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CALIFORNIA ENERGY COMMISSION

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IEPR LEAD COMMISSION WORKSHOP

WARREN-ALQUIST STATE ENERGY BUILDING

ART ROSENFELD HEARING ROOM, FIRST FLOOR

1516 NINTH STREET

SACRAMENTO, CALIFORNIA

MONDAY, JULY 22, 2019

10:00 A.M.

Reported by:

Peter Petty

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ADVISER

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PRESENTERS

Matt Coldwell, California Energy Commission

Aniss Bahreinian, California Energy Commission

Gopal Duleep, H D Systems

Mark Palmere, California Energy Commission

Bob McBride, California Energy Commission

Marshall Miller, UC Davis

PUBLIC COMMENT

Glenn Choe, Toyota Motors North America, Inc.

Monterey Gardiner

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P R O C E E D I N G S

10:01 A.M.

SACRMENTO, CALIFORNIA, MONDAY, JULY 22, 2019

MS. RAITT: So good morning everybody. Welcome to today's 2019 IEPR Commissioner Workshop on the Preliminary Transportation Energy Demand Forecast.

I'm Heather Raitt, the Program Manager for the IEPR. I'll just quickly go over housekeeping items.

If there's an emergency, please follow staff through the doors, across the street to Roosevelt Park.

Also, please be aware that we are broadcasting this workshop through our WebEx conferencing system, and it's being recorded, so we'll post an audio recording on our website in a few weeks or a couple weeks, and a written transcript in about a month.

There will be an opportunity for public comment at the end of the day. You can fill out a blue card and give it to me and we'll call on you at the end of the day.

And for WebEx participants, you can use the raise-your-hand feature that WebEx provides. If you'd like to make a comment, that's how you let us know that you'd like to. And then using that same feature, you can also lower your hand if you choose to not make a comment.

And materials for the meeting are in the entrance to this hearing room, and also posted on our website.

And written comments are welcome and due August 5th.

So with that, I'll turn it over to the Commissioner.

VICE CHAIR SCOTT: Great. Thank you so much, Heather.

Good morning everyone and welcome. I'm delighted to be here for the Preliminary Transportation Energy Demand Forecast. I am Janea Scott. I am the Vice Chair of the Energy Commission and the Lead Commissioner for the 2019 Integrated Energy Policy Report.

As you all know, our transportation sector in California is responsible for about 40 percent of the greenhouse gases in the state, and about 80 percent of the smog-forming nitrogen oxides, and 90 percent of the diesel particulate matter. And it's a key component, of course, to the energy demand here in California. So making sure that we've characterized that appropriately, the importance of that can't be understated.

So I'm looking forward to hearing from the team what they are finding for transportation in this preliminary workshop. And then, of course, there will be additional steps where were refine, we get additional information, and we'll have a draft Transportation Energy Demand Forecast coming after this.

So that is all I have to say this morning.

I'd also like to welcome Jana, who is Commission Monahan's -- one of Commissioner Monahan's advisers and representing her here today.

MS. ROMERO: Great. Thank you so much, Commissioner Scott.

Commissioner Monahan is unable to be here today. But meeting with Staff on this topic, she asked me to read in a few words for her as opening remarks, so I will read her statement now.

"First, I want to express my appreciation for the work of the Energy Forecasting Team. They are clearly dedicated to ensuring the IEPR reflects sounds science and is analytically rigorous.

"I offer my comments in the interest of continuous improvement as we look for opportunities to refine and enhance the IEPR in the future. As technology and changing norms open the door to radical changes in mobility and goods movement, the IEPR should evaluate the range of potential emissions outcomes, both good and bad. I have recommendations, two recommendations for the future.

"First, the IEPR should account for the three revolutions of autonomy, electrification, and mobility as a service. These three revolutions could be very good for the climate or very bad. Analysts find that global warming pollution could more than double if autonomy leads to more internal combustion cars driving more miles. This is a terrible scenario that spells disaster for the climate. But on the other end of the spectrum, in the ideal scenario with autonomous vehicles that are shared and electric, emissions could fall by 90 percent.

"While our understanding of emissions impacts to the three revolutions is nascent and evolving, the potential for good and bad outcomes is undeniable. We should wrestle with these analytical challenges in the IEPR to help agencies plan for mobility, future mobility, and the potential range of energy requirements under different scenarios.

"Second, for medium- and heavy-duty vehicles, we should explore more aggressive scenarios for alternative fuel use, especially for battery-electric and fuel cell vehicles.

"One city in China, Shenzhen, already has more battery-electric trucks than the high scenario projects for 2030 for all of California.

"Given the air quality and public health impacts of diesel trucks and goods movements broadly, we should deepen our analytical understanding of the potential fleet of trucks in the future and how business decisions around fuel choice could be affected by the falling prices of batteries, fuel cells and alternative fuels.

"I look forward to working with the Energy Forecasting Unit on these and other analytic questions. It's an exciting time to work on clean transportation."

And thank you for giving me the opportunity to read in that statement. And she is really wishing that she could be here.

VICE CHAIR SCOTT: Great.

MS. RAITT: Great. So our first person is Matt Coldwell.

MR. COLDWELL: Good morning. Is this on? Oh, yeah.

Good morning, Vice Chair Scott.

Good morning, Jana.

So I was going to talk a little bit about some of the emerging needs that we have with forecasting the transportation sector, but I think I would -- all I really have to do is just echo what was already said up at the dais by the Vice Chair and by Commission Monahan through Jana.

We agree there's -- you know, this is a dynamic sector and there's lots of change happening. And, you know, we, or the unit, really, you know, does a really good job at keeping track of all of the emerging trends in the transportation sector and doing their best to incorporate that into the forecast. And so, really, I'm just going to take this opportunity to thank the unit for putting together the forecast this year, and their dedicated work. They worked a lot of overtime to put it together and to prepare the presentations for you all today.

And one other thing, if you'll indulge me for a second, so I can make a quick introduction?

So this team has been operating without a direct supervisor for quite some time. And, unfortunately, they've had to rely on me since I've been managing the office for the last six months. But I'm excited to finally -- that we got somebody into the supervisor position for this unit. And I just want to make a quick introduction, if I can?

So it's -- her name is Heidi Javanbakht. I hope I said your last name right. And so this is her very first day, so she's only been here for about an hour now, and so we're kind of throwing her into the fire this morning in terms of what the unit's doing. And so -- but this really will serve as a good opportunity for her to sort of learn what the team does and kind of get the ins and outs.

And so, really, that's all I wanted to say. So do you want me to -- okay, so I think Aniss is next on the agenda.

Do you want to come up, Aniss?

VICE CHAIR SCOTT: Thank you very much.

And I do must want to say, welcome to Heidi, we're glad to have you. Good morning.

(Pause)

MS. BAHREINIAN: Good morning, Commissioners. Sorry about that. Good morning, Commissioner, stakeholders. I'm pleased to be here and make presentation on -- and give a presentation of the forecast overview of the models, methods and scenarios. And I'll be followed by other staff members who are going to present light-duty and heavy-duty forecasts for us.

Can we move to the other slide? This is not working. So, yeah, that's it. Thank you.

So in this presentation, what I'm going to do is to give a brief presentation of the models, it's just an overview. I'm going to follow that by a discussion of the key inputs, key assumptions, and then scenarios in the forecast.

You have -- we have made this presentation before, although this slide is not exactly as it has been presented before. And my apologies to those people who have heard it already, but I tried to incorporate some new materials, so it's also new to some of you.

Notice here that this is the whole suite of models that we are using in generating the forecast. All of the oval shapes that you see in this graph are all the behavioral, and by that I mean the models that respond to the changes in prices, whether it is price of fuel, whether it is price of vehicles, or whether it is income, so these are the behavioral models.

The two models that you see that are in square shape, government, rental, and other/bus, these are more spreadsheet models, accounting models that not responsive to the prices or income, although the government vehicles do grow. The growth rate in those models are determined by the growth in GSP.

On the top layer you see all of the different inputs that we incorporate and use in these models. They look simple but it takes a ton of processing in order to generate these input data and make them fit the models. For instance, we have one staff who is completely dedicated to the vehicle stock, the DMV data, and his focus is on the DMV data. And he does a lot of work in order to get those numbers in the way that we want them to be.

Also notice that we have, on the left-hand side, we have the two models that we call them personal vehicle choice and commercial vehicle choice models. And these models are built from -- based on the data from the 2017 California Vehicle Survey. So we conduct a survey periodically to update our models and update our data. But the 2019 IEPR is based on our 2017 California Vehicle Survey.

The output from the personal vehicle choice model, which is essentially the residential demand for light-duty vehicles, that output is then fed into the urban and intercity travel demand models, these are short-distance and long-distance travel demand models. And then those models then determine the VMT and how much fuel is consumed by different classes of vehicles for all of the LDVs, as well as the transit vehicles and others.

The commercial vehicle choice model, however, is self-standing, that is the same model that is generating both the light-duty vehicle stock, as well as the fuel consumption and the VMT. The government and rental also contributes to the LDV fuel and -- LDV stock and fuel, so it is determining the VMT stock and fuel consumption in the same model.

The truck choice model is essentially the Argonne Truck 5 model that we are using in order to forecast penetration rates of different fuel types in truck classes, so that model is used for trucks. And those truck -- the penetration, those penetration rates from the truck choice model is then fed into the green oval right below it, which is the freight movement.

And then we have an aviation model that is generating jet fuel demand and it is for multiple classes of aircraft. Aviation model is -- the lead staff for aviation model is Jesse Gage. But because he was on jury duty, we don't have any forecast on aviation for you today.

And then we have the other/bus that accounts for all the other medium- and heavy-duty vehicles that are not included in any of the other models. So notice, the transit buses are in urban transit model and intercity model, but the school bus, for instance, is in this other bus model that we make sure to account for all of the medium- and heavy-duty buses.

So these models generate two sets of forecasts, one which is the vehicle population, so we forecast the vehicle population of both light-duty, as well as medium- and heavy-duty vehicles. And then we also use these models to generate the forecast of fuel consumption, which is essentially the main job that we have here. We have to forecast the fuel.

Notice, also, that the vehicle attributes are federal into this forecast in different light-duty and heavy-duty choice models. And they are very important to the choices between different fuel types, fuel and technology types. This is done, usually, by an outside contractor. And the regulator impact and the California goals are considered in this vehicle attribute forecast that has been generated.

On top of all these, we also have incentives that are going into both light-duty vehicle forecast, as well as medium- and heavy-duty trucks.

All of those models, we refer to them as personal and commercial vehicle choice models, but all of those models are choice models, one way or the other, and we are accounting for a wide array of choices.

In the light-duty vehicles, consumers, in our model, have a choice between 15 different classes of vehicles, size classes of vehicle, and 7 fuel and technology types for each of the 362 household types. In other words, we divide all of California's population into 362 different types of households with different household size, different number of workers, different income category, as well as different levels of ownership. We have seen over and over, for instance, that the households that have three vehicles, that own three or more vehicles, had a higher preference for ZEV vehicles than the households that have only one vehicle. All of these have impacts on the forecast that we are generating.

When it comes to the truck choice, the truck choice model has choices between eight classes of medium- and heavy-duty trucks and nine choices, again, between nine fuel and technology types.

I should note -- I should bring your attention to the fact that when we are talking about the choices, particularly between the ZEV vehicles, as well as compared to ICE vehicles, that these models are accounting for the substitution and the computation, not just between ZEVs and ICE vehicles, but also within the ZEV. In other words, PHEVs compete with BEVs and hydrogen vehicles compete with both of them. So this is this competition and substitution within ZEV and between ZEVs and other vehicles.

When it comes to short-distance travel demand model, that's also a choice model, except that these choices are choices between different travel modes. We have -- we give our consumers a choice between driving their own vehicles versus driving light rail or bus for people movement. And then it comes to truck. For the short-distance travel we only allow trucks.

However, when it comes to long-distance travels the commercial sector, the freight shipment industry, has a choice between truck and rail, so that choice is also accounted for in our long-distance travel. When it comes to long-distance travel for personal travel, we have a choice between personal automobiles versus air travel, rail and bus.

So you can see that in all of our models, we have choices all over the map. And the consumers are making choices between either different types of vehicles or between different modes of travel.

Our light-duty vehicle choice models are based on light-duty survey. We feel that with the changes in technology and with the changes in the population of the ZEV vehicles in California, with the fast growth in this area, we feel that the consumers are going to change their preferences. Consumer preferences will change. The more people are exposed to these vehicles, their consumer preferences will change over time.

In order to make sure that we capture these changed preferences, we periodically conduct a light-duty vehicle survey. And as we mentioned before, the 2019 IEPR Light-Duty Forecast is based on the 2019 California Vehicle Survey. However, the 2019 California Vehicle Survey is ongoing right now. The data collection phase of that survey has been completed in June. And we are in the process of building the new models throughout the rest of this year.

So the 2019 California Vehicle Survey results and models will be used in the 2021 IEPR. If we are fast enough, we may be able to get it for 2020 IEPR, but we have to see how that one works.

