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<th>19-AB-2127</th>
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<tr>
<td><strong>Project Title:</strong></td>
<td>Implementation of AB 2127 Electric Vehicle Charging Infrastructure Assessments</td>
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<td><strong>TN #:</strong></td>
<td>236627</td>
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<td><strong>Document Title:</strong></td>
<td>Presentation - AB 2127 2-4-2021</td>
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<td><strong>Description:</strong></td>
<td>Supersedes TN Number: 236571</td>
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<td>Spencer Kelley</td>
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<td>California Energy Commission</td>
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<td><strong>Submitter Role:</strong></td>
<td>Commission Staff</td>
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<td>2/4/2021 11:41:19 AM</td>
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<td><strong>Docketed Date:</strong></td>
<td>2/4/2021</td>
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</tbody>
</table>
AB 2127 Electric Vehicle Charging Infrastructure Assessment

Lead Commissioner Workshop
February 4, 2021, 1:00-4:30 p.m.
Opening Remarks
Commissioner Patty Monahan
Introduction

Raja Ramesh
Air Pollution Specialist
• 1:00: **Opening Remarks**, Commissioner Patty Monahan
• 1:10: **Introduction**, Raja Ramesh
• 1:25: **Counting Chargers**, Thanh Lopez
• 1:40: **Charger Distribution Analysis (SB 1000)**, Tiffany Hoang
• 1:55: **Break**
• 2:05: **EVI-Pro 2 and EVI-RoadTrip**, Matt Alexander, followed by **Q&A**
• 3:05: **WIRED**, Alan Jenn, UC Davis, followed by **Q&A**
• 3:35: **Break**
• 3:40 **HEVI-LOAD**, Noel Crisostomo
• 3:55: **Off-Road Charging**, Jeffrey Lu, followed by **Q&A**
• 4:30: **Adjourn**
Transportation Emissions

- Vehicle Emissions (170 MMT) 40%
- Industrial – Fossil Extraction, Processing & Refining (47 MMT) 11%
- Transportation Related (216 MMT) 51%
- Other 14%
- Commercial & Residential 10%
- Industrial – Other Emissions 10%
- Electric Power 15%
Assessment Goals

Electric vehicle charging infrastructure needed to support:

• Assembly Bill 2127
  • By 2030, at least 5 million zero-emission vehicles (ZEVs)
  • By 2030, reduce greenhouse gas emissions to 40% below 1990 levels
• Executive Order N-79-20
  • By 2035, 100 percent ZEV sales for new passenger vehicles and 100% ZEV operations for drayage trucks and off-road vehicles and equipment
  • By 2045, 100 percent ZEV operations for medium- and heavy-duty vehicles, where feasible
Light-Duty ZEV Trajectories

California ZEV population

- CEC IEPR Mid
- CARB MSS
- California 2025 and 2030 goals
**Counting Chargers**

- Including in Low-income Communities *(SB 1000)*

**Future Chargers**

- **Electric Vehicle Infrastructure Projections (EVI-Pro 2)**
- **Electric Vehicle Infrastructure for Road Trips (EVI-RoadTrip)**
- **Widespread Infrastructure for Ride-hailing EV Deployment (WIRED)**
- **Medium- and Heavy-Duty EV Infrastructure Load, Operation, and Deployment (HEVI-LOAD)**
- Off-Road, Port and Airport Electrification

**Existing Chargers**

**Charging Hardware and Software** *(Equipment Components, Standards, and Interoperability)*

- Make-Ready Electrical Equipment *(Community-Centric Plans, Building Codes, and Grid Evaluation)*

- Other Programs to Accelerate the Adoption of Electric Vehicles *(Incentives, Investments, and Others)*

*Consider All Necessary Charging Infrastructure, Including, but Not Limited to:*
Actions to Support Widespread Deployment of Charging Infrastructure

1. Continue public support for charger deployment, using public funds to leverage private funds, and eventually transition to a self-sustaining private market.

2. Continue the quantitative modeling efforts to project the quantities, locations, and load curves of chargers needed to meet statewide travel demand, including for MD/HD vehicles.

