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COMMISSIONER WORKSHOP

AB 2127 ELECTRIC VEHICLE CHARGING INFRASTRUCTURE ASSESSMENT

REMOTE VIA ZOOM

THURSDAY, FEBRUARY 4, 2021

1:00 P.M.

Reported by:
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PROCEEDINGS

1:01 P.M.

THURSDAY, FEBRUARY 4, 2021

MR. CRISOSTOMO: Welcome to the Lead Commissioner Workshop on Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment at the California Energy Commission. My name is Noel Crisostomo and we’ll get started.

Note, please, that this Zoom webinar is being recorded, both via Zoom which will be posted on our website and via the Court Reporter, so please be sure to state your name and affiliation when participating in the interactive sessions and engaging on questions and answer. So, in the meantime, please feel free to use the chat as Staff will be monitoring that. And we are seeking your feedback. There’s a great amount of analysis that we’ll be presenting. And we’ll enjoy engaging with those questions.

But before that, I’d like to introduce Lead Commissioner on Transportation, Patty Monahan, for some opening remarks.

Commissioner Monahan?

COMMISSIONER MONAHAN: Thanks Noel.

Well, I want to welcome everybody to this workshop. And I'm very much looking forward to hearing feedback on the draft analysis. I think there was a lot of attention on the analysis, even before the Governor issued his executive order really calling for widespread transportation electrification in the next 15-ish years. And so now there's a lot more attention, I think, to the question of what kind of ZEV infrastructure are we going to need?

So this analysis that -- the team pivoted very quickly when the Governor issued his executive order to evaluate what the charging needs will be in 2030, not just for the 5 million target that we had under then Governor Brown, but also for the new target which, according to CARB, CARB estimates about 8 million ZEVs by 2030 will be needed to meet the ramp-up that we need. And this -- you know, and the numbers are -- I think at this point it's early days in terms of both CARB's analysis and our analysis.

The analysis is not just for light-duty, but also medium- and heavy-duty. That's really critically important to deliver air quality benefits to, especially, disadvantaged communities, but to all Californians. And so the assessment -- I mean, at least the draft numbers show pretty steep increase needed, so we'll need, according to the draft, the numbers, again, about 1.5 million chargers by 2030 for passenger vehicles, about 160,000 medium- and heavy-duty vehicles. So, you know, this is a big ramp-up from where we are today.

I actually don't want to hear myself talk. I want to hear both the Staff presentations and the comments. But we are -- I will say that we're going to be paying close attention to the comments that we receive, adjusting when appropriate. And we want to finalize this report by spring so that it can be -- we can help the legislature and the Governor's Office dan the stakeholders and everybody understand what it's going to mean to meet these targets in terms of the ramp-up of ZEV infrastructure.

So I'm going to turn it back over. I'm not sure if it's Raja or Noel but I'll turn it over to you. I'll go off video for now.

MR. CRISOSTOMO: To Raja.

Thanks Commissioner Monahan.

MR. RAMESH: You can go to the next slide whenever you're ready. Great.

Good afternoon everyone. My name is Raja Ramesh. I'm an Air Pollution Specialist in the Fuels and Transportation Division of the CEC and am one of the primary authors of the Assembly Bill 2127 Electric Vehicle Charging Infrastructure Report.

Thanks to Commissioner Monahan for her opening remarks. After my introduction, Thanh Lopez will present on counting chargers, an effort tracking the current status of charging infrastructure in California. Then Tiffany Hoang will present on Senate Bill 1000 which analyzes the distributional deployment of chargers. This will be followed by a break until 2:05, after which Matt Alexander will present on EVI-Pro 2 and EVI-Pro RoadTrip models which assess the charging needs for a non-transportation network company passenger vehicle trips. Then Alan Jenn will present on WIRED which models charging needs for transportation network company trips. We'll have another break until 3:40, after which Noel Crisostomo will be present on HEVI-LOAD which models charging needs for medium- and heavy-duty vehicles. We'll conclude with a presentation from Jeffrey Lu on off-road charging needs and adjourn at 4:30.

Next slide please.

Despite progress reducing statewide gas emissions, California’s transportation-related emissions now contribute more than half of the state’s GHGs. And emissions have been trending up since 2012. Transportation is a major source of the state’s air pollution, contributing nearly 80 percent of smog-forming nitrogen oxides and 95 percent of toxic diesel particulate matter. To achieve the state’s long-term air quality and GHG emission goals, California must rapidly transportation towards the widespread use of zero-emission vehicles powered by clean energy.

Next slide.

Transitioning to ZEVs requirements charging infrastructure. The goal of the 2127 assessment is to determine the charging infrastructure needed to support the following goals in particular.

From Assembly Bill 2127, by 2030 at least 5 million ZEVs on California roads, and reduce greenhouse gas emissions to 40 percent below 1990 levels.

From Executive Order N-79-20, by 2035, 100 percent ZEV sales for new passenger vehicles and, where feasible, 100 percent 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.

Next slide.

CEC's charging infrastructure models CEC's IEPR Transportation Energy Demand Forecast and CARB's Mobile Source Strategy Modeling as key inputs to connect the state's ZEV deployment goals to charging infrastructure demand through 2030.

This graph shows the recent 2020 mid-case transportation demand forecast in blue which reflects market conditions. And the CARB Draft Mobile Source Strategy scenario in yellow which takes a policy achievement approach, considering Executive Order N-79-20, among other policy goals. This report addresses public and shared private infrastructure needs to support both the statutory goal of 5 million ZEVs by 2030, shown as a green triangle in the middle of the slide, and the trajectory needed to achieve the goals outlined in yellow, N-79-20, including 8 million ZEVs by 2030, shown as a green star in the middle of the slide. We will also discuss initial work since the publication of the draft report on charging infrastructure needs in 2035.

Next slide.

This report considers the current status of charging infrastructure, as well as the future need for it. The existing charger section covers CEC tracking of current and planned installations, as well as some of the findings in the recently released SB 1000 Disproportional Deployment Assessment. The future charger section covers several quantitative charging infrastructure demand models that the CEC has developed through contracts. EVI-Pro 2 covers general light-duty electrification. RoadTrip covers long-distance trips. WIRED covers ride-hailing trips. HEVI-LOAD covers medium- and heavy-duty electrification. And a future analysis will cover off-road, port, and airport electrification. The report covers this last category qualitatively. The topics mentioned so far will be covered today, the first day of our two-day workshop.

Across all vehicles sectors the CEC is tasked with looking at charging hardware and software, make-ready electrical equipment, and other programs to accelerate the adoption of electric vehicles. The needs in these categories are assessed in the latter part of the report and will be discussed tomorrow.

Next slide.

These are seven actions the report identifies as being needed to support widespread and rapid deployment of charging infrastructure. And, broadly, they can be grouped into three categories.

First, continuing efforts to publicly fund and model charging infrastructure, bullets one and two.

Second, supporting an innovative and equitable best-fit approach that results in effecting charging solutions for all Californians based on needs identified by communities in the state, bullets three, four and five.

And third, prioritizing vehicle grid integration and standardized charging and communication protocols across all charging infrastructure in California to align charging with the renewable generation, decreased cost and impact on the grid, minimize the number of chargers needed, and make charging convenient and easy to use.

Next slide.

Here's a brief timeline of the development of the report. We published the Staff Report version of this assessment on January 7th. We're currently holding a workshop on this Staff Report where we'll also discuss additional modeling out to 2035. By spring of this year, we'll submit revisions and publication of Commission Report at a -- to a business meeting. And then ongoing in 2021, we'll have Staff and Consultant Methodology Reports. The report will be updated every two years.

Next slide.

Thanks to contributors from three CEC divisions who have written about their significant independent research stemming from a range of efforts in this report. Thanks, also, for analytical expertise from the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, and University of California Davis, as well as coordination with the Stanford

University, Pacific Northwest National Lab, and Argonne National Laboratory. Interagency coordination with the California Public Utilities Commission, the California Air Resources Board, Caltrans, and the South Coast Air Quality Management District were all essential to this report as well.

Next slide please.

We’d also like to thank stakeholders across industry, advocacy and government who -- especially for their participation in our workshops, ranging from stakeholders representing investor-owned utilities, publicly-owned utilities, auto manufacturers, electric vehicle service providers, charger manufacturers, environmental groups, environmental justice groups, and local jurisdictions.

Next slide please.

Thanks for attending. Here are emails of today’s presenters and a link to our web page where you can read the full report and get more information. The first opportunity for questions and comments will be after Matt Alexander’s presentation. Thanks.

Back to you, Noel.

MR. CRISOSTOMO: Thanks Raja.

We'll now have Thanh Lopez, Air Pollution Specialist in the Fuels and Transportation Division, discussing efforts to count chargers.

Thanh?

MS. LOPEZ: Thank you, Noel.

Good afternoon everyone. My name is Thanh Lopez, Staff in the Fuels and Transportation Division. I lead up the counting chargers effort at the Energy Commission. I'll be providing some background on the effort, the method, and the results.

Next slide please.

The purpose of the counting chargers effort is to get an aggregated count of public and shared private chargers in California. This allows us to track progress towards the state's 250,000 charger goal, including 10,000 direct-current fast chargers by 2025. Having this accurate data on public and shared private chargers in California is needed to determine if there is enough infrastructure to serve driver demand and meet the state's charger goals, as well as inform and improve public and private investment decisions for charging infrastructure.

Staff currently uses the Alternative Fuels Data Center, or AFDC, Station Locator Database to track publicly available chargers in the state. This data is combined with shared private charger counts obtained through quarterly voluntary surveys to network providers, utilities and public agencies. Shared private chargers are those that are shared by employees, tenants, visitors that aren’t usually available to the general public.

Combining the data collected through the quarterly surveys and the data from the AFDC Station Locator, Staff is able to share this information through the public-facing Zero Emission Vehicle and Infrastructure Dashboard, which I’ll talk more about later in a later slide.

I will note that private chargers that are privately owned and operated, usually dedicated for a specific driver or vehicle, such as a charger installed in the garage of a single-family home, is excluded from this effort as the 250,000 charger goal focuses on chargers that are shared use.

Next slide please.

Accurately quantifying the total number of electric vehicle chargers in California was difficult, in part due to the various terminology used by different entities, does cause issues such as double counting, counting stations versus connectors or ports, and preventive reliable data comparisons when looking at data shared between agencies. As part of this effort, CEC Staff coordinated with other sister agencies and the National Renewable Energy Laboratory to ensure consistent terminology and counting methods were used to gather charger counts. This ensures alignment in how chargers are counted in the AFDC database for public chargers and how the CEC counts shared private chargers to accurately measure progress for the state's EV charger goals.

Next slide please.

Here is a screenshot of the Zero Emission Vehicle and Infrastructure Statistics Dashboard. Through collaboration with the Energy Assessment's Division here at the Energy Commission, Fuels and Transportation Division staff was able to collaborate and create this public-facing dashboard to provide data on zero-emission vehicles and infrastructure. The dashboard shares the sales and population of light-duty zero-emission vehicles, the number of EV chargers serving light-duty electric vehicles, and also the number of hydrogen stations in California.

Here, you can see the EV Charger Dashboard shows over 67,000 public and shared private chargers in California. The data is broken out at the county level, technology level, and by access, so public or shared private. This dashboard is updated on a quarterly basis, with the exception of the vehicle population which is updated annually.

Next slide please.

So in addition to tracking the existing number of chargers in California, CEC Staff is also analyzing the charger needs for 1.5 million zero-emission vehicles in 2025 and 5 million zero-emission vehicles in 2030. Modeling results project that the state will need 968,000 public and shared private chargers in 2030 to support 5 million zero-emission vehicles, and over 1.5 million public and shared private chargers to support 8 million zero-emission vehicles. Here on the chart you can see the green bars indicate the chargers needed for 5 million zero-emission. And the blue bars represent the additional chargers needed for 8 million zero-emission vehicles.

As mentioned in the previous slide, there are nearly 67,000 public and shared private chargers available across the state as of the end of Q3 2020. Based on information collected on known proposed charging investments from other key funding mechanisms, such as state programs, utility investments, and settlement agreements, Staff projects over 121,000 chargers deployed by 2025. This means the state will need 780,000 more chargers than already installed and planned to meet the 968,000 chargers needed to support 5 million zero-emission vehicles, and over 1.3 million more chargers to meet the projected need to support 8 million zero-emission vehicles. Continued public support for charger deployment will be essential to help meet the state’s zero-emission vehicle goals.

I’ll go ahead and hand it off to the next speaker, Tiffany, to talk about existing charger distribution analysis.

MS. HOANG: Thank you, Thanh.

Good afternoon everyone. My name is Tiffany Hoang. I’m an Air Pollution Specialist in the Fuels and Transportation Division leading the Senate Bill 1000 analysis on plug-in electric vehicle charging infrastructure deployment.

Next slide please.

Today, I’ll be providing some background on SB 1000, going over our objectives for the first year of analysis, showing results from this first year, and I’ll end with a discussion of next steps for the analysis.

Next slide please.

SB 1000 was enacted in 2018 and directs the CEC to assess whether plug-in electric vehicle charging infrastructure is disproportionately deployed by population density, geographical area, or population income level. This includes assessing whether DC fast charging stations are disproportionately distributed and whether access to these charging stations is disproportionately available.

The analysis, which will be ongoing until Clean Transportation Program funding ends, will identify whether disparities in public EV charging access exist. Results will help inform the CEC's Clean Transportation Program investments on light-duty EV charging infrastructure. Staff recently published a final report with methodology and results from this first year of analysis.

A link to the report is provided on this slide which can be downloaded from the workshop events page and is also available on the 2127 web page under the reports menu. Results are summarized in the 2127 Report. And future results will be referenced in the Clean Transportation Program investments and updates. Written comments on the analysis can be submitted to the AB 2127 docket through February 26th, or anytime to the SB 1000 docket. We welcome feedback and participation throughout the analysis.

Next slide please.

As I mentioned, the analysis is conducted as part of the development of the Clean Transportation Program Investment Plan and will continue until the program ends. Our objectives for this first round were to define income levels, which include low, middle and high income levels, population density, and geographical area to evaluate statewide public charger numbers by location and population characteristics, as well as to begin to address factors that explain the deployment observed. In the next few slides I'll cover key results from this first assessment.

Next slide please.

These maps show residential population per square mile, PEVs registered per square mile, and public Level 2 and DC fast chargers per square mile by county. Population counts are from the U.S. Census Bureau. Our PEV counts are from the California Department of Motor Vehicles. And our charger counts are from the Alternative Fuels Data Center as of July 2020. As you can see, plug-in electric vehicles, public chargers, and population tend to be correlated which results in uneven geographic distribution of chargers.

Next slide please.

In addition to geographic distribution, we assessed income distribution of chargers. Analysis indicates that there is no correlation between per-capita chargers and census tract median household income. But when we binned these into three income categories, as shown on this slide, differences appear. Low-income communities, on average, have the fewest public Level 2 chargers and high-income communities have the most. Middle-income communities, on average, have the most DC fast chargers per capita and high-income communities have the least.

Next slide please.

The map to the right shows low-income communities in a light shade of blue, middle-income communities in that darker shade of blue, and high-income communities in purple. More than half of the state’s population lives within a low-income community which are defined as census tracts with medium household incomes at or below 80 percent of the statewide median income or with median household incomes at or below the limit designated as low-income by the Department of Housing and Community Development, so the HCDs, list of state income limits.