So what are the key inputs and outputs?

When it comes to the base year, we are populating our models with the vehicle stock. Our models -- our light-duty vehicle models have this feature of automatically calibrating the model to the stock of vehicles in 2017. So we have to feed the models with the 2017 stock vehicle -- light-duty vehicle stock for -- and so what we are using, we are using the DMV data. Jesse Gage, again, is doing the work. But we are also using the CARB's 2017 EMFAC and NTD. And, of course, staff does a whole bunch of analysis to get there. But for the heavy-duty vehicles, we use both our DMV data, as well as 2017 EMFAC, and NTD, of course, for the transit buses we use.

With the household type distribution, Mark Palmere does processing of the 2017 American Community Survey. We are looking at all of these different households. Remember, we talked about 362 households, those are the data that we have to derive from the 2017 American Community Survey.

When it comes to fuel consumption, Gordon Schremp, who is our Senior Fuel Specialist, he develops the total consumption of gasoline, diesel, E85, et cetera, are based on BOE (phonetic) data. However, that, too, in itself, has a lot of intricacies that people need to attend to, for instance, the difference between dyed diesel that is used in rail transportation versus regulation diesel that is used for trucks and light-duty vehicles on the road. So there really is a lot of work that goes into every single thing that we do here.

And another important part is the VMT. And for the different measures, metrics of VMT, we are using Caltrans data, the 2017 National Household Travel Survey, as well as 2017 CalY (phonetic). And, of course, our staff, Bob McBride, looks at all of these different sources in order to determine what the VMT should be.

When it comes to projecting the inputs, that is the inputs from 2018 to 2030, we use a lot of inputs. We use economic and demographic data, and those are mostly from Moody's, economy.com. Nancy Trans generate -- processes that data and provides that kind of data for us. And when it comes to population, we use the DOF, Department of Finance, data for population growth.

As for energy prices, our own staff are generating those forecasts, forecasts of fuel prices.

When it comes to electricity rates, we are considering both demand and supply.

When it comes to the petroleum fuel prices, we rely mostly on EIA data. And then we use the EIA data to come up with our own California gasoline/diesel/E85 prices.

For the vehicle attribute, we have been relying both on the contractors, as well as our staff. We have an outside contractor who is going to follow me in the presentation of the medium- and heavy-duty vehicle attributes.

As for the transit and school bus population, we are using CARB 2017 EMFAC. So we try to use as much as we can, the data that is used by other agencies, so that we are more consistent with other agencies. We use the regulations, CARB regulations, on transit electric buses, as well as, of course, the staff analysis of all of these data.

When it comes to freight analysis framework, again, Bob McBride is processing this Freight Analysis Framework 4.4 and uses that data in the freight model.

Vehicle attributes and incentives, for the light-duty vehicle, we have, as we said, 15 different size and class body and eight different fuel and technology types. But the number of attributes are quite substantial.

We have -- one of the attributes is vehicle prices which has been repeatedly confirmed, that has the most significant impact on consumers. We have the maintenance costs, the fuel cost per mile.

And we should also bring to your attention that when we had the fuel price forecast, we don't directly use the fuel prices, however, we use the fuel price combined with the MPG. And what is actually used in the model is the cost per mile, which has been repeatedly shown that electricity has the lowest cost per mile, and that is what we use in our model.

In addition to that, we use acceleration, refueling time, and, of course, time to fuel station which is an indicator of fuel infrastructure.

As for the incentives, we used the three statewide incentives, tax credits, state rebate, and HOV lane access. We do not account for regional incentives which are actually quite significant in some regions, essentially because the model doesn't allow us, not because we don't believe they have impact.

When it comes to medium- and heavy-duty vehicles, we have eight different size body classes, nine fuel technology types. However, we have a smaller number of vehicle attributes for the medium- and heavy-duty vehicles. We only consider vehicle price, fuel price, which is, again, reflected in the cost per mile, as well as MPG by range of operations for trucks only.

When it comes to incentives for the medium- and heavy-duty vehicles, we have the Heavy Vehicle Incentive Program, so we are using HVIP for that purpose.

What are the key assumptions?

Because our models do not allow us to regionalize the incentives or allocate the incentives according to income level, we are using the statewide incentives that apply to all households and commercial entities, regardless of income. So it doesn't matter if somebody's a millionaire or somebody has only $20,000, we give everybody an incentive in the model.

So to that extent, we are over-forecasting, somewhat, our demand for ZEV vehicles. Because if you look at the CVRP data, it shows that only 44 percent, about 44 or 45 percent of the households, or of those that who are buying ZEV vehicles, are actually receiving incentives.

On the other hand, we do not account for regional or local incentives. So by extension, that means that there are no regional or local incentives. And to that extent, then we are under-forecasting. So on the one hand you're over-forecasting, on the hand, we are under-forecasting, certainly at the regional levels.

These assumptions are really implicit in the model. It's because the way the models are using -- used and have been estimated in the past. However, in the 2019, we are planning to address those issues. And we are planning to introduce an income dimension into the incentives so that we can more accurately account for incentives.

We also make the assumption that all vehicles drive the same number of miles, regardless of their fuel type. So whether you have a BEV or PHEV or a hydrogen vehicle or gasoline vehicle or a hybrid, whatever car you have, all of them are driving the exact same number of miles. Now this might be, actually, over-forecasting transportation electricity consumption in the early years. But the fact of the matter is that market is moving in that direction. With the increase of range, people are capable of using their ZEV vehicles the same as they are using their ICE vehicles.

So we may be over-forecasting in the earlier years when it comes to transportation electricity consumption. But in the late years, we should be closer to what will actually happen. We believe that in the long run all of these ZEV vehicles are going to drive the same number of miles as all other vehicles would.

When it comes to electricity rates, we should say that we're using the average statewide residential electricity rates for the personal vehicle choice model for the residential sector, but we are using the commercial electricity rate, which is a little bit lower, for all of the other models.

I should also note here that we have not made use of the off-peak prices, off-peak electricity rates. We can, however, in the revised forecast certainly use the off-peak rates for our high scenario. Our model currently doesn't allow us to use two rates for the same scenario, so we have to run them one scenario at a time.

When it comes to petroleum fuel and vehicle prices, we are making the assumption that California does not impact those markets and those prices. With the way that we are using the fuel prices, with the way that we are generating the fuel forecast and the vehicle prices, California demand doesn't impact the prices but California demand is impacted by those prices.

It is realistic to say that petroleum fuel prices, as well as vehicle prices, are determined in the national and international markets, are affected by the national and international supplies. So if the price of vehicles, say in China, go down, it is reasonable to expect that the price of electric vehicles in the U.S. will eventually go down, to what rate, I don't know, but it is reasonable to expect that.

When it comes to electricity price, however, as we mentioned, we are impacted entirely by California supply and demand of electricity.

When it comes to the make and model of the vehicles, we should bring that to your attention that our model does not recognize make and model. So in other words, our consumers in our models do not care if they are buying a Tesla or a Ford or a Toyota, it doesn't matter the country of origin is Japan or China or U.S., because what we are using, we are using only classes of vehicles. So our forecast is actually class-based. We are forecasting by class of vehicle. In other words, we have a different forecast for every one of those 15 different classes of vehicles but not by make and model.

So to the extent that we have a Tesla, for instance, in the mix, then we are going to -- the attributes of that class of vehicle that is more similar to Tesla. So it doesn't have the name Tesla, but it does represent the attributes of a Tesla model.

Then we have a lot of uncertainties, of course. We have uncertainties about economic growth, as many of you know. For instance, the 2018 tax overhaul was based on the assumption that we are going to have a three percent economic growth sustained over the next ten years. Most economies do not agree with that. They don't believe that the three percent can be sustained in the long term, and our data provider, Moody's doesn't see that happening. So even in the high case, we don't have a three percent growth rate. And, of course, in the mid and low cases, we have even lower cases. Moody's believes that next year we will hit a recession. I was just reading this morning in the news that even Senator Warren is cautioning everybody about an economic crash. So to that extent, we are in line.

So our economic growth, we have different growth rates, however, they do not really reach the three percent. In Moody's, the only year when we are exceeding three percent is 2019 and that is in the high case. In all the other years the growth rate is below three percent.

Demographic dynamics are actually quite interesting because one of the other limitations of our models is that we do not account for age differences. We do not take that into consideration. And so as many of you know, millennials are believed to be behaving differently by most people. We think that millennials are going to behave differential. However, UC Davis' study has shown that millennials are more or less behaving in the same manner as their parents, although in the short time they may not have as many cars. But in the long term, when they have families, then they would end up buying cars, they would have to buy cars.

So there are these demographic dynamics that we are not accounting for. And there are a lot of questions about those. We don't know exactly what is going to happen in these areas.

When it comes to transportation energy prices, again, there are a ton of uncertainties there. We are talking about transportation fuel prices. So is there going to be a war in the Persian Gulf? Is it going to spread to the rest of the region? How long is the war going to last? And how much will it impact the fuel prices. There are a lot of questions, a lot of uncertainties.

When it comes to future vehicle technologies, of course, the talk is, as Commissioner Monahan mentioned, and the talk is about automated vehicles, are these automated vehicles going to increase the number of vehicles on the road or are they going to decrease the number of vehicles on the road? Are people going to be using and driving them more or less? We don't know. There are questions that we don't know. We have to look for answers in different places. And we will consider these in the future but we don't have all of the answers right now. Those are the things that we are planning to look into.

Another important factor is, well, what is going to happen to the shared ownership of vehicles? There is, obviously, all these conversations about share the ownership of vehicles, and some of these have to be ironed out.

I don't know how many of you have been following this, Mercedes Benz has, of course, some shared Mercedes Benz in Chicago. And I think last week they were reporting that about 75 of their vehicles that have been shared were actually stolen. And, obviously, this is going to impose a cost on Mercedes Company. And they may increase the membership fees. How high is this membership fee is going to go and how is it going to impact the shared economic? We don't know any of those. Those are all questions for the future.

Vehicle attributes, again, we have uncertainties, even in this area. If you have been following some of Bloomberg's most recent presentations, the battery prices can go down as low as $62.00. Others may disagree with them. And we had one of our workshops where there was disparity between different parties who were making presentations on those.

When it comes to transportation policies and standards, well, how are we going to pursue it? We don't know all of the policies and standards that are going to happen in the future. We only know what is going on right now. We don't know what will take place five years from now or six years from now or four years from now. And there are changes happening all the time. Clean vehicle incentive and funding, how much finding do we have? How long is it going to last? We don't know all the answers there.

So what we are going to do is in different scenarios that we have, we make different assumptions. This is our way of accounting for these uncertainties.

When it comes to trade policies, there is a ton of uncertainties. As many of you know, there is a trade war going on right now. How much will be the tariffs on automobile bills? We know that there are tariffs on steel and aluminum. How is that going to impact our vehicle prices? How is it going to impact exports of vehicles from the United States? All of these are unknown. I mean, there's a ton of uncertainties there.

So what do we do with these uncertainties?

Our answer is, all right, come up with different scenarios. And we try to comment combine these different factors into scenarios that are defining the best of the cases and the worst of the cases. But even with the best and the worst, you should always consider that our forecast, even the high and the low forecast, it can -- the actual values can go above the high and it can go below the low, so -- because of all these uncertainties, because of the things that we cannot account for.

So we have three demand cases, high demand, mid demand, and low demand. These are the scenarios that are used by all of the demand analysis office for all of the forecasting work that we do. Essentially, we have three key inputs into these scenarios and we account for those. One is the population growth, the other one is income growth, and, of course, a significant one are the fuel prices. In the high case, our population growth would be high, and it’s supposed to be mid and low would also be lower than the high case. However, we only have one population scenario from Department of Finance. So even though we are putting high, mid and low, high, mid and low are really all the same when it comes to population, essentially, because we only have one population forecast from Department of Finance.

One of the things that we do, however, we have two household population forecasts. And the difference between the two household population forecasts is really the household size. So if you have a larger household size the number of households is going to be different than if you have a smaller household size. So while we have the exact same population forecast, we do have two household forecasts that we use for forecasting light-duty vehicles.

When it comes to income growth, again, we're using Moody's, economy.com, Moody's is giving us three distinct scenarios, high, mid and low. However, even the difference between those are not very significant. For these reasons, you will see a lot of our forecasts are actually close to each other and we have to change the scale of the graph in order to make sure that it is clear to everybody what the differences are, that we do have three scenarios.

So because we are using the same population forecast and because our income scenarios are closer to each other than one would imagine, we have to change the scale of the different graphs in order to show the differences between the three different scenarios.

Finally, when it comes to fuel prices, notice on the top the title of this slide says it is electricity-centric. We designed these scenarios based on electricity demand. So when we are talking about the high demand we are talking about high electricity demand. When we are talking about the low demand we are talking about the low electricity demand. So in a high electricity demand world, then petroleum prices have to be very high. Notice the color change between the high and the low demand cases between petroleum prices and electricity, natural gas and hydrogen prices. Electricity, natural gas and hydrogen prices are low in the high demand case, while petroleum fuel prices are high. And the reverse happens in the low demand case with the high electricity, natural gas and hydrogen prices and low petroleum fuel prices.

