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CALIFORNIA ENERGY COMMISSION

STAFF IEPR WORKSHOP ENERGY DEMAND CASES AND

FORECAST OF VEHICLE ATTRIBUTES FOR

2015 TRANSPORTATION ENERGY DEMAND

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CALIFORNIA ENERGY COMMISSION

1516 NINTH STREET

ART ROSENFELD HEARING ROOM - FIRST FLOOR

SACRAMENTO, CALIFORNIA 95814

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Reported by:
Kent Odell

APPEARANCES

Gene Strecker, Energy Commission

Courtney Smith, Adviser to Commissioner Scott

Aniss Bahreinian, Energy Commission

Eva Borges, Energy Commission

Jim Lyons, Sierra Research

John Michel, Energy Commission

Bob McBride, Energy Commission

Kevin Walkowic, National Renewable Energy Laboratory

Marc Melaina, National Renewable Energy Laboratory*

Ryan Kenny, Clean Energy

Guihua Hua, Air Resources Board

Jesse Gage

*online participant

I N D E X

P R O C E E D I N G S

SEPTEMBER 30, 2015 10:05 A.M.

MS. STRECKER: Good morning. I think we'll get started. Thank you all for being here. It's a busy time of year for those of us at the Energy Commission that do forecasting work, so I'm sure everybody else is just as busy as we are. Thank you all for being here.

Before we get started, there's just a couple of housekeeping items we'd like to take care of.

If you're not familiar with this building, the restrooms are right outside of this room across the hallway. And there's a little café/snack bar on the second floor. Just look for the white awning at the top of the stairs.

And in case of an emergency, please follow staff out of the building and across the street to the park, and we will get organized there in the unlikely event of an emergency.

We are going to do a number of presentations today. We'd ask you to hold your questions until the end of each presentation and we'll give everyone an opportunity to ask questions and make comments at the end of each presentation.

We'll start off with questions and comments by people in the room, followed by the people on WebEx, and then last we'll go to the people who are phone-in only.

And before we get started, I'd like to introduce Courtney Smith in our executive office, and she's going to come up and say a few words before we really get going. Thank you.

MS. SMITH: Good morning everyone. As Gene said, my name is Courtney Smith. I serve as adviser to Commissioner Janea Scott. Unfortunately, she wasn't able to make it here today, but I did want to just thank you all for being here and I wanted to kind of step back for a second and sort of give the big picture for why this work that we're here to discuss today is so important.

So some of you may or may not know this. A lot of the forecasting work that staff do is really integral to the policy decisions and the policy framework that we create here at the Energy Commission through our Integrated Energy Policy Report.

And so today I really want to invite the public to give us your feedback. I know staff are here today to present a new set of demands in areas when it comes to transportation, vehicle forecasting. And our ability to be able to reflect the policy scene that we see right now is something that is a bit of a challenging endeavor on the state level, and so any input that you guys can provide to make sure that we are reflecting state policies in the most appropriate way would be very much appreciated.

This is particularly important given the current suite of policies and goals that the Governor and the Administration has laid out when it comes to transforming our transportation sector as we move toward a low carbon economy.

So thank you all for being here and I look forward to hearing what you all have to say.

MS. STRECKER: Thanks, Courtney. And I'd like to also agree with Courtney; we're really looking for your feedback today.

We're going to be going through a little bit of the scenarios or cases or inputs or whatever we call them that we used for our preliminary forecast, just as a review. And then we're going to follow that up by some of the changes that we're going to be making to our revised forecast.

Most importantly, we're going to be talking about our vehicle attributes today, our forecasted vehicle attributes for both light duty vehicles and medium and heavy duty vehicles.

In our forecasting models for light duty vehicles there's five attributes of particular interest or influence, and when Aniss comes up here she'll start to give you an overview of some of those. And then for our medium and heavy duty attributes, there's just two, vehicle prices and fuel economy.

I guess with that I'm just going to introduce Aniss Bahreinian to come on up and start with an overview of what we're going to be talking about today.

And again, please feel free to comment. We're really interested in hearing what folks have to say about what we're doing for forecasts. Thank you.

MS. BAHREINIAN: Good morning. My name is Aniss Bahreinian and I'm going to give you an overview of the vehicle attributes and scenarios that we are going to use in the revised demand forecast.

The purpose of this overview is to explain why vehicle attributes are important, how we use it, and which ones are the more important vehicle attributes. And also, first of all, tell you what those vehicle attributes are.

We divide this presentation into light duty and medium and heavy duty. As most of you know, our transportation demand forecast we cover all the different sectors whether they are light duty or heavy duty. We have a comprehensive set of models used to generate energy demand forecasts.

We also are going to talk about scenarios. We have made some changes to some of our input scenarios since the preliminary forecasts and we'd like to share that with you and seek your input regarding those scenarios.

So the first thing we are going to do is to, at least for the sake of this presentation, we'd like to be clear on the distinction between case versus scenario.

Case is a term that has been adopted by all of the different offices that are involved in forecasting at the Energy Commission in reference to demand cases. So what we are talking about when we talk about case, we are talking about energy demand cases.

Energy demand is the output of the models, and generally we have identified three, what we refer to -- again, this is an internal term that we are using -- common demand cases. These common demand cases are composed of high, reference or mid, and low demand forecasts.

Whether it is a forecast of electricity

demand or forecast or natural gas demand, which is not in transportation, or whether it is transportation energy demand, we all use the same terms, that is for common demand cases.

And we use the same input. That is, all of the demand cases across different offices are using same prices, same fuel prices, same income projections, and same population projects for each respective scenario cases.

What I'm using scenarios here in this presentation for is in reference to inputs. We have many, many inputs in these forecasts, so I'm using that term specifically for the inputs.

And it is important to know that some of these inputs are whereas the demand forecast is entirely generated by the staff, some of these input projections, we are getting it from vendors. For instance, income projections come from Mooney'sEconomy.com and IHSS Global Insight.

Some of these input scenarios are projected by contractors, such as vehicle attributes that Sierra Research is projecting.

And some of those are coming from public data or from other agencies. These other ones we obtain for free; however, we are limited by the nature, by the definition of the data that is coming from these different free public sources, and that will require more preprocessing before we can use them in our demand cases.

So just keeping this in mind, common demand cases, case refers to demand and scenarios refer to inputs. This is also going to help us understand why, for instance, in the high energy demand case we expect everything to be higher, right? But in contrary, we use low fuel prices. Whenever we are talking about demand we know that if the demand is going to go up, prices have to go down, so we use the low price scenario for the high energy demand case. So this distinction can also help that.

In addition to that, we don’t have three scenarios for all of our inputs. We have three scenarios for most but not for all of our scenarios. So this is going to make a little bit of distinction between the two.

So what are the vehicle attributes? What are we talking about when we talk about vehicle attributes?

Vehicle attributes are basically different characteristics that define a vehicle. Now, one characteristic could be a color. You could have a red car, for instance, and you could pay higher insurance, as I have heard from some people. Or you could have a car that is large. You can define a car by its body type like SUV versus sports vehicle. You can define a car by range. This is particularly of importance to the EVs. You can also define a car by the amount of time that it takes to fuel the car.

There are many different attributes. Acceleration is an indicator of performance of the car, for instance. Storage capacity. How big is the car, how much stuff can you put into the car.

And also the fuel cost, which is quite important. Fuel economy is very important to our consumers. And fuel cost, depending on where the fuel prices are, and where the relative fuel prices are that’s going to make a huge difference for different cars of different fuel types and in different classes.

So these are different attributes, and there’s a lot more really. When you go to the store and buy a car you consider a lot of different factors. How comfortable you are in the car. How does the car feel to you.

The problem is that there’s no way for us to model your feel or your comfort, so what we do, we try to use those things that can be quantified, such as the size of the car, for instance. Whether it is midsize, large or small. Or the mpg, how many miles per gallons does it take to drive this car.

Economic and demographic forecasts determine the total vehicle population in California. So if we want to look at the fleet size, if we want to forecast fleet size, economic and demographic variables, population, income, etcetera, are the factors that drive the vehicle population on California roads. They are the primary factors that will determine the fleet size.

However, when it comes to vehicle composition, composition of the fleet, then it is the attributes and fuel prices that speak the last word.

What do we mean by fleet composition? For instance, how much of the fleet is large vehicles, how much of it is small vehicles, what percentage of the vehicles are going to be EVs, what percentage is going to be gasoline, which percentage is diesel, the fuel type composition. All of these are going to be influenced by fuel prices and the vehicle attributes.

So the vehicle attributes are important in the sales of the new vehicles. We can say what the population of the fleet is going to be, population of the cars in California are going to be, but in order to determine the composition of this fleet, we will need the vehicle attributes.

So in our models consumers choose from ten different fuel vehicle technology composition. One is gasoline. Another one is gasoline electric hybrid. Most people just know it as hybrid. We try to distinguish that. Gasoline can also be used in flex fuel to fuel flex fuel vehicles, but so can E85.

So we have flex fuel vehicles, that’s another fuel technology type. Diesel is one. Diesel electric hybrid is another one. CNG, compressed natural gas is one vehicle. And again, gasoline can also be used in dual CNG gasoline fuel types. Battery electric vehicles. But we also have plug-in hybrid electric vehicles, PHEVs. And we also have hydrogen fuel cell vehicles.

So all of these different fuel vehicle technology combinations are choices for our consumers.

Our consumers also have a choice of 15 different classes of vehicle. There are a number of models that are operating in different places and are used for different studies, and some of these models only distinguish between cars and trucks, so those are the only two choices that are available to consumers.

In our model we have pretty extensive, I think probably more extensive than any other models. We give them the choice of 15 different classes of LDVs.

What are these? These are subcompact, compact, midsize, large, and sport cars. So as you can see, already we have four car classes here. No, five car classes here.

We also have three classes of cross utility, three size classes of sport utility vehicles. So we don't have just one sport utility vehicle, we don't have one SUV, we have three different sizes. We have compact, midsize, and large SUVs.

We also have two classes of vans and two classes of trucks.

Our surveys have shown, actually, that consumers have particular preferences for different classes of vehicle. They don't consider all cars the same, and they don't consider all trucks the same. And once they make a decision on picking a specific class of vehicle, they have somewhat made up their mind. So there are distinct preferences for different classes of vehicle.

We should also notice that what we do at the Energy Commission, we do not forecast demand for different vehicles by make and model. Rather, we forecast demand for vehicles by class, by vehicle class. So everything that we do is a class average. So all the prices that Jim Lyons is going to present later in the day, these are class-based prices. These are class-based MPGs. These are class-based attributes in general.

We all know that brand loyalty is quite important to a lot of people. Some people always buy Toyota. Some people always buy a Chevy. Some people always buy a Honda. Brand loyalty is important. It is just that we do not account for that in our model, but we do know it is important.

Instead, what we do, we look at the total number of makes and models within a class, and that is an indicator of choice for our consumers.

Mid-size class, for instance, is the highest selling class among the vehicles, and it has about 121 different makes and models in it. That is very substantial. It has the highest number of makes and models in it.

So the question is, well, are consumers buying it because there are 121, because there are more choices in this class? Or are the manufacturers producing more because they know consumers prefer this class size? I can't give you a definitive answer, but what I can tell you is that in our model we make the assumption that consumers are buying more of this because there are more vehicles in this class, because there are more makes and models. That is an underlying assumption of our model.

So among these vehicle attributes, vehicle price is a very important factor. If you go to the dealership and want to buy a car, you have to be able to afford that car, one way or the other, whether you are getting a loan or whether you are paying out of pocket or what have you, you have to have the money in order to purchase that car.

So vehicle price, not only in our survey but also in most of the studies that have been conducted, is one of the most important factors.

However, we should caution everybody that not all prices are the same. We have manufacturer suggested retail price, you're going to see that on every car when you go to any dealership. You're going to actually see that on everything that you buy. Any piece of clothing that you have on you, if you look at the tag it has MSRP. But how many of you have actually paid that MSRP? Usually these MSRPs are higher than the prices that the consumers are paying for the product.

However, it is an indicator when you’re looking across different makes and models that a manufacturer manufactures, this is a good indicator of differences in cost of different cars.

Manufacturer suggested retail price also includes the dealer markup and it includes the cost of some of the more popular options that come with the car automatically on a base car that is sold on the market.

Transaction price, on the other hand, includes not only those options that come usually with the car but also additional options. For instance, if you want to have a sun roof on your car, you have to pay extra for that. So these additional options keep adding to the price so you could leave a dealership paying a higher price there for it.

Also, the transaction price, we should notice that it excludes government incentives such as rebates and tax breaks.

These transaction prices are also influenced by your negotiation skills. Once you go to a dealership and try to negotiate a price, it depends on how good of a negotiator you are. If you go to a dealership you could get the same car at, say, $500 lower than someone else that has bought the exact same car. So it depends on your negotiation skills as well as the salesman's negotiation skills, so it is really individualized.

It can also change over time, these prices can change over time. In the beginning when a model is offered, let's say right now we have 2016 models coming to market, the price may be higher than at the end of it. In 2017 we still are going to have some 2016 model years that are going to be sold but most likely the prices are going to be lower because whatever is left is what has not been sold and usually dealers and manufacturers are going to offer greater discounts at the end compared to the beginning.

So what are these prices? These are some examples of the national market. This is not California market but the national market. As we can see here, we have average new MSRPs here, and you can see that it varies from one year to another year.

After the MSRP you have the manufacturer incentives. You also have the dealer incentive. This is going to result in total discounts of over $4,000 in 2012 and over $5,000 in 2013.

As you can see here in the bottom row, you have the percent of the total discounts. Now, these are private discounts, there's no government incentive here, these are private discounts. So the percentage of the total discount, that is manufacturer plus the dealer incentives, are a bit over 13 percent in 2012, but they are a bit over 14 percent in 2013.

What has caused these changes? Why do we have a higher percentage of discount in 2013 compared to 2012? There are a large number of factors that we are not really going to be able to pinpoint it unless we do a study of that.

The point here is that these are going to change over years, these are going to change over time. That's the main point. And that there is a difference between the MSRP and the transaction price and how close they are to each other is going to vary over time and over years.