3. Support innovative charging solutions and financing mechanisms.

4. Support local efforts to prepare for transportation electrification.

5. Ensure equitable distribution of charger deployment throughout the State.

6. Align charging with renewable generation and grid needs.

7. Prioritize standardized charger connectors and communications protocols.
An Evolving Report for a Changing Field

- **January 7, 2021**: Staff Report published (draft for comment)
- **February 4-5**: Workshop on Staff Report and discussion on additional modeling out to 2035
- **Spring**: Revisions and publication of Commission Report (final draft) that will be presented at a Business Meeting
- **Ongoing in 2021**: Staff/Consultant Methodology Reports
  - Four Infrastructure Models
  - Hardware-Software Standardization
  - Off-Road
- **Every two years**: Updated AB 2127 Charging Infrastructure Assessments
A Collaborative Effort

- Contributors from 3 CEC Divisions
  - Significant independent research stemming from a range of efforts
- Analytical expertise from NREL, LBNL, and UC Davis, as well as coordination with Stanford, PNNL, and ANL
- Interagency coordination with CPUC, CARB, Caltrans, SCAQMD
Thanks Also To

- Stakeholders across industry, advocacy, and government
  - IOUs
  - POUs
  - Auto manufacturers
  - Electric vehicle service providers
  - Charger manufacturers
  - Environmental
  - Environmental justice
  - Local jurisdictions

- Especially for participation in our workshops
Thank you! Questions or Comments?

Contacts:
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Thanh.Lopez@energy.ca.gov
Tiffany.Hoang@energy.ca.gov
Matt.Alexander@energy.ca.gov
AJenn@ucdavis.edu
Noel.Crisostomo@energy.ca.gov
Jeffrey.Lu@energy.ca.gov

Webpage:
https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127
Counting Chargers

Thanh Lopez
Air Pollution Specialist
COUNTING CHARGERS BACKGROUND

PURPOSE: Aggregated count of public and shared private chargers in California
1) Track progress towards the state's 250,000-charger goal by 2025
2) Inform and improve public and private investment decisions

METHOD:
1) Conduct quarterly surveys
2) Provide information through public-facing Zero-Emission Vehicle and Infrastructure Dashboard
Use Consistent Terminology To Count

**CHARGING STATION**
A physical address with one or multiple EVSEs.

**CONNECTOR**
A specific socket or cable assembly available for the electric vehicle to use. A charger may have multiple connectors.

**CHARGER = EVSE**
The device that controls the power supply to a single electric vehicle in a single session.

**COUNTING CHARGERS**
The number of vehicles that can charge at a single charger simultaneously, regardless of the number of connectors.
Provide Information on California Chargers

Zero Emission Vehicle & Infrastructure Statistics Dashboard

TOTAL EV CHARGERS
Total Public and Shared Private Electric Vehicle Chargers

- Public: 67,343
  - 41.10% (27,678)
  - 58.90% (39,665)

DC Fast Chargers by County:

- Los Angeles: 532
- Orange: 451
- Riverside: 343
- San Bernardino: 315
- San Diego: 306
- San Mateo: 267
- Alameda: 256

Level 2 Chargers by County:

- Los Angeles: 17,529
- San Diego: 14,350
- Orange: 4,427
- San Mateo: 3,469
- Alameda: 2,748

Source: https://www.energy.ca.gov/zevstats
Analyze Charger Needs, 2025 and 2030

Installed and Projected Charger Counts Compared with Charger Needs for 1.5 million ZEVs in 2025 and 5 million ZEVs in 2030

Existing Charger Distribution Analysis (SB 1000)

Tiffany Hoang
Air Pollution Specialist
Agenda

- Background on Senate Bill (SB) 1000
- Objectives
- Results
- Next Steps
Background

• Are plug-in electric vehicle charging stations disproportionately deployed by population density, geographical area, or population income level?

• Are direct current fast charging stations disproportionately distributed and is access to these charging stations disproportionate?

• Results will inform Clean Transportation Program (CTP) investments
  • 2020 analysis and results are published in a new staff report
  • Future analyses will inform CTP Investment Plan Updates
2020 Objectives

- Define income levels, population density, and geographical area
- Evaluate statewide public charger numbers by location and population characteristics
- Begin to investigate factors that influence location of public charging
Geographic Distribution Results

Population Density

PEV Density

Public Charger Density

Income Distribution Results

The California Department of Housing and Community Development (HCD) establishes state income limits for each county by household size.

