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CALIFORNIA ENERGY COMMISSION

IEPR COMMISSIONER WORKSHOP

In the Matter of:) Docket No. 20-IEPR-02

Plug-in Electric Vehicle Charging Infrastructure

CALIFORNIA ENERGY COMMISSION

PLUG-IN ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

REMOTE

SESSION 4: THURSDAY, AUGUST 6, 2020

2:30 P.M.

Reported by: Jacqueline Denlinger

APPEARANCES

CEC COMMISSIONERS (AND COMMISSIONER ADVISORS) PRESENT:

Patty Monahan, 2020 IEPR Update Lead Commissioner
David Hochschild, CEC Chair
J. Andrew McAllister, CEC Commissioner
Richard Corey, California Air Resources Board Executive Officer

STAFF PRESENT:

Heather Raitt, Assistant Executive Director, Policy Development
Jonathan Bobadilla
Rosemary Avalos, Public Advisor's Office
Matt Alexander

PRESENTERS:

Alan Jenn, UC Davis
Siobhan Powell, Stanford University
Eleftheria (Ria) Kontou, University of Illinois

PANELISTS:

Eric Wood, National Renewable Energy Laboratory
Dong-Yeon Lee, National Renewable Energy Laboratory
Bin Wang, Lawrence Berkeley National Laboratory

PUBLIC COMMENTS:

None

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P R O C E E D I N G S

AUGUST 6, 2020 2:30 P.M.

MS. RAITT: Good afternoon, everybody. Welcome to today's 2020 IEPR Update Commissioner Workshop on Plug-in Electric Vehicle Charging Infrastructure.

I'm Heather Raitt, the program manager for the IEPR. Today's workshop is being held remotely to encourage physical distancing to slow the spread of COVID-19. The meeting is being recorded. We'll post the recording and written transcript on our website. Also presentations for today have been posted. This is the fourth and final session of this workshop.

And today, this afternoon we'll be using the Q&A function in Zoom, including being able to vote on questions posed by others. So attendees may type questions for panelists by clicking on the Q&A icon. And before typing, please check to see if someone else has already posed a similar question, and if so, you can click the thumbs up to vote on it and that will move the question up in the queue. Well, reserve about five minutes at the end of the panel for attendee Q&A. And so given the time restrictions, we're likely not to be able to elevate all questions received.

So now I'll go over how to submit comments on the material in today's workshop. We'll have an opportunity for public comments at the end of the session. Please note that we will not have time for panelists to answer questions during that public comment period.

For those using Zoom online, click the raise hand icon to let us know if you'd like to make a comment. And if you're on the phone, press star 9 to raise your hand. Alternatively, written comments are welcome, and they are due on August 27 and you can look at the notice for all the instructions on how to submit written comments.

And with that I'll turn it over to Commissioner Patty Monahan. Thank you.

COMMISSIONER MONAHAN: Great. Thanks, Heather. And thanks everybody for joining the afternoon session. The morning was fascinating. We're really working hard at the Energy Commission to produce a report for the requirements of AB 2127 to evaluate the charging needs for meeting California's goals for transportation electrification, specifically having 5 million electric vehicles on the road by 2030.

One of the interesting things we heard this morning from Joshua Cunningham from the Air Resources Board is that in order to meet California's goals for having a carbon neutral economy by 2045, we may need more electric vehicles than are currently -- than are currently projected. And there may be an opportunity through new rulemaking for light-duty vehicles to accelerate some of the electric vehicle goals that we have as a state. So.

And I really view this research, research that's happening, some funded by us and some by other entities to evaluate charging needs to be really critical to being able to deploy electric vehicles. We know already that -- that we are sort of falling behind in terms of our infrastructure, meeting our infrastructure goals for 2025. And looking forward to 2030 we -- there's so much new technology on the horizon, new charging opportunities, and we need to work together with all these different entities, with utilities, with individual charging providers to make sure that we're doing all we can to support California’s transition to electric vehicles.

Some have likened this to the Manhattan Project. I wish there was like a less altruistic example of this but there is something to this idea that we need to harness innovation. We need all the best researchers on our side and helping implement this. And we need a private sector and a public sector partnership that's -- that is closely working together to make sure that we can build out the infrastructure needed for transportation electrification.

So with that, I think, although there's other folks mentioned on the dais, I'm not sure if they're actually here with me. I just want to confirm with Heather. Is there anybody else on the dais.

MS. RAITT: I don't see anybody else right now.

COMMISSIONER MONAHAN: Okay, great. So why don't we kick it off. I think, Heather, am I turning it over to you for introductions?

MS. RAITT: Sure. Thanks, Commissioner.

Yeah, so this afternoon we have a panel on Examining Existing and Future Infrastructure Needs Throughout California. And joining us again from this morning, we have panelists Eric Wood, DY Lee, and Bin Wang, and we have Matt Alexander who will -- is from the Energy Commission and he'll be moderating the panel.

So go ahead, Matt.

MR. ALEXANDER: Thank you, Commissioner Monahan and Heather for those opening remarks.

Yeah, I'd just like to echo the importance of these discussions and I think we've really assembled an excellent team for our work and for this discussion today. So I'm really excited to introduce three more presenters this afternoon to join Eric, DY, and Bin from this morning. I'll introduce each of them individually.

And we'll be starting with Alan Jenn, who is the Assistant Director at the Institute of Transportation Studies at the University of California, Davis. Alan's research is focused to plug-in electric vehicles, integration with the electric grid, adoption of the technology, use and ride-hailing companies, and its impact on transportation finance. Alan has a PhD in Engineering and Public Policy from Carnegie Mellon University and is an affiliate of Lawrence Berkeley National Labs.

Alan, please take it away.

MR. JENN: Great. Thank you very much for the introduction. Good afternoon, everyone.

So today I'll be talking about optimizing infrastructure deployment specifically for electric vehicles driving for TNCs, or transportation network companies, which you may know as companies such as Uber and Lyft.

So there's already been a lot of great discussion about infrastructure deployment in general. And this study that I'm presenting, which will highlight a couple of results, is mainly focused on EVs within this particular service.

And so the first question you might ask, if you can go to the next slide is well, why is this such a big deal? When we think about how many electric vehicles there are, you know, driving for services like Uber and Lyft, you're talking about on the order of a couple thousand these days in California. But when you think about the total number of electric vehicles in California, you're talking about over half a million vehicles. So it represents a very small proportion.

However, when we look at this chart here, one of the things that was pretty surprising when we looked at the data is that these TNCs, even though they represent a small fraction of the total number of vehicles, they're using a disproportionately large amount of public charging. And so because we expect this to grow, and for electrification to be happening within these service sectors continually over the next decade, I think that specific attention needs to be paid to our deployment of infrastructure to meet these needs.

So go on to the next slide.

So here this is kind of a real high-level overview of the modeling approach that we took to deploy infrastructure. And I think one of the unique things about our approach is that we're actually able to leverage real data from both Uber and Lyft in order to best understand how to complement the infrastructure deployment with the actual ride-hailing behavior that's happening both, you know, at particular time and in particular locations. And so I'll talk a little bit about going through each of these steps but I'm not going to spend too much detail. You can feel free to contact me afterwards if you'd like to learn a little bit more about the methods.

And so basically what we're doing here is we are simulating demand using real data so that we can look at different forecasts of electric vehicles being driven on Uber and Lyft platforms. And then we're figuring out essentially how to deploy the infrastructure in the ways that are reducing costs to charge, but also reducing downtime for drivers which includes both traveling to the charger, and the act of waiting to charge the vehicle itself. And of course, everything has to meet the actual energy requirements for the trips that are being provided. And so there's some kind of minimum number of chargers needed in order to fulfill that demand.

So go on to the next slide.

So this is a quick sort of demonstration of what's called bootstrapping. Essentially what we do is we sample from the empirical data and we say, hey, I'm going to just randomly pick out this trip and then I'm going to follow that car throughout that day and do that for X number of cars. And we can do that in this particular example for about 1,000 vehicles. And so -- so in this diagram, it’s showing every day where the demand is happening. And by doing this bootstrapping, we are getting very sort of good representation of what we expect in reality for that number of vehicles to be providing that level of service.

So go ahead to the next slide.

Did we -- did we lose the slides or --

MR. RAYNOLDS: Technical difficulty. One moment and they’ll be right back up. Sorry.

MR. JENN: Okay. No problem. I’ll -- I can -- I can sort of continue on while we bring the slides back up.

Because of the nature of the way we do the simulation, one of the benefits is that we can actually -- we can simulate different numbers of vehicles. And this is going to help with projections over time for how many electric vehicles you might expect to be driving on an Uber or Lyft platform. And so in the model scenarios that we're doing right now, we just have kind of rough order of magnitudes on running simulations with 100 vehicles, 1,000 vehicles, and 10,000 vehicles in each -- in each of the regions.