So MSRP almost always exceeds the negotiated or transaction price, so we have looked at that and we have seen that in almost all cases MSRP is higher than the transaction price.

Eva Borges is going to later talk about the transaction prices that she has arrived at using the DMV data.

I think I have seen only a couple cases of when MSRP is below the transaction price, and that is when buyers are adding a whole bunch of options to it.

I think I saw the case in Tesla when, of course Tesla buyers have a lot of money so they keep adding all these fancy options to it and you could reach a transaction price that is higher than MSRP. But for everybody else for the most part what you can say is that MSRP exceeds the transaction price.

To comply with regulations manufacturers can distribute profit differently among different models. So what does that mean?

That means, for instance, if a manufacturer is producing, let’s say ten different vehicles, they can have a loss on one vehicle and still they could have profit for the corporation, because what they do, they shift the profit centers from one vehicle to another vehicle.

This is a mechanism that can be used to comply with regulations. The manufacturers can price the EVs lower than what they would otherwise have in order to promote these vehicles in the early phases of the market. And then they can make adjustments as the sales go up, then they can benefit from the economies of scale, and the economies of scales can result in cost reductions that can increase profit for the manufacturers. But in the beginning phases this can certainly be used as a strategy by the manufacturers in complying with different regulations.

Sales rated average price, which is what Eva Borges is going to present, is based on transaction price and the number of vehicles sold of each of these vehicles in the market.

So for instance, in the midsize class what she has done is taken the transaction price of over 121 different makes and models and used the sales volume of each one of these 121 models in order to arrive at the sales weighted average price of these vehicles.

The sales weighted average prices are good for historical data. So we know if we have sold these many vehicles in 2014, if we know we already have sold this many vehicles in 2013, when we use the sales weighted average price we know that these are the price movements. These are the price movements that may have been responsible for causing the rise or decline in sales.

We also look at the attributes for medium and heavy duty vehicles. We should notice that while for light duty vehicles we have elaborate vehicle choice models in multiple segments in more than one market segment.

When it comes to medium and heavy duty,

Energy Commission does not have a vehicle choice model. So we don’t really use the vehicle attributes for choices but we do have, our models do allow for use of a market penetration rate, and that is what we need those attributes for.

What we do in a preprocessing step, Bob McBride uses the vehicle price and fuel economy forecasts that have been generated by Sierra Research using it in Argon Truck 5 model, in order to generate market penetration of different medium and heavy duty vehicle -- actually only trucks, by different fuel types. So it is used in that way.

It can say, for instance, that let’s say in 2020 percentage of natural gas vehicles is going to reach, say, 15 percent or something like that. That’s what we call as market penetration.

Now we are going to talk about is the scenarios. These are the LDV scenarios we are going to talk about first. And of course I have chosen my shirt to match the color of the car I have in this picture, both red, as you can all see. This is a Tesla, one of my favorite cars.

When it comes to preliminary forecast scenarios, we had the three common demand cases and they were defined by three different sets of model inputs for energy prices, income, and population. Those are still going to remain the same in the revised version.

In the preliminary forecast we also used one set of light duty vehicle attributes which was identified as reference scenario. We used one scenario because that was all that was available at the time and it was the same set of values that we have used for the 2013 IEPR. So for the preliminary forecast we used our 2013 vehicle attributes for the reference case, and there's only one case.

Demand cases are defined as high energy demand with low energy prices, high income and high population growth. This is going to create the higher boundaries of our demand. That doesn't mean that in reality we are not going to exceed that.

In the reference case we have the reference energy prices, income, and population growth.

In the low energy demand case we have the high energy prices, low income, and low population growth.

We know for a fact that even compared to our price projections in preliminary IEPR which was used in order to generate the preliminary demand forecasts, even our prices have changed since then. They have gone even lower, the fuel prices. Petroleum prices, more specifically.

How did we comply with ZEV in our preliminary demand forecasts?

ZEV regulations are targeting, are meant for manufacturers. Manufacturers need to comply with this. So in great sense, ZEV regulations really apply to the supply side of the equation.

We do not have a supply model. We do not have a light duty supply model. And therefore, in all of the past different IEPRs we have been working with different contractors in order to generate the vehicle attributes for us. And as part of our direction since ZEV regulations are meant for manufacturers, we have asked them to generate these vehicle attributes in a way that they can meet the ZEV regulations.

We should also say that there are also state and federal ZEV incentives, so when it comes to the demand side of the equation, we are in charge of that. And we use the incentives such as rebate, tax credit, HOV lane access, all of those we use that in our demand models.

In the past we also have held the consumer preferences constant. We have done that in the 2015 IEPR preliminary forecast and we have done that in all of the previous IEPR forecasts in the past.

However, in this revised forecast what we are going to do is to leverage a model enhancement that we initiated in 2014 and we added a time dimension to consumer preferences. So what we are going to do for the revised forecast, we are going to actually change consumer preferences. Staff is going to use the three scenarios for each of the following two attributes. It's vehicle price and makes and models. We do have three scenarios for those.

Vehicle prices have been derived from the LAVE-Trans model, which is the same model that has been used by NRC and also in David Greene's study of transition to alternative fuel vehicles. And so we are going to use the prices that have been developed using LAVE-Trans model based on the fuel prices that we have, based on our revised fuel price forecast.

Sierra may also take more aggressive measures such as greater ZEV vehicle price reductions to ensure that ZEV compliance happens in the reference case. Sierra will be talking about that later.

Now, in the revised forecast we are going to use three plug-in vehicle demand cases, but these PEV demand cases are very much in line with our vehicle demand cases, and our vehicle demand cases are very much in line with our energy demand cases. So I'm singling out the PEVs here but we really are talking about light duty vehicle demand cases and the energy demand cases with particular emphasis on PEVs.

In the low PEV demand case we have no change in consumer preferences, we keep it the same, just as we have done in all the previous IEPRs and in preliminary IEPR. It is plausible with the current petroleum prices at the levels that they are, we can reach a low PEV demand.

However, when it comes to the reference case, what we are going to do is to increase consumer preferences in favor of ZEV until we meet ZEV. This is what we are going to do in the revised forecast.

In the high PEV demand case, which is also going to be the high LDV demand case, which is also going to be the high energy demand case, we are going to be continuously increasing preferences just as we did in the reference case, but this time since our high demand case is also associated with high income and high population growth, we should be reaching higher levels of PEV demand.

This is a departure from past practice, as I have been saying it for a number of times now. The revised reference case forecast will be further constrained to meet the ZEV regulations, but particularly the most likely scenario of the ZEV.

This chart here is putting everything in perspective, making it easy for people to see things very clearly in a transparent way.

As you can see here, the column on the left-hand side has the common demand cases; high, reference, and low. And the columns are going to indicate different scenarios of different inputs that we are using in each of the demand cases. As you can see here in the high demand case, we are using the low fuel prices.

What is different in the revised forecast is the last column, consumer preferences. In the past, as we have said, it all has stayed the same, constant, we have not changed consumer preferences. But now we are going to change consumer preferences. We are actually going to increase preferences in favor of ZEV vehicles.

Do we have grounds for it? Is it reasonable to do that?

First of all, keeping it constant was only because we really couldn’t forecast consumer preferences. There is no good reliable way to forecast consumer preferences. In the future we do know, however.

If you look at the last three or four years, we have seen that consumer preferences for EVs have gone up. It is a fact. People are not viewing EVs the same way that they did four years ago.

In large part perhaps thanks to Tesla because they have infused so much style and performance into Tesla that they have made it really cool. Everybody would like to have one, they have made it really popular. On the other hand, Nissan has worked hard to make it more affordable.

So there are increased consumer preferences for these vehicles since 2013, so there are some grounds for actually implementing these increased preferences.

The question is how do we do that? Is there a way to project this into the future?

The way we are going to do is to increase it so much so that it will meet the ZEV regulations, that's how we are going to do it. It there's any better idea, then please let us know.

Any questions? I know that you said at the end, but I'm open to any questions any time.

How about the medium and heavy duty scenarios. Well, the truck that you see on the right-hand side, that's called Wave, that is the Walmart advanced technology vehicle. You see it is pretty cool, too.

The preliminary 2015 IEPR forecast we had three demand cases that are defined in the same way for the LDVs. In the preliminary 2015 IEPR staff used one CNG market penetration rate, so the only other fuel that we actually used in the preliminary forecast was really the CNG. This is the CNG market penetration rate.

Which was the same thing as the one that was used in 2013 IEPR. This was derived from National Petroleum Counselor, NPC's work in 2012, which was based on 2010 EIA fuel price forecast.

You can imagine that in 2010 EIA fuel price forecasts were more favorable to natural gas than they are today. The price differences between diesel and natural gas have changed substantially.

Therefore, for the revised forecast we are going to use the new price forecast that we have plus the vehicle price and the fuel economy forecast that Sierra Research has developed, used them in the Truck 5 model to generate multiple market penetrations for multiple fuel types, not just CNG but also other fuel types. Bob McBride is going to get into the details of this.

Later in the day, in addition to Bob’s presentation on heavy duty vehicles, we are also going to have NREL, who is going to make a presentation on heavy duty vehicle attributes. I guess that one is at the end of the day.

I should also add that another -- well, we don’t consider it a vehicle attribute but a fuel infrastructure attribute, which is fuel station availability, is of particular importance to FCVs, and Mark Maleina of NREL is going to talk about fuel infrastructure and fuel station availability later in the day.

Questions?

MALE VOICE: This question is from Sam Pournazeri (phonetic) who asks do you consider the role of incentives and policies in market share forecasts?

MS. BAHREINIAN: I’m going to have to let Bob answer that. I believe yes, but in order to get a more precise answer I’m going to let him respond to that since he is the one who is using those prices in Truck 5 model.

MR. MCBRIDE: I wanted to repeat the question so...

MALE VOICE: Do you consider the role of incentives and policies?

MR. MCBRIDE: Do you consider the role of incentives and policies?

MALE VOICE: Yeah.

MR. MCBRIDE: In a medium and heavy duty market share forecast. Today we're going to talk about input attributes, just vehicle prices and fuel economy. But yes, there's an opportunity in the truck model to insert an incentive. We can't really distinguish those between manufacturer and other incentives or subsidies, but we can insert them. Hope that answers the question.

MS. BAHREINIAN: So the answer, I believe, would be in part by price reductions you can include some of those incentives.

Any other questions?

MALE VOICE: The other question from Alejandro Komai. His question is would it also be possible to, instead of increasing preferences until ZEV is met, decrease EV prices until ZEV is met?

MS. BAHREINIAN: Of course it is possible to do that but we are not sure how much that price reduction is going to be, but we can generate a forecast using exactly that.

In other words, further decreasing prices, that means in addition and on top of what Sierra Research has come up with. Keep in mind that their direction has been to change the price or present price forecasts that they believe is going to meet the ZEV mandate. So if you do anything above that it’s going to be additional price reductions. But we can certainly look into that.

MR. KENNY: Good morning. My name is Ryan Kenny, I work for Clean Energy. We’re the nation’s largest provider of natural gas transportation fuel and renewable natural gas.

Just referring back to Slide No. 6, and I’m not sure if it’s a slight oversight, but there is the universe defined as ten fuel vehicle technologies. I just noted that liquefied natural gas and renewable natural gas is not listed as one of the technologies.

And as you may have heard, a week or two ago ARB did certify a .01 NOx heavy duty engine, and combined with renewable natural gas and heavy duty space it would be the cleanest vehicle possible. So I just wanted to make sure that's included in the conversation. Thank you.

MS. BAHREINIAN: I think that these are for LDVs, light duty vehicles, and I don't know of any light duty vehicle that runs on LNG, but we do include LNG for the heavy duty vehicles.

MALE VOICE: And one more question from Erik Seilo at SCE. How do we factor in very low lease prices?

MS. BAHREINIAN: Thanks for that question. Our models, in our survey we did ask people about leases, but our models are not accounting for lease. We consider all leases as purchase.

So you area really right. That is something that we are going to look into in the next round of survey to see if we could model that, but there were issues with consistency in duration of lease and different rates that we couldn't include it, but we certainly are going to look into it again for the new forecast. Or for the new survey -- sorry, not for the new forecast.

Any other questions?

MS. SMITH: This is Courtney Smith from the Energy Commission. On Slide 17 you present the revised forecast approach to dealing with the ZEV mandate, and I'm really excited to see that. I see that the cases, however, are constructed to focus largely on the plug-in electric vehicles, and so we're assuming that preferences are going to be increasing solely on the electric vehicle side, and I think there's some reasons for doing that for certain.

But I'd like to maybe start a conversation around how hydrogen fuel cell vehicles fit into that. I know that there's some folks here from the Air Board, so I don't know if they have any ideas on how the Air Board is seeing compliance moving forward with the two different technology types, and would love some conversation around how we think about that moving forward.

MS. BAHREINIAN: Just one point of clarification. We are increasing preferences for all ZEV vehicles, which means both FCVs, PHEVs, and EVs. We are increasing preferences for all of them and it is all meant to meet the ZEV regulation requirements, all of those are going to be met.

One of the reasons why we just focus on PEVs is that our other half in the demand analysis generates demand for electricity, and so they rely on our forecast for their forecast of electricity, that's why. Otherwise, we are meeting all of the different fuel types in ZEV.

But we will be very interested, as Courtney said, in hearing anything that you have to say about any one of the ZEV vehicle scenarios.

FEMALE VOICE: Excuse me. What is the name of the model that you used for forecasting.

MS. BAHREINIAN: For light duty vehicle or for all of them?

FEMALE VOICE: For all of them.

MS. BAHREINIAN: For all of them we have a software that we call Dyna Sim and we are -- which is short for Dynamic Simulation -- and we house all of our different models in Dyna Sim.

We do have a freight model. We have an urban travel model which is a short distance travel model. We have an intercity travel demand model which is long distance travel demand model. We have a light duty vehicle model for households, we call it personal vehicle choice model. And then we have a commercial vehicle choice model. In addition to that, we also have an aviation demand model.