Now the key, those -- that previous forecast, this one, as you are going to see when Mark Palmere is going to make his presentation on the light-duty vehicles, these different scenarios are going to impact the total fleet of -- or the total light-duty vehicle population or total vehicle population in general. Population and income are going to determine those, the total stock of light-duty and heavy-duty vehicles.

However, when it comes to the choices between different fuel types, that is when vehicle attributes and fuel prices are going to start playing their game. So we have to define different scenarios for PEVs so that we can differentiate between the high cases for electricity, the high -- the greater choices of the ZEVs versus ICE vehicles. So when it comes to the choices between ICE vehicles and ZEV vehicles, the vehicle attributes are playing the most important role, along with the fuel prices.

My colleague, Mark Palmere, is going to go over these in more detail. But I can also -- but I can only point out here is that if you look at the first line, we have consumers' preferences for PEVS, consumers' preferences for ZEVs in general. In the low case, we are saying that, well, we are going to stay where we are, so consumer preferences are not going to increase, so make the assumption that the consumer preferences are not going to increase at all, they're just going to stay where they are in 2017. However, in the other cases, we are growing the consumer preferences for PEVs and for ZEVs in general with the growth in market share. We have been doing this since 2017, but prior to 2017, essentially, we held a constant, but since 2017, we have been growing that.

Mark is going to talk about the rest of these attributes in his forecast but I wanted to bring this one to your attention.

Any questions, comments? I think this is the last one.

VICE CHAIR SCOTT: I do have a couple of --

MS. BAHREINIAN: Sure.

VICE CHAIR SCOTT: -- comments for you. This looks great. Thank you so much for the detailed overview of what everyone is looking at. I had a couple thoughts, maybe back on your slide 11, that I think are important.

I think we mentioned at the very beginning that we're working with sort of an older set of attributes --

MS. BAHREINIAN: Thank you.

VICE CHAIR SCOTT: -- that we're working to update. I think that's going to be really important as we go forward. And there's a lot more of the plugin electrics and fuel cell electrics and other technologies. That's going to keep going, I think, really fast.

MS. BAHREINIAN: Yes.

VICE CHAIR SCOTT: So we'll want to be able to update this to reflect that, or at least be able to kind of tease out the difference between what we have and where we are as we go along.

I'm really happy that we got the transportation, the electrified transportation set of the Demand Analysis Working Group members working together. I think that's incredibly important. So just in case any of them are listening, I want to make sure they know how important that is to us and how much we appreciate the input that they're adding there because, again, this is space that's changing pretty rapidly.

MS. BAHREINIAN: Absolutely.

VICE CHAIR SCOTT: And you mentioned the time-of-use rates or the off-peak rates that folks might be, for example, charging an electric car between midnight and 6:00 a.m., or something like that, and figuring out how we can start pulling that type of information in, I think, will be really useful.

And then we talked a little about updating some of these attributes, and maybe it's better for

Mark, and down at the refueling time and the time to station --

MS. BAHREINIAN: Yes.

VICE CHAIR SCOTT: -- to try to take into account the fact that if people are charging at home or if they're charging at work the time to station is probably zero --

MS. BAHREINIAN: Yes.

VICE CHAIR SCOTT: -- and just kind of figuring out how we tease out that nuance going forward, I think, is really important. And then if you're sitting at home, you're not as concerned, or sitting at work, probably, as the time to refuel.

MS. BAHREINIAN: Yes.

VICE CHAIR SCOTT: And so making sure we can determine how that impacts here, I think, is important. And you guys know that, as well, and I know you're working on it.

MS. BAHREINIAN: Thank you very much. Great ideas. What we can do is to actually generate scenarios that are doing exactly what you are mentioning right now.

VICE CHAIR SCOTT: Um-hmm.

MS. BAHREINIAN: In other words, with zero time to fuel station.

We should also bring your attention to -- if you look at the availability of PEVs --

VICE CHAIR SCOTT: Um-hmm.

MS. BAHREINIAN: -- while all of these scenarios low reference, high and aggressive, are based on our 2018 Attribute Forecast. If you look at the bookend, and we have been using H D Systems forecast of FCVs and PHVCs, PHVCs are plugin hybrid fuel cell vehicles that we include in our forecast, and you can see in Mark's presentation how the increase in the number of classes in PHVCs are offered is going to impact the forecast of FCVs in the future. And we have been saying this since 2013 IEPR, that the more classes these vehicles are introduced that the higher will be demand for these vehicles, any of them, whether it is BEV, PHEV or FCV. The demand will be higher if there are more classes of vehicles introduced in each of these.

Thank you very much.

Any other questions?

VICE CHAIR SCOTT: Thank you. Thank you very much.

MS. BAHREINIAN: Thank you.

MS. RAITT: Thanks Aniss.

So next we have K.G. Duleep from H D

Systems. And the presentation that we have today is a little bit different, I believe, than what is posted and what the Commissioner has -- oh, excuse me -- but we will get this revised one posted, hopefully today. Thanks.

MR. DULEEP: Thank you, Commissioners. Good morning. The revised version is actually just a slightly shortened version of this in the interest of time, so all the same facts, so there's really no major difference.

(Coughs.) Excuse me.

As Ms. Bahreinian mentioned, attribute forecasts are an input requirements to their models. And what vehicle attribute forecasts are essentially trying to do is model how auto manufacturers behave in trying to select what -- how much they should charge for their cars and what technology to put into. And so you can think of these as essentially representing a simulation of manufacturer behavior. And we've been providing such forecasts for the Energy Commission for a very long time. And we also do similar -- have done similar things for the Department of Energy. And, essentially, what we're trying to do is to provide these forecasts at the class and fuel levels that

Ms. Bahreinian described.

A few words on the methodology of forecasting.

In general, when manufacturers are asked to increase the fuel efficiency of their vehicles, they don't do that by making the vehicles smaller. What they're trying to do is incorporate more technology to provide consumers the attributes of the vehicles, that they want to keep those constant, and yet provide better fuel efficiency.

And so we are able to relate the costs of increased fuel economy because we know the cost of technology. And these costs of technology and the costs of improving fuel economy have been the subjects of major studies by, not only EPA and NHTSA, but also the National Academy of Sciences and the Department of Energy and so on. So we use all of these inputs to determine so-called supply curve, if you will, of technology and how that responds to changes.

The model is sensitive to two different kinds of scenarios. One is a free-market scenario where fuel economy is not regulated, which hasn't happened in years, in a while. But essentially what we find under that scenario is that manufacturers behave as though -- they introduce technologies that essentially pay for themselves in three years. So if they think that consumers will get the money back in three years and they put it in the car and it turns out there's kind of an average response time. And it's also quite similar to the three to four year loan period over which consumers pay back their new car loan. So if they can get their money back in fuel savings in three or four years, then they're willing to buy it. If it takes eight years, they are much less likely to buy it, and so the manufacturers won't put that on.

In a regulatory scenario, unfortunately, that is completely overturned because manufacturers have to meet the regulation, and so it changes the dynamic quite completely.

As you know, since 2008, the standards under the previous administration were first enforced. And we can see that in almost all the classes of vehicles, of light-duty vehicles, fuel economy has been going up almost like a straight line. And that -- and over this period, of course, we saw tremendous changes in fuel price. If you remember, it went to $120 a barrel, back down to $30, but fuel economy just had a continuous upward march, and that's largely because they're completely standards driven. And if you assume that the Obama standards will hold through 2025, depending on what happens this year, then we also expect that this trend will continue and that, in fact, it becomes almost insensitive to fuel prices and consumer demand because manufacturers have their feet held to the fire, if you will.

So the other issue is, you can -- you know, all of these are technologies, including electrification, but most technologies for improving conventional cars are not visible to the average consumer, exports ignored, but most cars, people don't know how many gears they have in their automatic transmission, or many people don't even know how many cylinders they have in their engine. So, basically, what we find is that manufacturers make those kinds of decisions. But when it comes to highly visible technologies, like electrification, then the consumer plays a much more active role.

So part of the split that we have among fuel types is what's visible and what's not, and that also determines what technologies are separated out as something chosen by the consumer choice models, as opposed to a manufacturer simulation model.

Another fact was that from 1990 to about 2010, the vehicle performance rose enormously, so horsepower rate was going up at a tremendous rate. And it’s shocking to think that a Corvette from 1990 had less horsepower than what you can get in a Honda Accord today. So -- but, interestingly, since 2010, the Obama standards came in, that’s completely gone away, that, in fact, performance has almost been flat since that point, although flat at a fairly high level of performance.

I know the importance of electric vehicles, and you have stressed that Commissioner. And the relationship to battery cost is, of course, very significant. And we have seen lots of press reports about what -- how much Tesla pays today and what it might cost tomorrow. Some of these we take with a grain of salt because they are from people who have a vested interest in it.

What we try and follow are studies that have -- that are technologically based on what influence can be conducted. And the one that we do use for our model is the Argonne National Labs Battery Pack Model that has also been used by ARB and has been used by EPA, and so on, trying to determine where costs could go in the next 10 or 15 years.

And the other aspect is what exactly is battery cost? Because, obviously, when you install a battery in a vehicle, you've got to do a bunch of other things. You have to cool the battery. You have to protect it from crashes and so on. So there's some in-car costs that are not accounted for in some of these statements. So the all-in cost is somewhat different than what you see in the popular literature.

Lastly, of course, is that you can size the battery to get a particular range. And that, as Ms. Bahreinian described, has been changing rapidly. We're seeing 200 miles becoming quite common now, some getting more than 300 miles. But we also see the emergence of a smaller urban-type vehicle with 100, 120 mile range that, we expect, will be coming out in the next few years. And those might be sort of a low-cost end for some parts of the market.

VICE CHAIR SCOTT: Just a quick clarifying question on your previous slide there. The second bullet, it mentions the press is saying what they think the battery costs are. Just to clarify, when they're -- on those, they're talking about that entire automotive battery, which includes the battery monitoring, battery cooling or -- okay, just we're comparing apples to apples?

MR. DULEEP: Like, typically, the press does not include the in-car costs, if you will.

VICE CHAIR SCOTT: Okay.

MR. DULEEP: So this would be sort of what the manufacturer might pay Panasonic or Samsung to buy a battery from them.

VICE CHAIR SCOTT: Um-hmm.

MR. DULEEP: But they may not include some of the costs, like for installation in a vehicle.

VICE CHAIR SCOTT: Okay. So when you say, up in your first bullet, an entire automotive battery, the second bullet isn't actually the entire automotive battery because it doesn't have a couple of those components in it?

MR. DULEEP: Because the press reports, they're also, sometimes, very unclear about --

VICE CHAIR SCOTT: Yeah.

MR. DULEEP: -- exactly what they are including and excluding, so we have to read between the lines on some of these things.

COMMISSIONER SCOTT: Um-hmm.

MR. DULEEP: But, yes, you're right, the all-in cost is somewhat different than usually what's quoted in the press.

VICE CHAIR SCOTT: Got it. Thanks.

MR. DULEEP: And as I mentioned to you, Bloomberg, UBS, and so on, have done that. We've used the BatPac model. Our review suggests that Tesla/Panasonic is probably the most efficient producers in the world today, just because they have very high volumes and they have the scale, economies of scale. And that looks like a battery cost coming out of the factory, again, not the installed or net cost of about, something in the range of $180 per kilowatt hour, but the net cost in the vehicle is probably closer to $210. That's from the financial analysis of Tesla's costs and so on. And so when we look at what the Argonne National Lab's BatPac model suggests, they suggest that the production costs will go down to about $160 in 2020. And then if you add sort of the profit of the battery manufacturer and the in-car costs, that's like equivalent to about $180. And based on that, we also go down further to 2030, based on both optimistic and pessimistic learning curves.

So this is sort of the cost range. The low-cost version gets down -- and these are total in-car costs, so not just the battery cost -- they get down to about, just close to $90, and the high end is at about $140. So that's kind of the range that we foresee for the in-car installed cost.

The second aspect of electric vehicle is the range. How do we decide what range they're going to be in the future? And, of course, economics tells us that increasing the price of the vehicle by putting in more battery makes it less attractive, but increasing the range makes it more attractive, so, obviously, there's a balance between the two. And that's what that little equation down there, if you remember your high school calculus, does. The only problem, of course, if that we don't know what the value of range is quite yet. And that seems to be itself, changing. And it could be a function of the range itself. Well, we know it's a function of the range because, obviously, once you get beyond 400 miles there's not a lot of added value to more range beyond that.

So what we try and do is to use this more as a sort of directional indicator of how to allocate range and cost, rather than an absolute solution. And, as I said, they expect the small car class will have a range of 100 miles or so, and the larger classes will get 250 and 300, or maybe up to 350 for the most expensive cars on the road.