The optimization has some straightforward portions of costs, which is simply how much it costs to install the infrastructure, how much it costs to charge the vehicle. But then we also try and include some waiting parameters for how drivers or how the system may value the time of drivers. So how long it takes to travel to charging stations and how long it takes to charge those vehicles.

So go on to the next slide.

And here I'm just going to highlight some of these results and what's happening. So this is an example in the Greater Los Angeles area where we have 100 TNC vehicles operating in Los Angeles compared to 1,000 vehicles. One of the consistent things that we're finding is that there's high demand at the metered airport. So LAX and in downtown. And that's consistent actually through all the cities that we looked at, San Diego, Los Angeles, and San Francisco. This may be sort of intuitively obvious, but the more vehicles that we're adding into our system, the more chargers that are necessary to meet those requirements. And so you can -- you can see that explicitly here. But it's -- but it is telling us sort of strategically where to place those chargers and actually how much those chargers are being utilized to meet the demand of these either 100 vehicles or 1,000.

So go on to the next slide.

As I mentioned before, one of the things that we can play around with is the value of the traveling time and the value of the charging time to the drivers. Because those are kind of not really explicit cost, but things that we can parameterize. And so here on the left-hand side, we can see what happens when we lower the waiting parameter. In other words, we say, oh, you know, the drivers don't mind so much spending a little bit more time to charge. And what ends up happening is you get a deployment of a lot of Level 2 chargers versus on the right-hand side you can see there's a lot fewer chargers but they're predominantly DC fast charging.

And so there is this sort of cost tradeoff between how much we value the time and how much we're willing to sort of put in. And so having this flexibility allows us to give a variety and set of different scenarios to interested stakeholders that are trying to figure out, you know, what the best deployment strategy will be.

Next slide.

One other set of scenarios that I that -- that I hadn't mentioned yet is that most of these baseline scenarios were basically assuming that a lot of the vehicles are doing public charging rather than -- public charging during the day, rather than charging in sort of off times -- off peak times. And that is kind of reflected by a lot of the behavior that we're seeing today, but that's not necessarily something that will continue on into the future, depending on how charging plans might happen, for example, and as a diversity of drivers may change.

And so we wanted to be able to look at sort of the other end of the spectrum. What happens if basically all the drivers are just maximizing overnight charging and so you only need public charging when you run out of battery during the day. And what that does is effectively lower the daytime charging demand. And you can see reflected in here, one of the scenarios which lets us look at how -- how fewer chargers are needed to meet that lower demand and the associated costs are going to decrease quite a bit as well.

Okay, move on to the next slide.

What is the value of reducing time to travel. One of the things that we found is that there's a clear gain in adding the chargers to reduce travel time. And so as I add more and more chargers, there's actually a sort of precipitous drop off in the time it takes to travel for those certain vehicles to get to the chargers. And so there's kind of this inflection point which you might consider sort of an, at least a minimum ideal number of chargers.

That's not to say that all those points on the right are scenarios that you don't want because they're actually doing other issues that are sort of graphed in here. You're increasing -- or you’re decreasing the charging time by having faster chargers. You're also needing to meet more demand as you increase the number of vehicles.

Let's go ahead to the last slide.

And so we are finalizing the developments of the WIRED model. As I mentioned before, you know, we're doing these rough estimations of 100,000, 10,000 vehicles, but we can calibrate this now to more realistic numbers that we might expect to see in each of those cities. So for example, you know, the Clean Mile Standard from the Air Resources Board regulation, that's going to have some projections associated with it and we can now sort of take some of those numbers and plug them into this model to see, you know, if we were to meet the Clean Mile Standard how we're going to meet that regulation and what the associated infrastructure deployment might be to meet that demand.

The other thing, sort of next steps for this project is you've heard a lot about a lot of the other infrastructure deployment models and so we want to be able to combine and work with them. And so, you know, the modeling here has actually left flexibility to start to plug-in existing stations or future projected stations all into this ecosystem so that it can allow these TNCs to charge at existing infrastructure and say, hey, what are the new infrastructures that we need in addition to what EVI-Pro 2 and RoadTrip are saying.

Yeah, and so I'll leave it at that. I know I'm kind of running out of time and so, yeah. Thanks for your attention and hopefully we'll get some good conversation soon.

MR. ALEXANDER: Thank you, Alan, for that presentation. The TNC modeling is really interesting and I think going to be impactful moving forward.

I'd next like to introduce Siobhan Powell. Siobhan is a fifth year PhD student at Stanford University where she is advised by Professor Ram Rajagopal. She also collaborates with the GISMo Group at the neighboring SLAC National Accelerator Laboratory where she has been part of the CEC-funded EV projects The Smart Charging Infrastructure Planning

Tool as well as Divine. Her dissertation is on modeling the impact of EVs on the grid both short- and long-term small and large scale.

Siobhan, with that, please take it away with your presentation.

MS. POWELL: Great, thank you so much for the kind introduction, Matt, and for the invitation. I'm really happy to be here today and share some of our work.

Today I'll be presenting on a new project called SPEECh. I'm not sure -- I don't see the slides, I'm not sure if that's just me. But I can continue until they come.

MR. ALEXANDER: I'm not seeing the slides, either, Siobhan, so hopefully we're working those technical difficulties out. Oh, I think they’re coming now.

MS. POWELL: Okay. Oh, great. Thank you.

So SPEECh stands for Scalable Probabilistic Estimates of EV Charging. And this is in its preliminary stages, so I won't show many results, but I'll focus more on the design of the framework and the methodology.

And so next slide, please.

So with this model, we're proposing a fast, flexible, data-driven framework that uses graphical modeling to take a statistical view of EV modeling and add a statistical layer on top of the more detailed methods. You could say that SPEECh is designed to speak to you about the data.

We have many collaborations. We're collaborating with Eric at NREL, as you heard from this morning, to add our framework as a statistical layer of analysis on top of EVI-Pro to make a tool we're calling EVI-Pro Turbo. We're also collaborating with Gustavo and the team at SLAC to build on the control modeling developed in SCRIPT. And working with Matt and Noel to extend the model further to offer insight on particular policies.

And before I go into further detail on any of these, I want to thank Eric, Gustavo, Matt, Noel, and our many collaborators at Stanford and SLAC for their support of this work.

To support each of these applications, the SPEECh framework is designed to capture the wide range of driver type behaviors, uncertainties, and use cases that drive scenarios of EV charging. And our goals for these scenarios is to support and contribute to planning for electrification in California and in communities around the world.

Next slide, please.

As a quick outline, I'll start by explaining the methodology and then I'll highlight and illustrate these five key features of the framework. The data-driven discovery of driver behaviors, the ability to combine multiple data types and data sources, our vision for the model as an interactive tool, the estimation of uncertainty, and the modeling of controlled charging.

Next slide, please.

So this slide presents the graphical model that's at the base of our methodology. It works by separating the drivers into different groups and then modeling the charging for each group. All of the models and distributions in this version are learned directly from charging data. So for example, let's consider a driver in Group Number 1. On a given weekday they may have an 80 percent probability of charging at their workplace. And then if they have a workplace charging session, the sessions model, following through the steps at the top, can generate a probable arrival time, duration, and energy for their session.

Then once we have these parameters of the session, there's the option to implement charging control, as we'll show later, and all together these define the load profile for that driver. So this together with the distribution over the different driver groups let's us quickly generate the profiles of many millions of individual drivers, which can combined to create scenarios for the overall load.

Next slide, please. Thank you.

So we do the -- we identify the different driver groups using clustering. And this approach lets us discover many interesting and surprising behaviors. To give a couple examples of behaviors we've identified in the charging data, we use -- we observed many drivers frequently topping up and charging small amounts of energy by habit, rather than waiting until they're empty. We observed many drivers who habitually used multiple types of charging, both workplace and public, for example. And we also see that some drivers choose to use timers to rely on their at-home charging with cheaper TOU periods, and others do not in the same situation.

Overall, we find that driver preferences and access, frequency charging, and battery capacity are the key drivers of the clustering. So here at the bottom is an example from the EVI-Pro Turbo using data output by EVI-Pro 1 that clusters into five driver groups. These five plots show the load profiles for a typical weekday for each group. And we can see in this example that the first driver group on the left has drivers who depend on residential charging. The second driver group uses more public charging. The third, workplace. The fourth has users that frequently use both public and residential. And the fifth has drivers that frequently use workplace and residential.

Next slide, please.

So this modular framework means that the driver groups are very flexible. Representing different segments of the load, as one example, we could have some drivers from our fleet modeling, combined with some drivers from individual drivers, as we've been talking about. It also means that the driver groups can span multiple data sets. So one driver group could be from EVI-Pro data where another driver group could be from another data source. And this helps us build a rich catalog with different behaviors to include together in the model.

