (2030)**
  - 15 - 21 min
  - 15 - 21 min
  - 10 - 16 min
  - 10 - 16 min
- **Time to Station (2030)**
  - 7 - 8 min
  - Same as gasoline
  - Same as gasoline
  - Same as gasoline

### Forecast Results
- **PEV Stock in 2030**
  - 2.6 million
  - 3.3 million
  - 3.9 million
  - 5.3 million
  - 5.9 million
- **Cost of State Rebate, 2018-2025**
  - $577 million
  - $4.2 billion
  - $4.6 billion
  - $5.2 billion
  - $5.4 billion
- **Cost of State Rebate Extension, 2026-2030**
  - -
  - -
  - -
  - -
  - $7.1 billion
  - $8.2 billion
Global Trends Show Increasing Vehicle Electrification

- **Global Vehicle Market**
  - Light-duty
    - Automakers increase electrified vehicle offerings
  - Heavy-duty
    - Tesla semi
    - Nikola One and Two
    - Toyota fuel cell truck

- **Global Transportation Policies**
  - California
  - China
  - India
  - Europe
VEHICLE DEMAND FORECAST
Overview of Vehicle Demand Forecast

- Historical and Projected Gasoline Prices
- Cost Per Mile Analysis
- Vehicle Stock
  - Light-Duty Vehicle Stock
  - Medium- and Heavy-Duty Vehicle Stock
Historical and Projected California Gasoline Prices

Source: Energy Information Administration (Historical), California Energy Commission (Projected)
Fuel Cost per Mile Trends

- **Light Duty Vehicles**
  - Electricity is projected to have the lowest cost per mile among fuel types throughout the forecast period
  - Hydrogen fuel costs are projected to decrease over the forecast period

- **Medium Duty Trucks**
  - Electricity fuel cost per mile remains relatively flat and offers the lowest cost per mile among fuel types

- **Heavy Duty Straight (No Trailer) Trucks**
  - Diesel-electric hybrid is the fuel type with the lowest cost per mile
  - Natural gas has increasing fuel cost advantage over diesel after 2018

- **Heavy Duty Tractor-Trailers**
  - Natural gas is the lowest cost per mile of trucks included
  - Tesla is guaranteeing electricity at 7 cents per kWh, announced too late for forecast
  - Nikola offers free hydrogen for a million miles; market price for hydrogen is highest but declines over forecast
Light-Duty Vehicle Fuel Cost per Mile Trends

Midsize Cars, Mid Case

Source: California Energy Commission
Truck Fuel Cost per Mile Trends
Medium-Duty (Class 4-6) Vehicles, Mid Case

Source: California Energy Commission
Light-Duty Vehicle Stock Grows with Population and Economy
ZEV and PHEV Share of Stock Increases

Share of Light-Duty Vehicle Stock, Mid Case

- BEV
- Plug-in Hybrid Electric
- FCEV
- Plug-in HFCV
ZEV and PHEV Share of New Vehicle Sales Grows
Share of Light-Duty Vehicle Sales, Mid Case

Drop due to 2026 removal of CA ZEV rebate (CVRP)
Medium & Heavy-Duty Truck Technologies

Powertrains considered in Truck Choice model (at least one truck class)

- Battery electric
- Catenary electric
- Compressed natural gas
- Diesel
- Diesel-electric hybrid
- Diesel-hydraulic hybrid
- Gasoline (including flex-fuel)
- Gasoline-electric hybrid
- E85 (Ethos)
- Hydrogen fuel cell
- Liquefied natural gas
- Propane (LPG)
New Alternative Fuel MDV Sales Increase

Medium Duty Truck Share by Fuel Type

LOW CASE

HIGH CASE
Alternative Fuel Heavy Duty Vehicle Stock Increases

- Electric
- Diesel-Electric Hybrid
- Natural Gas
- Hydrogen Fuel Cell
- Propane
- Gasoline-Electric Hybrid

MID CASE
LIGHT-DUTY ZEV ANALYSIS
Overview

- Trends in light-duty vehicle (LDV) electrification
- Battery electric vehicle (BEV) range
- Battery electric vehicle prices
- Zero-emission vehicle (ZEV) forecast and regulatory compliance
Recent Trends in LDV Electrification

- PEV share is increasing: up to 4.5% of new vehicle sales in 2017.
- NOTE: each powertrain has a different degree of electrification (see slide 5)

**Historical California Gasoline Prices**

- Note: Gray bars indicate economic recessions
- Sources: U.S. Energy Information Administration, Federal Reserve Bank of St. Louis

**Hybrid, Plug-in Hybrid, & BEV Sales Share**

Automaker Announcements

- Manufacturers are planning to offer more electrified models.
  - Electrification plans include hybrids.