The example of mid-size cars right here is we expect to see hybrid vehicles with a narrowing price differential. The price of conventional vehicles to meet the Obama standards is about $1,500 relative to the 2016 baseline. And we also expect PHEV range to get to about 50 miles on average, up from about 25 now, so that they maximize their ZEV credits. And the price increment will still be relatively high but declining rapidly, and BEVs will fall in cost.

So this issue of the crossover between BEV cost and conventional vehicle cost has also been discussed a lot in the press. But that, of course, depends on the range of the vehicle because if you make the -- if you put in a lot of battery to make the range more, then the cost is higher. But if range is maintained under 200 miles, we think the BEV cost will be very competitive with that of a conventional vehicle.

Heavy-duty vehicles is, again, I think as Ms. Bahreinian mentioned, there are a lot of classes that are being asked to model. And here again, much like the light-duty classes, there is a greenhouse gas regulation on heavy-duty vehicles. And so those have not changed under the new administration, so many of the modeling assumptions we used for the 2017 IEPR are being reused at this time.

One of the biggest issues has been the issue of well-defined baseline. And we've used multiple sources of information to get a baseline fuel economy because truck fuel economies are not measured or published the same way that car fuel economies are.

And we reexamined, essentially, the emergence of electric trucks in this forecast.

Just to give you an idea of the complexity, I know it's a busy slide, here's a list of all the classes and fuels we look at. Gasoline and diesel, of course, are common.

Another factor that I would like to mention in the heavy-duty market that's somewhat unique to the heavy-duty market is that many of the alternative fuel types are supplied by aftermarket suppliers. So the A in this graph refers to aftermarket, whereas the O is original equipment, like you'd buy it off a showroom. And CNG and our -- it's a typical example of an aftermarket installation where you might go to a supplier to get that from-- installed after you purchase the main truck from a manufacturer. Hydraulic hybrids are another example of these types of situations.

And I think the reason that we split it into these is that many of these aftermarket and pilot-production vehicles tend to be very low volume, and so they don't have the economies of scale and so the cost per vehicle tends to be quite high.

VICE CHAIR SCOTT: What's your dividing line between kind of the OEM and pilot production? And what makes me ask that is like when I look at the transit buses, so in the U.S., you know, or California, we only have about 158 or something like that on the roads, but as you mentioned and Commissioner Monahan's remarks, there's 16,000 buses in Shenzhen, China, just one city alone.

And so what level do you have to be at to go from sort of pilot back up into OEM?

MR. DULEEP: Typically, in the heavy-duty truck market a typical model, a diesel engine model has an annual production of about 20,000 per year or 24,000 per year for national sales. Aftermarket, they tend to leave things that go below 2,000 to the aftermarket. It doesn't make sense for them to be in a market that's that small for the OEMs.

And pilot production is something where they think that the market might appear in the future. And so they may be building at about 1,000 a year rate or 1,500 a year rate, and so that would be a pilot production rate.

As I mentioned, there are requirements for greenhouse gas emissions for heavy-duty trucks. And that, the Class 8 long haul vehicles, have the most stringent requirements. They're required to increase fuel consumption -- or reduce fuel consumption by 19 to 25 percent, depending on the tuck, by 2027. And a lot of that is from the aerodynamics of the truck because a very large amount of energy goes into overcoming drag.

Medium-duty trucks and urban and multipurpose trucks are somewhat lower at 15 to 20 percent improvement in the same period. And urban buses and vocational vehicles have the lowest requirement. So those essentially drive the technologies in that particular market.

We've looked at some of the alternative fuel types that have been specified to us. And CNG and LNG trucks, of course, have been around for a long time. But sadly, there's only one major player in this market, which is Westport, and they are supplying most of the engines. And most engines, so the CNG/LNG sold from the heavy-duty market, use spark ignition. And those are about 15 percent less efficient than the diesel model that they replace on an energy basis, not on a fuel-cost-per-mile basis because natural gas will be a different cost per unit of energy than diesel.

There's also a new system that Westport has come up with that is a dual-fuel system that uses diesel to get the combustion going but uses natural gas, but that system's quite expensive and so far we haven't seen a big impact in the market yet. So since these things have been around for such a long time and the lack of a large supplier base, we've continued this as an aftermarket-type vehicle.

Electric and hybrid trucks have been emerging. And right now there are several models of Class 4 and 5, which are the light, heavy and medium classes of trucks. Tesla has, of course, shown a big tractor for 2021 and these have been included in our forecast.

The one major factor for electric trucks is that the batteries, if they're using large batteries, the batteries have to be able to supply high power continuously, unlike that in a car. And because of that, they're much more expensive per kilowatt hour of energy. And we've received inputs from some battery manufacturers and truck manufacturers that, per kilowatt hour of energy, they're about 40 percent more expensive, just because of the very high power requirements imposed by trucks in the duty cycle.

And similarly, electric motor and controller costs also are must higher, simply because you have to run very high power much of the time, rather than just with the short accelerations for light duty.

In this particular forecast, we've also tried to include catenary trucks and fuel cell trucks. And catenary trucks, of course, run off an overhead wire, but they also have a battery so that they can go fairly short distances off the catenary, so for the last mile of delivery or something like that. And fuel cell trucks and buses are also there but, similar to batteries, the fuel cells have to run at very high power, so they have some cost disadvantages that are hard to overcome.

And we have looked at a study by UC Davis on this issue and we modified it slightly to come up with the prices of these trucks. And here's an example of a computation for a Class 8 day cab, which means sort of a short haul, a 200 to 300 mile haul-type truck. You can see, the diesel truck is about $125,000. And the catenary comes, actually, pretty close to the price. So if you look at cost per mile, it's much lower than that of a diesel, and so that may be very competitive. The fuel cell is still significantly higher.

And the battery-electric, of course, is the highest cost at this point simply because the amount of batteries that you need is enormous. And the weight of the batteries then detracts from the payload that the truck can carry. And so because of that effect, we have -- we have found that at current battery prices, these would be -- the battery-electric would be still quite, quite expensive. Now, of course, by 2030, we anticipate that will change significantly.

So in our forecasts we, coinciding with the three scenarios that Ms. Bahreinian described, we have battery prices, also, to go with those three scenarios, as I mentioned. And we anticipate that the continuation of the Obama standards are used in two of the three scenarios. And in the third scenario we have the Trump standards put in. And so what we find, of course, is that for light-duty vehicles, because the Obama standards are so strong, that all the rest of the stuff doesn't matter. If you have to meet that standard, that controls what happens to vehicles. And that's also quite similar to the case for heavy-duty.

And as I mentioned, we don't expect natural gas vehicle costs to change very much relative to diesel. We expect some decline because we assume it's a low-volume product.

And then we also -- and one change in the assumption that EPA has used is that they have fairly high numbers for aero drag reduction. But California highways are so crowded nowadays that the traffic speeds don't get you the full benefit of aero drag, and so we've reduced that, especially for the Class 8 long haul.

And I guess what we find for heavy-duty trucks in Class 3 and 4, they will increase, the fuel economy increase by 25 to 29 percent for a cost of about $1,500. And for medium-duty trucks that operate on mixed roads, you get a somewhat lower increase for about $3,200. And then vehicles that operate mostly like garbage trucks, urban buses, relatively small fuel economy improvements over the period of 9 to 12 percent.

And long-haul trucks, of course, we anticipate will see the largest improvements but the cost increases are quite high at about $9,500. This is consistent with what EPA has projected and DOT has projected. And one issue that Ms. Bahreinian also mentioned is that all of these things are competing with each other. So as gasoline and diesel vehicles become more efficient, the effect on electric vehicles is felt, so some of the efficiency changes. Because electric vehicles are already very efficient, they don't have much more room to grow. So as that margin shrinks we expect some better or a more competitive market from that issue. And we expect the spark ignition CNG vehicles to be somewhat more competitive as emission control costs for diesel has become much more challenging.

And that's the end of my presentation. I'd be happy to take any other questions that you may have.

VICE CHAIR SCOTT: Thank you. I asked mine as we went along.

Do you have any others? Okay. Great.

Thank you so much.

MR. DULEEP: Thank you.

MS. RAITT: Great.

So next, we have Mark Palmere from the Energy Commission.

MR. PALMERE: Good morning, Vice Chair, Jana, stakeholders, and everyone else in attendance. My name is Mark Palmere and I work on the Light-Duty Vehicle Demand Forecast as part of our overall transportation demand model. So today, I'm going to tell you a little bit about our findings and a summary of the results of the preliminary forecast.

To start with, let's take a look at some historical data. This is a graph of historical new ZEV sales in the state of California. As you can see, it has been rising quite dramatically, especially in the battery-electric sector. PHEVs are also rising but not quite as much. And then fuel cells are also increasing but at a lower level. Overall, ZEV sales surpassed 100,000 for the first time in 2018.

And this is another way of looking at that data as a way of the share of the overall light-duty vehicle sales statewide. So you can see, back in 2011, 2010, under one percent of total sales were ZEVS, and they have been increasing. And by 2018, the most recent full year, they reached eight percent of overall light-duty sales.

Now I'd like to take a closer look at the ZEV sales and break them down. These are specifically PEV sales, so not hydrogen but just BEV and PHEV. This is also historical and it just compares the ratio of sales of BEVs to sales of PHEVs. Early on with the introduction of the Chevy Volt, PHEVs were outselling BEVs by, in 2012, by a ratio of two-to-one. And they were still outselling them up until about 2014. But as you can see, gradually, BEVs have begun to overtake ZEVS and by 2018 have reached about 60 percent of PEV sales. And this is something that I'm going to come back to and show how the BEV-PHEV ratio looks in our forecast of future years but that's definitely something we take into account, BEVs versus PHEVs and which ones are more popular, because they do have different attributes and different benefits.

And speaking of attributes, this is a slide that sort of summarizes the vehicle attributes that we use. There's, obviously, a whole slate of them and they are weighted by importance based on the results of the consumer preferences survey of the California Vehicle Survey. And the attributes are, you know, used in those decisions and do account for regulatory requirements. The attributes are projected through 2030 and include that list, as you can see, range, price, fuel economy, acceleration, number of models, refueling time, maintenance cost, and cargo capacity. And from the survey, we have determined, consistently determined, that price is the most important to people. Range and fuel economy are also very important. But we do take into account all of them and their degree of importance.

And now I'd like to get to the overall results. This is total light-duty vehicle population, all fuel types, ICEs, alternative fuel vehicles, every light-duty vehicle. And right now we have about -- a little over 30 million LDVs on the road. By 2030, we are projecting somewhere between 34 and 36 million. And this is based on population and income, which are the biggest drivers of overall light-duty vehicle sales.

The attributes sort of effect what type of vehicle people are going to buy. But it's population and income, we have found, that affect how many vehicles are going to be on the road. And we get our population and income data from Moody's, as well as the U.S. Department of Finance.

And in the low case where we're predicting -- projecting lower population and income increases, it's a little under 35 million, whereas in the high case, which is the highest population and income numbers, it is over 35 million, closer to 36 million.

And this is a way of looking at that same graph, but this is just for the high case, but it's looking at it by fuel type. And as you can see, there's the -- in 2030 it is, as I said, a little over 35 million. But if you look at how it breaks down, the gasoline population is really not increasing throughout the forecast. It's pretty steady at around 27 million or so. And that's because, you can see, the red area is battery-electric vehicles which go from just a few hundred thousand to in the millions. We're going to look a little closer at that later but you can see that big increase accounts for a great percentage of the overall light-duty vehicle increase.

Similarly, PHEVs are also showing an increase. And hybrids and flex-fuel vehicles are staying pretty constant but still contribute to the alternative fuel portion of that chart. And it's the reason why there are no more gasoline vehicles in our high case in 2030 than there are this year.

And this table will probably look familiar because Aniss showed it, as well, but I want to talk a little bit more about some of the attributes and incentives. She went over preferences. But for incentives, we have the federal tax credit, as well as the state rebate and HOV lane access. And some of the issues with forecasting that is, we don't know, how long are these incentives going to exist? So we have to kind of project when it's most likely that they will expire.

And so we have, the reference case, we have the state rebate going until 2025 which, we think, is kind of a reasonable time when it will become, you know, very expensive for the state, given the high penetration of PEVs. But, obviously, we don't know that for a fact, which is why, in our aggressive and bookend case, we have it going through the entire length of the forecast. That would indicate more government policy in favor of PEVs which is what those cases are supposed to represent.

For the federal tax credit, since, as Aniss mentioned, we don't talk about it by make or model, we don't forecast by make or model, it's kind of a little difficult for that because the federal tax credit has expired for Tesla and GM this year, whereas in the other makes it's still $7,500. So we kind of do an average of what's the average tax credit that someone will receive, not knowing what make they're buying. And that will be decreasing because right now it's those two manufacturers, but a few of the other manufacturers, by the end of the forecast, we're projecting, will have also met it so it'll be a little less than average.