### Low-Income Communities:
- 120% State Median Income
- HCD Low-Income Limit
- OR
- State Median Income
- HCD Moderate-Income Limit
- OR
- 80% State Median Income
- HCD Low-Income Limit

### Middle-Income Communities:
- 120% State Median Income
- HCD Low-Income Limit
- OR
- State Median Income
- HCD Moderate-Income Limit
- OR
- 80% State Median Income
- HCD Low-Income Limit

### High-Income Communities:
- 120% State Median Income
- HCD Moderate-Income Limit
- OR
- State Median Income
- HCD Low-Income Limit
- OR
- 80% State Median Income
- HCD Low-Income Limit

Next Steps

- Expand analysis to urban and rural areas, dwelling types, and combinations of these
- Evaluate public charging access beyond charger numbers and location
- Identify communities with low public charging access and provide information on opportunities for deployment
Break

Return at 2:05
EVI-Pro 2
Matt Alexander
Air Pollution Specialist
What is EVI-Pro?

Simulation model to:

1) Estimate charging demand from light-duty PEVs (GVWM < 10,000 lbs) for **intra-regional travel**

2) Design supply of residential, workplace, and public charging infrastructure capable of meeting demand

Key outputs:

1) Number, type, and location of chargers required to meet charging demand

2) Load profiles associated with charging demand
## EVI-Pro 2 Updates

<table>
<thead>
<tr>
<th></th>
<th>EVI-Pro 1 (in 2025)</th>
<th>EVI-Pro 2 (in 2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZEV Population</td>
<td>1.5 million in 2025</td>
<td>2M, 5M, and 8M scenarios</td>
</tr>
<tr>
<td>PEV / Hydrogen Fuel Cell Electric Vehicle Split</td>
<td>87/13% in 2025</td>
<td>Shift towards more PEVs</td>
</tr>
<tr>
<td>Within PEVs, PHEV / BEV Split</td>
<td>45/55% in 2025</td>
<td>Shift towards more BEVs</td>
</tr>
<tr>
<td>Charging Behavior Objective</td>
<td>Maximize electric miles traveled</td>
<td>Mirror observed behavior</td>
</tr>
<tr>
<td>PEVs w/ Home Charging</td>
<td>92%</td>
<td>Decrease with larger fleet size based on survey data</td>
</tr>
<tr>
<td>Time-of-Use Rate Participation</td>
<td>Not included</td>
<td>Included</td>
</tr>
<tr>
<td>Infrastructure Utilization</td>
<td>Assumed</td>
<td>Observed</td>
</tr>
<tr>
<td>Travel Data</td>
<td>2012 CHTS</td>
<td>2012 CHTS + 2017 NHTS</td>
</tr>
</tbody>
</table>
# EVI-Pro 2 Scenarios

<table>
<thead>
<tr>
<th>Values for Year 2030</th>
<th>Core Forecast Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>ZEV Population</td>
<td>1.9 million</td>
</tr>
<tr>
<td>PEV / Hydrogen Fuel Cell Electric Vehicle Split</td>
<td>95/5%</td>
</tr>
<tr>
<td>Within PEVs, PHEV / BEV Split</td>
<td>38/62%</td>
</tr>
<tr>
<td>PEVs w/ Home Charging</td>
<td>81%</td>
</tr>
<tr>
<td>Time-of-Use Rate Participation</td>
<td>67%</td>
</tr>
</tbody>
</table>
2030 Network Results

- About **1 million** chargers needed to support **5 million** ZEVs
- Over **1.5 million** chargers needed to support **8 million** ZEVs
- Does not include residential chargers at single-family homes

<table>
<thead>
<tr>
<th>Type</th>
<th>Chargers Needed for 5 million ZEVs</th>
<th>Additional Chargers for 8 million ZEVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work (L2)</td>
<td>345</td>
<td>227</td>
</tr>
<tr>
<td>Public (L2)</td>
<td>386</td>
<td>231.5</td>
</tr>
<tr>
<td>Multi-Unit (L1+L2)</td>
<td>202</td>
<td>85</td>
</tr>
<tr>
<td>DCFC</td>
<td>31.3</td>
<td>23.2</td>
</tr>
</tbody>
</table>
Illustrate potential futures given the uncertainty of how the electric transportation landscape may evolve in the next decade.