And crucially, we can also define these driver groups even where there’s detailed travel data or charging data missing. So as one example, we're working with collaborators in India to develop an Indian use case of the model where some segments of the layers have less data available. For example, there are no large household travel surveys. But this framework lets us define driver groups in session statistics as user input. So the model can still work and include all of the segments.

Next slide, please.

So here's an example output from EVI-Pro Turbo using the five driver groups we looked at earlier. This scenario shows 1 million drivers, which took about 30 seconds to run. And within this framework, we can easily change the distribution of our driver groups. If we change that distribution to include more drivers with preference for charging at home, say from Group 1.

Next slide, please.

Then this is the result. And we can see the load shifted towards the evening, towards residential charging and away from workplace and public.

Next slide, please.

Another knob that we can turn is the distribution of our session’s behaviors. So we're using a mixture model for this sessions data where each mixture component captures a separate behavior. If we change the distribution over components to increase the proportion of drivers who delay and charge later into the night or into the morning.

Next slide, please.

Then we can see how the overall load profile changes.

Next slide, please.

Being able to change these distributions and turn knobs in the model is important because it creates the possibility of interacting with the model, kind of in real time to compare and generate different scenarios and see how the model interprets the charging data. This example here shows three plots with a sample load profile comprised of drivers from Groups 1 and 3. And the idea is that sliding the slider on the right can change the proportion of drivers from each of the groups and then you can see the immediate and dramatic effect on the overall scenario.

So the code that we’re developing for this tool will be all open source and run in Python really quickly and simply on a laptop. You saw the knobs that we can turn for driver types or charging behaviors. We also have a knob for control and we're working to add more to help us answer particular questions. So for example, how does the load profile change depending on the housing type of drivers, or if they're more later adopters.

Next slide, please. Thanks.

So another feature of the model is that it can be used to estimate sensitivities to different inputs or uncertainty in the load profile. In this example, we generated the load for 1,000 drivers from Group 4. And then reran that 1,000 times to calculate a range of estimates.

So the black line here on the right shows the median with sleeves for the 10th to 90th percentile of those outputs. And this estimate was generated, again, in about 30 seconds. Uncertainty is important -- important for planning and each element in the framework is probabilistic so the distributions underpinning the graphical model are really critical to modeling this.

Next slide, please.

Yeah, so finally control. In SCRIPT, the Smart Charging Infrastructure Planning Project, which is a project, an EPIC funded projects at SLAC National Lab. We developed a data-driven methodology for modeling the impacts of workplace charging control. So this example here uses the base case we saw earlier on the left, and then applies control for PG&E's E-19 rate schedule which affects many workplace parking lots in this area.

You can see here how the load has flattened. The green part is the workplace load but was flattened and moved away from the peak period, both earlier into the morning and spread throughout the afternoon. With that methodology, once the model is changed, applying the control to find the new load shape takes only a couple of seconds. So this can be another knob added to the tool.

Next slide, please.

So in conclusion, we've shown how SPEECh weaves together a broad catalog of behaviors, data sets, and assumptions to create insightful scenarios for policy and planning. But why is that important? We have to step back and take a look at the big picture. By design, the model has flexible data requirements and it's fast and inexpensive to run. So that makes it easy to apply the tool anywhere. This can help us bring EV modeling expertise developed here in California to planners around the world for facing the challenges of electrification.

Planning to support EVs is key to enabling decarbonization and we hope -- our goal for this work is to contribute to that planning, make it easier and help accelerate electrification and decrease global emissions.

So thank you very much for your time. Please email me, and if you want to learn more, I'm happy to discuss. And thank you again for the invitation.

MR. ALEXANDER: Thank you so much, Siobhan. I think this is a really impactful tool that I think a lot of people will be interested to learn more about and play around with once it's released.

Our last presentation before moving into the moderated discussion is from Dr. Ria Kontou who is an assistant professor in the Department of Civil Environmental Engineering at the University of Illinois at Urbana-Champaign since 2019. She received her PhD in Civil Engineering focusing on Electrified Transportation Systems from the University of Florida.

She is a postdoctoral research associate at the Transportation and Hydrogen System Center of NREL and conducted research at the Department of City and Regional Planning at the University of North Carolina at Chapel Hill before beginning her current faculty position at Illinois.

Ria, whenever you're ready, please take it away.

MS. KONTOU: Sure, good afternoon, all. I'm very excited to join you today and discuss our research on Economics of Electric Vehicle Public Charging.

This talk will present our analysis that quantifies tangible direct current fast charging stations value, as well as finances, and internal rate of return estimates of fast charging providers venture in San Diego. I would like to acknowledge my colleagues, Eric Wood and Matteo Muratori from the National Renewable Energy Lab, as well as Dr. Greene from the University of Tennessee at Knoxville, and Noel Crisostomo and Kadir Bedir from the California Energy Commission.

Next slide, please.

In our first project we quantify the value of public charging infrastructure to current and potential owners of plug-in electric vehicle which is essential to weighing its benefits and costs, and also predicting its impact on future sales. I would say that the focus on the value of the existence of public charging infrastructure to the consumer, apart from any charge for using it. In this sense, our estimates correspond to the economic concept of willingness to pay.

We develop a framework for estimating the tangible value of public electric vehicle recharging infrastructure that is a function of the consumer’s vehicle electric range, charging availability and location, vehicle miles traveled, powertrain type, and income.

In our second project we evaluate financial viability of a high-powered fast charging stations plaza in San Diego. And we do that by estimating investors profitability indices and there internal rate of return. We shed light into ways that high capital and electricity costs can be mitigated by, for example, integrating distributed energy resources. And this work is crucial for understanding challenges of sustaining events, charging network, and utilization levels, and other parameters nearby.

Next slide, please.

To quantify the tangible value of public charging infrastructure for battery electric vehicles, we rely on simulation studies that assist us with estimating functions relating with the availability of public charging infrastructure to additional enabled vehicle miles of travel.

The graph in the upper right corner of your screen demonstrates a quadratic relationship between charging availability and enabled annual travel mileage. Showing essentially that adding more infrastructure results in a greater share of annual miles being electrified with diminishing returns. Simulation studies provide estimates of the degree that public charging can enable plug-in hybrid electric vehicles to use more electricity in lieu of gasoline.

We turn to econometric analysis to estimate the value of enabled annual miles. And the figure on your lower right-hand side shows an illustration of an equation derived from our study demonstrating the effect of charging availability and electric driving range to the willingness to pay for charging infrastructure as it’s shown in the axis.

Next slide, please.

Willingness to pay for public charging, which is primarily Level 2 for a plug-in hybrid electric vehicle, is the present value of energy savings from additional miles being operated in charge-depleting mode, which allows more electricity to be used instead of gasoline. When it comes to willingness to pay for public chargers for a battery electric vehicles interregional travel, that is a function of enabled electrified miles multiplied by their value as well as the value of time denoting the additional time needed to access a charger. That is actually varying based on the driver's income. Note that that that the denser the station's network, the less the time it takes to access a charging port and the greater the value to the consumer.

Last, a willingness to pay for intercity travel enabled by installing fast chargers along highway routes is estimated similar to the interregional present value, but by discounting it by the time cost of recharging.

Next slide, please.

Conducting the California specific case study, we find that battery electric vehicle drivers' willingness to pay for direct current fast charging is actually greater for intercity travel compared to interregional travel when the electric driving range of the vehicle is less than 200 miles. And this is under the assumption that the charging station availability of select Californian levels in 2018. When charging availability is less than 20 percent, in the right-hand slide, you can see that for a battery electric vehicle is 150 miles and double, willingness to pay falls below 2,000.

The tangible value of direct current cost charging increases as charging availability increases with diminishing returns of both intra and interregional travel. The magnitude of the value of existing infrastructure for interregional travel is about 6,000 when the battery electric vehicle range falls below 100 miles. We observed that public stations can contribute to enhancing the utility of battery electric vehicles to drivers and to potentially lead to increasing electric vehicle sales as well as curb range anxiety.

Next slide, please.

In the second project that we worked on with California Energy Commission, we conduct High-Power Fast Chargers Financial Analysis for a specific San Diego site. We review the economic prosperity of certain endeavor that is important to sustain adequate infrastructure availability confidence and support electrified operations. Now in this case, we estimate profitability indices and break-even electricity prices under several scenarios of a direct current fast charging station configuration. For combinations of different port power levels, number of plugs per station, energy storage, and for the whole site location. So we have a lot of scenarios.

Geographic Information Systems Analysis is used in this case to determine the exact location of your charging station. Accounting for criteria such as the location of increasing chargers, land use characteristics, parking spots availability, proximity to substations, and property taxes. Now the determination of the charger’s percentage of utilization using the years of analysis, is achieved through NREL’s model EVI-Pro that Eric already discussed.