The attributes for the vehicles themselves, the number of models available is, obviously, higher in the high and aggressive case for BEVs and

PHEVs. Aniss mentioned the bookend case are Duleep's attributes where he has a lot more vehicles available in the fuel cell and plug-in hydrogen fuel cell vehicle fuel types. Battery prices, you can see there, anywhere from $120 per kilowatt in the low case to $70 in the aggressive and bookend case. And then range is, obviously, higher in the higher cases. And we talked a little bit -- Vice Chair Scott asked about the refueling time and time to station, this is what we have now. But, yeah, it's something we're working on, trying to see what we can do about the fact that EV charging is unique and very different from gasoline charging and that it's something you can do at home and it's something that, if you do it at night, it can be the equivalent of zero minutes because you just plug it in and don't worry about it until you need it again.

And the last row is our actual ZEV population numbers in 2030. And you can see, in the next chart, they range from 2.7 million in the low case to 4.5 million in the high case, and 5.6 million the aggressive and bookend cases. And, obviously, that's a pretty wide range and it kind of takes into account a lot of uncertainty in technology that's still quite new. But the reference case is usually the one that we have the most confidence in and it's over 3.5 million in this case because we definitely think, looking at the attributes, there's a lot of reason to think that ZEVs will see a large increase based on the trends, the attributes and the consumer preferences.

The black line is historical. So you can see, you can definitely notice, back in 2011, when it was introduced that it's certainly increasing exponentially. But we think that that will continue, at least in the -- at least, definitely, in the higher cases.

VICE CHAIR SCOTT: Mark, do you have the ability to tease out which of the attributes on the slide before or which of the incentives or different things are making -- which ones are the most effective in increasing the number of vehicles?

MR. PALMERE: Yeah, definitely. Our model works where we put our attribute input, so each attribute is input separately. So we're able to conduct tests with that where we can add, you know, increase the incentive by -- you know, we can double the incentive and see, how does that change it? So we can change, you know, one attribute at a time and see what sort of effect that has. So, yeah, we definitely have, not in this deck, but we have done experiments like that where we increase -- or increase every attribute by ten percent and see, like separately, and see how -- what an effect that has, and it has like a chart like that. And, yeah, so that's where we found that price is the most important and the incentives and range and fuel economy tend to be the next important, most important ones. But, yeah, that's definitely something we can do with our model.

VICE CHAIR SCOTT: Great. Thanks.

MR. PALMERE: And then this chart is very similar. It's the PEV stock forecast, which is the ZEVs minus the fuel cell vehicles. And it's a little bit lower. We're going to look at the hydrogen later. And it's a couple hundred thousand, so this just shows that the PEVs make up a vast majority of the ZEV population.

And as I mentioned, we do look at the specific fuel types within the PEVs, BEVs versus PHEVs. And right now on the road there's about a little under 60 percent of PEVs are battery-electric. But based on the attributes and based on the trends and where people's preferences are going and who is introducing new BEVs, we feel confident in this forecast that it will become a greater share of BEVs to PHEVS. In our mid case we have, of PEVs, over two-thirds are going to be BEVs in our model.

And then, as I mentioned, the fuel cell vehicles. This is the chart of just fuel cell vehicles. And, you know, right now there are a couple several thousand on the road. But even in our low case we see that number surpassing 100,000 by 2030. And in the aggressive case, it nears 200,000.

The bookend case, as Aniss mentioned, this is with Mr. Duleep's increased number of models available in FCV and plugin FCV classes, so that's why we see a lot more, over 300,000, because if the models are available then it's something that people will be a lot more likely to buy when they have a lot more choices because, you know, right now there are only three different FCV models available. But in the -- even in the highest cases where we have several more available we think that, you know, that's one of the big barriers right now, is class availability. So you can see the numbers are a lot higher in 2030 compared to where they are right now because it's a, you know, growing technology.

And that concludes my presentation. If anyone has comments or questions, I'm happy to take them now.

VICE CHAIR SCOTT: Great. Well, I asked mine as we went along. Okay. We are good. Thank you so much.

MR. PALMERE: Thank you.

MS. RAITT: Thanks.

Next is Bob McBride from the Energy Commission.

MR. MCBRIDE: Good day, Commissioner Scott, Adviser Romero, stakeholders, all participants. I'm Bob McBride of the Transportation Energy Forecasting Unit here to share to the preliminary forecast for medium-duty and heavy-duty vehicles, including their movement and energy consumption.

Let's see. That works. Good.

After a general description of the vehicles over 10,000 pounds, which is medium- and heavy-duty, I'll cover major changes in our data sources, also some key inputs and assumptions. Then we'll try and wrap our heads around how much larger the freight trucks are than an automobile as sort of a break between the hard stuff. Next, we go over results and model outputs at the center of our forecast. And finally, pose our first thoughts about how this forecast can be improved for the revised forecast in the fall.

Here's a nice summary of these vehicle types from the EPA Vehicle Technology Office. Look to the Department of Transportation version of this if you're inclined to count axles, which they do. It shows what they weight this year and what the common ones look like. Oh, and GVWR means gross vehicle weight rating in Classes 1 through 8, representing the legal maximum for each loaded weight.

Here's the population of conventional fuel medium and heavies: over 400,000 Class 3 to 6 trucks, that's medium-duty between 10,000 and 26,000 pounds gross; 200,000 heavy-heavy-duty tractor-trailers, also called combinations of semis; upward of 100,000 heavy-duty single-unit trucks -- hold on here -- these are also called straight trucks, and that means straight as opposed to the articulated tractor-trailers; well over

100,000 mobile homes; significant numbers of school buses, urban transit buses, shuttle buses, garbage and recycling trucks. Of the medium and heavy fleet in 2017, our base year, locally, natural gas transit buses and garbage or recycling trucks may be in the majority for their class, which we'll look at here.

Turning to the alternative fuels, we see about 6,500 natural gas transit buses and over 5,000 each for natural gas garbage or recycling trucks and natural gas school buses. Diesel hybrids have a good foothold in medium duty and some school and transit buses, and also in some heavy-duty straight trucks. ZEV trucks appear in meaningful numbers in medium-duty trucks with some school buses and catenary transit buses. Over 2,000 propane vehicles are mostly school buses and medium-duty trucks.

From the start of -- am I on the right slide? It says six. Oh, okay, I'm good.

From the start of 2020, purpose of transit buses with internal combustion engines must be low NOx, natural gas. In 2023, successively higher percentages of transit bus purchases must be ZEBs, zero-emission buses, up to 100 percent starting in

2029.

Here's our preliminary transit bus forecast. All three scenarios fully comply with the Innovative Clean Transit Regulations that CARB has. The blue mid scenario assumes that buses are retired as usual and that new purchases include no more than the minimum number of ZEV buses required to comply with the ICT. The green high scenario simply assumes more ZEV buses are purchased than are needed to comply. The red low scenario assumes that transit agencies accelerate the retirement of existing buses in order to increase the number of buses purchased before the ZEV requirements take effect. This should have the effect of delaying the purchase of the ZEV buses.

VICE CHAIR SCOTT: Hey, Bob, I have a quick question for you on that last slide, number seven. Do we incorporate, also, the total cost of ownership of the buses? And the reason I ask that is that we've heard folks like BYD and Proterra and others say that the total cost of ownership of electric bus is the same as a diesel bus today. So between the regulations and maybe if that comes down a little, does that change our higher mid case?

MR. MCBRIDE: Well --

VICE CHAIR SCOTT: Is that in there?

MR. MCBRIDE: -- you're absolutely right, Commissioner, and that's built in. The transit agencies will buy buses, mostly by grants, federal grants, and they are stuck with the operation cost, so that does make the ZEV attractive by itself.

But we don't model these on a cost basis for that very reason. They're not bought on a cost basis. They're bought by what you can get the grant for.

VICE CHAIR SCOTT: Okay. Thanks.

MR. MCBRIDE: Sure. I'm going to start at -- yeah, I didn't start it. Okay. Slide A. Good.

No regulatory requirement or target specifies electrification for school buses. However, a number of incentive programs can support or accelerate growth in battery-electric school bus numbers. Purchases still mostly rely on what's called the Local Control Funding Formula, administered by California Department of Education. Other national, state and local programs, at least listed here, can also help with funds. Most of the programs shown here are targeted to various alternative fuels. The Energy Commission's School

Bus Replacement Program this month made awards of $70 million to replace at least 200 older diesel buses with new battery-electric buses.

This is a snapshot of the vintages of school buses present in the 2017 population, and this is taken from the ARB EMFAC model, EMFAC 2017. It also roughly shows the rather variable pattern of bus purchases in historic years, less the retirements that have happened. Year to year, these purchases can more than double or be cut by more than half, so odd pattern there.

In Fall 2017 to Spring 2018 school year, more than 6 million students attended school in California. State law leaves the County Board of Education or school district to decide if home-to-school transportation is required. Federal law does require providing transportation to students with disabilities and homeless students. Given around 25,000 buses and a small number of routes per bus, we can infer that the majority of students walked, biked or got a ride in vehicles other than a school bus. We see a low rate of school buses per student in California as compared to the nation. This may be due, in part at least, to the greater proportion of students in California, that's 70 percent, that live within two miles of a school as compared to 50 percent living within two miles nationally.

School buses are usually medium-duty vehicles but both light- and heavy-duty versions exist. On the right side you see our single scenario for zero-emission school buses. That's somewhere around ten percent of school bus stock by 2030.

California Air Resources Board Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project, H-V-I-P or HVIP, provides voucher funds for both buses and trucks.

Now we turn to trucks. For our truck choice models, we reviewed the voucher funding from 2010 to 2018 to project into the future the voucher as a percent of the truck's incremental purchase price. Okay. So for natural gas, diesel hybrids and battery-electric trucks, incremental price is the purchase price minus the price of the least expensive conventional fuel type in each class. So if [the lowest cost truck is] gasoline, then it's one. If it's diesel, it's another. We project HVIP voucher funding fixed at the current percent of the incremental price through 2030 in the high demand case. Also, both low and mid cases follow this pattern through 2022.

From 2023 to 2030 the mid case reduces funding by just 10 percent to 90 percent of the current levels. For the low demand case the voucher funding is eliminated after 2023. That's not a prognostication. That's just a test so you can see what the impact of the vouchers are.

Yeah, we're in the texty part here, so bear with me.

Mr. Gopal Duleep has presented attributes for all vehicles, but I touch on the medium and heavies a little later in this presentation.

The Highway Administration creates periodic goods movement forecast datasets called the freight analysis framework by [travel] mode and within and between six California zones and elsewhere in North America. In 2017, we used version 4.3, and now we've updated to version 4.4, a new forecast. After 2002 the census discontinued their periodic Vehicle Inventory and Use Survey. Caltrans stepped up and funded the 2017 California Vehicle Inventory and Use Survey that we call CalVIUS. Working with Caltrans on this was both the CARB Mobile Source Division and our own Transportation Energy

Forecasting Unit; look for both of us to be making use of this data.

Most important is the pattern of annual vehicle miles for trucks in different classes as they age, shown in a later slide.

The thing about this data is it allows me to populate the market data sheet in our truck choice models in 42 slices, representing vehicle mile intervals, counts of trucks and their cumulative miles. The Argonne truck model, which was used for truck choice, calculates a market share for each fuel type of purchased new trucks for each of these 42 slices and then aggregates them up.

We use the NHTSA EPA Phase 2 Regulation fuel efficiency gains over the forecast period as a trend to extend the historic data in the CARB Mobile Source Division’s EMFAC 2017 model. This is because the attribute fuel economies were based on particular duty cycles. And we were looking at the total VMT through the state and the total diesel consumption and we only got there by using the EMFAC data.

Here’s our estimated three cases of the entire medium- and heavy-duty fleets, including trucks, buses, motorhomes, even those things with tires that look like cable cars.

If I can get the page turned I'll be good.

The number of vehicles, essentially, grows with the economy. Two anomalies appear here, one at 2020 and 2029, our kinks. For 2020, this reflects an inflection point in the freight analysis framework volume. And it reflects my linear interpolation on that five-year interval data. I'll most likely leave this in, in the revised forecast, since we prefer to shun any massaging of data.

The kink in 2029, however, popped up, we noticed it on this slide, so I looked into the cause last week. It turned out to be a code I had inserted in the truck turnover module that requires all trucks -- retires all the trucks over age 30, and I tested it. Either removing this statement or changing the age of forced retirement to over 31 eliminates the kink, so we'll correct it in the final -- in the revised forecast.

Ah, the break.

Since you patiently listened through the text slides, here's a bit of fun.

Consider the weight ratio between these two electric vehicles, the now-familiar electric auto and the still-to-be-commercialized electric tractor-trailer. The Chevy Bolt, that's curb weight there, 3,500-some pounds. Average person, according to somebody in the federal government, is 170 pounds. And then the gross weight loaded of a full size long-haul tractor-trailer, or even an in-state one, is 80,000 pounds. So what you -- you know, think of your guess of the weight ratio. Yeah, that's 20 -- over 21-to-1. And this is the Xos ET-One; Xos changed their name from Thor Trucks, which you may have heard of.