So we have multiple models, there are five or six different models that are housed into one software.

FEMALE VOICE: But they're all simulation models.

MS. BAHREINIAN: They are all, yes. We simulate for, yes, demand in the future.

Yes.

MR. HUA: Hello, I'm Guihua Hua (phonetic) from ARB working on renewable source emissions forecasting. I have a clarification question about vehicle attributes.

The price is listed as one of the vehicle attributes, so what kind of price, is that MSRP or OTD price, or just the overall price the car retail for average. Thank you.

MS. BAHREINIAN: Thank you. So the question is what kind of price do we use, what kind of price do we forecast. I'm going to let Sierra Research answer that question.

What is important for our choice models really are the relative prices. Whether we are using MSRP, the difference between MSRP and the transaction price when you are looking across different vehicle classes and fuel types, you could see that the ratios are kind of the same. And what is important for the choice model are the relative price of these vehicles. Not that we use them but in reality that's what matters.

So is the relative price of fuels. If electricity, for instance, goes up relative to gasoline, then it is going to have impact on demand for EVs. So both relative fuel prices and relative vehicle prices are important, but I'm going to let Jim Lyon of Sierra Research to respond to that question. Usually they use MSRP but he can answer that.

MR. LYON: We've been doing our price forecasting in terms of MSRP. As you may be aware, transaction price data and the public demand are fairly sparse and difficult to obtain, so that's why we've used that approach.

MS. BAHREINIAN: Any other questions, comments, suggestions? If there are no other questions or comments, I'm going to introduce Eva Borges. She's going to talk about the sales weighted average prices that we briefly referenced in my presentation.

At any time, later even in the day if you come up with a question related to anything I said, please feel free to ask those questions. Thank you.

MS. BORGES: Good morning, everybody. Today I'm going to present a general overview of vehicle prices. For the past five years you've seen the sales-weighted average price with California specific data.

So the DMV data is the only source that we use to calculate the sales-weighted average price for new vehicle sales in California. The sales-weighted average price requires two data items generated from the DMV data, and those are the new vehicle sales and the vehicle prices. And here is a brief description of what these two data items include.

The new vehicle sales have the monthly sales with make, model, series, model year, sell date, vehicle class, fuel type, and estimated price.

The estimated price is the calculated value from some purchase prices that DMV provides and these represent the transaction price after manufacturer incentives and before taxes and government incentives.

So with these two items we can calculate the sales-weighted average price for each make and model and for each vehicle class, specifically for light duty vehicles.

We have some data limitations in this analysis. The first one is that the oldest data that we have available for the sales-weighted average price is 2010, so as of today we have only five years of historical data.

The second limitation is that any vehicle with a purchase price above $96,600 is set in the DMV database with an estimated price of $96,600, and this is because the purchase price the DMV provides is based on the vehicle license fee code, that’s the limitation.

So for luxury cars that have a price above this limit number, it’s not a big impact in the light duty vehicles because they only represent less than one percent of the new vehicle sales in the light duty vehicles, but it represents a limitation for medium and heavy duty vehicles because they are mostly higher than $96,000. So the sales-weighted average price is then applied only for light duty vehicles because of this reason.

And as mentioned before, the sales-weighted average price is calculated by vehicle classes and by fuels or technologies, so here we have a list of the 15 light duty vehicle classes and the 8 fuels or technologies that apply for light duty vehicles.

And we also include some examples of models in each class. We also calculate the sales-weighted average price for each make and model that is in the class.

It’s important to mention that I’m going to be using the two main groups to explain some findings that we have from prices, so I’m going to be car as one group and light trucks for another group, and then I will go deeper to one of the classes in each group.

So here is an example of the sales-weighted average price for 2014 diesel compact cars sold in 2014. So we have the two elements for the sales-weighted average. In the horizontal axis we have the estimated prices that were paid for diesel compact cars, and in the wide axis we have the number of vehicles sold at each estimated price.

So for this class, the compact diesel, we had two main makes competing in this group, so we have Volkswagen and BMW. We can see the two big groups in the chart, they are a different range of prices. And in total we have only five makes and models combining with the two makes.

So using the estimated price and the volume of sales, we got a sales-weighted average price of $31,000 for a 2014 diesel compact car.

We also include the simple average price just to see the difference against the sales-weighted average price. In this case this was $6,000 difference.

Now I'm going to present some charts and tables using the five years of data that I mentioned we have available.

This chart represents basically the market share of fuels and technologies in new vehicle sales. In the table we have -- it's very small, but we have the percentage of sales of each fuel and technology per year.

The problem with this table, and we couldn't change it, it was too late, but is that the actual penetration of the fuels and technologies cannot be really appreciated combining all the classes, so we broke this analysis into cars and light trucks that I mentioned before, and that's how I'm going to explain a little bit. Sorry about the numbers, they're not going to represent what I'm saying.

But let's start with the light trucks. In this group they have no big changes of penetration of alternative fuels or technologies. In the last five years 90 percent of the new light trucks sales have been gasoline or ethanol, so only four percent having shared within the remaining fuels and technologies.

Now let's focus on the cars group.

In 2010 92 percent of the new vehicle car sales were gasoline or ethanol, and by 2014 it was reduced to 84 percent. So it went from 92 percent to 84 percent.

Of the remaining 16 percent, 9 percent were hybrids, almost 3 percent PHEVs -- and this is only on cars, okay -- and diesel and battery electric were around 2 percent of the total sales of cars. There were very few of natural gas and almost zero for hydrogen.

So this chart also has the new vehicle sales but now by classes, okay, these include all the sales.

Again, in order to identify the changes within classes we had to do the analysis by cars and light trucks first. The table again is showing combined data so I'm going to explain it by groups.

On average 65 percent of the new vehicle sales are cars and 35 percent are light trucks in the last five years that we have. In the light trucks have not been showing any changes between classes, they have been constant in the percentage or the preferences.

The closed utility trucks, for example, have had 50 percent of the market, followed by the pickups with 24 percent every year. The SUVs have 14 percent, and the vans have 13 percent.

In contrast with the car market we can see some changes between classes. In 2010 the midsize car had 32 percent of the market, and by 2014 it rose to 51 percent. So people started moving to midsize cars, especially the subcompact and the large one. The compact car stayed constant and it's actually the second largest class with about 3 percent on this market. The sports car, they stayed constant with around 3 percent every year.

So now I'm going to show some specific sales and sales-weighted average price for the largest class in sales, which is the midsize.

As mentioned before, alternative fuels and technologies have had real impact on the cars market and light trucks. So midsize car is a class where the hybrids have had the largest impact or penetration. They represent the second largest portion in sales in this class, in the midsize. In 2014 gasoline and hybrids accounted for 94 percent of the new vehicle sales in midsize cars. Of the remaining 6 percent, 3 percent were PHEVs -- this is in 2014 -- 1.4 percent were flex fuel vehicles, and another 1.4 are diesel. Battery electricity cars had almost 1 percent of sales in 2014.

Flex fuel vehicles went down, as you can see. In 2013 they had 6.6 percent, and by 2014 they went down to 1.4 percent. And this is because some of the top selling models switched to large cars, so the sales are counted but in a different class, such as the Dodge Charger. And also the Chevrolet Malibu was not produced in 2014 as a flex fuel model.

So now let's see the sales-weighted average price in this class. This class shows the prices for each fuel or technology in the last five years. And the table is showing the difference in prices against the gasoline midsize car. The one in parentheses indicate the lower price than gasoline.

So let’s start with the gasoline cars. They have gone from $29,000 in average in 2010 to $26,000 in 2014. They are $3,000 cheaper actually with their fuel economy.

The hybrids is the next fuel. They have gone in the opposite direction. They start with the sales-weighted average price of $26,000 in 2010, and they went up to $29,000 in 2014. By 2014 a hybrid car was $2,000 more expensive than gasoline cars in average.

The flex fuel vehicles were cheaper the first four years of this data, and that’s when they increased the market share as we can see in the previous slide. So you see the flex fuel vehicles here. In 2010 they only had 3.5 percent, and by 2011 they increased to 6.7 percent. But in 2014, like I say, it went down to 1.4 because some of the top models they moved to large cars. And the Chevrolet Malibu, which is also one of the best sellers, was not produced in flex fuel vehicles in 2014. So by 2014 in average the flex fuel vehicle was $5,000 more expensive than a gasoline car.

The price of PHEV hasn’t changed much in the last five years. They have been between $33,000 to $34,000. The difference in price against the gasoline, we can see is $7,000, $5,000, $6,000. It's basically because the gasoline cars are getting cheaper, so that's why there is a difference bigger. We know that the top selling PHEV is the Toyota Prius in this class.

The price for battery electricity cars is actually going down from $35,000 in 2010 to $30,000 in 2014, and the only option is the Nissan Leaf in this class.

The price of a diesel midsize car, which is almost the last one, went down in 2012 because of the introduction of the Volkswagen Passat. By 2014 there were new models from Audi and BMW with very good sales, so that's why the price or the difference in price against gasoline is bigger now, it's almost $14,000 more expensive than a gasoline car.

Now I'm going to talk about the second largest class, which is a car also, a compact car.

The market share of gasoline in the compact cars has been reduced from 95 percent in 2010 to 85 percent in 2014. So the remaining 15 percent in 2014, 6 percent are hybrids, 4 percent are PHEVs, followed by the diesel with a 3.4 percent.

For flex fuel vehicles there are new models offered in 2012. Dodge, Buick, and Cadillac, they started offering flex fuel vehicles, so the market increased to 1.7 percent.

For electric cars there are only two models in this class, the Ford Focus and the Honda Fit. The sales of hybrid electric cars are growing but they still have low penetration in the market with only have a percentage in 2014.

Natural gas we only have the Honda Civic. So that's on the prices in this class.

This graph shows the sales-weighted average price for each fuel and technology for compact cars. The table is showing the difference in prices against gasoline. And again, the one in parentheses indicates a lower price than gasoline.

Gasoline cars have gone from $22,000 in 2010 to $26,000 in 2014, so this is a similar price than a midsize gasoline car in average.

The hybrids have gone from being $10,000 more expensive than gasoline in 2010 to being $1,000 cheaper than gasoline in 2014.

Diesel compact cars have been known to be more expensive than gasoline in general. And as an example, the Volkswagen Jetta in diesel has a price of

$26,000 and the version in gasoline has a price of $20,000, so the same car with different fuels, diesel is more expensive.

The price of PHEVs have been around $40,000 with Chevrolet Bolt leading this class. The sales-weighted average price for a Chevrolet Volt has been reduced from $43,000 in 2010 to $34,000 in 2014. Prices of PHEVs have changed from $21,000 more expensive than gasoline to only $9,000. Well, it’s still high but it’s better than $21,000.

For flex fuel vehicles we have new models from Audi and BMW that were introduced in the last two years, and that increased the price of the flex fuel vehicles.

Battery electric cars went from $39,000 in 2012 to $33,000, so they reduced the price, but they are still more expensive by $7,000 more expensive than a gasoline car.

The price of a natural gas compact car, the Honda Civic, was actually very close to a gasoline, but it was not successful in the market.

The last class that I’m going to show is the cross utility small truck, is the third largest class in sales and it comes from a different group from the trucks.

As mentioned before, the truck market has not seen much changes in the penetration of alternative fuels or technologies. Gasoline or ethanol has accounted for 96 percent of the light truck market. And specifically for the cross utility small truck, 98 percent of the sales are gasoline or ethanol.

Sales of hybrids in the light truck market have gone down every year in general in the trucks. Some examples are the Ford Escape and the Ford (inaudible) are not very well on sales.

And also in the pickup a different class in this group of trucks, the sales are going almost to zero. And some examples are the Chevrolet Silverado and the GMC Sierra.

The only battery electric model that we have in this class is the Toyota Rav4, and by 2014 they reached almost 1 percent of the market.

So here are the prices. So in general we have very few options on the cross utility small truck, and most of the options are I think more expensive than gasoline. So that might explain a little bit why people goes to gasoline or ethanol fuels in this class.

So to finish my presentation I just want to mention or summarize that the California Energy

Commission staff calculated the sales-weighted average price by using DMV data, so this is data specific for California.

And the data that we have available, like I say, is only five years as of today, but we're going to increase historical data in the next years.

And we are using 15 vehicle classes for light duty vehicles and 8 different fuels and technologies for light duty vehicles.

And in general the sales-weighted average price is letting us do a deeper analysis of how the market is changing between fuels, preferences, and also between size preferences and the cars and in the light trucks markets. And they are based on transaction prices in California.

So we would like to hear any comment, feedback, question, or recommendation that you have in order to improve or complete this analysis. Is there any questions?

MALE VOICE: There is one question online that's more of a general question, again from Sam Pournazeri.

Where can we find technical documentation associated with the models, vehicle attribute model, consumer choice model, etcetera?

MS. BORGES: Where can we find technical? Okay, I'm going to let Aniss answer this question.

MS. BAHREINIAN: I can certainly send it to you, Sam, but we are thinking about creating a website and posting these online. They are not yet there.

MS. BORGES: Okay, no more questions? Okay. Thank you.

MS. STRECKER: Next up we have Jim Lyons with Sierra Research to talk about our light duty vehicle attribute forecasts.

MR. LYONS: Thank you, Gene. I'm going to point out at the beginning here that I'm pinch hitting today for Tom Carlson, who is our technical lead on this project. He's on vacation and I'm the project manager and I believe I'll be able to answer any questions you have, but I just wanted to let you know that up front.

This slide presents a brief overview or outline of my presentation. I'll give some background information and the key objectives of the work, talk about the data sources, methods, and assumptions that we've used, and then spend some time presenting and discussing the attribute forecasts that we've developed.

By way of background, as Aniss has pointed out, the vehicle attributes that we're preparing are used as input data for the Commission's consumer choice modeling to forecast the characteristics of the California vehicle fleet.

I guess one thing that's not conveyed there or maybe didn't come through in the earlier presentations is there's two parts of the attributes. There are the attributes for the existing vehicles where we've developed a detailed database that characterizes what's been put into the market. And then we use that as a point of departure along with methodologies and data to forecast what we believe those characteristics will be for the vehicles going forward into the future.