- Major automaker announcements in 2017 are shown below:

<table>
<thead>
<tr>
<th>Company</th>
<th>Target Year</th>
<th>Announcement</th>
</tr>
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<tbody>
<tr>
<td>BMW</td>
<td>2025</td>
<td>will offer 25 electrified vehicles – 12 will be fully-electric</td>
</tr>
<tr>
<td>Mercedes-Benz</td>
<td>2022</td>
<td>10 plug-in electric vehicles, rest will have hybrid option</td>
</tr>
<tr>
<td>Fiat Chrysler</td>
<td>2022</td>
<td>More than half of Maserati models will use some form of electric powertrain</td>
</tr>
<tr>
<td>Ford</td>
<td>2022</td>
<td>13 new electric (and plug-in hybrid) models</td>
</tr>
<tr>
<td>Volvo</td>
<td>2019</td>
<td>every new model will be electric, plug-in hybrid, or hybrid</td>
</tr>
<tr>
<td>GM</td>
<td>2023</td>
<td>20 new fully electric models</td>
</tr>
<tr>
<td>Hyundai Kia</td>
<td>NA</td>
<td>electric cars at the center of future product strategy</td>
</tr>
<tr>
<td>Jaguar Land Rover</td>
<td>2020</td>
<td>every new model will be electric, plug-in hybrid, or hybrid</td>
</tr>
<tr>
<td>Renault-Nissan</td>
<td>2022</td>
<td>12 pure electric models to be launched</td>
</tr>
<tr>
<td>Volkswagen Group</td>
<td>2030</td>
<td>will electrify (electric, plug-in hybrid, and hybrid) entire model portfolio by 2030</td>
</tr>
</tbody>
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Source: OEM Announcements as of **October 1st 2017**. Note: These announcements refer to OEMs global strategy. Not all models will be available in the United States.
Number of Projected ZEV Models

- Energy Commission staff collected media reports and OEM announcements to project number of ZEV and PHEV models through 2022.

- CARB projected about 80 models by 2021 in ZEV Midterm review (released Jan 2017).
  - OEM announcements accelerated through 2017.

Source: California Energy Commission and NREL.
BEV Range is Increasing

- Sales of longer range BEVs are increasing.
- Projected average BEV range in 2017 Forecast increases significantly.

**BEV Sales by Range**

**Projected Average BEV Range in 2030**

BEV Range is Projected to Grow
Projected BEV Range by Class

- Swings in BEV range (up or down) are due to expected introduction of new models.

Source: California Energy Commission
Battery Pack Cost Estimates

- Estimates in 2030 range from $73 – 120 per kWh.
- Energy Commission estimates align well with external sources.
BEV Prices Decline Over Time
Projected BEV Prices by Class

Source: California Energy Commission. “Large Car” and “Sports Car” prices, which are dominated by luxury vehicles, are above the displayed axis for the forecasted period.
BEV Range and Price

- Battery costs are falling...
- But average price of BEVs rose...
  
  “The average price of EVs rose again in 2016, but this reflects faster growth in more expensive models and does not take account of increases in driving range... reductions in battery costs are translating into longer ranges rather than lower vehicle prices”
  
  - International Energy Agency

- TEFU is using a new metric to show relative decline in BEV prices.

- CEC Forecast of Avg. BEV Range:
  - 2015 forecast: Flat at ~115 miles
  - 2017 forecast: Rising to 240-280 miles

Source: www.iea.org/newsroom/energysnapshots/average-ev-price-and-range.html
BEV Price per Mile of Range is Decreasing

\[ \text{Price per Mile of Range} = \frac{\text{BEV Price}}{\text{BEV Range}} \]

- The “relative” price of a BEV when holding range constant.
- Price per mile of range is projected to decline sharply over the forecast period for all BEV classes.