<table>
<thead>
<tr>
<th>Values for Year 2030</th>
<th>Core Forecast Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (1.9M ZEVs)</td>
</tr>
<tr>
<td>Business as Usual</td>
<td>~375k chargers</td>
</tr>
<tr>
<td>Unconstrained</td>
<td>N/A</td>
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<tr>
<td>No TOU Participation</td>
<td></td>
</tr>
<tr>
<td>Gas Station Model</td>
<td>N/A</td>
</tr>
<tr>
<td>40% w/ residential access</td>
<td></td>
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<tr>
<td>Level 1 Charging</td>
<td>N/A</td>
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<tr>
<td>Enabled at work &amp; public</td>
<td></td>
</tr>
<tr>
<td>PHEV eVMT Maximization</td>
<td>N/A</td>
</tr>
<tr>
<td>Charge at every stop</td>
<td></td>
</tr>
</tbody>
</table>
Alternative Future Network Results

Difference in Network Results Compared to Business as Usual Case

- **Unconstrained**: Net change = 0
- **Gas Station Model**: Net change = +14.3k
- **Level 1 Charging**: Net change = +251.8k
- **PHEV eVMT Maximization**: Net change = +111.3k

Chargers (in thousands)
Preliminary 2035 Network Results

- **1.5M** chargers needed to support **8M ZEVs in 2030**
- **2.3M** chargers needed to support **15M ZEVs in 2035**
- Does not include residential chargers at single-family homes
Implications

• For intra-regional light-duty travel demand:
  • 5 million ZEVs in 2030 require about 1 million chargers
  • 8 million ZEVs in 2030 require over 1.5 million chargers
  • 15 million ZEVs in 2035 require over 2.3 million chargers

• Gap of more than 750,000 chargers to meet 5M ZEV infrastructure needs

• Charger counts are one metric, but do not tell the whole story. We need to continually evaluate infrastructure needs as the market evolves.
Next Steps and Future Work

• Continued refinement of EVI-Pro 2 and results for final AB 2127 publication
  • Tweaking inputs, assumptions, and methodologies
  • Results broken down to at least the county level
  • Results for all years from 2020-2030, and preliminary 2035 results

• Standalone EVI-Pro 2 report
  • Detailed methodology, analysis, and results including sensitivities

• EVI-Pro 3!
EVI-RoadTrip

Matt Alexander
Air Pollution Specialist
What is EVI-RoadTrip?

Simulation model to:
1) Estimate charging demand from light-duty BEVs (GVWR < 10,000 lbs) for long-distance inter-regional travel over 100 miles
2) Design supply of DC fast charging infrastructure capable of meeting this demand

Key outputs:
1) Number, type, and location of DCFC chargers and stations required to meet demand
2) Load profiles associated with charging demand
3) Potential grid impacts (case study)
Methodology and Key Inputs

4 Step Model:
1) Road Trip Volume and Pattern
2) BEV Energy Use and Charging Simulation
3) Station Design (siting and sizing)
4) Capacity Analysis

Charge Power (kW) as Function of Battery SOC

Station siting example
Station ID: 793
Coord: -122.872, 38.626
TAZ ID: 542
Charging events/day: 10
Plugs: 2
Land use type: commercial
Healdsburg, CA
Sonoma county

Charging demands along the routes
2030 Network Results

Required Stations by Charging Behavior Type

<table>
<thead>
<tr>
<th></th>
<th>5 Million ZEVs</th>
<th>8 Million ZEVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPM</td>
<td></td>
<td></td>
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</table>

Required Chargers by Charging Behavior Type

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<tr>
<td>Hybrid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Station Locations

DCFC Stations by Land Use Type

- Retail/shopping: 55%
- Recreation (parks): 28%
- Gas stations: 14%
- Other (0.3%)
- Airports (2%)
Comparison of Load Profiles Based on Charging Behavior