Besides the energy storage and for the voltage carry through to NREL modeling frameworks and external resources were consolidated to determine average values for capital installation costs of infrastructure. Including data from utility Pacific Gas and Electric and now also San Diego Gas and Electric public grid integration type data are used to estimate the levelized cost of electricity for the utilization profile specified.

Finally, Electric Financial Analysis Simulation Model is adopted from NREL’s Hydrogen 1 in order to calculate profitability in this case for all the different scenarios that we examined.

Next slide, please.

The publicly available direct current fast charging plaza selected is located in the city of San Diego in a shopping center close to downtown with all constraints specified satisfied. The scenarios are multiple and are presented in table on top. Please feel free to reach out to me if you have any questions regarding these.

Next slide, please.

The results of our analysis demonstrate that as high-power fast charging load increases with the increased number of plugs, the break-even price of electricity actually decreases. So the price that the consumer would have to face when they recharge. Energy storage and photovoltaic operational savings seems these reduce the amount of electricity drawn from the grid can justify the high capital installation cost.

When we look into the best-case scenario, it is evident that energy storage location is actually beneficial since it reduces the impact of critical peak pricing that characterizes the type of San Diego Gas and Electric. Increasingly, the number of charging ports result in higher load level which justify the PI investment and end up in approximately 10 to 12 percent electricity break-even price reduction.

Next slide, please.

We conclude our analysis by pointing out that the willingness to pay function for charging infrastructure helps us estimate the driver surplus from the installation of additional charging infrastructure. And we are also gaining California specific insight on the value of charging. For example, to a purchaser of a new battery electric vehicle with 100 miles range, home charging, and located in Sacramento, urban public fast chargers worth approximately $1.5 thousand for interregional travel. For intercity travel with highway fast chargers, these are worth more than 6.5 thousand along interstate routes.

Our financial analysis of a plaza in San Diego for direct current fast charging shows that utilization volume is crucial in achieving financial viability. And that energy storage and solar panels colocation brings down operational costs as the driver demands grow. Electricity break-even prices range from 36 to 50 cents per kilowatt hour which are not so different from subscription rates offered today by existing network providers.

Next slide, please.

I think, I think that's pretty much it. So I would like to thank you for your attention, and I look forward to a fruitful discussion.

Thank you.

MR. ALEXANDER: Thank you so much, Ria.

That’s -- it's definitely interesting to have the financial perspective and I'm interested to explore that more in the moderated discussion.

This concludes our formal presentations for the afternoon. I would like to invite Commissioner Monahan and any other members of the dais to ask any questions to our three presenters, as well as Eric, DY, and Bin from this morning if there are any lingering questions there.

If all of our panelists could turn on their cameras so that they're able to answer questions, that would be really great. Thanks.

COMMISSIONER MONAHAN: Great. Well, thanks everybody. Nice to see all your faces on the -- on the grid.

So I think I'll discuss sequentially with the presentations this afternoon.

Alan, nice to see you, again. I had a question. I mean, I was kind of shocked by the 35 percent of the energy use of public chargers goes to TNCs. Could you talk a little bit about that data? Is that California specific? Was that provided by the -- by Lyft and Uber? Like, how'd you get that data?

MR. JENN: No, no, actually, that is data coming from an aggregation of several charging service providers, with the exception of Tesla. So 35 percent of non-Tesla public chargers. So that data is not coming from Uber and Lyft, it's coming from, at the time, a coverage of about 1600 out of the 1800 DC fast chargers back at the, sort of end of 2018 beginning of 2019. So fairly comprehensive.

But you should also know that there are like something like 2000 Tesla DC fast chargers. So, you know, I don't know how much those are getting utilized. We don't get any data from Tesla. But it is -- it is definitely very surprising and it's -- in that it comprises a pretty small number of vehicles that are responsible for a lot of that charging so.

COMMISSIONER MONAHAN: Well, you know, I -- I’m waiting to get a list on Uber or Lyft next to Tesla. So far I've not seeing that. You see that in the Netherlands, not so much here in California.

And maybe this is a question, maybe for Alan and Ria in terms of the analysis around the value of charging. I thought it was fascinating this idea that highway chargers are far, in terms of bonus pay, are much higher valued than urban chargers. And yet for TNC drivers, you would think it might be the opposite. I don't know, actually.

But have you thought, Ria, about this integration of TNC drivers, and Alan, you too, in terms of where are the chargers that would be most appropriate for those drivers?

MS. KONTOU: Yeah. So in our analysis, we focused primarily on personal light-duty vehicles. Right? So we -- our analysis on the annual vehicle miles traveled reflect better in these numbers. Essentially reflect better, the operation so, of let's say personal users. So it would be very interesting to account for the driving patterns of transportation as work companies' drivers. And also study a little bit where that concentration of charging stations that they regularly use is.

So I would -- I would envision that probably their patterns concentrate in downtown region so very urban, urban streets being covered there. So the intercity willingness to pay for charging would reflect better, but the value of charging for them. And we would also have to adjust a little bit in our calculation the value of offering such a service and having a battery range close to a full state of charge. Because they actually making money out of this endeavor compared to a regular driver who values more the time of driving because they want to reach a destination and conduct an activity.

MR. JENN: Yeah. Regarding TNCs sort of value for the infrastructure, the beauty of the way that we've sort of approached it is that we're basically saying we don't -- we don't really know, but we're going to kind of parameterize it so that we can see if someone like Ria is able to measure that and give us a sort of good estimate of how some of these values are looking in reality, we can -- we can plug that into the model. And right now, it's sort of kind of scenariorize. I don't know how to say that word. And so we can look at a whole bunch of different sensitivity for values of things like, you know, how much did the electricity cost? How much they value reducing the time to drive to the charger and how much they value not spending time at the charger. Right. Having the charging event happen quickly.

COMMISSIONER MONAHAN: Well, and this is a bigger question that we have been wrestling with internally about how to evaluate the investments that we're making in charging infrastructure. So Ria, some of your analysis, I think in willingness to pay, gives us some good food for thought about how to -- how to value our investments in charging infrastructure.

And I guess there's a -- there’s a two-piece question. One is, I mean, willingness to pay, it’s -- is one metric. Do -- are there other metrics that you would recommend or that would help us dig a little bit deeper into the value of charging? And I ask that because, you know, I'm thinking about how there's this intangible benefit to having a robust network that even if you don't use it, and willingness to pay, presumes, if I heard you correctly, that it's based on actual the value of the charging event to time of the day for how much you're actually using them, not just that second value.

MS. KONTOU: That's absolutely right. Yes. So we capture only the tangible -- the tangible value based on the electrified miles that can be achieved. Right? So it would be very interesting to capture intangible values with respect to visibility of charging stations and their effect on further adoption. So all these secondary facts, yeah, we need -- we need -- we need to do a more thorough analysis on that end. I think it's very valuable to get to know that.

In terms of our analysis, it's pretty useful because the value can be actually incorporated in a choice model, a vehicle ownership choice model. And can help us estimate in the future the number of sales of electric vehicles. So it would be, I would say, kind of straightforward to calculate the importance of the value on future investments to estimating the sales that these can produce.

COMMISSIONER MONAHAN: Well, and I think that's an important sort of what's the share of access to EV charging that could be attributed to the individual purchase of a -- of an electric vehicle. I think that's a very important question which helps us assess, like, what's the value of charging?

But then they also -- this value which we discussed a little bit this morning about the used car market and the fact that, you know, right now, most people who buy a new car are rich, fairly rich and they may live in their own single family home but then they sell that car to somebody else who maybe isn't so rich and needs -- doesn't have a single family home. Can't, you know, lives in apartment building, there's no charging.

So then all of a sudden, the value of public charging becomes higher for that -- for that used car owner. And for us in California, that's a really important aspect of all of the work we're doing is just we need to make sure this is for everyone, not just for rich people. We need to make sure that we have the charging infrastructure that's ready for that secondary use market and for people who can't afford to own single family homes.

So that aspect of the benefit for us, too, is really important. And I'm just, I want to make sure that I understand, Ria, that is it correct, am I saying it correctly that the willingness to pay metrics, it works really well for like that first car market buyer. It gets a little more complicated when we're talking used vehicles and, I would make sure transportation application for everyone.

MS. KONTOU: So that's absolutely correct. We -- I -- the metric works very well for new vehicle, electric vehicle owners with home charging installation. So these are kind of building assumptions in there.

For used vehicle owners and multiunit dwelling residents, we didn't have the ability to capture such affects in our model, given the very limited data that we have also in this field, which is another kind of obstacle in --

COMMISSIONER MONAHAN: Uh-huh.

MS. KONTOU: -- capturing this relationship.

But I totally believe that this is -- this is very important in the future. And this is a future direction, it’s a direction that we need to pay attention to.

COMMISSIONER MONAHAN: Right. I look forward to your future research in the space because we do need help on this one.