The HCD assess income limits by county and household size. Approximately 23 percent of Californians live in middle-income communities which are census tracts with median household incomes between 80 and 120 percent of the state median income, or between the low and moderate income limits established by the HCD. And about 21 percent of Californians live in high-income communities which are census tracts with median household incomes above 120 percent of the moderate income limit.

Next slide please.

At the county level, public chargers are generally collocated with population and PEVs. But at finer scales, we see that other factors appear to affect public charger locations, particularly land use. Public chargers tend to be located in census tracts with lower residential population density and more commercial land uses. There are fewer public chargers in high-population density census tracts that are smaller and, predominantly residential.

Next slide please.

Public charging infrastructure investments and deployments could be designed to serve low-income communities and high-population density neighborhoods to enable more proportionate infrastructure deployment. The analysis we've conducted so far considers location of public Level 2 and DC fast charging.

More analysis is needed to understand access to charging. Access may include home chargers, where the majority of charging takes place, or workplace charging. It may also include looking at distance and drive times to public charging stations.

An objective for this year's analysis, so the 2021 analysis, is to evaluate public charging access beyond charger numbers and locations. We also plan to expand the analysis to include urban and rural areas, dwelling types, and combinations of these to provide better characterization of communities and access. The goal is to identify communities with low public charging access based on charger availability and provide information and opportunities for deployment. We welcome input from you all throughout the analysis as we assess how to make charging infrastructure more accessible for all Californians.

This concludes my portion of the workshop. Thanks everyone.

Back to you, Noel.

MR. CRISOSTOMO: Thanks Thanh and Tiffany.

We're, actually, very much ahead of

schedule, so maybe we could actually seek any Q&A since we're about 20 minutes ahead.

So we can see folks raising their hands. And let me scroll to that. And we can un-mute you.

Ray Pingle, you should be allowed to talk.

MR. PINGLE: Great. Thank you, Noel. This is Ray Pingle from Sierra Club California.

First of all, I just want to commend Commissioner Monahan, you and the entire CEC team that's worked on this document. I think it's just phenomenal. I mean, the quality, the comprehensiveness of all the work you've done analytically, strategically, and with vision is tremendous. And I think what you're doing here is taking the first major step to create, really, the cookbook for the state and the nation on our to successfully plan for and implement and use technologies properly to maximize infrastructure. So, again, thank you so much for this awesome job.

I just have one question. And I know that the -- on the counting chargers, it specifically excludes private chargers, like in garages, because it’s driven by the 250,000 goal. But independent of the goal, when we want to look at how many chargers do we need to support, and we would recommend the goal for 2025 should be not 250,000 but to support 2.6, not the 1.5 million cars that was in Governor Brown’s executive order, but a 2.6 million that would be in the mobile source strategy.

So it seems to us that it would be helpful to have an idea of how many EV owners do have access to domestic charging to understand, you know, how much of the charging need is met with private chargers versus how much would have to be met with public chargers?

So any comments on that?

MR. CRISOSTOMO: Sorry Ray. You cut out for maybe five seconds on my end. Did you -- were you suggesting that we remodel a 2.5 million ZEV deployment by 2025 instead of or in addition to the 1.5 goal?

MR. PINGLE: Yes. Two things. One is to model 2.6 million cars by 2025.

And then, secondly, in order to determine how much public charging that you need, that you would look at -- you would need to understand how many privates there are out there. Because if there's not enough private charging, then the assumption is you would need more public charging.

MR. CRISOSTOMO: Yes. So first, thank you for the suggestion on the 2.5 million scenario. As Matt Alexander will describe in the following presentation related to EVI-Pro 2, we are analyzing a set of different ZEV populations and can take that suggestion into our work planning for the revisions. So thank you for that.

In terms of your second question with related -- with the relation to public charging, Matt will also describe how the kind of substitution effect between home charging and public charging is really a great, major factor in determining the relative deployments of the network. So maybe we can examine that in more detail after Matt's presentation, if you don't mind?

MR. PINGLE: Great. Happy to.

MR. CRISOSTOMO: And, Ray, for the Court Reporter and for everyone, do you mind, please, offering your affiliation for the record?

MR. PINGLE: Yeah. So I'm with Sierra Club California. Thank you, Noel.

MR. CRISOSTOMO: Thanks Ray.

Let's go to Q&A, just in chronological order. From Steph, "Is CEC open to public-private opportunities?"

Steph, if you want to raise your hand, I can un-mute you and you can clarify your question, if you'd like?

MS. MCGREEVY: Hi. Can you hear me okay?

MR. CRISOSTOMO: Yes.

MS. MCGREEVY: Hi. I'm Stephanie McGreedy with Open Energy Alliance.

Yeah, the question pertains to the amounts that are being proposed. As we all know, that will just barely touch the tip of the iceberg when it comes to covering costs for, whatever, DC charging, networks, ports, hubs. You know, there's a lot of work to be done.

And so my question to you is: Is the CEC open to working with the private sector to bring in funds for own-operate opportunities?

MR. CRISOSTOMO: Yes. The Clean Transportation Program has a variety of incentives that are offered across different vehicle segments, so not just the light-duty ones that were the focus of our first two presentations but, also, for medium- and heavy-duty vehicles, as well as off-road vehicles. So the Clean Transportation Program is very much one of the premiere opportunities for public-private partnerships. And we can send a link around for more information about the Clean Transportation Program, if you'd like?

MS. MCGREEVY: Yes, we'd like that. Thank you.

MR. CRISOSTOMO: Randy Chinn, I think Thanh is going to take that question.

MS. LOPEZ: Yes. Thanks Noel.

Randy Chinn asked, "How do you account for Tesla charging stations?"

So Tesla chargers are included in the ZEV dashboard charger counts. We get both the public Tesla charger counts and the shared private Tesla counts throughout AFDC and the survey process.

MR. CRISOSTOMO: Great. Thanks Thanh.

From Messay Betru, Tiffany, are there updates to the 1000 Report regarding equity?

MS. HOANG: Yeah. Thanks for that question, Messay. So we are continuing to conduct this analysis. And any updates will be provided within the Clean Transportation Investment Plan. So, for example, we're looking at charging access. And some metrics that we're looking at for charging access are looking at things like drive times from different community centers, so population centers to the nearest charger, and things like that.

MR. CRISOSTOMO: Great. The next question is from John Holmes.

John, would you like to un-mute yourself and identify your affiliation?

"Will part of the forthcoming task work be focused on studying the methods for distribution planning and the potential for VGI applications to be incorporated into these planning methods?"

Yes, that -- those two topics will be included during three presentations on our second day regarding the EVSE Deployment and Grid Evaluation tool equal great integration applications broadly and also control strategies from equipment hardware and software from my colleagues, Micah, Jeffrey and myself tomorrow. So we are focusing on the network deployments today but we'll be delving deep into those topics tomorrow.

Thank you, John.

And then Sean Tiedgen -- oh, sorry. I'm getting a suggestion to take the caller first, in terms of order. Let me un-mute the caller ending 903. I believe you are un-muted.

MR. COALE: (Feedback.) (Indiscernible.) My name is Bob Coale. I'm with Gladstein, Neandross & Associates.

The mere count of charging stations misses the point somewhat because of the variety of receptacles required for various vehicles, as well as the location of the plugin. Some are front, some are back, left of right. And when we get to very large vehicles, access alone to a charging port becomes very difficult. I'd like someone to address how that addresses the actual, just the pure county?

MS. HOANG: Yeah. Thanks for that question. I can -- I think I'm getting some feedback in the mike. I can address that question.

So this is going to be an ongoing analysis. And so for the first year of assessment, we wanted to provide the kind of high-level overview in terms of EV counts. And this was an attempt to try to meet the language within the statute that asks us to look at the distribution of chargers by population density and other population characteristics.

Moving forward we will be, you know, defining other metrics of access. And one of those components includes looking at, for example, drive times to a public charging station from where a person lives. In the future, we may be able to do analysis looking at, you know, how vehicles connect to chargers. So this is going to be an ongoing analysis. And we'll be looking at different components of access in the future.

MR. CRISOSTOMO: Yeah. And I'll add to that.

Interoperability is a key factor that effects network size. And we'll be focused on charging interface interoperability in a few of the presentations, first on Road-Trip. And then later, on the next day, your point around the connector and inlet locations across different vehicle models is not yet accounted for in our count analysis. So it's possible that there is going to be some potential for increasing numbers of the manufacturers who are making the ports in a way that's well replaced. But, hopefully, the EVSE manufacturers are working along with the OEMs to make sure that the sites are well set up.

Thanks for your question.

So let's go to Sean Tiedgen.

Raja, did you want to take that one on?

MR. RAMESH: Sure. So I'll take the question in three parts.

So the first part is how does CEC intend to use this analysis to inform future investments?

So CEC talks about some financial considerations and business model considerations in the penultimate chapter of the report, so you can look there for some suggestions. But there are sort of a myriad of ways the analysis could be used to inform future investments. EVI-Pro 1, a sort of precursor to some of the modeling in the report was used to inform the investments in the CALeVIP program, part of the Clean Transportation Program.

Moving on to the second question, is the analysis considering the economic needs to provide charging stations in rural, less dense areas where many people would travel or recreate post-COVID?

So the analysis considers -- uses a charging demand -- or a transportation demand forecast to determine where charging may be needed geographically and uses that to assess charging needs. And so we'll discuss that in greater depth later this afternoon.

And finally, for the third part, also, are you talking with the Public Utilities Commission to consider the utility impact where it needs to provide the estimated number of chargers?

We've shared the results of our analysis with the PUC. And they were developed with the PUC's input, in particular, the EVSE Deployment Grid Evaluation tool, EDGE, that CEC is developing, has been shared with the PUC in terms of the impact on distribution grids and how that tool could be used there.

Thanks for your question.

MR. CRISOSTOMO: Yes. And please tune in for more about EDGE tomorrow at around 1:00 p.m.

And Thanh was going to take Bonnie's

question.

MS. LOPEZ: Yes, Noel.

So Bonnie asked, "Since Tesla chargers are proprietary to Tesla users, how has this study accounted for it in terms of public charger counts? What percentage of public chargers in California are Tesla chargers, according to the study?"

So based on the Q3 public charger figures there were over 27,000 public chargers, that's Level 1, Level 2, and DC fast. Tesla superchargers and destination chargers accounted for over 4,500 of those, so about 16 percent of the public charger counts.

MR. CRISOSTOMO: Thanks Bonnie.

MS. HOANG: And then --

MR. CRISOSTOMO: Go ahead.

MS. HOANG: So I can --

MR. CRISOSTOMO: Hi Tiffany.

MS. HOANG: -- go ahead and take Ben's question here.

So Ben Wender asked, "Can you talk about the challenges in data needed to get better understanding -- to get a better understanding of the distribution of chargers within the counties, i.e. greater (indiscernible)? Thanks for the great work.”

So, yes, so for the SB 1000 analysis, this is very much an equity analysis where we’re looking at access by different communities. And so a part of looking at that is to get the -- go down to the census tract level, perhaps down to even the block or block-group level, for example, to look at urban and rural areas.

And so we do, you know, need data that’s provided in high resolution. And that gets to kind of that need for that level of detail for us to assess then what access may look like for that particular community. And so with this first analysis, you know, we look at public charging stations. And based off the availability of data there are some limitations in terms of looking at access to, for example, shared private chargers or private charging. And so there’s, you know, that fine balance between aggregating data and then looking at data more finely in high resolution levels to get meaningful results.

MR. CRISOSTOMO: Great. Thanks Tiffany.

And I’m realizing, probably, for the Court Reporter, this would help if we were to read the questions out.

Karim Farhat from ENGIE, "Thank you for this great effort by the CEC. The study seems to separate DC/FC from the rest of public charging. Two questions.

"One, does this mean that the current group labeled as public chargers are AC L2 chargers only?"

Karim, if you're referring to this graph, yes, the public chargers are Level 2 exclusively. And then DC fast are excluding L2.

And then two, "Will there be a discussion on the assumptions around what use cases and demand is fulfilled by public L2 versus these cases where demand is fulfilled by public DC FC?"

Yes. We will dive right into that with Alexander's following presentations that were the source of this waterfall chart momentarily.

Let's see. Are there any other questions? It looks like no hands of typed questions.

So we can take our break early if folks are okay with that? Let's stick to a ten-minute break. We did not anticipate going through questions so quickly but there's definitely a lot of content to come. So why don't we have a ten-minute break from 1:45 to 1:55 and we'll resume then.

(Off the record at 1:45 p.m.)

(On the record at 1:55 p.m.)

MR. RAMESH: Everyone, it's 1:55. Before moving to our next presentation, we just wanted to open up the opportunity again for any questions. Otherwise, we can begin with Matt's presentation. So I'll wait a few moments for anyone to raise their hand or add a question in the Q&A. Otherwise, we will continue to the next presentation.

(Pause)

MR. RAMESH: Okay. Let's move on then. So I'll now hand it over to Matt Alexander.

MR. ALEXANDER: Okay. Thank you, Raja.

Good afternoon everyone. My name is Matt Alexander. I'm an Air Pollution Specialist in the Electric Vehicle Infrastructure Unit in the Fuels and Transportation Division. I lead our light-duty modeling efforts here in the Fuels and Transportation Division. And I'm going to be talking about two models today, EVI-Pro 2 and EVI-RoadTrip.

Next slide please.

So I’ll start with EVI-Pro, which is a simulation model that estimates the charging demand from light-duty plugin electric vehicles for intra-regional travel, and then designs the supply of charging infrastructure capable of meeting this charging demand.

It’s important to note that for our modeling, we consider vehicles with gross weight ratings under 10,000 pounds to be light-duty.

The key outputs from EVI-Pro include the number, type and location of chargers required to meet charging demands, as well as the load profiles associated with this charging demand. EVI-PRO was originally developed in 2016 through a collaboration between the CEC and National Renewable Energy Laboratory. And the results from this first analysis informed Executive Order B-48-18 which set a target of 250,000 chargers statewide by 2025, including 10,000 DC fast chargers. With the establishment of AB 2127, we are now using EVI-Pro to continually assess the state’s infrastructure needs and improve the model along the way.

Next slide please.

So what's changed since EVI-Pro 1?

This table, which is adapted from Chapter 4 of our report, highlights some of the key updates and improvements made to EVI-Pro 2 compared to the EVI-Pro 1. There's a lot here and I'll walk through each row step by step.

So as you can see, EVI-Pro 1 assumed a ZEV population of 1.5 million vehicles in 2025. For EVI-Pro 2, we have three different forecast scenarios corresponding, roughly, to 2 million, 5 million, and 8 million ZEVs by 2030. And I'll explain these different scenarios more in the next slide.

And important difference between the two models is the composition of the ZEV fleets. In EVI-Pro 2 the PEV-to-fuel cell vehicle split has shifted about eight percent towards more PEVs in 2030, compared to our EVI-Pro 1 anal. In addition, within PEVs the PHEV-to-BEV split has shifted to favor more BEVs, indicating a larger preference for these vehicles in the market.