- Always Topping Off (ATO)
- Time Penalty Minimization (TPM)
Preliminary 2035 Network Results

Required Stations by Charging Behavior Type

- ATO: Lower Bound (1,000), Upper Bound (2,500)
- Hybrid: Lower Bound (1,500), Upper Bound (2,000)
- TPM: Lower Bound (2,000), Upper Bound (2,500)

Required Chargers by Charging Behavior Type

- ATO: Lower Bound (10,000), Upper Bound (16,000)
- Hybrid: Lower Bound (6,000), Upper Bound (8,000)
- TPM: Lower Bound (5,000), Upper Bound (7,000)
Preliminary 2035 Load Profile

Power (MW)

Always Topping Off (ATO)
Time Penalty Minimization (TPM)

Hour of Day
Moderation of Chargers over Time

Composition of Chargers by Power Level

- 50 kW
- 150 kW
- 250 kW
- 350 kW
- 450 kW

Number of Chargers
Implications

• For BEV inter-regional travel demand (100+ miles):
  • 5 million ZEVs in 2030 require average of 1,044 DCFC stations and 4,173 chargers
  • 8 million ZEVs in 2030 require average of 1,189 DCFC stations and 4,758 chargers
  • 15 million ZEVs in 2035 require average of 1,443 DCFC stations and 5,939 chargers

• Technology improvements will moderate growth in number of stations and plugs in the future, highlighting the importance of future proofing and connector interoperability today

• Inter-state collaboration is needed
Next Steps and Future Work

• Standalone EVI-RoadTrip report
  • Detailed methodology, analysis, and results including sensitivities

• EVI-Pro 3!
Questions & Answers

Please raise your hand and the moderator will unmute you.
Optimizing Charging Infrastructure Buildout For TNC Electrification

Alan Jenn, PhD
Assistant Director, Assistant Professional Researcher
Institute of Transportation Studies
University of California Davis
Chargers for EVs in TNCs

• EVs driving for TNCs pose several interesting challenges for the deployment of future infrastructure:
  • Significantly higher utilization at public DC fast charging, 2-3 times a day (compared to once every 2-3 weeks for the average EV driver)
  • Need for high-speed charging to minimize driving/service downtime
  • Spatial coverage to reduce travel/deadheading for TNC service vehicles
Framework for Infrastructure Buildout

Empirical Trip Data
- Uber
- Lyft

Bootstrap Data to Simulate Demand

Station Attributes
- ChargePoint
- EVgo

Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED) model

- Reduce costs to charge and downtime (traveling and charging) of drivers
- Meets energy requirements for trips provided throughout the day

Infrastructure Deployment Results
In the summer of 2020, the California Air Resources Board revealed some of the forecasts for EVs in TNCs to comply with the new Clean Miles Standard in California.

We take these estimates to forecast vehicle adoption in three major cities in California (right figure).

### Characteristics of vehicles that switched to ZEVs in the cost model

- 43% of 2030 TNC vehicles are switched to ZEVs
- In early years, primarily high mileage vehicles are switched
- Average age of vehicle switched to ZEV varied between 1-3 years

<table>
<thead>
<tr>
<th>Year</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Vehicles Switched</td>
<td>466</td>
<td>3,378</td>
<td>22,114</td>
<td>72,101</td>
<td>139,659</td>
<td>201,516</td>
<td>273,281</td>
<td>333,173</td>
</tr>
<tr>
<td>Avg. age vehicles switched</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Simulated Daily Energy Demand in 2030

Daily demand profiles are taken as the average day across simulated bootstrap trips over a 3-month period using empirical trip data from Uber and Lyft.
The vast majority of demand in scenarios with day-time charging is fulfilled with DC fast chargers. We find the highest demand in San Diego, Los Angeles, and San Francisco to be consistently located near major airports and around downtown areas.