So, Siobhan the SPEECh, your SPEECh model looks fascinating. What -- when's it going to be available?

MR. POWELL: That's a great question. We're working on the publications for it now. The first publications and hope to have some version of the tool running by the end of the year is the goal.

COMMISSIONER MONAHAN: That's great. Well, I really appreciate the fact that you were planning to make it open source and available for everybody. And we at the Energy Commission, we're trying to figure out how to do that, how to do -- how to do that as well with a lot of our data.

And I fear -- I understand there’s a ticking sound coming from my mic and I bet it's because I turned on my air conditioner because it got very hot in my tiny little office. Sorry about that. Is the ticking better now? Is it going away? Is it the air conditioner? Any clearer?

MS. POWELL: I don't hear anything.

COMMISSIONER MONAHAN: Okay. Well, that's good.

And -- oh, yeah, I was saying that we're also looking at ways to make our data more available. We're actually for the first time going to be releasing actually just simple EV sales data which before you couldn't get down to -- we had aggregated data, but not down to like a local level of giving out data, of course, hiding the privacy. Can't give out private information but working with DMV to do that. And so I appreciate the fact that you're looking at making this model open source.

MS. POWELL: Thank you.

COMMISSIONER MONAHAN: I -- and I had a question for you too around it sounds like the model is really, you're allowing people to put in different inputs. And so they can really structure the model whichever way they want. And we had a discussion also this morning about whether vehicles would be topped off in the -- in the heavy-duty space, in the heavy- and light-duty space or not and how that could have really different implications on the grid.

I'm wondering, are you going to be putting any constraints on that to reflect sort of where the data indicates the market is or is it really just the user input function?

MS. POWELL: Yeah. No, it's a great question. And as we've been thinking about how to build a tool, I mean, I think the idea is to have a base case but based on the data, and then have all these parameters that can be changed. So the base case kind of suggests this is what's possible and we might even put ranges on that. But I guess you could also use it to explore sort of extreme cases. I think it could use both.

I don't know if that's -- yeah. So right now --

COMMISSIONER MONAHAN: Great.

MS. POWELL: -- the example popping up is one behavior you might see from some drivers, but we would have the option to tune, you know, the proportion of behaviors for each driver group. So you could say, oh, if this driver group, 60 percent of their sessions is like a topping up behavior, you could sort of tune that down and change that by hand if you don't think that that's a likely scenario.

COMMISSIONER MONAHAN: Yeah, it would kind of be like, do you know the GREET models at Argonne National Laboratories puts out greenhouse gas emission, blah, blah, blah for transportation. I don't even know really what it stands for, but I've used it a lot. It could be like that where there's some basic stuff but if you want to tweak with the model you can -- you can do that if it's just in like Excel or spreadsheet. I mean, it sounds like --

MS. POWELL: I mean, the code -- I'm sorry. Yeah, I think with the code --

COMMISSIONER MONAHAN: It sounds like Alan --

MS. POWELL: I'm sorry, go ahead.

COMMISSIONER MONAHAN: No, you go. I'm sorry, Siobhan. You go.

MS. POWELL: Oh, I was just saying with the code published, then someone could download it and change the whole thing if they wanted to. If you have different scenario with really different data and different beliefs, then like having those sort of guidelines wouldn't prevent that.

Sorry. Now you go.

COMMISSSIONER MONAHAN: Yeah. Well, just what I heard, Alan, was it you? Maybe I actually getting -- am getting it incorrect about who was talking about the topping off with the vehicles. Do you have data on whether any of the TNC drivers using the public are in the topping off load just because they're always worried about like that --

MR. JENN: Yeah. Yeah.

COMMISSIONER MONAHAN: -- getting that next ride that's going to be long.

MR. JENN: Yeah, definitely. I actually didn't talk about that during this presentation, but I have talked and shown some stuff about that in the past. So the idea about topping off, when we look at the data and you, if I -- if I go down to the like specific vehicle, let's say it's a TNC driver who's driving a Nissan Leaf or a Chevy Bolt. I can actually go in and figure out, oh how many miles are they going every day? And about 15 percent of the time, the vehicles are exceeding the full capacity of the battery range of their vehicle. Which means that during the time that they are providing the service, they literally have to go and charge. But the rest of the 85 percent, they can get by without charging their vehicle every day.

But when we look at the data, there's this question of are they -- are they sort of skating by and just using what they have or are they constantly charging? And we find it's definitely the latter. And it makes sense from a psychological perspective because, you know, as a Uber or Lyft driver, you know, I don't -- I don't really have control of where I'm going to be going. Right? I don't -- I don't actually even get to see the destination for any pickup that I have until I go and pick up that person.

And I know that the TNCs now have some settings where you can say like mac rate -- max range and stuff like that. But we do find, you know, it's a fairly astounding statistic, you know, the average Californian who has an electric vehicle goes to a DC fast charger, or who's able to use the DC fast charger, goes about once every two and a half to three weeks. For a TNC driver, they're going about three to four times a day. So it's a -- it's a pretty stark difference. And we do find that they are doing this whole topping off behavior.

COMMISSIONER MONAHAN: Yeah. Well, I mean, and I want to concentrate more on this 35 percent of all the charging system by TNC, that's maybe we'll be growing with these announcements by Lyft and Uber around transportation electrification. So.

All right. Well, thank you all. I'm going to -- I'm going to pop off now and we'll move to the facilitated part of the discussion.

MR. ALEXANDER: Thank you, Commissioner Monahan, for those questions.

I wanted to start off the moderated discussion with a question that ties back to my presentation this morning. So I briefly discussed the need to engage with community to inform modeling efforts and appropriately assess needs that could be successful and accepted by local residents.

I'm wondering how you've incorporated socioeconomic considerations to ensure the transportation electrification is acceptable for all of California's communities.

I'd like to start off with Eric and dive a bit deeper into the evolution of residential access that he touched upon in his presentation. I think this is a pretty important discussion and I'm hoping that we might be able to pull up that slide from Eric's presentation this morning to go -- dive into that a little bit. I think it was Slide 7.

MR. WOOD: Yeah, thanks for the prompt there, Matt.

So, yeah, I think for -- for any kind of subpopulation within California, there are a number of different potential charging options that could provide them all the energy that they need.

You know, within EVI-Pro, we primarily simulate scenarios that rely upon home charging to try to take advantage of what we think the lowest cost and lowest -- lowest electricity and lowest installation cost electricity might be. However, that's not always a solution for everyone, particularly people that are renters or living in apartment buildings.

It was pretty interesting for me to hear some of the conversation during Tuesday's IEPR workshop, throwing around some different stats for California on renters and residents of apartment buildings. What our team has found reviewing data from the U.S. Census and California Department of Finance is that in California, renters make up about 45 percent of households, and about 30 percent of California households are individuals in apartment buildings.

And so maybe a little bit below what was discussed, you know, back on Tuesday of this week. And of course that number increases a little bit if you go ahead include single family attached housing like townhomes and condos with the apartments. The number actually can dip a little further, even, in some cases. So we mentioned, that, you know, vehicle ownership is typically lower in multifamily housing. So if you kind of take that into account and just look at the stock of vehicles in California, it's about 20 percent of California's light-duty vehicle stock is connected or owned by the people that live in apartment buildings.

And so I think, you know, for all the stakeholders out there listening, we'd be happy to, you know, connect with you on a local level and share notes on the data that we've been reviewing and get feedback on some of the data and assumptions that we've made. And obviously all these values vary a lot geographically. So in more the dense urban parts of the state, we would certainly expect that the renters share and the apartment share could be above 50 percent in some cases.

But when we look wholistically across the state including the more rural areas, you know, we get down into that 20, 30 percent, depending on exactly what houses you're talking about and how you're doing -- doing counting.

I do want to be careful, though, not to lose -- lose site of the bigger picture. And I think Commissioner Monahan has laid that out well is that we want to make sure that we're developing and planning for networks that are providing equitable access to charging for all California residents, particular those without home charging. So the results that I presented this morning really look at a single scenario for residential charging in the state’s 2030 goal for 5 million vehicles.

But we’ve also run additional scenarios using the model that look at higher shares for residents of multiunit dwellings and renters. And that’s something that we’re planning to include in the write-up. And so again to the extent that folks are willing to engage with us on this topic, we’d really like bake in more local considerations into -- into the modeling that we’re doing.

It looks like the slide got -- got pulled up there, Matt. I’m happy to talk to this if you don’t think I’m dominating the clock too much here.

MR. ALEXANDER: I think maybe if you could really quickly explain what each of these five scenarios entail in the survey. That might help draw the distinctions here. But then I would be interested to hear other’s perspectives on how they are incorporating these aspects into their work.

MR. WOOD: Sure. Happy to do so.

So Matt -- Matt kind of identified that the plot shows five different scenarios for residential charging access in California based on some of the survey work that we did.