I'd also like to note that we're really improved the level of detail for vehicles modeled in EVI-Pro 2. In EVI-Pro 1, we modeled two types of PHEVs and two types of BEVs which differed in their electric ranges. In EVI-Pro 2, we modeled seven different types of vehicles which all have unique attributes and characteristics that evolve over time. This has provided much more specificity and realism in EVI-Pro 2 to model the unique driving and charging capabilities of these vehicles. And if you're interested in learning more about these vehicle classes and the parameter that were used in this analysis, please review Appendix B of our Draft Report.

So we've also modified the charging behavior objective in the model to mirror observed behavior, rather than maximize electric vehicle miles traveled as was the case in EVI-Pro 1. We leverage revealed preference survey data from UC Davis to better capture where people charge, as well as how often they charge. For example, EVI-Pro 2 includes a much higher portion of no-charge days, and also includes elective charging for drivers to charge even when not necessary.

We've also made significant updates to our home charging assumptions. Last summer we executed a survey with NREL to better understand precedential charging availability. And we built a model around these results to estimate the evolution of residential charging access as a function of the PEV fleet share. The data and results from this survey represent a significant improvement upon previously available data. And now we see residential charging access decrease as the PEV fleet size increases over time. This makes sense when you consider PEV adoption moving out of the early adopters and into the mainstream markets where drivers, for example, may have limited home charging access because they live in a multi-unit dwelling.

Another important update in the EVI-Pro 2 is the incorporation of time-of-use rate participation. Projected participation levels by utility territory were provided by the CEC's Energy Assessments Division. And show in this -- yes. We implement county-level TOU participation in the model. And tomorrow, Noel Crisostomo will be diving deeper into how we implement TOU participation in the model.

We've also updated the infrastructure utilization inputs. EVI-Pro 1 simply made assumptions about charger utilization to determine lower and upper charger bounds. But we are now using observed charger utilization data from (indiscernible) to understand how the supply of charging infrastructure is designed to meet certain levels of charging demands. Applying this in EVI-Pro 2 results in a more realistic approach and has leveled to a much narrower gap between the lower and upper bounds on needed chargers.

And finally, we have updated our travel data inputs to include the California sample from the 2017 National Household Travel Survey which has doubled our sample size.

Next slide please.

All right, just a little bit more background before diving into the results. So now I'm going to walk through the differences between our three core forecast scenarios in EVI-Pro 2. Each scenario is based on a different vehicle forecast.

The low scenario is based on the low scenario found in the CEC's Trans Energy Demand Forecast for the 2020 IEPR. This is the most conservative forecast in the IEPR and reaches a population of about 1.9 million ZEVs by 2030.

Our baseline scenario is tied to the

aggressive case in the Transportation Energy Demand Forecast and reaches approximately 4.7 million ZEVs by 2030. However, we have scaled this up slightly to act as a proxy for the 5 million ZEVs by 2030 target called out in AB 2127.

And finally, our high scenario is based on CARB's Mobile Source Strategy Forecast which reaches almost 8 million ZEVs by 2030.

It's important to note the differences between these various forecasts. The transportation energy demand forecasts come from a consumer choice model that is influenced by various market conditions, such as vehicle cost, incentives, and more. In contrasts CARB's Mobile Source Strategy is focused on policy achievement to meet climate, greenhouse gas, and air quality goals. The takeaway from this is that while CARB's forecast indicates the level of ZEV adoption we may need to achieve our climate environmental goals with 8 million ZEVs by 2030, the CEC forecasts indicate that current market conditions are not expected to lead to that level of ZEV adoption, and that additional beneficial market conditions may be needed.

So moving on to the PEV-to-fuel cell vehicle split has shifted to around 95 percent PEVs in all three scenarios. And in addition, as I noted before, the PHEV-to-BEV split has shifted as well, indicating a larger preference for BEVs in the market.

I mentioned the updates to our home charging assumptions. And you can see in this table how this input for the model decreases as the PEV fleet size increases across these three scenarios, reaching 67 percent home charging access with 8 million ZEVs in 2030.

And finally, our time-of-use rate participation level is shown here as 67 percent across all three scenarios. This is a statewide average to display for simplicity. But we do implement county-level participation in the model.

Next slide please.

So now, moving into the results, I'm going to focus on the results for our baseline and high scenarios which, as I just noted, correspond to fleet sizes of 5 million and 8 million ZEVs, respectively. The blue bars in this figure represent the chargers needed for the baseline scenario, while the orange chargers represent the additional chargers needed in the high scenario to support 8 million ZEVs. The exact numbers seen in the bars are the average between the lower and upper bounds found in EVI-Pro 2. And you can find the complete set of those results in Table 6 of Chapter 5 in our report.

An so the main takeaway here is that EVI-Pro 2 projects California will need about 965,000 chargers in 2030 to support 5 million ZEVs for intra-regional travel. To support 8 million ZEVs in 2030, California will need over 1.5 million chargers. And these totals include chargers at workplaces, public destinations, and multi-unit dwellings but does not include the residential charging needs at single-family homes. I'll also emphasize again that these results are for intra-regional travel only. The next two presentations will discuss the infrastructure requirements for inter-regional, long-distance travel, and TNCs.

Next slide please.

In addition to the scenarios and results I just showed, we also investigated alternative future scenarios. These scenarios are meant to illustrate potential futures, given the uncertainty of how the electric transportation landscape may evolve in the next decade. Projected charger counts can change based on shifts in behavior, access, technology, incentives and more. And this is our first attempt to capture this uncertainty in EVI-Pro 2.

This also highlights the importance of conducting the AB 2127 analysis at least every two years to continually evaluate the charging infrastructure needs and factor in these changes over time. In the metrics shown here illustrates how we've assessed the alternative future so far.

As I mentioned before, we have three core forecast scenarios, but so far we have only completed alternative future analysis for the baseline case with 5 million ZEVs by 2030. Also, the results I showed in my last slide are tied to our business-as-usual inputs, assumptions, and methodologies. These conditions result in a demand of 1 million chargers in the baseline forecast and 1.5 million chargers in the high forecast.

So before I dive into the results, I also want to define each alternative future, which modifies a single input or assumption to generate a new set of network results and load profiles.

The first alternative future is an unconstrained scenario where there is no TOU participation. This means that there is no managed residential charging and, instead, the model's approach is very similar to our original EVI-Pro 1 anal.

The gas station model assumes that only 40 percent of vehicles have access to overnight charging. So as a reminder, my last -- a couple slides ago I showed that for 5 million zero-emission vehicles the residential charging access was about 72 percent, so this represents a pretty significant drop in that residential charging access.

The Level 1 charging scenario enables Level 1 charging as an option for public and workplace charging. In the business-as-usual case, Level 1 charging is only an option at single-family homes and multifamily-unit dwellings.

The last alternative future, PHEV eVMT maximization, alters the model methodology to force PHEVs to charge at every single stop they make in order to maximize the electric miles traveled.

I'll also just make a quick note that this table shows the results for the baseline case and has MAs (phonetic) for the low and high forecasts. But in our final AB 2127 report, we do plan to include results for all forecast scenarios.

Next slide please.

So shown here are the differences in network results for each alternative future compared to the business-as-usual case results that I previously walked through. As you can see, some scenarios result in decreases, as well as increases, depending on the type of charging infrastructure. And I have noted the net change for each scenario at the top of the chart.

So first you'll notice the unconstrained scenario results in no change to the infrastructure network. In our approach for this analysis, TOU participation was implemented through a post-processing step to shift load -- to shift charging load to midnight. As a result, removing TOU participation only changes the load profile, not the network results. However, Noel will be discussing this a bit more tomorrow in his presentation on VGI and load profiles.

The gas station model results in a moderate increase to the network with an additional 14,000 chargers being required. Since the residential charging access is significantly decreased the number of required MUD chargers shown in blue, of course, hauntingly decreases.

However, to make up the demand for this lost residential charging, additional workplace and public Level 2 chargers, as well as DC fast chargers, are needed. The DC fast charger increase is particularly important as this scenario results in 21,000 additional DC fast chargers which represents an almost 70 percent increase compared to the business-as-usual case. And this scenario demonstrates that, while residential charging access should still be a priority, the potential for a properly sized and distributed DC fast charging network to act as an alternative to home charging offers an opportunity for further EV penetration and increased alignment with solar generation through daytime charging.

The Level 1 charging scenario results in the largest network size, requiring more than 250,000 additional chargers compared to the business-as-usual case. While this scenario does substantially decrease the work in public Level 2 network by about 360,000 chargers, it replaces these with 620,000 Level 1 chargers. So although this indicates that there is technical potential to accommodate low-energy charge sessions and reduce the number of Level 2 plugs needed, this does not come as a one-to-one replacement. And the resulting 35 percent increase to the total network size would lead to additional equipment and site acquisition costs.

The final alternative future, PHEV eVMT maximization, results in network size increase between the previous two scenarios. The additional 111,000 chargers come in the form of additional public and work L2 chargers needed to meet the requirement for PHEVs to charge at every single stop. However, again, to tease Noel's presentation tomorrow, this scenario reflects an inefficient strategy where the costs outweigh the benefits, especially when you look at the load profile.

Next slide please.

So beyond what was included in our draft report, we have also conducted preliminary analysis to investigate the potential infrastructure needs in 2035, which has become a topic of great interest with the new executive order calling for 100 percent of light-duty passenger vehicle sales to be ZEVs by 2035.

So for this analysis we leveraged CARB's Mobile Source Strategy Forecast. This forecast achieves 100 percent ZEV sales, including PHEVs, in 2035. And this results in a fleet of about 15 million ZEVs in 2035, of which about 14 million are PEVs.

As I noted earlier, CARB's forecast projects about 8 million ZEVs by 2030, which EVI-Pro 2 estimates will require over 1.5 million chargers. 15 million ZEVs in 2035 are estimated to require over 2.3 million chargers. The most important drivers to this increase are, of course, the nearly doubling in ZEV fleet size, as well as the continual decrease in residential charging access over time as the PEV fleet size increases.

I also just want to emphasize that this is a preliminary analysis. And given current limitations in data inputs and forecasting, we've had to make a number of assumptions for this analysis. We will continue to investigate the infrastructure needs for 2035 and will closely coordinate with our Energy Assessments Division and CARB in this process.

Next slide please. Next slide please, Raja. I am not seeing the presentation advance on my end. Oh, perfect. Okay.

So now I want to talk about -- kind of summarizing this presentation and the implications of this work.

So, again, the infrastructure needs to support intra-regional and charging demand for 2030 and beyond are significant. To meet Executive Order N-27-20's goals of 100 percent ZEV passenger vehicle sales by 2035, we could need over 1.5 million chargers in the state by 2030 and 2.3 million chargers by 2035. All this is going to require a lot of planning, organization, and commitment. Even just looking at the infrastructure needs for 5 million ZEVs in 2030, we see that there is a gap of more than 750,000 charges, even after accounting for planned future installations.

I think it’s also important to stress just how important it is to continually evaluate the state’s infrastructure needs as the market evolves. As the alternative future scenarios demonstrated, evolving conditions and factors, such as residential charging access of charger type preference, can have significant impacts on the required infrastructure network.

There’s a very good chance that the results I presented here today could change a few years from now, perhaps due to increased charger utilization with more EV adoption, updated vehicle forecast projections, or gaining access to higher quality data to leverage in our efforts. And, fortunately, AB 2127 calls for the CEC to conduct this analysis at least every two years. And we will continue to improve our modeling and understanding of the market to keep benchmarking our infrastructure needs.

Next slide please.

I’d like to close the EVI-Pro 2 discussion by touching on our near-term steps, as well as our longer-term future work.

Over the next few months, we will continue refinements to the EVI-Pro 2 model, including tweaking some of the inputs, assumptions, and methodologies. We ultimately plan to update our analysis and results for the final AB 2127 report. Our final analysis will include results broken down to at least the county-level resolution and will provide infrastructure needs for every year in the next decade to aid in planning efforts. We will also include our preliminary 2035 analysis, although further collaboration and coordination with other agencies will be needed to fully address the executive order.

We welcome your feedback on our analysis and results thus far as we continue to make these updates. And I encourage you to submit comments to our docket on this.

We also plan to publish a standalone EVI-Pro 2 report separate from the final AB 2127 report. This will delve deeper into the methodologies and inner workings of EVI-Pro 2 and provide a more complete and robust set of analysis and results, including a more detailed sensitivity analysis. We hope to publish this, roughly, in the same time frame as the final AB 2127 report.

And finally, our long-term work will include the development of EVI-Pro 3. This will result in more substantial updates to the model, including increased smart charging capabilities, finer geographic resolution, and harmonization with our EVI-RoadTrip model which I'm about to discuss in the next presentation.

We also plan to, more closely, coordinate with the SB 2000 assessments to investigation charging gaps and ensure charging infrastructure is accessible for all.

So thank you all for listening. And, again, we welcome your feedback through comments to the docket. And I will now transition to my next presentation, after drinking some water.

All right. Next slide please, Raja.

So EVI-RoadTrip stands for Electric Vehicle Infrastructure for Road Trips. As the name implies, this model differs from EVI-Pro 2 in the scope of its analysis. Whereas EVI-Pro 2 is focused on intra-regional travel and charging demand, EVI-RoadTrip addresses long-distance inter-regional travel for trips over 100 miles. While EVI-RoadTrip still focuses on light-duty vehicles, this model only designs the supply of

DC fast charging infrastructure capable of meeting the charging demand from battery-electric vehicles to enable long-distance road trips.

Similar to EVI-Pro 2, the key outputs include the number, type, and location of DC fast chargers and stations required to meet demand, as well as load profiles associated with this charging demand. And I'll just note that by type of DC fast chargers, I am referring to the power level of those chargers.

As I will highlight in upcoming slides, the geographic resolution in this analysis allows us to pinpoint geolocations for these modeled stations. This, in turn, allows us to examine potential grid impacts in a more detailed manner, as we demonstrated through a case study for SCE's territory in the AB 2127 Draft Report.

Next slide please.

EVI-RoadTrip is a four-step model, beginning with determining road trip volume and pattern. To do this, we leveraged Caltrans's California Statewide Travel Demand Model, or CSTDM. This travel model projects the number of long-distance trips over 100 miles taken, as well as where those trips begin and end. In addition, this model includes incoming and outgoing trips that cross the state line, so we are able to capture travel and charging needs for more than just trips within the state. The final component in this step involves determining the number of trips taken by battery-electric vehicles.

We used the same three forecasts that I discussed in my EVI-Pro 2 presentation for this. So, again, we have a low scenario corresponding to CEC's low IEPR forecast, a baseline scenario corresponding to CEC's aggressive IEPR forecast which, again is a proxy for about 5 million ZEVs by 2030, and then our high scenario corresponding to CARB's Mobile Source Strategy which reaches almost 8 million ZEVs by 2030.

However, because the CSTDM model does not specify the number of long-distance trips taken specifically by BEVs, we apply the percentage of BEVs within the total light-duty fleet from each forecast to approximate the number of long-distance road trips taken by BEVs.

So the second step digs into the trip vehicle energy use and charging simulation. For this, we begin by using a tool called the Open Source Routing Machine to determine the routes taken based on -- or taken for road trips based on origins and destinations. We then simulate the vehicle energy use and charging patterns during these trips. This model is a bit simpler than EVI-Pro 2 in the types of vehicles that we model. And right now we simulate three types of BEVs, short-range cars, long-range cars, and SUVs. So future work will aim to harmonize this analysis with EVI-Pro 2.