The volume of DC fast chargers to meet demand is several times larger than exist today, despite fewer vehicles due to the high demand intensity of drivers for Uber and Lyft.
Conclusions

• High travel intensity of EVs driven for Uber and Lyft ride-hailing services is leading to a requirement for public fast charging several times than what exists today

• Infrastructure requirements are highly dependent on the amount of overnight charging—higher access to home/nighttime chargers will reduce dependency on DCFCs

• Currently working to integrate existing/projected public chargers from EVI-Pro2
Acknowledgements

Special thanks to Peter Day at Lyft and Michiko Namazu and Adam Gromis at Uber for providing data used for this analysis. Funding for this work was provided by the Pacific Southwest Region UTC of the National Center for Sustainable Transportation, the California Energy Commission, and the 3 Revolutions Mobility Program.

Research Supported by:

Other Research Partners:

3 Revolutions Future Mobility Program Sponsors:
Appendix: Infrastructure Development Model

\[
\text{min } \text{Downtime} = \sum_{jitr} x_{jitr}^{\text{occupied}} + \sum_{jrot} x_{jrot}^{\text{locDiff}} c_{ro}^{\text{travelTime}} + w \sum_{ir} x_{ir}^{\text{installed}} c_{i}^{\text{station Cost}}
\]

\[
\sum_{r} x_{jrt}^{\text{loc}} - 1 = 0, \forall jt
\]

\[
x_{jrt}^{\text{loc}} - c_{jrt}^{\text{travelIndicator}} \geq 0, \forall jrt
\]

\[
x_{jrt}^{\text{loc}} - \sum_{i} x_{jitr}^{\text{occupied}} \geq 0; \forall jrt
\]

\[
\sum_{i} x_{jitr}^{\text{occupied}} + c_{jrt}^{\text{travelIndicator}} - 1 \leq 0, \forall jrt
\]

\[
\sum_{ir} x_{jitr}^{\text{occupied}} - 1 \leq 0; \forall jt
\]

\[
\sum_{j} x_{jitr}^{\text{occupied}} - x_{ir}^{\text{installed}} + c_{ir}^{\text{existingStations}} \leq 0; \forall itr
\]

\[
\sum_{itr} x_{jitr}^{\text{occupied}} c_{i}^{\text{chrgRate}} - c_{j}^{\text{energyDemand}} \geq 0; \forall j
\]
Questions & Answers

Please raise your hand and the moderator will unmute you.
Break

Return at 3:40
HEVI-LOAD

Noel Crisostomo
Air Pollution Specialist
What is HEVI-LOAD?

Simulation model to:

1) Estimate charging demand from medium- and heavy-duty BEVs (weighing greater than 10,000 lbs GVWR) for intra-regional travel

2) Design supply of overnight and daytime charging infrastructure capable of meeting demand without behavior changes

Key outputs:

1) Number, type, and location of chargers required to meet charging demand

2) Load profiles associated with charging demand
## HEVI-LOAD Updates

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Preliminary (August 2020)</th>
<th>Medium Charging Demand</th>
<th>High Charging Demand</th>
<th>Mobile Source Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEV Population</td>
<td>130,000 in 2030</td>
<td>75,000 in 2030</td>
<td>81,000 in 2030</td>
<td>180,000 in 2030</td>
</tr>
<tr>
<td>Regional Populations Enhanced for Attainment</td>
<td>South Coast Air Quality</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
</tr>
<tr>
<td></td>
<td>Management District Counties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payload Associated with Vehicle Type</td>
<td>N/A (Assumed Electricity Consumption Rates)</td>
<td>3 choices, based on the relevant Weight Classes</td>
<td>Maximum GVWR for the relevant Weight Classes</td>
<td>Maximum GVWR for the relevant Weight Classes</td>
</tr>
<tr>
<td>Battery Energy Density Improvement (%/year)</td>
<td>None</td>
<td>7.2%</td>
<td>5.2%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>
• **157k** chargers needed to support **180,000 BEVs**

• **141,000 50 kW chargers** used overnight

• **16,000 350 kW chargers** used in the daytime
2030 MSS Scenario Load Profile

![Graph showing power consumption by vehicle type over the day.](image)

- **Hour of Day**
- **Power (MW)**
- **Vehicle Types**:
  - Medium-Duty Truck
  - Agriculture Truck
  - Other Freight Truck
  - Construction Truck
  - Utility Truck
  - Tractor-trailer
  - Drayage truck
  - Refuse truck
  - Bus