Attributes, again, are characteristics of the vehicles, which include vehicle price, as I indicated before, MSRP, fuel economy, the number of models available, as well as other characteristics such as vehicle performance and vehicle utility metrics.

We're forecasting light duty attributes for 15 light duty size and vehicle type categories which are used by CEC, and then 10 conventional and emerging alternative fuels; gasoline, diesel, compressed natural gas in the light duty vehicle market; ethanol, electricity, as well as conventional hybrids, plug-in hybrids, electric and fuel cell vehicles.

Again, the key objectives, as I just pointed out, were extending historical database, which has now been updated through the 2013 model year. And then we're forecasting model attributes for model years 2014 to 2026.

We've looked at three fuel economic and demographic scenarios which have been defined by CEC, the reference case. Low demand and high demand. I've labeled them as PEV here as they're evolving over time. However, the low demand case is, again as Aniss pointed out, characterized by high fuel prices, and the high demand case by low fuel prices.

And a key assumption for all of our work is that we need to have vehicle attributes that reflect compliance or will allow CEC to demonstrate that their forecasts will reflect compliance with adopted federal standards and regulations such as CAFE, the EPA greenhouse gas rules, the renewable fuel standard, as well as California state regulations, which include the zero emission vehicle and advanced green car standards as well as the low carbon fuel standard.

While there are a multitude of vehicle attributes that exist, our work is focused on five priority attributes. These are the numbers of makes and models that are available, vehicle prices and MSRP.

Vehicle fuel economy which is adjusted on-road. We use a 0.8 factor to discount CAFE numbers, which is based on work performed by the National Academy of Sciences, or NAS.

Driving range in miles, and then maintenance costs. The maintenance costs, I'm going to talk a little bit about. Those are five-year annual averages from the new vehicles. They exclude things that are covered under warranty that include things like tire replacements and brake wear, which are not generally covered by warranty.

And then the primary data sources that we've used in our work are with respect to price and fuel economy, the 2013 National Academy of Sciences study, "Transitions to Alternative Vehicles and Fuels." And within that there's something called the LAVE-Trans model, which is a model that was developed by David Greene to assess the impact of changes in vehicle attributes on market acceptance. It's not the consumer choice model that's used by CEC, but we've been using that as a surrogate for consumer choice model to make sure that our attribute forecasts for plug-in hybrids, electric vehicles and fuel cell vehicles look like they will generate the appropriate market response that would allow for the compliance with the California state regulations as well as CAFE.

We’re looking at ZEV sales targets from the Air Resources Board.

We’re getting our driving range data from the Energy Information Administration using their Annual Energy Outlooks.

And then we’re getting existing makes and models from existing data as well as maintenance costs and then using those for our future year forecasts.

So looking at how we’re forecasting attributes to change in the future, we’re using NAS technology penetrations for power train improvements. There’s a lot going on in the development of new more efficient engine technologies, direct injection, better transmissions, as well as the introduction of advanced technologies.

There’s also load reduction that’s being forecast in the future which we’re accounting for, and improvements from reducing the weight of vehicles, improving aerodynamics, lowering drag and the rolling resistance of tires, as well as changes to use more electric alternators and generators, which also result in vehicle efficiency improvements.

The points under the second bullet highlight some of the key NAS assumptions.

There is no further efficiency improvements assumed in the NAS studies for diesel engines given that those engines are designed for high efficiency in the future, so the assume improvements forecasts are associated with gasoline engines where performance rather than fuel economy has been more of a driving factor in the past.

For electric vehicles and plug-in hybrids, lithium-ion batteries are forecast to be the long-term technology. NAS assumes that weight reductions on the order of 15 to 20 percent are possible over the period from the 2010 to the 2030 model year, and we're accounting for those.

And then we're also using their assumption that there will be a trade-off between vehicle performance and utility and downsizing that is necessary for manufacturers to comply with the more stringent greenhouse gas and fuel economy standards that are applying between now and 2025.

Again some more detail on the NAS work that forms the kind of core of our work.

The technology costs reflect fully-learned high- volume production as well as phase-in schedules.

There are separate estimates that have been developed for internal combustion engine vehicles, or ICEs, hybrids, plug-in hybrids, and battery electric vehicles. The scaling factors for the vehicles that make greater use of batteries and bigger electric motors are shown there.

And then within the NAS study, fuel cell vehicle and compressed natural gas vehicle costs are constrained by the assumptions there that there’s going to be infrastructure issues. That’s on a national basis, not on a California basis where obviously there is much more work being done on hydrogen refueling infrastructure. For example, for fuel cell vehicles. And so we’ve had to work around those assumptions in doing our work.

As I mentioned, we’re using the LAVE-Trans model to look at these different technologies and generate fuel economy and vehicle price forecasts.

We’re using their estimates for fuel economy improvements in vehicle prices for gasoline internal combustion engines, hybrid electric vehicles, and CNG technologies.

And we’re doing the same for diesels in terms of load reduction improvements and also for using gasoline data to forecast fuel economy improvements and MSRP that are not related to improvements in engine technology.

For CEC we've created a diesel hybrid forecast which isn't in the NAS study, using the improvements from gasoline hybrids to characterize what hybrid diesel vehicles could look like.

And then we're using future battery costs that have been scaled from the NAS midrange estimates, which indicate a substantial reduction over time in battery costs for the different types of vehicles which use batteries.

Turning to model availability, for gasoline vehicles and conventional or hybrid electric vehicles we've scaled our model availability using results from LAVE-Trans.

For diesel vehicles we've done something different. We've grown them through the 2018 model year that's a forecast that's based on projections from Bosch which were presented to the Energy Commission back in 2013 and which we've been asked to consider.

For plug-in hybrids, electric vehicles and fuel cells, we've grown those model from the 2013 baseline to reflect the increase in sales of those vehicles that's mandated by the ZEV regulation.

Obviously to increase sales relative to 2013 in those vehicle technologies there’s going to need to be a greater offering of makes and models, and we have accounted for that in our work.

And we’ve accounted for the availability of these technologies in the car and truck fleets using forecasts or other information that we’ve obtained from CARB.

We’ve also accounted for changes in vehicle price that are driven by changes in fuel price. When fuel prices go up, then you expect the prices of more fuel efficient vehicles to go up in turn because of the greater demand for those vehicles. We’ve relied on a 2013 study from Busse that provides a methodology for accounting for that, which we’ve incorporated into our work.

As Aniss pointed out, our preliminary forecasts for ZEV vehicles led to projected sales that were substantially below compliance. In the current work which I’m presenting today we’ve adjusted vehicle prices and used the LAVE-Trans model to refine those price adjustments in order to get prices that we think will allow CEC to generate sufficient populations to demonstrate compliance.

It sounds like CEC has got some other

revisions planned that will also affect his, and we'll be working with them going forward in order to finalize both our attributes as well as their work.

So using all of the work that's gone into what I've previously summarized, we've forecasted vehicle prices and makes and models for the three different demand scenarios that CEC has provided to us, and we've projected fuel economy, driving range, and maintenance costs by the different fuel and vehicle technology groups and vehicle class groups.

We've, however, assumed that the characteristics of the vehicles themselves don't change as a function of demand scenario. Again, there might be changes in vehicle prices, but these other kind of more integral costs of the vehicles are assumed to stay the same but independent of the demand scenarios.

I'm going to walk through some of our results here.

First is fuel economy, this is for the compact car class, and you can see for the different fuel technologies what our forecasts are for fuel economy. This is generally driven by the need for vehicles to comply with the CAFE and greenhouse gas regulations.

This is an analogous slide for the midsize cross utility vehicle, which is in one of the truck classes. And again, the changes over time are driven by the need to comply with CAFE and greenhouse gas standards.

These are our forecasted vehicle prices. This slide is for the compact cars. And the most notable feature here are the two kind of V-shaped curves where you see a significant decline in price for electric and plug-in hybrid vehicles. It's anchored in 2013 by the actual data that we have, and then these reflect the adjustments that we've made using the LAVE-Trans model in order to get price forecasts that we believe will allow the demand model to show sufficient vehicle sales in order to comply with the regulations.

This slide shows the magnitude of the adjustments that we made for the electric vehicles and the plug-in vehicles in the compact car case. As you can see, they're fairly significant changes relative to what the NAS forecasts are.

This is the price slide for the cross utility vehicle in the truck category. Again the same behavior is seen for the electric vehicle and plug-in hybrid vehicles within this category.

This slide is very busy and I apologize for it. The top part of it shows the CARB ZEV compliance targets in terms of sales percentages in the different vehicle categories; plug-in hybrids, electric vehicles, and fuel cells, as well as the sum.

The second part of it shows what we got out of the LAVE-Trans model using the price adjustments that I discussed previously.

And then the bottom two rows shows how what we got out of LAVE-Trans compares to what the CARB forecasts were. The red slides show that we have a little bit of undercompliance [sic] the first couple of years, and then overcompliance [sic] thereafter. Given the way that credits can be traded within the ZEV program, those near-term shortfalls are made up by credits from later model years, and this is kind of the validation that we did to confirm that the price forecasts that we gave CEC should be reliable for generating ZEV compliance out of their consumer choice model.

Another busy slide, but this just shows the sensitivity of vehicle prices in the compact and -- the impacts of fuel prices in the -- a couple of the categories here you can see the price of an electric vehicle goes up for the higher fuel price cases you'd expect, and the price of the pickup goes down because people are going to not be as interested in buying a less efficient vehicle. And the converse occurs with low fuel prices.

The other thing that this slide shows is that the methodology that we used doesn't indicate that there would be large changes in average vehicle prices as a result of the changes in fuel prices.

These are the forecasts we've used for driving range. Again, these are taken from EIA. You'll note the flat line on the bottom for electric vehicles. That's because EIA either assumes 100 or 200 mile electric vehicle range. Addressing that issue is one of the things we'll be working with CEC staff going forward. Otherwise, you see that range is increasing as you would expect from the improved fuel efficiency of the vehicles that's been forecast.

The other thing I'd note about this is EIA is not assuming any downsizing of vehicle tanks, which would further reduce the weight of vehicles and lead to additional efficiency improvements. We're going back through and working to check on that assumption and may revise these estimates accordingly for our final attributes.

This is the same slide just for the midsize cross utility vehicle instead of the compact car. It shows you how our attribute forecasts for range are changing. Again, the same caveat applies for the electric vehicle range forecast.

These are our maintenance costs. I believe there's going to be an additional presentation that delves further into the maintenance costs so I'm not going to go through them in detail here. They are derived from existing vehicle data and are assumed for most technologies to remain constant over time.

You'll see again for the fuel cell vehicles and electric vehicles a large decrease. That's because on the far left they're tied to the limited data that actually exists, and then we're making adjustments for the future to account for the characteristics of those vehicles where they don't need oil changes, for example, and things like that.

And again, we're going to work with CEC staff to further refine the initial year estimates to make sure that we don't have any problems from discontinuities in the data and assumptions that are used.

The final point that I'll touch on are the forecasted makes and models. This shows all of the model forecasts across the different vehicle classes. The top line is gasoline vehicles which obviously dominate the current fleet and are expected to continue to dominate in terms of makes and models going forward.

You can see at the bottom that there is growth in the other vehicle categories. That’s expanded here where we’ve gotten rid of the gasoline vehicles and the top line is now the flexible fuel vehicles. And you can see that, for example, the number of plug-in hybrid models as well as electric and fuel cell vehicles are expected to increase fairly dramatically over time in our forecasts.

To close here, again, all of the forecasts that we’ve evaluated are based on a ZEV compliance assumption. We’ll be continuing to work with the Energy Commission going forward in light of the comments and input that we get today as well as the issues that we’ve identified leading up to the workshop. And then we’ll be delivering our final attribute forecasts as well as a report of how they were developed in the next month to CEC as part of the 2015 IEPR process.

This is just our contact information. I’ll take any questions now. If you have questions afterward, feel free to contact either us or CEC staff.

MALE VOICE: We do have one online question, again from Erik Seilo. Please expand on why PEV and PHEV prices increase on Slide 14.

MR. LYONS: Okay. As I mentioned during the presentation, I'm going to use Slide 15 to address this question rather than Slide 14. Again, this just pulls out the PHEV and EV data.

The solid lines show the adjustments that we had to make in order to get the LAVE-Trans model to predict enough technology adoption to be relatively confident that the CEC's vehicle demand models would show ZEV compliance. We need less in future years of an adjustment, and so our price forecasts trend back up toward the NAS forecast but they never get back to the NAS forecasts.

The dotted lines which show the NAS forecasts present what I think the commenter is looking for, which is a decrease in the forecast price technologies over time. So we did start with that, but because of the nature of the price adjustments we had to make in order to demonstrate ZEV compliance, especially in the early years, we've got this kind of discontinuity, if you will.

Okay, well, Thank you very much, then.

MS. STRECKER: Thank you, Jim.

Next we'll have John Michel from the Energy Commission talk about a methodology he prepared to determine or forecast maintenance costs for light duty vehicles.

MR. MICHEL: Hello. I am John Michel, and I'm just going to walk through the process that I used to update our maintenance cost attributes for this forecast.

Like Jim said, they did one and we're in the process of bringing our attribute forecast in-house for a future IEPR and this is just a step in that direction.

I did use historical data that Sierra provided for us from a previous transportation energy demand forecast. And we'll start by looking at what's out there.

For the previous two forecasts maintenance data has come from two sources; *Edmunds True Cost to Own* and AAA's *Your Driving Costs* brochure.

In the *True Cost to Own,* you take a make, model, and a year and they give you costs for each of the first five years of ownership in multiple categories; depreciation, taxes and fees, financing, maintenance, repairs, and a few other ones. We are only using the maintenance costs from this data.

And we like this data because it’s model specific but it only goes back to model year 2008 or so, so we need another source to go back further.

And also as we’ll see later, Edmunds does not have comprehensive data for alternative fuel vehicles so we had to make some assumptions there to fill in on our dataset.