It is also important to note that we used three different types of charging behavior as a sensitivity in this analysis, but I will discuss that more in my next slide.

The third step of this model designs the charging stations to meet the charging demand from the previous step. In this step the model cluster points where vehicles need to charge on their route and then finds a suitable location to place a station to support this charging demand. We used national land use data to locate charging stations in preferred sites and land use types, such as commercial areas. And station sizing is then determined based on individual station load profiles.

An illustration of this step is shown on the right where the different colors on the map correspond to different land use types. And the white dots along the corridor correspond to points where charging is demanded. And then we can cluster those points together to design a station that can meet that charging demand, which is denoted by the yellow star in this figure.

And the final step of this model looks at the available utility hosting capacity to determine how the charging load from road trips may or may not be accommodated. We leverage our in-house EVSE Deployment and Grid Evaluation, or EDGE tool, for this analysis, which Micah Wofford will discuss in more detail during tomorrow's workshop.

Next slide please.

So shown here are the 2030 network results from EVI-RoadTrip, including both the number of stations on the left and the number of chargers on the right that are required. The blue bars indicate the lower bound for stations and chargers, while the orange bar denotes the upper bound. For charging stations the lower bound is based on no limitation for the number of chargers that can be present at a station, while the upper bound enforces a ten-charger cap at each station. For chargers, the lower bound is based on 100 percent utilization rate, while the upper bound is based on a 25 percent utilization rate.

The results shown here are for our baseline and high forecasts which, again, correspond to 5 million ZEVs and 8 million ZEVs in 2030. In addition, this chart shows network results for different charging behaviors. So we used three different charging behaviors in this model. And I'm going to quickly walk through those now just to give everyone a sense of what those entail.

Our primary charging behavior is called time penalty minimization, shown on the graph as TPM. In this scenario, drivers do not charge all the way to 100 percent SOC. Instead, they end charging early, either to the SOC required to reach their final destination if their trip is almost complete, or to the second largest bending point in the SOC curves used for this analysis.

And, Raja, could you just flip back to the previous slide real quick?

So for those of you that may be

unfamiliar, the rate of charging substantially decreases once you reach a certain level or state of charging, such as 80 percent. And this is illustrated in the middle figure on this slide showing the charge power as a function of battery SOC. And so the goal of our time penalty minimization charging behavior is to optimize the time spent charging by ending early to avoid that drop in charging power.

All right. Thanks, Raja. You can go back to the other slide.

The network results published in our draft report are tied to the time penalty minimization behavior. But I also wanted to take this opportunity to present the results for two other behaviors. One of these is called always topping off, which is shown on the graphs as ATO. In this behavior, drivers always fully charge their vehicles.

The other behavior is called hybrid. And this follows the always topping off method of fully charging, except for the last charging session of the trip where drivers adopt the time penalty minimization behavior and only charge as much as is needed to reach their final destination.

As you can see, the time penalty minimization behavior, in general, results in the lowest number of charging stations and charges requirements, although the hybrid behavior is almost identical. However, the always topping off behavior results in a much larger network, indicating how important it is for drivers to understand EV charging, and for automakers to, perhaps, set an upper limit on the state of charge the drivers can go to.

It’s also important to note that, in practice, some DC fast charges will be used for both intra-regional and inter-regional purposes. The EVI-Pro 2 and EVI-RoadTrip results do not reflect this synergy yet. And, therefore, the results may slightly overestimate the number of needed DC fast chargers.

Next slide please.

As I noted before, EVI-RoadTrip determined the geolocations of charging stations, as shown in the map on the right. You can see that these follow our highway corridors pretty well. And you’ll also notice that some of the stations fall outside of California’s borders to accommodate trips with routes that include out-of-state segments.

Furthermore, our results indicate that the majority of these stations would be located at retail and shopping areas, with most of the remaining stations at recreation and park areas, gas station, and airports.

Next slide please.

So now I’m going to walk briefly through the load profile from the EVI-RoadTrip.

So the typical load profile projected by EVI-RoadTrip indicates the inter-regional DC fast charging demand will peak at nearly 40 megawatts between 2:00 and 4:00 p.m. in 2030 for the time penalty minimization charging behavior which, again, those drivers stop charging before reaching a full state of charge and, thus, maximize over all charging speed.

In contrast, the always topping off charging behavior results in more than doubling the charging peak to nearly 90 megawatts around 2:00 to 4:00 p.m. This is due to the longer charging times required which, in turn, creates more coincidence in load and really demonstrates the impact of charging behavior on system load.

Beyond the statewide load profile, we also have the ability to estimate the load profile of each individual station, which ties into step four of this model, ASTI (phonetic) analysis. However, I won’t be diving into this today. And I’ll let Micah touch on that tomorrow in his presentation.

Next slide please.

So like EVI-Pro 2, we’ve done a preliminary analysis looking at the infrastructure needs in 2035 to support long-distance inter-regional travel. This, again, uses CARB’s Mobile Source Strategy Forecast which in 2035 has about 10 million BEVs in the light-duty fleet. To support these vehicles, the time penalty minimization charging behavior results in a lower bound of around 1,200 stations and 2,500 chargers, while the upper bound results in about 1,700 stations and 9,000 chargers. Once again, the always topping off scenario results in a much larger network size with a 30 percent increase to the required stations and a 60 percent stations to the required chargers when looking at the upper bounds.

Next slide please.

So looking at the 2035 load profile, we can see that the peak load increases to nearly 100 megawatts around 2:00 to 3:00 p.m. with the time penalty minimization behavior. However, whereas the 2030 load profile showed the always topping off scenario resulting in about double the peak load, in 2035 this behavior resulted in a 2.5 times increase in peak load, nearing 250 megawatts, indicating that the effects of charging behavior on load could exacerbate over time.

Next slide please.

So this figure shows the charger requirements that follows CARB’s Mobile Source Strategy Forecast for the time penalty minimization charging behavior. While the growth in charges is roughly linear, this actually represents a diminishing growth trend over time when you consider the exponential growth in the PEV fleet size found in CARB’s Forecast. This trend arises as technology improvements, such as longer vehicle ranges and higher powered chargers come into play and moderate the number of chargers that you need in the network.

For example, this chart shows the

composition of charger types by power level and how this changes to favor high-powered chargers over time as the onboard charging power of vehicles increases. However, these replace lower-powered chargers and do not build upon the lower-power charging infrastructure designed in earlier years. This is really critical because it highlights the need for forward thinking and the importance of future-proofing equipment and ensuring charger interoperability today. If we don’t start building out high-power charging today, such as 350 kilowatt chargers we are already seeing in the market, we risk deployment of infrastructure that is not capable of serving future vehicles that demand high-power capacity.

Our model also assumes that any vehicle can charge at any station, basically assuming perfect interoperability. And this is also true in EVI-Pro 2. So without continued progress on interoperability, our results could underestimate the required charging network.

Next slide please.

Our analysis indicates that more than 1,000 DC fast charging stations will be required to support BEV inter-regional travel demands in

2030, including an average between 4,000 and 5,000 chargers depending on the number of vehicles. In 2035, this increases to nearly 1,500 stations and 6,000 chargers on average.

As I stressed before, technology improvements will moderate the growth in number of stations and chargers required in the future. This highlights the importance of forward thinking and preparing our infrastructure network to meet the needs of the future vehicle market. But it is also critical to prioritize charging interoperability so we can optimize the network size and simplify charging so that people on road trips don't have to search for a charger that works with their vehicle.

And finally, this analysis demonstrates the need to coordinate with our neighbors. This modeling effort considered trips into and out of California, resulting in charging stations outside of our borders. It will be essential to continue coordinating with other states and governments to ensure a harmonized charging infrastructure network that can enable long-distance travels for electric vehicles across the country.

Next slide please.

So the EVI-RoadTrip model is pretty much finalized for this round of work. We plan to release a standalone report for this analysis around the same time as the AB 2127 Final Report. And this standalone report will contain a detailed description of the methodologies, as well as a robust set of results, including various sensitivities.

As I've mentioned previously, our longer-term goal for this work is to harmonize this model with EVI-Pro 2. This will reduce potential overlaps in DC fast charger projections and result in a more optimized model and analysis.

So that wraps it up for me. Thank you all for listening. And I welcome any questions and comments on this work. Thank you.

MR. RAMESH: Thanks Matt.

We'll move into questions now. I think we'll start with the question from Mehdi Ganji. "What is the residential charging station data resource used for your analysis?"

MR. ALEXANDER: Yeah. Thank you for that question.

So we executed a survey last summer with

NREL. And that is serving as the basis for our new residential charging access inputs. So we built -- or NREL built a Vehicle Likely Adopter Model based on our survey results to project how residential charging access would evolve over time as the PEV fleet size increases.

It gets quickly complicated if I try to explain more than that. So I would recommend, if folks are really interested in diving into residential charging access and our new assumptions in the model, please follow up with us. And we're happy to dive deeper into that because it is really interesting and a significant update to our model.

MR. RAMESH: Next question is from Dean Taylor. Dean asks, "US DOE says average BEV today is 250-mile range per charge. Do you look at the impact of varying the range, especially for greater range?"

MR. ALEXANDER: Sure. So as I mentioned before, we are modeling seven different types of vehicle classes in EVI-Pro 2. So this means that we actually have completely different attributes for all of those classifications. So you know, we have small cars, large cars, large cars, sport cars, pickup trucks, SUVs, many different types of vehicles. So those evolve over time based on our forecast efforts, so we're leveraging the forecasts and attributes from our Energy Assessments Division for these attributes.

And we have done some sensitivity analysis to look at how modifying ranges and attributes for vehicle classifications impacts the results but we haven't published those results yet or finalized that analysis.

MR. RAMESH: I also do see hands raised, so I'll get to the raised hands after Kevin Karner's question.

But for now, we'll take Eric Carhill's question from SMUD. "On slide 33 for the multi-unit bar, is that assuming -- does that assume charging in new MUD construction only, or does that include retrofits? Might it be more likely that multi-unit dwelling residents living in existing construction will rely on ultra-fast charging for most of their charging needs? What are the underlying assumptions going into this model?"

MR. ALEXANDER: So we do not make assumptions about the type of building that MUD chargers are located at, so we don’t consider, you know, whether a charger is located at a new MUD building or if it’s, you know, the result of a retrofit or something like that.

I will note that our -- going back to the residential charging access, that assumption is based on a scenario where infrastructure installations are assumed in certain -- to a certain degree, so we are considering the ability to install new chargers. But, yeah, we don’t specify how the chargers are split between new construction and retrofits.

And I think, you know, the alternative future where we -- the gas station model where we decrease that residential charging access assumption, I think that really highlights how you do see an increase in fast charging to meet that need.

So you know, we saw the -- if you can flip to that slide, Raja? I think it’s 35.

So in the gas station model, you see that we decrease the MUD charger count by about 150,000 chargers roughly. And we make that up with public and workplace L2. But, really, a substantial increase to the DCFC network compared to the baseline case. And I think that’s indicating that, you know, people do have to make up that charging through fast charging and kind of relying on that as an alternative to home charging.

MR. RAMESH: Next question from Kevin Karner. “Two questions. Apologies if they were just in the report. First, what data is the 72 percent home charging assumption based on? Are housing unit predicator variables explained? Second, any anticipated timeline on the county-level forecast results? In that past, that’s been a great help.”

MR. ALEXANDER: Sure. So again, our home charging assumptions are based on survey results that we executed last summer. Sorry, the question went to answered, so I want to make sure that I’m touching on everything.

So we’re happy to dive deeper into that data source and the results, if you would like, after this workshop.

That 72 percent is a combination of different housing types. So our survey did have, you know, different housing types. And so we can see, you know, from the results what the charging

-- what the results were for low-rise apartments and mid-rise apartments, and single-unit detached homes and single -- or, yeah, single-family detached homes and single-family attached homes. So we do have differences in housing. But in EVI-Pro 2, we're using an aggregated residential charging access value.

For county-level forecast results, we are planning to incorporate those into our final AB 2127 Report. So as others have noted earlier in this workshop, that's on a timeline for spring. And I know folks have been interested in the results viewer and interacting with the results. And we are planning to update that as well but the timeline on that is still a bit uncertain at this time.

MR. RAMESH: Okay. I'm now going to un-mute Ray Pingle.

You should be able to ask your question now, Ray.

MR. PINGLE: Thanks. Noel, can you hear me clearly now?

MR. RAMESH: Yes, we can hear you.

MR. CRISOSTOMO: That's Raja but, yes, we can hear you.

MR. PINGLE: Okay. Thank you.

So great work, Matt. I mean, I've learned a lot of new things, even after having read the 2127 Report. I've got three recommendations. They all have to do with assumptions.

I think the most important assumption is what the demand scenarios are. And as we know, we've got many scenarios, we think too many. We've got Governor Brown's executive order for 5 million cars by 2030, which is also in the 2127 law. We have the CEC's recent Demand Forecast of 3.3 million as a mid-case, 4.8 million in the aggressive case, by 2030. And then we have the Mobile Source Strategy scenario of 8 million, which is required to support Governor Newsom's executive order to get us to be able to support 35 percent of car sales by 2035.

I think it's important at the CEC that we have one objective, and it should be the Mobile Source Strategy goal. This goal should also be used for consistency and appropriateness in the EVI-RoadTrip analysis, which currently is using the 5 million vehicles. And then one of the problems in having all of these goals is it's very confusing to stakeholders and really undermines the commitment that we all need to have to achieve the goal of hitting targets that Governor Newsom has laid out for us.

Now some believe that the MS -- Mobile Source Strategy goal is a pipedream but it's not. The three main obstacles to EV adoption have been cost, range, and charging infrastructure. The range concern is rapidly fading as a concern with nearly all new EVs having at least a 200-mile range, some now getting up to 400 miles-plus. And this is all going to increase as far as the fleet is concerned. And this concern is also mitigated with the robust charging infrastructure and as potential EV buyers are educated and understand how this all works.

And as far as cost, EVs will reach cost parity in 2023 for most vehicles. And after that, EVs with both cost less to buy and operate with costs for fuel and maintenance at least 50 percent lower than ICE cars. This will be an extraordinarily compelling driver to get more rapid EV adoption.

So we're quickly moving towards a major inflection point in EV adoption. And the only thing that could slow it down is inadequate charging infrastructure. So if we don't plan for these needed chargers we won't achieve the EV adoption required to meet our climate and other goals. Failure would become a self-fulfilling prophecy. By setting the right goal of 8 million cars by 2030 and achieving implementing the infrastructure to support that, we can facilitate potential EV purchasers buying these vehicles to be as confident that they'll be able to charge as they are today that they can find a gas station, and we have eliminated the third obstacle.

So we strongly recommend that the CEC, along with its sister agencies, adopt and wholly, wholeheartedly commit to the Mobile Source Strategy demand goal of 8 million vehicles by 2030 and abandon the other projection goals.

And a parallel to that is that we need to change the 2025 goal from 250,000 to 2.6 million and adjust what the goals are. And this is especially important because we've got to stay ahead of the need for chargers with having the chargers or we'll really have a very significant obstacle to overcome going forward. So setting the 2025 goal higher and realistically is very important.

And then I just have two other quick suggestions.

One is, if you look in Appendix B of the document, and that includes, I think, the seven model types, Matt, that you were talking about, and several of the assumptions for these model types look fine but many of them are showing battery sizes and ranges that are really low and are not tracking at all with new vehicles coming on the marketplace, so I think those should be addressed before the final report is completed.