You know, if we start maybe second to bottom, there’s a scenario with a red line labeled, “Existing Access.” So here we’re asking people for, you know, the location at your home where you currently park your vehicle, do you have access to electrical infrastructure at that location?

And that value's pretty low overall, so down on the order of 30 percent of California vehicles are currently parking, you know, where they have access to electrical infrastructure.

We also asked a question about 120-volt or Level 1 charging where we showed the survey respondents a picture of a standard U.S. wall outlet and asked them if they thought they could charge an electric vehicle on that. And so it turns out that a pretty low percentage of respondents in our survey thought you could charge an electric vehicle on a standard U.S. wall outlet.

And so if we -- if we, you know, take that education discount, that takes us down to our kind of bottom scenario, where at a large market, we're below 25 percent of California vehicles with access to residential charging. And so that just identifies that there's room for education on charging technology to improve perceptions around residential access within the state.

So moving up from the red line to the blue line, there we're just asking people, okay, maybe for if you don't have access to electrical infrastructure where you currently park, do you think that you could install access there to electricity if you wanted to? And so that identifies what we call an investment gap where folks on an individual level or if there's public support for residential investments, you know, access at residential locations could be increased, you know, maybe another, you know, 10, 20 percentage points or something like that.

And then the last two scenarios build on the existing access scenario and potential access scenario and look at the role that parking behavior has on access to residential charging. So maybe you live in a single family home and you do have access to a garage but it's currently full of woodworking equipment or storage or, you know, whatever else people do in garages. Right? So it wouldn't necessarily to be accessible for parking a vehicle and charging an EV.

And so there we're trying to quantify, you know, how much increased access to residential charging could the state see if residents were willing to modify where they're parking their vehicle both in single family homes as well as in apartment buildings. And so the education, investment, and behavior that different gaps that we're trying to highlight with this work.

MR. ALEXANDER: Thanks, Eric. Yeah, I think this is a pretty -- it takes a while for the impact of the figure to sink in. So thanks for kind of walking through that and highlighting the differences there.

I'd like to open it up to the rest of the panelists and see if they have any other thoughts on how they're incorporating socioeconomic considerations. You can feel free to kind of just raise your hand or jump in if you'd like.

Bin, the first volunteer.

MR. WANG: I have two quick comments from the perspective the medium- and heavy-duty vehicles.

For the local residential area, I guess it's worthwhile investigating the strategy of the high-power charger placement if the high-power charger placed within the same circuit with the residential areas rather than easily lose capacity if high-power charger are placed in the parallel branch or in the upstream branch that are power quality concerns for the residents.

Yep, quick comments.

MR. ALEXANDER: Yeah, that's really important, Bin. Thanks for raising that.

I think the grid impacts are really, you know, something that are going to be quite dramatic as we think about this charging load.

And I -- this actually leads me to my next question. You know, DY's analysis on EVI-Pro RoadTrip indicated that charging demand from interregional travels with a peak load of around 90 megawatts should be accommodated by the current grid infrastructure at least in the case study in SoCal

Edison's territory. Eric's presentation has an appendix slide where the preliminary load profiles project a peak of 3.5 gigawatts. And Bin, your presentation indicated the peak nearing 1 gigawatt.

So if we factor all these loads together, that, you know, is approaching or surpassing 5 gigawatts. I'm wondering if you could speak to the implications of these load impacts and what stakeholders such as policymakers, utilities, local entities, and electric vehicle service providers can do to avoid negative outcomes and maximize the benefits of potential electrification on the grid.

Yeah, Bin, go ahead.

MR. WANG: Thanks, Matt, this is a great question.

In terms of a load profile for the medium- and heavy-duty vehicles, I think besides low peak and timing, there are a couple of other dimensions we should think about with, you know, the ramp up rate for the -- for the high medium- and heavy-duty chargers because usually they are at high-power rating than the, you know, regular residential chargers.

You know for -- talking about the ballpark of megawatt level, you know, presumptively it will be equivalent to hundreds of single family homes. I guess most of the circuits interstate not ready for this, you know, instantaneous load happening in, you know, less than one minute. So I think we should have some kind of investigation to inform facility planners, you know, to develop some kind of monitoring system so that they are situational aware of what type of chargers will be in operation in the next couple minutes and how much load it will draw from the circuit.

Also, you know, if we take a look at the low profiles at different counties from medium- and heavy-duty vehicles. Even though the peak load for Los Angeles County can be as high as 90 megawatts, the low peak for the Butte County in the rural area is like between 6 and 7 megawatts. But the problem is, you know, L.A. County in the urban area may have more circuits available than the rural area.

So the problem could possibly be worse in the open area because, you know, the residents are sharing the, you know, a limited number of circuits. If one of the circuit, you know, went offline, it will cause a lot of more impact on the residents. You know, those are the concerns I have for the ramping rate of the low profile circuit distributions.

MR. WOOD: Yeah. And then from the light-duty perspective, I'll just point out to folks that the EVI-Pro 1 and EVI-Pro 2 aggregate statewide profiles have been brought up on the screen here.

I really just want to emphasize for folks that these should probably be thought of as worst-case scenarios as we're not attempting to simulate any load flexibility in these scenarios. So the way that the simulations are run, when an individual arrives at a location, where they're going to charge, they immediately begin to draw power kind of at full speed.

We know, you know, from field studies and simulation both that there is a lot of flexibility in both workplace charging loads and residential charging loads that could be exercised to try to improve the grid integration kind of case for EVs.

I also kind of like to think about, you know, this grid integration problem in a couple of different levels. You know, thinking about it from a bulk system generation level as well as from a distribution level which I think was kind of the emphasis that Bin was just providing.

You know, I know Alan's done a lot of work at the bulk system level that I understand suggests that there's a lot of generation capacity available for providing electricity for charging many, many electric vehicles in California and across the U.S. as well.

It seems that the bottleneck really comes, you know, more at a local level or a distribution level where you're starting to overload local circuits either through installation of, you know, fast charging plazas or residential neighborhoods where multiple, you know, homeowners have purchased Teslas and are all arriving home at the same time of day and charging at the same time.

And so I think that, you know, there's potential for load flexibility to be a resource at the distribution level as well certainly for residential and workplace. You know, there was the idea from this morning about the EV happy hour where, you know, all the vehicles could be potentially charging midday and help soak up some of the solar that's being curtailed in California currently.

Yeah, I think that's a really attractive idea. One thing just to kind of point out in that conversation is that, you know, that electrical access in the EV happy hour has to be facilitated through infrastructure where the vehicles are located during the day when the sun is shining. So if that's at workplaces, that means much more aggressive workplace infrastructure scenarios than what we've simulated either in EVI-Pro 1 or 2. And so some research into cost benefit, you know, absorbing that curtailed solar versus the infrastructure cost of workplace charging I think could be a really interesting area.

MR. ALEXANDER: Totally agree, Eric. Yeah, that's really interesting to consider.

Siobhan, I was also wondering if you could provide some perspective on this given your work in exploring the flexibility of load profiles. You highlighted in your presentation, you know, the ability to turn these knobs and see how profiles change. And your last slide showed kind of the smart charging potential to flatten out the curve.

Have you found other types of mechanisms or knobs that are particularly impactful in mitigating those types of load curves whether it's ramping or just high demands in other mechanisms?

MS. POWELL: In terms of knobs from this model, I think it might be too early to say. Although I can say that changing the -- turning those knobs really has a big impact on the load shape. So shifting some drivers toward workplaces Eric was saying would have a big impact.

I can speak a little bit, actually, to the sort of smaller scale grid impact from shifting discussed. For as a workplace charging case in particular, I mentioned SCRIPT but at SLAC we also have another project, an EPIC funded project called Divine where we recently looked at the impact of workplace charging on transformers. And we found that controlled charging can really help mitigate that impact, especially when you have a rate structure that has say a demand charge or something to try to minimize the peak. And then a workplace that doing controlled charging (indiscernible) just to minimize the rate schedule actually aligns with protecting the transformer.

So I think there's lots of ways that control can be used to mitigate the impact and it's one of the knobs. But as you mentioned, there are other things that can help with the grid impact as well.

MR. ALEXANDER: Got it. Thank you, Siobhan.

Do any other panelists have thoughts on this before switching the subject to a different question?

Okay. I don't see any hands raised.

So for this next question I want to dig in to the public DC fast charging infrastructure. So this is going to be for Ria, and then DY and then Alan. So I'm going to try to connect the thread here.

Ria, your quantifying tangible value where it highlighted the significant willingness to play for DC fast charger to enable interregional travel, as Commissioner Monahan noted as well, and your financial analysis looked at the business case for these stations.