AAA has been publishing its *Your Driving Costs* brochure since 1950, so it was used by both of our previous contractors to guide the historical trends that they used in their forecasts. And AAA gives, what they give is the average, class average costs for gasoline vehicles only in the following classes: small sedan, medium sedan, large sedan, SUV, and minivan. So they’re slightly different than the classes we use but they’re pretty easy to fill out and in.

And AAA, Edmunds, and us at the Energy Commission, we all use the same basic definition for maintenance costs. It’s the cost per mile of a vehicle driven 75,000 miles over its first five years. And that includes factory recommended scheduled maintenance, like oil changes, tire rotations, inspections, that sort of thing. And unscheduled maintenance like wheel alignment, replacing the battery or brakes or bulbs or anything that wears out.

We also include tires, and Edmunds puts that in unscheduled maintenance. AAA has it separately but they do provide it in all their brochures so that's easy to add in.

And AAA also includes the price of an extended warranty, which Edmunds puts in repairs, but that does not affect the results too much.

One other thing is that since the Edmunds data is model specific, it takes into account factory covered maintenance schedules.

Like BMW, for instance, you don't pay any maintenance costs for the first three, or now it's four years that you own the car. And Honda and Chevy have similar deals, and that's accounted for in our data and you can see it in the sales-weighted averages and it can significantly reduce the costs, as you might imagine.

Now that we know kind of what's been done, what's in the costs, we can set a goal for gathering new data for this forecast, and I made that goal to get updated maintenance cost data for every class and every fuel type that we use for model years 2011 to 2014.

And that covers classes that don't even have models currently in them, because our forecasting model requires that any class with available makes and models in a given model year needs to have an attribute value for that year. So by fully populating all the fuels and classes, we make the cost per mile independent of the makes and models available, and when that makes and models file changes, it becomes very easy to adjust our maintenance cost input to reflect those changes instead of having to recalculate everything.

When it came time to gather the data, we looked at the top five models per class according to Eva Borges's sales numbers, and got the maintenance cost information for as many of them as we could.

Some of the models were not in the database. For instance, in the electric car the Leaf is the only one that's in that database. The Rav4, Tesla's cars, smart cars, they're not in there.

And many of the alternative fuel vehicles like hydrogen are lease only and the maintenance is included in the lease price so we don't have separate data for that.

And also some classes don't have file models with sales data, so we used the best we could for the sales-weighted average.

Some fuel types we had no data for at all, and we’ll deal with those later. We had to make some assumptions to fill those in.

In the next slide we’ll see how those data points are distributed, and after that we’ll look at the data in the popular gas and hybrid classes and see what we see.

This table shows the number of models in each class for which I was able to get Edmunds data for model year 2014. And 2011, 12, and 13, they look pretty similar. Ideally, this would be populated all with 5’s, but that is not the case.

Gasoline is the only fuel type that had data for every one of our classes, which makes sense given the makeup of the current vehicle population. And because of this complete data, gasoline maintenance costs will factor heavily in our trends analysis.

There’s decent data for hybrids and ethanol and diesels. Plug-in hybrids and electrics, not as much. And for driver's license hybrids, natural gas, duel fuels, and hydrogen, there was no data available for any class. And that’s what we have, and we can now look at what we see in the data.

These are the sales-weighted average cost per mile for the top selling gasoline vehicle classes 2011 to 2014. It’s the smaller cars, subcompact, compact, midsize, and cross utility, cross utility small car, cross utility small truck.

You can see they’re all between about 4 and 7 cents per mile, which for reference is about $600 to $1,050 per year using our 15000-mile-per-year assumption. And you can see costs increasing gradually over time.

Midsize and compact cars, quite similar costs, those are the two bottom lines.

The subcompact is much higher than you might expect. You would expect it to be similar or lower than the midsize and compacts, and that’s because the subcompact is populated by BMW, Fiat, Lexus, instead of Honda, Toyota and Nissan which make up the bulk of the compact and midsize classes.

Also, one other thing to see is the subcompact goes down from 2012 to 2013 and the compact goes up similarly in 2012 to 2013, so I thought maybe there would be some crossing over there but it’s a coincidence, that’s just what happens in the data.

Now we can look at the hybrids.

The first thing that jumps out -- well, sorry. First of all, I should mention that these are the same classes as before except large car is replacing the smaller cross utility.

Right off the bat you can see that the cross utility small truck is much higher than any other class represented here. That's because its main contributors in this class are the Audi Q5 and the Porsche Cyan, brands that typically have higher maintenance costs.

Again you can see that subcompacts is higher here than midsize and compact, and that's because the majority are Lexus. There used to be in 2011 you can see it's lower, and that's because there was the Honda Insight and the CRZ, but then those sales dropped off and the Lexus sales picked up, and so the sales-weighted average came up. And it's a trend. Subcompact is more expensive than compact to maintain.

Overall here and hybrid costs are increasing, and that's another trend we see throughout the dataset. Thirty-five out of the fourty-one classes that we had data for show costs increasing, and the average increase is about 4 percent per year over those. There's three increases but over a four-year period.

And I don't have information graphics for them, but just to mention some other trends between the fuel types. That is, costs for diesel and hybrid, generally a little bit more than gasoline.

Flex fuel cars, also a little bit more than gas but that’s just not because of technology, it’s just because the makes that are offered similar to what we see in this cross utility line here, the makes that are offered are more expensive to maintain.

Plug-in hybrids, super close to hybrid from model to model. The sales-weighted averages are a little bit different. Plug-in hybrid ends up looking a little cheaper because of the sales-weighting that we do.

And finally electric is cheaper than gas to maintain because you don’t need any oil changes, there’s fewer moving parts, that kind of thing. It’s one of the selling points.

That’s just the sort of things we were looking for where we had data and we want to apply those trends to areas with less data. And there’s three kinds of missing data cases. There’s classes that have some years with data and other years that don’t have any data. Fuels that have data in some classes and not in other classes. And some fuels we don’t have any data for at all, and we’ll handle each one of those a little differently.

First off, one class that had some blank years but not all is the sport utility compact in the hybrid fuel type. So we look at the year-to-year trends within the other hybrid classes that we have data, scale them according to this data point that we do have, and presto, we fill in the blanks.

To fill in the remaining classes that don’t have any data at all, we compare the average hybrid maintenance cost to gasoline for the classes that we do have data, and we scale the maintenance costs from the corresponding gasoline class.

So for sport car we don’t have any hybrid data but we get a scale factor based on the data we do have and apply that to the gasoline sports car and that’s what we use for all these blank classes. And again, presto.

Now, any fuel type that had any data in it at all we have fully populated using these methods. All that is left is the fuels that don’t have any data, and we’ll handle each of those separately as well.

So the four fuels that have no data are diesel electric hybrid, natural gas, dual fuel, and hydrogen. And we populate each one of these based on just a blank assumption we made. There’s further details at the end of my slides because I didn’t want to clutter it up too much here, but I’ll explain them right now as we go.

Diesel electric hybrids, we make those by adding electric drive systems to conventional diesels just like with gas, so we assume that the maintenance costs would scale from diesel the same way that hybrid maintenance costs scale from gasoline. Straightforward.

For natural gas, we were able to find recommended maintenance schedules for two mass produced models, the Ford Crown Victoria, which was in the early 2000s, and the Honda Civic, which you could still find a new one but they're not going to produce any further model years. These models have gasoline and natural gas models so you can make a direct comparison there based on the maintenance schedules, and they were close enough to call a wash.

Unscheduled costs and tire costs, those don't really depend on fuel type, so therefore we assumed that natural gas maintenance costs equals gasoline maintenance costs.

Dual fuel, or bifuel, which are gasoline and natural gas, they're made by adding natural gas storage tanks and delivery systems to inject the natural gas directly into the valve. There's very little modification to the gas operation other than interrupting the fuel injectors when you're using CNG. And the added components don't require any special maintenance that would add significant costs. And for the models currently available, the tank, the valves, the controller, they're all under warranty that more than cover the five-year one that we're looking at. So therefore, we can assume that dual fuel also equals gasoline maintenance costs.

Hydrogen is kind of a similar case. It's a dual fuel in that apart from the hydrogen system the cars are basically electric cars. And hydrogen systems are so complicated and expensive that any maintenance is going to need to be done and probably paid for by the manufacturers. So therefore, we assume that the hydrogen maintenance costs are equal to the electric maintenance costs.

And using these assumptions we have now achieved our goal of having the maintenance costs for every class and every fuel type for years 2011 to 2014.

The next thing is to merge it with the previous historical data, project it into the future, and wrap it into a format that our forecasting model likes.

For the historical data we kept it pretty much as is except for 2011 where if there was overlapping data we just took the simple average of both.

Projecting into the future, you saw that Jim showed you most fuel types they projected flat. And we did pretty much the same thing, because historical trends, they go up and down pretty unpredictably. In 2011 they predicted that it would go down slightly from year to year, and they've been increasing ever since, so we had to use our best judgment there.

Remember that what's important here is the relationship between different classes of the same fuel and individual classes across fuel types. That's what going to inform the decision making in the consumer choice model.

So if we were comfortable with the costs that we came up with in a class, we projected it flat. But there are some classes like those outliers we saw earlier which we had to decide if we could expect those to change or stay the same.

Like for the hybrid cross utility trucks. Are non-luxury models going to be introduced in the hybrid that bring the average cost down toward where you might expect? Probably, it's a pretty fast growing class in gasoline and so we can expect that those models will be introduced intro hybrid as well, so we can project costs for that class to decrease in the future.

Will the subcompact costs come down near midsize and compact where we might expect them? Maybe, maybe not. Right now they're looking more like a specialty car than a kind of common everyday car, so we projected those to stay flat and stay high relative to the larger cars.

And we went through every class and made sure we were comfortable to obtain the final maintenance cost forecasts. Mostly we did keep them flat, we just made a couple adjustments for outliers, and we ended up with something that we're quite comfortable feeding into our personal vehicle choice model.

And that is all I have to say about that, unless there's questions. Does anyone have any questions?

Okay. As I mentioned, the details of the blank fuel assumptions are at the end here. I went through them so I'm not going to go any further, but that's it.

And now I would like to introduce lunch.

MS. STRECKER: Thank you, John.

Before we break, it is a good time to take a lunch break considering it’s five after 12:00. Does anybody have any questions or comments before we stop for the morning?

Okay. Then we will resume at 1:00 p.m. A quick lunch for most of us today. Thank you.

(Adjourned for Lunch at 12:05 p.m.)

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AFTERNOON SESSION

MS. STRECKER: Welcome back. We're going to get started again. This afternoon we just have a couple more presentations to go. Thank you for joining us, and we appreciate any feedback you can give us.

First up this afternoon is Bob McBride, and he's going to be talking about the work that he's done on medium and heavy duty vehicle attributes.

MR. MCBRIDE: Good afternoon. I'm Bob McBride, I'm the one-man show for medium and heavy duty vehicle analysis. Good afternoon to folks who could attend and to fellow staff, all those interested in the future market for efficient or alternative fuel medium and heavy trucks in California.

We're presenting our current numbers but we encourage anybody with the knowledge to point out where other values would be better.

First, I'll briefly describe why we gather this data. Next, I'll mention the six truck classes and six fuel types we described at our workshop in March, a couple of minor changes to them.

Most of our high demand, reference, and low demand case truck prices and fuel economy values are unique. In other words, we're not using the same ones for two cases. For a couple of classes we do use a set of values across two cases, as we'll see.

The fuel price and economy scenarios are the same as other forecasts produced concurrently in the Energy Assessments Division, which we're a part of, our office is part of.

At the end of the slides I've listed the key data sources I've used. Before that we'll see some graphs that display truck prices and fuel economy for four out of the six truck classes.

So first off, why truck attributes?

The quantities of energy consumed by trucks depend on their fuel type. Their fuel economy, the infrastructure barriers and the distance the trucks travel.

Fleet managers are the decision makers here. Weight, truck price, fuel economy, fuel price.

For past forecasts we borrowed the future mix of truck fuel types from other sources. In this forecast we'll be using the Argonne National Lab's truck model to simulate the market for fuel types. The 2015 IEPR will mark our first independently modeled forecast of these trucks.

So here are the six truck classes. Our motorhome class is not listed here but it's comprised mostly of private, not commercial, vehicles. That's the truck model that can't be used, so we don't need attributes.

Also, I've combined the Class 8 single unit trucks with Class 7 single unit and combinations, leaving the six truck classes here that require the attributes.

Beyond the six fuel types we identify separate prices in fuel economy for LNG and CNG trucks. Not that we separated CNG and LNG for the Argonne truck model, but in the revised forecast the fuel totals will be considered together as natural gas.

LNG trucks may use either spark-ignited or the new and more efficient compression ignited engines. CNG trucks in theory could use both those engines as well.

Also, where we see competitive propane truck prices in fuel economy for particular classes, we'll include that fuel type since it was included in earlier workshops.

Since preparing this presentation last week I've received some good information from industry sources, and that's why I'm putting the LPG back in.

We used the three common cases; low, reference, and high demand. Vehicle prices, fuel economy and fuel price projections are applied so that the low and high demand cases at least are a practical limit for our expectations. We may use the reference fuel economy in the high demand cases. I'll explain later as we look at the next slide.

So for our low demand case we used the highest fuel economy, miles per gallon, and in the high demand case we'll use the lowest.

The proposed EPA/NHTSA Phase 2 fuel efficiency and GHG rule is consistent with high fuel economy since it includes fuel saving from both drivetrain and vehicle technologies.

Since currents are currently being sought for the Phase 2 rulemaking, we'll not be using that in other classes. Phase 2 rules are proposed to take effect or have their first effect in 2021, or at least they have their first milepost of standards there.

For the reference and high demand cases we'll base fuel economy on the Phase 1 fuel economy rule, which conveniently was what the ARB's EMFAC model 2014 version now includes, and that's consistent with a low fuel economy, or average.

The current Phase 1 standard includes fuel saving mostly resulting from anticipated improved vehicle technologies, not the drivetrains so much.