And then secondly, on the assumption for the split between BEVs and PHEVs by 2030, you know, already in the Bloomberg New Energy Finance 2020 EV Outlook, they're showing the split globally going from 50/50 in 2015 to about 25 percent/75 percent in 2019, so we're already there. And they forecast that in the U.S. the ratio by '24 will be about 87 percent/13 percent. So if we did an intermediate in between those two, we should be at about 80/20 in 2030. So we would suggest that you alter that assumption as well.

Thank you very much. And really great

work.

MR. ALEXANDER: Thank you, Ray. There was a lot there, some really great comments. I would really appreciate if you could submit your thoughts and suggestions to the docket. And that will really help us home in on those points and try and address those, so Thank you.

MR. RAMESH: Okay. Next we'll go to Dean Taylor. "It would be great to see the difference in charging needs for those who can charge at attached and detached single-family homes at nice versus the needs of fleet vehicles versus the need of large apartments and condos. It seems counterintuitive that so much Level 2 is needed compared to DCFC, especially with 250- to 400-mile BEVs."

MR. ALEXANDER: Yeah. So let me try unpacking this one.

So we don't break down between attached and detached single-family homes. But we do have a charger count for single-family homes that I haven't included in the slides here but we do. You know that number is in the millions of chargers.

We -- so Alan Jenn will be presenting

after me on the needs for fleet vehicles and TNCs. So, hopefully, that will answer some of your questions there.

MUDs, again, yeah, we don't break down the needs between, for example, small apartments, mid-rise and high-rise apartments, so that's a capability that we currently don't have in the model.

I will also note that while, yes, we do have a large number of L2 chargers compared to DCFC, I think Noel's presentation tomorrow, when we look at the load profiles, is going to show that DCFC is really important. And a lot of the energy delivered to vehicles is coming from those DC fast chargers. So I would stay tuned for that. And there's some really interesting results coming out of the load profiles that I, unfortunately, wasn't able to fit into my presentation.

MR. RAMESH: Next question from Ross Zelen. "Nice tie-in to SB 1000. Is there also a tie-in to AB 617?"

MS. HOANG: And I can go ahead and take this one. This is Tiffany. I'm working on the SB 1000 analysis.

So moving on with SB 1000, we are going to be looking at communities with the highest pollution burden. And that's going to help us identify communities that might have the highest need for charging infrastructure. And we welcome input from stakeholders on different factors we can consider to assess community needs.

Thanks.

MR. RAMESH: Next question from Sam Houston. "Does the time penalty minimization scenario assume zero state of charge at final destination or some non-zero minimum so the driver is not stranded at the destination?"

MR. CRISOSTOMO: Raja --

MR. ALEXANDER: I --

MR. CRISOSTOMO: -- I've un-muted D.Y. to help answer this question.

MR. ALEXANDER: Awesome. Thanks Noel.

MR. LEE: Yeah. That's a great question. So the TPM scenario, which is one of the charging behavior models that we evaluated, the SOC at the final destination is assumed to be zero. We are using two different buffers for the final destination SOC. The first one is five percent of SOC as an absolute behavior regardless of charging behaviors. And, plus, we also used five-mile buffer so that, you know, PEVs are not stranded at their destination.

MR. ALEXANDER: Thanks D.Y.

And just for folks on the line, D.Y. is the main modeler at NREL working on the EVI-RoadTrip analysis and, also EVI-Pro 2.

So thanks for joining and helping out with that one, D.Y.

MR. RAMESH: Next question from James Russell at CLEAResult. "Great presentations regarding the EVI-Pro 2 results. How optimum must the distribution of chargers be for the 1 million chargers to be adequate in the baseline scenario? Is there an allowance for some chargers being located in what turn out to be suboptimal locations while other locations see more charging demand than available chargers?"

MR. ALEXANDER: So, yeah, I've been presenting statewide charger results, network results.

And, Eric, I'll also let you chime in if you would like.

But we are assuming varying utilizations by county. So I think, you know, once we, in our final report, get to the county-level resolution and have results for all of the counties and can really home in on, you know, the distribution of chargers, that will help a bit. But we do -- you know, we don't necessarily say, oh, this charger, you know, maybe it will wind up with no utilization, or this one might have really high utilization. We do assume kind of consistent utilizations that vary by county.

And, Eric, I'll let you chime in if I am incorrect on any of those points.

MR. WOOD: No. That was perfect, Matt.

So I just want to add, though, that in addition to designing the network for different levels of utilization geographically around the state, we also simulate what I would describe as some discretionary charging happening within the simulations. And so this is, you know, charging that happens during the simulation but isn't absolutely necessary in order for the vehicle or the individual to complete their travel for the day.

We've been tuning that discretionary charging based on survey data that's been published by UC Davis as part of the PHEV program at Davis. And it’s kind of one of the things that we’re looking forward to diving into next is looking at, you know, what role charging behavior plays on the demand for infrastructure and how different, you know, incentives could, perhaps, be used to drive behavior in different directions, including trying to better align load with solar production in the state.

MR. RAMESH: Great. Thank you both.

Next question from Marc Geller. “How does current retail/shopping charger utilization figure in the model? Do you have current utilization data for retail/shopping location chargers broken out by Level 2 and DC, and paid versus free? Any problems getting utilization data?”

MR. ALEXANDER: So I believe this is regarding EVI-Pro 2 and charger utilizations in that, also it could also apply to EVI-RoadTrip.

Maybe could we get Marc on the line just to clarify whether this is for EVI-Pro 2 or RoadTrip or both? And then we can address this.

MR. RAMESH: Yeah. Please raise your hand so we can un-mute you. Go ahead, Marc.

MR. GELLER: Great. Can you hear me?

MR. RAMESH: Yes.

MR. GELLER: Yeah. For both. I mean, it was a slide that included sort of perspective locations, a lot of charging at retail. And so I figured looking backward, what utilization data do you have? And it could apply to either scenario.

MR. ALEXANDER: Yeah. So -- and again, D.Y. and Eric, feel free to weigh in as well. I'll kick this off.

So RoadTrip is a bit different in terms of how it's siting the chargers compared to EVI-Pro 2.

So as I mentioned in -- Raja, could you flip back a few slides to the figure, the station siting example?

MR. RAMESH: Are you talking about this one?

MR. ALEXANDER: Yeah. Yeah. Perfect.

So this is an example of how we site the stations. And so you can see that these white dots on the corridor represent points where vehicles require charging and the model clusters these events together. And then using National Land Use Database data, we can look at, you know, what type of land is around here. So, for example, the green is -- I want to say it's like agriculture land. I think the blue is residential. And that red strip where the yellow star is located is commercial land use.

And so we implemented a ranked system of these land use types to say, okay, would we prioritize commercial land use over, you know, a park, park areas, recreational areas, et cetera? And by using that ranking system and clustering these charging events together, we can find where the optimal station location is to serve that demand. And so we're not necessarily using utilization data to say, oh, 55 percent of the charging stations should be located in retail shopping centers.

We did have discussions with stakeholders on, you know, our ranking system and, you know, how do you think about where to place your chargers, and that type of consideration? But we don't use actually utilization data to determine the station siting.

D.Y., would you add anything else to that?

MR. LEE: No. I think that's an accurate

description.

And then for the station utilization rate, I think, is one of the questions.

So for the RoadTrip side, we are using about 25 utilization rate for the DC fast charging folks based on the empirical data that we got at NREL for 300 different DC fast charging stations across the state in California.

MR. ALEXANDER: Yeah. So we're applying kind of a single utilization assumption to determine our lower and upper bounds. So we don't have quite the specificity that Eric was describing in EVI-Pro 2 where we have, you know, county-level utilization rates for different charger types, et cetera.

And you know, I would say that, you know, we're always looking for utilization data and improving this input. I think it's also one of the most -- it's a very impactful change compared to EVI-Pro 1. We had very large gaps between our lower and upper bounds in EVI-Pro 1. And now we've really narrowed that because of the updates and improvements in utilization data that we've incorporated into EVI-Pro 2. But we're still, you know, trying to get a better sense of utilization and how EVSPs balance charger supply and charging demands. And you know, I think it’s also a bit uncertain what it’s going to look like in a few years from now.

So you know, we’re always eager to get more utilization data. If folks want to help support this effort and have the data, that can help improve this.

MR. CRISOSTOMO: Yeah. And I’ll quickly add, we appreciate the engagements with the few EVSPs that --

MR. ALEXANDER: Yeah.

MR. CRISOSTOMO: -- we’ve been able to sanity check our approach on balancing customer experience, as well as the kind of network moderation potential from high utilization sites. So thank you for the EVSPs. You know who you are.

MR. RAMESH: Great. So just a time check. We have about five minutes left in the question and answer session, so we’ll take the --

MR. ALEXANDER: It seems like you cut out there, Raja.

MR. RAMESH: Ah. Okay. Just if you’d like to add a question, now is your last chance before this next presentation.

We'll read Karim Farhat's from ENGIE's question now. "Thank you again for this excellent work. Following up on the earlier question, slide 43 seems to provide use cases and demand for public DCFC. And I can confirm the model results are consistent with what we're observing in the industry. Do you have a similar slide for public L2 showing locations of chargers and breakdown by use case or demand?"

MR. ALEXANDER: Yeah. So again, this comes from a difference in methodology between the EVI-Pro 2 and RoadTrip. So again, EVI-RoadTrip, which, you know, Karim is referring to in slide 43, this is only focused on DC fast charging. So we don't have a similar slide for L2 in the RoadTrip context. And in RoadTrip, we were able to identify the specific charger locations and assign that to the land use type and have this fine breakdown. EVI-Pro 2, it's more complicated.

And we don't have this level of geographic resolution at this point, so we don't have similar breakdowns on, you know, this many Level 2 chargers from EVI-Pro 2 should be located in retail and shopping centers, or anything like that.

I’ll pause and see if Eric wants to jump in there?

MR. WOOD: Yeah. Thanks Matt. Yeah.

So I think the way I would kind of describe it is that the feed data for RoadTrip is really trips from a statewide travel demand model, so we’re looking at A-to-B trips, and then coming back, B-to-A. For EVI-Pro 2, it really requires us having access to at least a 24-hour sequence of trips over a day, and that’s typically a more challenging set of data to come across.

We’re currently relying on a composite of two travel surveys that have occurred over the last decade in California. But we’re also, you know, considering reviewing options for commercial data to inform the model from telematics and GPS providers. Those datasets, you know, come in great volumes, certainly, but also have tradeoffs in terms of the contextual information that’s available in a commercial dataset. Things like the trip purpose or demographics for the household typically aren’t included in that data but can be, you know, added, essentially, through data fusion techniques.

So that’s kind of the state of where we’re at with the feed travel data for the two models.

MR. RAMESH: Thanks Eric. Great.

So I don’t see any raised hands of further questions in the Q&A box. I see Ray has raised his hand.

So, Ray, you’ll have two minutes before our 6:05 p.m. next presentation -- or 3:05. Excuse me. Go ahead. Your un-muted now.

MR. PINGLE: Yeah. Ray Pingle, Sierra Club California. Thank you very much. This will be quick.

So I just did the math in terms of, you know, our goal right now is 250,000 chargers by 2025. But according to the Mobile Source Strategy, I believe the number of estimated vehicles, instead of 1.5, would be 2.6 million. And so just to extrapolate that, instead of 250,000 chargers, that would say that we need 433,000 chargers.

And so I just want to highlight that

because, again, I think we are going to have a fairly rapid inflection point. And we need to be planning for a larger number of chargers so that we don't have the problem of people having to line up and wait to get access to a charger, which would really put a chilling effect on increased EV adoption.

Thank you very much.

MR. ALEXANDER: Yeah. Thanks Ray. And I'll emphasize again that, for now, we've been laser focused on the 2030 and 2035 analyses and getting those results ready for the draft report. But we do plan to include intermediate year results, as well, so we will have, you know, year-by-year 2020 to 2030 what our -- what EVI-Pro 2 is projecting for the network size and the breakup. And EVI-RoadTrip, we have it every five years, so 2020, 2025, 2035 -- 2030 and 2035.

MR. RAMESH: All right. Thanks for all your questions everyone.

Next we'll have a presentation from Alan Jenn of UC Davis.

Go ahead, Alan.

MR. JENN: Hi. Good afternoon everyone. I'm Alan Jenn, a researcher at the Institute of

Transportation Studies at UC Davis. And I’ll be talking about infrastructure buildout specifically for TNC electrification. So TNCs are transportation network companies, so you can think of companies like Uber and Lyft.

So onwards to the next slide.

So the reason why this project has kind of its own carveout, as opposed to sort of integration with the other models, is that the electric vehicles that drive on these platforms are pretty different. There is a significantly higher utilization in current day at the public DC fast charging. And so what we observe from empirical data is that drivers on these services are typically charging about two to three times a day. And that’s in pretty stark contrast to your average electric vehicle owner who we find typically charges about once every two to three weeks.

In addition to this really sort of high density of charging events, electric vehicle drivers on these platforms also have sort of different requirements for high-speed charging in order to minimize the amount of downtime that they have so that they can provide their service without interruption.

And then the spatial coverage is also a very important issue because the strategic placement of these chargers may differ quite a bit from what you might require for your average driver because they want to reduce the amount of travel and we want to decrease the amount of deadheading from these vehicles going between where they're providing rides and then where they need to go to charge. And so I think that these sort of set of problems bring on a unique set of challenges in thinking about deploying infrastructure for these drivers.

So continuing on, so we built a model called WIRED. It's the Widespread Infrastructure for Ride-Hailing EV Deployment. And this model leverage real-world data on trips actually being performed from electric vehicles on Uber and Lyft platforms, as well as gas vehicles on that platform. And we use that to, essentially, simulate how we expect the use of electric vehicles is going to increase in specific areas in three case study cities in California.

So this simulation, combined with some information about station attributes, goes into this model. And from it we can determine, through an optimization algorithm, the sort of best places to deploy the infrastructure and also get an understanding of how they're going to actually be used to meet the charging demand from these drivers.

The optimization is based on reducing costs of deployment and costs of charging while, at the same time, making sure that all of the drivers can, one, meet the energy requirements. So, you know, they're driving quite a bit more every day and so the charging amount is going to be larger. And, too, sort of minimizes the interference of the actually charging events with the service that they have to be providing throughout the day. And so if this driver is providing a service, say from 1:00 p.m. to 5:00 p.m., he's not allowed to charge in that time period. And so this optimization takes all of those constraints into account when doing the deployment, both by space and then -- and also by time.

Okay, so in this slide the first thing that we need to sort of understand as an input into the WIRED model is, well, how many electric vehicles are actually going to be driving on the TNC platforms in the future? So this is a slide, sort of stolen directly, from a CARB workshop, from the Clean Miles Standard, which is providing some projections of expectations for electric vehicles on these platforms. And so you can see by 2030 there's an estimated, about, 300,000 vehicles, electric vehicles, that are going to be driving on surfaces such as Uber and Lyft.