So the takeaway here is a loaded truck needs over 20 times the battery if it's driving on the same drive cycle. Now, the fact is, they're not driving on the same drive cycle so the ratio will be higher. Truck drive cycles can be brutal, so there you are.

The fun's over. Sorry about that.

Here you see a summary of truck attributes used in the truck choice models for each class and forecast scenario.

First, our hypothetical projection of the HVIP funding levels, as we described, through to 2030 in the high case, ten percent down after 2022 in the mid, and zero after ‘22 in the low case.

Next, the percent improvement in fuel efficiency from 2017 we received from H P Systems, falls in the -- 2017, itself, falls in the NHTSA EPA Phase 1 implementation year. Phase 2 applies from 2018, and has mileposts in 2021 and 2027.

Next, the ZEV stock preliminary forecast ranged over 27,000, vehicle counts here are subject to revision in the revised forecast after we revisit the model inputs. Separately and for the mid case only, battery-electric incremental prices, compared to a diesel truck at the bottom in blue, it’s not low, mid and high, it’s just these years and just the mid case.

And the classes, we anticipate these trucks to be commercialized in large numbers. All four classes show something like 25 percent reduction in incremental price from 2020 to 2030.

No questions? Okay.

From the California Vehicle Inventory and Use Survey, CalVIUS, this graph summarizes quick and dirty linear regression fit. I did annual miles per truck stated by the fleets for each of our truck classes and truck ages. No surprise here that the interstate tractor-trailers, shown in black, go the furthest. Next, the in-state tractor-trailers in purple, on down to the 20,000 miles for the new Class 3 pickup or van which is pretty much what the biggest light-duty pickups and vans do. In general, the smaller trucks don't go as far and they age faster.

Here's a reminder of the fuel types that we applied to the truck classes. Truck class is along the left two columns and the fuel is along the top row. The O's represent an OEM vehicle. P's represent pilot production which extends from something like the demonstration, our demonstration phase, to early commercialization. As are aftermarket conversions. We also have a catenary electric in-state tractor-trailer limited in the preliminary forecast to the port trucks after 2020, which is why you don't see large numbers. We'll revisit that too. Battery-electric appears in medium-duty trucks, as well as transit and school buses. We also have attributes for an in-state fuel cell tractor-trailer.

Think, here we are, fuel cost per mile for a bit. Think of Class 4 and 5 as delivery vans and trucks, although there are other uses. The fuel cost for the battery-electric truck, the red line, owes the size of its advantage to the whole class more commonly having an urban drive cycle, start and stop, really good for electric because when you're sitting there, nothing's being consumed. This coupled with the high purchase price, we expect electric to thrive where the fleets are active all day, every day, racking up high mileage. We're assuming that all these are in the range of DC Fast changing.

Gasoline, the dashed line, is the highest for fuel cost but the vehicles are the cheapest, so they will persist for fleets that anticipate low annual miles, and as long as the gas prices hold out.

Between, we see a sandwich, propane, the dot-dashed line, and diesel-electric hybrid, the dotted line, on a bun of diesel in black and natural gas in blue. Propane spills upward and out of our sandwich towards 2030.

And here's the fuel cost per mile for the in-state tractor-trailer. A constant pattern with diesel in black, high, and electric in red, below. The dotted line shows hydrogen prices per mile cost out of the -- they're coming out of the clouds by 2030 but they still remain the highest. This picture is clouded because of the multiple duty cycles these trucks perform in from stop-and-go port trucks to interregional hauling within the state, and some sort of suburban delivery, mixed-duty cycles.

Here's the market share of these interstate tractor-trailers, just the natural gas and electric shares, natural gas shown in dotted lines and battery-electric shows as solid lines. The mid case, in black, and the high case, in blue, for battery-electric is introduced commercially in 2021 and gradually gains, showing the typical successful adoption curve of a newly-introduced fuel type.

Natural gas shows gains in the early '20s that persists through the forecast. The low case, not shown here, has zero new battery-electric trucks after 2022 due to the unfavorable fuel prices, and also to the absence of the HVIP vouchers when they begin to get off the floor. Natural gas trucks in the low case actually achieve nearly the mid case share.

So there's three incentivized fuel types in HVIP. The three next slides show these, you know, electric, natural gas and diesel hybrid. Battery-electric truck penetration is sensitive to truck prices and battery prices, both of which we plan to examine more closely for the revised forecast. For this reason, we're not yet concerned by direct comparison with the proposed CARB Advanced Clean Truck Regulation. Preliminary results show about 10,000 battery-electric trucks in the mid case, over 25,000 in the high case. These do not include the catenary trucks.

Incentivizing diesel hybrids may actually inhibit some battery-electric adoption since they occur in some of the same truck classes, but they also lower the number of gasoline [and diesel] trucks. And due to their large gain in efficiency over diesel and gasoline, this hybrid interplay with battery-electric is complicated and bears more investigation for the revised forecast.

Natural gas stock, both CNG and LNG, concentrate in the heavy-heavy truck classes,[and]compete with electric drive mainly in Class 6 and for the in-state tractor-trailers, but only in the regional and the port duty cycles, at least where I put them so far. Since the technology is well established and serves where regulations require alternative fuels are mandated, such as refuse trucks, significant numbers occur, even in the low demand case, where fuel prices and fuel efficiency are less favorable. Conditions for this purchase improve significantly in the high demand case.

So I'm going to skip this slide. It's three cases of this without the buses. So we're going to talk about this one.

Hydrogen buses and trucks are not expected to achieve competitive vehicle or fuel prices until close to 2030, but we expect current levels of interest and funding to continue, resulting in this modest population growth.

Most important here is sustaining the on-road experience with the large fuel cell vehicle technologies that's required to improve them for the future. There's some buzz around long-haul fuel cell, but not yet any commercialized truck on the market.

Here's an encouraging output from the energy forecast of just trucks. In all three cases, diesel consumption declines around 15 or 20 percent over the forecast, this, despite an increase in diesel truck population. That increases slower than the economy due to gains from alternative fuels. The fuel decline is largely due to the expected fuel efficiency gains under the Obama-era NHTSA EPA Phase 2 fuel efficiency and greenhouse gas requirements.

So after this workshop, we'll go back to the data and the models and provide an improved revised forecast. Here are some changes we're considering.

First, a deeper dive into incentive programs and their duration, updates to economic growth. After comments on our Demand Analysis Working Group presentation, we're considering how we want to incorporate the announced prices and fuel efficiency for manufacturers, especially where the demonstration trucks manage logged movement, electronic movement and fuel consumption data, we'd love to review those in a spreadsheet or database.

We welcome and will address other suggestions received as comments in the docket, as requested in the workshop notice. And we are open to more ideas.

So thank you for joining the medium- and heavy-duty vehicle forecasting odyssey. For those in the room, bring any questions to the podium. On the webcast, there's not -- oh, there are more people. Nice. On the webcast, please raise your digital hand and, for good measure, address the chat message to the WebEx host, if there are any.

So that's it.

VICE CHAIR SCOTT: Great.

MR. MCBRIDE: Any questions?

VICE CHAIR SCOTT: Thank you very much. I would just echo your call out to the folks who are in this medium-duty/heavy-duty space with the alternative fuel vehicles, like the fuel cells and the battery-electrics and in the hybrid space, to help get us as much information and data as they can about what they're thinking in this space and what they're seeing, as well, so we can incorporate it. So I will echo that call for data and information.

MR. MCBRIDE: Yes. Please. Thank you.

I also wanted to mention the people that helped a lot on this work, Elena Giyenko, Ysbrand van der Werf, our student intern, Alex Lonsdale, and our technical lead, Aniss Bahreinian.

VICE CHAIR SCOTT: Great.

MR. MCBRIDE: Thank you.

VICE CHAIR SCOTT: Thank you.

So I just wanted to do a time check. I see that we have two presentations left. It's almost noon. My instinct is to just power through, if that works for folks? Yeah? Okay. I'm not seeing any gasps of horror.

So let's go ahead and power through. We will keep going with the final two presentations.

MS. RAITT: Okay. So next is Aniss Bahreinian, sorry, instead of Jesse Gage.

And for the Commissioners, for you electronic compilation on the binder, it's actually the presentation, the first one under Panel 1, which was -- so it's 1A.

MS. BAHREINIAN: Thank you. Thank you. Good morning again if somebody has just recently joined. We are going to present the Preliminary Transportation Energy Demand Forecast and we want to emphasize the preliminary in it, which means that in the revised forecast, we are going to make all the changes that Commissioner and DAWG and all the other contributors, the stakeholders, have provided and the forecast is going to be a bit different for the revised forecast.

This forecast was initially on the agenda. Jesse Gage was going to make this presentation but Jesse was, as we mentioned, on jury duty, and so he didn't -- he couldn't generate the jet fuel demand forecast for that reason. And I was the backup on Jesse and so I ended up doing this thing.

I should also add that even though he was on jury duty, being the great team worker that he is, Jesse worked in the evening after the court and stitched all of the fuel demand together, because that's also one of the things that he does. In addition to being the lead staff in DMV data analysis and aviation demand, he also stitches all of these different forecasts from different sectors together to generate the total fuel demand forecast. And so we owe all of these slides, actually, the Jesse and his work in the evening after the court.

So the main determinants of transportation energy demand, it's essentially a three-legged stool. It depends on the number of vehicles and the vehicle population, as well as vehicle efficiency, and the VMT. You have noticed now with a presentation from Bob McBride that in some of the heavy-duty vehicles the trucks, in some classes, are driving over 100,000 miles. That is compared to an LDEV vehicle which has a much lower VMT. So the higher the VMT, the higher will be the fuel consumption.

And we also bring to your attention that while in the vehicle choice models, the MPG that we are using is the MPG that appears on the sticker because we think that that's when it is important to the consumers. When they go to the dealership to buy their vehicle, they look at the MPGs on the sticker as they examine different vehicles. However, when it comes to fuel consumption, what we use is on-road fuel economy. So all the fuel consumption that you see here is based on on-road fuel economy, not the sticker MPGs.

Both Bob and Mark have discussed the vehicle population for the light-duty and the heavy-duty vehicle. This graph is putting the two of them next to each other so you could see. I have deleted gasoline vehicle because then it would overpower everything else and you couldn't see anything but gasoline LDVs. And so I deleted that and this is for non-gasoline vehicle population. It is important to look at the relationship between MD, HD and LDVs here.

As you can see here, for the electric hybrid, plugin hybrid and flex fuel or ethanol vehicles, essentially what we have is light-duty vehicles, as well as hydrogen. You could see that the mark for the MD/HD is pretty low but the majority of them are present in the light-duty environment.

However, look at the diesel. You could see that clearly diesel is focused on heavy-duty vehicles. And that becomes important when we are talking about the scenario relations later on in this presentation. You can also notice that when it comes to propane or ethanol dedicated, we only have those in medium- and heavy-duty vehicles. Natural gas, as well, you can see that the vehicle population is focused in the medium- and heavy-duty vehicles.

But this picture is going to show you why we have the differences in some of these fuel types.

Preliminary transportation energy demand, this is the mid case. And what we are showing here, we have some dumped gasoline and diesel, and called it fossil fuels. As you can see from this graph the fossil fuels are showing a decline. You do see a decline. This decline is both the result of the growth of electrification and other alternative fuels, as well as the improvements in fuel economy. So both factors are accounting for the decline in fossil fuel demand.

Notice, however, that I have had to change this key here. The starting point is actually 15 billion gallons. Notice, also, that all of these are actually in gasoline gallon equivalent. Otherwise, we could sum them all up and put them on one graph. But in order to show that, we had to cut the scale and start out with 15 billion so that we could see the differences. That actually tells you about the enormity of the fossil fuels that's still in the market.

This is another picture. This in the high case. Again, we are looking at the high case because we are showing more of the alternative fuel vehicles in the high demand case. Remember that our high demand case is based on high electricity demand, it is electricity centric. And so in the high demand case, we are seeing, certainly, a good share of electricity and natural gas, but we are still -- look at the brown area and the light brown area, you could see diesel and gasoline are, still in 2030 for the high case, are overpowering everything.

This is the gasoline demand. This the preliminary forecast for gasoline demand. Again, notice the differences in the scale.

The starting point on the vertical access is 11-and-a-half billion gallons, again, to show the differences between the three scenarios. Notice, we mentioned that there are really -- we really only have one single scenario for population. And the differences between the three income scenarios are not very significant, therefore the impact on the forecast, if you want to see it, particularly for the high volume of demand, we have to change the scale so that we could see the difference between the three scenarios.

As you can see here, notice that in the high case, gasoline is lower, so that kind of, in a way, goes counterintuitive but it is because, again, our high case is defined by high electricity demand. And as we expect, we are going to expect that our high gasoline demand would be lower than the other cases. And it goes according to our expectation.

This is the transportation gasoline demand, again, preliminary forecast, but this is in the mid case. And what we are showing here is the difference between light and heavy duty. You can see here the trucks that have a small portion of gasoline demand. When it comes to gasoline, really, it is the light-duty vehicles that are speaking the last word. They are dominating the market. So LDVs dominate gasoline demand.