I was wondering if you could discuss the business case stations that are primarily dedicated to interregional travel, especially when we consider stations that may only have a few plugs in more remote regions as DY's results from EVI-Pro RoadTrip indicates. Your analysis looks kind of at 12, 24, 48 plugs. I'm wondering about, you know, what about stations that only have two, three, or four plugs for those types of use cases? Is there kind of a tradeoff there of the size of the station and what the business case is for those?

MS. KONTOU: Sure. That's a good question. A dense network of highway fast chargers, we found that it's worth than 6.5 thousand dollars along intercity routes. But at the first same time, we know that stations in remote regions that have fewer ports and low utilizations are not as profitable as bigger ones because the case right now.

It is not only important for us to consider encouraging further utilization but also encourage fleet operations to electrify their fleet and have appropriate electricity charging without demand chargers as well as depending on the side consider the effect of the BER distributed energy sources in lowering operational costs for the sites.

So there is always a tradeoff between utilization and high capital costs. Right? And it’s going to be important in this first year of market growth to find ways to alleviate the difficulties in the finances of the stations of that time.

MR. ALEXANDER: Got it. Thank you. To expand a little bit, you also noted how the wiliness to pay is greater for when you’re adding stations that are closer in proximity together that drivers don’t have to travel as far. But then the business case that you were just mentioning worsens when you have these smaller stations that don’t have this high utilization.

So I want to try connecting to DY here as well, but what do you think about the tradeoff between many stations kind of along these rural routes that may alleviate range anxiety and have a high willingness to pay but then have the not optimal business case.

MS. KOUNTOU: Yeah, exactly. We envision a network of stations, right? So provide there, I would assume that their business model is investing in locations of high demand but also in order to make sure that they provide stations that mitigate range anxiety and they help sort of an adoption of electric vehicles, they would have these remote stations.

So overall, and I don't know if we look into a specific business case, right, a specific site, but it's important to look into the total network and understand the tradeoffs there because we would expect a lot of demand reliability in stations that are busy which might be beneficial compared to stations that are outside of our normal demand hot spots that would be like that.

MR. ALEXANDER: Got it. Thank you.

And then DY, I was wondering if you could talk a little bit about the sensitivity in EVI-Pro RoadTrip to kind of separate anxiety consideration and how the fluctuation in station size and plug counts can change based on kind of the driver's -- that last interval of, you know, needing certain numbers of miles to be able to get to a station.

Can you speak to that sensitivity a little bit?

MR. LEE: Yeah, for sure. I'm not sure if you can pull up a slide that I had in my presentation in the morning.

MR. ALEXANDER: Yeah, what slide are you referring to?

MR. LEE: You can go to the very last slide in the appendix, so Slide Number 49.

MR. ALEXANDER: Okay. Hopefully we'll have that up shortly.

MR. LEE: Okay. So we can speak -- so in terms of the baseline scenario -- yeah, right here. So the first one is the baseline scenario that I presented in the morning. So this is baseline of grid EV adoptions scenario in 2030 and time penalty minimization charging behavior points to the number of plugs required to enable electrified road trips. The -- I expected to require at least 3,000 plugs by 2030. This is lower bound, so upper bound might be 12,000 plugs across the state.

And we -- we did some study analysis incorporating a wide variety of scenarios including different EV interruption scenario. The lower adoption in the second row and then different type behavior which is always popping up.

So as you can see, different type of behavior leads to very different number of plugs required for electrified road trips. And in terms of range entirety, it turns out that the growing electric vehicles need larger batteries which means longer range to make a big difference in terms of the number of plugs required for electrified road trips.

That's what you see in the number rural 4. And then for another range in there issue, which is related to people's comfort from the point where they realize they need to charge during the road trip and then the distance between that point to the station. So if you consider that distance as two miles as you can see in the middle both for two miles, the number of plugs will go up significantly.

And then if people have more confidence in terms of the distance they can travel between the points where they're realizing the charge to the charging stations, in this case we have ten miles, the number of plugs go down. So that's why we see in terms of stabilizing from the number of plugs to point.

And then obviously the largest impact for sensitivity case we see in this chart is the temperature. So if you assume that the entire state of California experiences 30 Fahrenheit degrees which is up almost 0 centigrade, the number of plugs doubles from 3,000 to about 5,000, which is hypothetically. But the temperature can play a role in terms of number of plugs and network size. But this is just a number of plugs so in terms of the station size, if we can go back to Slide Number 7.

So for the number of plugs don't directly influence the number of stations. So I don't -- so from the results we got from the road rip simulation, so as you can see -- yeah, thank you -- you can see on the left side the number of stations from directly -- is not directly proportional to the number of plugs if you look at the 2030 scenario lower, upper difference. So the number of plugs goes up to 11,000 from about 3,000. But the number of stations only go up to 1600 from 1,000.

And then as Matt already mentioned, on the right side of the map, the stations along the interstate highway connecting L.A. to Sacramento and San Francisco, stations along those interstate highways, they have huge federal volume going through those stations. So the stations, they're going to relatively larger having like the ten plug per station. But most of the stations in our simulation which is the northern part of California and eastern part of California, those stations actually have only a couple of plugs per station.

So I think the financial aspect that we discussed can be very meaningful and helpful in deploying stations there because they are relatively very small.

Hope this answers your question, Matt.

MR. ALEXANDER: Yeah. Thanks, DY. I think, you know, this really highlights the network design idea. And, you know, how -- how do we factor in the business cases, the size of stations, how far apart to place them. So I think it's really interesting analysis.

And I would encourage everybody who's listening in to take a look at DY's appendix slides. I think he has about 20 to 30 additional slides that really highlight the robust analysis that he did on this slide. It's really impressive. Thanks, DY.

MR. LEE: Thank you.

MR. ALEXANDER: Alan, I wanted to quickly end with you and focus more on the intraregional infrastructure.

So you mentioned how the modeling or your model looks at the quantity and geographic dispersion of DC and Level 2 charging as well as kind of those inflection points and tradeoffs there.

I was wonder if you could expand on those a bit, you know, how the different values of sites and power levels get characterized and I don't know if this starts going too into the weeds but is there a point where the model simulations kind of trigger a upgrade to a DC fast charger to a Level 2 or something similar to that and how those decisions get made.

MR. JENN: Yeah. I think that's -- in terms of the sensitivity to some of those weighing parameters that are causing the models to switch between lots of L2s or a few DC fast chargers, there's still some room to explore. I think we've left those kind of resolution of those kind of like bookends so now it’s kind of time to go in and look exactly where, you know, some of these inflection points are.

I will say, however, that in kind of exploring a lot of the results, we are finding that in the different cities, you do typically get a like super big gain in something like reducing travel time once you hit a certain number of chargers. And so that’s something we want to dive in to and be able to make like a really specific recommendation and say hey, look, you’re getting like marginally huge amounts of reduction in travel time to chargers for a lot of these TNC vehicles as long as you get up to, you know, X number of chargers in like San Diego, a lot of number of charges in Los Angeles and so on.

And so I definitely think that there are -- there are even though -- even though some of the stuff is subjective in terms of how much we’re -- we’re placing value into travel times and waiting times, you still get, I think, some kind of pretty large benefit to hit, you know, certain thresholds. It’s just so much more cost effective to get a certain number of chargers of a certain type.

And again, I can’t at this point speak really specifically to, you know, exactly how much we should be valuing, you know, each of these things for some operable number of chargers but I think that is kind of the direction that we want to head to in the IEPR work.

I think you're muted.

MR. ALEXANDER: Thank you. Thanks for that answer.

I wanted to follow up with another quick question to you tying back to the questions and discussion about TNC utilization and that 35 percent number.

Eric in his presentation this morning hypothesized that the variable changes in DCFC utilization could be due to the constantly changing TNC fleets. I'm wondering if you think the Clean Mile Standard or other, you know, EV adoption furthers in the next decade, do you anticipate those charging loads to be -- to flatten out and become steadier and more predictable or do you still kind of foresee TNC as a constantly evolving fleet that will be hard to predict?

MR. JENN: So what I would say is -- is that I'm reasonably confident that the TNC vehicles are going to be using public infrastructure to a much larger extent than privately owned EVs.

So that having been said, you know, there are things that could change in the future, right? A lot of -- I think a lot of that load happens to be the fact that some proportion of those TNCs were able to get charging for free. And maybe they'll shift from daytime charging to overnight charging if -- if you're starting to enforce certain types of pricing signals and so on and so forth.

But I still think at the end of the day, those type of service vehicles are going to be using public infrastructure way more than private vehicles. And so what does that mean? So with Clean Mile Standard, I anticipate that the growth of electric vehicles on these platforms is going to be really big. And so I think that that type of growth is probably going to outstrip a lot of the demand coming from privately-owned vehicles. Because now we have some sort of regulatory certainty that a lot of these vehicles are being electrified and we know that proportionately, they're just much higher -- putting much higher stress on public infrastructure.