And so, as I mentioned before, we are applying this model in the three largest cities in California, so that would be San Francisco, Los Angeles and San Diego. And we can, essentially, extrapolate from these numbers and interpolate based off the data that we see in the Uber and Lyft datasets to allocate these vehicles into all of those cities. And so on the right-hand side is just a simple graphic of the number of electric vehicles that we're expecting to be on ride-hailing platforms going out over the next decade. We're going all the way up to about 100,000 electric vehicles in Los Angeles, about 60,000 in San Francisco, and a little bit over 25,000 in San Diego by that time.

Okay, and so the first thing that I

mentioned was simulating the daily energy demand. And this is, essentially, how we're figuring out the locations for where the energy demand is going to happen. So, essentially, what we do is we do is we take the trips by doing a statistical sampling method called bootstrapping where we sort of randomly take trips that are observed in real data and we can expand that to a larger population size. And so based off of where people are asking for rides, we're able to, essentially, figure out how much energy demand there is in any particular area.

These energy demands, if you look at the sort of darkest blue, those buckets actually go up tremendously high in certain regions. And so the ceiling for some of these is orders of magnitude larger. It's pretty much what you would expect. In the trips that we observe, most of the -- or the largest places with the highest demands are happening in airport regions and in sort of downtown areas.

And so when you do this bootstrapping for a single day, you will actually observe quite a bit of variation in particular zones and regions because, you know, one day you might see a lot more trip demand in one area, and then on the next day you might see a lot less. And so what we do is we actually simulate this over a three-month period and then average it out in order to smooth the demand and make sure that when we think about the deployment of the infrastructure, you are meeting the requirements that you're going to see over a long period of time rather than just the variation that you might see in a single day. And so that's why you're -- that's why we're doing it over sort of a longer time period.

So let's go ahead and move on to the next slide.

So this is -- this slide is, basically, a high-level set of highlights coming from the outputs of the Infrastructure Deployment Model.

On the left-hand side, I'm showing an example in San Diego of charger deployments. In this case you can see the red -- most of the dots are red dots which are indicating DC fast chargers. The size of the dots are going to tell you how many plugs there are in any given location. And the vast majority of those plugs -- or a larger number of plugs are, again, happening in the high-demand areas, such as airports and downtown. And then you can see that the amount of energy that they're dispensing to meet the electricity demand for these chargers is also sort of captured in this model.

On the right-hand side are sort of high-level aggregate results that give us an understanding of how many chargers are going to be needed to fulfill those demand requirements. And like I mentioned before, vehicles driving on these surfaces tend to have a much higher demand. They're not only using them more often but they're also charging sort of a larger amount compared to your average electric vehicle.

And so for that reason there's a really sort of disproportionately large number of chargers that end up needing to be deployed in order to meet their demand, especially when you look at these set of results compared to some of the deployment numbers that we were seeing earlier. In the EVI-Pro 2 models, the number of chargers is quite a bit higher.

You can see from a DC fast charger perspective, you're talking on the order of several thousand chargers within each city, so you know, 4,000 DC fast chargers in Los Angeles alone, which is several times higher than the number of chargers that -- public chargers that are in place today. And so there is going to be a sort of substantial charger buildout required to meet that higher demand.

Okay, so I’ll go ahead to our conclusion slide. So again, sort of reiterating some of the points.

The high travel intensity of electric vehicles on these platforms is really one of the leading factors that is resulting in some of the outputs that we’re seeing from the WIRED model in that the number of chargers that need to be deployed is going to be quite a bit higher and disproportionately higher per vehicle than the average electric car.

One thing that I didn’t show any sort of results are, in this set of slides, is that the infrastructure requirements that we’re observing here are also really highly dependent on the amount of charging that happens overnight. And so in all of the results that I have shown in the previous slides, it’s operating under the assumption that the charging is going to take place in public charging during the day as they sort of fulfill the demand requirements. But -- and the motivation behind that is that a lot of the electric vehicle demand that we see today is undergoing that sort of pattern of charging. And so that's why we set it as some of the baseline.

But as electric vehicles become increasingly adopted in these platforms and surfaces, there is some compelling evidence that they might switch to overnight charging, you know, whether it's at residential locations or some overnight public locations. That will decrease the energy requirements in this deployment model. And when we run some of those results we find that the number of total chargers really decreases by a large amount, especially as you sort of go all the way down to, you know, low levels of public charging requirements. And so that's important to keep in mind when thinking about these results. There will also be other scenarios that are going to have lower levels of infrastructure requirements.

And then, lastly, I want to sort of tie in this work with what's being done in EVI-Pro 2. So this model currently is being deployed as a standalone where the infrastructure is sort of held independent from existing infrastructure and potential future infrastructure that's getting installed for the general public.

And the sort of big next step in our modeling trajectory is to include and integrate public chargers, existing public chargers and chargers that are going to be forecasted to be installed from EVI-Pro 2 and RoadMap [sic] and to be able to introduce competition with sort of your non-TNC EV drivers. And so that's likely going to influence some of the outputs of the model. And so at this point you can really think of the projections here as kind of a bookend of the infrastructure requirements for the vehicles on the platform.

And with that, I think I can end here. There's some acknowledgments. But I'm happy to take any questions about the model.

MR. RAMESH: Great. We have until 3:35 for questions.

MR. JENN: Okay.

MR. RAMESH: So I will take the questions from the Q&A box now. I don't see any raised hands yet.

So the first question is from Dean Taylor. "Did you factor the ongoing cost of home versus away from home charging when considering need and utilization? (Indiscernible) 2017 shows it to be about three to four times more for away from home charging versus home charging."

MR. ALEXANDER: And, Raja, I have a feeling that this is about EVI-Pro 2. I think this question popped up right at the beginning of Alan's presentation, so I'll --

MR. JENN: Yeah. Go ahead.

MR. ALEXANDER: -- jump in.

MR. JENN: Yeah.

MR. ALEXANDER: So, yeah, EVI-Pro 2, we don't factor in the actual cost, necessarily. You know, we don't have like a big cost spreadsheet at this point.

But, oh, I see that Dean has his hand raised. So maybe we can go to him and just make sure that we're addressing his question properly?

MR. RAMESH: Go ahead, Dean. You're un-muted now, or you can -- you're able to un-mute.

MR. TAYLOR: Can you hear me?

MR. RAMESH: Yeah. Go ahead.

MR. TAYLOR: Yeah. Matt was correct. I

was thinking mainly of EVI-Pro 2, but also maybe RoadTrip as well. And maybe it even affects the TNC model. I don't know.

MR. ALEXANDER: Gotcha. Yeah. So in EVI-Pro 2, we have -- we rank charging types based on preferences. So you know, it goes residential, then workplace L2, then public DC fast charging, and then public Level 2. We don't incorporate actual costs yet, although we are, you know, in future work planning to incorporate rate structures and those types of things. So that's how we're implementing this in EVI-Pro 2 right now.

MR. RAMESH: Great. Next question from Jim Frey at 2050 Partners, "For Alan, is your model exploring load curve impacts if more opportunity charging is available, possibly with wireless charging spots at well-assigned locations where TNC vehicles queue up?"

MR. JENN: Yeah. So good question. This is -- there are a couple things to unpack here.

In the model we actually, originally, had it as an individual vehicle sort of queuing system and traveling system. And that ended up making the model too complex. So we aggregated the vehicles and we have a proxy method for deploying the vehicles to a charger and ensuring that there's some kind of like congestion measures there so that you can't just like stack everyone at the same time. And so that part is kind of taken into account.

And the other thing that I'll say with regards to opportunity charging, especially thinking about, I think, this question is really thinking about opportunities with aligning with the like load curves so that if you wanted to, you know, try and promote charging during times where there's more solar, for example.

And so that's not currently integrated into the model. But we've designed it in such a way that we could integrate that pretty easily. So right now the like opportunity costs or the cost of charging is sort of just flat. And then you have distinctions on when they're charging based off of the like congestion proxy.

But what we can do is really easily introduce a price, a non-flat price, right, so you could have different prices over time. That would then induce the model to promote, you know, the drivers to be charging when it's cheaper.

And so that’s actually built into the model. It hasn’t been -- we haven’t added the variation in prices yet but it’s something that’s on the docket for sure.

MR. RAMESH: Thanks Alan.

Next question from C.J. Berg. And after B. Boyce’s question, I’ll take Ray Pingle’s question from the raised-hand list.

So C.J. Berg’s question is, “How does the WIRED model take into account Uber and Lyft 100 percent commitments by 2030?”

MR. JENN: Yeah. So as I mentioned, the projections of EVs on the platforms are based off of the ARB projections. I actually am not extremely knowledgeable about what sort of went into those projections and whether they’re considering these 100 percent commitments. They’re meant to sort of follow the Clean Mile Standard requirements. And so insofar as those line up with the commitments, then the model will sort of be taking that into account. If they’re not at 100 percent, then the WIRED model will probably be sort of underestimating the infrastructure requirements.

But, honestly, when I look at those

numbers, you're talking about 300,000 EVs on the platform by then, that's got to be a fairly high proportion of the vehicles that are currently driving on those platforms.

So if I had to guess, it would be fairly close if not at 100 percent.

MR. RAMESH: Great. Thanks.

It looks like B. Boyce's question will be answered in writing. Noel's typing an answer.

MR. JENN: Okay.

MR. RAMESH: Do you have anything to add orally?

MR. JENN: Yeah. So with -- the range of the vehicles is actually something that's considered pretty carefully in this analysis. In the current day, like 2020 runs, it's actually looking at the existing data. And it looks -- and we're actually able to observe, sort of on a model-by-model level, what the existing battery ranges are on the road, and so that's all taken into account.

And then as you move into the projections, the projections actually have more detailed breakdowns than what I was providing about just total number of electric vehicles.

They have like long-range and short-range BEVs, and plugin hybrids, and so those are all included, although I will say that what you saw here is mainly just for full battery-electric vehicles.

MR. RAMESH: Great. So I'm about -- I've just allowed Ray Pingle to talk.

Feel free to un-mute.

MR. PINGLE: Great. Ray Pingle, Sierra Club California.

So, Alan, I just had a question on this issue of overnight charging. So I'm not expert in TNCs. And just the few rides I've done the vehicles have been owned by the drivers.

MR. JENN: Um-hmm.

MR. PINGLE: And so it seems to me that if that were the case for the EVs, the drivers use them for their personal use whenever they're not on the meter, and they could charge them overnight and then they go to work at whatever time and, you know, they're on the meter. So it seems like there might be real opportunity for a higher percentage of these vehicles to be overnight charged.

But what conversations have you had with the TNCs on what the business models are on that?

MR. JENN: Yeah. So important question about overnight charging, as I mentioned right in my conclusion slides. That's going to play a really big role in what the model outputs are going to say.

So let me -- I guess I'll really quickly kind of reiterate that, you know, our model doesn't like explicit -- or endogenously sort of decide how much overnight charging there is. Because, you know, we have a lot of uncertainty about this, it's kind of left as this parameter that you can put on a sliding bar. And so everything I showed here was like the sliding bar on the extreme end where not -- where you're not really seeing much overnight charging.

And so the sort of impetus behind this is when we look at the data today, yes, there are some drivers that are doing overnight charging with privately owned vehicles. But the vast majority of the energy demand for the electric vehicles on TNC and Uber -- or on Uber and Lyft platforms are actually coming from like leased vehicles that are the short-term fleet rentals that are taking advantage of discounted public DC fast charging. And so most of the energy that is being supplied is coming from DC fast charging which, again, isn't to say that we don't think there's going to be any overnight charging in the future.

And so as a continuation of the work that you're seeing here, we've developed a whole bunch of additional scenarios where we do consider there to be lots of overnight charging. And it really does make a big difference in the number of public infrastructure that's required.

When we have sort of private conversations with TNCs, there's a lot of discussion about the sort of demographics of drivers and whether or not that really -- that possibility is going to become reality because, you know, there's a lot of questions about access to, you know, overnight charging, residential, you know, particularly if the driver doesn't own their own home and doesn't have the ability to, you know, have a plug where they're parking the vehicle overnight.

And so those conversations are happening. And from a modeling perspective, we're trying to leave that as an open-ended question where we just provide scenarios that we can see. You know, if we think there's, you know, 50 percent overnight charging or 80 percent overnight charging, we can run that and look at that.

MR. RAMESH: Okay. Thank you.

So time check. We have three minutes, actually, only left for this section but we'll try to get all the questions that have already been submitted in.

So with that in mind, this question also looks like it's some overlap with the last question from Jamie hall at GM. "Apologies if I missed this but what did you assume the overnight charging access and, particularly, home charging access? And can you go into any more detail on the compelling evidence that TNC charging will increasingly move overnight?"

MR. JENN: Yeah. So the only thing I guess I'll say about this, in adding on to what I've already said about the overnight, is that, you know, generally the more privately owned vehicles are tending to have higher proportions of overnight charging. And so insofar as Uber and Lyft sort of maintain, you know, the model where you have individual ownership as opposed to like a fleet-based ownership, you might expect that that proportion will increase. And that's the sort of main argument for that.

And again, like I think, hopefully, I've provided enough perspective that that is kind of muddying the waters both ways. I personally am not entirely sure, which is why we're kind of approaching the modeling in the way that I've described.

MR. RAMESH: Next question from Eric Carhill at SMUD. "Have you attempted to characterize infrastructure needs based on different ride-hail driver profiles, for example, full-time versus part-time, single-family home versus multi-unit dwelling residence, et cetera? Are there any simulations attempted based on assumptions for how much these different driver profiles are able to charge overnight?"

MR. JENN: Yeah, similar type of question.

The quick thing that I'll say is that the -- while we don't explicitly break out the different driver profiles, because they're -- because we're bootstrapping from real empirical data, we're capturing in a really sort of representative way the different profiles of the drivers. And so I think that the model does a good job of really capturing the heterogeneity drivers that are across the platforms.

MR. RAMESH: Next question from Kevin Karner. "Were those 90 percent of the TNC miles within five miles of where a driver last charged or within five miles of DC fast chargers in general? If it's the former, is that indicative of the range anxiety?"

MR. JENN: Yeah. So in this model the way that we deal with that is we have this sort of penalty weight that basically says, hey, if I have to drive really far from where I'm providing my ride to where I need to charge the vehicle, there's this penalty thing that the model applies for the infrastructure deployment. And so it's balancing all of these things about how far the drivers need to travel, how long it takes for them to charge. Yeah, so for the math geeks, you can see that here. And, obviously, this is described in more detail in the report.

But so we are explicitly taking into account the fact that distance to the charger is an important factor for the drivers.

MR. RAMESH: Great. Thanks. And just for the record, I'll read Kevin's full question. "In the published paper that corresponded to this research it was stated that some 90 percent of electric TNC trips were within five miles of the DC fast chargers. Were those 90 percent of eTNC miles within five miles of where a driver last charged or within five miles of DC fast chargers in general? If it's the former, is that indicative of range anxiety?"

MR. JENN: It's within five miles of the actual trips that are being provided, so origin or destination of the trips. And that is, actually, not something that we like explicitly put a cutoff for. That's actually something that the model ended up deciding based off the weight that we -- or the penalty weight that we put in.

MR. RAMESH: Got it.

A question from Sean. "It looks like the WIRED model only looks at the three most populous areas on California. Do you have plans to use the WIRED model to look at medium and small rural areas to see if trends all look to be similar or if a region may be different?"

MR. JENN: Yeah. So the reason why we're

able to do the -- run this model at such a high resolution is because we have good data from the TNCs in these specific zones. And so if I'm able to get access to data for areas outside of these cities, I'm happy to sort of run the model and apply it to those. But it really is more of a sort of data restriction that we are able to, you know, limit our analysis to those zones than anything else.