For a third case we may use the 2012 forecast by the National Petroleum Council. They use the Argonne Truck 5 model. If that fuel economy meets or exceeds the Phase 1 fuel economy.

Fuel economy projected. We may retain the NPC estimated truck prices for natural gas trucks in the high demand scenario in any case. If the fuel economy projected in NPC, reference, or high demand case exceeds the Phase 1 fuel economy, we'll use that.

So the payback period, or how long it takes to recover the cost of the technologies beyond the lowest price, is important to the fleet managers who are responsible for selecting and arranging the purchase of the new trucks.

Again, the truck price and fuel economy are big factors in determining the payback period. The Argonne truck model market penetration output simulates the fleet manager's choices.

So now we get to look at some actual vehicles. The Class 3 is the first of four truck classes we'll look at. Some not shown here are utility or box trucks, but the heaviest of pickups with four wheels and a rear axle are here. Also the new medium sized vans run a couple feet higher, somewhat wider than a Class 2, like an Econoline.

This Mercedes Benz in the picture has a four cylinder 2.1 liter turbo engine and averages around 20 miles a gallon, and some of these are fitted with suspension that puts them in Class 3, so they are right at the border.

So first look at the black lines here, the price of diesel fuel Class 3 trucks. The prices for the conventional fuels are relatively well understood since the fuels are common and the prices are published. The high demand case truck price is the lowest price, and the low fuel demand case is the highest vehicle price.

Now look up to the blue lines, the CNG version of the trucks. NPC forecast in the high case, the dashed line, does not decrease with time nearly as much with this counterintuitive outcome. For the alternative fuels considered in the NPD forecast the incremental price of the alternative fuel can be higher than its equivalent Phase 1 truck represented here as the reference case.

Still, the conventional fueled truck in the NPC’s high demand scenario is the cheapest. This is the basis for assigning NPC as high demand case for this presentation. As expected, the gasoline version is the cheapest for all demand cases.

Now turn to the green lines representing a Class 3 truck with a pure ethanol engine. In work funded by the Energy Commission comments developed the ethos, a very low carbon emission engine using E85 only. The cost is pegged $1,000 or $2,000 higher than the gasoline version. But the big surprise is the kink in 2021 due to the Phase 2 rules.

We'll be checking prices for the Class 3 and the Class 4 to 6 against the sales-weighted averages generated by Eva Borges from the DMV data BAC most of these are under $96,000.

So fuel economy for the ethanol is about equal to the gasoline Class 3 on a gallon-for-gallon basis.

On an energy equivalent basis, BTU-for-BTU, the E85 engine uses about 28 percent less energy to do the same work.

The high demand case fuel economy, the dashed lines, are actually stated in their native units, not gasoline gallon equivalent.

In greenhouse gas the high demand case fuel economy aligns with the reference case.

The Argonne truck model states fuel and gasoline gallon equivalent units but most medium and heavy truck fuel is diesel, normally stated in diesel gallon equivalents, so we have to watch this carefully.

Where Phase 1 is the higher fuel economy we'll be using the Phase 1 truck price and fuel economy for both reference and high demand cases. That will be a judgment call.

So in Classes 4 to 6 these are a bit bigger. Some are step vans, others are box trucks or flatbeds, small tank trucks, big utility trucks, and some other outfitted for special purposes. And the one on the right is a hybrid that's being owned by Toyota.

For visibility we've split the 4 to 6 Class graphs into two, so here's the prices, and I'll flip back and forth for you. Note that the vertical Y axis has different scaling here.

Average prices are upwards of $50,000 for all the fields. I see truck chassis around $30,000 in truck blue book, however, but the box or other equipment can be pricy even before the cost of the alternative fuel drive and the tanks. Still, the price for all given fuel types appear rather tightly packed so within each fuel there's much red between the high and the reference and the low. The bigger difference is the incremental price between the fuel types.

So then we move on to the fuel economy for these Class 4 to 6 trucks. Again, I’m splitting the two into two graphs, these fuel economies. The values are all scaled to gasoline gallon equivalents here.

For most of the Class 4 to 6 fuel economies the reference and high values are the same. These all behave intuitively with the low demand case diverging from the reference case fuel economy after 2019 when Phase 2 begins to kick in, anticipating the 2021 requirements. So, yeah.

High demand case fuel economy is distinct for the electric truck, as we used the LCFS energy efficiency ratio instead of the method calculated elsewhere to determine the fuel economy relative to the gasoline truck, just for electric trucks there.

So here’s the four types we have for trucks over 26,000 pounds. The tank is a single unit. Upper right, that’s the day cab. Lower left is the sleeper cab. And lower right a Class A garbage or recycling truck. We have four classes of these for modeling. We’re only going to look at the sleeper cabs and the refuse trucks now.

So prices. This graphs a bit simpler.

Diesel trucks show three distinct price cases, although you see the reference and high demand case truck prices converging.

I'm sorry. You see the natural gas and diesel converging toward 2026 for this low demand case.

The compression-ignited Cummins Westport engine that are usually paired with the LNG tanks, that's shown in blue. It can be introduced quickly once the price of diesel goes up, but right now it's on the shelf. They've pulled it from certification, mostly because of the low diesel prices.

So on the fuel economy, the natural gas tracks diesel again. Fuel penalty for the natural gas relative to diesel here is much smaller because of the compression ignition engine. It's only 4 percent as opposed to 15 percent for the spark ignited engines, so this is a big thing for natural gas.

For Phase 2 in the low demand case the potential for even higher fuel economy follows from the vehicle technologies that reduce wind and rolling resistance. These improvements come with slightly longer payback periods but are all still within two or three years, according to the EPA and NHTSA.

I put the refuse recycling class truck 8 in its own class because the operation is so strikingly different from other trucks and because the South Coast has a special emissions rule for these. We do see some cheaper models in the truck blue book but we're using an average.

The natural gas truck shows similar deflection year by year as the diesel truck price, with the incremental price for the natural gas one decreasing over time to a little bit different degree.

These garbage trucks move from one house or apartment group to the next, making many starts and stops. At each stop most operate some equipment that draws power from the drivetrain. For this class we're assuming spark-ignited natural gas engine, although they're also being -- I don't know where that's headed with the engine but they can be outfitted with either CNG or LNG.

Three miles per gallon for diesel in 2026 is a dramatic improvement over now. Possibly hybrid diesels outfitted with super capacitors instead of batteries might make sense but these are too early in their development to assign a price, or fuel economy, or what year they'd be introduced.

The weight of conventional batteries for a hybrid version would mean less waste could be hauled per truck to stay under the weight limit. More trucks would be required to haul the same waste, so we did not include a battery hybrid here for this reason. We do include hybrid in some other classes including the

Class 7 and 8 straight trucks.

Oh, I see. I'm going to conclude first, and this Slide 8 is doing double duty. Here we go.

Fleets are looking for a one- to three-year payback for sure, and we're calling it two, and that's our rule of thumb. The truck price and the cost of fuel are the biggest influences on the payback.

Dozens of technologies to increase fuel economy and potentially even more alternative fuel types will be available in the coming years, and we're going to use the Argonne National Lab's Truck 5 model with our freight energy demand model for the IEPR 2015 forecasting.

So here are the key sources we used to put these attributes together.

I've worked alongside Matt Malchow at Sierra Research, who provided much of the low demand case numbers. We both contributed to the reference case, and I prepared most of the high demand case.

The EPA/NHTSA Phase 2 documentation and EMFAC2014 provided the backbone for the low demand and reference cases.

Eva Borges has helped make sense out of some confusion using queries to the DMV data to sort out the fuel types, which are not always as they appear.

The two truck websites have been used ad hoc, not as they always appear. For instance, we had some trucks identified as electric. Turns out those were those Toyota hybrids, and until we found out what they we couldn't even look them up. The two truck websites have been used ad hoc, TruckertoTrucker and TruckBlueBook.

The natural gas paper and some others coming out of the Next Steps Program have been used for the natural gas and hybrid truck prices and fuel economy.

We'll be considering the truck price and fuel economy data presented by NREL in a few moments, as well.

I want to emphasize that we'd like to hear details of your experience and knowledge of alternative fuel and highly efficient trucks, especially their prices and fuel economy. We'll incorporate as much as possible in our forecast subject to the time we have.

And that's it. Are there any questions? None online. Okay. Thank you.

MS. STRECKER: Thank you, Bob.

Now we're going to have Kevin Walkowicz -- I hope I pronounced that correctly -- from NREL come and give a presentation on their work on medium and heavy duty vehicle attributes, as well. Thank you, Kevin.

MR. WALKOWICZ: Thank you. I'm Kevin Walkowicz with the National Renewable Energy Lab. I'm in the Transportation and Hydrogen Systems Center at NREL. We're primarily funded by the U.S. Department of Energy and the Vehicle Technologies Office within the Department of Energy, so a lot of what I'm going to talk about, a lot of our work and a lot of the information here has been developed probably over the last ten years or so through the DOE funded work.

I'm going to try to talk a lot about NREL's approach to quantity fuel economy, and somewhat the associated emissions, mainly for new and emerging technologies in the commercial vehicle market. So a lot of our work is very forward looking.

So throughout this presentation I'm going to talk a little bit about our approach, some of the data and tools that we use, and then some examples of how we're putting all this together on a few different projects.

So as noted earlier, when you're trying to understand consumer behavior and demand forecast for medium and heavy duty trucks, a lot of the medium and heavy duty commercial customers focus mostly on cost and fuel economy that kind of drive the ROI for those investments in the fleet.

I would also add that vehicle cost always includes maintenance costs, infrastructure costs, and a lot of the variability of fuel economy estimates based on the usage of that technology within the fleet, so these are the things that we try to drill down into and provide some of our research with the higher resolution data that maybe drives toward gaining an understanding of specific mile per gallon numbers or overall fuel costs. So we look at the attributes of mpg and cost but we try to look for what the drivers are behind that.

So a couple points I want to make.

One is that there's always the one-size-fits-all constraint in trucking. There's many, many different duty cycles, engine, chassis combinations. Someday maybe I'll try to quantify and add up how many exactly there are. But there's so many different versions of that.

A lot of the built sizes are very small compared to light duty vehicles, so as much as manufacturers would like to maximize their profitability by using economy as scale, they really need to thoroughly understand how the vehicle is being used and what that means as far as system performance and system requirements across that range of usages.

So fleet purchasing often based on assumptions of performance based on published studies, so a lot of times fleet managers will go out and look at, well, what do I know about this, what's been published? But at the end of the day I think we at NREL really try to add some additional information for fleets, OEMs, R&D organization and regulatory agencies and try to supplement some of that data with additional information that we can maybe use in some of these forecasting efforts. So we really do these deep dives into some of these technologies.

So a little bit of background on our approach.

We've been doing this for maybe a dozen years or a little bit more. But we try not to only publish the best possible mpg but also try to be an objective third party data source. And by that, I mean we will show the entire range of performance that you can expect from a technology across different usages.

A little more background. We've gathered quite a few miles of driving data for these advanced technologies, and typically we try to capture technology deployments that have just hit the street, so in the first year of hybridization in trucks, we tried to really gather up data on those. We're not doing so much on it now but we tried to give that early indication of what you can expect as far as fuel economy and costs out of a medium duty advanced technology.

So a lot of the data and analysis is shared with DOE, also our other lab partners. I think Bob mentioned Argonne, we work closely with them. Also Oakridge National Lab. And we also share with industry so that planning and strategies can be developed.

But at the end of the day I think it helps really guide intelligent usage of this technology, and I'll get into that a little bit more later, but you can expect a wide range of performance for some of these technologies, so where's the sweet spot to use some of these technologies, and how can we help fleets, users, OEMs, all understand what the best -- you know, if you're going to build one engine for a hybrid system what should that engine be? Or what should the ideal battery pack be? What are the sweet spots? Where can you find the most opportunity for communization to help work with those quantities of scale issues?

So real quick, we work with fleets and OEMs to understand the latest technology as it's being deployed. We collect usage data and vehicle data to analyze some of the attributes listed in the blue box there below, all of which will help define purchases and demands for new vehicles.

In essence, we try to provide data where not a lot exists on these types of attributes so that it might be able to feed other efforts to project or regulate, build, deploy, these types of advanced technologies.

Just to mention a few of those. You know, operating costs, we try to look at total operating costs and calculate that.

In-use fuel economy estimates and ranges that could be expected there.

We gather up chassis dynamometer emissions testing. It’s an easy way to compare apples to apples, so new technology versus old technology.

We look at unscheduled and scheduled maintenance costs to look at the whole, the total cost there again.

Warranty issues, try to dig into that on our studies. Sometimes these are hidden costs that won’t show up until a few years down the road, but if you have kind of a good understanding on what the failure rate are of some of the technologies you can really try to get a handle on what’s going to be happening three and four years out when the warranty is done.

Reliability, percent availability, miles between road calls, this all drives fleet sizing. How many vehicles do they need to actually buy to cover their routes? Do they have to buy five extra vehicles because of their reliability associated with a certain technology and what kind of costs do those add?

And then implementation issues, barriers, really digging into the cost of the infrastructure and a lot of the operational issues that emerge that the fleets have to deal with, so those all add up when you’re looking at total cost of operation and ownership.

Real quick I just wanted to show this. This is kind of a current portfolio of what we have going as far as digging into some of these technologies. But we’ll look at everything from how different fuels will affect costs, so we’re looking at biofuels. There’s some natural gas trucks we’re looking at. We’re looking at full EVs including a lot of the infrastructure costs.

Fleet Platooning, another fancy way of saying improved aerodynamics on over-the-road trucks. What effect of what opportunities do those really have in a fleet when you consider traffic patterns and terrain and weather and those types of things.

On the right column we've done quite a bit of work on some of the medium duty electric vehicle deployments that are out there, so looking at how efficient those trucks actually are and how they're being driven.

And then along the bottom there in the green is a few different projects that we're doing work not for the Department of Energy. South Coast, AQMD, CARB and EPA. We're working closely with them to deploy some of these processes and tools to help them understand everything from drive cycle to performance.

So we use a data and modeling approach to quantify miles per gallon and cost estimates for a lot of the new technologies.