And so I think that's something that we are starting to anticipate and that we need to start to think closely these now to address and get ready for.

I don't think that -- I actually think that the uncertainty about electrification on these platforms is actually going down a lot because of the Clean Mile Standard. It gives us confidence that electric vehicles are going to be on that platform and right with Lyft's recent announcement that they're electrifying these vehicles, that's also just kind of pointing in the direction that hey, look, we need to get ready for this pretty big growth.

You know, maybe it'll flatline after 2030 because they've saturated but until then, we -- we definitely need to get infrastructure ready to support that.

MR. ALEXANDER: Definitely. Thanks for those thoughts, Alan.

So we -- we only have about five minutes left and I wanted to end with kind of a lightning round question for -- for all of you.

A common theme throughout your analytical efforts that was discussed in some of the presentations is that the model is only as good as the data that it uses. So with that in mind, I was wondering if we could go around and thinking about the one or two types of inputs that would be at the top of your wish list to address the key gap in data to improve each of your analyses.

So I'd like to start out with Bin since I know the medium and heavy duty side is, you know, really on the cutting edge which unfortunately means that's also often lacking high quality data.

So Bin, let's start with you and then I'll say who should go next to help keep it orderly.

MR. WANG: Sure. Yeah, you know, as a heavy project progresses, we have received a lot of data sets from partners. However, those data sets are never enough to characterize the truck driving, parking, and charging behaviors we need in order to generate the load profile and the charging infrastructure need. Because the main reason behind that is there are so many different MSDEVs. They serve for different trip purposes and for different applications, their travel behaviors are quite different.

It seems like a number of them are managed by proprietor organizations. So understanding that behavior is critical to quantify the flexibility in order to, you know, in the future, how can we kind of shift the load to other time windows in order to minimize impact or kind of curtail their polar ratings when they are charging.

So in this regard, we are looking for, you know, two kinds of data set. As of now one is specific operation data that can give us the charging time preferences, for example, the fleet owner can prescribe the, you know, the vehicles to be charged at a given time and, you know, and at different power ratings. So this activity data will be very useful for us to characterize charging activities.

And the second type of data as we progress into the Phase 2 project is geospatial information of those charging activities. Because we want to overlay the trip with geospatial information so we can know where, you know, where to place those different levels in a map. So from this regard, our travel demand model or, you know, realistic trips will be very important as additional input to heavy probe.

MR. ALEXANDER: Thanks, DY -- I mean, sorry, Bin.

Maybe we can go to Ria next.

MS. KOUTOU: Sure. Yeah. So one obstacle that we stumbled upon is that it's very difficult when conducting an economical assessment or financial analysis to find data pertinent to capital and installation cost of fast charging stations or any actual level from Level 2 onward. Because these vary a lot based on time and space and we would like to be able to capture the heterogeneity.

Now utilities and certain companies are willing to share data with us and there is some literature out there that has certain values but it would be really helpful to have a distribution of those so that we could more accurately model them.

MR. ALEXANDER: Thanks, Ria. Yeah, that's really data that would be really valuable to have.

Siobhan, can we go to you next?

MS. POWELL: Sure. So I guess what I'm thinking, these are great suggestions, these would all be great data sets to have. What I'm thinking of is modeling later adopters, it's something we talked about a little bit today. Our modeling depends a lot on charging data and observed choices and preferences and access to different charging types. And I think that's one of the challenges is as you move away from residential charging, having more data about how people choose between the other options that are available to them will make the models better.

So over time that will improve and we'll get more of that data and I think that will be really valuable.

MR. ALEXANDER: Thanks.

Can we move to Alan next?

MR. JENN: Yeah, sure. So I would say I think I'm very blessed with having good data sets. We get stuff directly from Uber and Lyft and so I'm not going to complain about that, I don't want them to take any of my data away.

I would say it would be very interesting, I think, to look at how these patterns have changed more recently. I mean, our data stretches through 2018, some 2019. But of course the coronavirus pandemic is definitely going to shake things up. And, yeah, I guess I'm not entirely sure, I don't think anyone is, about what sorts of long-term impacts those can have but at the very least we could get a sense of sort of bounding in terms of how they've affected some of the TNC platform demand and how that may ostensibly sort of downshift some of the demand projections that we're seeing from the models that we're projecting out to 2030.

MR. ALEXANDER: Great. Thanks.

And then lastly, can we go to Eric and then DY?

MR. WOOD: Sure. As we go farther down the list, all the -- all the good answers get taken so I have to get more creative.

You know, I think -- I'm going to piggyback a little bit on Alan and say that, you know, the kind of commercial probe data that -- that companies like, you know, Google, Apple have had access to track mobility in real time is something that could be really informative for the kind of work that we do.

I know there's a few different vendors for that kind of data but, you know, thinking about some of the behavioral responses to COVID that may or may not stick in the long term, having observability on those trends I think would be really informative for the kind of stuff we're doing with EVI-Pro. You know, thinking about how many, you know, working individuals are going to continue or return to commuting on a regular basis of work from home would persist beyond the, you know, the pandemic itself even say like in a post-vaccine world.

I'll step on DY's toes a little bit and say, you know, mode shift from air to long distance auto is another potentially really interesting shift that you might hypothesize as resulting from the pandemic. And so that kind of cellular GPS data I think could be really insightful.

MR. ALEXANDER: Awesome. Thank you.

And then last, but not least, DY.

MR. LEE: Yeah, I think that's great question.

I would just reiterate what I said during my presentation. I think to improve the model in the real-world. I think we really need high resolution reliable data for characterizing driving and charging behaviors. And I like to echo what Alan said that we also need to look at longitudinal evolution of these evolving market of charging stations and electric vehicles.

And then I also would like to emphasize that we -- most of our models and projects are looking at station design and we really don't know what's happening in real-world in terms of how companies design their stations or how they locate their stations strategically. Most of those information might be proprietary or private and not accessible to us, but that could be one of the things that I hope to get down the road.

MR. ALEXANDER: Thank you, DY.

So I believe that wraps up my time for questions with all of you. I think this was a really great discussion and an amazing set of presentations today that really highlight the cutting edge work that all of you are doing and helping us, you know, assess the needs that we will require to get to our 2030 goals.

So I'd like to turn it over now to Jonathan to read any questions that have come up in the Q&A. But thank you again for your time and presentations today.

MR. BOBADILLA: All right. Thank you, Matt.

UNKNOWN SPEAKER: Thanks for leading the discussion, Matt.

MR. BOBADILLA: And this question is directed to Ria.

In addition to operating costs, what is the break-even point in years for the EVSC provider when including the capital infrastructure cost such as equipment, electrical upgrades, and installation costs for high-use locations?

MS. KOUTOU: Sure. So we do the analysis in the ten-year standpoint, looking ahead. Right? So in order to calculate the finances over time, we look into the next ten years starting from 2018 and making assumptions on the years onward because this analysis was completed at that time frame.

It would be interesting to look into this tipping point. I would -- I would need to dive a little bit into my files in order to find that. But the assumption was that as we were moving to bigger and bigger stations with more ports, this will be facilitated there so that they can deal with the bigger and bigger demand.

So it was kind of -- the growth of demand was analogous to the growth of the station. And this is where we've seen operational compared to capital tradeoffs. For the smaller stations, this wasn't the case upfront but we -- this was based on the assumptions that we made. So I would -- yeah, I could get back to you with a little bit more of looking into my files for that.

MR. BOBADILLA: All right. Thank you, Ria.

And with that, I'll give it back to Heather.

MS. RAITT: All right. Thank you, Matt. And thank you, panelists, so much for your time and expertise today.

So we'll now move on to public comments. And so if you are online using Zoom, you can go ahead and press the raise hand icon if you are interested in making comments. And press star 9 if you're on the phone. And we ask that one person per organization comment -- or not more than one person.

And we have Rosemary Avalos from the Energy Commission's Public Advisor Office to host the public comment portion.

So go ahead, Rosemary. Thank you.

MS. AVALOS: Thank you, Heather. At this point, I don't see any raised hands. So again, for those on the phone a reminder to hit star 9 in order to raise your hand if you'd like to make a comment.

Leave it open for a few more seconds to see if anyone would like to provide comments.

Okay. Seeing there are no raised hands, I'll pass the meeting over to Commissioner Monahan.

COMMISSIONER MONAHAN: Well, I want to thank Matt Alexander, he did a great job organizing, facilitating these panels. And just thanks to all the panelists who are helping to inform our research. This is an ongoing project, make sure that we are doing all we can to characterize the charging needs to meet our 2030 goals.

So just appreciate everybody’s participation. And more to come as we start rolling out the actual 2021 analysis publicly.

So thanks, everybody, hope you have a good evening.

(Thereupon, the Hearing was adjourned at 4:13 p.m.)

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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 disinterested person, and was under my supervision thereafter transcribed into typewriting.

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