But this is the diesel demand preliminary forecast. Notice here, in contrast to the gasoline demand, that the high is actually higher than the mid and the low. Why is that?

First of all, you can see, again, the scale has been different in order to see the differences between these three different scenarios. But the high is higher. And the main reason for it is that economic growth and income, GSP, actually dominates everything else when it comes to diesel. The freight movement grows with the economy, so the higher is the income, the higher is the GSP, gross state product, then the higher will be freight movement. And you can see here clearly that the high case is higher than the mid and the low in contrast to light-duty vehicle where we didn’t see that because the other factors are more important in light-duty vehicles.

Now looking at the same diesel demand but in the mid case, focusing on the main components here, you can see again that the trucks are dominating diesel demand here. The red area, the trucks, are dominating diesel demand, followed by light-duty, and then rail demand for rail movements.

When it comes to the E85, we have had to use a rule base because our models forecast population of flex-fuel vehicles, so we have a flex-fuel vehicle population forecast. However, not all of the fuel that is supplied for the flex fuel is E85, and so our assumption, based on our consultation with others, is that, first of all, at the present time it is the percentage of fuels that are fueled by flex-fuel vehicles, E85, it's about one percent of maybe a little over one percent currently. But we are expecting that maybe by 2030 the percentage of E85 being pumped into the flex-fuel vehicles is going to go five percent. So it is based on data assumption that we are making this forecast. It is based on data assumption and, of course, our forecast of flex-fuel vehicles.

As you can see here, again the flex fuel, the high case, is below because we believe that there's going to be growth in electrification, and flex-fuel vehicles are also going to be replaced by electric vehicles or ZEV vehicles in general.

Now, this is again --

VICE CHAIR SCOTT: Can I just ask a quick clarifying question --

MS. BAHREINIAN: Sure.

VICE CHAIR SCOTT: -- on that again?

So the slide before, you think the population of E85 vehicles will stay about the same but they will use more E85 and that's what's accounting for the uptick there?

MS. BAHREINIAN: Population of E85 vehicles, sort of like gasoline vehicles, can go down a bit --

VICE CHAIR SCOTT: Um-hmm.

MS. BAHREINIAN: -- over time because electric vehicles or ZEV vehicles are replacing all of these other fuel types.

VICE CHAIR SCOTT: Um-hmm.

MS. BAHREINIAN: However, the consumption per vehicle, we think it's going to grow from one percent or maybe a little bit -- maybe two percent at the present time --

VICE CHAIR SCOTT: Um-hmm.

MS. BAHREINIAN: -- that is of all the fuel that you are putting into the flex-fuel vehicle's annual fuel consumption of one vehicle, maybe two percent of it is E85. We expect or we assume that in -- by 2030, this is going to go to five percent.

VICE CHAIR SCOTT: Okay.

MS. BAHREINIAN: So it is the result of that five percent that you would see the increase.

VICE CHAIR SCOTT: I see. Thanks.

MS. BAHREINIAN: Sure.

And here is the transportation E85 demand, again, preliminary forecast, but this is in the mid case. And what we are trying to do is to show the difference between the light-duty and the trucks. Essentially, it's only the trucks that are using E85 in our forecast, and these are dedicated trucks. You can see that there's a significantly higher growth rate for truck use of E85. And the reason for that is that those are dedicated E85, they are not flex fuel, versus gasoline -- versus flex-fuel vehicles that are in the light-duty. Consumers have a choice to pump gasoline or pump E85. The dedicated E85 trucks, they don't have that choice. They only have to put E85 in the tank. That is why you see the significantly higher growth rate in trucks.

When it comes to transportation electricity demand, we didn't change the scale in this graph at all, but you can see that transportation electricity demand is growing fourfold between now and 2030. The high case is clearly higher than the low and the mid. And you can see that there is a kink in 2025. That kink in 2025 for mid and the high case is the result of the fact that we are discontinuing incentives. So if you go back to Mark's -- Mark Palmere's graphs on vehicle population and the PEV population, you could see the same kink in the PEV population, and that is reflected, also, in the transportation electricity demand.

The same transportation electricity demand, but in a high case, what we are doing, again, we are looking at light-duty vehicle, and here we are putting other transportation electricity demand. So it's not just medium- and heavy-duty, it's also what is being used in transit. So we have light rail, for instance, that is using electricity, cable cars in San Francisco and in other places. So all of those other uses add up to the red area that you can see here. So clearly, it is the light-duty vehicles that are dominating transportation electricity demand here.

This is, again, another graph. It kinds of shows the dynamics of transportation electricity going from 2018 to 2030. As you can see from the graph from the pie chart on the left side, that shows where we are now when it comes to total electricity demand. Seventy-five percent of total electricity demand is in light-duty vehicles. Moving on to 2030, that blue area becomes 91 percent. So this clearly shows, again, the growth of light-duty vehicle or PEVS that we have in the market.

But also look at the smaller pie chart. In 2018 versus 2080 [sic], you could see another significant change. And the yellow area that you can see here is for the bus, and these are all transit and electric -- electric transit buses, as well as school buses. So you see that the growth in the yellow area is quite significant.

Transportation hydrogen demand forecast, well, again, you see the same kink, and this is related to the discontinuation of the incentives for ZEV vehicles in 2025 in both mid and the high cases. And as you can see here, again, since the scenarios are designed as such, we have the high, low and the mid are going in the order that we expecting it, with high demand case showing higher transportation hydrogen compared to the low and the mid.

This next slide is going to show the distribution of this hydrogen demand between the light-duty and the MD/HD. You can see here, again, that the light-duty is speaking loudly here. It is dominating the hydrogen vehicle demand. We do have some medium and heavy duty and it is -- those are both in transit. So the red area that you see, those are the total hydrogen demand for the fuel cell vehicles in transit, as well as the few hydrogen trucks that we have. So it goes -- it is the sum of the trucks, the consumption by trucks, as well as buses, transit buses.

And this is our propane preliminary demand forecast. Propane is generally just used in the school buses, as well as in trucks, so this is the sum of those two. We don't have any propane in the light-duty sector, as you can see in the next slide, actually. You can see that kink or that kind of odd behavior in 2029. That is related to the retirement rule that Bob McBride was talking about. And that is going to disappear for the revised forecast.

When it comes to natural gas, again, we have the high, low and the mid scenario. And the high scenario is, obviously, higher than the other scenarios because again, according to our scenario design, this should happen and it is happening. We can see a much higher growth rate in the high case. And that is related to what Bob McBride was talking about regarding the growth of trucks. Otherwise, when we are looking at, for instance, school buses, we see also some increases in natural gas school buses, but in transit, most of the transit natural gas buses are being replaced by electricity -- or electric transit buses.

This shows the distribution between the light and the heavy duty. Really, that tiny little line of light duty that you see in the beginning is for -- is the consumption by the leftover vehicles. Otherwise, we don't introduce any natural gas vehicles in the light-duty sectors in 2018 and '19 or -- and after. The last vehicles introduced in California market, I think, was in 2016. And they stopped supplying those vehicles in the light-duty market in California. So it is 100 percent medium and heavy duty and that goes into natural gas transit buses. That is the sum of the natural gas transit buses, plus the natural gas trucks. And as Bob mentioned, with the volume of travel that they have, 100,000 miles and over, with the MPG, it's going to result in a huge share of natural gas.

And finally, this is a teamwork, and these are all of the staff on our team, whether they are in jury duty or not, they are working. They have been working hard to generate these forecasts. And if you have any questions, please let me know. And if you have any data, as has been mentioned already, please let us know. We appreciate any data that you can share with us.

VICE CHAIR SCOTT: Great. Thank you very much. I asked mine as we went along --

MS. BAHREINIAN: Um-hmm.

VICE CHAIR SCOTT: -- to you. And thank you for working after jury duty, and to the whole team for working really hard to put this data together. As I mentioned at the beginning of the workshop, it's really important for us to characterize our transportation sector well and robustly in this. And it's really good work, pulling together the preliminary forecast, so thank you.

MS. BAHREINIAN: Thank you.

MS. RAITT: Great.

So next is Marshall Miller from UC Davis.

MR. MILLER: Okay. This is work that I did, along with the Aspen Environmental Group. So briefly, I'll give a summary of sort of what the -- our study involves, what the methodology is.

We did the same study about four years ago and it's changed significantly. And in some cases the numbers have changed significantly, so I'll talk a little bit about why that is. And then I'll give preliminary results.

So, basically, the study purpose was to look at electricity demand for off-road vehicles. In some cases these are maybe more applications than vehicles. And in our last study, we looked at seven categories. This study we added a few categories, so I'll talk about the difference between those. And, of course, we'll produce a low, mid and high scenario for electricity usage from 2019 to 2030.

So the study that we did about four years ago looked at seven categories, truck stop electrification, trailer refrigeration units, industrial forklifts, port cargo handling equipment, airport ground support equipment, utility work trucks, these are bucket trucks, and shore power.

And we added to that a number of potential categories. You'll see locomotives, construction, mining, commercial harbor craft, possibly motorcycles. These categories we looked at, as I'll show, they're not really quite ready for electrification, and I'll talk a little bit why. Motorcycles, we're still in the process of looking at. We didn't know if we would actually get to this. Hopefully, we will get to it and finish it but it's not part of this particular -- the results yet.

I'll go pretty quickly through the methodology. Basically, we look at the present fleet stock. One difference from this time to last time is we made, in some cases, fairly interesting assumptions to try to find fleet stock because there was no data available. Now, there's much better data available in the ARB Orion Database, which is really wonderful. We estimate population growth based mostly on the state grow product increase. And then, of course, we estimate the activity of the vehicles or applications and look at fuel usage to understand how much actual fuel is used.

And by far the biggest uncertainty is our estimate of the percentage of electrified vehicles in these applications. You'll see in some cases there is not really a lot known on what to expect over the next ten years, so our estimates can vary by a significant amount. Basically, what we've done here is looked at stakeholders and, to a large extent, what ARB is thinking about in terms of regulation.

I'll skip that.

We do have a low, mid and high assumption or scenario for each of these. Basically, the mid is roughly what we think is most likely. The high takes very aggressive assumptions. And the low is, I would say, close to a lower bound but probably not really a lower bound. But assumptions are that infrastructure might not be in place or other things may not be in place to allow the electrification as might be expected.

Okay, so there's two large differences between what we did last time, about four years ago, and this year. One, as I mentioned, is the Orion Database, the ARB Orion Database. Due to reporting in these sectors, we have much better data than we did four years ago. And in some cases the numbers are not so different, in other cases they come out fairly different, the actual stock numbers. The Orion Database does not have electric vehicles because it only reports vehicles that produce criteria pollutant emissions, so, you know, battery-electric vehicles will not, so we had to try and understand electric vehicles outside of the Orion Database.

Another big change is ARB regulations. Back in 2015, many of these regulations were sort of vague, things were still in the planning stage. By now it’s much more specific, in some cases, regulations are actually in place. In other cases, regulations for specific dates are pretty much planned and expected to roll out in the relatively near future.

Okay, so now I’ll start going through each of the old seven categories, and then finally I’ll end up with the new categories that we added.

For ground support equipment, there was a study done in 2013 at LAX and it basically showed that electric ground support equipment is economically beneficial. And due to that, and due to airports demonstrating and purchasing electric equipment, a lot of airports and airlines are pushing hard to electrify that equipment. And already there's a fairly high percentage of equipment that's been electrified. So if you look at our midrange projections for certain things, like baggage tugs and belt loaders, we expect by 2030 to get to about 80 percent electrification. For other types of equipment, I think the low one was the AC widebody tug that is only about 30 percent; that's harder to electrify.

So if you look at the overall results, all of the plots I give will be gigawatt hours per year, again, for the mid, high and low scenarios. And the high, mid and low will always be high, mid and low in terms of [electricity] usage. So you can see here, there is growth, but it already starts at a fairly high level because there's so much electrification in the ports -- I mean, sorry, at the airports.

COMMISSIONER SCOTT: Just a quick question on the airports. That's literally all of the airports in California that you're looking at in that airport category or is it a subset?

MR. MILLER: That is the intent, yes.

VICE CHAIR SCOTT: Okay. Go it.

MR. MILLER: And that's true for all of these.

VICE CHAIR SCOTT: Got it.

MR. MILLER: The intent is to do the entire. It's not always so easy because we don't have the data --

VICE CHAIR SCOTT: Right.

MR. MILLER: -- in some cases.

VICE CHAIR SCOTT: Right. Okay. Thanks.

MR. MILLER: But, yes, that's -- so for port cargo handling equipment, this is one area where we found that Orion projected, or actually has data, showing a lower population than what we originally thought four years ago. ARB is thinking that they might start requirements for electrification in 2026. However, the two big ports, Port of Long Beach and Port Los Angeles, have goals of 100 percent electrification on the port by 2030. And those ports dominate the equipment at ports. About two-thirds of all equipment is at those two ports.

There is significant uncertainty, especially in the large forklift class. It's not clear how easy these will be to electrify in the next ten years. So while the other types of equipment probably can have significant electrification, this, there's greater uncertainty.