Source: California Energy Commission Analysis
Loan vs 3 year Lease for Chevrolet Volt

- Lease terms and loan payment information from Chevrolet.com, October 2017
- Estimated resale value for three year old (2014 MY) Volt from Kelly Blue Book, October 2017
ZEV and PHEV Stock Continues to Grow

Cumulative On-road BEVs, PHEVs, and FCEVs

Source: California Energy Commission, California Air Resources Board
Fuel-Cell Vehicle Stock is Projected to Grow

Source: California Energy Commission, California Air Resources Board
CEC’s Transportation Demand Forecast assesses market demand for ZEVs, and generates a forecast of sales.

By converting forecast of ZEV sales to ZEV credits, staff can check the forecast results for compliance with CARB’s ZEV regulations.

Result: **Forecast projects compliance in all cases**
Transit Bus Stock

- ZEV share grows for transit buses.

- Replacement takes time because stock is replaced every 12-18 years.

- Replacement driven by:
  - Competitive pricing
    - Federal policy covers 80% of vehicle cost for all transit buses.
  - State & local policy

Note: Forecast of active fleet vehicles only.
Source: California Energy Commission, National Transit Database.
Key Takeaways

- BEVs are expected to have more favorable characteristics such as longer range and lower prices, due in part to:
  - California’s ZEV Program
  - Decreasing cost of lithium-ion battery packs

- Statewide shift toward transportation electrification is underway.

- Given a stable policy and regulatory environment,
  - Transportation forecast projects that California is making progress toward its clean energy goals.
TRANSPORTATION FUEL DEMAND FORECAST
Fuel Demand Overview

- Fuel Economy Forecast

- Fuel Demand Forecast
  - Conventional Fuels (Gasoline, Diesel, Jet Fuel)
  - Alternative Fuels (Electricity, Natural Gas, Hydrogen, E85)
  - High-Speed Rail
## Overall Fuel Economy Increases

Compact Car MPG by Fuel Type, Mid Case

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>2017 MPG</th>
<th>2030 MPG</th>
<th>Increase</th>
<th>Percent Change</th>
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<tbody>
<tr>
<td>Diesel</td>
<td>33</td>
<td>44</td>
<td>12</td>
<td>35.4%</td>
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<tr>
<td>BEV</td>
<td>116</td>
<td>129</td>
<td>13</td>
<td>11.2%</td>
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<tr>
<td>Flex Fuel</td>
<td>23</td>
<td>25</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Gasoline</td>
<td>30</td>
<td>38</td>
<td>8</td>
<td>24.9%</td>
</tr>
<tr>
<td>Hybrid</td>
<td>47</td>
<td>56</td>
<td>8</td>
<td>17.6%</td>
</tr>
<tr>
<td>FCEV</td>
<td>68</td>
<td>73</td>
<td>6</td>
<td>8.6%</td>
</tr>
<tr>
<td>Plug-in Hybrid Electric</td>
<td>74</td>
<td>87</td>
<td>13</td>
<td>18.1%</td>
</tr>
</tbody>
</table>

Source: National Renewable Energy Laboratory, California Energy Commission
Sales-Weighted Fuel Economy Also Increases
Sales-Weighted Average Light-Duty Vehicle Fuel Economy by Model Year, All Fuel Types

- NOTE: “54.5 MPG” CAFE standard is actually ~35-36 MPG EPA label fuel economy in 2025.
Sustained Drop in Gasoline Demand

Conventional Fuel Demand Forecast, Mid Case

Source: California Energy Commission
Transportation Electricity Demand Increases

Alternative Fuel Demand Forecast, Mid Case
All Vehicles and Modes, Excluding High-Speed Rail

Source: California Energy Commission
Projected High-Speed Rail Electricity Consumption

Source: California High-Speed Rail Authority
Thank You

For further questions, please contact:

- Aniss Bahreinian, Lead Transportation Forecaster
  - Aniss.Bahreinian@energy.ca.gov
- Ysbrand van der Werf, Fuel prices
  - Ysbrand.vanderWerf@energy.ca.gov
- Bob McBride, Freight & VMT
  - Bob.McBride@energy.ca.gov
- Jesse Gage, DMV analysis
  - Jesse.Gage@energy.ca.gov
- Sudhakar Konala, ZEV Analysis
  - Sudhakar.Konala@energy.ca.gov
- Mark Palmere, Light Duty Vehicles
  - Mark.Palmere@energy.ca.gov