MR. RAMESH: Okay. And last question, also from Sean Tiedgen, "While not TNCs, have you considered or thought about public transit agencies that may be running ZEV microtransit services that operate similarly to TNCs and may want to have charging -- and may have charging needs like TNCs?"

MR. JENN: Yeah, that's an interesting thought. It's not something that we've really thought about yet. But, potentially, the approach and framework that we use here can be applied to something like that. And so if, yeah, I guess if there's a need and there's data availability, we'd be happy to take a look at it.

MR. RAMESH: Great. So with that, thanks everyone for the questions in this segment.

We’ll keep our five-minute break, so now running on a five-minute delay, and we’ll return at 3:43, so a three-minute delay.

(Off the record at 3:38 p.m.)

(On the record at 3:43 p.m.)

MR. RAMESH: We’ll now move into a presentation from Noel Crisostomo on the HEVI-LOAD model.

MR. CRISOSTOMO: Thanks Raja.

My name is Noel Crisostomo. I lead heavy vehicle charging infrastructure analysis in collaboration with colleagues at Lawrence National Laboratory, Bin Wang, Cong Zhang, and Doug Black, on a project titled On-Road Medium- and Heavy-Duty Electric Vehicle Infrastructure Load Operations and Deployment, or HEVI-LOAD for short.

Next slide.

HEVI-LOAD is a simulation model that estimates charging demand for vehicles that weigh more than 10,000 pounds gross vehicle weight rating which dovetails next to EVI-Pro 2. As directed by AB 2127, HEVI-LOAD was developed to expand CEC’s infrastructure analysis. And so, like electric trucks, it is relatively newly and, thus, its results are still in flux.

As I'll describe at the end of my presentation, this dynamism represents an open and ongoing call to action to work with our team. Today, HEVI-LOAD simulates the electricity demanded by BEVs traveling intra-regionally and designs a supply of overnight and daytime infrastructure necessary to meet demand without behavioral changes. Key outputs include the number, type by power level, and region of chargers, and the 24-hour load profile for a range of use cases.

Next slide.

HEVI-LOAD top-down phase was first presented in detail during our August IEPR workshop. So during this presentation, I will highlight major changes to the three sequential modules in the top-down scenario -- or top-down analysis, focusing principally on the Mobile Source Strategy scenario in the right-hand column.

The first module projects vehicle populations by county annually. In August, we used a draft of the Mobile Source Strategy and enhanced the vehicle population with regional adoption targets informed by the South Coast Air Quality Management District. Our update captures a higher penetration of medium- and heavy-duty vehicles aligned with the October version of the Mobile Emissions Toolkit Analysis, or META tool, used in the CARB recent Mobile Source Strategy update.

The second module just aggregates trips using a combination of actual truck operations and a simulation of hourly conventional fuel use. A key improvement from August was a transition from an assumed set of electricity consumption rates to one that leverages a vehicle powertrain physics model in which consumption is calculated by representing how a vehicle mass moves throughout a road network. To conservatively estimate consumption we chose the maximum GVWR for the relevant classes to the vehicle applications. In this case, we made simplifying assumptions to distribute the populations for vehicles in their applications that cross multiple weight classes.

The third module is a charging infrastructure assessment that assigns the probability of charging need according to a logical model of a truck's hourly driving, trips or parking behaviors throughout the day. Charging corresponds to the vehicles battery packs which are designed proportional to their classes. However, in this iteration, we've represented technology progress according to a conservative five percent per year improvement in energy density based on a continuation of recently-observed improvements among battery manufacturers. Like in August, charging options are set at predefined levels of 50 and 350 kilowatts, the maximum rating for passively-cooled CCS.

The next slide shows the Mobile Source Strategy scenario. The Mobile Source Strategy scenario yields, for a 2030 population of about 180,000 battery-electric medium- and heavy-duty vehicles, a network need of roughly 157,000 DC chargers, the majority of which are 50 kilowatt chargers used overnight. Those that are unable to sufficiently charge with this relatively low power also used 350 kilowatt chargers during the day.

One thing to note is the ratio of EVSEs to EVs is less than one, which represents the potential to share charging for fleets that are collocated. The trajectory shows overall proportional growth in the two charging options over time, according to the population of the MSS trajectory. But it is worth emphasizing that, again, these results will change as our analysis continues.

On the next slide I highlight the associated load profile with the 2030 network. The load showing here simplifies the Air Resources Board's emissions factors and CEC's Transportation Energy Demand Forecast tools where we have vehicle categories grouped into nine groups for simplification, medium-duty trucks, agriculture trucks, other freight trucks, construction trucks, utility trucks, tractor trailers, drayage trucks, refuge trucks, and buses.

While these groupings represent a wide range of use cases and classes and applications that vary by county and, in some cases, have not been well demonstrated commercially yet, we can observe rough estimations of the load profile on the right side of the chart, for example, medium-duty trucks charging in the evening and morning while they operate throughout the day on the road, buses charging primarily away from commuting hours, and drayage trucks charging after the morning and after daytime operations.

At this stage of the analysis for 2030 we are simulating a charge to vary from a minimum of about 1 gigawatt in the morning to 2 gigawatts during the evening. But as I'll describe on the next slide, these profiles will change.

To recap our modeling efforts thus far, quantifying medium- and heavy-duty battery-electric vehicle charging infrastructure necessarily is evolving. Which vehicle fleets will require chargers, of a range of power capabilities, where they're located across the state, and when they will actually show up depend on regulatory compliance. Local preparations for these electric upgrades to support this infrastructure will be critical given the unique use profiles across urban and rural economic activities. So as these change, we'll have to evolve our model as such. Data on this front, as well as fleet and driver behaviors, are critical to develop robust hourly energy profiles.

Simultaneously, the rapidly evolving

technologies in this sector require revisiting this analysis with up-to-date characterizations. Given the relatively smaller population of medium- and heavy-duty vehicles and the high variations in energy consumption across the classes, vehicle models and charging capabilities warrant close market monitoring, and then incorporation into the model. However, the uncertainties that I'm ascribing to these top-down estimates can and will be complimented with bottom-up modeling to progress on improving the definition of infrastructure which will be necessary for the state to meet its climate and air quality goals as described on the next slide.

The HEVI-LOAD Team is creating several features. First, it is improving the alignment among the Energy Commission's econometric choice models, alluded to earlier by Matt, and CARB's Mobile Sources Strategies, as well as the regional Air Quality Districts' implementation of their air quality targets so that our model not only meets attainment but also reflects fleet operators likely acquisition of fleets.

In addition, we are developing higher resolution load profiling, moving from the hourly basis to the minute level, leveraging vehicle telematics where possible.

Further, LBNL is developing agent-based modeling to reflect truck operations within the road network. This includes developing and economic activity model to represent trips between origins and destinations. And with this, we'll be able to improve the capability of chaining trips together and charging along the way at truck stops. We will also identify specific truck parking and fueling stations.

Another benefit from improved time resolution is the ability to transition from administratively assigning 50 or 350 kilowatt chargers as a prescribed power level. HEVI-LOAD is being updated to calculate a minimum power necessary to meet the trip up to the megawatt level. Improving the agent-based model has knock-on effects for station siting and sizing with respect to the power that is fed to each individual site. And upon this, HEVI-LOAD is tasked with a flexibility analysis where we will be incorporating utility tariff and smart charging into the analysis. Notably, this is not reflected in the load profile in the prior slide.

Flexibility and utility rates will be integrated into HEVI-LOAD, as well as the other loads that have been presented today, as we are developing EDGE, the EVSE Deployment and Grid Evaluation tool, which will be discussed by my colleague Micah tomorrow. This will culminate in a standalone HEVI-LOAD report in which a detailed methodology, county-level analysis, and the results to 2035 will be published.

Next slide.

To preview what the LBNL Team has in progress with respect to the agent-based model, we have some GIFs on the road network that is being modeled in the agent-based model.

On the left we have the road network with truck stops shown in blue and individual trucks moving about in red. You can see them moving throughout, primarily, the South Coast, but also taking long-haul trips through the Central Valley and along the 80. On the right we have an individual long-haul truck, more specifically, traveling from the South Coast, shown in blue, stopping, charging in the Central Valley, and then continuing along its way north to the Bay Area. This shows the potential for agent-based modeling.

The next slide shows how we can work together to improve this capability. The key to increasing the realism of the model and, therefore, the accountability of grid plans that these results may be used for, would be receiving your input and contributions. I'll review key topics. And we'll be happy to discuss these during the Q&A or during follow-up meetings.

First, we need your suggestions on how to characterize the state's efforts within the local context of specific regulatory measures, particularly in the regions where medium- and heavy-duty vehicle electrification in the near term is most critical to meet our air pollution reduction, clean air, and equity goals to support disadvantaged communities that are disproportionately affected by medium- and heavy-duty pollution.

Next, we are seeking travel data to support the simulated and telematics data that we have and are investigating the use of regional economic activity models. However, these are complimented best by interviews with fleets so that we can better understand drivers' preferences and design infrastructure accordingly.

In addition, we'd like to improve technology configurations, especially with near-term battery-electric truck models and, in the long term, accounting for improvements in battery technology, as well as understanding the role of plugin hybrid electric trucks of fuel cell battery-electric trucks, especially in alignment with CalEPA's ongoing Carbon Neutrality Study being conducted by the University of California.

In addition, we understand that this technology is rapidly changing but would like to understand the loading of charging over different states of charge on the megawatt scale in order to improve our grid upgrade analysis.

Lastly, we'd like to work with utilities to identify the potential for electrification within their territories as they understand their customers' existing electrical condition as well. HEVI-LOAD can identify where distribution systems will need reinforcement well ahead of time to reduce the time for construction, as my colleague Micah will describe tomorrow with EDGE.

I conclude on the next slide with a final note to publicize some recent efforts in the medium- and heavy-duty space. You might be aware of studies not directly related but complimentary to HEVI-LOAD with two highlighted. First is the West Coast Clean Transit Corridor Initiative Study from June 2020, and a Strategic Development Plan released in March 2020 by the West Coast Collaborative Medium- and Heavy-Duty Alternative Fuel Infrastructure Corridor Coalition. Notably, the survey is still active until the end of March to seek feedback on the demand from medium- and heavy-duty alternative fuel infrastructure on the West Coast.

These organizers seek input on funding levels for alternative fuel stations accessible to Class 5 and above vehicles, as well as locomotives, marine vessels, and other heavy-duty off-road equipment. If you have input, we encourage you to help the effort by completing the survey, of course, in addition to helping out with HEVI-LOAD.

So now to fully segue to off-road equipment, I'd like to introduce my colleague, Jeffrey Lu, who will give the next presentation.

Thank you.

MR. LU: Hey folks. My name is Jeffrey Lu. I'm Staff here at the CEC and one of the coauthors of this AB 2127 Charging Infrastructure Assessment. I want to wrap up today's presentations by going over some of our findings regarding off-road electrification and charging needs. Under AB 2127, the CEC is tasked with analyzing charging needs for both on-road and off-road sectors, and that includes, among other things, port and airport electrification.

Next slide please.

First off, Governor Newsom's executive order from late last year drastically compressed the timeline for off-road electrification. As a reminder, the order calls for 100 percent zero-emission off-road operations by 2035 where feasible. And I'll note that this is -- this goal targets operation and it's not simply a target for new sales.

Prior to the executive order, electrification in off-road sectors was largely driven by air quality goals. CARB has several zero-emission regulations in the works as part of their Mobile Source Strategy and, also, their Sustainable Freight Action Plan. One major regulation targets transportation refrigeration units and called -- previously called for zero-emission truck units and zero-emission stationary operation of trailer and railcar units. However, in light of the executive order, CARB recently announced that this rulemaking is being split between the truck and trailer TRUs to consider ways to achieving -- to achieve full zero-emission operation across both types of TRUs.

CARB is also working on regulations for cargo handling equipment that's used at ports and railyards, as well as forklifts, and also airport ground support equipment. These pending regulations from CARB will be really key in determining the future vehicle and equipment populations. And the CEC will align with CARB's population projections whenever they're available as a baseline for assessing off-road charging need here in the state.

Aside from CARB's efforts, many local Clean Air Action Plans also included electrifying off-road operations as well. So, for example, in 2017 the San Pedro Bay Ports published an update to their Clean Air Action Plan which targeted zero-emission cargo handling equipment wherever feasible. Similarly, if you look at Clean Air Plans for places like Los Angeles International Airport or San Jose International Airport, those plans have identified electrifying ground support equipment as a strategy to reduce local emissions and air pollution.

Next slide.

Now that's not to say that regulation has been the sole driver behind electrification in off-road. In fact, in the past year or two alone, many manufacturers have begun introducing electric offerings for a broad range of off-road sectors. Some of these are coming onto the market because of stricter local city emission policies in Europe. But I think a lot are also coming onto the market because the technology is ready and is increasingly cost competitive.

So I've picked out a couple examples here that we can briefly go over. From the left going clockwise, we have a backhoe from CASE. We have the mobile power station from Dannar which is a sort of multi-purpose vehicle that's compatible with existing industry attachments. At the top right we have a mini excavator from JCB. The bottom right an electric and, also, semiautonomous tractor from Monarch Tractors, and this is for agricultural use. And we're actually even seeing movement in electric aviation, particularly in vertical takeoff and landing. The one shown at the bottom there is from Lilium.

Next slide please.

In terms of charging needs, off-road needs are -- often have the same challenges as what we see in on-road medium-duty/heavy-duty. So most prominently, most off-road applications are extremely demanding in power and energy.

So as an example, a demonstration top handler at Port of Long Beach that's designed jointly by Taylor and BYD, that has nearly 1 megawatt hour of battery capacity onboard and it charges at 200 kilowatts. Now I suspect that the 200 kilowatt charge rate would be even higher if higher power connectors were more widely available.

In the future, when megawatt-capable connectors are available and more common, many vehicles will need the infrastructure to support that full charge power. One megawatt, or even two or three megawatts, is a lot of power. And it's challenging to support that load in any environment. Getting there will require, probably, distributed energy resources to manage existing grid constraints and, also, to avoid costly grid upgrades.

The space required for this sort of infrastructure is also a challenge, especially at ports where space can be really limited. In some sectors, such as agriculture or construction, for example, there may be no grid availability at all, meaning that customers who are electrifying will also have to investigate onsite generation as part of their investment.

Separately, we're heard, time and time again, complaints from early adopters and operators about the lack of interoperability of charge connectors, including, sometimes, between vehicles from the same manufacturer. There's a wide range of connectors used in off-road today. Some use the J1772 Level 2 connector for charging. Some use CCS. A lot of them use proprietary implementations that aren't compatible with other vehicles at all. Many connectors designed specifically for the medium-duty and heavy-duty sector are still under development.

And the CEC recognizes that while there is going to be a range of interfaces depending on use case, so for example, a robotic pantograph or a handheld conductive connector or a wireless charging, where possible the CEC is going to prioritize chargers which conform to standardized implementations, even if those interfaces may look different.

Off-road -- the off-road sector also sometimes faces challenges with who is responsible for charging infrastructure. And with landlord-tenant relationships the incentives are somewhat muddy. This is true, especially at our ports and airports where, generally, the equipment operators, so the terminal operators or the airlines, are not responsible for infrastructure investments at the port or airport. So scaling to 100 percent zero-emission will require a tighter level of coordination and planning between landlords and tenants.