We have a -- I'll talk about it in a minute, but we have a project called Fleet DNA. It's data from all our field evaluations as well as quite a few of our partner fleets to really help to define the usage.

And then analyzing, exploring, optimizing technology based on those duty cycles. We'll use a range of different vehicle models. We have our drive cycle analysis tool that kind of helps summarize how the vehicle's being driven.

We have what's called Fast Sim. It's a simulation model that we can quickly go through a lot of different drive cycles.

The A Fleet model is a model developed by Argonne National Lab to look at life cycle costs, and then we use autonomy.

We also use Gems Moves. NREL has a light duty fleet -- or a light duty technology adoption model called ADOPT. So we try to use those to look at projecting out to a national number, an analysis of national factors are important.

So we start with the individual vehicles on individual routes and we try to work our way up into what we can tell about different regions or states or national levels.

So Fleet DNA, real quick. It's a tool we use to really understand the breadth and the variability of a specific vocational usage. This variability can really affect the expected miles per gallon and really the lifetime costs of a given technology.

So you can imagine EVs and maybe the unknown battery life of an EV in a medium or heavy duty application. How long is that battery going to last? Well, it depends on the duty cycle, so you need to know a little bit about the duty cycle and a fleet manager will want to know that to know, hey, am I going to have to replace a 100 kilowatt hour lithium battery pack in five years or ten years or fifteen years? Battery costs are high so that can be a significant cost.

So we try to put all this data out there and really try to understand the duty cycle. A lot of the information is online posted on our website, but we also have a few opportunities to drill a little bit deeper and look at specific cases. So if anyone's interested in questions under any of these vocations, certainly let us or DOE know.

Just an example here of how we use Fleet DNA and the DRIVE tool, so each one of those blue dots are a day of operation that we measured on these, in this case utility bucket trucks. They actually have exportable power but they also have all electric operation both at the jobsite and through the driveline available.

So what we do is we go out there and try to understand how they're being used. The different shapes of different colors represent some of the standard drive cycles that you might have available to test to out there.

So what we do is try to overlay how the

vehicle is being used and then pick some appropriate drive cycles or even run some custom drive cycles based on that. And again, it can be anywhere from zero improvement out to 50, 60 percent improvement depending on what drive cycle you choose, so it’s very important that you understand how the vehicles are being used out in the field and test accordingly or pick the right test results accordingly.

When we project from kind of our individual data, our captured data, and we try to project that out to maybe a fleet or a regional or state or national level, we also have other datasets that we can draw from. Just a few examples here are shown.

Most importantly, we’ve done a lot of work lately on grade, so that obviously will affect the road load of the vehicle that it’s going to see and really affect the performance of the vehicle.

We use Moves and Polk data to provide us with some population estimates, again, when projecting out to a national level.

And then we also, we’ve been doing a lot of GIS street mapping work to help us understand maybe projected routing or routing opportunities or just general traffic road type and understanding how that’s going to be used so you can maybe pick based on where the vehicle is used, what type of operation it would see or maybe look for areas again to improve the performance.

So putting all that together, we try to provide input to component sizes and other vehicle characteristics in our vehicle model and run it through a variety of in-use conditions or drive cycles.

Outputs always include fuel economy or vehicle performance, but we can also estimate vehicle costs even for all these variable component sizes that we might be able to put in.

For light duty, again, we use the ADOPT model. We don’t really have a heavy duty version of it yet so I’m kind of interested to maybe work with the Truck 5 model that was mentioned earlier.

Here’s some examples of some of the output that we generate when we do some of these studies. So basically on the X axis you’re looking at a percent change in some of the vehicle attributes. And then on the Y axis is what kind of fuel economy change you might expect for that vehicle.

And each one of the dots in each of these examples is a different drive cycle or day of operation that we ran it on, so you can kind of see what the expected range, high, low and average, might be, you know, looking at drag, coefficient, or engine sizing, wheel rolling resistance, mass reductions. All those types of things, once we get the vehicle usage data we can understand what attributes might give the biggest bang for the buck when a fleet is looking to make a change.

So a few examples real quick that we've used these tools on. Again, working with OEMs. Right now we're working with Eaton, Oak Ridge, and Smith Electric Vehicle is looking at optimizing a multispeed gear box for their electric vehicle.

So again, understanding how it's used, what the duty cycle looks like, is going to dictate what your power and torque requirements are going to be. So really trying to optimize the technology again for some of the given use.

You can see down in the lower here, this is all of our packaged delivery data that we have on those types of vehicles.

City of Indianapolis, we went out and worked with them. They were interested in CNG and also transmission calibration.

So same process. We went out and tried to understand how the vehicles were being used, what the demands were on the vehicle system, and then looked at what opportunities there were based on some of the vehicle modeling that we did for them as far as how a CNG engine would perform, or maybe --

I know in the end the one thing they did do is they implemented a different shift schedule with Allison Transmission to improve their fuel economy by 4 or 5 percent. Simple fix but they figured out how they were driving them and what the transmission shift schedule should look like.

Looking at some of the regulatory work that we've done. I guess long story short here; we're working with EPA to try to help craft some of the greenhouse gas Phase 2 regulations, so putting some of the analysis behind the drive cycle selection and how that gets worked into the regulations to make sure that technology is quantified correctly based on how it's going to be, so if it's a standard cycle or maybe if someone's going to propose a more custom cycle.

Last one just real quick, you know, kind of looking further out. Looking at the aerodynamic drag on trucks. Truck platooning, same thing. We looked at what the technology does under a lot of different conditions, mapped that out.

Next step is we're going to try to understand what that means at a national level. So how often do the trucks drive at 65 miles an hour. You know, what does the terrain look like? What does the road grade look like?

So the chart in the middle there just shows all the different areas that we tested. And we looked at following distance versus vehicle load and vehicle speed and then how much fuel it saved. So again, providing that range and then understanding the usage you can kind of figure out where you might fall on that curve.

So last two projects real quick here.

One, working with South Coast AQMD. They're interested in understanding NOx expectations for some of the emerging technologies. And they really want to understand, you know, where are the big NOx producers? What vocations were they. Try to identify the top three vocations.

Go out and understand those vocations with some data collection and drive cycle analysis, and then do some simulation to try to look at what technology, again, might have the biggest bang for the buck to reduce NOx in those three specific vocations.

So these are just some slides I pulled from the actual project. But again, identifying kind of the top year, make, model, vocations of vehicles, and then we go out and we do some field data instrumentation to really understand the usage of the vehicles.

And then last task is going to be to do some simulation analysis of the powertrain technologies to look at what will affect the NOx in the most beneficial way.

Last project is kind of a follow-on to the first project. But again, working with AQMD, and in partnership in this case with Ricardo to create a potential zero emission vehicle roadmap which will look more closely at possible technology adoption rates and their effect on NOx and CO2 out into the 2023, 2032, and 2050 timeframe.

So a little more of a forward-looking effort to understand what technologies will be evolving and deploying, and then what the environmental effects might be for the various scenarios that come out of the roadmap.

So for this one we’re going to be using the Ricardo total cost of ownership model, which is kind of a fleet decision methodology tool. And we’ve done a little bit of work to make sure it complements the CARB sustainable freight initiative, so we’re trying to make sure all that comes together.

So again, actual use data driven approach to analyze mile per gallon fuel economy, CO_2 emissions, along with a lot of the other fleet costs. Cost of operation. And also concerns to try to understand how we might improve the penetration of some of these advanced efficient technologies into both today and tomorrow's market.

Last comment will be kind of looking forward in the future. I do want to mention that U.S. Department of Energy recently completed the Supertruck Project. I think three out of four of them wrapped up this year, and it's getting ready to kick off the Supertruck 2 Program, so a little plug for that.

But it's a really good source of information to try to get a look into what technology might be coming next in the heavy duty industry, so if you're interested in what technologies and what effects they have, I encourage you to look at the DOE Supertruck website.

A lot of those projects developed and tested a lot of different technologies on Class A trucks and there were some very nice gains associated with those trucks and those technologies in both fuel economy and engine efficiency. So definitely take a look if you want to see what's coming in the next five to ten years. I think a lot of what was developed there will be maybe cherry picked and deployed across a number of different vocations for trucks in the next few years.

So that’s it. If anyone has any questions, I can answer them.

MALE VOICE: We do have one online question, again from Sam Pournazeri. On Slide 11, how about vehicle speed limiter technology?

MR. WALKOWICZ: Vehicle speed limiter. Yeah, I think that kind of plays into the -- that could be a calculation we could definitely look at and that would be associated with the aerodynamic drag. Obviously it’s a square effect, so that would be an interesting thing to break out. We haven’t looked at that but we could certainly generate curves associated with different drag coefficient changes and limit it from going from 65 to 60 or 55 looking at mile per gallon improvements for that type of thing.

And again, Slide 11, that’s just kind of a sample. We probably have a dozen or 15 different attributes that we generally try to look at, or what we think we need to look at. So if anyone has other attributes they want us to analyze, certainly let me know. We’re always looking for good suggestions on what it is that people want to know from some of this data.

No other questions?

MS. STRECKER: That's it.

MR. WALKOWICZ: Okay. Thank you.

MS. STRECKER: Thank you, Kevin.

And for our last presentation of the day we're going to have Marc Melaina, also from NREL, talk about time to fueling station. And Marc is online, so hopefully he's there and can hear me and is ready to go.

MR. MELAINA: Yes, I'm here. Good afternoon. Can you hear me okay?

MALE VOICE: Yes, we can hear you. Just let me know when you want to change slides.

MR. MELAINA: Okay, great. So my name is Marc Melaina, I'm an analyst at NREL. I work in the same transportation center analysis group as Kevin Walkowicz. I'm going to talk about some of our analytic framework to look at these future trends that Kevin reviewed, extrapolating from near term data, looking into the future of how we think vehicles and fueling systems might evolve over time.

If we could go to the next slide.

There's four different topics that I'm going to cover. The first one is really just the estimation of drive times, or say definition of drive times. And the stations here that we're talking about are alternative fuel stations, so it's how far you'd have to drive to get to a fueling station if you have an alternative fuel vehicle, is the idea.

In the example that I'm going to show and that we've integrated into our own fair markets from Dr. Mike Nicholas from UC Davis.

The second topic is, given the understanding of drive times, how can those be translated into cost penalties within a vehicle choice analytic framework. So projecting how drive times might impact market adoption.

So I have an example from Dr. David Greene and Jen Hung Lin from Oak Ridge National Lab, their MA3T model uses this kind of cost penalty for market share projections. We use our own at NREL as well, but I'm going to try and make the connection there between the physical drive times and then those economic cost penalties for consumer choices.

Then number three is a caveat just on this basis of percent of gasoline stations. I think that'll be clear when I get to it.

And then four is sort of another caveat on drive times, physical drive times being very different from how consumers actually perceive refueling availability from sort of their understanding as a consumer rather than just say two minutes or three minutes as an analytic result. How do people actually think about refueling availability and how far they might have to drive.

So those are the four topics. I have a lot of slides I'm going to go through pretty quickly.

So for the average travel time metric, this is the definition from Mike Nicholas from UC Davis. He had an important paper from 2004. I think it was a Transportation Research Board paper. It was also part of some of his graduate work.

The idea that for all residents in a given urban area, how far would they have to drive to a station if there are only a limited number of stations in a city? So the model identified the best locations to minimize average travel time from the home, and then you could estimate how many stations would provide what level of convenience for new consumers of a new vehicle.

So in bold here that fourth bullet, the idea here is to try and estimate or quantify a sufficient level of coverage of stations. And this is especially important or most essential for dedicated alternative fuel vehicles such as CNG and hydrogen vehicles that really have to refuel at a retail station. There are some CNG home fill, but retail stations for dedicated vehicles, the idea is the critical market dynamic.

So this model from UC Davis is similar to the UC Irvine STREET model. They estimate things a little bit differently, but I think the drive time concept is generally the same.

And I'm not going to talk about planning too much, but the STREET model was used as an analytic tool in developing the California Fuel Cell Partnership Roadmap for hydrogen stations.

So the map here, I think is a good way to show that this is a result of just two stations in Sacramento, sort of the travel basin of where people would have to drive to get to those.

So analytically you would add up all those trips from all the people that live in those areas and figure out the average time for all the people in those cities if there are just two. And then you can gradually increase the number of stations to get lower drive times. We'll see that in the next couple slides.

If we can go to the next one.

So the result here analytically on the graph on the left -- again, this is from the Nicholas study

-- and the average travel time is minutes, going from 14 minutes down to zero. And then the number of alternative fuel stations on the horizontal axis increasing.

So very quickly, as you put in one, two, four, eight, sixteen stations, your average travel time for everybody in the city drops from 12 down to 4 minutes. Again, this is Sacramento. And what you see is a leveling out to about 2 minutes, which is sort of what we expect for gasoline in the city. So you see decreasing returns there.

The map on the right just shows the scatter of where those stations were located in Sacramento by the optimization model.

If we can go to the next slide.

So this is the number two topic from my overview slide. Given those estimates of travel time, how do we translate that into a cost penalty?

If someone is at the dealer and they're looking at a vehicle that has to be refueled and there's only a limited number of stations, how might they see that vehicle as being less valuable if they know there's only a limited number of stations available?

So here again, the horizontal axis is the number of stations but it’s shown as the percentage of gasoline stations in the city. And then as that percentage becomes small moving to the left, moving toward zero, the cost penalty increases exponentially.

You can imagine at zero, of course it’s infinity because you can’t refuel your vehicle. But as you add more stations to an urban area that cost penalty comes down fairly quickly.

So just as a reference point, it’s about a $500 cost penalty if 10 percent of the locations offered the fuel. So that’s the idea and that’s how it would be implemented in the model.

If we could go to the next slide. I’m not going to spend too much time on this. Hopefully, people are familiar with the kind of modeling that this refers to, but the consumer choice modeling weighs a lot of different attributes for a vehicle and monetizes them, and combines all the utility function to help determine what type of vehicle different consumers are buying.