24 hour load (Scaled to vehicle type)
Implications

• For BEV intra-regional travel demand:
  • Dependent on portfolio of vehicle classes complying with regulatory deadlines
  • County-level infrastructures are unique and signify importance of local planning

• Additional behavioral data (or economic activity assumptions) are necessary to more robustly profile diversity in energy needs

• Rapid changes in vehicle and charging technologies require ongoing market analysis

• Top-down estimates should be complemented with bottom-up modeling
Next Steps and Future Work

• HEVI-LOAD Model Features In-Progress
  • Scenario alignment among econometric choice and state and regional air quality attainment targets, including EMFAC 2021, META, TEDF
  • Higher resolution load profiling: hour to minute
  • Agent-Based Modeling to reflect truck operations within the road network
    • Economic activity model
    • Trip chaining and recharging stops
    • Truck parking and fueling stations
  • Charger power selection (up to MW) → Station siting and sizing
  • Utility tariff, smart charging, and integration with EDGE

• Standalone HEVI-LOAD report
  • Detailed methodology, county-level analysis, and results to 2035
Preliminary truck simulation results using UCR/WVU data

Single trip visualization w/ smart charging optimization
We seek input on the 2035 analysis:

- **Scenarios for 100% Drayage and toward 100% ZEV operations by 2045**
  - Aligning the Mobile Source Strategy and state & local regulatory measures with the Transportation Energy Demand Forecast to profile load

- **Travel origins-destinations and schedules and driver preferences**

- **Vehicle & charging technology configurations**
  - Make-model availability, especially to 2024-2025
  - Energy density growth rate, especially from 2030-2035
  - CalEPA and UC ITS Carbon Neutrality Study 1 regarding ZEV powertrains
  - Battery charge curves at the megawatt scale

- **Grid Impacts**
  - Identifying fleets (and vehicle composition) to utility customer locations and to public fueling stations to assist with distribution service planning
Survey and Additional Resources

Some complimentary stakeholder efforts supporting medium- and heavy-duty vehicle electrification:

• **West Coast Clean Transit Corridor Initiative Study** on preparing the Interstate 5 corridor (California, Oregon, Washington) for freight electrification

• **Medium and Heavy-Duty Alternative Fuel Infrastructure Strategic Development Plan** developed by the West Coast Collaborative Medium & Heavy-Duty Alternative Fuel Infrastructure Corridor Coalition (WCC AFICC)

• **Survey** to further support WCC AFICC efforts, **open until March 31, 2021**
Off-Road Charging

Jeffrey Lu
Air Pollution Specialist
Context: New Executive Order Will Accelerate Off-Road Electrification

100% zero-emission off-road operations by 2035 where feasible

Previously, electrification primarily driven by air quality goals:

- **CARB**
  - Transportation refrigeration units (bifurcated due to EO)
  - Cargo handling equipment (ports, railyards) + forklifts
  - Airport ground support
- **Local clean air action plans** (for example, ports and airports)
Growing Commercial Options Across Many Sectors

Clockwise from left: CASE, Dannar, JCB, Monarch, Lillium
Challenges Similar to On-Road MD/HD

- Many applications extremely energy intensive
  - Taylor-BYD top handler: 931 kWh, 200 kW charging
  - Megawatt-level connectors under development
  - Distributed energy resources to mitigate grid constraints
  - Agriculture and construction may have no grid access at all
- Operators dismayed by lack of charger interoperability, standardization
- Landlord-tenant relationships: Who is responsible for infrastructure?
- Rigid operating demands and rules
Detailed Report on Off-Road Charging

- Based on prior off-road electricity demand forecast (2019)
- Align with CARB regulatory actions and projected populations
- Broader range of analysis, including discussion of agriculture, eVTOL, construction
- Publication later this year
Questions & Answers

Please raise your hand and the moderator will unmute you.
Submit Comments to Docket 19-AB-2127

Electronic Commenting System

Comment by E-mail
E-mail: docket@energy.ca.gov
Subject Line: “Workshop on Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment”

All comments due by 5:00 pm on February 26, 2021

* If answering or providing comments on a specific matter included in this presentation, please reference the workshop session (date) and slide number.