And finally, many off-road applications have very rigid duty cycles and schedules. So if you think about cargo handling equipment at a port, for example, they have minimal downtime, even at night, I guess maybe two or three hours depending on the -- how the schedules are set up. These constraints mean that opportunity charging under existing setups is pretty challenging.

And there are also, sometimes, work rules about who is responsible for the refueling of equipment. And this can complicate the charger planning and, also, ongoing operations. Some interfaces, for example, that robotic pantograph I referenced for wireless charging, those may not have these same work rule problems because they're generally automated systems.

Next slide.

The CEC is working on a detailed report on off-road charging needs. And that's going to be based off a prior off-road electricity demand forecast that we completed in 2019 as part of a broader demand forecast analysis. The idea is that we're going to update this report with the latest population projections from CARB whenever they're available. That will generate an updated demand -- electricity demand forecast. And from there we can begin estimating charger needs throughout the state.

On top of that, this report is also going to feature a broader range of analysis, include sectors that were previously ignored, for example, agriculture, aviation such as eVTOL, and also construction. We're hoping to get this published later this year, so stay tuned for that.

I think that's all I have for today. Thank you all for making time and being here with us. We can move into question and answer. So please submit anything to the Q&A box or raise your hand if you'd like to speak.

MR. RAMESH: Thanks Jeffrey and Noel.

So this is our final question and answer session for today. It will be cumulative, if you'd like. And we'll take the questions in the order we receive them.

So starting with Dean Taylor, "In 2019, LBNL Class 7 and 8 medium- and long-range semitruck preliminary study found only 750 DC fast chargers needed away from home. Why so many more needed, 16,000 in HEVI-LOAD?"

MR. ZHANG: Okay. I can try to answer the question.

First, the difference comes from a few different reasons. First is about the forecasting year. In this report, it is for the report 2030.

And second is about the vehicles we are forecasting. And here we can see it is 180 thousand vehicle number here. And the third is about the methodology we are using where we assign a high charging power or the low charging power decided by the time. For the heavy- and medium-duty, we're saying in the daytime when it's working, it needs the high charging power because the time is expensive. And they can use low charging in the night.

So here the methodology is also different. First it's about the vehicle class type: we cover from the Class 4 until Class 8, which means -- meaning the vehicle weight is more than 10,000 pounds. And so here is a few different reasons that lead to the result.

And, also, I can give a, roughly, charger forecast here is for the 50 kilowatts charger, it's around 0.8 chargers per medium- and heavy-duty vehicle. For the 350 kilowatt charger, it's at around 0.09 per car. Yeah. Here is a rough estimation.

MR. RAMESH: Great. Thanks Cong.

Next question from Eric Cahill at SMUD.

"For Noel, has CEC given any consideration to using CALSTART's beachhead approach in which most EV-ready commercial applications and duty cycles are fulfilled ahead of other less EV-ready ones, e.g. buses, delivery vans, ahead of long-haul trucking?"

MR. CRISOSTOMO: Yes. So the vehicle projections is one of the key areas of change that is possible. And as I called out, the differences across -- Raja, if you could go to the slide with table? -- the differences across the medium demand scenario, the high-charging demand scenario, and the Mobile Source Strategy scenario do include very different populations of different applications over time. And this is coming as a result of the scenario tool at CARB, but also the economic metric tools that we're analyzing.

And so while we haven't applied the beachhead approach, that's actually, perhaps, a qualitative analysis that we may need to examine more closely to account for actual fleet behaviors in case there is early compliance in, say, the beachhead applications.

So if -- we'd like to suggest that, we'd welcome the comment filed and are open to having a further conversation on which portfolios to use.

MR. RAMESH: Next question from Bob Coale. "Has the HEVI-LOAD model considered battery changeout technology?"

MR. CRISOSTOMO: Yeah. Thanks Bob. The current iteration of HEVI-LOAD does not include battery swap out for these vehicle classes. It's exclusively a conductive connector-based charging opportunity. The main reason for this is, to our knowledge, we haven't seen battery swapping applied in these segments yet, as well as our participation in the Charging Interface Initiative Task Force for higher-power commercial vehicle charging on the megawatt level. So acknowledging the number of manufacturers, both of heavy-duty trucks and charging equipment, we haven't applied an analysis that looks at battery swapping.

MR. RAMESH: Okay. I'll take Ray, and then I'll go to Shiba Bhowmik.

Go ahead, Ray.

MR. PINGLE: Thanks. Ray Pingle, Sierra Club California. Just a few quick things.

So one, Noel, the Mobile Source Strategy had 40,000 trucks, medium-duty trucks, by 2030 and 170,000 heavy-duty, which totals to 210,000 versus the 180,000. And I don't know if you maybe discounted for fuel cells as part of that but just the number from Mobile Source is 210,000. So maybe you could answer that? And I've got two more quick things.

MR. CRISOSTOMO: Yeah. I believe the decrement there is the weight rating. So, for example, of the 10,000 above is HEVI-LOAD, and then 10,000 and below is EVI-Pro 2. So --

MR. PINGLE: Okay. I'm with you. Okay. Thank you.

And then --

MR. CRISOSTOMO: Matt had to take some of the medium classes into EVI-Pro 2.

MR. PINGLE: Gotcha. Gotcha. Okay.

And then one of the analyses that you used in the HEVI-LOAD is the CARB tool on, you know, truck viability, suitability. And that derived from Engine Manufacturers Association analysis they did on truck suitability, ranges, and those kind of things. And then CARB -- so that really was produced in 2018. And then CARB updated that tool in February of 2019, so it's been two years since that was done. And, obviously, we've got many more real electric vehicles that are coming on the road. Battery technology has improved a lot so ranges of those vehicle types has increased a lot. And I would think that that could have a material impact on the outcomes of your analysis.

So I would recommend seeing whether CARB could take a look at that one more time and update it again for your model.

MR. CRISOSTOMO: Yeah. Thanks, Ray, for reading the footnotes. Yes, the ACT rulemaking, led by Paul, was the key data source for that --

MR. PINGLE: Yeah.

MR. CRISOSTOMO: -- as well as Sarah's META tool. So thanks, Sarah, for joining.

Agreed that there are lots of changes going on. I'm always looking for new data. So if you would have suggestions on vehicle models? I just saw a report across my inbox for both fuel cell and battery-electric trucks. I'd like to incorporate them, especially in the near-term years.

MR. PINGLE: Okay. And then one last

thing is do you have any updated information on when the CharIN megawatt standard might be put in place? And, in any event, are you looking to maybe add another charging model type to go beyond the 50 and 350 and go to one or more megawatts in the near future, in future iterations in the model?

MR. CRISOSTOMO: Yes. I don't believe I can offer public information on the megawatt charging standard. But I provided a chat to their YouTube webinar. That happened, I want to say, late December. For the latest on that, I'll let the manufacturers speak for themselves.

In terms of megawatt incorporation, Cong and Bin, if you want to add to this, please feel free to un-mute yourself.

But, yeah, the goal is to include a transition from an hourly consumption pattern to a minute level. And that will allow us to quantify the kind of minimum power possible necessary to recharge the vehicle within the time frame that it's going to be normally operating or pause, pause at a parking space. So that is a feature in progress.

Cong or Bin, would you like to provide

any more preview than that?

MR. WANG: Sure. For the simulation analysis, different power levels are treated as, you know, inputs from the software users, so we can specify different power levels from -- you know, if it’s 50 kilowatt DCFC or 350 kilowatt chargers up to 1 megawatts, we can even specify lower power levels. So the charging load profiles will be estimated even these charging power selections.

However, in the optimization-based approach to determine the optimal load charger sizing, and these would specified a range of power ratings, and the algorithm will determine the optimal power level for the specific site.

MR. PINGLE: Very good. Thank you.

MR. RAMESH: Okay. I will now read the question from Shiba Bhowmik. “Great analysis and studies. Thanks for the CEC’s leadership and efforts to seriously consider infrastructure. My apologies at not studying the assessment report. Who is paying for the infrastructure?”

So maybe, Noel, you want to start off? But it sounds like --

MR. CRISOSTOMO: Yeah.

MR. RAMESH: -- this question is general, too, so if other people want to jump in as well?

MR. CRISOSTOMO: Yeah. Let's have Commissioner Monahan start. I'm un-muting her.

COMMISSIONER MONAHAN: Well, actually, just give me a second so I can put on my EarPods so you can hear me better.

So it's a good question about who pays. And this is something that I think we're wrestling with in California, and nationally as well. I mean, at this point the charging manufacturers aren't making money with a lot of the chargers. And so there needs to be public dollars in this period sort of before demand really escalates. And this is particularly important where there's, you know, a barrier in terms of access? So, for example, for people living in apartment buildings, we want to make sure that they have convenient refueling.

And we need to make this a transition that works for everybody. No matter where you live, whether you drive a Tesla or a used vehicle or you don't drive at all, we still want to make it, charging, to be ubiquitous and the refueling to be very easy no matter where you live.

Utilities are -- so the three major sources of funding right now, I would say, are governments, utilities, and the private sector. And we, in California, have a program called the California Electric Vehicle Infrastructure Project where we have a first-come-first-serve basis for rolling out charging infrastructure. But we're also investing in hydrogen refueling infrastructure. We have specific projects around multifamily dwellings and heavy-duty. So we're really trying to cover all the bases when it comes to building out infrastructure. But we're trying to do this in a really thoughtful and methodical way in partnership with the money that's coming from the private industry and from utilities.

MR. RAMESH: Great. Thanks, Commissioner Monahan.

Moving to the next question from -- oh, it looks like Shiba's raised their hand.

You can un-mute now.

MR. BHOWMIK: Thank you. Thank you, Raja. Can you hear me?

MR. RAMESH: Yes.

MR. BHOWMIK: Hi. Thanks for taking my

question. I really appreciate this. My name is Shiba Bhowmik. I'm from Sinewatts. We are a power electronics company, hopefully working on the next generation kind of infrastructure built into the vehicles.

So I had a basic question based on -- as a follow-up to my previous question, that is about who is paying for the infrastructure? And thanks for the Commissioner for explaining the process of how this is getting all deployed.

If the ratepayers or the taxpayers are burdened with carrying quite a bit of the infrastructure effort -- and there are, also, there are two pieces to this infrastructure, one is the chargers themselves, and then on top of delivering the energy to the chargers, which is basically the utility side and the infrastructure, on 100 percent clean platform within the storage and everything. So if you consider the entire things holistically, there may be some platforms that we ought to be probably looking at instead of trying to burden the taxpayers and the ratepayers with this in that sense, meaning -- let me explain this a little further.

If the right ratepayers are having to carry the burden of deploying that infrastructure, be it through the governments or through the utilities, wouldn’t this -- wouldn’t it be more prudent to start investing in the next generation technologies and innovations that would allow the vehicles to be the infrastructure for full scalability and full sustainability of this kind of a platform?

MR. CRISOSTOMO: Shiba, could you explain what you’re describing where the vehicle is serving as infrastructure?

MR. BHOWMIK: Well, so hypothetically speaking, and I’m not trying to advocate or promote any particular technology here, hypothetically speaking, I mean, CEC and the CPUC has taken quite a bit of leadership role with respect to the VGI, vehicle-to-grid integration, in particular with V2G. And once you bring in or once we are able to enable high-power bidirectionality of the electric vehicle that is onboarded with Level 3 charging capabilities and, also, full bidirectionality at that power level, it’s a very different infrastructure issue, considering, I mean, what amount of nightmare scenarios that you are going through, through your modeling effort.

They would have their individual challenges. But I think the carbon footprint, the decarbonization effort, and also with the reduction of them at content, all of that can be driven very significantly if the new generation technologies and the new level of innovation are probably, as opposed to --

MR. CRISOSTOMO: Yeah. Yes. Thanks Shiba. I believe you were attending our V2B workshop last Monday. So, definitely, we definitely appreciate the importance of vehicle-to-grid and bidirectional charging technologies. That will actually be featured pretty prominently during our tomorrow afternoon panel on VGI. So California is definitely committed to moving on a V2G future. And manufacturers are supporting the bulk of the activity, so definitely hear the interest in this potential.

And also during tomorrow’s workshop -- another plug -- Raja will be presenting on some results from our BESTFIT solicitation which highlighted a few projects that include vehicle-to-vehicle charging. So it’s not something that we've quantitatively modeled yet. A topic that is really intriguing when you think about the utilization benefits and the low grid impacts possible from shifting this load from instantaneous to arbitrage to time. But no quantitative answers, lots of opportunity. Please tune in tomorrow.

MR. RAMESH: Great. From B. Boyce at SMUD, "We are finding that many of the medium- and heavy-duty vehicles can and are planning to use 25 kilowatt charging. School buses and many of the delivery vehicles with short route are looking at even more power ratings. Will you be able to incorporate this diversity in the model going forward?"

MR. CRISOSTOMO: Yes. Bill, as the couple of prior questions asked similarly, we are incorporating a multiple choice option. And we'll have the next iteration be solving for different power levels to incorporate. For example, the high-power Level 2, if you will, option for the use cases that it's appropriate.

MR. RAMESH: And last question from Jim Frey at 2050 Partners -- by the way, we have two minutes left in the workshop -- "As your HEVI-

LOAD resolution improves, will you be able to explore the value of the moderate power mid-shift opportunity charging for longer dwell load/unloading stops at loading docks?”

MR. CRISOSTOMO: Bin, I’m wondering if you could talk about the smart charging envelope and how that is going to interplay with the ABM?

MR. WANG: Sure. Sure. Good question. Yeah, we are considering these mid-shift opportunities for different vehicle applications. The way we define this problem is to, you know, take a look at the historical travel behaviors of the specific vehicles to, you know, get an idea of when these vehicle will arrive and when this vehicle will have to leave and identify the, you know, stayed duration and the energy demand that we have to deliver before the vehicle leaves.

So using these parameters, we can define the, you know, energy boundary. So this boundary will quantify the flexibility of a specific vehicle just to ensure we can deliver as much energy, you know, before the vehicle leaves.

In this scenario, you know, when the vehicle is parking or unloading, as a drayage truck or the delivery vehicles, when there’s enough flexibility for the -- you know, assuming there's a charging coordinator, assuming there's enough flexibility to, you know, arrange charging for this vehicle, the HEVI-LOAD tool is able to simulate this behavior and accounting the charging load through the aggregated load profile.

MR. RAMESH: Thanks Bin.

Okay, and we're right at the 4:30 mark. It looks like there's no more raised hands. So, once again, thanks everyone for attending today's workshop. Be sure to come back tomorrow for the second half of the workshop where we'll discuss more on several other topics.

Additionally, we'd also like to remind you all to please submit written comments to the 19-AB-2127 docket. There's instructions on this slide, which you can also download from the event webpage on the Energy Commission website.

Thanks everyone.

(Off the record at 4:31 p.m.)

REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and

place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

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IN WITNESS WHEREOF, I have hereunto set my hand this 1st day of March, 2021.

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I certify that the foregoing is a correct transcript, to the best of my ability, from the electronic sound recording of the proceedings in the above-entitled matter.

Martha L. Nelson

MARTHA L. NELSON, CERT**367

March 1, 2021