So it’s a little bit of a complicated graph in the bottom left there, but it just shows green being the retail price of a vehicle, so it’s a baseline dollar-to-dollar relationship.

And then it shows how acceleration, range, and the volume of the vehicle, if those change, what is the resulting equivalent retail price penalty or benefit for a particular type of vehicle. So that's one way to visualize how these utility functions work in a consumer choice model.

And the previous slide was basically that same attribute from David Greene's model translated into a retail price equivalent, so that was that $500 one that I mentioned.

So we'll go to the next slide.

So what we've done, as Kevin mentioned, we try and expand our models to go national so we can look at markets across the country.

So again using the same travel time model, Mike Nicholas at UC Davis analyzed four major cities in California that had correlations with travel times and the population density of each city, and he identified the correlations shown in the top right figure.

So basically as the population density increases it's easier to give more people access with fewer number of stations. Just sort of an intuitive result, but the correlation is fairly strong.

And again, this is a travel time model for each city.

So what we’ve done is we took that parametrization and extrapolated it to all the cities in the country. We already know their population densities, so we just assumed that those travel times were sort of universal trends and that a lot of cities have the same basic structure. So given those correlations we could estimate travel times for any urban area in the country.

If we can go to the next model -- I’m sorry, the next slide.

This is the actual equations that we used that we generalized from the Nicholas study. And we used six minute drive time as sort of a baseline for a coverage station similar to the California Fuel Cell Partnership Roadmap.

Go to the next slide.

One of the things that we did to try and correct for just using California based stations is we analyzed very closely the number of gasoline stations across the country. The figure on the left is just an important trend so people understand the historical progression of gasoline stations. The number of stations have been going down over time as the number of vehicles goes up, so these are not really static numbers when we talk about gasoline stations.

And the figure on the right shows for different regions in the country the number of stations per area or per person varies depending on where you are in the country.

So before we extrapolate from those four cities in California we have to correct for that variation reaching across the country.

If we can go to the next slide.

This is a little bit more evidence for that. There's a paper we published with Dr. Joel Bremson from UC Davis. This again reinforces this idea that the number of gasoline stations in the country varies, so you see the major cities in the U.S. with station density, stations per square mile on the vertical axis, and then population density on the horizontal axis, and you see a pretty broad range from .5 stations per square mile up to 1.2 stations per square mile.

So what we've done is we've corrected for that lower bound sort of the dotted line along the bottom of this cluster of dots and we've used that as a baseline to try and correct for the variability in the density of gasoline stations. And then we have a little bit more accurate and consistent estimate of drive times for all U.S. urban areas.

Go to the next slide.

This is just basically the equation that we used to do that correction for the number of what we called threshold stations. And the cover there is from a report where there's some more details on this equation if people want to learn more about how we did that. It's the *Transportation Energy Futures Report* and there's details in the appendix on how we did this.

If we could go to the next slide.

I want to talk about just building on the actual traffic model used by Mike Nicholas at UC Davis compared to some other estimates such as the STREET model.

We also did another estimate by clustering the number of stations in urban areas to simulate what a reduced network of stations would look like.

And instead of going into this geometric figure here, I'm going to show sort of an animation if we could go to the next slide.

Just one example of a city. This is Birmingham, Alabama. The red dots are all the gasoline stations and the size of the dots is the volume of fuel from each station.

So analytically knowing the locations and the volume of all the stations, what we did is the first two stations that were closest to each other, we had basically the larger of the two sort of swallow up the smaller one and cluster them together, and we did that one by one for all the stations that are close to each other to simulate how the same amount of fuel would have to be delivered to a smaller number of stations, so that’s the clustering idea.

And what we did is each time we eliminated a station we said that the people who were going to refuel there had to drive an extra distance to get to the other station, and that’s how we estimated travel time if you had a reduced number of stations.

So hopefully that idea makes sense. And if we go through maybe one second at a time in the next couple slides, we start clustering these together.

So at .1 mile you don’t really see much change, but we’ve actually clustered at this point on Slide 15 31 percent of the stations have been eliminated from the network.

You still have really good coverage but here you can see that the volumes start to concentrate and the network of stations starts to thin out.

So now they’re clustered at .4 miles and half of them have disappeared, so people are having to drive further to a limited number of stations. And in the model we keep track of how many trips, how much fuel they're using, and how much further they have to go.

So now we're coming up on 1 mile cluster distance, so no station is within one mile of another station on Slide 23. So hopefully this sort of shows people what that drive time looks like if you start removing stations.

If we could click one more.

See, it's really becoming a more sparse network and I think coming up here we have to switch to another time or another volume scale, so it's going to switch to purple dots just to show people these circles get too big so we have to readjust the scale here.

If we stay on this one for a second, you can really see the distribution. The same amount of fuel analytically going through this limited number of stations. And we now know how much further people had to drive to get to this much sparser network of stations to get the same amount of fuel.

So that's how we estimated drive time for this particular model.

A couple more clicks and we'll be to sort of the bare bones coverage of 4 miles, now 5 miles between stations.

So this graph shows it for three cities. We actually did it for about 100 cities across the country and found pretty consistent results. And they did confirm that the more elaborate traffic model from the Nicholas study, the same sort of exponential trend.

So again, this is when we put a penalty on the time it takes to drive to the other station, we can have that consumer choice model price penalty for the purchase of a new vehicle, and this particular analysis sort of validated the same type of curve from the Nicholas study.

So that goes through the first three topics I was going to cover.

If we can go to the next slide.

I have sort of a different take on this travel time idea. What I’ve shown so far is what we refer to as a rational actor view of travel times. So rational meaning if somebody actually knew how far they had to drive, they’d project into the future how often they’d have to do it and they knew that it was sort of a nuisance cost of, say, $20, $30, $40 per hour to drive out of their way, we can calculate how that rational actor would perceive a vehicle as being less valuable. So that's what happens analytically in the model.

However, there's another way to look at it and that's to do a survey and ask people, try and give them good information about what kind of choices they would be making to buy a new car, and show them in this case very detailed maps of where they live and where stations might be located. And then through the screen choice framework for the survey, try and key that what that cost penalty might be from just their understanding of this information in the survey.

So this was a study that took us about two, two and a half years. We did three different versions of the survey. Each time we improved it a little bit more. The final one was about 400 -- I'm sorry, bottom bullet here -- about 500 participants in four major cities across the country, and we started getting statistically significant results to try and nail down these cost penalties associated with limited fueling availability.

So basically this is a panel of people in their homes. They had computers. PA Consulting worked with us to develop a survey. The panel members, you know, they corrected for the weights for which households they were drawing information from.

People would take the survey in their home and they would see that screen on the right and just sort of scroll down through all the questions, and then at the bottom they would choose the conventional vehicle on the left column and then the alternative fuel vehicle on the right.

It would show them the price of the vehicle , some other attributes and fuel costs. But in particular we wanted to weigh these maps of where stations were against those other vehicle attributes and then determine based on their responses how much they valued increased availability of stations.

So this is a couple zoom-ins on that screen to help explain what we did in the survey, if we could go to the next slide.

So this level of coverage was the metropolitan level. We asked people to find where they lived on the map to make sure they understood the map, and then we showed them different levels of coverage where the gasoline stations full coverage is on the left and the alternative fuel for the new vehicle purchase, hypothetical purchase decisions are the red dots on the right.

So they would look at this map and weigh this against the other vehicle attributes and try to decide which vehicle they would buy.

If we could go to the next one.

This just shows that in the survey itself we had four different levels. Full coverage is number one. Two and three are sort of the intermediary coverage levels. And then four is very close to maximum, and five is the same coverage as conventional vehicles.

One reason why we did this survey several times is we had to try and make these maps distinct enough that people could respond to them differently but statistically relevant interpretations of what these meant for their purchase decision. So that's the metropolitan coverage and this is just shown for Seattle.

Let's go to the next slide.

We moved to another level of coverage, and this is on the regional scale, so the circle there is 150 miles outside of Seattle. We have comparable maps for all the other cities and you can see some extreme cases of where stations would be shown.

Gasoline stations are everywhere, but if you want the alternative fuel vehicle you can only refuel at these locations with the red dots on the right.

If we could go to the next slide.

This will show you L.A. and all four levels of coverage that we had. The red dots are a little bit faint on number two in the top there, but there are just a few stations outside of L.A. where you could refuel. And then three and four you have much better regional coverage. And then level five you would say the alternative fuel is as available as gasoline. So that's the regional level.

And then we had one more level of coverage on the next slide, and it was along interstates.

So here we're back in Seattle and we say, well, if you buy this vehicle this is as far as you could drive on the interstate and still have access to fuel.

If we go to the next slide we show the four different levels again.

The first here being no travel outside of the metropolitan area. And these maps are for L.A. So we're switching between L.A. and Seattle.

So the first one is you can't actually drive out of the 150 mile region, so you can expect that there would be higher penalties for that one, and we did see that.

And then the top right, you can only drive a limited range. And the bottom left you can basically drive, say, halfway across the country. And then the fourth option is the same as gasoline, all destinations are possible.

I think on the next slide we show some of the results from the survey, and these are just bulleted results.

Again, we're talking about stated preferences so we know that these are probably not quite what people would do in the real world but we did get some interesting results.

For that first level of urban coverage, or lack of coverage of refueling availability, we saw penalties ranging from $750 to $4000, and this is basically against the purchase price of the vehicle. So for very low coverage the vehicle would look $4000 less valuable to a consumer if you didn't have enough urban stations.

Regional ranges were $1500 to $3000. And then those interstate maps, if there's not enough availability there, the penalties were surprisingly high at $2000 to $9000.

And our interpretation of these results is that these would be cumulative so that you would add all three of those up depending on how many stations were providing coverage to a particular urban area.

So we want to contrast those stated preference results with the earlier rational actor estimates, and the rational actor estimates are based upon travel times in our clustered approach and they're used in the Argonne MA3T model and I believe in the National (inaudible) model. Those are about three to four times lower, down to $250 to $1500 penalties for coverage of stations, and then they do not currently have sort of consistent penalties for those other levels of coverage.

But you can see there's a pretty broad range between these two different ways of estimating the cost penalties.

I think we show that graphically on the next slide.

So this is pretty busy, I'm not going to walk all the way through it, but the cost penalties on the vertical axis and it gets larger as you have fewer and fewer stations toward the left.

But what it shows is the very bottom one, below $1000, the dashed line,, is our clustering analysis results. That's the rational actor result.

And then the stated preference ones are shown above. Blue is Los Angeles. Green is Atlanta. The pink fuchsia is Seattle. And then Minneapolis.

And you can see there that order of magnitude of two to three to four, depending on which city it is for the stated preference penalties.

And I think I just have one more sort of detailed slide here. This just highlights that there is variability between cities. So in a lot of ways Los Angeles is an outlier.

So if you take a penalty from one city and say it applies to another city, you might be missing some important sort of geographic constraints.

In our survey we had higher penalties in Los Angeles for a limited number of stations compared to these other cities. The difference is shown in the bottom right where we just compare the purchase price penalty for Los Angeles versus Minneapolis as a function of the percent of stations offering the fuel.

So I think that’s all the material I wanted to present. I have one summary slide here just to review what I’ve presented.

You can estimate average travel times and distances using traffic models, which is a fairly satisfying way to try and understand how coverage can be provided in a given urban area. So I showed how the study from Mike Nicholas at UC Davis did that for four major cities in California.

And I showed how those travel times can be translated into price penalties in consumer choice models, which has been done in a few different models.

The third bullet here is just a reminder that there's a caveat on the percent of gasoline stations because the number of gasoline stations does vary between cities, between regions in the U.S., so you have to correct for that, especially if you're doing a national analysis.

What I've proposed here is that the rational actor penalties are sort of a floor. They're probably a little bit of a low estimate on what people would actually perceive this penalty as.

And then the fourth bullet is that in contrast the stated preference penalties are probably a little bit too high. And we showed how they differ by about three to four times in terms of the dollar retail purchase price equivalent.

And then finally I think people have been wondering this. If you haven't, you can wonder about it now. How do we use this information to try and talk about D.C. fast chargers? And I would just caution that charging for plug-in electric vehicles is much more complicated than the relatively simple dedicated vehicle only refuel at a retail station idea. So I think that this can be used as a guide, but it doesn't really untangle how D.C. fast chargers play a role in market adoption when plug-in electric vehicles can also charge at home or at work, it's a much different dynamic and more complicated, so I think it only partially guides us on understanding the role of D.C. fast chargers.

I think I went pretty quickly there. Let me see if there's any questions.

MS. STRECKER: Does anyone in the room have any follow-up questions?

MR. MCBRIDE: Sure. I'm just curious if there's any work like this for medium and heavy duty that anybody's aware of.

MR. MELAINA: I'm not aware of any, and I think it's a pretty different mental model in terms of a fleet manager making a purchase decision. Is that sort of what you're asking about?

MR. MCBRIDE: Yeah.

MR. MELAINA: Yes. I would say that this is generally not applicable to a fleet manager making a decision. This is really a little bit about household consumers. So I wouldn't say that there's much of this that can translate over.

There are a lot of fleets that refuel at retail locations, but the fleet managers take into account a whole different set of attributes and decisions when they purchase vehicles. They're much closer to the rational actor model, but they also know where they're going to refuel generally along their delivery routes, so it's a different framework for how they make that decision.

So I guess the answer is no, I don't know of a comparable type of analysis for fleet managers.

MS. STRECKER: Are there any other questions or comments from the room?

Looks like nothing else in the room. Nothing online. We have no questions or comments online, so this concludes our workshop for today.

I'd like to thank everybody for their participation and I encourage you all to submit your comments to our docket. If you need information how to do that please refer back to the workshop notice.

And we will be having our next workshop on November 4th, 2015, to discuss our revised Transportation Energy Demand Forecast.

Thank you, everyone.

(Adjourned at 2:21 p.m.)

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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.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 30th day of October, 2015.

Kent Odell
CER**00548

TRANSCRIBER'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 transcribed by me, a certified transcriber and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 30th day of October, 2015.

Terri Harper

Terri Harper
Certified Transcriber
AAERT No. CET**D-709