So here's the demand for the ports. There's a modest -- well, fairly significant difference between the high and the low demand, and a lot of that has to do with the uncertainty in forklifts, but also in just overall electrification because ARB is not requiring it. This is more a goal of the airport -- the ports.

So industrial forklifts absolutely dominate these classes of electricity demand. They're about two-thirds of the total for all the -- this off-road demand. Class 1 to 3 forklifts are electric. They actually are the higher percentage of the population of forklifts. Class 4 and 5 are fossil fuel and a slightly lower population.

ARB is seriously thinking of requiring all less than 8,000 pound class forklifts in the 4 or 5, Class 4 or 5 range to be electric by 2035. That's a significant change from four years ago. We estimate that the percentage of electrification in 2030 could range from something like the low 40s to the mid-60s. Some of the forklifts may be fuel cell, actually will be fuel cell. Some forklifts currently are fuel cell. So to the extent that groups that use forklifts decide to go the fuel cell route, that will push down battery-electric forklifts and therefore push down the electricity demand.

Here's the overall demand forecast, high, low and medium. Again, this is about two-thirds of the total that I'll show at the very end.

So transport refrigeration units, TRUs, four years ago, ARB expected to have what I would call modest regulation of these. They have changed their view and are thinking of requiring 100 percent electrification of larger forklifts greater than 25 horsepower by 2025, including out-of-state. Four years ago the thinking was that almost no out-of-state forklifts would be electrified out through about -- that was 2026 back then, so that's changed significantly.

A major potential issue is the likelihood of infrastructure. The trucks themselves can get an electric, or what we call an ETRU, but they have to be able to hook up and use it, so there must be infrastructure available at the various places where the TRUs are driving and parking and so on. And it's not clear that -- how fast that infrastructure will ramp up. ARB wants to have 100 percent electrification of smaller TRUs a little bit later, by 2031.

In 2015, our old study, we assumed our high scenario would be about 50, maybe a little higher, 60 percent electrification by 2026. And only the high scenario would have any out-of-state electrified TRUs. That's changed enormously, so the electricity demand forecast is much higher.

Now this looks a little interesting because there's this big bend in the forecast, and that's because in the high scenario and toward 2030 in the mid scenario the projected percentage of TRUs actually hits a maximum. So the only increase from that point has to do with the increase in actual stock of forklifts, and that's governed by the gross state product which only increases a few percent a year.

So shore power is an interesting category. There is an ARB inventory for oceangoing vessels, and it's one of the most wonderful pieces -- or databases I've ever seen. It is remarkably detailed. It made doing this projection almost trivially easy. The change from four years ago is we've added four vessel types. Before, we had container, reefer, cruise and tanker ships, and we added auto bulk, Ro-Ro and general. The percentage of electrification is actually similar to before because ARB had some fairly strict regulation already in place. There's a slightly lower electricity demand because of the actual lower population based on the ARB's inventory than we had before.

And so there you see, again, the projections are fairly high for electrification going out to 2030 because of the ARB requirements.

VICE CHAIR SCOTT: I have a quick question for you on that as well.

You know, they're starting to get these bigger and bigger and bigger and bigger ships, right, that are coming in. Does that trend towards these larger ships, when you plug it in does it go from like a megawatt when you plug it in to two megawatts or something, or do you see that inside of the increase in electricity demand?

MR. MILLER: Well, what we've used, again, is this ARB forecast.

VICE CHAIR SCOTT: Um-hmm.

MR. MILLER: So what they do is they have, as I said, amazing data for pretty much every ship type, and they have averages and ranges, so we've basically just used that.

Yes, I do think the bigger ships will have slightly higher electricity demand but not exceptionally higher because this is not to propel the ship, this is just the hotel loads while it's in berth, right.

VICE CHAIR SCOTT: Thanks.

MR. MILLER: Utility work trucks, these are bucket trucks. There are two types of bucket trucks, sort of large and small. What's happening here is that utilities would like to install batteries to provide power at the worksite through a PTO. So the vehicle itself would operate normally driving to and from worksites. But while it's at a worksite, it would be all electric and the power demand would be supplied by the batteries.

There was an Edison Electric Institute study several years ago that looked in detail at the electricity demand. And the goal was to try to push these electrified utility work trucks amongst all utilities. This is around the country. California utilities, we talked to some and some are very gung-ho on pushing this electrification.

We don't think things have changed significantly from before, so the percentage electrification is similar. The actual electricity demand is very low for these. There just aren't very many work trucks. Even if you electrify them all, it's almost no effect on the total electrification, even from off-road, and much less from, actually, all vehicles.

Truck stop electrification, basically, trucks can electrify the cab or the cabin. And at truck stops, they would plug in, if the infrastructure is there, such that they can actually have electricity run their hotel loads while they're parked. Basically, we look at how many truck stops there are in California. We estimate the percentage of trucks that would have their cabin electrified. And then the other question is: What would be the capacity factor? So at a given parking space that is electrified, how often would it be actually used throughout the day.

Again, this is a relatively amount of electricity used. And the results are fairly similar from before. And you see here, there's significant variation due to the uncertainty and what trucks will do and what infrastructure will be available.

Okay, so now I'm going to turn to the new equipment that we looked at. And I'll just say that, in general, this equipment, although there are some demonstrations and industry is looking at electrification or ZEV vehicles, at this point there's essentially not enough, apparently, not enough interest. The industry is not pushing to make these vehicles commercially available. ARB has no plans to require regulation that would -- well, to put regulation in place that would require electrification.

So that pretty much dominates our view of what will happen.

In harbor craft there are, actually, ZEV ferries. Norway has ZEV ferries. They are fuel cell ferries, not battery-electric. There is some interest in some demonstration projects in the near future of battery-electric ferries in California. But the general view is that the progress for harbor craft will likely be slow enough that we won't expect to see any significant or even modest electrification by 2030.

Construction and mining, again, ARB has no present plans to require electrification in the regulations. There are some demonstration products -- projects. There's a high-capacity forklift project at the Port of Stockton. Again, that's really more a forklift, not for construction or mining. So if something like this started to look feasible and companies started to make these available, it's possible that toward the later years you would see some electrification.

Australia has some fully electric mines. But mines, apparently, are very, very dependent on the actual type of operations as to whether electrification makes any sense. And again, the expectation in California is that none of this is very likely in the next ten years or so.

Finally, we looked at locomotives. ARB actually has no authority to regulate rail, it's a U.S. regulation, so ARB can't, in fact, require electrification.

The Class 1 locomotives, which is what we looked at are freight locomotives, there are some demonstrations scheduled in the next year or two. So it's possible that you will start to see a small number of freight locomotives be electrified. Likely, they would operate in sort of what they call a hybrid strategy where you might have several locomotives on a single train, one of which would be battery-electric, the others would be diesel operated.

But the bottom line is that, again, it just seems unlikely that there would be any electricity demand.

So this shows the sum of the seven categories I talked about earlier for electricity demand out to 2030. Again, this is dominated by industrial forklifts, about two-thirds. You can see that in about 2025 there's a slight kink in the high demand. And that comes from the TRUs that are reaching 100 percent that you saw that kink in the earlier slide. There's actually a kink in the mid one out by 2028 but it's almost impossible to see.

Okay. Thank you.

VICE CHAIR SCOTT: Great. Thank you. This is very good. I asked all my questions as we went through.

Do you? No.

Thank you for digging into the off-road sector. It's another important component, so I appreciate that. And thank you for being here today.

MS. RAITT: All right. So I think that

concludes our presentations.

VICE CHAIR SCOTT: Okay. Great.

So I don't have any blue cards but is there any public comment here in the room for this topic? Yes.

Can you please come up to the microphone and introduce yourself?

MR. CHOE: (Off mike.) (Indiscernible.)

VICE CHAIR SCOTT: Please turn the mike on.

MR. CHOE: Hi. Good morning. My name is Glenn Choe from Toyota Motors North America. I appreciate the opportunity to attend this workshop. The data and the presentations were very informative.

One of the questions I would have with regard to light-duty vehicle data, as well as the energy consumption, is that currently in the market, passenger car sales are shrinking and light-duty trucks and SUV vehicle sales are increasing, in the U.S. markets, above roughly 70 percent trucks and SUVs versus 30 percent passenger cars. In California, it's roughly now 55 percent light-duty trucks and SUVs and passenger cars are roughly 45 percent. We see this as a growing trend for the light-duty trucks and SUVs.

As the staff does the energy analysis, as well as the MANA (phonetic) analysis, we would request that they take a look at -- into the growth in the light-duty truck and SUV market because currently, in those markets, ZEV is only 15 percent of sales, so I just wanted to highlight that.

Thank you.

COMMISSIONER SCOTT: Yes. Thank you. And if you have any data that you could share with us, please make sure that you get that to my team. And they are right there.

MR. CHOE: I will reach out to them afterwards. Thank you.

VICE CHAIR SCOTT: Please do. And that is an important trend that we should look at, if we are not already.

MR. CHOE: All right. Thank you.

VICE CHAIR SCOTT: Great.

And is there any other public comment here in the room? Okay.

Seeing none, let me turn to Heather and see if we have public comment on the WebEx?

MS. RAITT: Yes. I think Monterey Gardiner, if you're on the -- we'll open up your line. I think you had a question for Bob McBride.

MR. GARDINER: Yeah. This is Monterey. Can you hear me?

MS. RAITT: Yes.

MR. GARDINER: I hear the echo there in the room.

Thank you for the presentations. I just had a quick question clarifying on slide 20 from Bob's presentation on the cost per mile. And if he would quickly just explain maybe three points for the cost per kilogram that was used for calculating that cost per mile, so 2020, '25, and maybe 2030, whether like $20.00 a kilogram, $15.00 or $10.00 or $5.00, but how that cost per mile would shift down at a kilogram level cost?

MR. MCBRIDE: Hi.

VICE CHAIR SCOTT: I think it was slide 20.

MR. GARDINER: Yeah.

MR. MCBRIDE: This one, yeah.

Hydrogen is one of the fuels in our fuel price forecasts, so we're just taking numbers directly from that. It is done separately. Does somebody want to help me here? I get the numbers. I use them.

MS. BAHREINIAN: Yes. NREL generates the hydrogen price forecast for us. And they are also working with our Fuels and Transportation Division Hydrogen Unit. And I think, if my memory serves? I think it's about $16.00 or $15.00 currently, and then it continues to go down through 2030 to something, I think, around maybe $8.00 or -- yes, $7.00 or $8.00, depending on the case.

So the starting point --

MR. GARDINER: That's great.

MS. BAHREINIAN: -- is around $16.00 or so per kilogram.

MR. GARDINER: Um-hmm.

MR. MCBRIDE: Yeah. My memory was --

MR. GARDINER: Okay. Yeah. I think the -- go ahead.

MR. MCBRIDE: Let's make that $7.00 to $9.00 because that's what I remember, but Aniss is probably right.

MS. BAHREINIAN: No. That's $7.00 to $9.00 in 2030. Presently, it's about $16.00 or so.

MR. GARDINER: Okay. And that will be cost without taxes or additional --

MS. BAHREINIAN: Yes.

MR. GARDINER: -- the $7.00 to $9.00? Okay. I think industry is targeting $5.00 at large scale when we're talking about the millions of, not just kilograms but working towards tons, so we'll see how that -- what other comments you get and feedback. But thank you for providing the forecast and showing where hydrogen lies.

And then one other thing. It doesn't look like you're focused on CO2 but at least most of the Hydrogen Council and industry is focusing on carbon-free hydrogen to be available within California and worldwide by 2030. So I'm not sure where emissions is taken into account or if this is just an energy focus, but that also might be something to consider.

MS. BAHREINIAN: This forecast is focused on the demand side. And on the demand side, consumers see the hydrogen without noticing what the source of that hydrogen is. However, on the supply side, we need to account for production of hydrogen using, whether it is natural gas reformation or electrolysis. And where we would have a CO2 impact would be in the electrolysis. But that is something that we would have to consider on the supply side.

MR. GARDINER: Okay. All right. Thank you very much.

MS. BAHREINIAN: Thank you.

MR. GARDINER: That's all my comments. And I appreciate the hard work going into these forecasts.

MS. BAHREINIAN: Thank you.

VICE CHAIR SCOTT: Do we have any other public comment on the WebEx?

MS. RAITT: I don't think so.

VICE CHAIR SCOTT: Okay. So I will just -- I see. No. Okay. All right.

Well, thank you to the public for your engagement on this topic. I think the datasets you have, the information, any great studies, we are always happy to receive those. Please feel free to send those to the docket. And if you're looking at our WebEx, you can see here, written comments are due on August 5th. This slide shows you how to get those comments to us. And you can also find that on our web page as well.

And let me check to see if Heather has any other closing remarks.

MS. RAITT: That's it. Thank you.

VICE CHAIR SCOTT: All right. Thank you everybody, and we're adjourned.

(The workshop adjourned at 12:41 p.m.)

REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

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